December 2021

Alternative Groundwater Sustainability Plan

for the Livermore Valley Groundwater Basin

WATER AGENCY

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AB	Assembly Bill
ACCDA	Alameda County Community Development Agency
ACEH	Alameda County Environmental Health
ACWD	Alameda County Water District
AF	acre-feet
AFY	acre-feet per year
AIS	Aerial Information Systems
AMP	Asset Management Plan
AOC	Areas of Concern
ARM	Aerial Recharge Model
BARDP	Bay Area Regional Desalination Project
BMO	Basin Management Objectives
BMP	Best Management Practices
CASGEM	California Statewide Groundwater Elevation Monitoring
CCE	California Conservation Easements
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CDFW	California Department of Fish and Wildlife
CE	Categorical Exemption
CEC	Contaminants of Emerging Concern
CEQA	California Environmental Quality Act
CIMIS	California Irrigation Management Information System
CIP	Capital Improvement Program
COC	Consituents of Concern
COL	Chain of Lakes
CPA	California Protected Area
CUWCC	California Urban Water Conservation Council
CWC	California Water Code
CWS	California Water Service
CY	calendar year
DAC	disadvantaged community
DCE	dichloroethene
DCP	Delta Conveyance Project
DCR	Delivery Capability Report
DDW	Division of Drinking Water
DSRSD	Dublin San Ramon Services District
DWR	Department of Water Resources
EACCS	East Alameda County Conservation Strategy
EBMUD	East Bay Municipal Utilities District
EBRPD	East Bay Regional Park District
EDF	Environmental Defense Fund
EHD	Environmental Health Division
EIR	Environmental Impact Report

ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency
ET	evapotranspiration
ETo	reference evapotranspiration
ft	feet
ft bgs	feet below ground surface
ft msl	feet above mean sea level
ft/day	feet per day
FY	fiscal year
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	Groundwater Dependent Ecosystem
GIS	geographic information system
GPQ	Groundwater Pumping Quota
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWE	groundwater elevation
GWMP	Groundwater Management Plan
HCM	Hydrogeologic Conceptual Model
HGA	HydroGeoAnalyst
HI	Hydrologic Inventory
HRL	Health Reference Level
ICSW	Interconnected Surface Water
IDC	Integrated Water Flow Model Demand Calculator
IM	Interim Milestone
IS	Initial Study
IWFM	Integrated Water Flow Model
LAMP	Local Agency Management Program
LARPD	Livermore Area Recreation and Park District
LAVWMA	Livermore-Amador Valley Water Management Agency
LDV	Lake Del Valle
LLNL	Lawrence Livermore National Laboratory
LVE	Los Vaqueros Reservoir Expansion
LWRP	Livermore Water Reclamation Plant
M&I	Municipal and Industrial
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MGD	million gallons per day
MGDP	Mocho Groundwater Demineralization Plant
MHI	median household income
MND	Mitigated Negative Declaration
MO	Measurable Objective
MODFLOW	USGS Modular Finite-Difference Flow Model
MOU	memorandum of understanding
MT	Minimum Threshold

MTBE	methyl tertiary-butyl ether
µg/L	micrograms per liter
NA	not applicable
NCCAG	Natural Communities Commonly Associated with Groundwater
ND	Negative Declaration
NDMI	Normalized Derived Moisture Index
NDVI	Normalized Derived Vegetation Index
NEPA	National Environmental Policy Act
NL	Notification Level
NMP	Nutrient Management Plan
NO3N	nitrate-nitrogen
NOAA-NMFS	National Marine Fishery Service
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
OWTS	onsite wastewater treatment systems
P/MA	Projects and Management Actions
PCE	tetrachlorethylene
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
POTWs	publicly-owned treatment works
PRG	Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
RL	Response Level
RMS	Representative Monitoring Sites
RMS-ICSW	Representative Monitoring Sites for Depletions of Interconnected Surface Water
RMS-WL	Representative Monitoring Sites for Chronic Lowering of Groundwater Levels
RMS-WQ	Representative Monitoring Sites for Degraded Water Quality
RRE	rural-residential-equivalence
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SBA	South Bay Aqueduct
SCADA	Supervisory Control and Data Acquisition
SCEP	Stakeholder Communication and Engagement Plan
SCVWD	Santa Clara Valley Water District
SDAC	severely disadvantaged community
SFPUC	San Francisco Public Utilities Commission
SGMA	Sustainable Groundwater Management Act
SLDMWA	San Luis & Delta-Mendota Water Authority

SMARA	Surface Mining and Reclamation Act
SMC	Sustainable Management Criteria
SMP	Salt Management Plan
SPA	Special Permit Areas
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TBA	tertiary-butyl alcohol
TCE	trichloroethylene
TDS	total dissolved solids
TNC	The Nature Conservancy
TPHd	total petroleum hydrocarbon as diesel
TPHg	total petroleum hydrocarbon as gasoline
TRE	TRE Altamira
TSS	Toxic Sites Surveillance
UCC	Urban Creeks Council
UR	Undesirable Result
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
UWMP	Urban Water Management Plan
VA	Veterans Administration
VBA	Visual Basic for Applications
VC	vinyl chloride
WBIC	weather-based irrigation controller
WMP	Well Master Plan
WQO	water quality objective
WR	Water Rights
WSCP	Water Shortage Contingency Plan
WSE	Water Supply Evaluation
WWMP	Wastewater Management Plan
WY	Water Year

EXECUTIVE SUMMARY

§ 354.4. Each Plan shall include the following general information:
(a) An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.

☑ **23 CCR § 354.4(a)**

ES.1. Introduction

On 16 September 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) to establish a framework to protect groundwater resources within the state's high and medium priority groundwater basins. SGMA empowers certain local agencies to form Groundwater Sustainability Agencies (GSAs) whose purpose are to manage basins sustainably through the development and implementation of Groundwater Sustainability Plans (GSPs). A GSA is able to submit an Alternative GSP if it is able to demonstrate that the basin it is responsible for managing has been operating within its Sustainable Yield for at least 10 years.

Under its authority as the exclusive GSA of the Livermore Valley Groundwater Basin (Basin), the Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7) submitted an Alternative GSP for the Basin in December 2016 (see **Figure ES-A**[1] for the Plan Area). The Basin is designated by the California Department of Water Resources (DWR) as a medium-priority basin and is not subject to the critical conditions of overdraft. DWR approved Zone 7's 2016 Alternative GSP in July 2019 and provided a list of recommended actions to consider in future updates to the Alternative GSP.

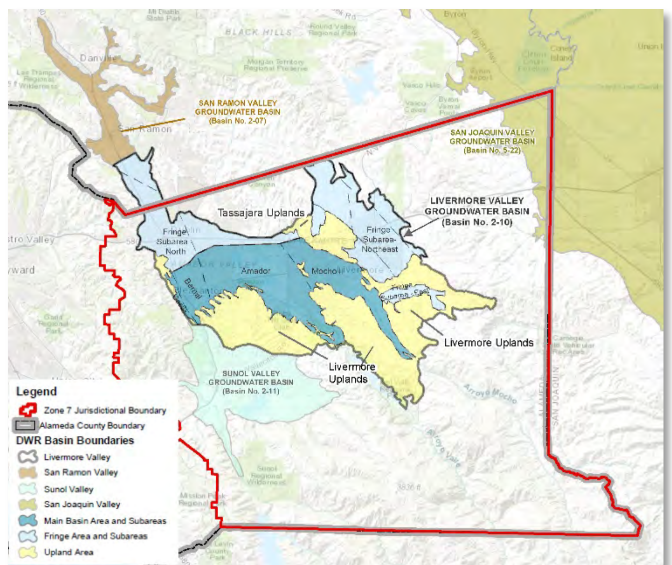


Figure ES-A: Map of Plan Area

Per SGMA requirements, each GSA shall evaluate its GSP or Alternative GSP at least once every five years and provide a written assessment to DWR that the basin has continued to operate within its Sustainable Yield and has not experienced Undesirable Results. This 2021 Alternative GSP was prepared by Zone 7 in accordance with SGMA regulatory requirements[2] to demonstrate that Zone 7 has continued to operate the Basin within its Sustainable Yield over a period of at least 10 years and is meeting the Sustainability Goal defined for the Basin. The 2021 Alternative GSP

[1] Full-sized versions of Figures ES-A through ES-F are available in corresponding sections of the Alternative GSP.
[2] Regulations for GSP development are contained within Title 23 of the California Code of Regulations (CCR) Division 2 Chapter 1.5 Subchapter 2. https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf

addresses the recommended actions provided by DWR in its assessment of the 2016 Alternative GSP and includes several additional updates to the Basin Setting, Sustainable Management Criteria, Monitoring Network, and Projects and Management Actions sections as further described below.

ES.2. Sustainability Goal

Zone 7 adopted the following Sustainability Goal for the Basin:

> *Continue to operate the Livermore Valley Groundwater Basin within its Sustainable Yield and to manage the groundwater resources for the prevention of significant and unreasonable: (1) chronic lowering of groundwater levels, (2) reduction of groundwater storage, (3) degradation of groundwater quality, (4) inelastic land subsidence, and (5) depletion of interconnected surface water supplies such that beneficial uses are not adversely impacted*.

ES.3. Plan Area

The Plan Area includes the entire Basin, which encompasses 69,600 acres in Alameda and Contra Costa counties. Cities overlying portions of the Basin include San Ramon, Dublin, Pleasanton, and Livermore. The Basin is bordered by the San Ramon Valley Basin on the northwest and the Sunol Valley Basin on the southwest, both of which are designated as very-low priority basins for SGMA compliance purposes. Land uses include urban, agricultural, mining, water bodies, parks, golf courses, and open space (see **Figure ES-B**). Current land use remains similar to that of the mid-2000s.

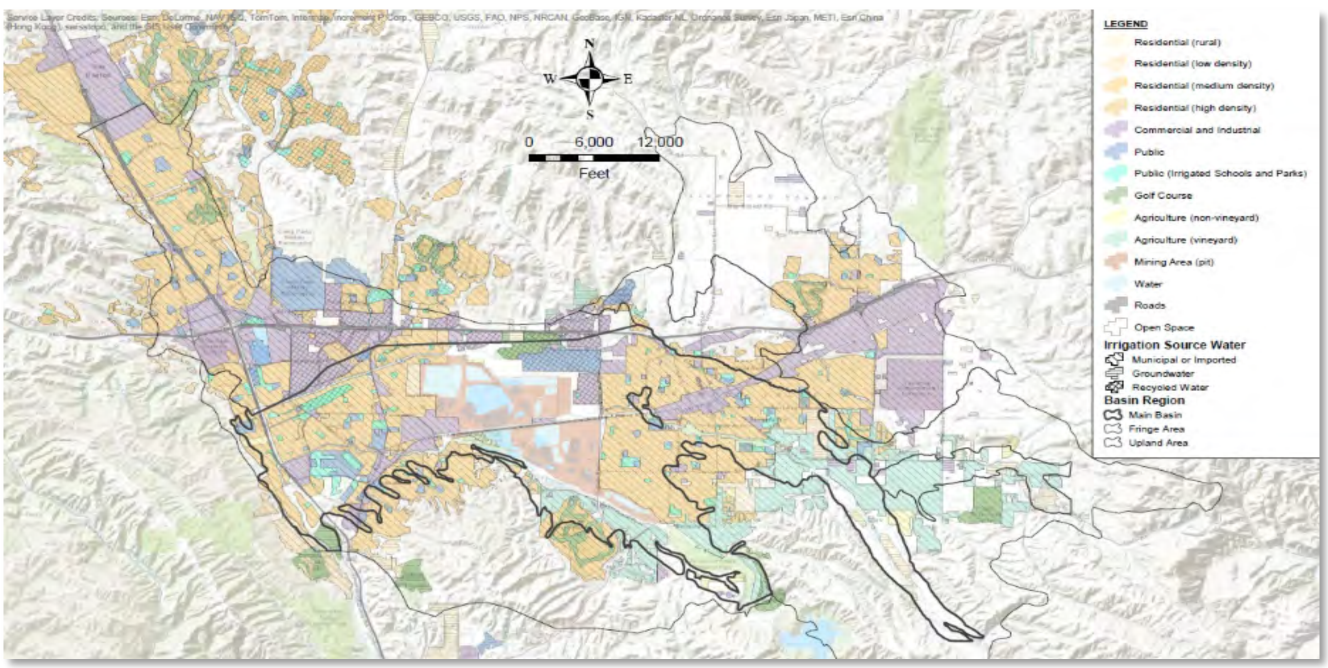


Figure ES-B: Current Land Use

As the sole water wholesaler within the Basin, Zone 7 primarily supplies treated State Water Project water to four local retail water supply agencies: California Water Service Company – Livermore District (Cal Water), Dublin San Ramon Services District (DSRSD), Livermore, and Pleasanton. In addition to the water purchased from Zone 7, Pleasanton and Cal Water operate their own municipal groundwater supply wells to meet remaining demands. Private wells in the area provide some of the water supply for industrial, agricultural, irrigation, domestic, and undifferentiated uses. DSRSD and Livermore provide recycled water for landscape irrigation.

There are three disadvantaged communities (DAC) in the Basin encompassing a total of 2,598 households and 6,678 people within the greater City of Livermore.

There are several areas of California Department of Fish and Wildlife (CDFW) owned and operated lands and conservation easements, Nonprofit California Protected Area (CPA) holdings, and California Conservation Easements (CCE) within the Basin.

Other jurisdictions in the Basin include Camp Parks Military Reservation/Reserve Forces Training Area, located on the northern boundary of the Basin and operated by the Department of Defense/ United States Army. On the southern side of the Basin, the Lake Del Valle State Recreation Area and Shadow Cliffs Regional Recreation Area are operated by East Bay Regional Park District (EBRPD). No specific California Native American tribal lands are known to be located within the Basin.

ES.4. Stakeholder Outreach Efforts

Zone 7 adopted a Stakeholder Communication and Engagement Plan (SCEP) in August 2020 to fulfill SGMA notice and communications requirements and encourage active engagement and input of all beneficial users of groundwater within the Basin. The goal of the outreach efforts described in the SCEP is to ensure that beneficial uses and users of groundwater within the Basin are adequately considered during the 2021 Alternative GSP development and implementation process. Venues for stakeholder engagement and input have included stakeholder workshops, Zone 7 Board meetings, direct outreach through Open Houses, E-newsletters and notification letters about groundwater management efforts, and a dedicated webpage for SGMA compliance activities. Zone 7's website (https://www.zone7water.com/) also contains materials presented at meetings, meeting minutes, copies of public notification letters, as well as a schedule for upcoming meetings and other workshops open to the public.

ES.5. Hydrogeologic Conceptual Model

As defined by DWR Bulletin 118 *(DWR, 1974 & 2016c*), the Livermore Valley Groundwater Basin (Basin No. 2-010) is an east-west trending, inland structural basin bounded by northwest-southeast trending faults on the east and west, upland bedrock hills of the Diablo Range on the south, and bedrock deposits of the Mt. Diablo thrust sheets on the north. For purposes of groundwater management, the Basin has been divided into three Management Areas: The Main Basin, Fringe, and Upland Management Areas.

Principal Aquifer units include the Upper Aquifer and Lower Aquifer within the Main Basin, the Fringe Aquifer within the Fringe Management Area, and the Upland Aquifer within the Upland Management Area. The Upper Aquifer consists of recent (Holocene) alluvial fill materials and extends continually across the Main Basin at depths up to 190 feet below ground surface (ft bgs), containing groundwater typically under unconfined conditions. The Lower Aquifer exists below a confining aquitard with thicknesses ranging from less than 5 feet up to 50 feet in the central and eastern parts of the Main Basin. The Lower Aquifer consists of Quaternary alluvial fill materials and the productive upper portion of the Livermore Formation, extending to depths of up to 800 ft bgs in the central Main Basin. A large majority of groundwater production occurs within the Lower Aquifer of the Main Basin. The Fringe Aquifer and Upland Aquifer are demonstrated to be of lower productivity and quality than the aquifers of the Main Basin, and groundwater production is limited to domestic and agricultural uses in these areas.

As part of the 2021 Alternative GSP update, Zone 7 made several refinements to the Hydrogeologic Conceptual Model (HCM) of the Basin, including: (1) migration of all well and borehole construction, geologic, lithologic, stratigraphic, and geophysical data into the Rockworks (2020) three-dimensional (3D) geologic modeling software program; (2) development of a 3D geologic model of the Basin; (3) and development of three new hydrostratigraphic cross-sections of the Basin that further extend into the Fringe and Upland Management Areas and more accurately delineate the Principal Aquifer units of the Basin. One of the new cross-sections is shown in **Figure ES-C.**

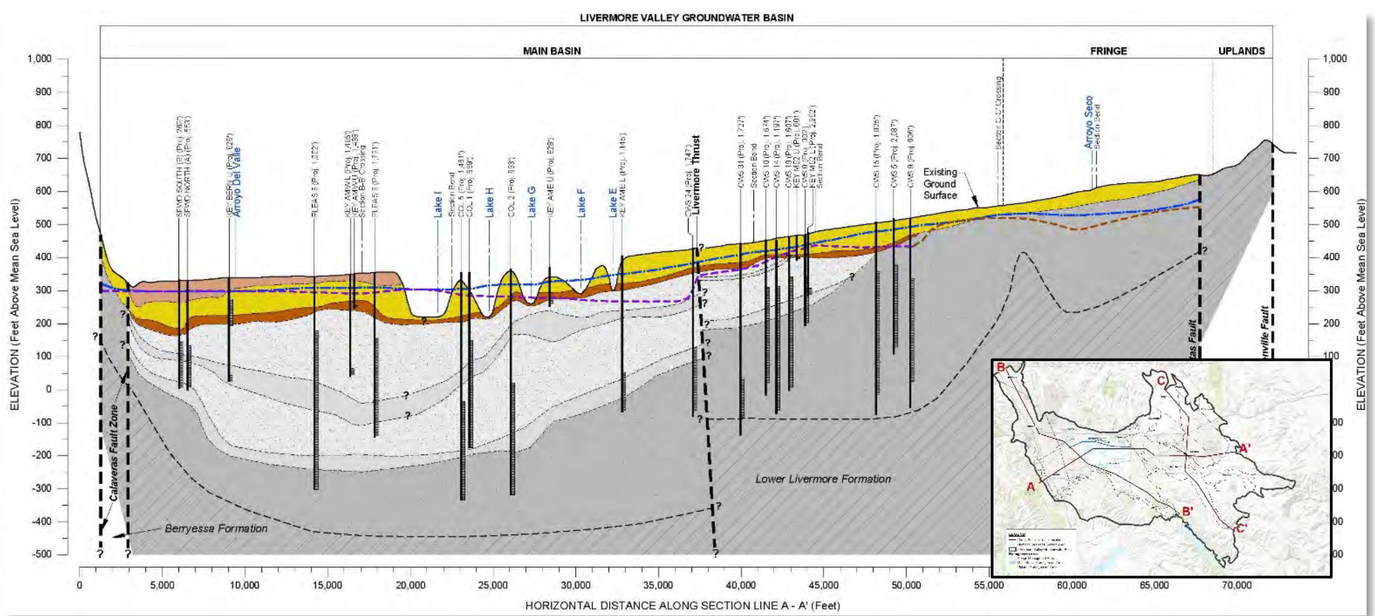


Figure ES-C: Cross Section A-A'

ES.6. Existing Groundwater Conditions

Information on the Basin's current groundwater conditions with respect to the six "Sustainability Indicators" defined under SGMA are presented in this Alternative GSP and include the following:

Water Levels: Groundwater levels are presented using contour maps depicting seasonal high (spring) and seasonal low (fall) conditions for the 2020 Water Year (WY), as well as hydrographs from wells located throughout the Basin that have extended historical records (see **Figure ES-D** for an example seasonal high map). Generally, the available data indicates that groundwater levels have remained stable or increased over the past 10 years and have recovered from drought conditions experienced during the 2012–2016 WYs, demonstrating continued sustainable groundwater management practices.

The 2021 Alternative GSP includes updates to the groundwater level monitoring program to better assess existing groundwater level conditions throughout the entirety of the Basin. Specifically, as part of this Alternative GSP Update, Zone 7 added twenty additional monitoring wells to the monitoring program, including five new wells in the Upland Aquifer and six new wells in the Fringe Aquifer. Additionally, Zone 7 updated the historic low map for the Upper Aquifer and Fringe Aquifer.

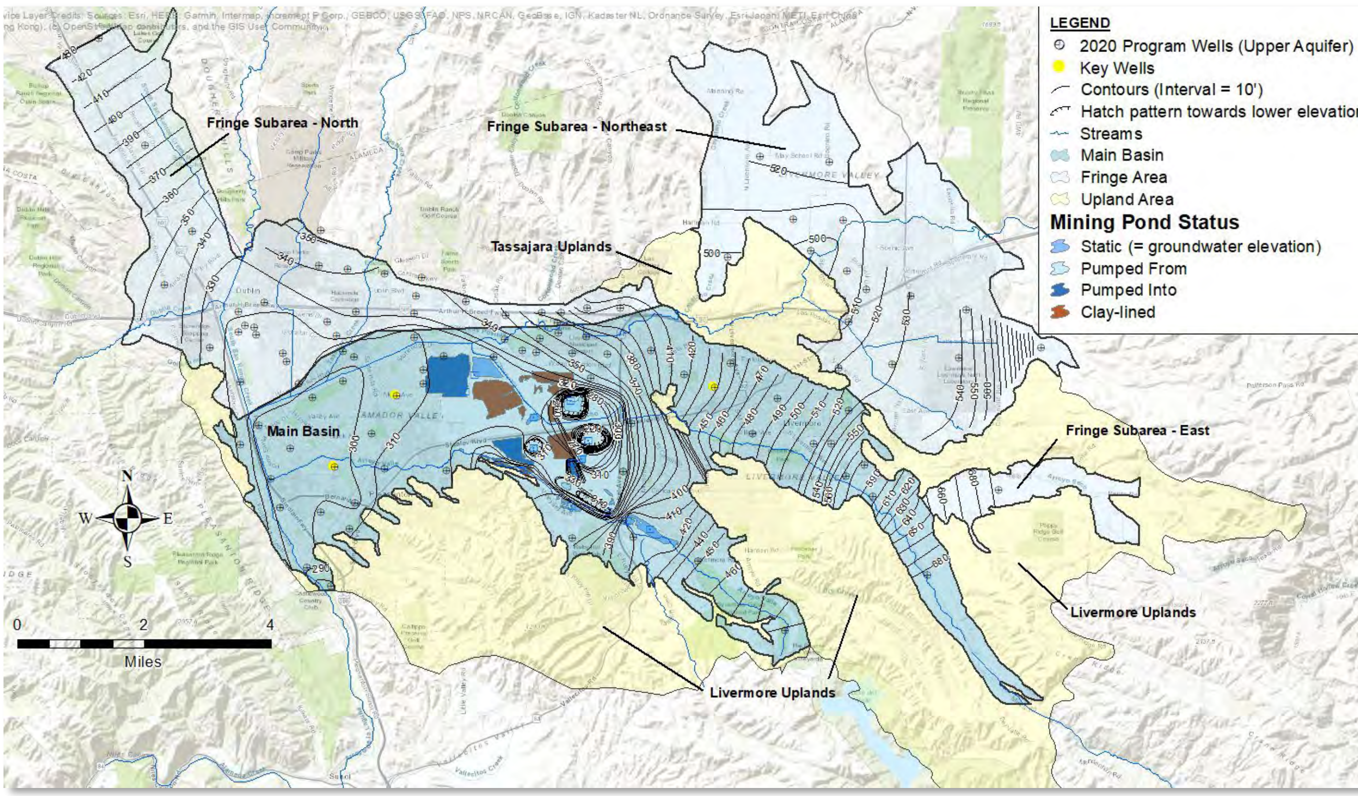


Figure ES-D: Spring 2020 Upper Aquifer Groundwater Gradient Map

Groundwater Storage: Zone 7 operates the Basin such that groundwater storage remains between 254 thousand acre-feet (TAF; full Basin volume) and 128 TAF (historic low volume). Changes in groundwater storage are estimated using both groundwater elevations and the Hydrologic Inventory (HI) (i.e., water budget) method. The available data indicates that groundwater storage has remained stable in the Basin over the past 10 years and has increased by approximately 15 to 40 TAF since the SGMA Baseline date (i.e., 2015 WY), indicating continued sustainable groundwater management practices.

As mentioned above, for the 2021 Alternative GSP, Zone 7 employed the Rockworks software platform to create a 3D geologic model of the Basin that more accurately delineates the thickness and extent of Principal Aquifer units. The Rockworks geologic model was also used to develop estimates of total available groundwater storage and groundwater storage changes for the Main Basin and Fringe Management Areas. These Rockworks' estimates were then compared to the current estimates developed using the existing groundwater elevation and HI methods. Additionally, for the 2021 Alternative GSP Zone 7 migrated its Aerial Recharge Model (ARM) to DWR's Integrated Water Flow Model Demand Calculator (IDC) platform and extended the IDC model to cover the entire Basin. The IDC model will be used to estimate recharge and runoff rates and to support groundwater storage change evaluations in the HI going forward. Future SGMA efforts will include additional reconciliation of methods used to estimate groundwater storage in the Basin, including updates to Zone 7's numerical groundwater flow model.

Water Quality: Groundwater quality is highest in the Main Basin and is generally suitable for most urban and agricultural uses. The primary constituents of concern within the Basin include total dissolved solids (TDS), nitrate, boron, and chromium. Continued monitoring and analysis of these constituents indicates generally stable water quality conditions within the Basin over the past 10 years, demonstrating continued sustainable management practices. Additionally, in the 2019 WY Zone 7 began sampling for per- and polyfluoroalkyl substances (PFAS), an Environmental Protection Agency (EPA) "contaminant of emerging concern". This 2021 Alternative GSP update includes a summary of a PFAS levels in both the Upper and Lower Aquifers and planned programs to further monitor and characterize PFAS in the Basin.

As part of the 2021 Alternative GSP update, Zone 7 updated projections of net annual salt loading, total salts, and average TDS concentrations within the Basin from 2020 to 2081 using long-term supply and demand estimates developed for Zone 7's 2020 Urban Water Management Plan (UWMP). Zone 7 also evaluated the change in nitrate concentrations and loading since 2015 when Zone 7's Nutrient Management Plan (NMP) was published and updated estimates of annual nitrogen loading and removal rates within the Basin under average hydrologic conditions.

Land Subsidence: Continued monitoring of land surface elevations indicates no inelastic land subsidence has occurred within the Basin over the past 60 years. Up until the 2018 WY, land surface elevations in the Main Basin were monitored using benchmark surveys. Beginning in the 2019 WY, Zone 7 has employed the Interferometric Synthetic Aperture Radar (InSAR) dataset provided by the United States Geologic Survey (USGS) and DWR for land subsidence monitoring instead of continuing the land surveying program. The coverage area was expanded to include the entire Basin. Recent InSAR data indicates that changes in land surface elevations changes were within +/- 0.04 feet between March 2015 and September 2020, which is within Zone 7's "elastic deformation" range. Land surface elevations have generally risen by about 0.02 to 0.06 feet since the 2015 WY in the vicinity of the main municipal pumping wells within the Basin, indicating continued sustainable management practices.

Seawater Intrusion: The Basin is located far from coastal areas, and therefore seawater intrusion is not considered to be a threat to groundwater resources.

Interconnected Surface Water (ICSW): At the time of 2016 Alternative GSP preparation, guidance on how to identify ICSW bodies and Groundwater Dependent Ecosystems (GDEs) was yet to be developed. Since then, DWR has provided the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset and other tools to assist in GDE and ICSW characterization.

As part of the 2021 Alternative GSP update, Zone 7 reviewed the newly available information to identify potential ICSW areas and GDE communities, conducted field visits and statistical analyses to verify their existence, and updated maps and tables of likely ICSW reaches and GDE communities. Likely ICSW reaches have been identified along several surface water features within the Basin, including Arroyo Valle, Arroyo

Mocho, Arroyo Las Positas, Altamont Creek, and the Springtown Alkali Sink. Generally, GDE communities were found in areas where ICSW was also present. In total, the Basin includes approximately 1,052 acres of likely GDEs, approximately 2% of the total Basin area. The Main Basin contains approximately 69% of the total likely GDE communities, the Fringe Management Area contains approximately 20%, and the Upland Management Area contains the remaining 11%.

After identifiying likely ICSW/GDE areas, Zone 7 expanded its ICSW/GDE monitoring program to include shallow monitoring wells and coupled streamflow gauging stations nearby each major ICSW/GDE area and defined Sustainable Management Criteria for the Depletions of Interconnected Surface Water Sustainability Indicator.

ES.7. Water Budget

Zone 7 has historically used the HI method to generate a water budget accounting for the volume of groundwater entering and leaving the Basin for historical, current, and projected future conditions. In 1994, Zone 7 developed a soil moisture balance spreadsheet model (i.e., the ARM), to estimate land surface components of the HI. As part of the 2021 Alternative GSP update, Zone 7 migrated the existing ARM to DWR's IDC platform and extended the IDC model to cover the entire Basin.

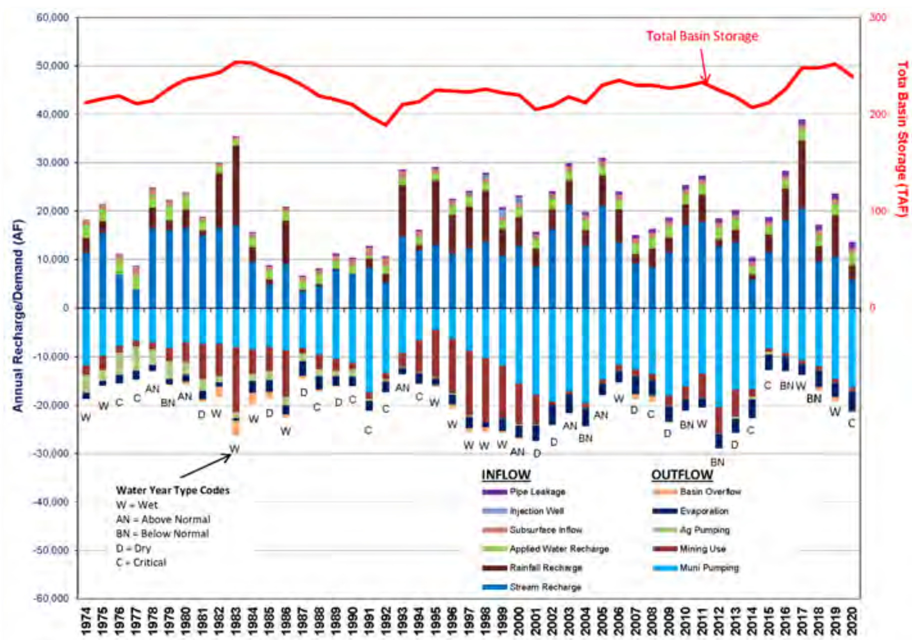


Figure ES-E: 1974-2020 WY Water Budget

The IDC model will be used to estimate recharge and runoff rates and to support ongoing groundwater storage change evaluations in the HI for future Alternative GSP updates. A historical water budget period (1974-2020 WYs) shows that long-term sustainability has been maintained in the Basin for at least 45 years, as groundwater storage conditions have remained generally stable to increasing and have shown resilience following dry periods (see **Figure ES-E**). The current water budget period represents conditions for the 2020 WY, and the projected water budget used the Water Supply Risk Model from Zone 7's 2020 UWMP to support water supply sustainability planning through 2081.

The volume of groundwater in storage in the Basin is managed within an operational storage range as the principal means of maintaining the basin water levels above historic lows. Since no Undesirable Results (URs) have been observed while operating within this storage range, average water budget targets are referred to as the Sustainable Yield estimates for the purposes of groundwater management. The Basin's

Sustainable Yield was estimated using the sum of two recharge components – "natural" and "artificial" recharge. "Natural" recharge includes groundwater inflows that are not managed by Zone 7 (i.e., those inflows to the Basin that occur naturally or that are managed by entities other than Zone 7). Zone 7 has managed municipal supply pumping since the early 1990s through a Groundwater Pumping Quota (GPQ) program, whereby pumping from retail water agencies is limited to a portion of the average natural recharge defined for the Basin. "Artificial" recharge includes imported surface water and managed recharge programs conducted by Zone 7 and is measured directly using operations records. The total Sustainable Yield of the Basin is estimated to be 18,700 acre-feet per year (AFY).

ES.8. Sustainable Management Criteria

Sustainable Management Criteria (SMCs) are the metrics by which groundwater sustainability is judged under SGMA. Key terms related to SMCs under SGMA include the following:

Undesirable Results: URs are the significant and unreasonable effects, for any of the six Sustainability Indicators defined under SGMA, caused by groundwater conditions throughout the Basin.

Minimum Thresholds: Minimum Thresholds (MTs) are the numeric criteria for each Sustainability Indicator that, if exceeded in a locally defined set of representative monitoring sites, may constitute an Undesirable Results for that indicator. Where appropriate, and as allowed under the California Code of Regulations Title 23 (23 CCR), the MTs for certain Sustainability Indicators have been set using groundwater levels as a proxy.

Measurable Objectives: Measurable Objectives (MOs) are specific, quantifiable goals for the maintenance or improvement of groundwater conditions. MOs use the same units and metrics as the MTs and are thus directly comparable.

Interim Milestones: Interim Milestones are a set of target values representing measurable groundwater conditions in increments of five (5) years over the 20-year statutory deadline for achieving sustainability.

As part of the 2021 Alternative GSP update and to address DWR recommended actions, Zone 7 defined MTs for the Basin at Representative Monitoring Sites for each applicable Sustainability Indicator to facilitate DWR evaluation. This included developing MTs for Chronic Lowering of Groundwater Levels and Reduction of Groundwater Storage for the Fringe and Upland Management Areas to better align with requirements for management areas, adding groundwater level monitoring sites in the Fringe and Upland Management Areas, and identifying the frequency and timing when groundwater levels would be collected at new monitoring sites and other relevant monitoring well construction information.

Based on the comparison of Basin conditions for the last ten years (i.e., from 2010 through 2020 WY) relative to the criteria used to identify potential URs, it is evident that Zone 7 has continued to sustainably manage the Basin to avoid URs for at least 10 years. In fact, most of the datasets discussed in this Alternative GSP date back to 1974 allowing for a comprehensive, long-term assessment of Zone 7's sustainable Basin management, including over three major droughts.

Chronic Lowering of Groundwater Levels is arguably the most fundamental Sustainability Indicator, as it can influence several other key Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, and possibly Depletions of Interconnected Surface Water and Degraded Water Quality.

As part of the 2021 Alternative GSP update, Zone 7 reviewed and updated the existing MOs and MTs for Chronic Lowering of Groundwater Levels for the Main Basin and developed quantitative SMCs in the Fringe and Upland Management Areas as listed in the table below. The SMCs for Chronic Lowering of Groundwater Levels were established at 12 Representative Monitoring Sites for Chronic Lowering of Groundwater Levels (RMS-WLs) based on spatial and temporal analysis of long-term groundwater level data at the RMS-WLs.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	Minimum Threshold	Measurable Objective
Chronic Lowering of Groundwater Levels	If and when a chronic decline in groundwater levels over the course of the planning and implementation horizon significantly and unreasonably impairs the reasonable and beneficial use of, and access to, groundwater for beneficial uses and users within the Basin.	Water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years.	Difference between the historic low water level and maximum annual rate of groundwater change for each RMS-WL, or the historic low if annual groundwater level change data is unavailable.	Historic low water level for each RMS-WL.

Significant ***Groundwater Storage*** exists within the Basin and is closely correlated to groundwater levels. As part of the 2021 Alternative GSP update, Zone 7 updated MOs and MTs for Reduction of Groundwater Storage based on the SMCs defined for Chronic Lowering of Groundwater Levels as shown in the table below. It is estimated that if Basin groundwater levels reached the MTs for Chronic Lowering of Groundwater Levels in all the Main Basin and Fringe Area RMS-WLs, the usable storage in the Basin would be reduced by approximately 16%. As such, it was determined to be sufficiently protective to define the SMCs for Reduction of Groundwater Storage based on the use of SMCs for Chronic Lowering of Groundwater Levels as a proxy.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	Minimum Threshold	Measurable Objective
Reduction of Groundwater Storage	If and when a reduction in storage in the Principal Aquifers of the Basin negatively affects the long-term viable access to groundwater for the beneficial uses and users within the Basin. Specifically, significant and unreasonable effects would include an aggregate reduction in usable groundwater storage of more than 50% within the Basin relative to the SGMA Baseline Storage volume for two consecutive years.	Water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years. Not applicable to Upland Management Area.	Main Basin and Fringe Area: Chronic Lowering of Groundwater Levels used as a proxy. Upland Area: No MTs established.	Main Basin and Fringe Area: Chronic Lowering of Groundwater Levels used as a proxy. Upland Area: No MOs established.

The SMCs for ***Degraded Water Quality*** are defined at 12 Representative Monitoring Sites for Degraded Water Quality (RMS-WQ) for TDS, Nitrate, Boron and Hexavalent Chromium. As part of the 2021 Alternative GSP update, Zone 7 refined the MOs and MTs for Degraded Water Quality, including for the Fringe and Upland Management Areas, based on newly available data as shown in the table below. The SMCs are developed based on SGMA Baseline concentrations (2015 concentrations) and regulatory water quality standards (i.e., the primary Maximum Contaminant Levels [MCLs] set by the EPA and the State of California Environmental Protection Agency [CalEPA]), when appropriate.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	Minimum Threshold	Measurable Objective
Degraded Water Quality	If groundwater recharge or extraction causes significant and unreasonable degradation of water quality in the Basin, such that these changes impact to the long-term viability of domestic, agricultural, municipal, environmental, or other beneficial uses over the planning and implementation horizon of this Alternative GSP. Significant and unreasonable changes to water quality associated with Undesirable Results would include a significant increase, on a regional basis, in concentrations of identified COCs above applicable state and federal regulatory thresholds, as a result of groundwater recharge or extraction.	If and when MTs are exceeded for any of the identified COCs in greater than 25% the RMS-WQs at least two consecutive years as a result of groundwater recharge or extraction, such that they cannot be managed to provide drinking water supply (i.e., that treatment or blending is not possible or practicable).	Greater of MCL (or other appropriate regulatory criteria) or the SGMA baseline concentration plus maximum historical annual range.	<u>TDS:</u> Recommended Secondary MCL (500 mg/L) in the Main Basin, Upper Secondary MCL (1,000 mg/L) or 2015 concentrations (whichever is greater) in the Fringe and Upland Areas <u>Nitrate:</u> Primary MCL (10 mg/L) <u>Boron:</u> Health Risk Limit (HRL; 1,400 µg/L) <u>Hexavalent Chromium:</u> Primary MCL (50 µg/L)

Although no historical record of inelastic ***Land Subsidence*** has been observed within the Basin, Zone 7 has recognized land subsidence as a potential UR. The 2005 Well Master Plan Environmental Impact Report (WMP EIR) indicated that the potential for inelastic (permanent) subsidence in the Main Basin increases as groundwater levels approach historic lows. Subsidence potential is limited to non-existent in the Upland Management Area given the underlying geology and limited pumping. Therefore, Zone 7 concluded that this Sustainability Indicator only applies to the Main Basin and Fringe Management Area and that groundwater elevations in the Main Basin and Fringe Management Area can be used as a guide for managing subsidence as shown in the table below.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	Minimum Threshold	Measurable Objective
Land Subsidence	If the occurrence of land subsidence substantially interferes with beneficial uses of groundwater and infrastructure within the Basin during the planning and implementation horizon of this Alternative GSP.	Water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years, that result in a confirmed decrease of 0.4 feet of land surface in any given cycle with a goal of experiencing no inelastic subsidence spatially and temporally. Not applicable to Upland Management Area.	Main Basin and Fringe Area: Chronic Lowering of Groundwater Levels used as a proxy, with the additional constraint of no more than 0.4 feet of inelastic land subsidence in any year Upland Area: No MTs established.	Main Basin and Fringe Area: Chronic Lowering of Groundwater Levels used as a proxy. Upland Area: No MOs established.

Preliminary SMCs for ***Depletions of Interconnected Surface Water*** have been developed as part of this 2021 Alternative GSP update. Zone 7 evaluated the seasonal range of depth-to-groundwater measurements in the vicinity of each likely ICSW/GDE area identified from the NCCAG and field investigations and compared the seasonal range of depth-to-groundwater measurements with each GDE's general groundwater requirements (e.g., rooting depth) to determine the maximum depth-to-groundwater conditions that could occur without resulting in long-term negative impacts to GDE health. This depth-to-groundwater analysis was used as the basis to inform quantitative, water-level based SMCs for ICSW as shown in the table below.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	Minimum Threshold	Measurable Objective
Depletions of Interconnected Surface Water	When groundwater extractions in the Basin cause significant and unreasonable depletions of hydrologically connected surface water, such that beneficial uses and users of the surface water (including the likely GDEs and protected species) are significantly and unreasonably harmed. Specifically, a significant and unreasonable negative effect would be experienced if the health of the GDE areas in the Basin are adversely impacted by mechanisms that can be directly attributed to pumping-related lowering of groundwater levels over time, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions or land use changes.	If and when Depletions of Interconnected Surface Water occur as a result of unsustainable groundwater extraction such that groundwater levels decline below their MTs in greater than 40% of the Representative Monitoring Sites for Depletions of Interconnected Surface Water (RMS-ICSW) for more than two consecutive years.	Historic low water levels measured at each RMS-ICSW, or when unavailable, estimated from Zone 7 groundwater elevation rasters.	Minimum water levels measured between 2014 and 2020 at each RMS-ICSW, or when unavailable, estimated from Zone 7 groundwater elevation rasters.

Seawater Intrusion is not considered a threat to groundwater resources within the Basin due to its considerable isolation from any oceans, bays, or other saltwater bodies.

Sustainability Indicator	Undesirable Results Definition
Seawater Intrusion	No Undesirable Results definition. Not applicable to the Basin due to geographic distance from the ocean.

ES.9. Monitoring Network

The objective of the SGMA Monitoring Network is to collect sufficient data for the assessment of the Sustainability Indicators relevant to the Basin and potential impacts to the beneficial uses and users of groundwater. Zone 7's SGMA Monitoring Network (see **Figure ES-F**) was developed to ensure sufficient spatial distribution and spatial density.

The SGMA Monitoring Network consists of 12 RMS-WLs for monitoring groundwater levels, 11 for monitoring groundwater storage (by proxy), and 11 for monitoring land subsidence (by proxy). Further, these 12 RMS-WLs are included in the 237 wells in Zone 7's Water Level Monitoring Program. As part of the 2021 Alternative GSP update, Zone 7 added 20 additional wells to the program, mainly in the Fringe and Upland Management Areas, and began collecting water level measurements from those wells.

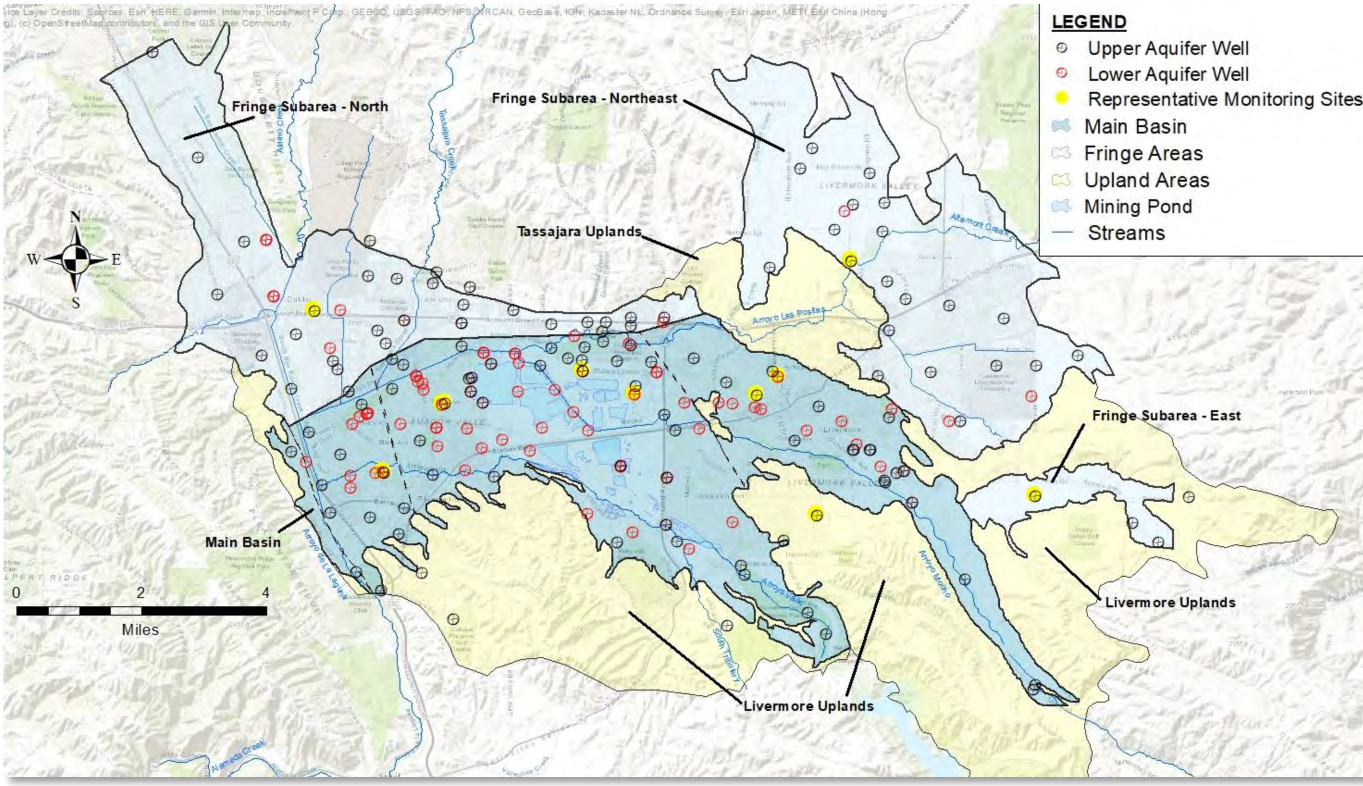


Figure ES-F: SGMA Monitoring Network

Additionally, there are 12 RMS-WQ for monitoring groundwater quality and 24 RMS-ICSWs for monitoring GDEs and ICSW (including 14 wells and 10 streamflow gauging sites). The SGMA Monitoring Network supplements other monitoring networks and programs in the Basin such as Zone 7's Climatological Monitoring Program, Zone 7's Surface Water Monitoring Program, the Chain of Lakes/Mining Area Monitoring Program, and DWR California Statewide Groundwater Elevation Monitoring (CASGEM) program.

Data collected from the SGMA Monitoring Network (and the additional monitoring sites as applicable) will be stored and managed into HydroGeoAnalyst (HGA), a proprietary environmental database management system. Monitoring data for each WY are presented in Zone 7's Annual Reports for the Alternative GSP. Zone 7 has previously uploaded well construction and water level data to the CASGEM website but is currently working with DWR To transfer the data to the SGMA data viewer in accordance with 23 CCR § 354.40.

ES.10. Projects and Management Actions

A suite of Project and Management Actions (P/MAs) are currently being implemented or otherwise proposed for future implementation to help Zone 7 continue to meet the Sustainability Goal for the Basin and adaptively manage its groundwater supply. The objectives of the P/MAs are to continue to avoid and/or address any potential URs and to meet the MOs for the relevant Sustainability Indicators. While many existing P/MAs are already in place, future P/MAs will be implemented incrementally on an as-needed basis to achieve this goal. At this time, Zone 7 acknowledges that details pertaining to which P/MAs will ultimately be initiated, P/MA timing, projected benefits, payments and cost allocations, etc. will be considered as part of P/MA and Alternative GSP implementation.

Projects within the P/MA portfolio focus on: (1) water supply augmentation, (2) water demand reduction, (3) improvement of groundwater quality, and (4) data gap-filling activities. Most P/MAs have expected benefits related to water quantity and/or water quality, with a direct or indirect benefit to the other Sustainability Indicators. Findings and outcomes from implemented P/MAs will be applied to further improve Zone 7's sustainable management of the Basin. The projected average annual cost for administering the SGMA compliance program and implementing P/MAs over the next five years (2022-2026) is approximately $2 million per year. Funding sources are anticipated to be a combination of water rates, connection fees, and available State/Federal grants. Implementation of P/MAs will be scheduled and conducted in accordance with priorities and funding availabilities.

Zone 7 involved the public, stakeholders, and local agencies throughout P/MA planning and implementation. Continuing stakeholder outreach efforts will be conducted in accordance with the SCEP developed as part of this Alternative GSP update.

ES.11. Conclusion

The passage of SGMA in 2014 ushered in a new era of groundwater management in California. The law and regulations emphasize the use of best available science, local control and decision making, and active engagement of affected stakeholders. Maintaining sustainability in the face of uncertain future water supply conditions while addressing and balancing the needs of all beneficial uses and users of groundwater will require significant effort, creative solutions, and unprecedented collaboration. Zone 7 recognizes the importance of maintaining groundwater sustainability for the Basin, and as the implementing agency, is committed to facing these challenges in a manner that upholds the interests of local landowners and constituents. Zone 7 has sustainably managed local surface and groundwater resources in the Basin for beneficial uses for over 45 years. The 2021 Alternative GSP presented herein builds on the approved 2016 Alternative GSP towards this end, and serves to demonstrate that Zone 7 has continued to operate the Basin within its Sustainable Yield over the past 10 years and is meeting the Sustainability Goal defined for the Basin.

INTRODUCTION

(SUBTITLE PAGE)

1. PURPOSE OF THE ALTERNATIVE GROUNDWATER SUSTAINABILITY PLAN

§ 356.4 Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.
(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.
(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.
(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.
(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:
(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.
(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.
(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.
(f) A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.
(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.
(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.
(i) A description of completed or proposed Plan amendments.
(j) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.
(k) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733.

☑ 23 CCR § 356.4

In compliance with California Code of Regulations (CCR) § 356.4, the purpose of this Alternative Groundwater Sustainability Plan (Alternative GSP or Plan) update is to provide assessment of the plan implementation and meet the regulatory requirements set forth in the three-bill legislative package consisting of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA) (California Water Code

[CWC] Sections [10720 - 10737.8]). SGMA defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results". Undesirable Results (URs) are defined by SGMA as any of the following effects caused by groundwater conditions occurring throughout a basin:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply;
- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable seawater intrusion;
- Significant and unreasonable degraded water quality;
- Significant and unreasonable land subsidence; and/or
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Per the requirements of SGMA, each Groundwater Sustainability Agency (GSA) shall evaluate its Groundwater Sustainability Plan (GSP) or Alternative GSP at least every five years provide a written assessment to the California Department of Water Resources (DWR). This 2021 Alternative GSP confirms that Alameda County Flood Control and Water Conservation District, Zone 7's (Zone 7 Water Agency or Zone 7) Plan implementation, including implementation of projects and management actions, is meeting the sustainability goal in the Livermore Valley Groundwater Basin (Basin). Specifically, this Plan demonstrates that Zone 7 has operated the Basin within its sustainable yield over a period of at least 10 years.

1.1. Background

Zone 7 provides water management in the Livermore Valley Groundwater Basin (DWR Basin No. 2-10) as part of its mission to "*Deliver safe, reliable, efficient, and sustainable water and flood protection services." (Zone 7, 2020b),* and more specifically to address the following Strategic Plan initiatives:

- #7 - Manage as the GSA and implement the groundwater management plan; and
- #8 - Study and refine knowledge of the groundwater basins.

Zone 7 manages imported surface water as the local wholesale agency. Although the Basin is not adjudicated, by agreements with the local Retailers, Zone 7 manages regional water supplies through the interrelated programs described above where previously agreed groundwater extraction quotas are tracked and annual water management accounting is conducted. Zone 7 also manages recharge operations to augment instream and mining pond aquifer recharge. Zone 7's groundwater extraction is managed as to not exceed the previously recharged amounts. In addition, Zone 7 has managed local surface and groundwater resources for beneficial uses for over 45 years.

In 2014, the State of California passed SGMA to empower local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities. SGMA also empowers local agencies to form GSAs for managing groundwater resources in a sustainable manner. Recognizing Zone 7's legal authority to implement SGMA for its service area, SGMA specifically designates Zone 7 as the exclusive GSA within its statutory boundaries (CWC §10723). As shown on **Table 14-5,** the Zone 7 Service Area includes almost all of the Basin, all of the Sunol Valley Groundwater Basin, and a small section of the Tracy Subbasin in the adjacent San Joaquin Valley Groundwater Basin.

As a requirement of SGMA, DWR ranked all of California's groundwater basins as having a high-, medium-, low-, or very low-priority based on groundwater use, population, and other factors. DWR designated the Basin and the Tracy Subbasin as medium-priority basins and the Sunol Groundwater Basin as a very low-priority basin. Under SGMA, high- and medium-priority groundwater basins are required to be managed under a GSP by January 31, 2022. The regulations also allow a GSA to submit an Alternative GSP instead of a GSP if the entire basin has been operating within its sustainable yield[3] for at least 10 years. Such an Alternative GSP must cover the entire groundwater basin and be functionally equivalent to a GSP.

Since the 2005 Water Year (WY), even prior to assuming the role of the GSA for the Basin, Zone 7 generated annual groundwater reports for public review and submission to the DWR. In 2005, Zone 7 adopted a Groundwater Management Plan (GWMP) for the Basin, which documented ongoing policies and programs for managing groundwater to support existing and future beneficial uses in the Basin (*Zone 7, 2005a*). The GWMP was amended in June 2015 with the adoption of the Nutrient Management Plan (*Zone 7, 2015c*), which added to both the GWMP and the 2004 Salt Management Plan (*Zone 7, 2004*). Given the ongoing sustainable management of the Basin, Zone 7 Water Agency submitted an Alternative Plan for compliance with SGMA and GSP regulations in December 2016 (*Zone 7, 2016e*). The 2016 Alternative GSP was approved by DWR in July of 2019[4]. Per the requirements of 23 CCR § 356.4, this document is the first Five-Year Update to the Alternative GSP (2021 Alternative GSP).

With regard to the Tracy Subbasin, Zone 7 has executed a memorandum of understanding (MOU) with the San Luis & Delta-Mendota Water Authority to support SGMA compliance. Accordingly, this Alternative GSP does not cover the Tracy Subbasin. As mentioned above, the Sunol Groundwater Basin does not require a GSP, given its current very-low priority status.

1.2. Summary of Major Plan Updates

In its July 2019 Alternative Assessment Staff Report, DWR included several recommended actions that Zone 7 "may wish to include in the first five-year update of the Alternative to facilitate the Department's

[3] SGMA defines Sustainable Yield as the maximum quantity of water (calculated over a base period representative of long-term conditions in the basin and including any temporary surplus) that can be withdrawn annually from a groundwater supply without causing an undesirable result.
[4] https://sgma.water.ca.gov/portal/alternative/all

ongoing evaluation and assessment of the Alternative as well as recommendations for improvements to the Alternative." The DWR recommendations are included in **Appendix A** and summarized below:

1. Identify those groundwater levels, taken at representative monitoring sites, that are used to define the minimum threshold for the Basin, to facilitate DWR evaluation.
2. Develop quantitative Minimum Thresholds (MTs) for Chronic Lowering of Groundwater Levels for the Fringe and Upland Management Areas (Fringe and Upland Areas) to better align with requirements for Management Areas and definition of MTs.
3. Develop quantitative MTs for Reduction of Groundwater Storage for the Fringe and Upland Areas to better align with the requirements for Management Areas and definition of MTs.
4. Include monitoring groundwater levels at additional locations in the Upland Area to monitor changes and manage groundwater resources to prevent undesirable results; identify the monitoring frequency and timing at new stations, and other relevant monitoring well construction information.

In addition, Zone 7 received two comment letters on its 2016 Alternative GSP, which recommended inclusion of information regarding beneficial use of water for managed wetlands and native vegetation water use sectors. At the time of 2016 Alternative GSP preparation, limited information was available on wetlands and vegetation associated with groundwater. Since then, DWR has provided the Natural Communities Commonly Associated with Groundwater (NCCAG) mapping, which is a useful tool to help in identifying potential Groundwater Dependent Ecosystems (GDEs).

In planning for this Five-Year Update (i.e., the 2021 Alternative GSP), Zone 7 applied for and was awarded a DWR Proposition 68 (Prop 68) planning grant to assist with funding of tasks to reduce data gaps and to better evaluate the effectiveness of specific management actions. The tasks and subtasks for the grant project and the 2021 Alternative GSP update (described below) were designed to address the above recommendations, especially those related to the Fringe and Upland Areas and to build on, extend, and improve other components of the 2016 Alternative GSP. Specifically, Zone 7 identified the following issues, data gaps, and needs (organized by the relevant Sustainability Indictaors) relevant to the Basin and addressed them as part of this 2021 Alternative GSP. Compliance with the GSP Regulations is documented in **Appendix B**.

1.2.1. Groundwater Level Program Updates

A Groundwater Level Program Update was needed to enhance groundwater level management of the Upland and Fringe Areas and to more fully integrate management of those areas with management of the Main Basin Management Area (Main Basin). Also, per DWR Recommendations 1 and 2, specific groundwater levels at representative monitoring sites (RMS) needed to be clearly identified as they relate to Sustainable Management Criteria (SMCs), including within the Upland and Fringe Areas, to better align with GSP Regulations §354.20(b)(2) and 354.28(b)(6).

Task 1: Zone 7 initiated efforts to address water level data gaps in the Basin, with an emphasis on addressing gaps in the Fringe and Upland Areas. Zone 7 reviewed existing data and data gaps, identified existing wells that could fill those data gaps, contacted well owners to obtain permission to monitor those wells, selected appropriate wells to be added to Zone 7's Water Level Monitoring Program, and began collecting water level measurements from those wells.

Deliverables: Map (**Figure 1-2**) and Table (**Table 1-1**) of wells to be added to the Groundwater Level Monitoring Program, and Water Level Monitoring Network section (**Section 14.2.1**).

Task 2: Zone 7 revised the depth-to-water map for the Basin and extended the historic low map layer to the Fringe Area and, to the extent possible, to the Upland Area.

Deliverables: New Minimum Depth-to-Water (**Figure 8-3**); Historic Low Groundwater Maps (**Figure 8-9** and **Figure 8-10**).

Task 3: Zone 7 reviewed and updated the existing Measurable Objectives (MOs) and MTs for Chronic Lowering of Groundwater Levels for the Main Basin and developed quantitative SMCs in the Fringe and Upland Areas, as appropriate. The new MOs and MTs are defined with specific reference to groundwater levels at specific RMS, and to ensure that operation of certain management areas will not cause URs in other management areas.

Deliverables: Updated Groundwater Levels Sections (**Section 8.3**, **Section 13.1**).

Task 4: Zone 7 updated the Groundwater Level Monitoring Program maps and tables. The Groundwater Level Monitoring Program includes specific RMS that are used to track conditions relative to the MOs and MTs, and information is provided relative to monitoring frequency and timing at the specific RMS and applicable monitoring well construction information.

Deliverables: Updated Table (**Table 14-1**) and Map of Monitoring Wells in Groundwater Level Monitoring Program (**Figure 14-1**) and **Section 14.2.1**.

1.2.2. Groundwater Storage Program Updates

A Groundwater Storage Program Update was needed to enhance management of groundwater storage in the Upland and Fringe Areas and to better integrate management of those areas with management of the Main Basin. An improved hydrogeologic conceptual model (HCM) for the Fringe and Upland Areas was developed by extending geologic cross sections across the Main Basin and into the Fringe and Upland Areas. For the integrated management of Main Basin, Fringe, and Upland Areas, Zone 7's existing Areal Recharge Spreadsheet Model (ARM) was migrated to DWR's Integrated Water Flow Model Demand Calculator (IDC) platform and extended to include the entire Basin. In response to DWR Recommendation 3, SMCs were developed for Reduction of Groundwater Storage across the Upland and Fringe Areas that are better aligned with the GSP Regulations §354.20(b)(2) and 354.28(b)(6).

Task 1: Zone 7 extended the e-log database and network to cover the Fringe and Upland Areas using Rockworks, a new software program, and prepared three new cross sections that trace through the major groundwater production areas of the Basin.

Deliverables: Cross Sections (**Appendix C** and **Figure 7-7 to Figure 7-11**)

Task 2: Zone 7 migrated the existing ARM to an IDC model that covers the entire Basin and revised the groundwater recharge and storage change calculations within the water budget as appropriate.

Deliverables: ARM Upgrade Technical Memorandum (**Appendix D**, **Section 8.4,** and **Section 9**)

Task 3: Zone 7 developed updated MOs and MTs for Reduction of Groundwater Storage based on the SMCs defined for Chronic Lowering of Groundwater Levels. In addition, an updated geographic information system (GIS) layer was developed that represents the Basin bottom based on the updated HCM.

Deliverables: Updated Groundwater Storage Section (**Section 13.2** and **Appendix E**); Map of Elevation of Bottom of Basin (**Figure 7-5**)

1.2.3. Groundwater Quality Program Update

A Groundwater Quality Program Update was needed to continue and improve management of groundwater quality and address new issues, such as per and polyflouroalkyl substances (PFAS). Improved definition was developed for the Degraded Water Quality SMCs, particularly in the Upland and Fringe Areas.

Task 1: Zone 7 updated its Total Dissolved Solids (TDS) and Nitrate Projections and addressed applicable Salt and Nutrient Management Plan updates to include recent TDS and Nitrate datasets, possible climate change effects, revised mining completion date estimates, and recent Delta Fix projections.

Deliverables: Summary of TDS and Nitrate Projects (**Section 8.6, Appendix L**)

Task 2: Zone 7 evaluated the effect of onsite wastewater treatment systems (OWTS) restrictions as per the 2015 Nutrient Management Plan recommended, and limits in "Areas of Concern" to minimize Nitrate loading to the Basin and created Nitrate concentration graphs. Zone 7 also updated representative groundwater concentration maps for other constituents of concern (COCs), as appropriate.

Deliverables: Descriptions (**Section 8.6.3.7**), maps (**Figure 8-26** and **Figure 8-27**) and/or tables (**Table 8-5**) on effectiveness of OWTS restrictions on high nitrate areas-of-concern. Description (**Sections 8.6.2, 8.6.4, 8.6.5,** and **8.6.6**), maps (**Figure 8-16** to **Figure 8-21** and **Figure 8-29** to **Figure 8-36**) and/or tables (**Table 8-2**) on COCs for the Basin.

Task 3: Zone 7 refined the MOs and MTs for Degraded Water Quality, including for the Fringe and Upland Areas, based on the data collected in previous tasks, as appropriate.

Deliverables: Updated Water Quality Sections (**Section 8.6, Section 13.4**)

1.2.4. Land Subsidence Program Update

While no known land subsidence has occurred, it remains a potential UR in the Basin. With a goal of no inelastic subsidence, accurate monitoring and careful consideration of Land Subsidence SMCs is needed. The Land Subsidence Program Update provides a re-evaluation of how MOs and MTs are defined in the Basin and includes new data protocols and procedures.

Task 1: Zone 7 evaluated the use of Interferometric Synthetic Aperture Radar (InSAR) on an annual basis, in lieu of the benchmark land surveys, to evaluate land subsidence over the entire Basin. Zone 7 utilized the results from the 2019 Zone 7 InSAR annual monitoring pilot program to develop a monitoring routine that analyzes subsidence and displays results graphically and supports development of MOs and MTs for Land Subsidence.

Deliverables: Updated Land Subsidence Sections (**Section 8.7, Section 13.5**).

1.2.5. Surface Water-Groundwater Interaction/Groundwater Dependent Ecosystems Program Update

At the time of 2016 Alternative GSP preparation, guidance was not available to identify interconnected surface water (ICSW) bodies and GDEs. Since then, DWR has provided the NCCAG mapping and relevant guidance became available. Consistent with its own practices and applying best available science, Zone 7 reviewed available information (e.g., NCCAG and other datasets) to identify ICSW areas, evaluate GDEs, refine MOs and MTs for Depletions of Interconnected Surface Water, and identify new monitoring locations and protocols.

Task 1: Zone 7 identified potential ICSW/GDE areas that were not recognized in the 2016 Alternative GSP, field-verified their existence, and added appropriate GDEs to the GDE inventory list, including revising and updating existing maps and tables of potential GDEs.

Deliverables: Updated GDE inventory table (**Table 8-J**) and location map (**Figure 8-46**)

Task 2: Zone 7 evaluated the seasonal range of depth-to-groundwater measurements in the vicinity of each potential ICSW/GDE area using data collected from Zone 7's Water Level Monitoring Program and compared the seasonal range of depth-to-groundwater with each GDE's general groundwater requirements (e.g., rooting zone depth) to refine the identification of GDEs and to provide a preliminary evaluation for defining SMCs.

Deliverables: Technical memorandum with preliminary evaluation for defining minimum thresholds (**Appendix F**)

Task 3: Zone 7 developed preliminary MOs and MTs for Depletions of ICSW.

Deliverables: Updated ICSW/GDEs Sections (**Section 8.8, Section 8.9, Section 13.6**).

Task 4: Zone 7 evaluated the need for additional monitoring locations and protocols, if appropriate, to adequately monitor groundwater elevations in the vicinity of the ICSW/GDE areas relative to the SMCs. *Deliverables*: ICSW/GDE monitoring point locations map (**Section 14.2.6** and **Figure 14-4**). Monitoring Protocol in the Alternative GSP Update (**Section 14.3** and **Appendix G**).

TABLE 1-1
WELLS INVESTIGATED FOR ADDITION TO 2021 GROUNDWATER PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map Name	Added?	Reason	Completed Date	Depth To Top Screen (ft)	Depth to Bottom Screen (ft)	Well Depth (ft)	Well Diameter (in)
2S2E21L001	21L1	Yes	May School Nitrate	5/1/1973	49	168	168	10
2S2E27K001	27K1	Yes	Springtown Alkali Sink	4/28/1954	49	88	96	8
2S2E27M002	27M2	Yes	Springtown Alkali Sink	7/16/1975	NA	NA	112	6
3S1E09H013	9H13	Yes	Lake I monitoring	NA	NA	NA	145	8
3S2E21K008	21K8	No	Similar to existing program well (K9)	NA	NA	NA	220	6
3S2E22E002	22E2	No	Similar to existing program well (R2)	NA	NA	NA	105	6
3S1E18M002	18M2	No	Too deep.	NA	NA	NA	550	6
3S1E28M002	28M2	Yes	Happy Valley	2/8/1962	80	141	141	5
3S3E18Q001	18Q1	No	Difficult to access	NA	NA	NA	NA	NA
3S1E33G005	33G5	Yes	Happy Valley and Upland	7/21/2006	11	35	35	2
3S2E15G011	15G11	No	No response from owner	7/29/2020	80	300	300	5
3S2E15L002	15L2	Yes	Data from Owner	1/14/2015	40	70	70.5	2
3S2E15M003	15M3	Yes	Data from Owner	1/13/2015	45.3	75.3	75.8	2
3S2E15Q008	15Q8	Yes	Data from Owner	1/14/2015	10.5	40.5	41	2
3S2E15R020	15R20	Yes	Data from Owner	1/14/2015	20.5	50.5	51	2
3S2E19K001	19K1	Yes	Mining, Fills Data Gap	NA	NA	NA	160	2
3S2E22E001	220	No	Similar to R002	12/8/1947	50	450	450	10
3S3E18Q004	18Q4	No	Difficult to access	NA	NA	NA	NA	NA
3S2E20R002	20R2	Yes	Upland	5/1/1985	107	252	257	9
3S2E21K009	21K9	Yes	Upland	NA	NA	NA	NA	6
3S2E21N001	21N1	No	Similar to R002	5/14/1987	110	310	320	8
3S2E28P002	28P2	No	Similar to 29L001, 33C001	1/18/1977	52	200	208	10
3S2E29J001	29J1	No	Similar to 29L001, 33C001	11/29/2001	5	20	20	2
3S2E29L001	29L1	Yes	Sycamore Grove	11/29/2001	8	23	23	2
3S2E29L002	29L2	No	Similar to 29L001, 33C001	12/1/2003	3	18	20	2
3S2E32A001	32A1	No	Similar to 29L001, 33C001	12/1/2003	2	17	17.5	2
3S2E33C001	33C1	Yes	Sycamore Grove	11/29/2001	5	20	20	2
3S1E33G004	33G4	No	Similar to G005	NA	NA	NA	35	NA
3S3E19C002	19C2	Quality Only	Fringe, NO3, GW Quality Only	NA	NA	66	66	8
3S3E20L004	20L4	Yes	Fringe, NO3	8/15/2005	NA	NA	340	5
3S3E20R004	20R4	Yes	Fringe, NO3	NA	NA	NA	NA	6
3S3E21C001	21C1	Yes	Upland, NO3	1/1/1977	60	124	128	12
4S2E01A001	1A1	Yes	Arroyo Valle	2/6/2015	45	130	130	6
4S3E06E004	6E4	Yes	Arroyo Valle	5/28/1976	184	212	220	10
	Added for levels:	**20**						
	Added for quality:	**21**						

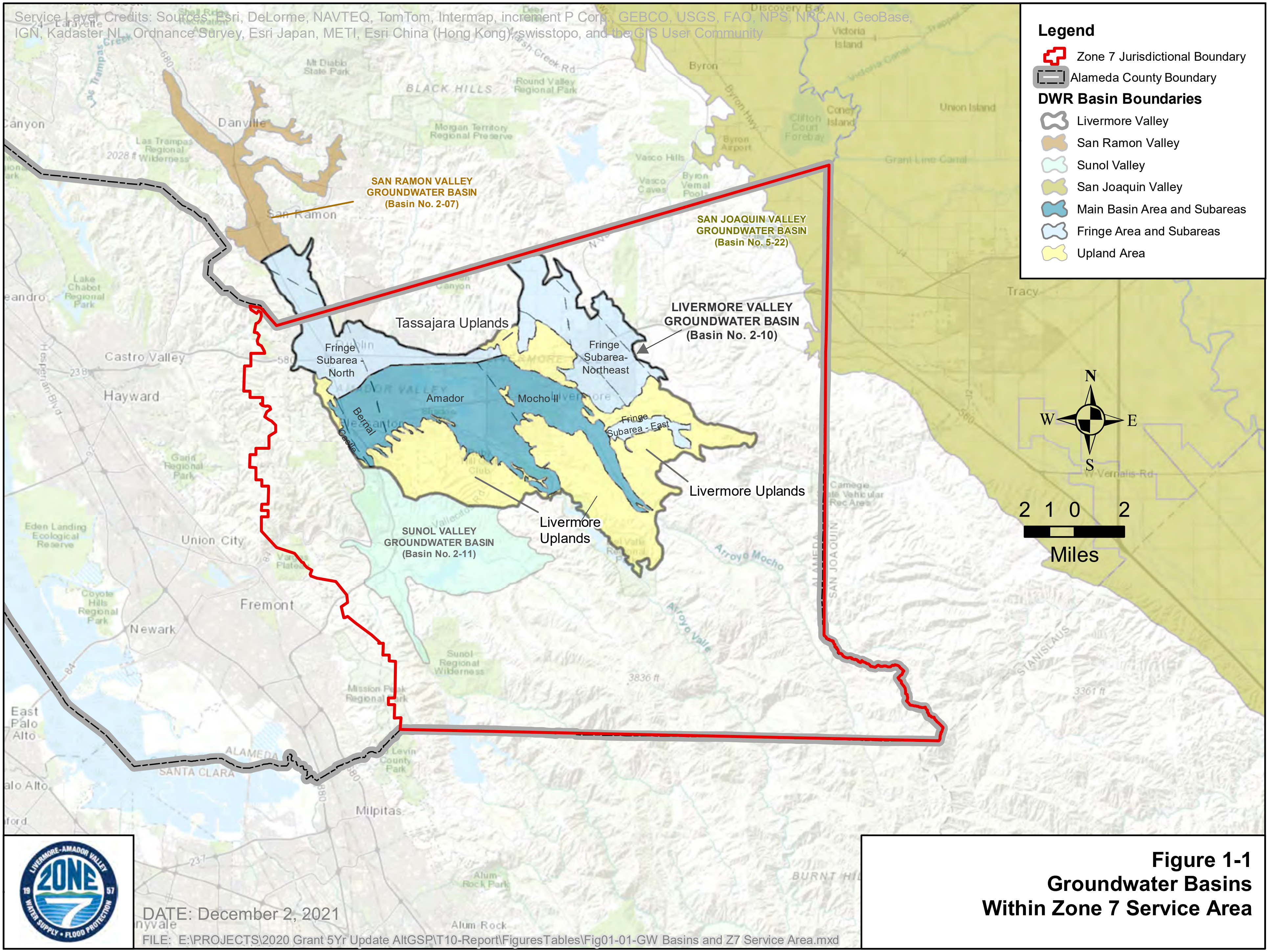


Figure 1-1
Groundwater Basins Within Zone 7 Service Area

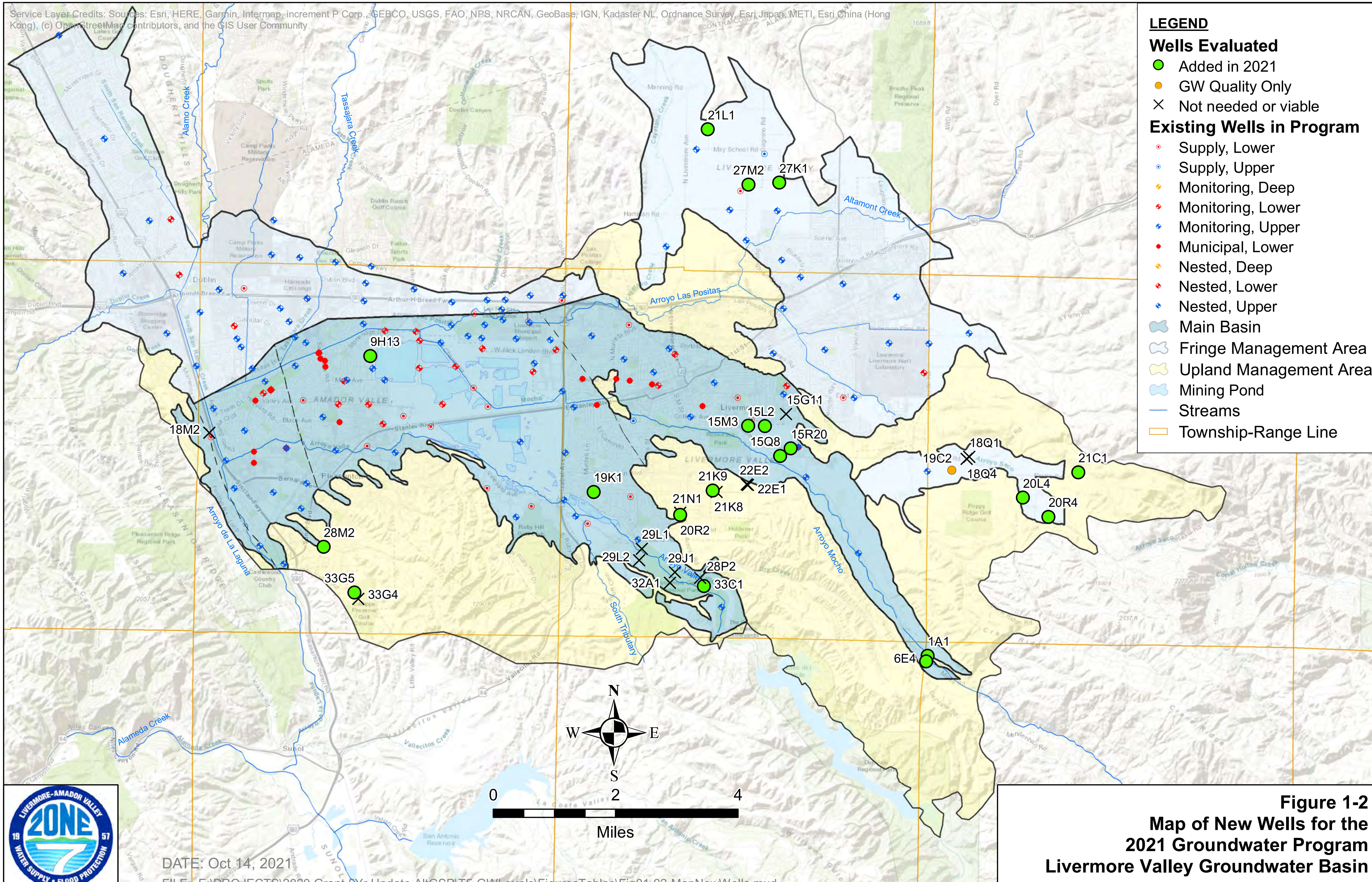


Figure 1-2
Map of New Wells for the 2021 Groundwater Program
Livermore Valley Groundwater Basin

2. SUSTAINABILITY GOAL

§ 354. 24 Sustainability Goal
Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

☑ **23 CCR § 354.24**

The Sustainable Groundwater Management Act (SGMA) requires that a Sustainability Goal be defined for each medium- or high-priority basin (California Water Code [CWC] § 10727(a)). The California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 further clarifies that the Sustainability Goal should culminate "in the absence of undesirable results within 20 years of the applicable statutory deadline" (23 CCR § 354.24).

The Alameda County Flood Control and Water Conservation District, Zone 7's (Zone 7 Water Agency or Zone 7) strategic planning (*Zone 7, 2020b*) focuses on seven goal areas that provide direction for achieving the vision and mission. Of these seven goals, "GOAL C - Groundwater Management" is to manage and protect the groundwater basin as the State designated Groundwater Sustainability Agency (GSA).

As the GSA, Zone 7 has adopted and met the following Sustainability Goal for the Livermore Valley Groundwater Basin (Basin):

> *Continue to operate the Livermore Valley Groundwater Basin within its Sustainable Yield[5] and to manage the groundwater resources for the prevention of significant and unreasonable: (1) chronic lowering of groundwater levels, (2) reduction of groundwater storage, (3) degradation of groundwater quality, (4) inelastic land subsidence, and (5) depletion of interconnected surface water supplies such that beneficial uses aren't adversely impacted.[6]*

Consistent with this Sustainability Goal and its long-term sustainable management of the Basin, Zone 7 has developed and/or adopted a series of policies, ordinances, and basin management objectives (BMOs) that have expanded over time to adapt management actions to groundwater conditions in the Basin. The primary objectives of the Zone 7 groundwater management program are to provide for:

[5] Sustainable Yield is defined by SGMA as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC §10721).

[6] The significant and unreasonable seawater intrusion is not applicable for the Basin as it is situated inland and does not interface with seawater.

- control and conservation of waters for beneficial future uses,
- conjunctive use of groundwater and surface water,
- importation of additional surface water, and
- use of the groundwater basin to store imported surface water for subsequent recovery during drought periods.

In Zone 7's 2005 Groundwater Management Plan (GWMP), a series of BMOs were identified as the guiding principles for Basin management decisions. Those BMOs addressed five Sustainability Indicators and remain relevant to this Alternative Groundwater Sustainability Plan (Alternative GSP). Because seawater intrusion is not a relevant issue for this inland basin, no BMOs or Sustainable Management Criteria (SMCs) are needed for this Sustainability Indicator. The primary BMOs implemented by Zone 7 in the GWMP are listed below, along with the Sustainability Indicator that relates to each of the BMOs:

- Monitoring and maintenance of groundwater levels through conjunctive use and management of regional water supplies (This BMO is equivalent to the Sustainability Indicators for Chronic Lowering of Groundwater Levels and Reduction of Groundwater Storage):
    - maintain the balance between the combination of natural and artificial recharge and withdrawal,
    - maintain water levels high enough to provide emergency reserves adequate for worst credible drought and unplanned import outages,
    - store surface water supplies in the groundwater basin for use during emergencies and drought-related shortages,
    - allow for gravel mining by optimizing groundwater levels while maintaining adequate reserves for municipal supply, and
    - prevent overdraft that would otherwise occur from too much pumping (maintain total pumping at or below sustainable/safe yields);
- Groundwater quality monitoring and management, including tracking and addressing any water quality degradation (This BMO is equivalent to the Sustainability Indicator for Degraded Water Quality):
    - protect and enhance the quality of the groundwater,
    - halt degradation from salt buildup (offset current and future salt loading),
    - reduce flow of poor-quality shallow groundwater into deep aquifers,
    - offset impacts of water recycling and wastewater disposal through integrated Salt Management Plan (SMP),

- recharge with relatively low total dissolved solids (TDS)/hardness imported or storm/local surface water,
- manage quality on a regional basis as measured at municipal wells (such as those operated by both the retail water agencies and Zone 7), protecting and improving groundwater quality within the Main Basin Management Area (Main Basin) (as protecting and improving groundwater quality within the Main Basin (as described in Chapter 3), and
- minimize threats of groundwater pollution through groundwater protection;

- Monitor and prevent inelastic land surface subsidence from occurring as a result of groundwater withdrawals (This BMO is equivalent to the Sustainability Indicator for Land Subsidence):
  - protect the storage capacity of Basin aquifers,
  - maintain water levels above historic lows,
  - monitor and minimize any identified impacts of gravel mining on the Upper Aquifer by encouraging the implementation of mitigation measures by mining companies, and
  - monitor benchmark elevations and shift pumping to other wells if inelastic subsidence is detected;
- Monitor and manage changes in surface water flow and quality, especially as they affect groundwater levels or quality, or are caused by groundwater pumping in the basin (This BMO is equivalent to the Sustainability Indicator for Depletions of Interconnected Surface Water):
  - augment stream flow through artificial recharge releases to improve groundwater supply and quality, and
  - monitor and protect recharge capacity of local arroyos.

Consistent with these GWMP BMOs, the Zone 7 Board of Directors has also adopted the 2004 SMP, the 2015 Nutrient Management Plan (NMP) and specific policy resolutions related to the protection of the Basin through wastewater management including:

- Water Quality Policy (Resolution 03-2494)
- Wastewater Management Policy (Resolution 1037)
- Prohibition against use of septic tanks for new development zoned for commercial or industrial use (Resolution 1165).

Finally, Zone 7 Board of Directors has also adopted the Reliability Policy for Municipal and Industrial (M&I) Water Supplies (Resolution 04-2662). In November 2012, the Zone 7 Board of Directors updated the reliability goals, which affect the quantity and urgency of new supply wells needed by Zone 7 as development occurs in the Basin. These refined goals are summarized below:

- ***Goal 1.*** Zone 7 will meet its treated water customers' water supply needs, in accordance with Zone 7's most current Contracts for M&I Water Supply, including existing and projected demands as specified in Zone 7's most recent Urban Water Management Plan (UWMP), during normal, average, and drought conditions, as follows:
  - At least 85% of M&I water demands 99% of the time
  - 100% of M&I water demands 90% of the time.
- ***Goal 2:*** Provide sufficient treated water production capacity and infrastructure to meet at least 80% of the maximum month M&I contractual demands should any one of Zone 7's major supply, production, or transmission facilities experience an extended unplanned outage of at least one week.

To support groundwater management activities, Zone 7 has developed and implemented an extensive series of Basin-wide monitoring networks and programs that have expanded and improved over time (see **Section 5.2** and **Section 14**). The overall objective of the monitoring networks is to provide sufficient information to allow for the tracking of groundwater conditions to meet the Sustainability Goal of the Basin, including the prevention of Undesirable Results. In addition to this overall objective, specific objectives for Basin-wide monitoring networks and programs have been identified for each of the Sustainability Indicators to accomplish the following requirements relative to SGMA:

- Demonstrate ongoing sustainability in the Basin,
- Monitor impacts to groundwater users and beneficial uses of groundwater,
- Monitor changes in groundwater conditions relative to Measurable Objectives (MOs) and Minimum Thresholds (MTs), and
- Quantify annual changes in water budget components.

Through the combination of the above policies and programs, this Alternative GSP demonstrates that Zone 7 has operated the Basin within its sustainable yield over a period of at least 10 years.

3. AGENCY INFORMATION

§ 354.6. When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:
(a) The name and mailing address of the Agency.
(b) The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.
(c) The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.
(d) The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.
(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

3.1. Name and Mailing Address of the Agency

☑ **23 CCR § 354.6(a)**

The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) is the exclusive Groundwater Sustainability Agency (GSA) for the Livermore Valley Groundwater Basin (Department of Water Resources [DWR] Basin No. 2-10, referred to herein as the "Basin").

The mailing address for the GSA is:

Zone 7 Water Agency
Attention: Groundwater Manager
100 North Canyons Parkway
Livermore, CA 94551

3.2. Organization and Management Structure of the Agency

☑ **23 CCR § 354.6(b)**

Zone 7 is one of ten active zones of the Alameda County Flood Control and Water Conservation District (District). Zone 7 is the only zone in the District that provides water services in addition to flood protection, and has a long history of managing imported and local surface and groundwater resources for beneficial uses and users in the Basin.

The Zone 7 water service area (**Figure 3-1**) is located about 40 miles southeast of San Francisco and encompasses an area of approximately 425 square miles of the eastern portion of Alameda County, including the Livermore-Amador Valley, Sunol Valley, and portions of the Diablo Range. Zone 7 also serves a portion of Contra Costa County (Dougherty Valley in San Ramon) through an out-of-service-area agreement with Dublin San Ramon Services District (DSRSD). As the water wholesaler, Zone 7 supplies treated State Water Project (SWP) water to four local retail water supply agencies (**Figure 3-1**).

- California Water Service —Livermore District (CWS)
- DSRSD
- City of Livermore (Livermore)
- City of Pleasanton (Pleasanton)

Zone 7 also provides imported, untreated surface water directly to 82 water customers. These direct connections largely supply local agricultural uses.

The history of Zone 7 Water Agency, including its statutory responsibilities and its ongoing coordination with other local agencies in the Basin, is described briefly below.

The Alameda County Flood Control and Water Conservation District was created in 1949 with authority to provide control of flood and stormwater and to conserve and manage local water for beneficial uses. The District comprises 10 active zones, of which Zone 7 covers the eastern portion of Alameda County (**Figure 3-1**). Pursuant to Section 36 of the District Act, Zone 7 Water Agency was established in 1957 to address regional and water supply issues. Zone 7 is governed by a seven-member Board of Directors (Zone 7 Board). Each director is elected at-large by residents within Zone 7's service area to a four-year term. The Zone 7 Board have full authority and autonomy to govern matters solely affecting Zone 7, independent of the Alameda County Board of Supervisors who govern the other nine zones of the District. The Zone 7 Board has played an active role in groundwater management and has adopted numerous policies and programs for sustainable management of local groundwater resources.

The Zone 7 Board also provides direction to Zone 7 management and staff through the Zone 7 General Manager and general counsel. Zone 7's organizational chart is included in **Figure 3-2.** The General Manager is assisted by an Assistant General Manager responsible for Finance and Human Resources. Three other Core Managers oversee the core functions of the Zone 7 Water Agency: Engineering, Production, and Integrated Water Resources. Groundwater management falls under the Integrated Water Resources function and coordinates within the group to also achieve stream management and flood protection, long-term planning, watershed and water quality protection, environmental planning, Asset Management and Capital Improvement Program planning.

Because the local streams are used for both flood protection and artificial recharge, Zone 7's climatology and stream monitoring programs are coordinated between the Flood Control and Groundwater sections. Zone 7 serves as the area's flood control agency and owns and/or maintains 37 miles of flood protection stream/channel corridors within a 425 square mile area. Zone 7 manages flood protection program through its Stream Management Master Plan.

Regarding water operations and long-term planning, Zone 7 became an early importer of water (in 1962) for artificial groundwater recharge as one of the 29 contractors for the SWP. As the water wholesaler for the Tri-Valley Area (Valley, i.e, Dublin, Pleasanton, and Livermore), Zone 7 imports surface water from the

SWP through the South Bay Aqueduct (SBA) for treatment, storage, and groundwater recharge. Zone 7 supplies treated drinking water to the four Retailers (see **Figure 3-1**), which deliver water to customers in their specific service areas. Zone 7 also supplies untreated water for local industry and agriculture. Thus, through its Retailers, Zone 7 serves water to an area with a population of approximately 266,000 (*Zone 7, 2021*).

Although the Basin is not adjudicated, by agreements with the local Retailers, Zone 7 manages regional water supplies through the interrelated programs described above where previously agreed groundwater extraction quotas are tracked and annual water management accounting is conducted. Zone 7 also manages recharge operations to augment instream and mining pond aquifer recharge. Zone 7's groundwater extraction is managed as to not exceed the previously recharged amounts. Water quality is also closely monitored and environmental cleanup sites are tracked. In addition, Zone 7 works closely with DWR, which manages Lake Del Valle and dam, to augment imported water supplies with local surface water runoff.

In summary, Zone 7 Water Agency conducts the followings:

- imports surface water via the SWP's SBA,
- stores local runoff in Lake Del Valle,
- manage recharge operations in the area,
- manages local and imported surface water and recovered supplies from groundwater banks to maximize conjunctive use of the supplies,
- treats and wholesales potable water to local retail water supply agencies (who in turn retail it to residents and other customers),
- delivers imported untreated water for irrigation to its agricultural customers, and
- provides protection of groundwater quality through the implementation of its Groundwater Management Plan, Salt and Nutrient Management Plan, and operation of its Mocho Groundwater Demineralization Facility.

Consistent with its management responsibilities, duties, and powers, Zone 7 Water Agency is designated as the exclusive GSA within its boundaries for the Sustainable Groundwater Management Act (SGMA) purposes. Since electing to be a GSA, the Agency has exercised its groundwater management authority consistent with its principal act and with SGMA. Continuing almost 60 years of active water resource management and over 45 years of active groundwater basin management, this Alternative Groundwater Sustainability Plan (Alternative GSP) will be implemented by the Zone 7 General Manager, assisted specifically by staff of the Agency's Integrated Water Resources Division.

3.3. Plan Manager

☑ 23 CCR § 354.6(c)

The Plan Manager is Ken Minn. Mr. Minn can be reached at:

Ken Minn, P.E.
Groundwater Resources Manager
Zone 7 Water Agency
100 North Canyons Parkway
Livermore, CA 94551
kminn@zone7water.com
(925) 454-5071

3.4. Legal Authority of the GSA

☑ 23 CCR § 354.6(d)

Recognizing Zone 7's legal authority to implement SGMA within its service area, SGMA specifically designates Zone 7 as the exclusive GSA within its statutory boundaries (Water Code §10723).

3.5. Estimated Cost of Implementing the Alternative GSP and the Agency's Approach to Meet Costs

☑ 23 CCR § 354.6(e)

Within Zone 7's Integrated Water Resources Division, the Groundwater Section is primarily responsible for the implementation of Zone 7's groundwater management practices. The Groundwater Section employs a staff of seven including a professional engineer, two hydrogeologists and four water resource technicians. One of the water resources technician positions is funded, in part, through fees collected under the Alameda County Well Ordinance program. Section budgets are set every two years or adjusted as needed to address emergencies and critical need. The annual Groundwater Section budgets for the 2020-21 and 2021-22 fiscal years are approximately $2M and $1.7M respectively. About 98% of the funding for these budgets will come from water sales and well permit revenues. The balance of the Section's funding will be from new water connection fees and property taxes. In addition, Zone 7 will seek state and federal grant funding to finance projects and studies. **Table 3-1** shows the estimated cost of implementing the Alternative GSP and associated special projects.

TABLE 3-1
LIVERMORE BASIN ALTERNATIVE GROUNDWATER SUSTAINABILITY PLAN IMPLEMENTATION COSTS

Account	*Fiscal Year 2021 Actual Amount*	*Fiscal Year 2022 Amended Budget*	*Fiscal Year 2023 Projected Budget*	*Fiscal Year 2024 Projected Budget*	*Fiscal Year 2025 Projected Budget*	*Fiscal Year 2026 Projected Budget*	*Funding Sources*
Labor	982,208.78	1,344,565.00	1,384,901.95	1,426,449.01	1,469,242.48	1,513,319.75	Water Rates
Professional Services	304,247.69	308,200.00	317,446.00	326,969.38	336,778.46	346,881.82	Water Rates
Communications	3,255.76	5,850.00	6,025.50	6,206.27	6,392.45	6,584.23	Water Rates
Repairs and Maintenance	3,560.62	8,600.00	8,858.00	9,123.74	9,397.45	9,679.38	Water Rates
Rental Services	-	500.00	515.00	530.45	546.36	562.75	Water Rates
General Office Services/ Supplies	15,677.07	34,450.00	35,483.50	36,548.01	37,644.45	38,773.78	Water Rates
Organizational Membership/ Participation	1,850.00	1,900.00	1,957.00	2,015.71	2,076.18	2,138.47	Water Rates
Other Services/ Supplies	2,010.20	6,250.00	6,437.50	6,630.63	6,829.54	7,034.43	Water Rates
Training and Travel	757.50	3,650.00	3,759.50	3,872.29	3,988.45	4,108.11	Water Rates
Other Planning Efforts and Capital Projects							
Well Master Plan update			180,000.00	180,000.00			Water Rates, Connection Fees, and grants
Groundwater Model Upgrade		90,000.00	90,000.00				Grant Funds
Salts and Nutrients Management Plan update					330,000.00		Grant Funds
PFAs Management Program		60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	Grant Funds
Total Other Planning Efforts and Capital Projects	-	150,000.00	330,000.00	240,000.00	390,000.00	60,000.00	
EXPENSES Total	**1,313,567.62**	**1,863,965.00**	**2,095,383.95**	**2,058,345.47**	**2,262,895.83**	**1,989,082.71**	

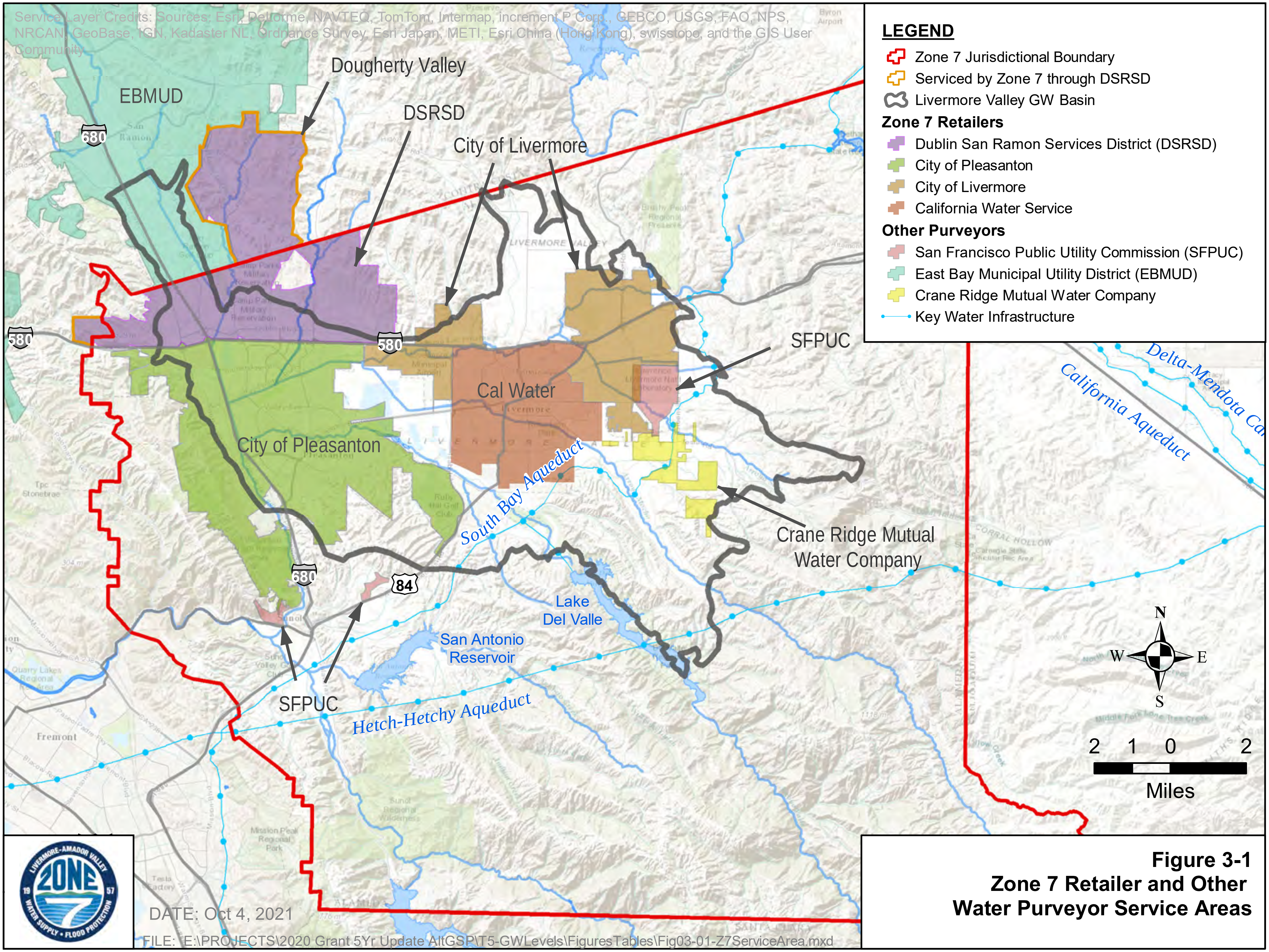
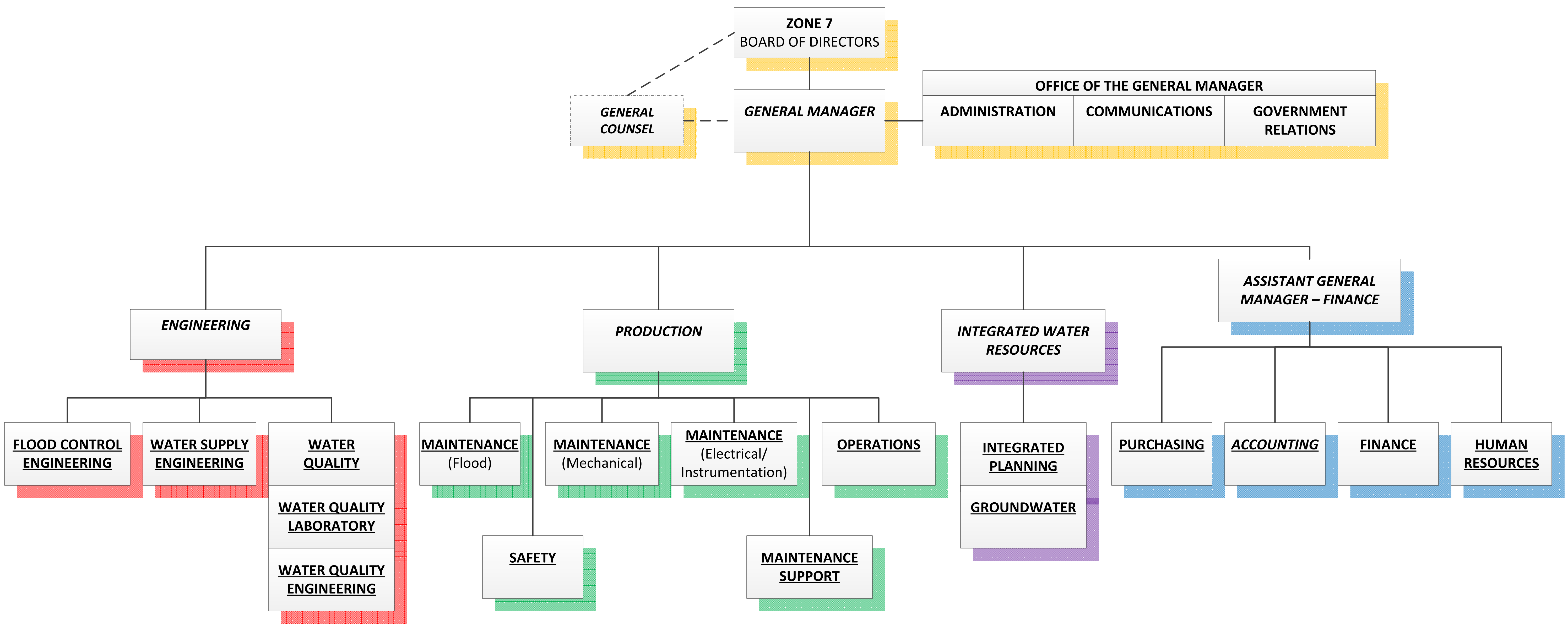


Figure 3-1
Zone 7 Retailer and Other Water Purveyor Service Areas

FIGURE 3-2
ZONE 7 WATER AGENCY
ORGANIZATIONAL STRUCTURE



4. ALTERNATIVE GSP ORGANIZATION

This 2021 Alternative Groundwater Sustainability Plan (Alternative GSP) is organized as follows and documentation of compliance with the GSP Regulations is documented in **Appendix B**:

- **Section ES** provides an **Executive Summary**, or overview, of the Alternative GSP.
- **Sections 1 through 4** comprise the **Introduction**, including the following sections:
  - **Section 1**. Purpose of the GSP
  - **Section 2**. Sustainability Goal
  - **Section 3**. Agency Information
  - **Section 4**. Alternative GSP Organization
- **Section 5** provides a **Description of the Plan Area**.
- **Sections 6 through 10** present the **Basin Setting**, including the following sections:
  - **Section 6.** Introduction to Basin Setting
  - **Section 7.** Hydrogeologic Conceptual Model
  - **Section 8**. Current and Historical Groundwater Conditions
  - **Section 9**. Water Budget Information
  - **Section 10.** Management Areas
- **Sections 11 through 13** present the **Sustainable Management Criteria**, including the following sections:
  - **Section 11**. Introduction to Sustainable Management Criteria
  - **Section 12**. Sustainability Goal
  - **Section 13**. Sustainability Indicators
- **Section 14** presents the **Monitoring Network**.
- **Section 15** presents the **Projects and Management Actions**.
- **References and Technical Studies** are included at the end of this document.
- Supporting information is provided in **Appendices**.

PLAN AREA

(SUBTITLE PAGE)

5. DESCRIPTION OF THE PLAN AREA

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(a) One or more maps of the basin that depict the following, as applicable:

(1) The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.

(2) Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.

(3) Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.

(4) Existing land use designations and the identification of water use sector and water source type.

(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.

(b) A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.

This section presents a description of the Plan Area and a summary of the relevant jurisdictional boundaries and other key land use features potentially relevant to the sustainable management of groundwater in the Livermore Valley Groundwater Basin (Basin). This section also describes the water monitoring programs, water management programs, and general plans relevant to the Basin and their influence on the development and execution of this Alternative Groundwater Sustainability Plan (Alternative GSP).

5.1. Summary of Jurisdicational Areas and Other Features

5.1.1. Area Covered by the Plan

☑ **23 CCR § 354.8(a)(1)**
☑ **23 CCR § 354.8(b)**

The Plan Area (**Figure 5-1**) is the entire Basin, designated in the California Department of Water Resources (DWR) Bulletin 118 as Basin No. 2-10 and encompassing approximately 69,600 acres (109 square miles) in Alameda and Contra Costa counties. The area is referred to as the "Plan Area," or simply "Basin" in this document and has not changed since submittal of the 2016 Alternative GSP. As shown in **Table 5-A,** the Basin includes three Management Areas, which is further discussed in **Section 10**. Adjacent groundwater basins are the San Ramon Valley (Basin No. 2-07), a very-low priority basin that extends to the northwest in Contra Costa County, and the Sunol Valley (No. 2-11), which is a very-low priority basin to the southwest of the Basin.

Table 5-A. Groundwater Basin Management Area

Management Area	Size (acres)
Main Basin Management Area	19,800
Fringe Management Area	22,041
Upland Management Area	27,759
Total	**69,600**

5.1.2. Adjudicated Areas, Other Agencies, and Alternative Areas

☑ **23 CCR § 354.8(a)(2)**
☑ **23 CCR § 354.8(b)**

The Basin is not adjudicated and does not contain any areas that are not covered by this Alternative GSP.

While the Alameda County portion of the Basin lies wholly within the Alameda County Flood Control and Water Conservation District, Zone 7's (Zone 7 Water Agency or Zone 7) Service Area, the northwestern portion of the Basin extends beyond the Zone 7 Service Area into Contra Costa County. In 2016, Zone 7 entered into a Memorandum of Understanding (MOU) with East Bay Municipal Utilities District (EBMUD), City of San Ramon, and Dublin San Ramon Services District (DSRSD) under which Zone 7 will serve as the Groundwater Sustainability Agency (GSA) for the Contra Costa portion of the Basin. Contra Costa County retains its authority as the well permitting agency for that area. Likewise, EBMUD retains its rights to continue to provide water service and the City of San Ramon remains as the primary land use agency.

Zone 7 supplies the majority of the water for the Tri-Valley Area (Valley, i.e., Dublin, Pleasanton, and Livermore); primarily through its four Retailers, including DSRSD, City of Pleasanton, City of Livermore, and California Water Company (Cal Water) (see **Section 3.2** and **Figure 5-2**). Three of these Retailers (DSRSD, City of Pleasanton, and City of Livermore) are public water supply agencies. Cal Water is a private water company providing water supply to portions of the City of Livermore. In addition to the treated water supplied by Zone 7, two of the Retailers (Pleasanton and Cal Water) have their own municipal groundwater supply wells. DSRSD and Livermore also provide recycled water for landscape irrigation to supplement treated water supply. The San Francisco Public Utilities Commission (SFPUC) supplies groundwater to the Castlewood Development in the western portion of Pleasanton. The Crane Ridge Mutual Water Company, a small private water purveyor, distributes potable water supplied by Cal Water to various domestic users in South Livermore. Alameda County Fairgrounds, in Pleasanton, is a small water system using groundwater.

5.1.3. Jurisdictional Boundaries

☑ 23 CCR § 354.8(a)(2)
☑ 23 CCR § 354.8(b)

The Basin is located mostly in Alameda County, with a northern extension into Contra Costa County. Cities overlying portions of the Basin include San Ramon, Dublin, Pleasanton, and Livermore (**Figure 5-3**). There are two Park Districts in the Valley: (1) the East Bay Regional Park District (EBRPD); and (2) the Livermore Area Recreation and Park District (LARPD).

According to the information made available by DWR's SGMA Data Viewer, there are no identified California Native American tribal lands within the Basin.

DWR presents information regarding U.S. Census Blocks, Tracts and Places that are defined as disadvantaged communities (DAC) or severely disadvantaged communities (SDAC) based on the median household income (MHI) of an area compared to the statewide MHI.[7] DAC communities are those with a MHI that is no more than 40% of the statewide MHI, and SDAC communities are those with a MHI that is no more than 20% the statewide MHI (California Code, Public Resources Code § 75005(g)). As shown on **Figure 5-3**, there are three block groups identified as DACs within the Basin. There are currently 2,598 disadvantaged households in the City of Livermore, with a total population of 6,678.

Based on application of DWR's SGMA Data Viewer, within the Plan Area there are several areas of California Department of Fish and Wildlife (CDFW) owned and operated lands and conservation easements, Nonprofit California Protected Area (CPA) holdings, and California Conservation Easements (CCE).

Other jurisdictions in the Basin include Camp Parks Military Reservation/Reserve Forces Training Area, located on the northern boundary of the Basin and operated by the Department of Defense/ United States Army. The facility is a semi-active mobilization and training center for army reserve personnel to be used in case of war or natural disaster. The site also includes a federal correctional institution. On the southern side of the Basin, the Lake Del Valle State Recreation Area and Shadow Cliffs Regional Recreation Area are operated by EBRPD. No tribal land is known to be located in the Basin.

5.1.4. Existing Land Use and Water Use Sector and Source

☑ 23 CCR § 354.8(a)(4)
☑ 23 CCR § 354.8(b)

5.1.4.1. Land Use Designations

Zone 7 monitors land use changes in the Valley as part of its long-range flood and water supply planning, which includes its Groundwater Management Program. The purpose of the Land Use Monitoring Program

[7] SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer

is to map and quantify Basin land use for areal recharge calculations (e.g., rainfall and applied water recharge) and to estimate unmetered agricultural groundwater pumping demands, and for consideration in water quality sustainability planning.

The Land Use Monitoring Program identifies significant changes in land use over time with an emphasis on changes in pervious areas and the volume and quality of irrigation water that could impact the volume or quality of water recharging the Basin. Land use data are derived from aerial photography (most recent available from May 2020), well permit applications, field observations, and City and County planning documents. New development plans and associated California Environmental Quality Act (CEQA) documentation are reviewed by Zone 7 staff to evaluate potential impacts to groundwater supply and quality.

For the purpose of Zone 7's Groundwater Management Program, primary land uses are mapped as polygons having one of the following designations:

- Residential (rural)
- Residential (low density)
- Residential (medium density)
- Residential (high density)
- Commercial and Business
- Public
- Public (Irrigated Park)
- Agriculture (vineyard)
- Agriculture (non-vineyard)
- Mining Area – Pit
- Water Body (including Chain of Lakes)
- Golf Course
- Open Space

Each individual land use polygon is also assigned one of the following sources of irrigation water based on Zone 7's understanding of the primary irrigation water source used for that particular area:

- Delivered (municipal) water
- Groundwater (non-municipal supply wells, e.g., private wells)
- Recycled water
- None

Land use categories are then assigned spatially to the groundwater model cells (500 feet by 500 feet), which are also the spatial units used for the areal recharge calculations (see **Appendix D**).

The 2020 Water Year (WY) land use areas are shown on **Figure 5-4**. For the 2020 WY, land use remained relatively unchanged from 2015 WY presented in the 2016 Alternative GSP (*Zone 7, 2016e*), and in fact still remains quite similar to the land use of the mid-2000s.

Implementation of existing land use plans by various jurisdictions has important ramifications for water supply sustainability. Urban, rural, and agricultural growth tends to increase water demand, but land use policies and programs can support sustainable water supply planning including water conservation, conjunctive use of surface water and groundwater supplies, water recycling, and stormwater management.

Land use planning and water resource management are regularly and closely coordinated across the Basin. This ensures that implementation of land use plans, which can change water demands or affect sustainable groundwater management, is occurring in a context of open collaboration among land use planners and water agencies. Moreover, development of various water management plans, including this update to the Alternative GSP, also has occurred through open collaboration. Such dynamic and interactive planning has been fundamental to sustainable groundwater management in the Basin.

As documented in **Section 5.3** all the cities overlying the Basin have developed General Plans that address water supply issues (as appropriate to their respective responsibilities) and all the cities have established urban growth boundaries or urban limit lines. Alameda County's East County Area Plan provides numerous policies that indicate commitment to work with Zone 7, local water retailers, and cities toward comprehensive water planning.

5.1.4.2. Water Use Sectors and Sources

Each individual land use polygon on **Figure 5-4** is also assigned one of the following water uses:

- Delivered (municipal surface water/groundwater mix) Water
- Groundwater (non-municipal supply wells, e.g., private wells)
- Recycled Water
- None

These water-use sectors represent the source of irrigation water based on Zone 7's understanding of the primary irrigation water source used for that particular area. The "Delivered Water" areas are supplied by a mixture of imported surface water (see **Section 7.7.6**) and pumped groundwater from municipal wells (**Figure 5-5** and **Figure 5-6**). The proportion of these two sources at most locations will vary significantly, both spatially and temporally, and depends on a variety of factors including the availability of imported water supplies and the proximity to an existing municipal well. The areas designated as "Groundwater" are outside the municipal delivery system and rely on private domestic and/or irrigation wells. The "Recycled Water" areas are supplied by delivered water for drinking water but use recycled water for irrigation.

Groundwater in the Basin is used for agricultural, municipal, industrial, domestic, and undifferentiated supply purposes. As illustrated in **Figure 5-5**, supply wells are distributed throughout the Basin with the greatest densities mostly in the central and southern portions of the Basin (i.e., Main Basin Management Area [Main Basin]). The Main Basin also is the locale of major municipal wells.

Currently most pumping is for municipal supply purposes. Municipal pumpers include City of Pleasanton, Cal Water, the SFPUC and Alameda County Fairgrounds; DSRSD receives its quota of pumped groundwater through Zone 7 (see **Figure 5-2**). In 1992, Zone 7 Water Agency calculated the natural sustainable yield for the Basin at 13,400 acre-feet (AF) and collaborated with the Retailers to allocate the yield. As a result, each retailer is limited to an annual independent Groundwater Pumping Quota (GPQ), which is generally based on average historical uses and is pro-rated based on the agreed upon natural sustainable yield. Together, the Retailers are permitted to pump a total average of 7,214 AF annually per calendar year without paying recharge fees to Zone 7. Averages are maintained with a process of carry-overs (limited to 20% of the GPQ) and recharge fees for all groundwater pumping exceeding the GPQ and carry-over credit.

Zone 7 regularly monitors groundwater pumping for all large capacity wells; records of other metered pumping wells are obtained when available. Pumping volumes from significant wells without meters are estimated. Groundwater use in 2020 by pumpers other than Zone 7 is listed in **Table 5-B.** The listed average amounts for the municipal pumpers represent the respective GPQ; the remaining averages are estimated.

Table 5-B: Groundwater Pumping by Others

PUMPING BY OTHERS	2020 WY (AF)	AVERAGE (AFY)
Pleasanton	3,110	3,500
Cal Water	1,063	3,069
DSRSD†	645	645
SFPUC	322	450
Fairgrounds	321	310
Domestic Wells**	108	200
Golf Courses**	247	227
Agricultural Pumping**	112	400
TOTAL PUMPING	5,928	8,802

*Average based on annual Groundwater Production Quota
** Estimated
† Pumped by Zone 7 for DSRSD

Zone 7 also pumps groundwater for municipal purposes, accounting for salt management, demand peaks, and any shortage or interruption in its surface water supply or treatment. This is not a portion of the natural sustainable yield, but represents water that had been stored in the Basin as part of the Zone 7 artificial recharge program. Zone 7 pumping for 2020 WY is summarized in **Table 5-C.**

Table 5-C: Zone 7 Groundwater Pumping

ZONE 7 PUMPING BY WELLFIELD	2020 WY (AF)
Amador Subarea	8,485
*Mocho wellfield**	5,477
COL wellfield	3,261
Stoneridge Well	2,195
Bernal Subarea	813
Hopyard wellfield	813
TOTAL PUMPING	11,746

* Includes 645 AF of groundwater pumped for DSRSD and Pump to waste

A map showing the clusters of municipal wells in the Basin is provided on **Figure 5-6**. The map includes Zone 7 wells and production wells operated by SFPUC, the City of Pleasanton, and Cal Water.

Figure 5-7 illustrates the major uses of groundwater (agricultural, municipal, domestic) from 1974 through 2020. As indicated, agricultural uses accounted for a major portion of groundwater use in the late 1970s, but dwindled to a small amount by 1990, mostly reflecting the urbanization in the Basin. Urbanization also caused an increasing trend in municipal pumping until 1991. Thereafter, with the 1992 adoption of the GPQ process, groundwater use by municipal pumpers has remained relatively steady.

Zone 7 municipal pumping has been quite variable since 1974 reflecting Zone 7's broad management role in the Basin, including artificial recharge and management of groundwater storage, salt management, and compensation for variations in surface water deliveries. As previously mentioned, Zone 7 pumping is not part of the natural sustainable yield but represents water that had been stored through the Zone 7 artificial recharge program. Zone 7's increased pumping during significant drought years, for example from 1987 to 1992 and from 2007 to 2009; illustrates how Zone 7 used its stored groundwater to maintain supply.

Some mining activities in the central portion of the Basin have caused groundwater losses due to export of moist gravels and groundwater that has been extracted from the quarry pits. Historically, a portion of the extracted groundwater was discharged into a stream without subsequent recharge; however, Zone 7 has worked with the mining companies to ensure that the pit-dewatered groundwater is now diverted to other existing ponds. The volume of the lost groundwater varied over time depending on the stage of mining in any given pit and the demand for aggregate resources (**Section 9.3.6.2**).

Groundwater pumping in the Fringe and Upland Management Areas (Fringe and Upland Areas) is minor relative to the Main Basin Management Area (Main Basin). Groundwater use in the Fringe Area is primarily for agricultural, domestic, and golf course irrigation. In the Upland Area groundwater is primarily used for domestic supply with minor pumping for agricultural uses. Estimated groundwater pumping in the Fringe and Upland Areas for an average WY is summarized in **Table 5-D**.

Table 5-D: Estimated Groundwater Pumping in the Fringe and Upland Management Areas in an Average WY

PUMPING BY OTHERS	FRINGE (AF)	UPLAND (AF)
Domestic Wells	85	178
Agricultural Pumping	77	92
TOTAL PUMPING	**728**	**217**

5.1.5. Well Density per Square Mile

☑ 23 CCR § 354.8(a)(5)
☑ 23 CCR § 354.8(b)

Figure 5-5 shows the distribution and density per square mile of water supply wells in the Basin, including industrial, municipal, agricultural, irrigation, domestic, and undifferentiated supply wells. The results are summarized below in **Table 5-E** below.

Table 5-E: Number of Wells by Management Area

Management Area	Domestic	Irrigation	Muni	Supply	Industrial	Total
Main	120	87	71	97	5	380
Fringe - Northwest	9	8	0	13	3	33
Fringe - Northeast	83	12	0	17	2	114
Fringe - East	56	4	0	1	0	61
Upland	287	61	0	84	0	432
TOTAL	555	172	71	212	10	1020

The last two categories include de minimis extractors. Well information was derived from Zone 7's database, which relies on permit records, field inspections, and property owner and driller reporting. All known active supply wells in the Basin are included on the map. Selection of the one-mile grid was performed automatically using geographic information system (GIS) software.

Figure 3-1 and Figure 5-2 show the service areas of the major water providers in the Basin, including EBMUD, DSRSD, Pleasanton, Livermore, and Cal Water. While these providers may use groundwater supply, none are wholly dependent on groundwater. Beyond their respective service areas, other beneficial users rely on groundwater. For the purposes of this map, an area in the Basin that is outside of the water utilities service areas is considered a groundwater dependent community. As shown on the map, groundwater dependent communities are present in the north-central and southeastern portions of the Basin, as well as a small pocket in the southwestern portion of the Basin (referred to as Happy Valley).

5.2. Water Resources Monitoring and Management Programs

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(c) Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.

(d) A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.

(e) A description of conjunctive use programs in the basin.

5.2.1. Existing Monitoring and Management Programs

☑ **23 CCR § 354.8(c)**

Zone 7 regulates more than half of the groundwater inflow and outflow from the Basin, managing the groundwater resources to provide a sustainable supply of high-quality water for residents of the Valley (mainly the Cities of Dublin, Pleasanton, and Livermore). Zone 7 serves as the lead for many of the water resource management programs and coordinates with groundwater resource programs of others in the Basin. A summary of such programs by others is provided in the following section. Key programs implemented by Zone 7 are also summarized herein and incorporated into the 2021 Alternative GSP.

Zone 7 Monitoring and Management Programs

Zone 7 has been monitoring and managing the groundwater basin for over 45 years. Zone 7's groundwater management policies and programs were first compiled and described in the 2005 Groundwater Management Plan (GWMP; *Zone 7, 2005a*) and then again in the first Alternative GSP (*Zone 7, 2016e*). These policies and programs, which are described in **Sections 8** and **14**, are updated in the Sustainable Groundwater Management Program annual reports, the most recent of which is located on the Zone 7 website[8]. Another important planning document included as an attachment is Zone 7's latest Urban Water Management Plan (UWMP; *Zone 7, 2021*, prepared every five years, 2020 UWMP is included as **Appendix K**). All these documents are also provided to the public on the Zone 7 website[9].

Zone 7 adaptively manages its groundwater supply with regard for current hydrologic conditions, water demands, water quality conditions, and future water supply/demand forecasts. As described in later sections and listed here, Zone 7 maintains the sustainability of the Basin through the following monitoring and management programs:

- Monitoring the long-term natural groundwater budget (described in **Section 9**),

[8] https://www.zone7water.com/sites/main/files/file-attachments/gsp2020annrptfinal.pdf?1619988363
[9] http://www.zone7water.com/publications-reports/reports-planning-documents

- Monitoring programs for groundwater levels, including Groundwater Level Monitoring Program, Key Well Program, California Statewide Groundwater Elevation Monitoring (CASGEM)/SGMA Data Viewer program, Del Valle Water Rights and other programs (described in **Section 14.2.1**),
- Monitoring programs for water quality, including routine water quality sampling, municipal supply well sampling, Del Valley Water Rights sampling, Salt/Nutrient Management Plan, Toxic Site Surveillance, wastewater and recycled water use monitoring (described below and in **Section 14.2.4**),
- Monitoring of land surface elevations (described in **Section 8.7 and 14.2.5**),
- Monitoring of interconnected surface water (described in **Section 14.2.6**),
- Other monitoring programs including Climatological Monitoring Program, Surface Water Monitoring Program, and Chain of Lakes/Mining Area Monitoring Program (described in **Section 14.2.7**),
- Importing, artificially recharging, and banking surface water to meet future demands (described in **Section 9.3.4**),
- Implementing a conjunctive use program that maximizes use of the storage capacity of the Basin (described in **Section 15.2.1.3**), including long-term implementation of the Chain of Lakes,
- Managing groundwater pumping for sustainability (described in **Section 5.1.4**),
- Maintaining sustainable long-term groundwater storage volumes, even when total outflows exceed the natural sustainable supply (see **Section 9.3.3**),
- Promoting increased and sound recycled water use (see **Section 15.2.2.1**), and
- Identifying and planning for future supply needs and demand impacts, which is often analyzed using Zone 7's numerical groundwater model of the Basin (**Section 8.2.2**).

Zone 7 also prepares plans and conducts programs that are more directed toward protection and improvement of groundwater quality, including wastewater monitoring and plans that support water recycling.

- Zone 7 administers the Well Ordinance Program, which requires permitting for the construction, repair, reconstruction, destruction, or abandonment of wells. Inspections are also completed as a part of the program.

- Zone 7 administers the Toxic Sites Surveillance (TSS) Program, which documents and tracks polluted sites across the Basin that pose a potential threat to drinking water and interfaces with lead agencies to ensure the Basin is protected. Information is gathered from state, county, and local agencies, as well as from Zone 7's well permitting program and the California State Water Resources Control Board's (SWRCB) GeoTracker website and compiled in a GIS database.

- The 2004 Salt Management Plan (SMP) is a substantial 450-page document reflecting a cooperative effort to address the increase in total dissolved solids (TDS) observed in some portions of the Basin. Implementation has included modifications to existing conjunctive use programs, plus development of the Zone 7 Mocho Groundwater Demineralization Plant (MGDP), which began operating in 2009 to strip salts from the produced groundwater and discharge them to the wastewater export pipeline that discharges treated wastewater to the San Francisco Bay.

- The 2015 Nutrient Management Plan (NMP, *Zone 7 2015c*) was conceived as an addendum to the SMP. Together, the NMP and SMP fulfill requirements of a joint Master Water Recycling Permit and the General Water Reuse Order adopted by the Regional Water Board and are consistent with the provisions of the State's Recycled Water Policy. Implementation of the NMP involves ongoing monitoring of nitrate in groundwater and coordination with land use agencies for Best Management Practices (BMP) requirements to manage nitrogen loading to the Basin, plus coordination with Alameda County Environmental Health (ACEH) for development of a Local Agency Management Program (LAMP) for onsite wastewater treatment systems (OWTS) that addresses certain high nitrate areas-of-concern (see next section).

As a water supply wholesaler, Zone 7 maintains close relationships with other groundwater users in the Basin and coordinates their actions with the groundwater monitoring and management activities of others. **Table 5-F** provides a summary of key cooperative programs; in addition, recent achievements of two programs are described in greater detail below.

Table 5-F: Summary of Cooperative Water Resource Management Programs

Water Resources Management Program	Other Local Agency	Zone 7 Cooperative Role
OWTS	ACEH	Reviews permit applications; Zone 7 approval is required in some cases
Toxic Sites Surveillance (TSS) Program	Regional Water Quality Control Board - San Francisco Bay Region (RWQCB) and ACEH	Tracks progress of site investigation/cleanup and provides input to lead agencies
Surface Mining Permits	Alameda County Community Development Agency (ACCDA)	Reviews permit changes and provides input as a future owner
CASGEM	DWR	Monitors and reports groundwater elevations in Tracy Subbasin, San Joaquin Valley Basin
Water Quality/Groundwater Elevation Monitoring	Retailers (City of Pleasanton, City of Livermore, DSRSD, Cal Water Service), Lawrence Livermore National Laboratory (LLNL)	Data sharing of water quality and elevation data
Referral Process (Development Reviews/CEQA Reviews)	Cities of Pleasanton, Livermore, and Dublin, and Alameda Co.	Review proposed site plans and comment on existing infrastructure as well as potential impacts

Water Resources Management Program	Other Local Agency	Zone 7 Cooperative Role
South Bay Contractors	Alameda County Water District (ACWD) and Santa Clara Valley Water District (SCVWD)	Work with other water agencies on allocating water supply available for recharge
Integrated Regional Water Management	San Francisco Bay Area water agencies	Local representative
Liaison Committee	Cities, Retailers, DSRSD, Elected Officials	Local representative to provide input and information
Tri-Valley Potable Reuse Feasibility Study	Retailers	Evaluating feasibility of potable reuse for the Valley
Living Arroyos	Dublin, Livermore, Pleasanton	Partner to improving the urban streams and streamside habitats
Adopt a Creek Spot Program	Livermore, Alameda County, Livermore Valley Joint Unified School District, Friends of the Arroyos, and Living Arroyos	Work with several "adoptees" of creek spots in the area, and help facilitate the annual Tri-Valley Creeks to Bay event in September
Alameda Creek Fisheries Restoration Workgroup	17 Workgroup Members	Chair of the workgroup, funding partner, develop agendas, facilitate meetings, help guide the studies done on behalf of the workgroup, and seek ongoing collaboration from all stakeholders
Alameda Creek Watershed Forum	Various agencies and organizations with stewardship interests	Serves on the planning committee
Arroyo de la Laguna Agency Collaborative	Alameda and Contra Costa County Flood Control Districts, San Francisco Public Utilities Commission, Dublin, Livermore, Pleasanton, and San Ramon	Serves as unofficial facilitator of the Collaborative, and hosts quarterly meetings/calls

OWTS Program

ACEH and Zone 7 cooperate on the approval and permitting process for OWTS. ACEH issues permits for the operation, installation, alteration, and repair of OWTS throughout Alameda County. However, for certain OWTS projects in Upper Alameda Creek Watershed, Zone 7 review and approval is required. Zone 7 approval is required for the following types of OWTS projects:

- New septic systems constructed partially or fully for a commercial or industrial use;
- Conversion or expansion of existing septic systems to a commercial or industrial use; or
- New residential septic systems that discharge greater than one rural-residential-equivalence (RRE) of wastewater per five acres (and one RRE per 10 acres inside the NMP nitrate areas-of-concern, **Section 15.2.3.6**).

In 1982, the Zone 7 Board of Directors adopted the "Wastewater Management Plan for the Unsewered, Unincorporated Area of Alameda Creek Watershed above Niles (WWMP; *Zone 7, 1982*)" and its recommended policies (*Resolution No. 1037*). A separate policy was established in 1985 that prohibits the use of septic tanks for new developments zoned for commercial or industrial uses (*Resolution No. 1165*). This prohibition can be waived by the Zone 7 Board if "…it can be satisfactorily demonstrated to the Board that the wastewater loading will be no more than the loading from an equivalent rural residential unit (on a five-acre lot) and said septic tank(s) will be in compliance with all other conditions and provisions." Zone 7's wastewater policies were incorporated in the ACEH Local Area Management Plan (LAMP, *ACEH, 2018*, available at https://deh.acgov.org/landwater-assets/docs/OWTS-LAMP.PDF).

Tri-Valley Potable Reuse Feasibility Study

This recently initiated study is a joint effort by the Tri-Valley Water Agencies, including Zone 7 and the four Retailers (Cal Water, DSRSD, Livermore and Pleasanton). Zone 7's February 2016 Water Supply Evaluation Update underscored the need to pursue water supply options to enhance long-term water supply reliability for the Valley. Potential future water supply options identified in the Update included the California WaterFix (a.k.a., Delta Conveyance), desalination, and potable reuse. In February 2016, participants in the Tri-Valley Water Policy Roundtable—which included elected representatives from Dublin, Livermore, Pleasanton, San Ramon, DSRSD, and Zone 7—agreed to proceed with a detailed study of potable reuse.

The primary goals of the study were to evaluate the feasibility of potable reuse for the Valley; to identify the most promising options based on technical, financial, and regulatory considerations; and, assuming that potable reuse is found to be feasible, to recommend next steps for the agencies. The options evaluated included groundwater recharge/injection, surface water augmentation, and connection upstream of the Zone 7 water treatment plants. Based on the book-end approach of considering alternatives, the major findings of this study (*Carollo, 2018*)[10] were:

- Potable reuse for the Tri Valley is technically feasible. There were no fatal flaws identified by the technical evaluation;
- All alternatives increase water supply reliability, with the degree of benefit varying depending on yield and, to a limited extent, end use (e.g., via groundwater recharge versus raw water augmentation);

[10]Available online at: https://www.zone7water.com/sites/main/files/file-attachments/potable_reuse_feasibility_study_may-2018.pdf?1619986611)

- All alternatives improve drinking water quality and some improve the overall Basin quality;
- There are good options available to site the Advanced Water Purification Facility; and
- Regulatory pathways exist for all options.

5.2.2. Operational Flexibility Limitations

☑ **23 CCR § 354.8(d)**

The above water resource monitoring and management programs are not expected to limit operational flexibility in the Basin and in fact are complementary management processes that have collectively resulted in Zone 7's on-going sustainable management of the Basin.

5.2.3. Conjunctive Use in Zone 7

☑ **23 CCR § 354.8(e)**

Since the 1960s, Zone 7 has actively embraced a "conjunctive use" approach to basin management by integrating local and imported surface water supplies with the local conveyance, storage, and groundwater recharge features. These features include "losing stream" local arroyos (which are also used as flood protection facilities during wet seasons) and two former quarry pits (Lake I and Cope Lake). A key component of Zone 7's conjunctive use program has been its artificial recharge program, which consists of releases of surface water to dry arroyos to recharge the Basin. The volume of artificial recharge is dependent on Zone 7's annual State Water Project (SWP) allocations, precipitation captured locally, and water supply operations plans. Typically, Zone 7 will commence artificial recharge operations during times of surplus imported water availability.

The location and timing of artificial recharge operations can be used as a water quality management tool as well as a temporal water storage activity. When practical to do so, Zone 7 prioritizes its SWP releases for recharge to occur in the spring and summer when TDS of the source water is low. Because each acre-foot that is subsequently pumped from the Basin (and not reapplied as irrigation) removes water with higher TDS, this can eventually improve the salinity of the Basin, helping achieve salt management objectives. The salt removal effectiveness of the conjunctive use is related to the difference in the TDS of recharge and pumped water and the annual volumes involved (see **Section 8.4**).

While groundwater pumping by the retailers is allocated to part of the "natural" sustainable yield (see above and **Section 9).** Zone 7's groundwater pumping and artificial recharge volumes are accounted for in the "conjunctive use" budget. Zone 7's annual groundwater production and artificial recharge operations vary with the availability of surface water, treatment plant capacity, and the available groundwater storage space.

Table 5-G below shows the artificial recharge and Zone 7's groundwater pumping totals for the 2020 WY. Since 1974, Zone 7 has artificially recharged 66,982 AF more than it has pumped (**Section 9.3.6.3**) These

totals do not include the water Zone 7 pumps for DSRSD (usually 645 acre-feet per year (AFY)), which is considered part of the "natural" demand.

Table 5-G: Conjunctive Use Supply and Demand, 2020 WY

Component	Estimated Sustainable Avg (AFY)	2020 WY (AF)	Percentage of Sustainable Average
Artificial Recharge	5,300	2,461	46%
Zone 7 Pumping	5,300	11,101	209%
Net Artificial Recharge	**0**	**-8,640**	**-163%***

AF = acre-feet
Avg = average
AFY = acre-feet per year
* = percent of Sustainable Artificial Recharge

5.3. Land Use Elements or Topic Categories of Applicable General Plans

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(f) A plain language description of the land use elements or topic categories of applicable general plans that includes the following:

(1) A summary of general plans and other land use plans governing the basin.

(2) A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects.

(3) A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.

(4) A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.

(5) To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.

☑ **23 CCR § 354.8(f)**

General plans affecting the Basin have been developed by Alameda and Contra Costa Counties and the cities of Dublin, Livermore, Pleasanton, and San Ramon. These general plans are described in further detail below.

5.3.1. Alameda County General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

The Alameda County General Plan consists of several documents. These include countywide elements that apply to the entire unincorporated area; of these relevant elements include the Community Climate Action Plan (2000), Conservation Element (1994), and Open Space Element (1994). In addition, the General Plan includes three area plans; of these, the East County plan is relevant. The County also developed a South Livermore Specific Plan in 1993 primarily to promote and maintain the South Livermore Valley as a wine region.

The policies and programs of the East County Area Plan, approved by voter initiative in 2000, reflect close collaboration with Zone 7 Water Agency in regional water planning, sustainable land use planning, water recycling, and water conservation. Key policies are listed below.

- Policy 251: The County shall work with the Alameda County Flood Control and Conservation District (Zone 7), local water retailers, and cities to develop a comprehensive water plan to assure effective management and long-term allocation of water resources, to develop a contingency plan for potential short-term water shortages, and to develop uniform water conservation programs. The water plan should include a groundwater pump monitoring and cost allocation system in order to facilitate groundwater management and to recover the cost of purchased water stored in the Basin. In developing this plan, EBRPD shall be consulted regarding potential direct or indirect effects of water use on EBRPD recreation facilities.
- Policy 252: The County shall encourage Zone 7 to pursue new water supply sources and storage facilities only to the extent necessary to serve the rates and levels of growth established by the Initiative and by the general plans of the cities within its service area.
- Policy 253: The County shall approve new development only upon verification that an adequate, long-term, sustainable, clearly identified water supply will be provided to serve the development, including in times of drought.
- Policy 254: The County shall encourage Zone 7 and local water retailers to require new development to pay the full cost of securing, conveying, and storing new sources of water.
- Policy 255: The County shall encourage Zone 7 to maximize use of the Chain of Lakes for water supply development and groundwater management. Zone 7 is encouraged to stage implementation of the system so that each component may be utilized as it becomes available.
- Policy 256: The County shall discourage water service retailers from constructing new water distribution infrastructure which exceeds future water needs based on a level of development consistent with the Initiative.
- Policy 257: The County shall support more efficient use of water through such means as conservation and recycling and shall encourage the development of water recycling facilities to help meet the growing needs of East County.

- Policy 258: The County shall encourage Zone 7, water retailers, and cities to sign the California Urban Water Conservation Council's (CUWCC) MOU which binds parties to implement Best Management Practices where feasible.
- Policy 259: The County shall include water conservation measures as conditions of approval for subdivisions and other new development.
- Policy 260: The County shall require major projects to mitigate projected water consumption by applying one or more Best Management Practices that reduce water consumption off-site.
- Policy 261: The County shall encourage the efficient use of water for landscape irrigation, vineyards, and other cultivated agriculture. To this end, the County shall encourage the use of recycled water for agricultural irrigation, treated by the reverse osmosis or other process, and meeting groundwater basin standards set forth by the Regional Water Quality Control Board.
- Policy 262: The County shall encourage Zone 7 and the water retailers to require separate service connections and meters where large quantities of water are used for special purposes such as golf courses and landscape irrigation so that consumption of water for these uses can be managed in times of drought. To this end, the County shall, if feasible, require the use of recycled water for golf courses and shall encourage use of recycled water for non-residential landscaping, irrigated agriculture, and groundwater recharge in accordance with Regional Water Quality Control Board adopted standards.
- Policy 263: The County shall continue to seek alternative methods for economic reuse of wastewater in addition to those already considered.

Implementation programs of the East County Plan include adoption by the County Board of Supervisors of the CUWCC's MOU to implement Best Management Practices; collaborative efforts by the County with appropriate agencies (e.g., County Agricultural Commission, Soil Conservation Service, and the University of California Experimental Station) to provide farmers with information about water conserving agricultural practices; and preparation and adoption of a water supply ordinance that provides for the distribution of recycled water in designated areas, including South Livermore Valley.

The County's Community Climate Action Plan, approved 2014, contains water conservation measures, including measures to require new landscaping projects to reduce outdoor use of potable water, to allow grey water use for subsurface irrigation, and to work with EBMUD and Zone 7 to redesign water bills to encourage water conservation.

5.3.2. Contra Costa County General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

Contra Costa County's current General Plan was adopted in 1991 and has been reconsolidated twice, once for 1990-2005 and again for 2005-2020. The plan is currently being updated to cover through the year

2040. The updated General Plan will respond to current concerns about sustainability, environmental justice, and affordable housing.

The current General Plan includes a Conservation Element which addresses water resources. The adopted General Water Resources Policies are:

- 8-74. Preserve watersheds and groundwater recharge areas by avoiding the placement of potential pollution sources in areas with high percolation rates.
- 8-75. Preserve and enhance the quality of surface and groundwater resources.
- 8-76. Ensure that land uses in rural areas be consistent with the availability of groundwater resources.
- 8-77. Provide development standards in recharge areas to maintain and protect the quality of groundwater supplies.

5.3.3. City of Dublin General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

The City of Dublin (Dublin) does not control the supply or the delivery of water to customers, control cost and pricing mechanisms related to water supply, or manage regional flood control facilities. However, the City of Dublin General Plan recognizes that Dublin works in collaboration with other agencies, notably Zone 7 and DSRSD, which provide these services, and therefore includes a Water Resources Element that reflects this reality. The scope of Dublin's influence extends mainly to promoting and encouraging water conservation among business and residential users, implementing Low Impact Development measures to help treat stormwater, and managing the stormwater runoff and pipelines that lead to flood control facilities. With regard to land use and growth, Dublin historically expanded to the west and east; currently, Dublin has established its Western Extended Planning Area (generally outside the Basin), consisting of steep terrain and oak woodlands, as open space. On the east, Dublin has established Urban Limit Lines along its eastern boundary to protect approximately 3,828 acres of land known as the Doolan-Collier Canyons from development. Dublin also has a Development Elevation Cap, defined as the 770-foot elevation that represents the highest serviceable elevation for water service and urban development. This cap represents a limit on urban development potential.

5.3.4. City of Livermore General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

The City of Livermore General Plan, first adopted in 2004 and subsequently amended, addresses water resource issues in its Infrastructure and Public Services element. Potable water and raw water for agricultural irrigation is provided to the City of Livermore (Livermore) from a variety of sources. Zone 7 is the water wholesaler, while Cal Water and Livermore Municipal Water provide retail service, and the San Francisco Hetch Hetchy water supply system provides water directly to Lawrence Livermore National Laboratory and Sandia National Laboratory. The City of Livermore General Plan presents an overall goal to provide sufficient water supplies and facilities to serve Livermore in the most efficient and financially sound manner, while maintaining the highest standards required to enhance the quality of life for existing and future residents. Objectives are to:

- Plan, manage and develop the public water treatment, storage, and distribution systems in a logical, timely and appropriate manner,
- Require coordination between land use planning and water facilities and service to ensure that adequate water supplies are available for proposed development, and
- Identify potential water conservation and recycling opportunities that could be served by Livermore's existing recycled water system.

With regard to land use, Livermore is completely surrounded by an Urban Growth Boundary. This boundary is intended to protect existing agricultural uses and natural resources outside Livermore from future urban development. Livermore has had an evolving residential growth policy in place since 1976.

5.3.5. City of Pleasanton General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

The City of Pleasanton (Pleasanton) General Plan, adopted in 2009, contains two overarching goals: to preserve Pleasanton's character and encourage sustainable development. This builds on the 1996 General Plan, which envisioned managed growth of Pleasanton consistent with a 29,000 unit residential cap and an Urban Growth Boundary. Consequently, residential and commercial development has been focused on infill sites. The 2009 General Plan includes a water element, which provides a regional overview of the watershed, water systems, wastewater systems, flood control, and stormwater management. Pleasanton receives water from Zone 7 and from its own wells. General Plan goals are to:

- Preserve and protect water resources and supply for long-term sustainability;
- Provide healthy water courses, riparian functions, and wetlands for humans, wildlife, and plants;
- Ensure a high level of water quality and quantity at a reasonable cost, and improve water quality through production and conservation practices which do not negatively impact the environment;
- Provide sufficient water supply and promote water safety and security;

- Provide adequate sewage treatment and minimize wastewater export;
- Minimize stormwater runoff and provide adequate stormwater facilities to protect property from flooding; and
- Reduce stormwater runoff and maximize infiltration of rainwater to improve surface and subsurface water quality.

5.3.6. City of San Ramon General Plan

☑ **23 CCR § 354.8(f)(1)**
☑ **23 CCR § 354.8(f)(2)**
☑ **23 CCR § 354.8(f)(3)**

The City of San Ramon (San Ramon) includes a northwestern portion of the Basin, but water supply is provided by EBMUD from non-groundwater sources. The San Ramon General Plan, adopted in 2015, includes a Growth Management Element that establishes San Ramon's first Urban Growth Boundary and encourages smart growth by promoting infill development and discouraging urban sprawl. Low Impact Development is promoted by San Ramon for its infill development; otherwise, San Ramon's General Plan has very little influence on the Basin.

5.3.7. Well Permitting Process

☑ **23 CCR § 354.8(f)(4)**

The construction, repair, reconstruction, destruction, or abandonment of wells within Zone 7's service area is currently regulated by Alameda County General Ordinance Code, Chapter 6.88. Pursuant to an MOU with Alameda County, Zone 7 administers the associated well permit program within its service area including within the three incorporated cities: Dublin, Livermore, and Pleasanton. As a result, any planned new well construction, soil-boring construction, or well destruction must be permitted by Zone 7 before the work is started. Additionally, all unused or abandoned wells must be properly destroyed; or, if there are plans to use the well in the future, a signed statement of future intent must be filed at Zone 7. This program allows Zone 7 to protect the Basin from any negative impacts that would be threatened by poorly constructed wells.

A copy of the current Zone 7 drilling permit application is available to the public for download from the Zone 7 website[11]. Well construction and destruction permit requirements are determined on a case-by-case basis, but generally follow DWR's *California Well Standards* (Bulletins 74-81 and 74-90, *DWR 1990*).

In April 2015, Alameda County amended its Water Wells Ordinance to: (1) be more compliant with the State standards; (2) clarify the County's role and procedure for well permitting; (3) provide for additional protection of groundwater quality by incorporating local hydrogeologic considerations into the

[11] http://www.zone7water.com/business/permits-fees/36-public/content/64-well-drilling-and-destruction-permits

regulations; and (4) establish a means for the County to delegate administrative authority to regulate well construction work to others in certain service areas. In June 2015, Alameda County and Zone 7 entered into a MOU that delegates the administrative authority for issuing of water well permits to Zone 7 for all wells within Zone 7's service area. An Appeals Process for permit complaints for approval and adoption by the Zone 7 Board was started in the 2016 WY. The implementation of the County fee program for permits also started in the 2016 WY. This fee program offsets a portion of the cost for program administration and field inspections by Zone 7 personnel.

As provided in the Water Wells Ordinance, Special Requirement Areas have been defined within Zone 7's jurisdiction where:

- Soil boring permits are required for boreholes at 10 feet or greater depth, regardless of groundwater depth,
- Supply wells are prohibited, and
- Special well construction techniques are required for boreholes and monitoring wells to prevent vertical spreading of contamination.

Currently, there are five Special Requirement Areas that are clearly identified on the Zone 7 website[12]; these are contamination sites where additional protection measures are required.

Well permitting in the Contra Costa County portion of the Basin is regulated by the *Contra Costa County Ordinance Code, Title 4, Article 414-4.8* and administered by the Environmental Health Division (EHD) of Contra Costa Health Services. EHD's Land Use Program reviews plans for well designs, issues construction permits and conducts inspections during the drilling to make sure wells will be installed or destroyed in a way that doesn't contaminate the county's groundwater. A permit from the EHD is required to construct, reconstruct, or destroy a well, including water wells, monitoring wells, cathodic protection wells and soil borings.

5.3.8. Implementation of Land Use Plans Outside the Basin

☑ **23 CCR § 354.8(f)(5)**

This Alternative GSP assumes that no land use plans being implemented outside of the Basin will impact the implementation of this Alternative GSP or prevent the Basin from continuing to achieve its Sustainability Goal.

[12] https://www.zone7water.com/post/well-drilling-and-soil-boring-permits

5.4. Additional GSP Elements

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:
(g) A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.

☑ **23 CCR § 354.8(g)**

This Alternative GSP addresses the following additional Plan elements included in Water Code Section 10727.4 as follows.

5.4.1. Control of Saline Water Intrusion

Because the Basin is located far from coastal areas, seawater intrusion is not considered to be an issue; therefore, no control measures for saline water intrusion have been established (**Sections 8.5** and **13.3**).

5.4.2. Wellhead Protection

Zone 7 currently operates an ongoing robust Water Quality Monitoring Program (**Section 8.6**) that includes an evaluation of emerging contaminants such as PFAS compounds which could become threats to Basin water quality and viability of drinking water supply. Zone 7 also has several management programs that are designed to maintain and/or improve the basin water quality including the Salt and Nutrient Management Programs (**Section 15.2.3**).

5.4.3. Migration of Contaminated Groundwater

Zone 7 administers the TSS Program, which documents and tracks polluted sites across the Basin that pose a potential threat to drinking water and interfaces with lead agencies to ensure the Basin is protected. Information is gathered from state, county, and local agencies, as well as from Zone 7's well permitting program and the SWRCB's GeoTracker website, and compiled in a GIS database (**Section 8.6.7**).

5.4.4. Well Abandonment and Well Destruction Program

In April 2015, Alameda County amended its Water Wells Ordinance to: (1) be more compliant with the State standards; (2) clarify the County's role and procedure for well permitting; (3) provide for additional protection of groundwater quality by incorporating local hydrogeologic considerations into the regulations; and (4) establish a means for the County to delegate administrative authority to regulate well construction work to others in certain service areas. In June 2015, Alameda County and Zone 7 entered into a MOU that delegates the administrative authority for issuing of water well permits to Zone 7 for all wells within Zone 7's service area (**Section 15.2.3.1**).

Well permitting in the Contra Costa County portion of the Basin is regulated by the *Contra Costa County Ordinance Code, Title 4, Article 414-4.8* and administered by the Environmental Health Division (EHD) of Contra Costa Health Services. EHD's Land Use Program reviews plans for well designs, issues construction permits and conducts inspections during the drilling to make sure wells will be installed or destroyed in a way that doesn't contaminate the county's groundwater. A permit from the EDH is required to construct, reconstruct or destroy a well, including water wells, monitoring wells, cathodic protection wells and soil borings.

5.4.5. Replenishment of Groundwater Extractions

Zone 7 has long implemented conjunctive use projects and managed groundwater extractions in the Basin that have contributed to the recovery and stabilization of groundwater levels (see **Sections 5, 9** and **15**).

5.4.6. Conjunctive Use and Underground Storage

Zone 7 has long implemented conjunctive use projects within the Basin that have contributed to the recovery and stabilization of groundwater levels (see **Sections 5, 9** and **15**).

5.4.7. Well Construction Policies

Well construction policies are detailed above in **Section 5.4.4**, above.

5.4.8. Groundwater Contamination Cleanup, Recharge, Diversions to Storage, Conservation, Water Recycling, Conveyance, and Extraction Projects

Significant details regarding matters related to contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects are provided in **Sections 8, 9** and **15**.

5.4.9. Efficient Water Management Practices

Zone 7's efficient water management practices are detailed in **Sections 9 and 15**.

5.4.10. Relationships with State and Federal regulatory agencies

As described herein, Zone 7 maintains productive working relationships with multiple State and Federal agencies, including DWR, the RWQCB, the SWRCB, etc. (**Table 5-F**).

5.4.11. Land Use Plans and Efforts to Coordinate with Land Use Planning Agencies to Assess Activities that Potentially Create Risks to Groundwater Quality or Quantity

Land use planning and water resource management are regularly and closely coordinated across the Basin. This ensures that implementation of land use plans, which can change water demands or affect sustainable groundwater management, is occurring in a context of open collaboration among land use planners and water agencies. Moreover, development of various water management plans, including this update to the Alternative GSP, also has occurred through open collaboration. Such dynamic and interactive planning has been fundamental to sustainable groundwater management in the Basin.

5.4.12. Impacts on Groundwater Dependent Ecosystems (GDEs)

Several likely GDE areas have been identified in the Basin. Avoidance of impacts is addressed in **Section 13** and **Appendix F**.

5.5. Notice and Communication

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

(1) An explanation of the Agency's decision-making process.

(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

Zone 7 developed its Stakeholder Communication and Engagement Plan (SCEP) in August 2020 to support fulfillment of public notice and communication requirements. The SCEP is available on the Zone 7's website(https://www.zone7water.com/sites/main/files/file-attachments/agsp_scep_2020-08-17.pdf?1619904615) and is included herein as **Appendix H**.

5.5.1. Beneficial Uses and Users of Groundwater

☑ **23 CCR § 354.10(a)**

As part of the SCEP, beneficial uses and users of groundwater in the Basin were identified (see SCEP Section 3). Additionally, a Stakeholder Constituency "Lay of the Land" exercise was developed which identified Basin stakeholders, key interests and issues, and the level of engagement expected with each stakeholder (see SCEP Table 2). This exercise will be updated during select phases of Alternative GSP development and/or implementation.

The beneficial uses and users of groundwater are also listed in **Table 5-H**.

Table 5-H. Beneficial Uses for Surface Water and Groundwater

WATERBODY	MUN	AGR	IND	PROC	GWR	COMM	COLD	MGR	RARE	SPWN	WARM	WILD	REC-1 & -2
Arroyo del Valle	X				X		X	P	X	X	X	X	X
Shadow Cliffs Reservoir					X	X	X			X	X	X	X
Del Valle Reservoir	X					X	X			X	X	X	X
Arroyo Mocho					X		X	X		X	X	X	X
Tassajara Creek					X		P	X	X	X	X	X	X
Arroyo las Positas					X		X	X	X	X	X	X	X
Alamo Canal					X		P	X		X	X	X	X
South San Ramon Creek											X	X	X
Arroyo de la Laguna					X		X	X		X	X	X	X
Livermore Valley Groundwater Basin	X	X	X	X									

Abbreviations:
MUN – Municipal and domestic water supply
AGR – Agricultural water supply
IND – Industrial service water supply
PROC – Industrial process water supply
GWR – Groundwater recharge
COMM – Commercial and sport fishing
COLD – Cold freshwater habitat
MGR – Fish migration
RARE – Preservation of rare and endangered species
SPWN – Fish Spawning
WARM – Warm freshwater habitat
WILD – Wildlife habitat
REC-1 and REC-2 – Water contact and noncontact water recreation

One of the significant updates of the Alternative GSP focused on improved delineation of GDEs in the Basin, as discussed in **Section 8.8**. To the extent that additional environmental users of groundwater are identified, they will be considered, and appropriate representatives will be engaged during implementation of the Alternative GSP.

5.5.2. Public Meetings Summary

☑ 23 CCR § 354.10(b)

The list below identifies public meetings, workshops, and direct outreach specific to Alternative GSP development. Detailed meeting minutes and materials are available on the Zone 7's website (https://zone7.docsonthecloud.com/WebLink/Welcome.aspx?cr=1).

5.5.2.1. Zone 7 Board Meetings

Zone 7 Board meetings are open to the public and are held on the third Wednesday of every month at 7:00 p.m. at Zone 7's offices, located at 100 North Canyons Parkway in Livermore. Due to the COVID-19 pandemic, and pursuant to the Governor's Executive Order (N-29-20), Board meetings have recently been held online. Video recordings of the meetings are available to the public and can be accessed through the Tri-Valley Community Television website (http://www.tri-valleytv.org/?q=node/59). Board meeting agendas and packets are posted to the Zone 7 website (http://www.zone7water.com/library/board-meetings).

Zone 7 has informed its stakeholders of key updates and decisions regarding the Alternative GSP during public Board meetings. These meetings provide a key venue for public engagement and discussion and will be where comments on the Alternative GSP will be documented and addressed, as appropriate. Presentation materials will be posted on the Zone 7 SGMA website (www.zone7water.com/altgsp). The following Board meetings discuss the Alternative GSP:

- 17 June 2020
- 5 May 2021
- 8 Nov 2021 to Board's Water Resources Committee.
- 15 Dec 2021 final ratification

5.5.2.2. Stakeholder Workshops

Zone 7 has held Stakeholder workshops on the following dates:

- 6 Jan 2021
- 17 Nov 2021
- 18 Nov 2021

5.5.2.3. Direct Outreach

Zone 7 has conducted the following direct outreach efforts as part of development of the Alternative GSP update:

- Zone 7 Open House (12 October 2019);
- Zone 7 sent out E Newsletter about groundwater management efforts supported with a half-million dollar grant (23 June 2020);
- Zone 7 published a dedicated webpage for the Alternative GSP (16 October 2020);
- Zone 7 presented to the RWQCB (21 January 2021) and ACEH (3 February 2021) on the background of the Alternative GSP and the salt and nutrient management tasks that will be included in the Alternative GSP;
- Zone 7 sent out three letters (dated 3 September 2020, 5 April 2021, and 15 September 2021) to Stakeholders notifying them of the progress of the project.

- Zone 7 sent out an email on 3 November 2021 notifying the Stakeholders of the Public Review Draft of the Alternative GSP and upcoming Stakeholder meetings.

The list above will be updated periodically throughout Alternative GSP implementation.

5.5.3. Comments Received Regarding the Alternative GSP

☑ **23 CCR § 354.10(c)**

Table 5-I below summarizes the public comments received on the draft Alternative GSP and Zone 7's responses. Detailed public comments received on the draft Alternative GSP will be listed in **Appendix H** along with Zone 7's responses.

Table 5-I. Public Comments on the Alternative GSP and Zone 7 Responses

Public Comment	Zone 7 Response
Edits to the public draft Alternative GSP text and supporting references were requested by Zone 7 Board Director Gambs and Director Figuers, and Mr. David Lunn.	Zone 7 provided references and made edits to the Alternative GSP text accordingly. See **Appendix H** for details.

5.5.4. Communication

The SCEP outlines the Zone 7's communication goals.

5.5.4.1. Decision Making Process

☑ **23 CCR § 354.10(d)**

The SCEP Section 2.2 outlines the Zone 7's decision-making process. Key Alternative GSP development and implementation decisions are made by the Zone 7's Board of Directors.

5.5.4.2. Public Engagement Opportunities

☑ **23 CCR § 354.10(d)(2)**

The SCEP Section 5 discusses public engagement opportunities and how public input and responses are handled. These opportunities include Zone 7 Board meetings, website communication, stakeholder outreach, the public hearing, and other direct outreach as identified in **Section 5.5.2** above.

5.5.4.3. Stakeholder Involvement

☑ **23 CCR § 354.10(d)(3)**

The SCEP Section 4 discusses how Zone 7 encourages the active involvement of diverse social, cultural, and economic elements of the population within the Basin. Zone 7 has developed objectives that support a basic philosophy of working cooperatively with groundwater stakeholders in the Basin including the public, irrigation and domestic well owners, gravel mining companies, Tri-Valley Retail Group, water purveyors, and planning agencies. These objectives include:

- Develop information, policies, and procedures for the effective long-term management of the Basin;
- Inform the public and relevant governmental agencies of the Zone's water supply potential and management policies and to solicit their input and cooperation; and
- Work cooperatively with the gravel mining industry to implement the Chain of Lakes reclamation plan.

Zone 7 actively involves the public, stakeholders, and local agencies in its planning and programs through meetings, data sharing, and online media. This approach was memorialized by Zone 7 as an explicit operational policy in the 1987 Statement on Groundwater Management. This statement, along with numerous examples of public involvement in the Zone 7 groundwater management program are also provided in the GWMP (see Section 4.3 and Appendix E of the GWMP) (*Zone 7, 2005*).

Consistent with this approach, Zone 7 has established positive ongoing working relationships with numerous other agencies involved in the Basin including, but not limited to DWR, RWQCB, Alameda County, Contra Costa County, California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, National Marine Fisheries Service (NOAA-NMFS), and the U.S. Army Corps of Engineers. Additional information on Zone 7's relationships and cooperation with other agencies in the Basin are also described in the SCEP (**Appendix H**).

For development of the 2004 SMP, Zone 7 assembled a Groundwater Management Advisory Committee including citizens and stakeholders and an independent Technical Advisory Group (including key stakeholders and water retailers). Similarly, the 2015 NMP was developed with support and input from the RWQCB, ACEH, ACCDA, Zone 7 Retailers, and other stakeholders and interested public. Most recently, the Tri-Valley Potable Reuse Feasibility Study was developed through a process involving a series of public Round Table discussions among representatives of Zone 7 and the Retailers, along with extensive outreach to the public, including a survey.

A major land use in the Valley is aggregate mining (see **Figure 5-4**), conducted by various mining companies. Groundwater is used for industrial mining purposes such as gravel washing and dust control (see locations of industrial wells in **Figure 5-5**). Most importantly, Zone 7 has worked closely with the mining companies in developing a quarry reclamation plan that recognized the importance of groundwater recharge and conveyance through the mining area. This resulted in the Chain of Lakes reclamation plan, wherein the mining area reclamation is being implemented to include a series of wet pits that will be owned and operated by Zone 7 for flood control and managed aquifer recharge. Zone 7 and the mining companies collaborate in groundwater and surface water (level and quality) monitoring.

Groundwater is also used for private domestic, golf course irrigation, and agricultural purposes (see **Figure 5-7**). Individual groundwater users have been active participants in Zone 7 GWMP, SMP, and NMP efforts; numerous private well owners participate in Zone 7 groundwater monitoring programs.

5.5.4.4. Public Notification

☑ **23 CCR § 354.10(d)(4)**

The SCEP Section 5 and 6 details the methodology that is being followed to inform the public on Alternative GSP updates, status, and actions. This includes presenting key GSP development decisions and updates in an open and transparent fashion during public Zone 7 Board meetings, holding periodic stakeholder outreach efforts to communicate progress on the Alternative GSP technical components to stakeholders, posting draft and interim deliverables on-line, and receiving input on upcoming decisions and work efforts. Zone 7 publicizes all Board meetings and any stakeholder workshops on its website (https://www.zone7water.com/) and provides email notice to the Zone 7 list of interested parties.

5.5.5. Interagency Coordination

The SCEP Section 3 identifies different agencies that are stakeholders and discusses how Zone 7 maintains close coordination with these agencies within its service area.

Currently, Zone 7 is working actively with other local agencies in its designated role as the exclusive GSA for the Basin. Zone 7, EBMUD, San Ramon, DSRSD and Contra Costa County have a MOU under which Zone 7 will serve as the GSA for the Contra Costa portion of the Basin.

5.5.6. Interbasin Coordination

The Zone 7 service area overlies almost all of the Livermore Valley Groundwater Basin (DWR 2-10), all of the Sunol Valley Groundwater Basin (DWR 2-11), and a small section of the Tracy Subbasin in the adjacent San Joaquin Valley Groundwater Basin (DWR 5-22.15). The Sunol Valley Groundwater Basin and San Ramon Valley Groundwater Basin are designated as very low priority and are therefore not subject to SGMA. No GSA has been formed within these two basins. Consistent with its management responsibilities, duties, and powers, Zone 7 is designated in SGMA as the exclusive GSA within its boundaries and, in electing to be the GSA for the Basin, will continue to exercise its groundwater management authority consistent with the District Act and with SGMA. In the Tracy Subbasin, Zone 7 has executed a MOU with the San Luis & Delta-Mendota Water Authority (SLDMWA) to support SGMA compliance, and a GSP for that subbasin is anticipated in January 2022.

Zone 7 will continue to actively participate in interbasin coordinating with the neighboring basins and subbasins throughout the Alternative GSP development process.

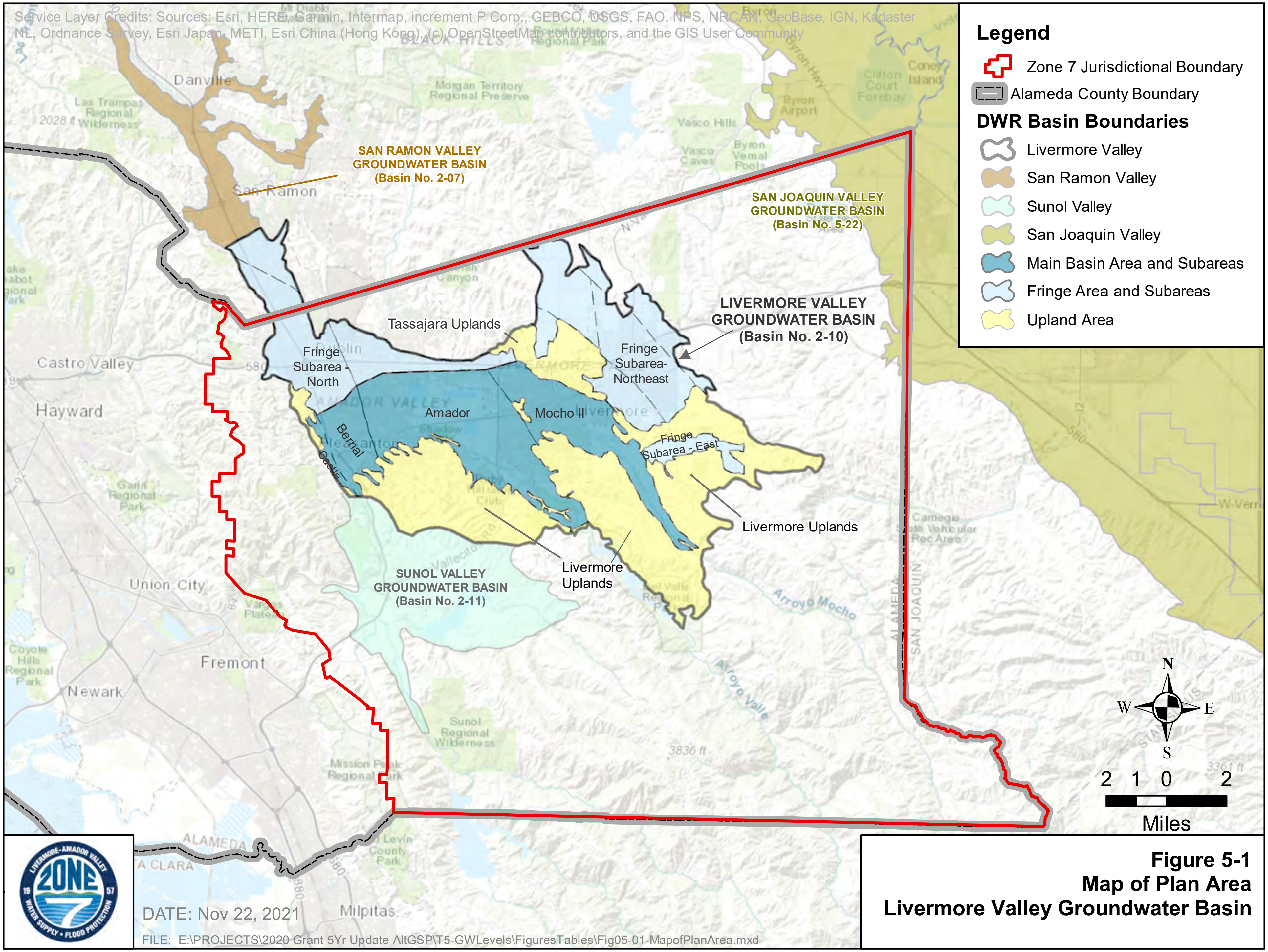


Figure 5-1
Map of Plan Area
Livermore Valley Groundwater Basin

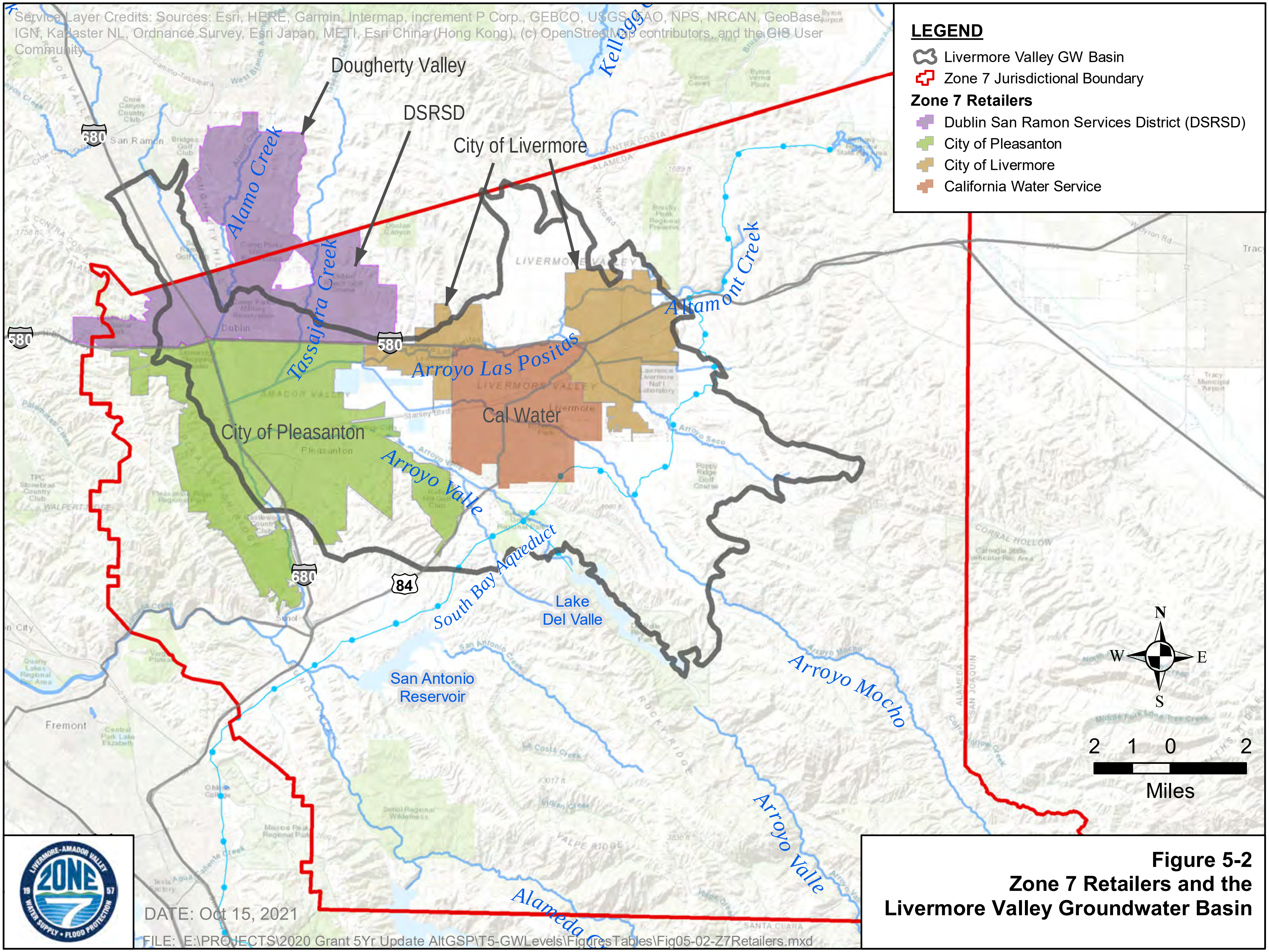


Figure 5-2
Zone 7 Retailers and the Livermore Valley Groundwater Basin

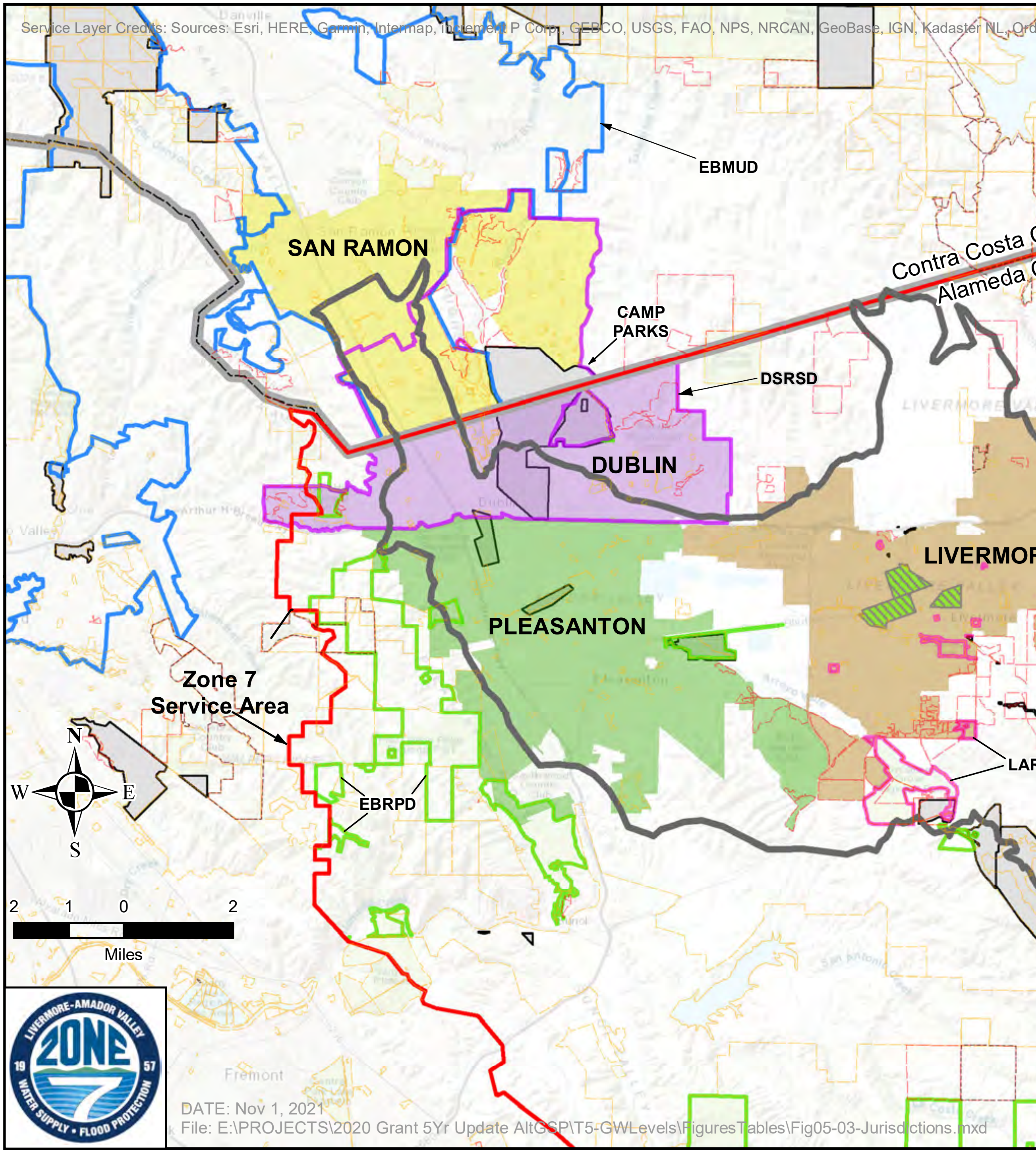


Figure 5-3
Jurisdictional Boundaries
Livermore Valley Groundwater Basin

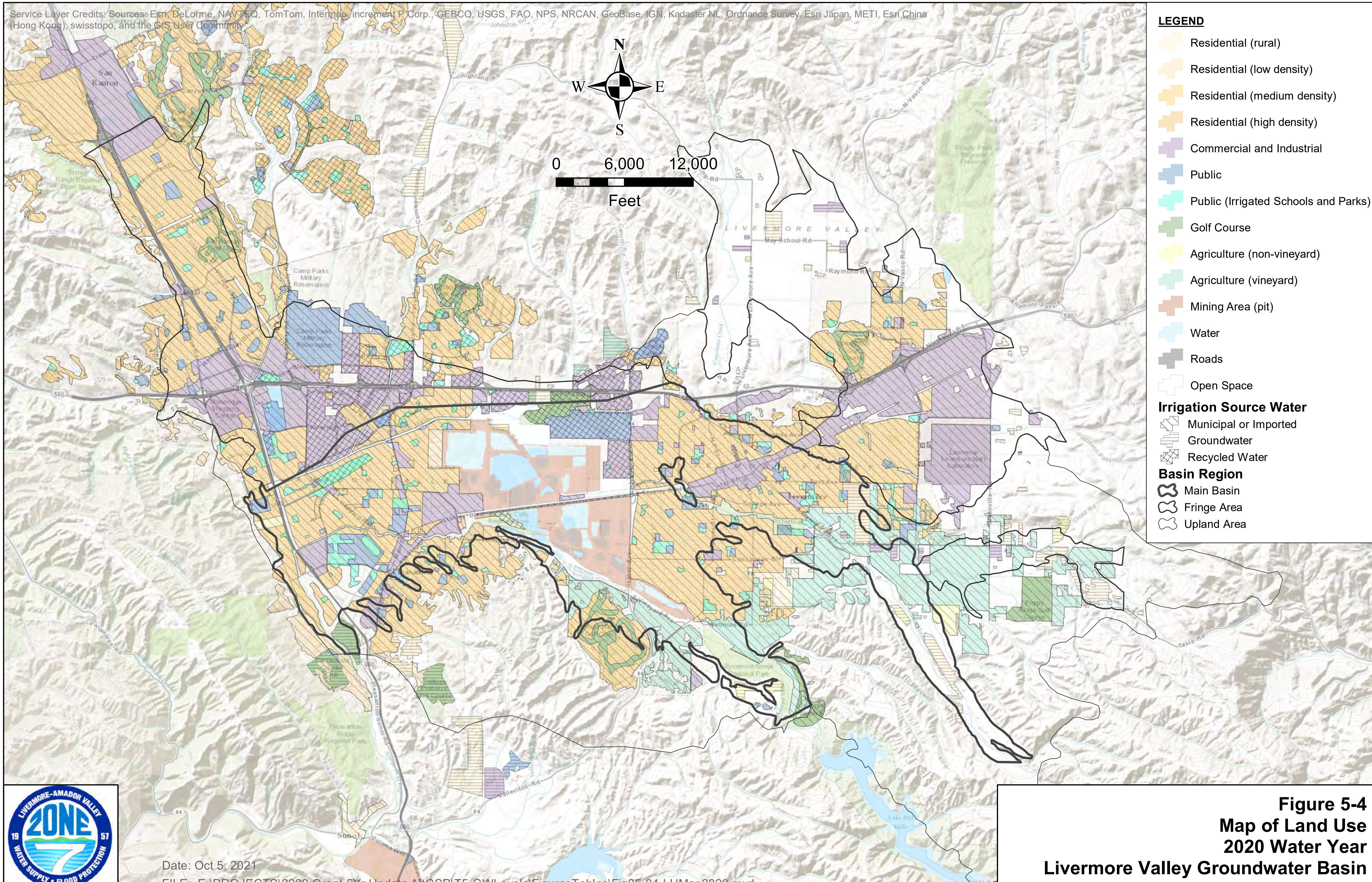


Figure 5-4
Map of Land Use
2020 Water Year
Livermore Valley Groundwater Basin

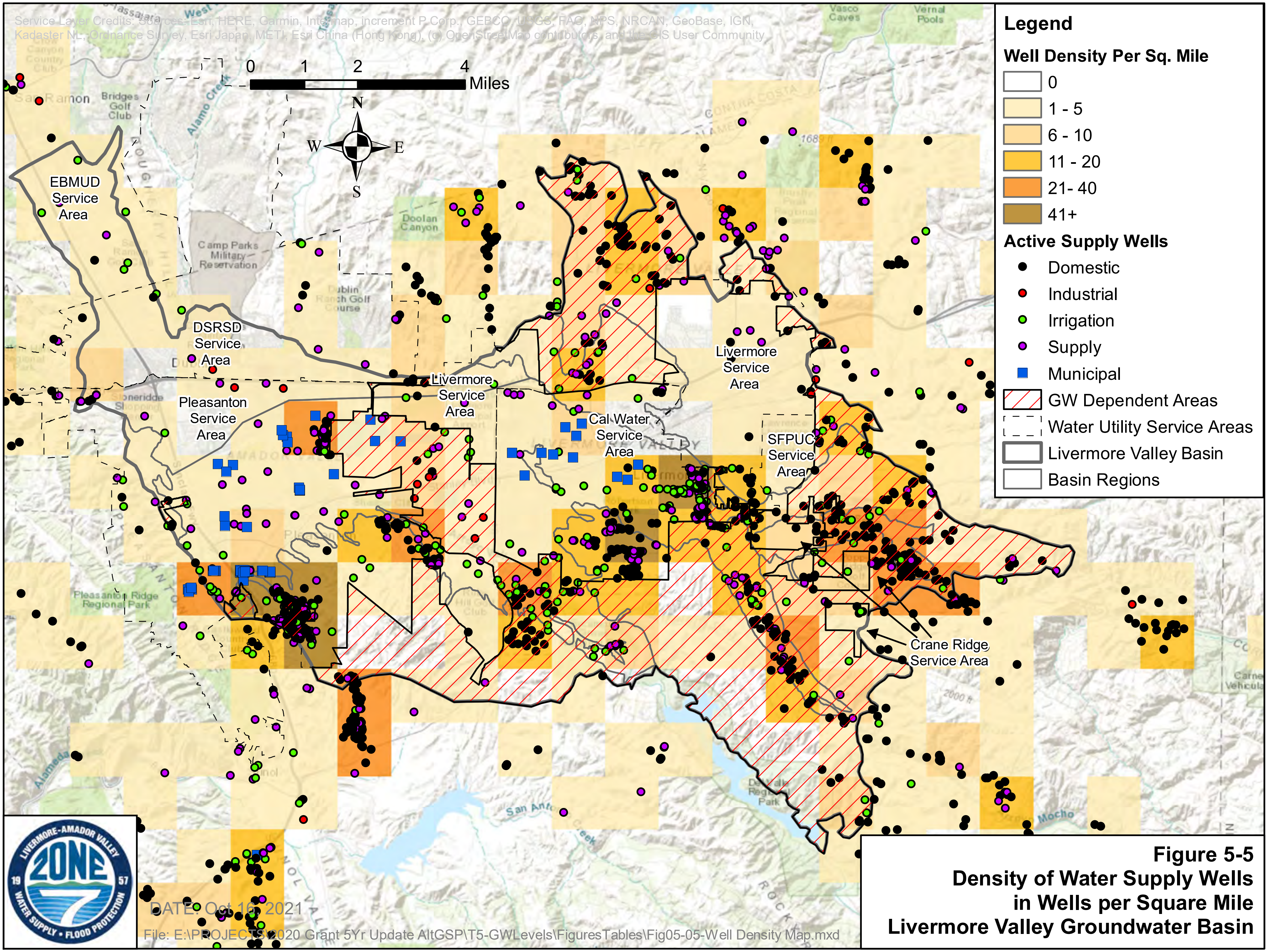


Figure 5-5
Density of Water Supply Wells in Wells per Square Mile
Livermore Valley Groundwater Basin

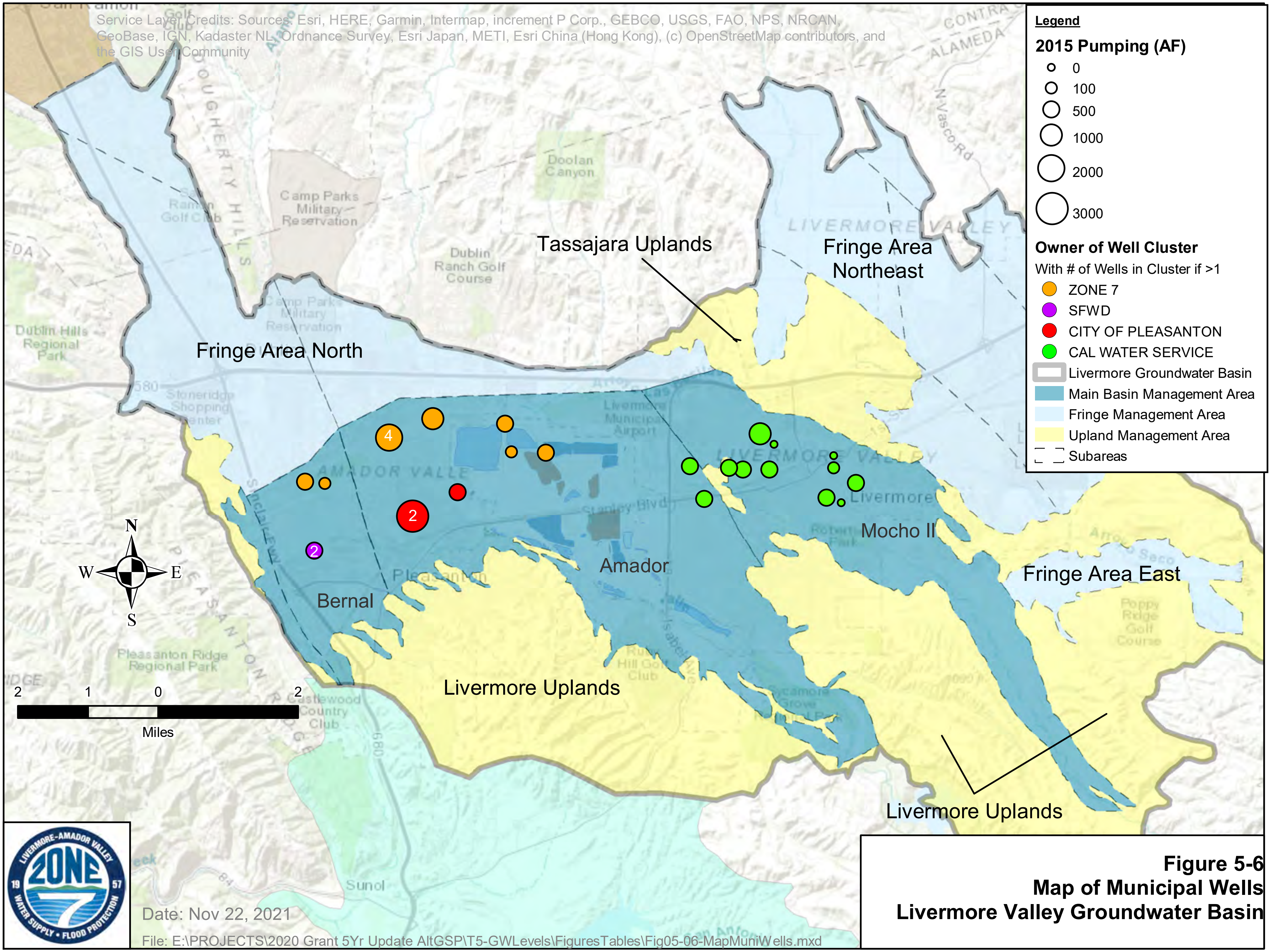
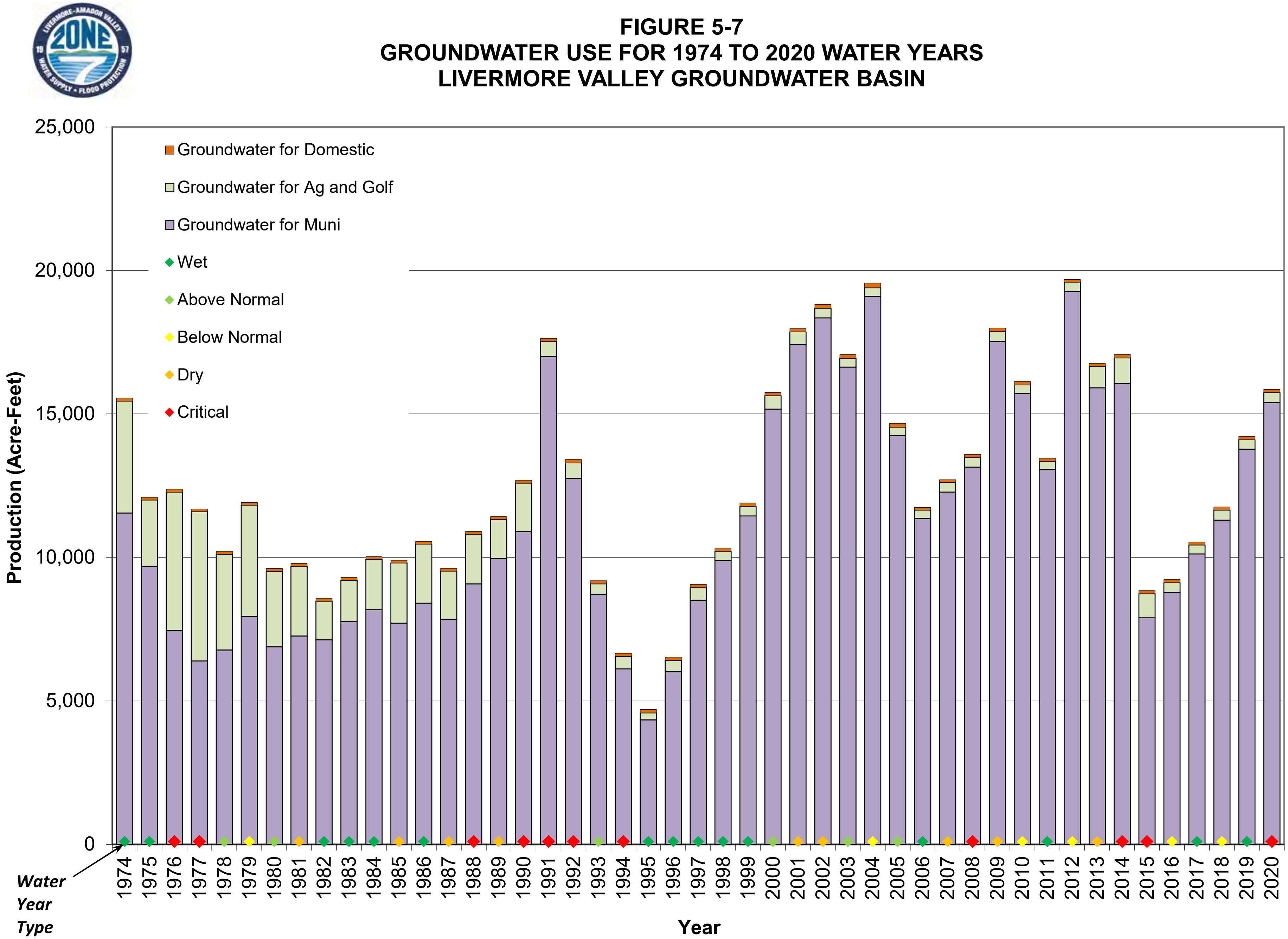


Figure 5-6
Map of Municipal Wells
Livermore Valley Groundwater Basin



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BASIN SETTING

(SUBTITLE PAGE)

6. INTRODUCTION TO BASIN SETTING

§ 354.12. Introduction to Basin Setting
This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

The following four sections describe the the physical setting, characteristics, and current groundwater conditions of the Livermore Valley Groundwater Basin (Basin) (**Figure 7-1)** including the Hydrogeologic Conceptual Model (HCM, **Section 7**), the Current and Historical Groundwater Conditions (**Section 8**), the Water Budget Information (**Section 9**), and a description of Management Areas designated in the Basin (**Section 10**). Existing data gaps and uncertainties within the Basin Setting are discussed in **Section 7.5**. The Basin Setting was prepared under the direction of professional geologist Tom Rooze (PG 6039, CEG 1918) and professional engineer Ken Minn (PE 54394).

7. HYDROGEOLOGIC CONCEPTUAL MODEL

§ 354.14. Hydrogeologic Conceptual Model
(a) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

☑ **23 CCR § 354.14(a)**

This section presents the Hydrogeologic Conceptual Model (HCM) for the Livermore Valley Groundwater Basin (Basin). As described in the HCM Best Management Practices (BMP) document (*DWR, 2016a*), a HCM provides, through descriptive and graphical means, an understanding of the physical characteristics of an area that affect the occurrence and movement of groundwater, including geology, hydrology, land use, aquifers and aquitards, and water quality. This HCM serves as a foundation for subsequent Basin Setting analysis including Groundwater Conditions (**Section 8**), Water Budgets (**Section 9**), and the development of Sustainable Management Criteria (**Sections 11** through **13**).

7.1. General Description

§ 354.14. Hydrogeologic Conceptual Model
(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:
(1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.
(2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.
(3) The definable bottom of the basin.
(4) Principal aquifers and aquitards, including the following information:
(A) Formation names, if defined.
(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.
(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.
(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.
(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.
(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model

7.1.1. Geological and Structural Setting

☑ 23 CCR § 354.14(b)(1)

The Livermore Valley Groundwater Basin (DWR Bulletin 118 Basin No. 2-010) is an east-west trending, structural basin located mostly in northeastern Alameda County that extends slightly into southern Contra Costa County (**Figure 7-1**). As shown on **Figure 7-2,** the Basin is an asymmetrical syncline of Miocene-Pliocene sandstones and conglomerates overlain by recent alluvial deposits. The Basin covers 69,557 acres and extends approximately 14 miles in an east-west direction with a width of between three and six miles. The Basin is generally bounded by the Calaveras Fault on the west, the Greenville Fault on the east, and bedrock deposits of the Plio-Pleistocene Tassajara and Livermore Formations to the north and south, respectively (**Figure 7-3**). For purposes of groundwater management, the Basin has been divided into the Main Basin Management Area (Main Basin, 19,809 acres), the Fringe Management Area (Fringe Area, 21,956 acres), and the Upland Management Area (Upland Area, 27,778 acres) (**Figure 7-4**).

Figure 7-2 presents a schematic geologic/tectonic map that illustrates the tectonic history and formation of the Basin. As indicated on the map, the Basin was formed as the result of deformation between the southward movement of the Mt. Diablo thrust sheets north of the Basin and the Diablo Range uplift south of the Basin. The tectonic history of the Basin began with the uplift of the Diablo Range, which created ancestral streams (including ancestral Arroyo Mocho) that initially flowed north toward San Ramon (and continuing northwest to the Concord area). Up to 12,000 feet (ft) of Pliocene-age sediments (including the Livermore Gravels and equivalent formations) were deposited in this Proto-Livermore Basin. These sediments were down-warped with the subsequent thrusting associated with Mt. Diablo to the north (see Mt. Diablo frontal thrust zone labeled on **Figure 7-2**). This thrust zone closed the Basin on the north and re-directed surface drainage to the southwest. Additional tectonic activity along the Calaveras and Greenville fault zones continues to deform the Basin.

The geologic map on **Figure 7-3** illustrates the older deformed sedimentary and bedrock units defining the Basin along with the valley-fill alluvial sediments; the Basin is outlined in black on the map. The map also shows many of the northwest-southeast trending faults that have offset the older geologic units and, in some cases, overlying shallow alluvial deposits.

As shown on **Figure 7-3**, the Basin is partially filled with Pleistocene-Holocene age alluvium (Qu), consisting of alluvial fan, fluvial, and lake deposits that range in thickness from a few feet along the margins to more than 400 ft in the west-central Basin. The alluvium consists of unconsolidated gravel, sand, silt, and clay. Within the Main Basin, these alluvial deposits consist primarily of sand and gravel that were deposited by the ancestral and present Arroyo Valle and Arroyo Mocho. These deposits are rimmed by slightly older terrace deposits (Qt) along the southern Basin boundary. The eastern and northern Fringe Areas are also filled with recent alluvial deposits, but these sediments were deposited from smaller streams and consist of thin, alternating layers of gravel, sand, silt, and clay that are laterally discontinuous.

Older, more consolidated geologic units underlie recent alluvial deposits throughout the Main Basin and Fringe Area and crop out at the surface in the Upland Area (see **Figure 7-3**). These units consist of the

Pliocene-Miocene Green Valley/Tassajara group [Tgvt] in the northern portion of the Basin and the younger Pliocene-Pleistocene Livermore gravels [QTl] in the southern portion of the Basin, as discussed in more detail below.

The Basin is bounded to the north by upland outcrops of the Tassajara and Green Valley Formations (Tgvt), which are consolidated units of Pliocene and Miocene age. These units consist of sandstone, tuffaceous sandstone/siltstone, conglomerate, shale, and limestone deposited under both brackish and freshwater conditions. The portion of the Tassajara Formation directly north of the Basin consists of tuffaceous-clay-rich sediments of low permeability that weather to mostly clay soils (see **Section 7.7.3**). Although the Tassajara Formation is in contact laterally and underlies the alluvium of the northern Fringe Area, extreme deformation associated with the Mt. Diablo thrust sheets has created numerous bounding faults and a steep geologic dip in the unit that serves to limit subsurface groundwater inflows to the Basin.

The southern portion of the Basin consists primarily of the Livermore Formation (QTl, also referred to as the Livermore Gravels). The formation consists of Pliocene-Pleistocene beds of clayey gravels, sands, silt, and clay that are unconsolidated to semi-consolidated. The formation is estimated to be 4,000 ft thick and dips to the south. The portion of the Livermore Formation within the Upland Area has relatively low permeability with typically low-yielding wells. Within the Main Basin, the upper 200-300 ft of the Livermore Formation is more weathered, has higher permeability, and is considered to be the lower portion of the Lower Aquifer, as further described in **Sections 7.3** and **7.4**.

Additional information regarding Basin boundaries, delineation of Management Areas and subareas, and definition of Principal Aquifer units is provided in **Sections 7.2** through **7.4** below. Additionally, three new cross-sections have been prepared for the Basin as part of the current (2021) Alternative Groundwater Sustainability Plan (Alternative GSP) Update. These cross-sections are presented and described in detail in **Section 7.6.**

7.2. Lateral Basin Boundaries

☑ **23 CCR § 354.14(b)(2)**

7.2.1. Overview

As described above, the Basin includes the recent alluvium and southern uplands of the Livermore Formation (see **Figure 7-3**). The sediments within the upper portions of the Livermore and Tassajara Formations and the overlying recent alluvium combine to form the aquifer system of the Basin, which has been subdivided into an Upper Aquifer and a Lower Aquifer in the Main Basin. The lower Livermore and Tassajara Formations and other upland bedrock units that outcrop around the alluvium have not been found to yield significant quantities of water in wells and thus represent the effective boundaries of the Basin, as described in **Section 7.3**.

As shown on **Figure 7-4** and further described in **Section 10**, the Basin has been divided into the Main Basin, Fringe, and Upland Management Areas based on notable differences in geologic and aquifer characteristics, land use, groundwater use, and management practices. The Main Basin and Fringe Areas have been further subdivided into subareas (previously referred to as subbasins), as shown on **Figure 7-4**. Boundaries of the Management Areas and subareas are described in more detail below and in **Section 10**.

7.2.2. Main Basin Management Area

The Main Basin covers 19,809 acres and contains the thickest alluvial deposits, the highest-yielding aquifers, and the best quality groundwater within the Basin. The Main Basin is defined by the following boundaries:

- on the west by the uplift of the California Coast Ranges (including Pleasanton Ridge) and the Calaveras Fault;
- on the north by relatively shallow bedrock and thin, clay-rich deposits of the lower Tassajara Formation;
- on the east by bedrock outcrops, thin alluvial deposits, and upland areas of the Basin; and
- on the south by outcrops of the lower Livermore Formation (Upland Area).

The Main Basin has a much larger capacity to store and convey groundwater than the surrounding Management Areas. The thick and generally more permeable aquifers have been divided into Upper and Lower Aquifers, discussed in more detail in **Section 7.4**. In particular, the Lower Aquifer is tapped by most of the Basin's production wells. Since the early 1900s, the Lower Aquifer of the Main Basin has been the most significant for local groundwater supply. Accordingly, many of The Alameda County Flood Control and Water Conservation District, Zone 7's (Zone 7 Water Agency or Zone 7) management actions have focused on enhancement and protection of the Main Basin aquifers.

7.2.3. Subareas within the Main Basin

7.2.3.1. Overview

The Main Basin has been subdivided into four subareas that are defined by many of the geologic features shown on **Figure 7-3**. The subarea names and boundaries are summarized below and shown on **Figure 7-4**.

7.2.3.2. Castle Subarea

The Castle Subarea is a thin strip that extends along the southwestern portion of the Main Basin. It is bounded to the south, west, and north by marine sediments of the Coastal Range and to the east by the Calaveras Fault. While usually included in the Main Basin, this subarea is not used for municipal groundwater production. This subarea is treated as a westward extension of the Bernal Subarea.

7.2.3.3. Bernal Subarea

The Bernal Subarea is in the southwestern portion of the Basin and is bounded to the west by branches of the Calaveras Fault, to the east by the inferred extension of the Pleasanton Fault, to the north by the Parks Boundary, and to the south by non-water-bearing formations. All the major streams in the area overlying the basin converge in the Bernal Subarea into the Arroyo de la Laguna, which drains from the Livermore Valley at the southwestern tip of the subarea.

The Recent (Holocene) and Quaternary alluvium in this subarea is estimated to be up to 400 ft thick and overlies the Livermore Formation, of which another 200 ft is suitable for groundwater production. This subarea is both unconfined (in the eastern portion of the Upper Aquifer) and confined (in the western portion of the Upper Aquifer and in the Lower Aquifer). Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges up to 3,500 gallons per minute (gpm), and specific capacities range from 3 to 260 gpm per foot of drawdown.

7.2.3.4. Amador Subarea

The Amador Subarea is in the west central portion of the Basin and is bounded to the west by the inferred extension of the Pleasanton Fault, to the east by the Livermore Fault (also referred to as the "Livermore Thrust"), to the north by the Parks Boundary, and to the south by low-permeability units of the Livermore Formation in the Upland Area.

The Recent (Holocene) and Quaternary alluvium in this subarea has a maximum thickness of approximately 600 ft and overlies the Livermore Formation, of which another 200-300 ft is suitable for groundwater production. This subarea contains most of the high-yielding wells and has both unconfined (Upper Aquifer) and confined (Lower Aquifer) aquifers. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges from 42 to 2,820 gpm and specific capacities range from 1.1 to 217 gpm per foot of drawdown.

7.2.3.5. Mocho Subarea

In the eastern portion of the Basin, the Mocho Subarea has been divided into two distinct areas, Mocho I (Fringe Area) and Mocho II (Main Basin), by a line of very low hills thought to be exposures of the Livermore Formation. The subareas are further distinguished by a change in groundwater chemistry.

The Mocho II Subarea is in the east central portion of the Basin and is bounded to the west by the Livermore Fault, to the east by the Livermore Formation and shallow alluvial deposits, to the north by the consolidated bedrock of the Tassajara Formation, and to the south by the Livermore Upland Area.

The Recent (Holocene) and Quaternary alluvium ranges in thickness from approximately 10 to 50 ft in Mocho I Subarea and up to 150 ft in Mocho II Subarea. In both subareas the alluvium overlies the Livermore Formation, both conformably and unconformably. The Mocho I and Mocho II Subareas appear to be hydraulically connected only in the shallow alluvial deposits. The water-bearing sediments are both unconfined and confined. Wells in these subareas are primarily owned and operated by California Water Company (Cal Water, see **Figure 5-6**). Production ranges up to 950 gpm with specific capacities of 2 to 50 gpm per foot of drawdown.

7.2.4. Fringe Management Area

As shown on **Figure 7-3** and **Figure 7-4**, the Fringe Area is defined by areas outside of the Main Basin that contain thinner deposits of Recent (Holocene) alluvium underlain by shallow, semi-permeable deposits of the Livermore and Tassajara Formations. The Fringe Area is also characterized by lower permeability aquifers overlain by clay-rich soils. Because the alluvium is generally thinner, the primary hydraulic connection between the Fringe Area and the Main Basin is through the Upper Aquifer. In general, Lower Aquifer units in the Main Basin do not extend into the Fringe Area. The most significant area of subsurface inflow from the Fringe Area into the Main Basin occurs in the northwestern portion of the Upper Aquifer (at the Bernal and Amador subareas) of the Main Basin across the Parks Boundary. Data from transect wells indicate that about 1,000 acre-feet per year (AFY) of groundwater flows across this boundary.

The Fringe Area has been subdivided into ten subareas to delineate areas of similar groundwater conditions and to provide a reference framework for locating wells. These subareas were defined in the 1970s primarily using inferred fault traces for many of the boundaries. Although the presence of some of the faults has either been re-interpreted or not confirmed, the subarea delineation provides a useful system for groundwater management and has been retained in subsequent groundwater documents. Subareas in the northwest include the Bishop, Dublin, and Camp. Subareas in the northeast include the Cayetano, May, Vasco, Altamont, Spring, and Mocho I.

7.2.5. Upland Management Area

The Upland Area is primarily defined by outcrops of the Livermore and Tassajara Formations and older bedrock units. These consolidated units are more resistant to erosion and form low rolling hills around the more-gently sloping alluvial valley. Most of the precipitation that falls on the Upland Area leaves the area as runoff and contributes to streams in the Fringe Area and the Main Basin. A small amount of deep percolation of precipitation in the Upland Area may also contribute to subsurface inflow. Formal subareas have not been delineated in the Upland Area because of the absence of significant groundwater pumping.

7.2.6. Neighboring Basin Boundaries

As shown on **Figure 7-1**, the Basin is bounded at the northwestern edge by the neighboring San Ramon Valley Groundwater Basin and at the southwestern edge by the neighboring Sunol Valley Groundwater Basin.

7.3. Bottom of the Basin

☑ **23 CCR § 354.14(b)(3)**

7.3.1. Main Basin Management Area

The bottom of the Main Basin is defined by the base of the Lower Aquifer (see **Section 7.4**) and represents the transition zone from prolific aquifers in the upper portion of the Livermore Formation to the more consolidated units in lower portions of the Livermore Formation. Although the thickness of the productive upper Livermore Formation varies, it has been estimated to be about 200 to 300 ft thick in the southern Main Basin (representing the lower 200-300 ft of the Lower Aquifer). The elevation of the bottom of the Main Basin and adjacent Fringe Area was estimated as part of cross-section development (see **Section 7.6**) and is shown on **Figure 7-5**.

As indicated by **Figure 7-5**, the base of the Lower Aquifer in the Main Basin extends below an elevation of -450 feet above mean sea level (ft msl) in the west-central portion of the Basin. Over most of the Main Basin (and including some of the northern Fringe Area), the Basin bottom is estimated to be between -400 to -200 ft msl. In the northwestern Fringe Area and the southern portions of the Main Basin, the Basin bottom is estimated to be between -250 and 0 ft msl, with a shallower base in the southeast reaches of Arroyo Valle. In the eastern portion of the Main Basin, the Basin bottom is estimated to be between -200 and +400 ft msl, with a shallower base in the southern reaches of Arroyo Mocho. In general, this Basin geometry is consistent with previous interpretations by the California Department of Water Resources (DWR; *DWR, 1974*).

7.3.2. Fringe Management Area

The bottom of the Basin in the Fringe Area (see **Section 7.4**) is defined by the transition zone from permeable deposits in the upper portion of the Livermore and/or Tassajara Formations to the more consolidated units in lower portions of the Livermore/Tassajara Formations. As described further in **Section 7.4**, the Livermore and Tassajara Formations are of lower productivity and quality within the Fringe Area, with maximum well depths ranging from 50 to 350 feet below ground surface (ft bgs) depending on location within the Fringe Area. The bottom of the Basin elevation of the Fringe Area is shown on **Figure 7-5**.

7.3.3. Upland Management Area

As discussed further in **Section 7.4**, the Upland Area is primarily defined by outcrops of the lower Livermore Formation and older bedrock units and does not yield significant quantities of groundwater. Only a small number of wells exist within the Upland Area and thus there is insufficient information to characterize the depth to the bottom of the usable aquifer system in this portion of the Basin.

7.4. Principal Aquifers and Aquitards

☑ 23 CCR § 354.14(b)(4)

7.4.1. Overview

Although multiple aquifer units have been identified in the Main Basin, wells have been classified generally as being completed in either the Upper or Lower Aquifer. Such differentiation is not applicable to the Fringe and Upland Areas.

Observed differences in water levels and water quality with depth have been used to delineate the Upper Aquifer and Lower Aquifer within the Main Basin. The Upper Aquifer and Lower Aquifer are generally separated by a relatively continuous silty clay aquitard, which is up to 50 ft thick and occurs between 80 and 175 ft bgs. In 2004, an important local hydrostratigraphic study was conducted in the Amador Subarea of the Main Basin to examine the aquifer system in more detail (*Norfleet Consultants, 2004*). This subarea contains up to about 1,000 ft of water-bearing sediments and highly productive aquifers. The subarea is also important in that it contains gravel quarries, referred to as the quarry area or “Chain of Lakes” (COL), some of which are used currently for conjunctive use; this program will be expanded in the future as ongoing gravel mining is completed and additional quarries are available for Zone 7 use (see **Section 15**).

The 2004 hydrostratigraphic study applied sequence stratigraphy techniques to the 1,000 ft of aquifers and aquitards in the subarea. Four overall hydrostratigraphic packages, or sequences, were mapped across the subarea based on the occurrence of generalized stratigraphic facies. These sequences were labeled (shallow to deep) cyan, gray, purple, and red. A cross-section from the 2004 study showing the sequences mapped across the subarea, along with the delineation of the Upper and Lower Aquifers is shown on **Figure 7-6**. The location of the cross-section is shown on **Figure 7-7**.

As indicated on **Figure 7-6**, the Cyan sequence is correlative to the delineation of the Upper Aquifer. Stratigraphic continuity within the Lower Aquifer was examined by the mapping of the remaining three sequences (gray, purple, and red). Although it is difficult to distinguish the basal units of the recent alluvium from the upper, productive zones of the Livermore Formation, the boundary between the purple and red sequences provides a reasonable stratigraphic framework.

As part of the current Alternative GSP Update, Zone 7 developed three stratigraphic cross-sections of the Basin as described in detail in **Section 7.6** and shown on **Figure 7-7** and **Figure 7-9** through **Figure 7-11**. These cross-sections further differentiate the Upper and Lower Aquifers of the Main Basin and extend into the Fringe Area and a small portion of the Upland Area. As mentioned above, there does not exist a strong differentiation between aquifer sediments, water levels, or water quality to support delineation of multiple Principal Aquifer units in the Fringe and Upland Areas. Further details regarding each Principal Aquifer unit defined within the Basin are provided below.

7.4.2. Upper Aquifer

The Upper Aquifer consists of recent (Holocene) alluvial materials, including primarily sandy gravel and clayey or silty gravels. These gravels are usually encountered underneath a confining surficial clay or silty clay layer typically 5 to 70 ft bgs in the west and exposed at the surface in the east, herein referred to as the Overburden. The thickness of the Overburden is shown on **Figure 7-12**. The base of the Upper Aquifer varies from about 70 to 190 ft bgs (*Norfleet Consultants, 2004*). A relatively thin Upper Aquifer is shown on **Figure 7-6** and **Figure 7-8**, located in the northern Main Basin (cross-section locations shown on **Figure 7-7**). On these west-to-east cross-sections, the thickness of the Upper Aquifer ranges from about 70 ft to 110 ft. These units are thicker to the south, ranging from about 70 ft thick in the west to about 190 ft thick in the southeast (see **Figure 7-10**).

In the 2004 hydrostratigraphic study, the Upper Aquifer was determined to contain several stratigraphic facies representing varying depositional environments across the central portion of the Basin. In that area, the Upper Aquifer contained fluvially-deposited gravels occurring primarily beneath aquitards of overbank and lacustrine deposits of clay and silt (**Figure 7-6**).

Groundwater in the Upper Aquifer is generally unconfined; however, when water levels are high, the zone becomes more confined in the western portion of the Main Basin where it is overlain by the Overburden.

7.4.3. Aquitard

A regional correlative lacustrine clay and silt unit, herein referred to as the Aquitard, underlies the Upper Aquifer deposits over much of the central and western Main Basin. A comparison of water levels from nested monitoring wells suggests that the Aquitard is a regional confining layer. However, the Aquitard appears to thin in the east, providing more hydraulic continuity between the two aquifers in this portion of the Basin (see **Figure 7-8** and **Figure 7-9**).

7.4.4. Lower Aquifer

Hydrologic connectivity between Lower and Upper Aquifers varies by location within the Main Basin depending on the presence and extent of the Aquitard (**Figure 7-8** and **Figure 7-9**).

All productive aquifer units encountered below the Aquitard in the central and eastern Main Basin are known collectively as the Lower Aquifer. Lower Aquifer materials consist of coarse-grained, water-bearing units interbedded with relatively low permeability, fine-grained units. The 2004 hydrostratigraphic study of the central portion of the Main Basin (*Norfleet Consultants, 2004)* indicated that aquifers were primarily Quaternary fluvial and deltaic sands and gravels interbedded with fluvial overbank and floodplain deposits (silts and clays).

Most of the recharge to the Lower Aquifer occurs through vertical leakage from the Upper Aquifer when piezometric heads in the Upper Aquifer are greater than those in the Lower Aquifer. Some replenishment may also come from the water-bearing members of the Livermore Formation that are in contact with the Lower Aquifer alluvium.

Within the Main Basin, the upper 200 to 300 ft of the Pliocene-Pleistocene Livermore Formation also appears to be sufficiently weathered and more permeable beneath the alluvium than in outcrops in the Upland Area. These zones comprise the lower portion of the Lower Aquifer, although sediment samples from wells are not sufficiently distinct to allow clear differentiation between these two units. Nonetheless, the lower portion of the Lower Aquifer is often characterized as having the thickest and most productive water-bearing deposits. The predominance of fluvial and deltaic sands and gravels in the lower portion of the Lower Aquifer can be seen on the western side of Norfleet 2004 Cross Section A-A' on **Figure 7-6** (labeled the Red Sequence). These lower sands are screened in many of the high-yielding production wells, especially in the western and central portions of the Main Basin.

7.4.5. Fringe Aquifer

Within the Fringe Area, a shallow (10 to 50 ft thick) sequence of recent (Holocene) alluvium directly overlies the upper portions of the Pliocene-Pleistocene Livermore and/or Tassajara Formations, depending on location. As mentioned above, there does not exist a strong differentiation between aquifer sediments, water levels, or water quality to support delineation of multiple Principal Aquifer units in the Fringe Area. As such, all water-bearing sediments encountered within the Fringe Area and associated subareas are collectively referred to as the Fringe Aquifer.

As mentioned above and discussed in greater detail in **Section 8**, the Fringe Aquifer is characterized by poorer water quality and lower well yields compared to the Principal Aquifer units encountered in the Main Basin.

7.4.6. Upland Aquifer

As mentioned above, the Upland Area is primarily defined by outcrops of the lower Livermore Formation and older bedrock units and does not yield significant quantities of groundwater. There are limited well completion reports and lithologic or geophysical information to characterize individual aquifer units or their depths and extents within the Upland Area. As such, all water-bearing sediments encountered within the Upland Area are collectively referred to as the Upland Aquifer.

7.4.7. Representation of Aquifers and Aquitards in Groundwater Model

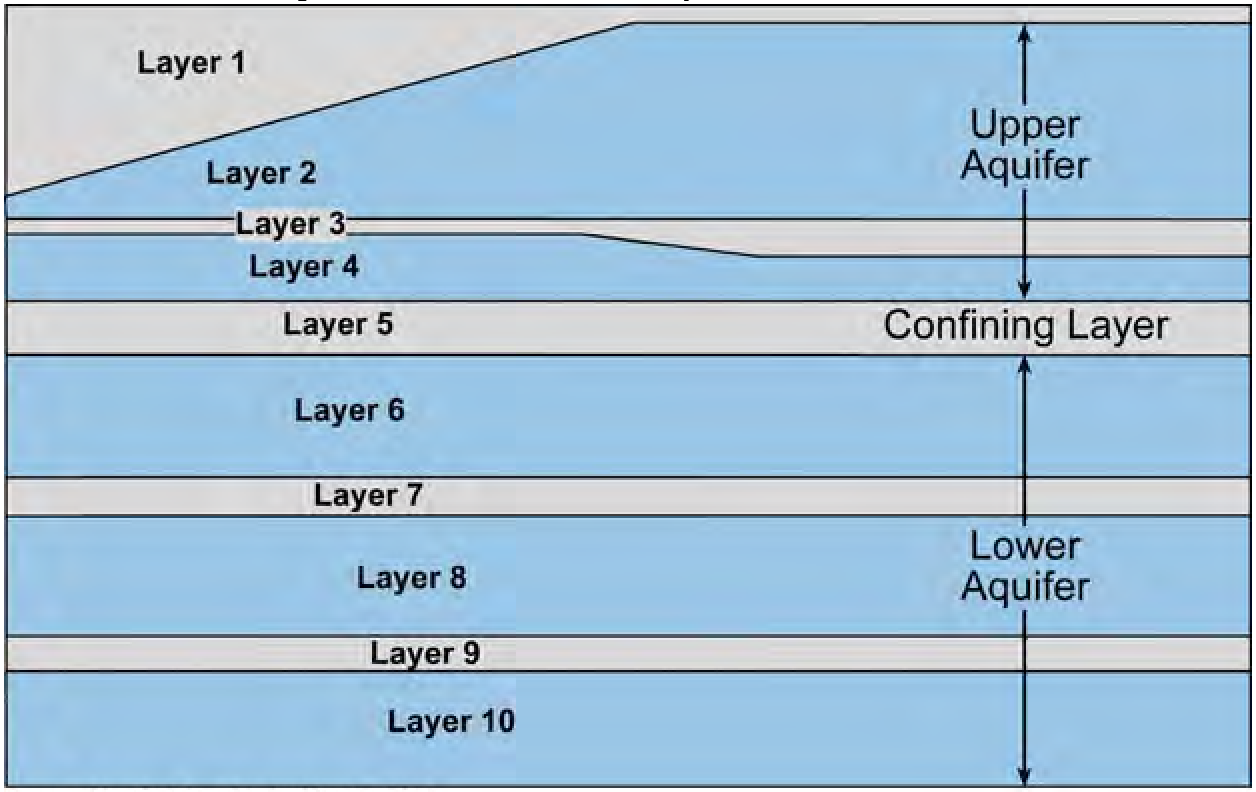
Zone 7 maintains a numerical groundwater model of the Basin (also referred to as model in the section) for simulating the effects of proposed Basin management actions (see also **Section 8.2.2)**. The model was originally developed in 2003 and has been updated as recently as 2017. The active part of the groundwater model covers subareas in both the Main Basin (Castle, Bernal, Amador, and Mocho II Subareas) and the northwestern Fringe Area (Bishop, Dublin, and Camp Subareas). The original version of the model consisted of three layers: the Upper Aquifer (Layer 1), the Aquitard (Layer 2), and the Lower Aquifer (Layer 3). Most municipal water supply production wells in the Basin were screened in the Lower Aquifer (Layer 3). Production in the Upper Aquifer (Layer 1) was limited primarily to small private wells (Layer 1).

In 2017 the model was upgraded to ten layers to represent primary intervals of aquifers and aquitards as summarized and shown in **Figure 7-A** below:

- Layer 1 – shallow clay layers overlying the Upper Aquifer in the western Basin (i.e., Overburden)
- Layers 2 and 4 – primary aquifer units within the Upper Aquifer
- Layer 3 – intervening clay layers within the Upper Aquifer
- Layer 5 – confining to semi-confining layer delineating the Upper Aquifer from the Lower Aquifer (i.e., Aquitard in **Section 7.4.3)**
- Layers 6, 8, and 10 – primary aquifer units within the Lower Aquifer
- Layers 7 and 9 – intervening clay layers between the aquifer units in the Lower Aquifer

The base of Layer 10 is estimated to be the base of the water-bearing units of the Lower Aquifer.

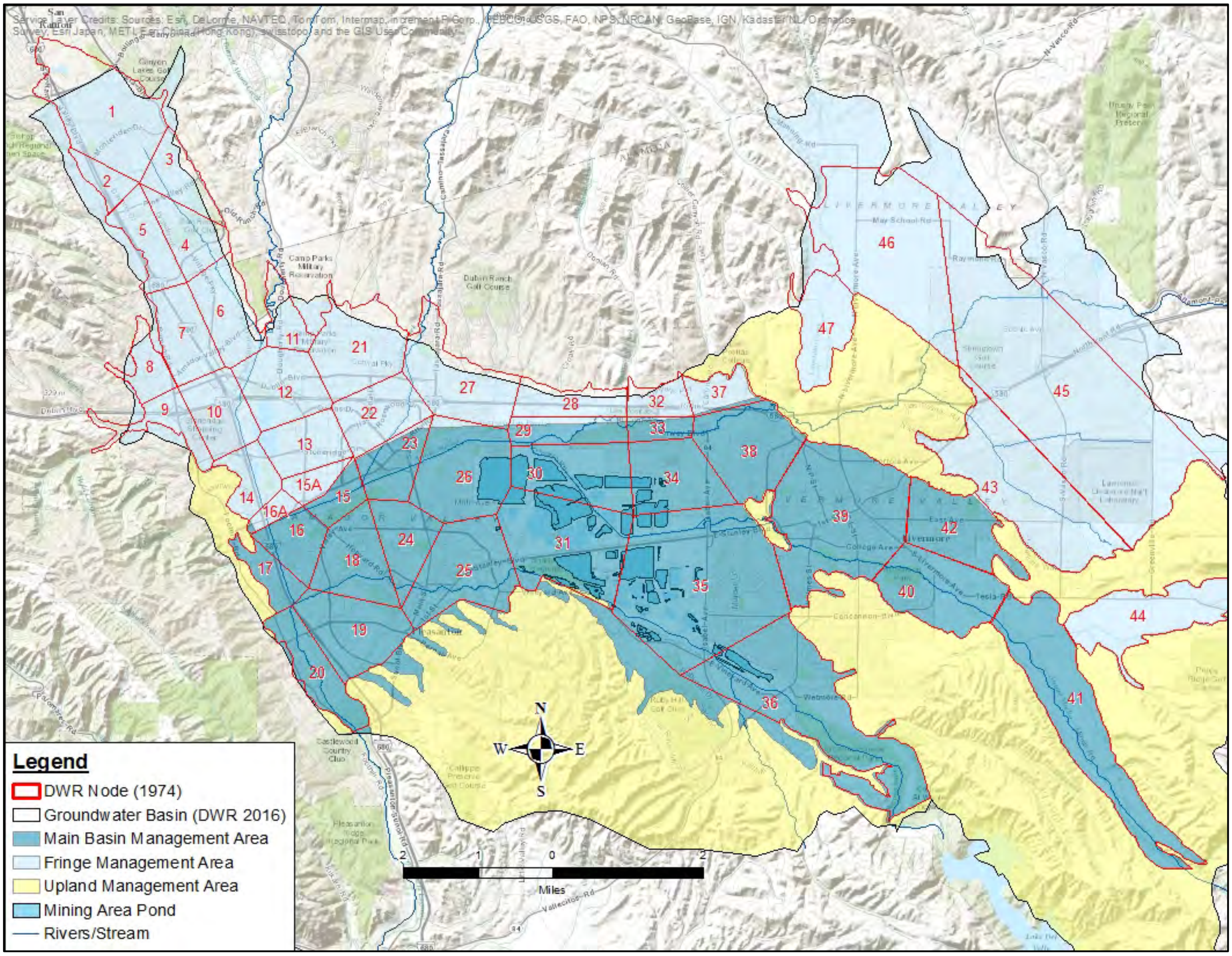
Figure 7-A: Schematic of 10-Layer Groundwater Model



Source: Modified from Hydro Metrics, 2016.

DWR originally delineated "Nodes" in their 1974 groundwater model that recognized the Upper and Lower Aquifers in the Main Basin as well as the thin alluvial Fringe Aquifer, as shown on **Figure 7-B** below. These nodes have aquifer parameters associated with them that have been confirmed over time and are used by Zone 7 for calculation of groundwater in storage, changes in storage, and groundwater quality analyses. The application of these nodes in Zone 7 groundwater management is described in more detail in the discussion of groundwater quality (**Section 8.6**) and Basin water budgets (**Section 9.2**).

Figure 7-B: DWR "Nodes" from 1974 Groundwater Model



7.5. Data Gaps and Uncertainty

☑ **23 CCR § 354.14(b)(5)**

Key data gaps and uncertainties identified during development of this HCM for the Basin include:

- Uncertainty in distinguishing specific areas in the Main Basin where Upper and Lower Aquifers are hydrologically connected;
- Uncertainty in hydraulic properties within the Fringe and Upland Areas due to limited boring logs;
- Uncertainty in subarea definition in the Fringe Area;
- Uncertainty in the thickness and extent of the Upland Area;
- Uncertainty in representation and extent of some major fault structures within the Basin (e.g., Livermore Thrust and Pleasanton Fault) that may serve as a hydraulic barrier to groundwater flow;

and

- Refinement of aquifer delineations, extents, and thicknesses in other parts of Basin outside of the three stratigraphic cross-sections developed for the current Alternative GSP update.

Additional data gaps related to the definition of groundwater conditions and water budget estimations are discussed in their relevant sections below. Data-gap filling activities proposed as part of implementation of this Five-Year Update to the Alternative GSP are presented in **Section 15.2.4**.

7.6. Cross-Sections

§ 354.14. Hydrogeologic Conceptual Model
(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.

☑ **23 CCR § 354.14(c)**

The three dimensional (3D) geologic modeling software platform RockWorks[13] was selected to support development of hydrogeologic cross-sections for the Basin. **Appendix I** summarizes the data sources, key assumptions, and step-wise development process that was used to build the HCM framework in RockWorks. **Appendix I** includes a detailed geologic interpretation of the cross-sections.

The cross-section trace locations are shown on **Figure 7-3** and **Figure 7-7.** A map of the surficial geology, major fault structures, and streams that were incorporated into the cross-sections is shown on **Figure 7-2.** A simplified schematic of the conceptual hydrostratigraphic model of the Basin and mapping between major stratigraphic facies and corresponding Principal Aquifer units is shown on **Figure 7-8.** The three cross-sections are shown on **Figure 7-9**, **Figure 7-10**, and **Figure 7-11**, respectively. The following sections document the principal geologic features, as well as the assumptions and references used to inform cross-section development.

7.6.1. Geologic Cross-Section A-A’

Cross-Section A-A’ depicts a generally west-to-east trace through the Basin (see **Figure 7-9**). The trace begins just west of the southwestern Basin boundary near the Calaveras Fault deformation zone and progresses eastward through the Main Basin (including the Castle, Bernal, Amador, and Mocho II Subareas), where a majority of groundwater production occurs in the Basin. The trace cuts directly through a narrow corridor of alluvium connecting the Mocho II and Mocho I Subareas (an area commonly referred to as “The Gap”) and continues through the southern portion of the Eastern Fringe Area (including

[13] RockWorks 2020 Standard Level License from RockWare was downloaded and installed on 15 October 2020: https://www.rockware.com/product/rockworks/

the Mocho I and Spring Subareas) before terminating in the Upland Area just west of the Greenville Fault deformation zone.

After crossing the main deformation zone of the Calaveras Fault and entering the Basin, Cross-Section A-A' cuts through the Castle Subarea, which consists of "uplands underlain by the Livermore Formation and… adjacent valley fill material" (*DWR, 1974*). Here, the Upper Aquifer is comprised of Holocene alluvial deposits ranging from approximately 50 to 75 ft thick. Most of the wells in the Castle Subarea draw from the upper 100 to 200 ft of Plio-Pleistocene Livermore Formation, which is present "as a sequence of gravel, sand, and silt interlayered by clay" (*DWR, 1974*). This productive upper zone of the Livermore Formation (herein referred to as the "Upper Livermore Formation") comprises the Lower Aquifer in the area. "All of these materials apparently slope toward the valley at dips ranging up to ten degrees" (*DWR, 1974*).

Cross-Section A-A' subsequently passes over another presumed splay of the Calaveras Fault and enters the Bernal Subarea, which acts as the point of convergence for all major streams and subsurface flows that eventually surface and drain the Basin via the Arroyo de La Laguna. Here, a confining surficial clay unit exists reaching up to 70 ft thickness (herein referred to as the "Overburden"). Beneath the Overburden is the Upper Aquifer, which is comprised of a 50 to >100-ft sequence of unconsolidated, Holocene sandy gravel and silty/clayey gravel deposits. Beneath the Upper Aquifer is a laterally extensive lacustrine clay and silt unit of up to 50 ft thick (herein referred to as the "Aquitard"). Below the Aquitard is a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts (*Norfleet Consultants, 2004*). These Quaternary (Pleistocene-Holocene) deposits are believed to represent a "structurally influenced, incised channel complex" deposited by the ancestral Arroyo Mocho stream (*Norfleet Consultants, 2004*) and are encountered up to >400 ft bgs in the area (*DWR, 1974*). Underlying the Quaternary fluvial and alluvial deposits is the Upper Livermore Formation, for which up to 200 ft is considered productive due to sufficient weathering and permeability relative to the more consolidated zones of the Lower Livermore Formation. The combined sequence of Quaternary alluvial/fluvial deposits and the Upper Livermore Formation are known collectively as the Lower Aquifer in the Main Basin. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges up to 3,500 gpm and specific capacities range from 3 to 260 gpm per foot of drawdown.

The trace subsequently crosses into the Amador Subarea, whereby a majority of groundwater production occurs in the Basin. The Overburden is present in the western half of the Amador Subarea, extending east approximately to the COL mining area, creating semi-confined conditions in the Upper Aquifer where it is present. Beneath the Overburden are Holocene alluvial deposits of the Upper Aquifer, which reach depths of up to 190 ft bgs in the subarea (and approximately 150 ft underlying Cross-Section A-A'). Here, the Upper Aquifer is consistent with the "Cyan" stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies. The Aquitard is present below the Upper Aquifer at a thickness of up to 50 ft under the COL area, before gradually thinning to the east. This unit is consistent with the "Grey Clay" sequence defined in the Norfleet (2004) and Zone 7 (2011) studies and serves to create semi-confined to confined conditions in the underlying Lower Aquifer. As in the Bernal Subarea, Lower Aquifer units in the western portion of the Amador Subarea are comprised of up to 400 ft of interbedded, Quaternary alluvial/fluvial deposits (consistent with the "Grey" and "Purple" sequences from Norfleet (2004) and Zone 7 (2011)), underlain by 200-300 ft of productive Upper Livermore deposits (consistent with the "Red" sequence in Norfleet (2004) and Zone 7 (2011)). The Basin reaches a maximum depth of >800 ft in the central Amador Subarea near the COL mining pits. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges from 42 to 2,820 gpm and specific capacities range from 1.1 to 217 gpm per foot of drawdown.

Moving further east through the Amador Subarea, Cross-Section A-A' eventually reaches the Livermore Thrust fault zone, which presents a significant unconformity that serves to restrict groundwater flow from the Mocho II Subarea to the Amador Subarea. According to Norfleet (2004):

> *"The Livermore Thrust ha[s] a westward motion and dip[s] at a high angle to the east. [It] dies out rapidly to the north and do[es] not extend all the way across the current Livermore Valley. Evidence for the Livermore fault was discussed in Thomas et al. (1959) and DWR (1963, 1966, and 1974). The fault has historically been considered to be a strike-slip fault, but the data are more consistent with an east dipping, west-moving thrust fault. The Livermore thrust cut and uplifted Livermore Gravels, suggesting that the fault developed after deposition of the classical Livermore Gravels." (Norfleet Consultants, 2004)*

Several varying interpretations exist in the literature regarding the nature and extent of this fault and the degree to which it impedes groundwater flow. In their Bulletin-118 description of the Basin, DWR notes:

> *"The Livermore [Thrust] is an effective barrier to ground water inflow from the Mocho subbasin except in the vicinity of the ancestral channel of Arroyo Mocho north of Oak Knoll, where ground water moves across this fault essentially unimpeded" (DWR, 1974).*

Cross-Section A-A' traces north of Oak Knoll, within the ancestral Arroyo Mocho paleochannel. However, based on nearby water level observations collected in Fall 2019, an apparent 80-foot drop in groundwater elevation is observed in the Lower Aquifer moving westward across the fault, indicating that some degree of hydraulic restriction occurs across the fault zone in this area. Notably, this groundwater flow barrier across the fault is not observed in the Upper Aquifer.

The total depths of wells in the Mocho II Subarea east of the Livermore Thrust suggest that the base of the Lower Aquifer (i.e., the bottom of the productive Upper Livermore Formation) is encountered 200-300 ft higher in this subarea than in the Amador Subarea west of the fault, indicating a significant discontinuity likely exists in the Lower Aquifer formations even within the incised ancestral Arroyo Mocho channel complex resulting from uplift on the eastern side of the fault. A relatively lower proportion of "clean gravels" is also observed east of the Livermore Thrust, resulting in lower productivity of the Lower Aquifer in the Mocho II Subarea (*Norfleet Consultants, 2004*). Upper Aquifer deposits progressively thin to around 50 ft thickness moving east through Mocho II Subarea. The Aquitard and underlying Quaternary deposits gradually diminish as the trace moves further east outside the ancestral Arroyo Mocho paleochannel, and eventually disappear before reaching the Mocho II – Mocho I boundary such that Pleistocene-Holocene alluvial deposits are directly underlain by deposits of the Upper Livermore Formation.

Another apparent steepening of the hydraulic gradient in the Lower Aquifer is observed west of the Mocho II/Mocho I boundary as deposits of the Upper Livermore Formation continue to reduce to a total depth of approximately 330 ft bgs at well 3S2E10Q002. A short distance to the east, a narrow, roughly 50-ft thick sequence of young alluvial deposits of the Arroyo Seco channel underlain by older, interbedded sand and gravel deposits of the Upper Livermore Formation connects the Main Basin to the Eastern Fringe Area in an alluvial channel known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south, also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within the Gap that serves to restrict the vertical cross-sectional area of connection between Upper and Lower Aquifer deposits in the Eastern Fringe Area and the Main Basin to the west (*DWR 1974, LLNL 1984*). There is considerable uncertainty to the degree which flow is restricted across The Gap, though Fall 2019 water level trends suggests this area acts as an apparent groundwater divide in both the Upper and Lower Aquifers.

As the trace of Cross-Section A-A' moves across The Gap and into the Mocho I Subarea of the Fringe Area, Upper Livermore deposits again deepen to a total depth around 350 ft bgs at well 3S2E11R046 near the southwestern corner of the Lawrence Livermore National Laboratory (LLNL). A local depression in Fall 2019 groundwater elevations was observed in the Fringe Aquifer in this area, likely due to groundwater pumping. These deposits then begin to dip upward to the northeast as the trace moves into the Spring Subarea, reducing to a total depth of 175 ft bgs at well 3S2E12J025 on the southeastern side of LLNL (*LLNL, 1984*). Here, the Upper Livermore deposits are described as a series of "beds of cemented gravel, sandy gravel, and sandy clay separated by beds of less-permeable clay and silty clay" (*DWR, 1974*). Overlying Pleistocene-Holocene valley-fill materials in this area "are of similar composition to the sediments of the Livermore Formation, as they are composed principally of reworked Livermore Formation detritus" (*DWR, 1974*). Both the valley fill and underlying Livermore deposits continue to dip upward to the northeast before reaching the Las Positas Fault, which likely truncates the Fringe Aquifer completely. The trace then briefly crosses into the Upland Area, where the Lower Livermore Formation is the dominant outcropping unit and no significant groundwater production occurs, before ending at the southeastern Basin Boundary near the Greenville Fault zone.

7.6.2. Geologic Cross-Section B-B'

Cross-Section B-B' depicts a generally northwest-to-southeast trace through the western portion of the Basin (see **Figure 7-10**). The trace begins at the northwestern Basin boundary with the neighboring San Ramon Valley Groundwater Basin to the north. It runs southeast through the Northern Fringe Area (including the Bishop, Dublin, and Camp Subareas) before entering the Main Basin. Cross-Section B-B' then passes through a large section of the west-central Main Basin (Amador Subarea) and continues southeast up the Arroyo del Valle stream corridor before terminating at the contact between the Amador Subarea and the Southern Upland Area near the southern Basin boundary.

The trace begins in the Bishop Subarea of the Northern Fringe Area, which contains "one of the deepest developed prisms of water-bearing materials in the Basin…[with] sediments up to 800 feet in depth"

(*DWR, 1974*). Surficial deposits are consistent with Holocene alluvial and fluvial sands and gravels, underlain by a thick sequence of relatively fine-grained deposits of the Pleistocene to Plio-Pleistocene Tassajara Formation. These contain “eight to ten separate zones of sand and gravel separated by zones of silt and clay” (*DWR, 1974*). It is assumed that “the greater portion of the sediments below a depth of 100 feet are part of the Tassajara Formation” (*DWR, 1974*). The Fringe Aquifer is defined as the collective sequence of surficial Holocene alluvial deposits and the thicker underlying sequence of permeable Tassajara Formation deposits (herein referred to as the “Upper Tassajara Formation”). Groundwater production is relatively minimal in this subarea and thus few borehole lithologic and e-log data are available to more accurately delineate individual aquifer zones within the Upper Tassajara Formation.

Moving further to the southeast, Cross-Section B-B’ enters the Dublin Subarea of the Northern Fringe Area. Here, deposits are very similar to those encountered in the Bishop Subarea, containing an “essentially flat-lying” sequence of sediments with a “maximum depth of…about 800 feet” (*DWR, 1974*). “Valley-fill materials lap northward onto older sediments of the Tassajara Formation”, though the depth at which the Tassajara Formation meets younger Holocene alluvial deposits is not well understood in the area (*DWR, 1974*). Based on available borehole lithology and e-log data, it appears the surficial clay layer (i.e., Overburden) encountered in the Main Basin as well as a laterally extensive clay layer (i.e., Aquitard) underlying the Holocene alluvium are encountered in the southern portion of the Dublin Subarea.

After passing through the Dublin Subarea, the trace makes a brief east-southeasterly turn and cuts through a small portion of the Camp Subarea of the Northern Fringe Area before moving southeast and entering the Main Basin (Amador Subarea). The Camp Subarea is similar in composition to the Dublin and Bishop Subareas to the northwest, containing “beds of sandy clay and sandy gravel which overly the Tassajara Formation” (*DWR 1974*).

The Camp Subarea is delineated from the Amador Subarea of the Main Basin by an observed groundwater flow barrier described as the “Parks Boundary” (*Norfleet Consultants, 2004*). The Parks Boundary was originally inferred as a fault in DWR’s Bulletin-118 hydrostratigraphy summary based on significant variations in groundwater elevations between the Dublin/Camp Subareas of the Northern Fringe Area and the Bernal/Amador Subareas of the Main Basin (*DWR, 1974*). However, updated interpretations provided in the Norfleet (2004) hydrostratigraphy study suggest that the Parks Boundary represents a buried valley wall delineating the northern extent of the “structurally influenced, incised-channel complex” deposited by the ancestral Arroyo Mocho stream (*Norfleet Consultants, 2004*). While the Holocene alluvial deposits of the Upper Aquifer and the underlying Aquitard appear to be generally consistent across the Parks Boundary, deposits in the Lower Aquifer south of the boundary consist of a thicker sequence of braided fluvial and deltaic “clean gravel” and sand deposits interbedded with fluvial overbank and floodplain clays and silts (*Norfleet Consultants, 2004*). These are underlain by the Upper Livermore Formation, as opposed to the Tassajara Formation north of the boundary. Based on nearby water level observations collected in Fall 2019, an apparent 30 to 40-foot drop in groundwater elevation is observed in the Lower Aquifer moving south across the Parks Boundary. Lower Aquifer deposits south of the Parks Boundary are known to be more productive than those north of the boundary, thus marking the southern edge of the Northern Fringe Area and the northern edge of the Main Basin.

As Cross-Section B-B’ moves southwards across the Parks Boundary and into the Main Basin, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel are encountered at depths up to 500 ft bgs. As mentioned above, these are underlain by deposits of the Upper Livermore Formation, which reach >200 ft thickness in the west-central portion of the Amador Subarea. Holocene alluvial deposits comprising the Upper Aquifer reach a maximum thickness of approximately 150 ft underlying the southern COL mining area within the subarea. Here, the Upper Aquifer is generally consistent with the “Cyan” stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies, while the Aquitard comprises the “Grey Clay” sequence and the interbedded sequence of Quaternary alluvial/fluvial deposits comprise the “Grey” and “Purple” sequences. Deposits of the Upper Livermore Formation are generally consistent with the “Red” sequence mapped in the Norfleet (2004) and Zone 7 (2011) studies.

Moving southeast through the Amador Subarea, deposits from the incised channel-complex are found roughly up to Concannon Road, where another water level lineation has historically been observed. Norfleet (2004) interpreted this area as the southern extent of the ancestral Arroyo Mocho paleochannel, and delineated this feature as the “Concannon Boundary”. South of the Concannon Boundary, deposits of the ancestral Arroyo Mocho paleochannel are not readily apparent and permeable deposits of the Upper Livermore Formation appear to directly underly the Upper Aquifer and Aquitard. Groundwater conditions range from “unconfined to confined” in this area, with unconfined groundwater occur[ing] principally near the channel of Arroyo del Valle and in the uppermost aquifer” (*DWR, 1974*).

Moving further southeast up the Arroyo del Valle stream corridor, the Upper Livermore Formation continues to dip upward to the south at an angle of one to three degrees (*DWR, 1974*). “Many of the aquifers merge near the course of Arroyo del Valle, where the combined aquifers are present as a deposit of sandy gravel up to 300 feet in thickness” (*DWR, 1974*). The Las Positas Fault, described as a “high-angle tear fault” that “cut and uplifted Livermore Gravels” south of the fault line (*Norfleet Consultants, 2004*), may act as a disconformity in the Upper Livermore Formation as maximum well depths are roughly 200 ft bgs southeast of the fault line. This may also explain the apparent confinement observed in Fall 2019 Lower Aquifer water levels in the vicinity of the fault. However, the degree to which the Las Positas Fault acts as a hydraulic barrier to groundwater flow is uncertain given the current lack of lithologic and geophysical data proximate to the fault line. Recent alluvial deposits of the Arroyo del Valle stream corridor (i.e., Upper Aquifer) continue to thin with the Upper Livermore Formation (i.e., Lower Aquifer) before pinching out at the contact between the Amador Subarea and the Southern Uplands, where the relatively impermeable Lower Livermore Formation begins to outcrop. This terminus in permeable deposits marks the effective southern edge of the Basin within the Arroyo del Valle stream corridor.

7.6.3. Geologic Cross-Section C-C’

Cross-Section C-C’ depicts a generally northwest-to-southeast trace through the eastern portion of the Basin (see **Figure 7-11**). The trace begins at the northeastern Basin boundary and progresses southeastward through a portion of the Northeastern Fringe Area (May and Spring Subareas). The trace then makes a turn to the south and continues through the Northeastern Fringe Area (Spring and Mocho I

Subareas) before cutting directly through a narrow corridor of alluvium connecting the Mocho I and Mocho II Subareas (an area commonly referred to as "The Gap"). The trace then progresses further south through the Main Basin (Mocho II Subarea), taking another southeasterly turn and continuing up the Arroyo Mocho stream corridor. It then briefly enters the Southern Upland Area before terminating at the southern Basin boundary.

Cross-Section C-C' begins in the May Subarea of the Northeastern Fringe Area, where outcrops of the relatively impermeable Lower Tassajara Formation define the northern edge of the Basin. South of the Basin boundary, "ground water occurs only in limited amounts in a relatively thin veneer of valley-fill materials which overlie a thick section of sediments belonging to the Tassajara Formation" (*DWR, 1974*). Here the Fringe Aquifer is defined as the thin veneer of recent (Holocene) alluvium deposited from smaller streams, which "does not exceed 40 ft" thickness in the May Subarea (*DWR, 1974*), directly underlain by the permeable upper deposits of the Plio-Pleistocene Tassajara Formation (herein referred to as the "Upper Tassajara Formation") where a majority of groundwater production occurs in the area. The Upper Tassajara Formation is comprised of "beds of sand and gravel, clay and gravel, clay, and silty clay… which range up to 50 ft in thickness [and] dip southward at an average gradient of ten degrees." (*DWR 1974*). Based on nearby water level observations collected in Fall 2019, it appears water level conditions are semi-confined to confined in within the Upper Tassjara Formation this area.

Cross-Section C-C' further progresses southeastward into the Spring Subarea of the Northeastern Fringe Area. Here, surficial deposits are very similar to those encountered in the May Subarea, containing a thin veneer of recent alluvium not exceeding 50 ft thickness. Deposits underlying the recent alluvium change in composition to reflect those of the Upper Livermore Formation, though the geometry of the contact between the Tassajara and Livermore Formations is not well understood in this area. Upper Livermore deposits in the Spring Subarea are described as a "wedge-shaped sequence" of permeable deposits that increase in depth moving southward (*DWR, 1974*). Upper Livermore deposits continue to deepen as the trace turns south and moves into the Mocho I Subarea (*LLNL, 1984*). The "valley-fill portion of the Mocho I province…consists of a heterogeneous mixture of gravelly fan detritus overlying truncated beds of the Livermore Formation" (*DWR, 1974*).

The base of the Upper Livermore Formation deepens in a southerly direction along the Cross-Section C-C' trace through the Mocho I Subarea to approximately 300 ft bgs while the upper surface of the formation stays within approximately 30 ft bgs (*LLNL, 1984*). Northeast of well 3S2E10Q002 the trace crosses through a narrow alluvial channel connecting the Mocho I and Mocho II Subareas, known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south (i.e., out of the plane of the cross-section), also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within The Gap that serves to restrict the vertical cross-sectional area of connection between the recent alluvium and underlying Livermore Formation deposits in the Northeastern Fringe Area and the Main Basin to the southwest (*DWR, 1974; LLNL, 1984*). There is considerable uncertainty in the degree to which flow is restricted across The Gap, though recent water level trends suggest this area acts as an apparent groundwater divide between the Fringe Aquifer and the Upper and Lower Aquifers of the Main Basin.

After moving across The Gap, Cross-Section C-C' progresses south through the Mocho II Subarea of the Main Basin. Here, "the valley-fill materials become separated into identifiable strata consisting of beds of sandy gravel and cemented gravel separated by beds of silt and clay" (*DWR, 1974*). In this area, Cross-Section C-C' encounters a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts known to be deposited by the ancestral Arroyo Mocho paleochannel throughout much of the Main Basin (*Norfleet Consultants, 2004*), consistuting the upper portions of the Lower Aquifer. Based on nearby water level observations collected in Fall 2019, it appears this thicker sequence of Quaternary alluvial/fluvial deposits creates some degree of confinement in the Lower Aquifer in the area.

As the trace turns to the southeast and begins traveling up the Arroyo Mocho stream corridor, Cross-Section C-C' travels over the Las Positas Fault. The Las Positas Fault may present an unconformity in the Upper Livermore Formation, though the degree to which it acts as a hydraulic flow barrier in the Lower Aquifer is not well understood.

As Cross-Section C-C' moves further southeast up the Arroyo Mocho stream corridor, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel pinch out and disappear. Here, the recent alluvial deposits of the Arroyo Mocho are underlain directly by semi-consolidated deposits of the Upper Livermore Formation. These deposits progressively thin moving up the stream corridor until they pinch out at the contact between the Mocho II Subarea and the Southern Upland Area. At this point, the relatively impermeable Lower Livermore Formation begins to outcrop, marking the effective southern edge of the Basin in the Arroyo Mocho stream corridor. Cross-Section C-C' further extends a short distance through the Southern Upland Area before reaching the southern Basin boundary.

7.7. Physical Characteristics

§ 354.14. Hydrogeologic Conceptual Model

(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:
- *(1) Topographic information derived from the U.S. Geological Survey or another reliable source.*
- *(2) Surficial geology derived from a qualified map including the locations of cross- sections required by this Section.*
- *(3) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.*
- *(4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.*
- *(5) Surface water bodies that are significant to the management of the basin.*
- *(6) The source and point of delivery for imported water supplies.*

7.7.1. Topographic Information

☑ 23 CCR § 354.14(d)(1)

Ground surface within the Main Basin and Fringe Area slopes gently west and southwest from an elevation of approximately 700 ft msl in the east to approximately 300 ft msl in the southwestern corner, which is the location of the Basin's surface and subsurface outflow. The highest elevations in the Basin are in the east-southeastern Upland Area where the ground surface is above 2,000 ft msl. In the southern Upland Area, ground surface elevations are above 1,100 ft msl. The highest elevations in the Main Basin are also in the southeast, along the upper reach of Arroyo Mocho, where elevations are around 1,000 ft msl. Ground surface elevations across the central Main Basin average about 400 ft msl. The overall topography across the Basin is shown on **Figure 7-13** as represented from a digital elevation model (± 3 meters) covering Alameda and Contra Costa Counties.

7.7.2. Surficial Geology

☑ 23 CCR § 354.14(d)(2)

The geologic map on **Figure 7-3** illustrates the older deformed sedimentary and bedrock units defining the Basin along with the valley-fill alluvial sediments; the Basin is outlined in black on the map. The map also contains many of the northwest-southeast trending faults that have offset the consolidated geologic units and, in some cases, shallow alluvium.

As shown on **Figure 7-3**, the Basin is partially filled with Pleistocene-Holocene age alluvium (Qu), consisting of alluvial fan, fluvial, and lake deposits that range in thickness from a few feet along the margins to more than 400 ft in the west-central Basin. The alluvium consists of unconsolidated gravel, sand, silt, and clay. The southern and southwestern alluvial deposits consist primarily of sand and gravel that were deposited by the ancestral and present Arroyo Valle and Arroyo Mocho. These deposits are rimmed by slightly older terrace deposits (Qt).

The eastern and northern Fringe Areas of the Basin are also filled with recent alluvial deposits, but these sediments were deposited from smaller streams and consist of thin, alternating layers of gravel, sand, silt, and clay that are laterally discontinuous. Consolidated units underlie the thin alluvial deposits as demonstrated by several areas in the northeast Basin where these units crop out at the surface (see **Figure 7-3**). These outcrops consist of the older consolidated units north and south of the Basin that underlie the alluvium (Pliocene-Miocene Green Valley/Tassajara group [Tgvt] units on the north and younger Pliocene-Pleistocene Livermore gravels [QTl] on the south).

7.7.3. Soil Characteristics

☑ 23 CCR § 354.14(d)(3)

Figure 7-14 shows the soil types throughout the Basin as mapped by the National Resource Conservation Service (NRCS). In general, the soils reflect the lithology of the upland source rocks. The predominant soils in the northern Fringe Area are low-permeability clay (Cl) and clay loams (ClL), associated with the Tassajara Uplands. Soils in the southern Basin consist of more permeable soils including gravelly loams (GrL) associated with the Livermore Uplands. Across the Main Basin, soils are also more permeable than northern soils and include gravelly coarse sandy loams (GrSaL), extremely gravelly sand (GrSa), sand (Sa), silt loam (SiL) and loam (L). The lower permeability soils in the Main Basin occur along the northern and western portions.

The low permeability soils along the northern and western areas of the Main Basin are also underlain by shallow clay deposits that overlie the Upper Aquifer. These shallow clay layers have been mapped by Zone 7 to identify areas where shallow clays may be impeding surface recharge (see **Figure 7-15**).

7.7.4. Recharge and Discharge Areas

☑ **23 CCR § 354.14(d)(4)**

7.7.4.1. Recharge Areas and Sources

Groundwater inflows to the Basin include percolation of artificial recharged surface water, percolation of applied irrigation water, percolation of streamflow from surrounding watersheds, percolation of canal leakage, percolation of precipitation, and percolation of municipal and industrial (M&I) effluent. **Figure 7-16** shows the recharge areas of the Main Basin from streams, mining area ponds, and surficial geology. Some of the mining area ponds in the central portion of the Basin (Amador Subarea) are in communication with the groundwater basin; and are currently or will be used in the future for conjunctive use (see **Sections 5.2.3**, **7.7.5**, and **15.2.1.3**).

Zone 7 has been importing and recharging State Water Project (SWP) water (artificial recharge) since the 1960s to replenish what has been pumped from the Basin. Zone 7 actively embraces a conjunctive use approach to Basin management by integrating management of local and imported surface water supplies with the management of local conveyance, storage, and groundwater recharge features, including local Arroyos (which are also used as flood protection facilities during wet seasons).

Both the Arroyo Valle and the Arroyo Mocho serve vital roles in Zone 7's groundwater recharge program, as does the Arroyo Las Positas but to a lesser extent. The upper portions of these arroyos are underlain by coarse soils and readily act as losing streams (**Figure 7-16**). At Zone 7's request, DWR releases water into these Arroyos to supplement the natural recharge of the Main Basin, while providing secondary aesthetic and environmental benefits. In addition to the managed (artificial) stream recharge conducted in these Arroyos, the stream channels also serve to recharge the Basin with natural rainfall and runoff. Basin recharge varies from less than 5,000 AF per year to more than 20,000 AFY depending on local hydrologic conditions and availability of SWP water. Historical natural (both from streams and rainfall) and artificial recharge (from streams) volumes are discussed in detail in **Section 9.3.2** with averages from 1974 to 2020 presented in **Table 7-A** below.

Table 7-A: Average Recharge Volumes from 1974 to 2020 (in acre feet)

Recharge From	Average Volume
Rainfall	4,700
Natural Flow in Streams	5,700
Artificial Flow in Streams	5,300

7.7.4.2. Discharge Area and Sources

Groundwater outflows from the Basin include groundwater pumping for agricultural, domestic and M&I uses, evaporation from mining area ponds, and discharges to streams within the Basin. The coarse-grained alluvium in the center of the Main Basin has been mined for aggregate since the 19th century, resulting in several mining area ponds between Pleasanton and Livermore. Continued mining has impacts on the local groundwater budget, levels, and flow. Most notably, many of the quarry pits have been dug deep into the Upper Aquifer and some are proposed to mine into the Lower Aquifer. This mining activity has removed aquifer material, created “windows” into the Basin, and exposed groundwater to large evaporative losses. Groundwater is also pumped from some of the pits and transferred to others or discharged to the Arroyos to facilitate gravel extraction; the latter can result in loss of water from the Basin. In addition, interruption of groundwater movement can result from the mining of aggregate resources and occasional placement of less permeable material in former pits.

Accordingly, Zone 7 has worked and is working closely with the mining companies and Alameda County Community Development Agency (the administrative representative of the State for mining operations and reclamation) to develop a reclamation plan whereby ownership of ten quarry lakes (COLs A through I and Cope Lake) is to be transferred to Zone 7 for water resources management purposes (**Section 15**). Two of the lakes have already been transferred to Zone 7 (Lake I and Cope Lake) and are currently operated and maintained by Zone 7 for storage and groundwater replenishment.

Numerous saline springs have been observed on the eastern Basin associated with upwelling along faults, especially those in the Greenville Fault zone. One such seasonal spring, Springtown Alkali Sink **(Section 7.7.5)**, has been documented and monitored in the northeastern Fringe Area of the Basin. Springtown Alkali Sink is located along Altamont Creek in the vicinity of Springtown golf course and is close to stream gauges on Altamont Creek monitored by Zone 7. When groundwater levels are sufficiently high, groundwater discharges to Altamont Creek, exiting the Springtown Alkali Sink as surface water. Much of this discharge is lost to evapotranspiration.

7.7.5. Surface Water Bodies

☑ **23 CCR § 354.14(d)(5)**

As shown on **Figure 7-3**, six major streams flow into and/or through the Basin and merge in the southwest where Arroyo de la Laguna flows out of the Basin. The other Arroyos and major surface water bodies include the Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, Alamo Creek, Altamont Creek, South San Ramon Creek, Tassajara Creek, COLs, and Springtown Alkali Sink.

Both the Arroyo Valle and Arroyo Mocho originate in the woodland forests of the Burnt Hills region in Santa Clara County, in the sub-watershed above Lake Del Valle. The two streams and their tributaries cover the largest drainage areas within the Zone 7 service area. The Arroyo Valle flows into Lake Del Valle above Lang Canyon, and then continues below the Del Valle Dam, flowing westerly through a regional park on the southern border of Livermore before reaching Pleasanton. Flowing southwesterly through the historic downtown area of Pleasanton, the Arroyo Valle ultimately joins the Arroyo de la Laguna at the southwestern outflow from the Basin. The Arroyo de la Laguna is a tributary to Alameda Creek.

The Arroyo Mocho remains a natural waterway as it flows southwest through the oak woodlands east of Livermore, then continues through the southern portion of Livermore. West of Livermore, the Arroyo Mocho has a graded and engineered channel, which proceeds through the gravel mining area and merges with the Arroyo Las Positas just northwest of Livermore. The Arroyo Las Positas mainly flows westerly along Interstate 580 and is fed by the Arroyo Seco, Altamont Creek, Cayetano Creek, Collier Canyon Creek, and Cottonwood Creek. At its confluence with the Arroyo Mocho in Livermore, the streambed becomes a wide, trapezoidal-shaped flood control channel. The Arroyo Mocho then flows into the Arroyo de la Laguna at the surface and subsurface outflow from the Basin.

Although minor springs contribute to the upper reaches of the Arroyo Mocho and Arroyo Valle above Lang Canyon, none of these springs contribute sufficient runoff to the Arroyos to cause continuous flow in the streams. Most are isolated and are subject to tectonic shifts and climatic conditions that impact the amount of flow emanating.

Figure 7-17 shows the COL, a series of gravel quarries in the central portion of the Basin (Amador Subarea). Some of COLs are used currently for conjunctive use, which will be expanded in the future as ongoing gravel mining is completed and additional quarries are available for Zone 7 use for flood control and managed aquifer recharge. Full implementation of the COLs by Zone 7 is not expected before 2058 when the mining operations are projected to be completed. The Arroyo Valle channel is located along the southern perimeter of the mining area, while the Arroyo Mocho channel has been directed through the middle of the mining area.

The Springtown Alkali Sink, as shown on **Figure 7-11**, is characterized by gently sloping lowland underlain by alluvium and confined in part by shallow bedrock. Historical springs within the Springtown Alkali Sink were caused by high groundwater levels. Development occurred in the area in the late 1960s when Altamont Creek was deepened (up to 15 ft bgs). The deepening of the creek is thought to have created a local drain for shallow groundwater and significant springs no longer occur in the Springtown Alkali Sink. As a result, groundwater elevations are lower than they once were, causing the wetlands to be more seasonal. Currently, less-prominent springs occur in various areas of the sink only during wet periods when the water table is high.

The Springtown Alkali Sink is considered a Groundwater Dependent Ecosystem (GDE) for the purposes of Sustainable Groundwater Management Act (SGMA), as discussed in **Section 8.8**. The Springtown Alkali Sink supports an alkali-saline wetland habitat with seasonal surface ponding and shallow, seasonal high-salinity groundwater. The Springtown Alkali Sink has a mound and swale topography allowing alkali scalds to form in surface water ponds where groundwater is shallow. These scalds support salt-tolerant plants. In areas with better drainage, water accumulates in pools supporting vernal pool biota. The Springtown Alkali Sink also contains several protected species including the Palmate-Bracted Bird's Beak, burrowing owl, tiger salamander, and the fairy shrimp (**Section 8.8**).

7.7.6. Source and Point of Delivery for Imported Water Supplies

☑ 23 CCR § 354.14(d)(6)

Zone 7 ensures that local water supplies (e.g., groundwater) are not depleted by importing approximately 80% of the Basin's water supply from SWP (delivered to Zone 7's retailers and agricultural customers) and recharging the Main Basin with surplus surface water when available (artificial recharge). **Figure 7-18** shows the point of delivery for imported water supplies.

Zone 7's surplus surface water supplies, which are accounted for by calendar year, come from the following sources:

- **State Water Project (SWP deliveries via the South Bay Aqueduct [SBA])** – As a SWP contractor, Zone 7 imports supplies from the SWP through the SBA. As of 1998, Zone 7 has had an annual maximum SWP contract amount of 80,619 AFY referred to as the "Table A Contract Amount." However, actual SWP deliveries are usually allocated in any given year by the DWR at a lower level based on numerous factors, including hydrologic conditions. Currently, the long-term reliable yield of the SWP is approximately 60% of the Table A amount (48,370 AFY).
- **Arroyo Valle Water Rights (Lake Del Valle)** – Zone 7 has temporary water rights for a portion of the natural flows into Lake Del Valle. Accordingly, Zone 7 coordinates releases from the reservoir into the Arroyo Valle to maintain downstream flows and streambed recharge at the levels that would have occurred had the reservoir not been constructed. Additional releases of Arroyo Valle water can be made from the lake when such water is available for Zone 7. Maintaining minimum flows is a condition of Zone 7's water rights permit for the Arroyo Valle water. Zone 7 can also use other portions of Arroyo Valle water for supply to its treatment plants and for supplemental aquifer recharge. Zone 7 is currently pursuing the permanent rights to this surface water source.
- **Kern County Subbasin (storage rights only)** – Zone 7 has purchased water storage rights in the Semitropic Water Storage District (78,000 AF) and in the Cawelo Water District (120,000 AF) in Kern County. These rights give Zone 7 the ability to remotely store surplus SWP water when available. When Zone 7 is ready to use the water locally; it can import that quantity of SWP water through an exchange procedure within the SWP system.
- **Lower Yuba River Accord (Yuba Accord)** – In 2008, Zone 7 entered a contract with DWR to purchase additional water under the Yuba Accord. The contract was amended in 2020 to extend through 2025. There are four different Components (types) of water available; Zone 7 has the option to purchase Component 2 and Component 3 water during drought conditions, and

Component 4 water when Yuba County Water Agency has determined that it has water supply available to sell. Zone 7 estimates the average yield from the Yuba Accord to be 850 AFY.

- **Dry Year Transfer Program** – The State Water Contractors, an organization composed of contractors of the SWP, facilitates the purchase of water from the Feather River Watershed for transfer to SWP contractors during dry years. This is an optional program that Zone 7 has utilized on an as-needed basis.
- **Other Transfers** – As part of Zone 7's long-term reliability program, Zone 7 actively seeks out transfers from other agencies or districts that have water available.

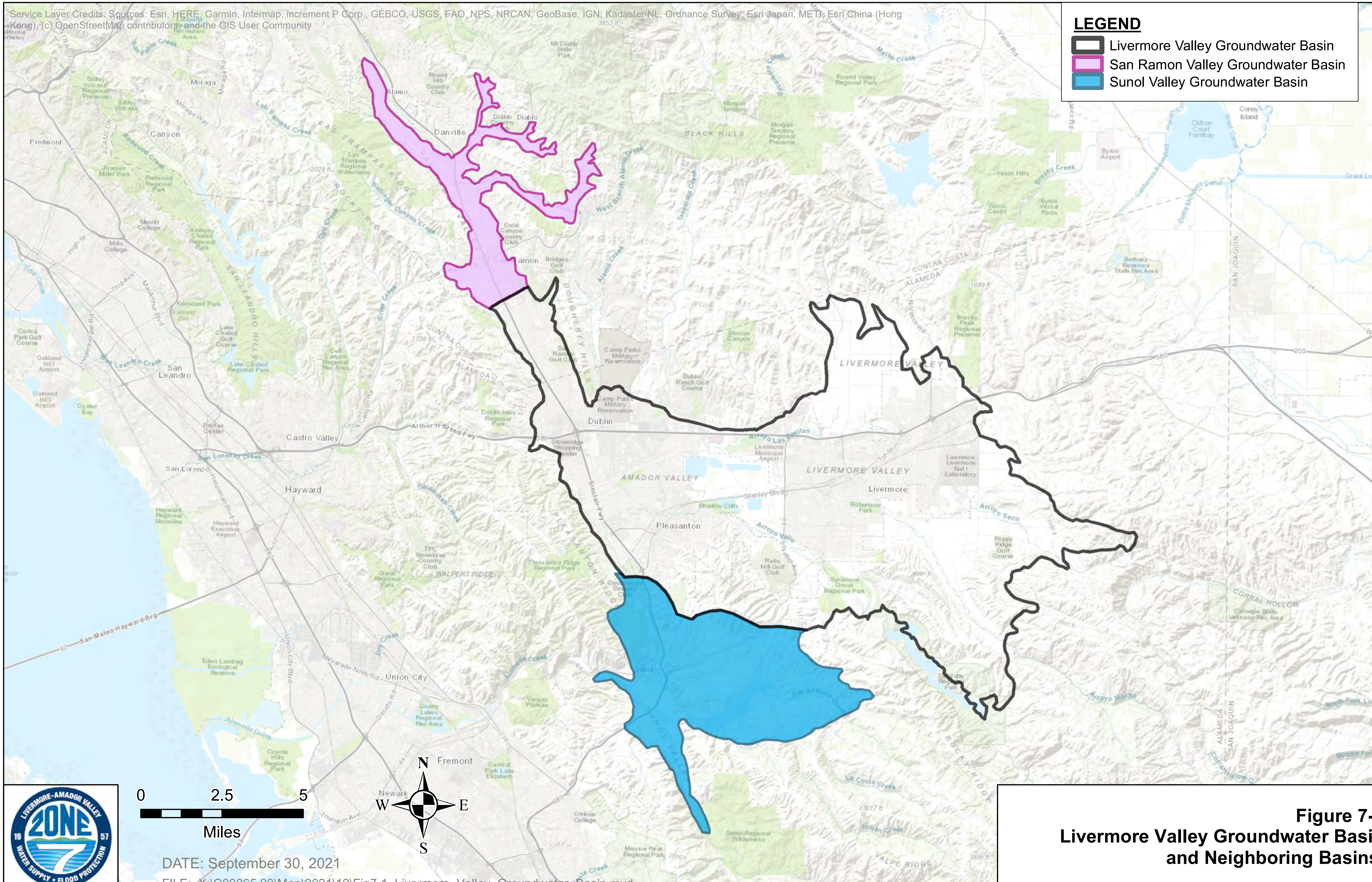
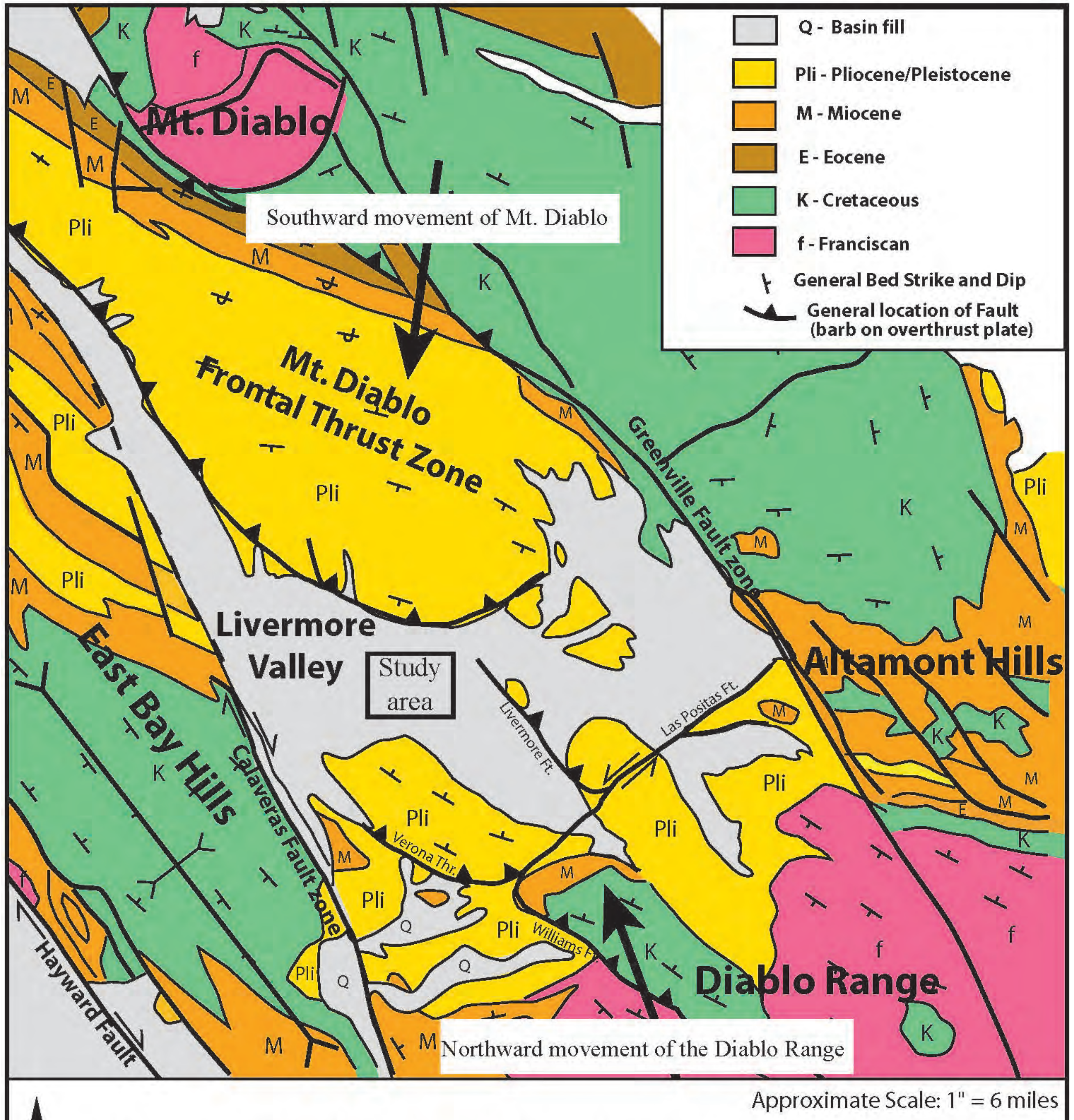


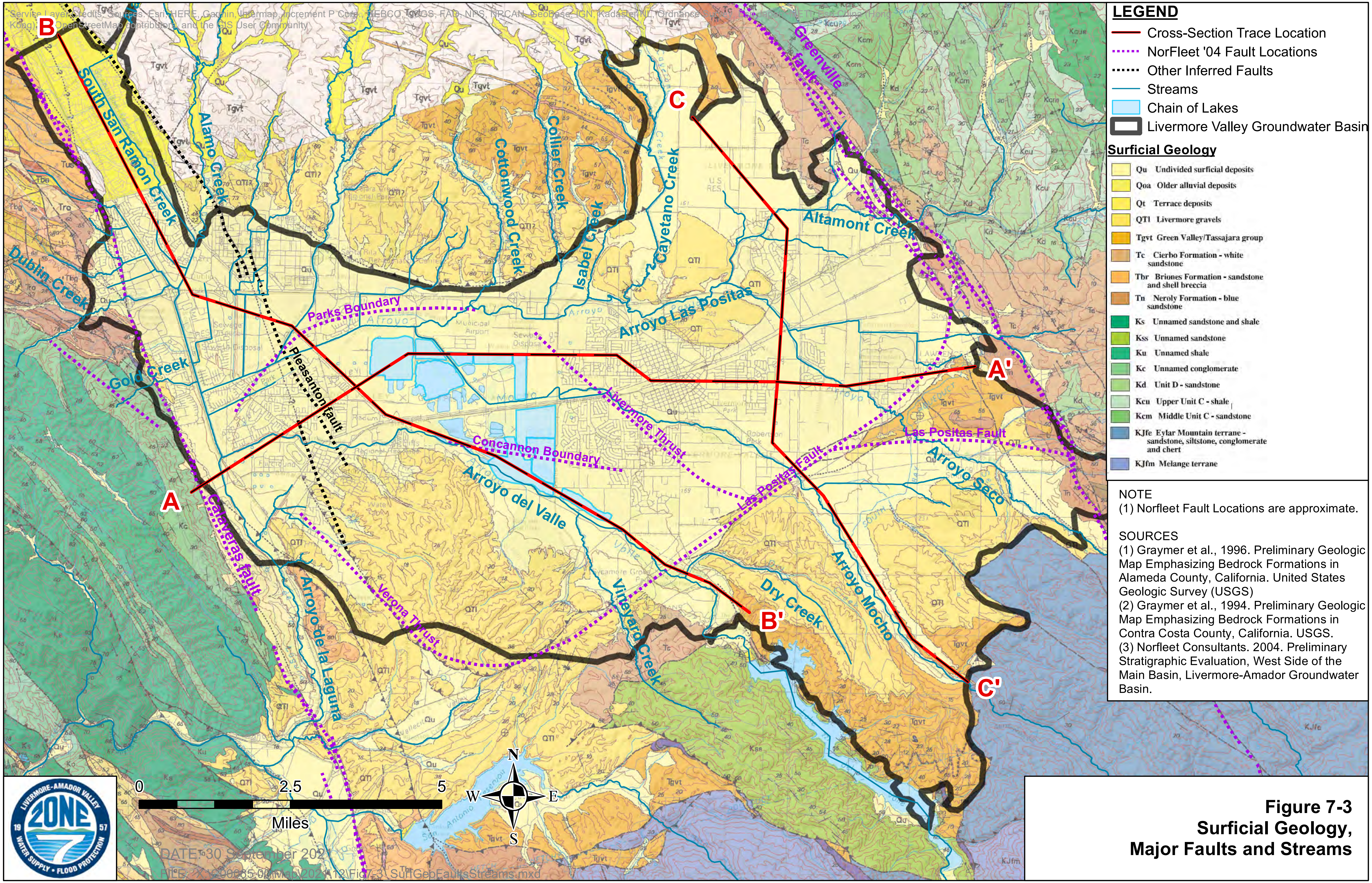
Figure 7-1
Livermore Valley Groundwater Basin and Neighboring Basins



A generalized geologic/ tectonic map of the greater Livermore Valley area. The current Livermore Valley is the result of the deformation of the Proto-Livermore Basin between the southward movement of the Mt. Diablo thrusts and the northward component of movement of the Diablo Range, south of the valley. There has been minor deformation of the Valley adjacent to the Calaveras and Greenville fault zones.

Source: Norfleet Consultants, 2004. *Preliminary Stratigraphic Evaluation, West Side of the Main Basin, Livermore-Amador Groundwater Basin.* Figure 3-1

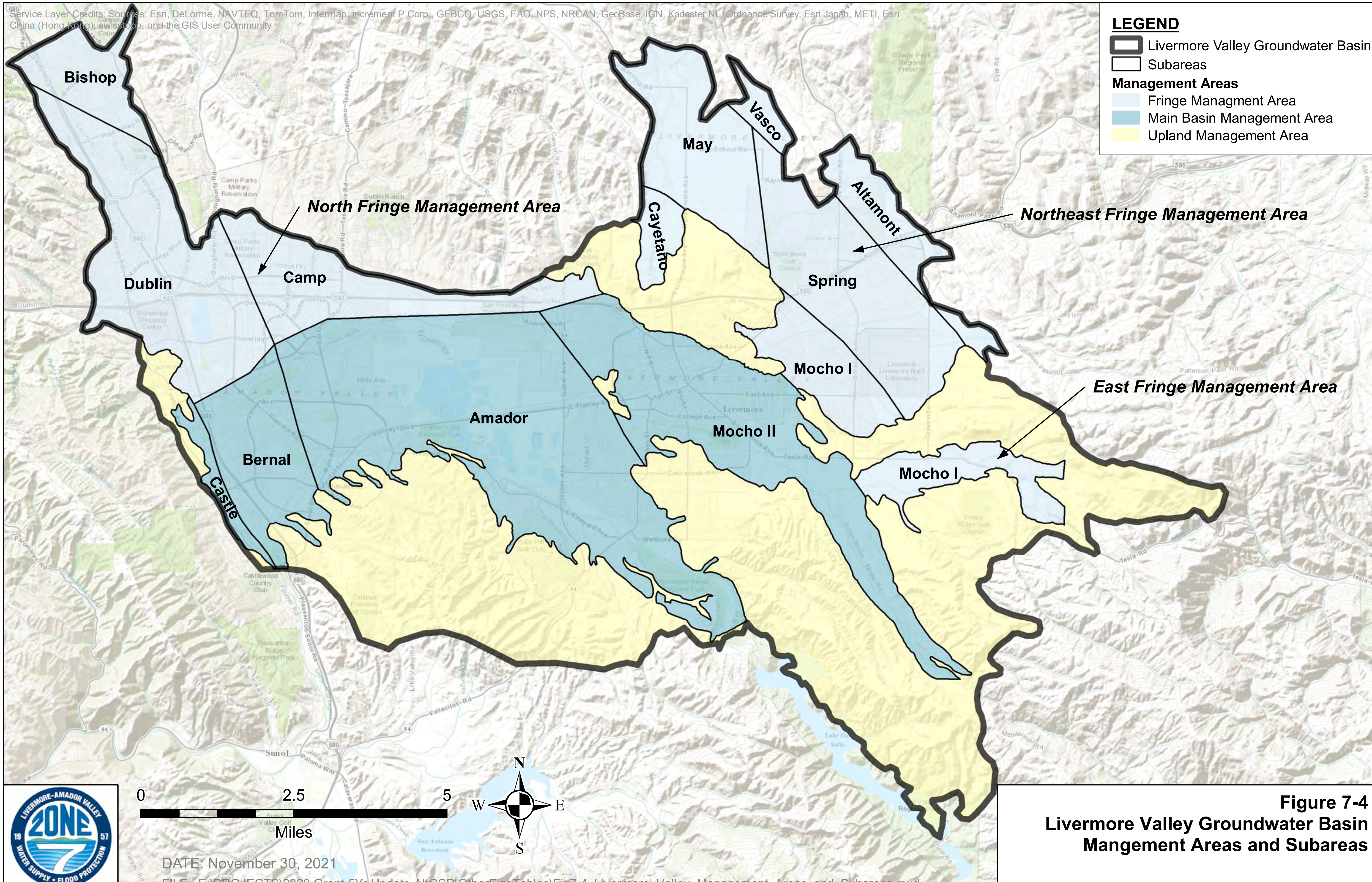
Figure 7-2
Generalized Geologic/Tectonic Map of the Livermore Valley



NOTE
(1) Norfleet Fault Locations are approximate.

SOURCES
(1) Graymer et al., 1996. Preliminary Geologic Map Emphasizing Bedrock Formations in Alameda County, California. United States Geologic Survey (USGS)
(2) Graymer et al., 1994. Preliminary Geologic Map Emphasizing Bedrock Formations in Contra Costa County, California. USGS.
(3) Norfleet Consultants. 2004. Preliminary Stratigraphic Evaluation, West Side of the Main Basin, Livermore-Amador Groundwater Basin.

Figure 7-3
Surficial Geology, Major Faults and Streams



DATE: November 30, 2021

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Figure 7-4
Livermore Valley Groundwater Basin
Mangement Areas and Subareas

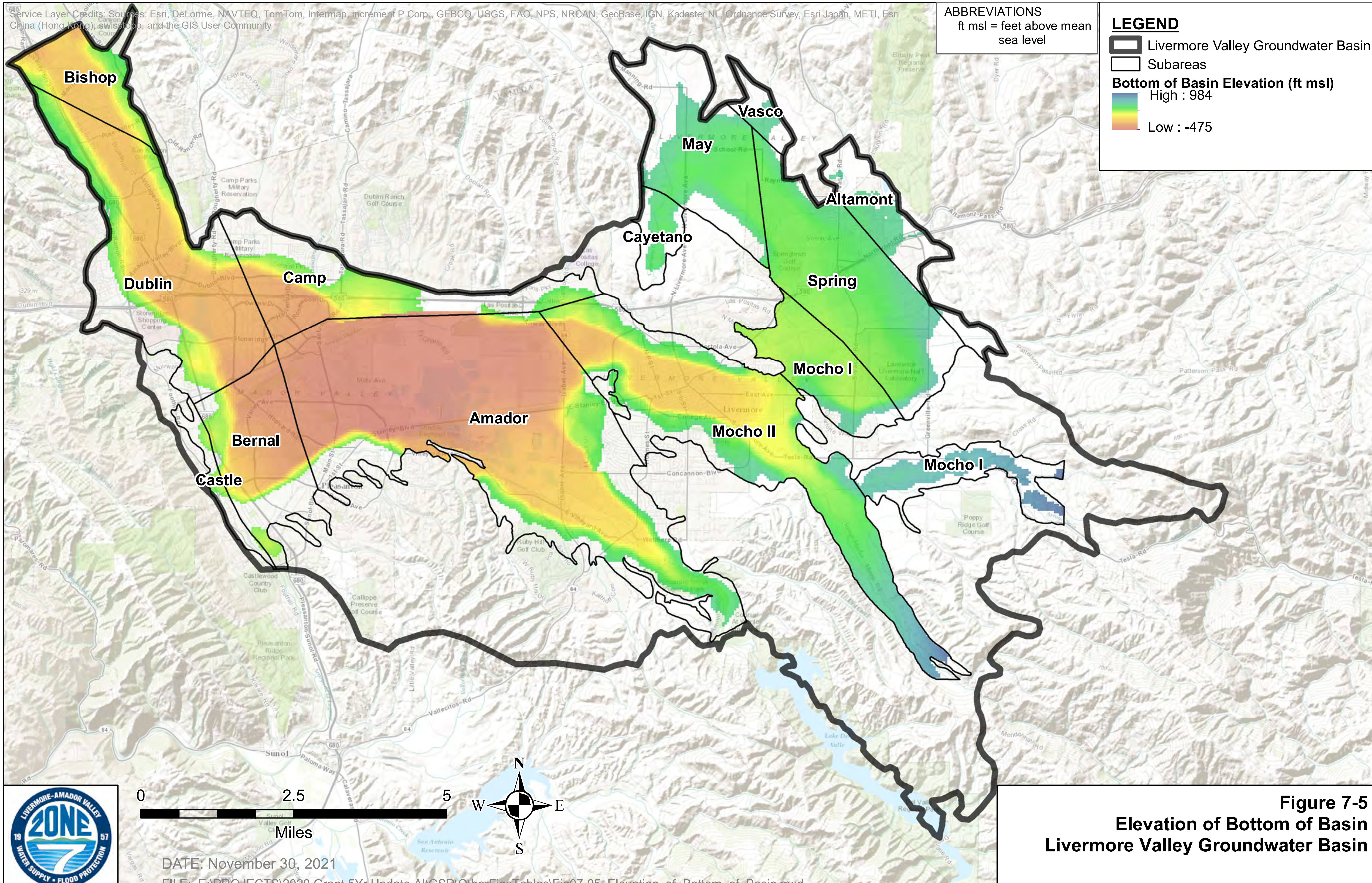
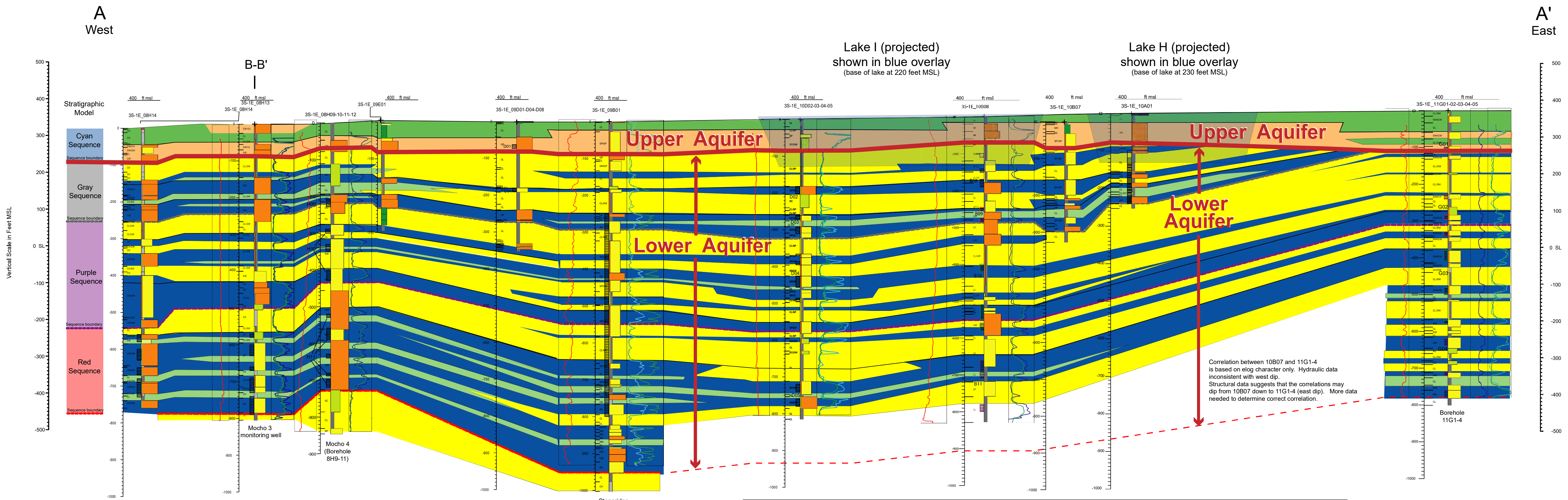


Figure 7-5
Elevation of Bottom of Basin
Livermore Valley Groundwater Basin



Source: Plate 3.
Cross Section A-A' Chain-of-Lakes Area
Livermore Valley

Zone 7 Water Agency

Stratigraphic Interpretation by
Kenn Ehman and Rick Blake
December 2003

Assistance from
Tom Rooze, Zone 7 Water Agency
David Lunn, Zone 7 Water Agency
Ken Stevens, CIS Solutions
Rick Cramer, Groundworks Environmental, Inc.
Sands Figuers, Norfleet Consultants

0 1000 2000 3000 4000 5000

Approximate Horizontal Scale in Feet

5:1 Vertical Exaggeration

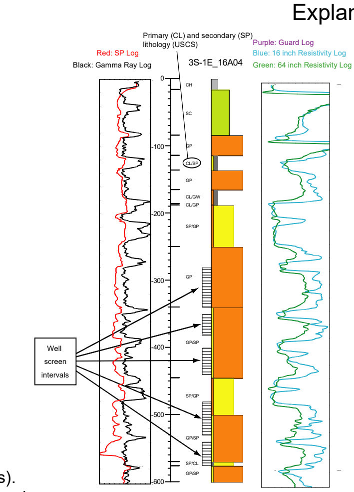
Skyline Ridge, Inc.

Explanation

Major Generalized Stratigraphic Facies

- Overbank and lacustrine clays and silts (aquitard facies) exposed at Lake I.
- Fluvial gravels ("Carol's Cut Gravel") (aquifer facies) exposed at Lake I.
- Fluvial overbank and floodplain clays and silts (aquitard facies). May include lacustrine facies.
- Fluvial and deltaic(?) sands and gravels (aquifer facies)
- Regional correlative lacustrine clay and silt units (aquitard facies). May include floodplain and overbank facies.

Colors at the request of Zone 7 for consistency with previous work.



Graphic Grainsize Log Explanation

USCS	Lithology
CH	Clays and silts
CL	
FI "Fill"	
OH	
OL	
MH	Silts and clays
ML	
SC	Silty and clayey sands
SM	
SP	Sands
SW	
GC	Gravels
GM	
RX "Rocks"	
GP	
GW	
PT Peat	

ZONE 7 LIVERMORE-AMADOR VALLEY WATER SUPPLY • FLOOD PROTECTION 1957

Figure 7-6
Norfleet 2004 Cross-Section A-A'

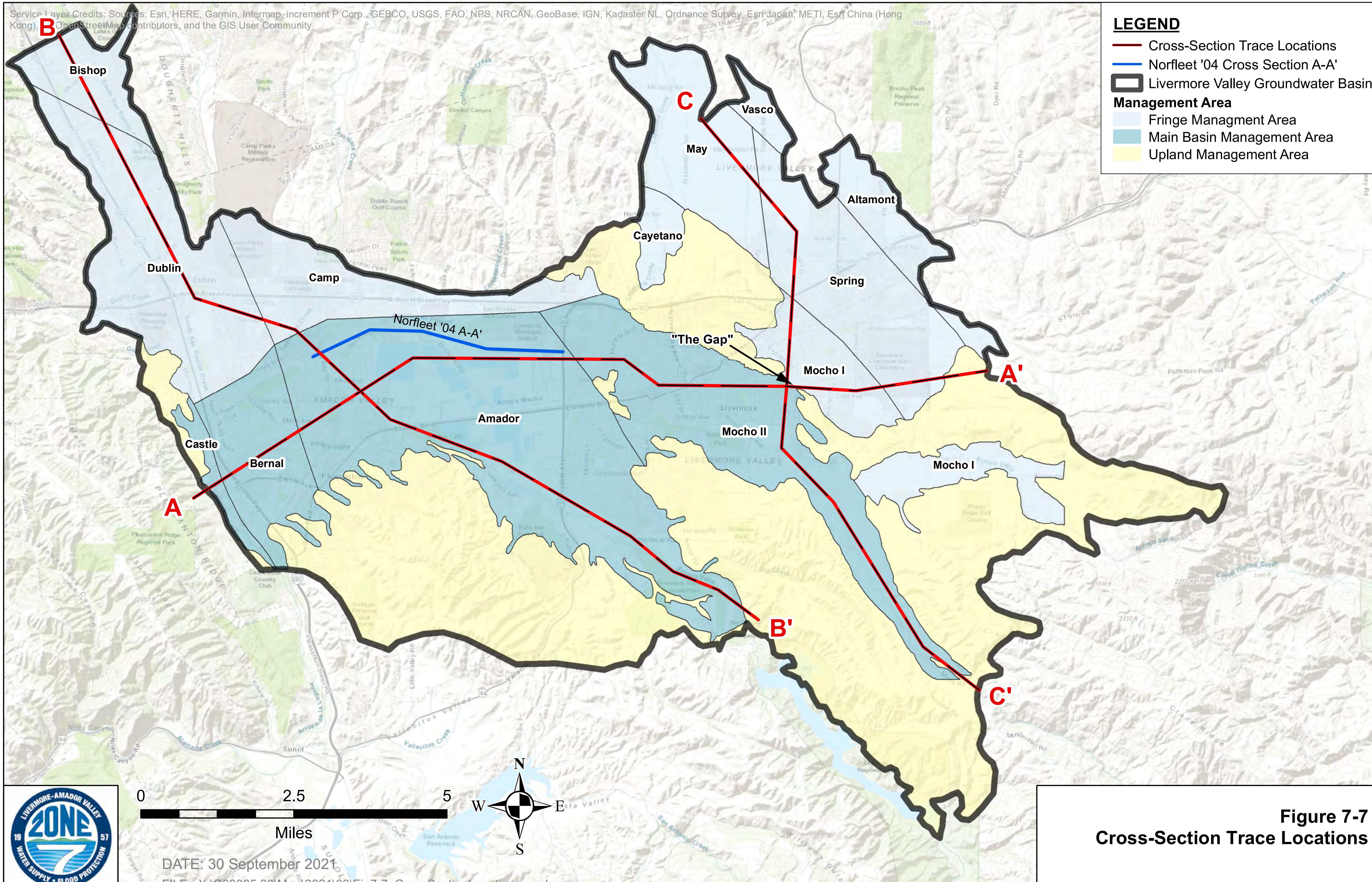


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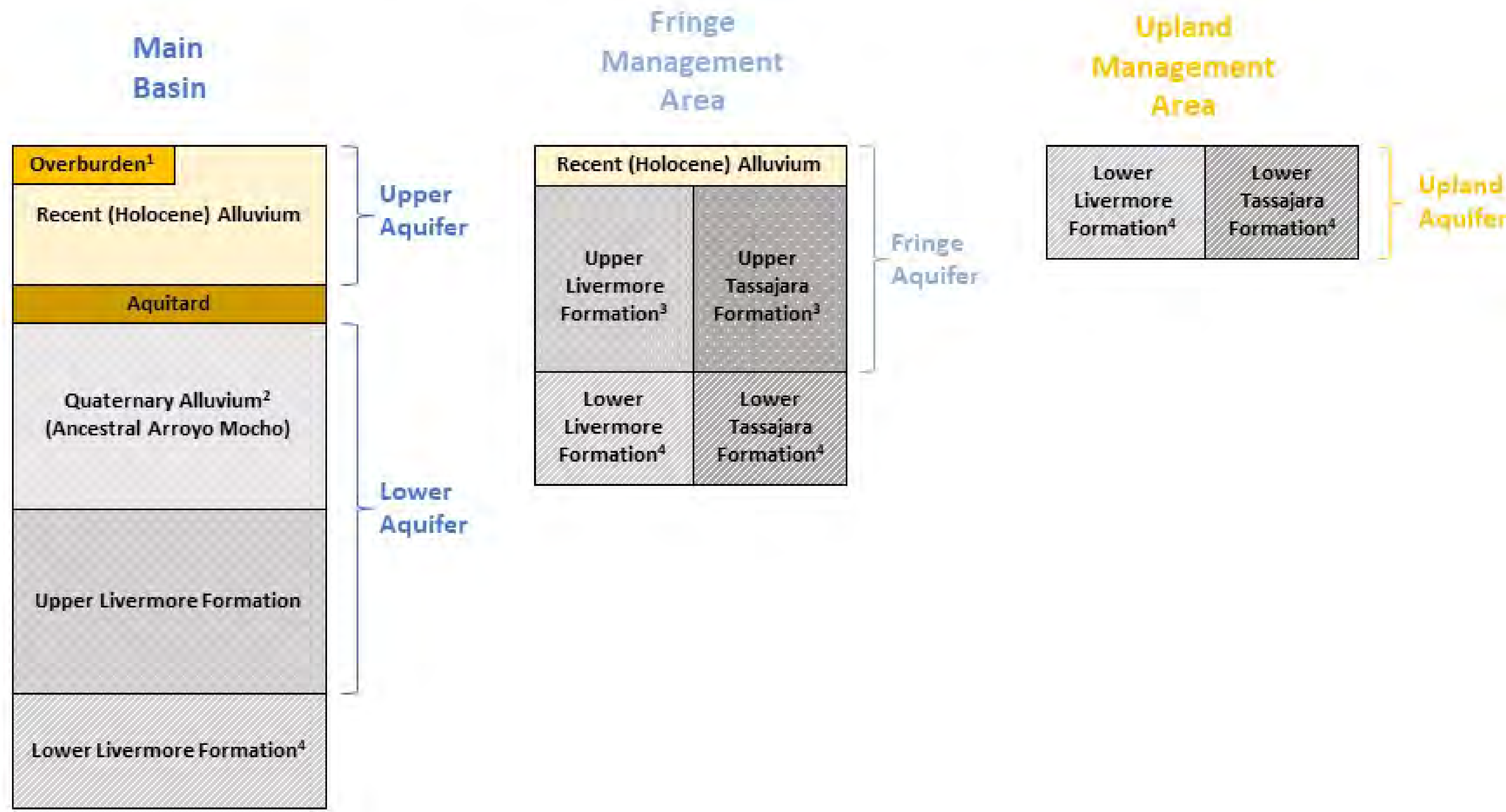
Figure 7-7
Cross-Section Trace Locations

Livermore Valley Groundwater Basin
Conceptual Hydrostratigraphy Model



Notes:

1 Only encountered in western portion of Main Basin (Bernal, Amador subareas)

2 Only encountered where Ancestral Arroyo Mocho incised valley complex exists (see Norfleet 2004, Figure 3-5)

3 Tassajara Formation encountered in northwestern (Bishop, Dublin, Camp subareas) and northeastern (May, Cayetano subareas) portion of Fringe Management Area; Livermore Formation encountered in all other Fringe subareas

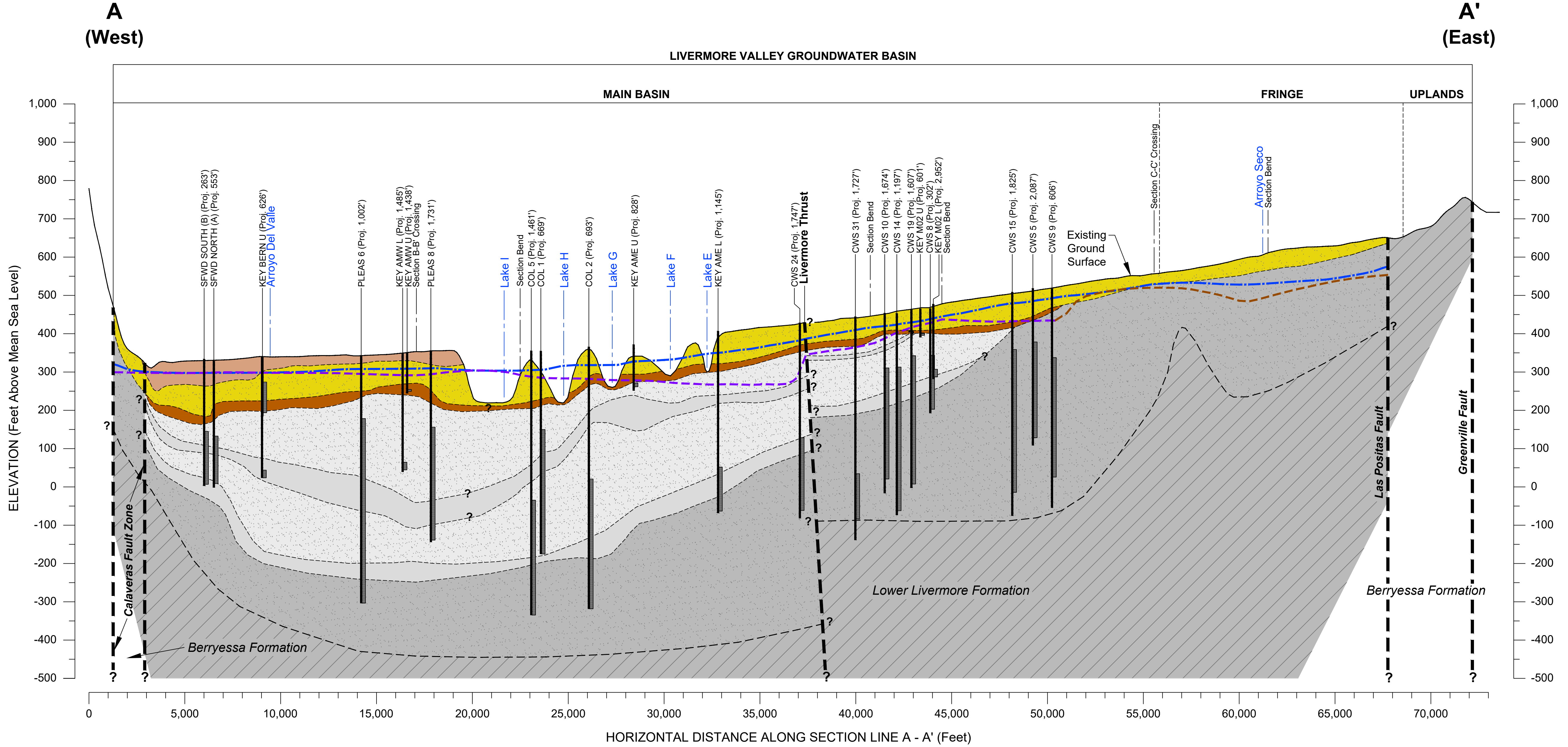
4 Considered generally impermeable and below the bottom of the usable groundwater basin

5 Drawings not to scale; for discussion purposes only

Conceptual Hydrostratigraphy Model

Zone 7 2022 Alternative GSP
Livermore, CA
October 2021
EKI C00065.00

Figure 7-8



Cross-Section A - A'

Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)

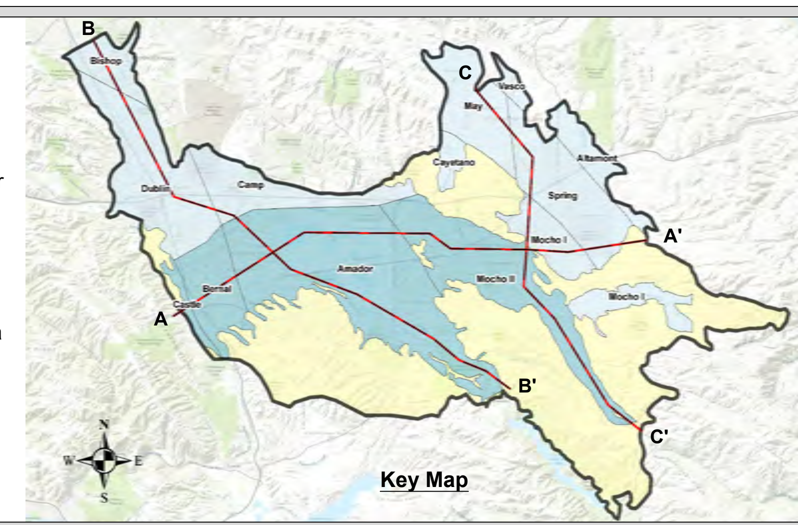
- Well Log
- Screen Interval

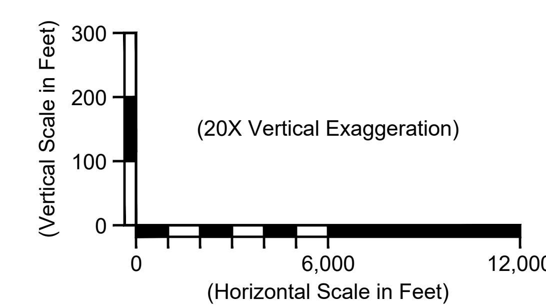
Map Elements

- A —— A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



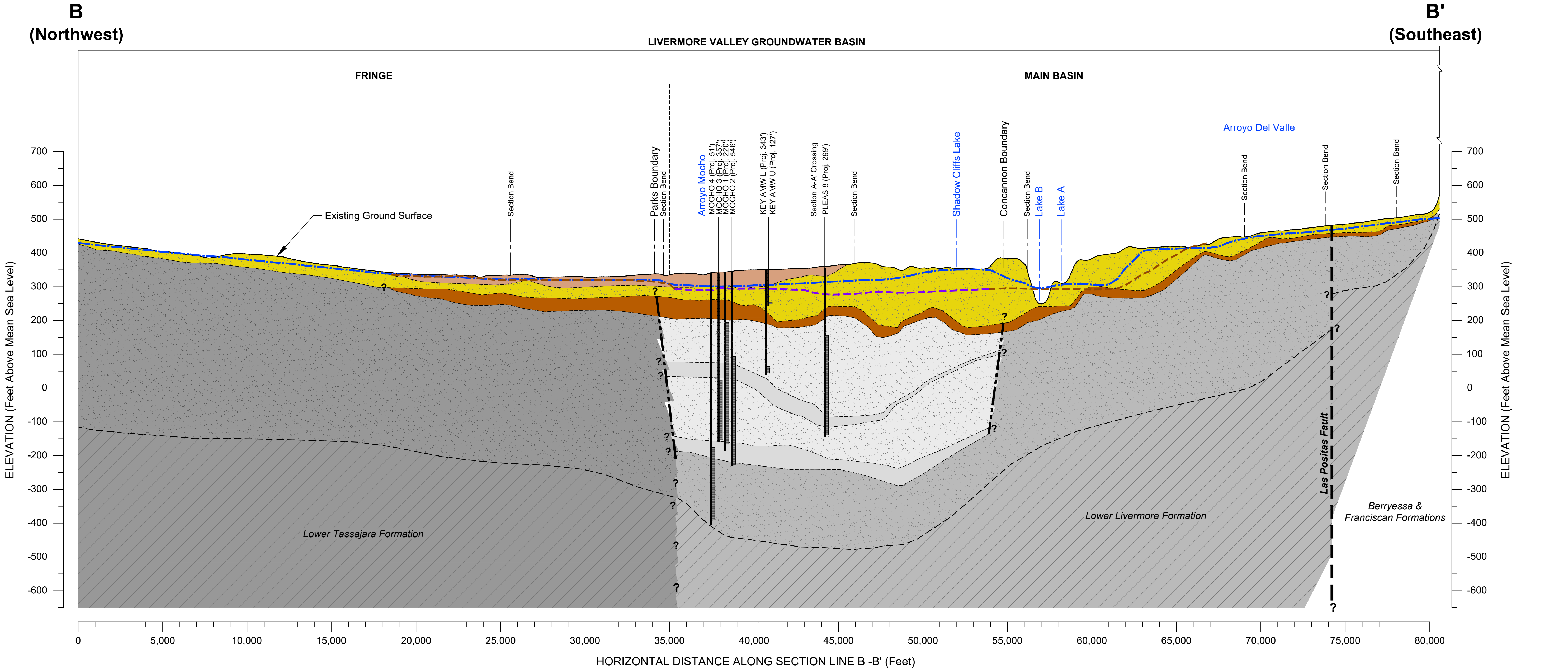


Geologic Cross-Section A - A'

Zone 7 2022 Alternative GSP
Livermore, CA
December 2021
EKI C00065.00

eki environment & water

Figure 7-9



Cross-Section B - B'

Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

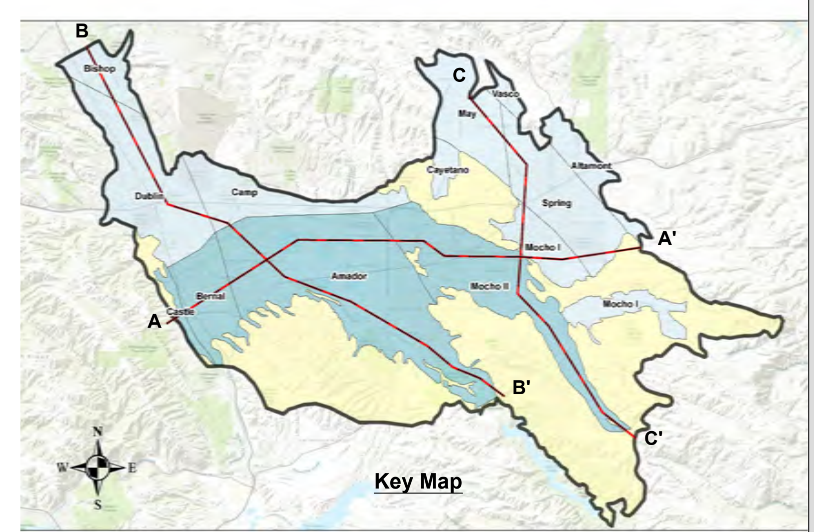
- Well Log
- Screen Interval

Map Elements

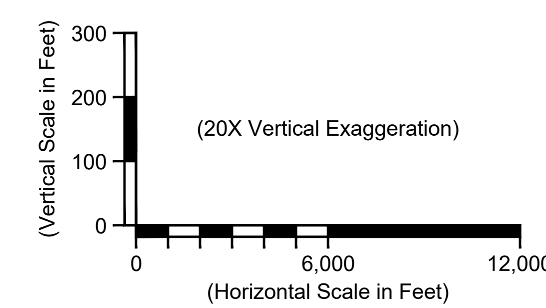
- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Key Map



Geologic Cross-Section B - B'

Zone 7 2022 Alternative GSP
Livermore, CA
October 2021
EKI C00065.00

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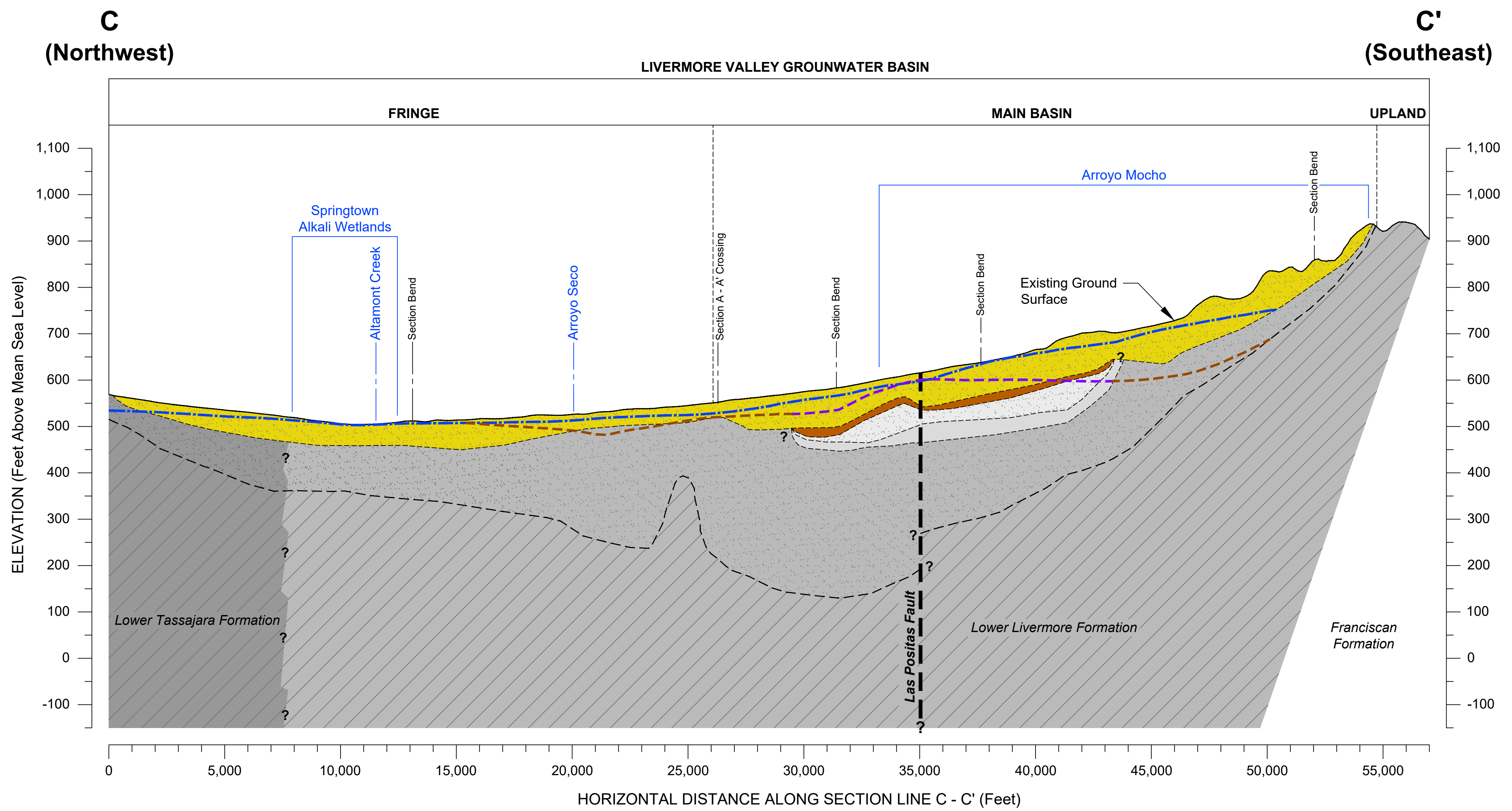
Figure 7-10

20210603.085531 G:\C00065.00\2021-06_Cross Section B-B.dwg Section B-B'



Cross-Section C - C'

Legend:

Stratigraphy

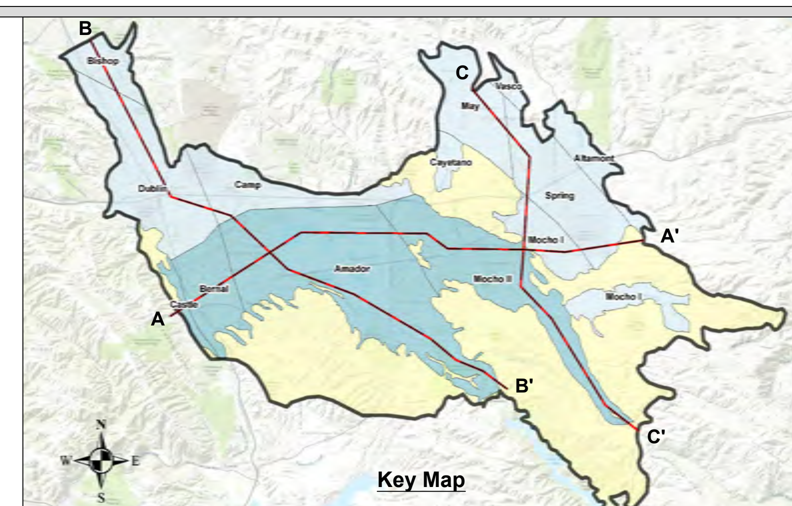
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Map Elements

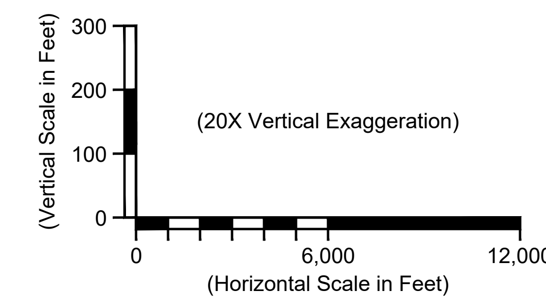
- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Key Map



Geologic Cross-Section C - C'

Zone 7 2022 Alternative GSP
Livermore, CA
October 2021
EKI C00065.00

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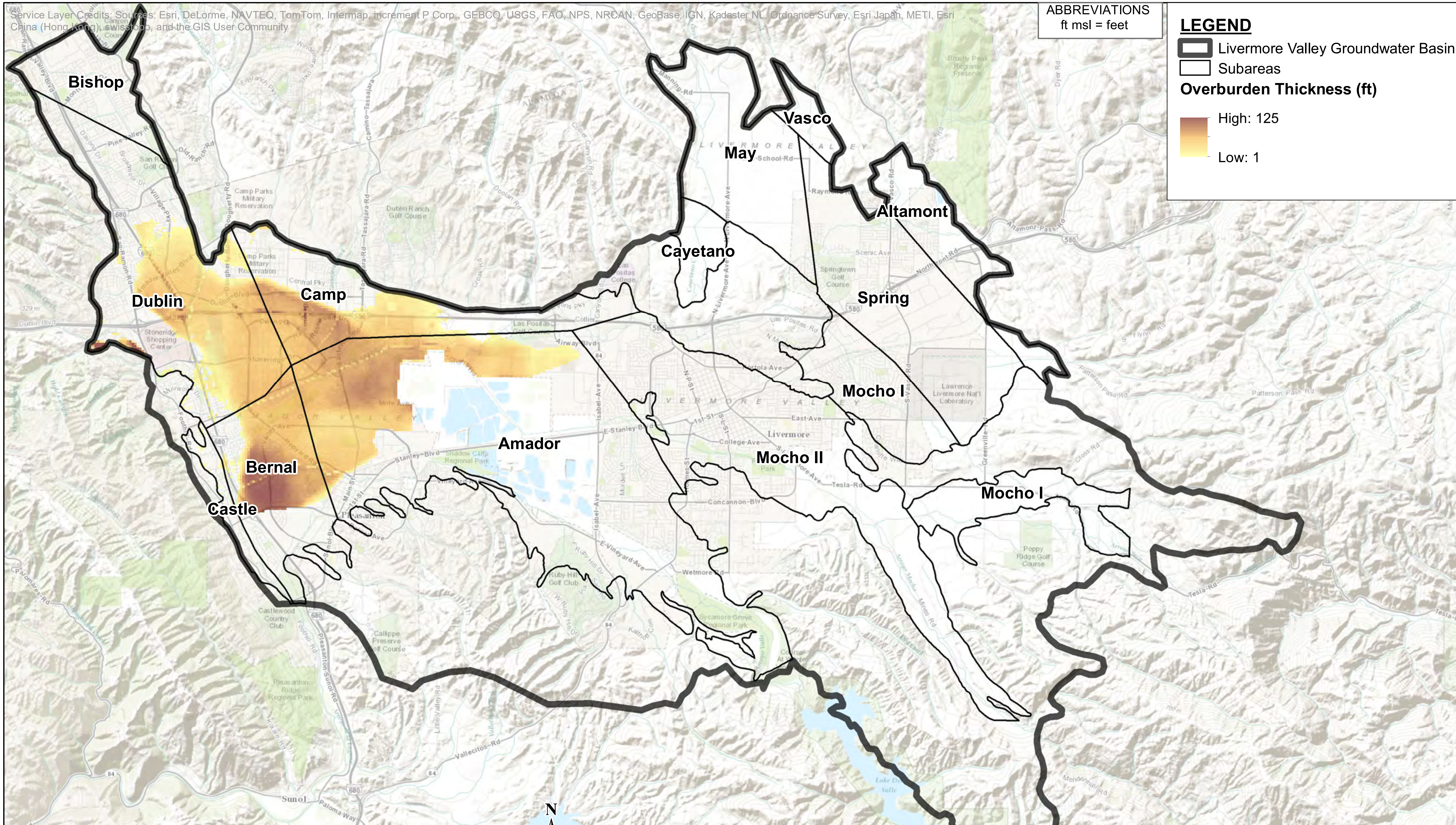
Figure 7-11

20210603.085444 G:\C00065.00\2021-06_Cross Section C-C.dwg Section C-C'



DATE: November 30, 2021

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Figure 7-12
Overburden Thickness
Livermore Valley Groundwater Basin

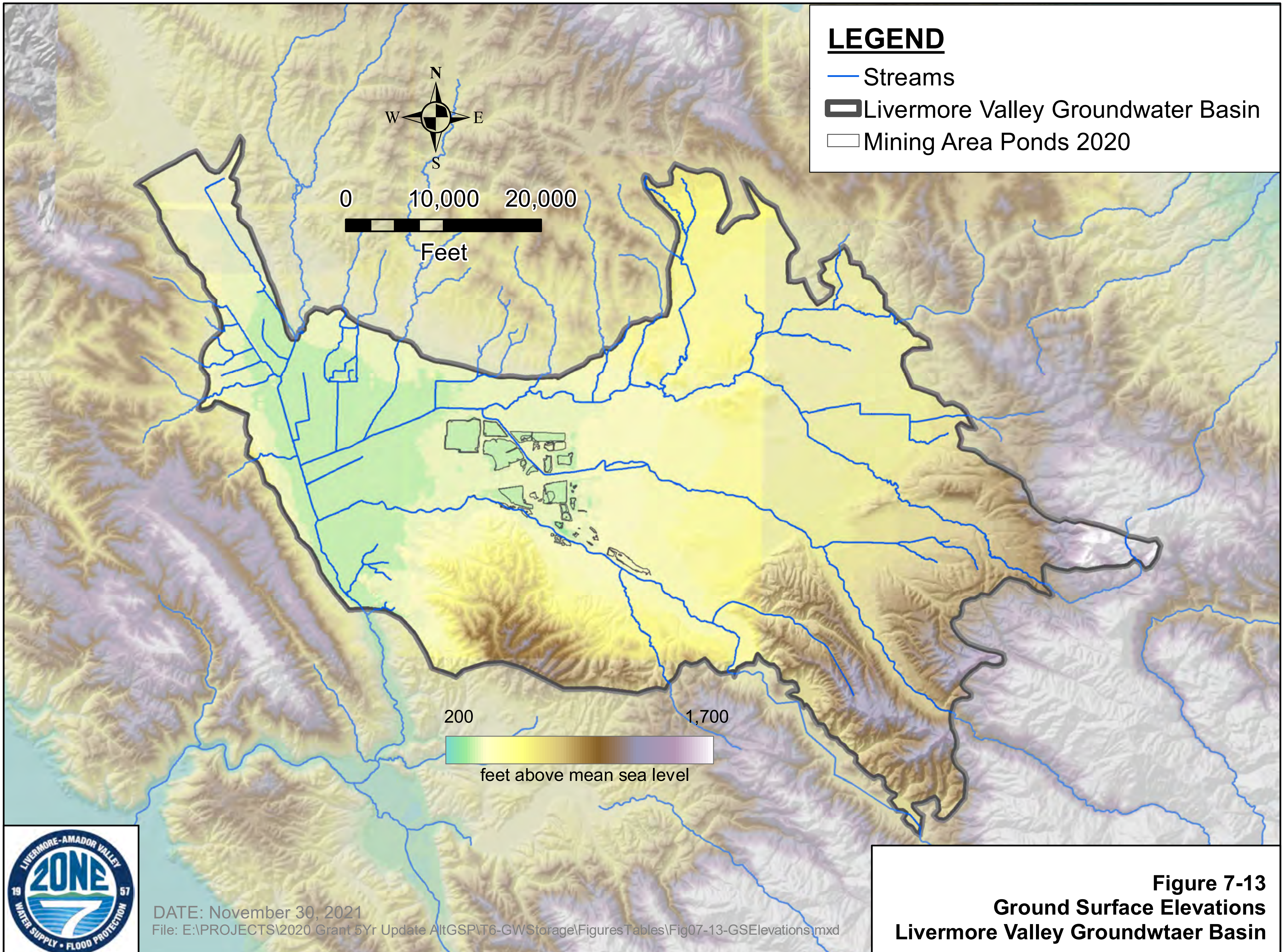


Figure 7-13
Ground Surface Elevations
Livermore Valley Groundwtaer Basin

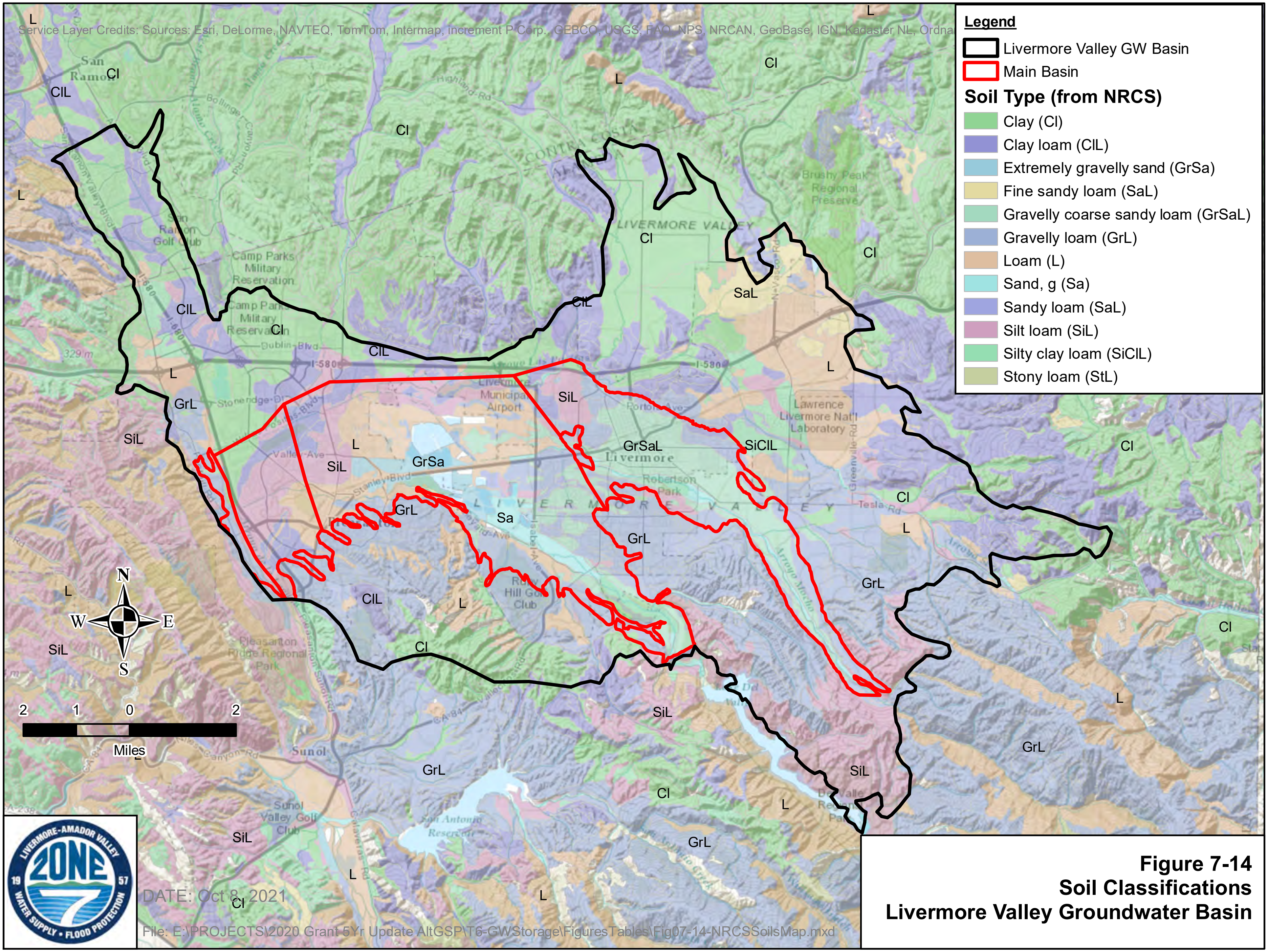


Figure 7-14
Soil Classifications
Livermore Valley Groundwater Basin

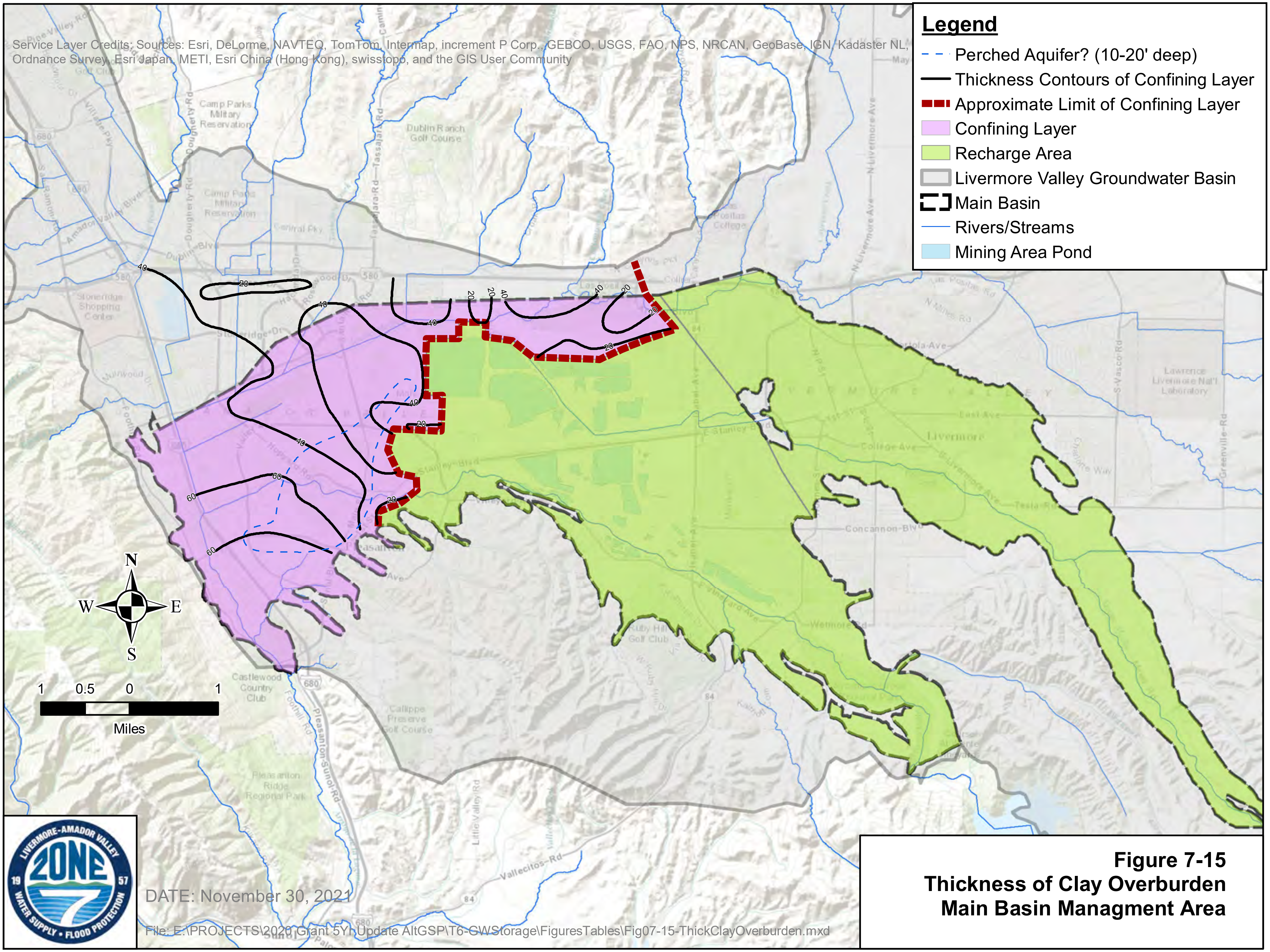
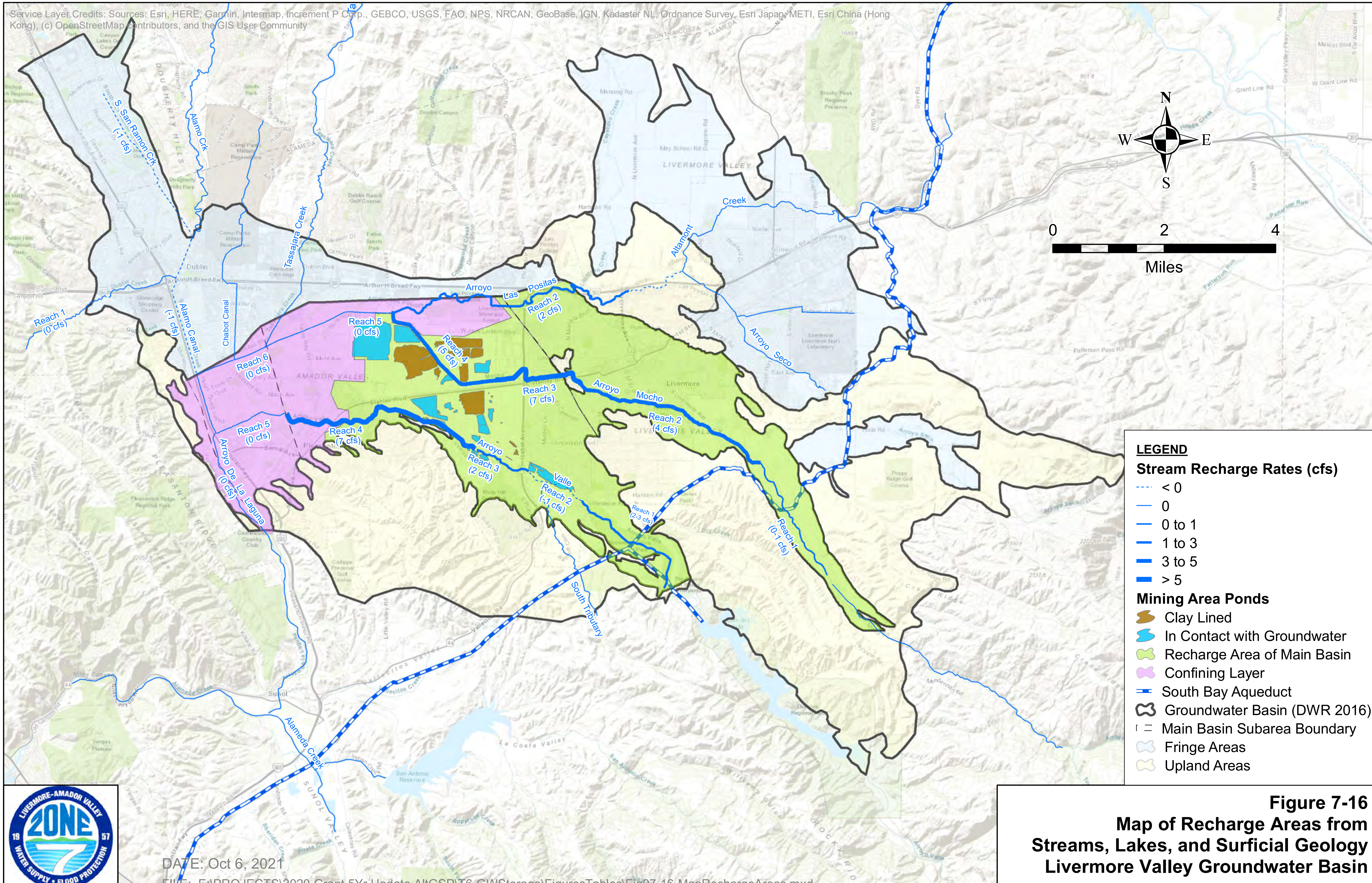


Figure 7-15
Thickness of Clay Overburden
Main Basin Managment Area



DATE: Oct 6, 2021

FILE: E:\PROJECTS\2020 Grant 5Yr Update AltGSP\T6-GWStorage\FiguresTables\Fig07-16-MapRechargeAreas.mxd

Figure 7-16
Map of Recharge Areas from Streams, Lakes, and Surficial Geology Livermore Valley Groundwater Basin

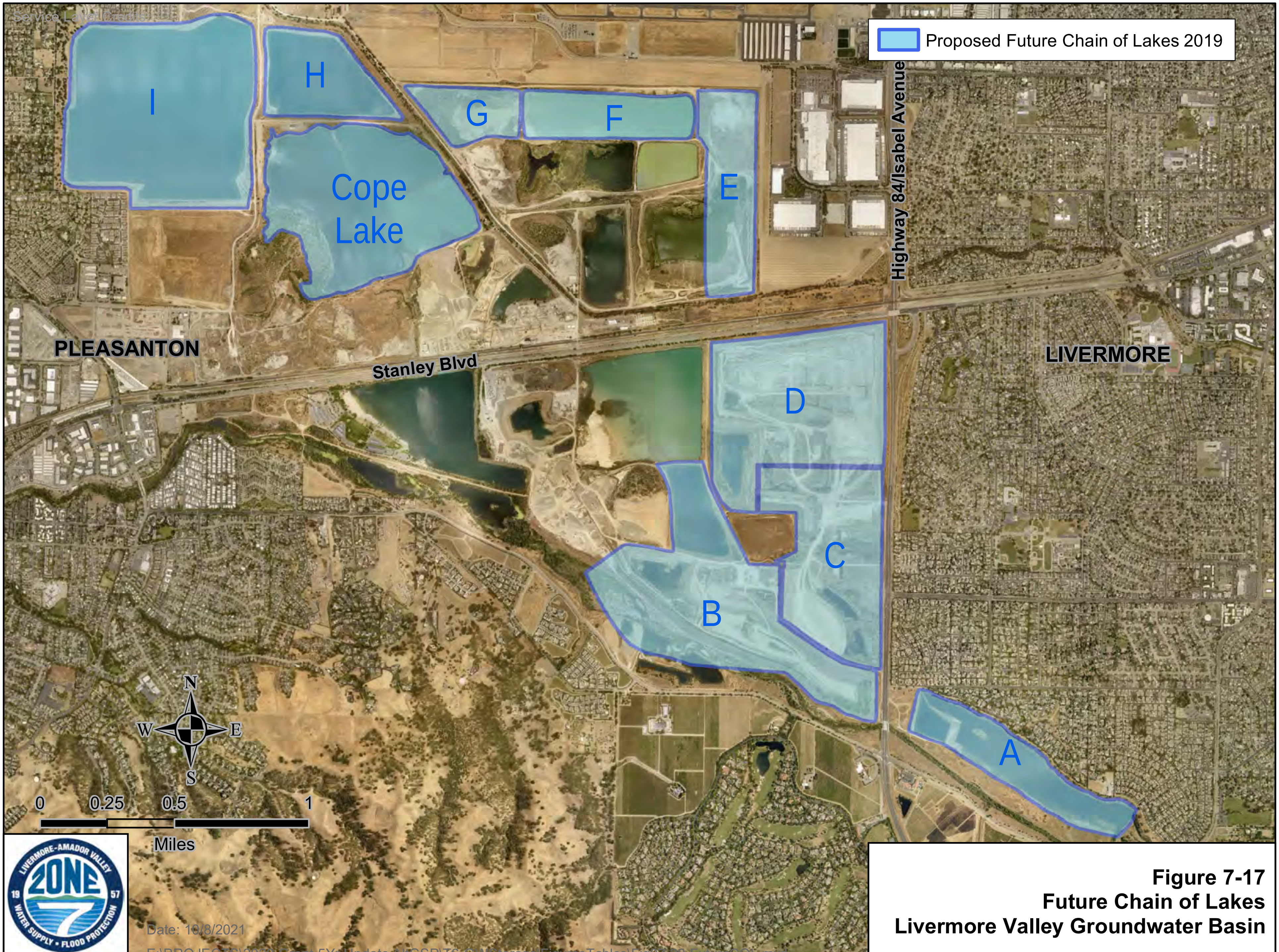


Figure 7-17
Future Chain of Lakes
Livermore Valley Groundwater Basin

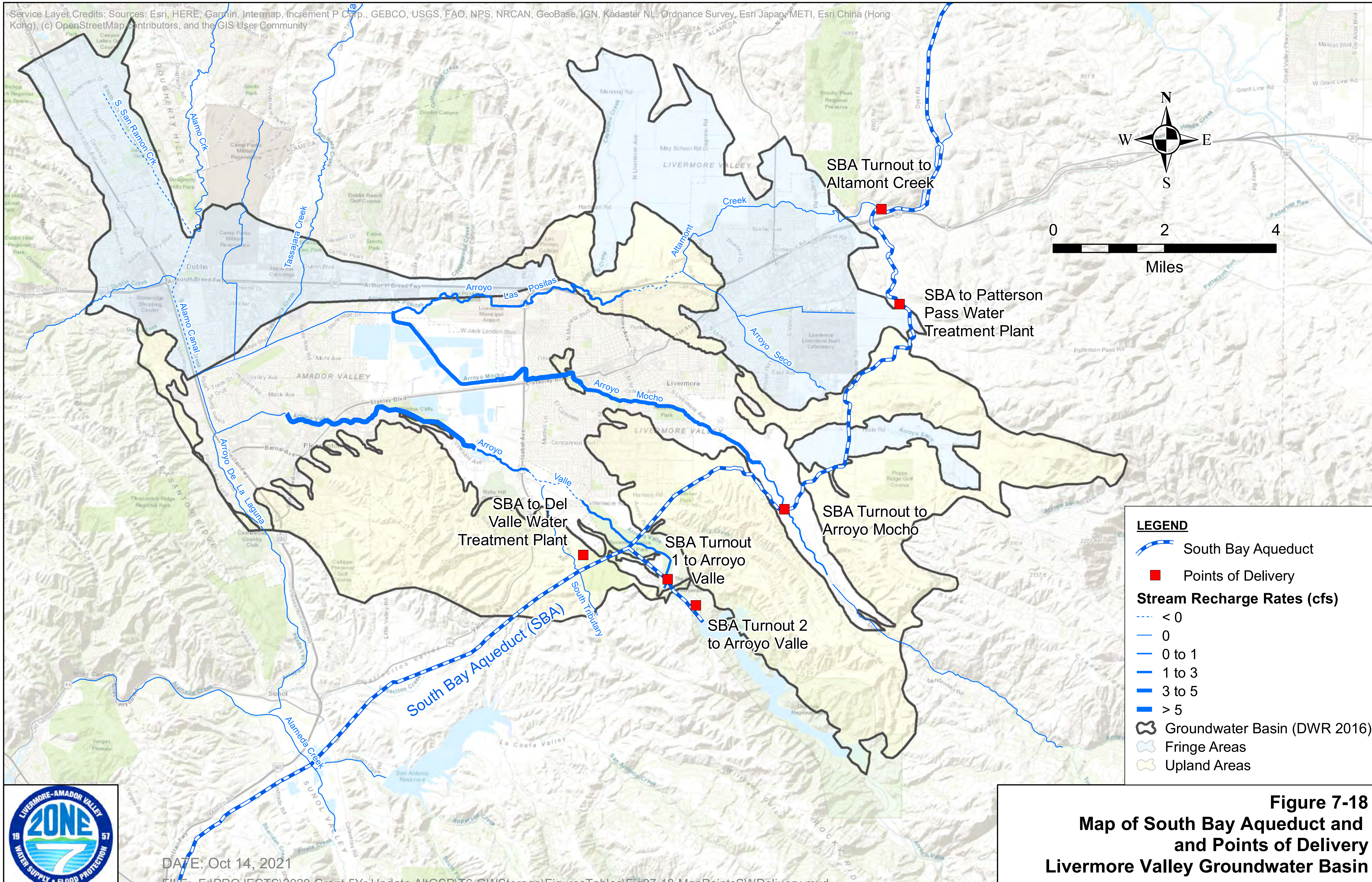


Figure 7-18
Map of South Bay Aqueduct and and Points of Delivery Livermore Valley Groundwater Basin

8. CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

8.1. Introduction

§ 354.16. Groundwater Conditions
Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

☑ **23 CCR § 354.16**

§ 356.4 Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.
...
(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.
(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.

☑ **23 CCR § 356.4 (a)**
☑ **23 CCR § 356.4 (c)**
☑ **23 CCR § 356.4 (d)**

This section characterizes current and historical groundwater conditions in the Livermore Valley Groundwater Basin (Basin). Best available data are used to characterize current conditions, 2020 Water Year (WY) conditions, and historical conditions (i.e., the period from 1974 WY to 2020 WY). Subsections below address data sources and compilation (**Section 8.2**), groundwater elevations and flow (**Section 8.3**), groundwater in storage (**Section 8.4**), seawater intrusion (**Section 8.5**), groundwater quality (**Section 8.6**), land subsidence (**Section 8.7**), Groundwater Dependent Ecosystems (GDEs; **Section 8.8**), and Interconnected Surface Water systems (ICSW; **Section 8.9**).

As demonstrated herein, consistent with the approved 2016 Alternative Groundwater Sustainability Plan (Alternative GSP) and the requirements of California Water Code (CWC) § 10733.6 (a)(3) and California Code of Regulations Title 23 (23 CCR) § 356.4, Zone 7 has continued to sustainably manage the Basin to avoid Undesirable Results (URs) (as defined in **Section 13**) for at least 10 years. In fact, most of the datasets discussed in this Alternative GSP date back to 1974 allowing for a comprehensive, long-term assessment of Zone 7's sustainable Basin management, including over three major droughts.

8.2. Data Sources and Compilation

§ 352.6. Data Management System
Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.

☑ **23 CCR § 352.6**

8.2.1. Databases and Software

Per the 23 CCR § 352.6, each Groundwater Sustainability Agency (GSA) "shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin." In support of the Alternative GSP development (i.e., the Hydrogeologic Conceptual Model [HCM] development, analysis of groundwater conditions, water budget development, and Plan Area definition), a substantial number of data sources were compiled, organized, processed, and stored within the data management system described below.

The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) stores its hydrologic data (e.g., groundwater levels, water quality, geology, well construction) into HydroGeoAnalyst (HGA), a proprietary environmental database management system designed for storing chemistry, hydrology, and geologic information. The program includes a detailed Quality Assurance/Quality Control (QA/QC) checking module that confirms data integrity during import. Once imported into the database, Zone 7 uses the reporting and mapping tools within HGA to view and report the datasets. Zone 7 also exports datasets from HGA for use in other programs such as Microsoft Excel, Microsoft Access, and ArcGIS to generate tables and figures in reports and other work products.

Zone 7 uses a proprietary program called Aquarius Time-Series (Aquarius) for managing time series datasets for:

- Surface water stage and flow,
- Groundwater elevation,
- Diversion flow,
- Precipitation, and
- Evaporation.

The program also allows Zone 7 to build rating curves, apply corrections, create comparison graphs, derive statistics, and report datasets.

Other datasets that are not appropriate for HGA or Aquarius (e.g., land surface elevations, wastewater volumes, land use) are entered into Microsoft Access databases and/or ArcGIS feature classes.

8.2.2. Groundwater Model

Zone 7 maintains a numerical groundwater model (based on of the Basin for predicting the consequences of proposed Basin management actions. The groundwater model is run using Groundwater Vistas with USGS's Modular Finite-Difference Flow Model (MODFLOW) packages (e.g., NWT, MT3D) to perform the modeling calculations. In 2016, Zone 7 and HydroMetrics WRI (HydroMetrics) reevaluated, recalibrated, and revised the groundwater model as described in the Annual Report for the Groundwater Management Program – 2005 WY (*Zone 7, 2006)*.

The active part of the groundwater model encompasses the Amador, Bernal, Bishop, Camp, Castle, Dublin, and Mocho II Subareas of the Basin. The groundwater model has been used for water supply well siting and planning (*Zone 7, 2003*). More recently, the groundwater model was used for the following analyses:

- Identify the maximum amount of groundwater Zone 7 could pump using existing wells during a six-year drought without going below historic lows;
- Predict the impacts that Zone's planned groundwater pumping would have on groundwater levels if the drought continued for two additional years;
- Evaluate and simulate salt loading impacts and the siting effects of a second Zone 7 groundwater demineralization plant planned for construction in the future; and assist with the Tri-Valley water agencies' Joint Tri-Valley Potable Reuse Technical Feasibility Study (*Carrolo, 2018*).

8.3. Groundwater Elevations and Flow Directions

§ 354.16. Groundwater Conditions
(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:
(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

☑ **23 CCR § 354.16(a)**
☑ **23 CCR § 354.16(a)(1)**
☑ **23 CCR § 354.16(a)(2)**

8.3.1. General Setting and Gradients

The geologic setting of the Basin comprises a complex stratigraphy of fluvial channels, floodplain deposits, and regionally extensive lacustrine deposits. As described in **Section 7,** for management purposes, in the Main Basin Management Area (Main Basin) these have been organized into an "Upper Aquifer" consisting primarily of sandy gravels underlain by a relatively continuous, silty clay aquitard and a "Lower Aquifer" that includes aquifers below the aquitard. Groundwater is generally unconfined in the Upper Aquifer and semi-confined to confined in the Lower Aquifer (see **Figure 7-4**). The Fringe Management Area (Fringe Area) is represented as an unconfined aquifer (the Fringe Aquifer) that consists of thin sequence of recent (Holocene) alluvium underlain directly by the Upper Livermore Formation. The Upland Management Area (Upland Area) is represented as one unconfined aquifer (the Upland Aquifer) that consists of the Lower Livermore Formation, as discussed in **Section 7.4**.

Zone 7 has a long-standing and extensive program of groundwater level monitoring throughout the Basin. Currently there are about 240 wells in the program (see **Section 14.1** for a description of the monitoring network). Groundwater elevations from these wells indicate that groundwater flow in the Fringe Aquifer and Upland Aquifer is generally from their respective Management Areas toward the Main Basin and associated aquifers. Most of the subsurface inflow occurs across the northern boundaries of the Main Basin—in particular the Dublin and western Camp Subareas—and flows in a southerly direction. Within the Main Basin, groundwater in both aquifers generally follows a westerly flow pattern, mirroring the surface water streams, along the structural central axis of the valley and toward the municipal pumping centers.

8.3.2. Current Groundwater Levels

As demonstrated herein (consistent with the approved 2016 Alternative GSP) and the requirements of CWC §10733.6 (a)(3) and 23 CCR §356.4, Zone 7 has continued to sustainably manage water levels in the Basin to avoid Undesirable Results (URs; as defined in **Section 13.1.1**) for decades, including over three major droughts.

8.3.2.1. Main Basin Upper Aquifer and Fringe Aquifer

Figure 8-1 and **Figure 8-2** show groundwater elevation contours in the Upper Aquifer for the Spring and Fall 2020 WY, representing the highest and lowest groundwater elevations observed during the water year, respectively. **Figure 8-3** shows the depth to water to the Upper Aquifer groundwater table in the Spring 2021 WY. The groundwater gradient in the Upper Aquifer was generally from east to west and ranged from 0.005 to 0.025 feet per feet (ft/ft). Quarry dewatering operations in the eastern Amador Subarea create groundwater depressions in pits where water is pumped and mounds in pits that are not clay-lined and where excess water is stored. The water from the dewatering of Lakes B (P42 on the figures) and J (P46) was discharged into other adjacent clay-lined mining pits; while the water from Lakes D and E was eventually discharged into Cope Lake, after which it was conveyed into Lake I and was recharged back into the groundwater basin.

During the first half of the 2020 WY, water levels in wells in the southwestern portion of the Main Basin near the Arroyo de la Laguna (as indicated primarily by the Bernal Upper Key Well, 3S1E20C007 and Well 3S1E29M004) were slightly above the upper threshold elevation at which basin overflow occurs. Consequently, approximately 146 acre-feet (AF) (**Section 9.2.3.4**) of water overflowed from the Upper Aquifer into the Arroyo de la Laguna during the 2020 WY and exited the valley.

Areas of shallow groundwater overlie the Fringe Aquifer where alluvial sediments are relatively thin and groundwater use is limited. Groundwater levels in the Fringe Aquifer and Upland Aquifer typically stay relatively constant, generally varying by less than 5.0 feet (ft). The groundwater gradients in the northwestern Fringe Area (Bishop, Dublin, and Camp Subareas) ranged from 0.002 to 0.02 ft/ft generally southward towards the Main Basin. The groundwater gradients in the Fringe Area - Northeast ranged from 0.001 to 0.004 ft/ft generally westward towards the Main Basin or gaining streams in the northwestern portion of the Basin (Altamont Creek and Cayetano Creek). The groundwater gradient in the Fringe Area - East was about 0.006 ft/ft westward towards the Main Basin.

8.3.2.2. Lower Aquifer

Figure 8-4 and **Figure 8-5** show groundwater elevation contours in the Lower Aquifer for the Spring high and Fall low of the 2020 WY, respectively. In general, the groundwater gradient runs toward the center of the Basin where there are piezometric depressions created around several municipal wellfields and three mining pits (Lakes B, D, and E) that appear to extend into the Lower Aquifer. The lowest groundwater elevation in the Lower Aquifer corresponded to the pond in mining excavation for Lake D (R28 at 168 ft above msl). The westernmost California Water Service (CWS) municipal supply wells (CWS 20 and CWS 24) also pull groundwater from this portion of the Basin.

At the end of the water year, there appeared to be a mound in the Lower Aquifer of about 10 feet underneath Lake I. This mound suggests that the diversion of excess mined water into Lake I (via Cope Lake) since 2014 is impacting the Lower Aquifer.

As is usually the case, groundwater elevations in the Mocho II Subarea during the 2020 WY were about 60 to 90 ft higher than those to the west, across the Livermore Fault in the Amador Subarea. Deep groundwater elevations in the Fringe Subarea - North were 15 to 30 ft higher than those across the Main Basin boundary to the south.

8.3.2.3. Upland Aquifer

Prior to this update, there was only one Upland Aquifer well in Zone 7's groundwater monitoring program. Groundwater levels in the well (3S2E32E007), which is used to monitor groundwater downgradient of Zone 7's Del Valle Water Treatment Plant, have been relatively steady at about 17 to 20 feet below ground surface. For this update Zone 7 added five additional wells in the Upland Aquifer (see **Section 14.5**). Results from these additional wells will be included in the 2021 Annual Report.

8.3.3. Historical Groundwater Levels

8.3.3.1. General Historical Trends

Figure 8-6 shows historical groundwater levels at the Bernal Upper Key Well (a.k.a., Fairgrounds Key Well) in the westernmost portion of the Main Basin from 1900 to present and demonstrates the long-term sustainable management of the Basin. Prior to groundwater development, much of the Main Basin experienced artesian conditions, as indicated by groundwater levels above the ground surface. In the late 1800s, the pre-development groundwater levels and hydraulic gradients caused groundwater to flow from east to west across the Basin and naturally exit the Basin as surface outflow (baseflow) into the Arroyo de la Laguna. In the early and mid-1900s, groundwater began to be extracted in appreciable quantities, causing groundwater levels to drop throughout the Basin. As a result, groundwater levels dropped below the point (about 295 feet above mean sea level [ft msl]) where groundwater would naturally flow into the Arroyo de la Laguna and continued to drop significantly during the 1940s and 1950s.

Zone 7 was established in 1957 partially to address the Basin overdraft conditions. The downward trend in groundwater elevation began to reverse in 1962 when Zone 7 began importing water from the State Water Project (SWP) and later in the 1960s when Zone 7 began capturing and storing local runoff in Lake Del Valle. The first imports were diverted to an off-stream recharge facility called Las Positas Pit. This facility was operated from 1962 until the late 1970s and again, briefly, in the 1980s. Thus, after experiencing historical groundwater lows in the 1960s, Main Basin water levels stabilized in the late 1960s and started to rise in the early 1970s with the advent of regional groundwater management programs.

Following a 'very critical dry' year in 1977, groundwater levels continued to recover and peaked in 1983, which is the modern maximum ("basin full") limit. Since 1983, water levels have been drawn down three separate times in response to times of limited water importation from the SWP but have not reached previous historic low levels. As shown on the hydrograph, groundwater levels subsequently recovered following the dry cycles in the early 1990s and the early 2000s because of Zone 7's managed aquifer recharge operations and a corresponding reduction in groundwater production. The recent severe drought cycle of 2012-2015 resulted in a lowering of Basin-wide water levels, but levels remained above those observed during the drought cycle of the early 1990s and significantly above historic lows (**Section 8.3.3.3**). These water level data are consistent with sustainable groundwater management practices since at least the early 1970s.

Hydrographs of the Amador West Key Wells (**Figure 8-7**) show that overall trends and fluctuations are quite similar in both the Upper Aquifer and Lower Aquifer. In general, seasonal fluctuations are slightly larger in the Lower Aquifer where most of the pumping occurs. Water levels in the Lower Aquifer can fall as much as 10 to 20 ft lower than levels in the Upper Aquifer during the high demand summer pumping season (e.g., 1973, 1976, 1991, 2001, and 2013). Water levels are higher during winter seasons and overall wet periods (e.g., 1978-1986). Data typically indicate a downward vertical gradient, although water levels in the Lower Aquifer rose higher than those in the Upper Aquifer during the wet seasons of the mid- to late-1990s, corresponding to a time of lower amounts of pumping.

Figure 8-8 shows hydrographs for the period 1974 to present from selected wells from the Main Basin, Fringe, and Upland Areas; an inset map shows the well locations. Along the top of the figure, seven wells represent groundwater level trends in the Northern and Northeastern Fringe Areas: Dublin, Bishop, Camp, May, Cayetano, and Spring Subareas. In addition, at right, one well represents conditions in the East Fringe Area (a.k.a., Mocho I Subarea). At left, one well shows groundwater levels for the Castle Subarea. All of these represent conditions in the Upper Aquifer (given that the Lower Aquifer generally is not present in these subareas). Except for a slight decrease in the May Subarea well, groundwater levels in these wells generally are steady and groundwater variations (both seasonal and long-term) are less than 20 ft. This generally reflects the relatively thin aquifer sediments in the Fringe Area and lack of groundwater use. Seasonal peaks in the Castle Subarea well may reflect seasonal pumping variations in the Main Basin.

The hydrographs along the bottom in **Figure 8-8** are from the eight Key Wells that represent groundwater level trends in each of the Main Basin subareas, including Mocho II, Amador (split into East and West on either side of the mining area), and Bernal Subareas. These hydrographs show clear seasonal variations, typically less than 20 ft. The two easternmost key wells (Mocho II) show seasonal variations (more pronounced in the Lower Aquifer) and response to drought (for example between about 1986 and 1992). Nonetheless, the overall trend is steady. Hydrographs for wells in the central and western portions of the Main Basin also indicate more pronounced seasonal variations in Lower Aquifer relative to the Upper Aquifer. Most significantly, these hydrographs show longer-term variations spanning 60 to even 100 vertical feet and extending over decades with troughs generally occurring about 1992, 2002, and 2014. These broad groundwater level changes reflect active management of groundwater storage in the Basin, whereby available surface water is stored during wet periods and then utilized during drought.

8.3.3.2. Historic Low Water Levels

Zone 7 has prepared contour maps representing historic low groundwater elevations in the Upper and Fringe Aquifers (**Figure 8-9**) and the Lower Aquifer (**Figure 8-10**). These historic low contour maps represent a compilation of historic recorded low groundwater elevations in various wells in the Basin. Zone 7 uses static water levels from local monitoring wells rather than pumping level data to evaluate the height above the historic lows. Data used to create the composite contours are typically from the 1960s, 1977, 1987-1992, or 2012-2015 drought periods. The historic low values are a function of both data availability and some variability in water levels during drought cycles. Although the 1960s generally represented the lowest water levels across the Basin, wells added to the monitoring program after the 1960s were used to provide more detailed information in areas of limited data or areas with a lack of historical pumping. By including historic lows for numerous generations of wells in the region, the historic low contour maps represent a more conservative benchmark and provide for adaptive management in the future.

The historic low contour map for the Lower Aquifer was first created in 2005 for the Zone 7 Well Master Plan (WMP) Environmental Impact Report (EIR; *Zone 7, 2005b*) to help define possible mitigation measures for the potential risk for groundwater pumping-induced subsidence. The historic low surface for the Lower Aquifer used in the Zone 7 WMP EIR was revised in 2009 and converted to a surface grid (i.e., ArcGIS raster image) for comparison with end-of-water-year groundwater elevations and for spatial analyses. The surface was modified again slightly in January 2014 and October 2015, as additional information became available and is presented herein as **Figure 8-10**. Similarly, an updated historic low map for the Upper Aquifer and Fringe Aquifer was created in 2021 as part of this update (**Figure 8-9**).

These historic low contour maps represent a groundwater management tool used by Zone 7 to guide management actions in the Basin. Zone 7 compares low water levels in each year to these values (see **Figure 8-11** and **Section 8.3.3.3** below) to ensure that the Basin is being operated in a sustainable manner and to identify areas to focus management actions. For example, as described in **Section 15**, such actions have included redistribution of pumping among wells, and focused conjunctive use, among others.

8.3.3.3. Comparison to Historic Low Water Levels

Figure 8-11 compares groundwater levels at the end of the 2020 WY and the historic lows for the Lower Aquifer. Groundwater levels in the vicinity of the Bernal Subarea were up to about 110 ft above the historic lows. In the Amador Subarea, levels were generally 25–90 ft above the historic lows except in the immediate vicinity of two mining excavations that were being dewatered during the 2020 WY; the water levels in Lake B (P42) were 2 ft below the historic lows, while water levels in Lake D (R28) were about 47 ft below the historic lows. These mining area excavations below the historic lows are expected to occur only while there is active mining and are closely monitored by Zone to ensure there are no undesirable results to the Basin. Over the central portion of the Mocho II Subarea where there is municipal pumping, the end-of-year groundwater levels were 50–135 ft above historic lows. Other portions of the Mocho II Subarea, not affected by the municipal pumping, remained relatively stable at or slightly above historic lows.

8.4. Groundwater Storage

§ 354.16. Groundwater Conditions
(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

☑ **23 CCR § 354.16(b)**

As demonstrated herein (consistent with the approved 2016 Alternative GSP) and the requirements of CWC §10733.6 (a)(3) and 23 CCR §356.4, Zone 7 has continued to sustainably manage groundwater storage in the Basin to avoid URs (as defined in **Section 13.2.1**) for decades, including over three major droughts.

8.4.1. Methodology for Calculating Storage

Zone 7 uses three methods to calculate groundwater storage in the Basin: (1) the Groundwater Elevation (GWE) Nodal method, (2) the Hydrologic Inventory (HI) method, and (3) the GWE Rockworks method.

The GWE Nodal method uses groundwater level data and storage coefficients to estimate the total volume of water in the Basin. To calculate the GWE storage in the Main Basin from the 1974 to 2020 WYs, Zone 7 uses polygonal areas (referred to as nodes) created for the 1974 California Department of Water Resources (DWR) study (*DWR, 1974*). Each node has its own set of hydrogeologic parameters, such as storage coefficient, nodal thickness, and nodal area. The saturated thickness of each node was calculated using the nodal thickness, average groundwater elevations from the fall semiannual measuring event, and storage coefficient. The groundwater storage of each node is then calculated by multiplying the saturated thickness by the total area of the node. The total Main Basin groundwater storage is equal to the sum of all the nodal storage values for the 22 nodes in the Main Basin. GWE storage calculations before 1992 were calculated assuming a constant storage coefficient for all the nodes (i.e., without differentiating between aquifers). However, starting in 2007, average groundwater elevations for each of the nodes and aquifers were calculated using *ArcGIS Spatial Analyst.*

The HI method, also known as the Water Budget (see **Section 9**), involved an accounting of all inflows and outflows and derivation of the change in storage as the residual of the water budget equation. The groundwater inflow and outflow components of the HI are summarized in **Table 8-A** below and discussed in more detail in **Section 9**. Each component was derived independently, either directly from the monitoring program results or calculated using the results of a monitoring program. Total storage in the HI method was originally estimated from the GWE Nodal method and is subsequently updated each year based on the results of the HI mass balance equation.

Table 8-A Groundwater Inflow and Outflow

<table>
<tr><th>INFLOWS</th><th>OUTFLOWS</th></tr>
<tr><td>Rainfall Recharge</td><td rowspan="3">Municipal Pumping
• Zone 7
• By Others</td></tr>
<tr><td>Stream Recharge</td></tr>
<tr><td>Applied Water Recharge</td></tr>
<tr><td>Subsurface Groundwater Inflow</td><td>Agricultural Pumping</td></tr>
<tr><td rowspan="2">Pipe Leakage</td><td>Mining Use</td></tr>
<tr><td>Groundwater Basin Overflow</td></tr>
</table>

The GWE Rockworks method, completed as part of this update, uses the same approach as the GWE Nodal method for calculating storage, except in this case the saturated thickness of each Principal Aquifer unit is informed by aquifer volumetrics produced from the three-dimensional (3D) geologic model of the Basin created using the Rockworks (2020) software platform as part of the current five-year update to the Alternative GSP (see **Appendix I** and **Appendix C**). The GWE Rockworks method currently uses the same storage coefficients as employed in the GWE Nodal method for the Upper Aquifer and Lower Aquifer (see **Appendix E**). While the GWE Nodal method is limited to calculating groundwater storage volumes in the Upper Aquifer and the first ~150-300 feet of the Lower Aquifer in the Main Basin (i.e., the “grey” and “purple” sequences described in **Section 7.4)**, the GWE Rockworks method also provides for a calculation of groundwater storage within the underlying Upper Livermore Formation (i.e., the “red” sequence) of the Lower Aquifer within the Main Basin, resulting in higher estimates of total storage. For the Upper Livermore Formation and Fringe Aquifer, the GWE Rockworks method employs a range of storage coefficients based on the best available information regarding aquifer lithologies and grain size distributions and applicable methodologies.

Historically for the Main Basin, results of the first two methods have been compared to each other, leading to periodic re-examination and refinement of each method, and then averaged to quantify the total storage, as described below.

8.4.2. Main Basin Management Area

8.4.2.1. Current Storage

Most of the groundwater storage is contained in the Main Basin, which is characterized by the largest saturated thickness. **Table 8-B** below shows the groundwater storage for the Main Basin. The GWE Nodal method yielded a total storage of 231.7 thousand acre-feet (TAF) for end of the 2020 WY, which is 16.8 TAF less than the total storage calculated for the 2019 WY. **Figure 8-12** shows the Upper and Lower Aquifer groundwater storage volumes for each node from the GWE Nodal method for the 2020 WY. The HI method produced a total storage value of 247.2 TAF for end of the 2020 WY, which is about 8 TAF less than the total storage calculated for the 2019 WY. The results of the HI method for the 2020 WY are discussed in more detail in **Section 9.**

Table 8-B: Groundwater Storage Summary, 2020 WY (in Thousand AF)

Storage Calculation Method	End of 2019 WY	End of 2020 WY	Change in Storage
GWE Nodal method	248.5	231.7	-16.8
Hydrologic Inventory (HI)	255.2	247.2	-8.0
TOTAL STORAGE (Average of GWE Nodal and HI)	**251.8**	**239.5**	**-12.3**
GWE Rockworks (includes Upper Livermore Formation)	286.0	276.0	-10.0

The total storage, which is calculated by averaging the storage from the GWE Nodal and HI methods, was 239.5 TAF. By comparison, the GWE Rockworks method yielded a total storage of 276.0 TAF[14] at the end of 2020 WY, which about 36 TAF greater than the total storage calculated using the average of the GWE Nodal and HI methods.

For the past few years, the differences of total storage calculated by the GWE Nodal and HI methods have been within approximately 6.0 TAF (**Figure 8-13**). However, total storage calculated by the GWE Nodal and HI methods dropped significantly (16.8 TAF and 8.0 TAF respectively) during the 2020 WY, with a cumulative difference of 15.5 TAF between the two storage values as of 2020 WY. While there have been significant differences between the two methods in the past that converged a few years later (e.g., 1992 and 2008/2009). The reason for this divergence is unclear but is mirrored using the GWE Rockworks method (see **Appendix E**).

8.4.2.2. Operational Storage

To avoid significant depletion of groundwater storage, Zone 7 operates the Basin such that groundwater in storage remains between a full basin volume (254 thousand acre-feet [TAF]) and the historic low storage

[14] Based on the lower-range storage coefficient for the Upper Livermore Formation (0.025).

of 128 TAF, or about one half of total storage volume. This 126 TAF (254 TAF – 128 TAF) is considered the Operational Storage (**Table 8-C**). Groundwater below this minimum threshold is regarded as Reserve Storage that is intended for use only during emergency conditions.

Table 8-C: Operational Storage, 2020 WY (in Thousand AF)

Storage Volumes	End of 2020 WY
Total Storage (Average of GWE Nodal and HI)	**239.5**
Reserve Storage (below Historic Lows)	128
Operational Storage (above Historic Lows)	111.5

8.4.2.3. Historical Change in Storage

As illustrated on **Figure 8-6**, the Main Basin was full in early 1900 and full again in 1983 (as measured by rising water levels in gravel quarries in the central Main Basin). Groundwater storages were drawn down to historic low levels in 1962 and 1966. Beginning in 1974, Zone 7 began calculating the basin storage by using the HI and GWE Nodal methods **Figure 8-13** shows the historical change in storage from 1974 to 2020 from both the HI and GWE Nodal methods and the resulting average between the two.

To avoid significant depletion of groundwater storage, Zone 7 has operated the Basin such that groundwater storage remains between the full basin volume of 254 TAF (based on the GWE Nodal method) and the historic low storage of 128 TAF, or about one half of total storage volume. This 126 TAF of storage (i.e., between 254 TAF and 128 TAF) is considered to be the “Operational Storage”. The significant amount of additional storage below 128 TAF is considered “Reserve Storage” that is available during emergency (e.g., drought) conditions. A schematic diagram showing the Operational Storage and changes in storage from the 1974 through 2020 WY is shown on **Figure 8-14**.

Figure 8-15 graphs the annual and cumulative change in groundwater storage, along with the annual groundwater use and water year type. **Table 8-1** shows the historical annual groundwater storage volumes for each subarea of the Main Basin from the 1974 through 2020 WY.

As mentioned in **Section 8.4.1**, the recently introduced GWE Rockworks method estimates a greater volume of total storage for the Main Basin than the GWE Nodal method due to its inclusion of the Upper Livermore Formation (i.e., the “red” sequence) of the Lower Aquifer. As such, the Operational and Reserve Storage volumes presented above are likely conservative and will be revisited in consideration of all three storage calculation methodologies as part of the next five-year update to the Alternative GSP.

8.4.3. Fringe and Upland Management Areas

As further described in **Section 9.3.1.2.** the Fringe Area is not used for municipal supply or managed groundwater storage primarily because of low aquifer transmissivity. Groundwater quality is also typically poor in the Fringe Area (see **Section 8.6**) due to natural elevated total dissolved solids (TDS) and boron concentrations. However, the Fringe Area does provide limited supply for domestic and agricultural users. For display and database purposes, the Fringe Area is considered to only consist of the Fringe Aquifer (**Section 7.4.4**). **Figure 8-12** shows the groundwater storage volumes for each node from the GWE Nodal method for the 2020 WY. **Table 8-D** below shows that the total groundwater storage for the Fringe Area estimated from three different methods:

- GIS Method- the area-weighted average thickness of the saturated area of each region was multiplied by the estimated Specific Yield (assume 0.05).
- Nodal Method - was calculated using nodal depth-of-alluvium estimates from DWR 1974.
- Rockworks Method (ranged low to high) – estimated storage using the Rockworks method (**Appendix E**), which was calculated a range (shown below as Low and High).

Table 8-D Estimated Fringe Area Storage (AF)

Fringe Region	GIS	Nodal	Rockworks Low	Rockworks High	Average
North	38,348	25,070	74,000	133,000	67,604
Northeast	61,656	45,002	23,000	46,000	43,914
East	1,630	1,153	300	600	921
Total	**95,509**	**71,224**	**97,300**	**179,600**	**112,439**

The total groundwater storage of the Upland Area is unknown because it consists of semi-consolidated bedrock of highly variable specific yields and of unknown thickness. The Upland Area provides only very limited groundwater supply for domestic and agricultural uses.

8.5. Seawater Intrusion

§ 354.16. Groundwater Conditions
(c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.

☑ **23 CCR § 354.16(c)**

The Basin is not a coastal basin subject to seawater intrusion, and therefore this sustainability indicator is not applicable and has not been included herein.

8.6. Groundwater Quality

§ 354.16. Groundwater Conditions
(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

☑ **23 CCR § 354.16(d)**

As demonstrated herein (consistent with the approved 2016 Alternative GSP) and the requirements of CWC §10733.6 (a)(3) and 23 CCR §356.4, Zone 7 has continued to sustainably manage groundwater quality in the Basin to avoid URs (as defined in **Section 13.4.1**) for decades, and is implementing multiple groundwater quality monitoring and management programs to that end.

8.6.1. General Water Chemistry and Constituents of Concern

8.6.1.1. Introduction

Zone 7 conducts annual sampling and analysis for inorganic constituents for meeting the Basin groundwater quality objectives (WQOs; see **Section 13** for Sustainable Management Criteria [SMC]). Zone 7's understanding of groundwater quality throughout the Basin has improved over time as additional monitoring points have been added to the monitoring network and additional analyses have been conducted when areas of concern (AOCs) have been identified. Consistent with adaptive management principles, Zone 7 has actively and pro-actively responded to numerous groundwater quality issues over time. This section provides a characterization of groundwater quality and changes in quality in space and time since 1974, a period of sustainable management. Although numerous groundwater quality challenges have arisen during this time, Zone 7 has been able to address each issue, preventing significant and unreasonable degradation of groundwater quality. **Section 13.4.1** defines significant and unreasonable URs with respect to groundwater quality and establishes Minimum Thresholds in compliance with Sustainable Groundwater Management Act (SGMA). Details on the Zone 7 water quality monitoring program are provided in **Section 14.2.4**.

In general, groundwater quality is highest in the Main Basin where it is suitable for most urban and agriculture uses with some minor localized water quality degradation. Primary constituents of concern in the Main Basin are locally high TDS (**Section 8.6.2**), nitrate (**Section 8.6.3**), boron (**Section 8.6.4**), and chromium (**Section 8.6.5**). Some of these elevated concentrations are naturally occurring in many areas of the Basin and are not caused or being exacerbated by groundwater extractions.

Zone 7 analyzes these constituents of concern through numerous maps and statistical analyses. For this Alternative GSP, basin-wide maps and chemographs are presented to characterize both current and historical conditions of groundwater quality and provide a broad view of Zone 7 management of groundwater quality. Zone 7 also prepares contour maps on an annual basis for each constituent of concern, which are presented in the sections below by constituent of concern and aquifer.

In general, groundwater is of lower quality in the Fringe Area, which is characterized by relatively high TDS and locally elevated boron. TDS and boron concentrations are particularly elevated in the shallow Fringe Aquifer and in the northeast, reflecting recharge from marine sediments adjacent to the Basin. High boron levels and lower yields can limit the use of some Fringe Area for extensive agricultural irrigation.

Per- and polyfluoroalkyl substances (PFAS, **Section 8.6.6**) are a large group of human-made substances that do not occur naturally in the environment. PFAS are classified by the Environmental Protection Agency (EPA) as “contaminants of emerging concern” (CECs). These substances have been used extensively in the United States since the 1940s, particularly in surface coating and protectant formulations due to their ability to repel oil, grease, and water. There is limited research to date, but some studies show that they may cause adverse health effects. Additional research is needed to determine the full scope of PFAS impacts on human health. Zone 7 started sampling for PFAS in the 2019 WY and is continuing to evaluate the extent and impact of PFAS on the Basin.

Releases of fuel hydrocarbons from leaking underground storage tanks and spills of organic solvents at industrial sites have caused minor-to-significant groundwater impacts locally throughout the Basin, although there is no impact on municipal wells to date. Zone 7 participated in the development of the Groundwater Ambient Monitoring and Assessment (GAMA) project, and except for methyl tertiary-butyl ether (MTBE), no fuel hydrocarbons were detected in any of the municipal wells. Proactive cooperation with regulatory agencies on site cleanup is helping to protect the Basin from fuel hydrocarbon contamination.

Zone 7 also reviews results from site cleanup projects made available through GeoTracker and from cleanup reports routinely sent to Zone 7 for review. Results of these programs are documented annually in Zone 7 reports. Chlorinated organic solvent releases to soil and groundwater are an issue, primarily in the Upper Aquifer in portions of the Fringe Area. Cleanup programs at Lawrence Livermore National Laboratory (LLNL) are in place to remediate this large superfund site from a 50-year-old plume associated with World War II activities. Zone 7 assisted LLNL during the initial year of cleanup and has been working cooperatively with them ever since. During the past decade, LLNL has been providing valuable assistance to Zone 7 in the monitoring and analysis of groundwater conditions within the Basin.

Zone 7’s current groundwater quality monitoring network, which includes approximately 240 wells, is discussed in detail in **Section 14.2.4**. Groundwater quality issues that may affect the supply and beneficial uses of groundwater are discussed below, including a description and map of the location of known groundwater contamination sites and plumes.

8.6.1.2. Municipal Wastewater and Recycled Water

The two largest wastewater collection and treatment plants are operated by the City of Livermore and Dublin San Ramon Services District (DSRSD), which treat over 99% of the wastewater in the Livermore-Amador Valley (Valley). Both of the publicly owned treatment works produce secondary-treated effluent, which is exported from the Valley through the Livermore-Amador Valley Water Management Agency

(LAVWMA) export pipeline, and tertiary-treated recycled water, which is used primarily for urban landscape irrigation. Currently, none of the recycled water is used for groundwater replenishment.

As summarized in **Table 8-E** below, approximately 7,176 AF of the 17,676 AF of the wastewater produced in the Valley was recycled and used for landscape irrigation in the 2020 WY. This use of recycled water represents conservation of groundwater storage, assuming that the irrigation demand would otherwise have been met with groundwater.

Table 8-E: Recycled Water Volumes (AF) for the 2020 WY

Water Type	LWRP	DSRSD	Total
Wastewater Influent	6,141	11,535	17,676
Treated Effluent Exported via LAVWMA	4,590	6,039	10,629
Total Volume Recycled	2,426	4,740	7,176
Recycled Volume-Main Basin**	609	427	1,036

* Does not include Zone 7 Demin Plant discharge to LAVWMA via DSRSD
** Only the portion of recycled water which was applied over Main Basin landscapes.

The recycled water from both wastewater plants meets the Title 22 water quality standards for irrigation uses. While salt and nutrients are the primary constituents-of-concern for wastewater and recycled water applications over the Main Basin, other COCs/CECs would need to be considered if recycled water was used in aquifer recharge projects.

A small amount of wastewater is also discharged to the Main Basin from the Veterans Administration (VA) Hospital wastewater treatment ponds located in southern Livermore, from other domestic onsite wastewater treatment systems (OWTS, also known as septic systems), and from leaking wastewater and recycled water pipelines that run throughout the Basin. Estimated volumes for the 2020 WY are presented in **Table 8-F** below.

Table 8-F: Wastewater Volumes (AF) for the 2020 WY

	VA Hospital*	OWTS (Main Basin)*	Pipe Leakage**	Total
Wastewater Leachate	50	80	400	530

OWTS = Onsite Wastewater Treatment Systems
* Total is estimated
** Calculated. Includes leakage from sanitary sewer and recycled water pipes

The contribution to the Main Basin groundwater supply (530 AF) was estimated using "typical" wastewater flows from domestic septic systems, an estimate for the VA Hospital ponds, and the pipe leakage. No significant changes have occurred in land uses or OWTS densities over the Main Basin that would change the estimated water volumes from these sources in recent years. **Section 8.6.3.7** evaluates the effect of Zone 7's Nutrient Management Plan (NMP) recommendations on the nitrate mass that leaches into the groundwater from OWTS.

8.6.2. Salt (as TDS)

8.6.2.1. Introduction

Every year, Zone 7 uses well and mining pit sampling data to contour salt (measured as TDS) concentrations in the Main Basin (Upper and Lower Aquifers) and Fringe Area (Fringe Aquifer) (**Sections 8.6.2.2** and **8.6.2.3**). Zone 7 then calculates average TDS concentrations in the Main Basin and Fringe Area (**Section 8.6.2.4**). Historical TDS concentrations are presented in **Section 8.6.2.5**. Zone 7 has sampled or estimated concentrations and volumes of all inflows into and outflows from the Basin from 1974 to 2020 to estimate the trends in overall TDS over time (**Section 8.6.2.6**). Zone 7 also uses a similar approach to estimate future projected salt concentrations (**Section 8.6.2.7**).

8.6.2.2. TDS in the Upper/Fringe Aquifer

Figure 8-16 shows TDS concentrations in the Upper/Fringe Aquifer in the 2020 WY. TDS concentrations in groundwater were lowest in the areas adjacent to the Arroyo Valle and the Arroyo Mocho, where they were generally less than 500 milligrams per liter (mg/L). There continues to be two main areas of the groundwater basin where TDS concentrations exceed 1,000 mg/L in the Upper Aquifer:

- In the western portion of the Fringe Area and extending south into the northwestern portion of the Main Basin. This high TDS area is most likely due to the combination of the concentrating effects of urban irrigation, leaching of buried lacustrine and marine sediments, recharge of poorer quality water from Arroyo Las Positas, and legacy wastewater and sludge disposal practices in the Pleasanton and Livermore areas.
- In the northeastern portion of the Fringe Area. This high-TDS area is likely due to poorer quality water that runs off marine sediments on the east and north of the Basin and recharges the Basin along the hill-fronts.

8.6.2.3. TDS in the Lower Aquifer

Figure 8-17 shows TDS concentrations in the Lower Aquifer in the 2020 WY. Water from the Lower Aquifer is generally of good drinking water quality (i.e., below 500 mg/L). Around the margins of the Main Basin, TDS concentrations are slightly higher, generally ranging from 500 mg/L to 900 mg/L in the 2020 WY. The distribution of TDS concentrations is likely caused by deep percolation of low-TDS surface waters in the central portion of the Basin and municipal pumping in the western Basin that pulls high-TDS groundwater laterally and downward from the north Fringe Area and the Upper Aquifer.

Many of the municipal supply wells in the Pleasanton area produced water with TDS concentrations greater than 500 mg/L (the Water Quality Objective for the Main Basin, see **Section 13**) during the 2020 WY. The highest concentrations were detected as follows:

- The Mocho wellfield in the Amador Subarea had one well with TDS above 800 mg/L (854 mg/L in Mocho 4).
- One of the San Francisco Public Utilities Commission (SFPUC) wells in the Bernal Subarea (SF-A) detected TDS at 932 mg/L.

- A monitoring well (3S1E17B004) in the Amador Subarea located central to four active wellfields (Mocho, Hopyard, Bernal, and Busch Valley) had TDS at 902 mg/L.

The source of these high TDS concentrations is believed to be the Upper Aquifer, which has had TDS concentrations as high as 2,000 mg/L in the same area directly above the Mocho well screened intervals. When the Mocho wells are pumped, a very large vertical gradient is created between the Upper and Lower Aquifers, inducing flow between the two zones. Zone 7 can strip and export much of the salts from the water produced by the Mocho wells with its onsite groundwater demineralization facility. See **Section 8.6.2.5** for details on the Mocho Groundwater Demineralization Plant's (MGDP). Other planned corrective actions and strategies are described in **Section 15**.

8.6.2.4. Average TDS Concentrations

Average TDS concentrations in the Main Basin, Fringe, and Upland Areas using 2020 WY data are shown on **Figure 8-18**. For the Main Basin, the average volume-weighted TDS concentrations for the Upper and Lower Aquifers are 623 and 524 mg/L, respectively, with the overall volume-weighted concentration averaging 578 mg/L. The average concentrations for each of the Fringe Area subareas range from 884 to 1,301 mg/L. The average concentrations across the entire Upland Area are approximately 673 mg/L.

8.6.2.5. Historical TDS Concentrations

Over the last 40 years there has been a general upward trend in TDS concentrations, principally in the western portion of the Main Basin. Concentrations in the eastern and central portions of the Valley have stayed relatively low, especially during times of significant stream recharge. The local Regional Water Quality Control Board (RWQCB) Water Quality Control Plan (Basin Plan) has set the water quality objective (WQO) at 500 mg/L (or ambient, whichever is lower) for the Main Basin and at 1,000 mg/L (or ambient, whichever is lower) for the Fringe Area.

Figure 8-19 shows TDS chemographs for the period 1975 to 2020. Most TDS concentrations are presented on the vertical axis from 0 to 1,600 mg/L, but two extend higher to include all concentrations: 3S1E06F003 to 3,800 mg/L and 3S2E01F002 to 2,200 mg/L. The graphs also include the minimum thresholds (dashed lines, blue for upper aquifer and red for lower aquifer) and measurable objectives (the WQO, in solid green line) for the representative monitoring sites as discussed in **Sections 13.4** and **14.4.** The inset map shows TDS concentrations in the upper aquifer in 2020 WY.

The top portion of **Figure 8-19** shows eight chemographs of TDS concentrations in the Fringe Area. All eight graphs show trends that generally are steady over the long term, although a slight increase is discernible in the May Subarea well. Most wells have TDS concentrations less than the WQO 1,000 mg/L except for those in the Spring Subarea (3S2E01F002) and in the Northeast Fringe Area (3S1E06F003):

- Spring Subarea (3S2E01F002) - generally has concentrations between 1,200 and 2,000 mg/L; this reflects recharge from local streams with high TDS and watersheds characterized by marine sediments and deep saline water associated with the numerous bounding faults in the area.

- Northeast Fringe Area (3S1E06F003) – concentrations are between about 1,200 mg/L and 1,700 mg/L in the late 1970s and early 1980s. In the late 1980s, concentrations rose significantly to around 3,000 mg/L and have been relatively steady since that time. The cause of the rise in TDS is unknown. Naturally occurring, low permeability clays and historic lake beds have been documented in the area and some elevated TDS concentrations could be naturally occurring. Localized point sources, such as historical wastewater and sludge disposal practices are also potential causes.

The bottom portion of **Figure 8-19** shows several chemographs from both the Upper (in blue) and Lower (in red) aquifers of the Main Basin, discussed below from west to east:

- Castle Subarea well (3S1W13J001) - Although Zone 7 considers Castle Subarea to be a part of the Main Basin, the Basin Plan WQO is the same as in the Fringe Area, recognizing the local, higher-salinity groundwater. The chemograph indicates that TDS concentrations in the Upper Aquifer are generally between 200 and 700 mg/L with a steady trend since about 1994.

- Bernal Subarea Key Wells - concentrations in both the Upper and Lower Aquifer were observed to increase in the late 1990s and early 2000s, but have stabilized since then at about 400 to 600 mg/L.

- Amador West Subarea Key Wells - Upper Aquifer concentrations are significantly higher (above 1,000 mg/L prior to 2009) but have recently declined and are now below the 500 mg/L WQO. Concentrations in the Lower Aquifer have been consistently around 450 mg/L.

- Amador East Subarea Key Wells - TDS concentrations in the Upper Aquifer varied considerably and were relatively high (between 500 and 1,000 mg/L) between 1975 and 1995 but have stabilized at about 600 to 800 mg/L in the last two decades. TDS concentrations in the Lower Aquifer, with concentrations between about 350 mg/L and 500 mg/L have been generally constant since 1976.

- Mocho II Key Wells - show relatively steady TDS trends with concentrations generally between 500 and 600 mg/L.

Because high-TDS groundwater from the Fringe Aquifer provides some subsurface inflow to the Upper Aquifer of the Main Basin, these concentrations are being carefully monitored for any additional increasing trends. Starting with Zone 7's Salt Management Plan (SMP; *Zone 7, 2004*), Zone 7 has been proactively addressing TDS concentrations (**Section 15.2)**, including demineralization projects, both ongoing (Mocho Wellfield demineralization) and planned (Tri-Valley Recycled Water Project).

TDS increases in the Basin, particularly in some Lower Aquifer wells such as the Bernal Subarea Key Well, triggered aggressive development and implementation of the SMP by Zone 7 beginning in 2004. By 2010, Zone 7 had developed a groundwater demineralization program, providing reverse-osmosis treatment and export of brine out of the Basin. Also, note that the Bernal Subarea Key Wells show that TDS concentrations in the Upper Aquifer are actually lower than in the Lower Aquifer in this area. This is thought to be due, in part, to the recharge of low TDS water along Arroyo Valle as part of the Zone 7 conjunctive use program. These ongoing projects, along with other SMP actions, are discussed in **Section**

15 of this Alternative GSP. Additional data and analyses conducted by Zone 7 for the examination of current and historical average TDS concentrations are discussed below.

8.6.2.6. Main Basin Salt Loading Calculations

Zone 7's Main Basin salt loading spreadsheet (**Table 8-2, Appendix L**) calculates the addition and removal of minerals in the Main Basin by tracking or estimating the salt mass associated with the recharge and discharge components of the Basin Hydrologic Inventory. These calculations include all salts, including those applied at the ground surface and those that may exist in the Overburden and interbedded aquitards. Therefore, the calculated concentrations are theoretical and differ from the average basin-wide salt concentrations described above, which are based on measurement of TDS concentrations in groundwater. This approach to calculating salt loads is a conservative or "worst case" analysis. Actual, measured TDS concentrations are shown in **Figure 8-16** to **Figure 8-19**. In general, salts are added to or removed from the Main Basin by the mechanisms listed in **Table 8-G.** Detailed calculations supporting the salt loading estimates are provided in **Appendix L**.

Table 8-G: Main Basin Salt Loading Calculation Components

SALT ADDITION	SALT REMOVAL

• Natural stream recharge
• Natural areal recharge
• Artificial stream recharge
• Subsurface groundwater inflow
• Pipe leakage
• Applied water (irrigation) recharge
  o Municipal
  o Groundwater
  o Recycled water
	• Municipal pumping, including brine export from the MGDP
	• Agricultural pumping
	• Mining area discharges and wet gravel export
	• Basin outflow

By assigning a TDS value for each inventory component, the net theoretical salt load is then calculated for each water year. Zone 7 calculates a theoretical average TDS concentration of the entire Main Basin by assuming a starting average concentration of 450 mg/L in 1973 (*DWR, 1974*), and calculating the net theoretical salt load and change in storage for every year since then. A negative value for the net theoretical salt mass from the Basin may not result in a lowering of the theoretical average TDS concentration if it is associated with a loss of storage.

Groundwater pumping removes salts from the Main Basin as solute in the produced groundwater. Some of this salt mass is then exported from the Main Basin in the municipal wastewater, brine from the MGDP, mining area discharges, and deliveries of groundwater to areas outside of the Main Basin. Other portions of the salt mass removed by Main Basin pumping are reapplied to the Main Basin as recharge from irrigation, pipe leakage, subsurface groundwater inflow, and to a lesser degree, onsite wastewater discharges.

The calculations account for evapotranspiration and evaporation of groundwater in the mining area ponds, which have the effect of concentrating salts in the Main Basin. Similarly, the salt-concentrating effects of water applications for irrigation are calculated. In contrast, rainfall recharge dilutes the salt concentrations as it adds essentially salt-free water to the system. Artificial recharge with low salinity SWP water also tends to dilute the Main Basin salt concentrations but does add some salt mass to the system. The amount of added salt accounts for the salinity of the water being recharged, which varies seasonally and annually, and the amount recharging the aquifers.

While theoretical, the calculations provide insights into the processes of salt addition and removal both geographically and temporally. **Figure 8-20** illustrates the results from 1974 to 2020 of the theoretical salt loading calculations in terms of annual salt loading and TDS concentrations. The graphs indicate considerable variability in salt loading from year to year. It should be noted that the salt loading is presented as mass (tons) entering or leaving the basin. The theoretical TDS concentration curve (Graph 3) is expressed as a concentration which accounts not only for the mass of salt (Graph 2, red line), but also the volume of groundwater in storage (Graph 2, blue line). Hence, an apparent increase in concentration can be associated with negative salt loading (i.e., decrease of salt mass) if the volume of groundwater is decreased with lower groundwater levels. Therefore, the theoretical TDS concentration generally increases during drought conditions, primarily due to a corresponding decrease in the volume of groundwater in storage. Such an increase is noted during the drought of the late 1980s and early 1990s. Predicted theoretical concentrations have been relatively stable between drought cycles.

8.6.2.7. Projected Salt Loading Calculations

Zone 7's salt management program uses an adaptive management approach to select the combination of salt management strategies to be implemented each year. The available strategies include salt removal by groundwater pumping, salt export through the operation of Zone 7's MGDP, and reduction of groundwater salinity by artificially recharging lower salinity imported water. In 2013, Zone 7 generated graphs that estimated future Main Basin salt concentrations (as TDS) from 2011 to 2050. These graphs were used to evaluate and develop long term plans (e.g., installing a second demineralization plant) for managing salt in the Main Basin.

For this update, Zone 7 updated these graphs using long-term supply and demand estimates developed for Zone 7's 2020 Urban Water Management Plan (UWMP, see **Section 9.4**). **Figure 8-21** shows three graphs with projections from 2020 to 2081:

- **Graph 1**: estimated net annual salt loading (tons) and net annual Basin storage change (AF);
- **Graph 2**: total salt in the Basin (tons) and total Basin storage (including all imported water added to the Chain of Lakes for recharge, in AF); and
- **Graph 3**: average Basin TDS concentrations (total salt/total storage, in mg/L).

The following milestones influence salt loading and TDS concentrations:

- Initially Zone 7 is expected to continue to rely on the Basin for municipal supply, which will both decrease Basin storage and increase salt removal. During this period TDS concentrations in the Basin are expected to stay relatively constant or increase slightly.
- In 2025, the Chain of Lakes (COL) Pipeline is expected to come online which will allow Zone 7 to recharge surface water into the COL. However, without additional imported surface water supplies, this will likely have little impact on the quality of the basin.
- In 2030, the Sites Reservoir and potable reuse projects are expected to come online, so Zone 7's reliance on the Basin will slowly decrease. In the beginning total salt will increase, but storage increases significantly, which will result in a decrease in Basin TDS concentrations.
- In 2040, the Delta Conveyance is expected to come online. For this scenario, this will not affect the available supply, but the TDS concentration of the imported surface water is expected to decrease, resulting in a decrease in the overall salt content in the basin.
- In 2060 mining will cease, and Zone 7 gets ownership of the remaining COL. The increased recharge capacity enables Zone 7 to install a second demineralization plant and increase pumping. This will result in further decreases in both total salt content and overall TDS concentrations.

TDS concentrations in the Fringe Area are generally not affected by Zone 7's conjunctive use and therefore are expected to continue trending as shown on the historical chemographs on **Figure 8-19**. Most of those chemographs show relatively constant TDS concentrations except for those in the Camp and May Subareas.

8.6.3. Nitrate

8.6.3.1. Introduction

The Zone 7 groundwater quality monitoring program addresses nitrate as one of the inorganic constituents of concern; accordingly, Zone 7 conducts numerous analyses for nitrate in the Basin similar to those presented above for TDS. Every year, Zone 7 uses well and mining pit sampling data to contour nitrate (as nitrate-nitrogen, NO_3-N) concentrations in the Main Basin (Upper and Lower Aquifers) and Fringe Areas (**Sections 8.6.3.2** and **8.6.3.3**). Zone 7 then calculates average nitrate (as N) concentrations in the Main Basin and Fringe Areas (**Section 8.6.3.4**). **Section 8.6.3.5** presents historical nitrate concentrations from 1974 to 1980. Zone 7 also calculates the net nitrate loading (**Section 8.6.3.6**) to estimate trends for each of the Management Areas. For this update, Zone 7 also evaluated the change in nitrate concentrations and loading since 2015 when Zone 7's NMP was published (**Section 8.6.3.7**).

8.6.3.2. Nitrate in the Upper Aquifer

The NMP identified ten local AOCs in the Upper Aquifer where nitrate (as N) has been detected at concentrations above the Maximum Contaminant Level (MCL) of 10 mg/L. These hot spots are shown in **Figure 8-22**. The descriptions below characterize each hot spot and identify potential sources of nitrate, current concentrations are also included:

- **Happy Valley** – This unincorporated, unsewered area has been subdivided into 1- to 5-acre lots and developed with rural residences relying on domestic wells for water supply. There are currently about 100 septic tanks or OWTS in use in Happy Valley. Very little additional development has been planned for Happy Valley because Alameda County has placed a moratorium on new OWTS construction in the area due to high nitrate detections in some of the domestic wells. There are no dedicated monitoring wells in the area; however, many of the domestic wells have been tested for nitrate since 1973. In 2013, Zone 7 and Alameda County Department of Environmental Health (ACEH) conducted voluntary testing of water samples from domestic wells in Happy Valley. Seven of the 31 wells had nitrate concentrations that exceeded the MCL. Most of the high nitrate occurrences were detected in the central portion of this enclosed subarea, which consists of only one aquifer (the Upland Aquifer). Nitrate concentrations were not monitored in this Upland Area AOC in the 2020 WY; however, when studied in the 2013 WY by Zone 7 and ACEH, the nitrate occurrences were found to be stable.
- **Staples Ranch** – This elongated AOC runs from west to east in the southern portion of the Camp Subarea and in the eastern portions of Dublin and Pleasanton. This area was heavily farmed in the past, and then left largely as undeveloped open space until recently. It is now planned for low- to medium-density residential and commercial development with connections to the municipal sewer, water, and recycled water. In the 2020 WY, the nitrate concentration was detected above the MCL threshold after dropping below in the 2019 WY (12.5 mg/L in the 2020 WY). A second area of elevated concentrations in this AOC existed historically to the west near Tassajara Creek; however, for the past few years, nitrate concentrations in this portion of the AOC have dropped below the MCL (9.3 mg/L in the 2020 WY in 3S1E05K006). The high nitrate levels are likely a remnant of past agricultural operations that included row crops, alfalfa cultivation, small dairy operations, and OWTS clusters. There is still some dry farming of hay in the area and a golf driving range in the eastern part with approximately 16 acres of irrigated turf. The future planned commercial development may effectively cap any potential buried nutrient sources from the historical agricultural land use, minimizing their leaching during rainfall events.
- **Bernal** – This AOC is based on nitrate concentrations from one well (3S1E22D002) in the southern portion of the Upper Aquifer of the Amador West Subarea. The long-term trend of concentrations in this well has been slowly declining. In the 2020 WY, the concentration was just below the MCL of 10 mg/L at 9.58 mg/L. This area is primarily sewered and developed as medium-density residential (about 2 to 8 dwellings per acre) with no future additional development planned. The source of high nitrate and the reason for the fluctuating concentrations has not been identified, but it is speculated that the nitrate may have been entering the Main Basin as hill-front recharge and/or subsurface inflow from the neighboring Upland Area to the south. These sources are likely diminishing as urban development and associated sewering spreads into the Upland Area.
- **Jack London** – This AOC extends from the eastern portion of the Mocho II Subarea to the northeastern portion of the Amador Subarea. The eastern portion is primarily sewered medium-density residential while the western portion is sewered commercial (including the Livermore airport) with little future development currently planned. A horse boarding facility operates in the most western part. Portions of this nitrate plume date back to at least the 1960s. Several wells in the Upper Aquifer have consistently had nitrate concentrations above the MCL. The highest

nitrate concentration detected in this AOC during the 2020 WY was 13.2 mg/L in 3S1E12D002. The most significant nutrient contributor is believed to have been the historical municipal wastewater disposal that was practiced at several locations in this AOC before the LAVWMA wastewater export pipeline was constructed. Historical and current agricultural practices, and current recycled water use are other potential nutrient loading sources for this area, although considered to be less significant.

- **Constitution** – This AOC exists near the boundary of the Mocho II, Camp, and Amador Subareas and is up-gradient from the Las Positas Golf Course in Livermore. This area is primarily sewered commercial with little future land use development. Nitrate concentrations were detected above the MCL in 3S1E01H003, at 15.7 mg/L during the 2020 WY. The source of the nitrate is unconfirmed but may be from historical OWTS use and agricultural practices, and current landscape fertilizer application and/or recycled water use.
- **May School** – The highest nitrate concentration detected in the groundwater basin is in a well (2S2E28D002) near May School Road in the Upper Aquifer of the May Subarea. For the 2020 WY, only 2S2E28D002 was sampled and had a concentration of 42 mg/L. The source of high nitrate has not been identified; however, it likely comes from agricultural land use in that area. Also, this unsewered area has a concentration of rural residences on Bel Roma Road that are served by OWTS. There are no known future development plans for the area.
- **Charlotte Way** – This AOC exists in the western portion of the Mocho I Subarea and may commingle with the Buena Vista AOC in the eastern portion of the Mocho II Subarea. The area is primarily sewered and developed as medium-density residential. There is no future development planned for the area. Elevated nitrate concentrations have been typically detected in three monitoring wells in this AOC. However, in the 2020 WY, only one of the three wells sampled exceeded the MCL; 13.8 mg/L in 3S2E03K003. Nitrate concentrations were detected just below the MCL in two other monitoring wells at 9.83 mg/L in 3S2E14A003 and at 9.35 mg/L in 3S2E10F003. The cause is believed to be historical OWTS, fertilizer applications, and other agricultural land uses that no longer exist in the area but continue to have impacts on groundwater quality.
- **Buena Vista** – This nitrate plume is defined by several wells in the central and eastern portion of the Mocho II Subarea in both the Upper and Lower Aquifers. This area is primarily unsewered low- to medium-density residential, vineyard and winery land uses with some future vineyard and winery development planned. The concentration in 3S2E22B001, near the proximal end of the plume, fluctuates above and below the MCL. During the 2020 WY, the highest concentration was detected in the northeastern portion of the plume at 15.2 mg/L in 3S2E10Q001. The potential sources of the nitrate are existing OWTS and historical agricultural practices, livestock manure, and composting vegetation. There are over 100 OWTS still in use near the proximal end of the plume, documented historical poultry farming, and crop and floral farming along Buena Vista Avenue.
- **Greenville** – This east Fringe Area AOC, located near the corner of Greenville Road and Tesla Road, is primarily developed as unsewered low-density residential, vineyard, and wineries. Additional vineyard and winery uses are planned for this AOC in the South Livermore Valley Specific Plan.

The highest concentration of nitrate recorded in this area was 37 mg/L in 2001 WY. In the 2020 WY, 3S2E24A001 had a concentration of 24.5 mg/L. The source of nitrate in this area is unconfirmed, but believed to be from historical poultry farming, and other agricultural land uses located up-gradient. There is concern for the potential increase in onsite wastewater disposal from the future commercial development planned for this area.

- **Mines Road** – This AOC is represented by a single well; 3S2E26J002, located in the southern portion of the Main Basin Upper Aquifer along Mines Road. Nitrate concentrations in this well have fluctuated widely, ranging from non-detect to a maximum of 21.4 mg/L in October 2011. For the 2020 WY, the nitrate concentration was below the MCL at 1.37 mg/L. The reasons for the fluctuations are unknown but may be related to agriculture and changes in precipitation. This area is primarily unsewered low-density residential with little future development planned.

8.6.3.3. Nitrate in the Lower Aquifer

In the Lower Aquifer, nitrate was detected above the MCL in only three areas (**Figure 8-23**):

- **Jack London** – While smaller in extent than the AOC for the Upper Aquifer, the general location of this AOC also underlies the shallow nitrate plume, suggesting communication between the Upper Aquifer and the Lower Aquifer. Nitrate was not detected above the MCL in any of the wells in this AOC during the 2020 WY.
- **Buena Vista** – The general location of this AOC underlies the Buena Vista nitrate plume in the Upper Aquifer, also suggesting that nitrate from the Upper Aquifer has migrated into the Lower Aquifer. This plume also appears to have migrated towards, and possibly co-mingled with, the Jack London plume. In the 2020 WY, nitrate concentrations exceeded the MCL in two monitoring wells (11.2 mg/L in 3S2E8H003 and 10.8 mg/L in 3S2E16A003). Four other wells, including two municipal supply wells located in the same AOC had nitrate concentrations that approached the MCL (8.7 mg/L in CWS 10, 8.04 mg/L in CWS 9, 9.6 mg/L in 3S2E15E002, and 9.35 mg/L in 3S2E05N001). Overall, this Lower Aquifer nitrate plume has been relatively stable over the last five years.
- **Southern Portion of Amador Subarea** – Historically, nitrate was detected in one well above the MCL (3S1E19D009 at 11.5 mg/L) in this area. There is no corresponding concentration of nitrate above the MCL in the Upper Aquifer; however, nitrate was detected at a slightly elevated concentration in a shallower well in the same nested set (6.12 mg/L in 3S1E19D007). The source of this nitrate is unknown but may come from historical agricultural land use in the vicinity. Nitrate was not detected above the MCL in any of the wells in this AOC during the 2020 WY.

8.6.3.4. Average Nitrate Concentrations

Each year, Zone 7 calculates the average nitrate concentrations for several areas in the Fringe Area and for the Main Basin (both Upper and Lower Aquifers) using groundwater quality contours based on actual measured monitoring data. The 2020 WY results are shown in **Figure 8-24**. In the Main Basin, the total average nitrate (as N) concentration for 2020 is 3.2 mg/L for both the Upper and Lower Aquifers. In the each of the Fringe Areas, average concentrations range from 2.9 to 8.3 mg/L. The average concentration across the entire Upland Area is approximately 3.7 mg/L. All concentrations are below the MCL; however, there are certain localized areas ("Nitrate Areas of Concern" on **Figure 8-22**) where the nitrate concentration exceeds the MCL.

8.6.3.5. Historical Nitrate Concentrations

Figure 8-25 shows chemographs of nitrate (as N) for the period 1975 to 2020. All nitrate concentrations are presented with a vertical axis from 0 to 50 mg/L. The graphs also include the minimum thresholds (dashed lines, blue for upper aquifer and red for lower aquifer) and measurable objectives (i.e., the Basin MCL of 10 mg/L, solid green line) for the representative monitoring sites as discussed in **Sections 13.4** and **14.4.** The inset map shows the areas where nitrate concentrations were above the MCL in the upper aquifer in 2015 WY (as black dashed lines) and, for comparison, in 2020 WY (as orange regions).

The top portion of **Figure 8-25** shows eight nitrate chemographs from 1975 to 2020 along the subareas of the North Fringe Area (Dublin, Bishop, Camp, May, Cayetano, Spring). For all chemographs except May Subarea, concentrations are below 10 mg/L and trends area generally steady over the long term. The graph for the May Subarea shows a significant increase in nitrate with concentrations varying in recent years between about 25 and 45 mg/L. As discussed below, this area has been identified in the NMP as one of ten local AOCs. Similarly, the nitrate graph for the East Fringe Area at the right also shows nitrate above the Basin Plan WQO; this area, too, has been identified as an AOC.

The bottom portion of **Figure 8-25** shows nitrate chemographs from the Upper (in blue) and Lower (in red) Aquifers of the Main Basin. These chemographs show that nitrate trends have been relatively steady over time, most of which have remained below the 10 mg/L WQO. The Amador East Upper Key well indicates nitrate concentrations in the Upper Aquifer have generally ranged between 10 to 25 mg/L with a few outliers. The two easternmost Key Wells (Mocho II Upper and Lower) show relatively steady nitrate trends with concentrations generally around 10 mg/L for both the Upper Aquifer and Lower Aquifer.

Only one nitrate concentration (below the detection limit) from 1987 was available from the 3S2E21K009 in the Upland Area.

8.6.3.6. Nutrient Loading Calculations and Trends

The nitrate loading and assimilative capacity of the Basin was studied as part of the NMP. Groundwater nitrate concentrations are good indicators of nutrient contamination, and graphing concentrations versus time can indicate whether nitrate conditions are changing or stable. Given the variability of nitrate in the environment, Zone 7 uses estimates of nitrogen loading to evaluate long-term nitrate trends. The primary nitrogen sources and losses assumed in the NMP are shown in **Table 8-H** below.

Table 8-H: Sources and Losses of Nitrogen in Groundwater

NITROGEN SOURCES	NITROGEN LOSSES
Stream Recharge	Soil Processes
Rainfall Recharge	• Denitrification
Pipe Leakage	• Soil texture (absorption)
Subsurface Inflow	• Plant Uptake
Horse Boarding (manure)	Groundwater Pumping Mining Export Subsurface Outflow
Rural (OWTS and livestock manure)	Mining Export
Winery (OWTS and process water)	Subsurface Outflow
Applied water (well water & recycled) water)	
Fertilizers (agriculture and turf)	

For this update, Zone 7 updated the estimated the future annual nitrogen loading and removal from all these components for average hydrologic conditions (**Table 8-3** for the Main Basin, **Table 8-4** for the Fringe and Upland Areas, **Appendix L**). Annual nitrogen loading from each known source was estimated and summed to predict future nitrate trends for each Management Area. The model results predict that average nitrate concentrations will decrease over time in the Main Basin and will increase in the Fringe and Upland Areas. Detailed calculations supporting the nutrient loading estimates are provided in **Appendix L**.

8.6.3.7. Effectiveness of NMP Strategies

To minimize nitrate loading to the Basin, the 2015 NMP recommended implementing OWTS loading limits in AOCs with existing OWTS. These "OWTS Special Permit Areas" (SPAs) are shown on **Figure 8-25 to Figure 8-27**. **Figure 8-25** also shows nitrate concentrations above the 10 mg/L MCL for the 2013 (when the NMP was first released) and 2020 WYs. **Figure 8-26 and Figure 8-27** include nitrate concentrations contours above the 10 mg/L MCL for the 2015 (just before the NMP recommendations were implemented) and 2020 WYs in the Upper and Lower Aquifers, respectively. These figures show that the contoured areas decreased for the Jack London, Staples Ranch and Bernal AOCs. The Buena Vista AOC appears to have increased slightly and has migrated down-gradient towards the California Water Company (Cal Water) municipal wells. The Greenville, May School, and Happy Valley AOCs show little change; however, all three have been represented by limited data, so the actual extent of those contoured areas is unknown. The graphs on **Figure 8-25** shows that the concentrations of 2S2E28D002 in the May School AOC and 3S2E24A001 in the Greenville AOC have both been increasing over time, suggesting that the plumes are either increasing or migrating down-gradient.

For this update, Zone 7 was able to obtain some OWTS data from the ACEH. **Figure 8-28** shows parcels with OWTS and locations with OWTS permits given by ACEH since 2015. **Table 8-5** shows the change in nitrogen loading from OWTS in the Basin and the SPAs and also estimates the change in loading attributable to the NMP recommendations (e.g., installing an advanced OWTS system with nitrogen reduction instead of a standard OWTS). The table shows that the NMP OWTS recommendations have reduced nitrogen loading by about 70 pounds (lbs) of nitrogen per year, primarily in the Buena Vista and Greenville SPAs.

8.6.4. Boron

8.6.4.1. Boron in the Upper Aquifer

Boron is a naturally occurring element typically found at very low concentrations in groundwater from the Basin. While there is no MCL for boron, the EPA has identified a Health Reference Level (HRL) of 1,400 micrograms per liter [µg/L] (1.4 mg/L). Boron also becomes a problem for irrigated crops when present at levels above 1,000 or 2,000 µg/L, depending on the crop sensitivity.

Boron exists at elevated concentrations in the Upper Aquifer in the following areas of the Basin (**Figure 8-29,** note that concentrations are shown on the figure in µg/L):

- There is a plume of elevated boron concentrations that extends along the boundary between the North Fringe Area and the Main Basin. This localized concentration of boron has been relatively stable for many years. The highest concentration measured in the 2020 WY (12,000 micrograms per liter [µg/L]) was found near the center of this area in monitoring well 3S1E04J005.
- Elevated boron concentrations were also detected in parts of the Northeast and East Fringe Areas. The highest concentration detected in these areas in the 2020 WY was detected at 29,000 µg/L in monitoring well 2S2E27P002.

The source of boron is likely from natural alkali/marine sediments in the east, but this is unconfirmed. It should be noted that the boron detected in the western portion of the Basin primarily occurs along the Arroyo Las Positas and lower Arroyo Mocho. This occurrence of elevated boron may be from high-boron groundwater discharging into the Arroyo Las Positas in the eastern portion of the Valley and flowing downstream to the Arroyo Mocho, recharging groundwater along the way. The eastern portion of the Arroyo Las Positas has been a gaining stream and continuously flowing into the Arroyo Mocho since the 1981 WY.

8.6.4.2. Boron in the Lower Aquifer

In general, boron concentrations are relatively low in the Lower Aquifer; detections are typically less than 1,000 µg/L. In the 2020 WY, boron was detected above 1,000 µg/L in the Lower Aquifer in the following areas of the Basin (**Figure 8-30**, note that concentrations are shown on the figure in µg/L):

- In municipal supply well Mocho 3, in Zone 7's Mocho Wellfield, at 1,000 µg/L .
- In monitoring well 3S2E23E002, in the southeastern portion of the Mocho II Subarea, at 2,600 µg/L.

The source of boron is unconfirmed but may originate in localized natural alkali/marine sediments or vertical migration through the leaky aquitard from the Upper Aquifer.

8.6.4.3. Historical Boron Concentrations

Figure 8-31 shows chemographs of boron (in µg/L) for the period 1975 to 2020. The boron concentrations are presented on the vertical axis from 0 to 5,000 µg/L (except for the graph for 3S2E01F002, which extends to 11,000 µg/L). The graphs also include the minimum thresholds (dashed lines, blue for upper aquifer and red for lower aquifer) and measurable objectives (i.e., the Basin Objective of 1,400 µg/L, solid green line) for the representative monitoring sites as discussed in **Sections 13.4** and **14.4**. The inset map shows the areas where boron concentrations were above the basin objective (1,400 µg/L) in the upper aquifer for the 2020 WY.

8.6.5. Chromium

8.6.5.1. Chromium in the Upper Aquifer

Chromium (Cr) is typically found at very low concentrations in groundwater in the Basin. It can be a naturally occurring element found in the Basin and is generally derived from the Franciscan Assemblage, which contains Serpentinite that tends to be rich in magnesium, chromium and nickel. Chromium can also be the result of an anthropogenic impact. Prior to August 2017, the Basin WQO and the Minimum Threshold in the Alternative GSP had been set at the MCL for hexavalent chromium (CrVI), which was 10 µg/L. In August 2017, under orders of the Superior Court, the State Water Resources Control Board (SWRCB) withdrew the CrVI regulation from the California Code of Regulations. Until the SWRCB establishes a new MCL for CrVI, they have returned to use the more general total Cr MCL of 50 µg/L to ensure public water systems are safe. Since all the Minimum Thresholds in the Alternative GSP have been set based on the State's drinking water standards, Zone 7 adjusted the Minimum Threshold for Cr to match the State's Cr MCL that is in effect; currently 50 µg/L (see **Section 13**). Chromium concentrations exceeded the 50 µg/L threshold in two Upper Aquifer monitoring wells during the 2020 WY sampling effort. Concentrations are presented on **Figure 8-32** (note that concentrations are shown on the figure in µg/L):

- Cr was detected at 94 µg/L in monitoring well 3S2E12C004 which is located on the LLNL site in the East Fringe Area.
- Cr was detected at 108 µg/L in monitoring well 3S1E07G007 located in the North Fringe Area just north of the Main Basin.

8.6.5.2. Chromium in the Lower Aquifer

Cr was not detected above the MCL in any of the monitored Lower Aquifer wells. However, Cr was detected in several monitoring and production wells at greater than the former Minimum Threshold of 10 µg/L as shown on **Figure 8-33** (note that concentrations are shown on the figure in µg/L).

Because the locations of the slightly elevated Cr concentrations in the Lower Aquifer do not coincide with those in the Upper Aquifer, it is likely that the Cr in the Lower Aquifer is not a result of vertical migration from the Upper Aquifer. It may be the result of localized leaching of naturally occurring chromium-rich minerals in those portions of the Lower Aquifer.

8.6.5.3. Historical Chromium Concentrations

Figure 8-34 shows chemographs of chromium (in µg/L) for the period 2000 to 2020 (no chromium results are available before the 2020 WY). The chromium concentrations are presented on the vertical axis from 0 to 80 µg/L. The graphs also include the minimum thresholds (dashed lines, blue for upper aquifer and red for lower aquifer) and measurable objectives (i.e., the Basin Objective of 50 µg/L, solid green line) for the representative monitoring sites as discussed in **Sections 13.4** and **14.4**. The inset map shows the areas where chromium concentrations were above the basin objective (50 µg/L) in the upper aquifer for the 2020 WY.

8.6.6. PFAS

8.6.6.1. Introduction

Per- and polyfluoroalkyl substances (PFAS) are a large group of human-made substances that do not occur naturally in the environment. PFAS are classified by the EPA as CEC. These substances have been used extensively in the United States since the 1940's, particularly in surface coating and protectant formulations due to their ability to repel oil, grease, and water. There is limited research to date, but some studies show that they may cause adverse health effects. Additional research is needed to determine the full scope of PFAS impacts on human health.

Zone 7 began sampling for PFAS compounds in the 2019 WY. Based on the detections in some of the supply wells and the limited set of monitoring wells sampled, Zone 7 hired Jacobs Engineering, Inc. to conduct a PFAS Potential Source Investigation (*Jacobs, 2020*). The investigation, which concluded in December 2020, included maps and cross sections showing PFAS concentrations in the Main Basin and recommendations for additional sampling of existing monitoring wells. Those wells will be incorporated into the 2021 WY sampling program. Jacob's PFAS Potential Source Investigation Report and other information on PFAS are located on the Zone 7 website: http://www.zone7water.com/pfas-information.

Of those PFAS compounds detected, only perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS) have any regulatory limits (see **Table 8-I**), and of those three compounds, PFOS had the highest concentrations relative to regulatory limits. **Figure 8-35** and **Figure 8-36** show PFOS concentrations (in part per trillion [ppt]) for the Upper and Lower Aquifers.

Table 8-I: Regulatory Limits for PFAS Compounds (in ppt)

Agency	Type of Limit	PFOS	PFOA	PFBS**
US EPA	Screening Level	40*	40*	-
	Preliminary Remediation Goal (PRG)	70*	70*	-
State Water Resources Control Board (SWRCB) - Division of Drinking Water (DDW)	Notification Level (NL)	6.1	5.1	500
	Response Level (RL)	40	10	5,000

* Either individually or combined.
** Pending

8.6.6.2. PFAS in the Upper Aquifer

Monitoring wells previously sampled and presented in the 2019 WY Annual Report were not resampled in the 2020 WY; however, additional wells were sampled to help determine the extent of PFOS in the Basin. The results from both water years are presented on **Figure 8-35**.

- While most of the wells sampled in the 2019 WY had PFOS detections, those concentrations that were above the EPA's 40 ppt screening level and above the DDW's 70 ppt response level (RL) appear to be northeast of the mining area in the vicinity of the Jack London Boulevard. The highest concentration detected in the Upper Aquifer remains 450 ppt in well 3S1E10A002 sampled in the 2019 WY, which is just southeast of the airport.
- Two wells sampled in the 2020 WY (3S2E19D007 and 3S2E19N003) that were east of Isabel Avenue and south of Stanley Boulevard were both non-detect for PFOS.
- In the 2020 WY five wells were sampled north and east of the highest concentration area. These wells ranged from non-detect to 40 ppt (in well 3S1E04J005). The PFOS detected in 3S1E04J005 does not appear to be connected to the plume southeast of the airport and may come from a separate source.

8.6.6.3. PFAS in the Lower Aquifer

Figure 8-36 shows PFOS concentrations in the Lower Aquifer wells that were sampled in either the 2019 or 2020 WYs. For wells that were sampled more than once, the map shows the highest PFOS concentrations detected. In nested well sets, the map shows the Lower Aquifer well with the highest PFOS concentration. The 2019 WY samples are labeled black with gray highlights in the map.

- Wells with concentrations above the EPA's 40 ppt screening level are within a roughly triangular area that stretched from the southwestern edge of the airport (north of the mining area) to the

City of Pleasanton's Wellfield (west of the mining area) and to Zone 7's Mocho Wellfield (northwest of the mining area).

- There were two areas where PFOS concentrations exceeded the DDW's RL (70 ppt):
    - The first extended west from the airport to Zone 7's Mocho Wellfield. This area included 3S1E10B008, which had the highest concentration detected in the Basin, at 1,400 ppt in the 2020 WY. Zone 7's Mocho 1 municipal well was the only municipal well in this area with PFOS concentrations above the RL at 110 ppt in the 2020 WY.
    - The second was at Pleasanton's Well 8 (Pleas 8 or P8), which had a maximum concentration of PFOS at 110 ppt in the 2020 WY. During the 2019 WY the PFOS concentrations ranged from 68 to 120 ppt. This area of elevated PFOS concentration appears to be relatively isolated as evidenced by several wells with concentrations below the RL both north (roughly up-gradient) and west (down-gradient) of Pleas 8.
- Eight of Zone 7's municipal wells have tested above the NL for PFOS (6.5 ppt) in the 2020 WY, but only one of the municipal wells, Mocho 1 (i.e., 3S1E09M002), had PFOS concentrations (110 ppt) that exceeded DDW's recommended RL of 70 ppt. Four of Zone 7's wells also tested above the NL for PFOA (5.1 ppt). Although additional PFAS compounds were also detected in Zone 7's water supplies, at present there are no regulatory guidelines for these contaminants.
- PFOS was detected in five of six CWS wells sampled in the 2020 WY. None of the wells had concentrations above the RL (70ppt).

8.6.6.4. Other PFAS Monitoring/Studies

Zone 7 continues to monitor and characterize PFAS in the Basin and is working with the San Francisco Region Water Board to identify potential sources. In preparation for a MCL setting for PFAS at the end of 2023 and compliance by Spring 2024, Zone 7 is undertaking design of a PFAS treatment facility project to ensure that water quality from the COL wells would be in compliance with the MCL and available for use. The project scope includes design and construction of a PFAS treatment facility located at the COL 1 well site. COL 1 has the chemical treatment facilities for all three existing wells (COL 1, 2, and 5) and future wells and shares a common manifold to the Zone 7 distribution system.

Zone 7 is also performing a Desktop Groundwater Contaminant Mobilization Study (Project) that will develop a model that can be used to simultaneously analyze flows, chemical transport, and geochemical interactions and evaluate the potential for chemical constituents or contaminants to mobilize under a variety of conditions. The Project will help Zone 7 better understand how existing and future groundwater pumping operations affect contaminants in the Basin. Model simulations could inform Zone 7's and retailers' pumping operations, and construction of new wells. Although this Project and other studies were originally identified as next steps in the Potable Reuse Feasibility Study completed in May 2018, the list of studies and their focus have transitioned to broader water supply and water quality efforts that will benefit overall water supply reliability and groundwater quality and management, including PFAS-related issues.

8.6.7. Toxic Sites

Zone 7 documents and tracks sites where groundwater has been impacted from anthropogenic sources and identifies those that pose a potential threat to drinking water. Zone 7 also coordinates closely with lead agencies to ensure protection of beneficial uses. Information is gathered from state, county, and local agencies, as well as from Zone 7's well permitting program and the SWRCB's GeoTracker website, and compiled in a geographic information systems (GIS) database. This tracking program is designated the Toxic Sites Surveillance (TSS) Program and is described in the Zone 7 Annual Reports.

Each site in Zone 7's TSS Program has been assigned a Zone 7 number, which corresponds to a file number containing reports or other information about the site. In addition, all sites are reviewed and given a priority designation (high, moderate, or low) based on the threat they pose to groundwater. For example, a site is designated as high priority if contamination at the site is present in groundwater at concentrations greater than the MCL and a water supply well is within 2,000 ft down-gradient of the site, or it is shown that drinking water or surface water will likely be impacted by the contamination at the site. High Priority sites are typically located in the Main Basin where Zone 7 and their retailers' wells are located. However, if another type of supply well (domestic, industrial, agricultural, etc.) located outside of the Main Basin is impacted or threatened the same criteria would apply.

In general, the TSS Program has found two types of contamination threatening groundwater in the Basin:

- **Petroleum-based fuel products** - including total petroleum hydrocarbon as gasoline (TPHg), TPH as diesel (TPHd), benzene, toluene, ethylbenzene, xylene (collectively known as BTEX), and fuel oxygenates, such as Methyl tert-butyl ether (MTBE) and tertiary-butyl alcohol (TBA). California has assigned clean-up standards (*Title 22, California Code of Regulations*) for the BTEX compounds and fuel oxygenates. However, a clean-up standard for total petroleum (TPHg or TPHd) has not officially been established.
- **Industrial chemical contaminants** – including the chlorinated solvents tetrachlorethylene (PCE), trichloroethylene (TCE), and their degradation by-products, such as vinyl chloride (VC) and dichloroethene (DCE). PCE is common in the dry cleaning business, and TCE is commonly used as a degreaser for electronics and automotive industries. Both PCE and TCE have an established MCL of 5 µg/L (*CCR, Title 17, Section 64444*).

In the 2020 WY, Zone 7 tracked the progress of 56 active sites where contamination has been detected in groundwater or is threatening groundwater. Eleven of these active sites have a contaminant plume that is within 2,000 ft of a water supply well or a surface water source and are therefore classified as "High Priority" cases due to their impact or threat of impact on potable groundwater supplies. Zone 7's database also contains 283 other contamination cases that have been either "Closed" or classified as "No Action Required" because they have been sufficiently cleaned up and/or pose minimal threat to drinking water supplies.

The locations of all the toxic sites, and their proximity to the Valley's municipal water wells, are shown on the accompanying individual area maps (**Figure 8-37** through **Figure 8-39**, Livermore, Pleasanton/Sunol, and Dublin subareas, respectively). Zone 7 also maintains a database for all the toxic sites that includes the case status, its priority, and which agency is responsible for providing oversight for the case. It also identifies the contaminants of concern for each case and provides brief notes regarding the cases. Zone 7's Annual Reports include tables that summarize the results for the year. In addition, copies of plans, reports, directive letters, and background data on the cases can be found at the SWRCB's GeoTracker website: http://geotracker.waterboards.ca.gov/.

8.7. Land Subsidence

§ 354.16. Groundwater Conditions
(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

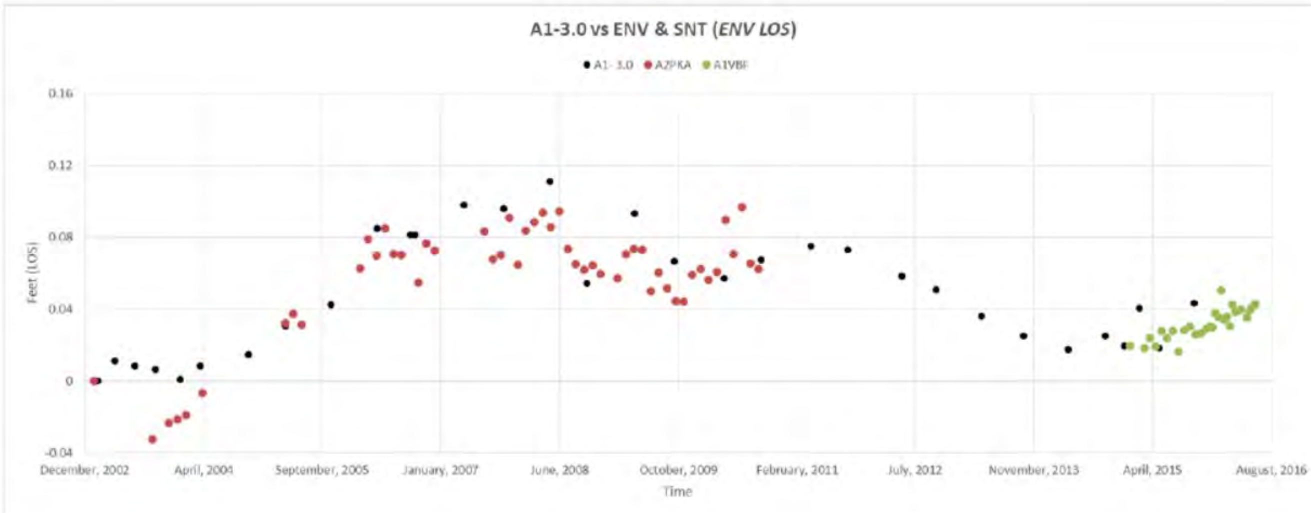
☑ **23 CCR § 354.16(e)**

As demonstrated herein (consistent with the approved 2016 Alternative GSP) and the requirements of CWC § 10733.6 (a)(3) and 23 CCR § 356.4, Zone 7 has continued to sustainably manage land subsidence in the Basin to avoid URs (as defined in **Section 13.5.1**) for decades, including over three major droughts.

Land surface elevations have been monitored in the Basin for over 60 years, with no evidence of inelastic land subsidence occurring; however, the data collected have revealed small seasonal fluctuations as well as larger cycles of elevation gains and losses that correlate with groundwater elevation trends. Up until the 2018 WY, land surface elevations in the Main Basin were monitored using benchmark surveys; several level survey circuits were run between 1947 and 1980, and more recently, semi-annual benchmark surveys were conducted as part of the Land Surface Elevation Monitoring Program starting in 2002.

In the 2016 WY, Zone 7 contracted with TRE Altamira (TRE) to evaluate Interferometric Synthetic Aperture Radar (InSAR) as an alternative to land surveying for subsidence monitoring. The study results correlated well with topographic surface measurements taken by land surveys within the same period (see **Figure 8-A** below, taken from Attachment I of Zone 7's 2016 Alternative GSP) and provided a basis to justify InSAR as an alternative method to monitor subsidence.

Figure 8-A: Comparison of Land Survey Point (A1-3.0) to InSAR Data

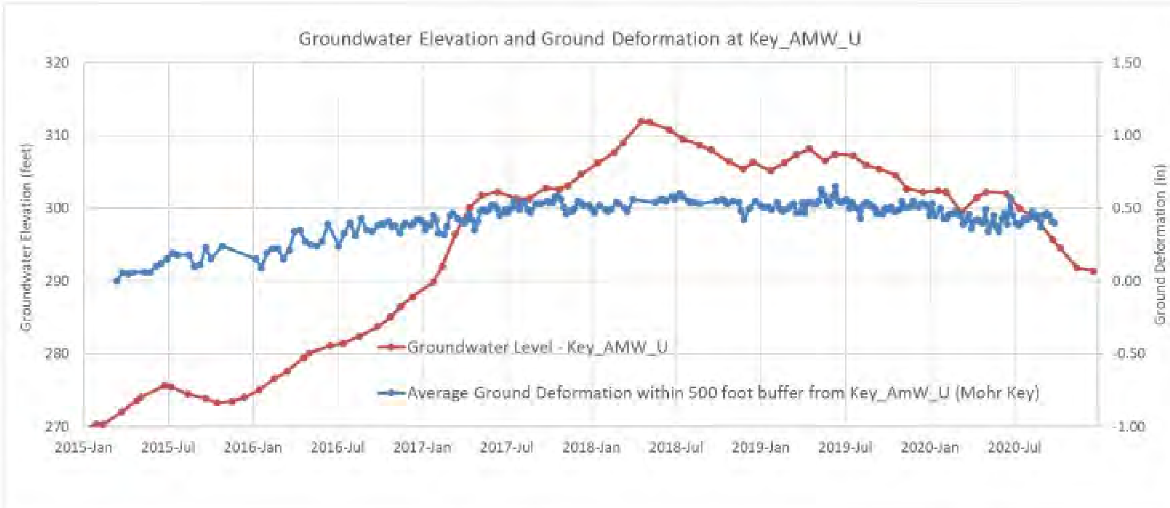


Starting in the 2019 WY, instead of continuing the land surveying program, Zone 7 used InSAR for monitoring land subsidence. For that year's study, TRE expanded the coverage area to include all the Basin, including the entire Main Basin, Fringe, and Upland Areas. For the 2020 WY, Zone 7 contracted again with TRE to perform an analysis of satellite data for the Valley collected since the 2016 WY. **Figure 8-40** shows the extent of the InSAR study performed this year, the locations of the selected InSAR points, and the total land surface deformation from March 2015 to September 2020. The figure shows that the overall changes in ground surface elevations are very small (from between -0.04 to +0.02 feet, represented by yellow and green dots) or have actually have generally risen (about 0.02 to 0.06 feet, represented by green and blue dots). These land surface elevation changes (i.e., within +/- 0.04 feet) are within the range Zone 7 considers to be "elastic deformation" (i.e., rebounds to the original elevation when groundwater levels return to previous levels). In fact, the general land surface increase since 2015 likely represents an "elastic" response to groundwater elevation increases following the drought in the early 2010s. The following items summarize other findings from the InSAR analysis:

- Several areas in the mining area appear to have dropped more than 0.10 feet (indicated by red dots in **Figure 8-40**). These are likely due to elevation changes from mining excavation and additional grading activities, and not from land subsidence.
- In the vicinity of Zone 7's wellfields, fluctuations in ground surface elevation have generally trended with changes in groundwater elevations and appear to be indicative of elastic land ground-surface deformations.

The TRE report (**Appendix J**) includes the following additional figures and tables: Figures 10 and 11 (pages 16 and 17) show the cumulative land surface elevation change from the 2019 to 2020 WYs. Figures 13 through 15 (pages 19 to 21, a portion of Figure 14 is reproduced in **Figure 8-B** below) show graphs of ground surface elevation and groundwater elevation.

Figure 8-B: Groundwater Elevation vs Ground Displacement at the Amador West Key Well



The ground deformation graphs in **Figure 8-A** and **Figure 8-B** show that no inelastic subsidence has been observed since the beginning of the land surveys in 2002.

In 2021, rather than contracting directly with TRE, Zone 7 will obtain TRE's InSAR dataset from DWR that is published as part of DWR's SGMA technical assistance to provide "important SGMA-relevant data to GSAs for GSP development and implementation". For more information about the TRE InSAR Subsidence Data for DWR, visit this website: https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence.

8.8. Groundwater Dependent Ecosystems

§ 354.16. Groundwater Conditions
(f) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

☑ **23 CCR § 354.16(g)**

The following sections describes the process used to identify likely GDEs within the Basin. A summary of the work effort is presented below and in **Appendix F**.

8.8.1. Preliminary Screening

Preliminary identification of likely GDEs within the Basin is performed based on the available data and tools, field and aerial photo surveys, and analysis conducted in general accordance with the process laid out in The Nature Conservancy (TNC) guidance (*Rohde et al., 2018*).

8.8.1.1. Data Sources

Primary data sources that were incorporated into the screening analyses or otherwise supported the GDE field investigation and identification include the following:

- GDE information from the DWR's Natural Communities Commonly Associated with Groundwater (NCCAG) dataset and TNC guidance documents (*Rohde et al., 2018; Klausmeyer et al. 2019; TNC, 2019*);
- GDE health indices from the TNC GDE Pulse tool[15], including the Normalized Derived Moisture Index (NDMI) and the Normalized Derived Vegetation Index (NDVI), which indicate the vegetation moisture and vegetation greenness, respectively;
- Additional resources regarding the presence of GDEs in the Basin, including GDE geospatial data and Sycamore alluvial woodland data;
- United States Geological Survey (USGS) ground surface elevation data;
- Well information, including locations and well construction details; and
- Groundwater elevation and depth to water data.

8.8.1.2. Depth to Groundwater Analysis

The NCCAG dataset identifies land areas by vegetation or wetland categories that potentially indicate the presence of GDEs, as shown on **Figure 8-41**. The NCCAG dataset also assigns the potential GDEs a polygon number. An additional GDE area (i.e., the Springtown Alkali Sink[16]) was not identified in the NCCAG dataset, but was included in this analysis and on **Figure 8-41** for completeness.

Based on review of the NCCAG dataset, the maximum rooting depth of various plant species associated with potential GDEs within the Basin is approximately 30 feet below ground surface (ft bgs).[17] As such, if the minimum depth to groundwater between 2015 and 2020 in the vicinity of the mapped potential GDEs was greater than 30 ft bgs,[18] it is unlikely that the mapped vegetation or wetland areas in the NCCAG dataset were accessing the principal aquifer[19] as their source of supply. Rather, these mapped vegetative communities are likely supplied by a surface water, perched groundwater, or other source (e.g., runoff or a man-made water feature) and are therefore not GDEs in the context of SGMA.

To further clarify whether the mapped vegetative communities from the NCCAG are likely GDEs that are dependent on the principal aquifer, the depth to groundwater for each potential GDE polygon (and the area of the Springtown Alkali Sink) was estimated by comparing the potential max GDE rooting depth (30

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[15] https://gde.codefornature.org/#/methodology; The GDE Pulse interactive map developed by TNC provides users easy access to satellite data to view long term temporal trends of vegetation metrics. These vegetation metrics serve as an indicator of vegetation health for GDEs. In addition, the GDE Pulse web app provides long-term temporal trends of groundwater depth and regional precipitation data. This provides users with a platform to infer relationships between groundwater levels, precipitation, and GDE vegetation metrics to monitor and sustainably manage groundwater and GDEs.

[16] The 2016 Alternative GSP identified the Springtown Alkali Sink as a GDE in Section 2.1.4.

[17] https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/

[18] Since the Plan is not required to address URs that occurred before, and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2015 is selected as the start of the analysis timeframe.

[19] Per § 351.(aa), "Principal aquifers" refer to aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. The Main Basin includes a single principal aquifer that includes two hydraulically connect zones with varying degrees of connectivity: the Upper Aquifer and Lower Aquifer.

ft bgs) to the measured depth to groundwater from nearby Upper Aquifer wells within the Basin. Upper Aquifer wells within a one kilometer (km) radius of the mapped potential GDEs were assumed to be representative of groundwater conditions within those areas (*Klausmeyer et al. 2019*). The locations of Upper Aquifer wells within the Basin that were used to evaluate shallow groundwater conditions are shown on **Figure 8-42**. If multiple wells were within one km of a GDE polygon, the minimum depth to groundwater between 2015 and 2020 from these wells was calculated.

If the minimum depth to water between 2015 and 2020 was greater than 30 ft bgs, then that respective GDE polygon was determined to likely not be a GDE that was dependent on the principal aquifer and was "removed" from further consideration. If the minimum depth to groundwater between 2015 and 2020 was less than 30 ft bgs or if no proximate groundwater data were available, the potential GDE polygon was preliminarily "retained" for further review. The retained and removed GDE polygons are shown on **Figure 8-42**.

8.8.1.3. Application of the TNC GDE Pulse Tool Methodology

The TNC GDE Pulse tool provides time series data for two remote sensing indices that are used to monitor a vegetation's health: (1) the NDMI, and (2) the NDVI, which indicate the vegetation moisture and vegetation greenness, respectively. Higher NDMI and NDVI values are associated with "healthier" vegetation. In the TNC GDE Pulse tool the NDMI and NDVI data are indexed to the same GDE polygon numbers included in the NCCAG dataset[20].

The premise of the TNC GDE Pulse tool is that, since the NDMI and NDVI indices can quantify changes in the rates and patterns of vegetation growth and moisture levels in plants over time, the relationship between these two indices and the depth to shallow groundwater can be evaluated to examine whether these measures of GDE "health" have a relationship to shallow groundwater conditions. Since limited depth to groundwater data are provided in the TNC GDE Pulse tool, depth to groundwater data collected within the Basin were used to supplement this analysis.

Time series data of these two indices and the nearby (i.e., within one km) depth to groundwater data were plotted for each retained GDE polygon, as shown on **Figure 8-43** and **Appendix F**. A linear correlation between the two indices and the local depth to groundwater data was then evaluated for each polygon. A negative correlation would mean that, when the depths to groundwater increase, the NDMI and NDVI indices decrease, indicating that the GDEs are less healthy when conditions are such that local groundwater elevations decrease, and vice versa.

Among the preliminarily retained GDEs (i.e., those GDE polygons where the minimum depth to groundwater in the Upper Aquifer between 2015 and 2020 was less than 30 ft bgs), 84% exhibited a negative correlation between NDMI and depth to groundwater, and 71% exhibited a negative correlation between NDVI and depth to groundwater. For the purpose of this analysis, correlation with a p-value that

[20] There are no TNC GDE Pulse data for Springtown Alkali Sink, so the analysis of groundwater level trends and the NDMI and NDVI indices could not be conducted for this GDE.

is less or equal to 0.05 is considered to be significant. Among the potential GDEs that have negative correlations, 46% of them have a significant correlation between NDMI and depth to groundwater, and 38% of them have a significant correlation between NDVI and depth to groundwater. The potential GDE areas that exhibited negative correlations for both NDMI and NDVI are shown on **Figure 8-44**. These data indicate that one factor impacting vegetative health in the retained GDE area could be the depth to groundwater.

It should be noted, however, that correlation is not the same as causation and a negative correlation does not necessarily confirm the presence of a GDE that would be impacted by changes in Upper Aquifer groundwater levels. Rather, what this analysis confirms is that GDEs are objectively less healthy when conditions are such that local groundwater elevations decrease, and vice versa. However, significant uncertainties remain. For example, the Overburden layer extent in the Fringe Area is uncertain, and therefore while vegetation along the Tassajara Creek and near Dublin (northeastern portion of the Basin) are retained as potential GDEs, they may be disconnected from the underlying Upper Aquifer and any apparent correlation would be meaningless.

8.8.2. Field Investigation & Verification

Field investigation and verification of likely GDE was conducted by a subconsultant, Stillwater Sciences (Stillwater). As described in **Appendix F,** Stillwater integrated the aforementioned screening analysis and other available local data to conduct a refined mapping of the potential GDEs within the Basin, including: the Classification and Assessment with Landsat of Visible Ecology Groupings (CalVeg) dataset; Urban Creeks Council (UCC) 2014 CalVeg update for third-order and higher channels; Aerial Information Systems (AIS) Springtown Alkali Sink Preserve Wetlands Mapping; and Sycamore Alluvial Woodland Tree Survey in Arroyo Mocho and Arroyo Valley. Man-made open water areas (e.g., the COL and golf course ponds) were removed from the refined vegetation map. As part of the ecological inventory, special-status species and sensitive natural communities that are potentially associated with GDEs in the Basin were also identified using regional and local databases.[21]

On 31 March 2021, Stillwater conducted field studies and surveyed aerial photography to verify the presence of GDEs at 12 unique sites throughout the Basin (Sites A through L as shown on **Figure 8-45**). These sites included areas where there were: (1) apparent "gaps" in the potential GDE map shown on **Figure 8-41** (i.e., where vegetation similar to GDEs occurred immediately upstream and downstream of the mapped site but was not identified as a GDE); (2) where the riparian vegetation was mapped along stream channels (i.e., where the mapped GDEs are potentially supported by surface water, not groundwater); and (3) where the mapped GDEs are underlain by thick clay layers (i.e., where perched groundwater, not the principal aquifer, could be the source). Additionally, Stillwater scientists assessed potential GDEs at sites where groundwater data are sparse (e.g., near Sycamore Park and Springtown).

[21] Databases used by Stillwater to identify special-status species include: (1) California Natural Diversity Database, (2) California Native Plant Society (CNPS) Manual of California Vegetation, (3) eBird, and (4) TNC freshwater species lists generated from the California Freshwater Species Database (CAFSD).

Likely groundwater dependence of these sites was determined by assessing various local water sources and the width of the riparian zone. Where riparian zones were narrow and relatively sparse, other water sources likely support the vegetation. Where existing vegetation and wetland areas extend beyond a narrow strip along the channel, groundwater dependence was considered likely (*Stillwater, 2021*).

Based on the totality of the above analysis, a final determination was made on the presence of likely GDEs within the Basin. The primary differences in GDE mapping relative to the initial NCCAG map of potential GDEs are summarized below and shown on **Figure 8-45**:

- Additional GDEs were identified in the northeast portion of the Basin where the AIS mapping occurred (Site H, **Figure 8-45**).
- Potential GDEs mapped in the NCCAG dataset that occur adjacent to man-made open water features along COLs (in the Arroyo Valle corridor) and near the City of Dublin were removed.
- Some further changes in GDE mapping reflect differences between the UCC update to the CalVeg map along Arroyo Mocho and Arroyo Valle. In particular, the width of the riparian vegetation along both streams increased in places, as seen in **Figure 8-45**.
- The reclassification of vegetation near Lake Boris on Arroyo Valle (downstream of Site I, **Figure 8-45**) reduced the extent of GDEs downstream of the lake.
- The vegetation was removed along Arroyo de la Laguna and west of Pleasanton (Sites B, C, and D, **Figure 8-45**) after conducting field investigations. These sites occur above a thick clay layer (known colloquially as the Overburden layer) that precludes connection to the principal aquifer. Observations during the field visit suggested that the riparian vegetation at Sites B, C, and D was likely dependent on surface water rather than groundwater due to the relatively narrow riparian zone.
- The potential GDE community near Site L was also removed since the very sparse riparian vegetation suggested the area was not connected to groundwater.
- Wetlands mapped within man-made lakes and ponds (e.g., Frick Lake in the eastern part of the basin) were also removed (*Stillwater, 2021*).

The final likely GDE map is presented on **Figure 8-46**. Likely GDEs are grouped and named based on their location and major vegetation types, as shown on **Figure 8-46** and in **Table 8-J.** However, significant uncertainties remain. For example, the Overburden layer extent in the Fringe Area is uncertain, and therefore while vegetation along the Tassajara Creek and near Dublin (northeastern portion of the Basin) are retained as potential GDEs, they may be disconnected from the Upper Aquifer. Other areas retained as potential GDEs include areas of non-native vegetation (such as Eucalyptus trees) or that are adjacent to shallow bedrock outcrops in the center of the Basin (e.g., the "Oak Knoll" area). These GDE areas have been preliminarily retained but will be further evaluated through monitoring and periodic visual inspections as discussed in **Section 14** below.

Table 8-J. GDE Region and Major Vegetative Composition

Management Area	Likely GDE Name	Acreages
Main Basin	Arroyo Valle – Riparian Mixed Hardwood	137
	Arroyo Valle – Sycamore Grove	343
	Arroyo Mocho – Riparian Mixed Hardwood & Sycamore	94
	Arroyo Mocho – Valley Oak	178
Fringe Area	Springtown Alkali Sink	173
	Arroyo Las Positas – Mixed Vegetation	56
Upland Area	Upland – Riparian Mixed Hardwood	35
Basin-Wide	Potential GDEs to be Further Evaluated	37
	Total Acreages	1,052

In total, the Basin includes approximately 1,052 acres of likely GDEs, approximately 2% of the total Basin area. The Main Basin contains approximately 69% of the total likely GDE area, the Fringe Area contains approximately 20%, and the Upland Area contains the remaining 11% of the likely GDEs. The most prevalent vegetation communities across all likely GDE units are the riparian mixed hardwood alliance and California sycamore alliance, which respectively comprise 40% and 30% of the likely GDE areas in the Basin and are located almost entirely in the Main Basin. The Alkaline mixed grasses and forbs alliance comprises 10% of total likely GDE area and is located almost entirely in the Fringe Area (*Stillwater, 2021*).

The Basin includes United States Fish and Wildlife Service (USFWS) designated critical habitat for four federally listed species: the Alameda whipsnake, California red-legged frog, California tiger salamander, and vernal pool fairy shrimp. As described in **Appendix F**, of the designated critical habitat, most of the habitat for the vernal pool fairy shrimp is co-located with mapped GDEs, but this species relies on vernal pools, which are dependent on rainfall, rather than groundwater and is therefore unlikely to be groundwater dependent. Most of the critical habitat for California red-legged frogs and Alameda whipsnake occurs outside of the defined GDEs, with approximately two acres of their critical habitat overlapping with a riparian GDE at the upstream end of Arroyo Mocho (*Stillwater, 2021*). Zone 7 adheres to the East Alameda County Conservation Strategy (EACCS) that was developed to preserve endangered species by developing a shared vision for long term habitat protection.[22]

As described in **Appendix F**, 22 special-status plants occur within the Basin, including Alkali milk-vetch, Heartscale, Brittlescale, Livermore tarplant, and Jepson's coyote-thistle. Of these, 12 plant types were likely dependent upon groundwater, four were possibly dependent on groundwater, one was unlikely to

[22] EACCS website, http://eastalco-conservation.org/about.html.

be groundwater dependent, and five were not groundwater dependent. All 12 special-status plants likely dependent on groundwater occurred in the Fringe Area, and three of the 12 occurred in the Upland Area. The likely groundwater dependent special-status plants in the Fringe Area mostly were observed in or around the Springtown Alkali Sink (*Stillwater, 2021*).

Thirty-one special-status terrestrial and aquatic wildlife species were identified as having the potential to occur within the Basin, including the Crotch bumble bee, Southwestern pond turtle, and American peregrine falcon. Of these, 14 were potentially groundwater dependent species: two amphibian species, two reptile species, seven bird species, and three mammal species. Additional information on these groundwater dependent species, including regulatory status and habitat associations, is provided in **Appendix F**. Ten of the groundwater dependent special status species are likely to occur in the Main Basin, eight of the groundwater-dependent special status species are likely to occur in the Fringe Area, and 13 of the groundwater-dependent special status species are likely to occur in the Upland Area (*Stillwater, 2021*).

8.8.3. Likely Groundwater Dependent Ecosystems

Based on the above analyses and field investigation, the Basin includes approximately 1,062 acres of likely GDEs, which encompass approximately 2% of the total Basin area. The most prevalent vegetation communities across all likely GDE units are the riparian mixed hardwood alliance, California sycamore alliance, and the Alkaline mixed grasses and forbs alliance. Most of the likely GDEs are located along the Arroyo Valle and Arroyo Mocho creeks in the Main Basin and around Altamont Creek in the Fringe Area.

8.8.4. Groundwater Dependent Ecosystem Demands

Quantifying groundwater consumptive use from GDEs can be estimated using a soil moisture balance model discussed in **Section 9**. Evapotranspiration (ET) uptake from groundwater occurs when the saturated groundwater table is accessible by the root zone of a GDE or is within a small enough depth below the root zone such that groundwater can be accessed via capillary rise. As part of this work effort, DWR's Integrated Water Flow Model Demand Calculator (IDC) soil moisture balance model is utilized to provide initial estimates of ET uptake from groundwater for the GDE communities identified in the above analyses. The IDC employs the "Root Water Uptake" package to simulate shallow groundwater uptake by GDE communities to meet ET demands (*DWR, 2020a*). In its current form, the Zone 7 IDC model explicitly simulates shallow groundwater uptake from the five largest and most contiguous GDE communities identified in the Basin, including:

- Arroyo Valle - Riparian Mixed Hardwood
- Arroyo Valle - Sycamore Grove
- Arroyo Mocho - Riparian Mixed Hardwood & Sycamore
- Arroyo Mocho - Valley Oak
- Springtown Alkali Sink

These GDE communities collectively comprise approximately 925 acres, or roughly 90% of the total mapped GDE areas within the Basin.

Based on IDC model outputs for DWR 2011 – 2020 WYs, approximately 2,900 acre-feet per year (AFY) of shallow groundwater are consumed by GDE communities to help meet ET demands, equating to approximately 3.0 acre-feet per acre (AF/acre). This represents roughly 70% of the total potential ET demand estimated for GDEs within the Basin (~4.3 AFY/acre) [23]. Given the considerable uncertainties in soil properties, shallow groundwater availability, and plant-specific groundwater uptake rates embedded in this calculation, a more reasonable range of average GDE groundwater demands within the Basin is likely somewhere between 2,000 AFY (~2 AFY/acre) and 4,000 AFY (~4 AFY/acre).

8.9. Interconnected Surface Water Systems

> *§ 354.16. Groundwater Conditions*
> *(g) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.*

☑ **23 CCR § 354.16(f)**

As demonstrated herein (consistent with the approved 2016 Alternative GSP) and the requirements of CWC § 10733.6 (a)(3) and 23 CCR § 356.4, Zone 7 has continued to sustainably manage ICSW depletion in the Basin to avoid URs (as defined in **Section 13.6.1**) for decades, including over three major droughts.

Locations of surface water bodies (e.g., streams) within the Basin are shown on **Figure 7-3**. In general, bottoms of the surface water channels are above the water table and provide recharge to the groundwater system where sufficiently permeable sediments occur beneath the arroyos. Wet reaches of the arroyos are correlated to discharge of surface water to the channel from mining operations or for conjunctive use. Surface water remains in several reaches of surface streams in the Basin where surficial clay deposits impede groundwater recharge. Nonetheless, groundwater does not generally contribute to baseflow along surface water reaches in the Basin. Statistical and geospatial analyses discussed in detail below are performed to identify stream reaches that are likely interconnected to shallow groundwater. A summary of the work effort is presented below and in **Appendix F**.

8.9.1. Preliminary Screening

8.9.1.1. Data Sources

A preliminary screening of potential ICSW locations was conducted using the following primary data sources:

[23] Based on local CIMIS station reference evapotranspiration (ETo) data and monthly riparian/native vegetation ET coefficients provided by DWR's Cal-SIMETAW model for the Livermore study area.

- Locations of surface water bodies;
- Stream daily flow data and gauge height between 2015 and 2020;
- Stream recharge rates shapefile provided by Zone 7 based on synoptic surveys;
- Groundwater elevation and depth to water data;
- Stream cross sections; and
- Guidance document from Environmental Defense Fund (EDF; *EDF, 2018*), USGS (*Winter et al., 1998*), and UC Berkeley (*Cantor et al., 2018*).

8.9.1.2. Physical and Operational Exemptions

Artificial stream sections (i.e., those that have been channelized and lined with concrete) were excluded from the depth to groundwater analysis discussed below that was used to identify potential ICSW. Similarly, stream sections that overlie the Overburden layer were excluded. The Overburden layer consists of a thick, continuous surficial lens of clay reaching up to 70 feet thickness that precludes connection to the Upper Aquifer, and mainly exists in the Main Basin and extends from the north central portion of the Basin to the western edge of the Basin.

COL is also excluded from ICSW consideration. Ongoing mining and reclamation are changing to some degree the connection between upper and lower aquifers and surface water, as some areas are capped or filled (thus reducing connection), and as excavation of wet pits effectively creates surface water ponds. However, no GDEs exist in the mining area, and the surface water pits are not identified for specific beneficial uses in the Regional Water Quality Control Board-San Francisco Bay Region (RWQCB) Water Quality Control Plan (Basin Plan). Releases of water for recharge along the arroyos have resulted in dry season flows in the arroyos; however, these flows are relatively warm and not equivalent to cool pre-mining flows that could support some native species.

8.9.1.3. Depth to Groundwater Analysis

The relationship between groundwater and surface water largely depends upon the depth to groundwater relative to the streambed depth. For groundwater to be interconnected with a stream channel, the depth to groundwater in the vicinity of the stream must be less than the streambed depth. Conversely, for surface water to seep to groundwater, which indicates disconnectivity between surface water and groundwater, the depth to groundwater in the vicinity of the stream must be deeper than the streambed depth.

The maximum streambed depth of the streams within the Basin is approximately 30 feet. As such, if the minimum depth to groundwater between 2015 and 2020 in the vicinity of the stream sections is more than 30 ft bgs, it is unlikely that the mapped stream sections are interconnected with groundwater[24].

[24] Since the Plan is not required to address URs that occurred before and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2015 is selected as the start of the analysis timeframe.

Conversely, if the depth to groundwater is less than 30 ft bgs along the stream sections, the groundwater and stream sections are likely to be interconnected. Depth to groundwater estimates in the vicinity of the mapped streams were made at 500-foot intervals along the length of the mapped streams from the 2015-2020 depth to groundwater rasters. Additionally, synoptic surveys have been performed by Zone 7, as shown on **Figure 7-16**, to identify the reaches of major streams in the Basin, whether they are gaining or losing and what the respective rates are.

Based on the above data and analysis, locations of potential ICSW locations are shown on **Figure 8-47**.

8.9.1.4. Correlation Analysis

SGMA requires that the sustainability criteria of the ICSW Sustainability Indicator be developed based on the "…rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water..."[25] Alternatively, groundwater levels can be used as a proxy.[26]

Based on the above, the potential correlation between Upper Aquifer groundwater elevation and streamflow data between 2015 and 2020, including gauge height and flow rate, were evaluated to examine whether the portions of the streams that were identified as likely ICSW have a quantifiable relationship to the principal aquifer. Stream gauging stations along potential ICSW sections and near likely GDEs (discussed in **Section 8.8**) were selected for the correlation analysis, as shown on **Figure 8-48**.

Upper Aquifer wells within a one km radius of the selected stream gauging stations were assumed to be representative of groundwater conditions in vicinity of the stations. If multiple wells were associated with (i.e., within one km of) a stream gauging station, average groundwater elevations from these wells were calculated. The Upper Aquifer wells within the one km buffer of each selected stream gauging station are shown on **Figure 8-48**. Since most of the groundwater elevations were measured monthly, monthly average flow data and gauge height were calculated.

Time series data of the gauge height and flow rate were plotted for each stream gauging station, as shown on **Figure 8-49** and in **Appendix F**. A linear correlation between the stream flow data (gauge height and flow rate) and the local groundwater elevation was then evaluated for each station. A positive correlation would mean that, when the gauge height or flow rate increases, the groundwater elevation also increases, indicating that there is potential interconnectivity between the stream and groundwater, and vice versa.

Zone 7 imports surface water from the SWP through the South Bay Aqueduct (SBA) for treatment, storage, and groundwater recharge as part of the active management of the Basin. Since the streams within the Basin are also used for artificial recharge, correlation between low flow, which better represents the natural streamflow conditions, and Upper Aquifer groundwater elevation was also performed. Low flow

[25] § 354.28(b)(6)

[26] § 354.28(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence

data for each stream gauging station were obtained by removing the gauge height and flow rate data that fell outside of the 90th percentile[27]. The low flow correlation result for each stream gauging station is also shown on **Figure 8-49** and in **Appendix F**.

Among the selected stream gauging stations (i.e., stations located along potential ICSW and near likely GDEs), only the AVNL station exhibited statistically significant positive correlations between streamflow data (gauge height and flow rate) and groundwater elevation data.[28] The ADVP station also showed a low but statistically significant positive correlation for low flow conditions only. Groundwater elevation measurements from the wells located close to the other stream gauging stations are generally collected biannually, and thus there is insufficient groundwater elevation data to support statistically significant correlation between groundwater levels and monthly average stream flow data. This data gap is addressed further under **Section 14**.

For the AVNL station, the correlation using all stream flow data has a larger correlation coefficient and smaller p-value than those for the correlation using low flow data only (i.e., for all stream flow data, correlation coefficients and p-values are 0.88 and 2.1e-22 for gauge height, 0.87 and 9.8e-22 for flow rate; for low flow data, the correlation coefficients and p-values are 0.35 and 0.006 for gauge height, 0.40 and 0.002 for flow rate). The AVNL station is located along Arroyo Valle and near the location where imported SWP water is released into the stream. Nearby likely GDEs (Sycamore Grove located in the southeastern portion of the Basin as discussed in **Section 8.8**) have been documented to rely on the released imported water for artificial recharge (*Zone 7, 2009*), which is also reflected in the higher correlation for all flow data (i.e., during active Zone 7 recharge operations).

Additionally, cross-correlation was performed for the AVNL station data to examine whether a time lag exists between the stream flow data and shallow groundwater elevations.[29] The cross-correlation result shows that maximum correlation is reached when time lag equals zero months and the correlation is significant, which indicates that limited time lag exists between the stream flow data and groundwater elevations for the AVNL station.

8.9.2. Potential Interconnected Surface Water

Based on the above analyses, likely ICSW sections have been identified along several reaches of the major surface water features within the Basin, including Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Altamont Creek. Unsurprisingly, most of the areas where potential ICSW sections occur also support likely GDEs as discussed in **Section 8.8**, as these stream corridors consistently encounter some of the shallowest groundwater elevations observed within the Basin, see **Figure 8-47**.

Where sufficient data and ICSW conditions exist, groundwater levels in the Upper Aquifer can be correlated to ICSW conditions and GDE locations. As such, Upper Aquifer wells and the selected stream

[27] Ratio of high flow events to low flow events is approximately 1:9 in most of the stream stations, and therefore 90th percentile is used as a threshold to retain low flow data.
[28] For the purpose of this analysis, correlation with a p-value that is less or equal to 0.05 is considered to be significant.
[29] Cross-correlation is a measurement that tracks the movements of two or more sets of time series data relative to one another.

gauging stations can serve as the representative monitoring sites for purposes of SGMA implementation, as discussed in **Section 14.2.6**, and sustainability criteria that are protective of both GDEs and ICSW can be developed using groundwater levels as a proxy, as discussed in **Section 13.6**.

8.10. Other Programs and Conditions

8.10.1. Land Use

Zone 7 monitors land use changes in the Valley as part of the long-range groundwater basin management program. The emphasis is on changes in pervious areas and quantity and quality of irrigation water that could affect the volume or quality of water recharging the Main Basin. The information is used by Zone 7 to quantify areal recharge (i.e., “rainfall recharge” and “applied water recharge”).

Land use data are derived from aerial photography, well permit applications, field observations, and City and County planning documents. Zone 7 staff also review new development plans and associated California Environmental Quality Act (CEQA) documentation to evaluate potential impacts to groundwater supply and quality.

For the purpose of Zone 7’s Groundwater Management Program, primary land uses are mapped as polygons having one of the following designations:

- Residential (rural)
- Residential (low density)
- Residential (medium density)
- Residential (high density)
- Commercial and Business
- Public
- Public (Irrigated Park)
- Agriculture (vineyard)
- Agriculture (non-vineyard)
- Mining Area – Pit
- Water Body (including COL)
- Golf Course
- Open Space

Each individual land use polygon is also assigned one of the following sources of irrigation water based on Zone 7’s understanding of the primary irrigation water source used for that particular area:

- Delivered (municipal) water
- Groundwater (non-municipal supply wells)
- Recycled water
- None

Land use categories and source water type are then assigned spatially to the groundwater model cells (500 feet by 500 feet), which are also the spatial units used for the areal recharge calculations. **Figure 8-50** and **Table 8-6** show the results of the Land Use program for the 2020 WY.

8.10.2. Wastewater and Recycled Water Use

Zone 7 monitors the quality and quantities of wastewater and recycled water as they apply to the Basin (recharge supply and quality). Assessments of wastewater quality and the contribution to the water budget are discussed in **Section 8.6.1.2** and **Section 9**, respectively, in this update.

The City of Livermore and DSRSD are currently responsible for treating and either discharging or recycling (see **Figure 8-50**) the vast majority of wastewater produced in the Valley. Both of these publicly-owned treatment works (POTWs) produce secondary-treated and tertiary-treated effluent, which is disinfected and either reclaimed and used for landscape irrigation or exported from the Valley through the Livermore-Amador Valley Water Management Agency (LAVWMA) export pipeline. Applications of recycled water are mostly conducted for landscape irrigation projects; however, a minor amount is used for dust suppression, grading projects, and crop irrigation.

Elsewhere in the Basin, a minor amount of untreated or partially-treated wastewater may reach the groundwater supply as percolate. The program assumes that there are small, but quantifiable amounts (estimated) of untreated wastewater that percolate in the Main Basin from onsite wastewater treatment systems (OWTS). The quantity of leachate is based on the estimated number of individual OWTS that overlie the Main Basin. The quality of the leachate is estimated from published technical literature. Zone 7 also receives monthly monitoring reports from the Department of Veteran Affairs for the VA Medical Center's sewage treatment system located in southern Livermore. Zone 7 also estimates contributions from leaking wastewater and recycled water pipelines that run throughout the Groundwater Basin. The quantity is based on the length and age of buried pipes (**Section 9.2.2.4**). The quality is based on sample data received from DSRSD and the City of Livermore.

8.10.3. Climatological

Zone 7's Climatological Monitoring Program tracks rainfall and evaporation in the Valley, employing a network of climatological stations. The primary objective of this monitoring network is to provide high quality basin-wide data for long-term studies, basin recharge calculations, and water management decisions. Specifically, the calculations of basin recharge are used in the annual water budget, change in groundwater storage, and the defined objectives of operational storage (**see Section 9**). Data are collected to provide short-term, seasonal, and long-term trends in local hydrologic conditions. Water year type is being incorporated into the analysis using DWR calculations for the Sacramento Valley. This hydrology is more consistent with the availability of imported supplies and generally approximates local rainfall patterns in the groundwater basin.

The Zone 7 Climatological Monitoring Program network consists of several rainfall stations, two pan evaporation stations, and one California Irrigation Management Information System (CIMIS) station (including rainfall and evaporation) located within the Alameda Creek Watershed.

There are two basic types of rainfall stations used in Zone 7's Climatological Monitoring Program: daily record stations and recorder stations (see **Section 14.2.7.1** for details of the monitoring metwork). A daily record station consists of a rain gauge at which, once-a-day, the observer measures and records the depth of rain that has fallen during the preceding 24 hours (see **Appendix G** for Monitoring Protocols). A recorder station, which provides rainfall intensity for periods of less than 24 hours as well as daily totals, consists of a computerized-tipping-bucket rain gauge and a data recorder. These semi-continuous-reading rain gauges generally provide rainfall totals on a 15-minute frequency.

Zone 7's Climatological Monitoring Program also contains both reference ETo and pan evaporation stations to determine water transfer to the atmosphere. Station 191 (CIMIS) is a reference ETo station, which estimates the ETo value of the water used by a well-watered, full-cover grass surface, whereas the pan evaporation stations at Lake Del Valle (LDV) and Livermore Water Reclamation Plant (LWRP) measure evaporation directly. LDV and LWRP pan evaporation data is converted to ETo using a conversion factor (ETo=Pan Evap x 0.6402). Zone 7 uses ETo to calculate evaporation from the gravel quarry ponds as well as in its applied water recharge model. The CIMIS Station's ETo is also used as part of Zone 7's Water Conservation Program to help regulate weather-based irrigation ("SMART") controllers.

8.10.4. Surface Water

Zone 7 monitors streamflow in the arroyos that run though the Basin, surface area and water levels of active and inactive gravel quarry ponds located in the central part of the Basin, and water transfers from arroyos and quarry ponds to those former quarry pits that are being used for aquifer recharge. In addition, Zone 7 tracks flow from the upper Arroyo Valle watershed into Lake Del Valle and the portion of Lake Del Valle storage for which Zone 7 has water rights. The objectives of Zone 7's Surface Water Monitoring Program are:

- **Surface Water Level and Flow Monitoring** – Quantify inflow and outflow of surface water to/from the groundwater basin. These data are used to quantify aquifer recharge resulting from streamflow (natural and artificial) and capture of gravel quarry discharges and as input for the evaporative losses determinations. They are also used in hydraulic modeling of the watershed for flood control management;
- **Surface Water Quality Monitoring** - Provide a record of water quality for the basin's recharge and discharge waters with which the groundwater basin's annual salt (TDS) loading is calculated; and
- **Del Valle Water Rights** - Satisfy the requirements of Zone 7's and Alameda County Water District's (ACWD) provisional water rights on the Arroyo Valle. This involves continuous flow monitoring and quarterly sampling at two surface water stations.

The program focuses on the four main gaining and losing streams that affect the Basin (Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Arroyo de la Laguna) and the diversions, releases, and natural runoff that affect the flows into and out of each of them. The program utilizes a network of main recorder stream gauge stations and flow meters (see **Section 14.2.7.2** for details of the monitoring network) to compute the quantity of water flowing past each station, and both, semi-continuous and periodic water level measurements to track change in surface water storage. Several of the gauges are owned and maintained by the USGS under Department of Interior 'Cooperative Agreements" with Zone 7 and others. Several other auxiliary surface water monitoring stations have been established as high flow and/or stream temperature monitoring stations to augment the data collected at the main stations for various ongoing flood management and habitat studies. Water samples are collected from the main recorder sites and significant quarry ponds at least once per year, and submitted to Zone 7's laboratory for analysis of metals, minerals and general properties (the same parameters that are routinely analyzed in the Groundwater Quality Monitoring Program).

Stream stage is converted to streamflow using calibrated stage-to-flow rating curves. Stream discharge measurements are periodically conducted at each station to recalibrate the rating curve, if necessary, to maintain its accuracy. **Appendix G** contains a description of Zone 7's discharge measurement procedure. Records from all gauge stations, including records of the rating curve corrections are stored in the Zone 7 maintained AQUARIUS Time-Series® database (**Section 8.2.1**), however, certain data can be viewed by the public in virtually "real-time" on the HydroSphere website[30].

Zone 7 calculates the basin groundwater budget (storage) using data from the gauge stations on the recharging streams (Arroyos Valle, Mocho, and Las Positas) and data from turnout flow meters that record the South Bay Aqueduct (SBA) releases made to these arroyos. The other gauges do not have significance for aquifer recharge, salt loading, or basin outflow; and are maintained primarily for flood control study and management purposes.

In general, surface waters flowing past gauges AMNL, ALPL and AVNL, or through the SBA/Arroyo Mocho turnout, represent surface water entering the Basin that has potential for groundwater replenishment. The gravelly middle reaches of Arroyo Valle and Arroyo Mocho, and to a lesser extent, Arroyo Las Positas, offer aquifer recharge potential; whereas, downstream of gauges ALP_ELCH, AM_KB, AMP and ADVP the channels are mostly incised in clayey overburden and therefore do not do not offer much recharge potential. Consequently, water flowing past these lower gauges will mostly flow out of the Valley, past ADLLV, and into Alameda Creek. For the water budget calculation, the differences between the amount of surface water entering the Basin upstream of the recharge reaches and that flowing past the gauges at the end of each respective recharge reach equates to the stream recharge components.

[30] https://cloud.xylem.com/hydrosphere/public-sites/OWA_1245EDE7887A4C7D888D3671A060A8E1

TABLE 8-1
TOTAL MAIN BASIN STORAGE BY SUBAREA (AF)
GROUNDWATER ELEVATION METHOD
1974 TO 2020 WATER YEARS

Water		Amador			
Year	Bernal	Amador West	Amador East	Mocho II	Total
1974	49,651	52,916	80,671	29,821	213,060
1975	51,149	54,220	80,840	28,872	215,080
1976	54,180	56,319	86,194	29,012	225,705
1977	51,970	53,968	81,889	27,954	215,782
1978	50,272	52,077	79,541	27,751	209,641
1979	52,863	56,739	89,122	29,210	227,933
1980	55,952	60,000	94,014	29,500	239,466
1981	57,910	61,890	95,688	30,224	245,712
1982	57,623	61,228	93,235	29,156	241,242
1983	58,654	63,488	100,642	31,492	254,277
1984	59,021	64,418	102,569	31,626	257,635
1985	58,487	64,024	95,703	31,568	249,782
1986	56,723	60,837	95,019	27,719	240,298
1987	55,723	58,635	91,170	25,147	230,675
1988	54,486	53,217	83,377	25,672	216,752
1989	52,754	51,260	82,836	27,433	214,282
1990	50,712	50,879	80,834	27,321	209,746
1991	44,627	49,348	76,543	24,631	195,148
1992	29,663	35,438	74,616	44,036	183,753
1993	29,749	38,787	83,714	58,498	210,748
1994	30,941	39,437	88,451	56,713	215,542
1995	32,193	43,156	89,301	60,834	225,484
1996	32,217	42,917	87,193	60,865	223,193
1997	32,240	41,992	88,828	59,157	222,217
1998	32,292	43,411	88,140	61,336	225,179
1999	32,065	43,310	86,508	60,595	222,479
2000	31,894	42,591	87,585	59,947	222,018
2001	30,720	40,853	73,393	58,231	203,198
2002	30,685	37,537	84,147	59,655	212,025
2003	30,597	41,563	87,510	60,749	220,419
2004	30,518	43,784	79,441	59,614	213,357
2005	31,969	48,734	93,670	61,720	236,093
2006	32,382	53,465	91,847	60,685	238,379
2007	32,401	54,368	90,478	54,733	231,980
2008	32,365	54,160	91,898	56,097	234,520
2009	32,350	51,088	91,755	57,605	232,798
2010	32,350	50,282	92,080	59,167	233,879
2011	32,353	50,631	92,729	59,214	234,927
2012	31,772	47,442	90,475	58,154	227,844
2013	30,892	44,226	87,086	58,684	220,889
2014	30,313	42,806	82,627	53,961	209,707
2015	31,411	46,734	81,465	55,215	214,826
2016	32,205	53,885	83,016	57,583	226,689
2017	32,391	67,540	86,119	59,564	245,614
2018	32,409	71,452	85,792	56,347	246,000
2019	32,410	70,196	85,031	60,942	248,579
2020	32,361	61,215	81,447	56,701	231,725

Calculated as one aquifer
Sum of Upper and Lower Aquifers

TABLE 8-2
HISTORICAL SALT LOADING (in tons)
1974 TO 2020 WATER YEARS

SALT INFLOW COMPONENTS	1974	1975	1976	1977	1978	1979	1980
NATURAL STREAM RECHARGE	**3,210**	**3,464**	**874**	**581**	**4,638**	**1,723**	**2,706**
Total Arroyo Valle	**1,018**	**1,041**	**391**	**315**	**957**	**707**	**777**
Flood releases recharge	100	344	0	0	216	0	128
Non Flood Natural Inflow	918	697	391	315	741	707	649
Arroyo Mocho	**1,717**	**2,043**	**293**	**76**	**3,206**	**636**	**1,358**
Arroyo Las Positas	**475**	**380**	**190**	**190**	**475**	**380**	**571**
AV PRIOR RIGHTS	**361**	**418**	**31**	**0**	**494**	**267**	**386**
ARTIFICIAL STREAM RECHARGE	**986**	**2,201**	**1,914**	**2,289**	**3,286**	**3,699**	**2,897**
Arroyo Valle	293	1,174	509	883	1,427	1,599	1,234
Arroyo Mocho	340	497	875	876	1,350	1,570	1,432
Arroyo Las Positas	353	530	530	530	509	530	231
INJECTION WELL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**
RAINFALL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*
LEAKAGE	**21**	**25**	**30**	**35**	**41**	**48**	**56**
APPLIED WATER RECHARGE	**7,670**	**7,218**	**9,123**	**10,675**	**8,352**	**8,304**	**7,175**
SUBSURFACE BASIN INFLOW	**2,038**	**2,038**	**2,058**	**3,648**	**2,506**	**2,017**	**1,325**
NET INFLOW	**14,286**	**15,364**	**14,030**	**17,228**	**19,317**	**16,058**	**14,545**

OUTFLOW COMPONENTS	1974	1975	1976	1977	1978	1979	1980
MUNICIPAL PUMPAGE	**-7,217**	**-6,577**	**-5,074**	**-4,382**	**-4,579**	**-5,351**	**-4,458**
Zone 7 Wells - Hop, Stone, COL	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Zone 7 Wells - Mocho	**-3,303**	**-2,057**	**-842**	**-201**	**-506**	**-532**	**-26**
Demin Salts Exported from Valley	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other Pumpage	**-3,914**	**-4,520**	**-4,232**	**-4,181**	**-4,073**	**-4,819**	**-4,432**
AGRICULTURAL PUMPAGE	**-2,289**	**-1,476**	**-2,997**	**-3,241**	**-2,081**	**-2,420**	**-1,678**
MINING USE	**-1,126**	**-1,725**	**-802**	**-668**	**-869**	**-1,603**	**-2,508**
Stream Export	-745	-1,345	-422	-287	-489	-1,223	-2,127
Evaporation	0	0	0	0	0	0	0
Processing Losses	-380	-380	-380	-380	-380	-380	-380
GROUNDWATER BASIN OVERFLOW	**0**	**0**	**0**	**0**	**0**	**-173**	**-612**
NET OUTFLOW	**-10,632**	**-9,778**	**-8,873**	**-8,291**	**-7,529**	**-9,547**	**-9,256**

NET SALT INFLOW (Tons)	**3,654**	**5,586**	**5,157**	**8,937**	**11,788**	**6,511**	**5,289**
CUMULATIVE SALT INFLOW (Tons)*	**3,654**	**9,240**	**14,397**	**23,334**	**35,122**	**41,633**	**46,922**

TDS Concentration Calculations	1974	1975	1976	1977	1978	1979	1980
Net Basin Recharge (AF)	-478	5,508	-4,311	-5,953	11,942	6,394	8,103
Basin Storage (HI Method)(AF)	211,522	217,030	212,719	206,766	218,708	225,102	233,205
Total Salt in Main Basin (tons)	133,252	138,838	143,995	152,932	164,720	171,231	176,520
Main Basin TDS Concentration (mg/L)	**464**	**471**	**498**	**544**	**554**	**560**	**557**
Cumulative Increase in TDS Conc (mg/L)**	**14**	**21**	**48**	**94**	**104**	**110**	**107**

* Basinwide salt buildup since 1973

** Basinwide TDS concentration increase relative to 1973 value of 450 mg/L

TABLE 8-2
HISTORICAL SALT LOADING (in tons)
1974 TO 2020 WATER YEARS

SALT INFLOW COMPONENTS	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
NATURAL STREAM RECHARGE	**1,513**	**4,803**	**7,657**	**5,286**	**3,058**	**4,941**	**2,852**	**2,610**	**2,782**	**2,480**
Total Arroyo Valle	**579**	**1,048**	**1,433**	**936**	**375**	**779**	**232**	**372**	**187**	**206**
Flood releases recharge	0	271	624	20	0	415	0	0	0	0
Non Flood Natural Inflow	579	777	809	916	375	364	232	372	187	206
Arroyo Mocho	**478**	**2,614**	**4,626**	**2,508**	**932**	**2,269**	**458**	**490**	**440**	**233**
Arroyo Las Positas	**456**	**1,141**	**1,598**	**1,842**	**1,751**	**1,893**	**2,162**	**1,748**	**2,155**	**2,041**
AV PRIOR RIGHTS	**251**	**502**	**381**	**236**	**328**	**286**	**283**	**325**	**356**	**125**
ARTIFICIAL STREAM RECHARGE	**3,238**	**1,617**	**184**	**0**	**0**	**0**	**0**	**525**	**1,585**	**1,809**
Arroyo Valle	1,719	663	0	0	0	0	0	0	51	132
Arroyo Mocho	1,394	894	184	0	0	0	0	525	1,534	1,677
Arroyo Las Positas	125	60	0	0	0	0	0	0	0	0
INJECTION WELL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
RAINFALL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
LEAKAGE	**65**	**74**	**84**	**94**	**105**	**115**	**125**	**136**	**147**	**158**
APPLIED WATER RECHARGE	**5,507**	**4,709**	**4,723**	**5,046**	**5,938**	**6,632**	**5,558**	**6,834**	**6,015**	**6,541**
SUBSURFACE BASIN INFLOW	**1,284**	**1,284**	**876**	**1,325**	**1,528**	**1,508**	**1,569**	**1,875**	**2,364**	**2,568**
NET INFLOW	**11,858**	**12,989**	**13,905**	**11,987**	**10,957**	**13,482**	**10,387**	**12,305**	**13,249**	**13,681**

OUTFLOW COMPONENTS	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
MUNICIPAL PUMPAGE	**-4,700**	**-4,748**	**-5,410**	**-5,525**	**-5,752**	**-6,465**	**-5,537**	**-6,662**	**-6,915**	**-7,185**
Zone 7 Wells - Hop, Stone, COL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-54**	**-441**
Zone 7 Wells - Mocho	**0**	**0**	**-17**	**-227**	**-863**	**-869**	**-326**	**-1,425**	**-2,082**	**-1,683**
Demin Salts Exported from Valley	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other Pumpage	**-4,700**	**-4,748**	**-5,393**	**-5,298**	**-4,889**	**-5,595**	**-5,211**	**-5,237**	**-4,779**	**-5,062**
AGRICULTURAL PUMPAGE	**-1,553**	**-844**	**-912**	**-1,015**	**-1,378**	**-1,428**	**-998**	**-1,043**	**-776**	**-944**
MINING USE	**-4,372**	**-4,161**	**-7,834**	**-2,857**	**-2,814**	**-6,011**	**-839**	**-2,301**	**-1,728**	**-918**
Stream Export	-3,992	-3,781	-7,454	-2,476	-2,433	-5,535	-364	-1,825	-1,253	-443
Evaporation	0	0	0	0	0	0	0	0	0	0
Processing Losses	-380	-380	-380	-380	-380	-475	-475	-475	-475	-475
GROUNDWATER BASIN OVERFLOW	**-635**	**-2,494**	**-3,418**	**-2,587**	**-1,386**	**-693**	**-693**	**-462**	**-122**	**0**
NET OUTFLOW	**-11,260**	**-12,247**	**-17,574**	**-11,984**	**-11,330**	**-14,597**	**-8,067**	**-10,468**	**-9,541**	**-9,047**

NET SALT INFLOW (Tons)	**598**	**742**	**-3,669**	**3**	**-373**	**-1,115**	**2,320**	**1,837**	**3,708**	**4,634**
CUMULATIVE SALT INFLOW (Tons)*	**47,520**	**48,262**	**44,593**	**44,596**	**44,223**	**43,108**	**45,428**	**47,265**	**50,973**	**55,607**

TDS Concentration Calculations	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Net Basin Recharge (AF)	-528	11,593	9,192	-4,203	-9,722	-1,684	-7,906	-9,106	-4,973	-5,692
Basin Storage (HI Method)(AF)	232,677	244,270	253,462	249,259	239,537	237,853	229,947	220,841	215,868	210,176
Total Salt in Main Basin (tons)	177,118	177,860	174,191	174,194	173,821	172,706	175,026	176,863	180,571	185,205
Main Basin TDS Concentration (mg/L)	**560**	**536**	**506**	**514**	**534**	**535**	**560**	**590**	**616**	**649**
Cumulative Increase in TDS Conc (mg/L)**	**110**	**86**	**56**	**64**	**84**	**85**	**110**	**140**	**166**	**199**

* Basinwide salt buildup since 1973

** Basinwide TDS concentration increase relative to 1973 value of 450 mg/L

TABLE 8-2
HISTORICAL SALT LOADING (in tons)
1974 TO 2020 WATER YEARS

SALT INFLOW COMPONENTS	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NATURAL STREAM RECHARGE	**3,356**	**3,665**	**5,743**	**2,544**	**4,376**	**4,331**	**4,639**	**5,704**	**3,727**	**3,409**
Total Arroyo Valle	**575**	**743**	**1,083**	**300**	**1,034**	**400**	**1,450**	**1,661**	**1,361**	**956**
Flood releases recharge	98	0	528	0	472	336	183	524	0	55
Non Flood Natural Inflow	477	743	555	300	562	64	1,267	1,137	1,361	901
Arroyo Mocho	**1,023**	**814**	**2,174**	**995**	**1,580**	**2,627**	**1,741**	**2,292**	**996**	**857**
Arroyo Las Positas	**1,758**	**2,108**	**2,486**	**1,249**	**1,762**	**1,304**	**1,448**	**1,751**	**1,370**	**1,596**
AV PRIOR RIGHTS	**290**	**151**	**276**	**321**	**306**	**87**	**93**	**188**	**149**	**175**
ARTIFICIAL STREAM RECHARGE	**1,590**	**410**	**1,953**	**2,795**	**1,026**	**491**	**1,325**	**500**	**1,352**	**2,276**
Arroyo Valle	36	185	385	293	49	31	472	107	321	242
Arroyo Mocho	1,554	225	1,568	2,502	977	460	853	393	1,031	2,034
Arroyo Las Positas	0	0	0	0	0	0	0	0	0	0
INJECTION WELL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**204**	**497**	**498**
RAINFALL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
LEAKAGE	**169**	**181**	**193**	**206**	**220**	**234**	**248**	**263**	**279**	**294**
APPLIED WATER RECHARGE	**6,918**	**5,793**	**5,109**	**4,989**	**3,323**	**4,071**	**4,887**	**4,367**	**3,479**	**4,314**
SUBSURFACE BASIN INFLOW	**3,423**	**3,199**	**2,710**	**2,221**	**2,017**	**1,875**	**1,386**	**1,651**	**1,528**	**1,846**
NET INFLOW	**15,746**	**13,399**	**15,984**	**13,076**	**11,268**	**11,089**	**12,578**	**12,877**	**11,011**	**12,812**

OUTFLOW COMPONENTS	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MUNICIPAL PUMPAGE	**-11,014**	**-8,752**	**-6,072**	**-3,867**	**-2,681**	**-3,874**	**-5,192**	**-6,468**	**-6,101**	**-8,560**
Zone 7 Wells - Hop, Stone, COL	**-1,679**	**-1,185**	**-859**	**-85**	**-87**	**-754**	**-270**	**-475**	**-2,362**	**-2,553**
Zone 7 Wells - Mocho	**-3,313**	**-2,111**	**-609**	**-24**	**-125**	**-767**	**-682**	**-397**	**-167**	**-783**
Demin Salts Exported from Valley	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other Pumpage	**-6,023**	**-5,455**	**-4,604**	**-3,757**	**-2,469**	**-2,353**	**-4,240**	**-5,596**	**-3,572**	**-5,224**
AGRICULTURAL PUMPAGE	**-249**	**-236**	**-142**	**-130**	**-88**	**-130**	**-155**	**-47**	**-46**	**-188**
MINING USE	**-970**	**-1,007**	**-2,134**	**-4,928**	**-6,883**	**-7,507**	**-9,983**	**-9,588**	**-8,642**	**-5,792**
Stream Export	-495	-532	-1,658	-4,453	-6,408	-7,041	-9,460	-9,084	-8,081	-5,316
Evaporation	0	0	0	0	0	0	0	0	0	0
Processing Losses	-475	-475	-475	-475	-475	-466	-523	-504	-561	-475
GROUNDWATER BASIN OVERFLOW	**0**	**0**	**0**	**0**	**-226**	**-968**	**-960**	**-998**	**-482**	**-175**
NET OUTFLOW	**-12,233**	**-9,995**	**-8,348**	**-8,925**	**-9,878**	**-12,479**	**-16,290**	**-17,101**	**-15,271**	**-14,715**

NET SALT INFLOW (Tons)	**3,513**	**3,404**	**7,636**	**4,151**	**1,390**	**-1,390**	**-3,712**	**-4,224**	**-4,260**	**-1,903**
CUMULATIVE SALT INFLOW (Tons)*	**59,120**	**62,524**	**70,160**	**74,311**	**75,701**	**74,311**	**70,599**	**66,375**	**62,115**	**60,212**

TDS Concentration Calculations	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Net Basin Recharge (AF)	-8,389	-6,628	14,974	592	13,031	1,873	-1,390	2,511	-4,911	-3,674
Basin Storage (HI Method)(AF)	201,787	195,159	210,133	210,725	223,756	225,629	224,239	226,750	221,839	218,165
Total Salt in Main Basin (tons)	188,718	192,122	199,758	203,909	205,299	203,909	200,197	195,973	191,713	189,810
Main Basin TDS Concentration (mg/L)	**688**	**725**	**700**	**712**	**675**	**665**	**657**	**636**	**636**	**640**
Cumulative Increase in TDS Conc (mg/L)**	**238**	**275**	**250**	**262**	**225**	**215**	**207**	**186**	**186**	**190**

* Basinwide salt buildup since 1973
** Basinwide TDS concentration increase relative to 1973 value of 450 mg/L

TABLE 8-2
HISTORICAL SALT LOADING (in tons)
1974 TO 2020 WATER YEARS

SALT INFLOW COMPONENTS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NATURAL STREAM RECHARGE	**3,666**	**3,267**	**7,097**	**3,105**	**5,796**	**4,962**	**3,260**	**4,078**	**4,367**	**5,080**
Total Arroyo Valle	**1,823**	**1,399**	**2,833**	**1,081**	**3,652**	**2,274**	**1,450**	**2,691**	**2,554**	**2,974**
Flood releases recharge	0	193	302	0	731	0	0	327	0	1,383
Non Flood Natural Inflow	1,823	1,206	2,531	1,081	2,921	2,274	1,450	2,364	2,554	1,591
Arroyo Mocho	**575**	**886**	**2,996**	**838**	**1,241**	**1,813**	**839**	**380**	**540**	**1,211**
Arroyo Las Positas	**1,268**	**982**	**1,268**	**1,186**	**903**	**875**	**971**	**1,007**	**1,273**	**895**
AV PRIOR RIGHTS	**224**	**399**	**416**	**383**	**80**	**524**	**219**	**100**	**407**	**0**
ARTIFICIAL STREAM RECHARGE	**1,351**	**3,503**	**2,811**	**2,480**	**1,949**	**1,266**	**1,359**	**727**	**1,248**	**1,690**
Arroyo Valle	501	647	399	476	619	330	782	727	686	635
Arroyo Mocho	839	2,855	2,412	2,004	1,300	914	577	0	562	1,055
Arroyo Las Positas	11	1	0	0	30	22	0	0	0	0
INJECTION WELL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
RAINFALL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
LEAKAGE	**313**	**333**	**352**	**372**	**393**	**414**	**436**	**458**	**481**	**504**
APPLIED WATER RECHARGE	**5,074**	**5,606**	**4,618**	**5,090**	**4,824**	**3,223**	**5,157**	**6,258**	**6,152**	**5,079**
SUBSURFACE BASIN INFLOW	**1,970**	**1,970**	**1,970**	**1,970**	**2,513**	**2,309**	**2,174**	**2,214**	**2,106**	**1,997**
NET INFLOW	**12,598**	**15,078**	**17,264**	**13,400**	**15,555**	**12,698**	**12,605**	**13,835**	**14,761**	**14,350**

OUTFLOW COMPONENTS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MUNICIPAL PUMPAGE	**-10,467**	**-12,061**	**-11,096**	**-12,419**	**-10,057**	**-5,557**	**-8,423**	**-9,271**	**-14,577**	**-12,609**
Zone 7 Wells - Hop, Stone, COL	**-3,867**	**-3,690**	**-3,360**	**-4,198**	**-1,858**	**-1,382**	**-1,340**	**-3,217**	**-3,920**	**-1,290**
Zone 7 Wells - Mocho	**-1,745**	**-3,322**	**-2,271**	**-3,762**	**-3,003**	**-1,170**	**-1,976**	**-1,402**	**-5,448**	**-6,563**
Demin Salts Exported from Valley	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*-798*	*2,759*
Other Pumpage	**-4,855**	**-5,049**	**-5,465**	**-4,459**	**-5,196**	**-3,005**	**-5,107**	**-4,651**	**-5,208**	**-4,756**
AGRICULTURAL PUMPAGE	**-182**	**-94**	**-73**	**-79**	**-80**	**-46**	**-43**	**-68**	**-68**	**-73**
MINING USE	**-4,520**	**-475**	**-276**	**-438**	**-454**	**-658**	**-584**	**-714**	**-1,341**	**-1,428**
Stream Export	-4,006	-111	0	-84	-94	-218	-274	-305	-913	-1,057
Evaporation	0	0	0	0	0	0	0	0	0	0
Processing Losses	-514	-364	-276	-354	-360	-440	-310	-409	-428	-371
GROUNDWATER BASIN OVERFLOW	**0**	**0**	**0**	**0**	**0**	**0**	**-738**	**-1,080**	**-171**	**0**
NET OUTFLOW	**-15,169**	**-12,630**	**-11,445**	**-12,936**	**-10,591**	**-6,261**	**-9,788**	**-11,133**	**-16,157**	**-14,110**

NET SALT INFLOW (Tons)	**-2,571**	**2,448**	**5,819**	**464**	**4,964**	**6,437**	**2,817**	**2,702**	**-1,396**	**240**
CUMULATIVE SALT INFLOW (Tons)*	**57,641**	**60,089**	**65,908**	**66,372**	**71,336**	**77,773**	**80,590**	**83,292**	**81,896**	**82,136**

TDS Concentration Calculations	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Net Basin Recharge (AF)	-11,666	62	8,309	-4,560	13,193	8,790	-3,639	-3,011	-4,997	4,290
Basin Storage (HI Method)(AF)	206,499	206,561	214,870	210,310	223,503	232,293	228,654	225,643	220,646	224,936
Total Salt in Main Basin (tons)	187,239	189,687	195,506	195,970	200,934	207,371	210,188	212,890	211,494	211,734
Main Basin TDS Concentration (mg/L)	**667**	**676**	**670**	**686**	**662**	**657**	**677**	**695**	**706**	**693**
Cumulative Increase in TDS Conc (mg/L)**	**217**	**226**	**220**	**236**	**212**	**207**	**227**	**245**	**256**	**243**

* Basinwide salt buildup since 1973

** Basinwide TDS concentration increase relative to 1973 value of 450 mg/L

TABLE 8-2
HISTORICAL SALT LOADING (in tons)
1974 TO 2020 WATER YEARS

SALT INFLOW COMPONENTS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	AVG	TOTAL
NATURAL STREAM RECHARGE	**5,459**	**2,026**	**2,242**	**1,820**	**3,735**	**3,366**	**4,948**	**1,315**	**3,531**	**1,952**	**3,654**	**171,744**
Total Arroyo Valle	**3,039**	**553**	**963**	**356**	**1,664**	**1,620**	**2,392**	**249**	**1,185**	**285**	**1,190**	**55,953**
Flood releases recharge	150	0	0	0	0	0	404	0	-53	0	165	7,751
Non Flood Natural Inflow	2,889	553	963	356	1,664	1,620	1,988	249	1,238	285	1,026	48,202
Arroyo Mocho	**2,056**	**949**	**751**	**973**	**1,472**	**945**	**1,882**	**430**	**1,648**	**834**	**1,335**	**62,735**
Arroyo Las Positas	**364**	**524**	**528**	**491**	**599**	**801**	**674**	**636**	**698**	**833**	**1,129**	**53,056**
AV PRIOR RIGHTS	**384**	**196**	**409**	**3**	**395**	**288**	**91**	**208**	**249**	**249**	**261**	**12,290**
ARTIFICIAL STREAM RECHARGE	**882**	**2,851**	**2,519**	**1,483**	**1,689**	**2,571**	**2,046**	**1,494**	**558**	**675**	**1,598**	**75,100**
Arroyo Valle	167	1,178	573	339	1,667	1,299	667	924	442	556	541	25,419
Arroyo Mocho	698	1,649	1,943	1,120	0	1,272	1,379	570	116	119	981	46,129
Arroyo Las Positas	17	24	3	24	22	0	0	0	0	0	76	3,552
INJECTION WELL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**26**	**1,199**
RAINFALL RECHARGE	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Lake Recharge	*0*	*0*	*0*	*1,603*	*2,736*	*3,641*	*6,743*	*8,295*	*6,864*	*3,979*	*720*	*33,861*
LEAKAGE	**527**	**551**	**403**	**600**	**625**	**651**	**677**	**703**	**778**	**821**	**299**	**14,038**
APPLIED WATER RECHARGE	**4,295**	**6,074**	**8,158**	**5,654**	**6,505**	**5,251**	**4,421**	**5,707**	**5,625**	**6,588**	**5,801**	**272,629**
SUBSURFACE BASIN INFLOW	**2,024**	**2,092**	**448**	**1,834**	**2,051**	**2,078**	**2,106**	**2,078**	**2,187**	**2,201**	**1,999**	**93,959**
NET INFLOW	**13,571**	**13,790**	**14,179**	**11,394**	**15,000**	**14,205**	**14,289**	**11,505**	**12,928**	**12,486**	**13,637**	**640,959**

OUTFLOW COMPONENTS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	AVERAGE	TOTAL
MUNICIPAL PUMPAGE	**-9,873**	**-16,765**	**-12,781**	**-11,831**	**-6,080**	**-6,194**	**-7,635**	**-8,700**	**-10,427**	**-12,388**	**-10,163**	**-339,102**
Zone 7 Wells - Hop, Stone, COL	**-1,197**	**-2,785**	**-3,595**	**-2,639**	**-870**	**-750**	**-1,107**	**-1,938**	**-1,982**	**-4,441**	**-2,470**	**-54,340**
Zone 7 Wells - Mocho	**-4,040**	**-8,204**	**-3,997**	**-3,713**	**-1,080**	**-666**	**-2,200**	**-2,642**	**-4,895**	**-4,890**	**-3,072**	**-67,576**
Demin Salts Exported from Valley	*2,006*	*4,064*	*2,479*	*1,047*	*76*	*183*	*949*	*1,168*	*1,869*	*1,231*	*362*	*17,033*
Other Pumpage	**-4,625**	**-5,766**	**-5,179**	**-5,583**	**-4,128**	**-4,779**	**-4,326**	**-4,120**	**-3,549**	**-3,057**	**-4,621**	**-217,186**
AGRICULTURAL PUMPAGE	**-68**	**-77**	**-393**	**-515**	**-490**	**-92**	**-84**	**-87**	**-101**	**-97**	**-666**	**-31,295**
MINING USE	**-2,756**	**-3,064**	**-3,042**	**-502**	**-417**	**-378**	**-364**	**-388**	**-368**	**-363**	**-3,412**	**-160,375**
Stream Export	-2,368	-2,665	-2,655	-442	0	0	0	0	0	0	-2,211	-103,914
Evaporation	0	0	0	0	0	0	0	0	0	0	0	0
Processing Losses	-388	-399	-387	-364	-417	-378	-364	-388	-372	-363	-415	-19,485
GROUNDWATER BASIN OVERFLOW	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-506**	**-758**	**-113**	**-435**	**-20,450**
NET OUTFLOW	**-12,697**	**-19,906**	**-16,216**	**-12,848**	**-6,987**	**-6,664**	**-8,083**	**-9,681**	**-11,654**	**-12,961**	**-11,557**	**-543,173**

NET SALT INFLOW (Tons)	874	-6,116	-2,037	-1,454	8,013	7,541	6,206	1,824	1,274	-475	2,081	97,786
CUMULATIVE SALT INFLOW (Tons)*	83,010	76,894	74,857	73,403	81,416	88,957	95,163	96,987	98,261	97,786		

TDS Concentration Calculations	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net Basin Recharge (AF)	6,893	-10,438	-5,542	-12,153	6,037	15,405	25,259	285	4,482	-7,932
Basin Storage (HI Method)(AF)	231,829	221,391	215,849	203,696	209,733	225,138	250,397	250,682	255,164	247,232
Total Salt in Main Basin (tons)	212,608	206,492	204,455	203,001	211,014	218,555	224,761	226,585	227,859	227,384
Main Basin TDS Concentration (mg/L)	**675**	**687**	**697**	**734**	**741**	**715**	**661**	**665**	**657**	**677**
Cumulative Increase in TDS Conc (mg/L)**	**225**	**237**	**247**	**284**	**291**	**265**	**211**	**215**	**207**	**227**

* Basinwide salt buildup since 1973

** Basinwide TDS concentration increase relative to 1973 value of 450 mg/L

TABLE 8-3
NITROGEN LOADING IN THE MAIN BASIN
LIVERMORE VALLEY GROUNDWATER BASIN

Loading Source	Loading Mechanism	Leachable N Loading Rate	Units	Num	Units	N Loading (lbs/yr)
Hydrologic (Wet) Loading	Rainfall Recharge	0.11	mg/L	4,300	AF	**1,321**
	Stream Recharge (natural)	0.18	mg/L	6,600	AF	**3,203**
	Stream Recharge (artificial)	0.34	mg/L	5,300	AF	**4,897**
	Groundwater Inflow	2.90	mg/L	1,000	AF	**7,888**
Applied Water	Pipe Leakage (flow weighted)	6.82	mg/L	1,000	AF	**18,554**
	Agricultural Irrigation	0.90	mg/L	300	AF	**736**
	Urban Irrigation	0.84	mg/L	1,300	AF	**2,987**
Fertilization	Vineyards	4.86	lbs/acre	1,516	acres	**7,366**
	Other Agriculture	3.24	lbs/acre	150	acres	**486**
	Golf Courses	20.02	lbs/acre	356	acres	**7,118**
	Urban (low/medium density)	5.79	lbs/acre	8,402	acres	**48,648**
	Urban (high density)	2.16	lbs/acre	2,269	acres	**4,902**
Rural/Residential	Fertilization	5.79	lbs/acre	126	acres	**730**
	OWTS (< 7 acre properties)*	34.00	lbs/property	217	properties	**7,378**
	OWTS (> 7 acre properties)**	62.17	lbs/property	35	properties	**2,176**
	Livestock (Manure)	21.50	lbs/acre	20	acres	**422**
Industrial	Horse Boarding	51.10	lbs/acre	257	acres	**13,113**
	Wineries (small)	54.00	lbs/winery	14	wineries	**756**
	Wineries (medium)	200.00	lbs/winery	3	wineries	**600**
	Wineries (large)	355.00	lbs/winery	2	wineries	**710**
Roads	Dry deposition from vehicles	0.50	lbs/acre	1,610	acres	**805**
TOTAL Nitrogen Mass Loading (lbs/yr):						**134,795**

Removal Source		Concentration	Units	Volume	Units	N Removed (lbs/yr)
Groundwater Pumping	Zone 7	3.62	mg/L	5300	AF	**52,189**
	Retailers	5.00	mg/L	6570	AF	**89,337**
	Other	2.23	mg/L	1585	AF	**9,612**
Mining	Processing Loss	0.00	mg/L	700	AF	**0**
Subsurface Outflow	Subsurface to Streams	0.00	mg/L	100	AF	**0**
TOTAL Nitrogen Mass Loading (lbs/yr):						**151,138**

NET NITROGEN LOADING (lbs/yr)	**-16,343**

OWTS = Onsite Wastewater Treatment Systems

* Assumes 1 Rural Residence Equivalence (RRE) per property

** Assumes 1.8 RRE per property (based on average # of buildings on parcels greater than 7 acres)

TABLE 8-4
NITROGEN LOADING FRINGE AND UPLAND BASINS
LIVERMORE VALLEY GROUNDWATER BASIN

Loading Source	Loading Mechanism	Loading Rate: Leachable N Loading Rate	Loading Rate: Units	Fringe Basin Northwest: Num	Fringe Basin Northwest: Units	Fringe Basin Northwest: N Loading (lbs/yr)	Fringe Basin Northeast: Num	Fringe Basin Northeast: Units	Fringe Basin Northeast: N Loading (lbs/yr)	Fringe Basin East: Num	Fringe Basin East: Units	Fringe Basin East: N Loading (lbs/yr)	Upland: Num	Upland: Units	Upland: N Loading (lbs/yr)
Hydrologic (Wet) Loading	Rainfall Recharge	0.11	mg/L	1,173	AF	**360**	973	AF	**299**	317	AF	**98**	3,235	AF	**994**
	Stream Recharge (natural)	0.20	mg/L	150	AF	**82**	659	AF	**359**	100	AF	**54**	0	AF	**0**
	Groundwater Inflow	4.50	mg/L	0	AF	**0**	0	AF	**0**	0	AF	**0**	0	AF	**0**
Applied Water	Pipe Leakage (flow weighted)	7.63	mg/L	301	AF	**6,247**	385	AF	**8,002**	21	AF	**427**	404	AF	**8,390**
	Agricultural Irrigation	1.55	mg/L	117	AF	**493**	71	AF	**299**	225	AF	**951**	812	AF	**3,427**
	Urban Irrigation	1.11	mg/L	416	AF	**1,257**	354	AF	**1,068**	30	AF	**91**	499	AF	**1,508**
Fertilization	Vineyards	4.86	lbs/acre	0	acres	**0**	46	acres	**224**	662	acres	**3,215**	1,841	acres	**8,945**
	Other Agriculture	3.24	lbs/acre	0	acres	**0**	4	acres	**14**	23	acres	**76**	193	acres	**625**
	Golf Courses	20.02	lbs/acre	231	acres	**4,631**	80	acres	**1,592**	0	acres	**0**	638	acres	**12,770**
	Urban (low/medium density)	5.79	lbs/acre	4,574	acres	**26,482**	2,059	acres	**11,922**	0	acres	**0**	3,687	acres	**21,346**
	Urban (high density)	2.16	lbs/acre	3,163	acres	**6,831**	2,474	acres	**5,343**	42	acres	**91**	474	acres	**1,025**
Rural/ Residential	Fertilization	5.79	lbs/acre	5	acres	**26**	10	acres	**55**	6	acres	**32**	27	acres	**156**
	OWTS (< 7 acre properties)*	34.00	lbs/ property	6	properties	**204**	84	properties	**2,856**	34	properties	**1,156**	280	properties	**9,520**
	OWTS (> 7 acre properties)**	35.25	lbs/ property	3	properties	**106**	22	properties	**776**	18	properties	**635**	131	properties	**4,618**
	Livestock (Manure)	21.50	lbs / acre	6	acres	**124**	16	acres	**339**	18	acres	**381**	36	acres	**770**
Industrial	Horse Boarding	51.10	lbs /acre	0	acres	**0**	0	acres	**0**	36	acres	**1,827**	43	acres	**2,223**
	Wineries (small)	54.00	lbs / winery	1	wineries	**54**	6	wineries	**324**	6	wineries	**324**	30	wineries	**1,620**
	Wineries (medium)	200.00	lbs / winery	0	wineries	**0**	0	wineries	**0**	0	wineries	**0**	2	wineries	**400**
	Wineries (large)	355.00	lbs / winery	0	wineries	**0**	0	wineries	**0**	0	wineries	**0**	1	wineries	**355**
Roads	Dry deposition from vehicles	0.50	lbs /acre	570	acres	**285**	131	acres	**65**	0	acres	**0**	93	acres	**47**
TOTAL Nitrogen Mass Loading (lbs/yr):						**47,183**			**33,535**			**9,358**			**78,737**

Removal Source	Removal Mechanism	Concentration	Units	Fringe Basin Northwest: Volume	Units	N Removed (lbs/yr)	Fringe Basin Northeast: Volume	Units	N Removed (lbs/yr)	Fringe Basin East: Volume	Units	N Removed (lbs/yr)	Upland: Volume	Units	N Removed (lbs/yr)
Groundwater Pumping	Ag	4.50	mg/L	32	AF	**-393**	16	AF	**-198**	29	AF	**-352**	92	AF	**-1,127**
	Domestic	2.9 - 8.3	mg/L	12	AF	**-91**	46	AF	**-384**	28	AF	**-632**	178	AF	**-1,791**
Subsurface Outflow	To Streams	0.11 - 25.59	mg/L	1111	AF	**-1,087**	2400	AF	**-712**	0	AF	**0**	4260	AF	**-66,399**
	Subsurface	4.99	mg/L	1000	AF	**-13,566**	0	AF	**0**	0	AF	**0**	0	AF	**0**
TOTAL Nitrogen Mass Loading (lbs/yr):						**-15,137**			**-1,294**			**-984**			**-69,317**

	Fringe Basin Northwest	Fringe Basin Northeast	Fringe Basin East	Upland
NET NITROGEN LOADING (lbs/yr)	**32,046**	**32,241**	**8,374**	**9,420**

OWTS = Onsite Wastewater Treatment Systems

* Assumes 1 Rural Residence Equivalence (RRE) per property

** Assumes 1.04 RRE per property (based on average # of buildings on parcels greater than 7 acres)

TABLE 8-5
CHANGE IN OWTS LOADING SINCE 2015
LIVERMORE VALLEY GROUNDWATER BASIN

Type	Net Loading (lbs/yr)	MANAGEMENT AREA				SPECIAL PERMIT AREAS (SPAs)		Total Count
		Main	Fringe Northeast	Fringe East	Upland	Happy Valley	BuenaVista/ Greenville	
Installed Advanced OWTS (* if in SPA)	23.8 (-10 in SPA)**	7	1	1	5	0	4	**7**
Abandonment	-34	4	0	0	6	2	0	**6**
Install Standard OWTS	34	0	0	0	4	1	1	**4**
Replace with Advanced OWTS*	-10.2	3	0	0	3	0	3	**3**
Replace with Standard OWTS	-10***	0	0	1	0	0	1	**1**
Total Net Loading (lbs/yr)		**-136.0**	**23.8**	**13.8**	**20.4**	**-34**	**-47.4**	**58**
***Net Loading Attibutable to NMP Recommendations**		**-71.4**	**0.0**	**0.0**	**-30.6**	**0.0**	**-71.4**	

* Attributable to Nutrient Management Plan Recommendations
** Assumes Standard OWTS would have been installed if not in SPA
*** Estimated. Leaking stardard system replaced with properly operating OWTS
OWTS = Onsite Wastewater Treatment Systems
NMP = Nutrient Management Plan (2015)
SPA = Special Permit Area

TABLE 8-6
LAND USE ACREAGE (in acres)
2020 WATER YEAR
LIVERMORE VALLEY GROUNDWATER BASIN

Category / Basin / Irrigation Water Source	Main Basin					Fringe Areas					Upland Areas				
	DW	GW	RW	none	Total	DW	GW	RW	none	Total	DW	GW	RW	none	Total
Agriculture (non-vineyard)	56	94	0	0	150	0	28	0	0	28	146	47	0	0	193
Agriculture (vineyard)	1,497	19	0	0	1,516	708	0	0	0	708	1,840	1	0	0	1,841
Total Agricultural	***1,552***	***113***	***0***	***0***	***1,666***	***708***	***28***	***0***	***0***	***735***	***1,986***	***48***	***0***	***0***	***2,033***
Commercial and Business	1,406	42	400	0	1,849	3,872	117	1,268	0	5,257	387	15	28	0	430
Public	563	0	400	0	962	957	3	57	0	1,018	143	0	88	0	232
Public (Irrigated Park)	563	0	118	0	680	185	0	87	0	272	97	0	11	0	108
Residential (high density)	421	0	0	0	421	264	0	158	0	422	29	0	15	0	44
Residential (medium density)	6,446	0	17	0	6,463	5,279	0	45	0	5,324	2,937	0	49	0	2,986
Residential (low density)	147	150	0	0	297	20	0	0	0	20	185	177	0	0	362
Roads	0	0	0	78	78	0	0	0	701	701	0	0	0	93	93
Total Urban	***9,545***	***192***	***934***	***78***	***10,749***	***10,576***	***120***	***1,616***	***701***	***13,013***	***3,778***	***192***	***192***	***93***	***4,255***
Golf Course	140	90	126	0	356	230	15	66	0	311	466	172	0	0	638
Residential (rural)	41	155	0	0	196	19	373	0	0	392	166	192	0	0	358
Mining Area (pit)	0	0	0	1,959	1,959	0	0	0	0	0	0	0	0	0	0
Open Space	0	0	102	3,748	3,850	0	0	0	7,440	7,440	0	0	0	20,324	20,324
Water	0	0	0	1,034	1,034	0	0	0	65	65	0	0	0	170	170
Total Other	***181***	***245***	***229***	***6,740***	***7,394***	***249***	***389***	***66***	***7,505***	***8,208***	***632***	***364***	***0***	***20,494***	***21,490***
TOTALS FOR 2020 WY	**11,278**	**550**	**1,163**	**6,818**	**19,809**	**11,532**	**536**	**1,681**	**8,206**	**21,956**	**6,396**	**603**	**192**	**20,587**	**27,778**
TOTALS FOR 2019 WY	**11,274**	**550**	**1,008**	**6,977**	**19,809**	**11,468**	**536**	**1,576**	**8,376**	**21,956**	**6,382**	**553**	**192**	**20,651**	**27,778**
CHANGE SINCE PREVIOUS YEAR	**4**	**0**	**155**	**-159**	**0**	**64**	**0**	**106**	**-170**	**0**	**14**	**50**	**0**	**-64**	**0**

Irrigation Water Sources
DW = Delivered Municipal Water
GW = Groundwater
RW = Recycled Water

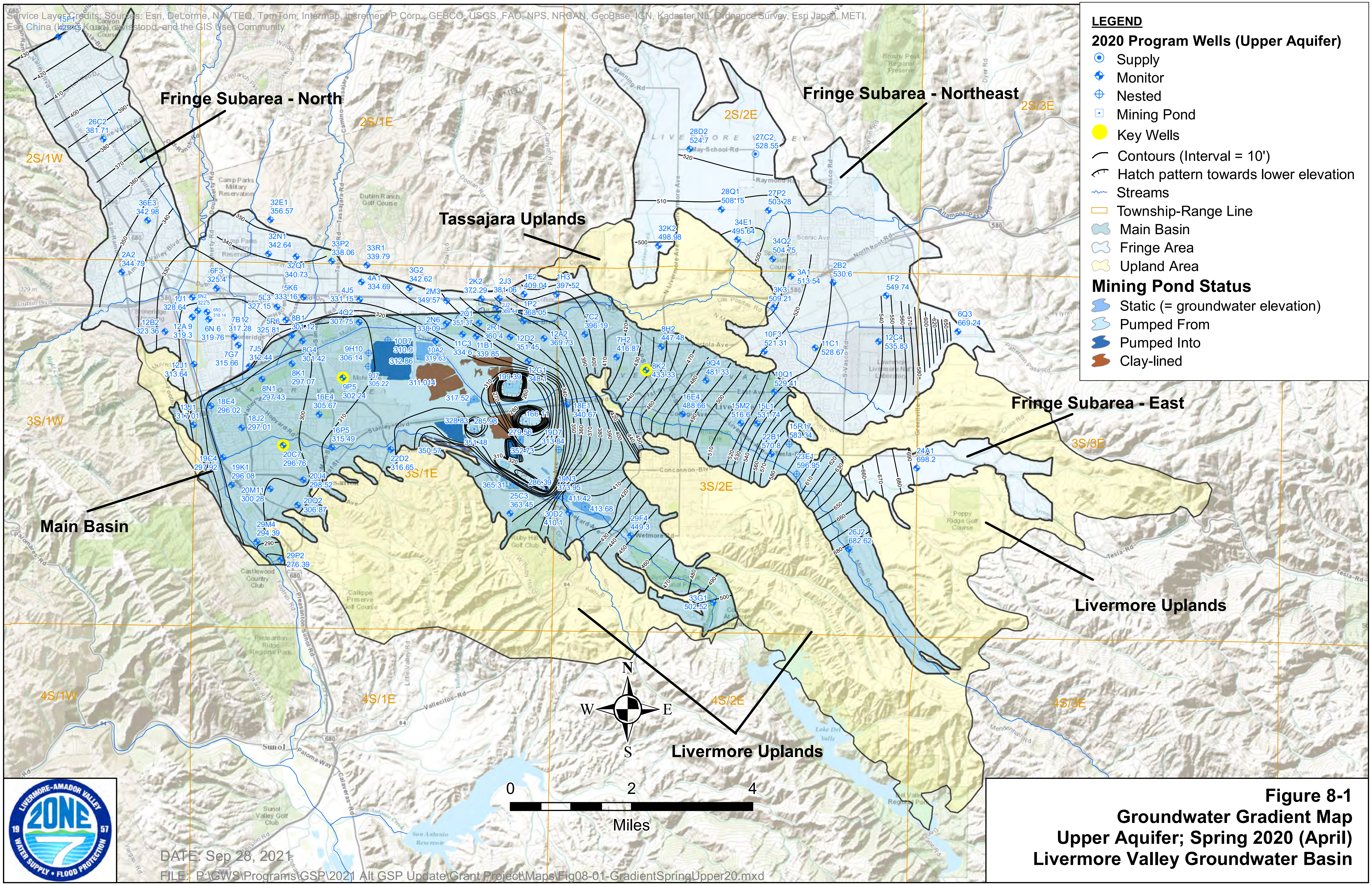


Figure 8-1
Groundwater Gradient Map
Upper Aquifer; Spring 2020 (April)
Livermore Valley Groundwater Basin

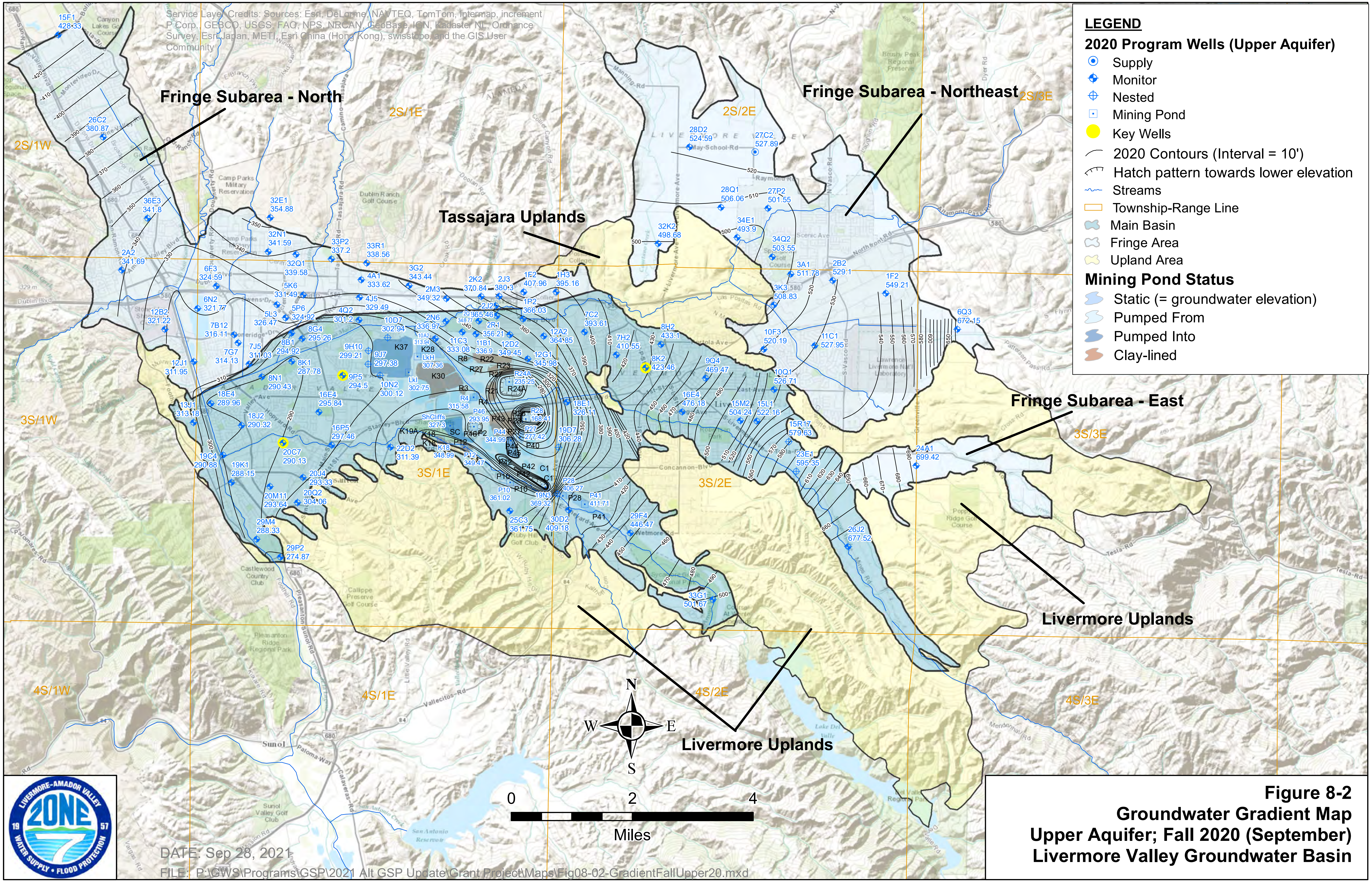


Figure 8-2
Groundwater Gradient Map
Upper Aquifer; Fall 2020 (September)
Livermore Valley Groundwater Basin

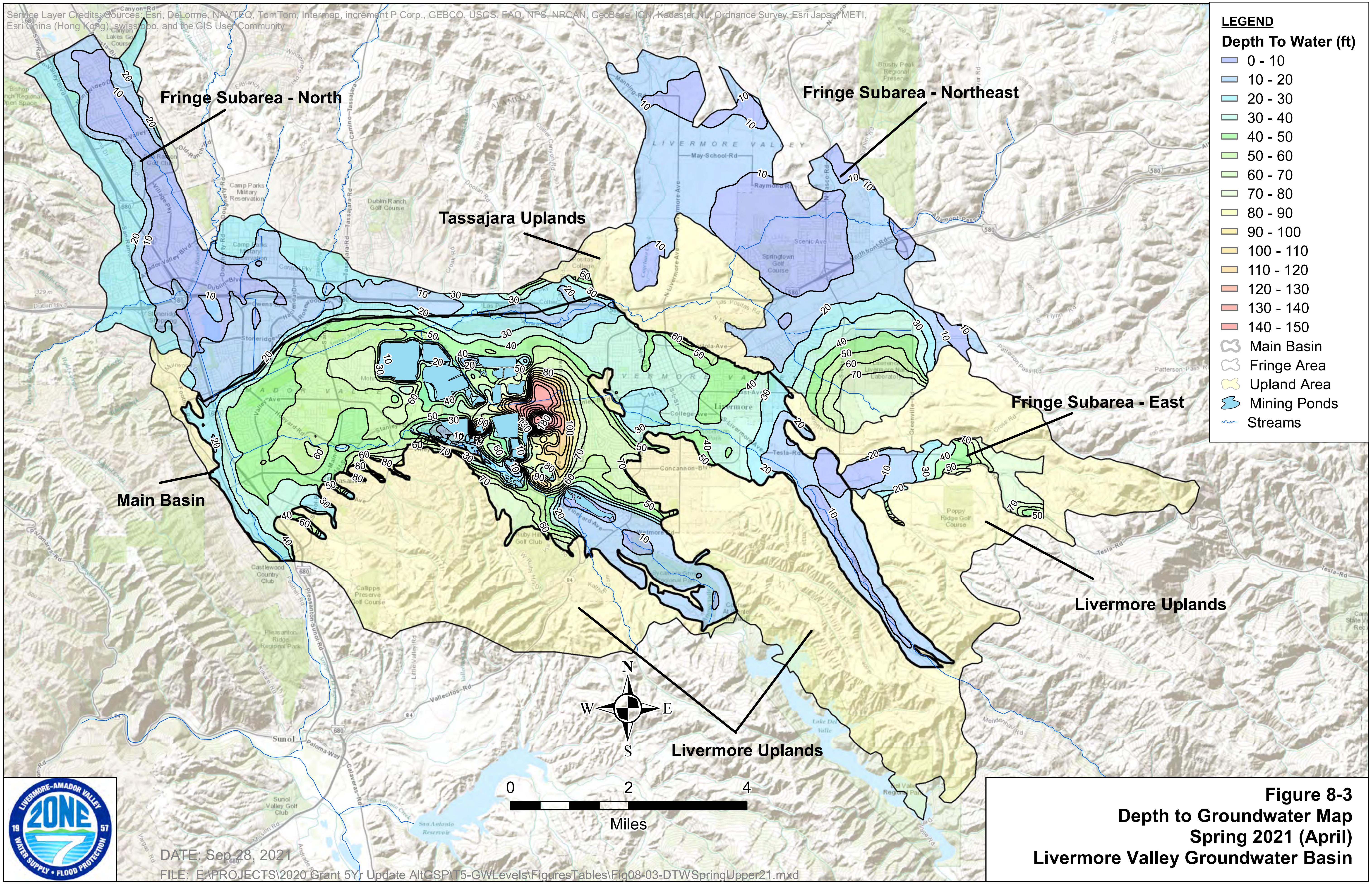


Figure 8-3
Depth to Groundwater Map
Spring 2021 (April)
Livermore Valley Groundwater Basin

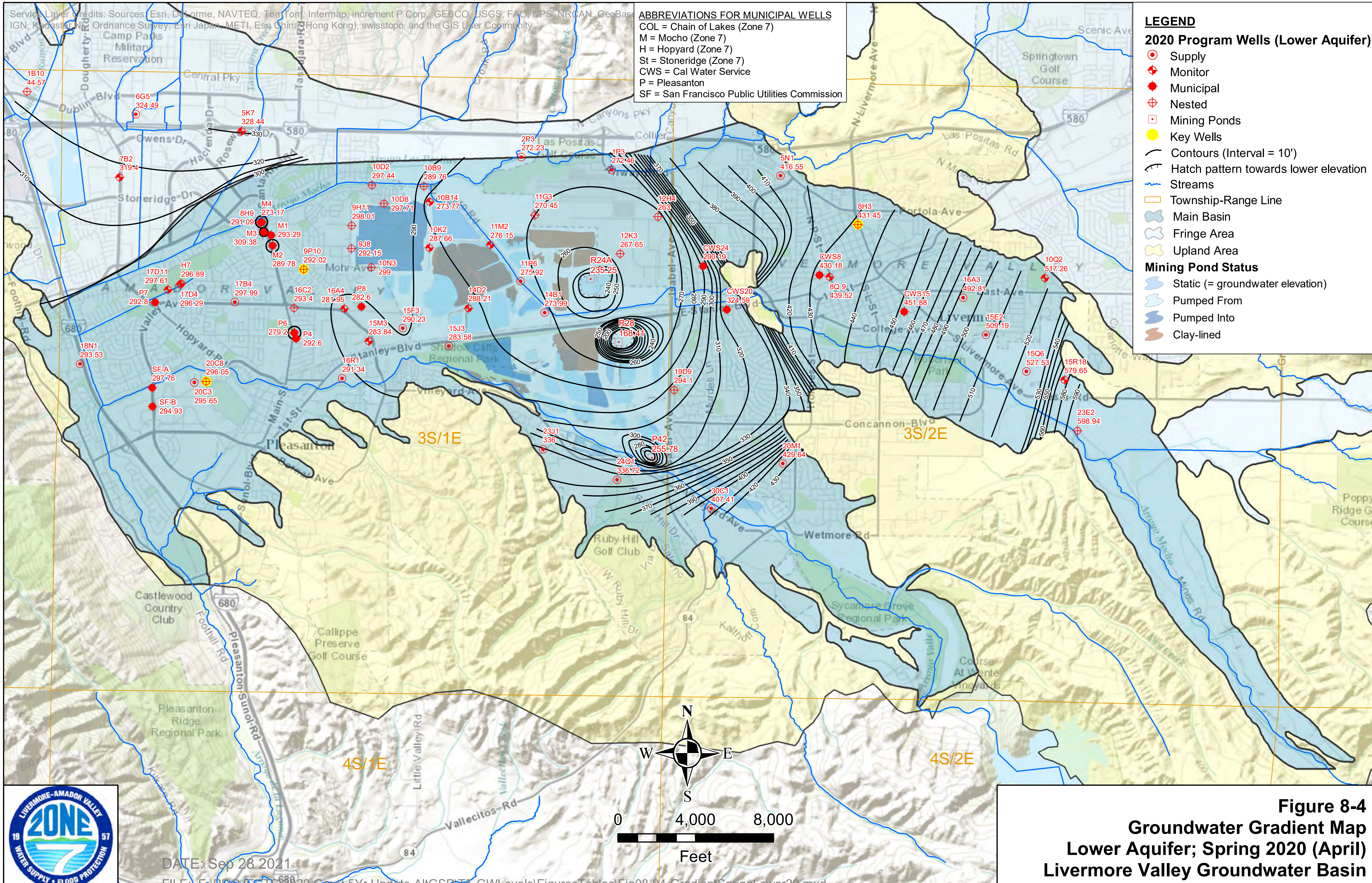


Figure 8-4
Groundwater Gradient Map
Lower Aquifer; Spring 2020 (April)
Livermore Valley Groundwater Basin

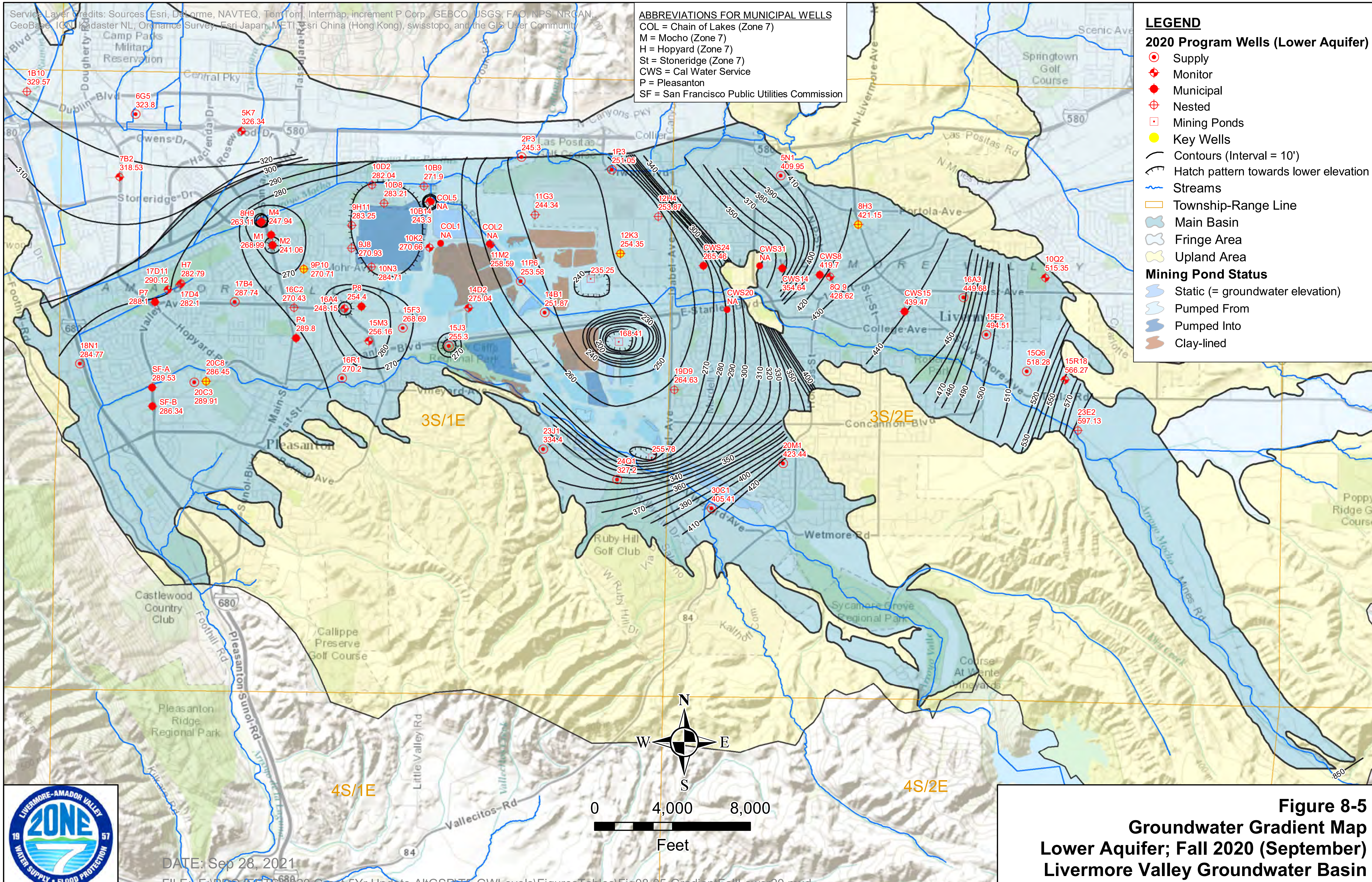
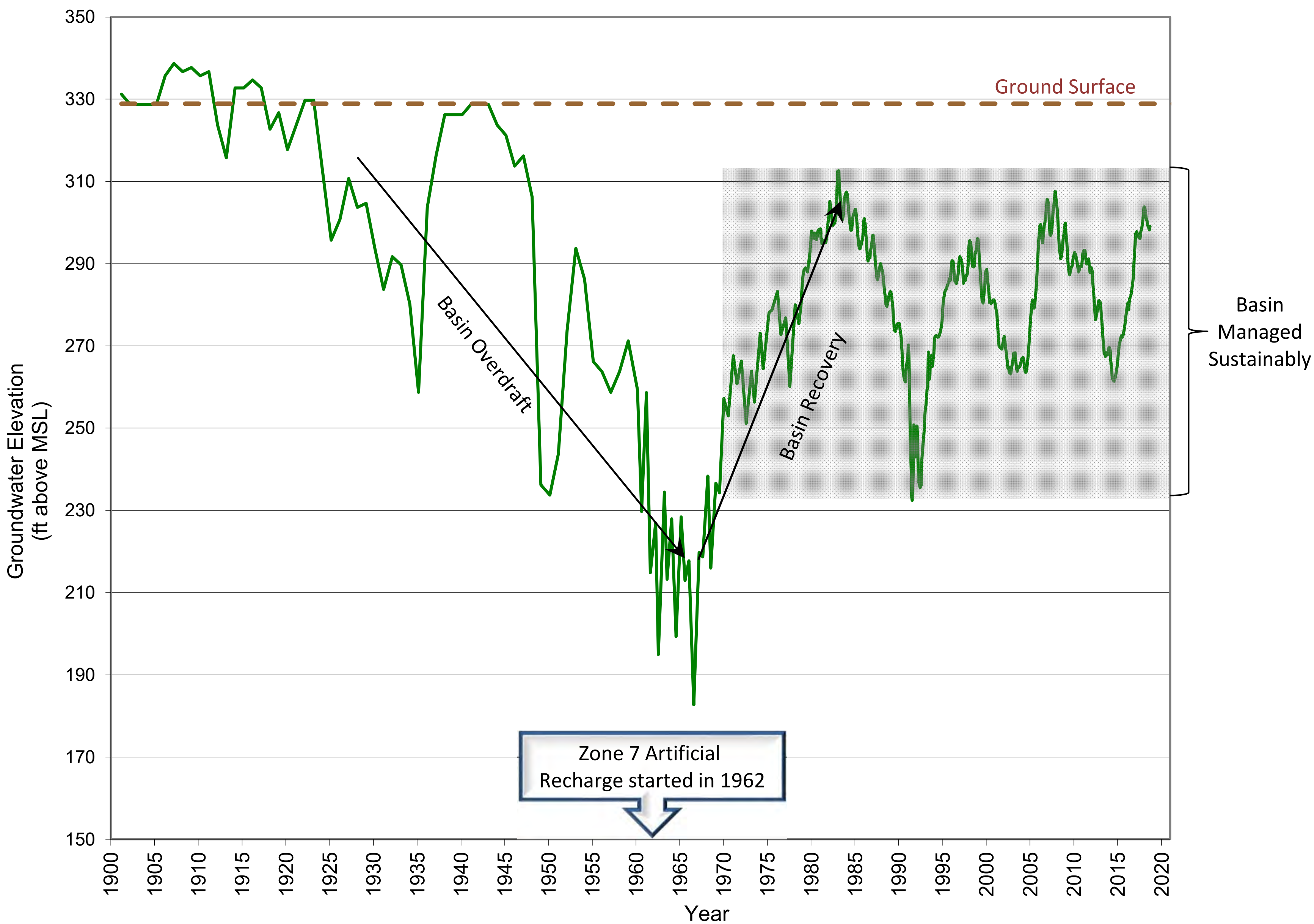


Figure 8-5
Groundwater Gradient Map
Lower Aquifer; Fall 2020 (September)
Livermore Valley Groundwater Basin

Figure 8-6
Graph of Bernal Key Well Groundwater Levels
Livermore Valley Groundwater Basin



9/28/2021
Fig08-06-GraphBernalKeyWells00to21.xlsx

Figure 8-7
Graph of Key Well Water Levels
in Amador West SubBasin (1973 to 2021)
Livermore Valley Groundwater Basin

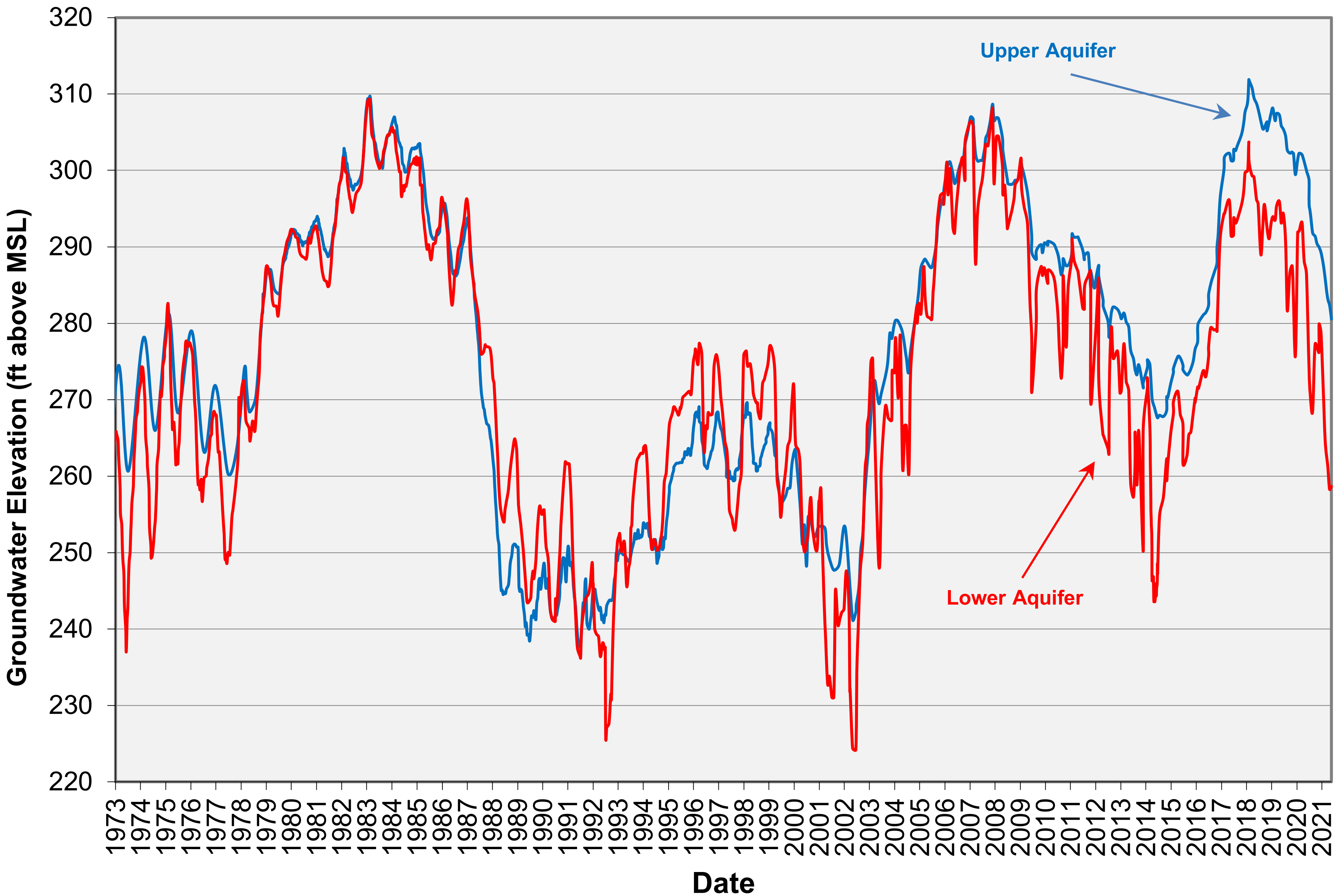


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Fig08-06-GraphBernalKeyWells00to21.xlsx

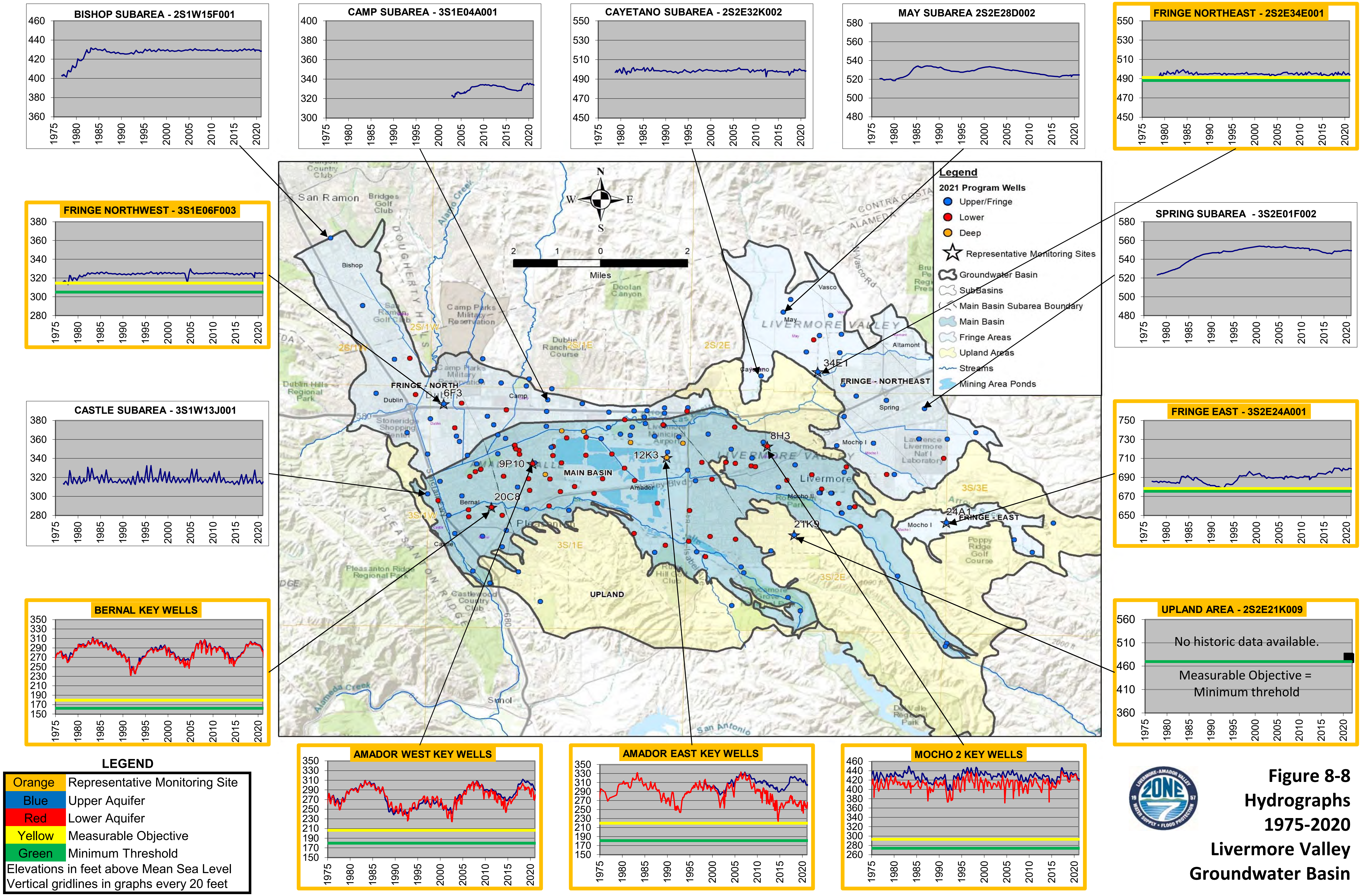

Figure 8-8
Hydrographs
1975-2020
Livermore Valley
Groundwater Basin

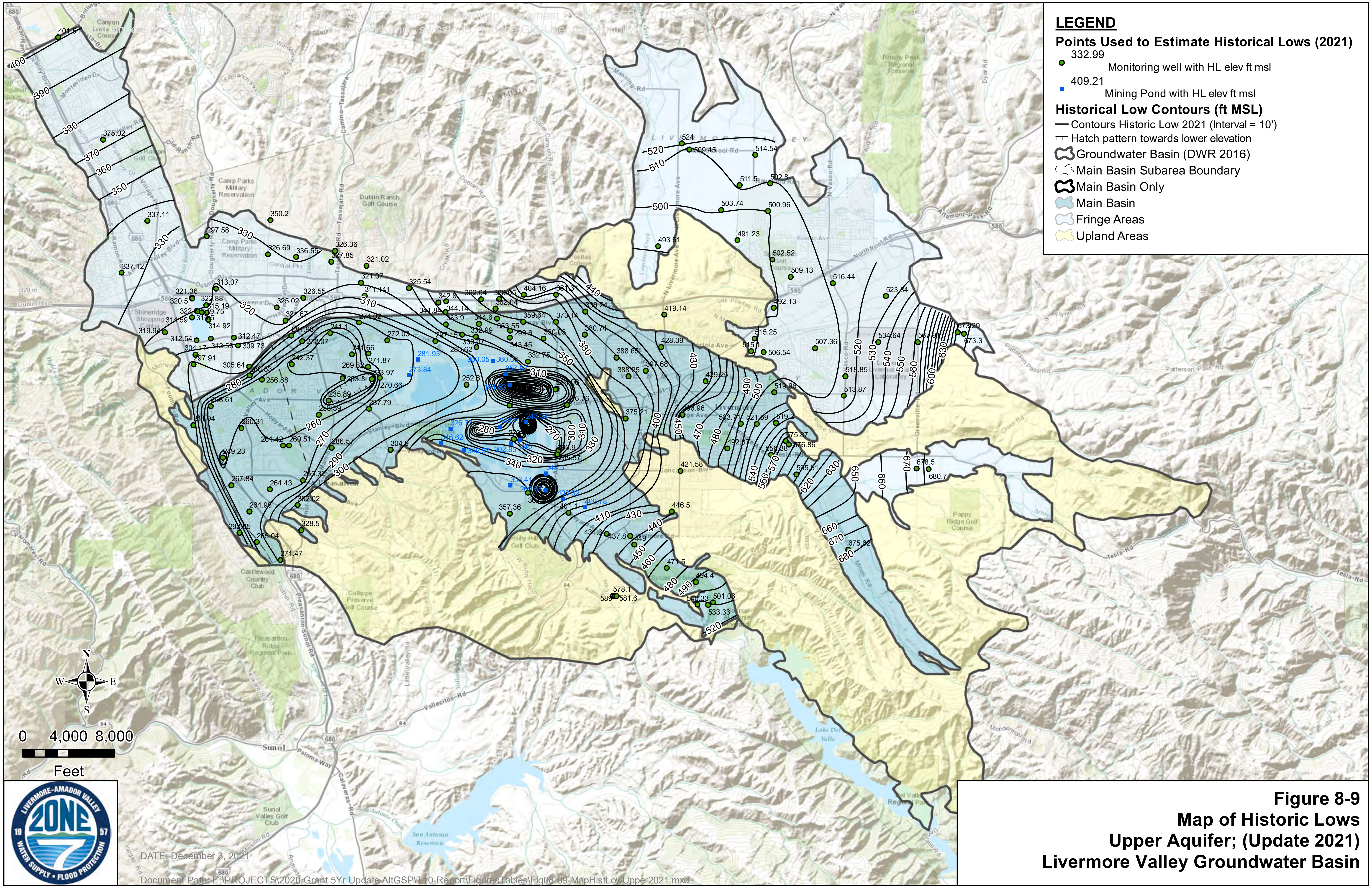

Figure 8-9
Map of Historic Lows
Upper Aquifer; (Update 2021)
Livermore Valley Groundwater Basin

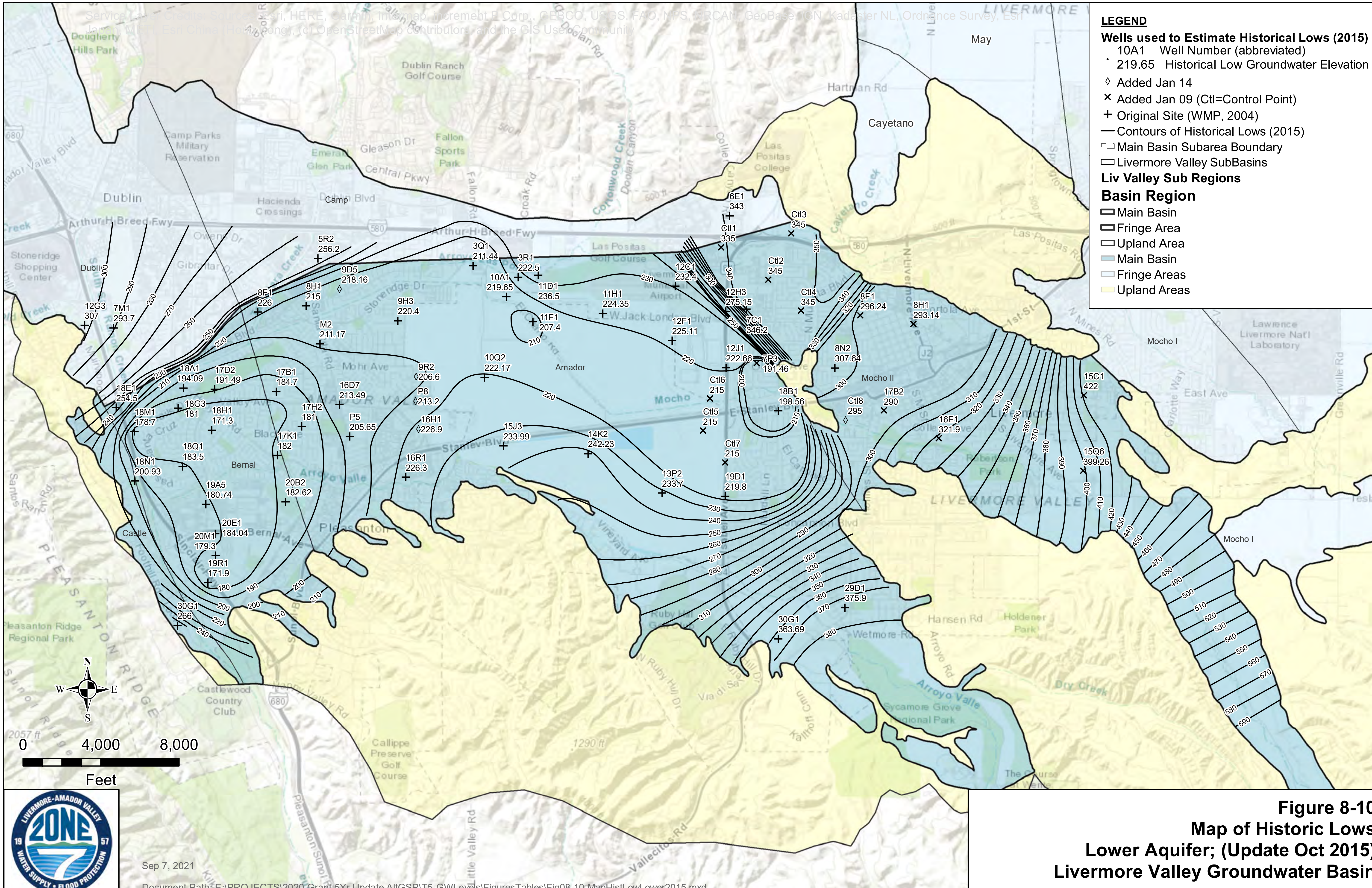

Figure 8-10
Map of Historic Lows
Lower Aquifer; (Update Oct 2015)
Livermore Valley Groundwater Basin

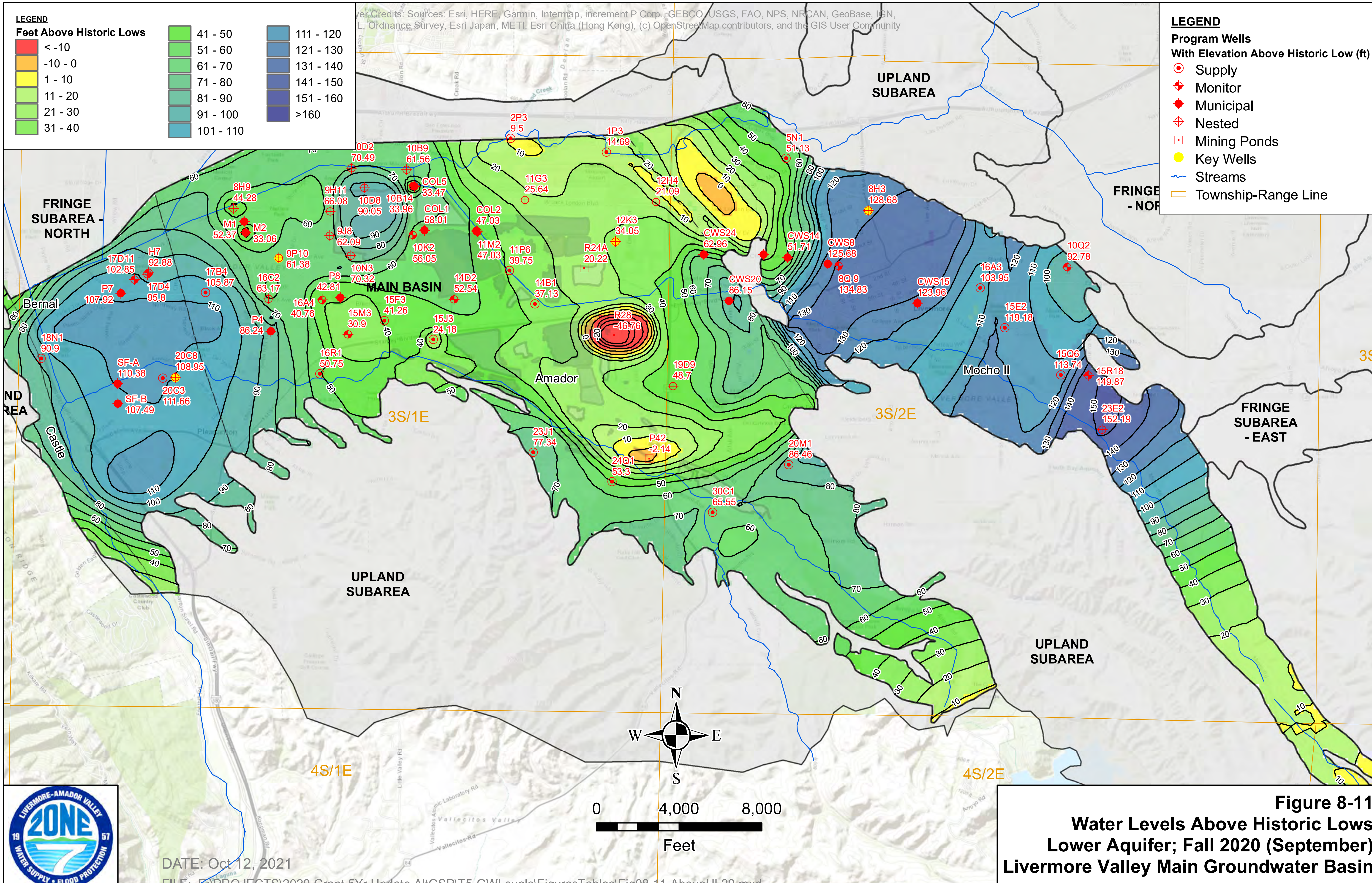

Figure 8-11
Water Levels Above Historic Lows
Lower Aquifer; Fall 2020 (September)
Livermore Valley Main Groundwater Basin

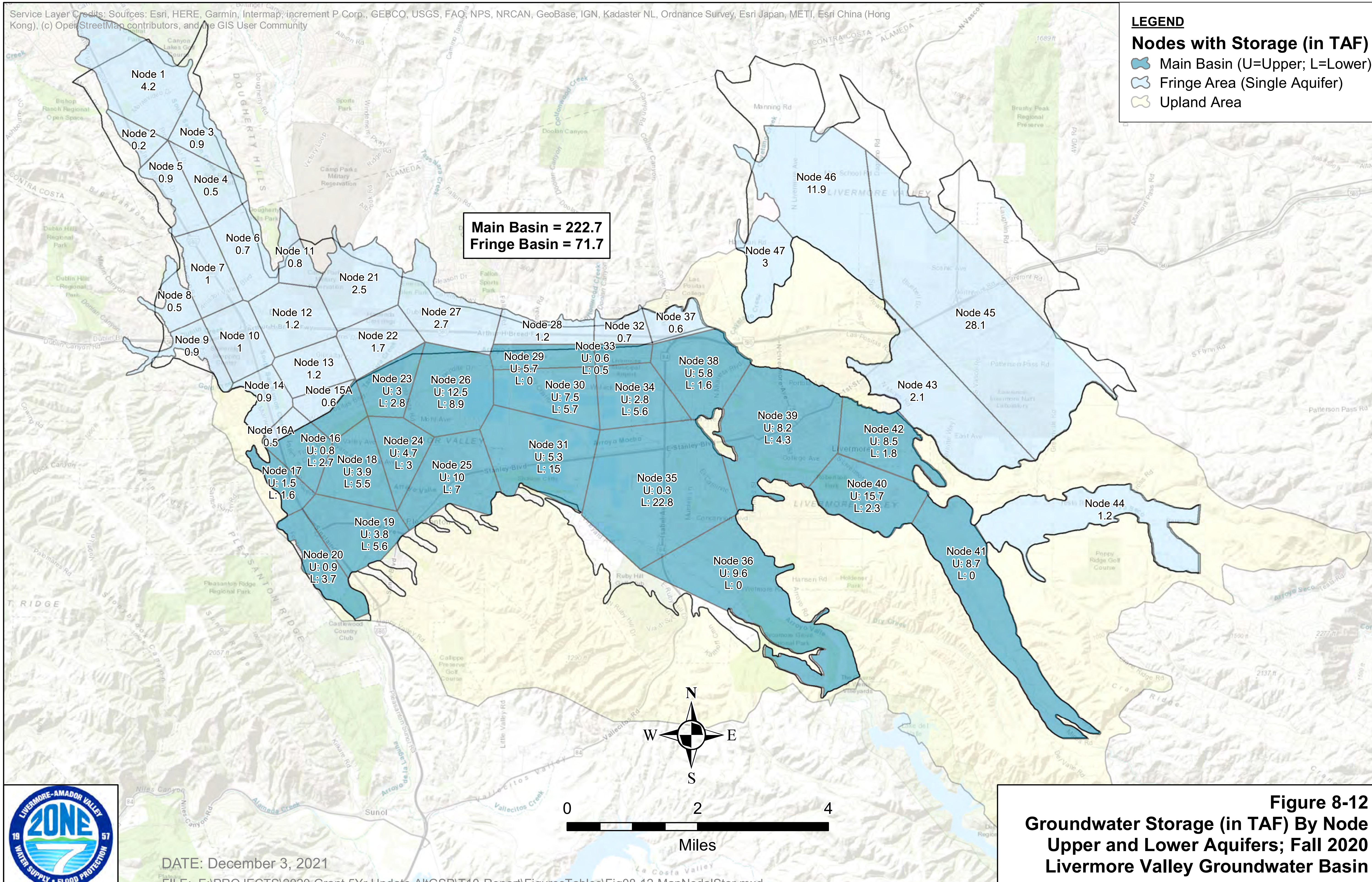

Figure 8-12
Groundwater Storage (in TAF) By Node
Upper and Lower Aquifers; Fall 2020
Livermore Valley Groundwater Basin

Figure 8-13
Graph of Groundwater Storage 1974 to 2020
Livermore Valley Groundwater Basin

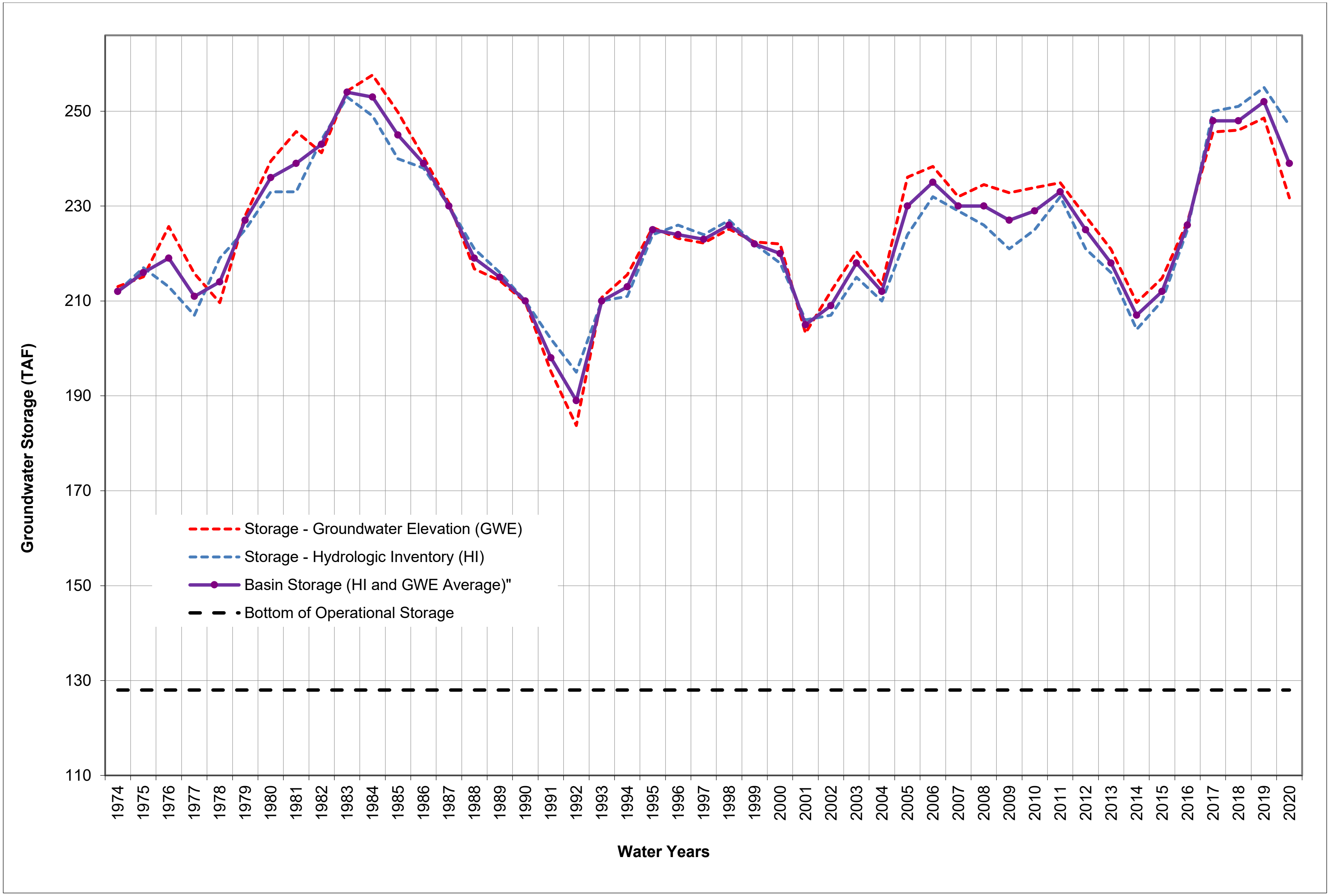

Figure 8-14
Graph of Operational and Reserve Storage 1974 to 2020
Livermore Valley Groundwater Basin

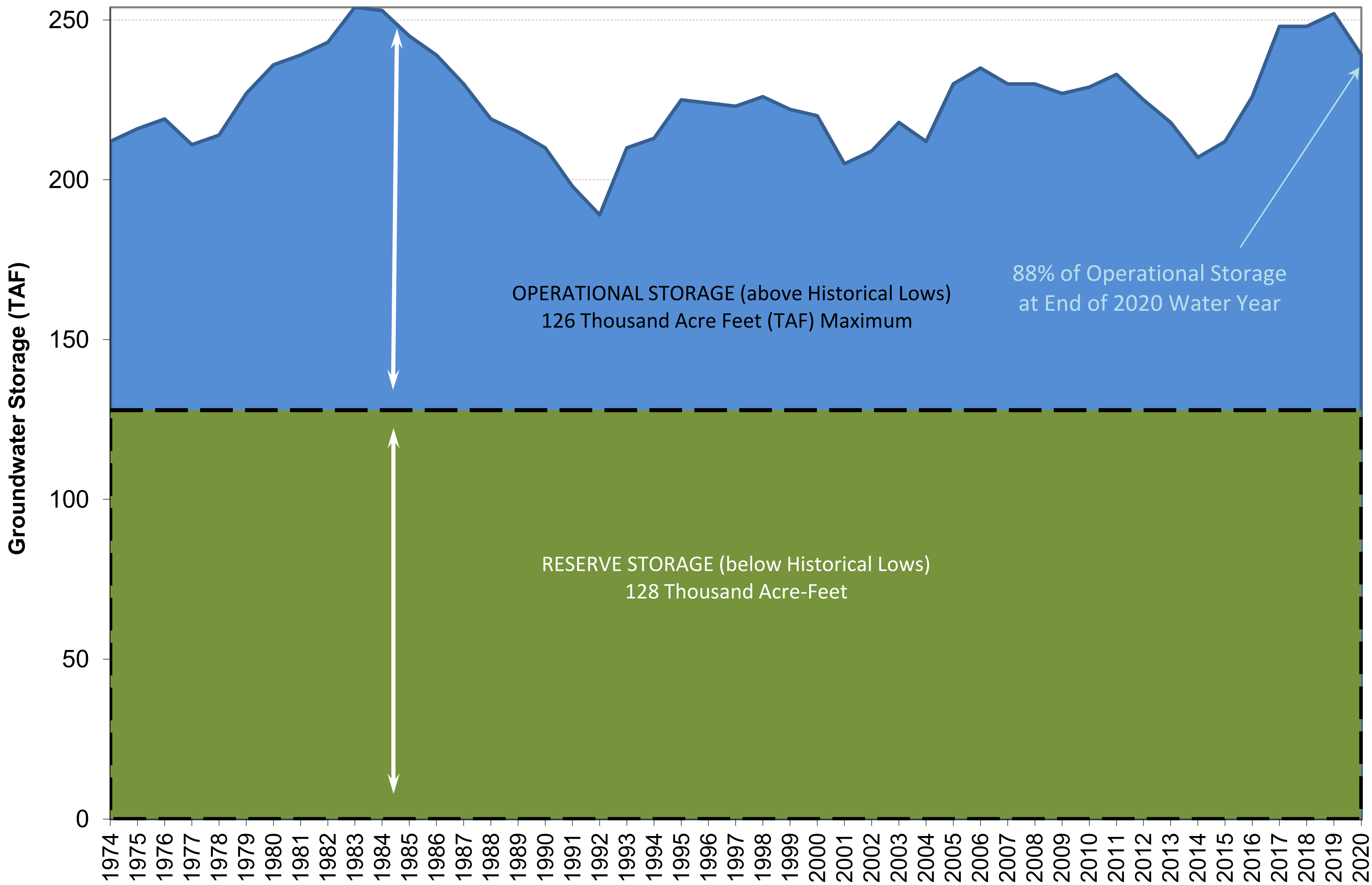

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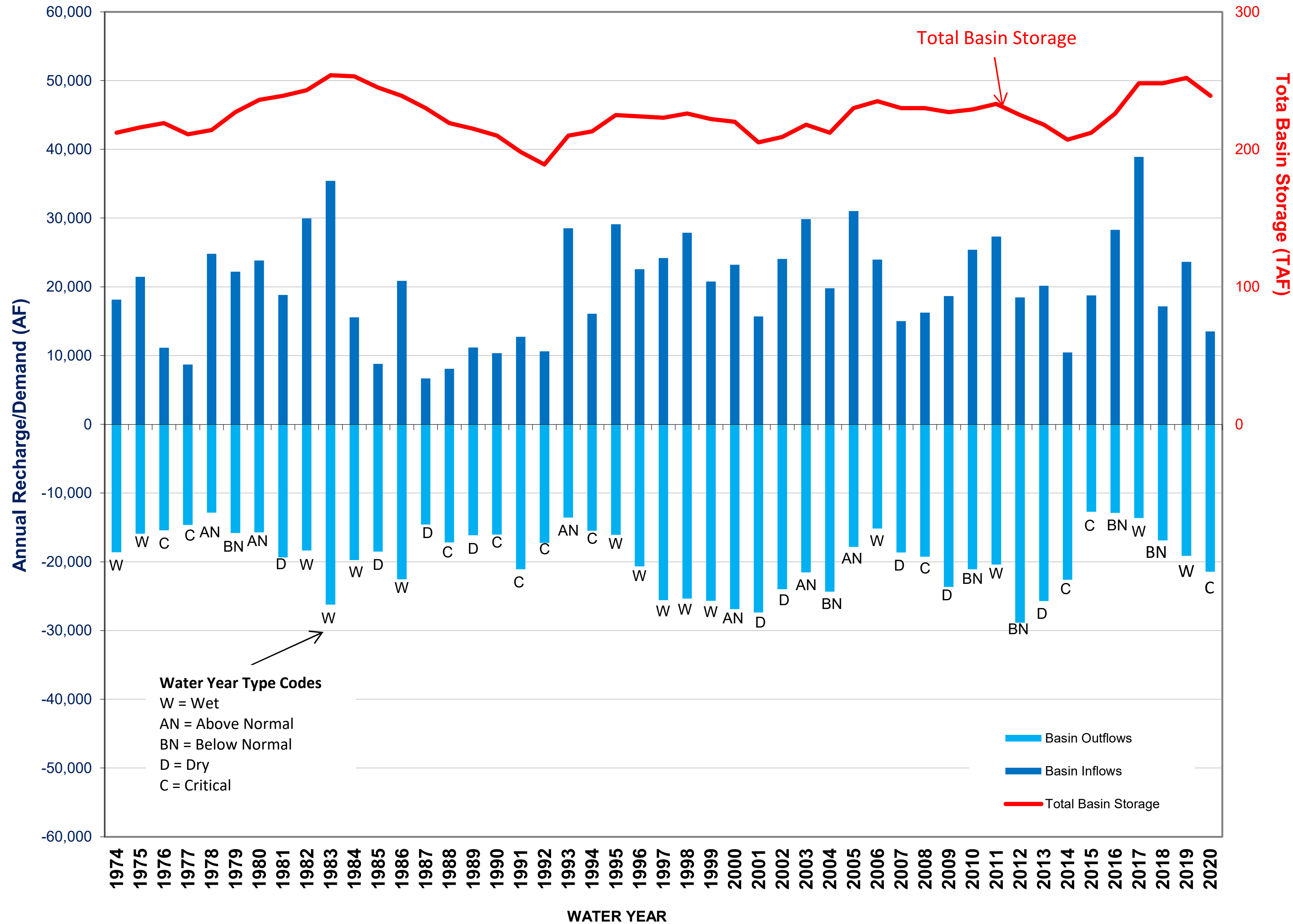
FIGURE 8-15
GRAPH OF GROUNDWATER STORAGE 1974 - 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN



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9/29/2021

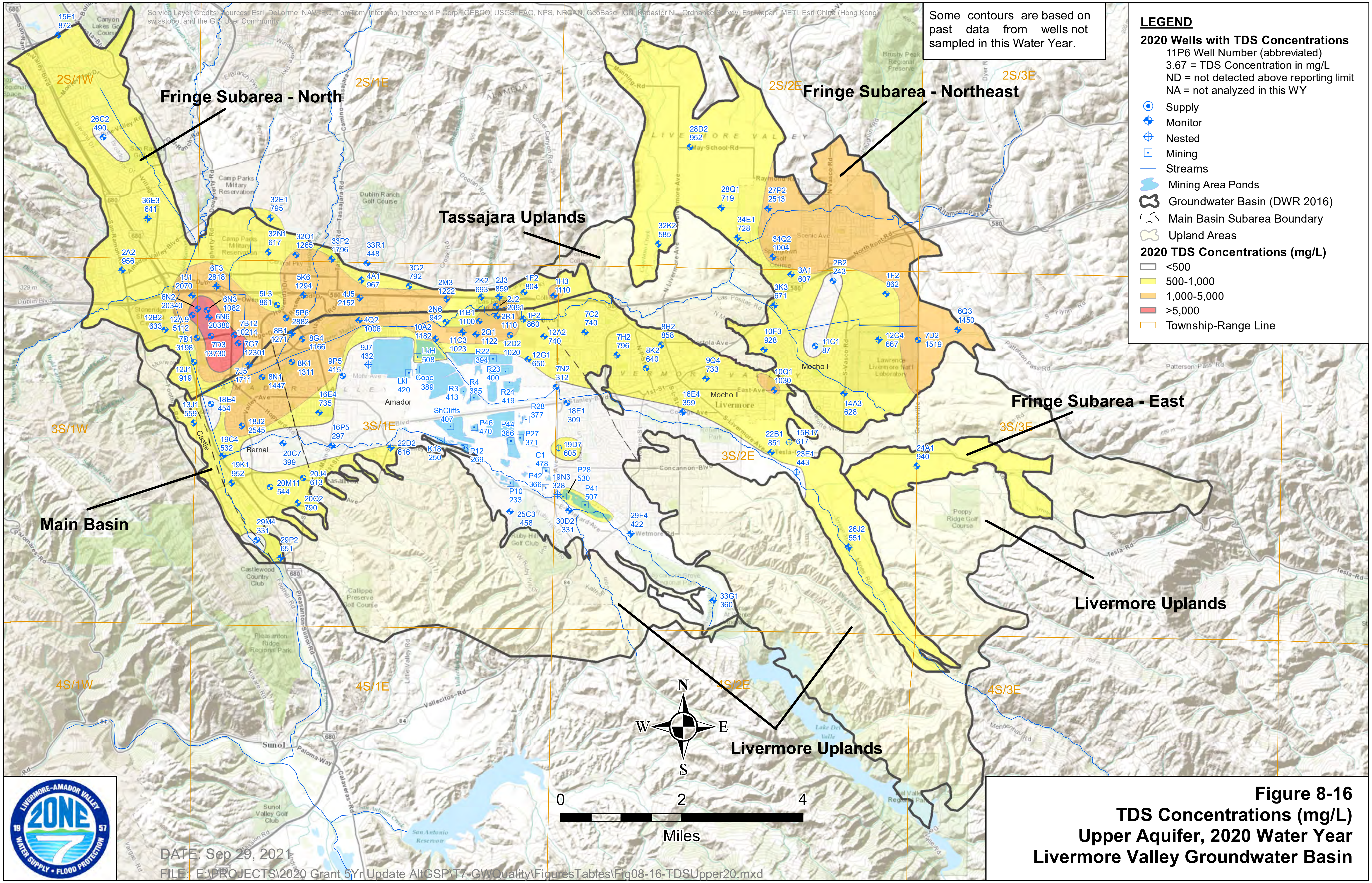


Figure 8-16
TDS Concentrations (mg/L)
Upper Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

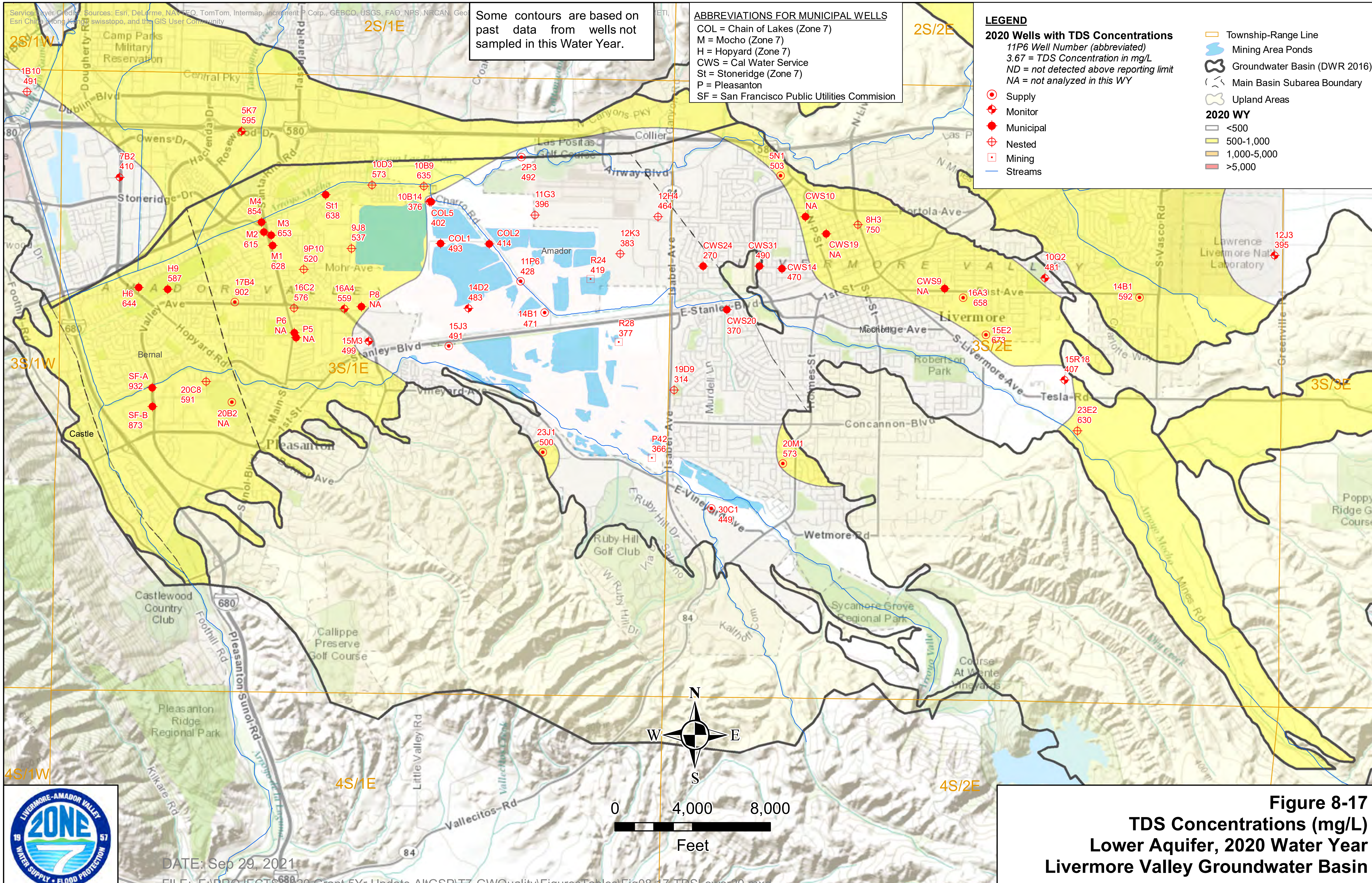


Figure 8-17
TDS Concentrations (mg/L)
Lower Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

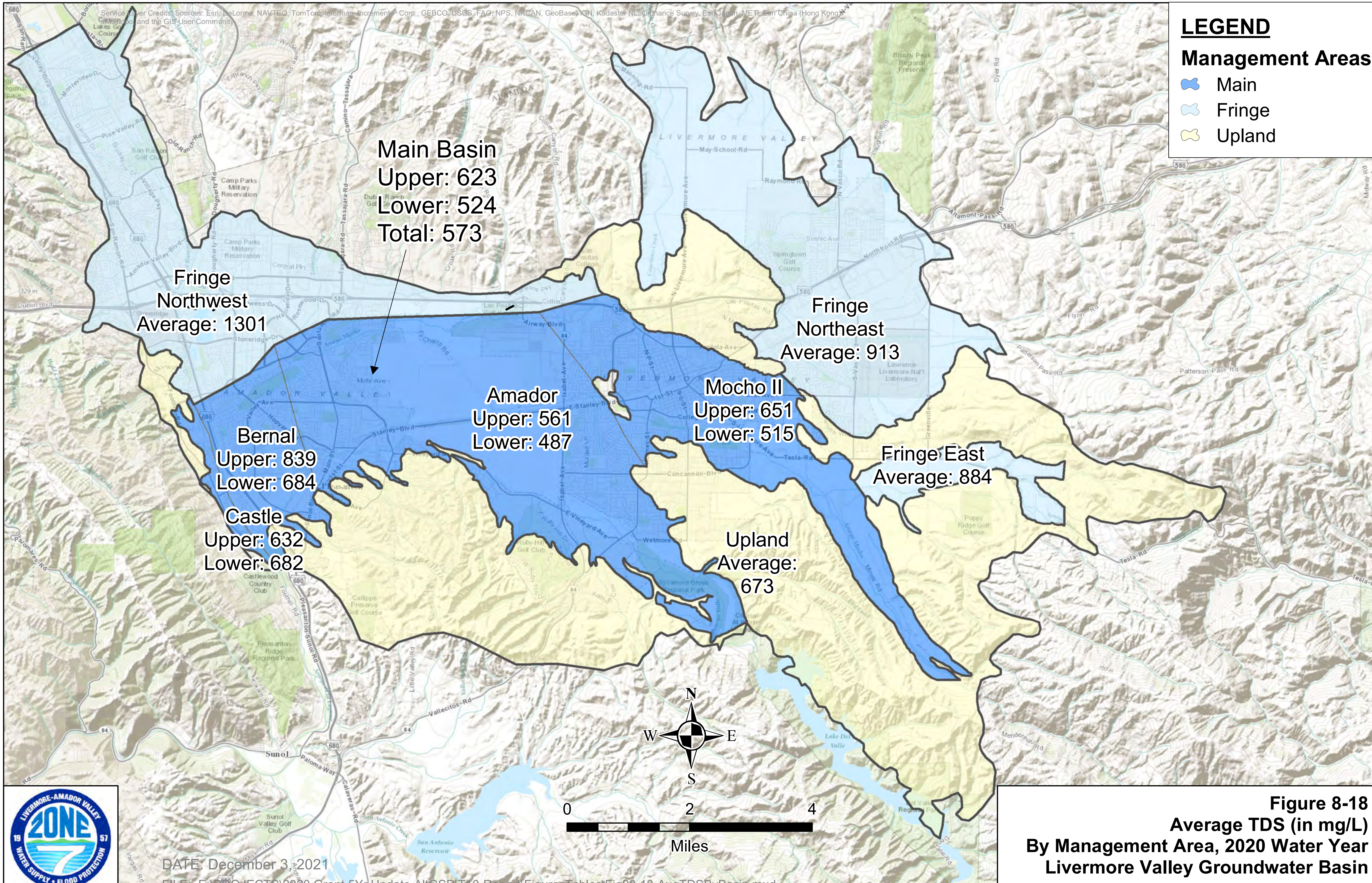


Figure 8-18
Average TDS (in mg/L)
By Management Area, 2020 Water Year
Livermore Valley Groundwater Basin

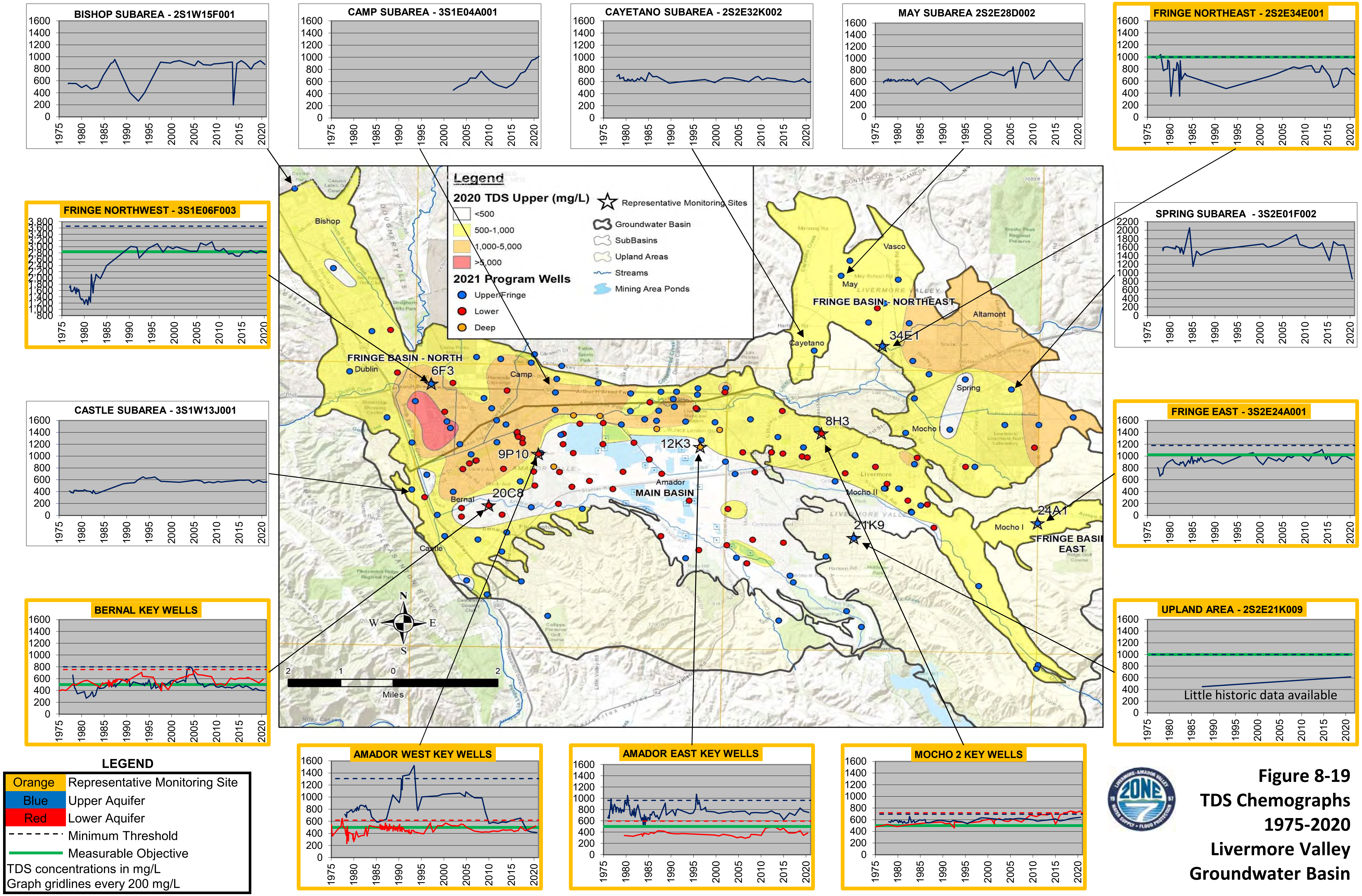
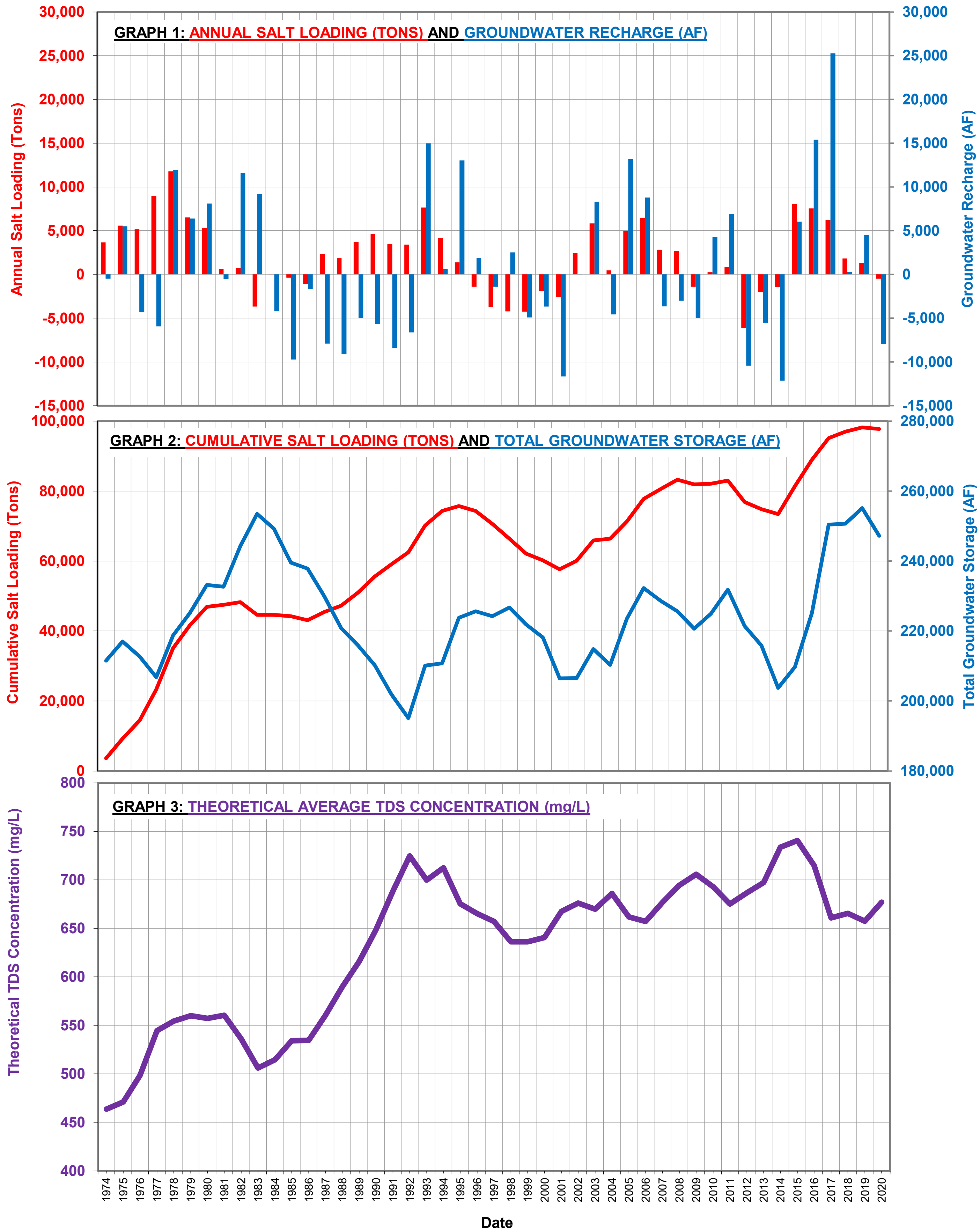


Figure 8-19
TDS Chemographs
1975-2020
Livermore Valley
Groundwater Basin

FIGURE 8-20
MAIN BASIN SALT LOADING AND TDS CONCENTRATION
1974 to 2020 WATER YEARS



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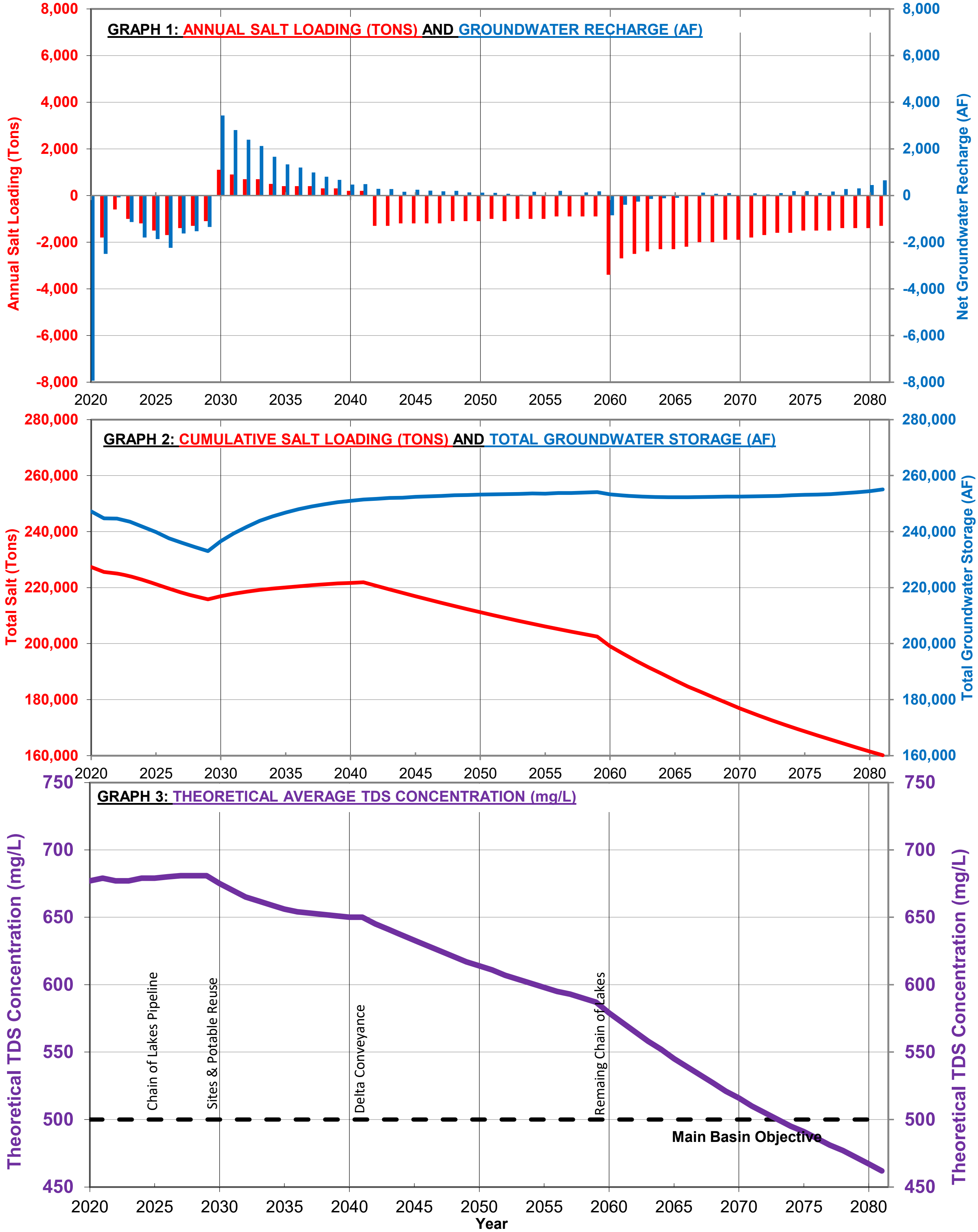
9/9/2021

FIGURE 8-21
MAIN BASIN PROJECTED SALT LOADING AND TDS CONCENTRATION 2020 to 2081 WATER YEARS



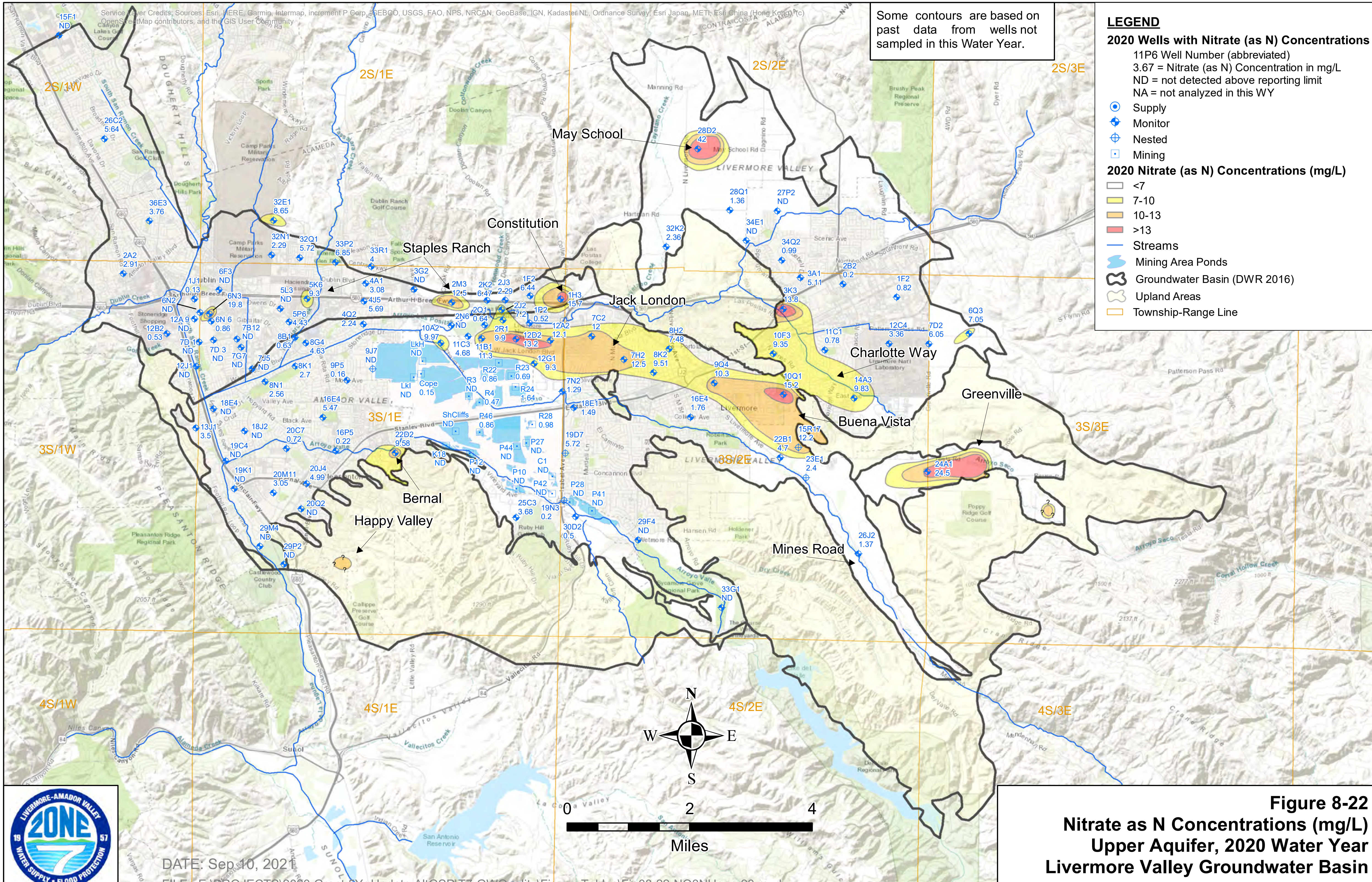


Figure 8-22
Nitrate as N Concentrations (mg/L)
Upper Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

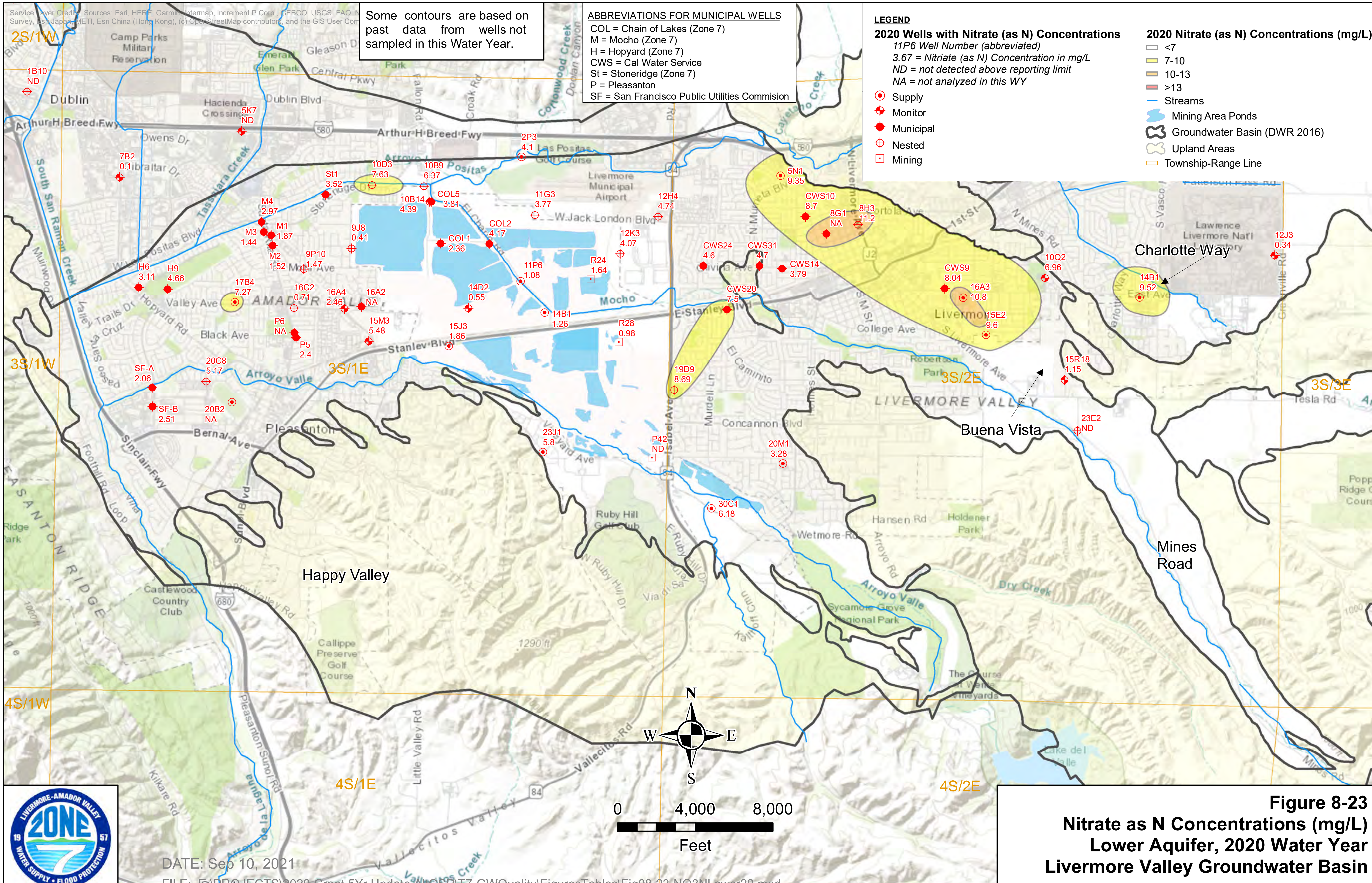


Figure 8-23
Nitrate as N Concentrations (mg/L)
Lower Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

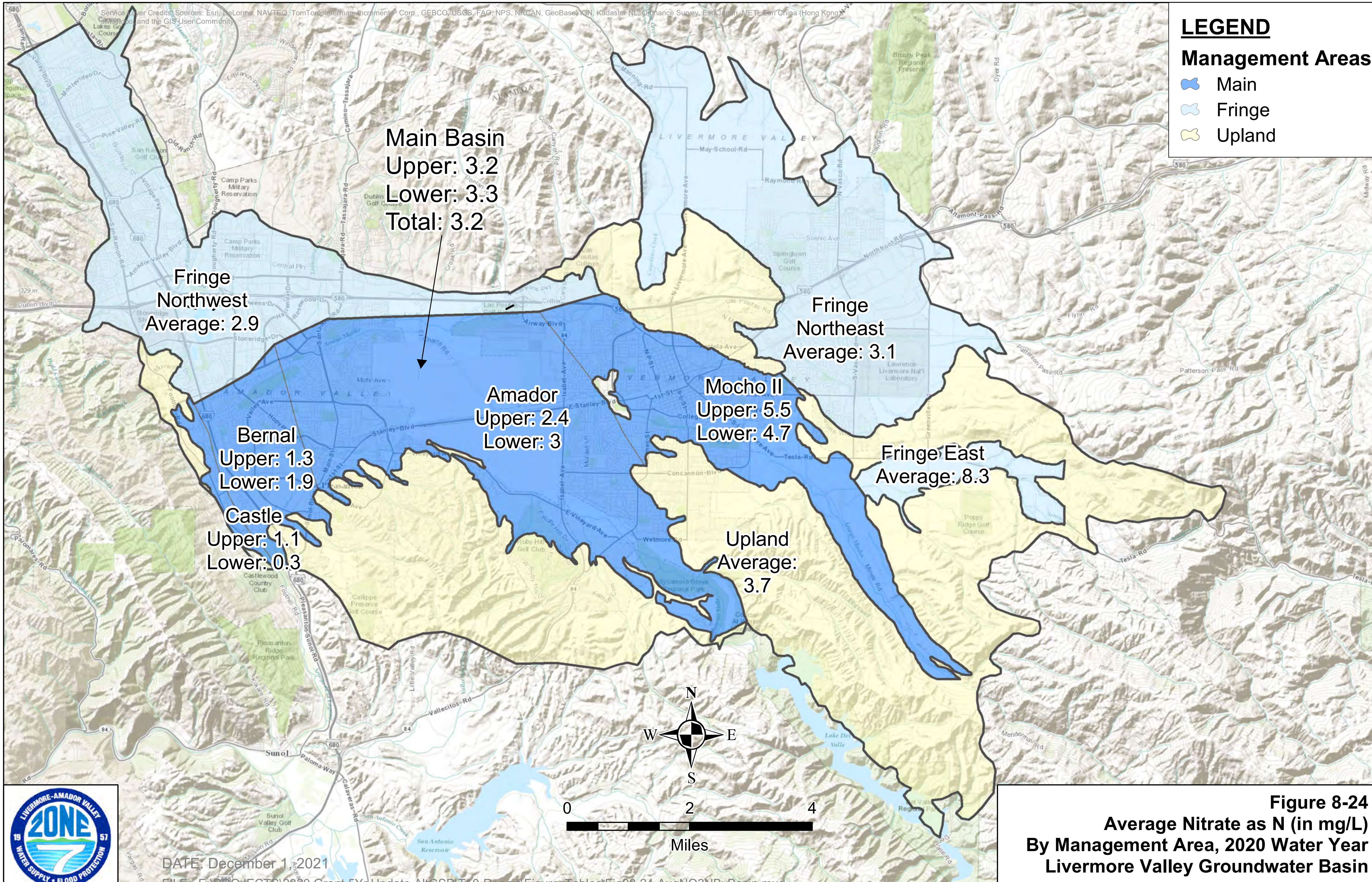


Figure 8-24
Average Nitrate as N (in mg/L)
By Management Area, 2020 Water Year
Livermore Valley Groundwater Basin

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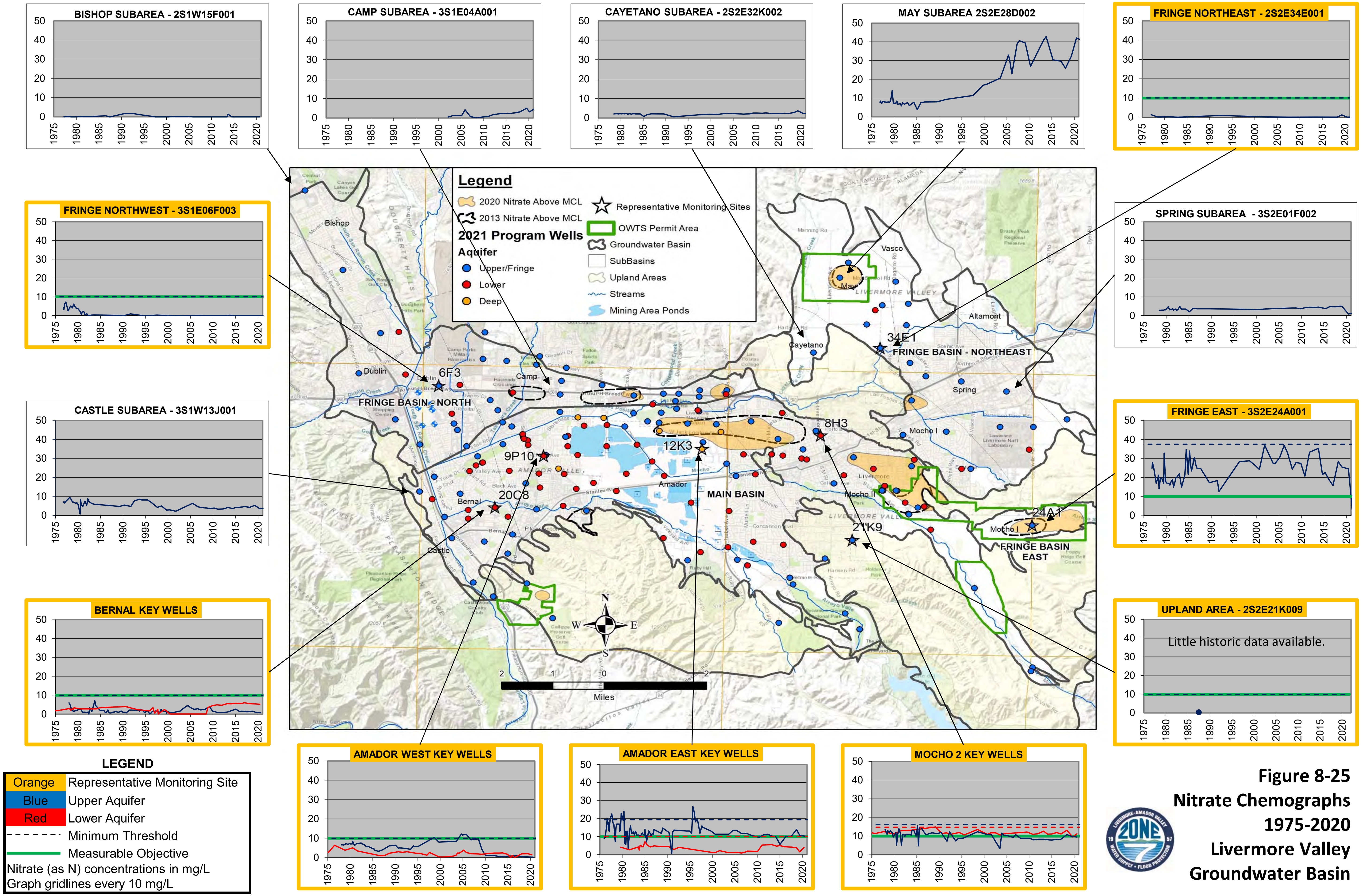

Figure 8-25
Nitrate Chemographs
1975-2020
Livermore Valley
Groundwater Basin

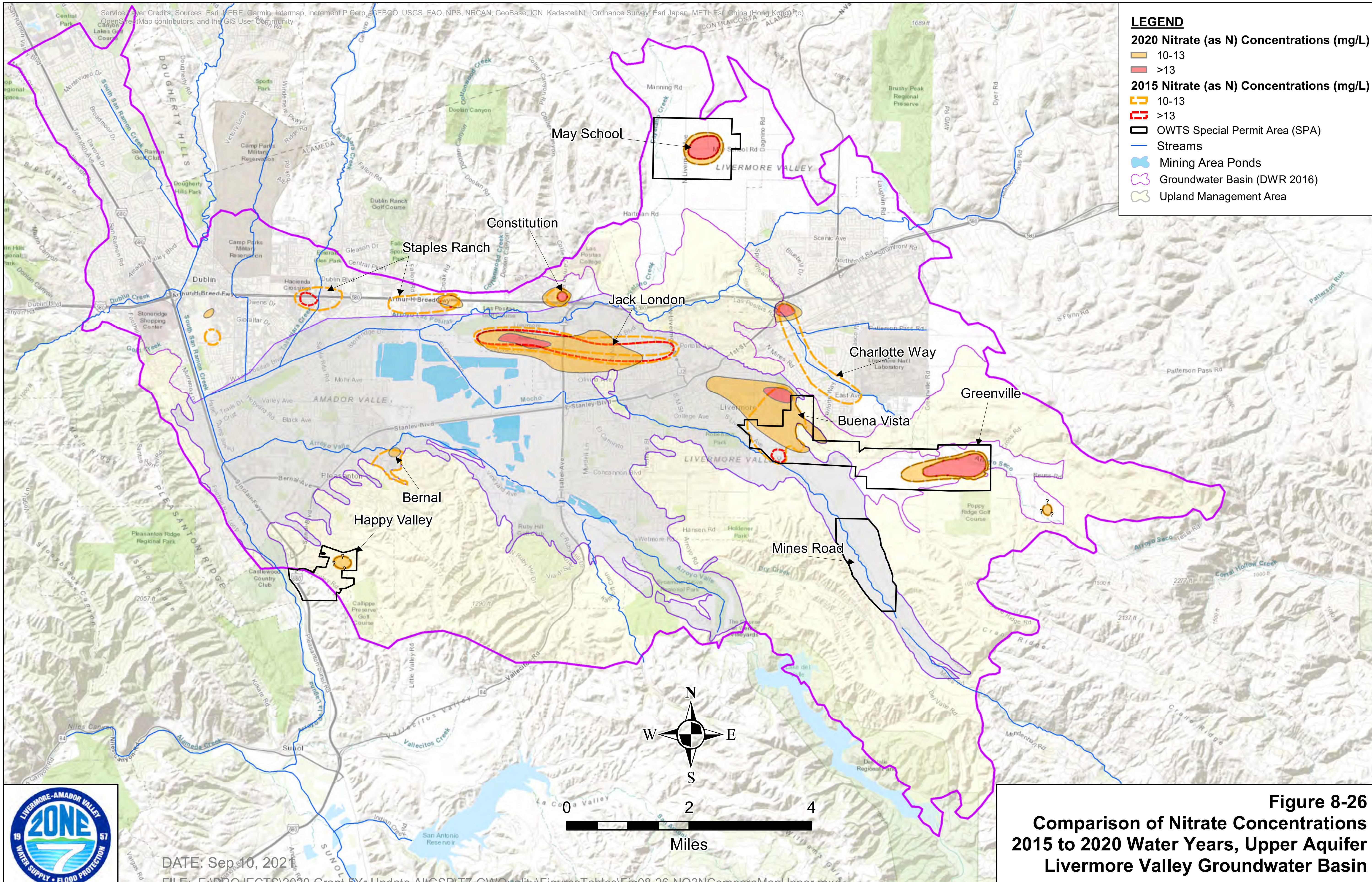

Figure 8-26
Comparison of Nitrate Concentrations 2015 to 2020 Water Years, Upper Aquifer Livermore Valley Groundwater Basin

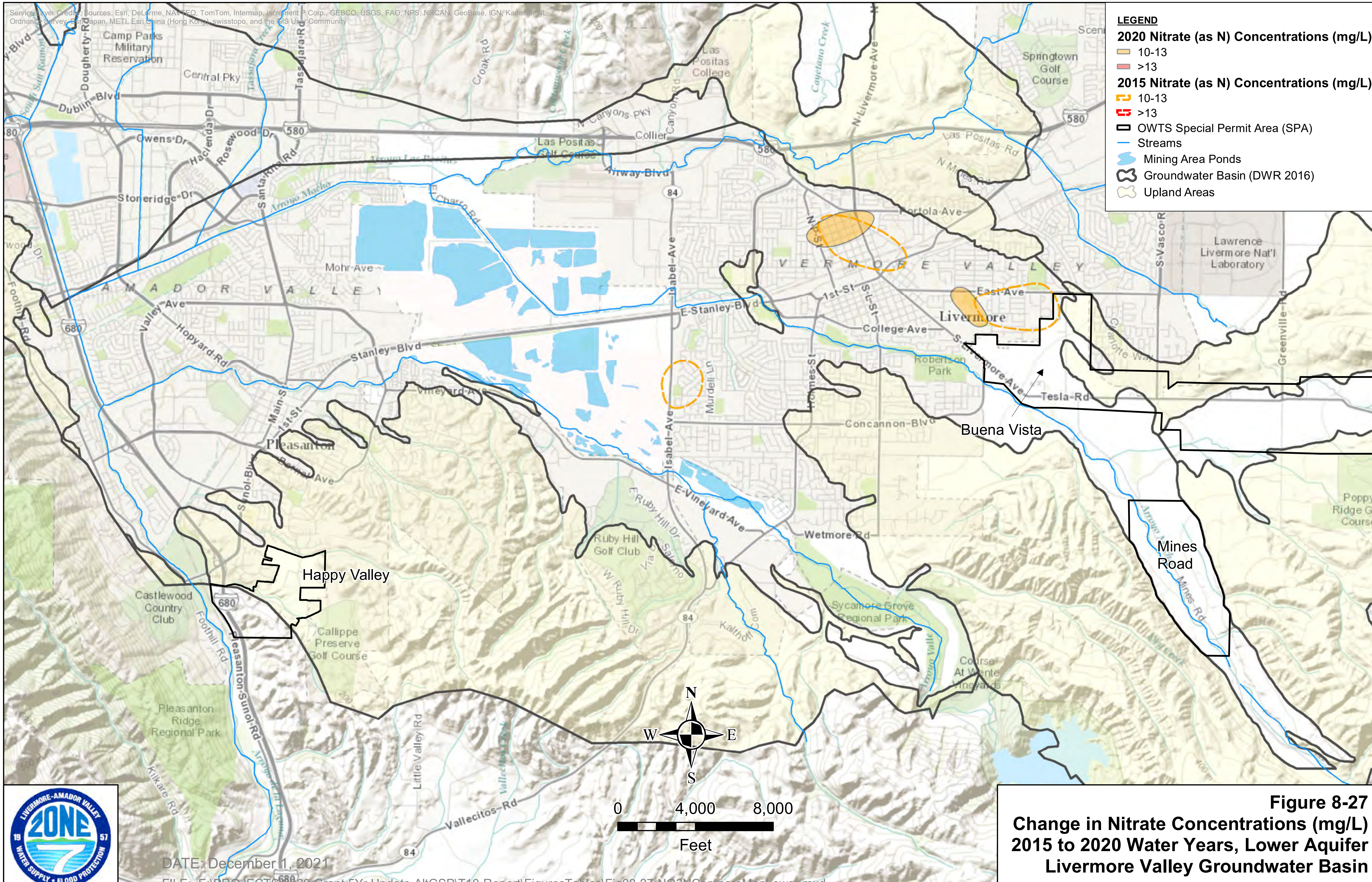

Figure 8-27
Change in Nitrate Concentrations (mg/L)
2015 to 2020 Water Years, Lower Aquifer
Livermore Valley Groundwater Basin

DATE: December 1, 2021
FILE: E:\PROJECTS\2020 Grant 5Yr Update AltGSP\T10-Report\FiguresTables\Fig08-27-NO3NCompareMapLower.mxd

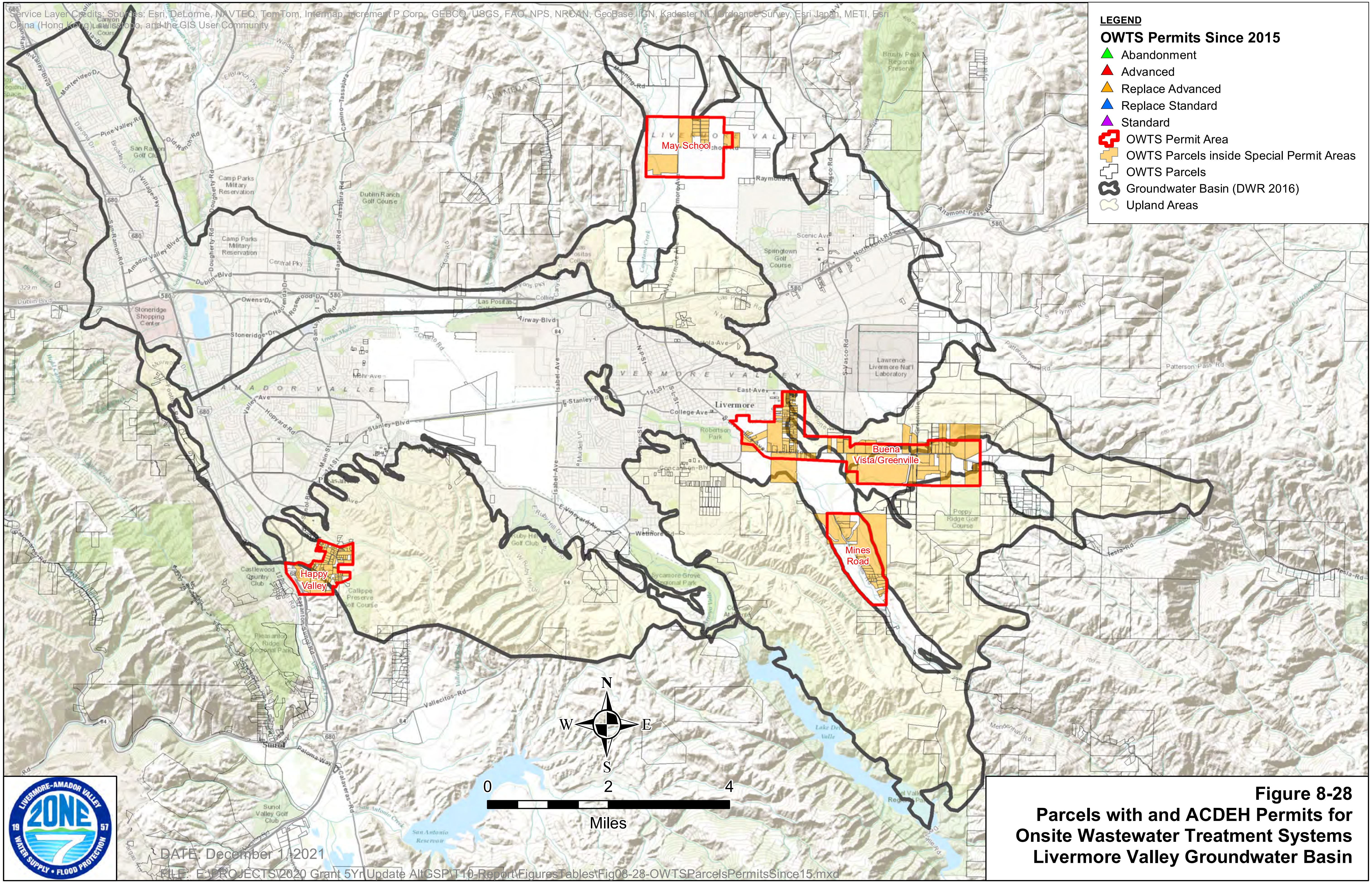

Figure 8-28
Parcels with and ACDEH Permits for Onsite Wastewater Treatment Systems Livermore Valley Groundwater Basin

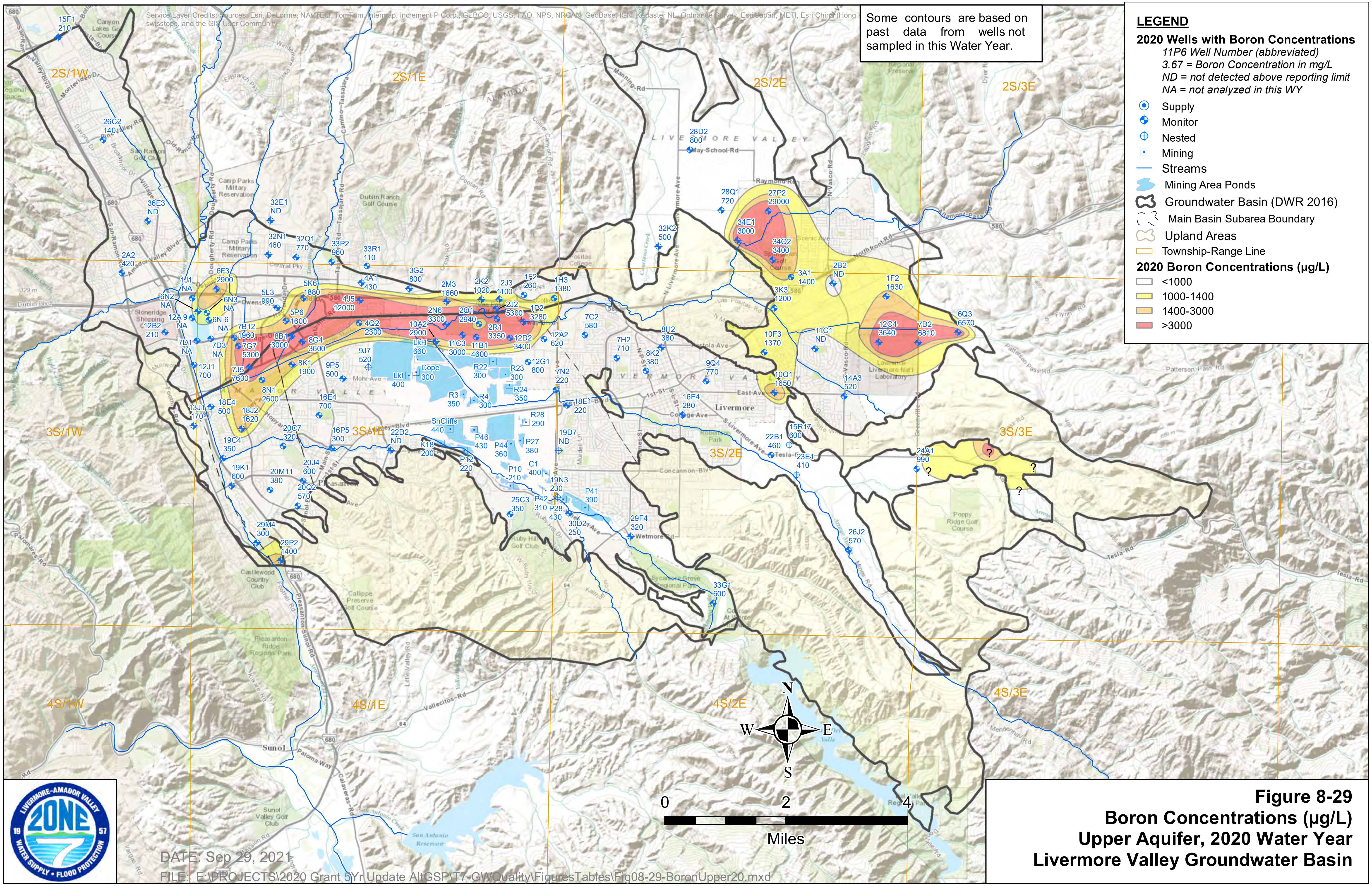

Figure 8-29
Boron Concentrations (µg/L)
Upper Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

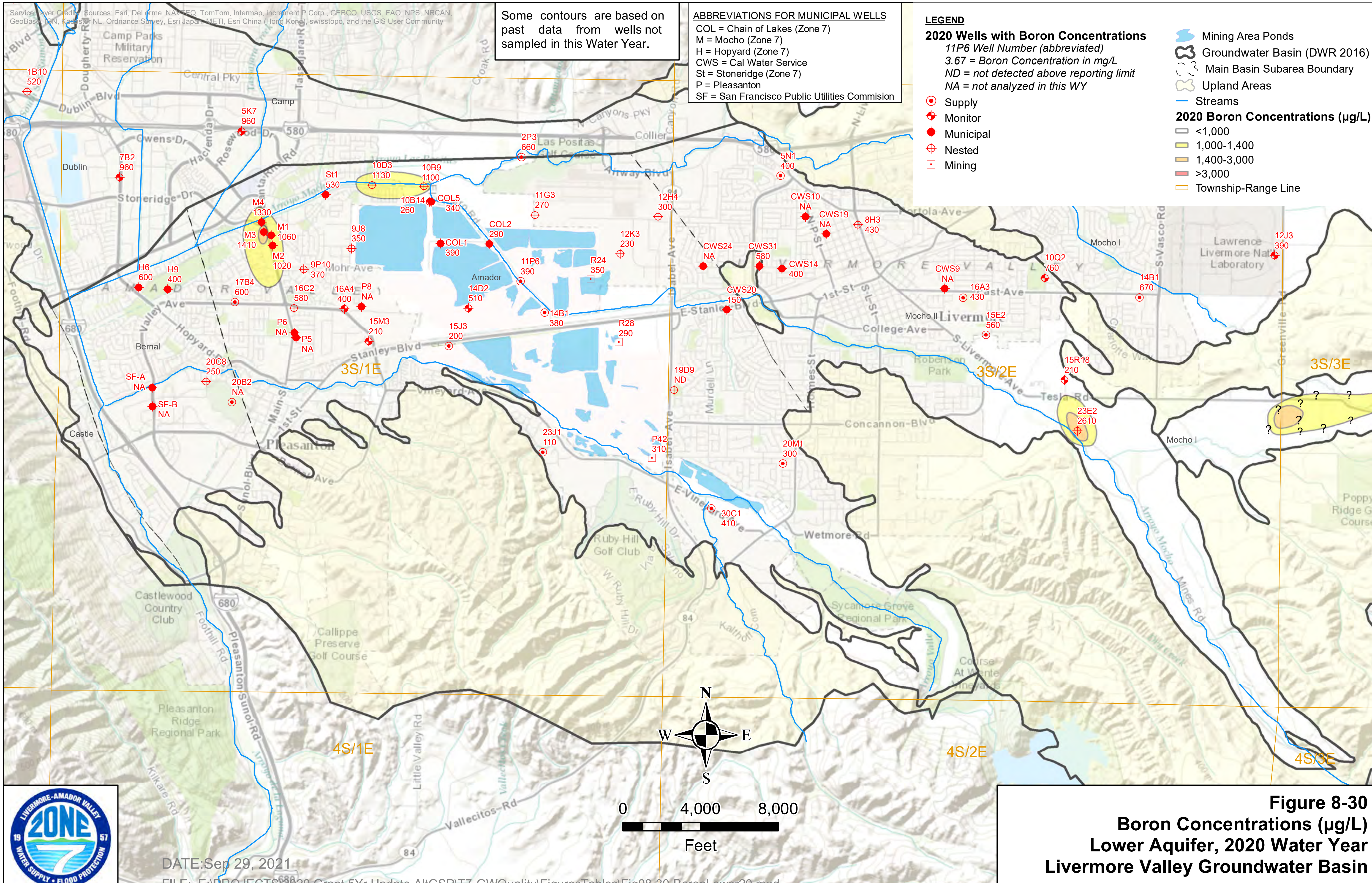

Figure 8-30
Boron Concentrations (µg/L)
Lower Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

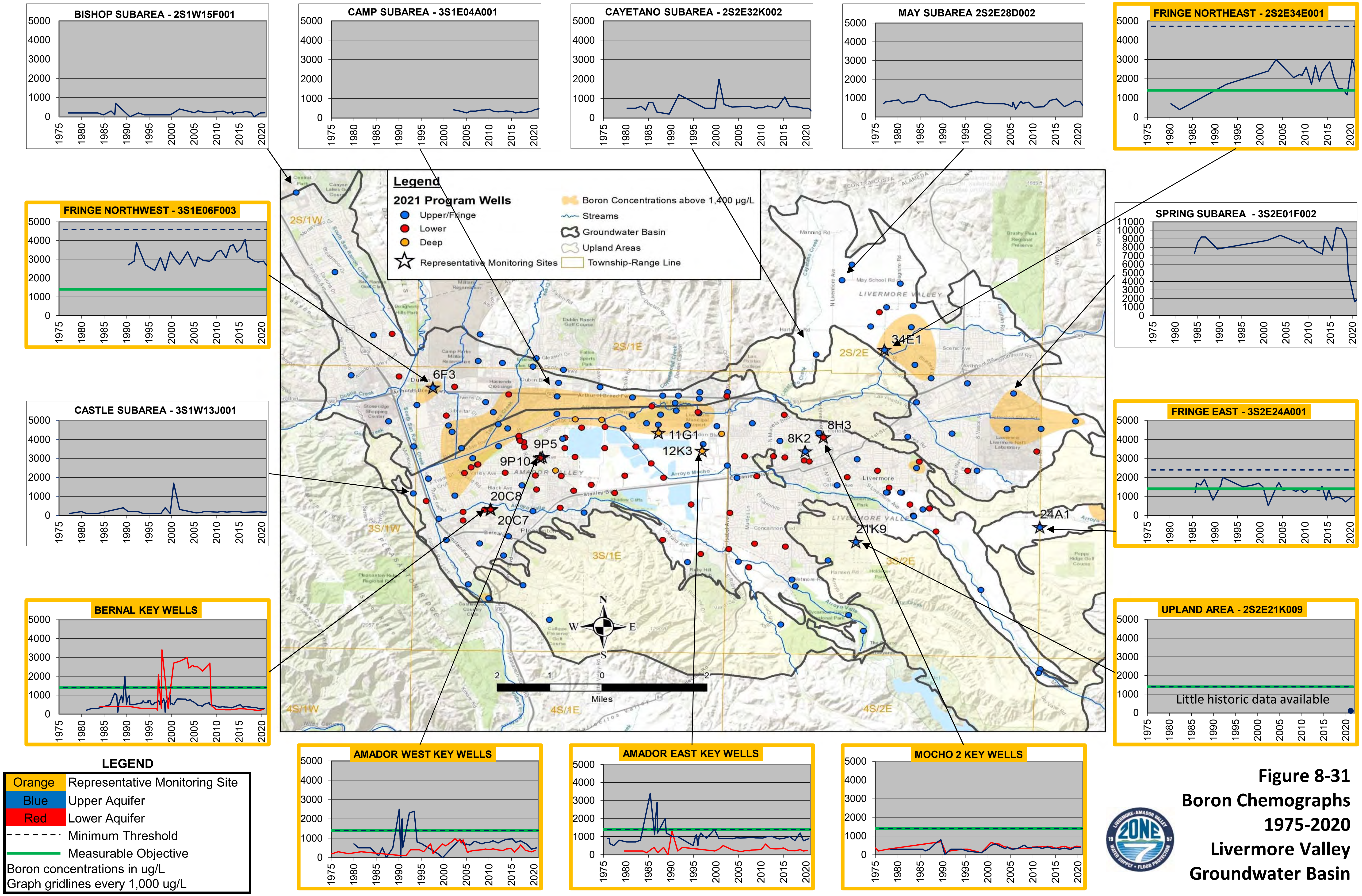

Figure 8-31
Boron Chemographs
1975-2020
Livermore Valley
Groundwater Basin

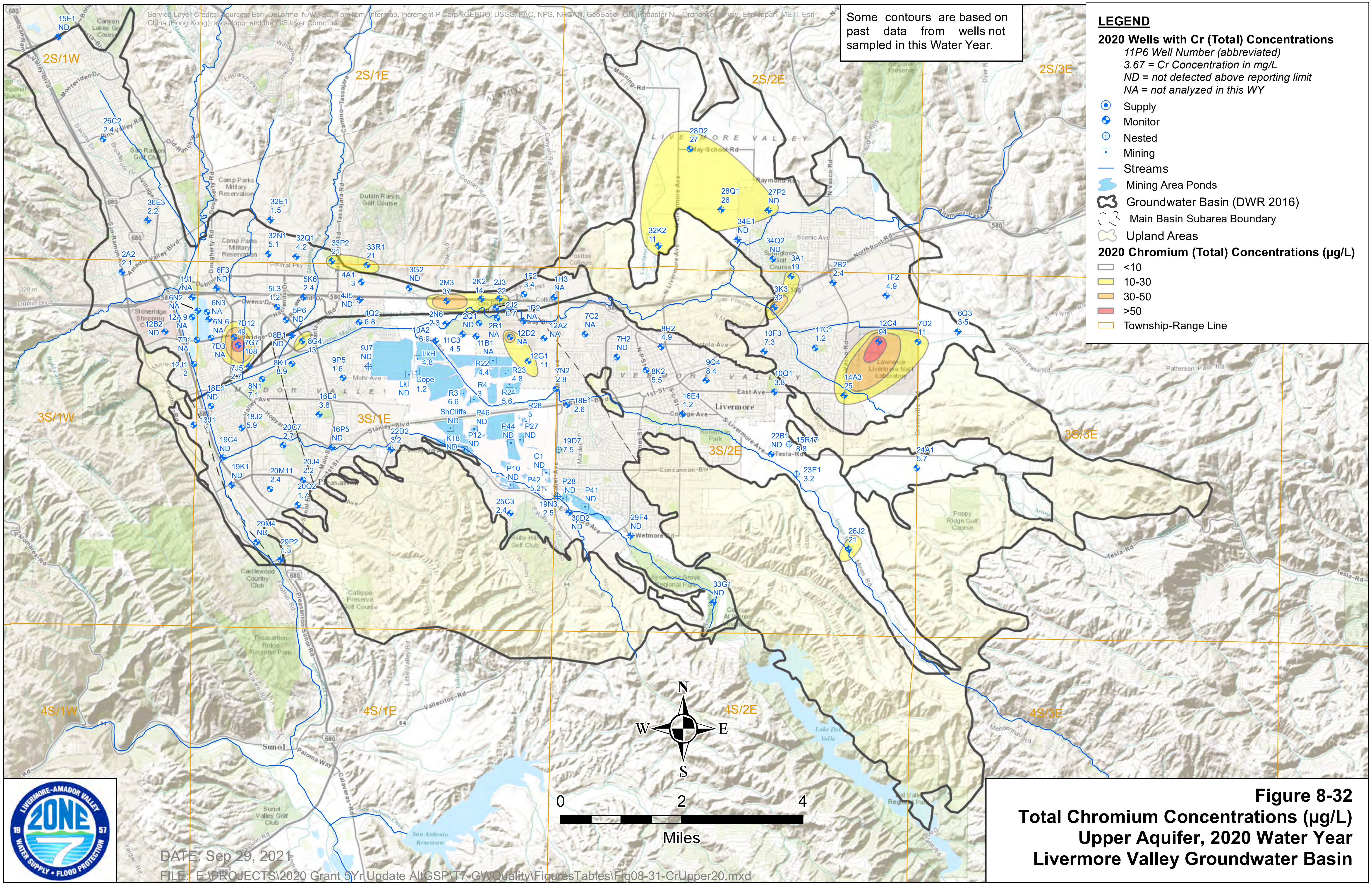

Figure 8-32
Total Chromium Concentrations (µg/L)
Upper Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

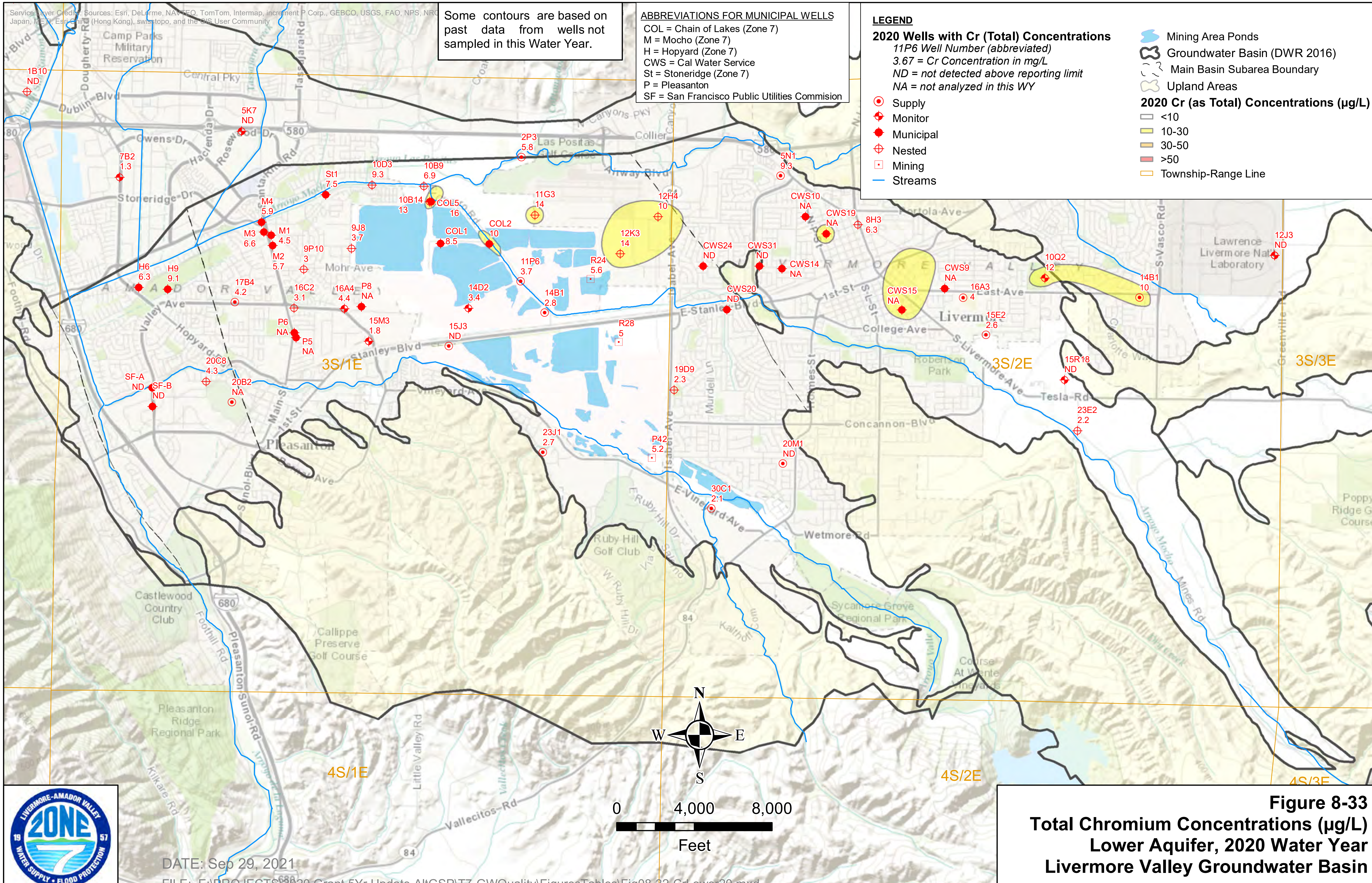

Figure 8-33
Total Chromium Concentrations (µg/L)
Lower Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

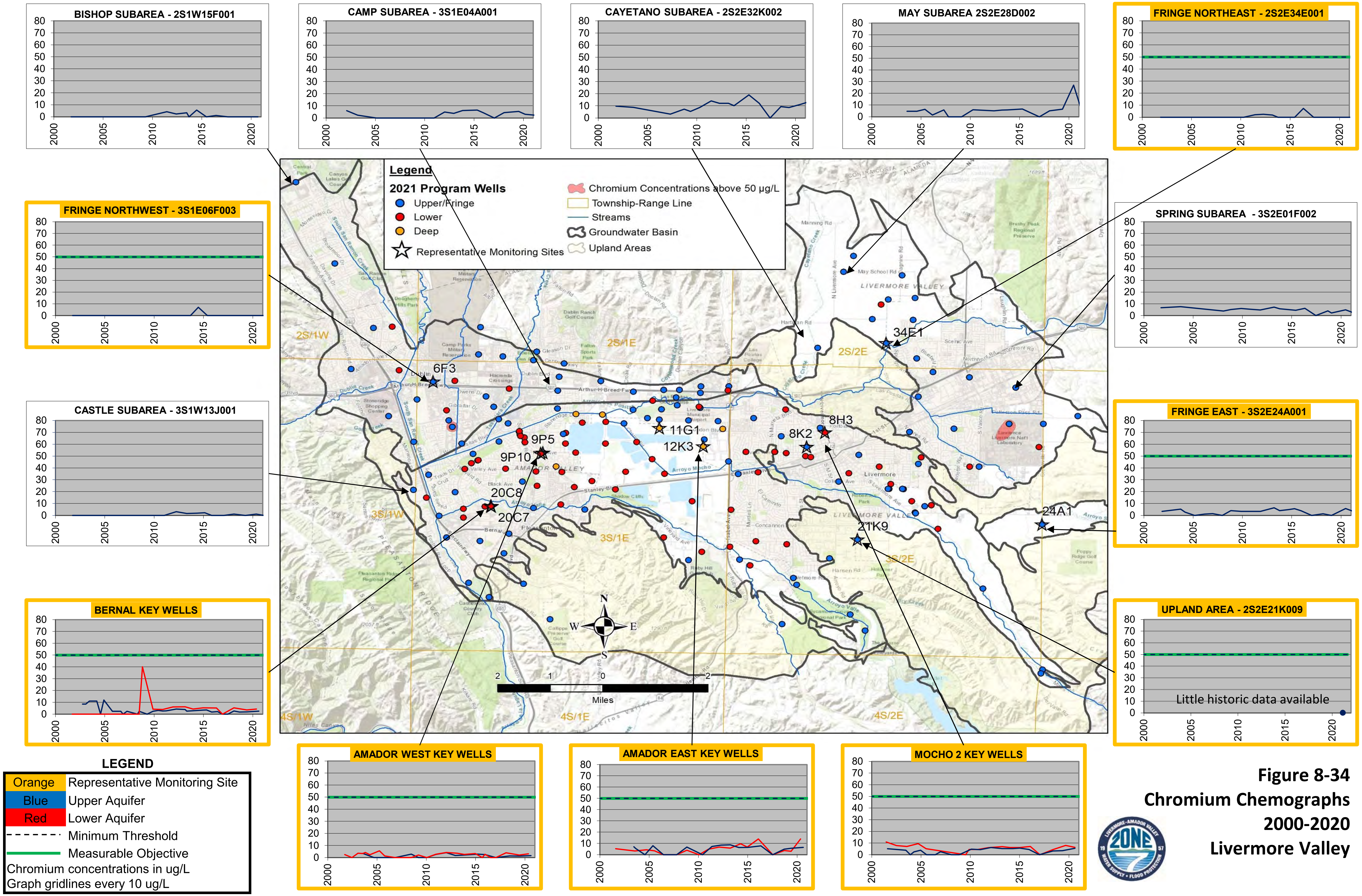

Figure 8-34
Chromium Chemographs
2000-2020
Livermore Valley

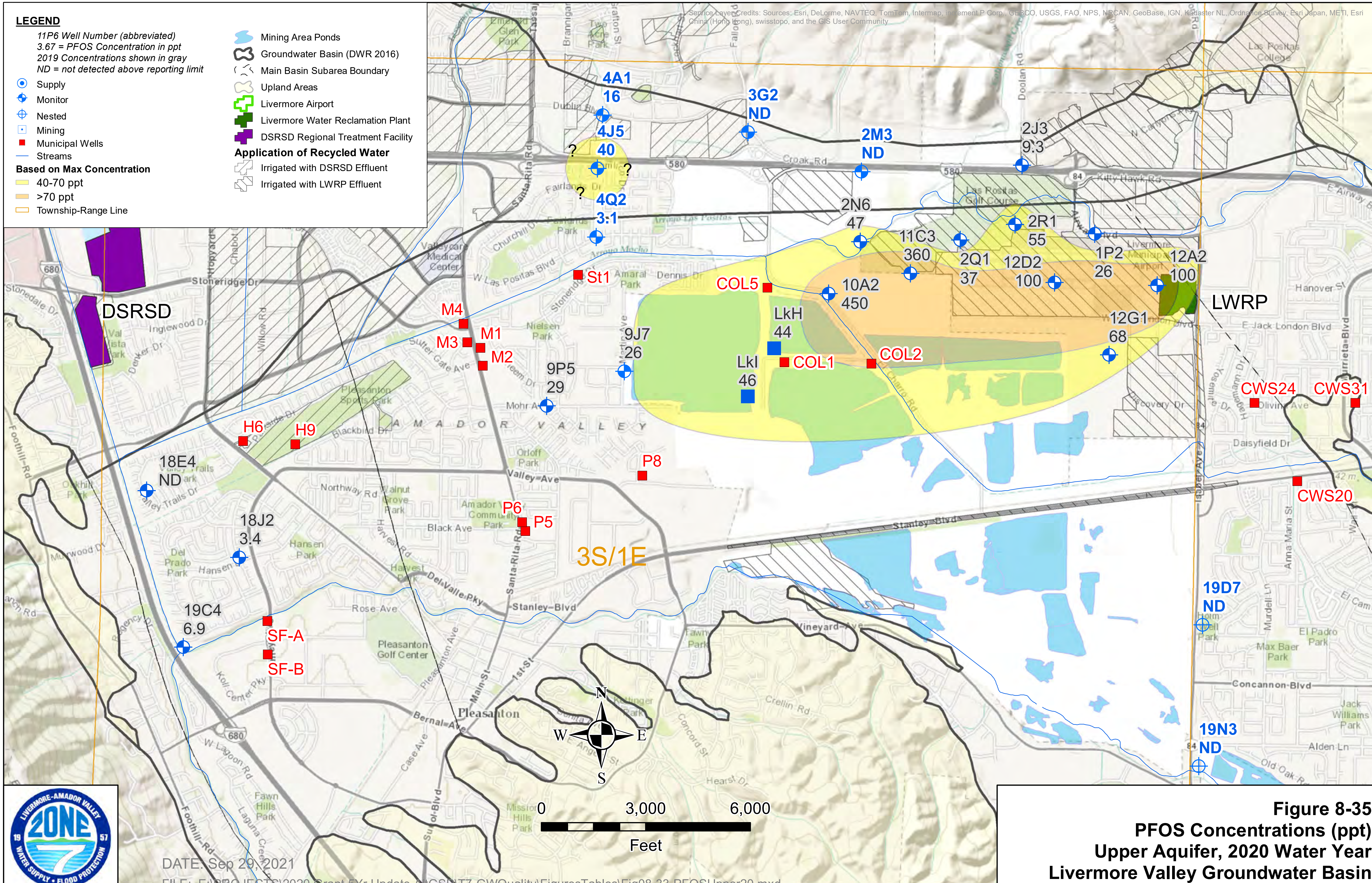

Figure 8-35
PFOS Concentrations (ppt)
Upper Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

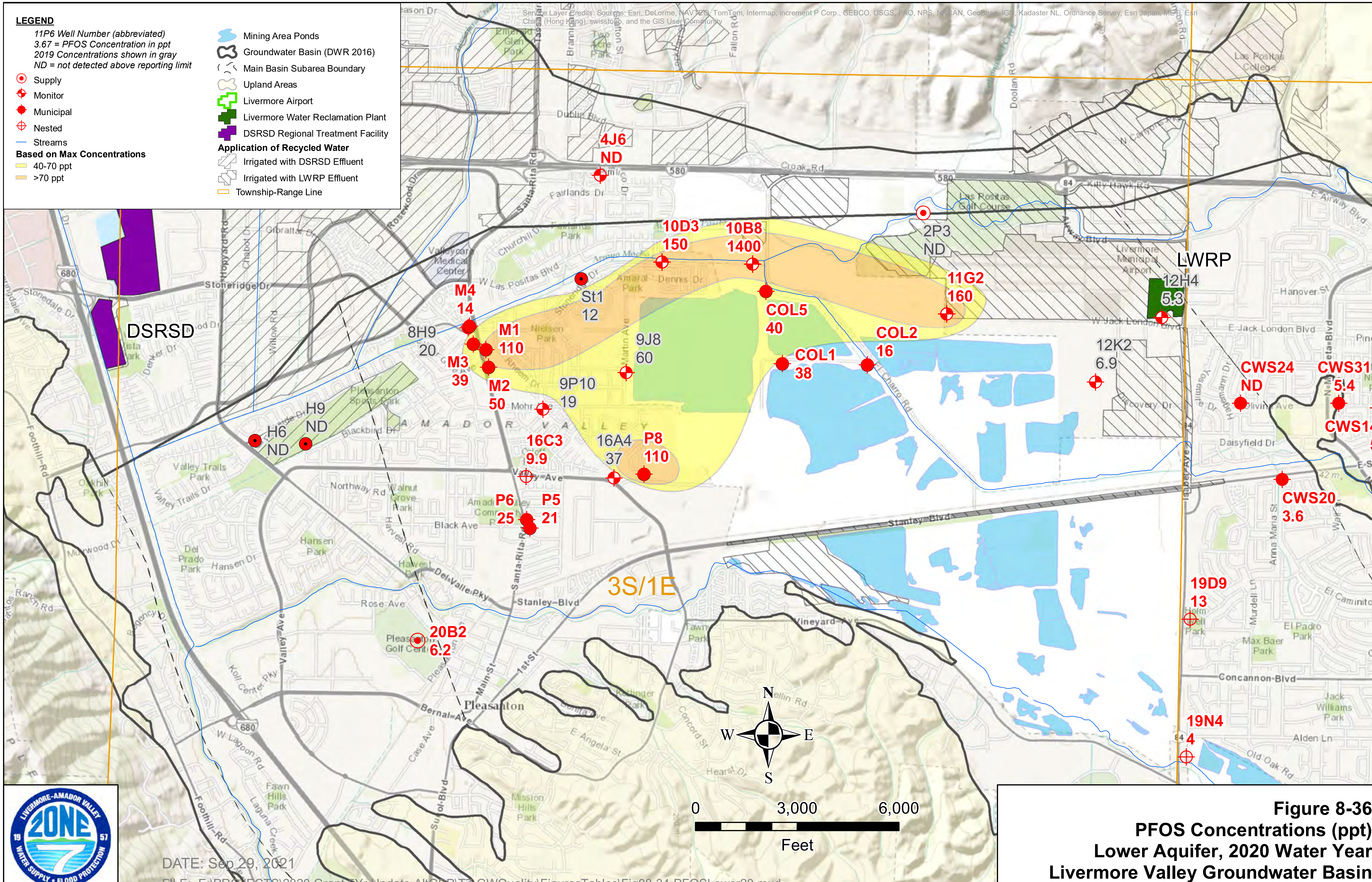

Figure 8-36
PFOS Concentrations (ppt)
Lower Aquifer, 2020 Water Year
Livermore Valley Groundwater Basin

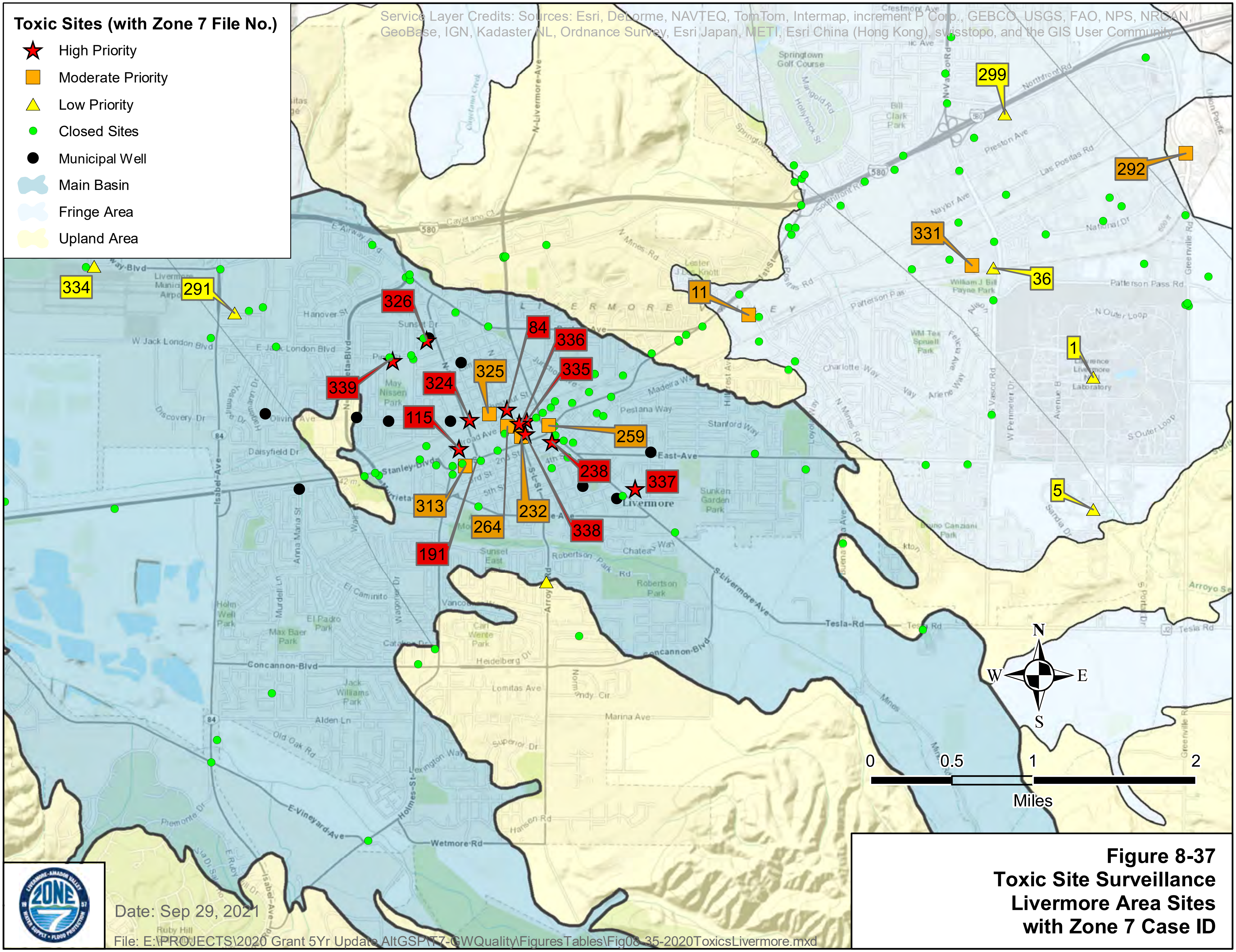

Figure 8-37
Toxic Site Surveillance
Livermore Area Sites
with Zone 7 Case ID

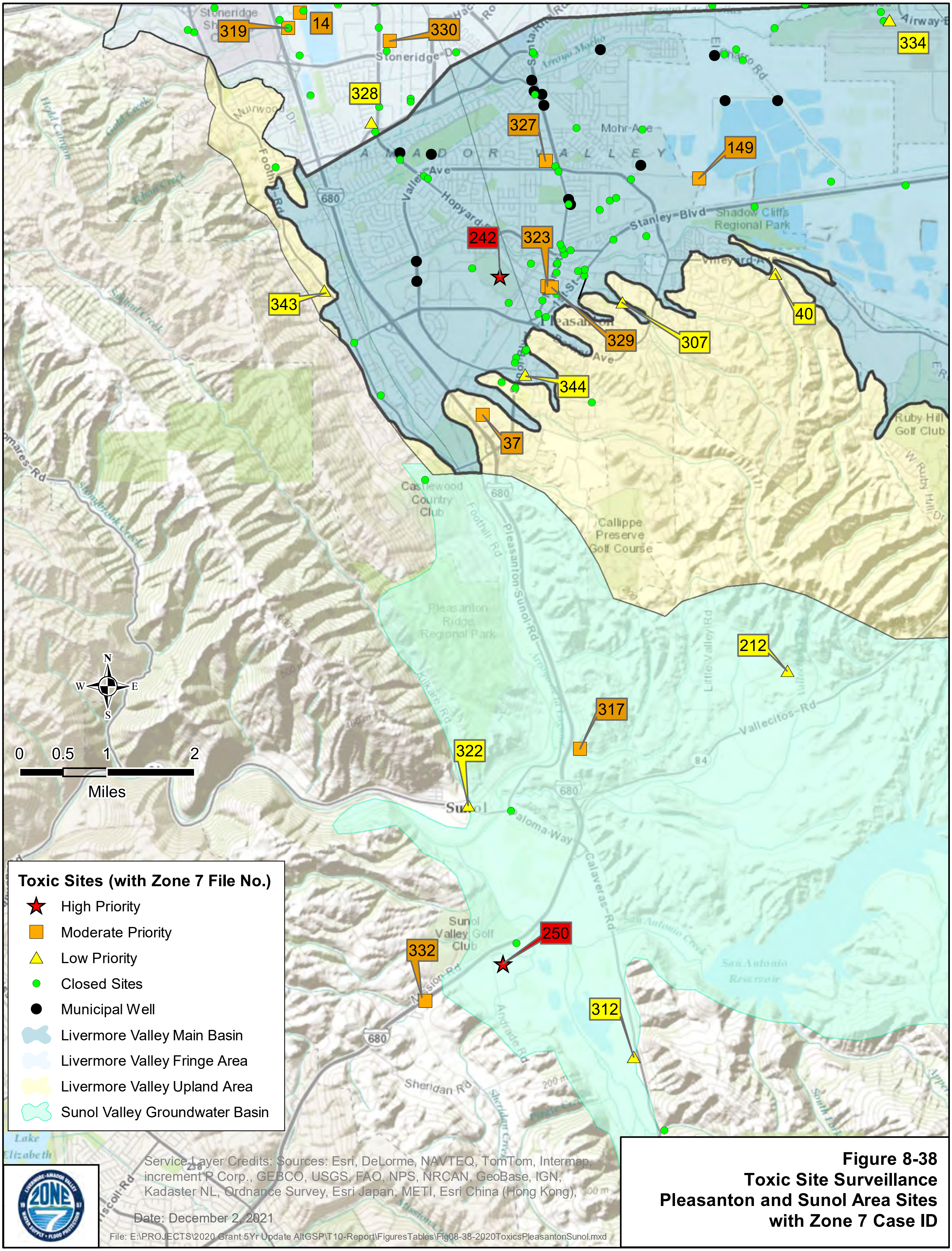

Figure 8-38
Toxic Site Surveillance
Pleasanton and Sunol Area Sites
with Zone 7 Case ID

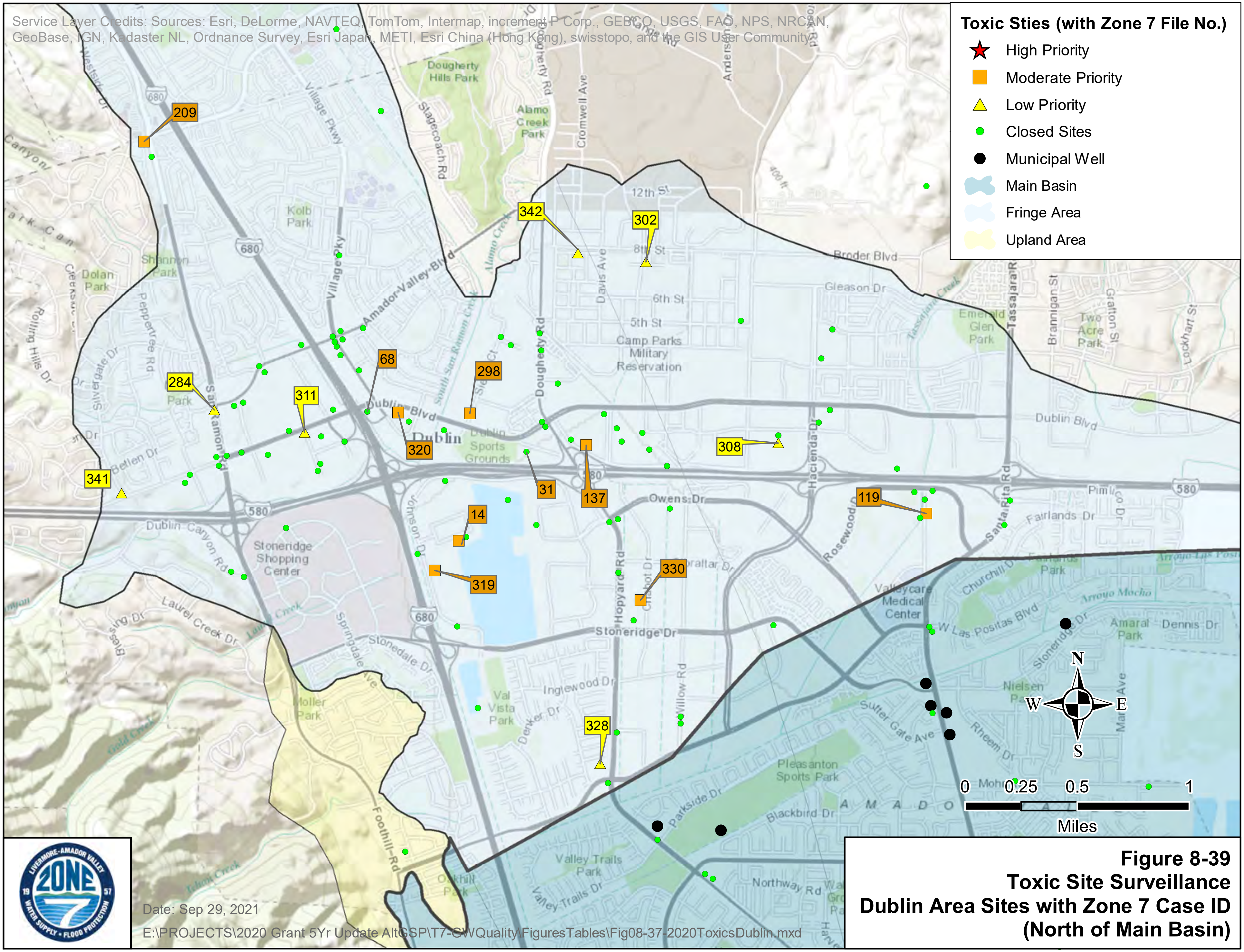

Figure 8-39
Toxic Site Surveillance
Dublin Area Sites with Zone 7 Case ID
(North of Main Basin)

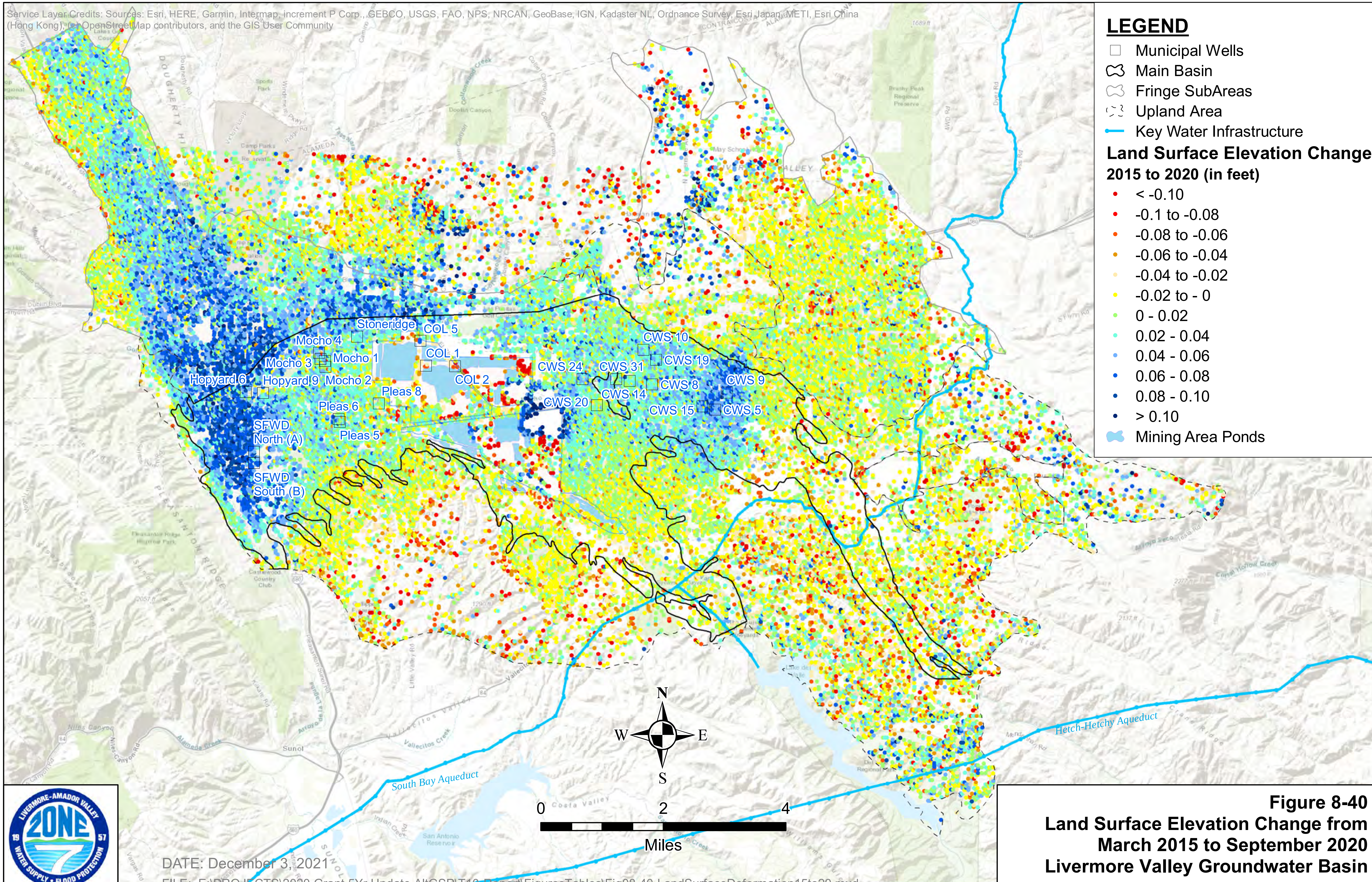

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Figure 8-40
Land Surface Elevation Change from March 2015 to September 2020
Livermore Valley Groundwater Basin

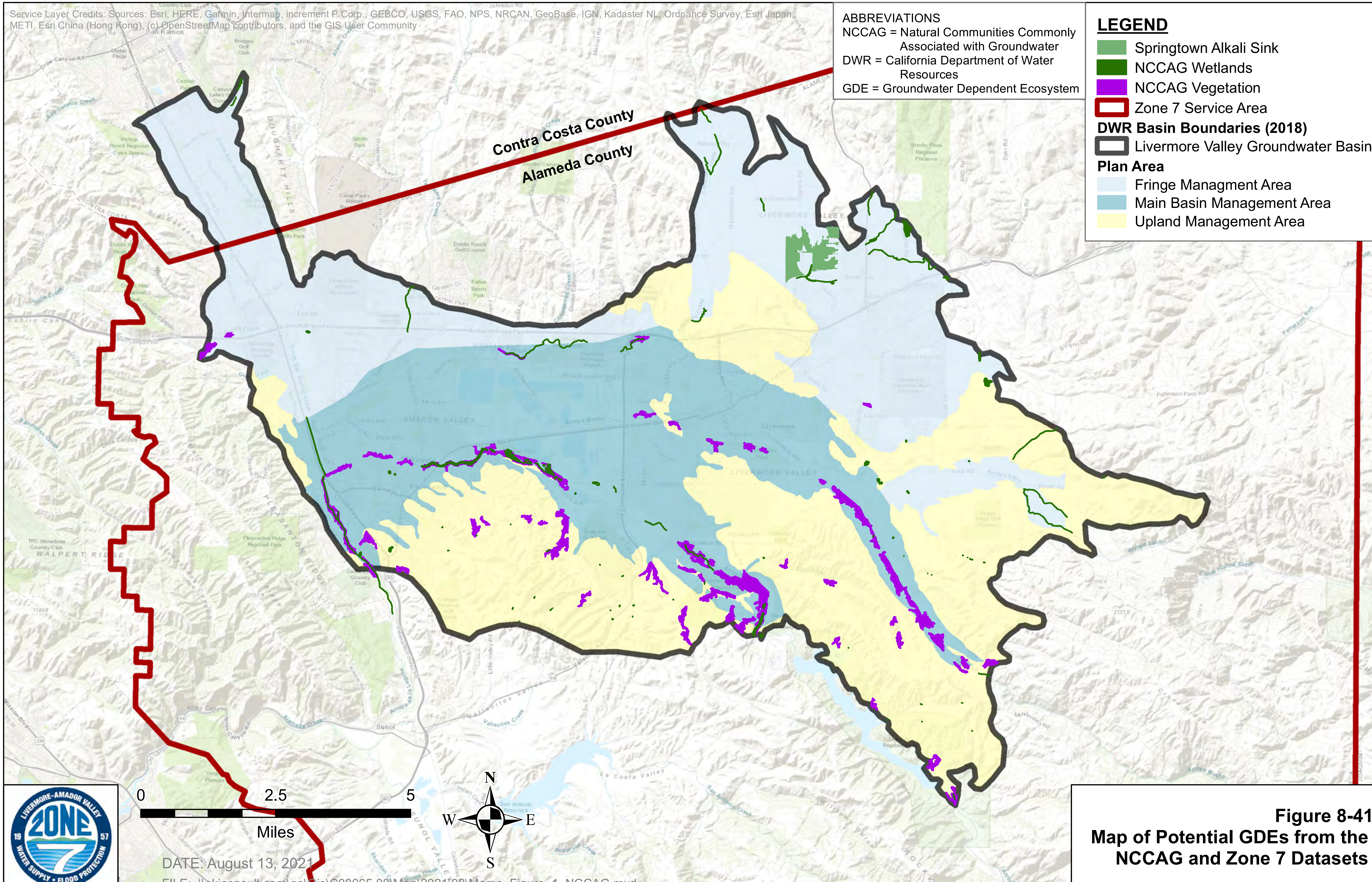


Figure 8-41
Map of Potential GDEs from the NCCAG and Zone 7 Datasets

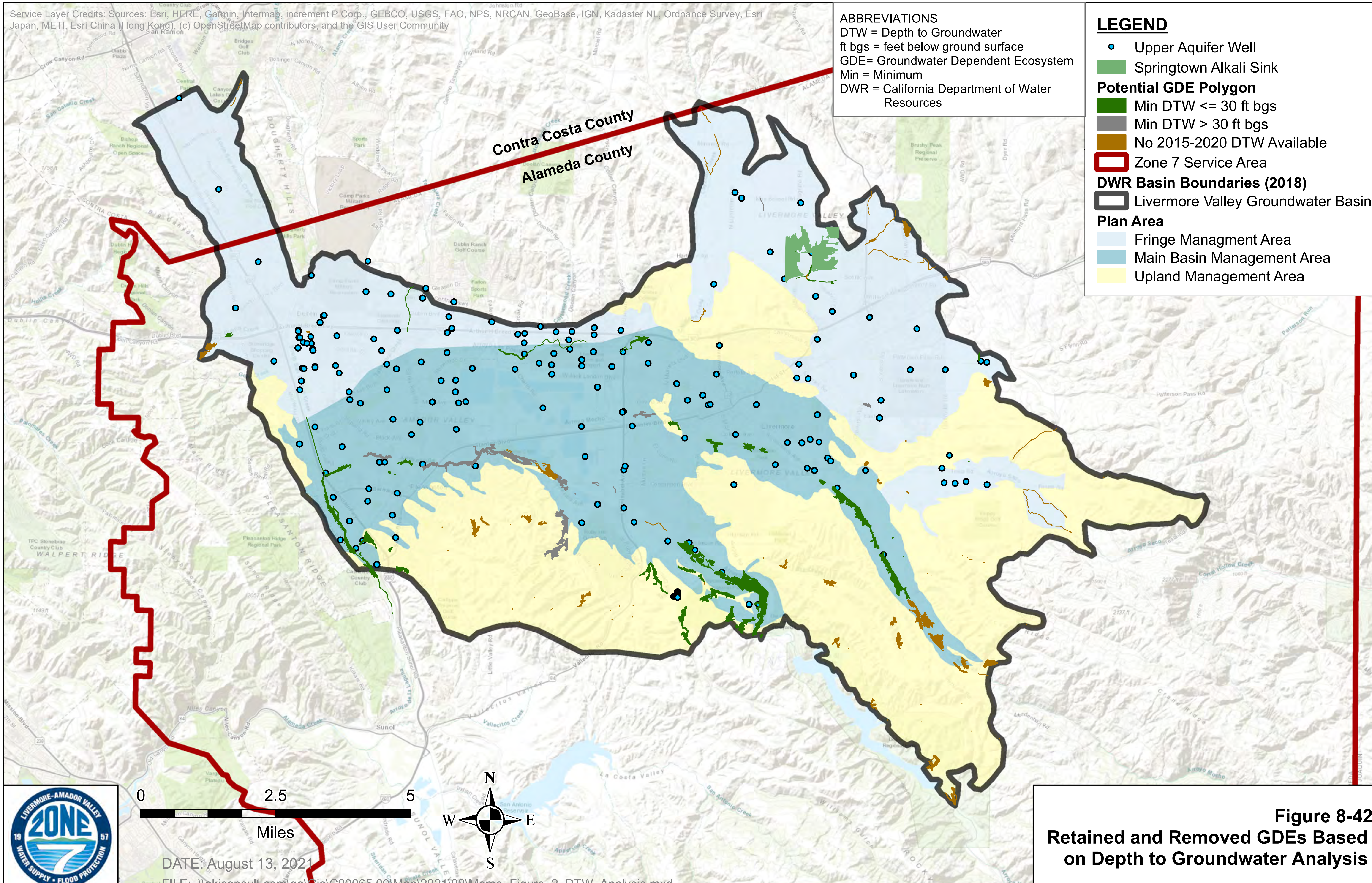


Figure 8-42
Retained and Removed GDEs Based on Depth to Groundwater Analysis

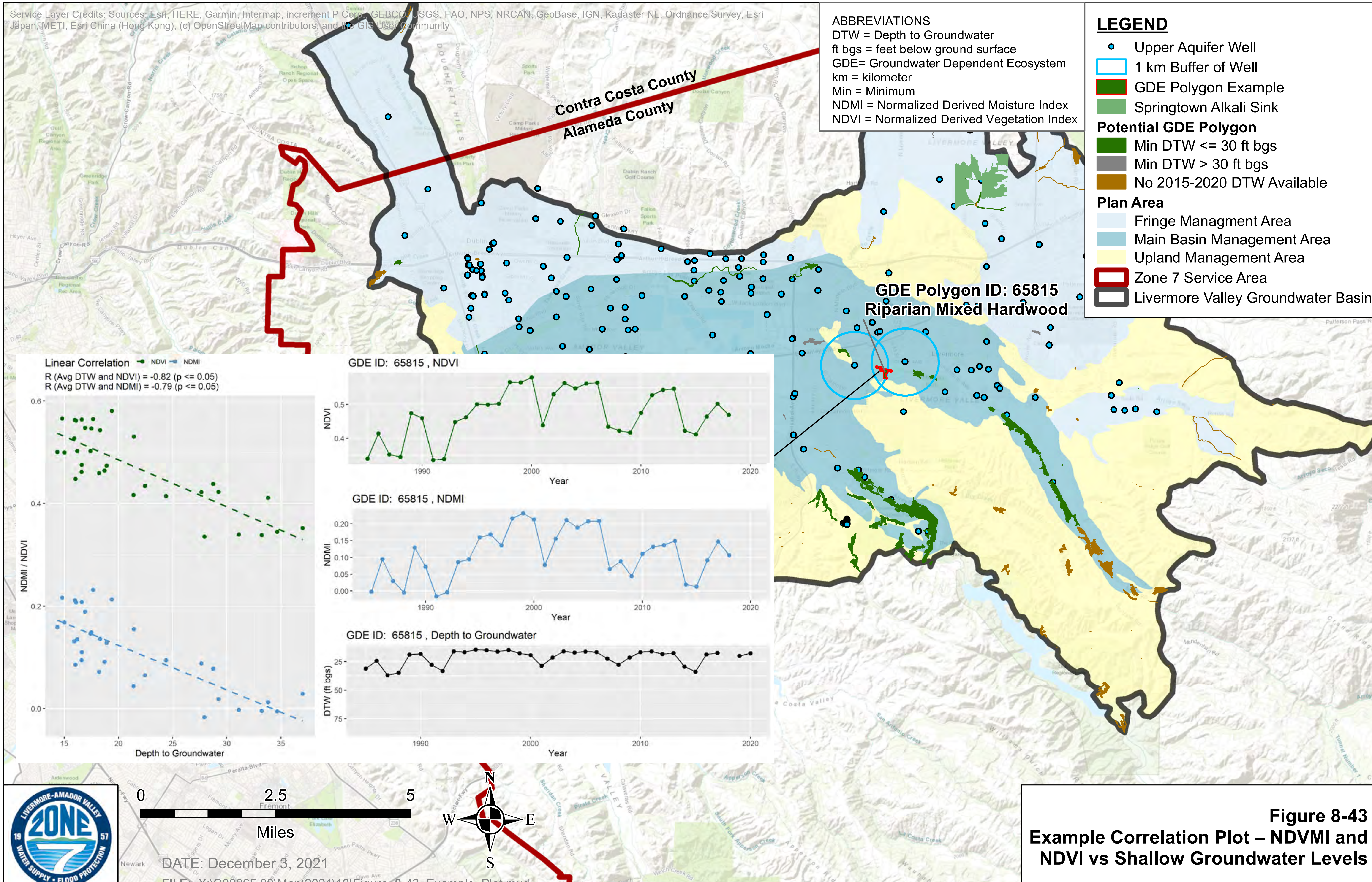


Figure 8-43
Example Correlation Plot – NDVMI and NDVI vs Shallow Groundwater Levels

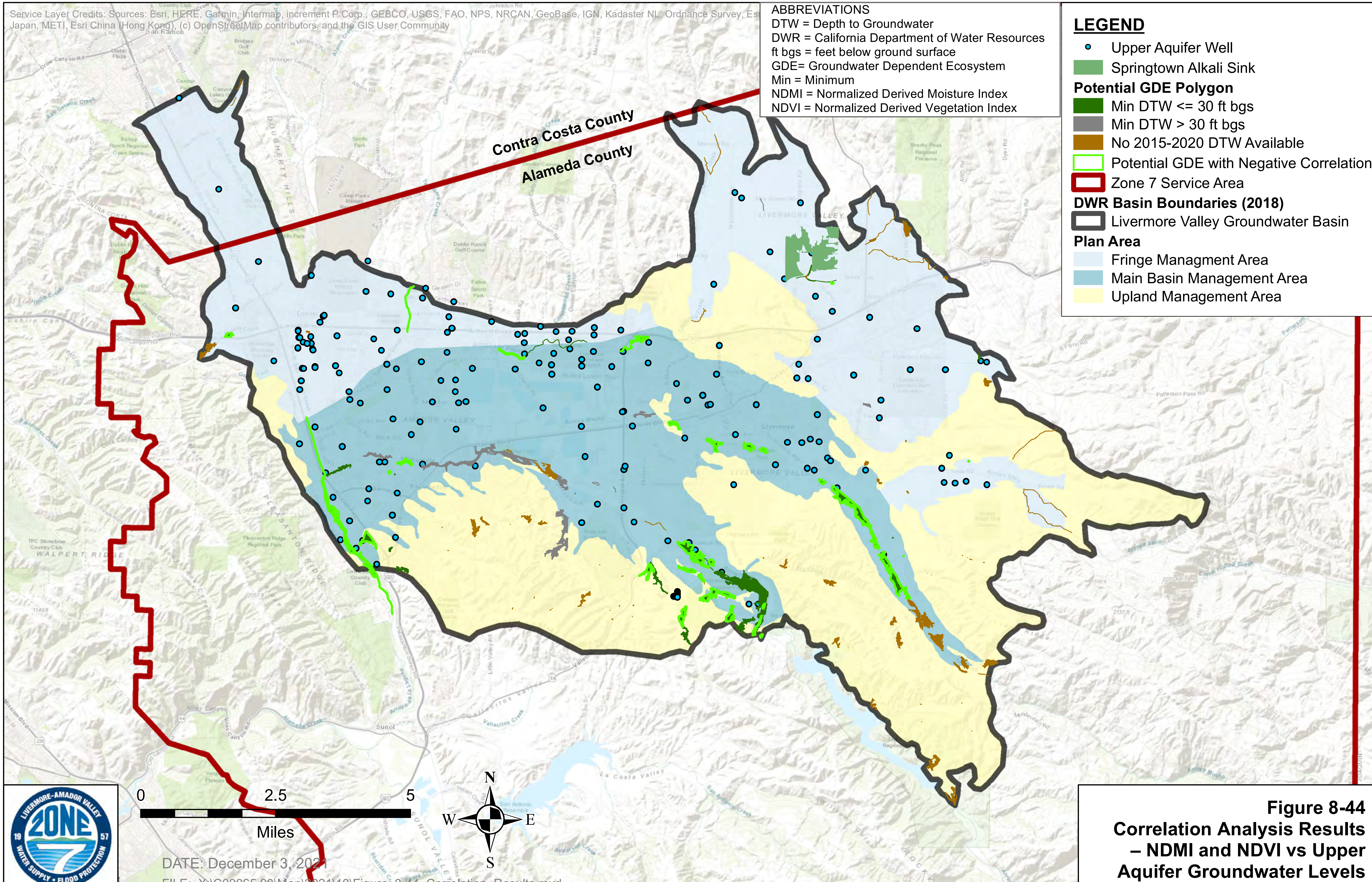
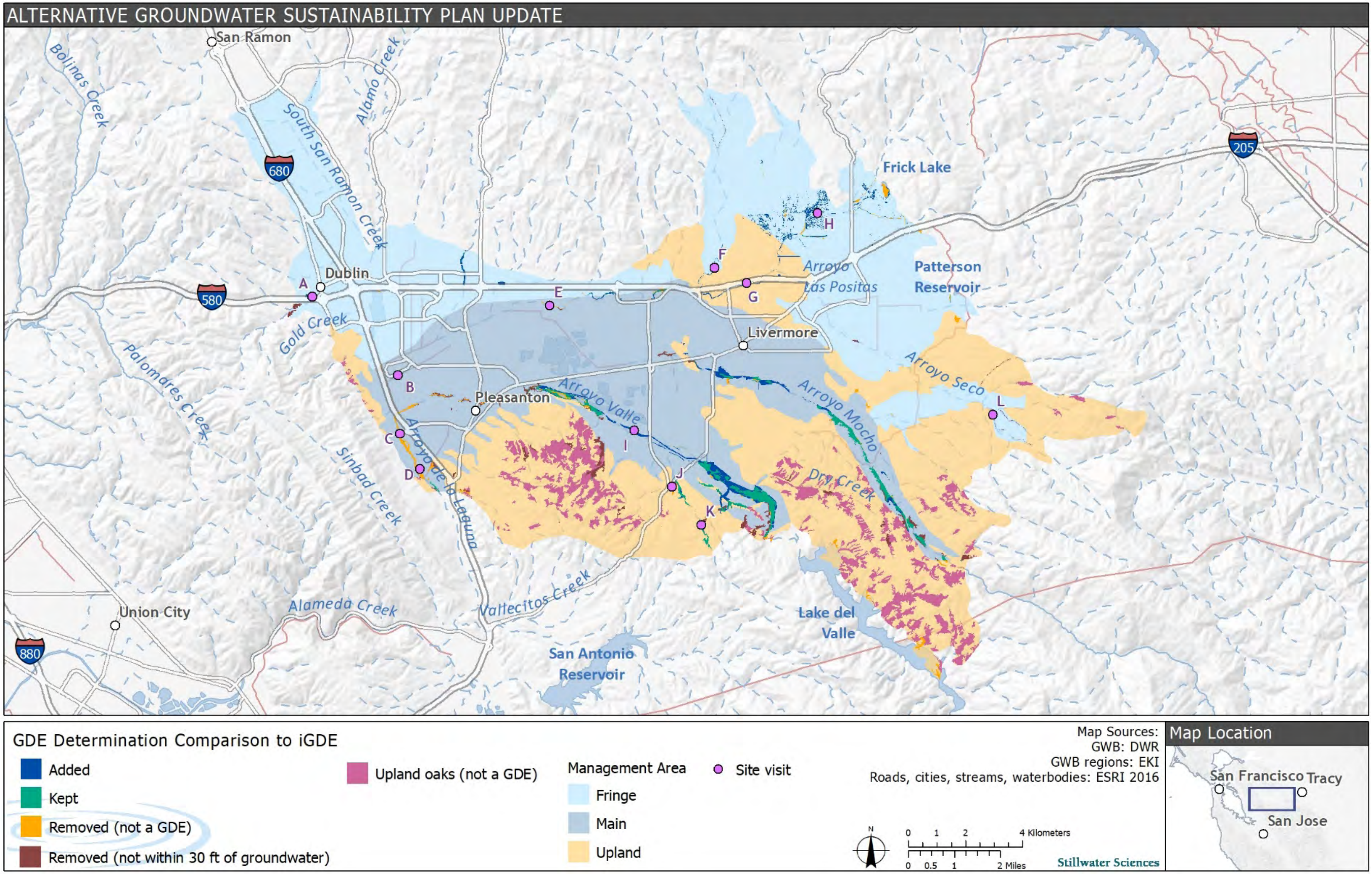


Figure 8-44
Correlation Analysis Results – NDMI and NDVI vs Upper Aquifer Groundwater Levels

Figure 8-45. Comparison of the Likely GDE Map with the NCCAG Dataset



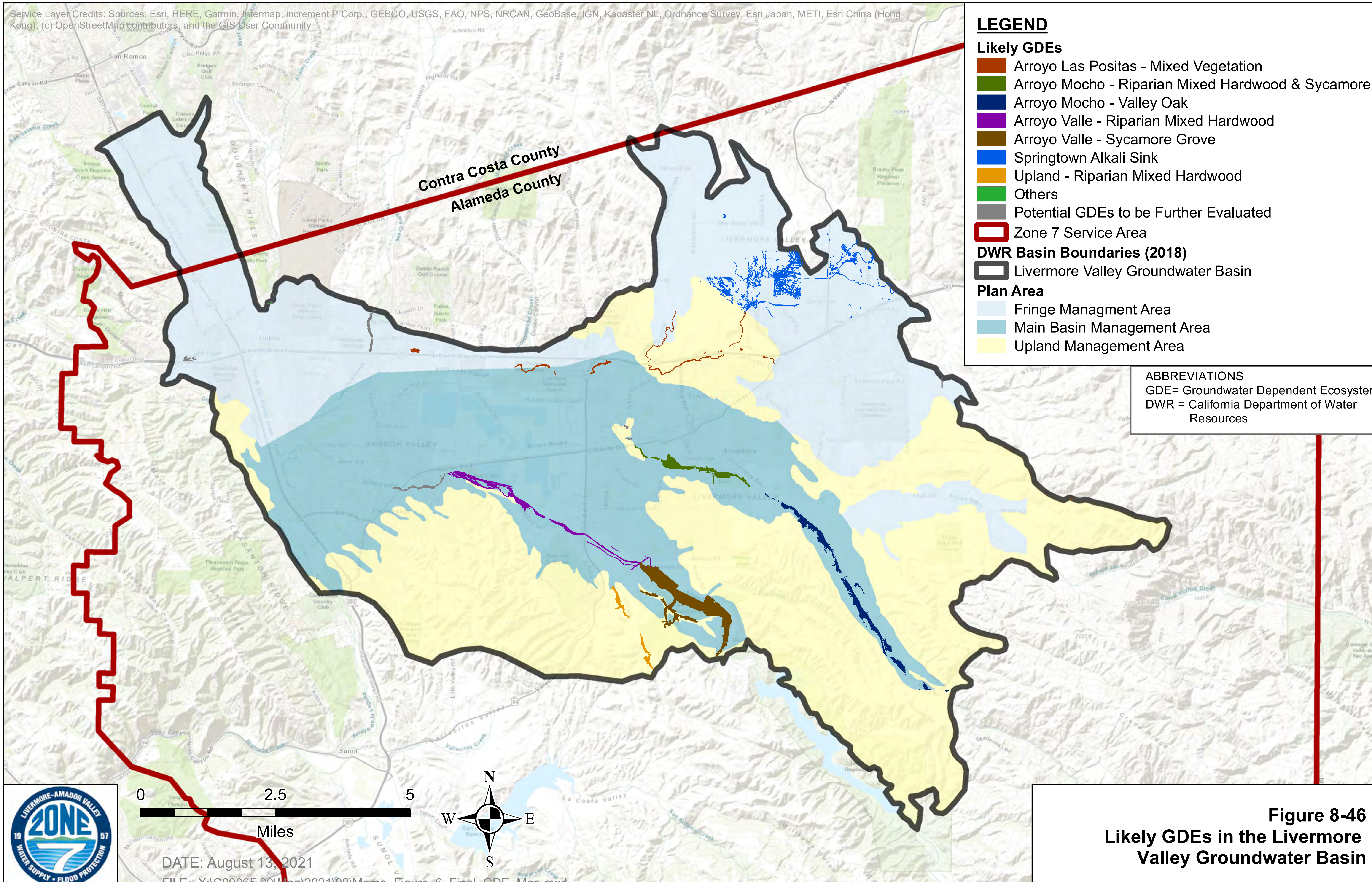


Figure 8-46
Likely GDEs in the Livermore Valley Groundwater Basin

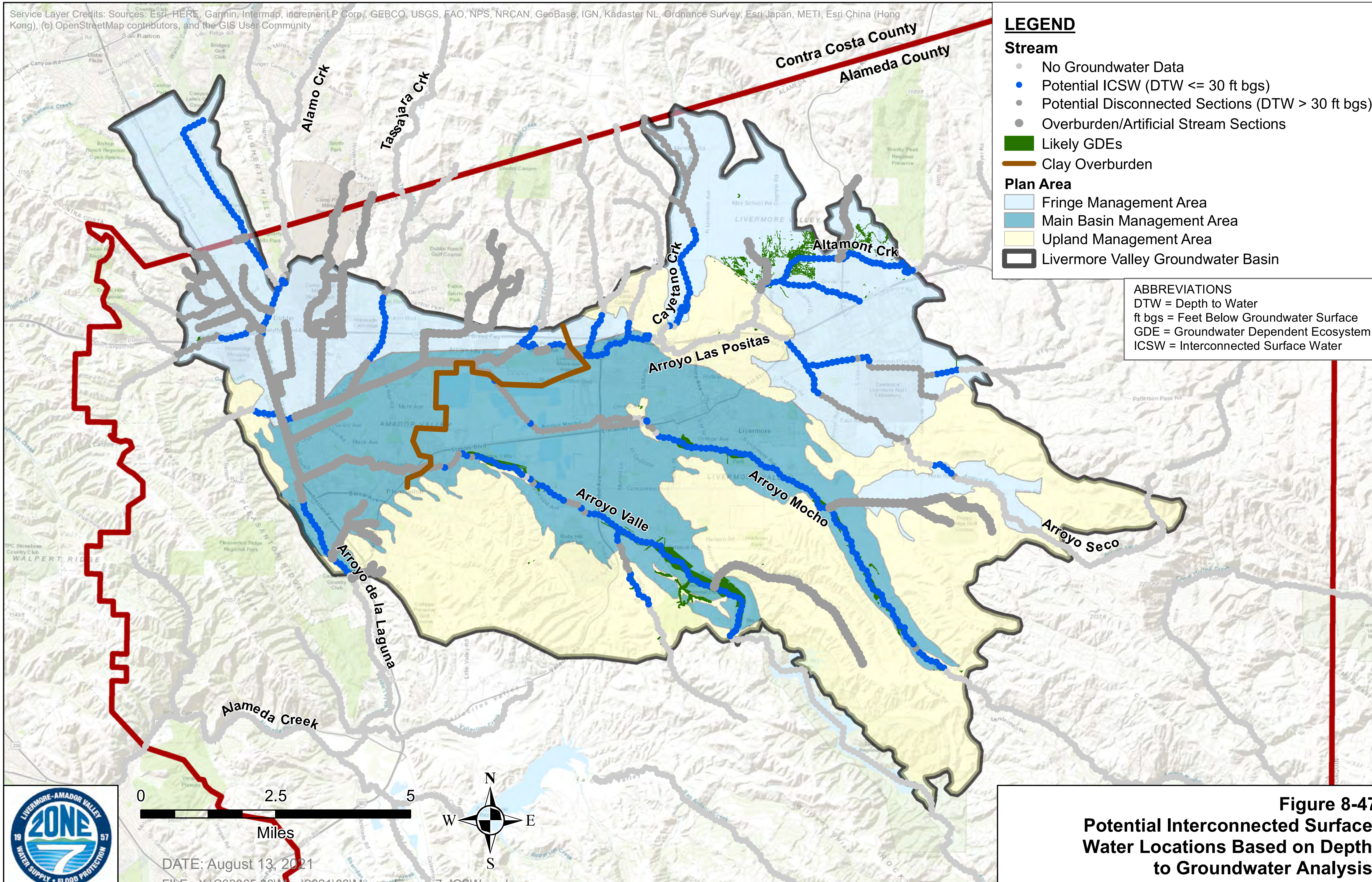


Figure 8-47
Potential Interconnected Surface Water Locations Based on Depth to Groundwater Analysis

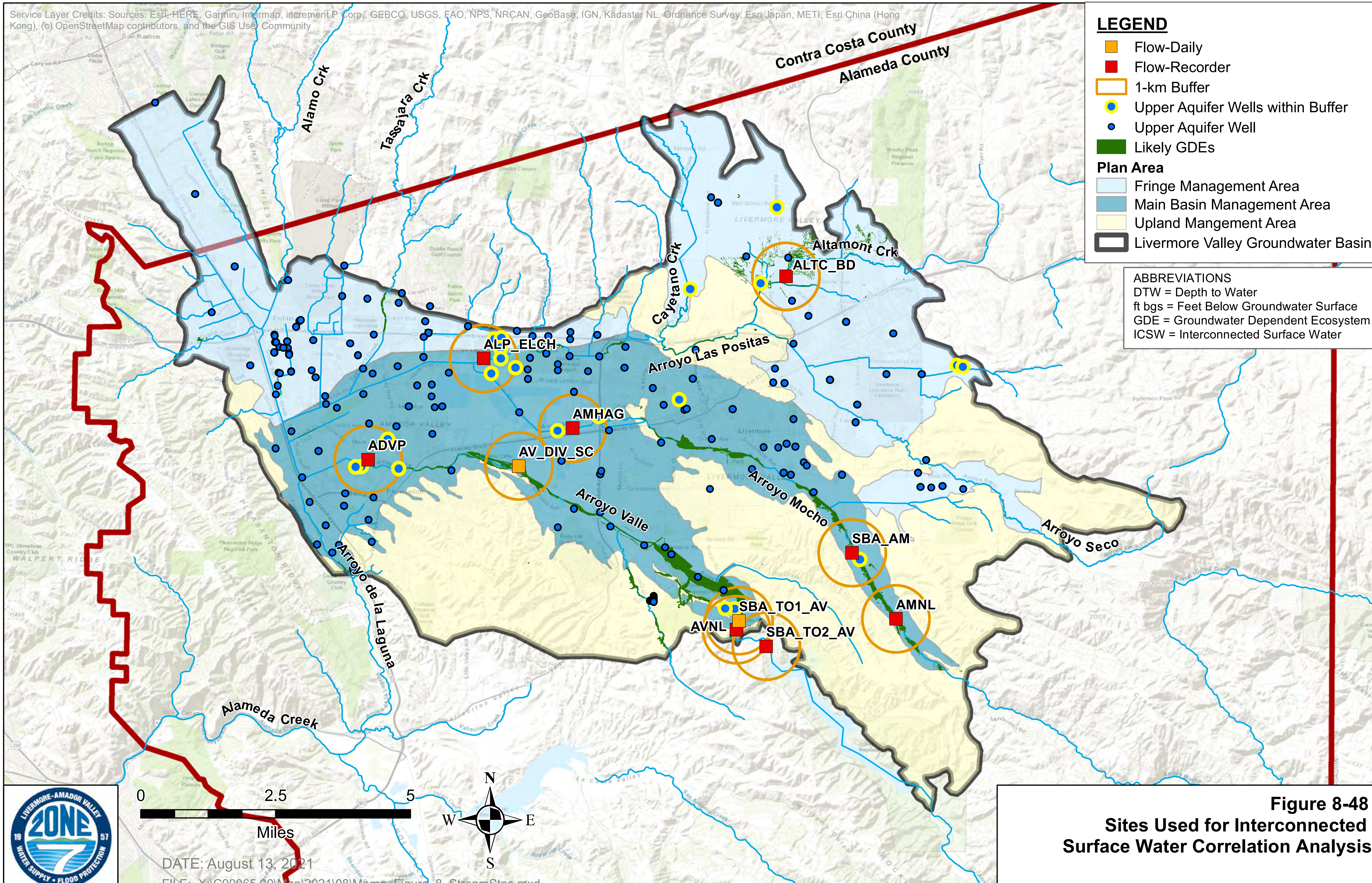


Figure 8-48
Sites Used for Interconnected Surface Water Correlation Analysis

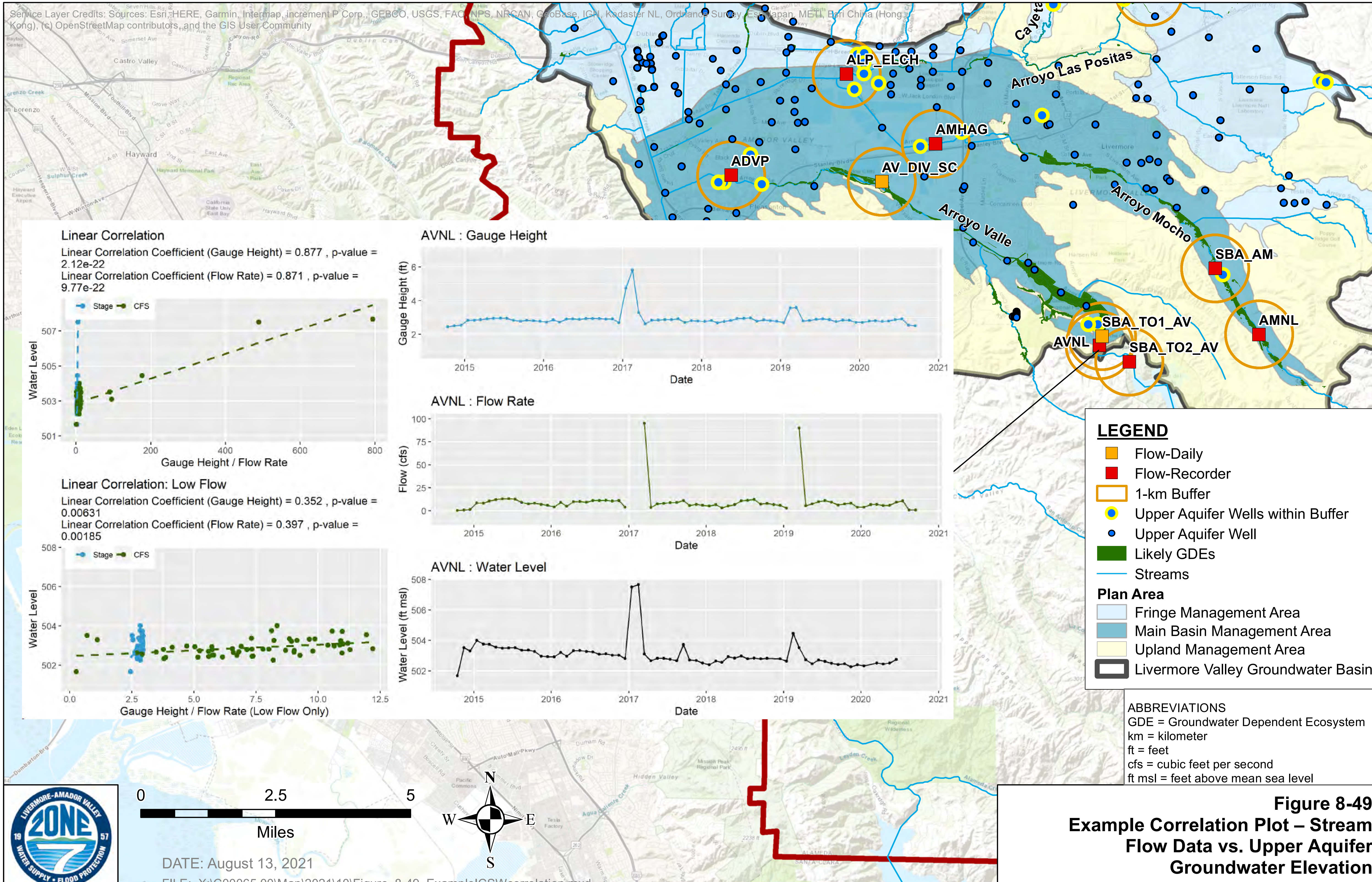


Figure 8-49
Example Correlation Plot – Stream Flow Data vs. Upper Aquifer Groundwater Elevation

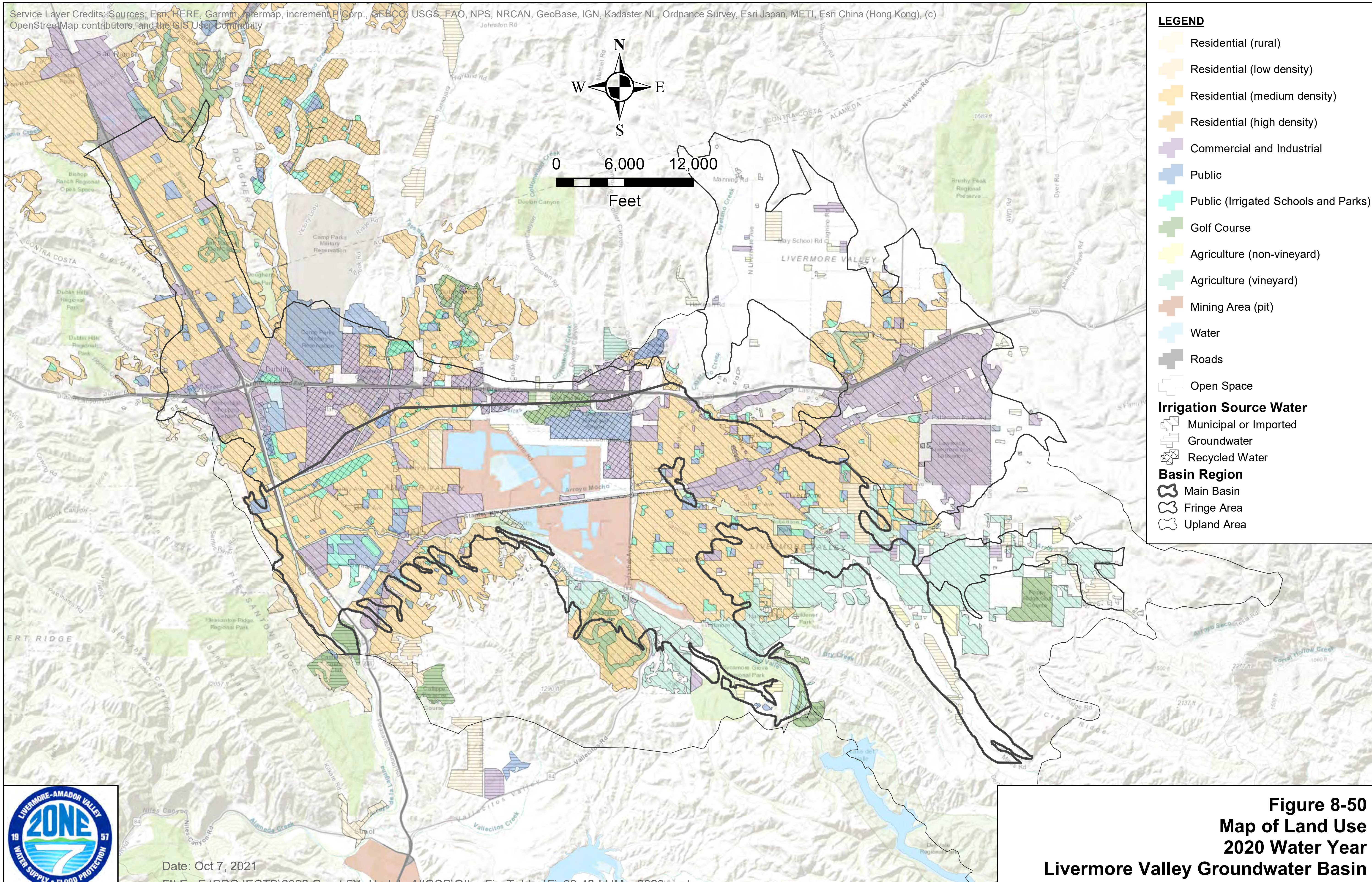


Figure 8-50
Map of Land Use
2020 Water Year
Livermore Valley Groundwater Basin

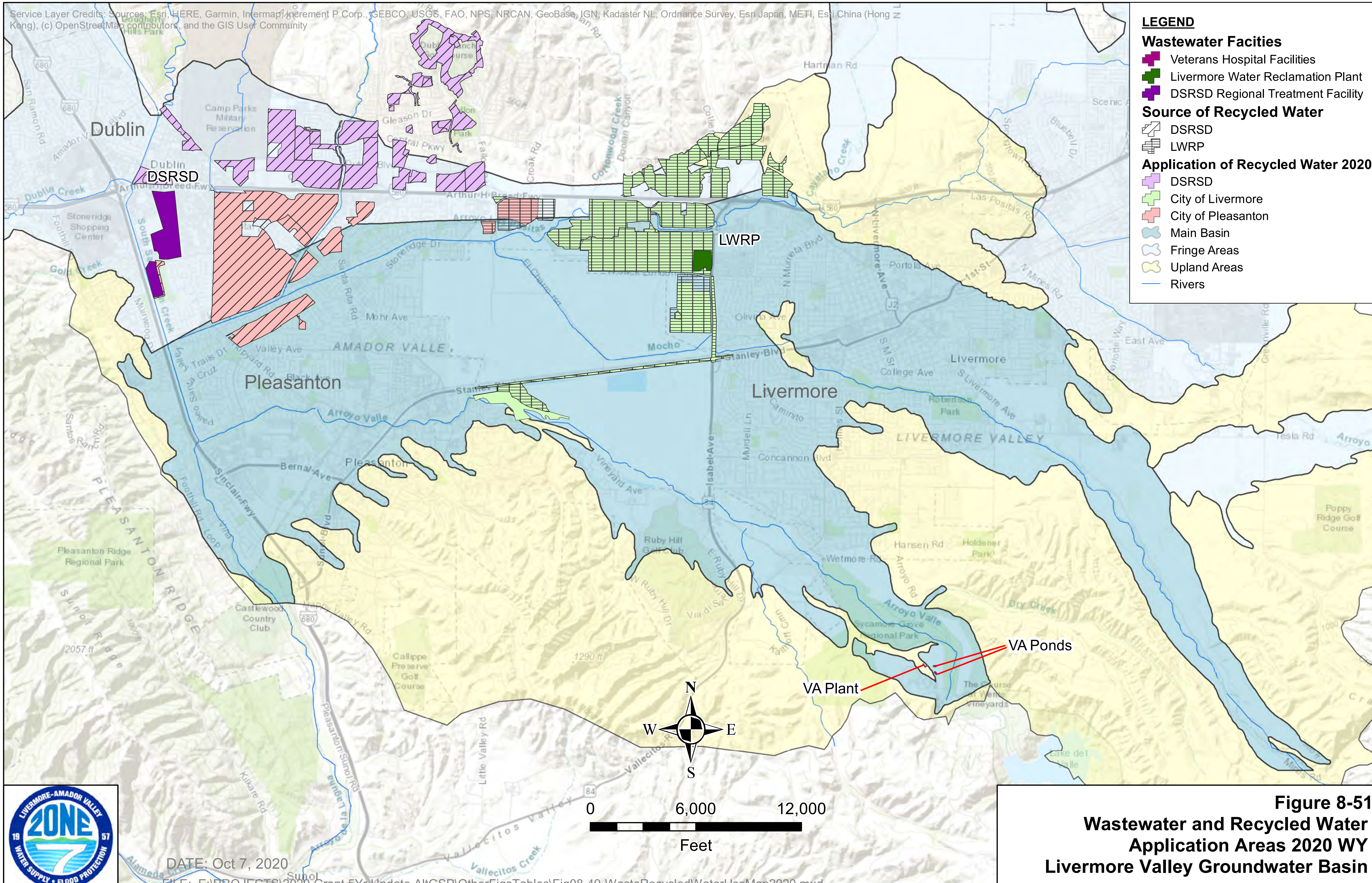


Figure 8-51
Wastewater and Recycled Water Application Areas 2020 WY
Livermore Valley Groundwater Basin

9. WATER BUDGET INFORMATION

§ 354.18. Water Budget

(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

(4) The change in the annual volume of groundwater in storage between seasonal high conditions.

(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

(6) The water year type associated with the annual supply, demand, and change in groundwater stored.

(7) An estimate of sustainable yield for the basin.

[…]

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Wat er Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

This section presents information on the water budget for the Livermore Valley Groundwater Basin (Basin). Consistent with the 23 California Code of Regulations (23 CCR) Division 2 Chapter 1.5 Subchapter 2 and the California Department of Water Resources' (DWR) Water Budget Best Management Practices (BMP) (*DWR, 2016b*), this water budget provides an accounting of the total annual volume of water entering and leaving the Basin for historical, current, and projected future conditions. Three water budget time periods are presented herein:

- A current conditions water budget period representing 2020 Water Year[31] (WY);
- A historical water budget period representing 46 years of historical hydrology for the period 1974 WY to 2020 WY; and
- A 61-year projected water budget used to evaluate potential changes to groundwater storage (2020 to 2081 WY).

This section also provides an overview of water budget methodologies and presents detailed discussions of the water budget components including surface water supplies, groundwater inflows, groundwater outflows, change in storage, historical overdraft conditions, water year type, and sustainable yield.

9.1. Water Budget Methods and Data Sources

☑ **23 CCR § 354.18(a)**
☑ **23 CCR § 354.18(d)**
☑ **23 CCR § 354.18(e)**
☑ **23 CCR § 354.18(f)**

9.1.1. Overview of Methodology

9.1.1.1. Inflow and Outflow Components

The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) has been compiling the Main Basin Management Area (Main Basin) Hydrologic Inventory (HI, herein referred to as the Water Budget) on a WY basis (from September 30 to October 1) for every year since 1974. The HI method, which involves an accounting of all inflows and outflows and calculation of the change in storage as the difference (i.e., inflows minus outflows), is the method used to develop the water budget for the purposes of this Alternative Groundwater Sustainability Plan (Alternative GSP).

All the HI components are listed in **Table 9-A** below and shown in **Table 9-1** along with their method of measurement and their approximate accuracy. Each component was derived independently, either directly from the monitoring program results or calculated using the results of a monitoring program.

[31] Water Year run from October of the previous year to September of the current year (e.g. Water Year 2015 is October 2014 – September 2015.

Table 9-A: Groundwater Inflow and Outflow Components

INFLOWS	OUTFLOWS
Rainfall Recharge	Municipal Pumping • Zone 7* • By Others*
Applied Water Recharge	
Stream Recharge	
Subsurface Groundwater Inflow*	Agricultural Pumping
Pipe Leakage	Mining Use*
	Subsurface Groundwater Outflow

* Main Basin Only

While the regulations for Groundwater Sustainability Plans (GSP) indicate use of annual storage change between seasonal high conditions (likely to occur in spring), Zone 7's accounting of the HI components is tabulated only at the end of the WY; use of autumn HI storage has proved effective and accurate in the Basin. Examination of the change in the annual low levels has allowed for a more accurate prediction of any trends for change in storage to fall below the operational storage guidelines established by Zone 7 for sustainable management. However, as described in **Sections 14.2.1** and **14.2.2**, Zone 7 evaluates both the spring (semi-annual) water level measurements in all the wells and monthly water levels in the Key Wells throughout the WY to estimate groundwater storage and adjust Basin management activities as appropriate.

9.1.1.2. Areal Recharge Model/Integrated Water Flow Demand Calculator

Around 1994, Zone 7 developed a soil-balance, root-zone, spreadsheet model (Areal Recharge Model [ARM]) to estimate some of the HI components, including rainfall recharge, rainfall runoff to streams, applied water recharge, and agricultural groundwater pumping for the Main Basin. ARM parameters include rainfall, evapotranspiration, soil moisture capacity, and irrigation efficiency, and account for land use, growing season, source water type (municipal, groundwater, or recycled water), and runoff location (stream reach). The ARM has been refined over the years to resolve the difference between the HI and the Groundwater Elevation (GWE) Nodal method for calculating storage (**Section 8.4.1**).

While the ARM has provided consistent and reasonable estimates of recharge to the Basin, it has a few disadvantages: (1) it takes several hours to run, (2) it is difficult to calibrate, (3) it requires Visual Basic for Applications (VBA) coding to modify and update, and (4) it does not cover the entire Basin. Therefore, for this Alternative GSP update, the ARM was migrated over to an off-the-shelf program (DWR Integrated Water Flow Model Demand Calculator [IDC]) that calculates the same datasets and expanded so that the modeled area covers the entire Basin. The details of the new model and the upgrade process are described in **Appendix D**.

9.1.2. Data Sources

Per 23 CCR §354.18(e), the best-available data were used to evaluate the water budget for the Basin. **Table 9-1** shows how all the individual components of the water budget are calculated or measured. Most of these components are either directly measured, obtained, or calculated by Zone 7 staff as part of its ongoing monitoring programs. These programs are described in detail in **Section 14** and are summarized below**:**

- **Precipitation and Evapotranspiration** – monitoring climatological conditions from a network of 18 precipitations stations and 3 evaporations conditions,
- **Surface Water** – collecting data for imported surface water and measuring stream flows from a network of 34 stations,
- **Mining Area** – monitoring mining activities and pond elevations in quarry-made lakes,
- **Groundwater Elevations** – monitoring groundwater levels using long-term well measurements from a network from about 240 wells,
- **Land Use** – monitoring land use over the Basin and the source of irrigated water (e.g., groundwater, municipal, recycled water), and
- **Wastewater and Recycled Water** – monitoring wastewater and recycled water volumes.

Most of the datasets discussed in this report date back to 1974, allowing a comprehensive, long-term assessment of Zone 7's Basin management. Although some datasets predate 1974, this date was chosen to represent the most comprehensive and consistent collection of data.

9.2. Water Budget Components

9.2.1. Surface Water Supplies and Demands

☑ **23 CCR § 354.18(b)(1)**

23 CCR §354.18(b)(1) requires quantification of total surface water entering and leaving the Basin by water source type. 23 CCR §351(a) defines water source type as "the source from which water is derived to meet the applied beneficial uses, including *[…]* surface water sources identified as Central Valley Project, the State Water Project, *[…]* local supplies, and local imported supplies". Based on this definition, Basin surface water inflows include (1) imported surface water and (2) natural streamflow into the Basin. Surface water outflows have included (1) natural streamflow leaving the Basin, (2) historical dewatering from mining pits discharged into the streams (**Section 9.3.6.2**), (3) Lake del Valle releases to maintain a "live stream" as required under Zone 7's Arroyo Valle Water Rights permit, (4) Lake del Valle flood releases, and (5) occasional episodes when Zone 7's artificial releases have exceeded the recharge capacity of the streams.

As discussed in **Section 7.7.6**, Zone 7 helps to ensure that local water supplies (e.g., groundwater) are not depleted by importing approximately 80% of the Basin's water supply (delivered to Zone 7's retailers and agricultural customers) and by recharging the Main Basin with surplus surface water when available (artificial recharge). **Table 9-B** below lists the sources of surface water from which Zone 7 can import along with the maximum volume available from each source. Actual volumes for the 1974 to 2020 WYs are discussed in **Section 9.3.1**. Individual surface water supply sources are discussed in further detail in **Section 7.7.6.**

Table 9-B: Imported Surface Water Supplies/Storage

Surface Water Supply Source	Maximum Volume Available (AFY)
State Water Project (Table A)	**80,619**
Lake Del Valle (AV Water Rights)	**8,000***
Kern County Subbasin (Storage Only)	**198,000**
Semitropic	78,000
Cawelo	120,000
Other	**3,000***
Yuba Accord	2,000*
Dry Year Transfer	1,000*
Other Transfers	varies

AV = Arroyo Valle
*Estimated maximum volume, may vary

As discussed in **Section 7.7.5**, six major streams flow into and/or through the Basin and merge in the southwest where Arroyo de la Laguna flows out of the Basin. Stream flows and surface water quality are monitored by the surface water monitoring program described in **Section 14**. Natural stream recharge and artificial stream recharge of surplus imported surface water are discussed in **Section 9.2.2.2**.

9.2.2. Groundwater Inflows

☑ 23 CCR § 354.18(b)(2)

9.2.2.1. Rainfall and Applied Water Recharge

Zone 7 has historically used the ARM (**Section 9.1.1.1**) to estimate rainfall recharge and applied water recharge for the Main Basin. Model parameters include rainfall, evapotranspiration, soil moisture capacity, and irrigation efficiency, and account for land use, growing season, source water type (municipal, groundwater, or recycled water). This model has been refined over the years to resolve the difference between the HI and the GWE methods for calculating storage. For this Alternative GSP update, Zone 7 upgraded the ARM model to IDC (see **Section 9.1.1.2**) and compared the resulting IDC recharge volumes to those from the ARM for the last 10 years (**Appendix D**). Moving forward starting with the 2021 WY, Zone 7 intends to use the IDC model for recharge accounting.

9.2.2.2. Stream Recharge

Stream recharge is categorized into the following three components:

- **Natural stream recharge** – runoff from rainfall into the streams, including both urban and rural runoff from the watershed, which naturally recharges the Basin's aquifers through the streambeds.

- **Artificial stream recharge** – aquifer recharge resulting from Zone 7-purchased SWP water being released from the South Bay Aqueduct (SBA) or from Lake Del Valle (both operated by DWR) into the Arroyos for the purpose of augmenting the natural stream recharge, maintaining habitat along Arroyo Valle, or as an alternate method of delivering water to Alameda County Water District (ACWD).
- **Arroyo Valle Prior Rights recharge** – aquifer recharge resulting from SWP or local water released from the SBA or Lake Del Valle to the Arroyo Valle to fulfill Zone 7 and ACWD's Arroyo Valle water rights requirements. The amount released is based on the amount that would have occurred if Lake Del Valle had not been constructed and is only required when Zone 7 and ACWD have local water stored in the lake.

Zone 7 calculates stream recharge for each stream reach by subtracting all stream outflows (e.g., flow at the downstream end of the reach and any diversions from the stream) from all inflows (flow entering the upstream end of the reach, diversions into the stream, and rainfall runoff). The three primary recharge streams (Arroyo Valle, Arroyo Mocho, and Arroyo Las Positas) have gauges upstream and downstream of the reaches along which recharge occurs (see **Figure 14-4** for stream gauge locations). To estimate rainfall runoff into each stream reach, Zone 7 uses either the ARM (to be replaced by IDC going forward) or a regression formula based on rainfall totals and stream flow at various gauge stations.

9.2.2.3. Subsurface Groundwater Flows

The Basin is a closed basin with little subsurface inflow into the Basin from the surrounding bedrock. There may be some subsurface inflow across the northern boundary from the San Ramon Basin, however the volume is unknown. Within the Basin, some subsurface inflow occurs from the Fringe Management Area (Fringe Area) into the Main Basin, primarily from the North Fringe Area across the northwestern border of the Main Basin. This inflow is estimated based on gradients across the Main Basin boundaries, aquifer structure, and the hydraulic conductivities of the aquifer sediments. Prior to 2000 WY, water levels were used to create rough estimates of subsurface inflow across boundaries; however, the subsurface inflow volumes varied little each year. Therefore, since the 2000 WY, Zone 7 has simply reported it as 1,000 AF per year.

9.2.2.4. Pipe Leakage

In the 2012 WY, Zone 7 staff began estimating the volume of water leaking from all underground water pipes into the Main Basin. Zone 7 estimates pipe leakage from water supply and sewage pipes into the Main Basin by using the following formula where pipe age is between 10 and 70 years old:

Leakage [gallon per day, gpd] = Pipe length [mile] x 50 [gpd/mile/year] x (Pipe Age [year] – 10).

The formula assumes that pipe leakage does not start until the pipe is at least 10 years old, after which it leaks at a rate of 50 gallons per day per mile (gpd/mi) for each year above 10 years old, up to a maximum of 3,000 gpd/mi.

9.2.3. Groundwater Outflows

☑ 23 CCR § 354.18(b)(3)

9.2.3.1. Zone 7 Groundwater Pumping

Zone 7 operates ten municipal supply wells in four wellfields (see **Figure 9-1**). Historically, Zone 7's annual groundwater pumping has varied with the availability of imported surface water and the capacity to treat that surface water. In general, Zone 7 operates its municipal supply wells for salt management, demand peaks, and compensation for a shortage or interruption in its surface water supply or treatment. Zone 7 pumps only water that has been recharged as part of its artificial recharge program using its surface water supplies. The decision of which well(s) to pump is based on pumping costs, pressure zone needs, delivered aesthetic water quality issues, salt management needs, local groundwater levels, and demineralization facility capacity.

9.2.3.2. Groundwater Pumping by Others

Zone 7 compiles pumping data for all large capacity wells within the Main Basin. This includes daily and monthly pumping totals from the retailers. Records of other pumping wells are obtained from well owners when available. Pumping volumes from significant wells without meters are estimated from utility records or from the associated land use (e.g., crop type and number of acres irrigated).

In addition to Zone 7's ten municipal wells, California Water Company (Cal Water) operates 12 wells in the Livermore area, and the City of Pleasanton operates 3 wells and San Francisco Public Utilities Commission (SFPUC) operates 2 wells in Pleasanton (see **Figure 9-1** for the relative locations of the municipal supply wells).

As discussed in **Section 9.3.1.2** below, there are no municipal supply wells in the Fringe and Upland Areas, and groundwater pumping is limited to domestic and agricultural uses.

9.2.3.3. Mining Area Losses

Mining area evaporation accounts for a large portion of the losses from the Basin and is second only to municipal pumping as an outflow component in the annual HI calculation. Zone 7 calculates the total monthly evaporative losses for the water bodies exposed to the atmosphere by mining operations (also referred to as mining ponds) using the net difference between total rainfall and estimated evaporation over the total pond area.

Mining activity losses also include groundwater lost due to export of moist gravels and groundwater that has been pumped from the quarry pits and discharged into a stream without subsequent recharge. The volume of this exported groundwater varies over time depending on the stage of mining in any given pit and the demand for aggregate resources. When the permitted gravel extraction operations are complete (currently envisioned for 2058), the associated operational groundwater losses (i.e., pit dewatering, gravel washing, and moisture export) will be eliminated.

9.2.3.4. Basin Outflow

Subsurface Basin outflow, which also occurs primarily in the Upper Aquifer, tends to discharge into the Arroyo de la Laguna and flows out of the Basin to the San Francisco Bay through Alameda Creek when water levels are above elevation 295 feet above mean sea level (ft msl) in this portion of the Bernal Subarea. Zone 7 used groundwater elevation data and synoptic streamflow measurements to develop a formula that estimates groundwater overflow rate based on the groundwater elevations in that part of the Basin.

When water levels are sufficiently high in the northeast Fringe Area, groundwater in the vicinity of the Springtown Alkali Sink (**Section 7.7.5**) discharges to Altamont Creek, exiting the Springtown Alkali Sink as surface water. Groundwater also constantly discharges from the northwest Fringe Area into the San Ramon Creek/Alamo Canal, which merges into the Arroyo de La Laguna and eventually flows out of the Basin. The volumes for both are estimated as part of the Fringe Area water budgets (see **Section 9.3.1.2**)

9.3. Current and Historical Water Budget

The current water budget for 2020 WY is shown on **Table 9-2**; the historical water budget for 1974 WY to 2020 WY is tabulated in **Table 9-3** and charted in **Figure 9-2** along with the water year type (e.g., wet, normal, dry, etc.) noted for each year.

9.3.1. Current Water Budget

§ 354.18. Water Budget
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.

☑ **23 CCR § 354.18(c)(1)**

The availability of State Water Project (SWP) supplies is fundamental to Zone 7's maintenance of its Basin measurable objectives for sustainable groundwater levels and storage, avoidance of subsidence, and protection of groundwater dependent eco-systems (GDEs). DWR accounts for the SWP supplies on a calendar year (CY) basis so these are presented as such in the tables and figures in this section. The SWP allocation for the 2020 CY was 20% (16,124 AF) of Zone 7's maximum allocation (80,619 AF). **Table 9-C** below shows Zone 7's imported water supplies for the 2020 CY and the amounts being carried over to the 2021 CY. Imported surface water supplies in the 2020 CY made up 60% of regional water demands.

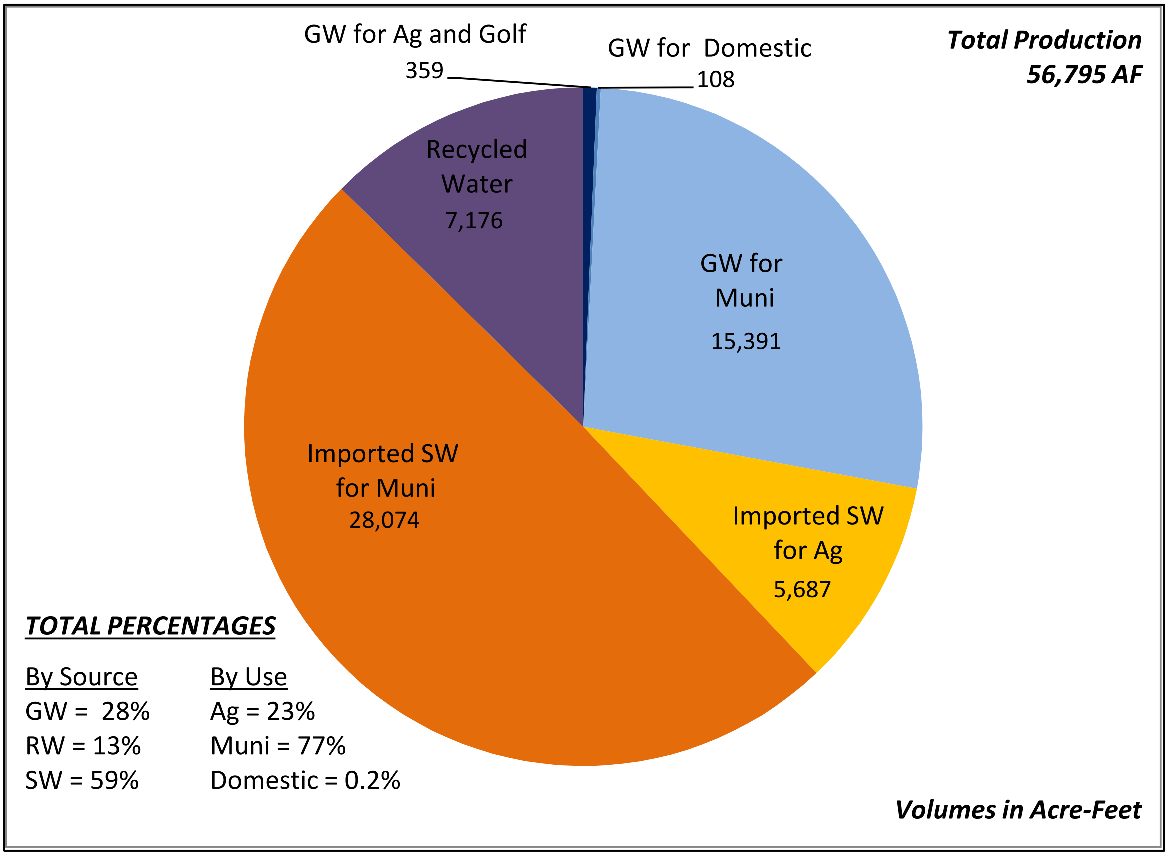
Table 9-C: Imported Water Sources for the 2020 Calendar Year (AF)

Source	Available at end of 2019	Added in 2020 *	Used in 2020	Carryover to 2021
State Water Project	**10,810**	**16,124**	**18,070**	**8,864**
Table A	0	16,124	7,260	8,864
Article 56	10,810	0	10,810	0
Lake Del Valle (AV Water Rights)	**8,100**	**600**	**8,700**	**0**
Kern County Subbasin	**117,075**	**0**	**1,000**	**116,075**
Semitropic	87,170	0	1,000	86,170
Cawelo	29,905	0	0	29,905
Other	**0**	**7,111**	**7,111**	**0**
Yuba	0	2,111	2,111	0
Dry Year Transfers	0	0	0	0
Other	0	5,000	5,000	0
Total	**135,985**	**23,835**	**34,881**	**124,939**

* 20% State Water Project Allocation for the 2020 WY
AV = Arroyo Valle

The volume of water produced and used in the Basin during the 2020 WY is shown in **Figure 9-A** below.

Figure 9-A: Basin-Wide Water Production for the 2020 Water Year (AF)



Ag = Agriculture; Muni = Municipal; GW= Groundwater; RW = Recycled Water; SW = Surface Water

Figure 9-3 shows the volumes of both the surface water imported and Basin-wide water produced during the 2020 WY**.** The following activities occurred during the 2020 WY.

- Total groundwater production in the Basin (including by Zone 7, retailers, agriculture, domestic, etc.) supplied about 28% of the total Basin-wide water demand.
- Of the 11,746 AF of groundwater pumped by Zone 7 during the 2020 WY, about 11,346 AF went into production; the remainder of which is accounted for in pumping losses and exported brine from the groundwater demineralization process.
- Zone 7's total produced groundwater was about 28% of the total treated water production that Zone 7 delivered to its retailers during the 2020 WY (on average, groundwater makes up about 15% of Zone 7's annual treated water deliveries).

9.3.1.1. Main Basin Management Area Budget

The Main Basin water budget involves accounting for inflows and outflows described in **Section 9.2** for each water year and adds the net change in storage to the previous year's volume to obtain the total storage. All the HI components are listed in **Table 9-1** along with their method of measurement and their approximate accuracy. The results of the HI method for the 2020 WY are summarized below in **Table 9-D** below and shown in detail on **Table 9-2.**

Table 9-D: Groundwater Inflow and Outflow Volumes, 2020 WY (AF)

CATEGORY	Sustainable Yield*	2020	% of Average
SUPPLIES	**19,800**	**13,515**	**68%**
Stream Recharge Artificial	5,300	2,461	46%
Stream Recharge Natural	6,600	3,511	53%
Rainfall Recharge	4,300	2,869	67%
Applied Water Recharge	1,600	2,465	154%
Pipe Leakage	1,000	1,209	121%
Subsurface Inflow	1,000	1,000	100%
DEMANDS	**18,800**	**21,447**	**114%**
Zone 7 Pumping excluding DSRSD	5,300	11,101	209%
Other Pumping	8,400	5,248	62%
Agricultural Pumping	400	112	28%
Mining Losses	1,400	700	50%
Evapotranspiration (ETo)	3,200	4,140	129%
Subsurface Outflow	100	146	146%
NET CHANGE (SUPPLY - DEMAND)	**1,000**	**-7,932**	
TOTAL STORAGE (HI Method)		**247,232**	

* Sustainable Yield and Allocated Outflows - See Section 9.3.6 for more details

The total groundwater storage for the Main Basin from the HI Method is 247.2 thousand acre-feet (TAF). For accounting purposes Zone 7 computes Main Basin storage by averaging the storage estimates from the GWE (231.7 TAF) and HI methods (247.2 TAF, **Table 8-B, Section 8.4.2**). As a result, the total groundwater in storage at the end of 2020 WY was calculated to be 239.5 TAF, with 111.5 TAF of groundwater available as operational storage, which is about 88% of the total operational storage capacity (i.e., 126 TAF from 1983 WY).

9.3.1.2. Fringe and Upland Management Areas Budget

Groundwater elevations in the Fringe and Upland Areas vary little over time, indicating that storage also remains relatively constant over time. Since groundwater pumping is minimal in these Management Areas, this constant storage volume suggests that variations in groundwater inflow volumes (e.g., from rainfall) are balanced by a corresponding change in basin overflow into the gaining streams and/or subsurface outflow into the Main Basin (**Section 9.3.3.2**). The HI method was used to estimate a groundwater budget for the Fringe and Upland Areas in an average water year (i.e., using average annual precipitation data, see **Table 9-E** below).

There is no pumping by Zone 7 or the retailers from the Fringe or Upland Areas. In general, wells within the Upland Area are completed within semi-consolidated to consolidated bedrock units, have relatively low yields, and are for domestic use by de minimis extractors. Most of the precipitation that falls on the Upland Area leaves the area as runoff and contributes to streams in the Fringe Area and the Main Basin. Information such as crop type and irrigated acreage was used in conjunction with the ARM/IDC models to estimate pumping by agricultural users and golf courses. Domestic well pumping was calculated by multiplying the number of known wells in those areas by an estimated 0.5 acre-feet per year (AFY) per well (estimated average annual use by a family).

Table 9-E: Estimated Average Groundwater Budget for Fringe and Upland Areas

COMPONENTS	Fringe Northwest	Fringe Northeast	Fringe East	Upland
INFLOW	**2,154**	**2,462**	**681**	**4,530**
Stream Recharge (natural)	150	659	100	0
Stream Recharge (artificial)	0	0	0	0
Rainfall Recharge	1,173	973	317	3,235
Leakage	301	385	21	404
Applied Water	530	444	243	892
Subsurface Inflow	0	0	0	0
OUTFLOW	**2,155**	**2,462**	**681**	**4,530**
Zone 7 Pumping				
Retailer Pumping				
Ag Pumping	32	16	29	92
Other Pumping	12	46	28	178
Mining Losses				
Basin Outflow	2,111	2,400	625	4,260
Outflow to Streams	1,111	2,400		4,260
Subsurface Outflow	1,000		625	
NET WATER BALANCE	**0**	**0**	**0**	**0**

9.3.2. Historical Water Budget

§ 354.18. Water Budget
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:
(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.
(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.
(C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.

9.3.2.1. Historical Surface Water Availability and Reliability

☑ **23 CCR § 354.18(c)(2)(A)**

Figure 9-4 shows that about 82.3 TAF more surface water (natural and artificial) has inflowed into the valley than what has outflowed over the last 15 years. As a SWP contractor, Zone 7 imports supplies from the SWP through the SBA. As of 1998, Zone 7 has had an annual maximum SWP contract amount of 80,619 AFY referred to as the "Table A Contract Amount." However, actual SWP deliveries are usually allocated in any given year by DWR at a lower level based on numerous factors, including hydrologic conditions. Currently, the long-term reliable yield of the SWP is approximately 50% of the Table A amount (40,300 AFY). Over that same 1974 to 2020 time period, the average delivered volume of imported water (not including imported water that was previously banked at one of the Kern County facilities) is about 25,500 AFY. Actual imported surface water volumes from 1975 to 2020 WY are shown on **Figure 9-5**.

9.3.2.2. Quantitative Assessment of Historical Water Budget

☑ **23 CCR § 354.18(c)(2)(B)**

The water budget has been evaluated using the methodologies described in **Section 9.1.1** for every year since 1974. The HI is updated and presented in the Annual Water Year Reports. **Table 9-3** shows the volume of groundwater inflows and outflow from the Basin from 1974 to 2020. **Figure 9-5** shows the historical percentage of groundwater production relative to total Valley-wide production end-of-year storage balances from the 1974 to 2020 WYs. **Figure 9-6** presents annual inflows (blue), outflows (red) and the cumulative change in groundwater storage from 1974 WY through 2020 WY. As shown on the figure, any given year may have an imbalanced inflow and outflow; but with adaptive management, long-term sustainability has been achieved for 45 years. Beginning in about 1974, the Basin had recovered from the historic lows in the early 1960s to more average water level conditions because of the Zone 7 conjunctive use program. Since that time, annual changes in groundwater storage have responded to wet and dry periods. However, only in the drought conditions of the 1990s did the cumulative change in Basin-wide groundwater storage persist below 1974 storage levels for more than two consecutive years. Even in the recent 2009-2015 drought conditions, changes in groundwater storage were managed above the 1974 volumes.

9.3.2.3. Operation Within Sustainable Yield

☑ **23 CCR § 354.18(c)(2)(C)**

Section 9.3.6 outlines how the sustainable yield of the Main Basin is budgeted in two categories:

- **Natural Recharge** (sustainable yield = 13,400 AFY) - water recharged naturally or by entities other than Zone 7. This is allocated to groundwater outflow not managed or pumped by Zone 7 (see **Section 9.3.6.2**).
- **Artificial Recharge** (sustainable average = 5,300 AFY) - imported surface water that Zone 7 recharges into the groundwater basin to manage and pump (i.e., "Conjunctive Use", see **Section 9.3.6.3**)

Figure 9-7 shows that the cumulative net natural recharge/outflow since 1974 is approximately -40 TAF (see **Section 9.3.6.2** for a more detailed description). Over that same time period, Zone 7 has recharged about 67 TAF more than it has pumped (**Figure 9-8, Section 9.3.6.3**). Without this recharge, natural demands would have outpaced the natural sustainable yield of the Basin. Since 1974, Zone 7 has imported and recharged about 220 TAF to keep the Basin sustainable.

9.3.3. Change in Groundwater Storage

☑ **23 CCR § 354.18(b)(4)**

9.3.3.1. Main Basin Management Area

Methodologies Zone 7 used to calculate groundwater storage in the Basin are described in **Section 8.4**. The GWE method yielded a total storage of 231.7 TAF at the end of the 2020 WY, which is 16.8 TAF less than the GWE value calculated for the 2019 WY. The HI method produced a total storage value of 247.2 TAF for the end of the 2020 WY, which is about 7.9 TAF less than the end of the 2019 WY HI value. The average of the both methods for the 2020 WY, summarized below in **Table 9-F,** indicates a storage loss of 12.3 TAF since the 2019 WY. **Table 9-G** shows the change in groundwater inflows and outflows for the 2020 Water Year.

Table 9-F: Change in Groundwater Storage 2020 WY (in TAF)

Storage Calculation Method	End of 2019 WY	End of 2020 WY	Change in Storage
Groundwater Elevations (GWE)	248.5	231.7	-16.8
Hydrologic Inventory (HI)	255.2	247.2	-7.9
Total Storage (average of GWE & HI)	251.8	239.5	-12.3
Operational Storage*	123.8	111.5	-12.3

* Operational Storage = Total Storage - Reserve Storage (i.e., 128 TAF)

Table 9-G: Change in Groundwater Inflows and Outflows 2020 WY (AF)

CATEGORY	Sustainable Yield*	2020 WY	Change from 2019 WY
SUPPLIES	**19,800**	**13,515**	**-10,110**
Artificial Stream Recharge	5,300	2,461	-482
Natural Stream Recharge	6,600	3,511	-4,151
Rainfall Recharge	4,300	2,869	-5,719
Applied Water Recharge	1,600	2,465	179
Pipe Leakage	1,000	1,209	64
Subsurface Inflow	1,000	1,000	0
DEMANDS	**18,800**	**21,447**	**2,305**
Zone 7 Pumping excluding DSRSD	5,300	11,101	3,081
Other Pumping	8,400	5,248	-1,366
Agricultural Pumping	400	112	-1
Mining Losses	1,400	700	0
Evapotranspiration (ETo)	3,200	4,140	1,255
Subsurface Outflow	100	146	-663
NET CHANGE (SUPPLY - DEMAND)	**1,000**	**-7,932**	**-12,415**
TOTAL STORAGE (HI Method)		**247,232**	**-7,932**

AF = acre-feet
DSRSD = Dublin San Ramon Services District
* Sustainable Yield and Allocated Outflows - See Section 9.3.6

Annual and cumulative changes in groundwater storage since 1974 WY are presented on **Figure 9-6** and in **Table 9-3.** Since 1974 WY, the Main Basin has experienced a cumulative gain in storage of +35 TAF.

9.3.3.2. Fringe and Upland Management Areas

Figure 8-8 shows that water levels in the Fringe Area vary little over time, indicating that storage remains relatively constant over time. Since groundwater pumping is minimal in these areas, this constant storage volume suggests that variations in groundwater inflow volumes (e.g., from rainfall) are balanced by a corresponding change in Basin overflow into the gaining streams and/or subsurface outflow into the Main Bain. **Section 9.3.1.2** shows the estimated average rainfall inflow and Basin outflow from the Fringe Area.

The same is believed to be the case for the Upland Area, however little groundwater and flow data is available to confirm this. For this Alternative GSP update, Zone 7 added several wells in the Upland Area to monitor changes in water levels over time (see **Section 14.2.1**).

9.3.4. Overdraft Conditions

☑ **23 CCR § 354.18(b)(5)**

The Basin is a medium-priority basin and is not designated as being in a condition of critical overdraft by DWR in its latest version of Bulletin 118 – California's Groundwater (*DWR, 2016c*). As described in **Section 8.3.3**, the groundwater levels in the Basin dropped significantly during the 1940s and 1950s. Zone 7 was established in 1957 partially to address the water supply overdraft. The downward trend in groundwater elevation began to reverse in 1962 when Zone 7 began importing water from the SWP and later in the 1960s when Zone 7 began capturing and storing local runoff in Lake Del Valle. The first imports were diverted to an off-stream recharge facility called Las Positas Pit. This facility was operated from 1962 until the late 1970s and again, briefly, in the 1980s. Since that time, the Zone 7 program of capturing and storing water has been expanded throughout the Main Basin.

Thus, after experiencing historical groundwater lows in the 1960s, Main Basin water levels stabilized in the late 1960s and started to rise in the early 1970s with the advent of regional groundwater management programs. Following a 'very critical dry' year in 1977, groundwater levels continued to recover and peaked in 1983, which is the modern maximum ("basin full") limit.

Since 1983, water levels have been drawn down three separate times in response to times of limited water importation from the SWP but have not reached previous historic low levels (see **Figure 8-1** of the Fairgrounds Key Well). As shown on **Figure 8-1**, groundwater levels subsequently recovered following the dry cycles in the early 1990s and the early 2000s because of Zone 7's managed aquifer recharge operations and a corresponding reduction in groundwater production. The recent severe drought cycle of 2012-2015 resulted in a lowering of Basin-wide water levels, but levels remained above the drought cycle of the early 1990s and significantly above historic lows (**Section 8.3.3**). These water level data are consistent with sustainable groundwater management practices since at least the early 1970s.

A "condition of long-term overdraft" is defined in Section 10735 of the California Water Code (CWC) as "the condition of a groundwater basin where the average annual amount of water extracted for a long-term period, generally 10 years or more, exceeds the long-term average annual supply of water to the basin, plus any temporary surplus. Overdraft during a period of drought is not sufficient to establish a condition of long-term overdraft if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods". Therefore, based on the above discussion and the definition of overdraft provided in the CWC, the Basin as a whole is not in a condition of overdraft.

9.3.5. Water Year Types

☑ **23 CCR § 354.18(b)(6)**

Zone 7's Climatological Monitoring Program tracks rainfall and evaporation in the Basin, employing a network of climatological stations. The primary objective of this monitoring network is to provide high quality Basin-wide climate data for long-term studies, Basin recharge calculations, and water management decisions. Specifically, the calculations of Basin recharge are used in the annual water budget, change in groundwater storage, and the defined objectives of operational storage (see **Section 8.4**). Data are collected to provide short-term, seasonal, and long-term trends in local hydrologic conditions.

As part of the Climatological Program, Zone 7 collects and displays (e.g., **Table 9-3**, **Figure 9-4**, and **Figure 9-5**) the Water Year type obtained from DWR's Sacramento Valley Water Year Index (https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST). This hydrology is more consistent with the availability of imported supplies, generally approximates local rainfall patterns in the Basin, and is used to show how supplies, demands, and groundwater storage changes vary in different water year types.

9.3.6. Sustainable Yield

☑ **23 CCR § 354.18(b)(7)**

9.3.6.1. Overview

As defined by Sustainable Groundwater Management Act (SGMA), Sustainable Yield is the amount of water that can be extracted from the Basin on an annual basis without causing Undesirable Results (defined in **Section 13**). Given that the Basin is a relatively closed basin with minor amounts of subsurface inflow and outflow, the volume of groundwater in storage can be managed within an operational storage range, using averages of each water budget component as a general method for avoiding historic lows. Because no Undesirable Results have been observed while operating within this storage range, average water budget targets are referred to as Sustainable Yield estimates for the purposes of groundwater management.

To maintain sustainable management of the Basin, Zone 7 developed target values for inflows and outflows in 1992 using the HI method. The Sustainable Yield of the Main Basin is budgeted in two categories, both of which are discussed in more detail in the next sections. As further described below, the total Sustainable Yield of the Basin is the sum of the following two categories:

- **Natural Recharge** (sustainable average = 13,400 AFY) - water recharged naturally or by entities other than Zone 7. This is allocated to groundwater outflow not managed or pumped by Zone 7 (see **Section 9.3.6.2**).
- **Artificial Recharge** (sustainable average = 5,300 AFY) - imported surface water that Zone 7 recharges into the groundwater basin to manage and pump (i.e., "Conjunctive Use", see **Section 9.3.6.3**)

Overall, Zone 7 maintains the sustainability of the Basin through the following actions to help avoid a repeat of historical overdraft of the Basin (**Section 9.3.4**):

- Monitoring the long-term natural groundwater budget
- Importing, artificially recharging, and banking surface water to meet future demands,
- Implementing a conjunctive use program that maximizes use of the storage capacity of the Basin
- Limiting long-term groundwater pumping to sustainably manage the Basin
- Maintaining sustainable long-term groundwater storage volumes, even when total outflows exceed the natural sustainable supply
- Promoting increased and sound recycled water use, and
- Identifying and planning for future supply needs and demand impacts. This is often performed using Zone 7's groundwater model of the Basin.

9.3.6.2. Natural Recharge and Non-Zone 7 Outflow

In 1992, Zone 7 estimated that the long-term average "natural" groundwater inflow into the Main Basin is about 13,400 AF annually (*Zone 7, 1992*). This long-term average (shown as the "sustainable yield" in the **Table 9-H** below) was primarily based on average local precipitation and natural recharge over a century of hydrologic records; however, the actual amount of natural recharge varies from year to year depending on the amount of local precipitation during the year. Recharge from irrigation (applied water) is also included in the "natural" inflow total, because of its steady, sustainable, contribution to groundwater recharge in the Basin.

Table 9-H: Natural Groundwater Inflow

Supply Component	Sustainable Yield Estimate (AFY)*	Actual Average (1974-2020 WY, AFY)
Natural Stream Recharge	5,700	5,715
Arroyo Valle Prior Rights	900	902
Rainfall Recharge	4,300	4,675
Applied (Irrigation) Water Recharge	1,600	2,061
Subsurface Groundwater Flow	900	597
Subsurface Inflow	1,000	986
Basin Overflow	-100	-389
TOTAL	13,400	13,950

* as calculated in *Zone 7, 1992*

In the early 1990s, Zone 7 collaborated with the Retailers to ensure that average natural recharge to the Basin was not less the non-Zone 7 groundwater outflow, which includes groundwater pumping (other than Zone 7's), evapotranspiration (ET), mining losses, and Basin overflow. As a result, each retailer was allocated an annual independent Groundwater Pumping Quota (GPQ), which is generally based on average historical uses and is pro-rated based on the agreed upon natural recharge. The retailers are permitted by contract to pump this GPQ (accounted for on a CY basis) without having to pay a replenishment fee to Zone 7. They can carry forward any un-pumped GPQ (up to 20% of their GPQ). **Table 9-I** below includes each retailer's GPQ, along with their groundwater pumping volumes for the 2020 CY. None of the retailers pumped more than their respective GPQ in 2020 CY.

Table 9-I: Retailer Groundwater Pumping and Quotas in 2020 Calendar

Retailer	GPQ	Carryover from 2019 CY	Pumped in 2020 CY	Carryover to 2021**
City of Pleasanton	3,500	3	3,110	393
Cal Water	3,069	614	1,063	614
DSRSD (pumped by Zone 7)	645	0	645	0
City of Livermore (not used)*	31	-	0	-
Total	**7,214**	**617**	**4,818**	**1,007**

AF =Acre-feet
GPQ = Groundwater Pumping Quota
* = Livermore no longer pumps groundwater, GPQ not included in totals or carryover.
** = Maximum of 20% of GPQ can be carried over

The remaining balance of the average natural recharge is allocated to other domestic, agricultural, and gravel mining uses as shown in **Table 9-J** below:

Table 9-J: Average Natural Sustainable Yield Outflow

Demand Component	Sustainable Average (AFY)	Actual Average (1974-2020 WY, AFY)
Municipal pumping by retailers (GPQs)	7,214[a]	6,272
Pleasanton	3,500	3,264
Cal Water	3,069	2,761
DSRSD	645	247
Other groundwater pumping[b]	1,186	1,188
Agricultural pumping	400	996
Mining area losses[c]	4,600	6,369
TOTAL	**13,400**	**14,825**

a. Based on calendar year. Livermore has a GPQ of 31 AF but it has not been used for many years.
b. For drinking water supply
c. Includes mining area evaporation, discharges that are diverted to arroyos and flow out of the Main Basin, and losses incurred during gravel production and export.

Since 1974 the average non-Zone 7 outflow has exceeded the average natural recharge by 875 AFY. **Figure 9-7** shows that the cumulative net natural recharge/outflow since 1974 is approximately -41 TAF. The graph shows that the cumulative dropped significantly from 1974 to early 2000. This drop was primarily because of losses due to mining activity, where groundwater was extracted from the mined pits and then discharged into the arroyos where it flowed out of the Basin. Starting in the early 2000s, the cumulative curve flattens out when Zone 7 worked with the mining companies to recapture their pit-dewatered groundwater in other unused ponds. In 2013 all dewatering discharged into the streams ceased when Vulcan Materials started discharging their dewatering groundwater into Cope Lake, which drains into neighboring Lake I and eventually reenters the Basin. As a result, since 2000 the average total non-Zone 7 outflow (13,463 AF) has been slightly less than the average total natural recharge (14,466 AF).

9.3.6.3. Zone 7 "Artificial" Supply and Demand (Conjunctive Use)

Since the 1960s, Zone 7 has actively embraced a "conjunctive use" approach to Basin management by integrating local and imported surface water supplies with the local conveyance, storage, and groundwater recharge features. These features include local Arroyos (which are also used as flood protection facilities during wet seasons) and two former quarry pits (Lake I and Cope Lake). Zone 7's "artificial recharge" operation involves releasing imported water supplies into the local "losing stream" arroyos to recharge the Basin. The volume of artificial recharge is dependent on Zone 7's annual SWP allocations, precipitation captured locally, and water supply operations plans. Typically, Zone 7 will commence artificial recharge operations during times of surplus imported water availability.

While groundwater pumping by the retailers is accounted for in the "natural" budget (see above), Zone 7's groundwater pumping and artificial recharge volumes are accounted for in the "conjunctive use" budget. Zone 7's annual groundwater production and artificial recharge operations vary with the availability of surface water, treatment plant capacity, and the available groundwater storage space. In the 2016 Alternative GSP (*Zone 7, 2016e*), Zone 7's historical artificial conjunctive use (i.e., artificial sustainable yield) for the Main Basin was estimated to be about 5,300 AFY (see **Table 9-K),** but the actual volumes have varied significantly depending on surface water supplies and hydrologic conditions. Since 1974, Zone 7 has artificially recharged about 67 TAF more than it has pumped (**Figure 9-8**). These totals do not include the water Zone 7 pumps for DSRSD (usually 645 AFY), which is considered part of the "natural" demand.

Table 9-K: Zone 7 Historical Conjunctive Use Balance

Component	Estimated Sustainable Average (AFY)	Actual Average (AFY)
Artificial Recharge	5,300	5,380
Zone 7 Pumping	5,300	3,955
Net Artificial Recharge	**0**	**1,425**

AFY = acre-feet per year

9.3.6.4. Total Sustainable Yield

The total Sustainable Yield of the basin, which is the sum of the natural (13,400 AF) and artificial (5,300 AF) recharge components, has been estimated to be **18,700 AF**. However, since 1974, the non-Zone 7 outflow has exceeded the natural recharge by about 41 TAF, primarily due to mining pit dewatering that was discharged into the arroyos prior to about 2000 (**Figure 9-7**). Over that same period Zone 7 has artificially recharged about 67 TAF more than it has pumped (**Figure 9-8**), which has more than covered the 41 TAF loss. **Figure 9-9** shows that the cumulative change in storage since 1974 is about +35 TAF.

Looking to the future, Zone 7 will continue to work with the mining companies to ensure that their dewatered groundwater does not leave the Basin so that future non-Zone 7 outflow will be equal to or less than the natural recharge (i.e., sustainable). Zone 7 also plans to increase its conjunctive use when it acquires the additional former quarries (Lakes A through H) that will become the area's future "Chain of Lakes" (COL). These additional lakes will provide additional capacity for artificial recharge and regional flood protection (see **Section 9.4** below).

9.4. Projected Water Budget

§ 354.18. Water Budget
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:
(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.
(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.
(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.
(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:
(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.
(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.
(3) Projected water budget information for population, population growth, climate change, and sea level rise.

9.4.1. Projected Water Budget Methods and Data Sources

☑ **23 CCR § 354.18(c)(3)(A)**
☑ **23 CCR § 354.18(c)(3)(B)**
☑ **23 CCR § 354.18(c)(3)(C)**

Zone 7's imported water supplies have decreased in reliability over the years as SWP reliability has declined while demand has increased due to continued population growth. Zone 7 regularly evaluates the Valley's water supplies and demands in their Water Supply Evaluation Updates (WSE; *Zone 7, 2016b*) and their Urban Water Management Plans (UWMP; *Zone 7, 2021*). About ten years ago, Zone 7 developed a Water Supply Risk Model as a powerful tool for water supply decision-making and planning. The dynamic model allows for a year-by-year analysis of water system operations in response to hydrologic conditions (e.g., drought). The Water Supply Risk Model simulates water system behavior and calculates reliability forecasts on an annual time scale using a Monte Carlo technique that generates a range of future water supply conditions, random Delta outage scenarios, and uncertain climate impacts. The projected water budget presented herein is consistent with the results of the Water Supply Risk Model applied as part of the 2020 UWMP.

9.4.2. Development of Projected Water Budget Scenarios

☑ **23 CCR § 354.18(c)(3)(A)**
☑ **23 CCR § 354.18(c)(3)(B)**
☑ **23 CCR § 354.18(c)(3)(C)**
☑ **23 CCR § 354.18(d)(3)**

In its 2020 UWMP (*Zone 7, 2021*), Zone 7's used the Water Supply Risk Model to evaluate future water supplies assuming long-term average hydrologic conditions, climate change impacts to local surface water supplies, and climate change impacts to SWP reliability based DWR's CalSim II water resources planning model (*DWR, 2020b*).

For the demand portion of the Water Supply Risk Model, Zone 7 worked closely with its retailers to develop demand projections and jointly completed a Regional Demand Study[32] (*Woodard & Curran, 2021)* concurrently with the 2020 UWMP. The primary goal of the Regional Demand Study was to develop a regional, land-use based water demand forecasting model that can be used for planning efforts. Historically, the retailers have conducted independent demand forecasting, with Zone 7 using those forecasts to develop a regional forecast (after some adjustment). The Regional Demand Study developed a consistent method for estimating demands across the Tri-Valley region, while still considering the unique characteristics of each of Zone 7's retailers, including demographic data, historical water use, demand hardening patterns, and future projections for land use and population. Zone 7 also developed projections for its direct retail customers, untreated water (agricultural) customers, and losses (i.e., unaccounted-for water) in its water supply system. As further described below, the Regional Demand Study also accounts for climate change impacts in developing projections of future outdoor water demands. See the 2020 UWMP (*Zone 7, 2021*) for more details of estimated future supplies and demands used in the Water Supply Risk Model.

For this Alternative GSP update, the Water Supply Risk Model was run from 2020 to 2081 WYs using the estimated future supplies and demands discussed above.

9.4.2.1. Climate Change Considerations

Climate change is anticipated to impact Zone 7's future water supply availability, demand, and operational patterns. Warmer temperatures are expected to increase irrigation demand and lengthen the growing season. In addition, climate change may impact hydrologic cycles, watershed management, surface water

[32] https://www.zone7water.com/sites/main/files/file-attachments/2020_tri-valley_demand_study.pdf?1627595774

quality, stream flow and groundwater recharge. Increased water efficiency and conservation, along with expanded use of recycled water by Zone 7's retailers, could mitigate the effects of climate change on water demands. More importantly, Zone 7's adaptive management and integrated planning will be required to account for effects of climate change and respond appropriately.

As mentioned above, projections of future SWP supplies in the Water Supply Risk Model were derived from DWR's CalSim II water resources planning model included in DWR's 2019 State Water Project Delivery Capability Report (DCR; *DWR, 2020b*). The Water Supply Risk Model specifically accounts for climate change impacts to future SWP supply reliability by employing the DCR 2035 Central Tendency climate scenario with 45-centimeter (cm) sea level rise for SWP supply forecasting. (*DWR, 2020b*). The Water Supply Risk Model also considers climate change impacts to local water supplies (i.e., Arroyo Valle) using a more conservative risk-based analysis (see 2020 UWMP for further details).

The Water Supply Risk Model additionally included a 5-year drought assessment and evaluated the impacts of climate change on Zone 7's future water demand and use patterns based on results from the Regional Demand Study. Specifically, the Regional Demand Study applied a 5% increase in outdoor water demands by 2040 to account for warmer temperatures increasing irrigation demand and lengthening the growing season. This demand multiplier starts at 0% in 2020, increases linearly to 5% by 2040, and remains at 5% through the remainder of the projected simulation (*Zone 7, 2021*).

9.4.3. Projected Water Budget Results

Table 9-4 shows the projected water supplies output from the Water Supply Risk Model, which projected normal year water supplies from 76,700 AF in 2025 to 90,700 AF in 2030 and down to 83,200 AF at buildout around 2040. Since the SWP is the main source of Zone 7's water supplies, climate change impacts to the SWP will impact Zone 7. As shown in **Table 9-4**, supplies derived from the SWP, including Table A deliveries, groundwater (i.e., stored SWP water), and SWP carryover, represent about 90 percent of Zone 7's 2025 supplies. This percentage remains high throughout the projected simulation period, with SWP-derived supplies comprising approximately 75 percent of Zone 7's total supplies in 2045.

Figure 9-10 shows projected groundwater storage from the modeled scenario. Initially Zone 7 is expected to continue to rely on the Basin for municipal supply, which will both decrease Basin storage. In 2025, the COL Pipeline is expected to come online which will allow Zone 7 to recharge surface water into the COL; however, SWP supplies are still expected to be limited, so storage will continue to drop. In 2030 the Sites Reservoir and potable reuse projects are expected to come online, so Zone 7's can rely less on the Basin. As a result, Basin storage increases significantly through the 2030s and eventually levels off as the Basin fills up. In 2060 Zone 7 retains ownership of the remaining COL. The increased recharge capacity enables Zone 7 to install a second demineralization plant and increase pumping, resulting in a temporary decrease in Basin storage. The cumulative change in storage shown **Figure 9-10** shows that groundwater storage in the Basin will remain stable or slightly increase over the 61-year projected water budget timeline upon full implementation of the projects and management actions described above (see also **Section 15**).

9.4.3.1. Future Refinements

Future refinements to the projected water budget will further incorporate climate change scenarios included in Zone 7's ongoing update to the Water Supply Risk Model. Additionally, Zone 7 plans to update its aerial recharge model (ARM) and groundwater flow model to directly incorporate DWR's 2030 and 2070 Climate Change Factors dataset (*DWR, 2018*) in simulations of future hydrology and resulting impacts to recharge and runoff rates within the Basin. Current ongoing and future planned updates to the Water Supply Risk Model and groundwater flow model are further described in **Section 15.2.4**.

TABLE 9-1
DESCRIPTION OF HYDROLOGIC INVENTORY COMPONENTS
LIVERMORE VALLEY GROUNDWATER BASIN

COMPONENTS	*DESCRIPTION/REMARK*	*Direct/ Indirect*	*HOW CALCULATED/MEASURED*	*ESTIMATED ACCURACY*
SUPPLY INDICES				
Rainfall	Pleasanton rainfall (Parkside Office)	Direct	Measured by Zone 7	0.5 in
Evaporation	Evaporation at Lake Del Valle Station	Direct	Collected by DWR	0.5 in
Streamflow	Arroyo Valle Streamflow if Lake Del Valle Dam did not exist	Direct	USGS Stream Gage Station AV_BLC	10 AF
Water Year Type	Indicator of Water Year in Sacramento Valley	Direct	DWR California Data Exchange Center	-
SUPPLY COMPONENTS				
NATURAL STREAM RECHARGE				
ARROYO VALLE	AV natural recharge.	Indirect	Stream Inflows - Stream Outflows	100 AF
ARROYO MOCHO	AM natural recharge.	Indirect	Stream Inflows - Stream Outflows	100 AF
ARROYO LAS POSITAS	ALP natural recharge.	Indirect	Stream Inflows - Stream Outflows	100 AF
ARTIFICIAL RECHARGE				
ARROYO VALLE	Total artificial recharge on Arroyo Valle minus AV_RC_PR	Indirect	Stream Inflows - Stream Outflows	100 AF
ARROYO VALLE PRIOR RIGHTS	AVBLC flow that would have recharged if no dam. Subset of AV_RC.	Indirect	Formula based on AVBLC flow.	100 AF
ARROYO MOCHO	Total artificial recharge on Arroyo Mocho	Indirect	Stream Inflows - Stream Outflows	100 AF
ARROYO LAS POSITAS	Total artificial recharge on Arroyo Las Positas	Indirect	Stream Inflows - Stream Outflows	100 AF
INJECTION WELL RECHARGE	Injection at Hop 6 from 1998 to 2000	Direct	Metered by Zone 7	10 AF
RAINFALL RECHARGE	Recharge from rainfall	Indirect	Calculated by Areal Recharge Model	1000 AF
PIPE LEAKAGE	Pipe leakage that recharges the GW basin	Indirect	Estimated using length and age of pipes	500 AF
APPLIED WATER RECHARGE				
URBAN MUNICIPAL (GW & SBA)	Applied recharge in urban area - delivered water (gw & sba)	Indirect	Calculated by Areal Recharge Model/IDC	100 AF
URBAN RECYCLED WATER	Applied water recharge from urban area - recycled water	Indirect	Calculated using Wastewater Plant deliveries	10 AF
AGRICULTURAL (SBA)	Total applied recharge from 'untreated' ag sources (untreated SBA)	Indirect	Calculated by Areal Recharge Model/IDC	100 AF
AGRICULTURAL (GW)	Total applied water recharge from groundwater ag sources	Indirect	Calculated by Areal Recharge Model/IDC	100 AF
GOLF COURSES (GW)	Applied water from golf courses on groundwater	Indirect	Calculated by Areal Recharge Model/IDC	100 AF
GOLF COURSES (RW)	Applied water from golf courses from recycled water	Indirect	Calculated using Wastewater Plant deliveries	10 AF
SUBSURFACE BASIN INFLOW	Subsurface Inflow from Northern Fringe Basin	Indirect	Estimated historically groundwater contours	500 AF
DEMAND COMPONENTS				
MUNICIPAL PUMPING				
ZONE 7	Total pumping by Zone 7, including pumping to waste	Direct	Metered by Zone 7	10 AF
DSRSD	*Pumping by Zone 7 for DSRSD.*	*Direct*	*DSRSD Groundwater Pumping Quota*	*0 AF*
PLEASANTON	Pumping by Pleasanton.	Direct	Metered by Pleasatnon	10 AF
CALIFORNIA WATER SERVICE	Pumping by CWS.	Direct	Metered by CWS	10 AF
SFPUC	Pumping by SF Public Utilities Commission	Direct	Metered by SFPUC	10 AF
FAIRGROUNDS	Pumping by Alameda County Fairgrounds	Indirect	Metered by Fairgrounds	10 AF
DOMESTIC	Pumping from active domestic, supply, and potable wells	Indirect	Estimated: Number of Wells x 0.5 AF/yr	50 AF
GOLF COURSES				
CASTLEWOOD GOLF COURSE	*Pumping for Castlewood Golf Course*	*Indirect*	*Estimated using historical meter data*	*50 AF*
TRI VALLEY GOLF CENTER	*Pumping for TriValley Golf Driving Range*	*Indirect*	*Calculated by Areal Recharge Model/IDC*	*50 AF*
AGRICULTURAL PUMPING	Unmetered pumping for agriculture	Indirect	Calculated by Areal Recharge Model/IDC	100 AF
MINING				
EXPORT	Total mining area releases that leave the basin	Indirect	Calculated from metered data and stream recharge rate	50 AF
EVAPORATION	Pond evaporation & rainfall.	Indirect	Calculated using lake area, evaporation, and rainfall	100 AF
PROCESSING	Mining Area processing losses	Indirect	Estimated at 700 AF/Yr	100 AF
SUBSURFACE BASIN OUTFLOW	Basin overflow leaving basin	Indirect	Formula based on GW elevation and synoptic data	100 AF

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9/13/2021

TABLE 9-2
GROUNDWATER STORAGE
HYDROLOGIC INVENTORY (HI) METHOD
2020 WATER YEAR (in Acre-Feet, except where indicated)

	Total for Water Year	Sustainable Average	Percent of Sust Avg
INDICES			
Rainfall at Livermore (inches)	10.48	14.46	72%
8 Station Rainfall Index (Northern CA)(inches)	31.74	50.16	63%
Evaporation at Lake Del Valle (inches)	76.37	67.14	114%
SUPPLY TOTAL (AF)	**13,515**	**19,800**	**68%**
Stream Recharge	**5,972**	**11,900**	**50%**
[1] Natural Stream Recharge	2,595	5,700	46%
Arroyo Valle	*793*	*1800*	*44%*
Arroyo Mocho	*1,072*	*2,600*	*41%*
Arroyo Las Positas	*730*	*1,300*	*56%*
[1] Arroyo Valle Prior Rights	916	900	102%
[3] Artificial Stream Recharge	2,461	5,300	46%
Arroyo Valle	*2,045*	*1,640*	*125%*
Arroyo Mocho	*416*	*3,530*	*12%*
Arroyo Las Positas	*0*	*130*	*0%*
Injection Well Recharge	**0**	**0**	**0%**
[1] **Rainfall Recharge**	**2,869**	**4,300**	**67%**
Lake Recharge	7,529	NA	NA
Pipe Leakage	**1,209**	**1,000**	**NA**
[1] **Applied Water Recharge**	**2,465**	**1,600**	**154%**
Urban - Municipal	2,109	1,280	165%
Urban - Recycled Water	129	26	496%
Agricultural - Municipal (SBA)	80	92	87%
Agricultural - Groundwater	14	12	117%
Golf Courses - Groundwater	66	146	45%
Golf Courses - Recycled Water	67	44	152%
[1] **Subsurface Inflow**	**1,000**	**1,000**	**100%**
DEMAND TOTAL (AF)	**21,447**	**18,800**	**114%**
Municipal Pumping	**16,349**	**13,700**	**119%**
[4] Zone 7	11,746	5,950	197%
[2] *Zone 7 pumping for DSRSD*	*645*	*645*	*100%*
GW through Demin Membranes	*1,458*	*-*	*-*
Demin Permeate to Z7 Distribution System	*1,131*	*-*	*-*
[2] City of Pleasanton	2,701	3,500	77%
[2] California Water Service	904	3,070	29%
[2] SFPUC	322	450	72%
[2] Fairgrounds	321	310	104%
[2] Domestic	108	200	54%
[2] Golf Courses	247	225	110%
GWP_Castle	*225*	*205*	*110%*
Tri Valley Golf	*22*	*20*	*110%*
[2] **Agricultural Pumping**	**112**	**400**	**28%**
SFWD	0	0	0%
Concannon	0	0	0%
Calculated	112	400	28%
[2] **Mining Use**	**4,840**	**4,600**	**105%**
Mining Discharges (Export) to Stream	0	700	0%
Mining Discharges to Cope Lake	*7,906*	*NA*	*NA*
Evaporation	4,140	3,200	129%
Processing	700	700	100%
[1] **Subsurface Overflow**	**146**	**100**	**146%**
SUBTOTALS (AF)			
Sustainable Yield - Natural Recharge [sum of [1]]	9,699	13,400	72%
Sustainable Yield - Demand Components [sum of [2]]	10,200	13,400	76%
Net Natural	-501		
Zone 7 - Artificial Recharge (Stream) [sum of [3]]	2,461	5,300	46%
Zone 7 - Municipal Pumping [sum of [4]]	11,101	5,300	209%
Net Artificial	-8,640		
NET RECHARGE (Supply - Demand)	**-7,932**	**1,000**	**-793%**
Check Net Natural/Artificial + pipe leakage	*-7,932*		
TOTAL STORAGE (AF)	**2020 WY**	**2019 WY**	**Δ Storage**
Hydrologic Inventory (HI)	247,232	255,164	-7,932
Nodal GW Elevations (NGE)	231,725	248,579	-16,854
Average Storage: (HI + NGE)/2	239,479	251,872	-12,393
Available Storage: Avg Storage - Reserve (128K AF)	111,479	123,872	-12,393

Sustainable average includes original estimates for Sustainable Yield components (shown with *)

Natural Component

Artificial Component

TABLE 9-3
HISTORICAL GROUNDWATER STORAGE
HYDROLOGIC INVENTORY (HI) METHOD
1974-2020 WATER YEARS (in Acre-Feet, except where indicated)

	WATER YEAR (Oct - Sep)																
COMPONENTS	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
INDICES																	
Rainfall at Livermore (in)	16.1	14.8	6.2	6.0	18.5	13.6	17.6	10.3	24.4	32.0	13.0	12.6	19.8	8.9	8.7	11.2	9.4
8 Station Rain Index (N. CA)(in)	78.6	48.8	28.3	19.0	71.6	39.1	59.6	37.6	84.8	88.5	58.1	37.8	72.1	28.6	34.9	50.1	36.0
Evap at Lake Del Valle (in)	60.9	62.7	63.5	66.0	64.2	67.7	59.7	72.1	60.5	59.7	70.2	64.9	61.1	64.0	66.9	63.6	65.9
Arroyo Valle Stream flow (AF)	30538	28307	475	177	43749	9721	45800	5817	61427	125882	25653	7282	67903	3023	1506	1988	815
Water Year Type*	W	W	C	C	AN	BN	AN	D	W	W	W	D	W	D	C	D	C
SUPPLY	**18,140**	**21,437**	**11,121**	**8,683**	**24,813**	**22,213**	**23,830**	**18,821**	**29,942**	**35,412**	**15,547**	**8,784**	**20,866**	**6,670**	**8,071**	**11,170**	**10,353**
Injection Well Recharge	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Stream Recharge	**11,340**	**15,400**	**6,910**	**3,820**	**16,330**	**16,110**	**16,480**	**15,040**	**16,420**	**17,158**	**9,486**	**4,747**	**9,045**	**3,565**	**4,549**	**7,880**	**7,026**
Artificial Stream Recharge	3,509	6,750	5,695	3,190	6,442	12,266	10,211	11,918	5,952	901	0	0	0	0	1,172	4,320	4,488
Arroyo Valle	*1,439*	*4,320*	*1,875*	*1,300*	*3,002*	*5,886*	*4,541*	*6,328*	*2,442*	*0*	*0*	*0*	*0*	*0*	*0*	*139*	*304*
Arroyo Mocho	*1,670*	*1,830*	*3,220*	*1,290*	*2,840*	*5,780*	*5,270*	*5,130*	*3,290*	*901*	*0*	*0*	*0*	*0*	*1,172*	*4,181*	*4,184*
Arroyo las Positas	*400*	*600*	*600*	*600*	*600*	*600*	*400*	*460*	*220*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Natural Stream Recharge	6,060	7,110	1,100	630	8,850	2,860	4,850	2,200	8,620	14,387	8,326	3,541	8,168	2,696	2,653	2,589	2,250
Arroyo Valle	*2,400*	*2,950*	*360*	*290*	*2,450*	*1,290*	*1,750*	*840*	*2,970*	*4,893*	*2,580*	*751*	*2,831*	*527*	*679*	*458*	*418*
Arroyo Mocho	*3,160*	*3,760*	*540*	*140*	*5,900*	*1,170*	*2,500*	*880*	*4,810*	*8,514*	*4,616*	*1,716*	*4,176*	*843*	*902*	*809*	*428*
Arroyo las Positas	*500*	*400*	*200*	*200*	*500*	*400*	*600*	*480*	*840*	*980*	*1,130*	*1,074*	*1,161*	*1,326*	*1,072*	*1,322*	*1,404*
Arroyo Valle Prior Rights	1,771	1,540	115	0	1,038	984	1,419	922	1,848	1,870	1,160	1,206	877	869	724	971	288
Rainfall Recharge	**3,031**	**2,523**	**0**	**0**	**4,398**	**2,002**	**3,891**	**967**	**11,423**	**16,357**	**3,110**	**1,249**	**9,008**	**290**	**398**	**283**	**141**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pipe Leakage	**31**	**37**	**44**	**51**	**60**	**71**	**82**	**95**	**109**	**124**	**139**	**155**	**169**	**185**	**200**	**217**	**233**
Applied Water Recharge	**2,738**	**2,477**	**3,158**	**3,022**	**2,795**	**3,041**	**2,727**	**2,089**	**1,360**	**1,344**	**2,162**	**1,884**	**1,904**	**1,860**	**2,004**	**1,630**	**1,694**
Urban - Municipal	1,074	766	1,354	1,375	1,087	1,179	810	1,284	668	690	1,253	1,027	998	1,328	1,377	1,053	1,025
Urban - Recycled Water	0	0	27	16	26	13	21	7	12	8	16	6	12	8	5	14	5
Agricultural - Municipal (SBA)	74	109	157	124	95	118	147	182	140	165	208	182	232	245	289	240	265
Agricultural - Groundwater	384	280	513	525	352	388	281	241	174	139	198	210	190	137	152	140	153
Golf Courses - Groundwater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golf Courses - Recycled Water	0	0	64	68	75	73	73	60	54	63	62	55	61	47	63	60	64
Others	1,206	1,322	1,042	915	1,160	1,270	1,394	315	312	279	425	404	411	95	118	123	182
Subsurface Basin Inflow	**1,000**	**1,000**	**1,010**	**1,790**	**1,230**	**990**	**650**	**630**	**630**	**430**	**650**	**750**	**740**	**770**	**920**	**1,160**	**1,260**
DEMAND	**18,618**	**15,929**	**15,432**	**14,636**	**12,871**	**15,819**	**15,727**	**19,349**	**18,349**	**26,220**	**19,750**	**18,506**	**22,550**	**14,575**	**17,176**	**16,143**	**16,045**
Municipal Pumpage	**11,806**	**9,881**	**7,782**	**6,721**	**7,022**	**8,207**	**6,982**	**7,361**	**7,281**	**7,965**	**8,473**	**7,990**	**8,652**	**8,152**	**9,431**	**10,393**	**11,255**
Zone 7 (excluding DSRSD)	5,403	3,090	1,292	309	776	816	41	0	0	25	348	1,199	1,163	480	2,017	3,213	3,327
Zone 7 for DSRSD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
City of Pleasanton	2,264	2,497	1,707	3,271	2,640	3,273	2,961	3,089	3,565	3,886	3,486	3,056	3,705	3,310	3,548	3,316	3,856
Cal. Water Service	2,612	2,852	2,781	1,312	1,964	2,358	2,489	2,695	2,286	2,660	3,035	2,788	2,774	3,276	2,761	2,850	3,073
Camp Parks	769	808	980	925	796	881	819	808	713	630	647	40	0	0	0	0	0
SFWD	302	242	495	374	397	413	372	402	348	321	378	353	484	491	472	443	362
Fairgrounds	200	200	200	200	200	200	200	267	217	242	281	272	280	280	280	280	280
Domestic	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Golf Courses	156	92	227	230	149	166	0	0	52	101	198	182	146	215	253	191	257
3S/1E 1P3	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*46*
Castlewood	*156*	*92*	*227*	*230*	*149*	*166*	*0*	*0*	*52*	*101*	*198*	*182*	*146*	*215*	*253*	*191*	*211*
Tri-Valley Golf	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Agricultural Pumpage	**3,744**	**2,217**	**4,596**	**4,970**	**3,191**	**3,711**	**2,628**	**2,433**	**1,295**	**1,342**	**1,556**	**1,914**	**1,911**	**1,470**	**1,476**	**1,166**	**1,478**
SFWD	500	0	62	304	252	365	168	513	150	549	107	410	543	663	493	359	548
Concannon	6	15	20	20	20	70	250	112	0	0	68	0	60	26	59	0	0
Calculated	3,238	2,202	4,514	4,646	2,919	3,276	2,210	1,808	1,145	793	1,381	1,504	1,308	781	924	807	930
Mining Use	**3,068**	**3,831**	**3,054**	**2,945**	**2,658**	**3,751**	**5,586**	**9,005**	**7,613**	**13,953**	**7,481**	**7,402**	**11,387**	**4,353**	**5,869**	**4,484**	**3,312**
Stream Export	1,219	2,200	690	470	800	2,000	3,480	6,530	6,050	12,760	4,340	4,265	8,858	558	2,443	1,808	665
Discharges to Cope Lake	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Evaporation	1,149	931	1,664	1,775	1,158	1,051	1,406	1,775	863	493	2,441	2,437	1,829	3,095	2,726	1,976	1,947
Production	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
Subsurface Basin Overflow	**0**	**0**	**0**	**0**	**0**	**150**	**530**	**550**	**2,160**	**2,960**	**2,240**	**1,200**	**600**	**600**	**400**	**100**	**0**
NET RECHARGE (AF)	**-478**	**5,508**	**-4,311**	**-5,953**	**11,942**	**6,394**	**8,103**	**-528**	**11,593**	**9,192**	**-4,203**	**-9,722**	**-1,684**	**-7,906**	**-9,106**	**-4,973**	**-5,692**
INVENTORY STORAGE (AF)	**211,522**	**217,030**	**212,719**	**206,766**	**218,708**	**225,102**	**233,205**	**232,677**	**244,270**	**253,462**	**249,259**	**239,537**	**237,853**	**229,947**	**220,841**	**215,868**	**210,176**

STORAGE CALCULATION	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
INVENTORY (Rounded to TAF)	212	217	213	207	219	225	233	233	244	253	249	240	238	230	221	216	210
GW ELEVATIONS (Rounded to TAF)	213	215	226	216	210	228	239	246	241	254	258	250	240	231	217	214	210
AVERAGE STORAGE (TAF)	**212**	**216**	**219**	**211**	**214**	**227**	**236**	**239**	**243**	**254**	**253**	**245**	**239**	**230**	**219**	**215**	**210**
AVAILABLE STORAGE (TAF)	**84**	**88**	**91**	**83**	**86**	**99**	**108**	**111**	**115**	**126**	**125**	**117**	**111**	**102**	**91**	**87**	**82**

Artificial Components Natural Components

*Water Year Type (CDEC Sacramento Valley)
W = Wet; AN = Above Normal;
BN = Below Normal; D = Dry; C = Critical

TABLE 9-3
HISTORICAL GROUNDWATER STORAGE
HYDROLOGIC INVENTORY (HI) METHOD
1974-2020 WATER YEARS (in Acre-Feet, except where indicated)

COMPONENTS	WATER YEAR (Oct - Sep) 1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
INDICES																				
Rainfall at Livermore (in)	11.3	11.6	21.3	11.8	21.3	20.0	15.1	25.3	13.1	14.1	11.0	11.2	17.0	13.1	19.3	17.5	9.7	10.7	11.4	14.8
8 Station Rain Index (N. CA)(in)	32.2	36.0	65.3	31.8	85.4	61.3	68.8	82.4	54.8	56.7	33.0	46.3	59.7	47.3	57.4	80.1	37.3	34.9	46.8	53.6
Evap at Lake Del Valle (in)	64.7	68.2	64.2	65.5	58.3	71.6	69.5	57.2	61.0	68.3	68.5	73.2	69.9	72.1	63.6	68.6	68.9	72.7	71.6	64.0
Arroyo Valle Stream flow (AF)	9909	11692	52831	3424	67142	51058	54115	87819	15169	18949	8156	7848	19648	11410	26930	28325	2027	18059	11231	12914
Water Year Type*	C	C	AN	C	W	W	W	W	W	AN	D	D	AN	BN	AN	W	D	C	D	BN
SUPPLY	**12,715**	**10,610**	**28,529**	**16,095**	**29,095**	**22,556**	**24,184**	**27,853**	**20,780**	**23,211**	**15,691**	**24,052**	**29,840**	**19,778**	**31,021**	**23,960**	**14,998**	**16,258**	**18,659**	**25,382**
Injection Well Recharge	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**652**	**1,524**	**1,146**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Stream Recharge	**8,347**	**5,247**	**14,714**	**11,838**	**13,058**	**11,109**	**12,284**	**13,603**	**10,813**	**12,842**	**8,601**	**16,195**	**21,483**	**12,885**	**21,025**	**13,418**	**9,154**	**8,448**	**11,249**	**17,144**
Artificial Stream Recharge	3,261	914	5,621	7,883	4,672	2,968	5,314	2,343	5,174	8,019	3,428	10,588	11,409	8,084	11,143	4,583	4,811	2,229	3,984	6,773
Arroyo Valle	*82*	*412*	*1,182*	*798*	*179*	*144*	*1,827*	*413*	*1,181*	*890*	*1,476*	*1,831*	*1,547*	*1,670*	*2,277*	*1,216*	*2,879*	*2,229*	*2,104*	*2,459*
Arroyo Mocho	*3,178*	*502*	*4,439*	*7,085*	*4,493*	*2,824*	*3,487*	*1,930*	*3,993*	*7,129*	*1,930*	*8,755*	*9,862*	*6,414*	*8,698*	*3,205*	*1,932*	*0*	*1,880*	*4,314*
Arroyo las Positas	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*22*	*2*	*0*	*0*	*168*	*162*	*0*	*0*	*0*	*0*
Natural Stream Recharge	4,418	3,997	8,247	3,080	7,259	7,743	6,607	10,533	5,091	4,178	4,512	4,476	8,462	3,458	9,589	6,905	3,536	5,913	6,018	10,371
Arroyo Valle	*1,215*	*970*	*2,754*	*735*	*2,818*	*1,426*	*2,753*	*4,401*	*1,796*	*1,389*	*2,440*	*2,259*	*4,397*	*1,447*	*5,980*	*3,043*	*1,941*	*4,030*	*3,958*	*6,909*
Arroyo Mocho	*1,883*	*1,711*	*3,903*	*1,263*	*3,144*	*5,226*	*2,670*	*4,560*	*1,833*	*1,539*	*961*	*1,279*	*2,980*	*1,082*	*2,854*	*3,104*	*858*	*1,077*	*970*	*2,547*
Arroyo las Positas	*1,320*	*1,315*	*1,591*	*1,082*	*1,297*	*1,091*	*1,184*	*1,572*	*1,462*	*1,250*	*1,111*	*939*	*1,085*	*929*	*755*	*758*	*737*	*806*	*1,090*	*915*
Arroyo Valle Prior Rights	668	337	846	876	1,127	398	362	727	548	644	660	1,131	1,612	1,343	293	1,930	807	306	1,247	0
Rainfall Recharge	**1,838**	**1,760**	**10,761**	**1,242**	**13,243**	**8,176**	**8,634**	**10,692**	**5,540**	**5,924**	**3,644**	**4,239**	**4,899**	**3,192**	**6,378**	**6,969**	**1,987**	**3,782**	**3,375**	**4,315**
Lake Recharge	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Pipe Leakage	**249**	**267**	**285**	**304**	**324**	**344**	**365**	**387**	**410**	**434**	**461**	**490**	**518**	**548**	**579**	**610**	**642**	**675**	**708**	**742**
Applied Water Recharge	**602**	**1,766**	**1,440**	**1,621**	**1,480**	**2,007**	**2,221**	**1,709**	**1,743**	**1,960**	**1,985**	**2,129**	**1,940**	**2,153**	**2,039**	**1,962**	**2,214**	**2,353**	**2,327**	**2,181**
Urban - Municipal	222	1,288	1,108	1,252	1,060	1,467	1,632	1,472	1,549	1,743	1,770	1,888	1,749	1,926	1,834	1,747	1,983	2,124	2,064	1,894
Urban - Recycled Water	2	0	11	14	13	18	21	15	12	21	19	30	10	14	15	26	24	7	52	84
Agricultural - Municipal (SBA)	242	279	177	192	257	347	401	104	57	64	59	67	66	64	63	63	62	68	68	67
Agricultural - Groundwater	109	133	96	100	92	100	109	26	11	12	11	13	12	12	12	12	12	13	13	12
Golf Courses - Groundwater	0	0	0	0	0	0	0	42	49	55	56	60	56	61	58	56	63	68	65	60
Golf Courses - Recycled Water	26	66	48	63	58	75	58	50	65	66	69	72	47	75	58	59	71	74	66	64
Others	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsurface Basin Inflow	**1,680**	**1,570**	**1,330**	**1,090**	**990**	**920**	**680**	**810**	**750**	**906**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
DEMAND	**21,104**	**17,237**	**13,555**	**15,503**	**16,064**	**20,683**	**25,574**	**25,342**	**25,691**	**26,885**	**27,357**	**23,991**	**21,531**	**24,338**	**17,828**	**15,169**	**18,636**	**19,269**	**23,656**	**21,091**
Municipal Pumpage	**17,355**	**13,331**	**9,132**	**6,499**	**4,594**	**6,324**	**8,824**	**10,264**	**11,832**	**15,520**	**17,806**	**19,307**	**17,123**	**19,635**	**14,686**	**11,697**	**12,681**	**13,516**	**18,022**	**16,064**
Zone 7 (excluding DSRSD)	8,119	5,136	2,215	213	368	2,388	1,565	1,682	4,912	6,140	9,864	11,047	7,734	11,175	6,213	3,157	4,146	6,210	9,439	8,274
Zone 7 for DSRSD	0	0	0	0	0	0	0	0	0	0	0	0	645	645	645	645	645	645	645	645
City of Pleasanton	4,164	3,368	3,252	2,578	1,262	1,333	3,208	3,935	2,563	4,558	3,112	3,579	3,674	3,688	3,604	3,587	3,638	2,387	3,660	3,280
Cal. Water Service	3,966	3,744	2,570	2,626	2,053	1,551	2,947	3,595	3,271	3,567	3,707	3,458	3,979	2,911	3,166	3,106	2,971	3,143	3,123	2,844
Camp Parks	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFWD	408	410	414	396	370	411	477	460	380	532	472	448	423	481	436	467	494	492	446	417
Fairgrounds	346	336	282	325	285	343	342	230	333	369	318	423	327	365	284	441	443	289	335	284
Domestic	100	113	113	116	116	117	117	113	116	109	109	134	134	167	131	93	96	109	123	112
Golf Courses	252	222	286	245	139	182	169	249	256	245	223	218	208	203	207	199	249	241	250	208
3S/1E 1P3	*101*	*36*	*138*	*36*	*41*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Castlewood	*151*	*186*	*131*	*186*	*82*	*159*	*146*	*236*	*235*	*223*	*193*	*193*	*193*	*173*	*191*	*177*	*222*	*213*	*222*	*188*
Tri-Valley Golf	*0*	*0*	*17*	*23*	*16*	*23*	*23*	*13*	*21*	*22*	*30*	*25*	*15*	*30*	*16*	*22*	*27*	*28*	*28*	*20*
Agricultural Pumpage	**382**	**355**	**213**	**218**	**150**	**212**	**266**	**73**	**81**	**231**	**227**	**119**	**93**	**92**	**88**	**88**	**87**	**96**	**95**	**94**
SFWD	20	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concannon	11	0	0	0	0	0	0	0	0	140	143	25	0	2	0	0	0	0	0	0
Calculated	351	346	213	218	150	212	266	73	81	91	84	94	93	91	88	88	87	96	95	94
Mining Use	**3,367**	**3,551**	**4,210**	**8,786**	**11,120**	**13,381**	**15,724**	**14,255**	**13,416**	**11,010**	**9,324**	**4,564**	**4,314**	**4,610**	**3,055**	**3,385**	**4,947**	**4,452**	**5,346**	**4,934**
Stream Export	639	712	2,219	6,070	9,071	10,577	12,661	12,617	10,082	7,827	5,461	143	0	163	150	487	594	523	1,493	1,996
Discharges to Cope Lake	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Evaporation	2,028	2,139	1,291	2,016	1,349	2,104	2,363	938	2,634	2,483	3,163	3,951	3,764	3,762	2,205	2,198	3,653	3,230	3,153	2,238
Production	700	700	700	700	700	700	700	700	700	700	700	470	550	686	700	700	700	700	700	700
Subsurface Basin Overflow	**0**	**0**	**0**	**0**	**200**	**766**	**760**	**750**	**362**	**125**	**0**	**0**	**0**	**0**	**0**	**0**	**921**	**1,205**	**194**	**0**
NET RECHARGE (AF)	**-8,389**	**-6,628**	**14,974**	**592**	**13,031**	**1,873**	**-1,390**	**2,511**	**-4,911**	**-3,674**	**-11,666**	**62**	**8,309**	**-4,560**	**13,193**	**8,790**	**-3,639**	**-3,011**	**-4,997**	**4,290**
INVENTORY STORAGE (AF)	**201,787**	**195,159**	**210,133**	**210,725**	**223,756**	**225,629**	**224,239**	**226,750**	**221,839**	**218,165**	**206,499**	**206,561**	**214,870**	**210,310**	**223,503**	**232,293**	**228,654**	**225,643**	**220,646**	**224,936**

STORAGE CALCULATION	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
INVENTORY (Rounded to TAF)	202	195	210	211	224	226	224	227	222	218	206	207	215	210	224	232	229	226	221	225
GW ELEVATIONS (Rounded to TAF)	195	184	211	216	225	223	222	225	222	222	203	212	220	213	236	238	232	235	233	234
AVERAGE STORAGE (TAF)	**198**	**189**	**210**	**213**	**225**	**224**	**223**	**226**	**222**	**220**	**205**	**209**	**218**	**212**	**230**	**235**	**230**	**230**	**227**	**229**
AVAILABLE STORAGE (TAF)	**70**	**61**	**82**	**85**	**97**	**96**	**95**	**98**	**94**	**92**	**77**	**81**	**90**	**84**	**102**	**107**	**102**	**102**	**99**	**101**

Artificial Components | Natural Components

*Water Year Type (CDEC Sacramento Valley)
W = Wet; AN = Above Normal;
BN = Below Normal; D = Dry; C = Critical

TABLE 9-3
HISTORICAL GROUNDWATER STORAGE
HYDROLOGIC INVENTORY (HI) METHOD
1974-2020 WATER YEARS (in Acre-Feet, except where indicated)

	WATER YEAR (Oct - Sep)										1974 - 2020		
COMPONENTS	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**AVG**	**Sust Avg**	**TOTAL**
INDICES													
Rainfall at Livermore (in)	16.2	8.8	10.7	6.8	13.1	15.4	25.6	12.4	17.1	10.5	14		
8 Station Rain Index (N. CA)(in)	72.8	41.5	46.3	31.3	37.2	57.8	94.6	40.9	70.7	31.7	53		
Evap at Lake Del Valle (in)	64.5	73.2	73.9	78.3	73.6	72.6	69.3	73.4	72.8	76.4	67		
Arroyo Valle Stream flow (AF)	28634	1557	7801	272	2217	19436	89173	2783	36944	2397	24892		**1169933**
Water Year Type*	W	BN	D	C	C	BN	W	BN	W	C			
SUPPLY	**27,315**	**18,442**	**20,158**	**10,452**	**18,753**	**28,293**	**38,895**	**17,164**	**23,625**	**13,515**	**20,165**	**19,800**	**947,750**
Injection Well Recharge	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**71**	**0**	**3,322**
Stream Recharge	**17,595**	**12,734**	**13,457**	**5,820**	**11,469**	**18,083**	**20,495**	**9,560**	**10,605**	**5,972**	**11,927**	**11,900**	**560,552**
Artificial Stream Recharge	4,555	8,778	7,887	3,826	3,766	8,910	9,615	6,773	2,943	2,461	5,309	5,300	249,528
Arroyo Valle	*768*	*3,613*	*1,916*	*924*	*3,718*	*3,983*	*3,271*	*3,778*	*2,168*	*2,045*	*1,799*	*1,640*	*84,555*
Arroyo Mocho	*3,671*	*5,059*	*5,961*	*2,844*	*0*	*4,927*	*6,344*	*2,995*	*775*	*416*	*3,400*	*3,530*	*159,802*
Arroyo las Positas	*116*	*106*	*10*	*58*	*48*	*0*	*0*	*0*	*0*	*0*	*110*	*130*	*5,172*
Natural Stream Recharge	11,272	3,355	4,200	1,987	6,822	8,289	10,433	1,938	6,439	2,595	5,715	5,700	268,614
Arroyo Valle	*8,540*	*1,676*	*2,790*	*891*	*4,567*	*4,749*	*6,053*	*740*	*3,419*	*793*	*2,539*	*1,800*	*119,315*
Arroyo Mocho	*2,293*	*1,225*	*838*	*587*	*1,748*	*2,794*	*3,775*	*590*	*2,393*	*1,072*	*2,290*	*2,600*	*107,624*
Arroyo las Positas	*439*	*454*	*572*	*509*	*507*	*746*	*605*	*608*	*627*	*730*	*887*	*1,300*	*41,675*
Arroyo Valle Prior Rights	1,768	601	1,370	7	881	884	447	849	1,223	916	902	900	42,409
Rainfall Recharge	**5,771**	**1,462**	**2,708**	**1,075**	**3,735**	**6,554**	**14,087**	**3,220**	**8,588**	**2,869**	**4,675**	**4,300**	**219,730**
Lake Recharge	*0*	*0*	*0*	*2,428*	*4,322*	*6,785*	*13,029*	*15,003*	*13,248*	*7,529*	*1,326*	*NA*	*62,343*
Pipe Leakage	**776**	**811**	**847**	**884**	**921**	**958**	**996**	**1,034**	**1,146**	**1,209**	**445**	**1,000**	**20,922**
Applied Water Recharge	**2,172**	**2,435**	**2,147**	**1,674**	**1,629**	**1,697**	**2,316**	**2,350**	**2,286**	**2,465**	**2,061**	**1,600**	**96,889**
Urban - Municipal	1,849	2,061	1,750	1,229	1,143	1,312	1,957	2,020	1,956	2,109	1,436	1,280	67,505
Urban - Recycled Water	133	159	189	220	275	160	147	106	119	129	48	26	2,242
Agricultural - Municipal (SBA)	61	68	64	66	61	88	77	80	80	80	137	92	6,461
Agricultural - Groundwater	11	13	7	20	18	15	14	14	14	14	117	12	5,504
Golf Courses - Groundwater	59	65	62	66	67	65	61	63	61	66	29	146	1,384
Golf Courses - Recycled Water	59	70	75	73	65	59	60	66	57	67	60	44	2,819
Others	0	0	0	0	0	0	0	0	0	0	233	0	10,973
Subsurface Basin Inflow	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**986**	**1,000**	**46,336**
DEMAND	**20,421**	**28,880**	**25,700**	**22,604**	**12,717**	**12,888**	**13,636**	**16,879**	**19,142**	**21,447**	**19,415**	**18,800**	**912,518**
Municipal Pumpage	**13,430**	**20,463**	**16,823**	**16,662**	**8,284**	**9,176**	**10,714**	**11,966**	**14,635**	**16,349**	**11,661**	**13,700**	**548,071**
Zone 7 (excluding DSRSD)	5,618	11,461	8,909	8,137	1,920	1,357	3,243	4,215	8,021	11,101	4,202	5,300	197,479
Zone 7 for DSRSD	646	644	646	645	645	645	645	645	645	645	247	645	11,611
City of Pleasanton	3,435	3,900	3,301	3,740	2,775	3,752	4,222	3,913	3,785	2,701	3,264	3,500	153,386
Cal. Water Service	2,673	3,333	2,770	3,085	2,012	2,575	1,878	2,389	1,296	904	2,761	3,070	129,780
Camp Parks	0	0	0	0	0	0	0	0	0	0	188	0	8,819
SFWD	442	482	482	398	309	286	214	253	286	322	403	450	18,956
Fairgrounds	301	318	350	286	268	231	208	196	270	321	288	310	13,527
Domestic	107	90	105	115	112	110	107	115	116	108	109	200	5,123
Golf Courses	208	236	260	257	243	220	198	240	216	247	200	225	9,390
3S/1E 1P3	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*8*	*0*	*397*
Castlewood	*187*	*214*	*233*	*227*	*213*	*195*	*176*	*218*	*194*	*225*	*178*	*205*	*8,351*
Tri-Valley Golf	*21*	*22*	*27*	*30*	*30*	*25*	*22*	*22*	*22*	*22*	*14*	*20*	*642*
Agricultural Pumpage	**85**	**95**	**486**	**640**	**590**	**115**	**109**	**113**	**113**	**112**	**996**	**400**	**46,818**
SFWD	0	0	0	0	0	0	0	0	0	0	128	0	6,015
Concannon	0	0	0	0	0	0	0	0	0	0	22	0	1,047
Calculated	85	95	486	640	590	115	109	113	113	112	846	400	39,756
Mining Use	**6,906**	**8,322**	**8,391**	**5,302**	**3,843**	**3,597**	**2,813**	**4,236**	**3,585**	**4,840**	**6,369**	**4,600**	**299,337**
Stream Export	4,277	4,676	4,796	850	0	0	0	0	0	0	3,345	700	157,219
Discharges to Cope Lake	*0*	*0*	*0*	*5,420*	*4,890*	*7,700*	*13,452*	*15,562*	*13,864*	*7,906*	*1,464*	*NA*	*68,793*
Evaporation	1,929	2,946	2,895	3,752	3,143	2,897	2,113	3,536	2,885	4,140	2,332	3,200	109,612
Production	700	700	700	700	700	700	700	700	700	700	692	700	32,506
Subsurface Basin Overflow	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**564**	**809**	**146**	**389**	**100**	**18,292**
NET RECHARGE (AF)	**6,893**	**-10,438**	**-5,542**	**-12,153**	**6,037**	**15,405**	**25,259**	**285**	**4,482**	**-7,932**	**750**	**1,000**	**35,232**
INVENTORY STORAGE (AF)	**231,829**	**221,391**	**215,849**	**203,696**	**209,733**	**225,138**	**250,397**	**250,682**	**255,164**	**247,232**	**223,876**	**13,400**	

STORAGE CALCULATION	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
INVENTORY (Rounded to TAF)	232	221	216	204	210	225	250	251	255	247
GW ELEVATIONS (Rounded to TAF)	235	228	221	210	215	227	246	246	249	232
AVERAGE STORAGE (TAF)	**233**	**225**	**218**	**207**	**212**	**226**	**248**	**248**	**252**	**239**
AVAILABLE STORAGE (TAF)	**105**	**97**	**90**	**79**	**84**	**98**	**120**	**120**	**124**	**111**

Artificial Components | Natural Components

*Water Year Type (CDEC Sacramento Valley)
W = Wet; AN = Above Normal;
BN = Below Normal; D = Dry; C = Critical

TABLE 9-4
PROJECTED WHOLESALE WATER SUPPLIES
FOR MODEL SCENARIO
LIVERMORE VALLEY GROUNDWATER BASIN

Water Supply		Projected Water Supply				
		2025	2030	2035	2040	2045
Purchased or Imported Water	SWP Table A[a]	47,000	46,000	45,000	43,500	43,500
Purchased or Imported Water	Yuba Accord (available mainly in dry years)	0	0	0	0	0
Supply from Storage	SWP Carryover[b]	10,000	10,000	10,000	10,000	10,000
Surface water (not desalinated)	Arroyo Valle[c]	5,500	5,500	5,500	5,500	5,500
Groundwater (not desalinated)	Main Basin	9,200	9,200	9,200	9,200	9,200
Supply from Storage	Semitropic (used mainly in dry years)	0	0	0	0	0
Supply from Storage	Cawelo (used mainly in dry years)	0	0	0	0	0
Other	SWP/Other Transfer[d]	5,000	5,000			
Other	BARDP or Potable Reuse[e]		5,000	5,000	5,000	5,000
Purchased or Imported Water	Sites Reservoir[f]		10,000	10,000	10,000	10,000
	Total	76,700	90,700	84,700	83,200	83,200

NOTES: Volumes are in AF.
a. Based on the 2019 Delivery Capability Report. "Existing" assumed for 2020, the "Future" applied to 2040; years in between were interpolated. The effect of the Delta Conveyance Project on water supply yield is still being analyzed and has not been included here.
b. Zone 7 regulalry carries over SWP water from year to year, targeting approximately 10,000 AFY.
c. Arroyo Valle: From 2019 Water Supply Evaluation, observed ten-year (2008 to 2017) average was 6,200 AFY, reduced to 5,500 AFY to reflect climate change impacts. This will be refined as more information on the role of the Chain of Lakes on capturing Arroyo Valle water is developed over the coming years.
d. Zone 7 is pursuing water transfer agreements for the period through 2030.
e. These projects are under consideration as potential components of Zone 7's future water supply portfolio.
f. Zone 7 is currently participating in the planning phase of Sites Reservoir at a level of 10,000 AFY of average yield.

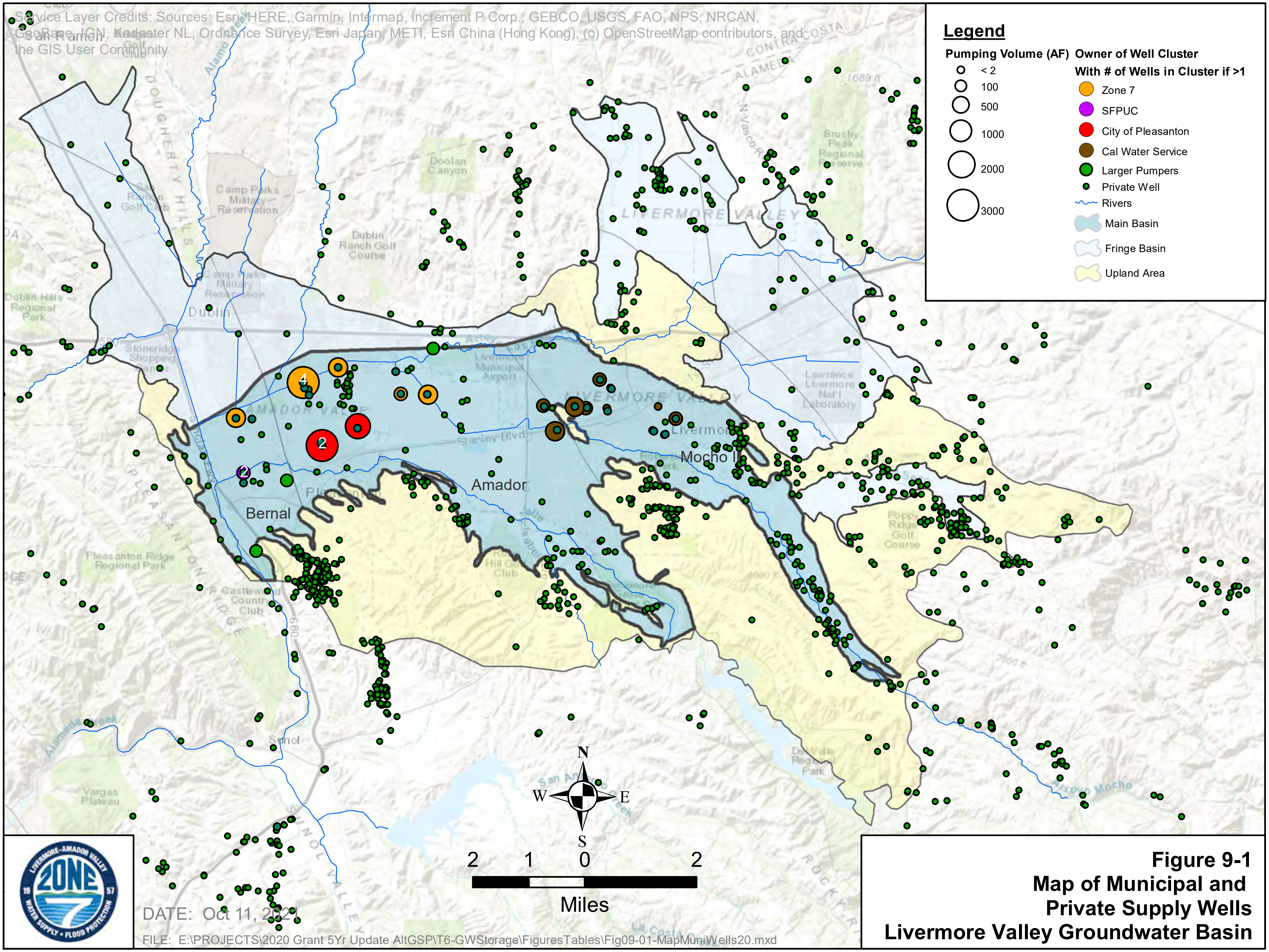
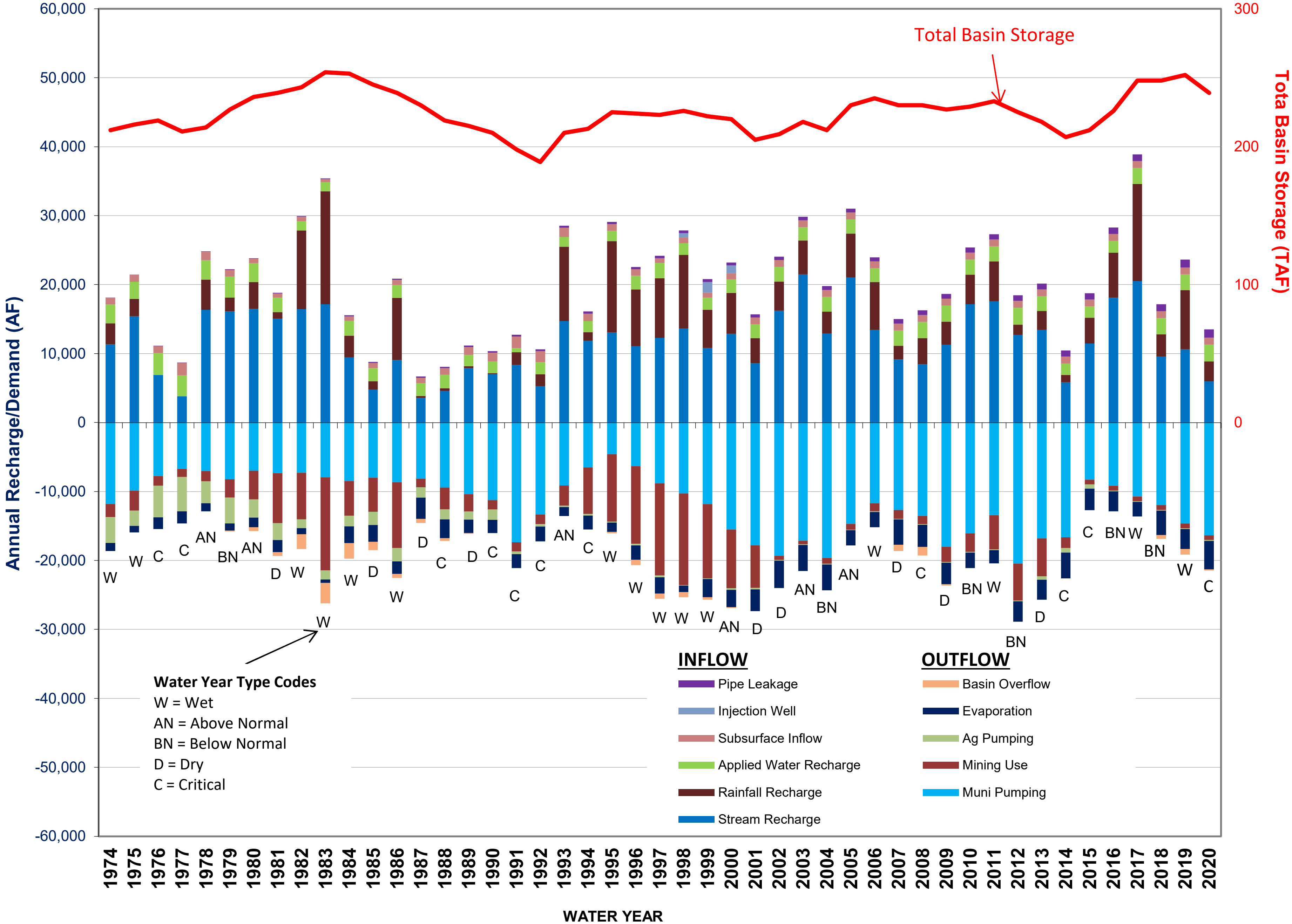


Figure 9-1
Map of Municipal and Private Supply Wells
Livermore Valley Groundwater Basin

FIGURE 9-2
GRAPH OF HYDROLOGIC INVENTORY 1974 - 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN



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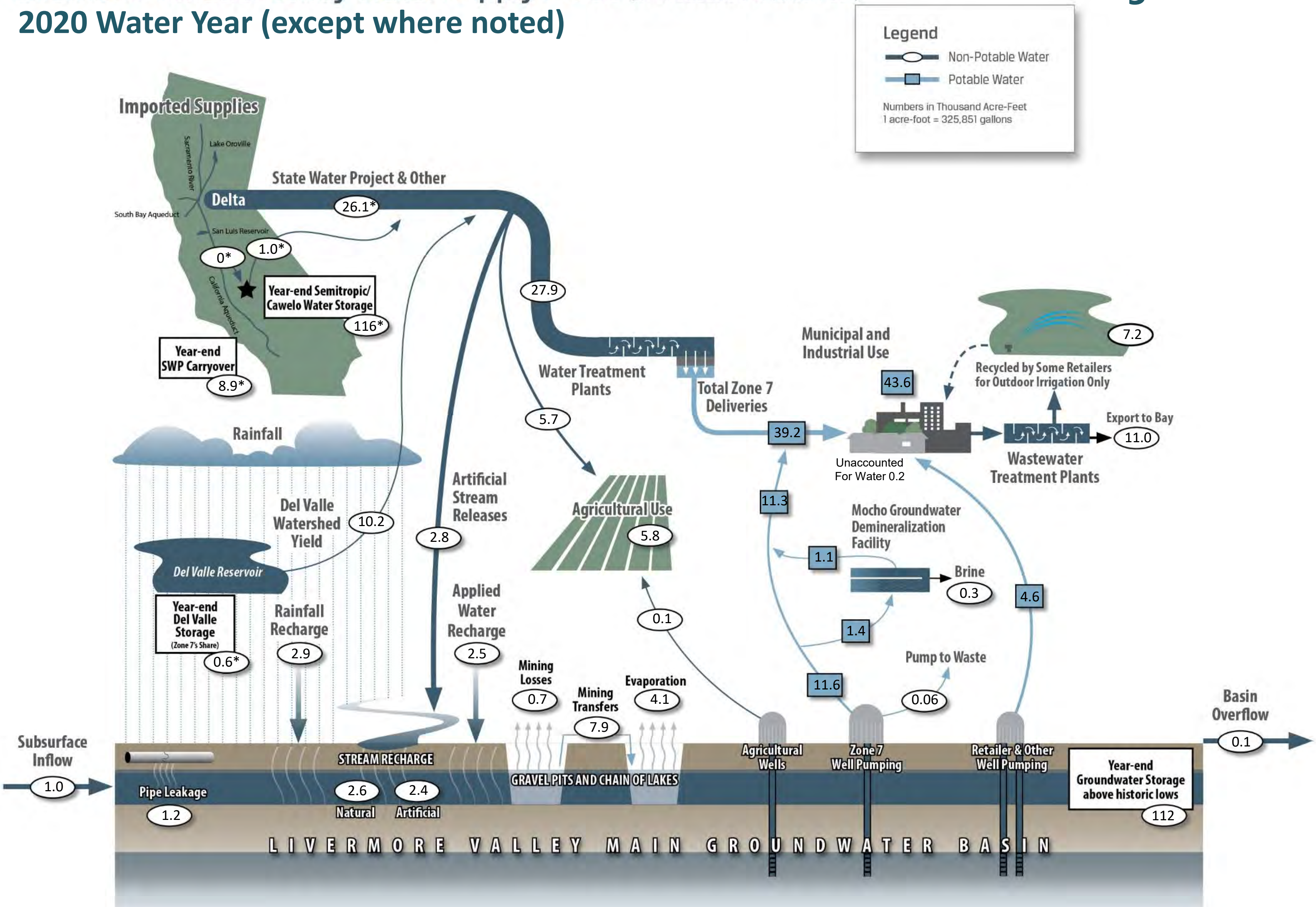
10/11/2021

Livermore-Amador Valley Water Supply & Use (in Thousands of Acre-Feet)

Figure 9-3

2020 Water Year (except where noted)



* 2020 Calendar Year

FIGURE 9-4
GRAPH OF SURFACE WATER INFLOWS/OUTFLOWS
2005 - 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN

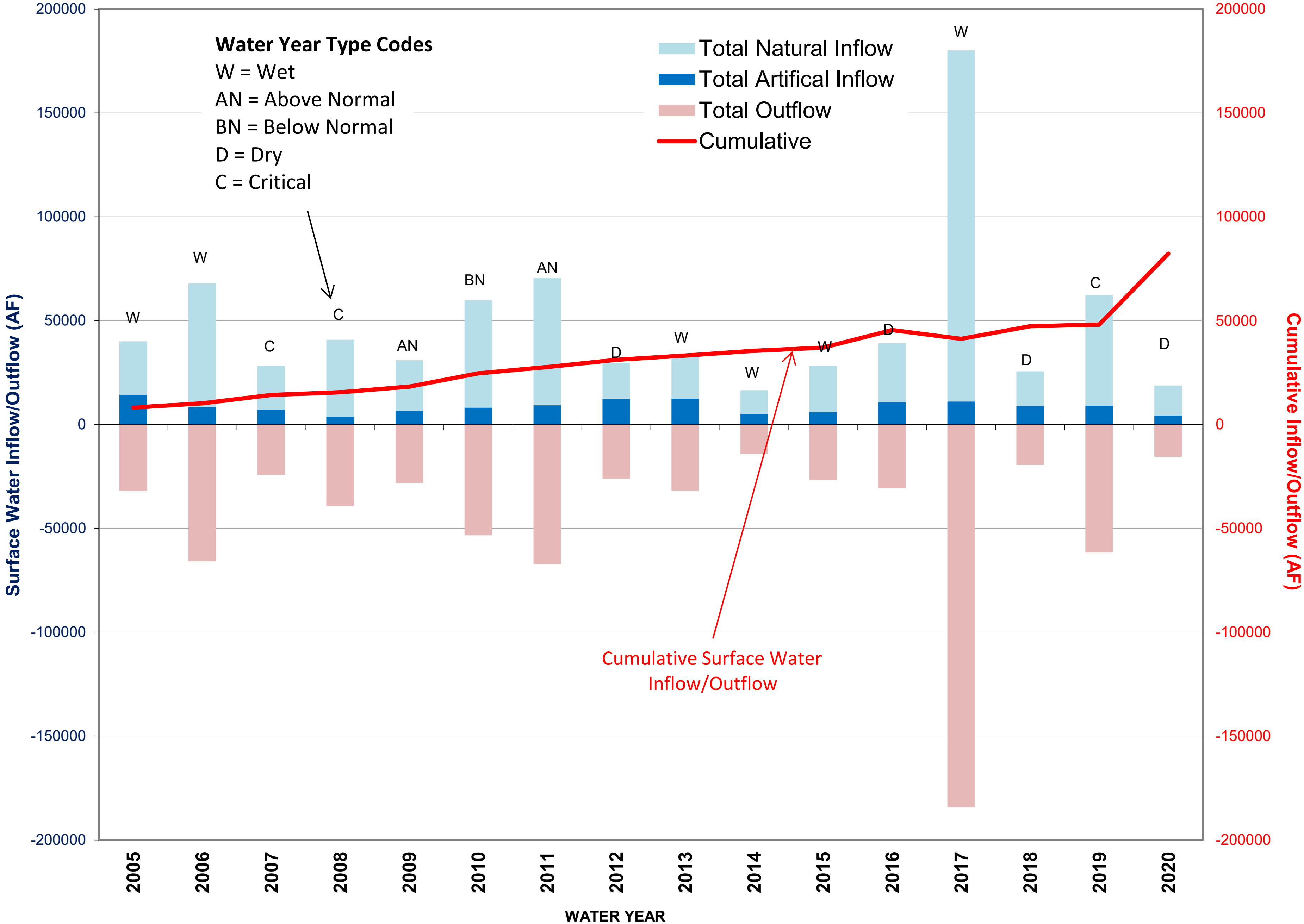


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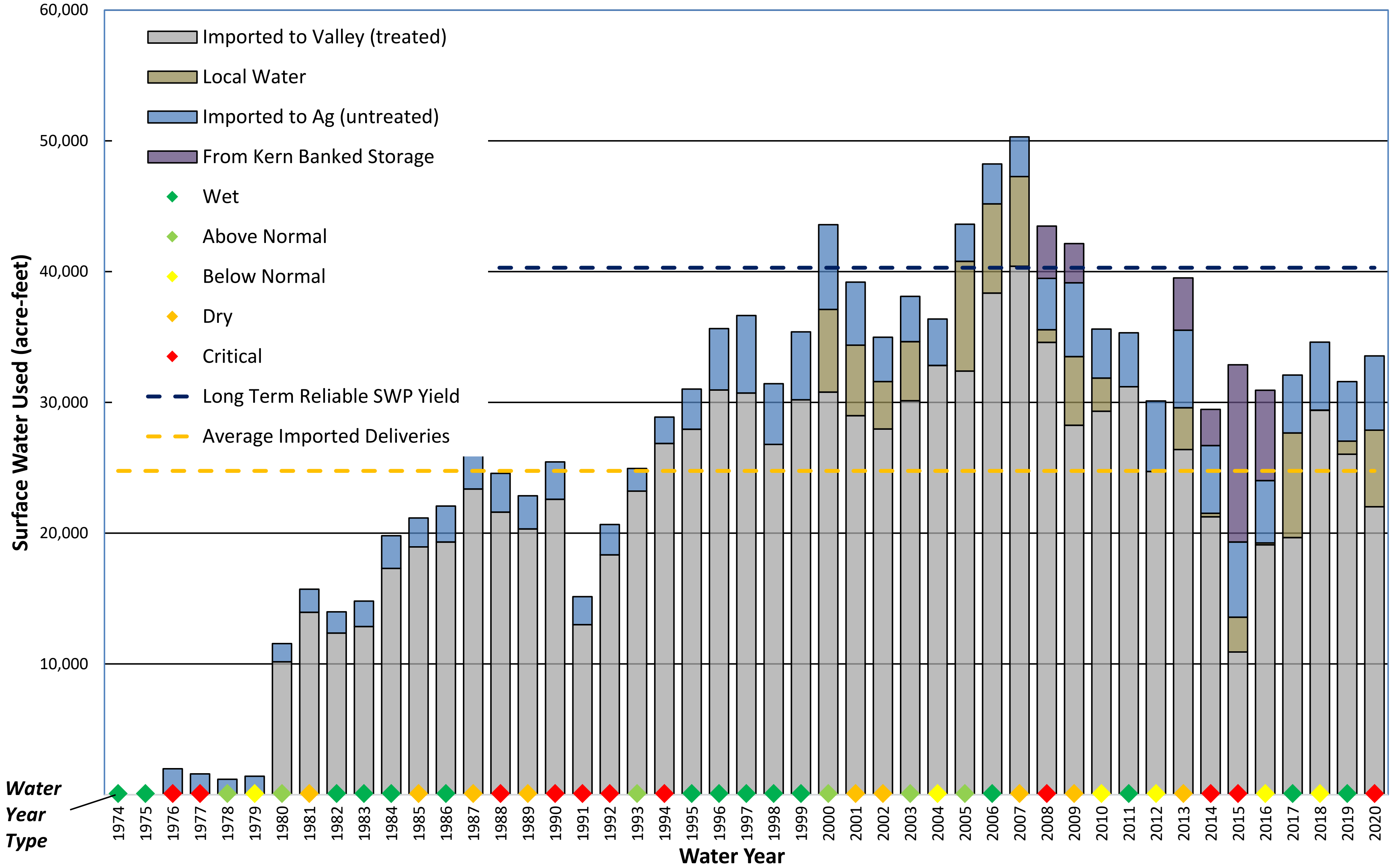
FIGURE 9-5
IMPORTED SURFACE WATER SUPPLIES
1974 TO 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN



12/1/2021
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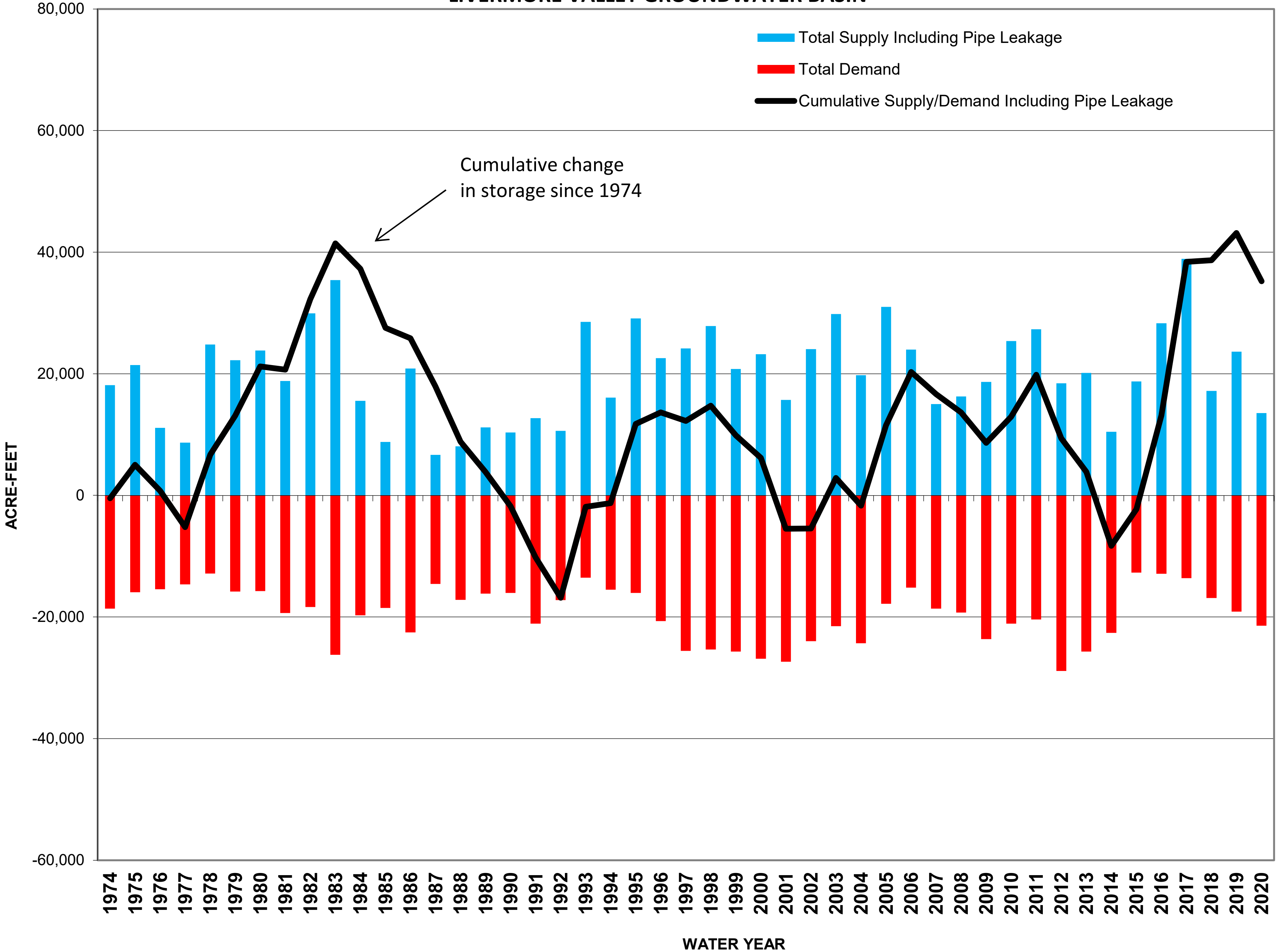
FIGURE 9-6

GRAPH OF ANNUAL AND CUMULATIVE GROUNDWATER INFLOWS AND OUTFLOWS

1974 - 2020 WATER YEARS

LIVERMORE VALLEY GROUNDWATER BASIN



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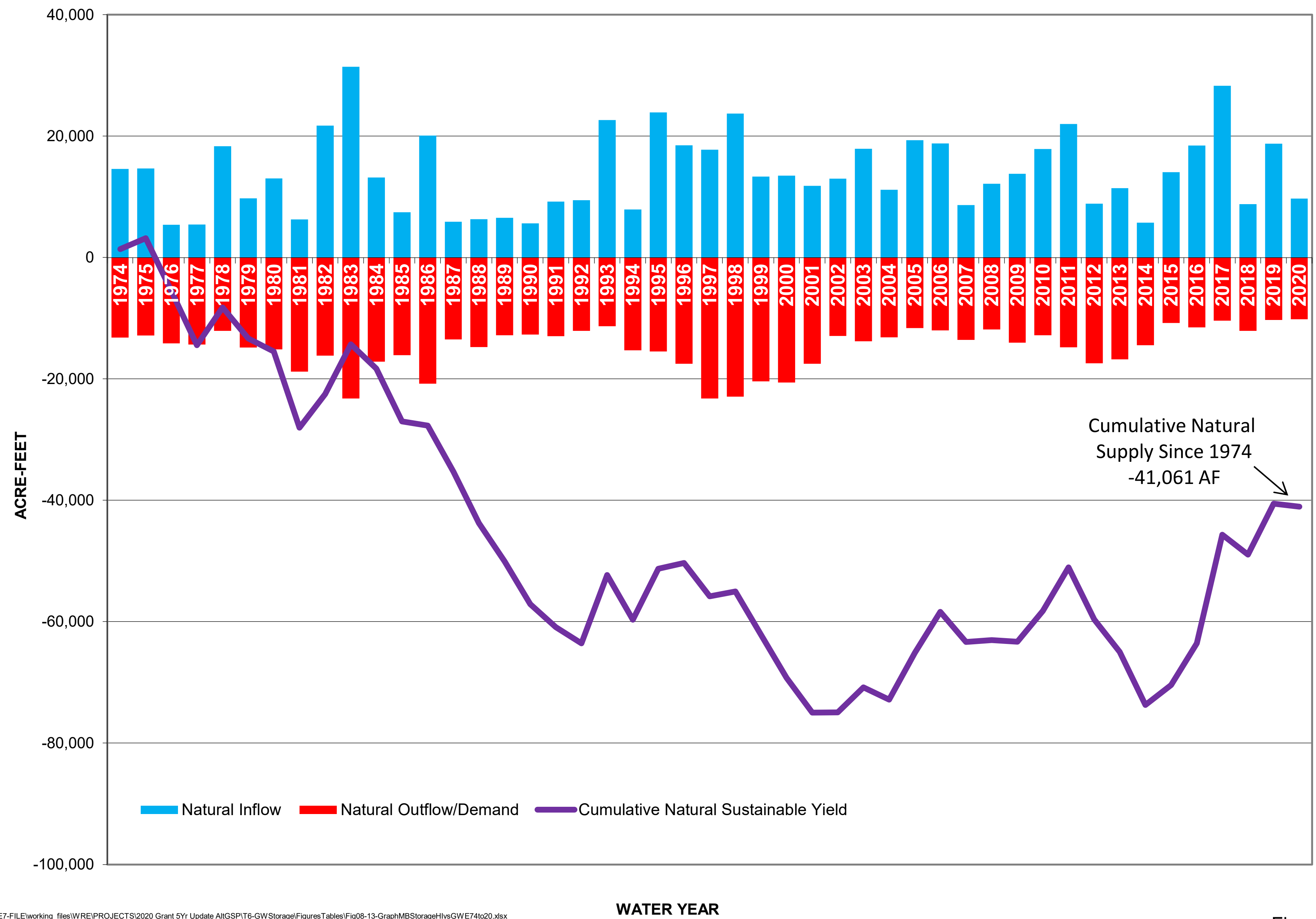
10/12/2021

FIGURE 9-7
GRAPH OF ANNUAL AND CUMULATIVE NATURAL INFLOWS AND OUTFLOWS
1974 - 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN



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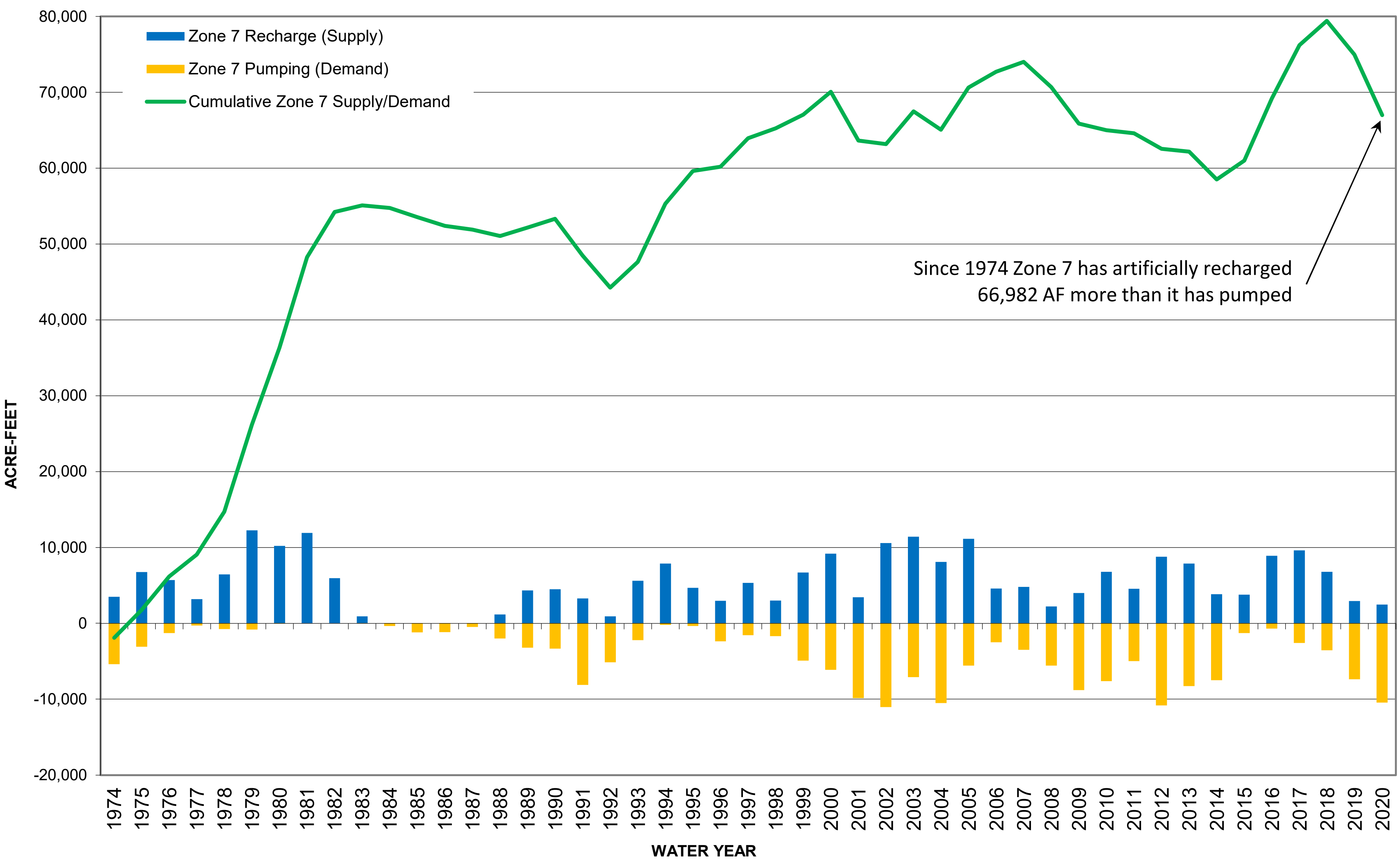
10/12/2021

FIGURE 9-8
GRAPH OF CUMULATIVE CONJUNCTIVE USE SUPPLY AND DEMAND SINCE 1974 WY
LIVERMORE VALLEY GROUNDWATER BASIN



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12/1/2021

FIGURE 9-9
CUMULATIVE CHANGE IN NATURAL AND ARTIFICIAL RECHARGE AND DEMAND 1974 - 2020 WATER YEARS
LIVERMORE VALLEY GROUNDWATER BASIN

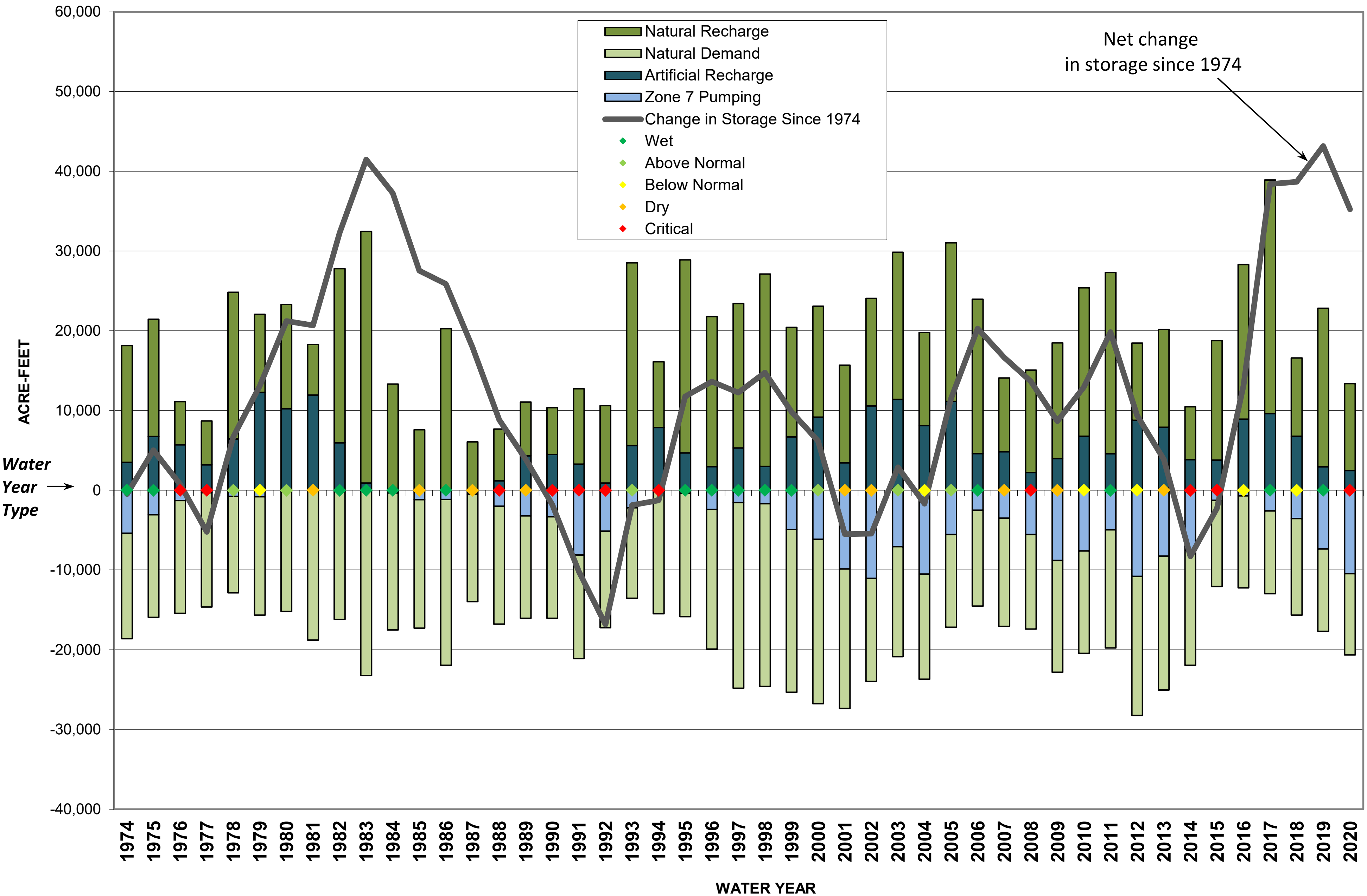

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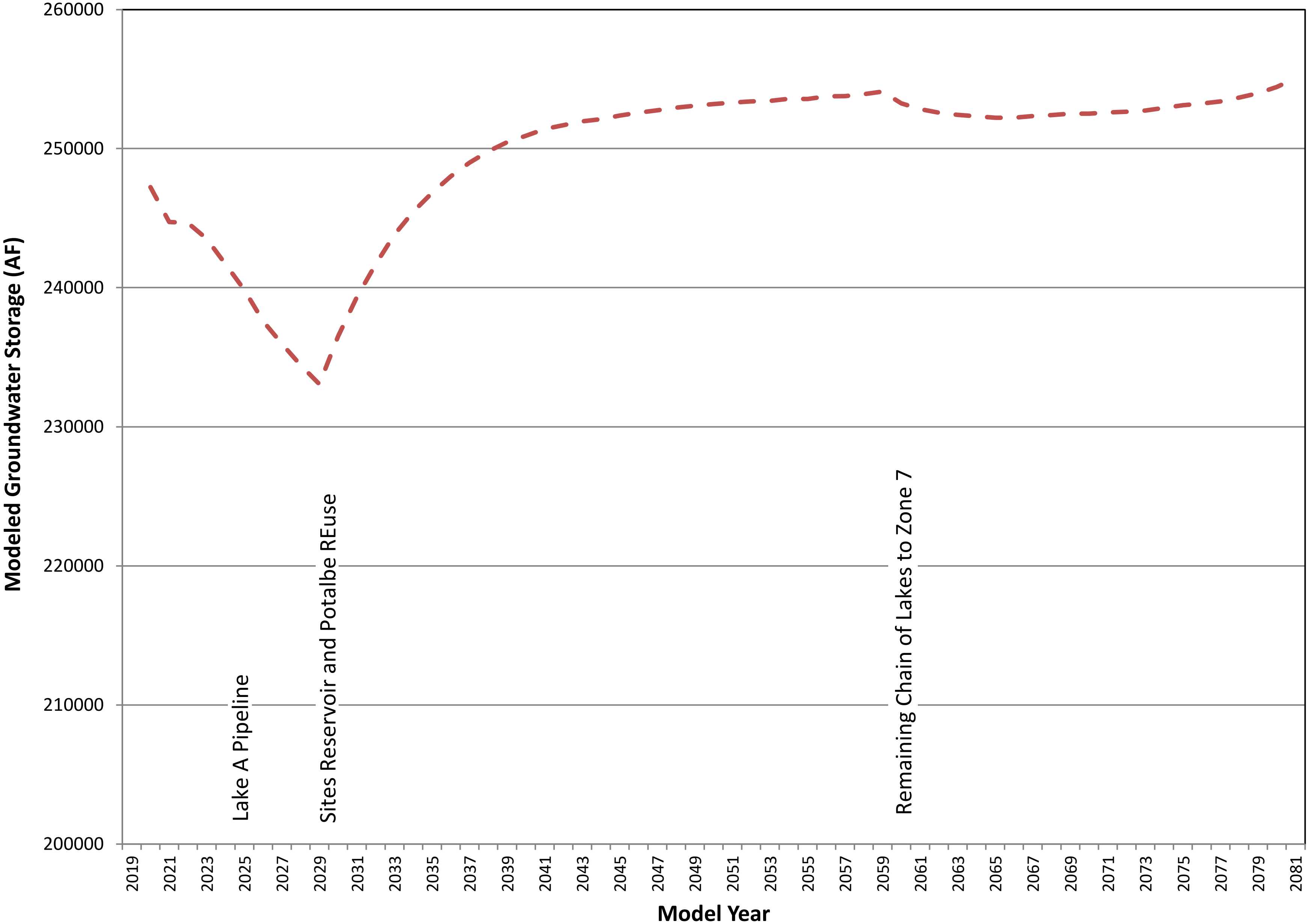
FIGURE 9-10
MODELED MAIN BASIN STORAGE
2020 to 2081 WATER YEARS



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10/12/2021

10. MANAGEMENT AREAS

§ 354.20. Management Areas
(a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.

☑ 23 CCR § 354.20(a)

For purposes of groundwater management, the Livermore Valley Groundwater Basin (Basin) has been divided by The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) into three Management Areas (and additional subareas). The Main Basin, Fringe, and Upland Management Areas are shown on **Figure 10-1** and listed in **Table 10-A**. The Management Areas are defined based on the following factors:

- Significant differences in geologic and aquifer characteristics (e.g., thickness, yield, quality) and groundwater use (i.e., volume of groundwater pumping) (see **Sections 7** through **9**);
- Land use characteristics (see **Section 5**); and,
- Degree of active groundwater management conducted by Zone 7 (see **Sections 5** and **15**).

Table 10-A: Basin Management Areas

Management Area	Area (acres)	General Description
Main Basin	19,809	Central portion of the Basin (i.e., the Livermore Valley); Includes the Castle, Bernal, Amador, and Mocho II Subareas; Highly urbanized land use; Upper and Lower Aquifers are actively managed for water supply benefits by Zone 7.
Fringe	21,956	Edges of the Basin and Livermore Valley; Includes the North Fringe (Bishop, Dublin, Camp Subareas), Northeast Fringe (Mocho I, Spring, Altamont, May, Vasco, and Cayetano Subareas) and East Fringe (Mocho I Subareas) Areas; Urban, agricultural, and open space land uses; limited groundwater use and management by Zone 7.
Upland	27,778	Edges of the Basin (i.e., gently sloping Livermore Valley wall); Low density residential, agricultural, and open space land uses; very limited groundwater use and management by Zone 7.
Total	**69,557**	

10.1. Description and Justification

§ 354.20. Management Areas
(a) A basin that includes one or more management areas shall describe the following in the Plan:
(1) The reason for the creation of each management area.
(b) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

☑ **23 CCR § 354.20(b)(1)**
☑ **23 CCR § 354.20(c)**

The unique characteristics of each Management Area are described below.

10.1.1. Main Basin Management Area

10.1.1.1. Hydrogeologic Description

The Main Basin Management Area (Main Basin) covers 19,809 acres within the center of the Basin (i.e., the Livermore Valley or Valley) and contains the thickest alluvial deposits, the highest-yielding aquifers, and the best quality groundwater within the Basin. As described in **Section 7,** the Main Basin contains up to over 800 feet of highly transmissive alluvial deposits spanning multiple geologic formations, including Holocene and Quaternary alluvial deposits as well as productive deposits of the upper Livermore Formation. The Principal Aquifer units of the Main Basin (i.e., the Upper Aquifer and Lower Aquifer) are considered to have very limited hydraulic connectivity to those of the Fringe and Upland Management Areas (Fringe and Upland Areas). As described in **Section 8,** the Main Basin contains the highest quality groundwater within the Basin and includes the majority of usable groundwater storage. As described in **Section 9**, the Main Basin supports most of the groundwater production within the Basin, with all municipal supply wells screened through the Lower Aquifer.

10.1.1.2. Land Use

As described in **Section 5** and shown on **Figure 5-1**, the Main Basin includes the highly urbanized Valley floor and the City of Pleasanton, the western portion of the City of Livermore, and the southern portion of the City of Dublin. The Main Basin also includes the Arroyo Valle and Arroyo Mocho stream corridors, through which Zone 7's artificial recharge operations occur (see **Sections 5** and **15**). The active mining operations related to the Chain-of-Lakes (COL) also exist within the Main Basin. As of 2020, approximately 56% (11,070 acres) of Main Basin lands were classified as urban, 27% (5,290 acres) as open space (including mining area pits), 11% (2,160 acres) as agricultural, and 7% (1,290 acres) as surface water bodies (including the COL).

10.1.1.3. Zone 7 Management

As described in **Section 9**, the majority of groundwater production within the Basin occurs through the Lower Aquifer unit of the Main Basin. Accordingly, many of Zone 7's management actions have focused on enhancement and protection of Main Basin aquifers. As described in **Sections 5**, **9**and **15**, Zone 7 has implemented a variety of groundwater management programs and policies within the Main Basin including: (1) providing imported surface water supplies to the four water agencies (Retailers) who supply potable water to urban areas within the Main Basin; (2) conducting artificial recharge operations through the Arroyo Valle and Arroyo Mocho stream corridors (and planning for future expanded recharge operations through the COL); (3) implementing a Groundwater Pumping Quota (GPQ) program to limit non-Zone 7 pumping to the "natural" Sustainable Yield calculated for the Main Basin; (4) implementing various groundwater quality management practices (such as the Salt and Nutrient Management Plans described in **Sections 5** and **15**); (5) administering the well permitting program[33] to enforce Alameda County's "Water Wells Ordinance" (General Ordinance Number 0-2015-20) in Eastern Alameda County, and (6) reviewing and permitting commercial Onsite Wastewater Treatment Systems (OWTS).. These groundwater management programs and policies are specifically designed to protect the long-term sustainable use of the Main Basin aquifers and are accounted for directly in the Hydrologic Inventory (HI) that Zone 7 has prepared for the Main Basin since the 1974 Water Year (WY; see **Section 9**).

10.1.2. Fringe Management Area

10.1.2.1. Hydrogeologic Description

The Fringe Area covers 21,956 acres on the edges of the Valley and contains thinner deposits of recent (Holocene) alluvium directly underlain by relatively impermeable deposits of the Livermore and Tassajara Formations. As described in **Section 7,** only a single Principal Aquifer unit is defined within the Fringe Area (i.e., the Fringe Aquifer) representing the combined Holocene alluvium and underlying Livermore/Tassajara deposits, and aquifer depths generally do not exceed 350 feet (based on the deepest wells in the area). As described in **Section 8**, the Fringe Aquifer is characterized by poorer groundwater quality and lower well yields than the Principal Aquifers of the Main Basin. As described in **Section 9,** there are no municipal supply wells within the Fringe Area and groundwater pumping is limited to domestic and agricultural uses. Groundwater conditions have historically remained stable in the Fringe Area, with very little observed changes in groundwater elevations or groundwater storage throughout the 46-year (i.e., 1974 WY to 2020 WY) historical HI period.

10.1.2.2. Land Use

As described in **Section 5** and shown on **Figure 5-1**, the Fringe Area includes the northern portion of the City of Dublin, the eastern and northern portions of the City of Livermore, as well as undeveloped (open space) and agricultural lands. As of 2020, approximately 62% (13,650 acres) of Fringe Area lands were classified as urban, 33% (7,250 acres) as open space, and 5% (1,160 acres) as agricultural.

10.1.2.3. Zone 7 Management

Given the limited groundwater production, low aquifer transmissivity, generally poor groundwater quality, and historically stable groundwater conditions observed in the Fringe Area, Zone 7 has historically

[33] This program covers permitting of new wells, soil, soil vapor, or groundwater sampling wells, boreholes greater than ten feet deep, well destruction, or well casing reconstruction (to extend, replace, or reperforate), and cathodic protection wells.

conducted limited groundwater management actions within this portion of the Basin. While the Fringe Area receives the benefits of Zone 7's imported surface water and groundwater quality management programs, Zone 7's active operations within the Fringe Area are currently limited to ongoing monitoring of groundwater conditions and administering permitting programs for wells and commercial OWTS. As part of this Five-Year Update to the Alternative Groundwater Sustainability Plan (Alternative GSP), Zone 7 conducted several data-gap filling activities to better delineate the nature and extent of the Fringe Aquifer (see **Sections 7 and 8.4**), quantify salt and nutrient loading (see **Section 8.6**), identify groundwater dependent ecosystems and interconnected surface water bodies (see **Sections 8.8** and **8.9**), and expand the Monitoring Network (see **Section 14**) within the Fringe Area.

10.1.3. Upland Management Area

10.1.3.1. Hydrogeologic Description

The Upland Area covers 27,778 acres on the edges of the Basin (i.e., outside the Valley) and is defined by relatively impermeable outcrops of the lower Livermore Formation and older bedrock units. As described in **Section 7,** the Upland Area does not yield significant quantities of groundwater and only a small number of domestic and agricultural wells exist within this portion of the Basin. All water-bearing sediments encountered within the Upland Area are considered a single Principal Aquifer unit and are collectively referred to as the Upland Aquifer. As described in **Section 8**, the Upland Aquifer is of generally poorer groundwater quality than in the Main Basin, and only provides a limited amount of groundwater supply for domestic and agricultural uses. There is insufficient information to characterize the thickness and total storage volume of the Upland Aquifer or to quantify storage changes over time, though all monitoring data collected suggests groundwater conditions have remained stable through the 46-year historical HI period.

10.1.3.2. Land Use

As described in **Section 5** and shown on **Figure 5-1**, the Upland Area mainly includes undeveloped (open space) and low-density residential areas as well as some agricultural lands. As of 2020, approximately 73% (20,390 acres) of Upland Area lands were classified as open space, 17% (4,670 acres) as urban, and 10% (2,720 acres) as agricultural.

10.1.3.3. Zone 7 Management

Given the insignificant groundwater production and low aquifer transmissivity coupled with the general lack of wells in the Upland Aquifer, Zone 7's active management of the Upland Area is currently limited to ongoing monitoring of groundwater conditions and administering permitting programs for wells and commercial OWTS. As part of this Five-Year Update to the Alternative GSP, Zone 7 conducted several data-gap filling activities to better delineate the nature and extent of the Upland Aquifer (see **Sections 7 and 8.4**), quantify salt and nutrient loading (see **Section 8.6**), identify groundwater dependent ecosystems and interconnected surface water bodies (see **Sections 8.8** and **8.9**), and expand the Monitoring Network (see **Section 14**) within the Upland Area.

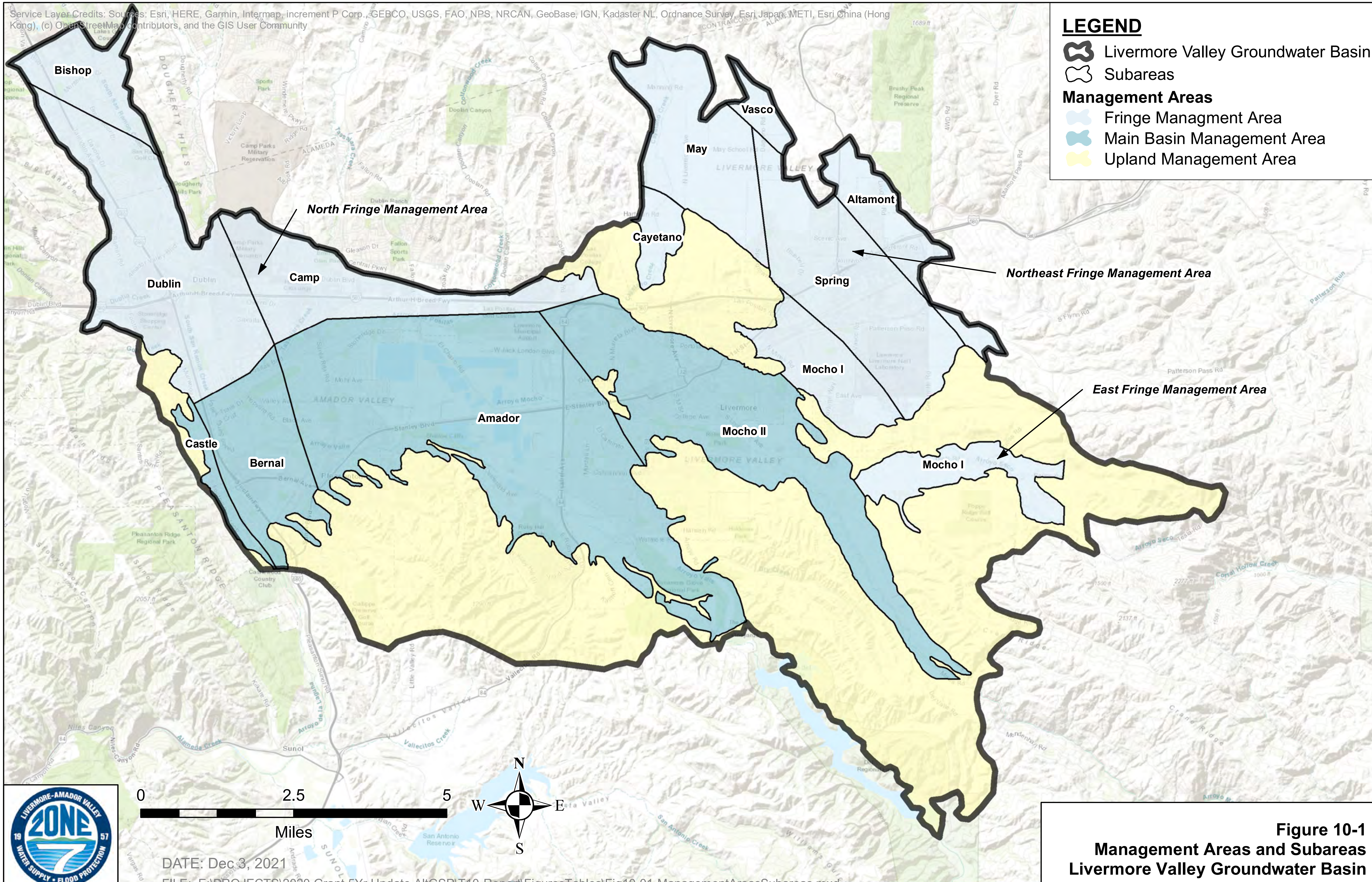

Figure 10-1
Management Areas and Subareas
Livermore Valley Groundwater Basin

SUSTAINABLE MANAGEMENT CRITERIA

(SUBTITLE PAGE)

11. INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

§ 354.22. Introduction to Sustainable Management Criteria
This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

☑ **23 CCR § 354.22**

§ 356.4 Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.

☑ **23 CCR § 356.4 (c)**

The Sustainable Groundwater Management Act (SGMA) legislation defines a "Sustainability Goal" as "the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield" (California Water Code [CWC] § 10721(u)). SGMA requires Groundwater Sustainability Agencies (GSAs) to develop and implement Groundwater Sustainability Plans (GSPs) to meet the Sustainability Goal (CWC § 10727(a)). The SGMA legislation and California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 define terms related to achievement of the Sustainability Goal, including:

- Undesirable Result (UR) – "one or more of the following effects caused by groundwater conditions occurring throughout the basin:
  (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
  (2) Significant and unreasonable reduction of groundwater storage.
  (3) Significant and unreasonable seawater intrusion.
  (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.

(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." (CWC § 10721(x));

- Minimum Threshold (MT) – "a numeric value for each sustainability indicator used to define undesirable results" (23 CCR § 351(t)).
- Measurable Objective (MO) – "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR § 351(s)); and
- Interim Milestone (IM) – "a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan" (23 CCR § 351(q))

Collectively, the Sustainability Goal, URs, MTs, MOs, and IMs are referred to herein as Sustainable Management Criteria (SMCs).

Each of the following are referred to as "Sustainability Indicators", which, as stated above, can constitute URs if they are "significant and unreasonable": (1) Chronic Lowering of Groundwater Levels, (2) Reduction of Groundwater Storage, (3) Seawater Intrusion, (4) Degraded Water Quality, (5) Land Subsidence, and (6) Depletions of Interconnected Surface Waters[34] (CWC § 10721(x)). The 23 CCR also specify how GSAs must establish SMCs for each applicable Sustainability Indicator. Further, in its July 2019 Alternative Assessment Staff Report, the California Department of Water Resources (DWR) provided the following recommended actions to The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) for consideration in the Five-Year Update to the Alternative GSP Update (Alternative GSP).

1. Identify those groundwater levels, taken at representative monitoring sites, that are used to define the MTs for the Basin, to facilitate DWR evaluation.
2. Develop quantitative MTs for lowering of groundwater levels for the Fringe and Upland Management Areas to better align with requirements for management areas and definition of MTs.
3. Develop quantitative MTs for reduction of groundwater storage for the Fringe and Upland Management Areas to better align with the requirements for definition of MTs.
4. Include monitoring groundwater levels at additional locations in the Upland Management Area to monitor changes in groundwater conditions and manage the groundwater resources to prevent undesirable results in future updates to the Alternative GSP. Zone 7 should identify the frequency

[34] Groundwater Dependent Ecosystems (GDEs) are considered under Depletions of Interconnected Surface Waters Sustainability Indicator.

and timing when groundwater levels would be collected at new monitoring stations, and other relevant monitoring well construction information in accordance with the GSP Regulations.

As such, **Sections 12** and **13** of this Alternative GSP describe the refined SMCs that have been developed for all applicable Sustainability Indicators in the Basin. As demonstrated herein (consistent with the approved 2016 Alternative GSP and the requirements of CWC § 10733.6 (a)(3) and 23 CCR § 356.4), Zone 7 has continued to sustainably manage the Basin to avoid URs for at least 10 years. In fact, most of the datasets discussed in this Alternative GSP date back to 1974 allowing for a comprehensive, long-term assessment of Zone 7's sustainable Basin management, including over three major droughts, see **Section 8**. **Table 11-A** below presents a summary of the applicable Sustainability Indicators and a summary of the Basin conditions for the last 10 years (i.e., from 2010 through 2020 Water Years [WY]) relative to the criteria used to identify potential URs.

Table 11-A: Summary of Sustainability Indicators and Ten Year Status

Sustainability Indicator	Undesirable Results Criteria	Minimum Threshold	Status 2010-2020 WY	Action Taken
Chronic Lowering of Groundwater Levels	Water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years.	Historic low minus maximum annual rate of groundwater level change, or historic low if maximum annual rate of groundwater level change is not available.	• MTs were not exceeded at any RMS-WLs, see **Figure 8-8**. • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor and maintain artificial recharge operations.
Depletion of Groundwater Storage	Water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years. Not applicable to Upland Management Area.	Water Level SMCs used as proxy.	• MTs were not exceeded at any RMS-WLs, see **Figure 8-8**. • Sufficient groundwater storage volume maintained above Reserve Storage, see **Figure 8-13.** • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor maintain artificial recharge operations.
Degradation of Groundwater Quality	If MTs are exceeded for any of the identified constituents of concern in greater than 25% of the RMS-WQs at least two (2) consecutive years as a result of SGMA-related groundwater management activities such that they cannot be managed to provide drinking water supply (i.e., that treatment or blending is not possible or practicable).	TDS > 1,000 mg/L or 2015 Baseline concentration plus maximum deviation, whichever is greater.	• TDS was not detected above the in any RMS-WQ, see **Figure 8-19** • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor and increase municipal supply pumping, implement SMP, increase operation of Mocho Groundwater Demineralization Plant (MGDP), and conduct artificial groundwater recharge with low TDS water.
		NO3 (as N) > 10 mg/L or 2015 Baseline concentration plus maximum deviation, whichever is greater.	• Nitrate was not detected above the MT in any RMS-WQs, see **Figure 8-25.** • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor and implement NMP.

Sustainability Indicator	Undesirable Results Criteria	Minimum Threshold	Status 2010-2020 WY	Action Taken
Degradation of Groundwater Quality (continued)		Boron > 1.4 mg/L, or 2015 Baseline concentration plus maximum deviation, whichever is greater.	• Boron was not detected above the MT in any RMS-WQs, see **Figure 8-31**. • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor.
		Total Chromium > 0.050 mg/L, or 2015 Baseline concentration plus maximum deviation, whichever is greater.	• Chromium was not detected above the MT in any RMS-WQs, see **Figure 8-32.** • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor.
		SMCs for PFAS in development	• Zone 7 began sampling for PFAS compounds in the 2019 WY (see **Figure 8-35** and **Figure 8-36**) and hired Jacobs Engineering, Inc. to conduct a PFAS Potential Source Investigation (*Jacobs, 2020*).	Continue to monitor
Land Subsidence	Water Level SMCs used as proxy for Main Basin and Fringe Management Area, and no more than 0.4 ft of irreversible land surface elevation decrease in one year. Not applicable to Upland Management Area.	Water Level SMCs used as proxy and irreversible land surface elevation decrease of 0.4 ft.	• MTs were not exceeded at any applicable RMS-WLs, see **Figure 8-8**. • Elastic fluctuations less than 0.04 ft for the year (see **Figure 8-40**). • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor
Depletion of Interconnected Surface Waters	If groundwater levels decline below their MTs in greater than 40% of the RMS-ICSWs for more than two consecutive years.	Historic low water levels or to be determined if historical water levels are not available.	• MTs were not exceeded at any RMS-ICSWs, see **Figure 13-1**. • Sustainable groundwater conditions over the long-term demonstrated in **Section 8**.	Continue to monitor

12. SUSTAINABILITY GOAL

§ 354.24 Sustainability Goal
Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

☑ **23 CCR § 354.24**

The Sustainable Groundwater Management Act (SGMA) requires that a Sustainability Goal be defined for each medium- or high-priority basin (California Water Code [CWC] § 10727(a)). The California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 further clarifies that the Sustainability Goal should culminate "in the absence of undesirable results within 20 years of the applicable statutory deadline" (23 CCR § 354.24).

The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) Organization-wide Goal "C" is to *manage and protect the groundwater basin as the state designated Groundwater Sustainability Agency* [GSA] and, as the GSA, has adopted the following Sustainability Goal for the Livermore Valley Groundwater Basin (Basin):

> *Continue to operate the Livermore Valley Groundwater Basin within its Sustainable Yield*[35] *and to manage the groundwater resources for the prevention of significant and unreasonable: (1) lowering of groundwater levels, (2) reduction in basin storage, (3) degradation of groundwater quality, (4) inelastic land subsidence, or (5) depletion of surface water supplies such that beneficial uses aren't adversely impacted.*[36]

[35] Sustainable Yield is defined by SGMA as the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.
[36] The significant and unreasonable seawater intrusion is not applicable for the Basin as it is situated inland and does not interface with seawater.

13. SUSTAINABILITY INDICATORS

13.1. Chronic Lowering of Groundwater Levels

As a wholesale municipal water supplier, The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) has existing policies and objectives relating to managing water levels in the Livermore Valley Groundwater Basin (Basin) (*Zone 7, 2016*e) and regularly monitors an extensive network of monitoring wells (see **Section 14**). Specifically, Zone 7 manages the Basin water levels for multiple objectives including:

- Maintaining groundwater emergency reserves for worst credible droughts and unplanned import outages supply interruption of imported surface water;
- Preserving storage capacity for recharge of available imported supplies;
- Keeping water levels sufficiently high to support beneficial uses; and,
- Minimizing impacts of high groundwater levels on gravel mining operations.

These objectives were directly considered as part of the development of the refined Sustainable Management Criteria (SMCs) described below.

13.1.1. Undesirable Results for Chronic Lowering of Groundwater Levels

§ 354.26. Undesirable Results

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

☑ **23 CCR § 354.26(a)**

Per the Sustainable Groundwater Management Act (SGMA), Undesirable Results for the Chronic Lowering of Groundwater Levels means a "chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon" (California Water Code [CWC] § 10721(x)(1)). However, it is important to note that SGMA also states that "overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (CWC § 10721(x)(1)).

The Undesirable Result (UR) for Chronic Lowering of Groundwater Levels is in the Basin defined herein as follows:

Undesirable Results would be experienced if and when a chronic decline in groundwater levels over the course of the planning and implementation horizon significantly and unreasonably impairs the reasonable and beneficial use of, and access to, groundwater for beneficial uses and users within the Basin.

The primary beneficial users of groundwater within the Basin are groundwater pumpers (environmental beneficial users are addressed in **Section 13.6**). As such, the definition of URs is focused on potential well impacts. If lowering of regional water levels resulted in wells no longer being capable of supporting their beneficial uses, that condition would be viewed as an UR. However, it should be noted that other factors -- such as well-age, poor well-design and well-integrity related impacts – can also affect wells and should not be part of the "significant and unreasonable" determination. For example, 42% of existing Basin wells are more than 30 years old[32] and would reasonably have to be replaced in the next 20 years due to expected average life spans for wells regardless of SGMA implementation or lowering of groundwater levels. As such, careful assessment of local water level and well conditions is needed to determine if any observed well impacts are URs that are directly attributable to changes in the groundwater levels in the basin, and not to some other factor (for example, aging equipment).

Some fluctuations in groundwater levels are expected, and a reduction in the groundwater level alone would not constitute an UR. Rather, a decrease in groundwater level would be considered an UR if that decrease was both chronic over the long term, and if the depletion rose to the level of significant and unreasonable as defined by this Alternative GSP. For decades, Zone 7 has managed groundwater levels to ensure that reductions in groundwater levels or storage during a period of drought/high demand are offset by increases in groundwater levels or storage during other periods. Consistent with the requirements of SGMA, overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed in this fashion.

13.1.1.1. Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Potential causes of URs related to Chronic Lowering of Groundwater Levels could include increased pumping and/or reduced recharge.

The URs may be experienced as water levels falling below pump intakes, falling below the top of screens, and/or reductions in well yields. These conditions could be triggered by the concurrence of a multi-year drought combined with severe cutbacks on imported supply and/or exacerbated by prior pumping in the Basin. Such conditions could result loss of water supply for groundwater users and a need for supplemental supplies at a time when they may be unavailable. Because the current primary use of groundwater in the Basin is for municipal purposes, increased groundwater pumping (up to the Groundwater Pumping Quota [GPQ]) could occur if demand for groundwater increases to supplement a shortage in imported surface water. Reduced recharge could occur due to increased agricultural irrigation efficiency, climate change that results in decreased precipitation, decreased natural surface water inflows, increased evapotranspiration (ET), and/or decreased deliveries of imported surface water supplies.

The above notwithstanding, it should be emphasized that wells located in the Fringe Management Area (Fringe Area) and Upland Management Area (Upland Area) rely mainly on natural recharge to maintain water supply. During below normal, dry, and critically dry hydrologic years, natural recharge may not be sufficient to maintain the groundwater levels in these wells and lack of sufficient natural recharge can potentially cause loss of production in these wells. In order to sustainably manage these management areas, groundwater pumping must be limited to available supply from natural recharge. Avoidance of well impacts under these natural conditions can likely only be managed through demand reduction efforts. Similarly, if the GPQs are reached in the Main Basin Management Area (Main Basin), demand reduction efforts would have to be implemented pursuant to the Water Shortage Contingency Plans (WSCPs) developed by Zone 7 and its Retailers.

To account for the uncertainty of how low water levels can be managed for in the Fringe and Upland Areas, any proposed new well construction (other than replacement wells) would need to be evaluated for the higher-density well areas (see well density discussion in **Section 5.1.5**). Zone 7's role in permitting new wells in the Basin allows an early assessment of any proposed wells to ensure that they are constructed to account for operating water levels in the Basin and do not result in over-pumping for any localized area of well clusters. Through its assigned authority to administer the Alameda County Water Wells Ordinance within the Zone 7 service area, Zone 7 can require, at its discretion, that a permit application be accompanied by a certified California Environmental Quality Act (CEQA) analysis supporting that the new well and its use would not significantly impact the local water levels. This requirement would reduce the uncertainty associated with new well constructions and pumping impacts in these areas.

In addition to the evaluation process for new wells, Zone 7 has authority to conduct numerous additional management actions to respond to URs for water level declines that are observed in the Basin through its Groundwater Elevation Monitoring Program (see **Section 14**). Some of these actions include increased conjunctive use, provision of an alternative water supply, and/or a pumping (or replenishment) assessment. All these options would be considered in any recovery plan that may be developed to ensure continued sustainable groundwater conditions.

13.1.1.2. Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**
☑ **23 CCR § 354.26(c)**

As discussed further below in **Section 13.1.2** and in **Section 14**, the Minimum Thresholds (MTs) for groundwater levels have been established at twelve (12) Representative Monitoring Sites for Chronic Lowering of Groundwater Levels (RMS-WLs). Per Section 354.26(b)(2) of the California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2, the description of URs must include the criteria used to define when and where the effects of groundwater conditions cause URs, based on a quantitative description of the number of MT exceedances that constitute an UR.

Based on the significant and unreasonable effects described above, the criteria for URs for Chronic Lowering of Groundwater Levels are as follows:

> *Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years.*

Per **Appendix E**, the proposed water level MTs are estimated to represent conditions where approximately 50% of the Total Usable Storage volume of the Basin is actively managed and used. The remaining "Reserve Storage" can be accessed by pumping wells, but pursuant to Basin operating policies is only available during emergency conditions. The UR criteria that are based on the RMS-WLs reaching their MT means that significant Total Usable Storage volume above the Reserve Storage will still be maintained. This approach is conservative and justified based on understanding of historic low and water level variability conditions throughout the Basin that have occurred and could occur in the future without causing significant and unreasonable effects for any Sustainability Indicators (*Zone 7, 2016e*) and is consistent with Zone 7's on-going sustainable management of the Basin.

13.1.1.3. Potential Effect of Undesirable Results

☑ **23 CCR § 354.26(b)(3)**

The primary potential effect of URs caused by Chronic Lowering of Groundwater Levels on beneficial uses and users of groundwater in the Basin is groundwater well dewatering. Potential effects could include increased pumping lift and effects on correlated Sustainability Indicators. Increased pumping lift results in more energy use per unit volume of groundwater pumped and corresponding higher pumping costs, as well as increased wear and tear on well pump motors and reduced well efficiency. Declining groundwater levels could adversely affect current and projected municipal uses. Correlated Sustainability Indicators include Reduction on Groundwater Storage, Land Subsidence, and Depletion of Interconnected Surface Waters (ICSW), although the degree of correlation has not been determined with certainty and is a data gap that will continue to be explored as part of the Alternative Groundwater Sustainability Plan (Alternative GSP) implementation. For example, while potential impacts of water levels in the Upper Aquifer unit on ICSW or Groundwater Dependent Ecosystems (GDEs) have not been observed to date in the Basin, the issue does warrant further study and future shallow groundwater monitoring efforts are discussed in **Section 14** and **15**.

13.1.2. Minimum Threshold for Chronic Lowering of Groundwater Levels

§ 354.28. Minimum Thresholds

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.

(B) Potential effects on other sustainability indicators.

☑ **23 CCR § 354.28(a)**
☑ **23 CCR § 354.28(b)**
☑ **23 CCR § 354.28(c)(1)**

Chronic Lowering of Groundwater Levels is arguably the most fundamental Sustainability Indicator, as it influences several other key Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, and potentially Depletions of Interconnected Surface Water and Degraded Water Quality. Groundwater levels are also the most readily available and measurable metrics of groundwater conditions, which allows for a systematic, data-driven approach to development of MTs to be applied. There are no state, federal, or local standards that relate to this Sustainability Indicator.

13.1.2.1. Minimum Threshold Development

Consistent with 23 CCR Division 2 Chapter 1.5 Subchapter 2 § 354.28(c), the definition of MTs for Chronic Lowering of Groundwater Levels in the Basin is based on consideration of trends in historical groundwater levels, projected water use in the Basin (i.e., by beneficial users), and the relationship to other Sustainability Indicators. This information was used to develop MT estimates using a quantitative algorithm that accounted for trends, historic lows, and water level variability (discussed below). This approach allowed for the most complete and representative historical water level information to inform the MTs.

For several decades, Zone 7 has operated the Basin to maintain water levels above historic low levels throughout the Main Basin – even during the 1970s, 1990s and recent droughts (see **Section 8**). Historic low water levels are therefore used as a starting point for MTs based on the fact that: (1) significant and unreasonable impacts to beneficial uses and users of groundwater are not known to have occurred when water levels were at their historic lows, and (2) Zone 7 wells are capable of pumping at or below historic low levels in localized areas if the need arises (*Zone 7, 2016e*).

As discussed in **Section 8.3.3.2**, historic low values are a function of both data availability and some variability in water levels during drought cycles. Zone 7 uses static water levels from local monitoring wells rather than pumping level data to evaluate the groundwater level height above the historic lows. Data used to create the composite historical contours for the Basin's Principal Aquifer units are typically from the 1960s, 1977, 1987-1992, or 2012-2015 drought periods. Outside of the Main Basin and Fringe Area, continuous aquifers may not be present and historic lows have not yet been definitively determined. However, water level data from various wells indicate that water levels in the Upland Area have not fluctuated significantly over time, and no areas of significant downward trends have been identified (see **Figure 8-8**).

Variability in groundwater levels, due in large part to variations in water year type, is then accounted for by calculating a maximum annual rate of groundwater elevation change (i.e., the difference between the annual high and low water level data in a given year) based on the historical water level record at each RMS-WL. This maximum annual water level change value reflects the fact that different locations and Principal Aquifer units within the Basin have experienced different amounts of water level variability over time in response to varied hydrologic conditions.

As discussed, to account for water level variations, the MTs for Chronic Lowering of Groundwater Levels are then established at each RMS-WL by subtracting the maximum annual rate of groundwater change from the historic low for each RMS-WL, as shown in the formula below. The resultant MTs for the RMS-WLs within the Basin are shown in **Table 13-A** and on **Figure 8-8**. Where maximum annual water level change is not available, the MT is set at the historic low. Because the water levels in the co-located Upper

Aquifer and Lower Aquifer RMS-WLs show nearly equivalent values and trends, the same MT values are applied, based on water level data from the Lower Aquifer RMS-WLs.

$$MT = Historical\ Low - Maximum\ Annual\ Rate\ of\ Groundwater\ Level\ Change$$

Or if maximum annual rate of groundwater level change is not available:

$$MT = Historical\ Low$$

Table 13-A. SMCs for Chronic Lowering of Groundwater Levels

RMS[1] Well		Management Area/Unit			Historical Conditions (ft)			SMCs[3] Water Levels	
Well Name	Map	Area	Subarea	Aquifer	Historic Low	Maximum Decrease[2]	Historic Low + Max Decrease	Minimum Threshold[4]	Measureable Objective[5]
3S1E20C007	20C7	Main	Bernal	Upper	179.5	-34.7	144.8	144.8	179.5
3S1E20C008	20C8	Main	Bernal	Lower	179.5	-34.7	144.8	144.8	179.5
3S1E09P005	9P5	Main	Amador West	Upper	206.7	-26.9	179.8	179.8	206.7
3S1E09P010	9P10	Main	Amador West	Lower	206.7	-26.9	179.8	179.8	206.7
3S1E11G001	11G1	Main	Amador East	Upper	219.9	-38.9	181.0	181.0	219.9
3S1E12K003	12K3	Main	Amador East	Lower	219.9	-38.9	181.0	181.0	219.9
3S2E08K002	8K2	Main	Mocho II	Upper	293.1	-38.0	255.1	255.1	293.1
3S2E08H003	8H3	Main	Mocho II	Lower	293.1	-38.0	255.1	255.1	293.1
3S1E06F003	6F3	Fringe	Northwest	Upper	314.6	-9.7	305.0	305.0	314.6
2S2E34E001	34E1	Fringe	Northeast	Upper	491.2	-3.0	488.2	488.2	491.2
3S2E24A001	24A1	Fringe	East	Upper	678.3	-2.8	675.5	675.5	678.3
3S2E21K009[6]	21K9	Upland	Upland	Upper	470.1	No Data	No Data	470.1	470.1

1 RMS = Representative Monitoring Site
2 Maximum Single Year Seasonal Decrease (Spring to Fall)
3 Sustainable Management Criteria
4 Historic Low + Maximum Seasonal Decrease
5 Measurable Objective = Historic Low
6 Recently added; no historical data available. Criteria to be adjusted in future.

13.1.2.2. Consideration of Impacts to Beneficial Users

The relationship of water level historic lows to well construction in municipal wellfields was examined in Zone 7's 2003 Well Master Plan (WMP). That plan evaluated numerous alternatives for new Zone 7 wellfields to meet future demands when imported water supply allocations are reduced or during water supply emergencies. The plan confirmed that Zone 7 wells are capable of pumping at or below historic low levels in localized areas if the need arises. However, rather than allowing water levels to exceed MTs, more typically Zone 7 will employ the adaptive management of optimizing groundwater pumping to wells in other portions of the Basin to minimize local impacts at any given well. Further, as with current wellfields and their operations, new Zone 7 wellfields are to be sited and operated to optimize groundwater recovery while maintaining Basin water levels above historic lows most of the time and minimizing localized drawdown in other Basin wells.

Although average conditions (normal and dry years) would not warrant sustained pumping below historic lows, drawdown to the MTs would be adaptively managed to ensure that any localized drawdown would be monitored and, if appropriate, addressed with a recovery plan. Factors such as transmissivity and the ability to recharge that portion of the Basin would be considered in the recovery plan, as would the length of time to remain below historic lows during recovery.

Other areas of the Basin with private supply wells (primarily small irrigation wells) have typically high water levels due to conjunctive use and low pumping volumes locally. However, installing additional wells and increased pumping can change water levels in these areas. Those wells located around the municipal pumping centers would be expected to be the first wells impacted by declining water levels. However, given that most of these wells are within a water purveyor service area and only supply a small landscape demand, it is anticipated that municipal water would be available to replace the minor lost well supply.

Again, it is important to note that wells located in the Fringe Area and Upland Area rely mainly on natural recharge to maintain water supply. During below normal, dry, and critically dry hydrologic years, natural recharge may not be sufficient to maintain the groundwater levels in these wells and consequently, lack of sufficient natural recharge can potentially cause declining water level and thus, loss of production in these wells. Avoidance of well impacts under these natural conditions can likely only be managed through demand reduction efforts.

Under extreme conditions, such as a prolonged drought or full loss of imported water due to an earthquake in the Sacramento Delta, water levels may be drawn below the historic low surface in some areas and could exceed the MT at one or more RMS-WLs; these would be evaluated for a recovery plan. This is a part of Zone 7's adaptive management strategy for long-term groundwater sustainability and is demonstrated by the drought recovery periods in the historical hydrographs of the key wells within the Basin (see **Section 8**).

13.1.2.3. Relationship to Other Sustainability Indicators

As described in detail in **Sections 13.2, 13.4, 13.5** and **13.6** below, MTs for Chronic Lowering of Groundwater Levels were designed to ensure they are sufficiently protective of Undesirable Results defined for all other relevant Sustainability Indicators to the Basin. A summary of the relationships between SMCs defined for Chronic Lowering of Groundwater Levels and for each of the other relevant Sustainability Indicators to the Basin is provided below:

- As described in **Section 13.2** and based on the analysis presented in **Section 8.4**, groundwater in storage is directly, if not linearly, related to groundwater levels. As further detailed in **Section 13.2.2.1,** groundwater storage volumes would remain no less than 84% in the Main Basin and 94% in the Fringe Areas if water levels were to drop from SGMA Baseline (i.e., Fall 2015) conditions to their MTs, indicating that total usable storage in the Basin will not be significantly impacted at MT water level conditions. These calculations therefore demonstrate that the SMCs defined for Chronic Lowering of Groundwater Levels are sufficiently protective of URs for Reduction of

Groundwater Storage and thus can serve as an effective proxy for defining Reduction of Groundwater Storage MTs in the 2021 Alternative GSP.

- As described in **Section 13.4** and based on the information and analysis provided in **Sections 5.2** and **Section 8.6**, Zone 7 has operated extensive water quality monitoring and management programs since 1974 in efforts to protect and enhance groundwater quality and minimize threats of groundwater pollution within the Basin. Given that the Basin has historically been managed to avoid occurrence of Undesirable Results related to Degraded Water Quality, it is reasonable to expect that maintaining water levels above historic lows will prevent the occurrence of "*a significant increase, on a regional basis, in concentrations of identified COCs above applicable state and federal regulatory thresholds, as a result of groundwater recharge or extraction"* (**Section 13.4.1**). As part of the 2021 Alternative GSP update, several additional projects and management actions (P/MAs) have been proposed to better understand and characterize the relationships between water levels and water quality conditions within the Basin. As discussed in **Section 14.2.4**, Representative Monitoring Sites for Degraded Water Quality (RMS-WQ) are entirely coincident with Representative Monitoring Sites for Chronic Lowering of Groundwater Levels (RMS-WL), which will provide for coupled monitoring of water level and water quality conditions going forward. Data collected from RMS-WL and RMS-WQ wells will be used to further evaluate correlations between water levels and COC concentrations that can help ensure that MTs for Chronic Lowering of Groundwater Levels are sufficiently protective of Degraded Water Quality and will allow for future refinements to the SMCs for both sustainability indicators as necessary. Furthermore, as discussed in **Section 15.2.4,** Zone 7 has included a Groundwater Contaminant Mobilization Study in its list of potential P/MAs to evaluate the impacts of existing and future groundwater management operations on water quality conditions and to identify expanded management strategies for COCs in the Basin. Additionally, any P/MAs proposed for future implementation in **Section 15** will require an independent evaluation of potential impacts to groundwater quality conditions and a corresponding mitigation plan as part of the P/MA planning and implementation process.
- As described in **Section 13.5** and based on the analysis presented in **Section 8.7**, historical land subsidence monitoring indicates the potential for inelastic (permanent) subsidence in the Main Basin and Fringe Area increases as groundwater levels approach historic lows. As such, it is reasonable to assign MTs for Land Subsidence using the MTs defined for Chronic Lowering of Groundwater Levels as a proxy, with the additional constraint that no more than 0.4 feet of inelastic subsidence can occur in any year. There is limited potential for subsidence in the Upland Area due to the prevalence of semi-consolidated bedrock. As such, no MTs for subsidence are established in the Upland Area.
- As described in **Section 13.6** and based on the analysis presented in **Sections 8.8** and **8.9**, where sufficient data are available, a reasonable correlation exists between groundwater levels in the Upper Aquifer at monitoring wells proximate to Interconnected Surface Water (ICSW) reaches and groundwater dependent ecosystems (GDEs) and corresponding ICSW and GDE conditions. Currently there are no significant quantitative data demonstrating negative impacts to ICSW and GDEs within the Basin under historic low water level conditions in the Upper Aquifer. As such, MTs

for Depletions of ICSW are defined as the historic low water level at the wells included in the Representative Monitoring Sites for Interconnected Surface Water (RMS-ICSW), consistent with the definition of MTs for Chronic Lowering of Groundwater Levels. As discussed in **Section 14.2.6**, 10 stream stations will also be included in the RMS-ICSW to record either flow rates and/or gauge heights along potential ICSW reaches within the Basin. These data, combined with water level measurements from the RMS-ICSW wells, will better quantify relationships between measured changes in groundwater levels and surface water flows that can help ensure that these MTs are sufficiently protective and will allow for future refinements to the SMCs as necessary.

13.1.2.4. Relationship to Adjacent Basins

As described in **Section 7.2.6**, the Basin is bounded at the northwestern edge by the neighboring San Ramon Valley Groundwater Basin and at the southwestern edge by the neighboring Sunol Valley Groundwater Basin. Both groundwater basins are designated by DWR as a low-priority basins and are thus not subject to SGMA. As such, the SMCs proposed in this Alternative GSP are not expected to cause undesirable results in adjacent basins or affect the ability of adjacent basins to achieve their sustainability goals.

13.1.3. Measurable Objectives and Interim Milestones for Chronic Lowering of Groundwater Levels

§ 354.30. Measurable Objectives

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

(f) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

☑ 23 CCR § 354.30(a)
☑ 23 CCR § 354.30(b)
☑ 23 CCR § 354.30(c)
☑ 23 CCR § 354.30(e)

13.1.3.1. Measurable Objective Development

The Measurable Objectives (MOs) for Chronic Lowering of Groundwater Levels are similarly developed based on historical groundwater levels. Specifically, the MOs are set equal to the historic low for each RMS-WL, based on the fact that significant and unreasonable impacts to beneficial uses and users of groundwater are not known to have occurred since the time when water levels were at their historic low (*Zone 7, 2016e*). The resultant MOs for the RMS-WLs within the Basin are shown in **Table 13-A** and on **Figure 8-8**. Because the water levels in the co-located Upper Aquifer and Lower Aquifer RMS-WLs show nearly equivalent values and trends, the same MO values are applied, based on water level data from the Lower Aquifer RMS-WLs.

The MOs for Chronic Lowering of Groundwater Levels do not mean that Zone 7 will manage the water levels within the Basin toward the historic lows. Rather, as they have for several decades, Zone 7 will continue to actively and sustainably manage the Basin to maintain water levels above historic low levels (i.e., at or above the MOs for Chronic Lowering of Groundwater Levels). The MOs are set to allow a reasonable Margin of Operational Flexibility to allow for on-going sustainable management of the Basin and are intended to accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities.

13.1.3.2. Interim Milestones Development

The Interim Milestones (IMs) for Chronic Lowering of Groundwater Levels are not defined or applicable because, as demonstrated herein, Zone 7 has continued to manage the Basin sustainably and maintain water levels above the applicable SMCs.

13.1.4. Demonstration of Sustainability

Per CWC 10733.6 (a)(3), this Alternative GSP must demonstrate that the Basin has been operating within its sustainable yield for at least 10 years. Relative to the Chronic Lowering of Groundwater Levels Sustainability Indicator, **Figure 8-8** demonstrates that water levels in the RMS-WLs have been maintained above the SMCs for the last 10 years, indicating long-term sustainability and absence of URs. Further, based on Zone’s 7 expansive SGMA Monitoring Network (**Section 14**), sustainable groundwater conditions over the long-term are demonstrated in **Section 8**.

13.2. Reduction of Groundwater Storage

13.2.1. Undesirable Results for Reduction of Groundwater Storage

☑ 23 CCR § 354.26(a)

Per SGMA, an UR for the Reduction of Groundwater Storage means a "significant and unreasonable reduction of groundwater storage" (CWC § 10721(x)(1)).

As further specified in CWC Section 10727.2(b)(4), a GSP or Alternative GSP "may, but is not required to, address URs that occurred before, and have not been corrected by, January 1, 2015". In approving Zone 7's 2016 Alternative GSP, the California Department of Water Resources (DWR) found that through 2015 Zone 7 had managed the Basin sustainably (i.e., absent of URs). As such it is appropriate to use groundwater conditions in 2015 as an effective "SGMA Baseline" to evaluate the reasonableness of any reductions in groundwater storage pursuant to the refined SMCs. In 2015 (considered the SGMA Baseline for purposes of this Alternative GSP), the usable storage in the Basin was slightly less than the Total Usable Storage.

Zone 7 has historically operated the Basin such that groundwater in storage remains between the Total Usable Storage or "full basin" volume[37] and the historic low water levels. Historic low water levels are estimated to represent conditions where about 50% of the Total Usable Storage volume is actively managed and used. The remaining "Reserve Storage" is available only during emergency conditions. The Reserve Storage Volume is estimated to be approximately 52% of the SGMA Baseline Storage volumes in the Main Basin.

Zone 7 plans its operations to operate the Basin at or above historic lows (i.e., at or above the MOs for Chronic Lowering of Water Levels). Under emergency conditions, Reserve Storage may need to be accessed. In this case, assessment of any URs will be related to whether the storage loss can be recovered at some time in the future. Emergency conditions will be evaluated on a case-by-case basis to determine if they create URs and can be evaluated by the monitoring networks and computer modeling that Zone 7 has already put into practice.

Given the long-term sustainable management of the Basin, and in consideration of SGMA requirements, the UR for the Reduction of Groundwater Storage is defined herein as follows:

Undesirable Results would be experienced if and when a reduction in storage in the Principal Aquifers of the Basin negatively affects the long-term viable access to groundwater for the beneficial uses and users within the Basin. Specifically, significant and unreasonable effects would include an aggregate reduction in usable groundwater storage of more than 50% within the Basin relative to the SGMA Baseline Storage volume for two consecutive years.

[37] Total Usable Storage is based on historic high water levels, see **Section 8.4 Groundwater Storage** and **Appendix E**.

The above definition is justified because it is consistent with Zone 7's policies which allow access Reserve Storage (which accounts for approximately 50% of the total storage volume of the Basin) under certain conditions.

13.2.1.1. Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Reduction of Groundwater Storage is directly correlated to Chronic Lowering of Groundwater Levels. Therefore, the potential causes of URs due to Reduction of Groundwater Storage are generally the same as the potential causes listed above for URs due to Chronic Lowering of Groundwater Levels (i.e., increased groundwater pumping and reduced recharge). Because of the direct correlation between groundwater elevation and groundwater storage volume, groundwater levels are used to measure conditions for this Sustainability Indicator.

13.2.1.2. Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**
☑ **23 CCR § 354.26(c)**

The criteria used to define URs for Reduction of Groundwater Storage are consistent with the criteria used to define URs for Chronic Lowering of Groundwater Levels, as follows:

Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years.

This approach is justified based on calculations of the "SGMA Baseline" storage volume in the Basin (approximately 343 – 583 TAF as of Fall 2015)[38] and the volume of storage depletion that would occur in the Principal Aquifer units if groundwater levels were to decline to the Chronic Lowering of Groundwater Levels MTs (approximately 28 – 95 thousand acre-feet [TAF]). These calculations are detailed in **Appendix E** and indicate that if all RMS-WLs were to decline from 2015 levels (i.e., the start of SGMA) to their respective Chronic Lowering of Groundwater Levels MTs, the percent of usable storage in the Basin would decrease by approximately 13%, which is less than the level deemed to be significant and unreasonable. Within the Main Basin, usable storage would decrease by 16% (23 – 84 TAF) relative to SGMA Baseline conditions (246 – 403 TAF), which is less than the level deemed to be significant and unreasonable. Within the Fringe Area, usable storage would decrease by 6% (5 – 11 TAF) relative to SGMA Baseline conditions (97 – 180 TAF), which is less than the level deemed to be significant and unreasonable.

[38] The usable storage volume in the Basin is calculated as the volume of groundwater between the groundwater level at the time of assessment (i.e., Fall 2015) and base of the "usable" aquifer system, i.e., where the deepest wells in the Basin are constructed within the Upper Livermore Formation of the Lower Aquifer. See **Appendix E** for further discussion.

Given the above analysis, the criteria set for Chronic Lowering of Groundwater Levels are considered protective against significant and unreasonable effects for Reduction of Groundwater Storage, and thus serve as a reasonable proxy.

13.2.1.3. Potential Effects of Undesirable Results

☑ **23 CCR § 354.26(b)(3)**

The primary potential effect of URs caused by Reduction of Groundwater Storage on beneficial uses and users of groundwater in the Basin (i.e., groundwater pumpers) would be less groundwater supply reliability. The effect would be most significant during periods of surface water supply shortage due to, for example, natural drought conditions, regulatory restrictions, natural disasters, or other causes. However, as discussed below in **Section 13.2.2**, there is significant usable groundwater storage within the Basin, and continued sustainable management of the Basin will most likely to minimize these effects to less than unreasonable and significant over the Alternative GSP planning and implementation horizon.

13.2.2. Minimum Threshold for Reduction of Groundwater Storage

§ 354.28. Minimum Thresholds
(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.

☑ **23 CCR § 354.28(c)(2)**

As discussed above, the UR definition for Reduction of Groundwater Storage equates to a volumetric decrease in storage amounting to a reduction in 50% of usable storage across the Basin over the planning and implementation horizon and the criteria for the URs are tied to groundwater levels measured in RMS-WLs and consistent with Zone 7's long-standing sustainable management of the Basin. It is logical to correlate these two Sustainability Indicators together, as the amount of groundwater in storage is directly, if not linearly, related to groundwater levels. Because of the close relationship between these two Sustainability Indicators, and because the MTs for Chronic Lowering of Groundwater Levels (discussed above) are protective of the beneficial uses and users of groundwater, the MTs for Chronic Lowering of Groundwater Levels are used as a proxy for the Reduction of Groundwater Storage Sustainability Indicator.

13.2.2.1. Use of Groundwater Levels as Proxy

§ 354.28. Minimum Thresholds

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

☑ 23 CCR § 354.28(d)

Pursuant to the GSP Emergency Regulations (23 CCR § 354.28(d)) and as further described in the DWR Sustainable Management Criteria Best Management Practices #6[39], MTs for the Reduction of Groundwater Storage Sustainability Indicator may be set using groundwater levels as a proxy if it is demonstrated that a correlation exists between the two metrics and if the MTs for Chronic Lowering of Groundwater Levels are sufficiently protective to ensure prevention of significant and unreasonable occurrences. The resultant MTs for the RMS-WLs within the Basin are shown in **Table 13-B** and **Figure 8-8** and discussed in more detail in **Section 14.4**.

Table 13-B. SMCs for Reduction of Groundwater Storage

RMS[1] Well		Management Area/Unit			Historical Conditions (ft)			SMCs[3] Water Levels				
Well Name	Map	Area	Subarea	Aquifer	Historic Low	Maximum Decrease[2]	Historic Low + Max Decrease	Minimum Threshold[4]	IM-5[5]	IM-10	IM-15	Measureable Objective[6]
3S1E20C007	20C7	Main	Bernal	Upper	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E20C008	20C8	Main	Bernal	Lower	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E09P005	9P5	Main	Amador West	Upper	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E09P010	9P10	Main	Amador West	Lower	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E11G001	11G1	Main	Amador East	Upper	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S1E12K003	12K3	Main	Amador East	Lower	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S2E08K002	8K2	Main	Mocho II	Upper	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S2E08H003	8H3	Main	Mocho II	Lower	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S1E06F003	6F3	Fringe	Northwest	Upper	314.6	-9.7	305.0	305.0	307.4	309.8	312.2	314.6
2S2E34E001	34E1	Fringe	Northeast	Upper	491.2	-3.0	488.2	488.2	489.0	489.7	490.5	491.2
3S2E24A001	24A1	Fringe	East	Upper	678.3	-2.8	675.5	675.5	676.2	676.9	677.6	678.3

[1] RMS = Representative Monitoring Site
[2] Maximum Single Year Seasonal Decrease (Spring to Fall)
[3] Sustainable Management Criteria
[4] Historic Low + Maximum Seasonal Decrease
[5] IM-# = Interim Milestone at # years
[6] Measurable Objective = Historic Low

To demonstrate that the updated MTs for Chronic Lowering of Groundwater Levels developed by Zone 7 as part of the 2021 Alternative GSP are sufficiently protective, a calculation was performed to estimate the volume of groundwater that would be removed from storage in the Principal Aquifer units if groundwater levels were to decline from SGMA Baseline (i.e., Fall 2015) levels to their respective MTs for Chronic Lowering of Groundwater Levels (see **Appendix E**). This volume is then compared to the volume

[39] DWR 2017, Sustainable Management Criteria Best Management Practices, dated November 2017, 38 pp.

of total usable storage within applicable Management Areas of the Basin[40] at SGMA Baseline water level conditions. Based on the analysis presented herein, the total usable storage in the Basin will not be significantly impacted at MT water level conditions, indicating that the MTs for Chronic Lowering of Groundwater Levels are protective for the Reduction of Groundwater Storage Sustainability Indicator.

The analysis presented herein notwithstanding, Zone 7 plans to upgrade the groundwater model for the Basin to integrate Fringe and Upland Areas into the model domain and calibrate the model to calculate Basin storage volume more accurately in coming years.

13.2.2.2. Main Basin Management Area

Table 13-C presents a summary of estimated available groundwater storage volumes for each Principal Aquifer unit within the Main Basin at MT water level conditions, along with their comparative SGMA Baseline storage volumes. Additional detail is provided in **Appendix E**.

Table 13-C. Available Groundwater Storage Estimates at MT Water Levels – Main Basin

Principal Aquifer Unit	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at MT (TAF)	Storage Volume at MT Relative to SGMA Baseline Storage (%)
Upper Aquifer	59 - 113 TAF	36 – 47 TAF	48%
Lower Aquifer (Quaternary Deposits)	102 - 120 TAF	102 TAF	92%
Lower Aquifer (Upper Livermore Formation)	85 – 170 TAF	85 – 170 TAF	100%
TOTAL (MAIN BASIN)	**246 – 403 TAF**	**223 – 319 TAF**	**84%**

As a whole, the Main Basin storage would remain no less than 84% under MT water levels relative to SGMA Baseline conditions, corresponding to a total reduction in groundwater storage of approximately 23 – 84 TAF (16%).

While groundwater storage in the Upper Aquifer unit appears to be most affected by groundwater level declines (23 – 66 TAF, or a 52% reduction), it is important to note that groundwater production in this unit is insignificant, and that SMCs in the Basin have been specifically designed to protect GDEs and prevent depletion of ICSW in the areas of the Basin where shallow groundwater conditions are known to occur (see **Section 13.1.2** and **Section 13.6.2**).

Within the quaternary deposits (i.e., “grey” and “purple” sequences) of the Lower Aquifer unit, an 18 TAF storage decline at MT water levels would still leave 92% of usable storage available relative to SGMA

[40] The Basin is divided into three Management Areas (Main, Fringe, and Upland). The Upland Area is not considered in this analysis as there are insufficient monitoring wells and groundwater elevation data available to inform comparisons of water level surfaces over time.

Baseline conditions. Meanwhile, the underlying Upper Livermore Formation portion of the Lower Aquifer unit retains 100% of its storage volume at the MT water levels relative to SGMA Baseline conditions, demonstrating that this portion of the Lower Aquifer unit is at virtually no risk of significant storage loss.

The above calculations thus demonstrate that the SMCs defined for the Chronic Lowering of Groundwater Levels Sustainability Indicator are sufficiently protective of URs for Reduction of Groundwater Storage and thus can serve as an effective proxy for defining Reduction of Groundwater Storage MTs in the 2021 Alternative GSP.

13.2.2.3. Fringe Management Area

Table 13-D presents a summary of estimated available groundwater storage volumes for each Principal Aquifer unit within the Fringe Area at MT water level conditions, along with their comparative SGMA Baseline storage volumes. Also provided is an estimate of the percentage volume of each Principal Aquifer unit at MT water levels relative to the SGMA Baseline storage volumes.

Table 13-D. Available Groundwater Storage Estimates at MT Water Levels – Fringe Area

Fringe Subarea	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at MT (TAF)	Storage Volume at MT Relative to SGMA Baseline Storage (%)
North Fringe	74 – 133 TAF	72 – 128 TAF	97%
Northeast Fringe	23 – 46 TAF	20 – 40 TAF	87%
East Fringe	0.3 – 0.6 TAF	0.2 – 0.4 TAF	67%
TOTAL (FRINGE AREA)	**97 – 180 TAF**	**92 – 168 TAF**	**94%**

As a whole, the Fringe Area storage volume would remain no less than 94% under MT water levels relative to SGMA Baseline conditions, corresponding to a total reduction in groundwater storage of approximately 5 – 11 TAF (6%). The North Fringe, Northeast Fringe, and East Fringe Subareas storage volumes will remain at least 97%, 87%, and 67% at MT water levels, respectively, relative to SGMA Baseline conditions, demonstrating that the SMCs defined for Chronic Lowering of Groundwater Levels will also be sufficiently protective of Reduction of Groundwater Storage within these areas of de minimis groundwater use.

13.2.2.4. Upland Management Area

The total groundwater storage of the Upland Area is unknown because it consists of semi-consolidated bedrock of highly variable specific yields and of unknown thickness. The Upland Area provides only very limited groundwater supply for domestic and agricultural uses, and thus there are currently insufficient monitoring wells and groundwater elevation data available to inform calculations of total available storage in the Upland Area at MT water level conditions. As such, no MTs for Reduction of Groundwater Storage are established in the Upland Area.

13.2.3. Measurable Objective and Interim Milestones for Reduction of Groundwater Storage

☑ 23 CCR § 354.30(c)
☑ 23 CCR § 354.30(d)
☑ 23 CCR § 354.30(e)

Consistent with the analysis presented in **Section 8.4**, a calculation was performed to estimate the volume of groundwater that would be removed from storage in the Principal Aquifer units if groundwater levels were to decline from SGMA Baseline (i.e., 2015) levels to their respective MOs for Chronic Lowering of Groundwater Levels (see **Appendix E**). The results of this analysis are presented below.

13.2.3.1. Main Basin Management Area

Table 13-E presents a summary of estimated available groundwater storage volumes for each Principal Aquifer unit within the Main Basin at MO water level conditions, along with their comparative SGMA Baseline storage volumes. Also provided is an estimate of the percentage of remaining storage volume of each Principal Aquifer unit at MO water levels relative to the SGMA Baseline storage volumes.

Table 13-E. Available Groundwater Storage Estimates at MO Water Levels – Main Basin

Principle Aquifer Unit	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at Measurable Objective (TAF)	Storage Volume at MO Relative to SGMA Baseline Storage (%)
Upper Aquifer	59 - 113 TAF	47 - 67 TAF	67%
Lower Aquifer (Quaternary Deposits)	102 - 120 TAF	102 - 110 TAF	95%
Lower Aquifer (Upper Livermore Formation)	85 – 170 TAF	85 – 170 TAF	100%
TOTAL (MAIN BASIN)	**246 – 403 TAF**	**234 – 347 TAF**	**90%**

As a whole, the Main Basin storage volume would remain no less than 90% under MO water levels relative to SGMA Baseline conditions, corresponding to a total reduction in groundwater storage of approximately 12 – 56 TAF (10%).

13.2.3.2. Fringe Management Area

Table 13-F presents a summary of estimated available groundwater storage volumes for each Principal Aquifer unit within the Fringe Area at MO water level conditions, along with their comparative SGMA Baseline storage volumes. Also provided is an estimate of the percentage of each Principal Aquifer unit storage volume at MO water levels relative to the SGMA Baseline storage volumes.

Table 13-F. Available Groundwater Storage Estimates at MO Water Levels – Fringe Area

Fringe Subarea	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at Measurable Objective (TAF)	Storage Volume at MO Relative to SGMA Baseline Storage (%)
North Fringe	74 – 133 TAF	73 – 131 TAF	99%
Northeast Fringe	23 – 46 TAF	21 – 43 TAF	91%
East Fringe	0.3 – 0.6 TAF	0.2 – 0.4 TAF	67%
TOTAL (FRINGE AREA)	**97 – 180 TAF**	**94 – 174 TAF**	**97%**

As a whole, the Fringe Area storage volume would remain no less than 97% under MO water levels relative to SGMA Baseline conditions, corresponding to a total reduction in groundwater storage of approximately 3 – 6 TAF (3%).

13.2.3.3. Upland Management Area

The total groundwater storage of the Upland Area is unknown because it consists of semi-consolidated bedrock of highly variable specific yields and of unknown thickness. The Upland Area provides only very limited groundwater supply for domestic and agricultural uses, and thus there are currently insufficient monitoring wells and groundwater elevation data available to inform calculations of total available storage in the Upland Area at MO water level conditions. As such, no MOs for Reduction of Groundwater Storage are established in the Upland Area.

13.2.4. Demonstration of Sustainability

Per CWC 10733.6 (a)(3), this Alternative GSP must demonstrate that the Basin has been operating within its sustainable yield for at least 10 years. Relative to the Reduction in Groundwater Storage Indicator, **Figure 8-8** demonstrates that water levels in the RMS-WLs have been maintained above the SMCs for the last 10 years, indicating long-term sustainability and absence of URs. **Figure 8-14** further demonstrates that groundwater storage volumes in the Basin have remained above Reserve Storage volumes, indicating sustainable conditions. Additionally, based on Zone's 7 expansive SGMA Monitoring Network (**Section 14**), sustainable groundwater conditions over the long-term are demonstrated in **Section 8**.

13.3. Seawater Intrusion

13.3.1. Undesirable Results for Seawater Intrusion

§ 354.26. Undesirable Results
(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

☑ **23 CCR § 354.26(d)**

The 23 CCR § 354.26(d) states that "An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators". Because the Basin is not located near any saline water bodies, seawater intrusion is not present and not likely to occur. The Seawater Intrusion Sustainability Indicator is therefore not applicable to the Basin, and no URs for this Sustainability Indicator are defined herein.

13.3.2. Minimum Threshold for Seawater Intrusion

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:

(A) Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.

(B) A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.

…

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

☑ **23 CCR § 354.28(c)(3)**
☑ **23 CCR § 354.28(e)**

The Seawater Intrusion Sustainability Indicator is not applicable for the Basin; thus, no MTs for this Sustainability Indicator are defined.

13.3.3. Measurable Objectives and Interim Milestones for Seawater Intrusion

The Seawater Intrusion Sustainability Indicator is not applicable for the Basin; thus, no MOs or IMs for this Sustainability Indicator are defined.

13.4. Degraded Water Quality

Section 8.6 provides a characterization of Basin groundwater quality spatially and over time since 1974, while **Sections 5.2, 8.6**, and **14.2** present information regarding Zone 7's extensive water quality monitoring and management programs, respectively, which include efforts to:

- protect and enhance the quality of the groundwater;
- halt degradation from salt buildup (offset current and future salt loading);

- reduce flow of poorer quality shallow groundwater into deep aquifers;
- offset impacts of water recycling and wastewater disposal through implementation of an integrated Salt Management Plan (SMP; *Zone 7, 2004*)[41] and Nutrient Management Plan (NMP; *Zone 7, 2015c*)[42];
- active Basin recharge with relatively low total dissolved solids (TDS)/hardness imported or storm/local surface water; and
- minimize threats of groundwater pollution through implementation of coordinated groundwater protection programs.

Consistent with the above efforts and adaptive management principles, Zone 7 has actively responded to numerous groundwater quality issues over time in the Basin and is committed to working with applicable regulatory agencies to ensure on-going protection of the Basin to meet beneficial uses (e.g., drinking water and agriculture). Key water quality management programs that are either led by or coordinated with Zone 7 are summarized throughout this Alternative GSP and will continue throughout the SGMA implementation horizon. As a compliment to the on-going efforts referenced above, this section discusses the development of SMCs for the following specific constituents of concern (COCs) in the Basin:

- TDS and Salt Loading
- Nitrate and Nutrient Loading
- Additional inorganic COCs (Boron and Hexavalent Chromium)
- Per- and polyfluoroalkyl substances (PFAS)

In general, as described in **Section 8.6** and other documents (e.g., the 2004 SMP; 2015 NMP; 2016 Alternative GSP; 2020 WY Annual Report) elevated concentrations of these COCs in the Basin are:

- localized,
- being actively managed,
- often elevated due to ambient sources or historical conditions in the Basin,
- not affecting beneficial uses at primary drinking water wells (municipal wells) in the Main Basin (i.e., are reasonably treatable), and
- have not been caused or exacerbated by Basin-wide management for sustainability.

As such, the SMCs presented herein (which are largely based Primary or Secondary Maximum Contaminant levels [MCLs] and the Regional Water Quality Control Board's [RWQCB] Basin Management Objectives [BMOs] that were incorporated by Zone 7 in its 2005 Groundwater Management Plan

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[41] Salt Management Plan, 2004, https://www.zone7water.com/sites/main/files/file-attachments/smp_tocexec-summ.pdf?1619909420

[42] Nutrient Management Plan, Livermore Valley Groundwater Basin, Zone 7 Water Agency, July 2015

[GWMP][43] and affirmed in subsequent documents) are designed to support Zone 7's continued sustainable management of the Basin's groundwater quality on a regional basis, while protecting groundwater quality for beneficial uses.

13.4.1. Undesirable Results for Degraded Water Quality

☑ **23 CCR § 354.26(a)**

SGMA defines an UR for Degraded Water Quality as "significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies" (CWC § 10721(x)). The UR for Degraded Water Quality is defined herein as follows:

An Undesirable Result for degraded water quality within the Basin is experienced if groundwater recharge or extraction causes significant and unreasonable degradation of water quality in the Basin, such that these changes impact to the long-term viability of domestic, agricultural, municipal, environmental, or other beneficial uses over the planning and implementation horizon of this Alternative GSP.

Significant and unreasonable changes to water quality associated with Undesirable Results would include a significant increase, on a regional basis, in concentrations of identified COCs above applicable state and federal regulatory thresholds, as a result of groundwater recharge or extraction.

The component of the significant and unreasonable effects definition regarding a regional basis draws a distinction between localized or isolated (e.g., well specific) effects, that are not necessarily under the purview of Groundwater Sustainability Agencies (GSAs) to manage (especially if related to well location and design relative to naturally-occurring or anthropogenically-caused impacts that pre-date SGMA), and broader, groundwater management-related regional effects which can fall under a GSA's purview. This approach is both consistent with the SGMA's definition of URs meaning "…effects caused by groundwater conditions occurring throughout the basin" (emphasis added) (CWC § 10721(x)) and reflects the fact that SGMA does not require GSPs to address URs that occurred before, and have not been corrected by, January 1, 2015. (CWC § 10727.2(b)(4)). In approving Zone 7's 2016 Alternative GSP, DWR found that through 2015 Zone 7 had managed the Basin sustainably (i.e., absent of URs). As such it is reasonable to use groundwater conditions in 2015 as an effective "SGMA Baseline" to evaluate any potential further degradation in groundwater quality. Therefore, the UR definition appropriately focuses on whether water quality conditions are significantly and unreasonably degraded as a result of changes in groundwater level or flow.

13.4.1.1. Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

URs due to Degraded Water Quality are the result of increases in concentrations of COCs in groundwater

[43] https://www.zone7water.com/sites/main/files/file-attachments/gw-mgmt-plan_2005.pdf?1619906741

in the Principal Aquifers of the Basin. These increases in concentration can occur through a variety of processes, some of which are causatively related to groundwater management activities (i.e., potentially under the purview of GSAs) and some of which are not. These can include:

- Declining water levels which can cause lateral migration from adjacent areas with contaminated or poorer quality groundwater, leaching from internal sources such as fine-grained, clay-rich interbeds, or upwards vertical flow from deeper zones below the bottom of the Basin;
- Salt loading from onsite wastewater treatment systems (OWTS) or recycled water use;
- Recharge from managed recharge projects;
- Contact with sediments with naturally-occurring elevated concentrations of a COC;
- Deep percolation of some portion of ineffective precipitation;
- Seepage from various natural and man-made channels;
- Irrigation system backflow into wells and flow through well gravel pack and screens from one formation to another; and/or
- Deep percolation of excess applied irrigation water and other water applied for cultural practices (e.g., for soil leaching).

13.4.1.2. Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**

As discussed further below in **Section 13.4.4 and Section 14.2.5,** the MTs for Degraded Water Quality are established at twelve (12) Representative Monitoring Sites for Degraded Water Quality (RMS-WQs). Based on the significant and unreasonable effects described herein, the criteria for URs for Degraded Water Quality are as follows:

Undesirable Results for Degraded Water Quality are defined to occur within the Basin if and when MTs are exceeded for any of the identified COCs in greater than 25% the RMS-WQs at least two (2) consecutive years as a result of groundwater recharge or extraction, such that they cannot be managed to provide drinking water supply (i.e., that treatment or blending is not possible or practicable).

The above criteria are justified because they relate to impacts that corresponds to a regional, rather than a well-specific, water quality issue. Further, the criteria acknowledge that URs only occur if the groundwater cannot be managed to provide drinking water supply (i.e., that treatment or blending is not possible or practicable). These criteria also acknowledge that the Fringe and Upland Areas already have poor water quality (as detailed in **Section 8.6**), so the focus is on preventing widespread contamination as a result of groundwater recharge or extraction that would further limit beneficial uses. For example, if a RMS-WQ already exceeded the MT in 2015, per the above definition, future detections above the MT would not count towards an UR unless the measured concentrations in groundwater at that RMW-WQ had increased *as a result of groundwater recharge or extraction.*

Similarly, and as discussed below, 23 CCR § 354.28 directs that "the Agency shall consider local, state, and federal water quality standards applicable to the basin" in setting the MT. In this Basin, the State Water Resources Control Board (SWRCB), RWQCB, and Alameda County Environmental Health (ACEH) each set regulatory standards and exercise enforcement authority related to water quality. It is important to note that while the standards set by those entities inform the development of the Degraded Water Quality MTs in this Alternative GSP, the GSA is not the entity responsible for developing or enforcing those standards, or remediating impacts of exceedances of those standards under their independent regulatory schemes. Rather, the exceedance levels set by those regulatory agencies serve as a helpful proxy and indicator, in some cases, to identify the circumstances under which degradation of water quality in the basin might arise to a UR under SGMA. Recognizing these overlapping regulatory schemes, and in the interest of avoiding duplication or conflicting requirements, this Alternative GSP focuses its MTs on COCs traditionally associated with impairment to groundwater supply or interference with beneficial use.

13.4.1.3. Potential Effects of Undesirable Results

☑ **23 CCR § 354.26(b)(3)**

The potential effects of URs caused by Degraded Water Quality on beneficial uses and users of groundwater may include: (1) increased costs to treat groundwater to drinking water standards if it is to be used as a potable supply source; (2) increased costs to blend relatively poor-quality groundwater with higher quality sources for drinking water users; (3) increased costs to purchase bottled water or water softeners; and/or (4) potential reduction in the usable volume of groundwater in the Basin if large areas are impaired to the point that they cannot be used to support beneficial uses and users.

13.4.2. Minimum Threshold for Degraded Water Quality

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

☑ **23 CCR § 354.28(c)(4)**

The 23 CCR § 354.28(c) states that the MT for Degraded Water Quality shall be the "degradation of water, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results". The regulations further state that the MT "shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin," and that "the Agency shall consider local, state, and federal water quality standards applicable to the basin." This language indicates that MTs for Degraded Water Quality can reasonably be based on concentrations of water quality COCs, as quantified by sampling measurements at the RMS-WQs.

13.4.2.1. Constituents of Concern

As described in **Section 8.6.1** and summarized below, several potential COCs have been identified in Basin groundwater. Per CWC Section 10725, the powers and authorities granted to GSAs to affect sustainable groundwater management under SGMA include, but are not limited to, conducting investigations, registration and metering of groundwater extraction facilities, acquiring surface water or groundwater, reclaiming waters for subsequent beneficial use, regulating groundwater extraction, and establishing accounting rules for groundwater extraction allocations. SGMA does not empower GSAs to develop or enforce water quality standards; that authority rests with the SWRCB, the RWQCB, and, in the case of this Basin, with the ACEH. Because of the non-exclusive purview of GSAs with respect to water quality, and the rightful emphasis on those constituents that may affect the supply and beneficial uses of groundwater, SMCs for water quality in the Basin are developed at the designated RMS-WQs for the following constituents of COCs:

- TDS and Salt Loading. TDS concentrations are measured in 233 wells throughout Basin and analyzed on an annual basis the as part of the Zone 7 Water Quality Monitoring Program and SMP (see **Sections 5.2** and **8.6**). As discussed in **Section 8.6.2**, with some exceptions, TDS concentrations generally meet the Basin Plan Water Quality Objectives (WQOs)/Secondary MCL (Recommended) standard of 500 milligrams per liter (mg/L) in the Main Basin. Any elevated TDS concentrations in drinking water supplies are managed through blending, increased artificial recharge with lower TDS imported water, and wellhead treatment (demineralization). In the Fringe and Upland Areas, TDS concentrations generally exceed the WQOs/Secondary MCL (Upper) of 1,000 mg/L. If TDS concentrations were to significantly increase relative to current conditions, the wells could become unusable for drinking water purposes without significant improvement or could impact the health of sensitive livestock and crops. However, based on historical trends, and the annual salt loading calculations conducted by Zone 7 as part of the SMP[44], it is not anticipated that TDS concentrations will increase significantly relative to current levels in these management areas.
- Nitrate and Nutrient Loading. Nitrate and nutrient (i.e., phosphate) concentrations are measured in 233 wells throughout Basin and analyzed on an annual basis the as part of the Zone 7 Water Quality Monitoring Program and NMP (see **Sections 5.2** and **8.6**). In addition, the municipal wellfields in the Basin have a rigorous groundwater sampling protocol as required by drinking water permits issued by the SWRCB Division of Drinking Water (DDW) to ensure that elevated Nitrate concentrations are not present in drinking water supplies. As discussed in **Section 8.6.3**, with some exceptions, Nitrate and nutrient concentrations in the Main Basin and Fringe Area are generally lower than the applicable regulatory thresholds and do not indicate water quality

[44] Zone 7's salt loading calculations provide an annual estimate of salt loading to the Basin in tons. Recognizing that salt addition and removal changes from year to year, Zone 7 strives for no long-term net loading. The theoretical salt loading calculations indicate that TDS concentrations are relatively stable at about 700 mg/L throughout the Basin, with small projected decreases expected over time due to Zone 7 management actions.

deterioration over time. Ten local Areas of Concern (AOCs)[45] have been identified with respect to Nitrate that are being addressed through ongoing monitoring of Nitrate in groundwater and coordination with land use agencies for Best Management Practice (BMP) requirements to manage nitrogen loading to the Basin, plus coordination with ACEH on its management program for OWTS (including imposition of a moratorium on additional OWTSs).

- Boron. Boron concentrations are measured in 233 wells throughout Basin and analyzed on an annual basis the as part of the Zone 7 Water Quality Monitoring Program (see **Sections 5.2** and **8.6**). As discussed in **Section 8.6.4**, Boron is a naturally-occurring element in the Basin related to the occurrence of alkali/marine sediments (particularly prevalent in eastern watersheds). However, if elevated Boron concentrations are detected in the Basin's municipal wellfields, beneficial uses (drinking water and agriculture) could be affected. Potential effects could include potential health issues related to excessive boron in drinking water and potential adverse effects on sensitive crops and landscaping.
- Hexavalent Chromium. Chromium (Cr) concentrations are measured in 233 wells throughout Basin and analyzed on an annual basis the as part of the Zone 7 Water Quality Monitoring Program (see **Sections 5.2** and **8.6**As discussed in **Section 8.6.5**, Chromium is a heavy metal that occurs naturally throughout the environment, including the Basin, associated with serpentinite-containing rock or chromium-containing geologic formations. Given the occurrence of locally elevated chromium concentrations in the Basin (which Zone 7 conservatively assumes is entirely Cr VI)[46], Zone 7 (with approval of the SWRCB DDW) blends water produced from any affected wells with other sources of water as needed to minimize any potential risk of MCL exceedance in delivered water. This protects the municipal drinking water use of groundwater consistent with Zone 7 BMOs and avoids URs.
- PFAS. PFAS are a large group of human-made chemicals that do not occur naturally and are classified by the United States Environmental Protection Agency (USEPA) as "contaminants of emerging concern" (CECs). Zone 7 began sampling for PFAS compounds in the 2019 Water Year (WY). Based on the detections in some of the supply wells and the limited set of monitoring wells sampled, Zone 7 retained Jacobs Engineering, Inc. to conduct a PFAS Potential Source Investigation (*Jacobs, 2020*)[47]. The investigation, which concluded in December 2020, included

[45] While a few of the AOCs are believed to have been caused by historical municipal wastewater practices, most high concentrations are caused by historical or ongoing use of onsite wastewater treatment systems (OWTS) and agriculture use including crop and livestock operations (e.g. vineyard fertilizers, cattle, poultry, horse stables) and leaching of decaying vegetation. The occurrence and causes of these nitrate AOCs are based on historical groundwater quality and ongoing sampling through the Zone 7 Groundwater Quality Monitoring Program, as well as Zone 7 investigations of local nitrate sources (including nitrate balances), and the Zone 7 NMP.

[46] The Zone 7 Water Quality Monitoring Program monitors for total chromium without distinction of CrIII (a required nutrient with very low toxicity) from CrVI, which is more toxic. To be conservative, Zone 7 assumes that the total chromium concentration is exclusively CrVI.

[47] Jacob's PFAS Potential Source Investigation Report and other information on PFAS are located on the Zone 7 website: http://www.zone7water.com/pfas-information.

recommendations for additional sampling of existing monitoring wells. Those wells will be incorporated into the 2021 WY sampling program.

As discussed in **Section 14.2.4**, drinking water wells are used as RMS-WQs so that they inherently consider groundwater quality effects on sensitive beneficial uses (i.e., drinking water users) and are also already sampled for constituents of health concern on a regular and known schedule (i.e., compliance with Title 22 CCR drinking water regulations for Primary MCLs). As part of Zone 7's overall management of the Basin, additional wells are regularly sampled and used for continued evaluation of groundwater quality trends within the Basin.

13.4.2.2. Toxic Sites

As discussed in **Section 8.6.7**, multiple toxic sites—where groundwater has been contaminated from anthropogenic sources—pose a potential threat to drinking water. Primary responsibility for toxic site regulation, investigation, monitoring and remediation lies with federal and state agencies. Nonetheless, these sites are addressed by Zone 7 in its BMO to minimize threats of groundwater pollution through groundwater protection and its ongoing sustainable groundwater management. This includes its Toxic Sites Surveillance (TSS) Program wherein Zone 7 gathers information on toxic sites from state, county, and local agencies, as well as from Zone 7's well permitting program and the SWRCB's GeoTracker website. The information is compiled in a geographic information systems (GIS) database, which serves as a basis for inter-agency coordination. In general, the TSS Program has found two basic causes of contamination threatening groundwater in the Basin, releases of petroleum-based fuel products (e.g., from gas stations) and releases of industrial chemical contaminants (e.g., dry cleaners and electronics and automotive industries). These sites are addressed by state and federal agencies, in cooperation with Zone 7, at a site-specific level. Given those overlying authorities, and the fact that programs are already in place to address these sites, no additional or specific SMCs have been developed to target these sites, which will be addressed on a case-by-case basis as they are identified by the TSS Program and referred to appropriate enforcement agencies.

13.4.2.3. Consideration of State, Federal and/or Local Standards

The State of California and the USEPA set Primary MCLs for constituents that may pose potential human health risks. Secondary MCLs are also established to address aesthetic concerns. As discussed above, although the GSA is not the entity responsible for developing or enforcing the MCLs, the Primary and Secondary MCLs serve as a useful quantitative tool to consider when establishing MTs under SGMA for Degraded Water Quality. The WQOs specified in the RWQCB's Basin Plan are also used to inform MT development, as well as other pertinent regulatory criteria.

13.4.2.4. Minimum Thresholds for Degraded Water Quality

As described below, to account for pre-2015 (i.e., SGMA Baseline) background concentrations and variations in groundwater quality data, the MTs for Degraded Water Quality are set for the applicable COCs at the greater of: (1) their respective MCLs or other appropriate regulatory criteria, or (2) the SGMA Baseline concentration plus maximum historical data range. The final MTs are shown in **Table 13-G**. It should be noted that monitoring for these and other water quality parameters will continue to be conducted at all water quality monitoring well locations as part of the Zone 7 Water Quality Monitoring Program, as discussed further in **Section 14.2.4**.

$$MT = MCL\ or\ Other\ Regulatory\ Criteria$$

$$or$$

$$MT = SGMA\ Baseline\ plus\ Maximum\ Annual\ Rate\ of\ Water\ Quality\ Change$$

- TDS and Salt Loading. For the Main Basin, the MT for TDS is established at the Recommended Secondary MCL (based on aesthetics, such as taste and odor) of 500 mgl/L, or the SGMA Baseline (i.e., 2015) concentrations plus maximum historical data range, whichever is greater. For the Fringe and Upland Areas, the MT for TDS is established at the Upper Secondary MCL of 1,000 mg/L, or the SGMA Baseline concentrations plus maximum historical data range, whichever is greater. These MTs are consistent with state and federal standards for drinking water quality, and background, pre-SGMA concentrations. Trends toward the MT or exceedances that are correlated to Zone 7 management actions will trigger management responses by Zone 7 in collaboration with the other municipal pumpers in the Basin. The responses can involve short-term actions including further investigation (e.g., resampling or investigation of causes) and reduction of pumping of the affected well along with redistribution of pumping or provision of other supplies to maintain a high-quality supply to customers. Longer-term actions include the salt management strategies identified in the SMP, such as artificially recharging the Basin with low TDS imported water when available; pumping and delivering additional groundwater to customers so more salts are exported as wastewater; and operating the Mocho Groundwater Demineralization Plant. Overall, the MTs will protect groundwater quality for beneficial uses and users of groundwater and, given the resultant reliable high quality water supply, will protect land uses and property interests.
- Nitrates and Nutrient Loading. The concentration of 10 mg/L for Nitrate (as N) or the SGMA Baseline concentrations plus maximum historical data range, whichever is greater, serves as the MT for all Management Areas within the Basin. This approach is consistent with the federal and state Primary MCL for drinking water, the Basin WQOs, and the expectations of SGMA. Zone 7 conducts ongoing monitoring of Nitrate in groundwater and coordinates with land use agencies for BMP requirements to manage nitrogen loading to the Basin and with ACEH on its management program for OWTS. Overall, the MT will protect groundwater quality for beneficial uses and users of groundwater (most notably domestic well owners). Such protection of rural water supply will support land uses and property interests, although a local moratorium on OWTS may require some landowners to seek alternatives to OWTS (e.g., local community wastewater systems).
- Boron. While there is no MCL for boron, the USEPA has identified a Health Reference Level (HRL) of 1,400 micrograms per liter [µg/L] (1.4 mg/L). Boron also becomes a problem for certain irrigated crops when present at levels above 1,000 or 2,000 µg/L, depending on the crop sensitivity. As such, the MT is set at 1,400 µg/L or the SGMA Baseline concentrations plus maximum historical data range, whichever is greater, for all Management Areas within the Basin. This is a conservative threshold that is protective of human health as well as sensitive crops and landscaping plants. Boron is a naturally occurring constituent, but its distribution can be affected by Basin-wide management activities. Management actions for Boron are included in the salt management

strategies identified in the SMP, such as artificially recharging the Basin with low TDS imported water when available; pumping and delivering additional groundwater to customers so more salts are exported as wastewater; and operating the Mocho Groundwater Demineralization Plant.

- Hexavalent Chromium. For hexavalent chromium (CrVI), the MCL of 50 µg/L (0.05 mg/L) or the SGMA Baseline concentrations plus maximum historical data range, whichever is greater, serves as the MT for all Management Areas within the Basin[48]. It is noted that this approach is conservative as some uncertainty exists with regard to concentrations of CrVI in the Basin. Specifically, the Zone 7 Water Quality Monitoring Program monitors for total chromium without distinction of CrIII (a required nutrient with very low toxicity) from CrVI, which is more toxic. To be conservative, Zone 7 assumes that the total chromium concentration is exclusively CrVI. When excessive concentrations are detected in one or more municipal supply well(s), Zone 7 (with approval of the SWRCB DDW) blends water produced from the affected well(s) with other sources of water as needed to minimize any potential risk of MCL exceedance in delivered water. This protects the municipal drinking water use of groundwater consistent with Zone 7 BMOs and avoids URs.
- PFAS. There are currently no federal or state regulatory standards (e.g., MCLs) for PFAS. As such, Zone 7 has not established any SMCs for PFAS; but continues to collect PFAS data, identify potential sources, and study the effects of potential contaminant migration (**Sections 14.5.2** and **15.2.3**). This issue will be addressed in the next Alternative GSP update once additional data have been collected and regulatory criteria established. However, Zone 7 manages and treats groundwater to meet current regulatory requirements for drinking water supply and plans to be in compliance with future water quality standards.

[48] Prior to August 2017, the Basin BMO and the MT in the 2016 Alternative GSP had been set at the MCL for hexavalent chromium (CrVI), which was 10 µg/L. In August 2017, under orders of the Superior Court, the SWRCB withdrew the CrVI regulation from the California Code of Regulations (CCR). Until the SWRCB establishes a new MCL for CrVI, they have returned to using the more general total Cr MCL of 50 µg/L to ensure public water systems are safe. Since all the minimum thresholds in the Alternative GSP have been set based on the State's drinking water standards, Zone 7 adjusted the MT and MO for Cr to match the State's Cr MCL that is in effect; currently 50 µg/L.

Table 13-G. SMCs for Degraded Water Quality

RMS-WQ	TDS and Salt Loading (mg/L)		Nitrates and Nutrient Loading (mg/L)		Boron (µg/L)		Hexavalent Chromium (µg/L)	
	MT	MO	MT	MO	MT	MO	MT	MO
3S1E20C007	800	500	10	10	1,400	1,400	50	50
3S1E20C008	754	500	10	10	1,400	1,400	50	50
3S1E09P005	1,308	500	10	10	1,400	1,400	50	50
3S1E09P010	617	500	10	10	1,400	1,400	50	50
3S1E11G001	962	500	19	10	1,400	1,400	50	50
3S1E12K003	596	500	10	10	1,400	1,400	50	50
3S2E08K002	696	500	16	10	1,400	1,400	50	50
3S2E08H003	718	500	15	10	1,400	1,400	50	50
3S1E06F003	3,655	2,845	10	10	4,590	1,400	50	50
2S2E34E001	1,000	1,000	10	10	4,720	1,400	50	50
3S2E24A001	1,179	1,024	38	10	2,400	1,400	50	50
3S2E21K009	1,000	1,000	10	10	1,400	1,400	50	50

13.4.3. Measurable Objectives and Interim Milestones for Degraded Water Quality

☑ 23 CCR § 354.30(c)
☑ 23 CCR § 354.30(e)

As with the MTs, the MOs for Degraded Water Quality are defined at the RMS-WQ in the Basin for the identified COCs, considering appropriate regulatory criteria while maintaining concentrations at approximately current levels, see **Table 13-G**. As current concentrations are below the MOs in most cases (i.e., meaning current water quality is better than MO), setting IMs for Degraded Water Quality based on extrapolation between current concentrations and the MOs would suggest that current water quality needs improvement to achieve MO. Therefore, setting variable IMs is not considered applicable unless current concentrations at the RMS-WQ are greater than the MO, in which case the IMs represent a linear interpolation between current concentrations and the MO.

- TDS and Salt Loading. For the Main Basin, the MO for TDS is established at the Recommended Secondary MCL (based on aesthetics, such as taste and odor) of 500 mg/L. For the Fringe and Upland Areas, the MO for TDS is established at the Upper Secondary MCL of 1,000 mg/L or 2015 concentrations, whichever is greater. These MOs reflect the historical variation in water quality across the Basin and are consistent with state and federal standards for drinking water quality, as well as background, pre-SGMA concentrations.
- Nitrates and Nutrient Loading. The concentration of 10 mg/L for Nitrate (as N) is established as the MO for all Management Areas within the Basin, which the Federal and State Primary MCL for drinking water.
- Boron. The HRL of 1,400 µg/L is established as the MO for all Management Areas within the Basin.

- Hexavalent Chromium. The Primary MCL of 50 µg/L is established as the MO for all Management Areas within the Basin.
- PFAS. There are currently no federal or state regulatory standards (e.g., MCLs) for PFAS. As such, Zone 7 has not established any SMCs for PFAS. This issue will be addressed in the next Alternative GSP update once additional data have been collected and regulatory criteria established.

13.4.4. Demonstration of Sustainability

Per CWC 10733.6 (a)(3), this Alternative GSP must demonstrate that the Basin has been operating within its sustainable yield for at least 10 years. Relative to the Degradation of Water Quality Sustainability Indicator, **Figure 8-19, Figure 8-25, Figure 8-31,** and **Figure 8-34** demonstrate that water quality in the RMS-WQs have been maintained below the corresponding MTs, or consistent with background levels, for the last 10 years, indicating long-term sustainability and absence of URs (i.e., there is no indication that water quality conditions have been significantly and unreasonably degraded *"as a result of groundwater recharge or extraction."*). TDS was detected above the MT in one RM-WQs, see **Figure 8-19**, but not as a result of groundwater recharge or extraction.

13.5. Land Subsidence

Generally, land subsidence is the lowering of land surface over a large area. It is most often the result of artificial causes such as excessive groundwater pumping, fracking, or mining activities. Natural phenomenon such as earthquakes and tectonic movement can also cause land subsidence. Two distinct types of land subsidence could occur from groundwater pumping: (1) the elastic (recoverable) subsidence that is temporary and reversible as groundwater levels recover, and (2) inelastic (permanent) subsidence, which results in the permanent lowering of the land surface even after pumping stops.

Although, there are no historical records of significant and unreasonable land subsidence within the Basin that has substantially interfered with surface land uses to date, Zone 7 Water Agency has recognized subsidence as a potential UR. For example, the 2005 GWMP includes a BMO that has been implemented by Zone 7 over the past ten years, that calls for monitoring and prevention of inelastic land surface subsidence as a result of groundwater withdrawals and specified that Zone 7:

- Protect the storage capacity of aquifer;
- Maintain water levels above historic lows;
- Monitor and minimize any identified impacts of gravel mining on the upper aquifer by encouraging the implementation of mitigation measures by mining companies; and
- Monitor benchmark elevations and shift pumping to other wells if inelastic subsidence is detected.

In addition, the adoption of the Well Master Plan Environmental Impact Report in 2005 (*Zone 7 WMP EIR, 2005b*) required the continuation of Zone 7's Land Surface Elevation Monitoring Program (see **Section 14.2.5**), as did the 2016 Alternative GSP.

13.5.1. Undesirable Results for Land Subsidence

☑ **23 CCR § 354.26(a)**

SGMA defines an UR for Land Subsidence as "significant and unreasonable land subsidence that substantially interferes with surface land uses" (CWC § 10721(x)). The UR for Land Subsidence is defined herein as follows:

An Undesirable Result for land subsidence would be experienced if the occurrence of land subsidence substantially interferes with beneficial uses of groundwater and infrastructure within the Basin during the planning and implementation horizon of this Alternative GSP.

The above definition of significant and unreasonable effects is developed recognizing that small amounts of subsidence could occur without negatively affecting the ability to use the critical infrastructure, and that only to the extent that subsidence causes a loss of functional capacity does it qualify as significant and unreasonable.

13.5.1.1. Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Land subsidence can be caused by several mechanisms, but the mechanism most relevant to sustainable groundwater management activities under the authority of GSAs is the depressurization of aquifers and aquitards due to lowering of groundwater levels, which can lead to compaction of compressible strata and lowering of the ground surface. Therefore, the potential causes of URs due to Land Subsidence are generally the same as the potential causes listed above for URs due to Chronic Lowering of Groundwater Levels (i.e., increased pumping and/or reduced recharge).

13.5.1.2. Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**

As discussed in **Section 8.7***,* measured vertical displacement in the Basin has been minor to date indicating that land subsidence and damage to critical infrastructure (shown on **Figure 8-40**) is not a significant concern in the Basin, based on the best available information. Furthermore, observed land surface elevation changes is within the range Zone 7 considers to be "elastic deformation" (i.e., rebounds to the original elevation when groundwater levels return to previous levels). Given that land subsidence and lowering of groundwater levels are closely related, it is reasonable to expect that the MTs for Chronic Lowering of Groundwater Levels will be protective to prevent significant and unreasonable effects from land subsidence in the Basin (*Zone 7 WMP EIR, 2005b*).

As such, the criteria used to define URs for Land Subsidence are consistent with the criteria used to define URs for Chronic Lowering of Groundwater Levels, as follows, with one addition:

Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if water levels in greater than 25% of the RMS-WLs decline below their respective MTs for two consecutive years, that result in a confirmed decrease of 0.4 feet of land surface in any given cycle with a goal of experiencing no inelastic subsidence spatially and temporally.

Publicly available subsidence data including Interferometric Synthetic Aperture Radar (InSAR) data will continue to be evaluated as part of Alternative GSP implementation. Should any indication of subsidence begin to be observed in the Basin, that issue will be addressed in future Alternative GSP updates, as needed.

13.5.1.3. Potential Effects of Undesirable Results

☑ **23 CCR § 354.26(b)(3)**

As documented in **Section 8.7**, no inelastic land subsidence has been observed in the Basin during the duration of the current Land Surface Elevation Monitoring Program includes 18 years of data (i.e., 2002 to 2020), nor anytime covered by two historical research efforts: 1992-2016 (*TRE, 2016*) and 1947-1980 (*Altamont Land Surveyors, 1994*). However, because alluvial aquifers are present under the urban area of the Basin, significant and unreasonable inelastic subsidence would represent a potential UR, with several potential effects on beneficial uses and users of groundwater and on land uses and property interests. These could include:

- Potential differential subsidence affecting the gradient of surface drainage channels, locally reducing the capacity to convey floodwater and causing potential nuisance ponding and seepage; the westernmost portion of the Basin is crossed by a system of engineered stream channels and canals the grades of which are constructed and maintained to minimize flooding problems.
- Potential differential subsidence affecting the grade of other infrastructure such as transportation facilities; the western Basin is urbanized, crossed by two interstate highways and BART.
- Potential differential subsidence affecting State Water Project (SWP) South Bay Aqueduct (SBA) and other conveyance facilities such that conveyance capacities are impacted.
- Potential subsidence around a pumping well, disrupting wellhead facilities or resulting in casing failure.
- Potential non-recoverable loss of groundwater storage as fine-grained layers collapse.

13.5.2. Minimum Threshold for Land Subsidence

§ 354.28. Minimum Thresholds
(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:
(A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.
(B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

☑ 23 CCR § 354.28(c)(5)

13.5.2.1. Main Basin and Fringe Management Areas

The GSP regulations allow GSAs to use groundwater levels as a proxy metric for the land subsidence sustainability indicator if there is a correlation between groundwater levels and the land subsidence. The 2005 WMP EIR indicated that the potential for inelastic (permanent) subsidence in the Main Basin increases as groundwater levels approach historic lows. There is limited potential for subsidence in the Fringe Area due to the prevalence of semi-consolidated bedrock. Therefore, Zone 7 has long concluded that groundwater elevations in the Main Basin and Fringe Management Areas can be used as a guide for subsidence prevention. The resultant MTs for the RMS-WLs within the Basin are shown in **Table 13-H** and **Figure 8-8** and discussed in more detail in **Section 14.4**.

Table 13-H. SMCs for Land Subsidence

RMS[1] Well		Management Area/Unit			Historical Conditions (ft)			SMCs[3] Water Levels				
Well Name	Map	Area	Subarea	Aquifer	Historic Low	Maximum Decrease[2]	Historic Low + Max Decrease	Minimum Threshold[4]	IM-5[5]	IM-10	IM-15	Measureable Objective[6]
3S1E20C007	20C7	Main	Bernal	Upper	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E20C008	20C8	Main	Bernal	Lower	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E09P005	9P5	Main	Amador West	Upper	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E09P010	9P10	Main	Amador West	Lower	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E11G001	11G1	Main	Amador East	Upper	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S1E12K003	12K3	Main	Amador East	Lower	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S2E08K002	8K2	Main	Mocho II	Upper	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S2E08H003	8H3	Main	Mocho II	Lower	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S1E06F003	6F3	Fringe	Northwest	Upper	314.6	-9.7	305.0	305.0	307.4	309.8	312.2	314.6
2S2E34E001	34E1	Fringe	Northeast	Upper	491.2	-3.0	488.2	488.2	489.0	489.7	490.5	491.2
3S2E24A001	24A1	Fringe	East	Upper	678.3	-2.8	675.5	675.5	676.2	676.9	677.6	678.3

[1] RMS = Representative Monitoring Site
[2] Maximum Single Year Seasonal Decrease (Spring to Fall)
[3] Sustainable Management Criteria
[4] Historic Low + Maximum Seasonal Decrease
[5] IM-# = Interim Milestone at # years
[6] Measurable Objective = Historic Low

As such, it is reasonable to relate the Land Subsidence Sustainability Indicator with the Chronic Lowering of Groundwater Levels Sustainability Indicator, with the additional constraint that no more than 0.4 feet of inelastic subsidence can occur in any year.

If these MTs are triggered, an analysis of the factors influencing the ground surface elevation will be undertaken. Other preventative actions may include shifting groundwater extraction to other wells and/or placing a moratorium on all new well construction in the area of concern until levels recover or the investigation determines that other factors are likely causing subsidence (such as fault movement or shallow expansive soils). Two factors fundamental to assessing and preventing the exceedance of these MTs are: (1) land surface monitoring, and (2) groundwater level monitoring. Both are included in Zone 7's Monitoring Program (see **Section 14**).

13.5.2.2. Upland Management Area

In the Upland Area the prevalence of semi-consolidated bedrock means that there is very limited potential for subsidence. As such, no MTs for Land Subsidence are established in the Upland Area.

13.5.3. Measurable Objectives and Interim Milestones for Land Subsidence

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(d)**
☑ **23 CCR § 354.30(e)**

13.5.3.1. Main Basin and Fringe Management Areas

As discussed in **Section 13.5.2**, the Land Subsidence Sustainability Indicator and the Chronic Lowering of Groundwater Levels Sustainability Indicator are closely linked. As with the MTs, the MOs and IMs for Chronic Lowering of Groundwater Levels are used as proxy for the Land Subsidence Sustainability Indicator and would provide an adequate Margin of Operational Flexibility. It is therefore unnecessary to set a unique MO and IM for Land Subsidence in the Main Basin and Fringe Area.

13.5.3.2. Upland Management Area

In the Upland Area the prevalence of semi-consolidated bedrock means that there is very limited potential for subsidence. As such, no MOs for Land Subsidence are established in the Upland Area.

13.5.4. Demonstration of Sustainability

Per CWC 10733.6 (a)(3), this Alternative GSP must demonstrate that the Basin has been operating within its sustainable yield for at least 10 years. Relative to the Land Subsidence Sustainability Indicator, **Figure 8-8** demonstrates that water levels in the RMS-WLs have been maintained above the SMCs for the last 10 years, indicating long-term sustainability and absence of URs. **Figure 8-B** further demonstrates that land subsidence rates have not exceeded 0.4 feet. Additionally, based on Zone's 7 expansive SGMA Monitoring Network (**Section 14**), sustainable groundwater conditions over the long-term are demonstrated in **Section 8**.

13.6. Depletions of Interconnected Surface Water

This section describes the proposed SMCs for Depletions of Interconnected Surface Water, including the URs, MOs and MTs for areas of the Basin that have likely ICSW and/or GDEs. These SMCs were developed in consideration of the CWC §10727.2(b)(4) which states that the Plan may, but is not required to, address URs that occurred before, and have not been corrected by, January 1, 2015. It is further noted that the GSP Emergency Regulations (23 CCR § 354.28(c)) state that the SMCs for a given Sustainability Indicator can be set by using groundwater levels as a proxy, which is the approach utilized herein.

13.6.1. Undesirable Results for Depletions of Interconnected Surface Water

☑ **23 CCR § 354.26(a)**

URs are defined in the SGMA as "when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin". For Depletions of ICSW, SGMA defines an UR as "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water".[49]

As shown in **Appendix F**, based on information provided by The Nature Conservancy (TNC),[50] the area-weighted average change in the size of the GDE areas between 2014 and 2018 within the Basin was approximately 40% (i.e., the mapped GDE area in 2014 was 40% smaller than the GDE areas mapped in 2018).[51] Based on this change in GDE area analysis, a 40% reduction in GDE area is within the historical range of GDE area fluctuation under recently-observed, post-SGMA hydrologic conditions.

As such, the URs for Depletions of ICSW would be experienced in the Basin when groundwater extractions in the Basin cause significant and unreasonable depletions of hydrologically connected surface water, such that beneficial uses and users of the surface water (including the likely GDEs and protected species) are significantly and unreasonably harmed. Specifically, a significant and unreasonable negative effect would be experienced if the health of the GDE areas in the Basin are adversely impacted by mechanisms that can be directly attributed to pumping-related lowering of groundwater levels over time, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions or land use changes.

[49] CWC § 10721(x) (6)

[50] Statewide raster data that show Normalized Derived Vegetation Index (NDVI) trends are provided by TNC on 30 August 2021. Since NDVI is used to estimate vegetation greenness and provides a proxy for vegetation growth, change in GDE area can be estimated using TNC GDE Pulse raster data that shows the NDVI trends between 2014 and 2018. Moderate to large increases in NDVI trends represent an increase in the GDE area and moderate to large decreases in NDVI trends represent a decrease in the GDE area. Therefore, the change in GDE area can be estimated by subtracting GDE area with decreasing NDVI trends from GDE area with increasing NDVI trends.

[51] Since the Plan is not required to address undesirable results that occurred before, and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2014 is selected as the start of the analysis timeframe. 2018 is selected as the end of the analysis timeframe since it is a recent wet year when GDE conditions might be above average.

This UR definition is preliminary pending the collection of additional data. At this time, as described above, the relationship between ICSW, GDE health and groundwater conditions has not been definitively determined and the ability of Zone 7 to manage the ICSW and GDE areas is limited given the significant other factors that impact their occurrence and health (e.g., climate, hydrology, invasive species, land development, etc.). Furthermore, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs. Zone 7 will continue to monitor the ICSW and GDE areas and may refine the definition of URs once the information regarding the relationship between the occurrence of ICSW and GDEs and the management of the Basin is better understood.

13.6.1.1. Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Depletions of ICSW are generally correlated to Chronic Lowering of Groundwater Levels in a system of ICSW and groundwater. Therefore, the potential causes of URs for the Depletions of ICSW are generally the same as the potential causes for URs due to Chronic Lowering of Groundwater Levels, including increased groundwater pumping and reduced recharge. Additional causes directly related to surface water bodies can also influence depletions including, but not limited to, hydrology, increased diversions, reduced return flows, and water consumption by riparian vegetation. Additional causes related to GDEs can include hydrology, land use changes and the occurrence of invasive species, among other things. Currently there are little to no quantitative data regarding the impacts from these potentially contributing causes to ICSW and GDEs within the Basin.

13.6.1.2. Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**

Per Section 354.26(b)(2) of the GSP Emergency Regulations, the description of URs must include a quantitative description of the combination of MT exceedances that constitute an UR. The MTs for Depletions of ICSW are described below in **Section 13.6.2**.

Based on application of the MTs at the Representative Monitoring Sites for Interconnected Surface Water (RMS-ICSW) and the significant and unreasonable negative effect discussed above, URs will be experienced if and when Depletions of Interconnected Surface Water occur as a result of unsustainable groundwater extraction such that groundwater levels decline below their MTs in greater than 40% of the RMS-ICSW for more than two consecutive years.

This UR criteria is preliminary pending the collection of additional data. At this time, as described above, the relationship between ICSW, GDE health and groundwater conditions has not been definitively determined and the ability of Zone 7 to manage the ICSW and GDE areas is limited given the significant other factors that impact their occurrence and health (e.g., climate, hydrology, invasive species, land development, etc.). Furthermore, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs. Zone 7 will continue to monitor the ICSW and GDE areas and may refine the criteria used to determine URs once the data gaps are filled, additional information are gathered, and the relationship between the occurrence of ICSW and GDEs and the management of the Basin is better understood.

13.6.1.3. Potential Effects of Undesirable Results

☑ **23 CCR § 354.26(b)(3)**

Potential effects of URs for Depletion of Interconnected Surface Water may include impacts to environmental users, such as likely GDEs, critical habitat for federally listed species, special-status plants, and special-status terrestrial and aquatic wildlife species, as discussed in **Section 8.8**. Furthermore, there may be reduced surface water flows to support downstream or in-stream uses. Conversely, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs.

13.6.2. Minimum Threshold for Depletions of Interconnected Surface Water

§ 354.28. Minimum Thresholds
(6) Minimum thresholds for each sustainability indicator shall be defined as follows:
(7) Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:
(A) The location, quantity, and timing of depletions of interconnected surface water.
(B) A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.

☑ **23 CCR § 354.28(c)(6)**

The sections below discussed the development of MOs, IMs, and MTs for Depletions of ICSW.

The GSP Emergency Regulations (23 CCR 354.28(c)) state that the MT for Depletions of ICSW "shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial users of the surface water and may lead to undesirable results". Based on the analysis presented in **Sections 8.8** and **8.9**, where sufficient data are available, a reasonable correlation exists between groundwater levels in the monitoring wells included in the RMS-ICSW and the ICSW and GDE conditions.

As such, for the purposes of developing SMCs, water levels in those monitoring wells are used as a proxy for developing the MTs.

13.6.2.1. Minimum Threshold Development

☑ **23 CCR § 354.28(c)(6)(A)**
☑ **23 CCR § 354.28(c)(6)(B)**

MTs are the numeric criteria for each Sustainability Indicator that, if exceeded, may cause URs for that indicator or for other indicators by proxy. This section describes the MTs that have been developed to avoid URs related to the of Depletions of ICSW in the Basin.

Water levels are considered reasonably effective (and the best available) criteria because they can be utilized to help maintain conditions and instream flows that support environmental water users and, in the case of Zone 7, Basin recharge operations. A composite map of historic lows observed in the Upper Aquifer, as shown on **Figure 8-9**, has been prepared by Zone 7. For several decades, Zone 7 has operated the Basin to maintain water levels above historic low levels throughout the Main Basin [without causing URs] (*Zone 7, 2016e*). Water levels outside of the Main Basin have not fluctuated significantly over time, and no areas of significant downward trends [or areas with URs] have been identified (*Zone 7, 2016e*).

Generally consistent with the definition used for the SMCs for the Chronic Lowering of Groundwater Levels, the MT for the Depletions of ICSW is defined as the historic low water level at the wells included in the Representative Monitoring Sites for Interconnected Surface Water (RMS-ICSW). The resultant MTs for the RMS-ICSW within the Basin are shown in **Table 13-I** and **Figure 13-1**. Where historical water level measurements are not available, estimated values at the RMS-ICSWs are sourced from the groundwater elevation rasters developed by Zone 7 as discussed in **Section 8.3**. **Appendix F** shows the hydrograph and SMC for the Depletions of ICSW for each RMS-ICSW.

Currently there are no significant quantitative data representing negative impacts from the contributing causes identified in **Section 13.6.1.1** to ICSW and GDEs within the Basin. Therefore, historical groundwater conditions are concluded to be sufficient to sustain ICSW and GDEs within the Basin.

As discussed in **Section 14.2.6**, the 10 stream stations located along the potential ICSW within the Basin (as shown in **Table 14-4**) will record either flow rates and/or gauge heights. These data, combined with water level measurements from the RMS-ICSW wells, will better quantify relationships between measured changes in groundwater levels and surface water flows that can help ensure that these MTs are protective and will allow for refinement of the SMC approach over time.

Table 13-I. SMCs for Depletions of Interconnected Surface Water

Well Name	Minimum Thresholds (ft msl)	Interim Milestones (ft msl)			Measurable Objectives (ft msl)
		IM-5	IM-10	IM-15	
2S2E27P002	501.0	501.0	501.0	501.0	501.0
2S2E34E001	491.2	492.1	492.4	492.7	493.0
3S1E05K006	326.0	328.2	328.2	328.2	328.2
3S2E30D002	401.0	403.8	404.7	405.6	406.5
3S1E16P005	285.2	285.2	285.2	285.2	285.2
3S2E33G001	501.0	501.1	501.2	501.2	501.3
3S2E29F004	437.8	441.2	442.3	443.5	444.6
3S2E33C001	482.1	484.2	484.8	485.5	486.2
3S1E02R001	345.3	349.4	350.8	352.2	353.6
3S1E02N006	331.5	333.9	333.9	333.9	333.9
3S2E16E004	466.9	466.9	466.9	466.9	467.0
3S2E23E001	595.4	595.4	595.4	595.4	595.4
4S2E01A001	781.2 *	781.2 *	781.2 *	781.2 *	781.2 *
3S2E32E007	591.4	591.4	591.4	591.4	591.4

* RMS 4S2E01A001 is a new well and there are insufficient water level data to establish an MT, MO, and IM based on historical water levels. As such, initial MT, MO, and IM for this RMS are based on the minimum water level values sourced from 2014 to 2020 groundwater elevation rasters developed by Zone 7 for the Basin.

13.6.3. Measurable Objectives and Interim Milestones for Depletions of Interconnected Surface Water

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(d)**
☑ **23 CCR § 354.30(e)**

13.6.3.1. Measurable Objective Development

As described in the SMC Best Management Practices document, “Measurable Objectives should be set such that there is a reasonable margin of operation flexibility (or ‘margin of safety’), between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities” (*DWR, 2017*).

The MOs for Depletion of ICSW were similarly developed based on measured groundwater levels in the monitoring wells included in the RMS-ICSW. Specifically, the MOs are equal to the minimum water levels measured between 2014 and 2020 at each RMS-ICSW, which represents the recent groundwater conditions that sustain ICSW and GDEs following the adoption of SGMA. Where water level measurements between 2014 and 2020 are not available, estimated values at the RMS-ICSWs are sourced from the groundwater elevation rasters developed by Zone 7 as discussed in **Section 8.3**. The hydrographs and SMCs for the Depletions of ICSW at each monitoring well in the RMS-ICSW are shown in **Appendix F**.

Based on the defined MOs and MTs (**Table 13-I**), Zone 7 considers there to be a sufficient Margin of Operational Flexibility at each monitoring well in the RMS-ICSW. Data collected regularly from the RMS-ICSW will better quantify relationships between measured changes in groundwater levels, surface water flows and GDE areas that can help ensure that these MOs are protective and will allow for refinement of the SMC approach over time.

13.6.3.2. Interim Milestones Development

The IMs for Depletion of ICSW are defined herein based on an estimated trajectory for groundwater levels informed by the groundwater level trends since 2015, and the MOs and MTs. If the RMS-ICSWs have decreasing groundwater level trends since 2015, the IM for the first 5-year period is set as the average between MOs and MTs, and the IMs for the following three 5-year periods are set as groundwater elevations that are linearly interpolated between IM for the first 5-year period and the MO. This trajectory allows for and assumes a continuation of current groundwater level trends for the first 5-year period, and recovery towards the MOs over the following three 5-year periods. Conversely, if the RMS-ICSWs have increasing groundwater level trends since 2015, the subsequent IMs are all equal to the MOs. The IMs are presented in **Table 13-I** and the methodology used to develop them is shown in **Table 13-J**.

Table 13-J. Interim Milestone Trajectory for Depletion of Interconnected Surface Water

Calendar Year	Interim Milestone for Depletion of Interconnected Surface Water	Basis for Interim Milestone
2022	Not applicable	Not applicable
2027	IM-5	½ * (MO + MT)
2032	IM-10	IM-5 + 1/3 * (MO -IM-5)
2037	IM-15	IM-5 + 2/3 * (MO -IM-5)
2045	MO	MO

Where:
IM-5, IM-10, and IM-15 are the IM for Depletion of ICSW after 5 years, 10 years and 15 years respectively; and MO and MT are the MO and MT for Depletion of ICSW defined previously.

13.6.4. Demonstration of Sustainability

Per CWC 10733.6 (a)(3), this Alternative GSP must demonstrate that the Basin has been operating within its sustainable yield for at least 10 years. Relative to the Depletions of the Interconnected Surface Water Sustainability Indicator, **Figure 13-1** demonstrates that water levels in the RMS-ICSWs have been maintained above the MO/MT for the last 10 years, indicating long-term sustainability and absence of URs. Further, based on Zone's 7 expansive SGMA Monitoring Network (**Section 14**), sustainable groundwater conditions over the long-term are demonstrated in **Section 8**.

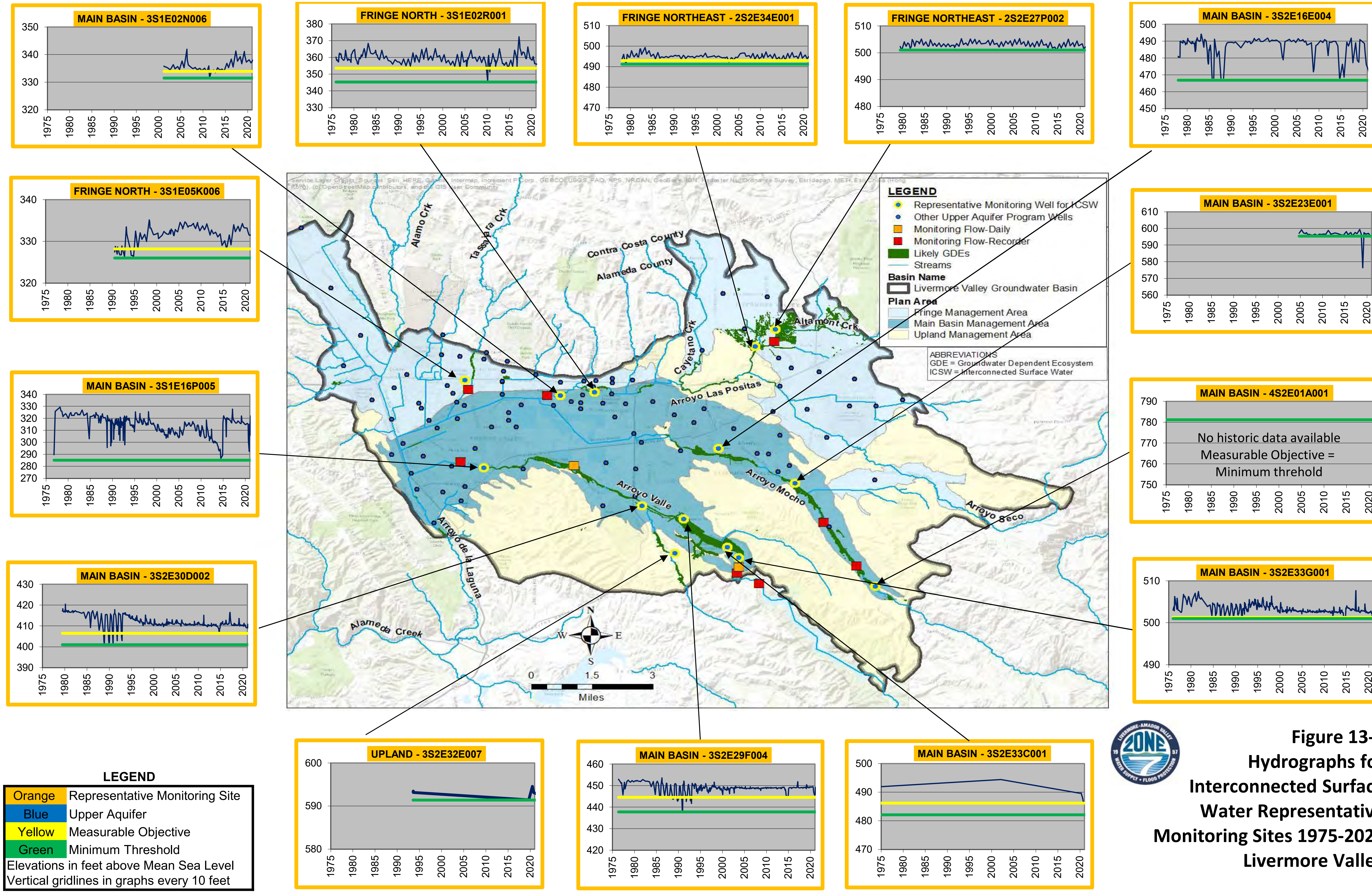

Figure 13-1
Hydrographs for Interconnected Surface Water Representative Monitoring Sites 1975-2020
Livermore Valley

MONITORING NETWORK

(SUBTITLE PAGE)

14. MONITORING NETWORK

14.1. Introduction to Monitoring Network

§ 354.32. Introduction to Monitoring Networks

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This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

☑ **23 CCR § 354.32**

§ 356.4 Periodic Evaluation by Agency

Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:

(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:

(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.

(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.

(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.

☑ **23 CCR § 356.4 (e)**

This section describes the "Sustainable Groundwater Management Act (SGMA) Monitoring Network." That has been identified for the Livermore Valley Groundwater Basin (Basin). Pursuant to the California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2, the objective of the design and management of the Basin's SGMA Monitoring Network is to collect sufficient data for the assessment of the Sustainability Indicators relevant to the Basin and potential impacts to the beneficial uses and users of groundwater. Further, in its July 2019 Alternative Assessment Staff Report, the California Department of Water Resources (DWR) recommended that The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) include monitoring groundwater levels at additional locations in the Basin to monitor changes and manage groundwater resources to prevent undesirable results. Zone 7 complied with this recommendation, as described herein, and identified and added additional wells to its SGMA Monitoring Network.

Per 23 CCR § 354.34(e), the SGMA Monitoring Network incorporates elements, to the extent possible, from the existing monitoring programs occurring within the Basin (see **Section 5.2.1**) and includes additional components to comply with the 23 CCR. All monitoring will be performed in accordance with the protocols developed for the Basin, as described in **Section 14.3**.

14.2. Description of Monitoring Network

§ 354.34. Monitoring Network

(a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.

(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

(1) Demonstrate progress toward achieving measurable objectives described in the Plan.

(2) Monitor impacts to the beneficial uses or users of groundwater.

(3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.

(4) Quantify annual changes in water budget components.

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:

(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.

(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.

(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.

(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.

§ 354.34. Monitoring Network

(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.

(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:

(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.

(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.

(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.

(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

(1) Amount of current and projected groundwater use.

(2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.

(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.

(4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

§ 354.34. Monitoring Network

(g) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.

(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

(j) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.

☑ **23 CCR § 354.34(a)**
☑ **23 CCR § 354.34(b)**
☑ **23 CCR § 354.34(d)**
☑ **23 CCR § 354.34(f)**
☑ **23 CCR § 354.34(g)**

To support groundwater management activities, Zone 7 has developed and implemented an extensive, Basin-wide monitoring program that has expanded and improved over time. As shown on **Figure 14-1** through **Figure 14-4,** the Basin's SGMA Monitoring Network includes multiple monitoring sites for each Sustainability Indicator that is relevant to the Basin. The SGMA Monitoring Network is composed of: (1) Representative Monitoring Sites (RMSs) where Sustainability Management Criteria (SMCs) have been established (herein referred to as the "SGMA Representative Monitoring Network", see **Section 13** and **14.4**); and (2) additional monitoring sites where data will continue to be compiled or collected on an ongoing basis to support understanding of the Basin where SMCs are not established. The SGMA Monitoring Network includes:

- Chronic Lowering of Groundwater Levels: 237 wells in the Groundwater Level Monitoring Program, including 12 Representative Monitoring Sites (RMS-WL) (**Figure 14-1**, **Table 14-2**, and **Table 14-2**).

- Reduction of Groundwater Storage: using Chronic Lowering of Groundwater Levels monitoring network as a proxy, including 11 of the RMS-WL.
- Degraded Water Quality: 233 wells in the Groundwater Quality Monitoring Program, including 12 Representative Monitoring Sites (RMS-WQ) (**Figure 14-2** and **Table 14-3**).
- Land Subsidence: using Chronic Lowering of Groundwater Levels monitoring network as a proxy, including 11 of the RMS-WL, and land surface elevation monitoring data from the Interferometric Synthetic Aperture Radar (InSAR) dataset provided by TRE Altamira (**Figure 14-3**).
- Depletions of Interconnected Surface Water: 34 streamflow gauging and/or flow meter stations in the Surface Water Monitoring Program, including 10 streamflow gauges as Representative Monitoring Sites for Depletions of Interconnected Surface Water (RMS-ICSW-Gauge), and 14 wells from the Groundwater Level Monitoring Program as a proxy for monitoring Depletions of Interconnected Surface Water (RMS-ICSW-Well) (**Figure 14-4 and Table 14-4**).

The objective of the SGMA Monitoring Network is to collect data with sufficient temporal frequency and spatial density necessary to evaluate Alternative Groundwater Sustainability Plan (Alternative GSP) implementation in the Basin as it relates to:

- Monitoring short-term, seasonal, and long-term trends in groundwater and surface water conditions;
- Demonstrating ongoing sustainability in the Basin through achieving the Measurable Objectives (MOs) and Sustainability Goal described in the Alternative GSP (**Section 12**);
- Monitoring impacts to the beneficial uses and users of groundwater;
- Monitoring changes in groundwater conditions relative to the MOs and Minimum Thresholds (MTs); and
- Quantifying annual changes in water budget components.

The SGMA Monitoring Network consists of a series of monitoring sites that meet the following criteria: (1) nearly all sites are included in monitoring programs already implemented by Zone 7 and/or other existing monitoring programs that are active within the Basin; (2) the sites have been demonstrated to be representative of groundwater or other relevant conditions within the Basin; (3) the sites are spatially distributed and located in proximity to beneficial uses and users of groundwater (e.g., public supply wells, production wells, and groundwater dependent ecosystems [GDEs]); and, (4) the RMSs are where SMCs (e.g., MOs, MTs and Interim Milestones [IMs]) will be defined for at least one of the relevant Sustainability Indicators for the Basin[52]:

- Chronic Lowering of Groundwater Levels;
- Reduction of Groundwater Storage;

[52] As discussed below in **Section 14.2.3**, the Basin is at little to no risk for seawater Intrusion; therefore, the Sustainability Indicator is not applicable.

- Degraded Water Quality;
- Land Subsidence; and,
- Depletions of Interconnected Surface Water.

Per 23 CCR § 354.34(g), other factors considered in the development of the SGMA Monitoring Network and the selection of each monitoring site and RMS include:

- Availability of existing technical information (e.g., well location, construction information, condition, status, etc.);
- Quality and reliability of historical data at the site;
- "Representativeness" to local groundwater conditions and nearby well populations inferred from the SGMA Monitoring Network (per 23 CCR § 354.36); and,
- Projected availability of long-term access to the site.

Pursuant to 23 CCR § 354.34(f), the spatial distribution, spatial density, and temporal frequency of measurements collected from each site is determined for each applicable Sustainability Indicator based on the following considerations:

- Amount of current and projected groundwater use;
- Aquifer characteristics, including any vertical and/or lateral barriers to groundwater flow;
- Potential impacts to beneficial uses and users of groundwater, land uses and property interests affected by groundwater production, and the adjacent San Ramon Valley and Sunol Valley Groundwater Basins; and
- Availability of historical data to evaluate long-term trends in groundwater conditions associated with the above factors.

Table 14-A summarizes the site type, site count, measured constituent(s), measurement frequency, and spatial density of the SGMA Monitoring Network for each of the relevant Sustainability Indicators mentioned above. As discussed in **Sections 13.2 and 14.2.2,** the SMCs for Chronic Lowering of Groundwater Levels will be used as a proxy for the Reduction of Groundwater Storage Sustainability Indicator, and thus the SGMA Monitoring Network for water levels will also be used to evaluate Reduction in Groundwater Storage. As discussed in **Sections 13.5 and 14.2.5,** the SMCs for Chronic Lowering of Groundwater Levels will be used as a proxy for the Land Subsidence Sustainability Indicator along with land surface elevation data collected from InSAR. As discussed in **Sections 13.6 and 14.2.6,** several additional wells from the Groundwater Level Monitoring Program (including at least one RMS-WL) will be used as a proxy for monitoring Depletions of Interconnected Surface Water in conjunction with streamflow gauge data. Further details about the SGMA Monitoring Network for each Sustainability Indicator can be found in **Sections 14.2.1 to 14.2.7.**

Table 14-A. Summary of SGMA Monitoring Network

Sustainability Indicator	Monitoring Network Type	Site Type	Site Count	Measurement	Measurement Frequency	Spatial Density (# sites/100 mi^2)
Chronic Lowering of Groundwater Levels	SGMA Representative	RMS-WL	12	Water Level	Varies by Site, minimum is Semiannually	11.0
	Groundwater Level Monitoring Program	*Well*	237	*Water Level*	Varies by Site, minimum is Semiannually	218
Reduction of Groundwater Storage	SGMA Representative	RMS-WL (as proxy)	11	Water Level	Varies by Site, minimum is Semiannually	10.1
	Groundwater Level Monitoring Program	*Well (water level as proxy)*	237	*Water Level*	Varies by Site, minimum is Semiannually	218
Degraded Water Quality	SGMA Representative	RMS-WQ	12	See constituent list in **Section 13.4**	Annually	11.0
	Groundwater Quality Monitoring Program	*Well*	233	See constituent list in **Section 14.2.4**	*Varies by Site, minimum is Annually*	214
Land Subsidence	SGMA Representative	InSAR	NA[b]	Land Surface Elevation	12 days	NA[b]
	SGMA Representative	RMS-WL (as proxy)	11	Water Level	Varies by Site, minimum is Semiannually	
Depletions of Interconnected Surface Water	SGMA Representative	RMS-ICSW-Gauge	10	Stage and/or Stream Flow	Per Event	NA[c]
	SGMA Representative	RMS-ICSW-Well	14	Water Level	Varies by Site, minimum is Semiannually	
	Surface Water Monitoring Program	Gauge or Meter	*34*	*Stage and/or Streamflow*	*Per Event*	

Abbreviations:

InSAR = Interferometric Synthetic Aperture Radar
mi^2 = square miles
NA = not applicable
RMS-ICSW-Gauge = Representative Monitoring Site for Depletions of Interconnected Surface Water – Streamflow Gauge
RMS-ICSW-Well = Representative Monitoring Site for Depletions of Interconnected Surface Water – Monitoring Well
RMS-WL = Representative Monitoring Site for Chronic Lowering of Groundwater Levels
RMS-WQ = Representative Monitoring Site for Degraded Water Quality

Notes:

(a) Shaded cells represent the total number of sites monitored for each Sustainability Indicator
(b) InSAR data is collected via satellite and covers the entirety of the Basin
(c) The number of gauges and wells is determined by local hydrogeologic conditions (i.e., where there is known or suspected surface water / groundwater connection or GDEs).

Pursuant to 23 CCR § 354.34(i), in all cases the SGMA Monitoring Network will adhere to the monitoring protocols specified for the Basin as described in **Section 14.3**. **Section 14.4** discusses the subset of SGMA Monitoring Network sites included in the SGMA Representative Monitoring Network for each Sustainability Indicator in greater detail. **Section 14.5** outlines the procedures and activities for evaluating and addressing data gaps in the SGMA Monitoring Network, including updates to the monitoring network addressed as part of this Alternative GSP update. Finally, the data management system is discussed in **Section 14.6**.

14.2.1. Monitoring Network for Chronic Lowering of Groundwater Levels

☑ **23 CCR § 354.34(c)(1)**

The SGMA Monitoring Network for Chronic Lowering of Groundwater Levels includes 237 wells, 12 of which have been selected as RMS-WL (see **Section 14.4**). As part of the current Alternative GSP update, Zone 7 added 20 additional wells to the program (**Figure 1-2**), mainly in the Fringe Management Area (Fringe Area) and Upland Management Area (Upland Area), to address DWR's recommendations on the 2016 Alternative GSP (**Appendix A**)**.** These additions are detailed in **Section 14.5.3.**

Figure 14-1 shows the locations of all the wells in SGMA Monitoring Network for Chronic Lowering of Groundwater Levels. A list of all the wells in the program and the frequency of monitoring is provided in **Table 14-1**. **Table 14-2** lists the well construction details for the program wells. Each well in the program is monitored to fulfill one or more of the specific objectives listed below.

Groundwater Level Monitoring Program - Groundwater elevations in all wells are measured at least two times during the water year during seasonal extremes (i.e., spring highs and fall lows) to confirm sustainability objectives are being met and to calculate storage. Water level measurements are also made monthly in several wells to track performance of recharge and pumping operations, and to ensure groundwater levels are not falling below the MOs (generally defined by "Historic Low" water levels, see **Section 13.1**) anytime during the water year. The monthly data are also used to identify when the seasonal peaks are occurring so that semi-annual water level measurements can be scheduled appropriately. A few of the monthly monitored wells have recording pressure transducers installed to record drawdown caused by supply wells cycling on and off in the subarea. This information is used to evaluate aquifer connectivity and distance-drawdown impacts of the pumping wells. Additionally, 18 nested well clusters are used to analyze spatiotemporal trends in vertical gradients between Principal Aquifer units (see **Section 7.4**).

Key Well Program – Groundwater elevations are monitored at least monthly in eight key index monitoring wells located in the central parts of the three largest subareas of the Main Basin Management Area (Main Basin) – Bernal, Amador, and Mocho II Subareas – where the municipal pumping occurs. Because the Amador Subarea is over twice the size of the other two subareas, it is split into the Amador West and Amador East Subareas. Each subarea is represented by an upper and a lower aquifer well. The wells currently being monitored for the Key Well Program are shown on the **Table 14-B** below.

Table 14-B. Key Well Program Wells

Subarea	Aquifer	Key Well Name	Current Well
Bernal	Upper	Key_Bern_U	3S1E20C007*
	Lower	Key_Bern_L	3S1E20C008*
Amador-West	Upper	Key_AmW_U	3S1E09P005*
	Lower	Key_AmW_L	3S1E09P010*
Amador-East	Upper	Key_AmE_U	3S1E11G001
	Lower	Key_AmE_L	3S1E12K003*
Mocho II	Upper	Key_Mo2_U	3S2E08K002*
	Lower	Key_Mo2_L	3S2E08H003*

* 15-minute water level data being recorded

The Key Well datasets are composite records as the actual monitoring wells have been replaced in-kind over time. However, the hydrographs for the Key Wells represent some of the oldest and longest-running continuous record of water levels for the Basin, some dating back to the early 1900s, and are often used in reports when discussing the history of groundwater levels in the Basin (**Figure 8-8)**. Although water levels are measured and plotted in the Key Well hydrographs as monthly data, many of the Key Wells have pressure transducers and data recorders installed that collect water level information at 15-minute intervals.

CASGEM/SGMA Data Portal – In 2012, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program to track groundwater elevations in California groundwater basins to satisfy the requirements under Water Code §10920, *et seq*. The program requires monitoring entities, such as Zone 7, to submit groundwater level data semiannually to DWR. Working collaboratively with DWR staff, Zone 7 selected ten wells (the eight Key Wells plus two others) to represent overall groundwater elevations in the Basin. Two more wells were added to the CASGEM program in 2015, when Zone 7 replaced the Key Well representing Lower Amador East (3S1E12K002) with another one from the same nested group (3S1E12K003) that has a slightly deeper well screen. At that time, it was decided to add the replacement well (3S1E12K003) and the next deeper screened well in the nested group (3S1E12K004) to the program, and to keep the former key well (3S1E12K002) in the program as well. An additional well (3S2E29F004) was voluntarily added in 2019 at the request of a member of the public. The wells currently being monitored for the Key Well and CASGEM Programs are shown in the map on **Figure 14-A**. The CASGEM Program wells are listed in the **Table 14-C** below.

Figure 14-A: Map of Key and CASGEM Wells

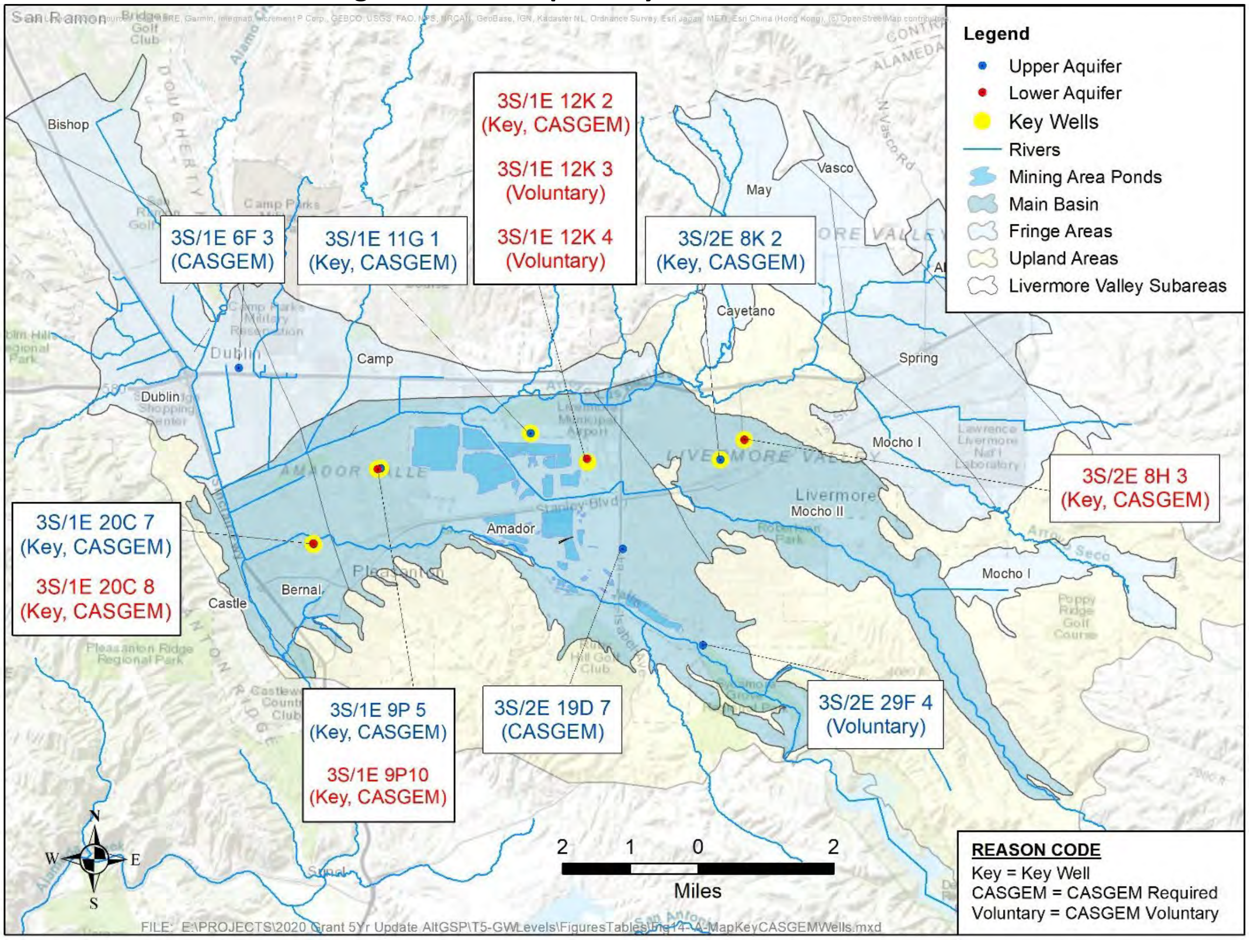

Table 14-C. CASGEM Wells for the 2020 Water Year

Well Number	Subarea	Aquifer	Key Well
3S1E20C007	Bernal	Upper	x
3S1E20C008	Bernal	Lower	x
3S1E09P005	Amador West	Upper	x
3S1E09P010	Amador West	Lower	x
3S1E11G001	Amador East	Upper	x
3S1E12K003	Amador East	Lower	x
3S2E08K002	Mocho II	Upper	x
3S2E08H003	Mocho II	Lower	x
3S1E12K004	Amador East	Lower	
3S1E06F003	Northern Fringe	Upper	
3S2E19D007	Southern Amador	Lower	
3S2E29F004*	Southern Amador	Upper	

* = Voluntary CASGEM monitoring well.

Zone 7 is in the process of migrating the CASGEM datasets and other monitoring well results, including the RMS-WLs (**Section 14.4**), to the SGMA Data Viewer as required by DWR[53]. Therefore, the CASGEM program will not be applicable for the 2021 Water Year (WY).

Del Valle Water Rights (WR) – continuous and monthly monitoring of water levels is required in six specific wells to maintain Zone 7's surface water rights on the Arroyo Valle (see **Table 14-D**).

Table 14-D. Del Valle Water Rights Monitoring Wells

Monitoring Well	Monitoring Frequency
3S1E16P005	Continuous*
3S1E20C007	Continuous*
3S1E29M004	Monthly
3S2E29F004	Monthly
3S2E30D002	Continuous*
3S2E33G001	Monthly

* 15-minute water level data being recorded

Other Programs (Other) – water level monitoring is conducted continuously or monthly for other programs that monitor mining area activities, vertical gradients in nested wells, wastewater/recycled water use and irrigation, and/or elevation changes from municipal production.

[53] https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions

14.2.2. Monitoring Network for Reduction of Groundwater Storage

☑ 23 CCR § 354.34(c)(2)

As described in **Section 13.2**, the criteria used to define SMCs for the Reduction of Groundwater Storage are directly tied to those developed for the Chronic Lowering of Groundwater Levels. As such, the SGMA Monitoring Network for Reduction of Groundwater Storage is comprised of the same wells included in the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels as described in **Section 14.2.2.** The information collected from the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels will be sufficient to estimate the annual change in groundwater storage.

14.2.3. Monitoring Network for Seawater Intrusion

☑ 23 CCR § 354.34(c)(3)
☑ 23 CCR § 354.34(j)

As described in **Section 8.5**, the Seawater Intrusion Sustainability Indicator is not applicable to the Basin, and, per 23 CCR §354.34(j), a SGMA Monitoring Network has not been defined.

14.2.4. Monitoring Network for Degraded Water Quality

☑ 23 CCR § 354.34(c)(4)

The SGMA Monitoring Network for Degraded Water Quality includes 233 wells, 12 of which have been selected as RMS-WQ (see **Section 14.4**). Zone 7 maintains a robust monitoring network of water quality monitoring wells that are sampled at least annually for water quality analyses. Most of the groundwater quality results used to meet the objectives above come from sampling and analyses conducted by Zone 7's Water Quality Laboratory. The Zone 7 Water Quality Laboratory is an Environmental Laboratory Accreditation Program (ELAP) -accredited laboratory, certified to conduct testing for: Inorganic Chemistry; Toxic Chemical Elements; Volatile and Semi-volatile Organic Chemistry; and Radiochemistry in drinking water. Other groundwater quality data are sourced from other agencies' programs, such as: Dublin San Ramon Services District's (DSRSD) monitoring of their wastewater treatment operations; Alameda County's oversite of onsite wastewater systems, domestic water supply, and leaking underground storage tank cleanup sites; and the State Water Resources Control Board's (SWRCB) GeoTracker database.

Figure 14-2 shows the locations of all the wells in the SGMA Monitoring Network for Degraded Water Quality. **Table 14-3** lists all the wells in the program along with the represented Management Area and Principal Aquifer units, the frequency of sampling, and any other programs that are satisfied by their sampling. Additional well construction details for each of the wells in the program are provided in **Table 14-2**. Each well in the program is sampled to fulfill one or more of the specific objectives listed below:

Routine Water Quality Sampling – routine water quality sampling of groundwater is performed annually, with samples collected from each of the wells in the Groundwater Elevation Monitoring Program that can be sampled (**Section 14.2.2**). Some wells are sampled more frequently if required for an additional program described below. Also, some wells are sampled and analyzed by outside entities. In those cases, results are supplied to Zone 7 and then imported into the HydroGeoAnalyst (HGA) database (**Section 8.2**). In general, samples are analyzed for physical water parameters, inorganic minerals and select metals. **Table 14-E** below is a partial list of the analytes common to all the groundwater and surface water quality programs except the Toxic Site Surveillance (TSS) Program. No hydrocarbon or other organic chemical parameters are included in the routine analyses of these monitoring well samples. The sampling and sample handling procedures are described in **Section 14.3**.

Table 14-E: List of Standard Analytes for Zone 7's Water Quality Programs

Minerals	Metals	Other
Calcium	Boron	Total Dissolved Solids
Magnesium*	Arsenic	Total Hardness
Sodium	Chromium	Electrical Conductivity
Potassium	Manganese	Alkalinity
Bicarbonate	Selenium	Calcium Hardness
Sulfate	Iron	
Chloride	Lead	
Nitrate	Copper	
Silica	Mercury	
Carbonate	Others	

** Calculated*

Del Valle Water Rights (WR) – semi-annual sampling for water quality is required for the same wells that are in the Del Valle Water Rights Groundwater Elevation Monitoring Program to maintain Zone 7's Arroyo Valle water rights application. The laboratory analyses are the same as the analyses conducted for the routine Water Quality Sampling objective (**Table 14-E**).

Municipal Supply Well (Muni) – quarterly or annually sampling for water quality and drinking water operating permit compliance are conducted on the municipal supply well samples. The analyses conducted include the routine analyses of Zone 7's Water Quality Sampling described above plus the analyses required for compliance with Title 22 Domestic Water Quality and Monitoring Regulations as established by the California Division of Drinking Water (22 *CCR Section 64416*).

Salt/Nutrient Management Plan (SMP/NMP) – annual sampling and routine water quality analyses from program wells to identify salt and nutrient quantity and migration in groundwater. Twenty-one of these wells were installed in the early 2000s as part of the original SMP (*Zone 7, 2004*) to monitor salt concentrations in the Upper Aquifer across the Basin. Information on Zone 7's SMP and NMP are provided in **Section 5.2.** As part of the NMP, Zone 7 embarked on a study (*Zone 7, 2016a*) in South Livermore to help delineate three Areas of Concern (AOCs) identified in the NMP (Buena Vista, Greenville, and Mines

Road) and to better characterize the potential groundwater nitrate contamination. Sampling results from that study are included in **Section 8.6**.

Toxic Site Surveillance (TSS) – Data are also collected from the TSS Program to obtain data from sites that are contaminated with other (organic) contaminants (petroleum hydrocarbons, synthetic organic compounds, solvents, etc.). The TSS Program, described in detail in **Section 8.6**, is administered by Zone 7 for the purpose of identifying and monitoring sites that pose a potential threat to drinking water. Zone 7 also coordinates closely with lead agencies to ensure protection of beneficial uses. Information is gathered from state, county, and local agencies, as well as from Zone 7's well permitting program and the SWRCB GeoTracker website and compiled in a geographic information systems (GIS) database. Each site in Zone 7's TSS Program has been assigned a Zone 7 number, which corresponds to a file number containing reports or other information about the site. In addition, all sites are reviewed and given a priority designation (high, moderate, or low) based on the threat they pose to groundwater.

Wastewater/Recycled Water Use - Zone 7 monitors the quality and quantities of wastewater and recycled water as they apply to the Basin (recharge supply and quality). Assessments of wastewater quality and the contribution to the water budget are discussed in **Section 8.10.2** in this Alternative GSP. The City of Livermore and Dublin San Ramon Services District (DSRSD) are currently responsible for treating and either discharging or recycling (see **Figure 8-51)** the vast majority of wastewater produced in the Basin. Applications of recycled water are mostly conducted for landscape irrigation projects; however, a minor amount is used for dust suppression, grading projects, and crop irrigation.

The program assumes that there is small, but quantifiable, amounts (estimated) of untreated wastewater that percolate in the Main Basin from onsite wastewater treatment systems (OWTS). The quantity of leachate is based on the estimated number of individual OWTS that overlie the Main Basin. The quality of the leachate is estimated from published technical literature. Zone 7 receives monthly monitoring reports from the Department of Veteran Affairs (VA) for the VA Medical Center's sewage treatment system located in southern Livermore. Zone 7 also estimates contributions from leaking wastewater and recycled water pipelines that run throughout the Basin. The quantity is based on the length and age of buried pipes (**Section 9.2.2.4**). The quality is based on sample data received from DSRSD and the City of Livermore.

14.2.5. Monitoring Network for Land Subsidence

☑ **23 CCR § 354.34(c)(5)**

The SGMA Monitoring Network for Land Subsidence includes annual land surface elevation surveys from InSAR as well as 11 of the RMS-WLs included in the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels as a proxy for monitoring potential land subsidence impacts (see **Section 14.4**).

Zone 7's Land Surface Elevation Monitoring Program tracks ground surface elevation changes across the Basin to help identify any significant long-term trends. The program began in 2002 when Zone 7 conducted a study of historical benchmark elevation data throughout the western portion of the Basin. The study concluded that there was no evidence of significant inelastic subsidence in the Basin up to that point in time.

From 2002 to 2018, Zone 7 contracted with a licensed land surveyor to conducted high precision spirit level surveys at least twice a year across the Bernal and Amador Subareas where most of the groundwater pumping occurs in the Basin. The survey began and ended at stable bedrock elevation stations and passed through or near Zone 7 and City of Pleasanton wellfields. From this main circuit, several looped or branched circuits were also surveyed in the same manner to assess ground surface elevation changes within other Zone 7 wellfields and across the northern Main Basin boundary. Background information regarding Zone 7's land surface elevation monitoring is provided in *Section 2.3.9, Land Subsidence,* of the 2016 Alternative GSP.

In the 2016 WY, Zone 7 contracted with TRE Altamira (TRE) to evaluate InSAR as an alternative to land surveying for subsidence monitoring. TRE analyzed InSAR data from three different satellites over a 24-year period (from 1992 to 2016) which included approximately 120 satellite images with between 415 and 1,202 measuring points per square mile. Each measuring point contains a deformation time series, including cumulative displacement, average deformation rate, acceleration, and seasonal amplitude. The study results correlated well with topographic surface measurements taken by land surveys within the same period. An added benefit of the InSAR dataset was that it included a larger area (i.e., the entire Main Basin) than the land surveying. The resulting TRE 2016 report was included in the 2016 Alternative GSP.

Starting in the 2019 WY, instead of continuing the land surveying program, Zone 7 contracted directly with TRE to use InSAR for monitoring land subsidence. For this study, TRE included all of the Basin. The results of TRE's study were originally presented in the Annual Report for the 2020 WY and is included in this report as **Appendix J**. For this update, Zone 7 also evaluated DWR's InSAR dataset collected from TRE and compared it with the previous InSAR analyses collected directly from TRE in the 2019 and 2020 reports. Based on the results of that analysis, Zone 7 will use the DWR InSAR dataset as part of its SGMA Monitoring Network for Land Subsidence going forward.

14.2.6. Monitoring Network for Depletions of Interconnected Surface Water

☑ **23 CCR § 354.34(c)(6)**

The SGMA Monitoring Network for Depletions of Interconnected Surface Water (ICSW) includes 34 streamflow gauging or flow meter stations, 10 of which are included as RMS-ICSW-Gauge sites (see **Section 14.4**). Additionally, the SGMA Monitoring Network for Depletions of ICSW includes 14 wells from the Groundwater Level Monitoring Program (see **Section 14.2.1**) as RMS-ICSW-Well sites.

Figure 14-4 shows the location of the RMS-ICSW-Gauge and RMS-ICSW-Well sites. **Table 14-4** shows the RMS-ICSW details, including the nearby likely GDEs, nearby stream gauging stations, monitoring methods, monitoring frequency, and well construction information.

As discussed in **Sections 8.8** and **8.9**, the locations of likely GDEs communities within the Basin are largely coincident with the presence of ICSW reaches. The proposed RMS-ICSW sites are therefore comprised of selected Upper Aquifer wells from the Groundwater Level Monitoring Program and stream gauging stations along the ICSW reaches and near the likely GDEs identified in **Sections 8.8** and **8.9**. The RMS-ICSW presented in this section is thus designed to provide a “dual benefit” of: (1) assessing ongoing surface water - shallow groundwater connectivity within ICSW reaches, as well as (2) supporting monitoring of groundwater conditions that are one of the factors that can contribute to the health nearby GDE communities.

In developing the RMS-ICSW, the Environmental Defense Fund (EDF) guidance, which recommends a monitoring location every four to six miles along an ICSW stream for a “reasonable balance between rigor and practicality” was considered (*Hall et al., 2018*). Upper Aquifer wells with a long period of record and located in close proximity to a stream gauging station were preferentially selected and a higher density of monitoring wells was selected in some likely ICSW reaches to sufficiently cover nearby likely GDEs.

Data from the RMS-ICSW-Gauge and RMS-ICSW-Well sites will be collected manually every month, semi-annually, or using data loggers every 15 minutes, depending on the site.[54] These data will be evaluated annually to assess the correlation between shallow groundwater levels and GDE health and ICSW flow rates to confirm that groundwater levels can serve as an appropriate proxy for purposes of developing and applying sustainability criteria. Monitoring frequency will be re-evaluated if groundwater levels decline below their MTs in the RMS-ICSW-Well sites, and if those declines uniquely correlate to observed GDE impacts.

In addition to monitoring the proposed RMS-ICSW, Zone 7 plans to perform periodic visual inspections to monitor the health of likely GDEs and ICSW conditions. Visual inspections will include either an examination of areal images or field investigation, or a combination thereof. Bi-annual or monthly monitoring of the remaining Upper Aquifer program wells will also continue, which will provide additional data and perspective on Upper Aquifer conditions within the Basin.

14.2.7. Other Monitoring Networks

In addition to the SGMA Monitoring Networks described above that are used to directly monitor Sustainability Management Criteria, Zone 7 has several other monitoring programs that are used to help sustainably manage the groundwater basin. These supplementary monitoring programs are described below.

14.2.7.1. Climatological Monitoring Program

Zone 7's Climatological Monitoring Program tracks rainfall and evaporation in the Basin, employing a network of climatological stations. The primary objective of this monitoring network is to provide high quality Basin-wide data for long-term studies, Basin recharge calculations, and water management decisions. Specifically, the calculations of Basin recharge are used in the annual Water Budget (**Section 9**) and change in groundwater storage (**Section 8.4**). Data are collected to provide short-term, seasonal, and

[54] Two of the RMS-ICSW-Wells (3S1E16P005 and 3S2E30D002) currently have data loggers installed.

long-term trends in local hydrologic conditions. Water year type is being incorporated into the analysis using DWR calculations for the Sacramento Valley. This hydrology is more consistent with the availability of imported supplies and generally approximates local rainfall patterns in the Basin.

Zone 7 uses a network of climatological stations (see **Figure 14-5** and **Table 14-5**) to provide high-quality data for water inventory calculation and management decisions, including both daily record stations and 15-minute recorder stations. Zone 7's climatological monitoring program also contains both reference evapotranspiration (ETo) and pan evaporation stations to determine water losses to the atmosphere. Station 191 California Irrigation Management Information System (CIMIS) is a reference ETo station which estimates the ETo value of the water used by a fully-watered, full-cover grass surface. The pan evaporation stations at Lake Del Valle (LDV) and Livermore Water Reclamation Plant (LWRP) measure evaporation directly. This data is then converted to ETo to use with the CIMIS readings to calculate pond evaporation. The CIMIS Station's ETo is also used as part of Zone 7's Water Conservation program to help regulate weather-based irrigation controllers (WBICs, also known as "SMART" Controllers).

14.2.7.2. Surface Water Monitoring Program

Zone 7's Surface Water Monitoring Program focuses on the four main gaining and losing streams that affect the Basin (Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Arroyo de la Laguna) and the diversions, releases, and natural runoff that affect the flows into and out of each of them. **Figure 14-6** shows all the streamflow gauging and flow meter stations monitored for the 2020 WY. **Table 14-6** includes pertinent details of all the stations.

The Surface Water Monitoring Program utilizes a main network of stream gauge stations and flow meters to compute the quantity of water flowing past each station and the amount of water recharging the Basin between them. At least once per year, water samples are collected from the 10 main stations and submitted to Zone 7's laboratory for analysis of Total Dissolved Solids (TDS), nutrients, metals, and other minerals from which salt and nutrient loading (and removal) are computed (see **Section 8.6**).

Several other auxiliary surface water monitoring stations have been established as high flow and/or stream temperature monitoring stations to augment the data collected at the 10 main stations for various ongoing flood management and habitat studies (**Figure 14-6** and **Table 14-6**).

14.2.7.3. Chain of Lakes/Mining Area Monitoring Program

The Chain of Lakes/Mining Area Monitoring Program includes water level measurements and water quality analysis for many of the mining area ponds or quarry lakes within the Basin (**Figure 14-7** and **Table 14-7**). Presently, two mining companies, CEMEX and Vulcan Materials, have on-going surface mining operations for the extraction and sale of sands and gravels. Finer-grained materials (e.g., silts) that have been excavated but have not been sold are stored onsite and/or are used to backfill quarry excavations.

All water generated during mining that is discharged to a non-quarry property is metered and tracked as it exits the Basin in the Arroyos. This program also tracks mining evaporation and includes estimates of groundwater lost due to the export of moist gravels. In general, quarry pits have been excavated into the Upper Aquifer; however, recently a few have been excavated into layers that appear to connect to the

Lower Aquifer, exposing Lower Aquifer to mining operation dewatering. Zone 7 is evaluating the impacts of these changes in mining activities to drinking water supplies. Groundwater is pumped from some of the pits and transferred to others or discharged to the Arroyos to facilitate the gravel extraction in the pits being actively mined. In addition, backfill of former quarry ponds with fine-grained materials results in an impediment to groundwater flow in the aquifers.

Ownership of 10 mining quarry lakes ("Chain of Lakes" or "COLs", Lakes A through I and Cope Lake) will ultimately be transferred to Zone 7 for future water resources management purposes. To date, Zone 7 has received titles to two lakes: Lake I and Cope Lake. Project and Management Actions on the COLs Recharge Projects in the 2020 WY are discussed in **Section 15.2**

14.3. Monitoring Protocols for Data Collection and Monitoring

§ 352.2. Monitoring Protocols
Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

☑ **23 CCR § 352.2**

Zone 7 has established monitoring protocols for each of its SGMA Monitoring Networks and other Basin monitoring programs to ensure the quality of the data collected. These protocols are described in detail in **Appendix G.** The frequency for data collection has been developed to allow tracking of short-term, seasonal, and long-term trends of groundwater and related surface water conditions. The data management system for storing this data is discussed in **Section 14.6**.

14.4. Representative Monitoring

§ 354.36. Representative Monitoring
Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

(a) . Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.

(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

(1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.

(2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

☑ **23 CCR § 354.36**

"Representative monitoring" refers to monitoring sites within a broader network of sites that typifies one or more conditions within the Basin or a subarea of the Basin. As discussed in **Section 14.1***,* Zone 7 has defined a SGMA Monitoring Network for each relevant Sustainability Indicator. The SGMA Monitoring Network is composed of a vast network of monitoring sites of which a subset has established SMCs (referred to as "Representative Monitoring Sites"). This subset of the SGMA Monitoring Network is referred to as the "SGMA Representative Monitoring Network".

The SGMA Representative Monitoring Network and associated data collection activities are comprised primarily of a subset of sites and activities that are already part of existing monitoring and reporting programs that will now also be used for SGMA reporting purposes. The data from the SGMA Representative Monitoring Network will be used to monitor the Sustainability Indicators and evaluate Alternative GSP implementation with respect to meeting the Sustainability Goal defined for the Basin. This objective can be achieved by data showing compliance with the Basin SMCs. Each RMS within the SGMA Representative Monitoring Network was selected to ensure that it represents general conditions in the area, with specific considerations regarding the following:

- Current and projected groundwater use;
- Aquifer characteristics;
- Potential impacts to beneficial uses and users of groundwater, land uses or property interests, and

adjacent basins;

- Availability, quality, and reliability of historical data;
- Availability of site-specific technical information;
- "Representativeness" to local groundwater conditions; and
- Long-term access.

Table 14-8 lists the RMS for the SGMA Representative Monitoring Network for Chronic Lowering of Water Levels (RMS-WL) along with their MTs and MOs. In the Main Basin, RMS-WL sites consist of the four Lower Aquifer Key Wells, which Zone 7 has used for several decades to track general trends in each of the Main Basin subareas. These Key Wells are screened in a single Principal Aquifer unit, are centrally located in the subareas, are far enough away from the major municipal wellfields such that they are not affected by short-term pumping variations, and are believed to be representative of overall subarea conditions. Zone 7 monitors the elevations in these wells monthly to track and estimate groundwater storage in between the semi-annual monitoring events (when all the wells in the program are measured).

In the Fringe Area, water level hydrographs from various wells indicate that water levels have not fluctuated significantly over time and no areas of significant downward trends have been identified (see **Figure 8-8**). The three RMS-WLs selected for the Fringe Area show a similar trend, are screened wholly in the Fringe Aquifer, are centrally located in each of the Fringe subareas (Northwest, Northeast, and East), and have a relatively long data record.

The Upland Area consists primarily of the Livermore Formation and older bedrock units that are typically consolidated, more resistant to erosion, highly variable, and provide little water for supply. As a result, there are few supply wells in this area and very little data available. Prior to this update, there was only one Upland Aquifer well in Zone 7's groundwater monitoring program. The well (3S2E32E007) was used to monitor groundwater downgradient of Zone 7's Del Valle Water Treatment Plant. For this Alternative GSP update, Zone 7 added five additional wells in the Upland Aquifer (see **Section 14.5.3**). Of these six Upland wells, Well 3S2E21K009 is located in an area with a relatively higher density of domestic supply wells. Therefore, this well was selected as the RMS-WL for the Upland Area. Zone 7 plans to collect additional data and reassess whether this well is representative of water level conditions in the Upland management area in future updates.

Water level measurements and calculated groundwater elevations may be used as a proxy for monitoring other Sustainability Indicators when they are correlated, uncertainty is adequately represented by the specified margin of operational flexibility, and the RMSs are shown to reflect general conditions in the Basin or subarea of the Basin. **Sections 13 and 14.1** discuss how the RMS-WL sites will also be used as a proxy for monitoring Reduction of Groundwater Storage and Land Subsidence Sustainability Indicators (**Table 14-9**). In all cases, the SMCs defined for Chronic Lowering of Groundwater Levels have been designed to be protective of Reduction of Groundwater Storage and Land Subsidence.

Table 14-10 lists the RMS included in the RMS-WQ along with their MTs and MOs for each of the Constituents of Concern discussed in **Section 13.4**. These RMS-WQs are considered representative of overall Basin conditions due to their screened intervals, central locations, and data history.

Table 14-11 and **Figure 14-8** show the RMS included in the RMS-ICSW, including both RMS-ICSW-Well and RMS-ICSW-Gauge. As discussed in **Appendix F** and based on the analysis presented in **Sections 8.8** and **8.9**, where sufficient data are available, a reasonable correlation exists between groundwater levels in RMS-ICSW-Wells and both ICSW and GDE conditions. As such, water levels are used as a proxy for monitoring the Depletions of Interconnected Surface Water.

14.5. Assessment and Improvement of Monitoring Network

§ 354.38. Assessment and Improvement of Monitoring Network

(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.

(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

(1) The location and reason for data gaps in the monitoring network.

(2) Local issues and circumstances that limit or prevent monitoring.

(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

(1) Minimum threshold exceedances.

(2) Highly variable spatial or temporal conditions.

(3) Adverse impacts to beneficial uses and users of groundwater.

(4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

☑ **23 CCR § 354.38**

14.5.1. Review and Evaluation of the Monitoring Network

Zone 7's monitoring programs have historically been focused on the Main Basin where most of the groundwater pumping occurs and most of the management actions are needed. Many of Zone 7's existing monitoring programs also extend into the Fringe Area, especially to evaluate changes in groundwater levels or quality. Historically, monitoring in the Upland Area has been limited due to the relatively low number of active wells, the relatively low well yields, and historically low groundwater use in the area. Even in areas of relatively high density of wells, groundwater use is small. As discussed in **Section 9**, inflows from these areas are a minor portion of the Basin Hydrologic Inventory. As part of this Alternative GSP update, Zone 7 added additional wells in both the Fringe and Upland Areas to its monitoring programs. Zone 7 also designated RMSs in the SGMA Representative Monitoring Network for each of the applicable Sustainability Indicators and assigned preliminary SMCs at those wells. The site type, site count, measured constituent(s), measurement frequency, and spatial density of the SGMA Monitoring Network for each of the relevant Sustainability Indicators are listed in **Table 14-A**. On-going monitoring will assess the reasonableness and completeness of the Basin's monitoring networks. In particular, additional transducers and data loggers may need to be added to procure high resolution data related to better understanding groundwater and surface water interactions as part of the Depletion of Interconnected Surface Water Sustainability Indicator.

14.5.2. Identification and Description of Data Gaps

Key data gaps and uncertainties identified from the SGMA Monitoring Network include:

- Limited long-term water level data or historic low data in the Fringe and Upland Areas;
- Limited high resolution water level data to evaluate groundwater and surface water interactions;
- Limited well data in several of the Nitrate Areas of Concern (AOC), in particular the May School, Happy Valley, and Greenville AOCs.
- Limited long-term well data on the extent and migration of PFAS compounds in the western portion of the Main Basin

14.5.3. Description of Steps to Fill Data Gaps

The SGMA Monitoring Network developed for each Sustainability Indicator includes a sufficient density and spatial distribution of monitoring sites to meet the monitoring objectives outlined in **Section 14.2**. Data collected from the SGMA Monitoring Network will be used to fill data gaps identified above. In addition, the Basin SGMA Representative Monitoring Network will be reevaluated in the next five-year Alternative GSP update, including a determination of uncertainty and whether there are additional data gaps that could affect the ability of the Alternative GSP to achieve the Sustainability Goal for the Basin. Zone 7 will also continue to seek opportunities (e.g., through the well permitting program) to add new and/or existing private wells to the program by offering free annual well sampling to well owners that offer their wells for inclusion in the program.

14.6. Reporting Monitoring Data to the Department

§ 354.40. Reporting Monitoring Data to the Department
Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

☑ **23 CCR § 354.40**

Zone 7 stores its environmental data (e.g., groundwater levels, water quality, geology, well construction) into HGA, a proprietary environmental database management system designed for storing chemistry, hydrology, and geologic information. The program includes a detailed Quality Assurance/Quality Control (QA/QC) checking module that confirms data integrity during import. Once imported into the database, Zone 7 uses the reporting and mapping tools within GIS/Key to view and report the datasets. Zone 7 also exports datasets from GIS/Key for use in other programs such as Microsoft Excel, Microsoft Access, and ArcGIS to generate tables and figures in reports and other work products.

Zone 7 uses a proprietary program called Aquarius Time-Series (Aquarius) for managing time series datasets for:

- Surface water stage and flow,
- Groundwater elevation,
- Diversion flow,
- Precipitation, and
- Evaporation.

The program also allows Zone 7 to build rating curves, apply corrections, create comparison graphs, derive statistics, and report datasets. Other datasets that are not appropriate for GIS/Key or Aquarius (e.g., land surface elevations, wastewater volumes, land use) are entered into Microsoft Access databases and/or ArcGIS feature classes.

Monitoring data for each WY are presented in Zone 7's Annual Reports for the Alternative GSP which are available at this website:

https://www.zone7water.com/reports-planning-documents.

Prior to 2021, Zone 7 uploaded well construction and water level data to the CASGEM website (**Section 14.2.1**). Zone 7 is currently working with DWR to transfer the CASGEM data to the SGMA Data Viewer website in accordance with DWR requirements:

https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions.

TABLE 14-1
MONITORING WELLS IN 2021 GROUNDWATER LEVELS PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
1S4E31P005	31P5	CASGEM Tracy WAPA	Tracy	U	monitor	unknown	Zone 7	2							
2S1E32E001	32E1	End of Arnold Rd	None	U	monitor	active	Zone 7	2							
2S1E32N001	32N1	Camp Parks	Camp	U	monitor	active	Zone 7	2							
2S1E32Q001	32Q1	Summer Glen Dr	Camp	U	monitor	active	Zone 7	2							
2S1E33L001	33L1	Gleason Dr @ Tassajara	None	U	monitor	active	Zone 7	2							
2S1E33P002	33P2	Central Pkwy at Emerald Glen Pk	Camp	U	monitor	active	Zone 7	2							
2S1E33R001	33R1	Central Pkwy @ Grafton	None	U	monitor	active	Zone 7	2							
2S1W15F001	15F1	BOLLINGER	Bishop	U	monitor	active	Zone 7	2							
2S1W26C002	26C2	PINE VALLEY	Dublin	U	monitor	active	Zone 7	2							
2S1W36E003	36E3	Kolb Park	Dublin	U	monitor	active	Zone 7	2							
2S1W36F001	36F1	Dublin High shallow	Dublin	L	nested	active	Zone 7	2							
2S1W36F002	36F2	Dublin High mid	Dublin	L	nested	active	Zone 7	2							
2S1W36F003	36F3	Dublin High deep	Dublin	L	nested	damaged	Zone 7	2							
2S2E21L001	21L1	Merlin	May	U	domestic	active	Zone 7	2							
2S2E27C002	27C2	Dagnino Rd	Spring	U	domestic	active	Zone 7	2							
2S2E27K001	27K1	Livermore #196	Spring	U	livestock	inactive	Zone 7	2							
2S2E27M002	27M2	Kwan	May	U	domestic	active	Zone 7	2							
2S2E27P002	27P2	hartford ave east	Spring	U	monitor	active	Zone 7	2			X				
2S2E28D002	28D2	May School	May	U	monitor	active	Zone 7	2							
2S2E28J002	28J2	FCC Well	May	L	industrial	active	Zone 7	2							
2S2E28Q001	28Q1	hartford ave	May	U	monitor	active	Zone 7	2							
2S2E32K002	32K2	jenson's N liv. Ave	Cayetano	U	monitor	active	Zone 7	2							
2S2E34E001	34E1	Mud City	May	U	monitor	active	Zone 7	2		X	X				
2S2E34Q002	34Q2	Hollyhock & Crocus	Spring	U	monitor	active	Zone 7	2							
2S3E01D001	1D1	CASGEM Tracy PGE	Tracy	U	irrigation	unknown	Zone 7	2							
3S1E01F002	1F2	Constitution Dr	Camp	U	monitor	active	Zone 7	2							
3S1E01H003	1H3	Collier Canyon g1	Camp	U	monitor	active	Zone 7	2							
3S1E01J004	1J04	Collier Vineyards	Camp	L	irrigation	active	Zone 7	2							
3S1E01L001	1L1	Kitty Hawk	Camp	U	monitor	active	Zone 7	2							
3S1E01P002	1P2	Airport gas g5	Amador	U	monitor	active	Zone 7	2							
3S1E01P003	1P3	New airport well	Amador	L	supply	inactive	Zone 7	2							
3S1E02J002	2J2	Maint. Bldg	Camp	U	monitor	active	Zone 7	2							
3S1E02J003	2J3	Doolan Rd East	Camp	U	monitor	active	Zone 7	2							
3S1E02K002	2K2	Doolan Rd West	Camp	U	monitor	active	Zone 7	2							
3S1E02M003	2M3	Friesman Rd North	Camp	U	monitor	active	Zone 7	2							
3S1E02N006	2N6	Friesman Rd South	Amador	U	monitor	active	Zone 7	2			X				
3S1E02P003	2P3	Crosswinds Church	Camp	L	domestic	active	Zone 7	2							
3S1E02Q001	2Q1	LPGC #1	Amador	U	monitor	active	Zone 7	2							
3S1E02R001	2R1	Beebs	Amador	U	monitor	active	Zone 7	2			X				
3S1E03G002	3G2	fallon rd	Camp	U	monitor	active	Zone 7	2							
3S1E04A001	4A1	SMP-DUB-2	Camp	U	monitor	active	Zone 7	2							

TABLE 14-1
MONITORING WELLS IN 2021 GROUNDWATER LEVELS PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
3S1E04J005	4J5	Pimlico shallow	Camp	U	monitor	active	Zone 7	2							
3S1E04J006	4J6	Pimlico deep	Camp	U	monitor	active	Zone 7	2							
3S1E04Q002	4Q2	gulfstream	Amador	U	monitor	active	Zone 7	2							
3S1E05K006	5K6	Rosewood shallow	Camp	U	monitor	active	Zone 7	2			X				
3S1E05K007	5K7	Rosewood deep	Camp	L	monitor	active	Zone 7	2							
3S1E05L003	5L3	Oracle	Camp	U	monitor	active	Zone 7	2							
3S1E05P006	5P6	Owens Park	Camp	U	monitor	active	Zone 7	2							
3S1E06F003	6F3	Dublin Ct	Dublin	U	monitor	active	Zone 7	2		X				X	
3S1E06G005	6G5	Nissan Repair	Dublin	L	industrial	GPO Intent to use	Zone 7	2							
3S1E06N002	6N2	DSRSD MW-3	Dublin	U	monitor	active	Zone 7	2							
3S1E07B002	7B2	Hopyard rd	Dublin	L	monitor	active	Zone 7	2							
3S1E07B012	7B12	Hacienda Arch	Dublin	U	monitor	active	Zone 7	2							
3S1E07G007	7G7	Chabot Well	Dublin	U	monitor	active	Zone 7	2							
3S1E07J005	7J5	Thomas Hart School	Dublin	U	monitor	active	Zone 7	2							
3S1E08B001	8B1	Lizard Well	Amador	U	monitor	active	Zone 7	2							
3S1E08G004	8G4	Apache	Amador	U	monitor	active	Zone 7	2							
3S1E08H009	8H9	Mocho 4 Nested Shallow	Amador	L	nested	active	Zone 7	2							
3S1E08H010	8H10	Mocho 4 Nested Middle	Amador	L	nested	active	Zone 7	2							
3S1E08H011	8H11	Mocho 4 Nested deep	Amador	D	nested	active	Zone 7	2							
3S1E08H013	8H13	Mocho 3 mon	Amador	D	monitor	active	Zone 7	2							
3S1E08H018	M4	Mocho 4	Amador	L	muni	active	Zone 7	2							
3S1E08K001	8K1	Cockroach well	Amador	U	monitor	active	Zone 7	2							
3S1E08N001	8N1	sports park	Bernal	U	monitor	active	Zone 7	2							
3S1E09H010	9H10	NW Lake I Shallow	Amador	U	nested	active	Zone 7	2							X
3S1E09H011	9H11	NW Lake I Deep	Amador	L	nested	active	Zone 7	2							X
3S1E09H013	9H13	Lister	Amador	U	domestic	active	Zone 7	2							X
3S1E09J007	9J7	SW Lake I Shallow	Amador	U	nested	active	Zone 7	2							X
3S1E09J008	9J8	SW Lake I Middle	Amador	L	nested	active	Zone 7	2							X
3S1E09J009	9J9	SW Lake I Deep	Amador	L	nested	active	Zone 7	2							X
3S1E09M002	M1	Mocho 1	Amador	L	muni	active	Zone 7	2							
3S1E09M003	M2	Mocho 2	Amador	L	muni	active	Zone 7	2							
3S1E09M004	M3	Mocho 3	Amador	L	muni	active	Zone 7	2							
3S1E09P005	9P5	Key_AmW_U (Mohr Key)	Amador	U	monitor	active	Zone 7	12		X		X		X	
3S1E09P009	9P9	Mohr Ave Shallow	Amador	L	nested	active	Zone 7	12	15						X
3S1E09P010	9P10	Key_AmW_L	Amador	L	nested	active	Zone 7	12		X		X		X	
3S1E09P011	9P11	Mohr Ave Deep	Amador	L	nested	active	Zone 7	12							X
3S1E10A002	10A2	El Charro Rd	Amador	U	monitor	active	Zone 7	2							
3S1E10B008	10B8	Kaiser Rd Shallow	Amador	L	nested	active	Zone 7	2							
3S1E10B009	10B9	Kaiser Rd Middle 1	Amador	L	nested	active	Zone 7	2							
3S1E10B010	10B10	Kaiser Rd Middle 2	Amador	L	nested	unknown	Zone 7	2							
3S1E10B011	10B11	Kaiser Rd Deep	Amador	D	nested	active	Zone 7	2							

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
3S1E10B014	10B14	COL 5 Monitoring	Amador	L	monitor	unknown	Zone 7	2							
3S1E10D002	10D2	Stoneridge Shallow	Amador	L	nested	active	Zone 7	2							
3S1E10D003	10D3	Stoneridge Middle 1	Amador	L	nested	active	Zone 7	2							
3S1E10D004	10D4	Stoneridge Middle 2	Amador	L	nested	active	Zone 7	2							
3S1E10D005	10D5	Stoneridge Deep	Amador	D	nested	active	Zone 7	2							
3S1E10D007	10D7	North Lake I Shallow	Amador	U	nested	active	Zone 7	2							X
3S1E10D008	10D8	North Lake I Cluster 2	Amador	L	nested	active	Zone 7	2							X
3S1E10K002	10K2	COL 1 Monitoring	Amador	L	monitor	active	Zone 7	2							
3S1E10N002	10N2	South Lake I Shallow	Amador	U	nested	active	Zone 7	2							X
3S1E10N003	10N3	South Lake I Deep	Amador	L	nested	active	Zone 7	2							X
3S1E11B001	11B1	Airport West	Amador	U	monitor	active	Zone 7	2							
3S1E11C003	11C3	LAVWMA ROW	Amador	U	monitor	active	Zone 7	2							
3S1E11G001	11G1	Key_AmE_U	Amador	U	nested	active	Zone 7	12		X		X		X	
3S1E11G002	11G2	Rancho Charro Middle 1	Amador	L	nested	active	Zone 7	12							X
3S1E11G003	11G3	Rancho Charro Middle 2	Amador	L	nested	active	Zone 7	12							X
3S1E11G004	11G4	Rancho Charro Deep	Amador	D	nested	active	Zone 7	12							X
3S1E11M002	11M2	COL 2 Monitoring	Amador	L	monitor	active	Zone 7	2							
3S1E11P006	11P6	New Jamieson Residence	Amador	L	domestic	unknown	Zone 7	2							
3S1E12A002	12A2	Airport South	Amador	U	monitor	active	Zone 7	2							
3S1E12D002	12D2	LWRP G6	Amador	U	monitor	active	LWRP	2							
3S1E12G001	12G1	Oaks Park Shallow	Amador	U	monitor	active	Zone 7	2							
3S1E12H004	12H4	LWRP Shallow	Amador	L	nested	active	Zone 7	2							
3S1E12H005	12H5	LWRP Middle 1	Amador	L	nested	active	Zone 7	2							
3S1E12H006	12H6	LWRP Middle 2	Amador	L	nested	active	Zone 7	2							
3S1E12H007	12H7	LWRP Deep	Amador	D	nested	active	Zone 7	2							
3S1E12K002	12K2	Oaks Park Mid	Amador	L	nested	active	Zone 7	12							X
3S1E12K003	12K3	Key_AmE_L	Amador	L	nested	active	Zone 7	12		X		X		X	
3S1E12K004	12K4	Oaks Park Deep	Amador	D	nested	active	Zone 7	12						X	X
3S1E13P005	13P5	LGA Grant Nested 1	Amador	U	nested	active	Zone 7	12							X
3S1E13P006	13P6	LGA Grant Nested 2	Amador	L	nested	active	Zone 7	12							X
3S1E13P007	13P7	LGA Grant Nested 3	Amador	L	nested	active	Zone 7	12							X
3S1E13P008	13P8	LGA Grant Nested 4	Amador	L	nested	active	Zone 7	12							X
3S1E14B001	14B1	Industrial Asphalt	Amador	L	industrial	unknown	Zone 7	2							
3S1E14D002	14D2	South Cope Lake	Amador	L	monitor	active	Zone 7	2							
3S1E15F003	15F3	Kaiser #8	Amador	L	supply	inactive	Zone 7	2							
3S1E15J003	15J3	shadow cliff	Amador	L	supply	unknown	Zone 7	2							
3S1E15M003	15M3	Bush/Valley South	Amador	L	monitor	active	Zone 7	2							
3S1E16A004	16A4	Bush/Valley Mid	Amador	L	monitor	active	Zone 7	2							
3S1E16B001	16B1	Bush/Valley North	Amador	D	monitor	active	Zone 7	2							
3S1E16C002	16C2	Santa Rita Valley Shallow	Amador	L	nested	active	Zone 7	2							
3S1E16C003	16C3	Santa Rita Valley Middle	Amador	L	nested	active	Zone 7	2							

TABLE 14-1
MONITORING WELLS IN 2021 GROUNDWATER LEVELS PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
3S1E16C004	16C4	Santa Rita Valley Deep	Amador	L	nested	active	Zone 7	2							
3S1E16E004	16E4	black ave - cultural	Amador	U	monitor	active	Zone 7	2							
3S1E16L002	P4	Pleas 4	Amador	L	muni	unknown	Pleas	2							
3S1E16P005	16P5	Vervais Monitor	Amador	U	monitor	active	Zone 7	12			X		X		
3S1E16R001	16R1	Stanley Berry Farm	Amador	L	supply	unknown	Zone 7	2							
3S1E17B004	17B4	Casterson	Amador	L	supply	unknown	Zone 7	2							
3S1E17D003	17D3	Hopyard Nested Shallow	Bernal	L	nested	active	Zone 7	2							
3S1E17D004	17D4	Hopyard Nested Middle 1	Bernal	L	nested	active	Zone 7	2							
3S1E17D005	17D5	Hopyard Nested Middle 2	Bernal	L	nested	active	Zone 7	2							
3S1E17D006	17D6	Hopyard Nested Middle 3	Bernal	L	nested	active	Zone 7	2							
3S1E17D007	17D7	Hopyard Nested Deep	Bernal	D	nested	active	Zone 7	2							
3S1E17D010	H7	Hopyard 7	Bernal	L	monitor	active	Zone 7	2							
3S1E17D011	17D11	Hopyard 9 Monitoring Well	Bernal	L	monitor	active	Zone 7	2							
3S1E18A005	P7	Pleas 7	Bernal	L	muni	inactive	Pleas	2							
3S1E18E004	18E4	Valley Trails II	Bernal	U	monitor	active	Zone 7	2							
3S1E18J002	18J2	camino segura	Bernal	U	monitor	active	Zone 7	2							
3S1E18N001	18N1	merritt	Bernal	L	irrigation	unknown	Zone 7	2							
3S1E19A010	SF-B	SFWD South (B)	Bernal	L	muni	active	Zone 7	2							
3S1E19A011	SF-A	SFWD North (A)	Bernal	L	muni	active	Zone 7	2							
3S1E19C004	19C4	del valle & laguna	Bernal	U	monitor	active	Zone 7	2							
3S1E19K001	19K1	680/bernal	Bernal	U	monitor	active	Zone 7	2							
3S1E20C003	20C3	Fairgrounds Potable Backup	Bernal	L	supply	active	Zone 7	2							
3S1E20C007	20C7	Key_Bern_U	Bernal	U	monitor	active	Zone 7	12		X		X	X	X	
3S1E20C008	20C8	Key_Bern_L	Bernal	L	nested	active	Zone 7	12		X		X		X	
3S1E20C009	20C9	Fair Nested Deep	Bernal	L	nested	active	Zone 7	12							X
3S1E20J004	20J4	civic center	Bernal	U	monitor	active	Zone 7	2							
3S1E20M011	20M11	S.F "M"LINE	Bernal	U	monitor	active	Zone 7	2							
3S1E20Q002	20Q2	20Q2	Bernal	U	monitor	active	Zone 7	2							
3S1E22D002	22D2	vineyard trailer	Amador	U	monitor	active	Zone 7	2							
3S1E23J001	23J1	1627 vineyard trailer	Amador	L	domestic	unknown	Zone 7	2							
3S1E24Q001	24Q1	Ruby Hills	Amador	L	irrigation	unknown	Zone 7	2							
3S1E25C003	25C3	Katz Winery Mansion	Amador	U	monitor	unknown	Zone 7	2							
3S1E28M002	28M2	Bargar	Upland	U	supply	active	Zone 7	2							
3S1E29M004	29M4	f.c. channel	Castle	U	monitor	active	Zone 7	12					X		
3S1E29P002	29P2	castlewood dr	Bernal	U	monitor	active	Zone 7	2							
3S1E33G005	33G5	Pleasanton Calippe 33G5	Upland	U	monitor	unknown	Zone 7	2							
3S1W01B009	1B9	DSRSD Shallow	Dublin	L	nested	unknown	Zone 7	2							
3S1W01B010	1B10	DSRSD Middle	Dublin	L	nested	unknown	Zone 7	2							
3S1W01B011	1B11	DSRSD Deep	Dublin	L	nested	unknown	Zone 7	2							
3S1W02A002	2A2	McNamara's	Dublin	U	monitor	active	Zone 7	2							
3S1W12B002	12B2	Stoneridge Mall Rd	Dublin	U	monitor	active	Zone 7	2							

TABLE 14-1
MONITORING WELLS IN 2021 GROUNDWATER LEVELS PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
3S1W12J001	12J1	DSRSD South	Dublin	U	monitor	active	Zone 7	2							
3S1W13J001	13J1	muirwood dr	Castle	U	monitor	active	Zone 7	2							
3S2E01F002	1F2	Brisa at Circuit City	Spring	U	monitor	active	Zone 7	2							
3S2E02B002	2B2	south front rd	Spring	U	monitor	active	Zone 7	2							
3S2E03A001	3A1	Bluebell	Spring	U	monitor	active	Zone 7	2							
3S2E03K003	3K3	first & S. front rd	Mocho I	U	monitor	active	Zone 7	2							
3S2E05N001	5N1	Spider Well	Mocho II	M	supply	inactive	Zone 7	2							
3S2E07C002	7C2	jaws - york way - G4	Mocho II	U	monitor	active	Zone 7	2							
3S2E07H002	7H2	dakota	Mocho II	U	monitor	active	Zone 7	2							
3S2E07N002	7N2	Isabel & Arroyo Mocho	Amador	U	monitor	active	Zone 7	2							
3S2E07P003	CWS24	CWS 24	Amador	L	muni	active	Zone 7	2							
3S2E07R002	7R2	CWS 31 Monitoring	Mocho II	D	monitor	active	Zone 7	2							
3S2E07R003	CWS31	CWS 31	Upland	L	muni	active	Zone 7	2							
3S2E08H002	8H2	North k	Mocho II	U	monitor	active	Zone 7	2							
3S2E08H003	8H3	Key_Mo2_L	Mocho II	L	nested	active	Zone 7	12		X		X		X	
3S2E08H004	8H4	N Liv Ave Deep	Mocho II	L	nested	active	Zone 7	12							X
3S2E08K002	8K2	Key_Mo2_U (Livermore Key)	Mocho II	U	monitor	active	Zone 7	12	15	X		X		X	
3S2E08N002	CWS14	CWS 14	Mocho II	L	muni	active	Zone 7	2							
3S2E08P001	CWS8	CWS 8	Mocho II	L	muni	active	Zone 7	2							
3S2E08Q009	8Q 9	D-2	Mocho II	L	monitor	active	Zone 7	2							
3S2E09Q004	9Q4	school st	Mocho II	U	monitor	active	Zone 7	2							
3S2E10F003	10F3	hexcel	Mocho I	U	monitor	active	Zone 7	2							
3S2E10Q001	10Q1	almond	Mocho II	U	monitor	active	Zone 7	2							
3S2E10Q002	10Q2	LLNL W-703	Mocho II	L	monitor	unknown	LLNL	2							
3S2E11C001	11C1	joan way	Mocho I	U	monitor	active	Zone 7	2							
3S2E12C004	12C4	LLNL W-486	Spring	U	monitor	unknown	LLNL	2							
3S2E12J003	12J3	LLNL W-017A	Spring	L	monitor	unknown	LLNL	2							
3S2E14A003	14A3	S. vasco @east ave	Mocho I	U	monitor	active	LLNL	2							
3S2E14B001	14B1	5763 east ave	Mocho I	L	domestic	unknown	Zone 7	2							
3S2E15E002	15E2	Retzlaff Winery	Mocho II	L	irrigation	active	Zone 7	2							
3S2E15L001	15L1	Concannon 2	Mocho II	U	monitor	active	Other	2							
3S2E15L002	15L2	Concannon 6D	Mocho II	U	monitor	active	Other	2							
3S2E15M002	15M2	Concannon 1	Mocho II	U	monitor	active	Other	2							
3S2E15M003	15M3	Concannon 5D	Mocho II	U	monitor	active	Other	2							
3S2E15Q006	15Q6	Concannon Old Pumping	Mocho II	L	irrigation	abandoned	Zone 7	2							
3S2E15Q008	15Q 8	Concannon 4	Mocho II	U	monitor	active	Other	2							
3S2E15R017	15R17	Buena Vista Shallow	Mocho II	U	nested	active	Zone 7	2							
3S2E15R018	15R18	Buena Vista Deep	Mocho II	L	monitor	active	Zone 7	2							
3S2E15R020	15R20	Concannon 3	Mocho II	U	monitor	active	Other	2							
3S2E16A003	16A3	Memory Gardens	Mocho II	L	irrigation	active	Zone 7	2							
3S2E16C001	CWS15	CWS 15	Mocho II	L	muni	active	Zone 7	2							

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MONITORING WELLS IN 2021 GROUNDWATER LEVELS PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Meas By	Frequency (per year)	Recorder (min)	RMS	ICSW	Key	WR	CASGEM	Other
3S2E16E004	16E4	pepper tree	Mocho II	U	monitor	active	Zone 7	2			X				
3S2E18B001	CWS20	CWS 20	Amador	L	muni	active	Zone 7	2							
3S2E18E001	18E1	Stanley East of Isabel	Amador	U	monitor	active	Zone 7	2							
3S2E19D007	19D7	Isabel Shallow	Amador	U	nested	active	Zone 7	12						X	X
3S2E19D008	19D8	Isabel Middle 1	Amador	L	nested	active	Zone 7	12							X
3S2E19D009	19D9	Isabel Middle 2	Amador	L	nested	active	Zone 7	12							X
3S2E19D010	19D10	Isabel Deep	Amador	L	nested	active	Zone 7	12							X
3S2E19K001	19K1	Cavicchi	Amador	L	supply	active	Zone 7	2							X
3S2E19N003	19N3	Shallow Cemex Nested	Amador	U	nested	active	Zone 7	12							X
3S2E19N004	19N4	Deep Cemex Nested	Amador	L	nested	active	Zone 7	12							X
3S2E20M001	20M1	Alden Lane	Amador	L	supply	unknown	Zone 7	2							
3S2E20R002	20R2	Ravenswood South Well	Upland	U	irrigation	active	Zone 7	2							
3S2E21K009	21K9	Hughey Marina Ave	Upland	U	domestic	active	Zone 7	2		X					
3S2E22B001	22B1	grapes	Mocho II	U	monitor	active	Zone 7	2							
3S2E23E001	23E1	Murrieta Nested Shallow	Mocho II	U	nested	active	Zone 7	2			X				
3S2E23E002	23E2	Murrieta Nested Deep	Mocho II	L	nested	active	Zone 7	2							
3S2E24A001	24A1	S. greenville	Mocho I	U	monitor	active	Zone 7	2		X					
3S2E26J002	26J2	mines rd	Mocho II	U	monitor	active	Zone 7	2							
3S2E29F004	29F4	Wetmore	Amador	U	monitor	active	Zone 7	12			X		X	X	
3S2E29L001	29L1 (P3)	Sycamore Grove P3	Amador	U	monitor	active	Zone 7	2							X
3S2E30C001	30C1	Vineyard 30C 1	Amador	L	supply	active	Zone 7	12							X
3S2E30D002	30D2	vineyard	Amador	U	monitor	active	Zone 7	12	15		X		X		
3S2E32E007	32E7	DVWTP 32E7	Upland	U	monitor	active	Zone 7	2			X				
3S2E33C001	33C1 (P1)	Sycamore Grove P1	Amador	U	monitor	inactive	Zone 7	2			X				
3S2E33G001	33G1	Crohare	Amador	U	monitor	active	Zone 7	12			X		X		
3S3E06Q003	6Q3	PPWTP South Monitoring	Altamont	U	monitor	active	Zone 7	2							
3S3E07D002	7D2	7D 2	Spring	U	monitor	active	LLNL	2							
3S3E20L004	20L 4	Vail on Tesla	Mocho I	U	domestic	active	Zone 7	2							
3S3E20R004	20R 4	Buonanno on Tesla	Mocho I	U	domestic	active	Zone 7	2							
3S3E21C001	21C1	Russell on Reuss	Upland	U	domestic	active	Zone 7	2							
4S2E01A001	1A1	Gallagher Ag	Mocho II	U	irrigation	active	Zone 7	2			X				
4S3E06E004	6E4	Gallagher Domestic	Mocho II	U	domestic	active	Zone 7	2							
WELLS IN THE GROUNDWATER LEVELS PROGRAM = 237															

RMS = Representative Monitoring Site
ICSW = Interconnected Surface Water
WR = Water Rights

TABLE 14-2
GROUNDWATER PROGRAM
WELL CONSTRUCTION DETAILS
2021 WATER YEAR

Site	Map	Type	Other Name	Completed	Basin	Aquifer	RP	TD	Dia	Perf
2S1E32E001	32E1	monitor	End of Arnold Rd	12/28/2000	None	U	392.56	70	2	55 - 70
2S1E32N001	32N1	monitor	Camp Parks	7/1/1976	Camp	U	360.79	44	2.5	35 - 41
2S1E32Q001	32Q1	monitor	Summer Glen Dr	12/29/2000	Camp	U	367.55	45	2	30 - 45
2S1E33L001	33L1	monitor	Gleason Dr @ Tassajara	12/27/2000	None	U	389.46	80	2	65 - 80
2S1E33P002	33P2	monitor	Central Pkwy at Emerald Glen	12/20/2000	Camp	U	370.05	55	2	45 - 55
2S1E33R001	33R1	monitor	Central Pkwy @ Grafton	10/23/2001	None	U	358.5	60	2	40 - 60
2S1W15F001	15F1	monitor	BOLLINGER	9/28/1976	Bishop	U	439.44	60	2.5	50.3 - 55.3
2S1W26C00	26C2	monitor	PINE VALLEY	9/28/1976	Dublin	U	406.53	50	2.5	40 - 45
2S1W36E00	36E3	monitor	Kolb Park	9/13/1977	Dublin	U	346.51	60	2.5	50 - 55
2S1W36F001	36F1	nested	Dublin High shallow	5/8/1996	Dublin	L	342.71	190	2	140 - 180
2S1W36F002	36F2	nested	Dublin High mid	5/8/1996	Dublin	L	342.71	320	2	270 - 310
2S2E27K001	27K1	livestock	Livermore #196	4/28/1954	Spring	U	521.8	96	8	49 - 88
2S2E27M002	27M2	domestic	Kwan	7/16/1975	May	U	521	112	6	0 - 0
2S2E27P002	27P2	monitor	hartford ave east	6/18/1979	Spring	U	505.43	68	4	35 - 63
2S2E28D002	28D2	monitor	May School	11/2/1976	May	U	555.15	55	2.5	45 - 50
2S2E28J002	28J2	industrial	FCC Well	7/26/1984	May	L	522.292	230	6	50 - 230
2S2E28Q001	28Q1	monitor	hartford ave	11/2/1976	May	U	513.04	28	2.5	17.6 - 22.6
2S2E32K002	32K2	monitor	jenson's N liv. Ave	12/20/1977	Cayetano	U	507.43	43	2.5	33 - 38
2S2E34E001	34E1	monitor	Mud City	12/21/1977	May	U	499.73	49	2.5	40 - 45
2S2E34Q002	34Q2	monitor	Hollyhock & Crocus	12/12/2001	Spring	U	507.24	50	2	25 - 50
3S1E01F002	1F2	monitor	Constitution Dr	12/18/2000	Camp	U	428.44	40	2	25 - 40
3S1E01H003	1H3	monitor	Collier Canyon g1	12/20/1977	Camp	U	422.8	80	2.5	70 - 75
3S1E01J004	1J04	irrigation	Collier Vineyards	2/6/2018	Camp	L		300	12	260 - 280
3S1E01L001	1L1	monitor	Kitty Hawk	12/19/2000	Camp	U	403.04	70	2	60 - 70
3S1E01P002	1P2	monitor	Airport gas g5	12/11/1975	Amador	U	389.64	50	2.5	40 - 45
3S1E01P003	1P3	supply	New airport well	7/28/1988	Amador	L	394.44	480	12	245 - 460
3S1E02J002	2J2	monitor	Maint. Bldg	7/16/2003	Camp	U	380.89	41	2	31 - 41
3S1E02J003	2J3	monitor	Doolan Rd East	7/16/2003	Camp	U	406.35	65	2	55 - 65
3S1E02K002	2K2	monitor	Doolan Rd West	12/10/1975	Camp	U	397.04	46	2.5	36.5 - 41.5
3S1E02M003	2M3	monitor	Friesman Rd North	11/13/2000	Camp	U	365.04	50	2	35 - 50
3S1E02N006	2N6	monitor	Friesman Rd South	11/13/2000	Amador	U	366.14	55	2	40 - 55
3S1E02P003	2P3	domestic	Crosswinds Church	9/26/1977	Camp	L	371.73	380	10	340 - 372
3S1E02Q001	2Q1	monitor	LPGC #1	7/16/2003	Amador	U	369.92	45	2	35 - 45
3S1E02R001	2R1	monitor	Beebs	11/1/1975	Amador	U	376.29	33	2.5	21 - 26
3S1E03G002	3G2	monitor	fallon rd	1/18/1978	Camp	U	354.24	50	2.5	40 - 45
3S1E04A001	4A1	monitor	SMP-DUB-2	10/23/2001	Camp	U	350.67	49.5	2	29.5 - 49.5
3S1E04J005	4J5	monitor	Pimlico shallow	10/25/2001	Camp	U	345.2	47	2	22 - 47
3S1E04J006	4J6	monitor	Pimlico deep	10/24/2001	Camp	U	345.55	110	2	68 - 110
3S1E04Q002	4Q2	monitor	gulfstream	12/13/1977	Amador	U	345.42	90	2.5	80 - 85
3S1E05K006	5K6	monitor	Rosewood shallow	6/7/1990	Camp	U	346.05	75	4	40 - 70
3S1E05K007	5K7	monitor	Rosewood deep	6/8/1990	Camp	L	346.19	150	4	134 - 144
3S1E05L003	5L3	monitor	Oracle	12/11/2001	Camp	U	339.43	40	2	15 - 40
3S1E05P006	5P6	monitor	Owens Park	12/19/2000	Camp	U	336.65	35	2	25 - 35
3S1E06F003	6F3	monitor	Dublin Ct	9/29/1976	Dublin	U	329.82	36	2.5	27 - 32

RP = Reference Point Elevation (in feet above MSL)
TD = Total Depth of well (in feet below ground surface)
Dia = Diameter of well casing (in inches)
Perf = Preferated interval (in feet below ground surface), uppermost - lowermost

Site	Map	Type	Other Name	Completed	Basin	Aquifer	RP	TD	Dia	Perf
3S1E06N002	6N2	monitor	DSRSD MW-3	3/20/1985	Dublin	U	335.2	67	4	47 - 67
3S1E06N003	6N3	monitor	DSRSD MW-4	12/4/1984	Dublin	U	340.74	72		52 - 72
3S1E06N006	6N6	monitor	DSRSD NE-76	11/9/2007	Dublin	U	333.58	75	2	50 - 70
3S1E07B002	7B2	monitor	Hopyard rd	5/17/1979	Dublin	L	327.77	152	4	143 - 149
3S1E07B012	7B12	monitor	Hacienda Arch	7/31/2002	Dublin	U	327.82	70	2	50 - 70
3S1E07D001	7D1	monitor	DSRSD SW-75	11/6/2007	Dublin	U	330.09	75	2	54 - 74
3S1E07D003	7D3	monitor	DSRSD SE-70	11/2/2007	Dublin	U	332.28	70	2	45 - 65
3S1E07G007	7G7	monitor	Chabot Well	1/22/2002	Dublin	U	327.33	55	2	35 - 55
3S1E07J005	7J5	monitor	Thomas Hart School	7/10/2002	Dublin	U	326.78	50	2	30 - 50
3S1E08B001	8B1	monitor	Lizard Well	5/31/1979	Amador	U	338.28	148	4	55 - 82
3S1E08G004	8G4	monitor	Apache	12/19/2001	Amador	U	341.47	85	2	60 - 85
3S1E08H009	8H9	nested	Mocho 4 Nested Shallow	12/12/1996	Amador	L	338.53	240	2	210 - 230
3S1E08H010	8H10	nested	Mocho 4 Nested Middle	12/12/1996	Amador	L	339.26	440	2	290 - 430
3S1E08H011	8H11	nested	Mocho 4 Nested deep	12/21/1996	Amador	D	339.26	720	2	520 - 720
3S1E08H013	8H13	monitor	Mocho 3 mon	12/11/1998	Amador	D	338.96	800	2	570 - 790
3S1E08H018	M4	muni	Mocho 4	11/1/2000	Amador	L	341.94	745	20	515 - 730
3S1E08K001	8K1	monitor	Cockroach well	1/23/1978	Amador	U	332.37	99	2.5	89 - 94
3S1E08N001	8N1	monitor	sports park	8/27/1976	Bernal	U	323.68	72	2.5	62 - 67
3S1E09B001	St1	muni	Stoneridge	1/28/1992	Amador	L	349.23	810	20	250 - 800
3S1E09H013	9H13	domestic	Lister		Amador	U		145	8	-
3S1E09J007	9J7	nested	SW Lake I Shallow	11/23/2004	Amador	U	357.36	145	2	120 - 140
3S1E09J008	9J8	nested	SW Lake I Middle	11/23/2004	Amador	L	357.55	305	2	280 - 300
3S1E09J009	9J9	nested	SW Lake I Deep	11/23/2004	Amador	L	357.68	505	2	480 - 500
3S1E09M002	M1	muni	Mocho 1	4/6/1964	Amador	L	343.95	530	16	150 - 510
3S1E09M003	M2	muni	Mocho 2	5/4/1967	Amador	L	347.47	575	18	250 - 570
3S1E09M004	M3	muni	Mocho 3	11/1/2000	Amador	L	342.89	498	20	315 - 493
3S1E09P005	9P5	monitor	Key_AmW_U (Mohr Key)	12/6/1977	Amador	U	349.4	105	2.5	95 - 100
3S1E09P009	9P9	nested	Mohr Ave Shallow	3/23/2005	Amador	L	349.59	210	2	185 - 205
3S1E09P010	9P10	nested	Key_AmW_L	3/23/2005	Amador	L	349.51	310	2	285 - 305
3S1E09P011	9P11	nested	Mohr Ave Deep	3/23/2005	Amador	L	349.44	425	2	405 - 420
3S1E10A002	10A2	monitor	El Charro Rd	5/10/1979	Amador	U	367.35	88	4	70 - 80
3S1E10B008	10B8	nested	Kaiser Rd Shallow	6/18/1997	Amador	L	353.6	200	2	100 - 190
3S1E10B009	10B9	nested	Kaiser Rd Middle 1	6/18/1997	Amador	L	353.49	294	2	244 - 284
3S1E10B010	10B10	nested	Kaiser Rd Middle 2	6/18/1997	Amador	L	353.52	600	2	400 - 590
3S1E10B011	10B11	nested	Kaiser Rd Deep	6/18/1997	Amador	D	353.52	810	2	660 - 800
3S1E10B014	10B14	monitor	COL 5 Monitoring	2/26/2014	Amador	L	355.591	690	2	390 - 690
3S1E10B016	COL5	muni	COL 5	7/19/2014	Amador	L	357.584	690	18	390 - 690
3S1E10D002	10D2	nested	Stoneridge Shallow	9/10/1998	Amador	L	349.32	212	2	182 - 212
3S1E10D003	10D3	nested	Stoneridge Middle 1	9/10/1998	Amador	L	349.28	322	2	262 - 312
3S1E10D004	10D4	nested	Stoneridge Middle 2	9/10/1998	Amador	L	349.3	616	2	366 - 606
3S1E10D005	10D5	nested	Stoneridge Deep	9/10/1998	Amador	D	349.32	790	2	710 - 780
3S1E10K002	10K2	monitor	COL 1 Monitoring	1/17/2007	Amador	L	358.68	590.6	4	195.5 - 585.6
3S1E10K003	COL1	muni	COL 1	2/27/2008	Amador	L	363.79	530	18	205 - 530
3S1E11B001	11B1	monitor	Airport West	12/11/1975	Amador	U	369.35	43	2.5	33 - 38
3S1E11C003	11C3	monitor	LAVWMA ROW	12/22/2003	Amador	U	364.82	55	2	35 - 55
3S1E11G001	11G1	nested	Key_AmE_U	4/8/1997	Amador	U	371.62	120	2	100 - 110
3S1E11G002	11G2	nested	Rancho Charro Middle 1	4/8/1997	Amador	L	371.61	350	2	230 - 340
3S1E11G003	11G3	nested	Rancho Charro Middle 2	4/8/1997	Amador	L	371.64	590	2	380 - 580
3S1E11G004	11G4	nested	Rancho Charro Deep	4/8/1997	Amador	D	371.68	790	2	620 - 780
3S1E11M002	11M2	monitor	COL 2 Monitoring	9/25/2007	Amador	L	365.96	700	4.5	199 - 699
3S1E11M003	COL2	muni	COL 2	2/14/2008	Amador	L	369.24	684	18	345 - 684

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Site	Map	Type	Other Name	Completed	Basin	Aquifer	RP	TD	Dia	Perf
3S1E11P006	11P6	domestic	New Jamieson Residence	3/10/2000	Amador	L	376.67	400	5	240 - 380
3S1E12A002	12A2	monitor	Airport South	12/11/1975	Amador	U	401.35	69	2.5	63.7 - 68.7
3S1E12D002	12D2	monitor	LWRP G6		Amador	U	384.45	44.6		36 - 41
3S1E12G001	12G1	monitor	Oaks Park Shallow	12/12/1975	Amador	U	404.47	73	2.5	63 - 68
3S1E12H004	12H4	nested	LWRP Shallow	1/8/1998	Amador	L	407.75	270	2	185 - 260
3S1E12H005	12H5	nested	LWRP Middle 1	1/8/1998	Amador	L	407.78	400	2	360 - 390
3S1E12H006	12H6	nested	LWRP Middle 2	1/8/1998	Amador	L	407.75	480	2	410 - 468
3S1E12H007	12H7	nested	LWRP Deep	1/8/1998	Amador	D	407.67	684	2	609 - 674
3S1E12K002	12K2	nested	Oaks Park Mid	11/1/2005	Amador	L	406.29	300	2	210 - 295
3S1E12K003	12K3	nested	Key_AmE_L	11/1/2005	Amador	L	406.83	475	2	355 - 470
3S1E12K004	12K4	nested	Oaks Park Deep	11/1/2005	Amador	D	406.71	575	2	550 - 570
3S1E13P005	13P5	nested	LGA Grant Nested 1	11/2/2010	Amador	U	399.97	135	2	110 - 130
3S1E13P006	13P6	nested	LGA Grant Nested 2	11/2/2010	Amador	L	399.93	255	2	230 - 250
3S1E13P007	13P7	nested	LGA Grant Nested 3	11/2/2010	Amador	L	399.97	375	2	350 - 370
3S1E13P008	13P8	nested	LGA Grant Nested 4	11/2/2010	Amador	L	399.94	605	2	580 - 600
3S1E14B001	14B1	industrial	Industrial Asphalt		Amador	L	384.2	435	8	200 - 410
3S1E14D002	14D2	monitor	South Cope Lake	8/30/2006	Amador	L	371.83	740	14.5	170 - 740
3S1E15J003	15J3	supply	shadow cliff	12/2/1980	Amador	L	344.59	196	8	154 - 184
3S1E15M003	15M3	monitor	Bush/Valley South	12/15/1998	Amador	L	362.88	600	2	280 - 590
3S1E16A002	P8	muni	Pleas 8	3/27/1992	Amador	L	358.2	500	20	200 - 495
3S1E16A004	16A4	monitor	Bush/Valley Mid	12/3/1998	Amador	L	359.36	603	2	260 - 580
3S1E16B001	16B1	monitor	Bush/Valley North	12/18/1998	Amador	D	355.81	805	2	605 - 800
3S1E16C002	16C2	nested	Santa Rita Valley Shallow	4/14/2005	Amador	L	344.38	190	2	165 - 185
3S1E16C003	16C3	nested	Santa Rita Valley Middle	4/14/2005	Amador	L	344.27	305	2	280 - 300
3S1E16C004	16C4	nested	Santa Rita Valley Deep	4/14/2005	Amador	L	344.16	375	2	355 - 370
3S1E16E004	16E4	monitor	black ave - cultural	12/15/1977	Amador	U	351.69	105	2.5	95 - 100
3S1E16L005	P5	muni	Pleas 5	4/4/1962	Amador	L	358.05	685	18	149 - 650
3S1E16L007	P6	muni	Pleas 6	6/1/1966	Amador	L	354.47	647	18	165 - 647
3S1E16P005	16P5	monitor	Vervais Monitor	10/8/1976	Amador	U	354.51	75	2.5	64 - 69
3S1E17B004	17B4	supply	Casterson	1/1/1950	Amador	L	337.69	248	8	0 - 248
3S1E17D003	17D3	nested	Hopyard Nested Shallow	8/6/1996	Bernal	L	325.13	108	4	92 - 98
3S1E17D004	17D4	nested	Hopyard Nested Middle 1	8/6/1996	Bernal	L	325.14	236	4	206 - 226
3S1E17D005	17D5	nested	Hopyard Nested Middle 2	8/6/1996	Bernal	L	325.13	308	4	266 - 286
3S1E17D006	17D6	nested	Hopyard Nested Middle 3	8/6/1996	Bernal	L	325.12	408	4	378 - 398
3S1E17D007	17D7	nested	Hopyard Nested Deep	8/6/1996	Bernal	D	325.13	684	4	654 - 674
3S1E17D011	17D11	monitor	Hopyard 9 Monitoring Well	12/16/1998	Bernal	L	324.84	603	2	340 - 505
3S1E17D012	H9	muni	Hopyard 9	11/5/1999	Bernal	L	327.9	315	18	235 - 310
3S1E18A006	H6	muni	Hopyard 6	2/1/1987	Bernal	L	326.74	500	18	158 - 490
3S1E18E004	18E4	monitor	Valley Trails II	5/31/1979	Bernal	U	320.21	83	4	69 - 79
3S1E18J002	18J2	monitor	camino segura	10/20/1977	Bernal	U	323.02	71	2.5	61 - 66
3S1E19A010	SF-B	muni	SFWD South (B)		Bernal	L	337.02	331		189 - 327
3S1E19A011	SF-A	muni	SFWD North (A)	10/9/2001	Bernal	L	334.27	330	18	196 - 320
3S1E19C004	19C4	monitor	del valle & laguna	6/11/1979	Bernal	U	322.23	78	4	68 - 73
3S1E19K001	19K1	monitor	680/bernal	12/8/1975	Bernal	U	321.54	57.6	2.5	47.6 - 52.6
3S1E20B002	20B2	supply	Fairgrounds Potable	12/27/1961	Bernal	L	344.03	500	12	218 - 500
3S1E20C003	20C3	supply	Fairgrounds Potable Backup		Bernal	L	338.6	110	14	74 - 107
3S1E20C007	20C7	monitor	Key_Bern_U	6/15/2000	Bernal	U	338.66	153	2	65 - 145
3S1E20C008	20C8	nested	Key_Bern_L	10/20/2008	Bernal	L	338.67	315	2	295 - 315
3S1E20C009	20C9	nested	Fair Nested Deep	10/20/2008	Bernal	L	338.78	515	2	495 - 515
3S1E20J004	20J4	monitor	civic center	12/5/1975	Bernal	U	331.62	72	2.5	62 - 67
3S1E20M011	20M11	monitor	S.F "M"LINE	10/12/1977	Bernal	U	325.73	71	2.5	61 - 66

RP = Reference Point Elevation (in feet above MSL) TD = Total Depth of well (in feet below ground surface)
Dia = Diameter of well casing (in inches) Perf = Preferated interval (in feet below ground surface), uppermost - lowermost

Site	Map	Type	Other Name	Completed	Basin	Aquifer	RP	TD	Dia	Perf
3S1E20Q002	20Q2	monitor	20Q2	2/17/1976	Bernal	U	325.82	65	10	45 - 53
3S1E22D002	22D2	monitor	vineyard trailer	10/28/1976	Amador	U	368.05	72	2.5	62 - 67
3S1E23J001	23J1	domestic	1627 vineyard trailer	3/4/1958	Amador	L	428.2	120	8	0 - 120
3S1E25C003	25C3	monitor	Katz Winery Mansion	11/28/1990	Amador	U	454.16	146	2	70 - 140
3S1E28M002	28M2	supply	Bargar	2/8/1962	Upland	U	0	141	5	80 - 141
3S1E29M004	29M4	monitor	f.c. channel	12/4/1975	Castle	U	310.94	57	2.5	47 - 52
3S1E29P002	29P2	monitor	castlewood dr	12/9/1975	Bernal	U	302.82	42	2.5	32 - 37
3S1E33G005	33G5	monitor	Pleasanton Calippe 33G5	7/21/2006	Upland	U	0	35	2	11 - 35
3S1W01B00	1B9	nested	DSRSD Shallow	2/15/1996	Dublin	L	333.56	162	2	122 - 152
3S1W01B01	1B10	nested	DSRSD Middle	2/15/1996	Dublin	L	333.57	414	2	274 - 404
3S1W01B01	1B11	nested	DSRSD Deep	2/15/1996	Dublin	L	333.74	560	2	480 - 550
3S1W01J001	1J1	monitor	DSRSD MW-1	12/4/1984	Dublin	U	334.36	70		47 - 64
3S1W02A00	2A2	monitor	McNamara's	10/7/1976	Dublin	U	369.4	47	2.5	37 - 42
3S1W12B00	12B2	monitor	Stoneridge Mall Rd	6/21/1996	Dublin	U	342.89	39.5	4	20 - 50
3S1W12J001	12J1	monitor	DSRSD South	12/9/1975	Dublin	U	329.31	62	2.5	52 - 57
3S1W13J001	13J1	monitor	muirwood dr	10/7/1976	Castle	U	343.94	48	2.5	39 - 44
3S2E01F002	1F2	monitor	Brisa at Circuit City	12/22/1977	Spring	U	572.99	68.6	2.5	59 - 64
3S2E02B002	2B2	monitor	south front rd	6/7/1976	Spring	U	539.45	46	2.5	36.9 - 41.9
3S2E03A001	3A1	monitor	Bluebell	12/21/1977	Spring	U	517.63	54	2.5	44 - 49
3S2E03K003	3K3	monitor	first & S. front rd	12/12/1977	Mocho I	U	522.83	60	2.5	50 - 55
3S2E05N001	5N1	supply	Spider Well	10/5/1977	Mocho II	M	444	210	10	0 - 210
3S2E07C002	7C2	monitor	jaws - york way - G4	4/6/1978	Mocho II	U	420.84	49	2.5	39 - 44
3S2E07H002	7H2	monitor	dakota	7/29/1989	Mocho II	U	442.85	54	2	44 - 54
3S2E07N002	7N2	monitor	Isabel & Arroyo Mocho	12/20/2012	Amador	U	422	162	2	132 - 152
3S2E07P003	CWS24	muni	CWS 24	4/4/1972	Amador	L	431.46	510	16	300 - 490
3S2E07R003	CWS31	muni	CWS 31	9/20/2002	Upland	L	446	583	16	410 - 528
3S2E08F001	CWS10	muni	CWS 10	5/15/1954	Mocho II	L	456.24	470	16	143 - 433
3S2E08H002	8H2	monitor	North k	6/14/1976	Mocho II	U	469.61	46	2.5	36 - 41
3S2E08H003	8H3	nested	Key_Mo2_L	7/10/2009	Mocho II	L	477.25	195	2	170 - 190
3S2E08H004	8H4	nested	N Liv Ave Deep	7/10/2009	Mocho II	L	476.97	385	2	360 - 380
3S2E08K002	8K2	monitor	Key_Mo2_U (Livermore Key)	12/13/1977	Mocho II	U	464.78	74	2.5	64 - 69
3S2E08N002	CWS14	muni	CWS 14	1/16/1958	Mocho II	L	453.64	526	10	140 - 515
3S2E08Q009	8Q 9	monitor	D-2	6/15/1999	Mocho II	L	464.7	114	2	99 - 114
3S2E09Q001	CWS9	muni	CWS 9	2/18/1952	Mocho II	L	518.15	572	14	180 - 492
3S2E09Q004	9Q4	monitor	school st	11/1/1977	Mocho II	U	505.425	80	2.5	70 - 75
3S2E10F003	10F3	monitor	hexcel	12/12/1977	Mocho I	U	534.84	45	2.5	35 - 40
3S2E10Q001	10Q1	monitor	almond	11/1/1976	Mocho II	U	555.36	43.5	2.5	33.5 - 39
3S2E10Q002	10Q2	monitor	LLNL W-703	12/3/1990	Mocho II	L	549.569	325	4.5	298 - 325
3S2E11C001	11C1	monitor	joan way	11/1/1976	Mocho I	U	556.347	66.2	2.5	56.2 - 61.2
3S2E12C004	12C4	monitor	LLNL W-486	3/11/1988	Spring	U	591.46	108	4.5	100 - 108
3S2E12J003	12J3	monitor	LLNL W-017A	5/20/1981	Spring	L	631.05	160	5	127 - 157
3S2E14A003	14A3	monitor	S. vasco @east ave	12/13/1977	Mocho I	U	602.24	110	2.5	100 - 105
3S2E14B001	14B1	domestic	5763 east ave	5/26/1983	Mocho I	L	593.36	300	9	146 - 234
3S2E15E002	15E2	irrigation	Retzlaff Winery	11/14/1983	Mocho II	L	549.69	192	8	104 - 189
3S2E15L001	15L1	monitor	Concannon 2	10/10/2013	Mocho II	U	561.5	40.5	2	20 - 40.5
3S2E15M002	15M2	monitor	Concannon 1	10/10/2013	Mocho II	U	549.46	45	2	25 - 45
3S2E15R017	15R17	nested	Buena Vista Shallow	12/14/2006	Mocho II	U	592.41	63	2	38 - 58
3S2E15R018	15R18	monitor	Buena Vista Deep	12/15/2007	Mocho II	L	592.47	138	2	113 - 133
3S2E16A003	16A3	irrigation	Memory Gardens	5/1/1972	Mocho II	L	527.06	240	10	91 - 240
3S2E16C001	CWS15	muni	CWS 15	2/18/1958	Mocho II	L	510.97	584	16	150 - 523
3S2E16E004	16E4	monitor	pepper tree	12/15/1977	Mocho II	U	506.26	45	2.5	35 - 40

RP = Reference Point Elevation (in feet above MSL)
TD = Total Depth of well (in feet below ground surface)
Dia = Diameter of well casing (in inches)
Perf = Preferated interval (in feet below ground surface), uppermost - lowermost

Site	Map	Type	Other Name	Completed	Basin	Aquifer	RP	TD	Dia	Perf
3S2E18B001	CWS20	muni	CWS 20	1/30/1961	Amador	L	438.56	497	16	190 - 465
3S2E18E001	18E1	monitor	Stanley East of Isabel	4/22/1977	Amador	U	423.86	133.8	2.5	123.8 - 128.8
3S2E19D007	19D7	nested	Isabel Shallow	1/29/1999	Amador	U	415.07	180	2	100 - 180
3S2E19D008	19D8	nested	Isabel Middle 1	1/29/1999	Amador	L	415.04	260	2	210 - 260
3S2E19D009	19D9	nested	Isabel Middle 2	1/29/1999	Amador	L	414.98	390	2	280 - 390
3S2E19D010	19D10	nested	Isabel Deep	1/29/1999	Amador	L	414.89	470	2	420 - 470
3S2E19K001	19K1	supply	Cavicchi		Amador	L	0	160	2	0 - 0
3S2E19N003	19N3	nested	Shallow Cemex Nested	7/27/2018	Amador	U	418.45	120	2	105 - 115
3S2E19N004	19N4	nested	Deep Cemex Nested	7/27/2018	Amador	L	417.96	203	2	188 - 198
3S2E20M001	20M1	supply	Alden Lane	9/15/1928	Amador	L	478.79	184	12	0 - 184
3S2E20R002	20R2	irrigation	Ravenswood South Well	5/1/1985	Upland	U	522	257	9	107 - 252
3S2E21K008	21K8	supply	Roberts on Marina.		Upland		0	220	6	0 - 0
3S2E21K009	21K9	domestic	Hughey Marina Ave		Upland	U	0	0	6	0 - 0
3S2E22B001	22B1	monitor	grapes	7/8/1976	Mocho II	U	585.88	31.9	2.5	21.9 - 26.9
3S2E23E001	23E1	nested	Mines Nested Shallow	9/2/2004	Mocho II	U	613.36	40	2	20 - 35
3S2E23E002	23E2	nested	Mines Nested Deep	9/2/2004	Mocho II	L	613.23	110	2	95 - 105
3S2E24A001	24A1	monitor	S. greenville	11/1/1976	Mocho I	U	717.7	46.3	2.5	36.3 - 41.3
3S2E26J002	26J2	monitor	mines rd	12/27/1977	Mocho II	U	689.92	44	2.5	34 - 39
3S2E29F004	29F4 (W	monitor	Wetmore	10/28/1976	Amador	U	457.5	36	2.5	26 - 31
3S2E29L001	29L1 (P	monitor	Sycamore Grove P3	11/29/2001	Amador	U	457.96	23	2	8 - 23
3S2E30C001	30C1	supply	Vineyard 30C 1	3/16/1995	Amador	L	439.41	150	6	125 - 145
3S2E30D002	30D2	monitor	vineyard	6/18/1979	Amador	U	431.6	44	4	24 - 39
3S2E32E007	32E7	monitor	DVWTP 32E7	7/16/1991	Upland	U	610.94	37	6	19 - 34
3S2E33C001	33C1 (P	monitor	Sycamore Grove P1	11/29/2001	Amador	U	493.23	20	2	5 - 20
3S2E33G001	33G1 (C	monitor	Crohare	12/12/1975	Amador	U	511.52	17	2.5	9 - 14
3S2E33K001	33K1	monitor	VA		Amador	U	546.83	15	2.5	7 - 12
3S2E33L001	33L1	monitor	VA/CROHARE FENCE		Amador	U	557.63	16	2.5	11 - 16
3S3E06Q003	6Q3	monitor	PPWTP South Monitoring	8/29/2016	Altamont	U	681.07	30	2	20 - 30
3S3E07D002	7D2	monitor	7D 2	11/1/1976	Spring	U	621.94	72	2.5	64 - 69
3S3E18Q001	18Q1	domestic	Nagy on Tesla		Mocho I		0	0	0	0 - 0
3S3E19C002	19C2	domestic	Wilker well 2		Mocho I	U	740.7	66	8	0 - 66
3S3E20L004	20L 4	domestic	Vail on Tesla	8/15/2005	Mocho I	U	0	340	5	0 - 0
3S3E20R004	20R 4	domestic	Buonanno on Tesla		Mocho I	U	0	0	6	0 - 0
3S3E21C001	21C1	domestic	Russell on Reuss	1/1/1977	Upland	U	0	128	12	60 - 124
4S2E01A001	1A1	irrigation	Gallagher Ag	2/6/2015	Mocho II	U		130	6	45 - 130
4S3E06E004	6E4	domestic	Gallagher Domestic	5/28/1976	Mocho II	U		220	10	184 - 212

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TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
2S1E32E001	32E1	End of Arnold Rd	None	U	monitor	active	Zone 7	1					
2S1E32N001	32N1	Camp Parks	Camp	U	monitor	active	Zone 7	1					
2S1E32Q001	32Q1	Summer Glen Dr	Camp	U	monitor	active	Zone 7	1					
2S1E33L001	33L1	Gleason Dr @ Tassajara	None	U	monitor	active	Zone 7	1					
2S1E33P002	33P2	Central Pkwy at Emerald Glen Pk	Camp	U	monitor	active	Zone 7	1					
2S1E33R001	33R1	Central Pkwy @ Grafton	None	U	monitor	active	Zone 7	1					
2S1W15F001	15F1	BOLLINGER	Bishop	U	monitor	active	Zone 7	1					
2S1W26C002	26C2	PINE VALLEY	Dublin	U	monitor	active	Zone 7	1					
2S1W36E003	36E3	Kolb Park	Dublin	U	monitor	active	Zone 7	1					
2S1W36F001	36F1	Dublin High shallow	Dublin	L	nested	active	Zone 7	1					
2S1W36F002	36F2	Dublin High mid	Dublin	L	nested	active	Zone 7	1					
2S2E21L001	21L1	Merlin	May	U	domestic	active	Zone 7	1					
2S2E27K001	27K1	Livermore #196	Spring	U	livestock	inactive	Zone 7	1					
2S2E27M002	27M2	Kwan	May	U	domestic	active	Zone 7	1					
2S2E27P002	27P2	hartford ave east	Spring	U	monitor	active	Zone 7	1					
2S2E28D002	28D2	May School	May	U	monitor	active	Zone 7	1					
2S2E28J002	28J2	FCC Well	May	L	industrial	active	Zone 7	1					
2S2E28Q001	28Q1	hartford ave	May	U	monitor	active	Zone 7	1					
2S2E32K002	32K2	jenson's N liv. Ave	Cayetano	U	monitor	active	Zone 7	1					
2S2E34E001	34E1	Mud City	May	U	monitor	active	Zone 7	1	X				
2S2E34Q002	34Q2	Hollyhock & Crocus	Spring	U	monitor	active	Zone 7	1					
3S1E01F002	1F2	Constitution Dr	Camp	U	monitor	active	Zone 7	1					
3S1E01H003	1H3	Collier Canyon g1	Camp	U	monitor	active	Zone 7	4					
3S1E01J004	1J04	Collier Vineyards	Camp	L	irrigation	active	Zone 7	1					
3S1E01L001	1L1	Kitty Hawk	Camp	U	monitor	active	Zone 7	1					
3S1E01P002	1P2	Airport gas g5	Amador	U	monitor	active	Zone 7	1					
3S1E01P003	1P3	New airport well	Amador	L	supply	inactive	Zone 7	4					
3S1E02J002	2J2	Maint. Bldg	Camp	U	monitor	active	Zone 7	1					
3S1E02J003	2J3	Doolan Rd East	Camp	U	monitor	active	Zone 7	1					
3S1E02K002	2K2	Doolan Rd West	Camp	U	monitor	active	Zone 7	1					
3S1E02M003	2M3	Friesman Rd North	Camp	U	monitor	active	Zone 7	1					
3S1E02N006	2N6	Friesman Rd South	Amador	U	monitor	active	Zone 7	1					
3S1E02P003	2P3	Crosswinds Church	Camp	L	domestic	active	Zone 7	1					
3S1E02Q001	2Q1	LPGC #1	Amador	U	monitor	active	Zone 7	1					
3S1E02R001	2R1	Beebs	Amador	U	monitor	active	Zone 7	4					
3S1E03G002	3G2	fallon rd	Camp	U	monitor	active	Zone 7	1					
3S1E04A001	4A1	SMP-DUB-2	Camp	U	monitor	active	Zone 7	1					

TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S1E04J005	4J5	Pimlico shallow	Camp	U	monitor	active	Zone 7	1					
3S1E04J006	4J6	Pimlico deep	Camp	U	monitor	active	Zone 7	1					
3S1E04Q002	4Q2	gulfstream	Amador	U	monitor	active	Zone 7	1					
3S1E05K006	5K6	Rosewood shallow	Camp	U	monitor	active	Zone 7	1					
3S1E05K007	5K7	Rosewood deep	Camp	L	monitor	active	Zone 7	1					
3S1E05L003	5L3	Oracle	Camp	U	monitor	active	Zone 7	1					
3S1E05P006	5P6	Owens Park	Camp	U	monitor	active	Zone 7	1					
3S1E06F003	6F3	Dublin Ct	Dublin	U	monitor	active	Zone 7	1	X				
3S1E06N002	6N2	DSRSD MW-3	Dublin	U	monitor	active	Zone 7	1					
3S1E06N003	6N3	DSRSD MW-4	Dublin	U	monitor	active	Other	1					
3S1E06N006	6N6	DSRSD NE-76	Dublin	U	monitor	active	Other	1					
3S1E07B002	7B2	Hopyard rd	Dublin	L	monitor	active	Zone 7	1					
3S1E07B012	7B12	Hacienda Arch	Dublin	U	monitor	active	Zone 7	1					
3S1E07D001	7D1	DSRSD SW-75	Dublin	U	monitor	unknown	Other	1					
3S1E07D003	7D3	DSRSD SE-70	Dublin	U	monitor	unknown	Other	1					
3S1E07G007	7G7	Chabot Well	Dublin	U	monitor	active	Zone 7	1					
3S1E07J005	7J5	Thomas Hart School	Dublin	U	monitor	active	Zone 7	1					
3S1E08B001	8B1	Lizard Well	Amador	U	monitor	active	Zone 7	1					
3S1E08G004	8G4	Apache	Amador	U	monitor	active	Zone 7	1					
3S1E08H009	8H9	Mocho 4 Nested Shallow	Amador	L	nested	active	Zone 7	1					
3S1E08H010	8H10	Mocho 4 Nested Middle	Amador	L	nested	active	Zone 7	1					
3S1E08H011	8H11	Mocho 4 Nested deep	Amador	D	nested	active	Zone 7	1					
3S1E08H013	8H13	Mocho 3 mon	Amador	D	monitor	active	Zone 7	1					
3S1E08H018	M4	Mocho 4	Amador	L	muni	active	Zone 7	4				X	
3S1E08K001	8K1	Cockroach well	Amador	U	monitor	active	Zone 7	1					
3S1E08N001	8N1	sports park	Bernal	U	monitor	active	Zone 7	1					
3S1E09B001	St1	Stoneridge	Amador	L	muni	active	Zone 7	4				X	
3S1E09H013	9H13	Lister	Amador	U	domestic	active	Zone 7	1					
3S1E09J007	9J7	SW Lake I Shallow	Amador	U	nested	active	Zone 7	1					
3S1E09J008	9J8	SW Lake I Middle	Amador	L	nested	active	Zone 7	1					
3S1E09J009	9J9	SW Lake I Deep	Amador	L	nested	active	Zone 7	1					
3S1E09M002	M1	Mocho 1	Amador	L	muni	active	Zone 7	4				X	
3S1E09M003	M2	Mocho 2	Amador	L	muni	active	Zone 7	4				X	
3S1E09M004	M3	Mocho 3	Amador	L	muni	active	Zone 7	4				X	
3S1E09P005	9P5	Key_AmW_U (Mohr Key)	Amador	U	monitor	active	Zone 7	1	X	X			
3S1E09P009	9P9	Mohr Ave Shallow	Amador	L	nested	active	Zone 7	1					
3S1E09P010	9P10	Key_AmW_L	Amador	L	nested	active	Zone 7	1	X	X			

TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S1E09P011	9P11	Mohr Ave Deep	Amador	L	nested	active	Zone 7	1					
3S1E10A002	10A2	El Charro Rd	Amador	U	monitor	active	Zone 7	1					
3S1E10B008	10B8	Kaiser Rd Shallow	Amador	L	nested	active	Zone 7	1					
3S1E10B009	10B9	Kaiser Rd Middle 1	Amador	L	nested	active	Zone 7	1					
3S1E10B010	10B10	Kaiser Rd Middle 2	Amador	L	nested	unknown	Zone 7	1					
3S1E10B011	10B11	Kaiser Rd Deep	Amador	D	nested	active	Zone 7	1					
3S1E10B014	10B14	COL 5 Monitoring	Amador	L	monitor	unknown	Zone 7	1					
3S1E10B016	COL5	COL 5	Amador	L	muni	active	Zone 7	4					
3S1E10D002	10D2	Stoneridge Shallow	Amador	L	nested	active	Zone 7	1					
3S1E10D003	10D3	Stoneridge Middle 1	Amador	L	nested	active	Zone 7	1					
3S1E10D004	10D4	Stoneridge Middle 2	Amador	L	nested	active	Zone 7	1					
3S1E10D005	10D5	Stoneridge Deep	Amador	D	nested	active	Zone 7	1					
3S1E10K002	10K2	COL 1 Monitoring	Amador	L	monitor	active	Zone 7	1					
3S1E10K003	COL1	COL 1	Amador	L	muni	active	Zone 7	4				X	
3S1E11B001	11B1	Airport West	Amador	U	monitor	active	Zone 7	4					
3S1E11C003	11C3	LAVWMA ROW	Amador	U	monitor	active	Zone 7	1					
3S1E11G001	11G1	Key_AmE_U	Amador	U	nested	active	Zone 7	1	X	X			
3S1E11G002	11G2	Rancho Charro Middle 1	Amador	L	nested	active	Zone 7	1					
3S1E11G003	11G3	Rancho Charro Middle 2	Amador	L	nested	active	Zone 7	1					
3S1E11G004	11G4	Rancho Charro Deep	Amador	D	nested	active	Zone 7	1					
3S1E11M002	11M2	COL 2 Monitoring	Amador	L	monitor	active	Zone 7	1					
3S1E11M003	COL2	COL 2	Amador	L	muni	active	Zone 7	4				X	
3S1E11P006	11P6	New Jamieson Residence	Amador	L	domestic	unknown	Zone 7	1					
3S1E12A002	12A2	Airport South	Amador	U	monitor	active	Zone 7	4					
3S1E12D002	12D2	LWRP G6	Amador	U	monitor	active	LWRP	4					
3S1E12G001	12G1	Oaks Park Shallow	Amador	U	monitor	active	Zone 7	4					
3S1E12H004	12H4	LWRP Shallow	Amador	L	nested	active	Zone 7	1					
3S1E12H005	12H5	LWRP Middle 1	Amador	L	nested	active	Zone 7	1					
3S1E12H006	12H6	LWRP Middle 2	Amador	L	nested	active	Zone 7	1					
3S1E12H007	12H7	LWRP Deep	Amador	D	nested	active	Zone 7	1					
3S1E12K002	12K2	Oaks Park Mid	Amador	L	nested	active	Zone 7	1					
3S1E12K003	12K3	Key_AmE_L	Amador	L	nested	active	Zone 7	1	X	X			
3S1E12K004	12K4	Oaks Park Deep	Amador	D	nested	active	Zone 7	1					
3S1E13P005	13P5	LGA Grant Nested 1	Amador	U	nested	active	Zone 7	1					
3S1E13P006	13P6	LGA Grant Nested 2	Amador	L	nested	active	Zone 7	1					
3S1E13P007	13P7	LGA Grant Nested 3	Amador	L	nested	active	Zone 7	1					
3S1E13P008	13P8	LGA Grant Nested 4	Amador	L	nested	active	Zone 7	1					

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S1E14B001	14B1	Industrial Asphalt	Amador	L	industrial	unknown	Zone 7	1					
3S1E14D002	14D2	South Cope Lake	Amador	L	monitor	active	Zone 7	1					
3S1E15J003	15J3	shadow cliff	Amador	L	supply	unknown	Zone 7	1					
3S1E15M003	15M3	Bush/Valley South	Amador	L	monitor	active	Zone 7	1					
3S1E16A002	P8	Pleas 8	Amador	L	muni	active	Pleas	1					
3S1E16A004	16A4	Bush/Valley Mid	Amador	L	monitor	active	Zone 7	1					
3S1E16B001	16B1	Bush/Valley North	Amador	D	monitor	active	Zone 7	1					
3S1E16C002	16C2	Santa Rita Valley Shallow	Amador	L	nested	active	Zone 7	1					
3S1E16C003	16C3	Santa Rita Valley Middle	Amador	L	nested	active	Zone 7	1					
3S1E16C004	16C4	Santa Rita Valley Deep	Amador	L	nested	active	Zone 7	1					
3S1E16E004	16E4	black ave - cultural	Amador	U	monitor	active	Zone 7	1					
3S1E16L005	P5	Pleas 5	Amador	L	muni	active	Pleas	1					
3S1E16L007	P6	Pleas 6	Amador	L	muni	active	Pleas	1					
3S1E16P005	16P5	Vervais Monitor	Amador	U	monitor	active	Zone 7	2			X		
3S1E17B004	17B4	Casterson	Amador	L	supply	unknown	Zone 7	1					
3S1E17D003	17D3	Hopyard Nested Shallow	Bernal	L	nested	active	Zone 7	1					
3S1E17D004	17D4	Hopyard Nested Middle 1	Bernal	L	nested	active	Zone 7	1					
3S1E17D005	17D5	Hopyard Nested Middle 2	Bernal	L	nested	active	Zone 7	1					
3S1E17D006	17D6	Hopyard Nested Middle 3	Bernal	L	nested	active	Zone 7	1					
3S1E17D007	17D7	Hopyard Nested Deep	Bernal	D	nested	active	Zone 7	1					
3S1E17D011	17D11	Hopyard 9 Monitoring Well	Bernal	L	monitor	active	Zone 7	1					
3S1E17D012	H9	Hopyard 9	Bernal	L	muni	active	Zone 7	4				X	
3S1E18A006	H6	Hopyard 6	Bernal	L	muni	active	Zone 7	4				X	
3S1E18E004	18E4	Valley Trails II	Bernal	U	monitor	active	Zone 7	1					
3S1E18J002	18J2	camino segura	Bernal	U	monitor	active	Zone 7	1					
3S1E19A010	SF-B	SFWD South (B)	Bernal	L	muni	active	Zone 7	1					
3S1E19A011	SF-A	SFWD North (A)	Bernal	L	muni	active	Zone 7	1					
3S1E19C004	19C4	del valle & laguna	Bernal	U	monitor	active	Zone 7	1					
3S1E19K001	19K1	680/bernal	Bernal	U	monitor	active	Zone 7	1					
3S1E20B002	20B2	Fairgrounds Potable	Bernal	L	supply	active	Zone 7	1					
3S1E20C003	20C3	Fairgrounds Potable Backup	Bernal	L	supply	active	Zone 7	1					
3S1E20C007	20C7	Key_Bern_U	Bernal	U	monitor	active	Zone 7	2	X	X	X		
3S1E20C008	20C8	Key_Bern_L	Bernal	L	nested	active	Zone 7	1	X	X			
3S1E20C009	20C9	Fair Nested Deep	Bernal	L	nested	active	Zone 7	1					
3S1E20J004	20J4	civic center	Bernal	U	monitor	active	Zone 7	1					
3S1E20M011	20M11	S.F "M"LINE	Bernal	U	monitor	active	Zone 7	1					
3S1E20Q002	20Q2	20Q2	Bernal	U	monitor	active	Zone 7	1					

TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S1E22D002	22D2	vineyard trailer	Amador	U	monitor	active	Zone 7	1					
3S1E23J001	23J1	1627 vineyard trailer	Amador	L	domestic	unknown	Zone 7	1					
3S1E25C003	25C3	Katz Winery Mansion	Amador	U	monitor	unknown	Zone 7	1					
3S1E28M002	28M2	Bargar	Upland	U	supply	active	Zone 7	1					
3S1E29M004	29M4	f.c. channel	Castle	U	monitor	active	Zone 7	1					
3S1E29P002	29P2	castlewood dr	Bernal	U	monitor	active	Zone 7	1					
3S1E33G005	33G5	Pleasanton Calippe 33G5	Upland	U	monitor	unknown	Zone 7	1					
3S1W01B009	1B9	DSRSD Shallow	Dublin	L	nested	unknown	Zone 7	1					
3S1W01B010	1B10	DSRSD Middle	Dublin	L	nested	unknown	Zone 7	1					
3S1W01B011	1B11	DSRSD Deep	Dublin	L	nested	unknown	Zone 7	1					
3S1W01J001	1J1	DSRSD MW-1	Dublin	U	monitor	unknown	Other	1					
3S1W02A002	2A2	McNamara's	Dublin	U	monitor	active	Zone 7	1					
3S1W12B002	12B2	Stoneridge Mall Rd	Dublin	U	monitor	active	Zone 7	1					
3S1W12J001	12J1	DSRSD South	Dublin	U	monitor	active	Zone 7	1					
3S1W13J001	13J1	muirwood dr	Castle	U	monitor	active	Zone 7	1					
3S2E01F002	1F2	Brisa at Circuit City	Spring	U	monitor	active	Zone 7	1					
3S2E02B002	2B2	south front rd	Spring	U	monitor	active	Zone 7	1					
3S2E03A001	3A1	Bluebell	Spring	U	monitor	active	Zone 7	1					
3S2E03K003	3K3	first & S. front rd	Mocho I	U	monitor	active	Zone 7	1					
3S2E05N001	5N1	Spider Well	Mocho II	M	supply	inactive	Zone 7	1					
3S2E07C002	7C2	jaws - york way - G4	Mocho II	U	monitor	active	Zone 7	4					
3S2E07H002	7H2	dakota	Mocho II	U	monitor	active	Zone 7	1					
3S2E07N002	7N2	Isabel & Arroyo Mocho	Amador	U	monitor	active	Zone 7	1					
3S2E07P003	CWS24	CWS 24	Amador	L	muni	active	Zone 7	1					
3S2E07R003	CWS31	CWS 31	Upland	L	muni	active	Zone 7	1					
3S2E08F001	CWS10	CWS 10	Mocho II	L	muni	active	CWS	1					
3S2E08H002	8H2	North k	Mocho II	U	monitor	active	Zone 7	1					
3S2E08H003	8H3	Key_Mo2_L	Mocho II	L	nested	active	Zone 7	1	X	X			
3S2E08H004	8H4	N Liv Ave Deep	Mocho II	L	nested	active	Zone 7	1					
3S2E08K002	8K2	Key_Mo2_U (Livermore Key)	Mocho II	U	monitor	active	Zone 7	1	X	X			
3S2E08N002	CWS14	CWS 14	Mocho II	L	muni	active	Zone 7	1					
3S2E08Q009	8Q 9	D-2	Mocho II	L	monitor	active	Zone 7	1					
3S2E09Q001	CWS9	CWS 9	Mocho II	L	muni	active	CWS	1					
3S2E09Q004	9Q4	school st	Mocho II	U	monitor	active	Zone 7	1					
3S2E10F003	10F3	hexcel	Mocho I	U	monitor	active	Zone 7	1					
3S2E10Q001	10Q1	almond	Mocho II	U	monitor	active	Zone 7	1					
3S2E10Q002	10Q2	LLNL W-703	Mocho II	L	monitor	unknown	LLNL	1					

TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S2E11C001	11C1	joan way	Mocho I	U	monitor	active	Zone 7	1					
3S2E12C004	12C4	LLNL W-486	Spring	U	monitor	unknown	LLNL	1					
3S2E12J003	12J3	LLNL W-017A	Spring	L	monitor	unknown	LLNL	1					
3S2E14A003	14A3	S. vasco @east ave	Mocho I	U	monitor	active	LLNL	1					
3S2E14B001	14B1	5763 east ave	Mocho I	L	domestic	unknown	Zone 7	1					
3S2E15E002	15E2	Retzlaff Winery	Mocho II	L	irrigation	active	Zone 7	1					
3S2E15L001	15L1	Concannon 2	Mocho II	U	monitor	active	Other	1					
3S2E15L002	15L2	Concannon 6D	Mocho II	U	monitor	active	Other	1					
3S2E15M002	15M2	Concannon 1	Mocho II	U	monitor	active	Other	1					
3S2E15M003	15M3	Concannon 5D	Mocho II	U	monitor	active	Other	1					
3S2E15Q008	15Q 8	Concannon 4	Mocho II	U	monitor	active	Other	1					
3S2E15R017	15R17	Buena Vista Shallow	Mocho II	U	nested	active	Zone 7	1					
3S2E15R018	15R18	Buena Vista Deep	Mocho II	L	monitor	active	Zone 7	1					
3S2E15R020	15R20	Concannon 3	Mocho II	U	monitor	active	Other	1					
3S2E16A003	16A3	Memory Gardens	Mocho II	L	irrigation	active	Zone 7	1					
3S2E16C001	CWS15	CWS 15	Mocho II	L	muni	active	Zone 7	1					
3S2E16E004	16E4	pepper tree	Mocho II	U	monitor	active	Zone 7	1					
3S2E18B001	CWS20	CWS 20	Amador	L	muni	active	Zone 7	1					
3S2E18E001	18E1	Stanley East of Isabel	Amador	U	monitor	active	Zone 7	1					
3S2E19D007	19D7	Isabel Shallow	Amador	U	nested	active	Zone 7	1					
3S2E19D008	19D8	Isabel Middle 1	Amador	L	nested	active	Zone 7	1					
3S2E19D009	19D9	Isabel Middle 2	Amador	L	nested	active	Zone 7	1					
3S2E19D010	19D10	Isabel Deep	Amador	L	nested	active	Zone 7	1					
3S2E19K001	19K1	Cavicchi	Amador	L	supply	active	Zone 7	1					
3S2E19N003	19N3	Shallow Cemex Nested	Amador	U	nested	active	Zone 7	1					
3S2E19N004	19N4	Deep Cemex Nested	Amador	L	nested	active	Zone 7	1					
3S2E20M001	20M1	Alden Lane	Amador	L	supply	unknown	Zone 7	1					
3S2E20R002	20R2	Ravenswood South Well	Upland	U	irrigation	active	Zone 7	1					
3S2E21K009	21K9	Hughey Marina Ave	Upland	U	domestic	active	Zone 7	1	X				
3S2E22B001	22B1	grapes	Mocho II	U	monitor	active	Zone 7	1					
3S2E23E001	23E1	Murrieta Nested Shallow	Mocho II	U	nested	active	Zone 7	1					
3S2E23E002	23E2	Murrieta Nested Deep	Mocho II	L	nested	active	Zone 7	1					
3S2E24A001	24A1	S. greenville	Mocho I	U	monitor	active	Zone 7	1	X				
3S2E26J002	26J2	mines rd	Mocho II	U	monitor	active	Zone 7	1					
3S2E29F004	29F4	Wetmore	Amador	U	monitor	active	Zone 7	2			X		
3S2E30C001	30C1	Vineyard 30C 1	Amador	L	supply	active	Zone 7	1					
3S2E30D002	30D2	vineyard	Amador	U	monitor	active	Zone 7	1					

TABLE 14-3
MONITORING WELLS IN 2021 GROUNDWATER QUALITY PROGRAM
LIVERMORE VALLEY GROUNDWATER BASIN

Well	Map	Alias	Basin	Aquifer	Type	Status	Sampled By	Frequency (per year)	RMS	Key	WR	Muni	Other
3S2E32E007	32E7	DVWTP 32E7	Upland	U	monitor	active	Zone 7	1					
3S2E33C001	33C1 (P1)	Sycamore Grove P1	Amador	U	monitor	inactive	Zone 7	1					
3S2E33G001	33G1	Crohare	Amador	U	monitor	active	Zone 7	2			X		
3S3E06Q003	6Q3	PPWTP South Monitoring	Altamont	U	monitor	active	Zone 7	1					
3S3E07D002	7D2	7D 2	Spring	U	monitor	active	LLNL	1					
3S3E19C002	19C2	Wilker well 2	Mocho I	U	domestic	active	Zone 7	1					
3S3E20L004	20L 4	Vail on Tesla	Mocho I	U	domestic	active	Zone 7	1					
3S3E20R004	20R 4	Buonanno on Tesla	Mocho I	U	domestic	active	Zone 7	1					
3S3E21C001	21C1	Russell on Reuss	Upland	U	domestic	active	Zone 7	1					
4S2E01A001	1A1	Gallagher Ag	Mocho II	U	irrigation	active	Zone 7	1					
4S3E06E004	6E4	Gallagher Domestic	Mocho II	U	domestic	active	Zone 7	1					
WELLS IN GROUNDWATER QUALITY PROGRAM = 233													

RMS = Representative Monitoring Sites
WR = Water Rights
Muni = Municipal

TABLE 14-4
TABLE OF ICSW MONITORING NETWORK AND NEARBY GDEs
LIVERMORE VALLEY GROUNDWATER BASIN

RMS Well	Well Type	Nearby GDE	Nearby ICSW	Nearby Stream Station (<=1km)	Monitoring Method	Monitoring Frequency	RP Elev (ft msl)	Top Perf (ft bgs)	Bot Perf (ft bgs)	Well Depth (ft bgs)
2S2E27P002	Program Well	Springtown Alkali Sink	Altamont Creek	ALTC_BD	Collect Manually	SemiAnnual	505.43	35	63	68
2S2E34E001	Program Well	Springtown Alkali Sink	Altamont Creek	ALTC_BD	Collect Manually	SemiAnnual	499.73	40	45	49
3S1E05K006	Program Well	TC-Riparian Mixed Hardwood	Tassajara Creek	TC_BI580	Collect Manually	SemiAnnual	346.05	40	70	75
3S2E30D002	Program Well	AV-Riparian Mixed Hardwood	Arroyo Valle	--	Logger (existing)	15 Minutes	431.6	24	39	44
3S1E16P005	Program Well	AV-Riparian Mixed Hardwood	Arroyo Valle	ADVP	Logger (existing)	15 Minutes	354.51	64	69	75
3S2E33G001	Program Well	AV-Sycamore Grove	Arroyo Valle	AVNL, SBA_TO1_AV, SBA_TO2_AV	Collect Manually	Monthly	511.52	9	14	17
3S2E29F004	Program Well	AV-Sycamore Grove	Arroyo Valle	--	Collect Manually	Monthly	457.5	26	31	36
3S2E33C001	New Program Well (Monitoring)	AV-Sycamore Grove	Arroyo Valle	--	Collect Manually	SemiAnnual	493.23	5	20	20
3S1E02R001	Program Well	ALP-Mixed Vegetation	Arroyo Las Positas	--	Collect Manually	SemiAnnual	376.29	21	26	33
3S1E02N006	Program Well	ALP-Mixed Vegetation	Arroyo Las Positas	ALP_ELCH	Collect Manually	SemiAnnual	366.14	40	55	55
3S2E16E004	Program Well	AM-Riparian Mixed Hardwood & Sycamore	Arroyo Mocho	--	Collect Manually	SemiAnnual	506.26	35	40	45
3S2E23E001	Program Well	AM-Valley Oak	Arroyo Mocho	--	Logger (to be added)	15 Minutes	613.36	20	35	40
4S2E01A001	New Program Well (Ag)	AM-Valley Oak	Arroyo Mocho	AMNL	Collect Manually	SemiAnnual	819.76	45	130	150
3S2E32E007	Program Well	Upland-Riparian Mixed Hardwood	Vineyard Creek	--	Collect Manually	SemiAnnual	610.94	19	34	37

ICSW = Interconnected Surface Water
RMS = Representative Monitoring Site
GDE= Groundwater Dependent Ecosystem

Perf = Perferated Interval (in feet below ground surface), uppermost - lowermost
RP = Reference Point Elevation (in feet above MSL)

TABLE 14-4
TABLE OF ICSW MONITORING NETWORK AND NEARBY GDEs
LIVERMORE VALLEY GROUNDWATER BASIN

Station ID	*Measures*	*Nearby GDE*	*Nearby ICSW*	*Flow Frequency*	*Gauge Height*	*Flow Rate*
ALTC_BD	Streamflow	Springtown Alkali Sink	Altamont Creek	15 Min	x	x
ALP_ELCH	Streamflow	ALP-Mixed Vegetation	Arroyo Las Positas	15 Min	x	x
ADVP	Streamflow	AV-Riparian Mixed Hardwood	Arroyo Valle	15 Min	x	x
AV_DIV_SC	Diversion From AV	AV-Riparian Mixed Hardwood	Arroyo Valle	Daily	-	x
AVNL	Streamflow	AV-Sycamore Grove	Arroyo Valle	15 Min	x	x
SBA_TO1_AV	Release into AV	AV-Sycamore Grove	Arroyo Valle	15 Min	-	x
SBA_TO2_AV	Release into AV	AV-Sycamore Grove	Arroyo Valle	15 Min	-	x
SBA_AM	Release into AM	AM-Valley Oak	Arroyo Mocho	15 Min	-	x
AMNL	Streamflow	AM-Valley Oak	Arroyo Mocho	15 Min	x	x
TC_BI580	Streamflow	Tassajara Creek - Riparian Mixed Hardwood	Tassajara Creek	15 Min	x	x

ICSW = Interconnected Surface Water
RMS = Representative Monitorin¡ Perf = Perferated Interval (in feet below ground surface), uppermost - lowermost
GDE= Groundwater Dependent E RP = Reference Point Elevation (in feet above MSL)

Perf = Perferated Interval (in feet below ground surface), uppermost - lowermost
RP = Reference Point Elevation (in feet above MSL)

TABLE 14-5
TABLE OF CLIMATOLOGICAL STATIONS
2020 WATER YEAR

PRECIPITATION NETWORK								
SITE	COMPUTER SITE ID	STATION NAME	LOCATION	OBSERVER	ELEV-ATION	STATION ESTABLISHED	15 MIN RECORD	MEAN ANNUAL (IN)
15E	CM_015E**	Hafner NOAA Livermore	Wellingham Drive, Livermore	Mr. Ron Hafner	480	1871 to 2020	-	14.49
17	CM_017	Del Valle Plant	601 East Vallecitos Rd, Livermore	ZONE 7	640	1974	1978 to Present	15.97
24	CM_024	Patterson Plant	Patterson Pass Rd, Livermore	ZONE 7	680	1963	1969 to 2016	12.85
34	CM_034	Mocho Wellfield	Santa Rita Rd, Pleasanton	ZONE 7	340	1968	1970 to 2010	17.88
44	CM_044	Mt Hamilton	Lick Observatory, Mt. Hamilton	Lick Observatory	4209	1881	-	24.34
101	CM_101	Tassajara	Camino Tassajara Rd, Danville	Mrs. Joan Hansen	800	1912	-	18.46
170	CM_170	Parkside	Parkside Drive, Pleasanton	ZONE 7	330	1986	1986 to 2005	20.51
191	CM_191	CIMIS Station	Alameda County Fairgrounds Golf Course	DWR	335	2004	2004 to Present	17.03
ALTC_BD	CM_ALTC_BD	Altamont Creek	at ALTC_BD surface water station	ZONE 7	500	2015	2015 to Present	13.26
AMNL	CM_AMNL	Arroyo Mocho Near Livermore	at AMNL surface water station	ZONE 7	750	2015	2015 to Present	12.80
AMP	CM_AMP	Arroyo Mocho Pleaslanton	At AMP Surface Water Station	ZONE 7	335	2016	2016 to Present	12.97
AVBLC	CM_AVBLC	Arroyo Valle Below Lang Canyon	at AVBLC surface water station	Alameda County	757	2016	2016 to Present	-
KLVK	CM_KLVK**	Rain Gauge Lat Livermore Municipal Airport	Livermore Municipal Airport	NOAA	395	1998	-	13.48
LG1_DB	CM_LG1_DB	Line G-1 at Dublin BLVD	Dublin Blvd and Scarlett Dr, Dublin	ZONE 7	336	2019	2019 to Present	-
LJ1_BDB	CM_LJ1_BDB	Line J-1 Below Dublin BLVD	Dublin Doulevard, Dublin	ZONE 7	332	2019	2019 to Present	-
NC	CM_NC	North Canyons Office	Zone 7's North Canyons building	ZONE 7	450	2015	2015 to Present	12.23
SGE	CM_SGE	Rain Gauge at Sunol Glen Elementary School	Sunol Glen Elementary School at Main St and Bond St	ZONE 7	253	2016	2016 to Present	-
TC_BI580	CM_TC_BI580	Tassajara Creek below I-580	Old Santa Rita Rd, Pleasanton	ZONE 7	342	2018	2019 to Present	-
EVAPORATION NETWORK								
SITE	COMPUTER SITE ID	STATION NAME	LOCATION	OBSERVER	ELEV-ATION	STATION ESTABLISHED	15 MIN RECORD	MEAN ANNUAL (IN)
LDV	CM_LDV	Lake Del Valle	Lake Del Valle	DWR	760	1968	-	43.18
LWRP	CM_LWRP	Livermore Water Reclamation Plant	Lake Del Valle	LWRP	410	1974	-	46.17
191	CM_191	CIMIS Station	Alameda County Fairgrounds Golf Course	DWR	335	2004	2004 to Present	51.29

* Stations LDV and LWRP record evaporation using pan evaporation equipment. ETo is derived using : ETo= Pan Evaporation x 0.6402

** Livermore Rainfall Index comprises of CM_015E to June 2020 and CM_KLVK thereafter.

TABLE 14-6
TABLE OF SURFACE WATER MONITORING STATIONS AND MONITORING INFORMATION
2020 WATER YEAR

Station ID	Station Name	Station Type	Flow Range	Flow Freq	Gauge Height	Flow (Q)	Water Temp	Other Parameters	WQ Freq	Primary Operator
ALAMO CANAL - LINE F										
ACNP	Alamo Canal near Pleasanton	Stream Gauge	Entire	15 Min	x	x	15 Min	SSD	-	USGS
AC_WCD	Alamo Creek at Willow Creek Dr	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Zone 7
ALTAMONT CREEK - LINE R										
ALTC_BD	Altamont Creek at Bluebell Drive	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Zone 7
SBA_ALTC	SBA Turnout to Altamont Creek	Flow Meter	Low	15 Min	-	x	-	-	-	DWR
ARROYO DE LA LAGUNA - LINE B										
ADLLV	Arroyo De La Laguna at Verona	Stream Gauge	Entire	15 Min	x	x	15 Min	pH, SC	Annual	USGS
ARROYO LAS POSITAS - LINE H										
ALP_ELCH	Arroyo Las Positas above El Charro Road	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Annual	Zone 7
ALPL	Arroyo Las Positas at Livermore	Stream Gauge	Entire	15 Min	x	x	15 Min	Turb, SSD	Annual	Zone 7
LLNL_ALP	LLNL Treated Groundwater Discharge to ALP	Estimated	Low	Daily	-	x	-	-	-	LLNL
ARROYO MOCHO - LINE G										
AMHAG	Arroyo Mocho at Livermore	Stream Gauge	Entire	15 Min	x	x	15 Min	Turb, SSD	Annual	Zone 7
AM_KB	Arroyo Mocho at Kaiser Bridge	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Annual	Zone 7
AMNL	Arroyo Mocho near Livermore	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Annual	Zone 7
AMP	Arroyo Mocho near Pleasanton	Stream Gauge	Entire	15 Min	x	x	15 Min	Turb, SSD	Annual	Zone 7
MA_COPE_I	Cope Lake to Lake I	Lake Gauge	Low	Hourly	x	x	-	-	-	Zone 7
MA_VUL_COPE	Vulcan Discharge to Cope Lake	Flow Meter	Low	Daily	-	x	-	-	-	Vulcan
SBA_AM	SBA Turnout to Arroyo Mocho	Flow Meter	Low	15 Min	-	x	-	-	-	DWR
ARROYO SECO - LINE P										
AS_SFR	Arroyo Seco at Southfront Rd	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Balance
ARROYO VALLE - LINE E										
ADVP	Arroyo Valle at Pleasanton	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Quarterly*	Zone 7
AVADLL	Arroyo Valle above Arroyo De La Laguna	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
AVBLC	Arroyo Valle below Lang Canyon	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Annual	USGS
AVCAT	Arroyo Valle along Camp Arroyo Trail	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
AVDCC	Arroyo Valle at Dry Creek Confluence	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
AV_DIV_SC	Arroyo Valle Diversion to Shadow Cliffs	Flow Meter	Low	Daily	-	x	-	-	-	EBRPD
AV_ISABEL	Arroyo Valle at Isabel Ave	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
AVNL	Arroyo Valle near Livermore	Stream Gauge	Entire	15 Min	x	x	15 Min	-	Quarterly*	USGS
AVSCPK18	Arroyo Valle at Shadow Cliffs Pond K18	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
AVSGP	Arroyo Valle at Sycamore Grove Park	Water Temp	-	-	-	-	15 Min	-	-	Zone 7
LDV_FLD_GATE	Lake Del Valle Flood Gate	Calculated	High	15 Min	-	x	-	-	-	DWR
SBA_TO1_AV	SBA Turnout 1 to Arroyo Valle	Estimated	Low	15 Min	-	x	-	-	-	Zone 7
SBA_TO2_AV	SBA Turnout 2 to Arroyo Valle	Flow Meter	Low	15 Min	-	x	15 Min	-	-	DWR
CHABOT CANAL - LINE G-1										
CCNP	Chabot Canal below Stoneridge Drive nr Pleasanton	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Zone 7
LG1_DB	Line G1 at Dublin Blvd	Stream Gauge	High	15 Min	x	-	15 Min	-	-	Zone 7
SOUTH SAN RAMON CREEK - LINE J										
LJ1_BDB	Line J1 Below Dublin Blvd	Stream Gauge	High	15 Min	x	-	15 Min	-	-	Zone 7
SSRC_AVBLVD	South San Ramon Creek above Amador Valley Blvd	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Zone 7
TASSAJARA CREEK - LINE K										
TC_BI580	Tassajara Creek below I580	Stream Gauge	High	15 Min	x	x	15 Min	-	-	Zone 7

* Satisfies water rights requirements. Turb = Turbidity. SSD = Suspended Sediment Discharge. SC = Specific Conductance.

TABLE 14-7
MINING AREA EXCAVATIONS AND PONDS
2020 WATER YEAR
LIVERMORE VALLEY GROUNDWATER BASIN

EXCAVATIONS								CURRENT PONDS								
Excavation	Chain of Lake	Display Name	Original Ground Elev	Deepest Mined Depth (ft) *Elev*	*Depth*	Pit Area *(acres)*	Mining Status	Pond Name	Pond Area *(acres)*	Contact with Aquifer	Water Elev Status	Mining Use	Pond Elevation (ft MSL, NAVD88) *Fall 19*	*Spring 20*	*Fall 20*	*WY Diff*
CALROCK/RHODES & JAMIESON/PLEASANTON GRAVEL COMPANY/CALMAT/VULCAN																
MA-C001	Lake C	C1/ Lake C	410	360	50	32.2	Excavated	MA-C001	6	No	Static	Unused	361.9	NM	358.6	-3.26
MA-C002		C2	410	360	50	6.1	Excavated									
MA-C003		C3	410	360	50	11.3	Excavated									
MA-C004		C4	400	390	10	1.7	Backfilled									
MA-C005		C5	400	290	110	19.2	Backfilled									
MA-C006	Lake C	C6/ Lake C	400	385	15	12.4	Excavated									
MA-C007	Lake D	C7/ Lake D	400	330	70	22.1	Backfilled									
MA-C008A	Lake D	C8A/ Lake D	410	330	80	20.2	Backfilled									
MA-C009	Lake D	C9/ Lake D	410	310	100	20.8	Active Mining									
MA-C008B	Lake D	C8B/ Lake D	410	340	70	26.8	Backfilled									
MA-C010	Lake D	C10/ Lake D	410	310	100	62.3	Active Mining									
MA-R003		R3	370	240	130	14.8	Excavated	MA-R003	7.8	No	Lined	Settling Pond	343.6	343.94	345.6	2.06
MA-R004		R4	380	240	140	16.5	Excavated	MA-R004	11	Yes	InFlux	Water Storage	309.7	317.52	315.6	5.9
MA-R005		R5	380	240	140	31.1	Backfilled									
MA-R008	Lake G	R8/ Lake G	365	260	105	46	Excavated	MA-R008	6.7	No	Lined	Water Storage	NM	NM	NM	
MA-R010		R10	380	370	10	2.2	Backfilled									
MA-R011		R11	390	370	20	3.4	Backfilled									
MA-R012		R12	370	240	130	39.4	Backfilled									
MA-R013		R13	370	270	100	28.3	Backfilled									
MA-R014		R14	400	380	20	11.5	Backfilled									
MA-R021		R21	380	280	100	44.2	Excavated	MA-R021	28	No	Lined	Settling Pond	NM	NM	NM	
MA-R022	Lake F	R22/ Lake F	380	290	90	79.3	Excavated	MA-R022	64.4	No	Lined	Water Storage	366.3	365.02	364	-2.25
MA-R023		R23	380	270	110	27.5	Excavated	MA-R023	21.6	No	Lined	Settling Pond	359.7	360.24	360.7	0.94
MA-R024	Lake E	R24A/ Lake E	390	155	235	55.9	Excavated	MA-R024A	30.6	Yes	Depressed	Dewatering	184.4	199.39	235.3	50.87
MA-R025	Lake E	R25/ Lake E	395	300	95	43.7	Backfilled									
MA-R027		R27	380	300	80	59.5	Excavated	MA-R027	21.1	No	Lined	Unused	NM	NM	NM	
MA-R028	Lake D	R28/ Lake D	400	165	235	62.9	Active Mining	MA-R028	0.2	Yes	Depressed	Dewatering	220.9	166.11	168.4	-52.52

COL = Chain of Lake, A = Annual; SA = Semiannual,
WY Diff = Water Year Difference (Fall to Fall)

TABLE 14-7
MINING AREA EXCAVATIONS AND PONDS
2020 WATER YEAR
LIVERMORE VALLEY GROUNDWATER BASIN

EXCAVATIONS								CURRENT PONDS								
Excavation	Chain of Lake	Display Name	Original Ground Elev	Deepest Mined Depth (ft) *Elev*	*Depth*	Pit Area *(acres)*	Mining Status	Pond Name	Pond Area *(acres)*	Contact with Aquifer	Water Elev Status	Mining Use	Pond Elevation (ft MSL, NAVD88) *Fall 19*	*Spring 20*	*Fall 20*	*WY Diff*
KAISER GRAVELS/HANSON AGGREGATES																
MA-K001		K1	350	325	25	3.4	Backfilled									
MA-K002		K2	350	325	25	3.2	Backfilled									
MA-K004		K4	350	315	35	13	Backfilled									
MA-K005		K5	350	315	35	10.4	Backfilled									
MA-K006		K6	350	325	25	13.4	Backfilled									
MA-K007		K7	350	320	30	11.7	Backfilled									
MA-K008		K8	350	320	30	17.7	Backfilled									
MA-K009		K9	360	305	55	57.4	Backfilled									
MA-K010		K10	370	355	15	4.4	Backfilled									
MA-K011		K11	370	315	55	24	Backfilled									
MA-K012		K12	370	275	95	37.7	Backfilled									
MA-K013		K13	370	275	95	14.9	Backfilled									
MA-K014		K14	370	275	95	5.6	Backfilled									
MA-K015		K15	360	265	95	142.3	Excavated	MA-K015	81.8	Yes	Elevated	Water Storage	331.3	328.83	327.3	-3.99
MA-K018	Lake Boris	K18/ Lake Boris	360	330	30	24.5	Excavated	MA-K018	11.9	Yes	Lined	Unused	350.4	350.57	349	-1.41
MA-K019		K19A	350	335	15	8	Excavated	MA-K019A	2.1	Yes	Static	Unused	NM	NM	NM	
MA-K024		K24	360	220	140	87.9	Backfilled	MA-K024								
MA-K028	Lake H	K28/ Lake H	360	220	140	89.6	Reclaiming	MA-K028	67.3	Yes	Static	Water Storage	316.2	312.86	307.4	-8.86
MA-K030	Cope Lake	K30/ Cope Lake	370	240	130	233.9	Reclaimed	MA-K030	188.2	No	Lined	Settling Pond	333.4	NM	331.3	-2.06
MA-K032		K32	360	335	25	34.2	Backfilled									
MA-K033		K33	360	335	25	12.8	Backfilled									
MA-K037	Lake I	K37/ Lake I	360	220	140	300.8	Reclaimed	MA-K037	258.8	Yes	Elevated	Water Storage	314.8	311.014	302.8	-12.06

COL = Chain of Lake, A = Annual; SA = Semiannual,
WY Diff = Water Year Difference (Fall to Fall)

TABLE 14-7
MINING AREA EXCAVATIONS AND PONDS
2020 WATER YEAR
LIVERMORE VALLEY GROUNDWATER BASIN

EXCAVATIONS								CURRENT PONDS								
Excavation	Chain of Lake	Display Name	Original Ground Elev	Deepest Mined Depth (ft)		Pit Area	Mining Status	Pond Name	Pond Area	Contact with Aquifer	Water Elev Status	Mining Use	Pond Elevation (ft MSL, NAVD88)			
				Elev	*Depth*	*(acres)*			*(acres)*				*Fall 19*	*Spring 20*	*Fall 20*	*WY Diff*
PACIFIC AGGREGATE/RMC/LONESTAR/CEMEX																
MA-P001		P1	380	360	20	0.8	Backfilled									
MA-P002		P2	380	360	20	1.9	Excavated	MA-P002	1.2	Yes	Elevated	Water Storage	NM	NM	NM	
MA-P003		P3	400	360	40	8.5	Backfilled									
MA-P004		P4	400	360	40	7.8	Excavated									
MA-P006		P6	380	280	100	28.8	Backfilled									
MA-P007		P7	380	280	100	16.7	Backfilled									
MA-P010		P10	400	340	60	34	Excavated	MA-P010	16.5	Yes	Static	Unused	363.8	365.31	361	-2.81
MA-P011		P11	380	340	40	6.9	Excavated									
MA-P012	Island Pond	P12/ Island Pond	360	330	30	29.5	Excavated	MA-P012	14.9	Yes	Lined	Unused	351.4	351.48	349.5	-1.97
MA-P013		P13	380	300	80	2.6	Backfilled	MA-P013	1	Yes	Elevated	Water Storage	NM	NM	NM	
MA-P021		P21	380	240	140	10.5	Backfilled									
MA-P027		P27	390	250	140	31	Excavated	MA-P027	10.1	Yes	Static	Water Storage	280.4	279.56	277.4	-2.97
MA-P028	Lake A	P28/Lake A	420	360	60	24.6	Reclaiming	MA-P028	8.2	Yes	Static	Water Storage	407.3	411.42	406.3	-1.01
MA-P034		P34	380	270	110	46	Backfilled									
MA-P039	Lake B	P39/ Lake B	410	380	30	36.4	Active Mining									
MA-P040		P40	390	260	130	14.5	Excavated	MA-P040	0.2	Yes	Static	Unused	NM	NM	NM	
MA-P041	Lake A	P41/ Lake A	410	370	40	91.3	Reclaiming	MA-P041	57.5	Yes	Static	Water Storage	412.2	413.68	411.7	-0.52
MA-P042	Lake B	P42/ Lake B	380	250	130	101.8	Active Mining	MA-P042	8.6	Yes	Depressed	Dewatering	292.9	286.39	255.8	-37.16
MA-P043		P43	390	240	150	130.9	Excavated	MA-P043	99.4	No	Lined	Settling Pond	NM	NM	NM	
MA-P044		P44	390	250	140	20	Excavated	MA-P044	15	Yes	Elevated	Water Storage	352.9	352.73	345	-7.91
MA-P045		P45	380	310	70	25	Excavated	MA-P045	17.7	Yes	Elevated	Water Storage	NM	NM	NM	
MA-P046	Lake J	P46/ Lake J	380	251	129	23.8	Active Mining	MA-P046	7.5	Yes	Depressed	Active Mining	NM	285.98	294	

COL = Chain of Lake, A = Annual; SA = Semiannual,
WY Diff = Water Year Difference (Fall to Fall)

TABLE 14-8
REPRESENTATIVE MONITORING SITES FOR GROUNDWATER LEVELS
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical Conditions (ft)			SMCs[3] Water Levels				
Well Name	Map	Area	Subarea	Aquifer	Historic Low	Maximum Decrease[2]	Historic Low + Max Decrease	Minimum Threshold[4]	IM-5[5]	IM-10	IM-15	Measureable Objective[6]
3S1E20C007	20C7	Main	Bernal	Upper	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E20C008	20C8	Main	Bernal	Lower	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E09P005	9P5	Main	Amador West	Upper	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E09P010	9P10	Main	Amador West	Lower	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E11G001	11G1	Main	Amador East	Upper	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S1E12K003	12K3	Main	Amador East	Lower	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S2E08K002	8K2	Main	Mocho II	Upper	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S2E08H003	8H3	Main	Mocho II	Lower	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S1E06F003	6F3	Fringe	Northwest	Upper	314.6	-9.7	305.0	305.0	307.4	309.8	312.2	314.6
2S2E34E001	34E1	Fringe	Northeast	Upper	491.2	-3.0	488.2	488.2	489.0	489.7	490.5	491.2
3S2E24A001	24A1	Fringe	East	Upper	678.3	-2.8	675.5	675.5	676.2	676.9	677.6	678.3
3S2E21K009[7]	21K9	Upland	Upland	Upper	470.1	No Data	No Data	470.1	470.1	470.1	470.1	470.1

[1] RMS = Representative Monitoring Site

[2] Maximum Single Year Seasonal Decrease (Spring to Fall)

[3] Sustainable Management Criteria

[4] Historic Low + Maximum Seasonal Decrease

[5] IM-# = Interim Milestone at # years

[6] Measurable Objective = Historic Low

[7] Recently added; no historical data available. Criteria to be adjusted in future.

TABLE 14-9
REPRESENTATIVE MONITORING SITES
FOR GROUNDWATER STORAGE AND SUBSIDENCE
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical Conditions (ft)			SMCs[3] Water Levels				
Well Name	Map	Area	Subarea	Aquifer	Historic Low	Maximum Decrease[2]	Historic Low + Max Decrease	Minimum Threshold[4]	IM-5[5]	IM-10	IM-15	Measureable Objective[6]
3S1E20C007	20C7	Main	Bernal	Upper	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E20C008	20C8	Main	Bernal	Lower	179.5	-34.7	144.8	144.8	153.4	162.1	170.8	179.5
3S1E09P005	9P5	Main	Amador West	Upper	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E09P010	9P10	Main	Amador West	Lower	206.7	-26.9	179.8	179.8	186.5	193.2	199.9	206.7
3S1E11G001	11G1	Main	Amador East	Upper	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S1E12K003	12K3	Main	Amador East	Lower	219.9	-38.9	181.0	181.0	190.7	200.4	210.2	219.9
3S2E08K002	8K2	Main	Mocho II	Upper	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S2E08H003	8H3	Main	Mocho II	Lower	293.1	-38.0	255.1	255.1	264.6	274.1	283.6	293.1
3S1E06F003	6F3	Fringe	Northwest	Upper	314.6	-9.7	305.0	305.0	307.4	309.8	312.2	314.6
2S2E34E001	34E1	Fringe	Northeast	Upper	491.2	-3.0	488.2	488.2	489.0	489.7	490.5	491.2
3S2E24A001	24A1	Fringe	East	Upper	678.3	-2.8	675.5	675.5	676.2	676.9	677.6	678.3

[1] RMS = Representative Monitoring Site

[2] Maximum Single Year Seasonal Decrease (Spring to Fall)

[3] Sustainable Management Criteria

[4] Historic Low + Maximum Seasonal Decrease

[5] IM-# = Interim Milestone at # years

[6] Measurable Objective = Historic Low

TABLE 14-10
REPRESENTATIVE MONITORING SITES FOR GROUNDWATER QUALITY
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical TDS (mg/L)				SMCs[4] for TDS (mg/L)				
Well Name	Map	Area	Subarea	Aquifer	2015 Baseline[2]	Maximum Deviation[3]	Baseline + Max Deviation	Basin Objective	Minimum Threshold[5]	IM-5[6]	IM-10	IM-15	Measurable Objective[7]
3S1E20C007	20C7	Main	Bernal	Upper	482	318	800	500	800	725	650	575	500
3S1E20C008	20C8	Main	Bernal	Lower	607	147	754	500	754	691	627	564	500
3S1E09P005	9P5	Main	Amador West	Upper	618	690	1,308	500	1,308	1,106	904	702	500
3S1E09P010	9P10	Main	Amador West	Lower	444	173	617	500	617	588	559	529	500
3S1E11G001	11G1	Main	Amador East	Upper	617	345	962	500	962	847	731	616	500
3S1E12K003	12K3	Main	Amador East	Lower	470	126	596	500	596	572	548	524	500
3S2E08K002	8K2	Main	Mocho II	Upper	616	80	696	500	696	647	598	549	500
3S2E08H003	8H3	Main	Mocho II	Lower	522	196	718	500	718	664	609	555	500
3S1E06F003	6F3	Fringe	Northwest	Upper	2,845	810	3,655	1,000	3,655	3,453	3,250	3,048	2,845
2S2E34E001	34E1	Fringe	Northeast	Upper	681	248	929	1,000	1,000	1,000	1,000	1,000	1,000
3S2E24A001	24A1	Fringe	East	Upper	1,024	155	1,179	1,000	1,179	1,140	1,102	1,063	1,024
3S2E21K009	21K9	Upland	Upland	Upper	534[8]	167	701	1,000	1,000	1,000	1,000	1,000	1,000

1 Representative Monitoring Site
2 Average concentration during 2015 Water Year
3 Maximum Single Year Decrease or Increase
4 Sustainable Management Criteria
5 Maximum of (Baseline + Max Deviation) or Basin Objective
6 IM-# = Interim Milestone at # years
7 from Basin Objective
8 No data available for 2015. Used average of all results.

TABLE 14-10
REPRESENTATIVE MONITORING SITES FOR GROUNDWATER QUALITY
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical Nitrate (mg/L)				SMCs[4] Nitrate (mg/L)				
Well Name	Map	Area	Subarea	Aquifer	2015 Baseline[2]	Maximum Deviation[3]	Baseline + Max Deviation	Basin Objective	Minimum Threshold[5]	IM-5[6]	IM-10	IM-15	Measurable Objective[7]
3S1E20C007	20C7	Main	Bernal	Upper	2.39	5.0	7	10	10	10	10	10	10
3S1E20C008	20C8	Main	Bernal	Lower	5.67	1.1	7	10	10	10	10	10	10
3S1E09P005	9P5	Main	Amador West	Upper	0.77	5.2	6	10	10	10	10	10	10
3S1E09P010	9P10	Main	Amador West	Lower	1.7	3.6	5	10	10	10	10	10	10
3S1E11G001	11G1	Main	Amador East	Upper	5.72	13.6	19	10	19	17	15	12	10
3S1E12K003	12K3	Main	Amador East	Lower	5.01	3.5	9	10	10	10	10	10	10
3S2E08K002	8K2	Main	Mocho II	Upper	7.88	8.3	16	10	16	15	13	12	10
3S2E08H003	8H3	Main	Mocho II	Lower	11.1	3.6	15	10	15	14	12	11	10
3S1E06F003	6F3	Fringe	Northwest	Upper	ND	3.1	3	10	10	10	10	10	10
2S2E34E001	34E1	Fringe	Northeast	Upper	ND	1.2	1	10	10	10	10	10	10
3S2E24A001	24A1	Fringe	East	Upper	22.6	14.9	38	10	38	31	24	17	10
3S2E21K009	21K9	Upland	Upland	Upper	5.7[8]	no data	6	10	10	10	10	10	10

[1] Representative Monitoring Site
[2] Average concentration during 2015 Water Year
[3] Maximum Single Year Decrease or Increase
[4] Sustainable Management Criteria
[5] Maximum of (Baseline + Max Deviation) or Basin Objective
[6] IM-# = Interim Milestone at # years
[7] from Basin Objective
[8] No data available for 2015. Used most recent result.

ND = not detected (i.e., below lab detection limits)

TABLE 14-10
REPRESENTATIVE MONITORING SITES FOR GROUNDWATER QUALITY
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical Boron (ug/L)				SMCs[4] Boron (ug/L)				
Well Name	Map	Area	Subarea	Aquifer	2015 Baseline[2]	Maximum Deviation[3]	Baseline + Max Deviation	Basin Objective	Minimum Threshold[5]	IM-5[6]	IM-10	IM-15	Measurable Objective[7]
3S1E20C007	20C7	Main	Bernal	Upper	490	180	670	1,400	1,400	1,400	1,400	1,400	1,400
3S1E20C008	20C8	Main	Bernal	Lower	280	210	490	1,400	1,400	1,400	1,400	1,400	1,400
3S1E09P005	9P5	Main	Amador West	Upper	970	400	1,370	1,400	1,400	1,400	1,400	1,400	1,400
3S1E09P010	9P10	Main	Amador West	Lower	470	270	740	1,400	1,400	1,400	1,400	1,400	1,400
3S1E11G001	11G1	Main	Amador East	Upper	900	500	1,400	1,400	1,400	1,400	1,400	1,400	1,400
3S1E12K003	12K3	Main	Amador East	Lower	370	250	620	1,400	1,400	1,400	1,400	1,400	1,400
3S2E08K002	8K2	Main	Mocho II	Upper	350	300	650	1,400	1,400	1,400	1,400	1,400	1,400
3S2E08H003	8H3	Main	Mocho II	Lower	340	119	459	1,400	1,400	1,400	1,400	1,400	1,400
3S1E06F003	6F3	Fringe	Northwest	Upper	3,590	1,000	4,590	1,400	4,590	3,793	2,995	2,198	1,400
2S2E34E001	34E1	Fringe	Northeast	Upper	2,880	1,840	4,720	1,400	4,720	3,890	3,060	2,230	1,400
3S2E24A001	24A1	Fringe	East	Upper	1,360	1,040	2,400	1,400	2,400	2,150	1,900	1,650	1,400
3S2E21K009	21K9	Upland	Upland	Upper	110[8]	no data	110	1,400	1,400	1,400	1,400	1,400	1,400

[1] Representative Monitoring Site
[2] Average concentration during 2015 Water Year
[3] Maximum Single Year Decrease or Increase
[4] Sustainable Management Criteria
[5] Maximum of (Baseline + Max Deviation) or Basin Objective
[6] IM-# = Interim Milestone at # years
[7] from Basin Objective
[8] No data available for 2015. Used most recent result.

TABLE 14-10
REPRESENTATIVE MONITORING SITES FOR GROUNDWATER QUALITY
LIVERMORE VALLEY GROUNDWATER BASIN

RMS[1] Well		Management Area/Unit			Historical Chromium (ug/L)				SMCs[4] Chromium (ug/L)				
Well Name	Map	Area	Subarea	Aquifer	2015 Baseline[2]	Maximum Deviation[3]	Baseline + Max Deviation	Basin Objective	Minimum Threshold[5]	IM-5[6]	IM-10	IM-15	Measurable Objective[7]
3S1E20C007	20C7	Main	Bernal	Upper	3.5	2	5	50	50	50	50	50	50
3S1E20C008	20C8	Main	Bernal	Lower	5.3	2	7	50	50	50	50	50	50
3S1E09P005	9P5	Main	Amador West	Upper	2.8	2	5	50	50	50	50	50	50
3S1E09P010	9P10	Main	Amador West	Lower	3.3	4	8	50	50	50	50	50	50
3S1E11G001	11G1	Main	Amador East	Upper	6.5	3	9	50	50	50	50	50	50
3S1E12K003	12K3	Main	Amador East	Lower	6.7	7	14	50	50	50	50	50	50
3S2E08K002	8K2	Main	Mocho II	Upper	5.6	2	8	50	50	50	50	50	50
3S2E08H003	8H3	Main	Mocho II	Lower	6.2	4	10	50	50	50	50	50	50
3S1E06F003	6F3	Fringe	Northwest	Upper	ND	0	ND	50	50	50	50	50	50
2S2E34E001	34E1	Fringe	Northeast	Upper	ND	1	1	50	50	50	50	50	50
3S2E24A001	24A1	Fringe	East	Upper	5.6	3	9	50	50	50	50	50	50
3S2E21K009	21K9	Upland	Upland	Upper	ND[8]	no data	ND	50	50	50	50	50	50

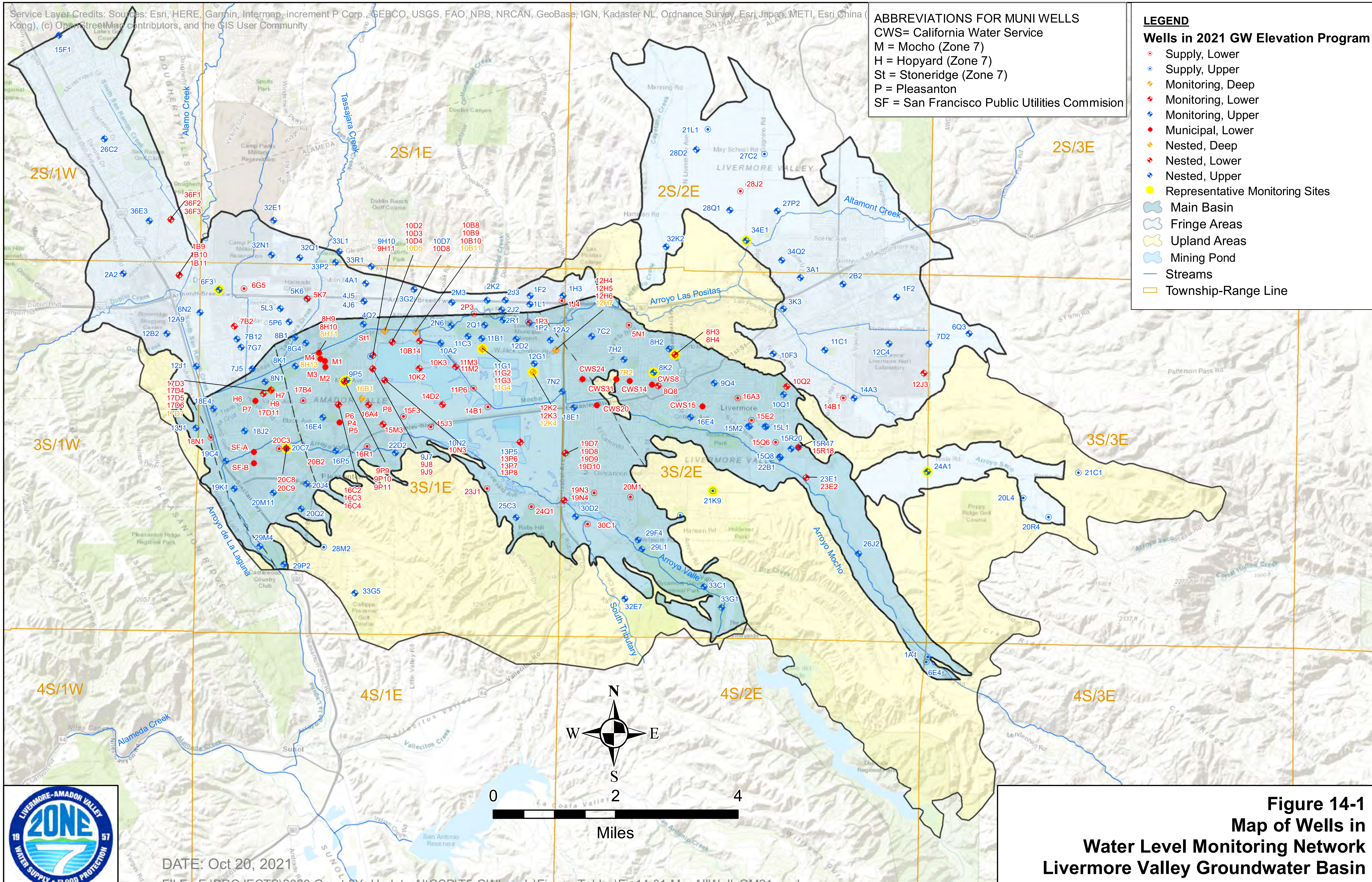
1 Representative Monitoring Site
2 Average concentration during 2015 Water Year
3 Maximum Single Year Decrease or Increase
4 Sustainable Management Criteria
5 Maximum of (Baseline + Max Deviation) or Basin Objective
6 IM-# = Interim Milestone at # years
7 from Basin Objective
8 No data available for 2015. Used most recent result.

ND = not detected (i.e., below lab detection limits)

TABLE 14-11
REPRESENTATIVE MONITORING SITES FOR ICSW
LIVERMORE VALLEY GROUNDWATER BASIN

RMS Well	***Management Area***			***Sustainable Criteria for Interconnected Surface Water***				
	Area	***Subarea***	***Aquifer***	***Minimum Threshold***	***IM-5***	***IM-10***	***IM-15***	***Measurable Objective***
3S2E30D002	Main	Amador	Upper	401	403.8	404.7	405.6	406.5
3S1E16P005	Main	Amador	Upper	285.2	285.2	285.2	285.2	285.2
3S2E33G001	Main	Amador	Upper	501	501.1	501.2	501.2	501.3
3S2E29F004	Main	Amador	Upper	437.8	441.2	442.3	443.5	444.6
3S2E33C001	Main	Amador	Upper	482.1	484.2	484.8	485.5	486.2
3S1E02N006	Main	Camp	Upper	331.5	333.9	333.9	333.9	333.9
3S2E16E004	Main	Mocho II	Upper	466.9	466.9	466.9	466.9	467
3S2E23E001	Main	Mocho II	Upper	595.4	595.4	595.4	595.4	595.4
4S2E01A001	Main	Mocho II	Upper	781.2	781.2	781.2	781.2	781.2
2S2E27P002	Fringe	Spring	Upper	501	501	501	501	501
2S2E34E001	Fringe	May	Upper	491.2	492.1	492.4	492.7	493
3S1E05K006	Fringe	Camp	Upper	326	328.2	328.2	328.2	328.2
3S1E02R001	Fringe	Camp	Upper	345.3	349.4	350.8	352.2	353.6
3S2E32E007	Upland	Upland	Upper	591.4	591.4	591.4	591.4	591.4

ICSW = Interconnected Surface Water
RMS = Representative Monitoring Site
IM = Interim Milestone



ABBREVIATIONS FOR MUNI WELLS
CWS= California Water Service
M = Mocho (Zone 7)
H = Hopyard (Zone 7)
St = Stoneridge (Zone 7)
P = Pleasanton
SF = San Francisco Public Utilities Commision

LEGEND

Wells in 2021 GW Elevation Program

- Supply, Lower
- Supply, Upper
- Monitoring, Deep
- Monitoring, Lower
- Monitoring, Upper
- Municipal, Lower
- Nested, Deep
- Nested, Lower
- Nested, Upper
- Representative Monitoring Sites
- Main Basin
- Fringe Areas
- Upland Areas
- Mining Pond
- Streams
- Township-Range Line

DATE: Oct 20, 2021

FILE: E:\PROJECTS\2020 Grant 5Yr Update AltGSP\T5-GWLevels\FiguresTables\Fig14-01-MapAllWellsGM21.mxd

Figure 14-1
Map of Wells in
Water Level Monitoring Network
Livermore Valley Groundwater Basin

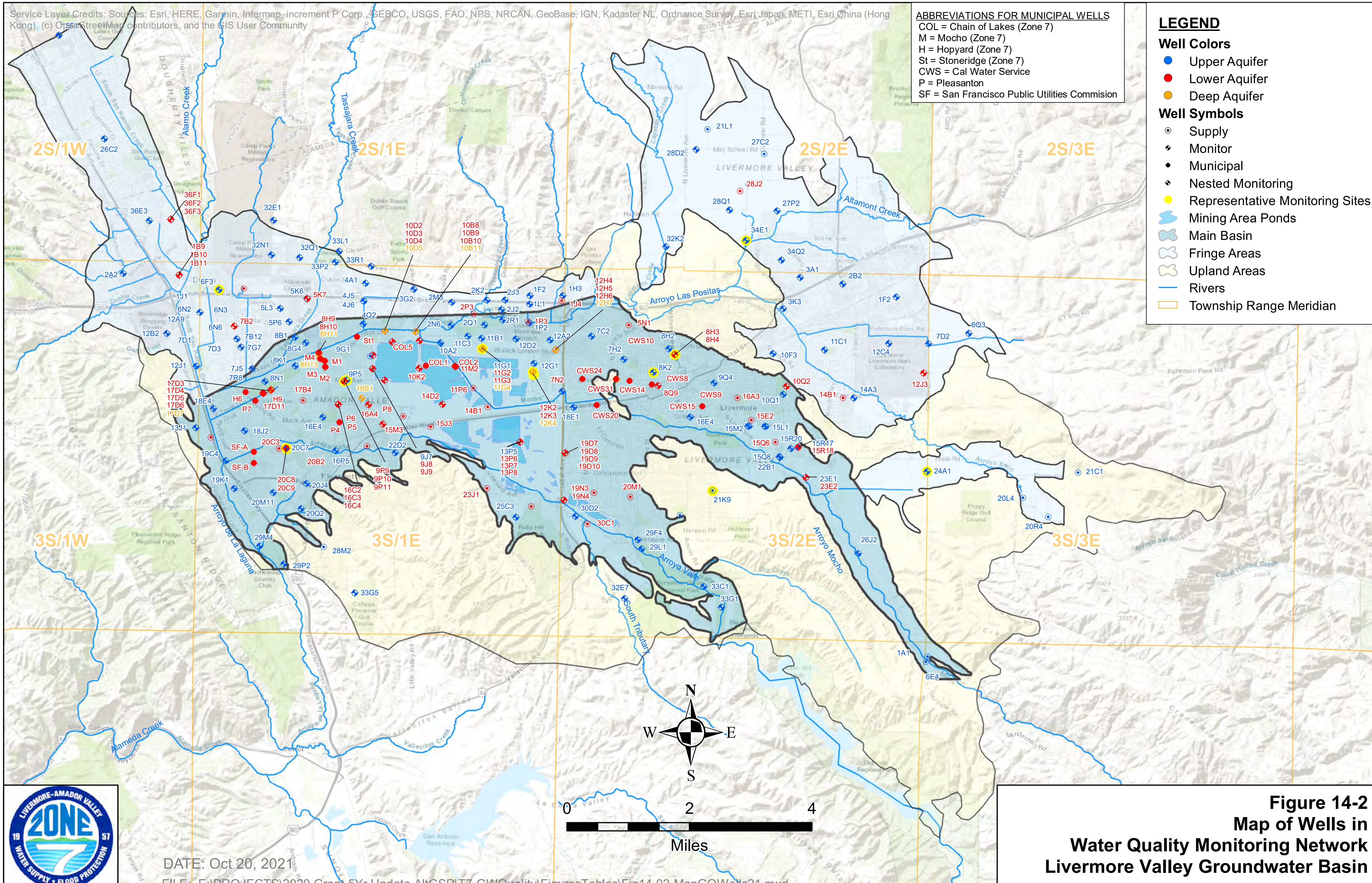
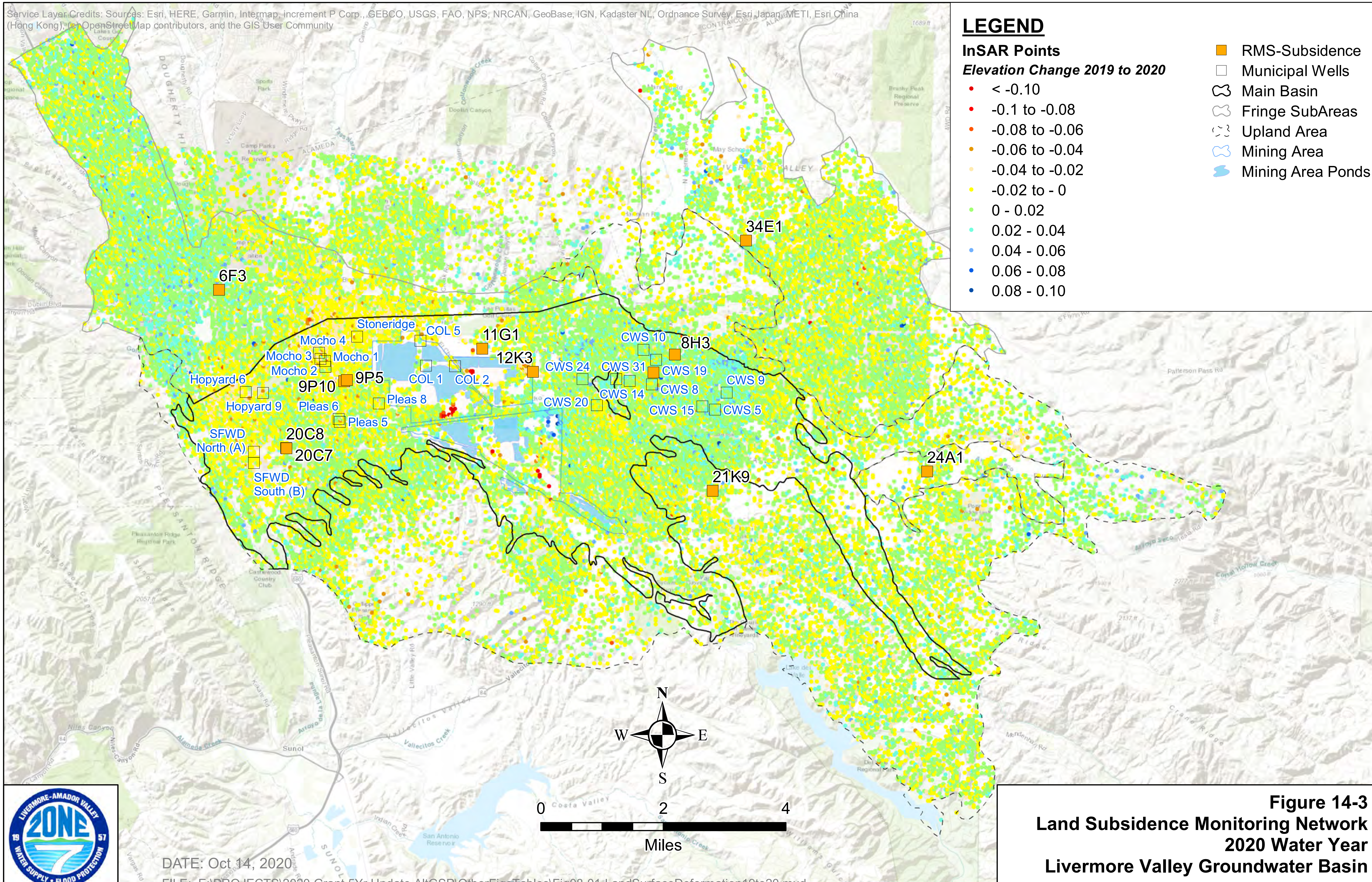


Figure 14-2
Map of Wells in
Water Quality Monitoring Network
Livermore Valley Groundwater Basin

DATE: Oct 20, 2021

FILE: E:\PROJECTS\2020 Grant 5Yr Update AltGSP\T7-GWQuality\FiguresTables\Fig14-02-MapGQWells21.mxd



DATE: Oct 14, 2020

FILE: E:\PROJECTS\2020 Grant.5Yr Update AltGSP\OtherFigsTables\Fig08-01-LandSurfaceDeformation19to20.mxd

Figure 14-3
Land Subsidence Monitoring Network
2020 Water Year
Livermore Valley Groundwater Basin

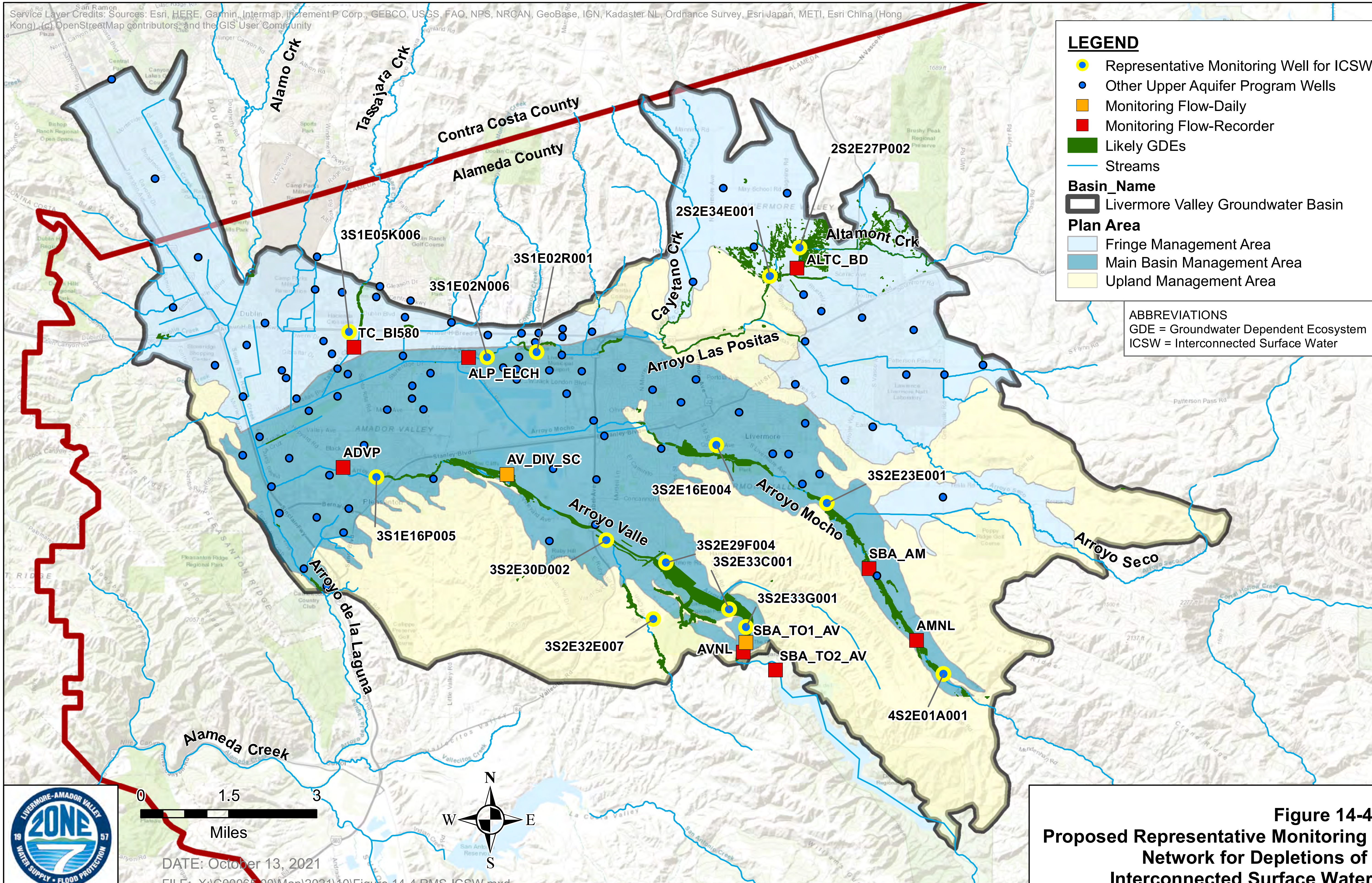


Figure 14-4
Proposed Representative Monitoring Network for Depletions of Interconnected Surface Water

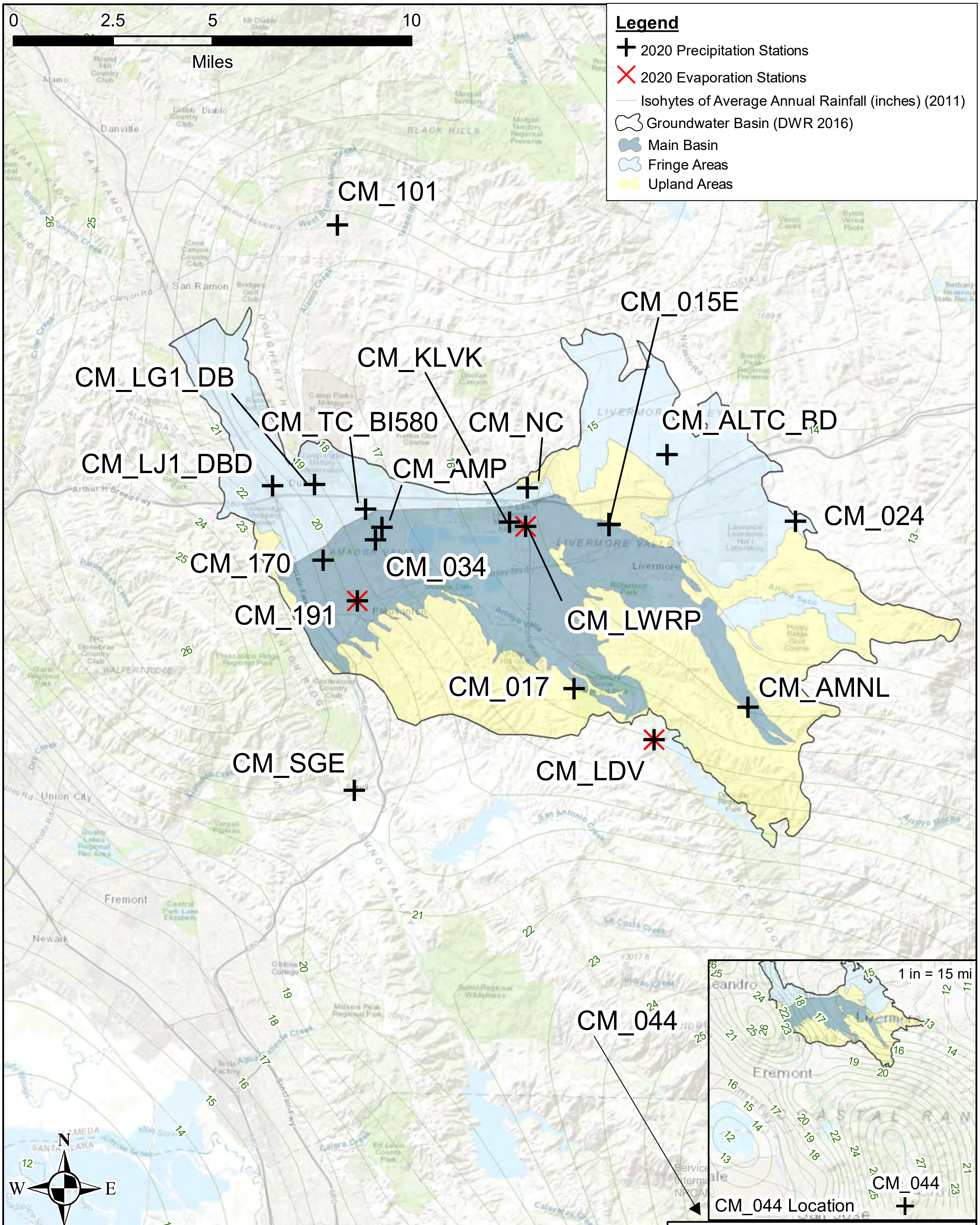
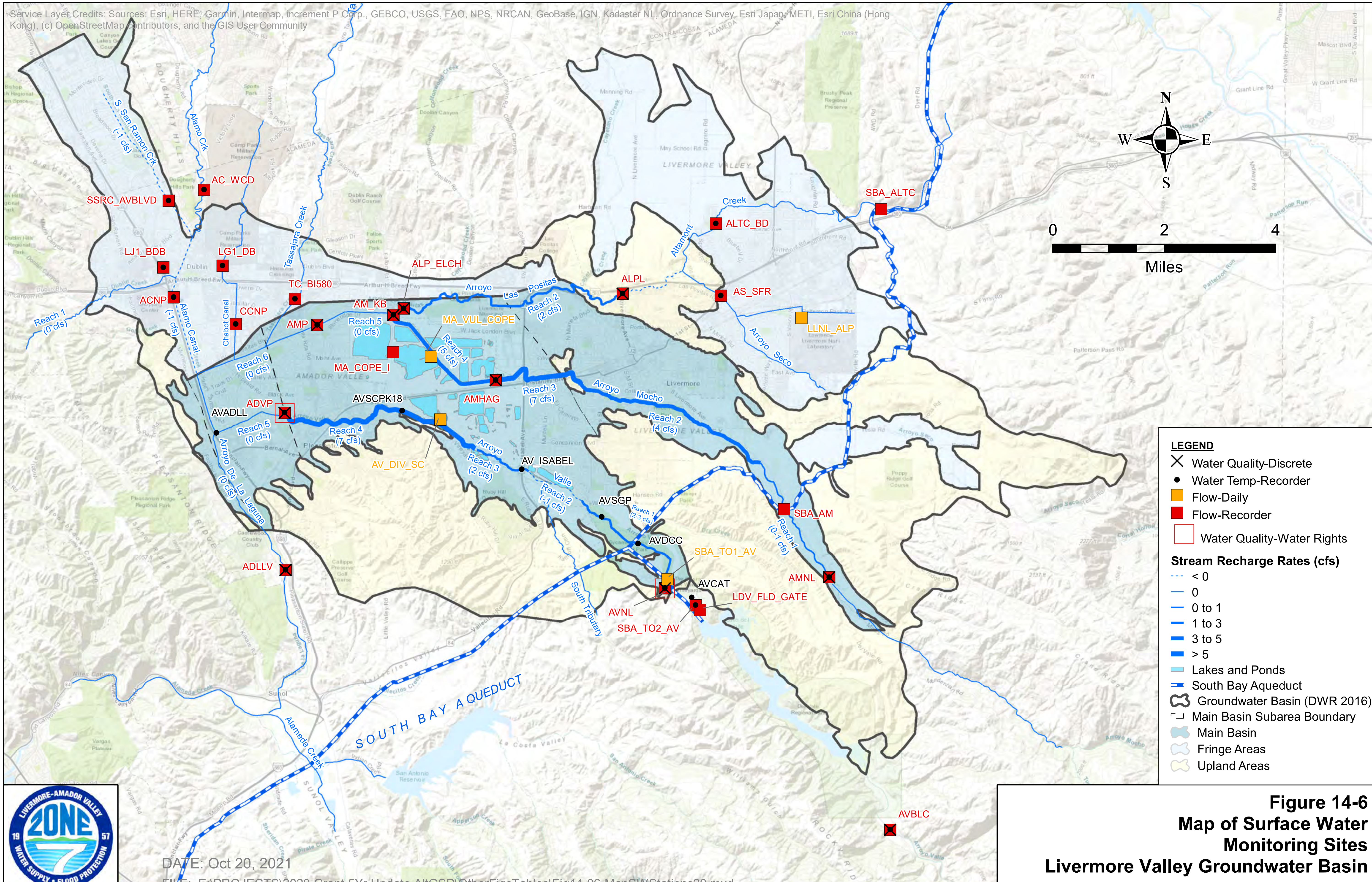


Figure 14-5
Climatological Monitoring Stations with Contours of Average Annual Rainfall (in)

Date: Oct 20, 2021

F:\PROJECTS\2020 Grant 5Yr Update AltGSP\OtherFigsTables\Fig14-05-MapClimateStations20.mxd



DATE: Oct 20, 2021

FILE: E:\PROJECTS\2020 Grant 5Yr Update AltGSP\OtherFigsTables\Fig14-06-MapSWStations20.mxd

Figure 14-6
Map of Surface Water Monitoring Sites
Livermore Valley Groundwater Basin

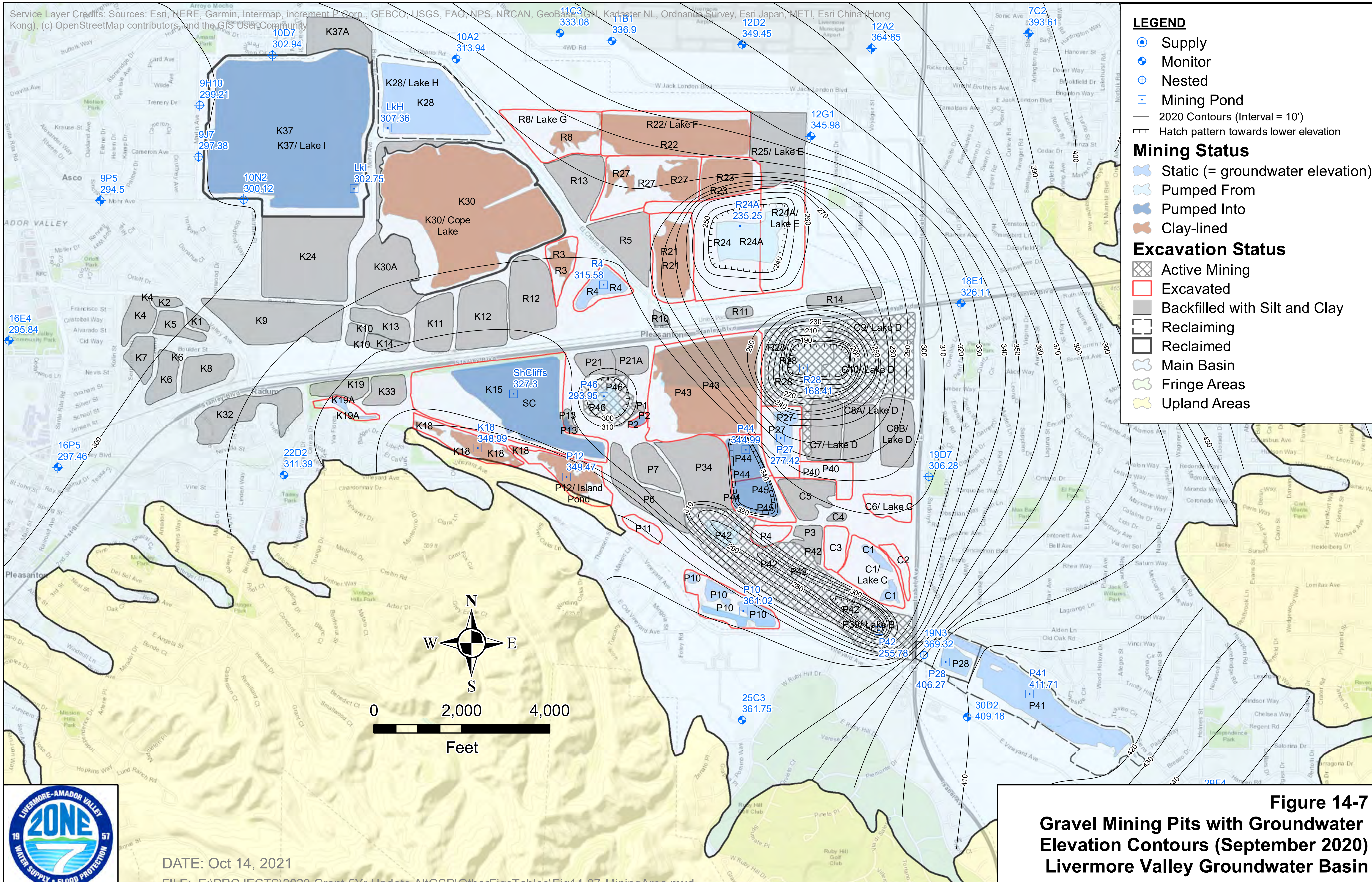


Figure 14-7
Gravel Mining Pits with Groundwater Elevation Contours (September 2020)
Livermore Valley Groundwater Basin

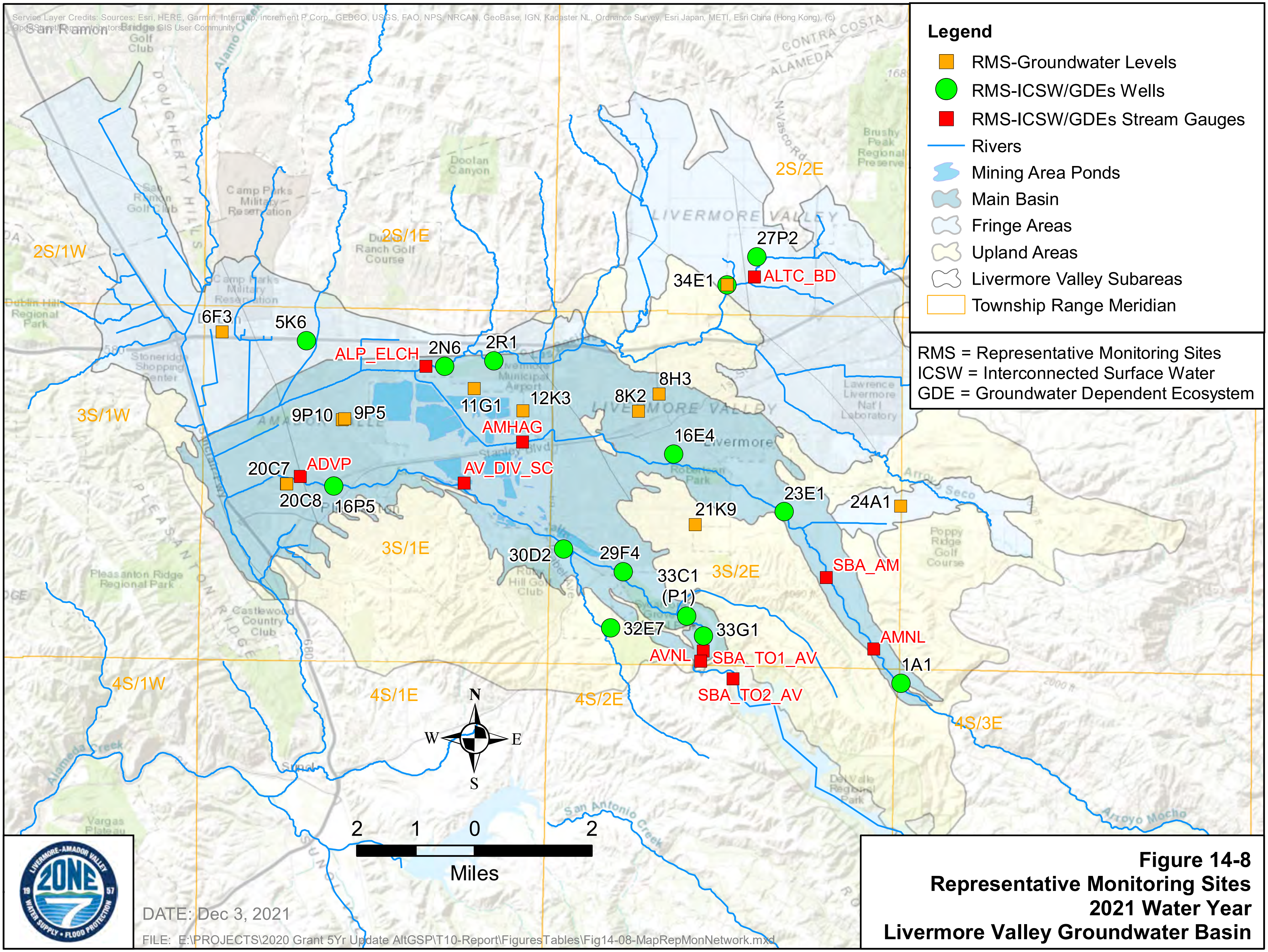


Figure 14-8
Representative Monitoring Sites
2021 Water Year
Livermore Valley Groundwater Basin

PROJECTS AND MANAGEMENT ACTIONS

(SUBTITLE PAGE)

15. PROJECTS AND MANAGEMENT ACTIONS

§ 354.42. Introduction to Projects and Management Actions
This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.

☑ **23 CCR § 354.42**

§ 356.4 Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:
(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.
...
(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.
(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.

☑ **23 CCR § 356.4 (b)**
☑ **23 CCR § 356.4 (g)**
☑ **23 CCR § 356.4 (h)**

This section presents the Projects and Management Actions (P/MAs) currently under implementation by The Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7 Water Agency or Zone 7) or otherwise proposed for future implementation to support continued achievement of the Sustainability Goal for the Livermore Valley Groundwater Basin (Basin). As described in **Section 5.2** and **Sections 8** through **13**, consistent with the approved 2016 Alternative Groundwater Sustainability Plan (Alternative GSP) and the requirements of California Water Code (CWC) § 10733.6 (a)(3) and California Code of Regulations Title 23 (23 CCR) § 356.4, Zone 7 has been actively implementing specific plans, programs, and P/MAs for decades to sustainably manage groundwater resources for all beneficial uses and users of groundwater within the Basin. As demonstrated herein, Zone 7 has continued to sustainably manage the Basin to avoid Undesirable Results (URs) (as defined in **Section 13**) for at least 10 years.

A summary of the P/MAs currently being implemented by Zone 7 and their resulting effects on groundwater conditions and benefits to the Sustainability Indicators is provided below. These P/MAs currently being implemented, including ordinances and enforcement actions, help Zone 7 to continue to meet the Sustainability Goal for the Basin and adaptively manage its groundwater supply. In addition to continuing the monitoring programs that are critical to Zone 7's sustainable groundwater management, Zone 7 is also working to improve long-term surface water supply reliability, maximize conjunctive use opportunities, provide watershed protection, support water recycling operations, and encourage water conservation. Also provided in this section is a description of additional P/MAs that have been proposed to foster continued sustainable management of the Basin over the 50-year Alternative GSP planning and implementation horizon.

In addition to the P/MAs presented herein, Zone 7 Water Agency (Zone 7) will continue to conduct data gap filling activities as part of Alternative GSP implementation that may include, but are not limited to: (1) collecting and analyzing additional data related to aquifer conditions and properties (e.g., aquifer tests, water level measurements, water quality data, subsidence measurements), (2) refining the Hydrologic Inventory parameters based on additional data and modeling to improve estimates of Basin water balance and storage, and (3) conducting additional analysis to refine the Sustainable Management Criteria and related Basin conditions to assess if Undesirable Results (URs) are occurring (e.g., improving the understanding of the relationship of relevant Sustainability Indicators to Zone 7's Sustainable Groundwater Management Act [SGMA] implementation efforts).

15.1. Goals and Objectives of Projects and Management Actions

☑ **23 CCR § 354.44(b)(1)**

This section presents the goals and objectives of the P/MAs that are consistent with Zone 7's on-going sustainable management of the Basin, including the relevant Sustainability Indicators and the categories of benefits from P/MA implementation.

15.1.1. Relevant Sustainability Indicators

Per the California Code of Regulations Title 23 (23 CCR) § 354.44, P/MAs must address any existing or potential future URs for the identified relevant Sustainability Indicators. In Zone 7's case, the P/MAs will be utilized to meet Measurable Objectives (MOs) and avoid exceedance of Minimum Thresholds (MTs) for the relevant Sustainability Indicators. As described in **Section 13,** the following Sustainability Indicators are applicable to the Basin:

1) Chronic Lowering of Groundwater Levels
2) Reduction of Groundwater Storage
3) Degraded Water Quality
4) Land Subsidence
5) Depletions of Interconnected Surface Water

Consistent with other Zone 7 planning efforts (see **Section 5.2**), Zone 7 manages all its available water supplies—imported surface water from the State Water Project (SWP), local surface water, groundwater, and recycled water—by applying conjunctive use principles and adaptive management strategies. Recognizing the importance of sustainable management of the Basin, Zone 7 has long championed groundwater quality protection and worked to preserve access to high-quality groundwater supplies. As such, the P/MAs presented herein focus on the maintenance of high-quality imported surface water supplies to support the ongoing protection of groundwater levels, storage, and quality and to prevent the occurrence of land subsidence and interconnected surface water depletions within the Basin. Therefore, the MOs for each of the Sustainability Indicators are expected to continue to be met with the benefit of the P/MAs.

15.1.2. Benefit Categories

The primary categories of realized or expected benefits from P/MAs include:

1) Water supply augmentation, including:
    a. Expanded access to and reliability of imported surface water supplies
    b. Expansion of groundwater recharge program
2) Water demand reduction, including
    a. Expanded recycled water use
    b. Water conservation measures
    c. Continued management of groundwater extractions by groundwater pumping quotas
3) Improvement of groundwater quality
4) Data gap-filling activities
    a. Monitoring well installation
    b. Water level data collection (increased location and frequency in some instances)
    c. Water quality data collection
    d. Groundwater extraction data collection
    e. Groundwater model update to improve Hydrologic Inventory and Basin storage estimates
    f. Rockworks model update
    g. Analysis of relationship of Sustainability Indicators trends with Zone 7 SGMA management activities to assess URs (e.g., Interconnected surface waters and groundwater dependent ecosystems, groundwater quality, etc.)

15.2. List of Projects and Management Actions

§ 354.44. Projects and Management Actions

(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.

(b) Each Plan shall include a description of the projects and management actions that include the following:

(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:

(A) A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.

(B) The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.

(2) If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.

(3) A summary of the permitting and regulatory process required for each project and management action.

(4) The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.

(5) An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.

(6) An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.

(7) A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.

§ 354.44. Projects and Management Actions

(8) A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.

(9) A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.

(c) Projects and management actions shall be supported by best available information and best available science.

(d) An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.

☑ **23 CCR § 354.44(b)(1)**
☑ **23 CCR § 354.44(c)**
☑ **23 CCR § 354.44(d)**

This section provides a list of the P/MAs currently implemented or otherwise proposed for future implementation by Zone 7. A more detailed description of P/MAs currently under implementation and proposed future P/MAs can be found in Zone 7's 2020 Urban Water Management Plan (UWMP) (*Zone 7, 2021*; **Appendix K)**.

The P/MAs are developed or will be supported by the best available information and science. At this time, Zone 7 acknowledges that details pertaining to which future P/MAs will ultimately be initiated, P/MA timing, projected benefits, payments and cost allocations, etc. will be considered as part of P/MA and Alternative GSP implementation. Each future P/MA will have a distinct implementation process and the details will be determined on a case-by-case basis and may differ depending upon observed conditions in the Basin, available opportunities, and the particulars of each P/MA.

Zone 7 further acknowledges uncertainty in the discussions of water supply reliability and water demand projections. With regard to the latter, uncertainty is inherent and the rate of increase of total demands and the ultimate demands will be affected by economic conditions, regulations (e.g., land use ordinances), technology (e.g., water efficiency of future appliances), behavior, and other factors. In response, Zone 7 continues to re-evaluate demand trends annually. With respect to supply, Zone 7 actively manages the Basin through extensive monitoring and other analysis as discussed in prior sections, and investment in multiple diverse supply sources and management actions as described below.

15.2.1. Water Supply Augmentation Projects

15.2.1.1. Existing Imported Water Supplies

As described in **Section 7.7.6,** Zone 7 ensures that local water supplies (e.g., groundwater) are not depleted by importing approximately 80% of the Basin's water supply (delivered to Zone 7's retailers and agricultural customers) and by recharging the Main Basin Management Area (Main Basin) with surplus surface water when available (artificial recharge). As described in further detail in **Section 7.7.6**, imported surface water supplies secured by Zone 7 include:

- **State Water Project (SWP deliveries via the South Bay Aqueduct [SBA])** – As a SWP contractor, Zone 7 imports supplies from the SWP through the SBA. As of 1998, Zone 7 has had an annual maximum SWP contract amount of 80,619 acre-feet per year (AFY) referred to as the "Table A Contract Amount." However, actual SWP deliveries are usually allocated in any given year by the California Department of Water Resources (DWR) at a lower level based on numerous factors, including hydrologic conditions. Currently, the long-term reliable yield of the SWP is approximately 60% of the Table A amount (48,370 AFY). This should increase if the California Water Fix is implemented by the State.

- **Arroyo Valle Water Rights (Lake Del Valle)** – Zone 7 has temporary water rights for a portion of the natural flows into Lake Del Valle. Accordingly, Zone 7 coordinates releases from the reservoir into the Arroyo Valle to maintain downstream flows and streambed recharge at the levels that would have occurred had the reservoir not been constructed. Additional releases of Arroyo Valle water can be made from the lake when such water is available for Zone 7. Maintaining minimum flows is a condition of Zone 7's water rights permit for the Arroyo Valle water. Zone 7 can also use other portions of Arroyo Valle water for supply to its treatment plants and for supplemental aquifer recharge. Zone 7 is currently pursuing the permanent rights to this surface water source.

- **Kern County Subbasin (storage rights only)** – Zone 7 has purchased water storage rights in the Semitropic Water Storage District (78,000 acre-feet [AF]) and in the Cawelo Water District (120,000 AF) in Kern County. These rights give Zone 7 the ability to remotely store surplus SWP water when available. When Zone 7 is ready to use the water locally; it can import that quantity of SWP water through an exchange procedure within the SWP system.

- **Lover River Yuba Accord (Yuba Accord) –** In 2008, Zone 7 entered a contract with DWR to purchase additional water under the Yuba Accord. The contract was amended in 2020 to extend through 2025. There are four different Components (types) of water available; Zone 7 has the option to purchase Component 2 and Component 3 water during drought conditions, and Component 4 water when Yuba County Water Agency has determined that it has water supply available to sell. Zone 7 estimates the average yield from the Yuba Accord to be 850 AFY.

- **Dry Year Transfer Program –** The State Water Contractors, an organization composed of contractors of the SWP, facilitates the purchase of water from the Feather River Watershed for transfer to SWP contractors during dry years. This is an optional program that Zone 7 will utilize on an as-needed basis.

- **Other Transfers** – As part of Zone 7 's long-term reliability program, Zone 7 actively seeks out transfers from other agencies or districts that have water available.

15.2.1.2. Future Water Supply Projects

As described in **Section 9.4,** Zone 7 anticipates future supply deficits as SWP reliability continues to decline and Zone 7's service area population grows. As a result, Zone 7 is pursuing several water supply reliability projects to obtain additional water storage and water supplies, address the need for alternative conveyance in the Delta, and improve access to groundwater and local emergency supplies. These future water supply projects are described in detail in the 2020 UWMP (**Appendix K**) and summarized below:

- **Capital Improvement Program (CIP)** – As part of its existing CIP, Zone 7 is planning to construct a reliability intertie with another major water agency (e.g., East Bay Municipal Utilities District [EBMUD] or San Francisco Public Utilities Commission [SFPUC]) to help mitigate some of the risk during a major water supply interruption from the Delta and to create opportunities for transfers/exchanges. This intertie could allow Zone 7 to acquire emergency water supplies to help meet minimum health and safety water supply needs during a major Delta outage, assuming the partnering agency has available supply and the transmission capacity available during the emergency period. The intertie is planned for completion around 2029/2030.

- **Bay Area Regional Desalination Project (BARDP)** – Brackish water desalination for Zone 7 would be accomplished through the BARDP. The project would involve constructing a regional brackish water treatment plant in eastern Contra Costa County producing 10-20 million gallons per day (MGD). Water would be diverted using Contra Costa Water District's (CCWD) Mallard Slough Pump Station. Using existing water right license and permit, both held by CCWD, and/or a new or modified water right, Zone 7 could potentially receive up to 5,000 AFY. Zone 7 could take delivery of this new water supply through a reliability intertie with EBMUD or through the Delta/SBA by exchanging water with CCWD. Furthermore, this project could potentially provide a new water supply component for the Los Vaqueros Reservoir Expansion (LVE) project and make use of LVE's additional storage and new conveyance facilities. A more detailed description of the LVE project is provided below.

- **Delta Conveyance Project (DCP)** – DWR's proposed DCP would install a new tunnel to convey freshwater from north of the Delta to a point south of the Delta. The DCP would likely increase SWP reliability and improve water quality. It would also serve to protect the reliability of SWP supplies from the effects of climate change and seismic events, among other risks. DWR's current schedule for the DCP environmental planning and permitting extends to 2024. The DCP will potentially be operational around 2040 following extensive planning, permitting, and construction. With permitting being completed over the next few years, quantitative information on the reliability associated with the DCP will be evaluated as part of the next Five-Year Update to the Alternative GSP.

- **Potable Reuse –** In 2018, the Tri-Valley Water Agencies completed the Joint Tri-Valley Potable Reuse Technical Feasibility Study (Potable Reuse Study) (*Carollo Engineers, 2018*) to evaluate the feasibility of a wide range of potable reuse options for the Tri-Valley based on technical, financial, and regulatory considerations. The Potable Reuse Study investigated three potential end uses for purified water in detail: (1) groundwater augmentation or recharge via injection wells; (2) groundwater recharge via Chain of Lakes surficial recharge; and (3) raw water augmentation to Zone 7's Del Valle Water Treatment Plant. Looking at annual yields ranging from 5,500 to 10,000 AFY, the Potable Reuse Study concluded that potable reuse is technically feasible for the Tri-Valley, with benefits to reliability and water quality. The lower yield would use only Livermore wastewater supply with year-round operations, while the higher yield would be achieved with seasonal availability of Dublin San Ramon Services District (DSRSD) wastewater supply. Water availability would increase over time as development occurs in the Tri-Valley and more wastewater is generated and collected. In Zone 7's 2019 Water Supply Evaluation (WSE) Update, raw water augmentation was modeled with the option for a two-phased project that initially produces a lower yield but increases to the maximum yield in 2035 (following a growth in available wastewater). Reflecting a more conservative estimate of future wastewater availability, the 2019 Water Supply Evaluation Update used a reduced yield of 4,000 AFY starting in 2027 and 7,000 AFY after 2035. Technical studies will be completed over the next few years to support continued evaluation of potable reuse options and their costs and benefits.

- **Sites Reservoir** – Sites Reservoir is a proposed 1.5 million AF off-stream storage reservoir in northern California near Maxwell. Sacramento River flows will be diverted during excess flow periods and stored in the off-stream reservoir and released for use in the drier periods. The Sites Reservoir aims to supplement and optimize use of the State's existing storage and conveyance systems. The participants in the Sites Reservoir project include 30 entities, including Zone 7 and several other SWP contractors. Sites Reservoir is currently undergoing environmental planning and permitting and is expected to provide over 200,000 AFY of additional deliveries on average to participating agencies. In December 2016, Zone 7 authorized participation in Phase 1 at a cost of $850,000. In December 2019, the Board authorized participation in Phase 2 (2019 Sites Reservoir Project Agreement) at a cost of $600,000. In July 2020, the Board authorized a Second Amendment to Phase 2 at a cost of $1 million at a participation level of 10,000 AFY. Key work under these two phases includes planning, design, financial analysis, and environmental review and permitting. In the 2019 WSE Update, Zone 7 considered 5,000 to 10,000 AFY of average yield from Sites Reservoir, in combination with other water supply options.

- **Los Vaqueros Reservoir Expansion (LVE)** – Constructed in 1997, Los Vaqueros Reservoir is an off-stream reservoir owned by Contra Costa Water District (CCWD) and located in southeastern Contra Costa County. It currently has a capacity of 160,000 AF following its expansion (Phase 1) from 100,000 AF in 2012. CCWD is planning to further expand the reservoir to 275,000 AF (Phase 2) and construct the Transfer-Bethany Pipeline, which would connect the reservoir to the SBA and the California Aqueduct. Recognizing LVE's potential benefits as emergency conveyance and storage, the Zone 7 Board approved participation in the Los Vaqueros Reservoir Expansion Project Planning in September 2016, with a $100,000 cash contribution. In January 2019, the Zone 7 Board approved continued participation in the project's planning activities through execution of the Multi-Party Agreement in an amount not-to-exceed $355,000. In August 2020, the Zone 7 Board approved continued participation in the LVE Multi-Party Agreement through December 2021 at a cost up to $1.014 million. While some new water supply may be available from LVE, Zone 7 is primarily evaluating the project as storage due to the uncertainty of the availability of such supplies given increasing Delta restrictions. The 2019 WSE Update assumed emergency storage in Los Vaqueros Reservoir at 10,000 AF.

15.2.1.3. Conjunctive Use

As described in **Section 5.2.3,** since the 1960s, Zone 7 has actively embraced a "conjunctive use" approach to Basin management by integrating management of local and imported surface water supplies with the management of local conveyance, storage, and groundwater recharge features. These features include local Arroyos (which are also used as flood protection facilities during wet seasons) and two former quarry pits (Lake I and Cope Lake). Zone 7's "artificial recharge" operation involves releasing imported water supplies into the local "losing stream" arroyos to recharge the Basin. The volume of artificial recharge is dependent on Zone 7's annual SWP allocations, precipitation captured locally, and water supply operations plans. Typically, Zone 7 will commence artificial recharge operations during times of surplus imported water availability.

15.2.1.4. Well Master Plan

In the early 2000s, Zone 7 identified the need to increase its groundwater production capacity to meet customer demands during projected droughts and water shortage emergencies. Zone 7's Well Master Plan (WMP), adopted by the Zone 7 Board in 2005, estimated that Zone 7 would need to install seven to nine new municipal water supply wells over the next 30 years to maintain Zone 7's potable water reliability goal. This estimate was based on Zone 7's then-current goal of maintaining 100% reliability even during worse-case drought conditions. Additional benefits of these new wells would include providing Zone 7 with improved operational flexibility to pump its stored water resources, optimizing groundwater production while maintaining groundwater levels above localized historic lows, and removing dissolved salts from more of the Basin.

The WMP provides a road map to guide construction of new Zone 7 wells in the Basin. Preparation of the WMP included development of hydrogeologic cross sections, compilation of aquifer test data, groundwater modeling, review of water quality data, field inspection of existing wells, and discussions with operations staff. Several levels of impact analysis were performed for potential well sites. Potential basin-wide water level impacts were assessed by comparing simulated drought water levels with historic lows. Potential impacts of Zone 7's planned drought operations on individual municipal wells were evaluated by comparing simulated water level lows to well construction information. Instances where simulated water levels fall below either the pump setting or top of well screen were noted and potential impacts to the well assessed.

The WMP recommended that Zone 7 install several municipal water supply wells in the Chain of Lakes (COL) and Gravel Pit Wellfields. The first two wells (COL 1 and 2) were completed in 2008, and the next well (COL 5) was completed in 2014. Another well (BV 1) is being planned for a site near Boulder Street and Valley Avenue in Pleasanton.

In November 2012, Zone 7's Board adopted the Water Supply Reliability Policy[55] which may change the quantity and urgency of new supply wells needed by Zone 7 as development occurs in the Basin (see

[55] As per board resolution: https://zone7.docsonthecloud.com/WebLink/DocView.aspx?id=14999&dbid=0&repo=Zone7

Section 3.2). With the adoption of the new reliability goals, implementation of additional water conservation measures, and expansion of recycled water use over the past ten years by Retailers the need for new wells has changed. Accordingly, the need for new supply wells and the timing of their construction will be further explored during future water supply planning efforts.

15.2.1.5. Chain of Lakes Recharge Projects

The coarse-grained alluvium in the center of the Main Basin has been mined for aggregate since the 19th century. Continued mining has impacts on the local water budget, groundwater levels and groundwater flow conditions (see **Sections 8** and **9**). Most notably, many of the quarry pits have been dug deep into the Upper Aquifer and some have been mined into the Lower Aquifer. This mining activity has removed aquifer material, created "windows" into the Basin, and exposed groundwater to large evaporative losses. Groundwater is also pumped from some of the pits and transferred to others or discharged to Cope Lake to facilitate gravel extraction. In the past the quarry operators discharged to the Arroyos which resulted in loss of water from the Basin. The quarries still maintain the permits which allow discharges to the arroyos, but they haven't exercised it since 2013. In addition, interruption of groundwater movement can result from the mining of aggregate resources and occasional placement of less permeable material in former pits.

Accordingly, Zone 7 has worked and is working closely with the mining companies and Alameda County Community Development Agency (the administrative representative of the State for mining operations and reclamation) to develop a reclamation plan whereby ownership of ten quarry lakes ("Chain of Lakes" A through I and Cope Lake, **Figure 15-1**) is to be transferred to Zone 7 for water resources management purposes. Two of the lakes have already been transferred to Zone 7 (Lake I and Cope Lake) and are currently operated and maintained by Zone 7 for storage and groundwater replenishment.

Full implementation of the Chain of Lakes use by Zone 7 is not expected before 2050 according to mining estimates and completion projections. However, Zone 7 is working on several interim projects that are designed to convey, capture, and recharge imported SWP water and captured mining releases, and/or detain peak stormwater flows.

In 2013, a water discharge pipeline was extended from the existing Arroyo Mocho discharge point to Cope Lake so that groundwater pumped during quarry operations could be captured in Cope Lake. Later in 2014, Zone 7 installed a pipeline between Cope Lake and Lake I to convey the discharge water to Lake I, where there is a much higher capacity for storage and ability for aquifer recharge.

Zone 7 continues working closely with Hanson, Inc. and Alameda County Community Development Agency to help complete final reclamation of Lake H. When reclamation is complete, Lake H will be deeded over to Zone 7 for water management.

In 2012, CEMEX, the current mining company primarily operating in the southern part of the Chain of Lakes area (Lakes A and B), started the amendment process for their surface mining permit due to anticipated changes in their planned mining. These proposed changes include realigning the Arroyo Mocho and changing the shape and size of Lakes A and B. Zone 7 staff reviewed and accepted the CEMEX conceptual design. The Supplemental Environmental Impact Report and Eliot Plant Reclamation Plan Amendment were approved by the Alameda County Planning Commission in June 2021.

15.2.2. Water Demand Reduction Management Actions

15.2.2.1. Existing and Future Non-Potable Recycled Water Use

Zone 7 views recycled water as a valuable component of the local water portfolio, when managed appropriately under a Salt/Nutrient Management Plan. Recycled water can reduce the demand for surface water imports and pumped groundwater and contribute to groundwater storage when incidental percolation occurs during irrigation of landscapes and crops.

Currently, the City of Livermore and DSRSD treat over 99% of the wastewater in the Basin and produce about 5,600 AFY of tertiary-treated (non-potable) recycled water. Initially the recycled water use was permitted under a Master Water Recycling Permit authorized by the California Regional Water Quality Control Board-San Francisco Bay Region (*RWQCB Order No. 93-159*) and jointly held by Zone 7, DSRSD and the City of Livermore. Livermore and DSRSD's recycled water production and distribution are now operating independently under *RWQCB's Order 96-011*, General Water Reuse Requirements for Municipal Wastewater and Water Agencies. The General Order includes requirements for self-monitoring and reporting to the RWQCB on at least an annual basis.

Most of this recycled water is used for landscape irrigation, with a minor amount used for dust suppression, grading projects, and crop irrigation. Only a small portion of the recycled water applied as irrigation percolates to the groundwater supply; most of the applied water is evaporated, taken up by plant roots, lost through plant transpiration, or retained as moisture in the unsaturated zone. In general, less than about three percent of the groundwater inflow comes from incidental recharge of recycled water. Currently, none of the recycled water is used for groundwater replenishment projects; however the use of purified recycled water as a future potable water supply is currently under consideration as a joint effort by Zone 7 and the four Retailers (California Water Company [Cal Water], DSRSD, Livermore, and Pleasanton) (see **Section 15.2.1.2)**.

Both City of Livermore and DSRSD plan to expand the use of recycled water for turf and landscape irrigation projects over the next few years. Similarly, Pleasanton is planning to use recycled water from DSRSD and/or Livermore for irrigation of city parks and landscapes located over the Main Basin. In 2020, the City of Pleasanton supplied its customers approximately 1,224 AF of recycled water *(West Yost, 2021)*. While recycled water is currently only a minor contributor to salt accumulation in the Main Basin, the average Total Dissolved Solid (TDS) concentration of the applied recycled water tends to be over twice the average TDS concentration of the potable water served by Zone 7. Mitigation of the water quality concerns related to salt and nutrient loading from recycled water use is addressed in Zone 7's Salt Management Plan and Zone 7's Nutrient Management Plan. Together, these reports meet the requirements of the State Water Board's Recycled Water Policy (*State Water Board, Resolution No. 2009-0011, adopted February 2009*). Zone 7 is collaborating with Livermore, DSRSD, and Pleasanton to mitigate for additional potential impact to groundwater quality from the future planned recycled water use (see **Section 5.1.2**).

15.2.2.2. Water Conservation

By managing water demands, water conservation is basic to ongoing achievement the Sustainability Goal for the Basin, including management of groundwater levels and storage, avoidance of land subsidence, maintenance of groundwater quality, and protection of environmental benefits associated with interconnected surface water.

Water conservation by Zone 7 and the Retailers is ongoing and will be maintained over the implementation horizon. Responsive to the Urban Water Management Planning Act, all the urban Retailers in the Basin (Cal Water, DSRSD, Livermore, and Pleasanton) have prepared at least 2010, 2015, and 2020 UWMPs. Zone 7 adopted its first UWMP in 1985, and then prepared an updated UWMP in 1991 in cooperation with Livermore, Pleasanton, and DSRSD. Zone 7 has prepared and adopted UWMPs every five years since 1995. Agency outreach and public noticing is included in the UWMP process, and public information is part of the ongoing implementation of water demand management measures. These water demand management measures are described in detail in the 2020 UWMP (**Appendix K**) and summarized below:

- **Metering** – Zone 7's wholesale water deliveries are fully metered, and calibration is verified on an annual basis. All facilities except for three wholesale meters (Cal Water Turnout #7, Cal Water Turnout #8, and Livermore Turnout #8) are fully equipped with Supervisory Control and Data Acquisition (SCADA) and security alarms and are maintained by Zone 7 mechanical, electrical, and instrumentation staff. Maintenance is performed per contract with the receiving wholesale customer. Zone 7 has metered its water deliveries over the past five years and plans to continue this effort into the future.

- **Public education and outreach** –Zone 7 promotes water conservation both independently and in coordination with its Retailers. Zone 7 collaborates on water conservation programs, including public education and outreach, with its Retailers through the Tri-Valley Water Conservation Task Force (Task Force). Zone 7's outreach is conducted mainly through events/workshops and its website, which contains links to educational resources on water conservation, calendar of upcoming workshops and events, rebate programs, landscaping and gardening tips, and profiles of Tri-Valley residents saving water.

- **Water Conservation Program coordination and staffing support** – The Task Force meets about six to eight times a year, as needed, to discuss and coordinate on current and future conservation programs, legislative activities related to conservation and water use efficiency, and public outreach and training activities. With Zone 7's Conservation Coordinator active in state-wide and regional organizations and committees, the Task Force also serves as a main venue for information/knowledge exchange among the agencies. During the recent drought, the Task Force led the coordination of drought response activities, with more active participation from management. Zone 7 has designated staff to actively develop, promote, enforce, and maintain water conservation programs. Zone 7 has a full-time Water Conservation Coordinator position, supported by administrative staff as needed on rebate processing and customer inquiries. A full-time Communications Specialist currently leads public outreach and education activities, including administration of the Schools Program and media campaigns.

- **Wholesale Supplier Assistance Programs** – Zone 7 offers several rebate programs in cooperation with three of its Retailers (Livermore, Pleasanton, and DSRSD). In recent years, Cal Water has administered its own statewide rebate conservation program. Zone 7 provides funding for the rebates and assists with the Retailers' rebate administration, including follow-up with applicants. Zone 7 coordinates with its Retailers to offer rebate programs to promote water efficiency. Along with three of its Retailers (DSRSD, Livermore, and Pleasanton), Zone 7 currently jointly offers three rebate programs to encourage indoor and outdoor water savings: Water-Efficient Lawn Conversion, Weather-Based Irrigation Controllers, and High-Efficiency Clothes Washers. Cal Water oversees their own statewide conservation program. These programs can reduce the cost for customers to increase water efficiency, thereby reducing water demand.

- **Asset Management** – As water infrastructure assets age, renewal and replacement become critical. Zone 7 utilizes an asset management process that systematically prioritizes rehabilitation and replacement and ensures long-term infrastructure sustainability. To maintain a reliable and high-quality water supply, Zone 7's asset management strategy focuses on core framework areas such as long-range planning, life-cycle costing, proactive operations and maintenance, long-term funding strategies, and capital replacement plans. Zone 7's Asset Management Plan (AMP) formally summarizes its asset management process and strategy by forecasting near-term renewal needs and long-term funding requirements through fiscal year (FY) 2057/2058. The AMP is updated regularly, with the most recent update in 2017.

The Zone 7 2020 UWMP also documents the Water Shortage Contingency Plan (WSCP), which provides a response to drought and other shortages. The WSCP presents six stages of action that Zone 7 established with the Retailers. The stages of action (from up to 10% to greater than 50% shortage) are linked to demand reduction targets, specified voluntary and/or mandatory actions, and triggers for implementation. Zone 7 works with the Retailers to monitor daily water production rates and water deliveries, and thereby allow the Retailers to evaluate the effectiveness of reduction efforts.

15.2.2.3. Groundwater Pumping Quota Program

As described in **Section 5.1.4** and **Section 9.3.6**, Zone 7 manages a Groundwater Pumping Quota (GPQ) program to limit groundwater pumping from the four Retailers (Cal Water, DSRSD, Livermore, and Pleasanton) to the "natural sustainable yield" of the Basin. In 1992, Zone 7 Water Agency calculated the natural sustainable yield for the basin at 13,400 AFY and collaborated with the Retailers to allocate the yield. As a result, each retailer is limited to an annual independent GPQ, which is generally based on average historical uses and is pro-rated based on the agreed upon natural sustainable yield. Together, the retailers are permitted to pump a total average of 7,214 AF annually per calendar year without paying recharge fees to Zone 7. Averages are maintained with a process of carry-overs (limited to 20% of the GPQ) and recharge fees for all groundwater pumping exceeding the GPQ and carry-over credit.

15.2.3. Projects to Improve Drinking Water Quality in Zone 7 Service Area

15.2.3.1. Well Ordinance Program

The construction, repair, reconstruction, destruction or abandonment of wells within Zone 7's service area is currently regulated by *Alameda County General Ordinance Code, Chapter 6.88*. As described in **Section 15.2.1**, Zone 7 administers the associated well permit program within its service area and the three incorporated cities (Dublin, Livermore, and Pleasanton) pursuant to a Memorandum of Understanding (MOU) with Alameda County. As a result, any planned new well construction, soil-boring construction, or well destruction must be permitted by Zone 7 before the work is started. Additionally, all unused or abandoned wells must be properly destroyed; or, if there are plans to use the well in the future, a signed statement of future intent must be filed at Zone 7. The program is transparent to the public; a copy of the current Zone 7 drilling permit application is available for download from the Zone 7 website. Well construction and destruction permit requirements are determined on a case-by-case basis, but generally follow DWR's *California Well Standards* (*Bulletins 74-81 and 74-90*).

As provided in the Alameda County Water Wells Ordinance, Special Requirement Areas have been defined within Zone 7's jurisdiction where soil boring permits are required for boreholes at 10 feet or greater depth, regardless of groundwater depth; supply wells are prohibited; and special well construction techniques are required for boreholes and monitoring wells to prevent vertical spreading of contamination. In addition, five Special Requirement Areas are clearly identified on the Zone 7 website; these are contamination sites where additional protection measures are required.

This program is active and ongoing and will be continued to the planning horizon. It provides benefits to several Basin management objectives, most notably protection of the Basin from any negative impacts that would be threatened by poorly constructed wells. Implementation of the Well Ordinance Program allows identification and compilation of data on all pumping wells in the basin; this indirectly supports the monitoring program (whereby wells may be identified for potential monitoring) and potential management of groundwater pumping, with potential future benefits to management of groundwater levels, storage, and subsidence.

15.2.3.2. Toxic Site Surveillance Program

As described in **Section 15.2.1** and **Section 8.6.7,** Zone 7 documents and tracks polluted sites that pose a potential threat to drinking water through its Toxic Sites Surveillance (TSS) Program.

15.2.3.3. Salt Management

As described in **Section 15.2.1**, Zone 7 prepared a Salt Management Plan (SMP) in 2004 to protect the long-term water quality of the Main Basin while expanding the area's use of recycled water. Recycled water is a critical part of the diverse water supply portfolio for the Livermore-Amador Valley (Basin). The SMP was a permit condition of the Master Water Recycling Permit, *RWQCB Order No. 93-159*, issued jointly to Zone 7, the City of Livermore, and DSRSD. The SMP was approved by the RWQCB in October 2004 and then incorporated into Zone 7's Groundwater Management Plan (GWMP) in 2005.

15.2.3.4. Groundwater Demineralization Program

The Mocho Groundwater Demineralization Plant (MGDP) has operated since 2009 to remove salts from the Basin while improving delivered drinking water quality. Since its construction, the MGDP has extracted 18,631 tons of salt from pumped groundwater (see **Table 15-A** below).

Table 15-A: Salts Removed by Zone 7's Mocho Groundwater Demineralization Plant Operations

Water Year	Brine Volume Exported from Valley (AF)	Average Brine TDS Concentration (mg/L)	Salt Mass Exported* (Tons)	Salt Removed per AF of Brine Export (Tons/AF)
2009	192	3,059	798	4.16
2010	675	3,010	2,760	4.09
2011	429	3,445	2,008	4.68
2012	935	3,198	4,062	4.34
2013	518	3,522	2,478	4.78
2014	214	3,607	1,049	4.9
2015	16	3,474	76	4.75
2016	51	2,662	184	3.61
2017	244	2,863	949	3.89
2018	268	3,209	1,168	4.36
2019	480	2,867	1,869	3.89
2020	344	2,633	1,230	3.58
TOTAL	**4,366**	**3,141**	**18,631**	**4.27**

AF = acre-feet
mg/L = milligrams per liter
TDS = total dissolved solids
* Exported directly to the LAVWMA pipeline

Zone 7 has used its groundwater model to evaluate salt loading impacts from the MGDP and the effects of a second Zone 7 groundwater demineralization plant planned for construction in the future.

15.2.3.5. Nutrient Management

As described in **Section 15.2.1**, Zone 7 adopted its NMP in June 2015, and by resolution the RWQCB concurred with the findings and measures of the NMP in March 2016. The NMP assesses the existing and projected future groundwater nutrient concentrations relative to the current and planned expansion of recycled water projects and future development in the Basin and outlined plans to minimize nitrogen loading from existing sources. The NMP also presented planned actions for addressing positive nutrient loads and high groundwater nitrate concentrations in localized Areas of Concern (AOCs) where onsite wastewater treatment systems (OWTS, e.g., septic systems) use is the typical method for sewage disposal (which can be a contributor to nitrate contamination). To minimize nitrogen loading, the NMP called for the continued use of Best Management Practices (BMPs) for such facilities as horse boarding facilities, vineyards, irrigated turf/landscapes, and wineries. The NMP also recommended implementing additional OWTS performance measures for new and replacement OWTS in the AOCs (see **Section 15.2.3.5** below). The NMP included an implementation schedule that recognized the ongoing monitoring and BMPs and presented a specific schedule for AOC investigations. Zone 7 continues to actively work with Alameda County Environmental Health (ACEH) to implement the NMP measures.

15.2.3.6. OWTS Management

As described in **Section 8.6.1.2**, there is a small, but quantifiable amount (estimated) of untreated wastewater that percolate to the Main Basin from OWTS and leaky sewer pipes discharges. In 1982, the Zone 7 Board of Directors adopted the "*Wastewater Management Plan for the Unsewered, Unincorporated Area of Alameda Creek Watershed above Niles* (WWMP)" and its recommended policies (*Resolution No. 1037*). A separate policy was established in 1985 that prohibits the use of septic tanks for new developments zoned for commercial or industrial uses (*Resolution No. 1165*). As a result of these policies, currently ACEH issues permits for the operation, installation, alteration, and repair of OWTS in Alameda County, while Zone 7 approval is required for the following types of OWTS projects located within the Upper Alameda Creek Watershed.

- New septic systems constructed partially or fully for a commercial or industrial use;
- Conversion or expansion of existing septic systems to a commercial or industrial use; or
- New residential septic systems that discharge greater than one Rural Residential Equivalence (RRE) of wastewater per five acres (one RRE per 10 acres inside the NMP nitrate Areas-of-Concern).

The Zone 7 NMP recommends that ACEH implement additional performance measures for new and replacement OWTS in the AOCs. No new performance measures were recommended for properly-working existing OWTS. These measures were designed to prevent nitrogen loading from increasing, and in the long term, to help decrease the loading in these nitrate "hot spots". Currently, Zone 7 is cooperating with ACEH in its implementation of the Local Agency Management Program (LAMP) for OWTS.

15.2.4. Data Gap-Filling and Other Alternative GSP Implementation Projects

Pending future available internal and grant funding, Zone 7 may conduct the following data gap filling activities and/or projects as part of Alternative GSP implementation:

- **Refinement and update of numerical groundwater flow model:** the current groundwater model domain mostly covers the Main Basin and only extends into a portion of the Fringe Area. With the expansion of active sustainable groundwater management to the Fringe and Upland Areas, it is imperative to update the model domain to cover all Management Areas and refine the model to reflect better understanding of hydrogeology and Basin characteristics. The updated model will become an essential tool to sustainably manage all applicable Sustainability Indicators for the entire Basin and render key management decisions as well as to determine more accurate Basin storage volume. Additionally, the updated model may be used to directly account for future climate change impacts to local hydrology using DWR's Climate Change Factors dataset (*DWR, 2018*) and to evaluate the efficacy of proposed P/MAs in mitigating climate change impacts.

- **Expansion of Water Quality Monitoring Program:** As described in **Section 14**, Zone 7 currently operates an ongoing robust Water Quality Monitoring Program. However, the expansion of the scope is warranted to address emerging contaminants such as PFAS compounds which could become threats to Basin water quality and viability of drinking water supply. Once implemented, the expanded Water Quality Monitoring Program will become a cornerstone to manage Basin water quality, wellhead protection and contaminant mobilization and aid operational decision making.
- **Expansion of Groundwater Level and Water Quality Monitoring Network in the Fringe and Upland Management Area:** Historically, Zone 7 focused groundwater level and quality monitoring in the Main Basin. With the expansion of active sustainable groundwater management to the Fringe and Upland Areas additional data gaps have been identified for both water level and quality, and the current monitoring network needs to be expanded (or measurement frequency increased) to cover data gap areas particularly in the Fringe and Upland Areas. Further, a refined understanding of the relationship, if any, of water quality to groundwater levels and Zone 7's groundwater management efforts need to be better understood so that the Sustainable Management Criteria (SMCs) can continue to be met and/or refined as appropriate. Similarly, a refined understanding of the relationship, if any, of groundwater dependent ecosystems to groundwater management efforts needs to be better understood so that the SMCs can continue to be met and/or refined as appropriate.
- **Groundwater Contaminant Mobilization Study:** To develop management strategies for constituents of concerns (including PFAS), Zone 7 plans to perform and update integrated water quality fate and transport simulations to evaluate existing and future groundwater operations, and the impact of constituents that pose existing and/or anticipated challenges. A specific scenario that this model can also be used for is the evaluation of whether introducing purified water into the Main Basin will mobilize any contaminants of concern.
- **Well Master Plan Update**: To account for sustainable management needs and the latest available data, Zone 7 plans to update the Well Master Plan in coming years.
- **Salt and Nutrient Management Plans Update**: Updates to the current SMP and NMP are planned.
- **Well Metering and Pumping Record**: To accurately track groundwater extraction data, Zone 7 plans to assess needs for well metering and groundwater pumping data collection. Based on this assessment, a pumping data collection program may be implemented.
- **Address and Resolve the Groundwater Storage Differences:** Moving forward, Zone 7 plans to continue to address and resolve the groundwater storage differences between those calculated from the Hydrologic Inventory (HI), Nodal / Rockworks Groundwater Elevation (GWE), and cross section methods and make revisions as appropriate (**Sections 8.4** and **9**). Zone 7 also plans on expanding the focus area of the Rockworks model beyond the areas focused on for this update for developing the three cross sections. In the long run Zone 7 is planning on using the cross sections,

the expanded Rockworks model, and the updated IDC model to update Zone 7's groundwater model.

- **Water Supply Risk Model:** Zone 7 maintains and utilizes a risk model to assess the reliability of its existing and planned water supplies. The risk model evaluates Zone 7's operations under various hydrologic conditions. The current excel-based risk model runs on an annual time step, and thus produces a simplified representation of water supply operations. Zone 7 is currently developing a robust risk model using RiverWare software. This model will run on a monthly time step, and it will be able to represent the seasonal availability of supplies including local runoff, imported surface water, recovered water from groundwater banks and local groundwater in an integrated manner. The new risk model will also be able to account for the risks associated with 2030 and 2070 climate change scenarios on water supply. The risk model can be used to conduct various long-term planning studies and reports, as well as short-term planning and operating decisions. Additionally, the risk model can be used in conjunction with the groundwater model to analyze sustainable management of the groundwater basin.

15.3. Circumstances for Implementation

☑ **23 CCR § 354.44(b)(1)(A)**

As stated above, the goals and objectives of the P/MAs presented herein are to avoid and/or address any potential URs and to meet the MOs for the relevant Sustainability Indicators. While many existing P/MAs are already in place, future P/MAs will be implemented incrementally on an as-needed basis to achieve this goal. For example, P/MAs will be selected for implementation based on observed Basin conditions (i.e., if MTs are exceeded in Representative Monitoring Sites [RMS], see **Section 13**), further consideration of the magnitude of expected P/MA benefit, the relative cost and ease of implementation, and other factors (e.g., when grant funds are obtained or upon completion of feasibility studies, economic evaluations, and/or other necessary planning studies). The planning and implementation of P/MAs will be supported by the best available information and science.

15.4. Public Notice Process

☑ **23 CCR § 354.44(b)(1)(B)**

Zone 7 involves the public, stakeholders and local agencies in its planning and programs through meetings, data sharing, and online media and has memorialized this approach as an operational policy in the Agency's 1987 Statement on Groundwater Management (*Zone 7, 2016a*) and through development of a Stakeholder Communications and Engagement Plan (SCEP) as part of this Five-Year Update to the Alternative GSP (see **Section 5.5** and **Appendix H**).

15.5. Addressing Overdraft Conditions

☑ 23 CCR § 354.44(b)(2)

As demonstrated in **Sections 8** and **9**, the Basin is not in a condition of overdraft. The P/MAs presented herein are designed to maintain ongoing compliance with the Sustainability Goal for the Basin and to prevent the occurrence of URs throughout the 50-year Alternative GSP planning and implementation horizon.

15.6. Permitting and Regulatory Process

☑ 23 CCR § 354.44(b)(3)

The permitting and regulatory requirements vary for the different P/MAs depending on whether they are infrastructure projects, recharge projects, management actions, and so forth. The various types of permitting and regulatory requirements (not all applicable to every P/MA) may include the following:

- Federal
  - National Environmental Policy Act (NEPA) documentation, if federal grant funds are used;
  - National Pollution Discharge Elimination System (NPDES) stormwater program permit (administered by the California State Water Resources Control Board [SWRCB]);
- State
  - CEQA documentation, including one or more of the following: Initial Study (IS), Categorical Exemption (CE), Negative Declaration (ND), Mitigated Negative Declaration (MND), Environmental Impact Report (EIR);
  - SWRCB permits and regulations regarding recycled water use, waste discharge, and stormwater capture for recharge;
  - California Surface Mining and Reclamation Act (SMARA) regulations;
  - California Division of Safety of Dams regulations;
- Regional
  - RWQCB permits for work involving waters of the state or work in channels/arroyos
- County/Local
  - Encroachment or enter to do work permits

Upon initiation of any new P/MA, the regulatory and permitting requirements of the P/MA will be re-examined. As with any P/MA planned or implemented under the SGMA, actions undertaken will remain in compliance with existing water rights constraints and processes under California and Federal law.

15.7. Status and Implementation Timetable

☑ 23 CCR § 354.44(b)(4)

As mentioned previously, most of the P/MAs discussed herein have already been implemented as part of Zone 7's on-going sustainable management of the Basin or are currently in the planning and permitting stages. Any future P/MAs that have not been implemented will be initiated in a manner and sequence that supports continued compliance with the Sustainability Goal for the Basin and ensures that SMCs are being met for each applicable Sustainability Indicator within the Basin throughout the 50-year Alternative GSP planning and implementation horizon.

15.8. Expected Benefits

☑ 23 CCR § 354.44(b)(5)

The different categories of expected benefits are presented above in **Section 15.1.2.** Most P/MAs have expected benefits related to water quantity and/or water quality, with a direct or indirect benefit to the other Sustainability Indicators. Once a P/MA is implemented, it is important to evaluate, ideally to quantify, the benefits resulting from that P/MA as part of monitoring and data collection activities. The specific way in which P/MA benefits are evaluated and/or quantified depends on the P/MA. Ultimately the success of the collective implementation of P/MAs will be determined by whether the Sustainability Goal for the Basin continues to be achieved.

For those P/MAs that involve direct supply augmentation, the benefit is quantified directly through measurement of those supply augmentation volumes and groundwater levels. For the P/MAs that involve water demand reduction the benefit will be evaluated by comparison of the water demand before and after the P/MA was in place. For the P/MAs that involve water quality improvement, the benefit will be evaluated by continued monitoring of groundwater constituents of concern (COCs) before and after the P/MA was in place. Because it is not possible to determine with certainty what the condition without the P/MA would be like, quantification of the benefits is inherently uncertain.

15.9. Source and Reliability of Water from Outside the Basin

☑ 23 CCR § 354.44(b)(6)

As described in **Section 9.4,** Zone 7 anticipates future supply deficits as SWP reliability continues to decline and Zone 7's service area population grows. As a result, Zone 7 is pursuing several water supply reliability projects to obtain additional water storage and water supplies, address the need for alternative conveyance in the Delta, and improve access to groundwater and local emergency supplies. These future water supply projects are described in detail in the 2020 UWMP (**Appendix K**) and summarized above.

15.10. Legal Authority Required

☑ 23 CCR § 354.44(b)(7)

Per California Water Code (CWC) § 10725 through 10726.8, as the exclusive Groundwater Sustainability Agency (GSA) for the Basin, Zone 7 possesses the legal authority necessary to implement the supply augmentation and demand management P/MAs described herein and will enforce these P/MAs as necessary to enforce the Alternative GSP.

15.11. Estimated Costs and Plans to Meet Them

☑ 23 CCR § 354.44(b)(8)

Zone 7 invests in long-term financial planning and fiscal organizational sustainability in order to ensure all areas of Zone 7 are ready and resilient for any economic storms. It's accomplished by maintaining tight budgetary controls, embodied in the two-year budget approved by Zone 7's Board of Directors. The annual appropriated budget is made up of the operating budget (consisting of total operations and operating projects) and the capital budget (consisting of capital project expenditures). The most recent budget supports the adopted 2020-2024 strategic plan, which was adopted on June 17, 2020, and subsequently amended FY 2021-22 on June 16, 2021.

The funding for SGMA compliance is an integral part of Zone 7 budget. As such, funding mechanisms for P/MA implementation will be formulated and planned in upcoming budget cycles in accordance with their priorities and implementation schedules. Funding sources will include water rate, connection fees, and State/Federal grants. **Table 15-B** shows projected budget for next five years.

Table 15-B: Five-Year Projected Budget

	Livermore Basin Alternative Groundwater Sustainability Plan Implementation Costs						
Account	Fiscal Year 2021 Actual Amount	Fiscal Year 2022 Amended Budget	Fiscal Year 2023 Projected Budget	Fiscal Year 2024 Projected Budget	Fiscal Year 2025 Projected Budget	Fiscal Year 2026 Projected Budget	Funding Sources
Labor	982,208.78	1,344,565.00	1,384,901.95	1,426,449.01	1,469,242.48	1,513,319.75	Water Rates
Professional Services	304,247.69	308,200.00	317,446.00	326,969.38	336,778.46	346,881.82	Water Rates
Communications	3,255.76	5,850.00	6,025.50	6,206.27	6,392.45	6,584.23	Water Rates
Repairs and Maintenance	3,560.62	8,600.00	8,858.00	9,123.74	9,397.45	9,679.38	Water Rates
Rental Services	-	500.00	515.00	530.45	546.36	562.75	Water Rates
General Office Services/ Supplies	15,677.07	34,450.00	35,483.50	36,548.01	37,644.45	38,773.78	Water Rates
Organizational Membership/ Participation	1,850.00	1,900.00	1,957.00	2,015.71	2,076.18	2,138.47	Water Rates
Other Services/ Supplies	2,010.20	6,250.00	6,437.50	6,630.63	6,829.54	7,034.43	Water Rates
Training and Travel	757.50	3,650.00	3,759.50	3,872.29	3,988.45	4,108.11	Water Rates
Other Planning Efforts and Capital Projects							
Well Master Plan update			180,000.00	180,000.00			Water Rates, Connection Fees, and grants
Groundwater Model Upgrade		90,000.00	90,000.00				Grant Funds
Salts and Nutrients Management Plan update					330,000.00		Grant Funds
PFAs Management Program		60,000.00	60,000.00	60,000.00	60,000.00	60,000.00	Grant Funds
Total Other Planning Efforts and Capital Projects	-	150,000.00	330,000.00	240,000.00	390,000.00	60,000.00	
EXPENSES Total	**1,313,567.62**	**1,863,965.00**	**2,095,383.95**	**2,058,345.47**	**2,262,895.83**	**1,989,082.71**	

15.12. Management of Recharge and Groundwater Extractions during Periods of Drought

☑ **23 CCR § 354.44(b)(9)**

The supply augmentation P/MAs are designed and to be implemented to recover groundwater levels and storage declines during future drought periods by increasing groundwater levels and storage during other normal and wet years. In addition to these supply augmentation P/MAs, the portfolio also includes policy-based management actions aimed at demand reduction. Through this combination of increased recharge during wet years and demand reduction, Zone 7's P/MA efforts have and will ensure that lowering of groundwater levels and storage during drought is offset by increases in groundwater levels and storage during other periods (see **Section 8.3.3**).

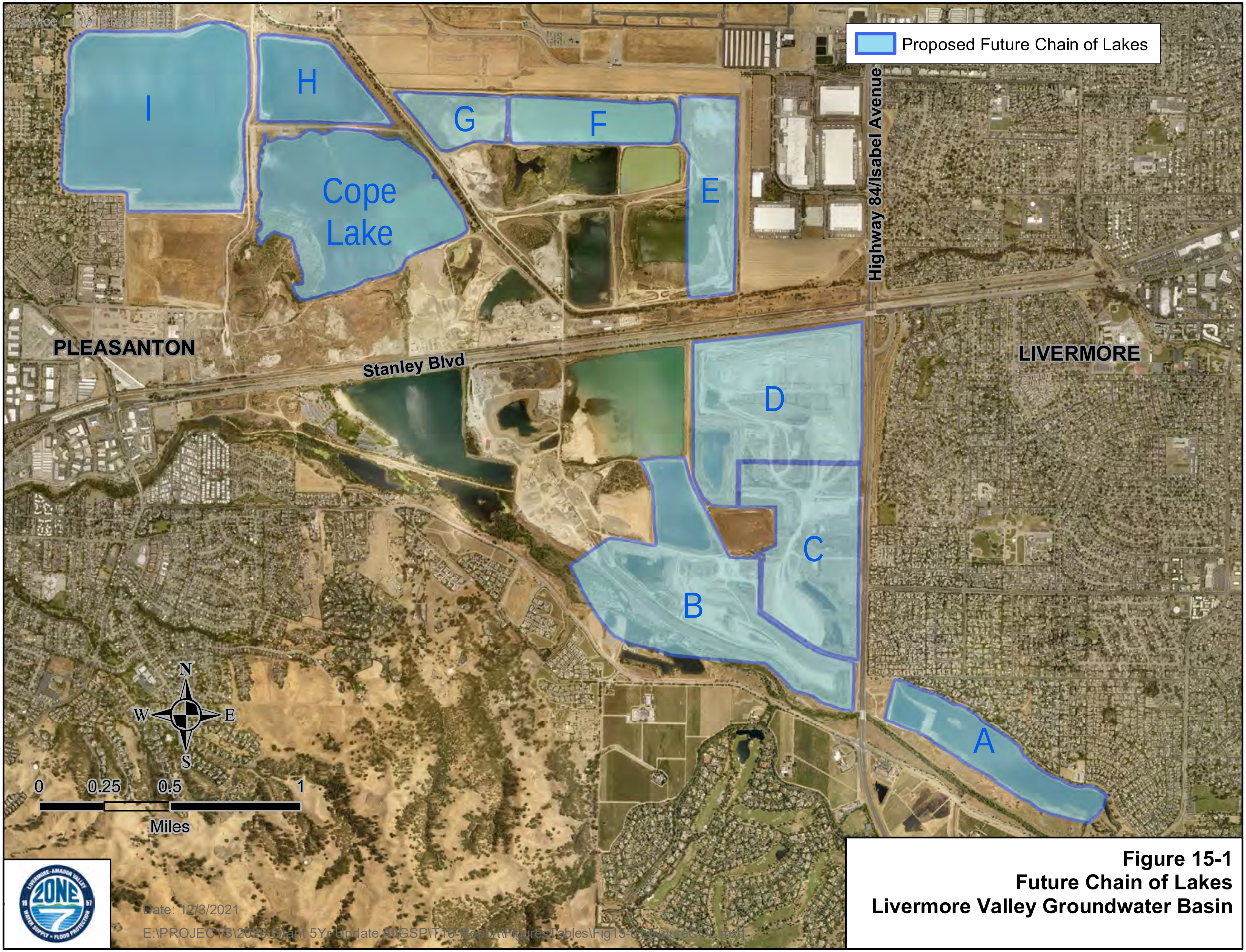


Figure 15-1
Future Chain of Lakes
Livermore Valley Groundwater Basin

REFERENCES AND TECHNICAL STUDIES

(SUBTITLE PAGE)

16. REFERENCES

☑ 23 CCR § 354.4

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Zone 7 Water Agency
100 North Canyons Parkway, Livermore, CA 94551

December 2021

Alternative Groundwater Sustainability Plan

for the Livermore Valley Groundwater Basin

Appendices

ZONE 7 WATER AGENCY
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APPENDIX A

DWR'S RECOMMENDATIONS ON THE 2016 ALTERNATIVE GSP

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER
MANAGEMENT OFFICE
901 P Street, Room 313-B | Sacramento, CA 95814 | P.O. Box 942836 | Sacramento, CA 94236-0001

July 17, 2019

Mr. Matt Katen
Zone 7 Water Agency
100 N. Canyons Parkway
Livermore, California 94551

Dear Mr. Katen,

The Department of Water Resources (Department) has evaluated the alternative submitted for the Livermore Valley Basin. Based on recommendations from the Staff Report, included as an exhibit to the attached Statement of Findings, the Department has determined that the Livermore Valley Alternative satisfies the objectives of the Sustainable Groundwater Management Act (SGMA) and is approved. The Staff Report also proposes recommended actions for the consideration of the Zone 7 Water Agency that the Department believes will enhance the Alternative and facilitate future evaluation by the Department. The recommended actions do not constitute a qualified approval of the Alternative; however, the Department encourages they be given due consideration and suggest incorporating any resulting changes to the Alternative in future updates.

As required by SGMA, the Department shall review approved alternatives to ensure they remain in compliance with the objectives of the Act. Approved alternatives are required to submit annual reports to the Department on April 1 of each year, and to resubmit the alternative by January 1 every five years. The first five-year update is due by January 1, 2022.

Please contact me at (916) 651-0870 or Craig.Altare@water.ca.gov if you have any questions related to the Department's evaluation or your implementation of the approved alternative.

Thank You,

Craig Altare, P.G.
Supervising Engineering Geologist

Attachments:

1. Statement of Findings Regarding the Approval of the Livermore Valley Basin Alternative

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

STATEMENT OF FINDINGS REGARDING THE APPROVAL OF THE LIVERMORE VALLEY BASIN ALTERNATIVE

The Department of Water Resources (Department) is required to evaluate and assess whether submitted alternatives to groundwater sustainability plans satisfy the objectives of the Sustainable Groundwater Management Act (SGMA) pursuant to Water Code Section 10733.6. This Statement of Findings explains the Department's decision regarding the alternative (Alternative) submitted by Zone 7 Water Agency for the Livermore Valley Groundwater Basin (Basin No. 2-10). The Alternative was submitted under Water Code Section 10733.6(b)(3), which allows for the submittal of an analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years.

Department management has reviewed the Department staff report, entitled Sustainable Groundwater Management Program Alternative Assessment Staff Report – Livermore Valley Basin (Staff Report), attached as Exhibit A, recommending approval of the Alternative. Based on its review of the Staff Report, Department management is satisfied that staff have conducted a thorough evaluation and assessment of the Alternative and concurs with staff's recommendation and all the recommended actions, and thus hereby approves the Alternative on the following grounds:

1. The Alternative was submitted within the statutory deadline of January 1, 2017 (Water Code Section 10733.6(c)).

2. The Alternative is within a basin that is in compliance with Part 2.11 (commencing with Water Code Section 10920) as required by Water Code Section 10733.6(d).

3. The Alternative has been submitted by Zone 7 Water Agency pursuant to Water Code Section 10733.6(b)(3) and included a report prepared by a registered professional geologist who is licensed by the state and was submitted to the Department under that geologist's seal. The data submitted in support of the Alternative included continuous data from the end of the 10-year period to current conditions. 23 CCR Section 358(c)(3).

4. The Zone 7 Water Agency explained how the elements of the Alternative are functionally equivalent to the elements of a groundwater sustainability plan required by Articles 5 and 7 of the GSP Regulations, 23 CCR Section 350 et seq., in the Alternative Elements Guide submitted by the Agency.

5. Based on Paragraphs 3 and 4 above, the Alternative is considered complete and includes the information required by SGMA and the GSP Regulations, sufficient to warrant an evaluation by the Department. 23 CCR Section 358.4(a)(3).

6. The Alternative applies to and covers the entire Basin as required by 23 CCR Section 358.2(a) and 358.4(a)(4), respectively, and as discussed in Section IV.D of the Staff Report.

7. The Zone 7 Water Agency has the legal authority and financial resources necessary to implement the Alternative.

8. The Department has received public comments on the Alternative and has considered them in the evaluation of the Alternative as required by 23 CCR Section 358.2(f).

Department management makes the following specific findings based on the evaluation and assessment of the Alternative prepared by Department staff:

9. The Alternative demonstrated that the Zone 7 Water Agency had, prior to SGMA, established goals and implemented projects and management actions to address historical overdraft experienced in the early 1900s until the mid-1960s.

10. The Alternative demonstrates that the Zone 7 Water Agency has a sufficient and reasonable understanding of the groundwater conditions in the Livermore Valley Basin that would cause undesirable results and how to avoid those undesirable results by stabilizing groundwater levels through importing water, implementing groundwater management programs and artificial recharge.

11. The Zone 7 Water Agency developed a natural sustainable yield for the Basin, relying on sufficient and credible information and data, and developed groundwater pumping quotas based on the sustainable yield. The groundwater pumping quotas, in addition to artificial recharge and other management actions, has ensured the Basin has been operated within its sustainable yield for a period of at least 10 years.

12. The Zone 7 Water Agency will continue to implement its projects and management actions to ensure the Livermore Valley Basin will be operated within its sustainable yield.

13. In light of Paragraphs 1-12 above, the Alternative satisfies the objectives of SGMA.

In addition to the grounds listed above, the Department also finds that:

1. The Alternative has demonstrated that the Basin is being operated within it sustainable yield and is consistent with the state policy regarding the human right to water (Water Code Section 106.3) and the public trust doctrine.

2. The evaluation and assessment of whether the Alternative submitted by the Zone 7 Water Agency for the Livermore Valley Basin satisfies the objectives of SGMA is a project under CEQA, but that the project is exempt from CEQA under the common sense exemption for the following reasons.

   No physical change to the environment is associated with the evaluation and assessment of the alternatives undertaken by the Department. The Alternative submitted by the Agency is based on a Groundwater Management Plan and projects and management actions that were previously adopted and the Agency has already begun implementing.

   By finding that the Alternative satisfies the objectives of SGMA, the Agency is authorized to continue to manage the basin subject to that Alternative, without the need to develop a GSP. As a result, the evaluation and assessment of the Alternative undertaken by the Department creates no foreseeable indirect impacts, and any impacts that might occur would be difficult to predict with any accuracy and too speculative to allow the Department to provide for meaningful analysis and review.

Based on the above, the Alternative submitted by the Zone 7 Water Agency for the Livermore Valley Basin is approved. Recommended actions identified in the Staff Report will assist the Department's review of the Alternative's implementation for consistency with SGMA and are thus recommended to be included in the resubmitted Alternative, due on January 1, 2022, as required by Water Code Section 10733.6(c).

Signed:

Karla A Nemeth

Karla Nemeth, Director

Date: July 17, 2019

Exhibit A: Sustainable Groundwater Management Program Alternative Staff Report – Livermore Valley Basin

State of California
Department of Water Resources
Sustainable Groundwater Management Program
Alternative Assessment Staff Report

Groundwater Basin Name:	Livermore Valley (Basin No. 2-010)
Submitting Agency:	Zone 7 Water Agency
Recommendation:	Approve
Date Issued:	July 17, 2019

I. Summary

The Zone 7 Water Agency (Zone 7 or Agency) submitted an alternative (Livermore Valley Alternative *or* Alternative) for the Livermore Valley Groundwater Basin (Livermore Valley Basin or Basin) to the Department of Water Resources (Department) for evaluation and assessment as provided by the Sustainable Groundwater Management Act (SGMA).[1] The Livermore Valley Alternative is based on an analysis of basin conditions that demonstrates the basin has operated within its sustainable yield over a period of at least 10 years.[2] The Livermore Valley Alternative uses information developed previously as part of water resources planning efforts, which are described in other related documents and referenced through the Alternative Report. After a review of the Alternative Report, other related documents, and consideration of public comments submitted to the Department, Department staff find that the Livermore Valley Alternative satisfies the objectives of SGMA and recommends approval of the Alternative.

Zone 7 was established in 1957 to address water supply and flooding in the Livermore Valley and manage the Livermore Valley Basin to reverse the then-existing overdraft condition of the Basin.[3] Zone 7 represents one of ten zones in the Alameda County Flood Control and Water Conservation District area within Alameda County. The Agency has been addressing water resources issues since it was established.[4] The planning documents referenced in the Alternative Report document established goals and implemented projects and management actions by the Agency to address historical overdraft experienced in the early 1900s until the mid-1960s. The Livermore Valley Alternative demonstrates that the Agency has a good understanding of groundwater

[1] Water Code § 10720 *et seq*.
[2] Water Code § 10733.6(b)(3)
[3] Groundwater Management Plan, Section 2.1, p. 2-3
[4] Groundwater Management Plan, Section 2.1, pp. 2-1 to 2-4

conditions and sustainable management, and has stabilized groundwater levels through importing water, implementation of groundwater management programs, and artificial recharge.

Furthermore, Department staff considers the information that the Agency provided to be sufficient to demonstrate the Basin has been operating within the sustainable yield for at least 10 years. The Agency has accomplished operating within the Basin's sustainable yield by managing to target values for inflows and outflows from the Basin. These target values of inflows were developed in 1992, based on the Agency's approximation of the natural sustainable yield of the Basin, which is the sum of the average amount of natural recharge from percolation of rainfall, natural stream flow, and irrigation waters, and inflow of subsurface water.[5] The natural sustainable yield of the Basin was then used by the Agency as the basis for allocating pumping amounts to municipal pumpers, which each have an established groundwater pumping quota. In general, this management approach, in addition to artificial recharge by the Agency has kept the Basin from repeating historical overdraft conditions.[6] The Agency states that use of an established groundwater pumping quota, artificial recharge, and other management actions have maintained operation of the basin within the sustainable yield. The Alternative includes a description of an extensive monitoring program and data enabling the Department and the public to track conditions over time.

The Alternative sufficiently demonstrates that the Livermore Valley Basin has operated within its sustainable yield for a period of at least 10 years. In addition, staff have identified recommended actions that are designed to facilitate the Department's ongoing evaluation and assessment of the Plan including implementation and a determination of whether the Plan continues to satisfy the objectives of SGMA or adversely affects an adjacent basin.

The remainder of this assessment is organized as follows:

- **Section II. Review Principles** describes the legal and other considerations regarding the Department staff's assessment and evaluation of alternatives.
- **Section III. Alternative Materials** describes materials (i.e., plans, reports, data, and other information) submitted by the Agency that, collectively, the Department considered as the Alternative.
- **Section IV. Required Conditions** describes whether the Alternative satisfies each of the four conditions required for the Department to review an alternative.
- **Section V. Alternative Contents** describes the information contained in the Alternative submittal.

[5] Alternative Report, Section 2.4.4, pp. 2-90 to 2-92
[6] Alternative Report, Section 2.4.4, pp. 2-90 to 2-92

- **Section VI. Assessment** describes Department staff's evaluation of the Alternative, whether it satisfies the objectives of SGMA, and, if applicable, describes recommended actions proposed for the first five-year update.

II. Review Principles

The Department has evaluated the Alternative to determine whether it satisfies the objectives of SGMA for the Livermore Valley Basin. To satisfy the objectives of SGMA, an alternative based on an analysis of basin conditions must demonstrate that the basin has been operated within its sustainable yield for a period of at least 10 years.[7] The SGMA definition of sustainable yield requires the avoidance of undesirable results.[8] As a result, an alternative based on an analysis of basin conditions must demonstrate that the submitting agency has an understanding of groundwater conditions that would cause undesirable results, as well as analysis in the alternative demonstrating the absence of undesirable results over a 10-year period.

An alternative, to be evaluated by the Department, must be submitted by the statutory deadline and be within a basin that complies with Part 2.11 of Division 6 of the Water Code.[9] The submitted alternative must also be complete and must cover the entire basin.[10] The GSP Regulations[11] require the Department to evaluate an Alternative "in accordance with Sections 355.2, 355.4(b), and Section 355.6, *as applicable*, to determine whether the Alternative complies with the objectives of the Act".[12] The elements of the cited sections are not all applicable to alternatives. Some provisions apply to GSPs and alternatives alike, to alternatives only prospectively, or do not apply to alternatives at all.[13] Ultimately, the purpose of the evaluation is to determine whether an alternative satisfies

[7] Water Code § 10733.6(b)(3)
[8] Water Code § 10721(w)
[9] Water Code § 10733.6(c)-(d)
[10] 23 CCR § 358.4(a)
[11] 23 CCR § 350 *et seq.*
[12] 23 CCR § 358.4(b) (emphasis added)
[13] Procedural requirements, including submissions by the agency, posting by the Department, and the public comment period, apply equally to plans and alternatives (23 CCR § 355.2(a)-(c)). The periodic review of Plans (23 CCR § 355.6(a)) applies to alternatives prospectively but does not apply to initial submissions. Other regulatory provisions are inapplicable to alternatives, including the two-year review period (23 CCR § 355.2(e)), which is based on the statutory time-frame that applies to Plans but not alternatives (Water Code § 10733.4(d)); the "incomplete" status that allows the agency to address "one or more deficiencies that preclude approval, but which may be capable of being corrected by the Agency in a timely manner" (23 CCR § 355.2(e)(2)), which applies to plans undergoing development, but not alternatives that purportedly satisfy the objectives of SGMA at the time of their submission (Water Code § 10733.6(a)); and, for the same reason, corrective actions to address deficiencies in plans (23 CCR § 355.4(a)(4)), which applies to plans developed after the adoption of SGMA, but is inapplicable to alternatives that predate SGMA.

the objectives of SGMA.[14] The agency must explain how the elements of an alternative are "functionally equivalent" to the elements of a GSP required by Articles 5 and 7 of the GSP Regulations and are sufficient to demonstrate the ability of an alternative to achieve the objectives of SGMA.[15] The explanation by the agency that elements of an alternative are functionally equivalent to elements of a GSP furthers the objective of demonstrating that an alternative satisfies the objectives of SGMA. Alternatives based on groundwater management plans or historical basin management practices that predate the passage of SGMA or adoption of GSP Regulations, although required to satisfy the objectives of SGMA, are not necessarily expected to conform to the precise format and content of a GSP. The Department's assessment is thus focused on the ability of an alternative to satisfy the objectives of SGMA as demonstrated by information provided by the agency; it is not a determination of the degree to which an alternative matched the specific requirements of the GSP Regulations.

When evaluating whether an alternative satisfies the objectives of SGMA and thus is likely to achieve the sustainability goal for the basin, staff reviews the information provided by and relied upon by the agency for sufficiency, credibility, and consistency with scientific and engineering professional standards of practice.[16] The Department's review considers whether there is a reasonable relationship between the information provided and the assumptions and conclusions made by the agency, whether sustainable management criteria and projects and management actions described in an alternative are commensurate with the level of understanding of the basin setting, and whether those projects and management actions are feasible and likely to prevent undesirable results.[17] Staff will recommend that an alternative be approved if staff believe, in light of these factors, that alternative has achieved or is likely to achieve the sustainability goal for the basin.[18]

An alternative based on a demonstration that the basin has operated within its sustainable yield over a period of at least 10 years may be approved based on information that demonstrates that objective criteria defining operating standards that governed groundwater management for the basin were established and consistently achieved. Even when staff review indicates that an alternative will satisfy the objective of SGMA, the Department may recommend actions to facilitate future evaluation of that alternative and to allow the Department to better evaluate whether an alternative adversely affects

[14] Water Code § 10733.6(a)). The Department considers the regulatory language in 23 CCR § 358.2(d) ("complies with the objectives of [SGMA]") to be equivalent to the statutory threshold upon which it is based.
[15] 23 CCR § 358.2(d)
[16] 23 CCR § 351(h)
[17] 23 CCR § 355.4(b)(1), (3), and (5).
[18] 23 CCR § 355.4(b)

adjacent basins. DWR proposes that recommended actions be addressed by the submission date for the first periodic evaluation.

Staff assessment of an alternative involves the review of information presented by the agency, including models and assumptions, and an evaluation of that information based on scientific reasonableness. The assessment does not require Department staff to recalculate or reevaluate technical information provided in an alternative or to perform its own geologic or engineering analysis of that information. The staff recommendation to approve an alternative does not signify that Department staff, were they to exercise the professional judgment required to develop a plan for the basin, would make the same assumptions and interpretations as those contained in an alternative, but simply that Department staff has determined that the assumptions and interpretations relied upon by the submitting agency are supported by adequate, credible evidence, and are scientifically reasonable.

III. Alternative Materials

The Agency submitted an alternative based on an analysis demonstrating the Basin has operated within its sustainable yield for a period of at least 10 years, pursuant to Water Code Section 10733.6(b)(3). The Livermore Valley Alternative includes the following documents:

- Alternative Groundwater Sustainability Plan for the Livermore Valley Groundwater Basin, December 2016 (Alternative Report *or* Report). The Alternative Report is the primary document relied upon by the Agency to show the Basin operated within its sustainable yield for at least 10 years.
- Groundwater Management Plan for Livermore-Amador Valley Groundwater Basin, 2005 (Groundwater Management Plan).[19] The Groundwater Management Plan was prepared by the Agency to provide the framework for groundwater management planning and has been implemented in coordination with other water management planning efforts since adoption in 2005.
- Annual Report for the Groundwater Management Program, 2015 Water Year (2015 Annual Report). The 2015 Annual Report was completed for the Groundwater Management Program and conveys data for historical and 2015 groundwater elevation monitoring, 2015 surface water flows and quality monitoring, historical and 2015 groundwater quality monitoring, 2015 water level and water quality data from mining area ponds or quarry lakes as part of the Chain of Lakes/Mining Area Monitoring Program, ground surface elevation changes at

[19] The basin name used in the Groundwater Management Plan was the Livermore-Amador Valley Groundwater Basin.

benchmark locations as of 2015 (as part of Land Surface Elevation Monitoring Program), and historical and 2015 climate monitoring.

- Annual Report for the Groundwater Management Program, 2014 Water Year (2014 Annual Report). The 2014 Annual Report was completed for the Groundwater Management Program and conveys data for historical and 2014 groundwater elevation monitoring, 2014 surface water flows and quality monitoring, historical and 2014 groundwater quality monitoring, 2014 water level and water quality data from mining area ponds or quarry lakes as part of the Chain of Lakes/Mining Area Monitoring Program, ground surface elevation changes at benchmark locations as of 2014 (as part of Land Surface Elevation Monitoring Program), and historical and 2014 climate monitoring.
- Salt Management Plan, 2004. The Salt Management Plan was prepared to address the increasing level of total dissolved solids in the main groundwater basin (Main Basin) and provides technical information and analysis that support the Agency's salt management strategy.
- Nutrient Management Plan, Livermore Valley Groundwater Basin, 2015 (Nutrient Management Plan). The Nutrient Management Plan was prepared as an addendum to the Agency's Salt Management Plan and provides an assessment of the existing and future groundwater nutrient concentrations in the Basin and presents planned actions for addressing nutrient loads and high groundwater nitrate concentrations in localized areas of concern.
- 2015 Urban Water Management Plan (UWMP). The UWMP documents the Agency's most recent (as of 2015) water supply planning efforts which address water demand, water supply, and water resource management for the region covered by the urban water suppliers (Dublin San Ramon Services District, Livermore, Pleasanton, and California Water Service Company) in the Livermore-Amador Valley.
- Water Supply Evaluations Update, 2016. The Water Supply Evaluations Update provides an evaluation of Zone 7's long-term water supply and incorporates key assumptions, an approach, an analysis, and results that were vetted with the Livermore-Amador Valley's local water supply retailers.
- Draft Report Well Master Plan, 2003. The Draft Report Well Master Plan presents an understanding of the hydrogeology of the basin through cross sections, compilation of aquifer test data, groundwater modeling, and water quality data. The intent of the document was to identify preferred locations for wells and wellfields, and provide a preliminary guide for well construction, well production rates, total well yield, spacing requirements, design, cost, and potential water quality impacts.
- Historical SqueeSAR Ground Deformation Analysis over Livermore and Pleasanton, (CA) using ERS, ENVISAT and Sentinel Satellites, TRE Altimara, 2016 (Ground Deformation Analysis) (InSAR Report). The InSAR Report

documents an InSAR analysis that was performed using radar data for the 24-year period between 1992 and 2016, from three different satellites, to evaluate ground movement by measuring surface deformation in the areas of Livermore and Pleasanton.

- A Report of the History of Adjusted Values of Bench Marks Located in the Vicinity of the Main Groundwater Basin of the Livermore-Amador Valley, Altamont Land Surveyors, 1994 (Benchmark Report). The Benchmark Report documents a compilation of the available recorded elevations of localized bench marks established and monitored by Federal and Local Government agencies in what is referred to in the report as the main groundwater basin of the Livermore-Amador Valley.

The Agency also submitted an Alternative Elements Guide (Elements Guide) and a notice of exemption from the requirements of the California Environmental Quality Act (CEQA). The Agency has submitted Annual Reports, as required.[20] Other information provided to or relied upon by the Department has been posted on the Department's website and includes material submitted by the Agency, public comments, and correspondence.

IV. Required Conditions

An alternative, to be evaluated by the Department, must be submitted by a statutory deadline and be within a basin that complies with Part 2.11 of Division 6 of the Water Code.[21] The submitted alternative must also be complete and must cover the entire basin.[22]

A. Submission Deadline

SGMA requires that an alternative for a basin categorized as high- or medium-priority as of January 31, 2015, be submitted no later than January 1, 2017.[23]

The Agency submitted the Livermore Valley Alternative on December 29, 2016, before the statutory deadline.

B. Part 2.11 (CASGEM) Compliance

SGMA requires that the Department assess whether an alternative is within a basin that is in compliance with Part 2.11 of Division 6 of the Water Code,[24] which requires that

[20] The Annual Report is not part of the Alternative and was not reviewed by the Department for the purpose of approving the Alternative.
[21] Water Code § 10733.6
[22] 23 CCR § 358.6
[23] Water Code § 10733.6(c). Pursuant to Water Code § 10722.4(d), a different deadline applies to a basin that has been elevated from low- or very low-priority to high- or medium-priority after January 31, 2015.
[24] Water Code § 10733.6(d)

groundwater elevations in all groundwater basins be regularly and systematically monitored and that groundwater elevation reports be submitted to the Department.[25] To manage its obligations under this law, the Department established the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. The acronym CASGEM is used in this document to denote both the program and the groundwater monitoring law.[26]

SGMA specifies that an alternative does not satisfy the objectives of SGMA if the basin is not in compliance with the requirements of CASGEM.[27] The Department confirmed that the Livermore Valley Basin was in compliance with the requirements of CASGEM prior to evaluating this Alternative and confirmed that the Basin remained in compliance with CASGEM through the last reporting deadline, prior to issuing this assessment.

C. Completeness

GSP Regulations specify that the Department shall evaluate an alternative if that alternative is complete and includes the information required by SGMA and the GSP Regulations.[28] An alternative submitted pursuant to Water Code Section 10733.6(b)(3) must include an analysis demonstrating the basin has operated within its sustainable yield over a period of at least 10 years. That analysis must include a report prepared by a registered professional engineer or geologist who is licensed by the state, and that report must be submitted under that engineer's or geologist's seal. The alternative must include an explanation of how the elements of the alternative are functionally equivalent to the elements of a GSP required by Articles 5 and 7 of the GSP Regulations and are sufficient to demonstrate the ability of the alternative to achieve the objectives of SGMA.[29]

The Agency submitted an analysis under the seal of a licensed Professional Geologist along with an Alternative Elements Guide, which includes the Agency's explanation of how the elements of the Alternative are functionally equivalent to the elements of a GSP. The Department staff found the Alternative to be complete and containing the required information, sufficient to warrant an evaluation by the Department.

D. Basin Coverage

An alternative is required to cover the entire basin.[30] An alternative that is intended to cover an entire basin may be presumed to do so if the basin is fully contained within the jurisdictional boundaries of the submitting agency. However, an alternative submitted by

[25] Water Code § 10920 *et seq*.
[26] Stats.2009-2010, 7th Ex.Sess., c. 1 (S.B.6), § 1
[27] Water Code § 10733.6(d)
[28] 23 CCR § 358.4(a)(3)
[29] 23 CCR § 358.4(c)-(d)
[30] 23 CCR § 358.4(a)(4)

an agency whose jurisdictional boundaries do not include all areas of the basin may nevertheless be found to effectively cover the entire basin. Because the intent of SGMA is to provide for sustainable management of groundwater that does not cause undesirable results, an alternative effectively covers the entire basin if it results in groundwater management that avoids undesirable results.[31] An alternative that cannot avoid undesirable results is not sustainably managing the basin even if the entire basin is within the jurisdiction of the managing agency, but an alternative that avoids undesirable results throughout the basin is sustainably managing that basin even if some part of the basin lies outside the jurisdiction of that agency.

The Alternative addresses the entire area of the Basin as currently defined by the Department. The Agency has jurisdiction over the portion of the basin within Alameda County, which covers most of the basin (Figure 1). For the remaining portion of the basin outside the Agency's jurisdiction that extends into Contra Costa County, the Agency has developed a memorandum of understanding with those agencies with jurisdiction including Contra Costa County, Contra Costa Water Agency, the City of San Ramon, the East Bay Municipal Utility District, and the Dublin San Ramon Services District. The MOU gives the Agency the delegated authority to be the GSA for the portion of the Basin outside of the jurisdiction of the Agency, which is located within the jurisdictions of those agencies listed above.[32]

Based on the facts provided, Department staff determined that the Alternative covers the entire Basin.

[31] Water Code § 10721(v)
[32] Alternative Report, Appendix A, PDF p. 229

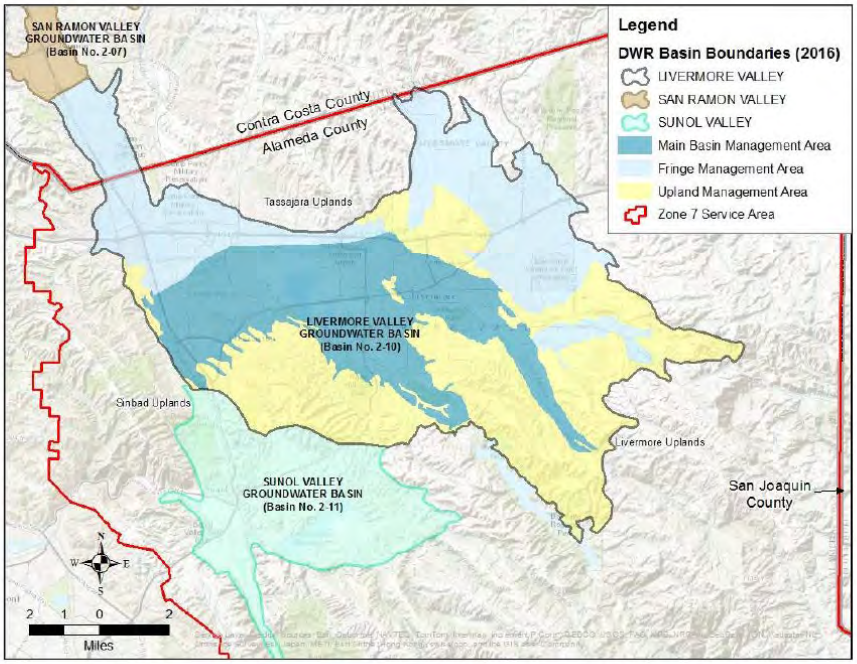

Figure 1. Map of Plan Area, Livermore Valley Groundwater Basin[33]

V. Alternative Contents

GSP Regulations require the submitting agency to explain how the elements of an alternative are functionally equivalent to the elements of a GSP as required by Article 5 of the GSP regulations[34] and are sufficient to demonstrate the ability of an alternative to achieve the objectives of SGMA.[35]

As stated previously, alternatives based on historical basin management practices that predate the passage of SGMA or adoption of GSP Regulations, although required to satisfy the objectives of SGMA, are not necessarily expected to conform to the precise format and content of a GSP, and the criteria for adequacy of an alternative is whether the Department is able to determine that an alternative satisfies the objectives of SGMA. Department staff rely on the submitting agency's determination of functional equivalence of alternative elements to facilitate its evaluation and assessment of an alternative (*see* Assessment, below). Although the exact components of a GSP are not required for an alternative, for organizational purposes the discussion of information contained in the Alternative Report and related documents provided by the Agency generally follows the elements of a GSP provided in Article 5 of the GSP Regulations. The reference to

[33] Alternative Report, Figure 1-4, p. 1-8
[34] 23 CCR § 354-354.44
[35] 23 CCR § 358.2(d). The requirements pertaining to Article 7 of the GSP Regulations (23 CCR § 356-356.4) relate to annual reports and periodic evaluation and are not applicable to review of the initial alternative.

requirements of the GSP Regulations at the beginning of each section is to provide context regarding the nature of the element discussed but is not meant to define a strict standard applicable to alternatives.

A. Administrative Information

GSP Regulations require information identifying the submitting agency, describing the plan area, and demonstrating the legal authority and ability of the submitting agency to develop and implement a plan for that area.[36]

The Alternative Report contains information describing the Agency, which represents one of ten active zones in the Alameda County Flood Control and Water Conservation District (District), and the legal authority of the Agency to implement projects and management actions. SGMA designated the Agency as the exclusive Groundwater Sustainability Agency within its statutory boundaries.[37] The Agency's key water resource responsibilities include the following:[38]

- Serve as the contractor with DWR for the State Water Project
- Manage the local water right on Arroyo Valle
- Procure other water supplies as necessary to meet demands
- Provide wholesale treated water supply
- Provide untreated water for agriculture
- Operate and maintain water treatment and transmission systems
- Manage regional stormwater for public safety and protection of property
- Sustainably manage the Livermore Valley Basin

Under the Agency's Groundwater Management Program, the Agency administers management of the Basin and prevents groundwater overdraft.

The Alternative Report provides a description of the plan area, existing water resource monitoring and management programs, conjunctive use programs, and applicable general plans.[39] The Alternative Report states that the Agency involves the public, stakeholders and local agencies in its planning and programs through meetings, data sharing and online media and has memorialized this approach as an operational policy in the Agency's 1987 Statement on Groundwater Management.[40] The Agency describes

[36] 23 CCR § 354.2 et seq.
[37] Water Code § 10723 (c)(1)(A)
[38] Alternative Report, Section 1.2.2, pp. 1-3 to 1-4
[39] Alternative Report, Section 1.3, pp. 1-8 to 1-29
[40] Alternative Report, Section 1.3.5, pp. 1-27 to 1-28

how they routinely consider other agencies and interested parties in the Basin during management activities.[41]

B. Basin Setting

GSP Regulations require information about the physical setting and characteristics of the basin and current conditions of the basin, including a hydrogeologic conceptual model, a description of historical and current groundwater conditions, and an assessment of the water budget.[42]

1. Hydrogeologic Conceptual Model

The GSP Regulations require a descriptive hydrogeologic conceptual model of the basin that includes a written description supported by cross sections and maps.[43]

The Alternative Report describes the hydrogeologic conceptual model of the Basin, including the geologic and structural setting, basin boundary definitions, and the basin hydrostratigraphy, and identifies principal aquifers and aquitards.[44] The Alternative Report describes the Livermore Valley Basin as a structural basin bound on the east and west by northwest-southeast trending faults, a thrust fault on the north, and bedrock hills to the south.[45] The Alternative Report divides the Basin into three areas based on geologic, hydrogeologic, and groundwater conditions.[46] These three areas include the Main Basin Management Area, the Fringe Management Area, and the Uplands Management Area (*see* Figure 1, above).[47] The hydrogeologic conceptual model discusses the conditions of the entire Basin, but the focus is on the Main Basin Management Area. The Main Basin Management Area refers to the central portion of the Basin that produces approximately 93 percent of groundwater in the Basin from a thick alluvial sequence that contains the highest yielding aquifers, the best quality groundwater, and the major municipal wells.[48] The Agency referred to this portion of the Basin as the central basin between 1980 and 1988 and began using the term Main Basin in 1988.[49]

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[41] Outreach effort are listed on the Agency website: https://www.zone7water.com/; and Alternative Report, Section 1.3.5, pp. 1-27 to 1-28
[42] 23 CCR § 354.12 et seq.
[43] 23 CCR § 354.14(a)
[44] Alternative Report, Section 2.2, pp. 2-10 to 2-25
[45] Alternative Report, Section E-2.2, p. E-4
[46] Alternative Report, Section E-1.2, p. E-3
[47] 23 CCR § 351(r) "Management area" refers to an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors.
[48] Alternative Report, Table 2-21 and Table 2-22, p. 2-88; and Table 2-24, p. 2-91. Average demands in the Main Basin, Fringe, and Upland Management Areas are 13,400 acre-feet per acre (93.4 percent), 728 acre-feet per acre (5.1 percent), and 217 acre-feet per acre (1.5 percent), respectively. Groundwater Management Plan, Section 3.1.4, p. 3-4
[49] Groundwater Management Plan, Section 3.1.4, p. 3-4

The Main Basin is bounded by several subsurface barriers to lateral groundwater movement, including numerous faults, which have been observed and investigated by Zone 7 and others.[50] The Fringe Management Area is characterized as having thinner alluvium with low groundwater storage, low well yields, and poorer groundwater quality. The Uplands Management Area is underlain by a low-yielding aquifer and, as a result, there are few wells in the area.[51]

The Alternative Report incorporates detailed information pertaining to the basin hydrology, geology, aquifers and aquitards, and climatic conditions into the hydrogeologic conceptual model of the Basin. The Agency also maintains a numerical groundwater flow model of the basin for predicting the consequences of proposed groundwater basin management actions.[52] The active part of the numerical model covers subareas in both the Main Basin Management Area and the northwestern Fringe Management Area and generally uses the understanding of the hydrostratigraphy of the Basin as the basis for groundwater model layers and aquifer parameters.[53]

2. Groundwater Conditions

The GSP Regulations require a description of historical and current groundwater conditions in the basin that includes information related to groundwater elevations, groundwater storage, seawater intrusion, groundwater quality, subsidence, and interconnected surface water, as applicable. The GSP Regulations also require an identification of groundwater dependent ecosystems.[54]

The Alternative Report and supporting documentation describe groundwater conditions for the Basin, with emphasis on the Main Basin Management Area (*see* Figure 1, above).[55] The Agency relies on data from numerous monitoring locations[56] primarily located in the Main Basin Management Area and Fringe Management Area to characterize groundwater use, current and historic conditions of groundwater elevation, groundwater in storage, water quality, land subsidence, and surface water-groundwater interaction.[57] The Agency presents groundwater elevation hydrographs from key wells throughout the Main Basin Management Area and the Fringe Management Area in the Alternative Report.[58] These hydrographs illustrate that groundwater elevations have

[50] Groundwater Management Plan, Section 3.1.4, p. 3-4
[51] Alternative Report, Section E-1.2, p. E-3
[52] Alternative Report, Section 2.6, p. 2-96; and 2015 Annual Report, Section 11.5, p. 11-14
[53] Alternative Report, Figure 2-14, p. 2-23; and Section 2.2.3.4, p 2-23 and pp. 2-25 to 2-27
[54] 23 CCR § 354.16
[55] Alternative Report, Section 2.3, p. 2-2; 2015 Annual Report, Section 5, p. 5-1; and Section 11, p. 11-1
[56] Alternative Report, Section 4, p. 4-1; Groundwater Management Plan, Appendix C, PDF p. 137; 2015 Annual Report, Section 2.2, p.2-1; Section 3.2, p. 3-1; Section 4.2, p.4-2; Section 5.2, p. 5-7; Section 6.2, p. 6-5; Section 7.2, p. 7-2; and Section 8.2, p. 8.2
[57] Alternative Report, Figure 2-17, p. 2-28
[58] Alternative Report, Figure 2-21, pg. 2-35

generally been stable for the periods of records dating back to the 1970s in most cases, except for drought periods (in the early 1990s and 2012-2015), where groundwater levels in some wells experienced temporary declines. Groundwater elevations recovered in those wells that experienced groundwater elevation declines.[59] The Agency created groundwater level maps using detailed information from a series of wells distributed through the Main Basin Management Area and Fringe Management Area.[60] The resulting contour maps are presented in the Alternative Report and present groundwater flow directions and gradients consistent with the hydrogeologic conceptual model.[61]

The Agency operates the basin to remain above historic low groundwater levels throughout the Main Basin Management Area.[62] To quantify these levels, a contour map of historic lows has been prepared by the Agency for management purposes.[63] The map of historic low groundwater levels was first generated during the Agency's efforts to produce the Draft Report Well Master Plan.[64] The historic lows map was generated using a compilation of recorded low groundwater elevations in various wells in the basin typically from the 1960s, 1977, or 1987-1992 drought periods. Outside of the Main Basin Management Area, historic lows have not yet been determined; however, groundwater level hydrographs from various representative wells in the Fringe Management Area indicate that groundwater levels have not fluctuated significantly over time.[65]

The Agency presents the estimated groundwater storage in the Main Basin Management Area from 1974 to 2015 in the Alternative Report and describes how groundwater storage was calculated.[66] The Agency calculated the Main Basin as having a storage capacity of more than 250,000 acre-feet. The Agency states that when groundwater elevations were at their historic lows, the estimated remaining groundwater in storage was 128,000 acre-feet. The Agency describes groundwater storage of 128,000 acre-feet (when groundwater elevations are at historic lows) or less as "reserve storage" and the additional 126,000 acre-feet above this amount to be "operational storage". The Agency maintains "reserve storage" by operating the basin to keep groundwater levels above historic lows and actively manages the remaining 126,000 acre-feet for supply reliability.[67] The Alternative Report illustrates that the groundwater storage in the Main Basin Management Area has been within the "operational storage" range for the period reported, from 1974 to 2015.[68] The Agency estimates the groundwater in storage in the upper alluvial aquifer of the

[59] Alternative Report, Figure 2-21, p. 2-35
[60] Alternative Report, Figure 2-17, p. 2-28
[61] Alternative Report, Figure 2-24, p. 2-41; and Figure 2-25, p. 2-26
[62] Alternative Report, Figure 2-29, p. 2-48; and Section 2.3.6, p. 2-45
[63] Alternative Report, Figure 2-23, p. 2-28; Section 2.3.4.2, p. 2-36; and Section 2.3.4.3, p. 2-37
[64] Draft Report Well Master Plan, Section ES.2, pp. ES-2 to ES-3
[65] Alternative Report, Figure 2-21, p. 2-35
[66] Alternative Report, Figure 2-30, p. 2-50
[67] Alternative Report, Section 2.3.7.1, pp. 2-49 to 2-50
[68] Alternative Report, Figure 2-30, p. 2-50

Fringe Management Area is about 200,000 acre-feet, but that groundwater is not used for municipal supply or managed groundwater storage in this area, primarily due to poor groundwater production.[69] The groundwater in storage in the Uplands Management Area was not estimated because the Agency states that it consists of semi-consolidated bedrock of highly-variable specific yields and is of unknown thickness.

The Alternative Report describes the primary groundwater quality issues in the three management areas of the Basin, monitoring networks used for analysis of groundwater quality, and statistical analyses used to evaluate constituents of concern. Primary constituents of concern in the Main Basin Management Area are locally high TDS, hardness, nitrate, organic compounds and naturally occurring boron and chromium. The Alternative Report acknowledges locally elevated levels of these constituents in the Basin and describes the management actions taken to address water quality issues in the Basin. [70] The Agency conducts routine water quality sampling which is typically analyzed in the Agency's water quality laboratory, monitoring to comply with the Del Valle water rights permits and Title 22 domestic Water Quality and Monitoring Regulations. Monitoring also includes sampling and analysis in accordance with the Salt/Nutrient Management Plan and the Toxic Site Surveillance Program. The Salt Management Plan, which was incorporated into the Agency's Groundwater Management Plan and was designed to identify strategies to stop or offset degradation of salt and mineral buildup from water recycling and wastewater disposal. The Toxic Site Surveillance Program tracks sites where groundwater has been impacted from anthropogenic sources and identifies those that pose a potential threat to drinking water. Management actions taken when water quality conditions at a well exceed or approach the identified threshold, includes blending groundwater with demineralized water from Zone 7's Mocho Groundwater Demineralization Plant to meet water quality thresholds.[71] Other management actions taken by the Agency to offset degradation of salt and mineral buildup include artificial recharge with low TDS imported water (when available), pumping and delivering groundwater to customers (salts are exported as wastewater), and operating groundwater demineralization facilities that export salts as a waste by-product (concentrate/brine).[72]

The Alternative Report describes that land surface elevations have been monitored for over 60 years in parts of the Basin and that the Agency has found no evidence of inelastic subsidence.[73] Data collection over the period captures a range of elastic surface

[69] Alternative Report, Section 2.3.7.2, pp. 2-50 to 2-51
[70] Alternative Report, Section 4.6, p. 4-18; Groundwater Management Plan, Section 5.3, p. 5-9; 2015 Annual Report, Section 12, p. 12-1; Nutrient Management Plan, Section 6, p. 63; and Salt Management Plan, Section 7 through Section 12
[71] Alternative Report, Section 5.3.3.3, p. 5-11
[72] Alternative Report, Section 5.3.3.2, p. 5-10
[73] Alternative Report, Section 2.3.9, p. 2-74

elevations that are associated with cycles of elevation gains and losses that mimic dry/wet hydrologic cycles and correlate with groundwater elevation trends. The Agency has observed elastic surface elevation fluctuations in the range of 0.3 feet per cycle.[74] The Agency has an ongoing monitoring program to collect land surface elevation data semi-annually at more than 60 elevation benchmarks to evaluate subsidence in the Main Basin Management Area.

The Alternative Report describes surface water - groundwater interaction in the Basin and states that groundwater generally does not contribute to baseflow along surface water reaches in the basin. However, the Agency does recognize a surface water-groundwater connection for seasonal springflow in the Springtown Alkali Sink (or Alkali Sink) area and recognizes interaction of groundwater and surface water in gravel mining areas.[75]

The Springtown Alkali Sink is in the Fringe Management Area of the Basin along Altamont Creek, near stream gages on the creek monitored by Zone 7. The Agency describes a hydrologic analysis prepared for the City of Livermore in 1998 to characterize the localized aquifers and groundwater conditions near Springtown Alkali Sink.[76] Historical springs were present in the Alkali Sink area, caused by high groundwater levels in the underlying shallow aquifer zone. Development in the late 1960s deepened Altamont Creek, which was believed to have created a local drain for shallow groundwater, and a reduction in the presence of significant springs. The Agency reports that as a result, groundwater elevations are lower, which caused the alkali-saline wetland habitat, supported by the springs, to be seasonal.[77] The relationship of groundwater and surface water in the Alkali Sink area has been investigated with the development of a three-dimensional numerical groundwater flow MODFLOW model and the development of a modeled water budget for the sink. Groundwater in the Alkali Sink is monitored and managed to maintain groundwater levels to avoid surface water depletion.[78] The Alternative Report acknowledges the presence of groundwater dependent ecosystems in the Springtown Alkali Sink and states that the Sink is habitat to over a dozen federally-listed, state-listed or state-listed-as-sensitive plant and animal taxa and is critical habitat for other species.[79] As a result, the Springtown Alkali Sink and adjacent creeks are protected either as Preserves of the City of Livermore or conservation easements or are owned and managed by the Agency or the Federal Communications Commission.[80] In

[74] Alternative Report, Section 2.3.9, p. 2-74
[75] Alternative Report, Section 2.3.10, p. 2-76
[76] Alternative Report, Section 2.1.4, p. 2-7
[77] Alternative Report, Section 2.1.4, p. 2-8
[78] Alternative Report, Section 3.3.5.1, p. 3-23
[79] Alternative Report, Section 2.3.10.2, p. 2-77
[80] Alternative Report, Section 2.3.10.2, p. 2-77

addition, restoration of the sink is identified as a designated project of the Bay Area Integrated Water Resources Management Plan.[81]

The Agency identifies a second possible exception of surface water and groundwater interaction where the water table is exposed in gravel quarries in gravel mining areas. The Agency, in coordination with the two active mining companies in the basin, CEMEX and Vulcan Materials, monitor water levels and water quality in select mining area ponds or quarry lakes to track and document evaporation, circulation, and conveyance of water between pits. The data collected from these monitoring stations factor into the Agency's groundwater elevation maps for the Basin, water budget calculations, groundwater quality assumptions, and groundwater model efforts.[82] The Agency states that no groundwater-dependent ecosystems exist in the mining area and the quarry pits are not are not identified for specific beneficial uses in the Basin Plan developed by the Regional Water Quality Control Board.[83] The Agency is working closely with the mining companies to develop a quarry reclamation plan in the future to provide groundwater recharge and conveyance through the mining area.[84]

3. Water Budget

GSP Regulations require a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored, as applicable.[85]

The Alternative Report includes discussion of the current water budget that includes inflows, outflows, change in storage, sustainable yield, operational groundwater storage, surface water supplies, and other factors affecting the Agency's ability to operate the basin within its sustainable yield.[86] The Agency also discussed their projected water budget and plans for future management.[87] The information provided in the Alternative Report describes the current methods used by the Agency to calculate water budgets for the Main Basin Management Area, the Fringe Management Area, and the Uplands Management Area.

The Agency has evaluated the water budget in the Main Basin Management Area since 1974 and has documented the water budget in Annual Water Year Reports, published to the Agency's website.[88] The Agency provides an overview of its methodologies used to

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[81] Alternative Report, Section 2.3.10.2, p. 2-77
[82] Alternative Report, Section 4.4, p. 4-8
[83] Alternative Report, Section 2.3.10.3, p. 2-78
[84] Alternative Report, Section 2.3.10.3, p. 2-77
[85] 23 CCR § 354.18
[86] Alternative Report, Section 2.4.2, p. 2-81
[87] Alternative Report, Section 2.5, p. 2-95
[88] Alternative Report, Section 2.4.3, p. 2-89

calculate the water budget in the Main Basin Management Area, which includes using two independent methods to estimate the current water budget, one that estimates the inflows and outflows and calculates the change in total groundwater storage (referred to by the Agency as the Hydrologic Inventory), and a second method that uses the groundwater elevation and storage coefficients to estimate the total change in groundwater storage (referred to by the Agency as the Groundwater Elevation method).[89] The Agency states that these two methodologies have been used for comparison and has allowed periodic re-examination and refinement of water budget computations, which the Agency later describes in the Alternative Report.[90] Inflows into the Main Basin Management Area using the Hydrologic Inventory method include rainfall recharge, stream recharge, applied water recharge, subsurface groundwater inflow, and pipe leakage. Outflows from the Main Basin Management Area using the Hydrologic Inventory method include municipal pumping, agricultural pumping, mining use, and groundwater basin overflow. The components of the water budget are derived independently, either directly from monitoring program results or calculated using the results of the monitoring program.[91] The Alternative Report presents the results from the calculations of inflows, outflows, and total change in storage for Water Year 1974 through Water Year 2015.[92] Furthermore, Figure 10-7 of the 2015 Annual Report provides a detailed table that presents the data used to generate Figure 2-40 provided in the Alternative Report.[93]

The Agency states that the Hydrologic Inventory method was used to estimate the water budget for the Fringe Management Area, using the same inflow and outflow components as described for the Main Basin Management Area, with the addition of a few outflow components specific to the management area (e.g., golf courses, domestic wells, subsurface to streams, subsurface to Main Basin).[94] The Agency presents a simplified groundwater budget for the Uplands Management Area, identifying rainfall/stream recharge as the inflow component and outflow identified as agricultural pumping and domestic wells.[95]

The Agency acknowledges that approximately 80 percent of the water supply is imported. Therefore, maintaining imported water supplies allows the Agency to operate the Basin within the sustainable yield.[96] The Agency describes sources of imports and surface water supplies that include supplies from the State Water Project, Lake Del Valle, groundwater banking (including Semitropic and Cawelo), and other water transfers.[97] The Agency

[89] Alternative Report, Section 2.4, pp. 2-79 to 2-90
[90] Alternative Report, Section 2.4.1, pp. 2-79 to 2-81
[91] Alternative Report, Section 2.4.1, p. 2-80
[92] Alternative Report, Figure 2-40, p. 2-89 and Section 2.4.3, pp. 2-89 to 2-90
[93] 2015 Annual Report, Figure 10-7, PDF pp. 182-183
[94] Alternative Report, Section 2.4.2.5 and Table 2-21, pp. 2-87 to 2-88
[95] Alternative Report, Section 2.4.2.6, p. 2-88
[96] Alternative Report, Section 2.4.4.2, p. 2-93
[97] Alternative Report, Section 2.4.4.2, pp. 2-93 to 2-94

states that imported water is either delivered to Zone 7's retailers and agricultural customers or it is used for artificial recharge in the Main Basin Management Area when surplus surface water is available.[98]

4. Management Areas

GSP Regulations authorizes, but does not require, an agency to define one or more management areas within a basin if the agency has determined that creation of management areas will facilitate implementation of the GSP.[99]

The Agency has identified three management areas: the Main Basin Management Area, the Fringe Management Area, and the Uplands Management Area that are within the Livermore Valley Basin. The Agency defines these management areas based on geologic, hydrogeologic, and groundwater conditions in the Basin. The Main Basin Management Area is described as having the highest yielding aquifers, best quality groundwater, and is where municipal wells are located. Whereas the Fringe Management Area is described as having low yielding aquifers with few wells for domestic, agricultural, and golf course irrigation purposes. The Upland Management Area is described as having low yielding aquifer and few wells used for domestic supply and agricultural purposes.[100]

C. Sustainable Management Criteria

GSP Regulations require a sustainability goal that defines conditions that constitute sustainable groundwater management for the basin, the characterization of undesirable results, and establishment of minimum thresholds and measurable objectives for each applicable sustainability indicator, as appropriate.[101]

1. Sustainability Goal

GSP Regulations require that sustainable management criteria include a sustainability goal that culminates in the absence of undesirable results within the appropriate timeframe, and includes a description of the sustainability goal, describes information used to establish the goal for the basin, describes measures that will be implemented to ensure the basin operates within its sustainable yield, and contains an explanation of how the sustainability goal will be met. [102] The sustainability goal for an alternative based on an analysis of basin conditions represents the criteria that allowed the basin to be

[98] Alternative Report, Section 2.4.4.2, p. 2-93
[99] 23 CCR § 354.20
[100] Alternative Report, Section E-1.2, p. E-3; and Section 2.3.2, p. 2-32
[101] 23 CCR § 354.22
[102] 23 CCR § 354.24. For an alternative based on a demonstration of 10 years of sustainable management, the sustainability goal, or its functional equivalent, would have been developed at some previous time during basin management, and its goals met by the time the Alternative was submitted to the Department.

operated within its sustainable yield for a period of at least 10 years, which includes the avoidance of undesirable results.[103]

The Agency's goal is to continue to operate the Basin within its sustainable yield and to manage groundwater resources to prevent undesirable results.[104] The Agency also has a stated goal of managing the local groundwater resources to provide a reliable supply and to protect the groundwater resources for all beneficial uses.[105]

2. Sustainability Indicators

The GSP Regulations specify that an agency define conditions that constitute sustainable groundwater management for a basin, including the characterization of undesirable results and the establishment of minimum thresholds and measurable objectives for each applicable sustainability indicator.[106]

Sustainability indicators are defined as any of the effects caused by groundwater conditions occurring throughout the basin that, *when significant and unreasonable*, cause undesirable results.[107] Sustainability indicators thus correspond with the six undesirable results – chronic lowering of groundwater levels indicating a depletion of supply if continued over the planning and implementation horizon, reduction of groundwater storage, seawater intrusion, degraded water quality, including the migration of contaminant plumes that impair water supplies, land subsidence that substantially interferes with surface land uses, and depletions of interconnected surface water that have adverse impacts on beneficial uses of the surface water[108] – but refer to groundwater conditions that are not, in and of themselves, significant and unreasonable. Rather, sustainability indicators refer to the effects caused by changing groundwater conditions that are monitored, and for which criteria in the form of minimum thresholds are established by the agency to define when the effect becomes significant and unreasonable, producing an undesirable result.

The sustainability indicators section thus conflates three requirements of the sustainable management criteria set out in the GSP Regulations: undesirable results, minimum thresholds, and measurable objectives. Information pertaining to the processes and criteria relied upon to define undesirable results applicable to the basin as quantified through the establishment of minimum thresholds are discussed for each sustainability indicator. However, a submitting agency is not required to establish criteria for an

[103] Water Code § 10721(w)
[104] Alternative Report, Section 3.1, p.3-1
[105] Alternative Report, Section 3.1, p. 3-1; and Groundwater Management Plan, Section 4.1, p. 4-1
[106] 23 CCR § 354.22
[107] 23 CCR § 351(ah)
[108] Water Code § 10721(x)

undesirable result when the agency can demonstrate that an undesirable result for that sustainability indicator is not present and is not likely to occur in the basin.[109]

a. Chronic Lowering of Groundwater Levels

GSP Regulations specify that the minimum threshold for chronic lowering of groundwater levels be based on groundwater elevations indicating a depletion of supply that may lead to undesirable results.[110]

The minimum thresholds for groundwater levels only apply to the Main Basin Management Area and a small portion of the Fringe Management Area. The Agency uses the historical low groundwater level map (*see* Groundwater Conditions, above), to define the minimum thresholds for the Main Basin Management Area and a small portion of the Fringe Management Area. The Alternative Report uses the historical low groundwater level map, rather than identifying groundwater levels from individual wells in a tabular format, to define the minimum thresholds.

The Agency states that groundwater levels are routinely measured in the Fringe Management Area, and occasionally in the Uplands Management Area.[111] Groundwater level hydrographs from seven wells in the Fringe Management Area are presented in the Alternative Report, with six presenting data collected extending back to the 1980s and one presenting data collected back to the early 2000s.[112] The Agency does not provide information regarding the frequency or timing of when groundwater level data has been collected historically in the Uplands Management Area. The Agency states that if it is determined that wells in areas outside the Main Basin Management Area are experiencing loss of beneficial uses, then the conditions would be reviewed, and a recovery plan would be created.[113]

The Agency states that the area with the highest density of wells outside of the Main Basin Management Area, occurs in the Uplands Management Area and is referred to as the Happy Valley Area. This area is unincorporated, unsewered, and relies on domestic wells for water supply. However, due to high nitrate detections in some domestic wells, Alameda County has placed a moratorium on new onsite wastewater treatment system construction in Happy Valley, reducing the potential for additional development. In addition, the Agency states that discussions are underway between City of Pleasanton and Alameda County Local Agency Formation Commission (LAFCO) for the incorporation

[109] 23 CCR § 354.26(d)
[110] 23 CCR § 354.28(c)(1)
[111] Alternative Report, Section 4.5, p. 4-12
[112] Alternative Report, Figure 2-21, p. 2-35
[113] Alternative Report, Section 3.3.1.2, p. 3-7

of Happy Valley into the City limits and/or expansion of city water and sewer services to Happy Valley parcels.

The Agency identifies an alternative minimum threshold to account for areas outside the Main Basin Management Area, which requires any new well construction (other than replacement wells) in higher density well areas be evaluated by the Agency. The objective of the Agency's evaluation would be to complete an early assessment of any proposed wells to ensure the construction of proposed wells does not result in over-pumping for any localized area of well clusters.[114] Through the Agency's authority permitting new wells within its jurisdiction, the Agency can require that new well permit applications are accompanied by a certified CEQA analysis supporting that the new well would not significantly impact local water levels.[115]

The Agency describes an undesirable result as the lowering of regional water levels resulting in wells no longer capable of supporting their beneficial uses.[116] This undesirable result may be experienced as water levels falling below pump intakes, falling below the top of screens, and/or reduction in well yields. The Agency further explains that for municipal wells, the loss of one well in a wellfield or multiple for a short time might be compensated through a short-term redistribution of pumping or purchase of supplemental supplies.[117] The Agency has an ongoing policy in place to re-distribute pumping in areas that experience short-term declines to mitigate local impacts.[118] The Agency also focuses artificial recharge efforts near wellfields and plans to establish new wellfields in areas where levels routinely remain above historic lows. The Agency further states that a systemic failure of wellfields or long-term loss of wells would be an undesirable result.[119] For rural, domestic wells, the loss of even one well could cause an undesirable result if it leads to the well no longer being able to support its beneficial use.[120]

The Agency describes an undesirable result in areas outside the Main Basin Management Area as over-pumping that could locally impact beneficial uses of private wells, especially in groundwater dependent areas.[121]

[114] Alternative Report, Section 3.3.1.2, p. 3-9
[115] Alternative Report, Section 3.3.1.2, p. 3-9
[116] Alternative Report, Section 3.3.1.1, p. 3-5
[117] Alternative Report, Section 3.3.1.1, p. 3-5
[118] Alternative Report, Section 3.3.1.1, p. 3-5
[119] Alternative Report, Section 3.3.1.1, p. 3-5
[120] Alternative Report, Section 3.3.1.1, p. 3-5
[121] Alternative Report, Section 3.3.1.1, p. 3-5

b. Reduction of Groundwater Storage

GSP Regulations specify that the minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results.[122]

The minimum threshold for reduction of groundwater storage is based on the basin storage when groundwater levels throughout the Main Basin Management Area are at historic lows. The Agency uses historical low groundwater levels throughout the Main Basin Management Area to calculate the minimum threshold for basin storage, which is estimated as 128,000 acre-feet.[123] Over the last 40 years the Agency has operated the basin within the operational storage range above the minimum threshold (*see* Groundwater Conditions, above). If an emergency condition were to require the reserve storage to be accessed, the Agency states that they would develop a recovery plan with specific, and time-relevant, recovery actions. The Agency states that loss of storage in the Fringe and Upland Management Areas would not have the same detrimental effect on operational storage as in the Main Basin Management Area.[124] Minimum thresholds in the Fringe and Uplands management areas are not provided in the Alternative Report.

The Agency defines undesirable results in the Main Basin Management Area as being represented by groundwater levels falling significantly below historic lows across most of the area as well as storage volumes in the area being reduced into the reserve storage in a non-emergency situation.[125]

c. Seawater Intrusion

GSP Regulations specify that the minimum threshold for seawater intrusion be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results.[126]

The Agency states that seawater intrusion is not a relevant issue for this inland basin, and do not identify an objective or sustainability indicator.[127] The Agency presents information to demonstrate that the Basin is an inland basin that is structurally-bound basin by northwest-southeast trending faults on the east and west, upland bedrock hills on the south, and the Mt. Diablo thrust fault to the north.[128]

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[122] 23 CCR § 354.28(c)(2)
[123] Alternative Report, Section 3.3.2.2 and Figure 3-3, pp. 3-10 to 3-11
[124] Alternative Report, Section 3.3.2.1, p. 3-10; Figure 2-21, PDF p. 96; and Tables 2-21 and 2-22, p. 2-88
[125] Alternative Report, Section 3.3.2, p. 3-9
[126] 23 CCR § 354.28(c)(3)
[127] Alternative Report, Section 3.1 footnote 3, p. 3-1
[128] Alternative Report, Section E-2.2, p. E-4

d. Degraded Water Quality

GSP Regulations specify that the minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the agency that may lead to undesirable results.[129]

The Agency sets minimum thresholds established at levels required to meet federal and state standards.[130] The Agency states that trends toward the minimum thresholds triggers management responses in coordination with the Agency's retailers, which could include short-term actions or long-term actions further described in the Alternative Report.[131] The Agency has implemented management actions to address water quality issues like TDS, nitrate, toxic sites, and salt loading (*see* Groundwater Conditions, above).

The Agency states an undesirable result in the Main Basin Management Area is the loss of beneficial uses as measured at each of the municipal wells in the area caused by degradation of the Lower Aquifer with TDS, key inorganic constituents, and/or toxic substances such that levels in municipal wellfields cannot be blended, treated, or managed to provide drinking water supply.[132] The Agency states an undesirable result in the Fringe and Upland Management Areas is the loss of beneficial uses due to contamination when treatment is not possible or practicable.[133]

The Agency has actively responded to numerous groundwater quality issues in the Basin over time. The Agency has been able to address each issue and prevent or reduce significant and unreasonable degradation of groundwater quality in the Basin through management actions. The Agency works adaptively with regulatory agencies to ensure protection of the Basin to meet beneficial uses. Groundwater quality is managed on a regional basis as measured at municipal wells while protecting and improving groundwater quality within the Main Basin Management Area.[134]

e. Land Subsidence

GSP Regulations specify that the minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results.[135]

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[129] 23 CCR § 354.28(c)(4)
[130] Alternative Report, Section 3.3.3, p. 3-11
[131] Alternative Report, Section 3.3.3.2, p. 3-18
[132] Alternative Report, Section 3.3.3.1, p. 3-12
[133] Alternative Report, Section 3.3.3.1, p. 3-12
[134] Alternative Report, Section 3.3.3, p. 3-11
[135] 23 CCR § 354.28(c)(5)

The Agency uses historical low groundwater levels as minimum thresholds for land subsidence since no inelastic land subsidence occurred when groundwater levels were previously at historic lows.[136]

The Agency states that inelastic subsidence would represent a potential undesirable result in the Basin, with several potential effects on beneficial uses and users of groundwater and on land uses and property interests in this urban area. The Agency further defines what potential effects in detail in the Alternative Report.[137]

The processes defining land subsidence potential throughout the basin were investigated in detail in the Draft Well Master Plan, which included numerical groundwater modeling to evaluate different operational scenarios in the Basin.[138] The Draft Well Master Plan identified areas in the Basin that would be most prone to groundwater drawdown below historical low groundwater levels and recommended subsidence monitoring in those areas.[139] The outcome of studies completed for the Well Master Plan resulted in the development of the Agency's detailed land surface elevation monitoring program.[140] The Agency states and provides data from two research efforts, to support the conclusion that no inelastic land subsidence has occurred in the Basin within the 13-year monitoring period between 2002 and 2015.[141] The InSAR Report and Benchmark Report, provided as Appendices to the Alternative Report, document the monitoring network, results from the two research efforts, and demonstrate that no undesirable results associated with land subsidence would substantially interfere with surface land uses in the Basin.

f. Depletion of Interconnected Surface Water

GSP Regulations specify that the minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.[142]

According to the Agency, interconnected surface water and groundwater dependent ecosystems are limited in the Basin, with interconnected surface water existing primarily in the Springtown Alkali Sink area, seasonally (*see* Groundwater Conditions, above).[143] The Agency sets minimum thresholds to avoid surface water depletion in the Springtown Alkali Sink as the historic low groundwater elevations recorded at two wells located in the

[136] Alternative Report, Section 3.3.4, p. 3-20
[137] Alternative Report, Section 3.3.4.1, pp. 3-20 to 3-21
[138] Alternative Report, Section 2.3.9, p. 2-74; and Draft Report Well Master Plan, Section 2.4, p. 2-7
[139] Draft Report Well Master Plan, Section 2.4, pp. 2-7 to 2-9
[140] Alternative Report, Section 2.3.9, p. 2-74
[141] Alternative Report, Section 2.3.9, p. 2-74; and Section 3.3.4, p. 3-20
[142] 23 CCR § 354.28(c)(6)
[143] Alternative Report, Section 2.3.10, p. 2-76; and Section 3.3.5, p. 3-22

Springtown Alkali Sink Wetlands.[144] The Agency states that using the lowest recorded groundwater elevation as a proxy provides for a margin of uncertainty and is consistent with the management strategy of using historic low groundwater elevations throughout the Basin.[145]

The Agency defines an undesirable result as depletion of surface water in the Springtown Alkali Sink, potentially resulting in adverse effects on the Springtown Alkali Sink ecosystem and protected species.[146]

The Agency monitors five wells near the Springtown Alkali Sink. Groundwater level trends in these monitoring wells generally have been steady. The Agency states that maintenance of groundwater levels and flow patterns are criteria for avoiding undesirable results. The Agency states that their role in permitting wells allows the Agency an early assessment of any proposed wells to ensure that they are constructed to account for operating groundwater levels in the basin and do not result in over-pumping for any localized area of well clusters.[147]

D. Monitoring Networks

GSP Regulations require that each basin be monitored, and that a monitoring network include monitoring objectives, monitoring protocols, and data reporting requirements be developed that shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions.[148]

The Alternative Report relies on a network of monitoring wells and other monitoring sites to gather data on groundwater levels, surface water flow conditions, groundwater and surface water quality, climate, and land surface elevation.[149] The Alternative Report includes the Agency's standard operating procedures as Appendix B, which outlines the protocols followed by the Agency to ensure the quality of data collected for the monitoring program.[150] Data collected from the monitoring networks was used to support the development of a numerical model for the Basin.

The Agency's groundwater elevation monitoring program includes measurement of groundwater levels in about 240 wells across the Main Basin Management Area and a

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[144] Alternative Report, Section 3.3.5.2, pp. 3-24 to 3-25
[145] Alternative Report, Section 3.3.5.2, p. 3-25
[146] Alternative Report, Section 3.3.5.1, p. 3-23
[147] Alternative Report, Section 3.3.1.2, p. 3-9; and Section 3.3.5, p. 3-22
[148] 23 CCR § 354.32
[149] Alternative Report, Section 4, p. 4-1; Appendix C, PDF p. 247; 2015 Annual Report, Section 2.2, p. 2-1; Section 3.2, p. 3-1; Section 4.2, p. 4-2; Section 5.2, p. 5-7; Section 6.2, p. 6-5; Section 7.2, p. 7-2; and Section 8.2, p. 8-2
[150] Alternative Report, Appendix B, PDF p. 237

portion of the Fringe Management Area. This network includes nested wells, which are used to determine local vertical groundwater gradients.[151] The monitoring and sampling frequency for wells associated with these objectives ranges from continuous to semi-annually.[152] The Agency does not identify wells in the Upland Management Area as part of the monitoring network.

The Agency monitors groundwater quality in more than 230 wells across the Basin as part of the Agency's groundwater quality monitoring program. The Agency's Groundwater Quality Monitoring Program is primarily focused on the Main Basin Management Area, but routinely monitors wells in the Fringe Management Area, and occasionally in the Uplands Management Area. The Groundwater Quality Program has several objectives for Routine Water Elevation Monitoring, Del Valle Water Rights, Municipal Water Supply, Salt Management Plan, Nutrient Management Plan, Dublin San Ramon Services District, and Toxic Site Surveillance. Wells monitored and sampled for the respective objectives are widespread across the Main Basin Management Area and different sampling and frequency associated with those objectives. The monitoring and sampling frequency for wells associated with these objectives ranges from quarterly to annually.

As part of the Agency's surface water monitoring program, the Agency monitors and collects semi-continuous streamflow measurements and periodic water level measurements to track surface water storage. The Agency collects surface water quality at least once per year at 10 recorder sites and quarry ponds.[153] The Agency's climate monitoring network tracks rainfall and evaporation daily, or every 15 minutes, in the Livermore Valley with climatological stations spread across the basin.[154]

The Agency's Land Surface Elevation Monitoring Program includes a network of more than 60 elevation benchmarks locations spanning the Agency's production wellfields in the Main Basin Management Area and includes the collection of semi-annual measurements.

Monitoring sites for groundwater levels and land surface elevation are not reported for the Uplands Management Area. The Agency acknowledges the limited monitoring programs for the Upland Management Area and states that monitoring is done on an issue- or as-needed basis. The Agency states that this management strategy is justified because there is a low number of active wells in the Upland Management Area, with low well yields, and historically low groundwater use in the area.[155]

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[151] Alternative Report, Section 4.5, p. 4-12
[152] Alternative Report, Section 4.5, p. 4-12
[153] Alternative Report, Section 4.3, p. 4-4
[154] Alternative Report, Section 4.2, p. 4-1; 2015 Annual Report, Figure 2-5, PDF pp. 41-42; and Figure 2-7, PDF p. 44
[155] Alternative Report, Section 4.10, p. 4-27

E. Projects and Management Actions

GSP Regulations require a description of the projects and management actions the submitting agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the Basin.[156]

The Agency has over 40 years of experience managing the Basin and implementing plans and programs and identifies numerous on-going and proposed projects whose implementation have helped the Agency operate the Basin for at least 10 years within the Basin's sustainable yield.[157] The ongoing projects and management actions are implemented to ensure the sustainability of the Basin's groundwater supply and groundwater quality out to the planning horizon.

The Agency acknowledges that approximately 80 percent of the Basin's water supply is from imported surface water that is delivered to the Agency's retailers and agricultural customers and is used for artificial recharge in the Main Basin Management Area. The Agency acknowledges the uncertainty of future imported water supplies and describes other projects and management actions that are ongoing or planned to provide water supply reliability, should supplemental supplies be required for supply or recharging the Basin.[158]

In addition to the import of surface water, those projects and management actions include allocation of groundwater pumping quotas to municipal pumpers, conjunctive use projects, Draft Well Master Plan, Chain of Lakes Recharge Projects, existing and future recycled water projects, and water conservation.[159] The Agency identifies artificial recharge program as a key component of the Agency's conjunctive use program, which consists of recharging the groundwater basin through release of surface water to dry arroyos. The artificial recharge program is used as a mechanism for improving groundwater storage and as a water quality management tool, managing releases to arroyos when TDS of source water is low.[160] The Well Master Plan was developed in 2003 and has resulted in the construction of several municipal supply wells.[161] Projects associated with the Chain of Lakes Recharge Projects have been ongoing, with full implementation not expected before 2050.[162] The Agency's existing recycled water projects include use for landscape irrigation and other minor amounts for dust

[156] 23 CCR § 354.44
[157] Alternative Report, Section 5, p. 5-1; Water Supply Evaluations Update, Section 6 through Section 11; and 2015 Urban Water Management Plan, Section 6 through Section 8
[158] Alternative Report, Section 5.2.1, p. 5-1
[159] Alternative Report, Section 5.2, p. 5-1
[160] Alternative Report, Section 5.2.2, p. 5-3
[161] Alternative Report, Section 5.2.3, p. 5-4
[162] Alternative Report, Section 5.2.4, p 5-4

suppression, grading projects, and crop irrigation. Future recycled water projects could include use for groundwater recharge/injection, surface water augmentation, and connection upstream to water treatment plants. The Agency recognizes use of recycled water as a valuable component of water supply portfolio when it is managed under the Salt Management Plan and Nutrient Management Plan.[163]

The Agency identifies several ongoing programs that support maintaining groundwater quality and indirectly support maintaining groundwater supply, which include the Well Ordinance Program, Toxic Site Surveillance Program, Salt Management, Nutrient Management, and Offsite Wastewater Treatment Systems.[164] The Agency identifies the ongoing Well Ordinance Program as providing multiple benefits, with the most notable being protection of the Basin from negative impacts associated with poorly-constructed wells.[165] The Toxic Site Surveillance Program is an ongoing program that informs the Agency by documenting, tracking, and giving priority to sites based on the potential threat to groundwater posed by the site.[166] The 2004 Salt Management Plan is an active, ongoing program and includes strategies to reduce salt loading to groundwater basin and mitigate future salt impacts from planned increased recycled water use in the Main Basin (see Groundwater Conditions, above).[167] One of the strategies identified by the Salt Management Plan, lead to the construction of Zone 7's Mocho Groundwater Demineralization Plant, which is operated to remove salts from the groundwater basin while improving delivered drinking water quality through blending demineralized water with extremely low TDS with groundwater (see Groundwater Conditions, above). The Nutrient Management Plan was developed in 2015 to assess existing and future nutrient contributions from current and planned expansion of recycled water projects and future development in the Livermore Valley. The Nutrient Management Plan identifies best management practices to minimize nitrogen loading in the Basin and identifies ongoing monitoring and future opportunities to add new monitoring wells and/or soil borings.[168] The Alternative Report also describes Offsite Wastewater Treatment System Management, which includes multiple policies established by the Agency and implemented in cooperation with the Alameda County Environmental Health.[169] Further, the Nutrient Management Plan recommends future actions to prevent nutrient loading from increasing in areas of concern.

[163] Alternative Report, Section 5.2.5, p. 5-6
[164] Alternative Report, Section 5.3, p. 5-8
[165] Alternative Report, Section 5.3.1, p. 5-8
[166] Alternative Report, Section 5.3.2, p. 5-9
[167] Alternative Report, Section 5.3.3, p. 5-9
[168] Alternative Report, Section 5.3.4, p. 5-11
[169] Alternative Report, Section 5.3.5, p. 5-13

V. Assessment

The following describes the evaluation and assessment of the Alternative for the Livermore Valley Basin as determined by Department staff. In undertaking this assessment, Department staff did not conduct geologic or engineering studies, although Department staff may have relied on publicly available geologic or engineering or other technical information to verify claims or assumptions presented in the Alternative.[170] As discussed above, Department staff has determined that the Livermore Valley Alternative satisfied the conditions for submission of an alternative.[171] The Alternative was submitted within the statutory period, the Basin was found to be in compliance with the reporting requirements of CASGEM, and staff finds the Alternative to be complete and to cover the entire Basin (*see* Required Conditions, above). Based on its evaluation and assessment of the Livermore Valley Alternative, as discussed below, Department staff finds that the Agency sufficiently demonstrated that the Basin has operated within its sustainable yield over a period of at least 10 years. Staff recommends that the Livermore Valley Alternative be approved.

A. Evaluation of Alternative Contents

The Alternative Report's description of the Agency's responsibilities and authority under the 2003 Assembly Bill 1125 and provided additional information were adequate to demonstrate the Agency's authority to manage groundwater in the Livermore Valley Basin. The information and descriptions regarding the hydrogeologic conceptual model in the Alternative Report demonstrate a thorough understanding of the Basin and were sufficient for evaluating the Alternative to determine whether the basin has operated within its sustainable yield.

The Agency has sufficiently characterized groundwater use, current and historic conditions of groundwater elevation, groundwater in storage, water quality, land subsidence, and surface water-groundwater interaction. The primary focus of the Alternative Report and existing monitoring networks is the Main Basin Management Area and a part of the Fringe Management Area. The Alternative Report presented groundwater level data from wells in the Fringe Management Area and in the Main Basin Management Area. The Department staff found it reasonable that the primary focus of the Alternative Report is on the Main Basin area because all municipal groundwater pumping and approximately 93 percent of Basin-wide pumping occurs in the Main Basin Management Area, and only minor pumping occurs in the Fringe and Upland management areas. The lack of data and information presented in the Fringe and

[170] Instances where the Department review relied upon publicly available data that was not part of the Alternative are specifically noted in the assessment.
[171] 23 CCR § 358.4(a)

Uplands management areas does not preclude the Department staff from making an evaluation of the sustainability of the Basin.

The Department staff finds that the methods used to calculate water budgets are based on sufficient and credible data and use standard practices and methodology for calculations. The Alternative Report describes the current methods used by the Agency to calculate water budgets for the Main Basin Management Area, the Fringe Management Area, and the Uplands Management Area. The calculation method and input datasets are well-documented and appear reasonable for the intended use. Any data gaps identified in the future by the Agency or by Department staff for the Basin or any of the three management areas should be addressed in the annual reports or updates to the Alternative Report.

Department staff find the use of historical low groundwater levels to be a reasonable approach, supported by sufficient and credible information, for defining minimum thresholds for chronic lowering of groundwater levels. The Agency demonstrates that they have established this minimum threshold for groundwater levels and have operated above the historical lows for more than 10 years and that staying above historical groundwater levels has avoided undesirable results in the Basin. However, the Alternative Report relies on a water level surface rather than the water level data for the minimum thresholds. Department staff believe it would facilitate future review and assessment of the Alternative if the water level data for historical lows was provided (see Recommended Action 1).

In addition, the minimum thresholds only cover Main Basin Management Area and a small portion of the Fringe Management Area. The Agency states groundwater levels are routinely measured in the Fringe Management Area, and occasionally in the Uplands Management Area.[172] The Department staff find it reasonable that the Alternative Report lacks minimum thresholds defined for the majority of the Fringe Management Area and the Uplands Management Area because of the lack of groundwater use and looking forward it is unlikely that further development will lead to groundwater declines in these portions of the Basin (*see* Chronic Lowering of Groundwater Levels, above). However, to facilitate ongoing review and assessment of the Alternative, Department staff recommend developing quantitative thresholds for the Fringe and Uplands Management areas (See Recommended Action 2).

The Department staff find that the Agency provided adequate information to demonstrate that the Basin is not experiencing depletion of groundwater storage and has been operated sustainably for at least 10 years. The Department staff finds that the Alternative Report demonstrates that the Main Basin Management Area will likely continue to be

[172] Alternative Report, Section 4.5, p. 4-12

operated sustainably based on the description of the Agency's basin management. The Agency manages the groundwater within the limits of operational storage to maintain adequate supplies and prevent overdraft, operating within the sustainable yield of the basin. The Agency states that the groundwater in storage in the Main Basin Management Area has remained above 200,000 acre-feet for over 40 years, except for a period during the drought in the 1990s. The groundwater in storage has never reached the minimum threshold of 128,000 AF during the period of historical groundwater management, between 1974 and 2015.

The Agency states that seawater intrusion is not a relevant issue for this inland Basin and is not likely to occur in the Basin. Department staff agree with the Agency's conclusion and consider it to be reasonable that the Agency has not developed criteria for this sustainability indicator, given the physical setting of the basin, as described in the Hydrogeologic Conceptual Model.

The Agency sets minimum thresholds for groundwater quality based on federal and state standards. The Agency states that undesirable results would be experienced if municipal wellfields experience a loss in beneficial uses and groundwater cannot be blended, treated, or managed to provide drinking water supply. The Department staff find this to be a reasonable approach to managing groundwater quality and that the Agency demonstrated that through management actions, water quality sampling pursuant to Title 22 requirements, and implementation of regulatory programs, the Basin has been adaptively managed and has not experienced undesirable results with respect to water quality (*see* Groundwater Conditions and Projects and Management Actions, above).

The Department staff find that the Agency provides adequate data to demonstrate that the Basin has not experienced undesirable results with respect to inelastic land subsidence in the Basin over the 10 years and provides a reasonable approach for monitoring and documenting changes in land surface elevation in the Basin. Staff also find it reasonable to use historical low groundwater levels as minimum thresholds for land subsidence.

The Agency identifies the Springtown Alkali Sink as a possible location of interconnected surface water in the Basin and establishes the minimum thresholds as the historic low groundwater elevation at two wells in the Alkali Sink Wetlands, consistent with the management strategy used for several other sustainability indicators in the Basin. Department staff find that the Agency's monitoring and management of the Basin has demonstrated that groundwater levels maintained above historic low groundwater elevations in the Basin has avoided undesirable results associated with depletion of surface water near the Springtown Alkali Sink and is reasonably protective of the Springtown Alkali Sink ecosystem and protected species.

The monitoring network provides a comprehensive network of wells and other measuring methods to evaluate the sustainability indicators. The Agency maintains decades of monitoring results and demonstrates detailed knowledge and understanding of the Basin. The Agency actively monitors for changes in groundwater conditions and uses the monitoring data to manage the Basin sustainably. It is noted that the monitoring network identified in the Alternative Report does not designate specific monitoring wells to collect groundwater elevation data or designate benchmark locations for measuring land surface elevation in the Uplands Management Area. Department staff find that the Agency's justification for not including a detailed monitoring network for the Uplands Management Area is reasonable, because of the limited use of groundwater in this portion of the basin, the low production potential, the limited potential for further development due to a moratorium on onsite wastewater treatment systems in the county in high density well areas, and the Agency's oversight in reviewing and issuing well permits (see Recommended Action 4).

Although the description of future Projects and Management actions are not required for this type of analysis, the Alternative Report demonstrated that through the historical implementation of projects and management actions, the Basin has reached a locally-defined level of sustainability and is operating to a sustainable yield.

B. Recommended Actions

The following recommended actions include information that the District may wish to include in the first five-year update of the Alternative to facilitate the Department's ongoing evaluation and assessment of the Alternative as well as recommendations for improvements to the Alternative.

Recommended Action 1.

Staff recommends that in the first update to the Alternative Report, the Agency identify those groundwater levels taken at representative monitoring sites, that are used to define the minimum threshold for the Basin, to facilitate the Department's ongoing responsibility to evaluate the Alternative Report.

Recommended Action 2.

Staff recommends that the Agency should develop quantitative minimum thresholds for the chronic lowering of groundwater levels for the Fringe and Upland management areas to better align with the requirements for management areas and definition of minimum thresholds, as defined in 23 CCR Sections 354.20(b)(2) and 354.28(b)(6).

Recommended Action 3.

Staff recommends that the Agency develop quantitative minimum thresholds for reduction of groundwater storage for the Fringe and Upland management areas to better align with the requirements for management areas and definition of minimum thresholds, as defined in 23 CCR Sections 354.20(b)(2) and 354.28(b)(6).

Recommended Action 4.

Staff recommends that the Agency include monitoring groundwater levels at additional locations in the Uplands Management Area to monitor changes in groundwater conditions and manage the groundwater resources to prevent undesirable results in future updates to the Alternative Report. The Agency should identify the frequency and timing when groundwater levels would be collected at new monitoring stations, and other relevant monitoring well construction information in accordance with the GSP Regulations.

Sustainable Groundwater Management Program

Alternative Assessment Summary

Livermore Valley Basin

Determination: APPROVED

Submitting Agency:

Zone 7 Water Agency (Zone 7)

Alternative Type:

Analysis of basin conditions demonstrating operation within the sustainable yield for at least 10 years

Assessment Summary:*

- The alternative prepared by Zone 7 satisfied the objectives of the Sustainable Groundwater Management Act (SGMA) by successfully demonstrating that the Livermore Valley Groundwater Basin operated within its sustainable yield for a period of at least 10 years. Operation within the sustainable yield means groundwater use in the basin did not cause any of the six undesirable results identified in SGMA during that 10-year period.
- The alternative demonstrated an acceptable understanding of groundwater conditions in the basin. The alternative identified some previously undesirable results which appear to have been alleviated due to State Water Project imports and local groundwater management projects.
- Zone 7 is identified as an exclusive local agency under SGMA and is the Groundwater Sustainability Agency (GSA) for portions of the basin within its jurisdictional area. Additionally, Zone 7 has a memorandum of understanding with other local agencies that give it the delegated authority to be the GSA for areas of the basin outside its jurisdiction.
- The Department of Water Resources provided recommendations related to groundwater levels taken at representative monitoring sites, quantitative thresholds for groundwater storage, and timing of groundwater level measurements for Zone 7 to address in its first five-year update to the alternative, which is due in January 2022.

*For more details, refer to the staff report at https://www.water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Alternatives.

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June 1, 2018

Trevor Joseph
California Department of Water Resources
901 P Street, Room 313B
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Submitted to "New Comment" in the SGMA Portal/Alternative

RE: Public Comments on the Annual Report for Basin 2-010 LIVERMORE VALLEY

The Nature Conservancy (the Conservancy) appreciates the opportunity to comment on the Water Year 2017 Annual Report submitted by Zone 7 Water Agency in accordance with the Sustainable Groundwater Management Act (SGMA). This letter supplements a number of prior Nature Conservancy comment letters to the Department related to SGMA materials. We greatly appreciate the open process that the Department has used in carrying out the complex and demanding tasks that SGMA has required, and we look forward to continued participation in SGMA implementation.

The Conservancy is an international non-profit organization dedicated to conserving the lands and waters on which all life depends. We have been deeply involved in the legislative creation and regulatory development of the SGMA. The Conservancy has focused its groundwater work extensively on protection for groundwater dependent ecosystems (GDEs) through the implementation of Groundwater Sustainability Plans (GSPs). That protection depends heavily on how the Department directs the identification and consideration of GDEs in GSPs, Alternatives and Annual Reports.

Below we offer general comments related to this first group of Annual Reports that are related to the Alternatives submitted in March of 2017. Following these general comments, we provide specific comment on the Livermore Valley Annual Report.

1. **The adequacy of the Annual Report may be a function of the adequacy of the Alternative**

   In our previous comments to the Alternatives we noted that most of the submittals did not meet requirement to be," functionally equivalent to the elements of a Plan as required by Articles 5 and 7" as specified in Section 385.2(d) of the GSP Regulations. The submitting agencies failed to include adequate identification and consideration of GDEs as beneficial use of groundwater and interconnected surface water. In addition, native vegetation was frequently excluded as a water use sector, as required for the water budget. In reviewing these initial Annual Reports, we observe that if the required material related to GDEs was missing in the Alternative submitted last year, the required information is also commonly missing in the Annual Report, resulting in an inadequate Annual Report.

2. **Annual Reports Are Required to Address All Water Use Sectors**

   Section 356.2 of the GSP Regulations specifies that data related to groundwater extraction for the preceding water year (§356.2(b)(2)) and total water use (§356.2(b)(4)) must be provided "by water use sector". This requirement to address the full range of human and natural use of water is consistent with the direction of the State policy established in SGMA:

   > §113. STATE POLICY OF SUSTAINABLE, LOCAL GROUNDWATER MANAGEMENT It is the policy of the state that groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and **environmental benefits for current and future beneficial uses**. Sustainable groundwater management is best achieved locally through the development, implementation, and updating of plans and programs based on the best available science. *(emphasis added)*

   Unfortunately, we find that these initial Annual Reports only considered the human side of water use and fail to address the full range of water use sectors as defined in the GSP Regulations.

   > §351 (al) "Water use sector" refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, **managed wetlands**, managed recharge, and **native vegetation**. *(emphasis added)*

   We believe that it is essential that all SGMA documents (GSPs, Alternatives and Annual Reports, etc.) consistently meet the requirements related to the beneficial use of water by nature. Because the subject Annual Reports are the first of their kind, it is critical that the Department require full compliance with SGMA and the GSP Regulations.

Related specifically to the Annual Report submitted for the Livermore Valley Basin, we find it to be comprehensive and well organized; however, it does not include the required information regarding groundwater extractions/use and total water use for the managed wetlands and native vegetation water use sectors as specified in the GSP Regulations. As noted previously, SGMA requires that sustainable groundwater management consider all beneficial uses of groundwater and interconnected surface water, both those for human use and those for nature. We strongly recommend that this required information be included in the Annual Report before it is deemed adequate.

We further note that through the development of a GSP, the information systems and data to meet these requirements would be available. In a GSP, GDEs in the basin would be identified and considered, a water budget including all water use sectors would be established and other SGMA requirements related to the full range of beneficial uses would be addressed. The Alternative submitted for the Livermore Valley Subbasin and this Annual Report do not meet all the requirements of SGMA.

The Nature Conservancy appreciates the opportunity to comment on this Annual Report and pledges to work to assist the Department and GSAs as the process of implementing California's groundwater sustainability law moves forward.

Sincerely,

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

CC Matt Katen

The Nature Conservancy
Protecting nature. Preserving life.

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1 April 2017

Acting Director William Croyle
California Department of Water Resources
P.O. Box 942836
Sacramento, California 94236

Submitted online via DWR's SGMA portal:
http://sgma.water.ca.gov/portal/alternative/all

Re: Alternative Submittal from Zone 7 Water Agency

Dear Director Croyle:

The Nature Conservancy (TNC) appreciates the opportunity to comment on the alternative submittal from Zone 7 Water Agency (Zone 7) under the Sustainable Groundwater Management Act (SGMA).

Background on Our Interest

TNC is a global, nonprofit organization dedicated to conserving the lands and waters on which all life depends. We have over 100,000 California members and seek to achieve our mission through science-based planning and implementation of conservation strategies. TNC was part of a stakeholder group formed by the Water Foundation in early 2014 to develop recommendations for groundwater reform and actively worked to shape and pass SGMA.

Our reason for engaging is simple: California's freshwater biodiversity is highly imperiled. We have lost more than 90 percent of our native wetland and river habitats, leading to precipitous declines in native plants and the populations of animals that call these places home. These natural resources are intricately connected to California's economy providing direct benefits through industries such as fisheries, timber and hunting, as well as indirect benefits such as clean water supplies. Given the inextricable connection between groundwater and surface water, SGMA must be successful for a sustainable future in California.

California continues to use more water than nature provides. While surface water rights and access to surface water may be curtailed, the balance of water consumed is coming from groundwater – an estimated 60% California's water during the drought was supplied by groundwater. SGMA provides a path for California to sustainably manage groundwater so that the critical groundwater reserves are available when surface water is not.

SGMA is now law, but implementation is just beginning. The success of SGMA depends on bringing the best available science to the table, engaging all stakeholders in robust dialog, providing strong incentives for beneficial outcomes and rigorous enforcement by the State of California.

The recently submitted alternatives mark the first opportunity for the Department of Water Resources (Department) to hold local agencies accountable for sustainability. We ask the Department to fully exercise its authorities granted under SGMA to ensure the adequacy of plans. Given our mission to preserve the plants and animals on which all life depends, we are particularly concerned about the inclusion of nature, as required, in groundwater sustainability plans (GSPs).

"Functionally Equivalent" Requires Fully Addressing Nature's Water Needs

Zone 7 submitted an alternative submittal based on basin conditions. To meet the requirements provided under SGMA, the alternative submittal must:

1. Provide "(a)n analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years" (23 CCR §358.2(b)(3)); and
2. "(E)xplain how the elements of the Alternative are functionally equivalent to the elements of a Plan required by Articles 5 and 7 of this Subchapter and are sufficient to demonstrate the ability of the Alternative to achieve the objectives of the Act." (23 CCR §358.2(d)

To be "functionally equivalent," the alternative submittal must fully incorporate the numerous requirements to address nature's water needs under SGMA. While there are certainly additional provisions regarding nature's water needs, for the purposes of our review, we focused on the following elements:

1. Are groundwater dependent ecosystems (GDEs) identified? (23 CCR §354.16(g)) Are GDEs and surface water dependent species included as beneficial uses? (23 CCR §354.10(a))

2. Are interconnected surface waters identified and are estimates of the quantity and timing of any depletions specified? (23 CCR 354.16(f), §354.28(c)(6)(A))

3. Do water budgets include water needs for managed wetlands and native vegetation, as defined water use sectors, as well as total surface water inflows and outflows? (23 CCR §354.18(b))

4. Do undesirable results and minimum thresholds describe potential effects on beneficial uses (especially GDEs), land uses (including recreational uses) and property interests (including open space and conservation lands), particularly for the chronic lowering of groundwater, degraded water quality and depletions of interconnected surface waters? (23 CCR §354.26, §354.28,

§355.4(b)(4)) Are these undesirable results being avoided? (Water Code §10733.6(b)(3)) Has the basin operated sustainably for at least the past 10 years? (23 CCR §358.2(c)(3))

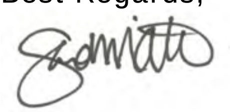
5. Does the sustainability goal include the environment, and if so, does the plan include measurable objectives and interim milestones to achieve the environmental portion of the sustainability goal within 20 years? (23 CCR §354.30)

6. Does the monitoring network monitor impacts to beneficial uses? (23 CCR §354.34(b)(2))

Our comments related to the above questions are provided in Attachment A: TNC Evaluation of Zone 7 Water Agency's Alternative Submittal. Based on our review, Zone 7's alternative submittal could be improved by including measurable objectives and interim milestones for achieving the environmental element of the sustainability goal within 20 years.

Thank you for fully considering our comments as you evaluate the adequacy of this alternative submittal.

Best Regards,



Sandi Matsumoto
Associate Director, Water Program
The Nature Conservancy of California

Attachment A: TNC Evaluation of Zone 7 Water Agency's Alternative Submittal

1. Are groundwater dependent ecosystems (GDEs) identified? Yes. Are GDEs and surface water dependent species included as beneficial uses? Indirectly by way of the Regional Water Quality Control Board (RWQCB), San Francisco Region, Basin Plan.

   GDEs: §354.16g: See Zone 7's *Alternative Groundwater Sustainability Plan for the Livermore Valley Groundwater Basin*, December 2016, (AGSP) pages E-12, 2-7 through 2-8, 2-76 through 2-77, and pages 3-22 to 3-25. Below is a brief quote from page 2-8:

   The Alkali Sink may be considered a groundwater dependent ecosystem for the purposes of SGMA, although effects are clearly seasonal. The sink supports an alkali-saline wetland habitat with seasonal surface ponding and shallow, seasonal high-salinity groundwater.

   Beneficial Uses: §354.10a: Zone 7 cooperates with the RWQCB to meet the water quality objectives in the RWQCB Basin Plan. Among the beneficial uses specified in the Basin Plan are commercial and sport fishing, cold freshwater habitat, fish migration, preservation of rare and endangered species, fish spawning, warm freshwater habitat, and wildlife habitat. See AGSP pages 1-28 to 1-29.

2. Are interconnected surface waters identified and are estimates of the quantity and timing of any depletions specified? Yes.

   §354.16f: See AGSP pages 2-76 to 2-79.

   Undesirable Results §354.28c6: See AGSP pages 3-22 to 3-25, which include a description of the potential UR due to depletion of surface water in the Springtown Alkali Sink. Page 3-24 illustrates a minimum threshold to avoid surface water depletion in the Alkali Sink area.

3. Do water budgets include water needs for managed wetlands and native vegetation, as defined water use sectors? No, not as water use sectors.

   §354.18b: The water budget information provided on pages 2-79 through 2-95 seems to meet the intent of Section 354.18b.

4. Do undesirable results (UR) and minimum thresholds describe potential effects on beneficial uses, land uses and property interests, particularly for the chronic lowering of groundwater, degraded water quality and depletions of interconnected surface waters? Yes. Are these UR being avoided? Yes. Has the basin operated sustainably for at least the past 10 years? Yes.

§354.26: See AGSP pages 3-4 through 3-25 for descriptions and discussion of potential UR, minimum thresholds, and sustainability indicators.

§354.28: Minimum thresholds are discussed for potential UR on pages 3-4 through 3-25 of the AGSP.

Presence of UR: The AGSP reports no UR have been observed for several decades (pages 1-30, 2-90, 3-4 through 3-24).

Sustainable operations for more than 10 years, §358.2c3: Yes.

5. Does the sustainability goal include the environment, and if so, does the plan include measurable objectives and interim milestones to achieve the environmental portion of the sustainability goal within 20 years? The environment is included in Zone 7's sustainable management goal indirectly by preventing depletion of surface water supplies (AGSP page 3-1):

> *The sustainable management goal for this Alternative Plan is to continue to operate the Livermore Valley Groundwater Basin within its sustainable yield and to manage the groundwater resources for the prevention of significant and unreasonable (1) lowering of groundwater levels, (2) reduction in basin storage, (3) degradation of groundwater quality, (4) inelastic land subsidence, or (5) depletion of surface water supplies such that beneficial uses are adversely impacted.* [We assume Zone 7 meant "such that beneficial uses are not adversely impacted".]

§354.30: AGSP pages 2-37 to 2-48 describe historic and current groundwater levels, and Section 3, *Sustainable Management* Criteria, describes basin management objectives, sustainable management objectives and equivalents of sustainability indicators for the following potential UR: chronic lowering of groundwater levels and reduction of groundwater storage, degraded water quality, land subsidence, and depletion of interconnected surface water.

A potential UR of ISW depletion would be depletion of surface water in the Alkali Sink and potential adverse effects on the Sink's ecosystem and its species. Pages 3-24 to 3-25 explain the minimum threshold for this potential UR and the monitoring conducted to protect the Alkali Sink. MODFLOW was used to develop a water budget for the sink (page 3-23).

6. Does the monitoring network monitor impacts to beneficial uses? Yes.

§354.34b2: AGSP Section 4 describes the monitoring objectives and programs intended to track factors affecting the sustainability indicators described in Section 3.

APPENDIX B

DWR CHECKLIST

Article 5.

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
§ 356.4			**Periodic Evaluation by Agency**					
			Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended, and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:					
(a)			A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.	140:183	8.3:8.9	8-1:8-49, 8-A:8-B	8-1:8-5, 8-A:8-J	
(b)			A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.	411:425	15.2	15-1	15-A	
(c)			Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.	138:186, 295:297	8, 11			
(d)			An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.	138:186	8.1:8.10	8-1:8:-51, 8-A:8-B	8-1:8-6, 8-A:8-J	
(e)			A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:					
	(1)		An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.	344:361, 364:365	14.1:14.2, 14.5	14-1:14-6, 14-A	14-1:14-11, 14-A:14-E	
	(2)		If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.	364:365	14.5			
	(3)		The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.	364:365	14.5			
(f)			A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the GSP Emergency Regulations, Article 7: Annual Reports and Evaluations by the Agency Page 3 evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.	35:36	1.2			
(g)			A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.	408:409,411:425	15, 15.2			
(h)			Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.	408:409,411:425	15, 15.2			
(i)			A description of completed or proposed Plan amendments.	35:39	1.2			

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(j)			Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.	47:49, 84	3.2, 5.5.5:5.5.6	3-1		
(k)			Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733.	311, 320, 331, 336, 342	13.1.4, 13.2.4, 13.4.4, 13.5.4, 13.6.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10728, 10728.2, 10733.2, and 10733.8, Water Code.					
§ 354.			**Introduction to Plan Contents**					
			This Article describes the required contents of Plans submitted to the Department for evaluation, including administrative information, a description of the basin setting, sustainable management criteria, description of the monitoring network, and projects and management actions.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
SubArticle 1.			**Administrative Information**					
§ 354.2.			**Introduction to Administrative Information**					
			This Subarticle describes information in the Plan relating to administrative and other general information about the Agency that has adopted the Plan and the area covered by the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.4.			**General Information**					
			Each Plan shall include the following general information:					
(a)			An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.	17:30	ES.1:ES.11	ES-A:ES-F		
(b)			A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.	432:436	16			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
§ 354.6.			**Agency Information**					
			When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:					
(a)			The name and mailing address of the Agency.	47	3.1			

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.	47:49	3.2	3-1:3-2		
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.	50	3.3			
(d)			The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.	50	3.4			
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.	50	3.5		3-1	
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.8, 10727.2, and 10733.2, Water Code.					
§ 354.8.			**Description of Plan Area**					
			Each Plan shall include a description of the geographic areas covered, including the following information:					
(a)			One or more maps of the basin that depict the following, as applicable:					
	(1)		The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.	56:57, 85	5.1.1	5-1	5-A	
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.	57, 86	5.1.2	5-2		
	(3)		Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.	58, 87	5.1.3	5-3		
	(4)		Existing land use designations and the identification of water use sector and water source type.	58:63, 88, 91	5.1.4	5-4, 5-7	5-B:5-D	
	(5)		The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.	63, 89:90	5.1.5	5-5:5-6	5-E	
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.	56:63	5.1			
(c)			Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.	64:69	5.2.1		5-F	

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(d)			A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.	69	5.2.2			
(e)			A description of conjunctive use programs in the basin.	69:70	5.2.3		5-G	
(f)			A plain language description of the land use elements or topic categories of applicable general plans that includes the following:					
	(1)		A summary of general plans and other land use plans governing the basin.	70:76	5.3.1:5.3.6			
	(2)		A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects	70:76	5.3.1:5.3.6			
	(3)		A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.	70:76	5.3.1:5.3.6			
	(4)		A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.	75:76	5.3.7			
	(5)		To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.	76	5.3.8			
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.	77:78	5.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10720.3, 10727.2, 10727.4, 10733, and 10733.2, Water Code.					
§ 354.10.			**Notice and Communication**					
			Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:					
(a)			A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.	79:80	5.5.1, Appendix B		5-H	
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.	80:82	5.5.2, Appendix B			
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.	82	5.5.3, Appendix B		5-I	
(d)			A communication section of the Plan that includes the following:					

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		An explanation of the Agency's decision-making process.	82	5.5.4.1, Appendix B			
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.	82	5.5.4.2, Appendix B			
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.	82:83	5.5.4.3, Appendix B			
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.	84	5.5.4.4, Appendix B			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.8, 10728.4, and 10733.2, Water Code					
SubArticle 2.			**Basin Setting**					
§ 354.12.			**Introduction to Basin Setting**					
			This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.14.			**Hydrogeologic Conceptual Model**					
(a)			Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.	94:119	7.1:7.7			
(b)			The hydrogeologic conceptual model shall be summarized in a written description that includes the following:					
	(1)		The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.	95:96	7.1	7-1:7-3		
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	97:99	7.2	7-4		
	(3)		The definable bottom of the basin.	99:100	7.3	7-5		
	(4)		Principal aquifers and aquitards, including the following information:					

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(A)	Formation names, if defined.	100:105, 127	7.4	7-8		
		(B)	Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.	100:105	7.4			
		(C)	Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.	100:105, 131	7.4	7-12		
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	100:105	7.4			
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	100:105	7.4			
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model	105:106	7.5			
(c)			The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.	106:113, 125:126, 128:130	7.6	7-6:7-7, 7-9:7-11		
(d)			Physical characteristics of the basin shall be represented on one or more maps that depict the following:					
	(1)		Topographic information derived from the U.S. Geological Survey or another reliable source.	114, 132	7.7.1	7-13		
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	114, 122	7.7.2	7-3		
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	114:115, 133:134	7.7.3	7-14:7-15		
	(4)		Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.	115:116, 135	7.7.4	7-16	7-A	
	(5)		Surface water bodies that are significant to the management of the basin.	116:118, 122, 136	7.7.5	7-3, 7-17		
	(6)		The source and point of delivery for imported water supplies.	118:119, 137	7.7.6	7-18		
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10733, and 10733.2, Water Code.					
§ 354.16.			**Groundwater Conditions**					
			Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:					

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(a)			Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:					
	(1)		Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.	141:142, 197:201	8.3.2	8:1-8:5		
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	142:145, 202:207	8.3.3	8:6-8:11		
(b)			A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.	145:149, 187, 208:211	8.4	8:12-8:15	8-1, 8-A:8-F	
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	149	8.5			
(d)			Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.	150:170, 188:195, 212:235	8.6	8:16-8:39	8-2:8-5; 8-G:8-I	
(e)			The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	170:172, 236	8.7	8-40		
(f)			Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	179:183, 243:245	8.9	8-47:8-49		
(g)			Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	172:179, 237:242	8.8	8-41:8-46	8-J	
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, and 10733.2, Water Code.					
§ 354.18.			**Water Budget**					
(a)			Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.	248:272	9			
(b)			The water budget shall quantify the following, either through direct measurements or estimates based on data:					
	(1)		Total surface water entering and leaving a basin by water source type.	251:252	9.2.1		9-B	

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				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.	250, 252:253, 280:287	9.2.2	9-2:9-3	9-A	
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	250, 254:255, 280:287	9.2.3	9-2:9-3	9-A	
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.	261:263, 284	9.3.3	9-6	9-F:9-G	
	(5)		If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.	263:264	9.3.4			
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.	264	9.3.5			
	(7)		An estimate of sustainable yield for the basin.	264:268	9.3.6		9-H:9-K	
(c)			Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:					
	(1)		Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.	255-259, 273:274	9.3.1	9-A	9-1:9-2, 9-C:9-E	
	(2)		Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:					
		(A)	A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.	260, 282:283	9.3.2.1	9-4:9-5		
		(B)	A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.	261, 275:277, 284	9.3.2.2	9-6	9-3	
		(C)	A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.	261, 285:286	9.3.2.3	9-7:9-8		

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	(3)		Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:					
		(A)	Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.	269:272, 278, 288	9.4	9-10	9-4	
		(B)	Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.	269:272, 278, 288	9.4	9-10	9-4	
		(C)	Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.	269:272, 278, 288	9.4	9-10	9-4	
(d)			The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:					
	(1)		Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.	249:251, 260:263	9.1, 9.3			
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.	249:251, 255:259	9.1, 9.3			
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.	249:251, 269:272	9.1, 9.4			

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(e)			Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.	249:251	9.1			
(f)			The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.	249:251	9.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10727.6, 10729, and 10733.2, Water Code.					
§ 354.20.			**Management Areas**					
(a)			Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.	289:293	10	10-1	10-A	
(b)			A basin that includes one or more management areas shall describe the following in the Plan:					
	(1)		The reason for the creation of each management area.	290:292	10.1			
	(2)		The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.	290:292, 301:341	10.1, 13			
	(3)		The level of monitoring and analysis appropriate for each management area.	290:292, 344:366	10.1, 14			
	(4)		An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.	290:292, 301:341	10.1, 13			
(c)			If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.	290:292	10.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					

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SubArticle 3.			**Sustainable Management Criteria**					
§ 354.22.			**Introduction to Sustainable Management Criteria**					
			This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.24.			**Sustainability Goal**					
			Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.	300	12			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10727, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.26.			**Undesirable Results**					
(a)			Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			
(b)			The description of undesirable results shall include the following:					
	(1)		The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			

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	(2)		The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			
	(3)		Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			
(c)			The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			
(d)			An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.	301:305, 312:314, 319:320, 320:324, 332:333, 336:338	13.1.1, 13.2.1, 13.3.1, 13.4.1, 13.5.1, 13.6.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.28.			**Minimum Thresholds**					
(a)			Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.	305:310, 314:320, 324:330, 334:335, 338:341	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2		13-A:13-J	
(b)			The description of minimum thresholds shall include the following:					
	(1)		The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			

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	(2)		The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			
	(3)		How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			
	(5)		How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.	305:310, 314:317, 320, 324:330, 334:335, 338:340	13.1.2, 13.2.2, 13.3.2, 13.4.2, 13.5.2, 13.6.2			
(c)			Minimum thresholds for each sustainability indicator shall be defined as follows:					
	(1)		Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:					
		(A)	The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.	305:310	13.1.2			
		(B)	Potential effects on other sustainability indicators.	305:310	13.1.2			

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	(2)		Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.	314:317	13.2.2			
	(3)		Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:					
		(A)	Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.	320	13.3.2			
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.	320	13.3.2			
	(4)		Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.	324:330	13.4.2			
	(5)		Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:					
		(A)	Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.	334:335	13.5.2			
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.	334:335	13.5.2			
	(6)		Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:					

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		(A)	The location, quantity, and timing of depletions of interconnected surface water.	338:340	13.6.2			
		(B)	A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.	338:340	13.6.2			
(d)			An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.	338:340	13.6.2			
(e)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.	338:340	13.6.2			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10733, 10733.2, and 10733.8, Water Code.					
§ 354.30.			**Measurable Objectives**					
(a)			Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.	307, 311, 315:320, 330:331, 334:335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3		13-A:13-J	
(b)			Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.	311, 318:319, 320, 330:331, 335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			
(c)			Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.	311, 318:319, 320, 330:331, 335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			

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(d)			An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.	311, 318:319, 320, 330:331, 335, 340:341	13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			
(e)			Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.	311, 318:319, 320, 330:331, 335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			
(f)			Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.	311, 318:319, 320, 330:331, 335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			
(g)			An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.	311, 318:319, 320, 330:331, 335, 340:341	13.1.3, 13.2.3, 13.3.3, 13.4.3, 13.5.3, 13.6.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					
SubArticle 4.			**Monitoring Networks**					
§ 354.32.			**Introduction to Monitoring Networks**					
			This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.34.			**Monitoring Network**					

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(a)			Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.	344:406	14			
(b)			Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:					
	(1)		Demonstrate progress toward achieving measurable objectives described in the Plan.	345:361	14.2			
	(2)		Monitor impacts to the beneficial uses or users of groundwater.	345:361	14.2			
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.	345:361	14.2			
	(4)		Quantify annual changes in water budget components.	345:361	14.2			
(c)			Each monitoring network shall be designed to accomplish the following for each sustainability indicator:					
	(1)		Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:					
		(A)	A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.	351:354, 367:377, 399	14.2.1	14-1	14-1:14-2	
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.	351:354, 367:372, 399	14.2.1	14-1	14-1	
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.	355	14.2.2			
	(3)		Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.	355	14.2.3			
	(4)		Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.	355:357, 378:384, 400	14.2.4	14-2	14-3	

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	(5)		Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.	357:358, 401	14.2.5	14-3		
	(6)		Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:					
		(A)	Flow conditions including surface water discharge, surface water head, and baseflow contribution.	358:359, 385:386, 402	14.2.6	14-4	14-4	
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.	358:359, 385:386, 402	14.2.6	14-4	14-4	
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.	358:359, 385:386, 402	14.2.6	14-4	14-4	
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.	358:359, 385:386, 402	14.2.6	14-4	14-4	
(d)			The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.	345:361, 392:398	14.2		14-8:14-11	
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.	345:361	14.2			
(f)			The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:					
	(1)		Amount of current and projected groundwater use.	345:361	14.2			
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.	345:361	14.2			
	(3)		Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.	345:361	14.2			
	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.	345:361	14.2			

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(g)			Each Plan shall describe the following information about the monitoring network:					
	(1)		Scientific rationale for the monitoring site selection process.	345:361	14.2			
	(2)		Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.	345:361	14.2			
	(3)		For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.	345:361, 392:398	14.2		14-8:14-11	
(h)			The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.	367:386, 399:402, 406	14.2	14-1:14-4, 14-8	14-1:14-4	
(i)			The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.	361	14.3			
(j)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.	355	14.2.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, 10728, 10733, 10733.2, and 10733.8, Water Code					
§ 354.36.			**Representative Monitoring**					
			Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:					
(a)			Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.	362:364, 392:398	14.4		14-8:14-11	
(b)			(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:					
	(1)		Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.	362:364	14.4			

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	(2)		Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.	362:364	14.4			
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.	362:364	14.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2 and 10733.2, Water Code					
§ 354.38.			**Assessment and Improvement of Monitoring Network**					
(a)			Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.	364:365	14.5			
(b)			Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.	364:365	14.5			
(c)			If the monitoring network contains data gaps, the Plan shall include a description of the following:					
	(1)		The location and reason for data gaps in the monitoring network.	364:365	14.5			
	(2)		Local issues and circumstances that limit or prevent monitoring.	364:365	14.5			
(d)			Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.	364:365	14.5			
(e)			Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:					
	(1)		Minimum threshold exceedances.	364:365	14.5			
	(2)		Highly variable spatial or temporal conditions.	364:365	14.5			
	(3)		Adverse impacts to beneficial uses and users of groundwater.	364:365	14.5			
	(4)		The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.	364:365	14.5			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10728.2, 10733, 10733.2, and 10733.8, Water Code					
§ 354.40.			**Reporting Monitoring Data to the Department**					

Article 5.

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.					
SubArticle 5.			**Projects and Management Actions**					
§ 354.42.			**Introduction to Projects and Management Actions**					
			This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.44.			**Projects and Management Actions**					
(a)			Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.	411:425, 430	15.2	15-1	15-A	
(b)			Each Plan shall include a description of the projects and management actions that include the following:					
	(1)		A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:					
		(A)	A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.	425	15.3			
		(B)	The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.	425	15.4			
	(2)		If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.	426	15.5			

Article 5.

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		A summary of the permitting and regulatory process required for each project and management action.	426	15.6			
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.	427	15.7			
	(5)		An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.	427	15.8			
	(6)		An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.	427	15.9			
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.	428	15.10			
	(8)		A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.	428	15.11		15-B	
	(9)		A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.	429	15.12			
(c)			Projects and management actions shall be supported by best available information and best available science.	408:430	15			
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.	408:430	15			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

APPENDIX C

GEOLOGIC CROSS-SECTIONS
TECHNICAL MEMORANDUM

14 October 2021

TECHNICAL MEMORANDUM

To: Tom Rooze (Zone 7 Water Agency [Zone 7])
Colleen Winey (Zone 7)
Carol Mahoney (Zone 7)

From: Anona Dutton, PG, CHg (EKI Environment & Water, Inc. [EKI])
Aaron Lewis (EKI)
Susan Xie, EIT (EKI)

Subject: **Draft Geologic Cross-Sections for 2022 Alternative Groundwater Sustainability Plan** (EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to provide to Zone 7 Water Agency (Zone 7) a revised draft technical memorandum presenting three geologic cross-sections of the Livermore Valley Groundwater Basin (Basin) and accompanying written descriptions. Pursuant to our approved scope of work, EKI's work efforts include application of 3D geologic modeling software to develop three cross-sections for the Basin. A final version of these cross-sections and accompanying descriptions is anticipated to be included in the Basin Setting section of the 2022 Alternative Groundwater Sustainability Plan (Alt GSP).

BACKGROUND

Pursuant to Title 23, Section 358.2(a) of the California Code of Regulations (23-CCR §358.2(a)), Groundwater Sustainability Agencies (GSAs) with an approved Alternative Groundwater Sustainability Plan (Alt GSP or Plan) must resubmit an updated Plan to the California Department of Water Resources (DWR) every five years. As part of the five-year update process to the 2016 Alt GSP, Zone 7 contracted EKI to extend the existing Hydrogeologic Conceptual Model (HCM) framework to encompass the entirety of the Basin and to subsequently develop three geologic cross-sections of the Basin for subsequent inclusion in the 2022 Alt GSP. The cross-section locations are shown on Figure 1. A map of the surficial geology, major fault structures, and streams that were incorporated into the cross-sections are shown on Figure 2.

As described in EKI's *Progress Update on Extending Existing Hydrogeologic Framework* (dated 02 April 2021), the RockWorks[1] three-dimensional (3D) geologic modeling software platform was selected by Zone 7 to support data integration, HCM representation, and cross-section development. EKI has further refined the 3D geologic model in Rockworks and imported draft cross-section outputs into the AutoCAD[2] software program to assist in developing cross-section figures for inclusion in the 2022 Alt GSP. Two

[1] RockWorks 2020 Standard Level License from RockWare is downloaded and installed on 15 October 2020: https://www.rockware.com/product/rockworks/
[2] https://www.autodesk.com/products/autocad/overview?term=1-YEAR&support=null

versions of the geologic cross-sections are included in this technical memorandum. The first version includes all nearby borehole lithology and geophysical data used to inform cross-section development (see Figures 3a, 4a and 5a). The second version presents the total depth and screen intervals of Zone 7's nearby municipal and SGMA monitoring wells and labels the principal surface water features encountered along each trace (see Figures 3b, 4b, and 5b). Accompanying each cross-section is a written description documenting the principal geologic features, as well as the assumptions and references used to inform cross-section development. Also provided is a simplified schematic of the conceptual hydrostratigraphic model of the Basin which maps major stratigraphic facies to corresponding Principal Aquifer units defined for each Management Area in the Alternative GSP (see Figure 6).

GEOLOGIC CROSS-SECTION A-A'

Cross-Section A-A' depicts a generally west-to-east trace through the Basin (see Figures 3a and 3b). The trace begins just west of the southwestern Basin boundary near the Calaveras Fault deformation zone and progresses eastward through the Main Basin (including the Castle, Bernal, Amador, and Mocho II subareas), where a majority of groundwater production occurs in the Basin. The trace cuts directly through a narrow corridor of alluvium connecting the Mocho II and Mocho I subareas (an area commonly referred to as "The Gap") and continues through the southern portion of the Eastern Fringe Area (including the Mocho I and Spring subareas) before terminating in the Upland Area just west of the Greenville Fault deformation zone.

After crossing the main deformation zone of the Calaveras Fault and entering the Basin, Cross-Section A-A' cuts through the Castle subarea, which consists of "uplands underlain by the Livermore Formation and… adjacent valley fill material" (*DWR, 1974*). Here, the Upper Aquifer is comprised of Holocene alluvial deposits ranging from approximately 50 to 75 ft thick. Most of the wells in the Castle Subarea draw from the upper 100 to 200 ft of Plio-Pleistocene Livermore Formation, which is present "as a sequence of gravel, sand, and silt interlayered by clay" (*DWR, 1974*). This productive upper zone of the Livermore Formation (herein referred to as the "Upper Livermore Formation") comprises the Lower Aquifer in the area. "All of these materials apparently slope toward the valley at dips ranging up to ten degrees" (*DWR, 1974*).

Cross-Section A-A' subsequently passes over another presumed splay of the Calaveras Fault and enters the Bernal subarea, which acts as the point of convergence for all major streams and subsurface flows that eventually drain the Basin via the Arroyo de La Laguna. Here, a confining surficial clay unit exists reaching up to 70 ft thickness (herein referred to as the "Overburden"). Beneath the Overburden is the Upper Aquifer, which is comprised of a 50 to >100-ft sequence of unconsolidated, Holocene sandy gravel and silty/clayey gravel deposits. Beneath the Upper Aquifer is a laterally extensive lacustrine clay and silt unit of up to 50 ft thick (herein referred to as the "Aquitard"). Below the Aquitard is a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts (*Norfleet Consultants, 2004*). These Quaternary (Pleistocene-Holocene) deposits are believed to represent a "structurally influenced, incised channel complex" deposited by the ancestral Arroyo Mocho stream (*Norfleet Consultants, 2004*) and are encountered up to >400 ft bgs in the area (*DWR, 1974*). Underlying the Quaternary fluvial and alluvial deposits is the Upper Livermore Formation, for which up to 200 ft is considered productive due to sufficient weathering and permeability relative to the more consolidated zones of the Lower Livermore Formation. The combined sequence of Quaternary alluvial/fluvial deposits and the Upper Livermore Formation are known collectively as the Lower Aquifer in the Main Basin. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges up to 3,500 gpm and specific capacities range from 3 to 260 gpm per foot of drawdown.

The trace subsequently crosses into the Amador subarea, whereby a majority of groundwater production occurs in the Basin. The Overburden is present in the western half of the Amador subarea, extending east approximately to the Chain of Lakes (COL) mining area, creating semi-confined conditions in the Upper Aquifer where it is present. Beneath the Overburden are Holocene alluvial deposits of the Upper Aquifer, which reach depths of up to 190 ft bgs in the subarea (and approximately 150 ft underlying Cross-Section A-A'). Here, the Upper Aquifer is consistent with the "Cyan" stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies. The Aquitard is present below the Upper Aquifer at a thickness of up to 50 ft under the COL area, before gradually thinning to the east. This unit is consistent with the "Grey Clay" sequence defined in the Norfleet (2004) and Zone 7 (2011) studies and serves to create semi-confined to confined conditions in the underlying Lower Aquifer. As in the Bernal Subarea, Lower Aquifer units in the western portion of the Amador subarea are comprised of up to 400 ft of interbedded, Quaternary alluvial/fluvial deposits (consistent with the "Grey" and "Purple" sequences from Norfleet (2004) and Zone 7 (2011)), underlain by 200-300 ft of productive Upper Livermore deposits (consistent with the "Red" sequence in Norfleet (2004) and Zone 7 (2011)). The Basin reaches a maximum depth of >800 ft in the central Amador subarea near the COL mining pits. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges from 42 to 2,820 gpm and specific capacities range from 1.1 to 217 gpm per foot of drawdown.

Moving further east through the Amador Subarea, Cross-Section A-A' eventually reaches the Livermore Thrust fault zone, which presents a significant unconformity that serves to restrict groundwater flow from the Mocho II subarea to the Amador subarea. According to Norfleet (2004):

> *"The Livermore Thrust ha[s] a westward motion and dip[s] at a high angle to the east. [It] dies out rapidly to the north and do[es] not extend all the way across the current Livermore Valley. Evidence for the Livermore fault was discussed in Thomas et al. (1959) and DWR (1963, 1966, and 1974). The fault has historically been considered to be a strike-slip fault, but the data are more consistent with an east dipping, west-moving thrust fault. The Livermore thrust cut and uplifted Livermore Gravels, suggesting that the fault developed after deposition of the classical Livermore Gravels." (Norfleet, 2004)*

Several varying interpretations exist in the literature regarding the nature and extent of this fault and the degree to which it impedes groundwater flow. In their Bulletin-118 description of the Basin, DWR notes:

> *"The Livermore [Thrust] is an effective barrier to ground water inflow from the Mocho subbasin except in the vicinity of the ancestral channel of Arroyo Mocho north of Oak Knoll, where ground water moves across this fault essentially unimpeded" (DWR, 1974).*

Cross-Section A-A' traces north of Oak Knoll, within the ancestral Arroyo Mocho paleochannel. However, based on nearby water level observations collected in Fall 2019, an apparent 80-foot drop in groundwater elevation is observed in the Lower Aquifer moving westward across the fault, indicating that some degree of hydraulic restriction occurs across the fault zone in this area. Notably, this groundwater flow barrier across the fault is not observed in the Upper Aquifer.

The total depths of wells in the Mocho II subarea east of the Livermore Thrust suggest that the base of the Lower Aquifer (i.e., the bottom of the productive Upper Livermore Formation) is encountered 200-300 ft higher in this subarea than in the Amador subarea west of the fault, indicating a significant discontinuity likely exists in the Lower Aquifer formations even within the incised ancestral Arroyo Mocho channel complex resulting from uplift on the eastern side of the fault. A relatively lower proportion of "clean gravels" is also observed east of the Livermore Thrust, resulting in lower productivity of the Lower Aquifer in the Mocho II subarea (*Norfleet Consultants, 2004*). Upper Aquifer deposits progressively thin to around 50 ft thickness moving east through Mocho II subarea. The Aquitard and underlying Quaternary deposits gradually diminish as the trace moves further east outside the ancestral Arroyo Mocho paleochannel, and eventually disappear before reaching the Mocho II – Mocho I boundary such that Pleistocene-Holocene alluvial deposits are directly underlain by deposits of the Upper Livermore Formation.

Another apparent steepening of the hydraulic gradient in the Lower Aquifer is observed west of the Mocho II/Mocho I boundary as deposits of the Upper Livermore Formation continue to reduce to a total depth of approximately 330 ft bgs at well 3S2E10Q002. A short distance to the east, a narrow, roughly 50-ft thick sequence of young alluvial deposits of the Arroyo Seco channel underlain by older, interbedded sand and gravel deposits of the Upper Livermore Formation connects the Main Basin to the Eastern Fringe Area in an alluvial channel known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south, also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within the Gap that serves to restrict the vertical cross-sectional area of connection between Upper and Lower Aquifer deposits in the Eastern Fringe Area and the Main Basin to the west (*DWR 1974, LLNL 1984*). There is considerable uncertainty to the degree which flow is restricted across The Gap, though Fall 2019 water level trends suggests this area acts as an apparent groundwater divide in both the Upper and Lower Aquifers.

As the trace of Cross-Section A-A' moves across The Gap and into the Mocho I subarea of the Fringe Area, Upper Livermore deposits again deepen to a total depth around 350 ft bgs at well 3S2E11R046 near the southwestern corner of the Lawrence Livermore National Laboratory (LLNL). A local depression in Fall 2019 groundwater elevations was observed in the Fringe Aquifer in this area, likely due to groundwater pumping. These deposits then begin to dip upward to the northeast as the trace moves into the Spring subarea, reducing to a total depth of 175 ft bgs at well 3S2E12J025 on the southeastern side of LLNL (*LLNL, 1984*). Here, the Upper Livermore deposits are described as a series of "beds of cemented gravel, sandy gravel, and sandy clay separated by beds of less-permeable clay and silty clay" (*DWR, 1974*). Overlying Pleistocene-Holocene valley-fill materials in this area "are of similar composition to the sediments of the Livermore Formation, as they are composed principally of reworked Livermore Formation detritus" (*DWR, 1974*). Both the valley fill and underlying Livermore deposits continue to dip upward to the northeast before reaching the Las Positas Fault, which likely serves to truncate the Fringe Aquifer completely. The trace then briefly crosses into the Upland Area, where the Lower Livermore Formation is the dominant outcropping unit and no significant groundwater production occurs, before ending at the southeastern Basin Boundary near the Greenville Fault zone.

GEOLOGIC CROSS-SECTION B-B'

Cross-Section B-B' depicts a generally northwest-to-southeast trace through the western portion of the Basin (see Figures 4a and 4b). The trace begins at the northwestern Basin boundary with the neighboring San Ramon Valley Groundwater Basin to the north. It runs southeast through the Northern Fringe Area (including the Bishop, Dublin, and Camp subareas) before entering the Main Basin. Cross-Section B-B' then passes through a large section of the west-central Main Basin (Amador subarea) and continues southeast up the Arroyo del Valle stream corridor before terminating at the contact between the Amador subarea and the Southern Upland Area near the southern Basin boundary.

The trace begins in the Bishop subarea of the Northern Fringe Area, which contains "one of the deepest developed prisms of water-bearing materials in the Basin…[with] sediments up to 800 feet in depth" (*DWR, 1974*). Surficial deposits are consistent with Holocene alluvial and fluvial sands and gravels, underlain by a thick sequence of relatively fine-grained deposits of the Pleistocene to Plio-Pleistocene Tassajara Formation. These contain "eight to ten separate zones of sand and gravel separated by zones of silt and clay" (*DWR, 1974*). It is assumed that "the greater portion of the sediments below a depth of 100 feet are part of the Tassajara Formation" (*DWR, 1974*). The Fringe Aquifer is defined as the collective sequence of surficial Holocene alluvial deposits and the thicker underlying sequence of permeable Tassajara Formation deposits (herein referred to as the "Upper Tassajara Formation"). Groundwater production is relatively minimal in this subarea and thus few borehole lithologic and e-log data are available to more accurately delineate individual aquifer zones within the Upper Tassajara Formation.

Moving further to the southeast, Cross-Section B-B' enters the Dublin subarea of the Northern Fringe Area. Here, deposits are very similar to those encountered in the Bishop subarea, containing an "essentially flat-lying" sequence of sediments with a "maximum depth of…about 800 feet" (*DWR, 1974*). "Valley-fill materials lap northward onto older sediments of the Tassajara Formation", though the depth at which the Tassajara Formation meets younger Holocene alluvial deposits is not well understood in the area (*DWR, 1974*). Based on available borehole lithology and e-log data, it appears the surficial clay layer (i.e., Overburden) encountered in the Main Basin as well as a laterally extensive clay layer (i.e., Aquitard) underlying the Holocene alluvium are encountered in the southern portion of the Dublin subarea.

After passing through the Dublin subarea, the trace makes a brief east-southeasterly turn and cuts through a small portion of the Camp subarea of the Northern Fringe Area before moving southeast and entering the Main Basin (Amador subarea). The Camp subarea is similar in composition to the Dublin and Bishop subareas to the northwest, containing "beds of sandy clay and sandy gravel which overly the Tassajara Formation" (*DWR 1974*).

The Camp subarea is delineated from the Amador subarea of the Main Basin by an observed groundwater flow barrier described as the "Parks Boundary" (*Norfleet Consultants, 2004*). The Parks Boundary was originally inferred as a fault in DWR's Bulletin-118 hydrostratigraphy summary based on significant variations in groundwater elevations between the Dublin/Camp subareas of the Northern Fringe Area and the Bernal/Amador subareas of the Main Basin (*DWR, 1974*). However, updated interpretations provided in the Norfleet (2004) hydrostratigraphy study suggest that the Parks Boundary represents a buried valley wall delineating the northern extent of the "structurally influenced, incised-channel complex" deposited by the ancestral Arroyo Mocho stream (*Norfleet Consultants, 2004*). While the Holocene alluvial deposits of the Upper Aquifer and the underlying Aquitard appear to be generally consistent across the Parks

Boundary, deposits in the Lower Aquifer south of the boundary consist of a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts (*Norfleet Consultants, 2004*). These are underlain by the Upper Livermore Formation, as opposed to the Tassajara Formation north of the boundary. Based on nearby water level observations collected in Fall 2019, an apparent 30 to 40-foot drop in groundwater elevation is observed in the Lower Aquifer moving south across the Parks Boundary. Lower Aquifer deposits south of the Parks Boundary are known to be more productive than those north of the boundary, thus marking the southern edge of the Northern Fringe Area and the northern edge of the Main Basin.

As Cross-Section B-B' moves southwards across the Parks Boundary and into the Main Basin, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel are encountered at depths up to 500 ft bgs. As mentioned above, these are underlain by deposits of the Upper Livermore Formation, which reach >200 ft thickness in the west-central portion of the Amador Subarea. Holocene alluvial deposits comprising the Upper Aquifer reach a maximum thickness of approximately 150 ft underlying the southern COL mining area within the subarea. Here, the Upper Aquifer is generally consistent with the "Cyan" stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies, while the Aquitard comprises the "Grey Clay" sequence and the interbedded sequence of Quaternary alluvial/fluvial deposits comprise the "Grey" and "Purple" sequences. Deposits of the Upper Livermore Formation are generally consistent with the "Red" sequence mapped in the Norfleet (2004) and Zone 7 (2011) studies.

Moving southeast through the Amador Subarea, deposits from the incised channel-complex are found roughly up to Concannon Road, where another water level lineation has historically been observed. Norfleet (2004) interpreted this area as the southern extent of the ancestral Arroyo Mocho paleochannel, and delineated this feature as the "Concannon Boundary". South of the Concannon Boundary, deposits of the ancestral Arroyo Mocho paleochannel are not readily apparent and permeable deposits of the Upper Livermore Formation appear to directly underly the Upper Aquifer and Aquitard. Groundwater conditions range from "unconfined to confined" in this area, with unconfined groundwater occur[ing] principally near the channel of Arroyo del Valle and in the uppermost aquifer" (*DWR, 1974*).

Moving further southeast up the Arroyo del Valle stream corridor, the Upper Livermore Formation continues to dip upward to the south at an angle of one to three degrees (*DWR, 1974*). "Many of the aquifers merge near the course of Arroyo del Valle, where the combined aquifers are present as a deposit of sandy gravel up to 300 feet in thickness" (*DWR, 1974*). The Las Positas Fault, described as a "high-angle tear fault" that "cut and uplifted Livermore Gravels" south of the fault line (*Norfleet Consultants, 2004*), may act as a disconformity in the Upper Livermore Formation as maximum well depths are roughly 200 ft bgs southeast of the fault line. This may also explain the apparent confinement observed in Fall 2019 Lower Aquifer water levels in the vicinity of the fault. However, the degree to which the Las Positas Fault acts as a hydraulic barrier to groundwater flow is uncertain given the current lack of lithologic and geophysical data proximate to the fault line. Recent alluvial deposits of the Arroyo del Valle stream corridor (i.e., Upper Aquifer) continue to thin with the Upper Livermore Formation (i.e., Lower Aquifer) before pinching out at the contact between the Amador subarea and the Southern Uplands, where the relatively impermeable Lower Livermore Formation begins to outcrop. This terminus in permeable deposits marks the effective southern edge of the Basin within the Arroyo del Valle stream corridor.

GEOLOGIC CROSS-SECTION C-C'

Cross-Section C-C' depicts a generally northwest-to-southeast trace through the eastern portion of the Basin (see Figures 5a and 5b). The trace begins at the northeastern Basin boundary and progresses southeastward through a portion of the Northeastern Fringe Area (May and Spring subareas). The trace then makes a turn to the south and continues through the Northeastern Fringe Area (Spring and Mocho I subareas) before cutting directly through a narrow corridor of alluvium connecting the Mocho I and Mocho II subareas (an area commonly referred to as "The Gap"). The trace then progresses further south through the Main Basin (Mocho II subarea), taking another southeasterly turn and continuing up the Arroyo Mocho stream corridor. It then briefly enters the Southern Upland Area before terminating at the southern Basin boundary.

Cross-Section C-C' begins in the May subarea of the Northeastern Fringe Area, where outcrops of the relatively impermeable Lower Tassajara Formation define the northern edge of the Basin. South of the Basin boundary, "ground water occurs only in limited amounts in a relatively thin veneer of valley-fill materials which overlie a thick section of sediments belonging to the Tassajara Formation" (*DWR, 1974*). Here the Fringe Aquifer is defined as the thin veneer of recent (Holocene) alluvium deposited from smaller streams, which "does not exceed 40 ft" thickness in the May subarea (*DWR, 1974*), directly underlain by the permeable upper deposits of the Plio-Pleistocene Tassajara Formation (herein referred to as the "Upper Tassajara Formation") where a majority of groundwater production occurs in the area. The Upper Tassajara Formation is comprised of "beds of sand and gravel, clay and gravel, clay, and silty clay… which range up to 50 ft in thickness [and] dip southward at an average gradient of ten degrees." (*DWR 1974*). Based on nearby water level observations collected in Fall 2019, it appears water level conditions are semi-confined to confined in within the Upper Tassjara Formation this area.

Cross-Section C-C' further progresses southeastward into the Spring subarea of the Northeastern Fringe Area. Here, surficial deposits are very similar to those encountered in the May subarea, containing a thin veneer of recent alluvium not exceeding 50 ft thickness. Deposits underlying the recent alluvium change in composition to reflect those of the Upper Livermore Formation, though the geometry of the contact between the Tassajara and Livermore Formations is not well understood in this area. Upper Livermore deposits in the Spring subarea are described as a "wedge-shaped sequence" of permeable deposits that increase in depth moving southward (*DWR, 1974*). Upper Livermore deposits continue to deepen as the trace turns south and moves into the Mocho I subarea (LLNL, 1984). The "valley-fill portion of the Mocho I province…consists of a heterogeneous mixture of gravelly fan detritus overlying truncated beds of the Livermore Formation" (*DWR, 1974*).

The base of the Upper Livermore Formation deepens in a southerly direction along the Cross-Section C-C' trace through the Mocho I subarea to approximately 300 ft bgs while the upper surface of the formation stays within approximately 30 ft bgs (*LLNL, 1984*). Northeast of well 3S2E10Q002 the trace crosses through a narrow alluvial channel connecting the Mocho I and Mocho II subareas, known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south (i.e., out of the plane of the cross-section), also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within The Gap that serves to restrict the vertical cross-sectional area of connection between the recent alluvium and underlying Livermore Formation deposits in the Northeastern Fringe Area and the Main Basin to the southwest (*DWR, 1974; LLNL, 1984*). There is considerable uncertainty in the degree to which flow is restricted across The

Gap, though recent water level trends suggest this area acts as an apparent groundwater divide between the Fringe Aquifer and the Upper and Lower Aquifers of the Main Basin.

After moving across The Gap, Cross-Section C-C’ progresses south through the Mocho II subarea of the Main Basin. Here, “the valley-fill materials become separated into identifiable strata consisting of beds of sandy gravel and cemented gravel separated by beds of silt and clay” (*DWR, 1974*). In this area, Cross-Section C-C’ encounters a thicker sequence of braided fluvial and deltaic “clean gravel” and sand deposits interbedded with fluvial overbank and floodplain clays and silts known to be deposited by the ancestral Arroyo Mocho paleochannel throughout much of the Main Basin (*Norfleet Consultants, 2004*), consistuting the upper portions of the Lower Aquifer. Based on nearby water level observations collected in Fall 2019, it appears this thicker sequence of Quaternary alluvial/fluvial deposits creates some degree of confinement in the Lower Aquifer in the area.

As the trace turns to the southeast and begins traveling up the Arroyo Mocho stream corridor, Cross-Section C-C’ travels over the Las Positas Fault. The Las Positas Fault may present an unconformity in the Upper Livermore Formation, though the degree to which it acts as a hydraulic flow barrier in the Lower Aquifer is not well understood.

As Cross-Section C-C’ moves further southeast up the Arroyo Mocho stream corridor, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel pinch out and disappear. Here, the recent alluvial deposits of the Arroyo Mocho are underlain directly by semi-consolidated deposits of the Upper Livermore Formation. These deposits progressively thin moving up the stream corridor until they pinch out at the contact between the Mocho II subarea and the Southern Upland Area. At this point, the relatively impermeable Lower Livermore Formation begins to outcrop, marking the effective southern edge of the Basin in the Arroyo Mocho stream corridor. Cross-Section C-C’ further extends a short distance through the Southern Upland Area before reaching the southern Basin boundary.

LIST OF FIGURES

REFERENCES

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Rogers, T.H., 1966, Geologic Map of California, California Division of Mines and Geology.

Zone 7 (Alameda Flood Control and Water Conservation District, Zone 7) 2011. Hydrostratigraphic Investigation of the Aquifer Recharge Potential for Lakes C and D of the Chain of Lakes, Livermore, California. Prepared by Zone 7 in cooperation with the Department of Water Resources' Local Groundwater Assistance Grant Program, May 2010.

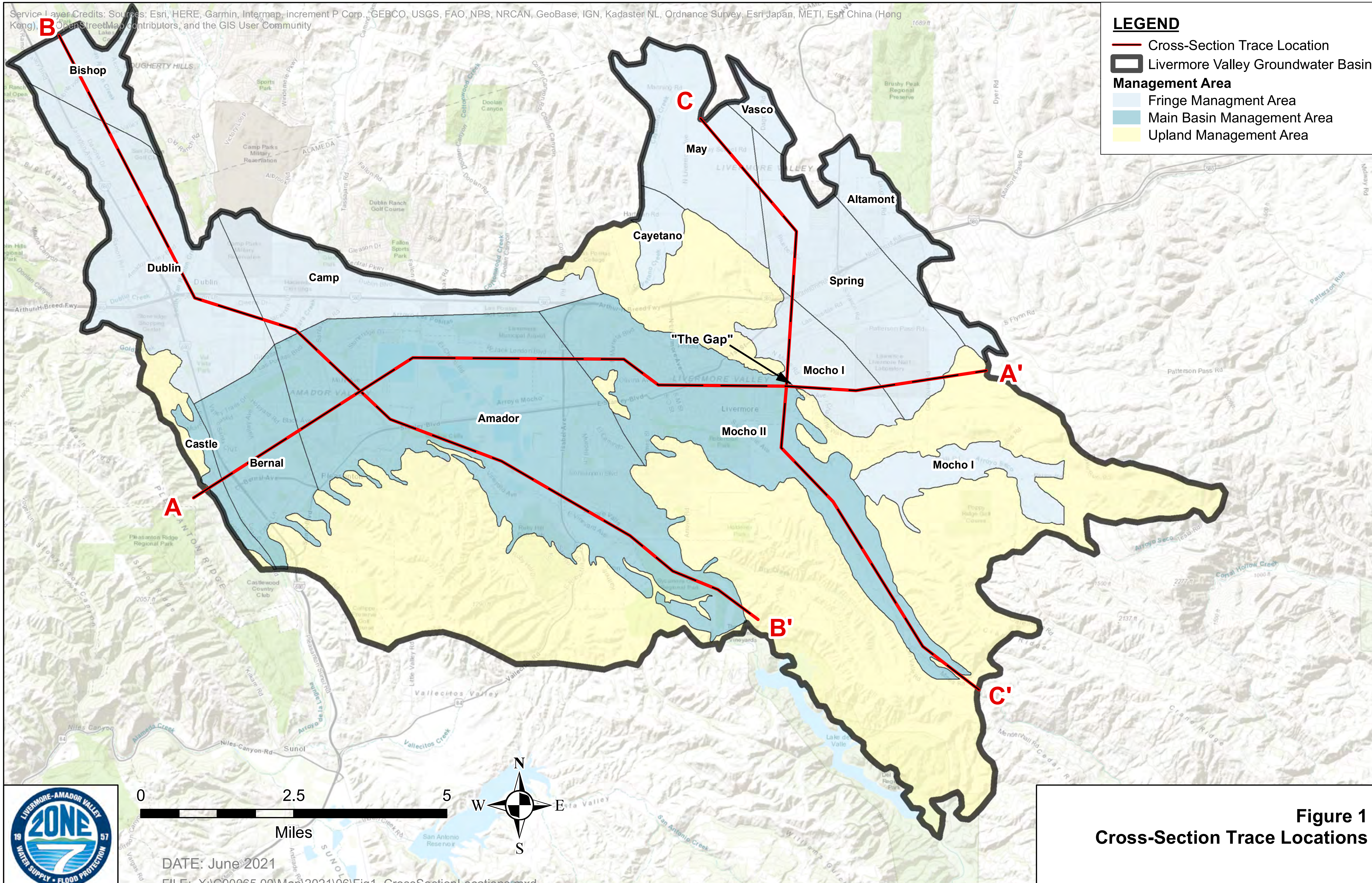
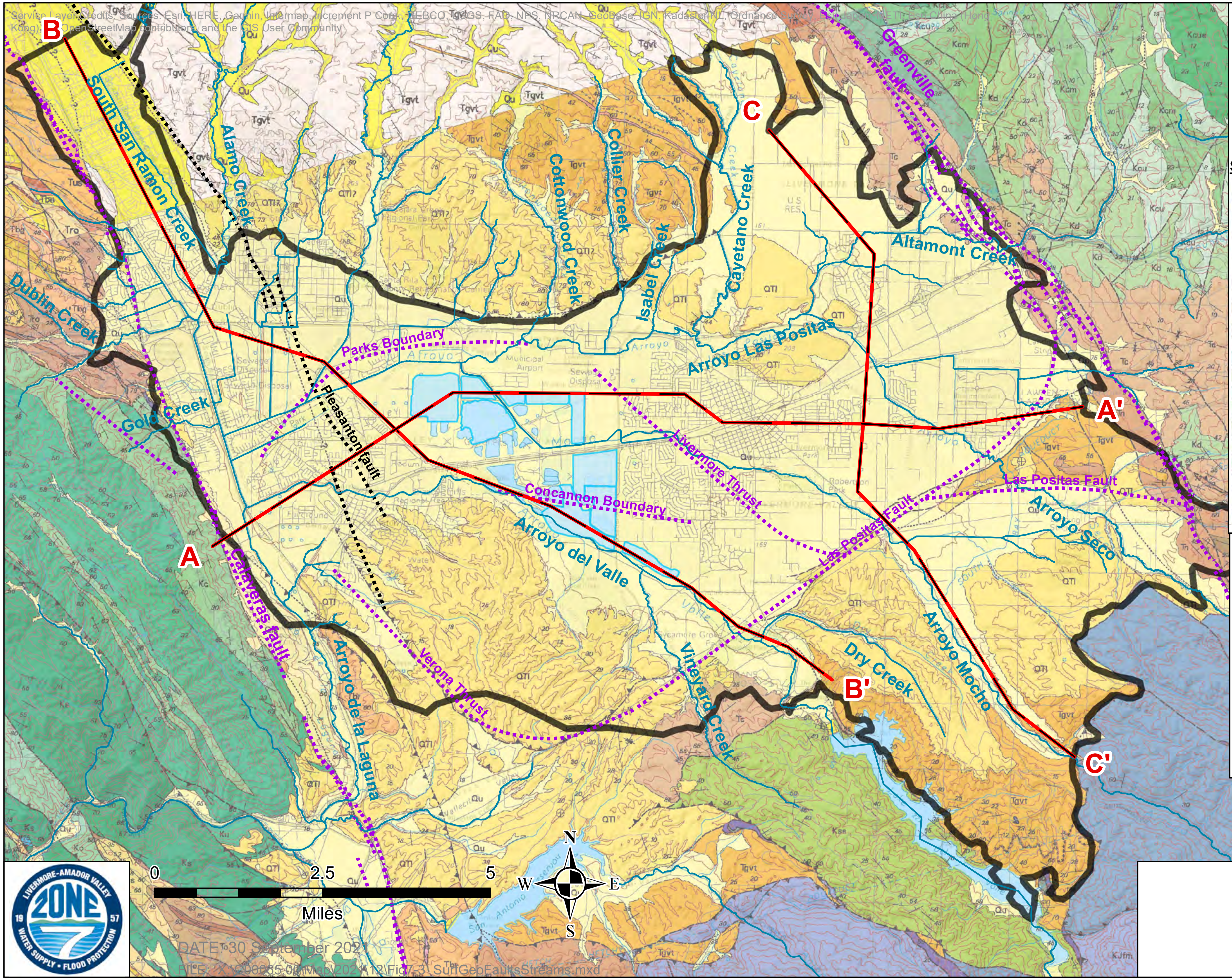


Figure 1
Cross-Section Trace Locations



LEGEND

- Cross-Section Trace Location
- NorFleet '04 Fault Locations
- Other Inferred Faults
- Streams
- Chain of Lakes
- Livermore Valley Groundwater Basin

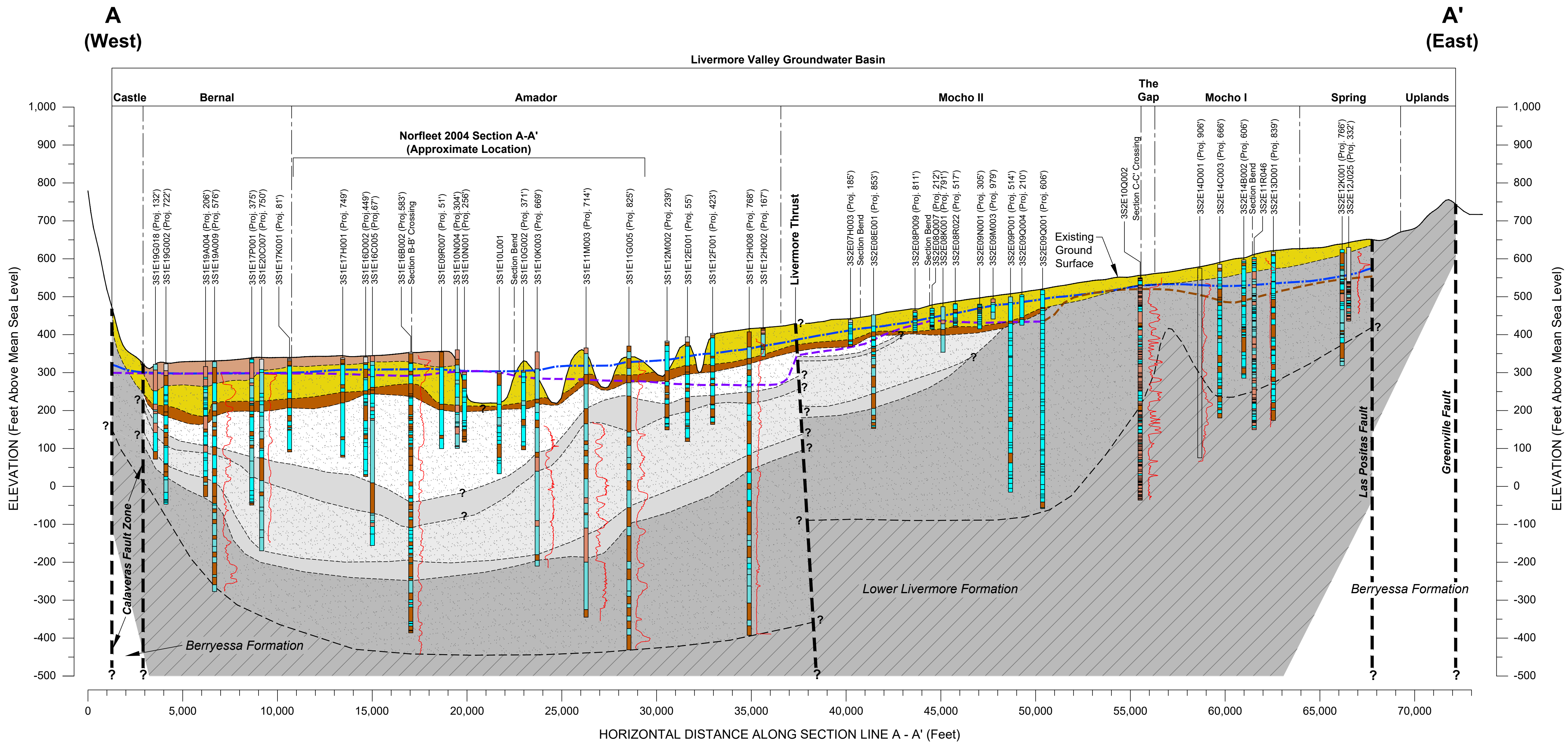
Surficial Geology

- Qu Undivided surficial deposits
- Qoa Older alluvial deposits
- Qt Terrace deposits
- QTl Livermore gravels
- Tgvt Green Valley/Tassajara group
- Tc Cierbo Formation - white sandstone
- Tbr Briones Formation - sandstone and shell breccia
- Tn Neroly Formation - blue sandstone
- Ks Unnamed sandstone and shale
- Kss Unnamed sandstone
- Ku Unnamed shale
- Kc Unnamed conglomerate
- Kd Unit D - sandstone
- Kcu Upper Unit C - shale
- Kcm Middle Unit C - sandstone
- KJfe Eylar Mountain terrane - sandstone, siltstone, conglomerate and chert
- KJfm Melange terrane

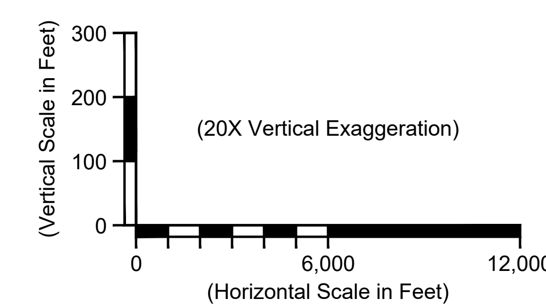
NOTE
(1) Norfleet Fault Locations are approximate.

SOURCES
(1) Graymer et al., 1996. Preliminary Geologic Map Emphasizing Bedrock Formations in Alameda County, California. United States Geologic Survey (USGS)
(2) Graymer et al., 1994. Preliminary Geologic Map Emphasizing Bedrock Formations in Contra Costa County, California. USGS.
(3) Norfleet Consultants. 2004. Preliminary Stratigraphic Evaluation, West Side of the Main Basin, Livermore-Amador Groundwater Basin.

Figure 2
Surficial Geology, Major Faults and Streams



Cross-Section A - A'



Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

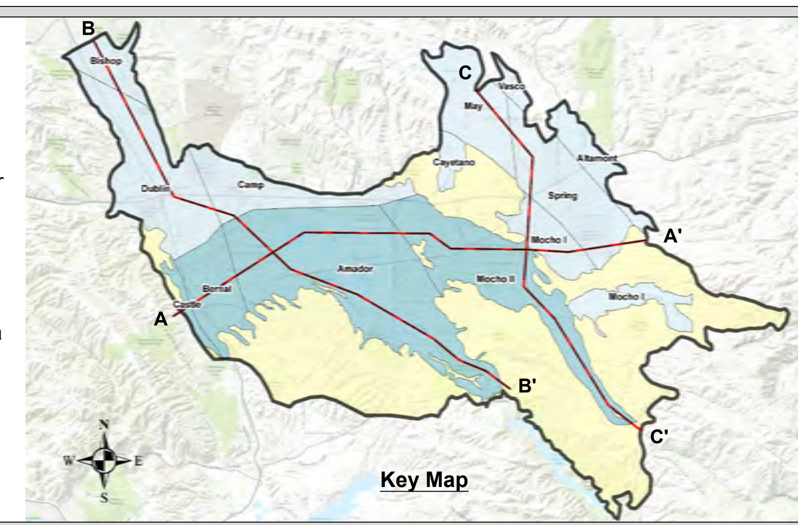
- Long-Normal Resistivity

Map Elements

- A A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Geologic Cross-Section A - A'

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December 2021
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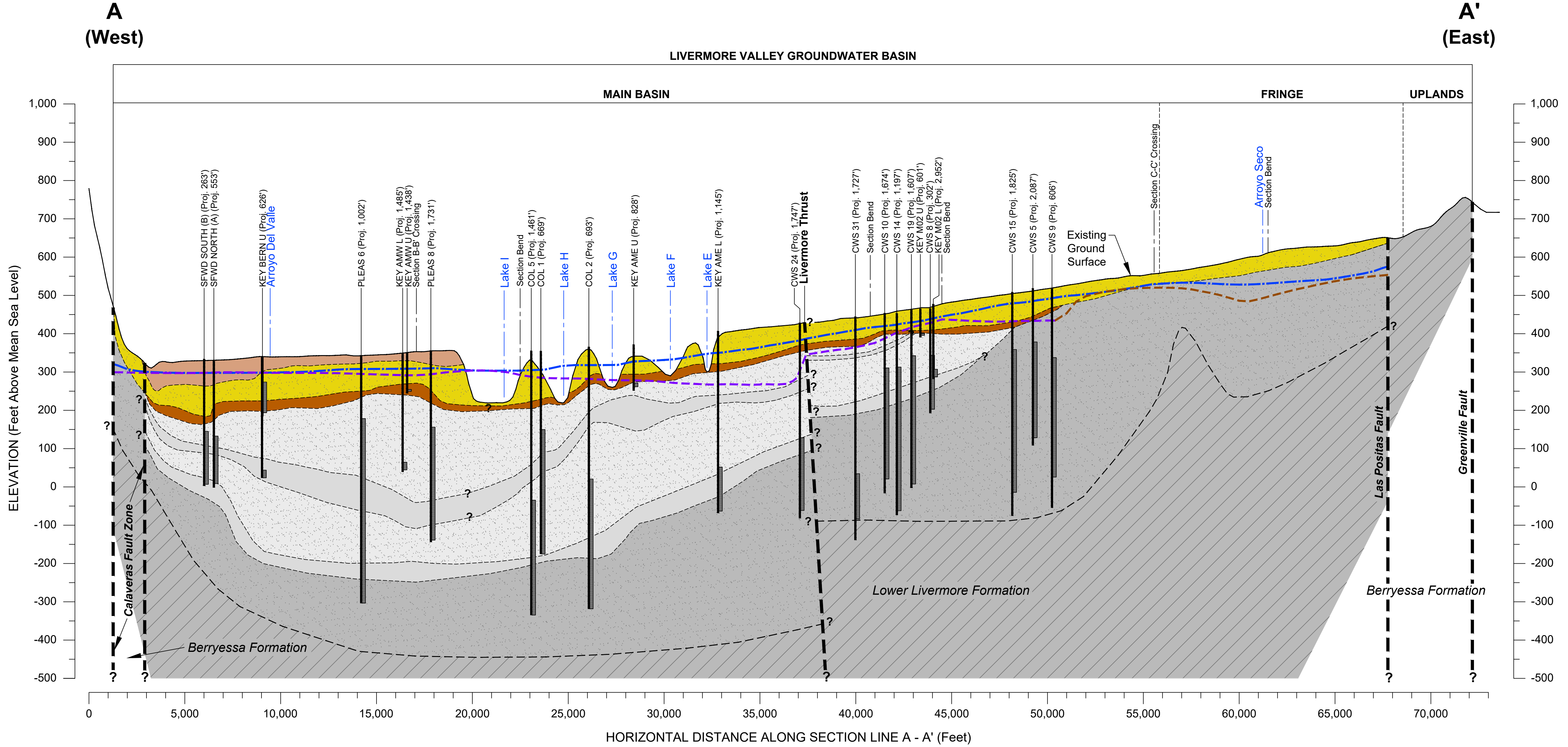
Figure 3a

20210603.092158 G:\C00065.00\2021-06\Cross Section A-A.dwg Section A-A'



Cross-Section A - A'

Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)

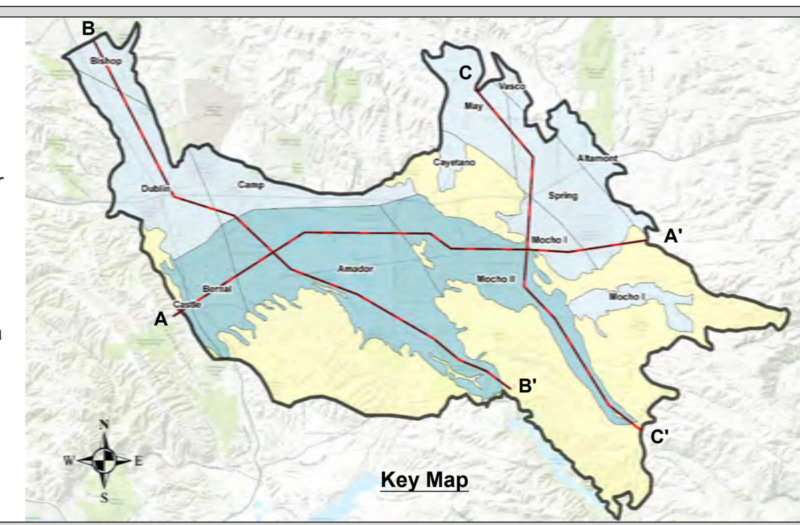
- Well Log
- Screen Interval

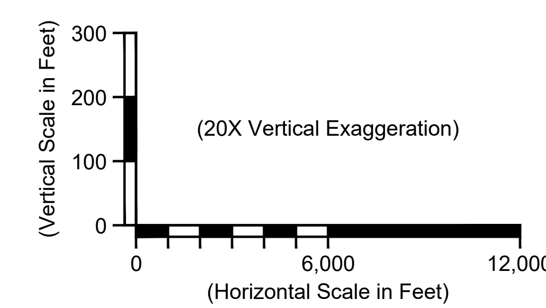
Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area





Geologic Cross-Section A - A'

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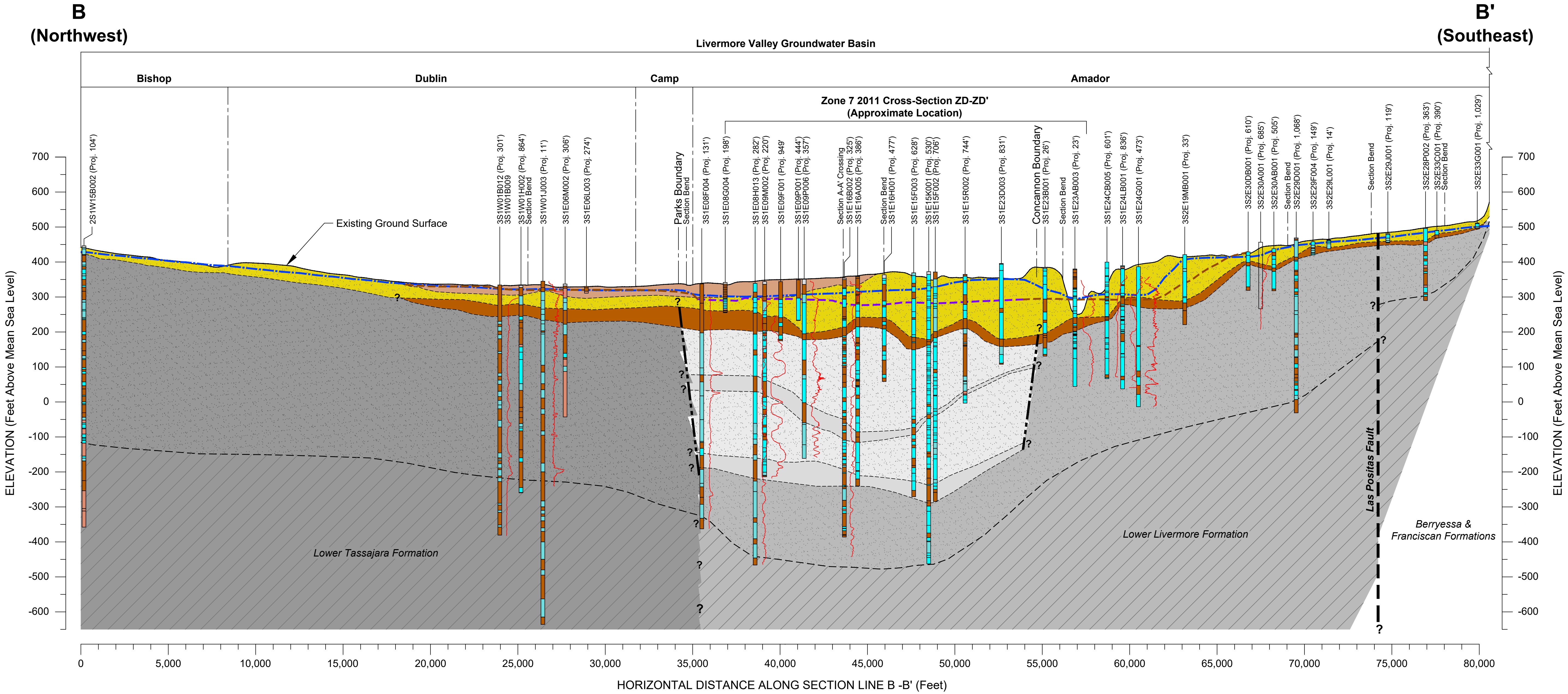
Figure 3b



Cross-Section B - B'

Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

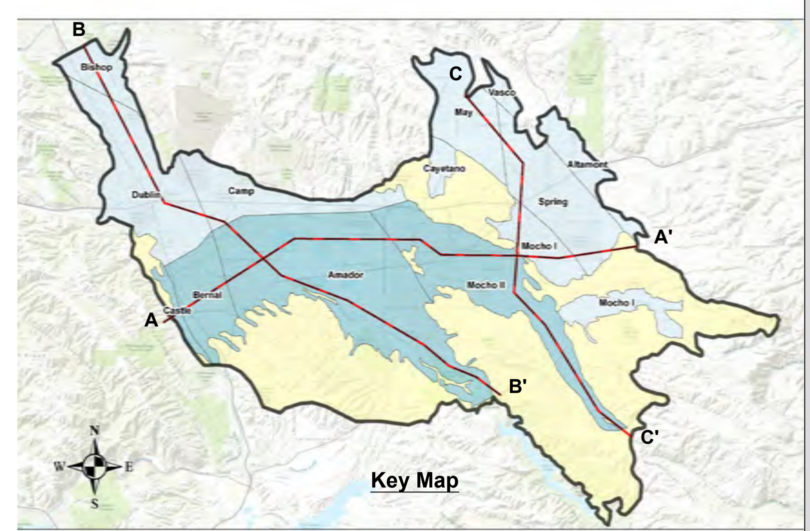
- Long-Normal Resistivity

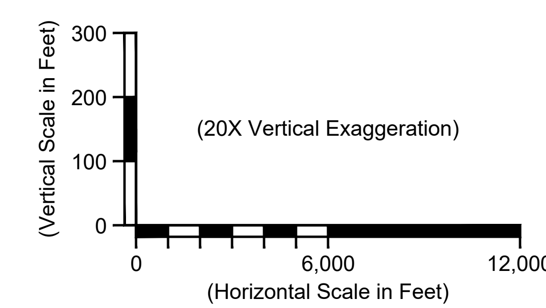
Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area





Geologic Cross-Section B - B'

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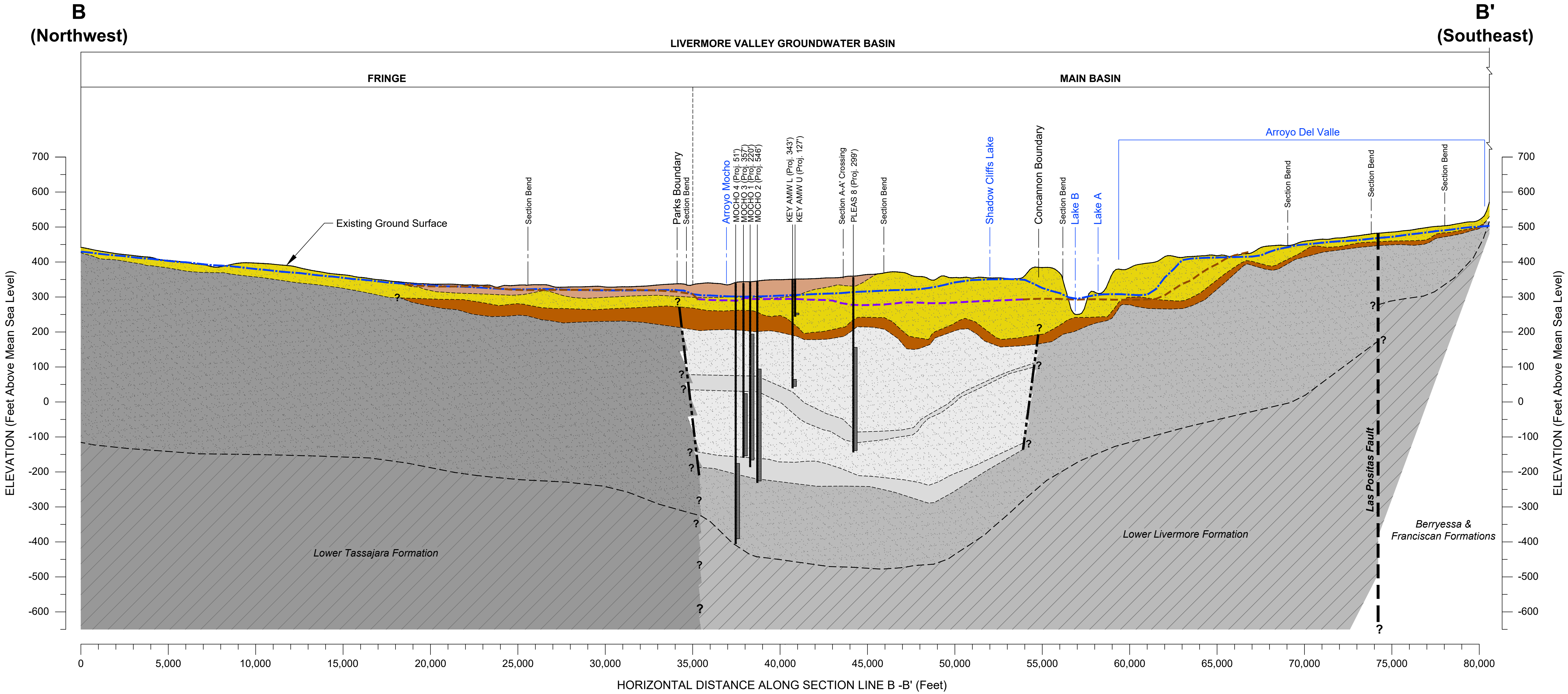
Figure 4a

20210603.085738 G:\C00065.00\2021-06\Cross Section B-B.dwg Section B-B'



Cross-Section B - B'

Legend:

Stratigraphy

- Surficial Clay (Overburden)
- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
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- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

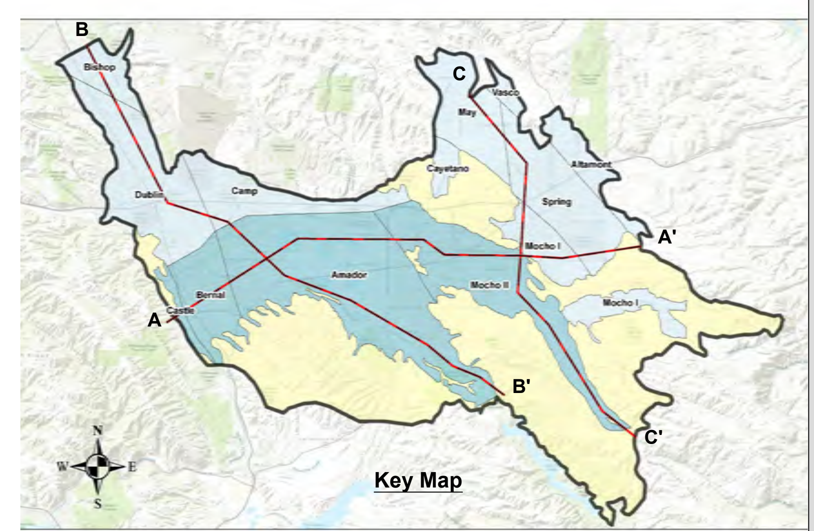
- Well Log
- Screen Interval

Map Elements

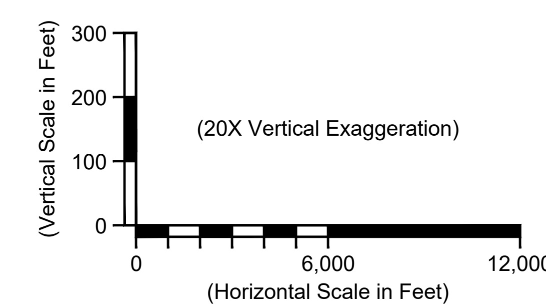
- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Key Map



Geologic Cross-Section B - B'

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Figure 4b

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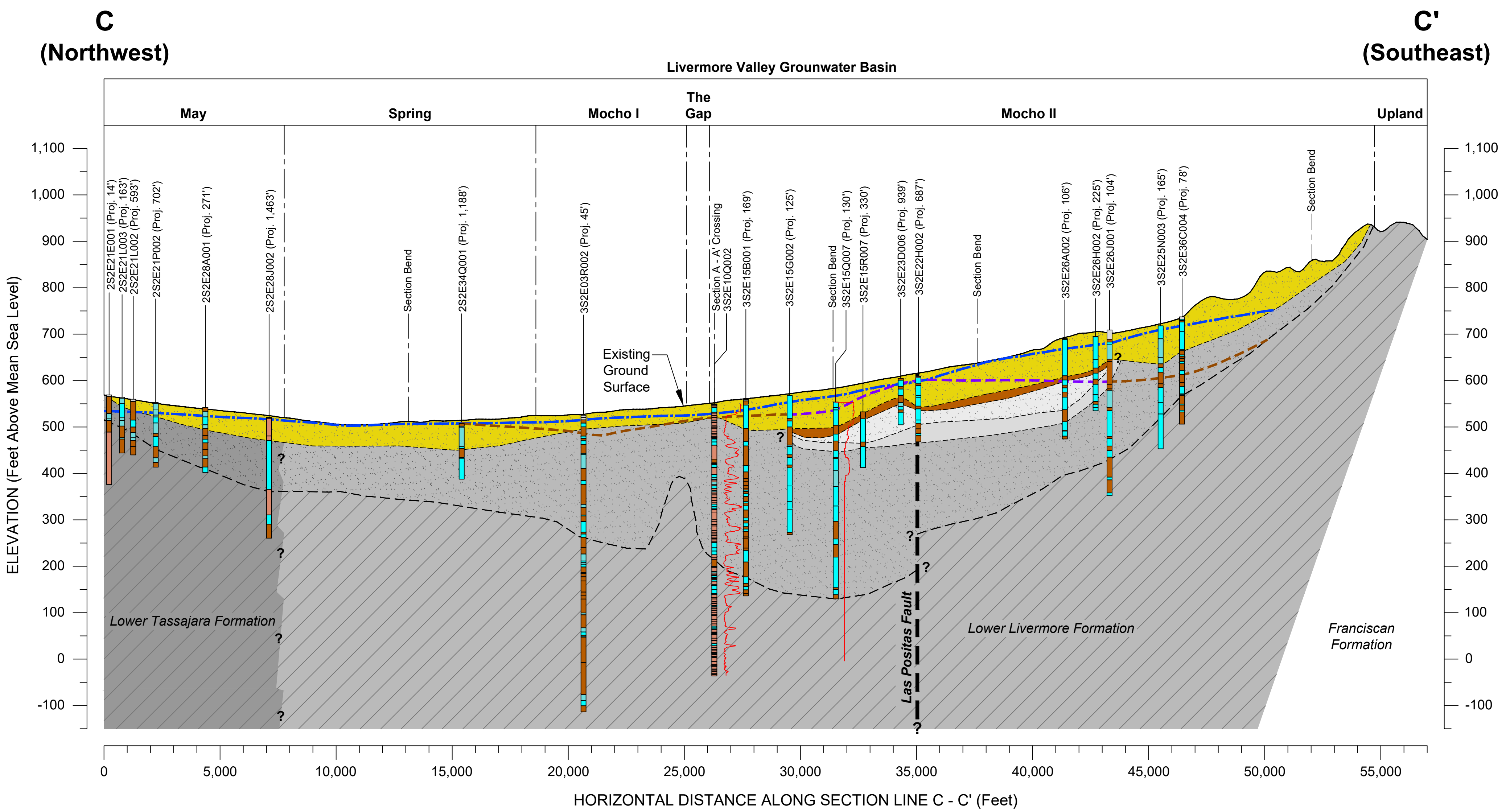

Cross-Section C - C'

Legend:

Stratigraphy

- Holocene Alluvium
- Lacustrine Clay (Aquitard)
- Quaternary Alluvium (Gravels/Sands)
- Quaternary Alluvium (Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
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Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

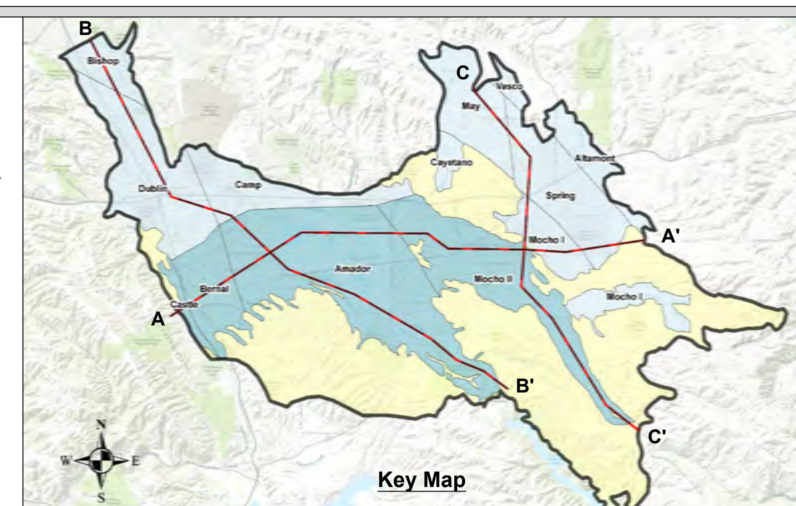
- Long-Normal Resistivity

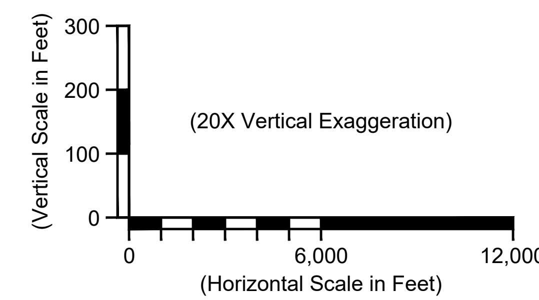
Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area





Geologic Cross-Section C - C'

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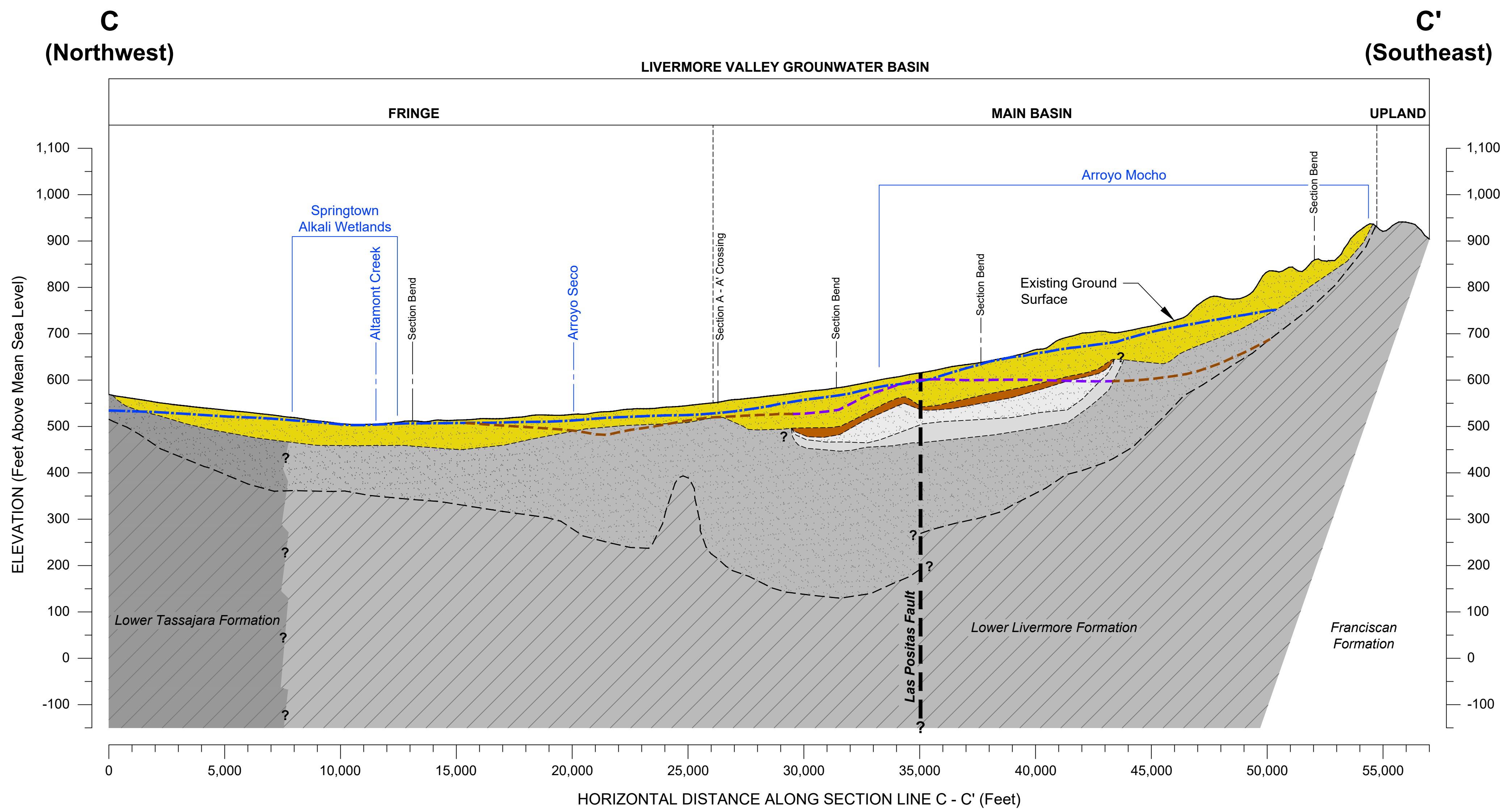
Figure 5a

20210603.085708 G:\C00065.00\2021-06\Cross Section C-C.dwg Section C-C'



Cross-Section C - C'

Legend:

Stratigraphy

- Holocene Alluvium
- Lacustrine Clay (Aquitard)
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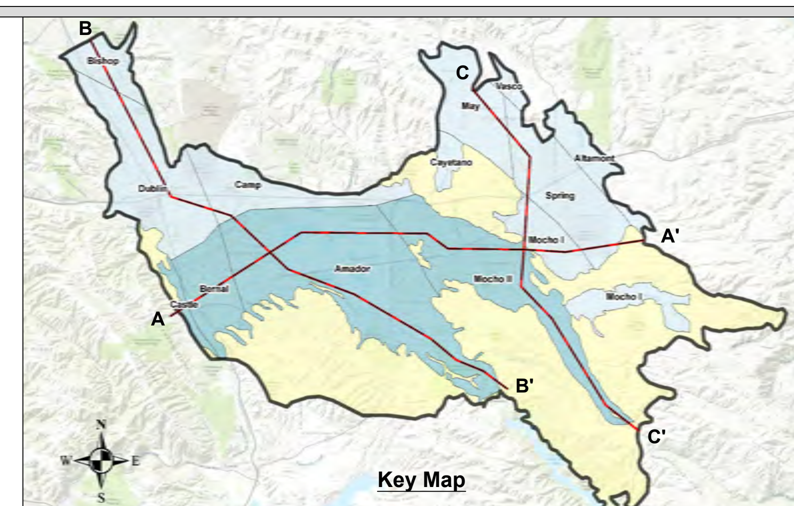
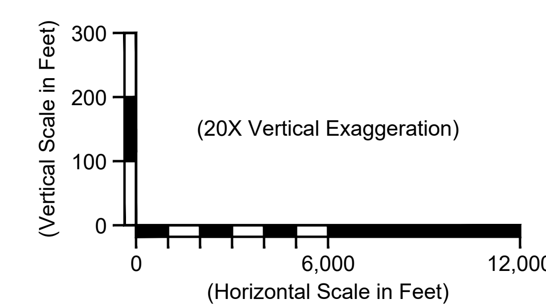
Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area





Geologic Cross-Section C - C'

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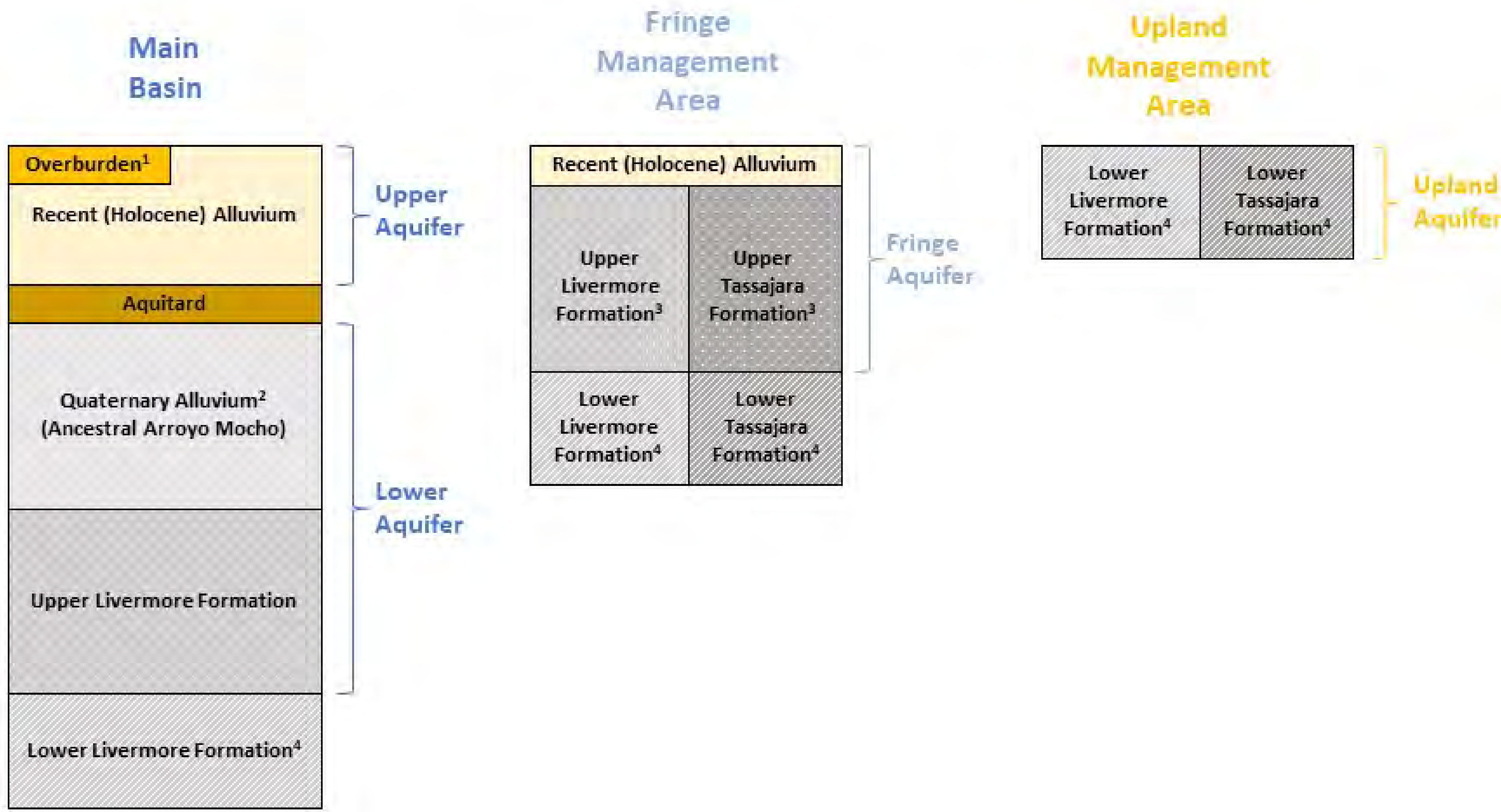
Figure 5b

Livermore Valley Groundwater Basin
Conceptual Hydrostratigraphy Model



Notes:

1 Only encountered in western portion of Main Basin (Bernal, Amador subareas)
2 Only encountered where Ancestral Arroyo Mocho incised valley complex exists (see Norfleet 2004, Figure 3-5)
3 Tassajara Formation encountered in northwestern (Bishop, Dublin, Camp subareas) and northeastern (May, Cayetano subareas) portion of Fringe Management Area; Livermore Formation encountered in all other Fringe subareas
4 Considered generally impermeable and below the bottom of the usable groundwater basin
5 Drawings not to scale; for discussion purposes only

Conceptual Hydrostratigraphy Model

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EKI C00065.00

Figure 6

APPENDIX D

UPDATE OF AERIAL RECHARGE MODEL TO IDC FRAMEWORK TECHNICAL MEMORANDUM

15 September 2021

DRAFT TECHNICAL MEMORANDUM

To: Tom Rooze, PG, Zone 7 Water Agency (Zone 7)
Ken Minn, PE, Zone 7
Colleen Winey, PG, Zone 7
Carol Mahoney, PG, Zone 7

From: Anona Dutton, PG, CHg, EKI Environment & Water, Inc. (EKI)
Aaron Lewis, EIT, EKI
Christina Lucero, PG, EKI
Nigel Chen, PhD, EKI

Subject: **Migration and Update of Aerial Recharge Model to Integrated Water Flow Model Demand Calculator (IDC) Framework**
(EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to provide to Zone 7 Water Agency (Zone 7) this draft technical memorandum documenting our development of an Integrated Water Flow Model Demand Calculator (IDC) model of the Livermore Valley Groundwater Basin (Basin). The IDC model is intended to serve as a replacement to Zone 7's existing Aerial Recharge Model (ARM) to provide a framework for estimating spatiotemporal recharge and runoff rates within the Basin and to inform updates to Zone 7's Hydrologic Inventory (HI) spreadsheet water budget model of the Basin. We anticipate that a final version of this technical memorandum will be included as an Appendix to the 2022 Alternative Groundwater Sustainability Plan (Alt GSP) being developed for the Basin.

BACKGROUND

Pursuant to Title 23, Section 358.2(a) of the California Code of Regulations (23-CCR §358.2(a)), Groundwater Sustainability Agencies (GSAs) with an approved Alternative Groundwater Sustainability Plan (Alt GSP or Plan) must resubmit an updated Plan to the California Department of Water Resources (DWR) every five years. As part of the five-year update process to the 2016 Alt GSP, Zone 7 contracted EKI to: (1) integrate Zone 7's existing ARM spreadsheet model into the IDC platform and extend coverage of the ARM across the entire Basin; (2) run the IDC model to calculate monthly historical recharge and applied water rates over the last 10 years; (3) calibrate the IDC model to any available historical groundwater recharge and/or pumping data within the Basin; and (4) compare IDC model outputs to the ARM to assess model performance.

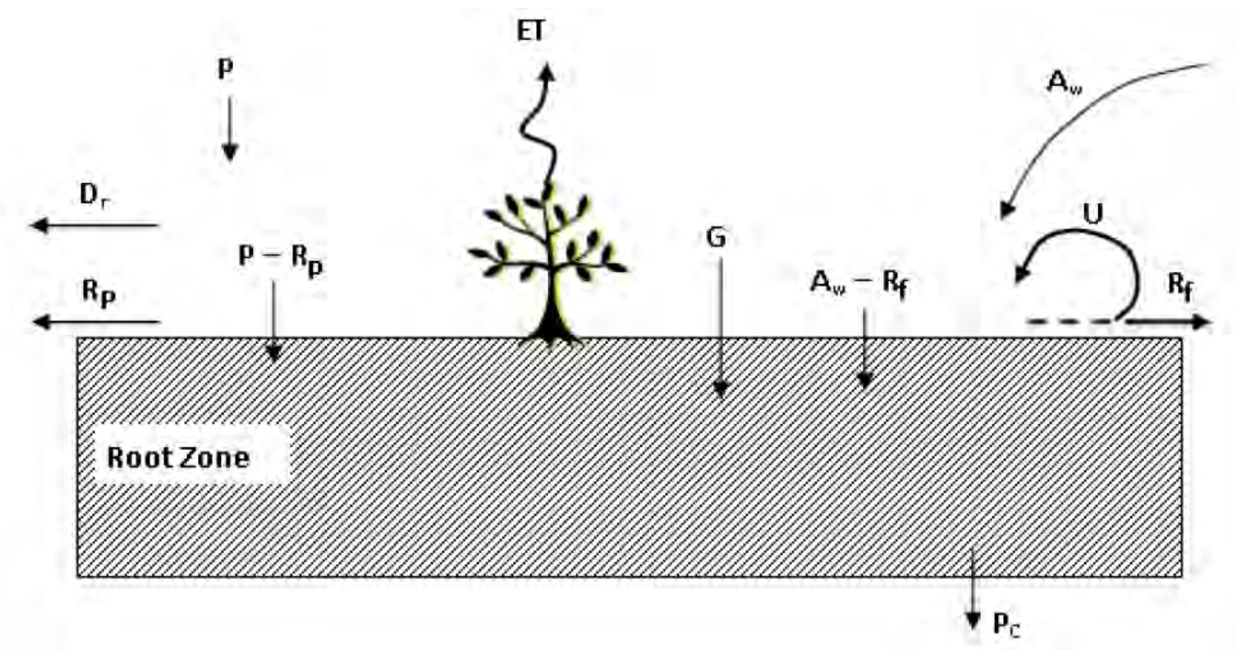
DESCRIPTION OF IDC MODEL FRAMEWORK

IDC is a peer-reviewed, open-source software program developed by the California Department of Water Resources (DWR) designed to simulate root zone flow processes and calculate agricultural and urban applied water demands based on available climate, land use, soil properties, and water supply datasets.

IDC is the stand-alone version of the root zone simulation engine used in DWR's Integrated Water Flow Model (IWFM) finite-element groundwater flow modeling software program.

Figure 1 below provides a schematic representation of the root zone flow processes simulated by IDC. A full description of the IDC model framework (including a full accounting of all root zone components and calculations, instructions for preparing input datasets, and the description of the supporting computational framework) is provided in the IDC Theoretical Documentation and User's Manual (see **Attachment A**).

Figure 1. Schematic representation of root zone flow processes simulated by IDC[1].



The Livermore Valley Groundwater Basin IDC model (herein referred to as "IDC model") was developed using version 2015.0.102 of IDC software (released May 18, 2021).

DEVELOPMENT OF IDC GRID

The existing ARM model is discretized into a rectangular grid composed of 19,920 grid cells at 500 x 500-foot spatial resolution, including 10,743 active grid cells within the Basin. The ARM grid aligns with Zone 7's existing MODFLOW numerical groundwater flow model ("MODFLOW model") grid, which covers most of the Basin except for the eastern portion of the Mocho I subarea (within the Fringe Management Area) and the southeastern corner of the Upland Management Area.

To preserve the capability of linking recharge outputs from the IDC model with Zone 7's existing MODFLOW model, the IDC grid aligns identically with the ARM and MODFLOW grid for all grid cells

[1] Dogrul, E.C. & Kadir, T. N., 2021. *IWFM Demand Calculator (IDC-2015, Revision 102). Theoretical Documentation and User's Manual.*

encountered within the Basin and maintains a 500 x 500-foot spatial resolution. Additionally, the IDC grid covers the remaining areas of the Basin that were not previously included in the ARM model.

As IDC is set up using a finite-element formulation, the IDC grid is defined using "Nodes" (i.e., point-based coordinates) that are located at the corners of each grid cell. Each grid cell (herein referred to as "Element") of the IDC model is subsequently linked to four Nodes that comprise the corners of each Element. To limit IDC computational demands, all grid cells from the ARM model that are located outside the Basin boundaries were excluded from the IDC grid. The final IDC model grid is comprised of 12,626 Nodes comprising 12,107 Elements, as shown on **Figure 2**. A comparison of the IDC and ARM model grid is shown on **Figure 3**.

IDC MODEL HISTORICAL SIMULATION PERIOD

The IDC model was set up to simulate historical root zone flow processes for a ten-year period covering DWR Water Years[2] (WY) 2011 through 2020, consistent with the ARM model historical simulation period.

MIGRATION OF ARM DATASETS

To begin population of IDC input datasets, EKI extracted and processed all relevant datasets from Zone 7's existing ARM model for migration into the IDC input file framework and extended those datasets to cover the portions of the Basin that were not previously covered by the ARM model. Datasets extracted from the ARM include:

- **Precipitation Data** (*Daily, station-based)* – EKI extracted the daily "Index" precipitation rates from the ARM model for inclusion into the IDC model. The "Index" precipitation rates represent an average of daily precipitation rates from nearby California Irrigation Management Information System (CIMIS) Stations #15, #191, #17, and #24.
- **Reference Evapotranspiration (ETo) Data** (*Daily, station-based)* – EKI extracted the daily "Index" reference evapotranspiration (ETo) rates from the ARM model for inclusion into the IDC model. The "Index" ETo rates represent a composite of ETo measurements recorded at CIMIS Stations #191 and pan ET measurements at Zone 7's Lake Del Valle (LDV) and Livermore Water Reclamation Plant (LWRP) climate stations. For the LDV and LWRP stations, pan ET was converted to ETo using conversion factors specific to each station
- **Precipitation Multipliers** (*Constants, grid-cell specific)* – EKI extracted grid-cell specific precipitation multipliers from the ARM to scale precipitation rates across the Basin. Precipitation multipliers were originally developed by Zone 7 using a comparison between precipitation rates measured at the CIMIS climate stations and a raster of Alameda County average rainfall rates. The same process was repeated to calculate corresponding precipitation multipliers for IDC Elements located outside the ARM grid. Element-specific precipitation multipliers are shown on **Figure 4**.
- **Land Use Data** (*Annual, grid-cell specific)* – EKI extracted annual land use categories for all grid cells included in the ARM. For IDC Elements located outside the ARM grid, land use data was

[2] The DWR Water Year is defined as October of the previous year through September of the following year. For example, DWR Water Year 2020 covers the period October 1, 2019 through September 30, 2020.

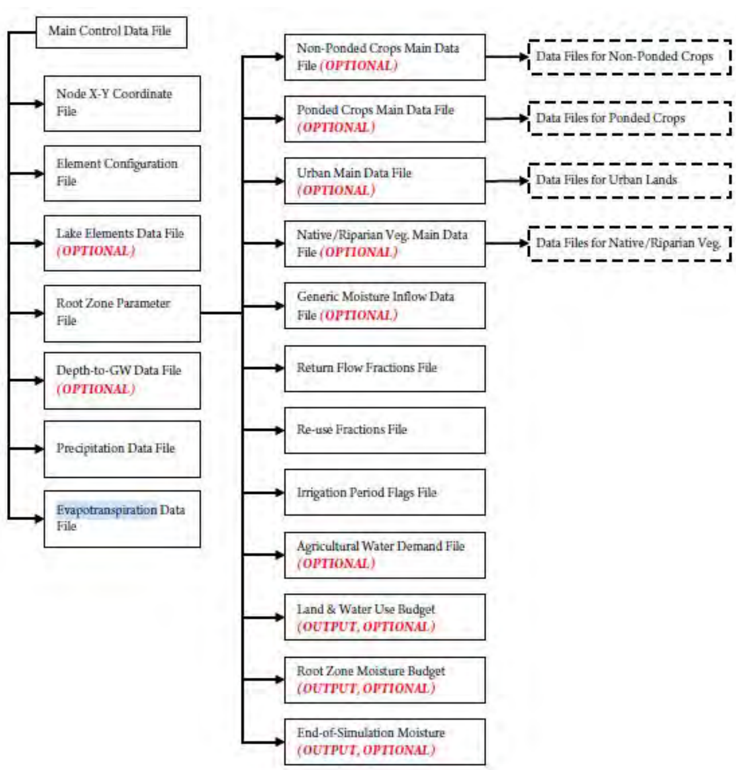
derived from Zone 7's annual land use GIS files. Land use types were subsequently reclassified to fit the land use categories defined in the IDC framework, as further described below. Element-specific land use types for WY 2020 are shown on **Figure 5**.

- **Runoff Curve Numbers** (*Constants, categories)* – EKI extracted runoff curve numbers provided for each land use - hydrologic soil group[3] combination included in Zone 7's original land use and soil type categories included in the ARM. These runoff curve numbers were subsequently employed to define IDC Element-specific runoff curve numbers for each land use and soil type encountered within the Basin.
- **ARM Model Zones** *(Constants, categories)* – EKI extracted various zonal attributes of the ARM grid for later use in comparing IDC model outputs to ARM model outputs in like areas of the Basin. Zonal attributes extracted from the ARM model included the "MdlBasin" attribute (which defines the Management Area of each ARM grid cell), the "DrainsTo" attribute (which defines the contributing watershed of each ARM grid cell), and the "Source" attribute (which defines the source of applied water supplies for each ARM grid cell).

DEVELOPMENT OF IDC INPUT FILES

IDC input files are set up using a tiered file structure as summarized in **Figure 6** below and described in detail in the IDC Theoretical Documentation and User's Manual (see **Attachment A**). A summary of the methods and assumptions used to develop each IDC input file is provided below.

Figure 6. Schematic representation the IDC input file structure[4].



[3] Hydrologic soil groups are derived from the USDA-NRCS SSURGO Soils Database as described in detail below.
[4] Dogrul, E.C. & Kadir, T. N., 2021. *IWFM Demand Calculator (IDC-2015, Revision 102). Theoretical Documentation and User's Manual.*

Main Control File

The main control file (*IDC_MAIN.in)* is used to direct the IDC batch file (*IDC.bat*) and executable file (*IDC2015_x64.exe)* to all other input files required by the IDC software program. Additionally, it allows the user to initialize the model start and end dates (*BDT* and *EDT*) as well as the model time step *(UNITT)*.

As described above, the IDC model was set up to simulate historical root zone flow processes for a ten-year period covering WY 2011 – WY 2020, consistent with the ARM model historical simulation period. The model is initialized on October 1, 2010 and ends on September 30, 2020.

The IDC model is set up to run on a daily timestep, which allows the model to accurately simulate runoff and recharge (otherwise termed "percolation" in IDC output files) processes associated with high-intensity precipitation events. Daily outputs have been compiled into monthly and/or annual timesteps for reporting purposes. The standard length unit used in the IDC simulation is feet.

Grid Files

IDC requires the user to specify the properties of the IDC grid in several input files, including:

- *NodeXY.dat* – specifies the total number of Nodes (*ND* = 12,626), Node identifiers (*ID*), Nodal X and Y coordinates, and a coordinate conversion factor (*FACT* = 1). For the Zone 7 IDC model, Nodal coordinates are specified using the NAD 1983 State Plane Coordinate System for California Zone 3 (NAD 83 SPCS CA III) projected coordinate system, and are listed in units of feet.
- *Element.dat* – specifies the total number of Elements (*NE* = 12,107), Element identifiers (*IE*), and corresponding Node identifiers (*IDE*). Node identifiers for each Element must be listed in counterclockwise fashion starting with any Node.
- *LakeElems.dat* – specifies the total number (*NTELAKE*) and identifier (*IELAKE)* of Elements to be assigned as lakes in the IDC model. IDC removes lakes from all root zone calculations. For the Zone 7 IDC model, 271 Elements were assigned as lakes based on ARM grid cells identified as Water ("Wat") or Mining Area Ponds ("MA-Pond") in Zone 7's land use dataset. Lake Elements are generally limited to the Chain of Lakes areas as well as a few other surface water features scattered throughout the Basin (e.g., Lake del Valle).

Area Files

IDC classifies different land use types into four main categories based on unique methodologies for calculating irrigation demands and recharge/runoff rates: (1) Non-Ponded Crops (i.e., all agricultural lands not using flood irrigation practices); (2) Ponded Crops (i.e., agricultural lands using flood irrigation practices); (3) Native/Riparian Vegetation (i.e., any native lands or non-irrigated lands); and (4) Urban Lands. For Non-Ponded and Ponded Crops[5], any number of crop types can be specified by the user. For Native/ Riparian Vegetation, all lands must be specified as Native or Riparian. For Urban Lands, lands must be grouped by a common area (e.g., municipality or water service area).

[5] There are no Ponded Crops in the IDC model domain, as demonstrated in Table 1 below.

To meet the input file requirements of IDC, EKI reclassified Zone 7's original land use categories provided in the ARM into the following IDC land use categories presented in **Table 1.**

Table 1. Zone 7 Original and IDC Land Use Categories

Zone 7 Original Land Use Category	IDC Land Use Category
URH - Urban Residential High Density	Urban
URM – Urban Residential Medium Density	Urban
URL – Urban Residential Low Density	Urban
RR – Rural Residential	Urban
UP – Urban Park	Urban
UC – Urban Commercial and Industrial	Urban
Pub - Public	Urban
Ro – Roads	Urban
OS – Open Space	Native
MA-Pit – Mining Area Pits	Native
MA-Other – Mining Area Other	Native
Ag-Vine – Vineyards	Non-Ponded Crops (Vineyards)
Ag-Other – Other Ag	Non-Ponded Crops (Misc. Field Crops)
GC – Golf Courses	Non-Ponded Crops (Golf Courses)
MA-Pond – Mining Area Ponds	Lake Element
Wat – Water	Lake Element

Reclassified land use types were subsequently entered into their corresponding input files by Element (i.e., *UrbanArea.dat*, *NonPondedAgArea.dat*, or *NVRVArea.dat*) for each water year included in the simulation. IDC allows the user to specify a fractional area occupied by a particular land use category for each Element; however, EKI elected to assign 100% of the area of each Element to a single land use category consistent with the land use discretization employed in the ARM. The reclassified land use categories are shown for WY 2020 in **Figure 7.**

Climate Files

IDC requires the user to provide normalized precipitation and ET rates at a time unit rate equivalent to the timestep specified for the simulation (i.e., days for the Zone 7 IDC model). IDC allows the user to specify any number of precipitation or ET rates to use for different Elements and/or land use categories, so long as the dataset covers the entire simulation period. Units are in 1/length, where the length unit can be anything so long as an appropriate conversion factor (*FACTRN* or *FACTET*) is provided that converts the normalized values to the standard IDC length unit of feet.

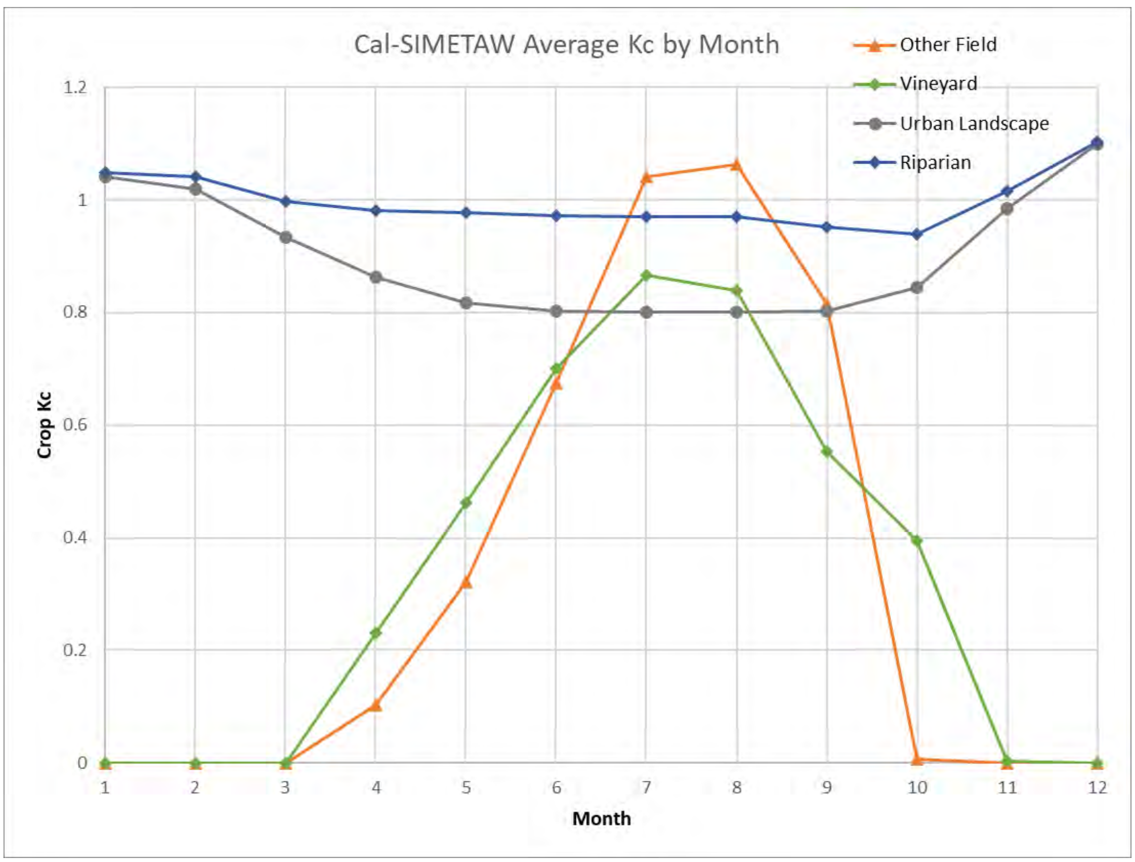
EKI incorporated the daily "Index" precipitation rates extracted from the ARM into the *Precip.dat* file. Precipitation rates are provided in units of inches/day and are subsequently converted to feet/day using *FACTRN* = 0.08333. Precipitation rates are subsequently scaled for each Element using the precipitation multipliers extracted from the ARM as further described below.

For ET, EKI incorporated the daily "Index" ETo rates extracted from the ARM into the *ET_Calsim.dat* file. Additionally, EKI included unique ET rates for four land use categories simulated within the IDC model: (1)

Native/Riparian Lands, (2) Vineyards, (3) Urban Lands, and (4) Other Agriculture (presumed to be Miscellaneous Field Crops). ET rates for these four land use categories were informed by the Cal-SIMETAW historical ET dataset provided by DWR[6]. The Cal-SIMETAW dataset provides monthly estimates of historical ETo and crop ET for 20 crop categories, as well as native/riparian, open water, and urban land use classes for October 1999 – September 2015 based on data from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) and CIMIS datasets. It is a crop coefficient method, meaning an ETo is converted into crop ET using crop coefficients (Kc), where crop ET = ETo x Kc based on assumptions about plant growth rates, harvest timing, et cetera. Estimates are provided for each 4x4 km detailed analysis unit (DAU) by county throughout the state.

EKI calculated average monthly Kc values from the Cal-SIMETAW data for the Livermore DAU (DAU # 45) for the four land use categories mentioned above. The average monthly Kc rates are shown for each category in **Figure 8** below.

Figure 8. Average Crop Coefficient (Kc) Values from Cal-SIMETAW for Livermore DAU



The daily "Index" ETo rates included in the ARM were subsequently multiplied by average monthly Kc values for each land use category to come up with a daily ET rate for Native/Riparian Lands, Vineyards, Urban Lands, and Other Agriculture (Misc. Field Crops) land use types. ET rates for all other land use types

[6] https://data.ca.gov/dataset/cal-simetaw-unit-values

simulated in the Basin were represented by the "Index" ETo dataset. ET rates are provided in units of inches/day and are subsequently converted to feet/day using *FACTET* = 0.08333.

Root Zone Files

The Zone 7 IDC model employs Version 4.11 of the Root Zone package. The features of v4.11 and other versions are described in detail in the IDC Theoretical Documentation and User's Manual.

IDC requires that various soil attributes are provided in the *ROOTZONE_v411_MAIN.dat* file for Each element, including:

- Wilting point (*WP*)
- Field capacity (*FC*)
- Total porosity (*TN*)
- Pore size distribution index (*LAMBDA*)
- Saturated hydraulic conductivity (*K*)
- Capillary rise (*CPRISE*)

To populate the required soil properties, EKI extracted soils data from the United States Department of Agriculture Natural resources Conservation Service's (USDA-NRCS) Soil Survey Geographic Database (SSURGO)[7]. The SSURGO dataset provides GIS files of soil types at a high spatial resolution and is accompanied by an Access database that contains the required soil properties information described above for most soil types. EKI imported SSURGO data for the Basin into GIS and joined soil classes to each Element of the IDC grid. Element-specific SSURGO soil types are shown on **Figure 9**.

Relevant soil properties were then extracted from the SSURGO dataset using the accompanying Soil Data Viewer GIS add-in and applied to each Element based on soil class. EKI choose to use the "Weighted Average" aggregation method included in the SSURGO dataset to define Elemental soil properties, where applicable. Where multiple soil types were contained within a single Element, an area- weighted average was calculated for each soil property contained within that Element. Where the soil types were missing certain soil properties, missing soil properties were inferred from other similar soil types. Select soil properties (e.g., saturated hydraulic conductivity [*K]*) were subsequently adjusted during IDC model calibration, as further described below. Final saturated hydraulic conductivities (*K*) assigned to each element are shown on **Figure 10**.

The *ROOTZONE_v411_MAIN.dat* file also requires the user to specify certain parameters controlling root zone flow processes within the simulation engine, including:

- Method to represent hydraulic conductivity vs. moisture content curve (*RHC*)
- Precipitation multipliers (*FRNE*)
- Pointers to the *PipeLeak.dat* Generic Moisture Source data file by Element (*IMSRC*)
- Destination types (*TYPEDEST*) and locations (*DEST*) for runoff (for use if linking IDC to an IWFM groundwater flow model)

[7] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

The Zone 7 IDC model employs Campbell's Equation (*RHC* = 1) to represent unsaturated hydraulic conductivities as a function of soil moisture. Precipitation multipliers (*FRNE*) are specified for each Element based on the precipitation multipliers included in the ARM. The Generic Moisture Source package is employed to simulate pipe leakage within urban areas and generic moisture data sources (*ISMRC*) are specified for urban cells based on their corresponding water agency service areas, as further described below. Because IDC is being used as a stand-alone package, all runoff is routed "outside the model area" (*TYPEDEST = 0*). IDC currently does not have the capability to link runoff outflows between adjacent Elements, and therefore runoff occurring on individual Elements cannot contribute to ET or recharge in adjacent Elements.

Finally, the *ROOTZONE_v411_MAIN.dat* file contains several pointer attributes used to direct the IDC executable to accompanying files of the Root Zone package, each of which are further described below.

Non-Ponded Crops Files

The *NonPondedAg_MAIN.dat* file is used to specify certain attributes and pointers to accompanying files for each non-ponded crop type simulated in the IDC model, including:

- Number of non-ponded crops (NBCROP) and crop type codes (*BCCODE*)
- Maximum crop rooting depths (*ROOT*) and pointers for the *RootDepthFrac.dat* fractional rooting depth file (*ICROOT*)
- Curve numbers by Element and crop type (*CN*)
- Pointers to the *ET_CalSim.dat* ET data file by crop type (*ICET*)
- Pointers to the agricultural water supply requirement data file by crop type (*ICAW*) (not in use)
- Pointers to the *IrrigPeriod.dat* irrigation period data file by crop type (*ICIP*)
- Pointers to the *MinSoilMoist.dat* minimum soil moisture data file by crop type (*ICMSM*)
- Pointers to the *TargetSoilMoist.dat* target soil moisture data file by crop type (*ICTRGSM*)
- Pointers to the *ReturnFlowFrac.dat* irrigation water return flow fractions data file by crop type *(ICRTRNF)*
- Pointers to the *ReuseFrac.dat* irrigation water reuse fractions data file by crop type *(ICRUF)*
- Pointers to the minimum percolation fractions data file by crop type (*ICDPF*) (not in use)
- Initial Soil Moisture Conditions (*SOILM*) and fraction of initial soil moisture due to precipitation (*FSOILMP*)

As described earlier, there are three unique non-ponded crop types simulated in the Zone 7 IDC model: (1) Vineyards ("AV"); (2) Other Agriculture (Misc. Field Crops, "AO"); and (3) Golf Courses ("GC"). Vineyards and Other Agriculture are assigned a maximum crop rooting depth (*ROOT*) of 3 feet, while maximum rooting depths for Golf Courses is set at 1 foot. Maximum rooting depths were estimated based on relevant studies of crop rooting depths[8]. It is conservatively assumed that all crop types will remain at 100% rooting depths throughout the entire simulation (*RDFRC* = 1 in the *RootDepthFrac.dat* file).

[8] http://ucmanagedrought.ucdavis.edu/Agriculture/Irrigation_Scheduling/Evapotranspiration_Scheduling_ET/Frequency_of_Irrigation/Crop_Rooting_Depth/

Curve numbers are specified by Element and crop type based on the hydrologic soil group (i.e., A-D) identified for each Element in the SSURGO dataset and the corresponding curve number properties for their respective Zone 7 land use - hydrologic soil group combinations provided in the ARM.

As described earlier, unique ET rates are assigned to Vineyards and Other Ag. (Misc. Field Crops) in the *CalSim_ET.dat* data file based on monthly average crop coefficients provided by Cal-SIMETAW. ET rates for Golf Courses are set at the ETo rate, as it is assumed well-watered turf grasses will closely mimic ETo.

Irrigation periods are specified by crop type in the *IrrigPeriod.dat* data file. Irrigation periods are based on assumptions included in the ARM, and are set as:

- Vineyards: April through October
- Other Ag.: April through September
- Golf Courses: January – December (year-round)

Minimum soil moisture fractions (*SMMIN*, specified as a fraction of Total Available Water [TAW = FC – WP]) are used as a trigger for irrigation events and are generally included in IDC as tunable parameters to control minimum irrigation rates for each crop type. *SMMIN* was set at 0.5 in the *MinSoilMoist.dat* file for all crop types, as is commonly used in other IDC models.

Target soil moisture fractions (*SMTRG,* specified as a fraction of FC) are used to compute irrigation water demands and are generally included in IDC as tunable parameters to control maximum irrigation rates for each crop type. They are also commonly employed to simulate deficit irrigation practices, which is known to be a common practice on Vineyards. *SMTRG* values were estimated by crop type in the *TargetSoilMoist.dat* file and were subsequently adjusted during IDC model calibration, as further described below. Final *SMTRG* values were set at 0.7 for Vineyards, 0.8 for Other Ag., and 0.9 for Golf Courses.

No return flows (i.e., recapture of excess irrigation runoff) or return flow reuse (i.e., recycled irrigation of recaptured return flows) are simulated in the Zone 7 IDC model.

Initial soil moisture conditions (*SOILM)* are set as 50% of TAW (i.e., [FC – WP]/ 2) for all Elements and it is presumed 100% of initial soil moisture is sourced from precipitation (*FSOILMP* = 1) at the first model timestep.

<u>Native/Riparian Vegetation Files</u>

The *NonPondedAg_MAIN.dat* file is used to specify certain attributes and pointers to accompanying files for the native/riparian land use classes simulated in the IDC model, including:

- Native/riparian vegetation rooting depths (*ROOTNV* and *ROOTRV*)
- Curve numbers for native/riparian Elements (*CNRV*)
- Pointers to the *ET_CalSim.dat* ET data file (*ICETNV* and *ICETRV)*
- IWFM stream nodes at which surface water will be used to satisfy unmet riparian ET demands (not in use)
- Initial Soil Moisture Conditions (*SOILM*) and fraction of initial soil moisture due to precipitation (*FSOILMP*)

As described earlier, all Elements with "OS", "MA-Pit", and "MA-Other" Zone 7 land use classes were reclassified as Native Elements in the IDC model. No riparian Elements are simulated, as there is no accompanying IWFM model or stream network simulated to supply unmet riparian vegetative demands.

Native Elements are assigned a rooting depth (*ROOTNV*) of 3 feet based on an analysis of native vegetation classes within the Basin[9] and The Nature Conservancy's (TNC) plant rooting depth database[10].

Curve numbers are specified by Element based on the hydrologic soil group (i.e., A-D) identified for each Element in the SSURGO dataset and the corresponding curve number properties for their respective Zone 7 land use - hydrologic soil group combinations provided in the ARM.

As described earlier, unique ET rates are assigned to Native Elements in the *CalSim_ET.dat* data file based on monthly average crop coefficients provided for Native/Riparian Vegetation by Cal-SIMETAW.

Initial soil moisture conditions (*SOILM)* are set as 50% of TAW for all Elements.

Urban Lands Files

The *Urban_MAIN.dat* file is used to specify certain attributes and pointers to accompanying files for the Urban land use class simulated in the IDC model, including:

- Urban landscape rooting depths (*ROOTURB*)
- Pervious area fractions for Urban Elements (*PERV*)
- Curve numbers for Urban Elements (*CNURB*)
- Pointers to the *Population.dat* population data file used to specify total populations of each Urban area defined in the IDC model
- Pointers to the *WaterUse.dat* water use data file used to specify per capita water demands for each Urban area defined in the IDC model
- Relative proportion of the total Urban demands specified in *WaterUse.dat* at each Urban Element (*FRACDM)*
- Pointers to the *ET_CalSim.dat* ET data file (*ICETURB)*
- Pointers to the *ReturnFlowFrac.dat* irrigation water return flow fractions data file for Urban elements *(ICRTFURB)*
- Pointers to the *ReuseFrac.dat* irrigation water reuse fractions data file for Urban Elements *(ICRUFURB)*
- Pointers to the *UrbanSpecs.dat* urban water use specifications data file used to specify the fraction of total urban water that is used indoors for each Urban area defined in the IDC model
- Initial Soil Moisture Conditions (*SOILM*) and fraction of initial soil moisture due to precipitation (*FSOILMP*)

Urban Elements have been classified into four distinct groups based on the water service areas that they are located in. These include: (1) Dublin San Ramon Services District (DSRSD); (2) Cal Water Livermore; (3) City of Livermore; and (4) City of Pleasanton. Each Urban group will have distinct populations, per capita

[9] Stillwater Sciences, 2021. *Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin.*
[10] https://groundwaterresourcehub.org/public/uploads/pdfs/Plant_Rooting_Depth_Database_20180419.xlsx

water demands, and Urban indoor use fractions based on information contained in their respective Urban Water Management Plans (UWMPs), as further described below. The four water service areas in the Basin are shown on **Figure 11**. A fifth group has also been included for roads, and per-capita water demands have been set to zero to avoid any applied water occurring on road Elements. Each Urban Element within a water service area is assumed to have the same proportional population and per-capita water use demands (i.e., *FRACDM* = -1).

Pervious area fractions (*PERV)* were estimated for each Urban Element using DWR's 2021 Landscape Area Estimates Project[11] dataset and accompanying GIS files. As part of this study, DWR contracted Quantum Spatial, Inc., an NV5 company, with support from Eagle Aerial Solutions, to provide landscape area estimates for single-family and multi-family residential parcels for all urban retail water suppliers in California. DWR provided Zone 7 with separate reports and GIS databases of residential urban landscape area estimates at a parcel level for each of the four water service areas included within the Basin. EKI subsequently linked these GIS files to the IDC grid to calculate a representative PERV value for each Urban Element. An average *PERV* value was also calculated for each of Zone 7's original urban land use classes ("URH", "URM", etc.) to assign to Urban Elements located outside of the DWR Landscape Area study area. *PERV* values were subsequently adjusted during IDC model calibration, as further described below. Final *PERV* values assigned to each Urban Element are shown on **Figure 12**.

Urban populations (*POPUL)*, per-capita water use rates *(WU*), and indoor water use fractions (*URINDR*) are estimated for each water service area based on information contained in their individual UWMPs. *POPUL, WU, and URINDR* rates were compiled from the 2010, 2015, and 2020 UWMPs for each water service area and were subsequently interpolated for WY 2011 – 2020. *POPUL* estimates were downscaled based on the percentage of each water service area located within the Basin. Indoor water use fractions (*URINDR*) were further adjusted to reflect the monthly variability in indoor/outdoor water use trends observed throughout the year. *URINDR* values were rescaled by month based on analyses of indoor/outdoor water use trends included in Woodward & Curran's 2020 Tri-Valley Municipal and Industrial Water Demand Study[12] prepared for Zone 7.

Urban Elements are assigned a rooting depth (*ROOTNV*) of 1 foot based on relevant studies of turf grass rooting depths[13].

Curve numbers are specified by Element based on the hydrologic soil group (i.e., A-D) identified for each Element in the SSURGO dataset and the corresponding curve number properties for their respective Zone 7 land use - hydrologic soil group combinations provided in the ARM.

As described earlier, unique ET rates are assigned to Urban Elements in the *CalSim_ET.dat* data file based on monthly average crop coefficients provided for Urban Landscaping by Cal-SIMETAW.

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[11] Quantum Spatial, Inc., 2021. *California Department of Water Resources Landscape Area Estimates Project.* Contract No. EA-133C-16-CQ-0044

[12] Woodward & Curran, 2020. *2020 Tri-Valley Municipal and Industrial Water Demand Study.*

[13] http://ucmanagedrought.ucdavis.edu/Agriculture/Irrigation_Scheduling/Evapotranspiration_Scheduling_ET/Frequency_of_Irrigation/Crop_Rooting_Depth/

Initial soil moisture conditions (*SOILM)* are set as 50% of TAW for all Elements.

Optional Packages

EKI has activated two additional (optional) IDC packages to simulate: (1) leakage from water supply distribution systems within the Basin; and (2) shallow groundwater uptake from known groundwater dependent ecosystems (GDEs) within the Basin. Each of these packages are described in further detail below.

Pipe Leakage (Generic Moisture Source Package)

Leakage rates (i.e. "losses") from water supply distribution systems are simulated using IDC's optional Generic Moisture Source package. Leakage rates are specified by water service area in Zone 7's 2010 and 2015 UWMPs and in the 2020 Tri-Valley Demand Study. These leakage rates were normalized by the total area of Urban Elements within each water service area and were interpolated to calculate annual normalized leakage rates (in units of ft/yr) within each Urban Element for WY 2011 – 2020. Normalized leakage rates were entered into the *MSRC* columns of the *PipeLeak.dat* generic moisture source file, and appropriate *IMSRC* pointers were specified by Element by water service area in the *ROOTZONE_V411_MAIN.dat* root zone file. Urban Elements with an assigned leakage rate in the generic moisture source package are shown on **Figure 13.**

GDE Groundwater Uptake (Root Water Uptake from Groundwater Package)

Shallow groundwater uptake from known GDE communities within the Basin are simulated using IDC's optional Root Water Uptake from Groundwater package. Simulation of GDE groundwater uptake was limited to the five major GDE areas in the Basin based on Stillwater Sciences recent evaluation of GDE communities[14]. These GDE areas include: (1) Arroyo Mocho – Riparian Mixed Hardwood & Sycamore; (2) Arroyo Mocho – Valley Oak; (3) Arroyo Valle – Riparian Mixed Hardwood; (4) Arroyo Valle – Sycamore Grove; and (5) Springtown Alkali Sink. In total, ~947 acres of GDEs are included in these areas, representing approximately 90% of the total GDE acreage within the Basin (~1,051 acres) reported in the Stillwater Sciences study. A comparison of GDE areas simulated in the IDC model and GDE areas mapped by Stillwater Sciences is shown on **Figure 14.**

Monthly depth to groundwater within the GDE areas was estimated from nearby Upper Aquifer monitoring wells included in Zone 7's Program Wells Monitoring Program. Well IDs and their locations are also shown on **Figure 14**. Depth to water rates were specified for each GDE area in the *DGW* columns of the *DepthtoGW.dat* file, and appropriate pointers were provided for each GDE element in the *IDGW* attribute. Specific Yield (*SY*) was assumed to be 0.2 based on available aquifer storage properties information for the Upper Aquifer. The *GWUPTK* flag was turned on in the *ROOTZONE_V411_MAIN.dat* root zone file, and capillary rise (*CPRISE*) was set at 10 feet based on a recommendation from the IDC head developer (Can Dogrul).

[14] Stillwater Sciences, 2021. *Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin*.

IDC MODEL CALIBRATION

Individual root zone flow processes (such as recharge, ET uptake, and runoff rates) are very hard to measure directly. In the events where soil moisture probes or other monitoring devices are used to evaluate root zone flows over time, these monitoring data are typically only relevant at a local (e.g., parcel) scale and may not completely represent root zone dynamics or their variability at a Basin level. As such, Basin-level root zone flow simulations are typically evaluated and "calibrated" based on comparisons to other existing root zone flow models within the study area along with other qualitative means of analysis.

The following evaluations were made to assess IDC model performance and inform updates to root zone and/or crop parameters in order to improve the reliability of IDC recharge and runoff estimates throughout the Basin:

- Comparison to ARM outputs within common model areas
- Evaluation of watershed-based runoff estimates
- Evaluation of irrigation efficiencies, applied water rates, and ET uptake rates
- Evaluation of normalized recharge, runoff, and ET rates and their spatial distribution

Each of these evaluations are described in greater detail below.

<u>Comparison to ARM Outputs</u>

Monthly and annual outputs from IDC were compiled for Elements also included within the ARM grid, and results between the two models were compared to determine how closely the IDC model replicates core root zone flow components estimated by the ARM. This comparison informed further adjustment of IDC parameters (e.g., scaling of hydraulic conductivity [*K*] and urban pervious area fractions [*PERV*]) to more closely replicate the spatiotemporal trends in recharge, runoff, and total applied water rates observed in the ARM.

An annual comparison of total recharge, runoff, and total applied water rates between the ARM and calibrated IDC models in common areas is shown in **Figures 15 through 17** below. All values are reported in units of acre-feet per year (AFY).

On average, the calibrated IDC model estimates approximately 90% recharge, 106% runoff, and 92% total applied water compared to the ARM in common model areas, indicating that the two models are reasonably comparable. The recharge, runoff, and total applied water rates also track well throughout the 10-year historical model simulation period, indicating that the IDC model does not present any significant change in root zone dynamics relative to the ARM.

Figure 15. Comparison of Annual Recharge Rates between IDC and ARM Models

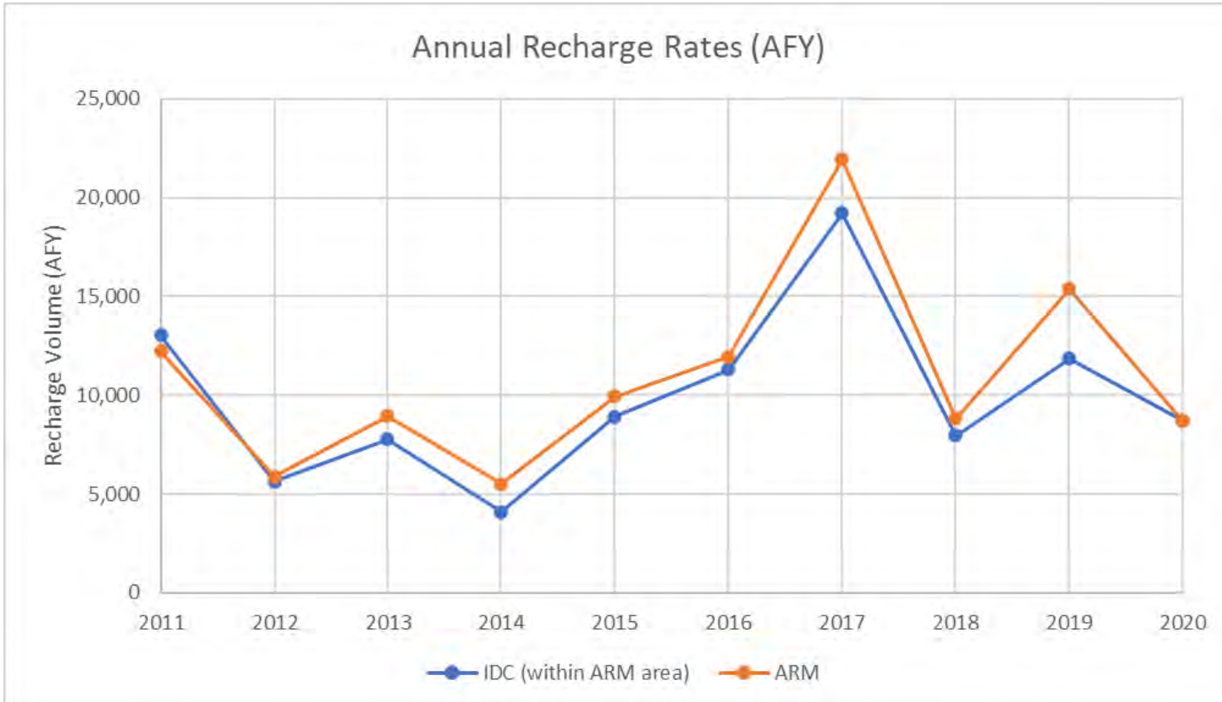


Figure 16. Comparison of Annual Runoff Rates between IDC and ARM Models

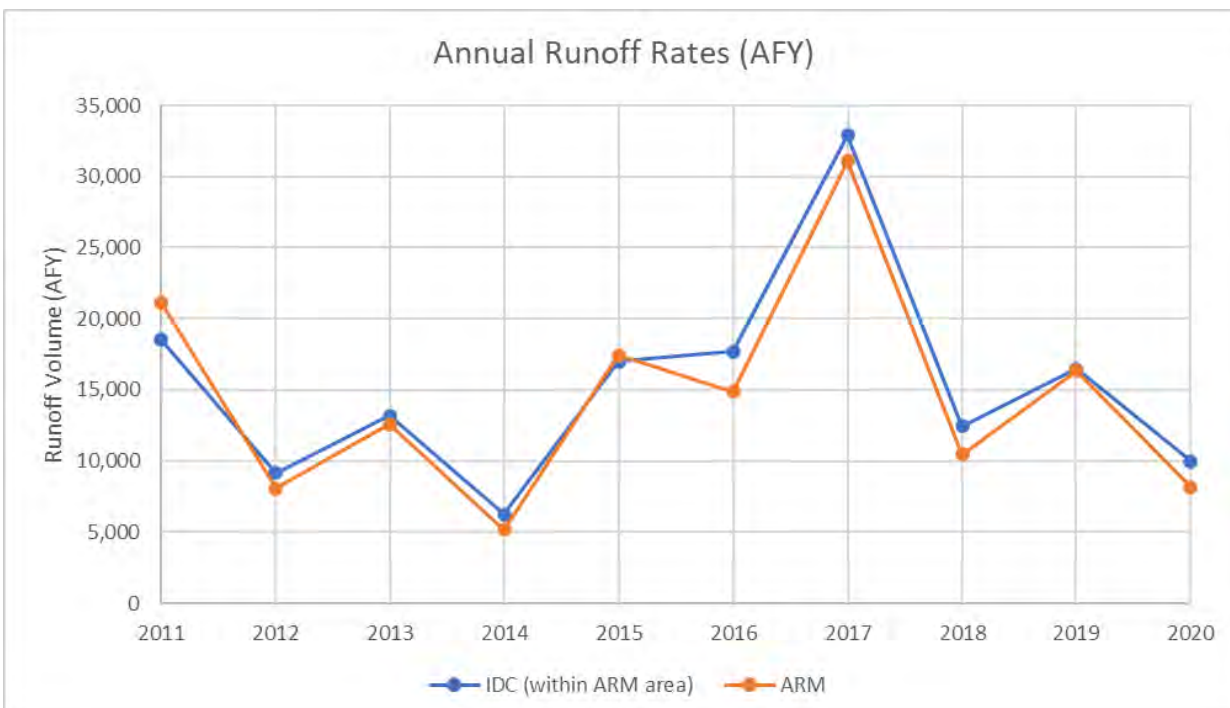
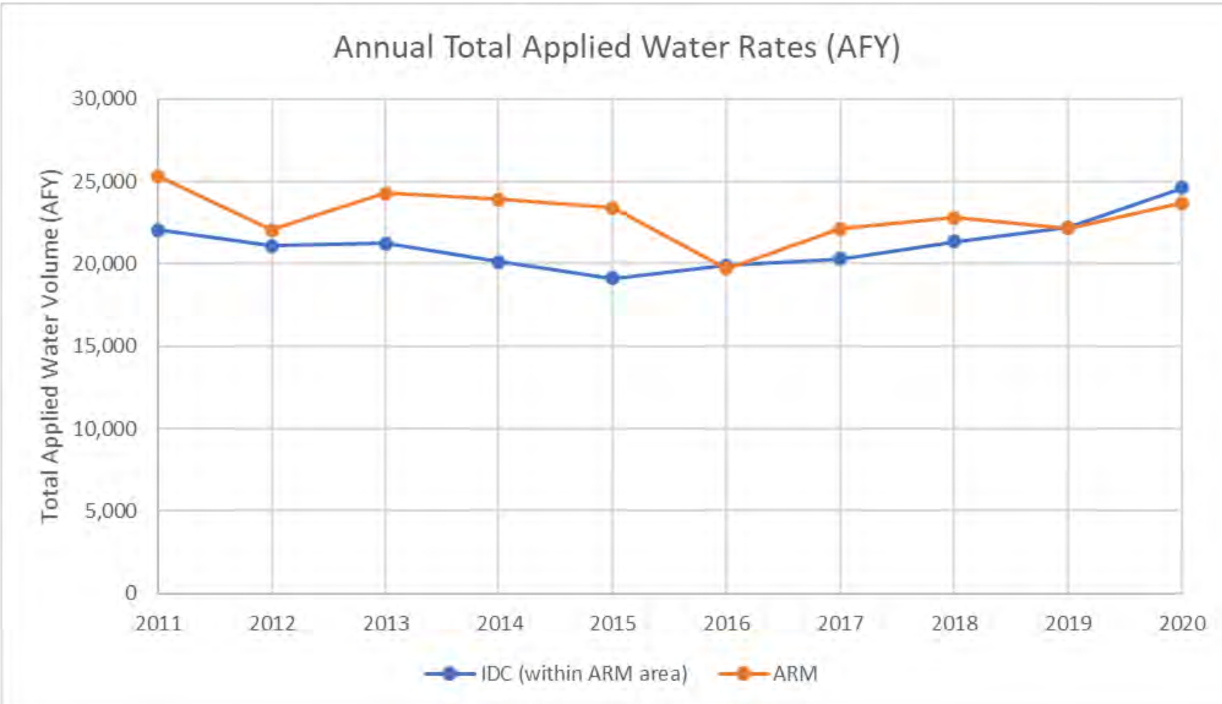


Figure 17. Comparison of Annual Total Applied Water Rates between IDC and ARM Models



Evaluation of Watershed Based Runoff Estimates

Monthly runoff outputs were extracted from the IDC model for three major watersheds that drain into the Arroyo Valle, Arroyo Mocho, and Arroyo Las Positas creeks within the Basin. These values were subsequently compared to analogous outputs from the ARM as well as prior estimates of runoff rates into each major creek based on empirical formulas derived from streamflow records and mass balance assessments. This exercise was completed to evaluate if IDC can reasonably predict contributing runoff to major streams within the Basin relative to other existing methods, and to inform any adjustments to soil parameters accordingly.

A monthly comparison of average runoff rates between the ARM, calibrated IDC model, and empirical formulas are presented for the Arroyo Valle, Arroyo Mocho (Reaches 1 – 3), and Arroyo Las Positas contributing watersheds in **Figures 18 through 20** below. All values are reported in cubic feet per second (cfs).

In the Arroyo Valle watershed, IDC runoff rates track very closely with both the ARM and Zone 7's empirical formula, both in magnitude and in temporal patterns. Average runoff rates from IDC were approximately 95% of the ARM rate, and approximately 91% of the empirical formula-derived rate.

In the Arroyo Mocho watershed, IDC runoff rates track reasonably closely with the ARM, though both IDC and ARM runoff rates are much higher on average than the empirical formula-derived rate. Average runoff rates from IDC were approximately 118% of the ARM rate, and approximately 256% of the empirical formula-derived rate. Based on the graph presented in **Figure 19**, it appears the empirical formula does not simulate as much runoff during low-to-medium intensity precipitation events as the IDC or ARM models, which may explain why average runoff rates from both root zone models are over twice as high as the empirical formula-derived runoff rates.

In the Arroyo Las Positas watershed, IDC runoff rates are significantly lower than reported by the ARM, but are closer to the runoff rates calculated by the empirical formula. Average runoff rates from IDC were approximately 41% of the ARM rate, and 180% of the empirical formula-derived rate. In this instance, it appears the ARM drastically overestimates runoff within the Arroyo Las Positas watershed during high-intensity precipitation events while the IDC model produces more comparable (but still higher) results relative to the empirical formula.

It is important to note that IDC runoff rates are currently being routed "outside the model area", and thus there is no further tracking of runoff once it leaves an IDC Element. This results in 100% of runoff within a contributing watershed being counted as a source of inflow to the streams outlined above. In reality, runoff will pass over adjacent lands and migrate into and through contributing tributaries to each of these major stream networks, which may result in additional recharge (either on adjacent lands or within the tributaries) before runoff reaches the major stream. A more reliable approach for estimating runoff into major streams would be to link runoff rates from the IDC model to individual stream reaches that are explicitly simulated as part of a larger, integrated groundwater flow model (either using IWFM or MODFLOW's streamflow routing package). Explicitly simulating runoff into individual stream reaches may produce more accurate estimates of contributing runoff to streamflow within these major stream networks because it allows for a more spatially resolved tracking of runoff migration throughout the Basin and can account for any additional recharge resulting from runoff as it migrates through the Basin before reaching the major stream networks.

Figure 18. Comparison of Average Monthly Runoff Rates in the Arroyo Valle Contributing Watershed

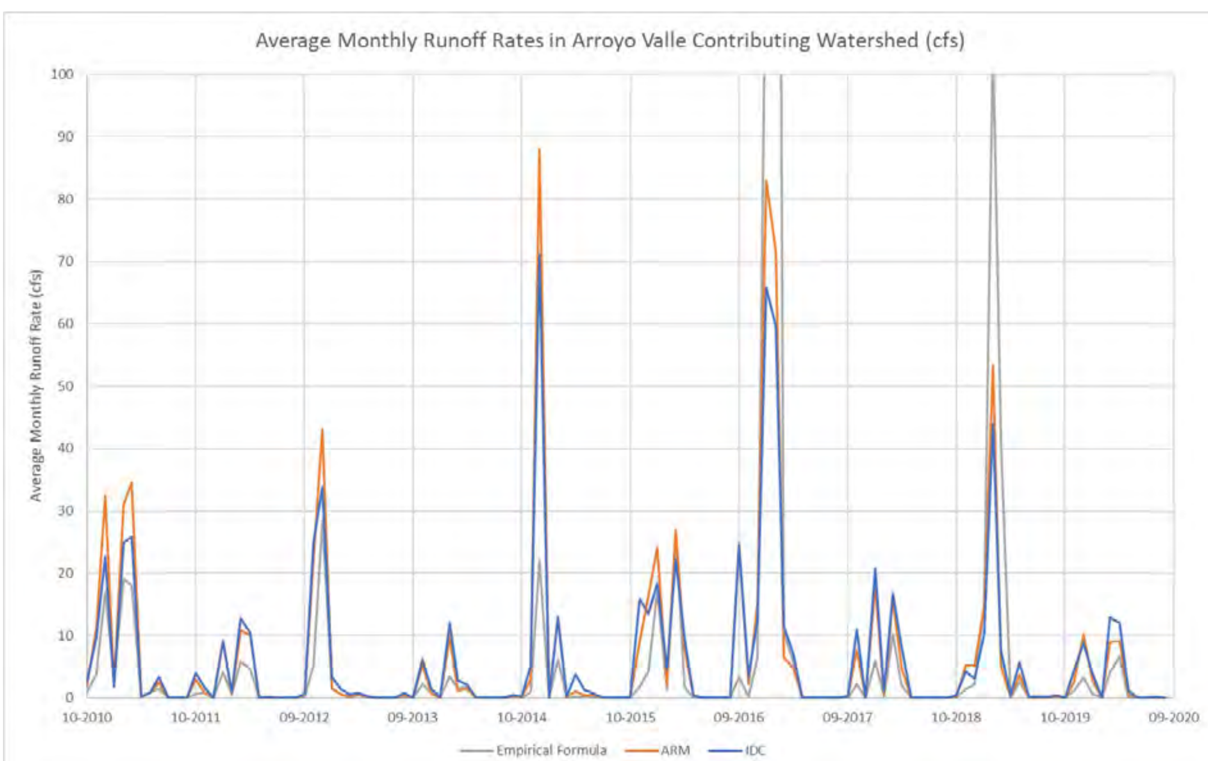


Figure 19. Comparison of Average Monthly Runoff Rates in the Arroyo Mocho Contributing Watershed

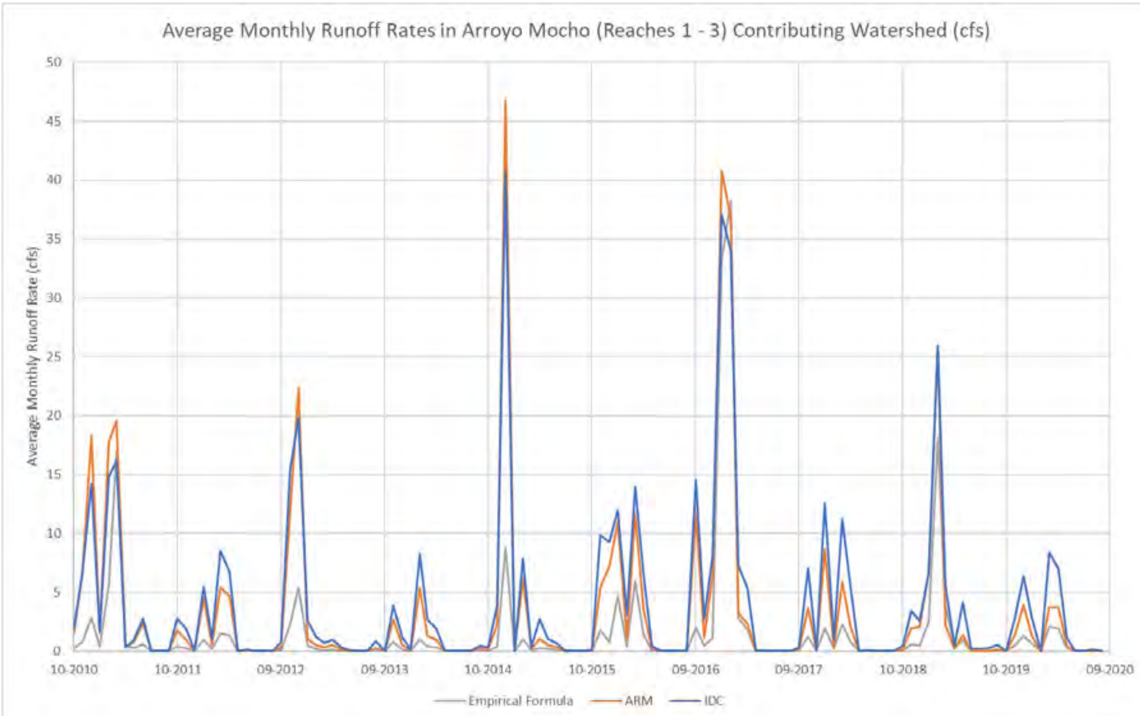
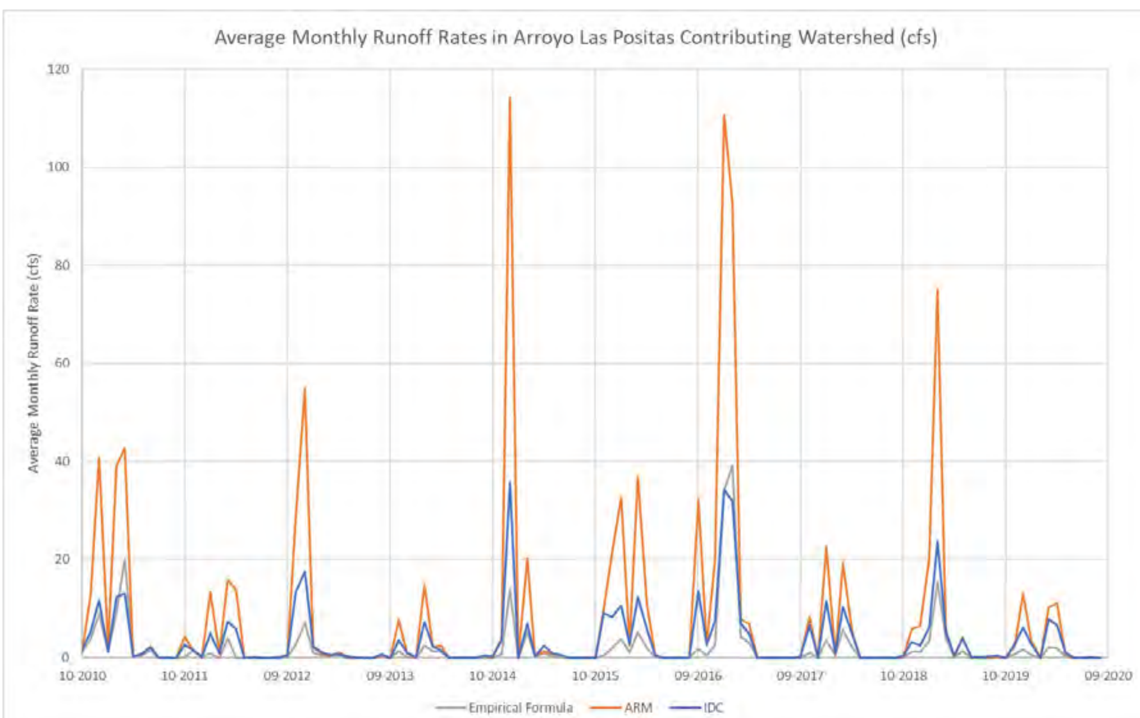


Figure 20. Comparison of Average Monthly Runoff Rates in the Arroyo Las Positas Contributing Watershed



Evaluation of Irrigation Efficiencies, Applied Water Rates, and ET Uptake Rates

To evaluate the performance of the Non-Ponded Crops component of the IDC model, average irrigation efficiencies, applied water unit rates, and ET uptake rates were calculated for each non-ponded crop being simulated in the IDC model (i.e., Vineyards, Other Ag. [Misc. Field Crops], and Golf Courses). These values were subsequently compared to representative values from relevant studies[15,16,17,18] to inform adjustments to parameters within the non-ponded crops domain (e.g., target soil moisture *[ICTRGSM]*).

The following average irrigation efficiencies were calculated from the calibrated IDC model outputs:

- Vineyards – 84%
- Other Ag. (Misc. Field Crops) – 75%
- Golf Courses – 87%

These irrigation efficiencies are in line with estimates for high-efficiency sprinkler to micro-drip irrigation systems provided in the literature and help to confirm that total applied water rates and applied water recharge rates calculated for non-ponded crops are reasonable.

The following applied water unit rates were calculated from the calibrated IDC model outputs:

- Vineyards – 1.1 feet/yr
- Other Ag. (Misc. Field Crops) – 1.96 ft/yr
- Golf Courses – 4.0 ft/yr

These applied water unit rates are in line with estimates reported in the literature for each crop category. They also help to confirm that Vineyards are being simulated under realistic deficit irrigation practices, which is common practice for wine growers.

The following ET uptake rates (actual ET / potential ET) were calculated from the calibrated IDC model outputs:

- Vineyards – 57%
- Other Ag. (Misc. Field Crops) – 90%
- Golf Courses – 96%

These ET uptake rates help to confirm that actual ET rates are in line with the irrigation practices designed for each crop category. Specifically, they show that Vineyards are being managed under deficit irrigation practices to limit ET uptake in order to provide for more fruit-heavy vines. Other Ag. (Misc. Field Crops) and Golf Courses are being irrigated to near field capacity to maximize plant yields or maintain healthy, green fairways.

[15] https://aic.ucdavis.edu/publications/Economic%20wine%20and%20water.pdf
[16] https://www.gcsaa.org/docs/default-source/Environment/phase-2-water-use-survey-full-report.pdf?sfvrsn=2b39123e_4
[17] http://www.fao.org/3/t7202e/t7202e08.htm
[18] http://www.itrc.org/reports/pdf/californiacrop.pdf

Evaluation of Normalized Recharge, Runoff, and ET Rates and their Spatial Distribution

Another method used to evaluate IDC model performance at a Basin-level was by comparing normalized recharge, runoff and ET rates to precipitation and total applied water rates. These metrics help inform how inputs to the root zone are being distributed proportionally between recharge, runoff, and ET.

The Basin received approximately 14 inches of precipitation per year on average over WY 2011 – 2020. Based on calibrated IDC model outputs, another 4.3 inches of total applied water was introduced to the root zone from irrigation practices along with 0.3 inches from pipe leakage, equating to 18.6 inches of total inflows to the root zone. Approximately 30% of these inflows became runoff (5.6 inches), 55% of went to satisfying ET requirements (10.3 inches), and the remaining 15% became groundwater recharge (2.8 inches).

Annual Elemental recharge and runoff outputs from IDC are shown in **Figure 21** and **Figure 22**, respectively. Recharge rates (**Figure 21**) are generally highest in: (1) irrigated agricultural areas, (2) pervious urban areas, and (3) topographic low areas and/or areas with soils of high hydraulic conductivity, including within the Arroyo Valle and Arroyo Mocho stream corridors. Runoff rates (**Figure 22**) are generally highest in: (1) impervious urban areas, (2) along foothills and other high-sloping areas, and (3) areas of low hydraulic conductivity, including in the Upland Management Area and North Fringe subarea. The spatial distribution in recharge and runoff intensity closely mimic what is observed in the ARM and are in line with what is expected based on their relationships to soil properties, topography and land and water use characteristics.

RESULTS

The *ZoneBudget* IDC postprocessing tool was used to aggregate outputs from IDC for five distinct Management Area zones. Management Areas within the Basin include the (1) Main Basin, (2) North Fringe, (3) Northeast Fringe, (4) East Fringe, and (5) Upland Management Areas, as shown in **Figure 23.**

Annual results from the IDC model are presented by Water Year and Management Area, along with a Basin-wide summary, in **Tables 2 through 7.**

LIST OF TABLES

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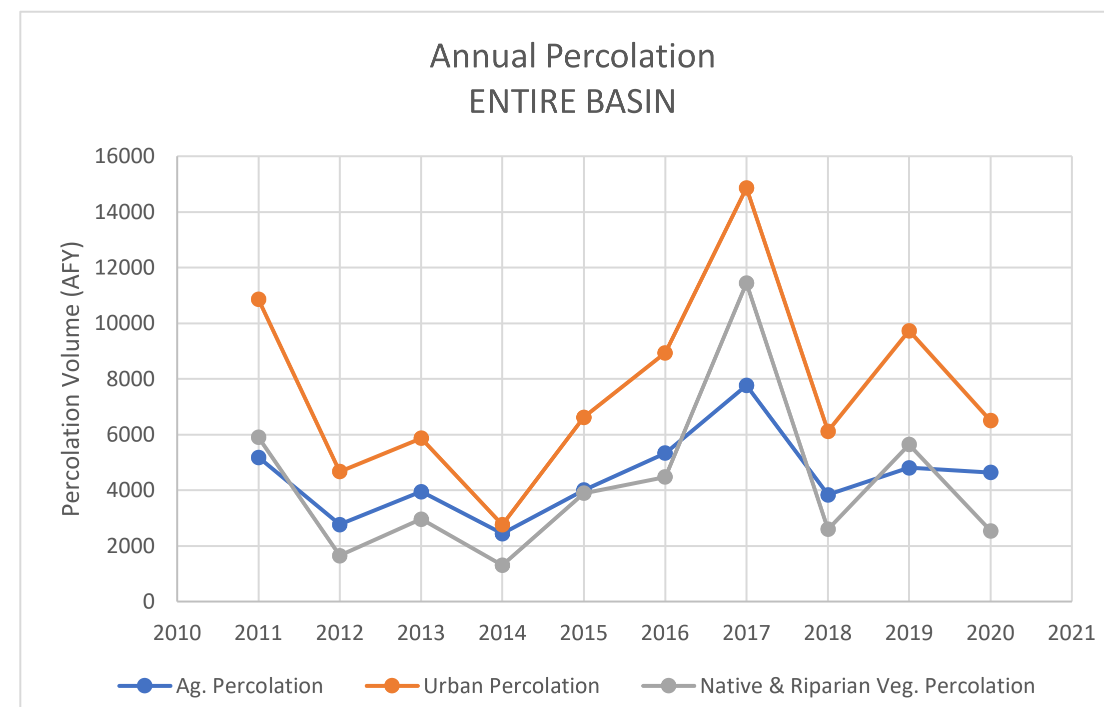
TABLE 2
IDC RESULTS BY WATER YEAR
ENTIRE BASIN SUMMARY

	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
Water Year	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	7,740	8,351	9,946	5,177	1,241	43,630	30,226	2,087	27,023	10,851	24,730	51,350	2,755	41,041	5,900	12,429	102,720	38,577	78,010	21,928	38,400
2012	4,308	9,991	10,990	2,769	463	24,102	28,131	2,010	25,281	4,668	12,586	26,251	2,805	22,364	1,649	4,756	54,662	38,123	58,636	9,085	17,805
2013	5,588	11,120	11,605	3,946	1,105	29,343	27,203	1,924	22,814	5,872	17,471	31,479	2,869	21,151	2,961	9,533	66,409	38,323	55,570	12,779	28,109
2014	3,141	11,148	11,608	2,442	219	17,299	25,633	1,850	21,799	2,758	8,645	18,689	2,456	17,174	1,304	2,689	39,129	36,781	50,581	6,505	11,553
2015	6,288	10,716	11,324	4,001	1,677	34,449	24,362	1,767	20,897	6,623	22,067	37,160	2,872	22,073	3,888	14,404	77,896	35,078	54,295	14,512	38,147
2016	7,561	10,365	11,365	5,333	1,217	42,416	25,099	1,849	25,337	8,932	23,975	45,635	3,044	32,174	4,477	11,720	95,611	35,464	68,877	18,743	36,912
2017	12,292	9,618	11,073	7,766	3,070	68,845	26,011	1,930	26,448	14,862	43,364	74,676	2,949	38,132	11,441	27,966	155,813	35,629	75,653	34,070	74,400
2018	5,332	10,300	10,984	3,838	805	29,934	27,053	2,013	23,382	6,120	16,852	32,516	2,943	24,998	2,593	7,883	67,782	37,353	59,364	12,551	25,540
2019	7,181	9,666	11,065	4,807	970	40,386	28,386	2,096	25,277	9,726	22,574	43,724	2,912	31,063	5,642	9,532	91,291	38,052	67,405	20,175	33,075
2020	4,557	12,279	11,506	4,636	570	25,323	29,157	2,178	23,143	6,497	13,848	26,061	3,004	21,426	2,537	5,384	55,941	41,436	56,074	13,670	19,802
AVERAGE	**6,399**	**10,355**	**11,147**	**4,471**	**1,134**	**35,573**	**27,126**	**1,970**	**24,140**	**7,691**	**20,611**	**38,754**	**2,861**	**27,160**	**4,239**	**10,630**	**80,725**	**37,481**	**62,446**	**16,402**	**32,374**
in/yr	*13.2*	*21.4*	*23.0*	*9.2*	*2.3*	*15.0*	*11.4*	*0.8*	*10.2*	*3.2*	*8.7*	*13.8*	*1.0*	*9.7*	*1.5*	*3.8*	*13.9*	*6.5*	*10.8*	*2.8*	*5.6*

Abbreviations:
Ag. = Agricultural
ET = Evapotranspiration
IDC = Integrated Water Flow Demand Calculator
in/yr = inches per year
Veg. = Vegetation

Notes:
1) All values listed in units of acre-feet per year (AFY) unless specified otherwise.



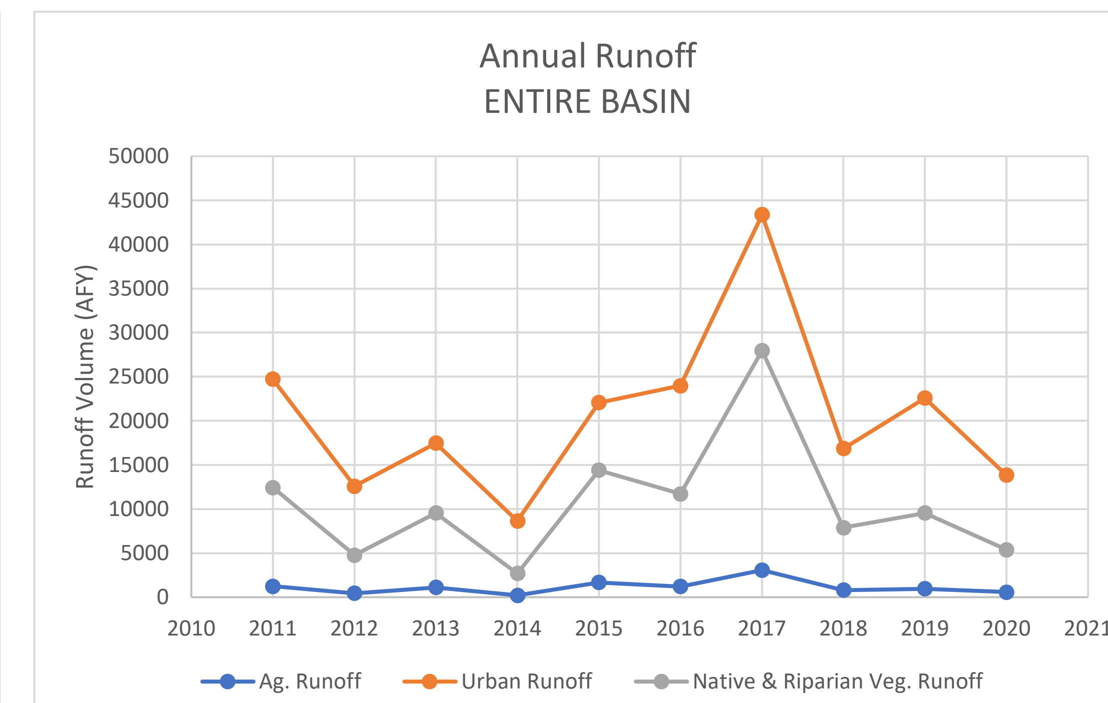


TABLE 3
IDC RESULTS BY WATER YEAR
MAIN BASIN MANAGEMENT AREA

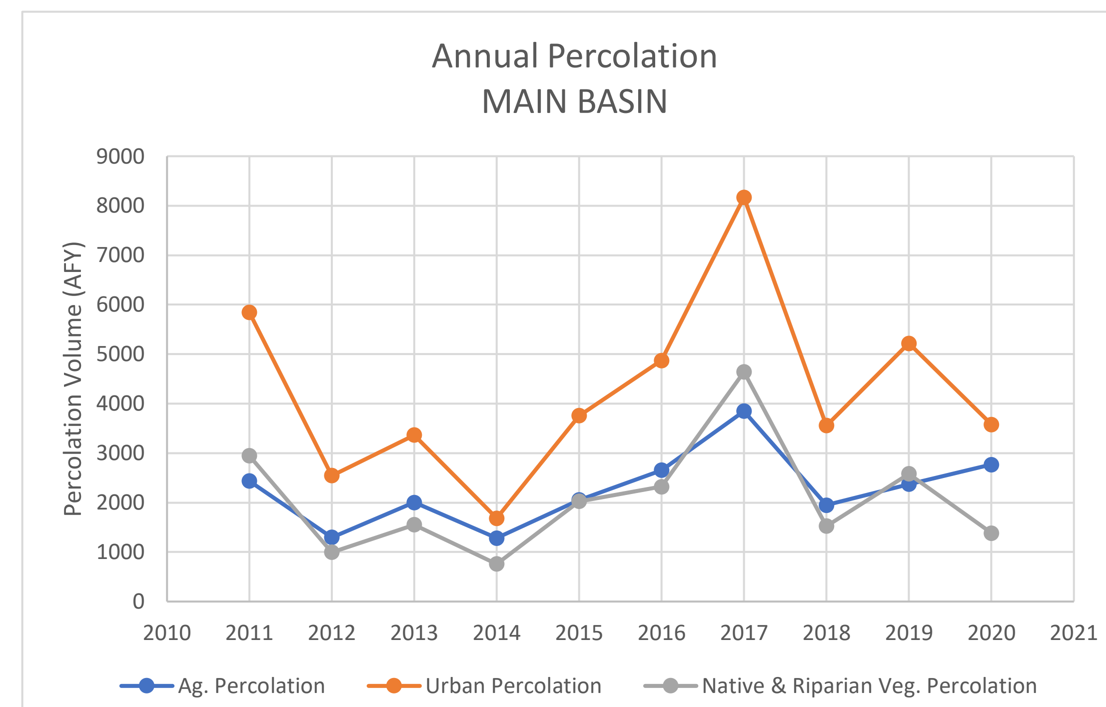
	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
Water Year	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	2,754	3,493	3,676	2,434	187	16,823	13,673	792	10,839	5,840	8,695	8,875	1,898	7,155	2,946	1,355	28,453	17,166	21,670	11,220	10,236
2012	1,367	3,689	3,694	1,294	56	9,023	12,372	789	9,993	2,542	4,360	4,751	1,877	5,031	996	529	15,141	16,062	18,718	4,832	4,946
2013	2,040	4,588	4,363	2,004	234	11,062	11,857	780	9,159	3,362	6,009	5,293	1,929	4,372	1,549	1,139	18,395	16,445	17,894	6,915	7,382
2014	1,129	4,456	4,263	1,284	33	6,482	10,834	777	8,546	1,684	3,077	3,228	1,547	3,725	758	282	10,838	15,290	16,534	3,726	3,391
2015	2,282	4,326	4,180	2,055	366	12,904	10,180	771	8,148	3,753	7,464	6,390	1,938	4,520	2,023	1,815	21,577	14,506	16,848	7,831	9,645
2016	2,832	4,394	4,360	2,654	207	16,073	10,906	825	9,957	4,871	8,234	7,579	2,096	6,074	2,321	1,227	26,484	15,301	20,391	9,846	9,668
2017	4,565	4,066	4,208	3,846	574	25,870	11,327	880	10,323	8,169	14,510	12,724	2,030	6,843	4,640	3,225	43,159	15,393	21,373	16,656	18,309
2018	1,970	4,300	4,184	1,949	138	11,254	11,930	938	9,385	3,556	5,801	5,551	2,026	5,164	1,522	896	18,775	16,230	18,733	7,026	6,835
2019	2,654	4,084	4,201	2,371	164	15,174	12,806	993	10,203	5,216	7,756	7,459	2,005	5,726	2,579	1,075	25,287	16,891	20,130	10,165	8,995
2020	1,705	6,238	5,087	2,766	101	9,465	13,335	1,048	9,618	3,577	4,758	4,325	2,066	4,440	1,383	581	15,495	19,573	19,144	7,726	5,440
AVERAGE	**2,330**	**4,363**	**4,222**	**2,266**	**206**	**13,413**	**11,922**	**859**	**9,617**	**4,257**	**7,066**	**6,618**	**1,941**	**5,305**	**2,072**	**1,212**	**22,360**	**16,286**	**19,144**	**8,594**	**8,485**
in/yr	*13.7*	*25.7*	*24.8*	*13.3*	*1.2*	*14.8*	*13.2*	*0.9*	*10.6*	*4.7*	*7.8*	*14.2*	*4.2*	*11.4*	*4.4*	*2.6*	*13.5*	*9.8*	*11.6*	*5.2*	*5.1*

Abbreviations:

Ag. = Agricultural
ET = Evapotranspiration
IDC = Integrated Water Flow Demand Calculator
in/yr = inches per year
Veg. = Vegetation

Notes:

1) All values listed in units of acre-feet per year (AFY) unless specified otherwise.



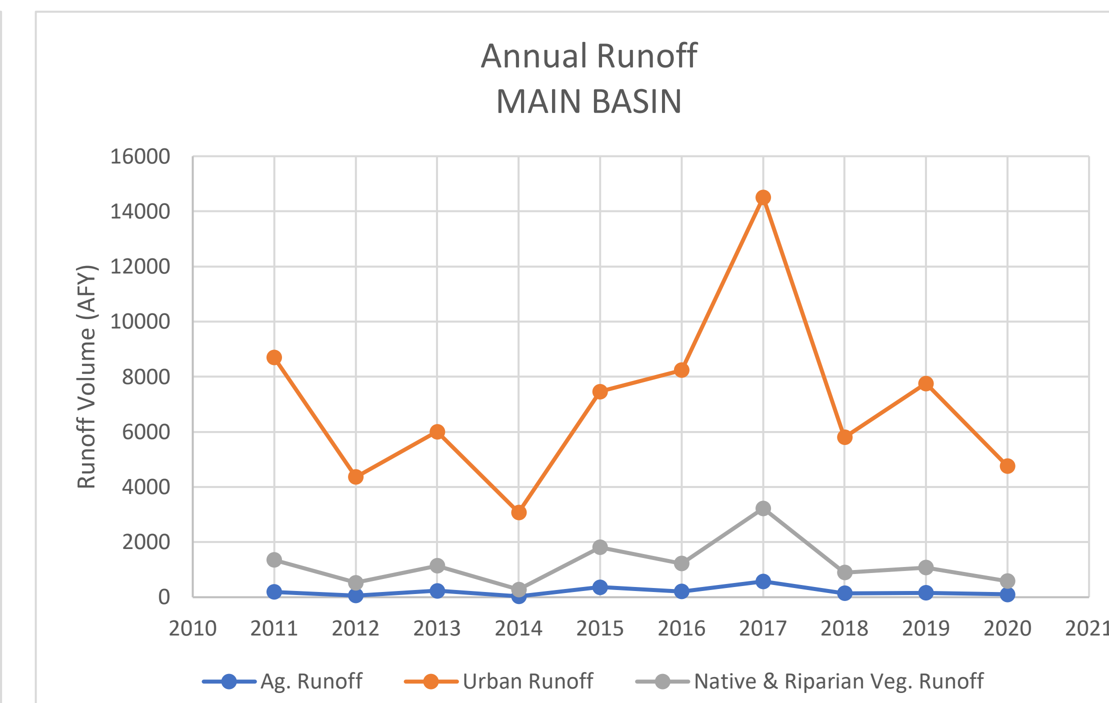


TABLE 4
IDC RESULTS BY WATER YEAR
NORTH FRINGE MANAGEMENT AREA

Water Year	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	395	809	943	208	49	13,999	5,189	305	6,145	2,038	8,908	2,701	0	2,046	137	805	17,095	5,997	9,135	2,383	9,762
2012	200	874	959	104	13	8,096	5,290	305	5,868	992	4,726	801	0	554	15	170	9,097	6,164	7,382	1,111	4,909
2013	243	907	972	133	45	9,826	5,104	304	5,186	1,055	6,474	983	0	544	41	336	11,052	6,011	6,703	1,230	6,855
2014	143	964	1,007	92	6	5,782	4,945	304	4,975	402	3,205	586	0	446	15	103	6,512	5,909	6,428	509	3,314
2015	285	935	981	162	77	11,509	4,700	302	4,826	1,234	8,176	1,169	0	593	53	513	12,964	5,635	6,400	1,448	8,766
2016	379	917	1,054	195	47	13,980	4,804	302	6,136	1,733	8,906	1,553	0	881	66	474	15,912	5,720	8,072	1,993	9,427
2017	617	835	1,022	287	144	22,809	5,266	300	6,653	2,908	16,122	2,504	0	1,121	246	1,137	25,930	6,101	8,796	3,440	17,403
2018	269	929	1,019	146	33	9,915	5,397	297	5,538	1,083	6,231	1,097	0	726	39	328	11,280	6,327	7,283	1,269	6,592
2019	362	883	1,010	189	42	13,380	5,657	295	6,134	1,961	8,342	1,450	0	919	119	399	15,193	6,540	8,064	2,269	8,782
2020	218	540	546	118	33	8,340	5,771	295	5,247	1,225	5,102	751	0	525	40	196	9,310	6,311	6,318	1,383	5,332
AVERAGE	**311**	**859**	**951**	**163**	**49**	**11,764**	**5,212**	**301**	**5,671**	**1,463**	**7,619**	**1,360**	**0**	**836**	**77**	**446**	**13,434**	**6,071**	**7,458**	**1,703**	**8,114**
in/yr	*15.6*	*43.2*	*47.8*	*8.2*	*2.5*	*17.0*	*7.5*	*0.4*	*8.2*	*2.1*	*11.0*	*16.3*	*0.0*	*10.0*	*0.9*	*5.4*	*16.8*	*7.6*	*9.3*	*2.1*	*10.2*

Abbreviations:
Ag. = Agricultural
ET = Evapotranspiration
IDC = Integrated Water Flow Demand Calculator
in/yr = inches per year
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Notes:
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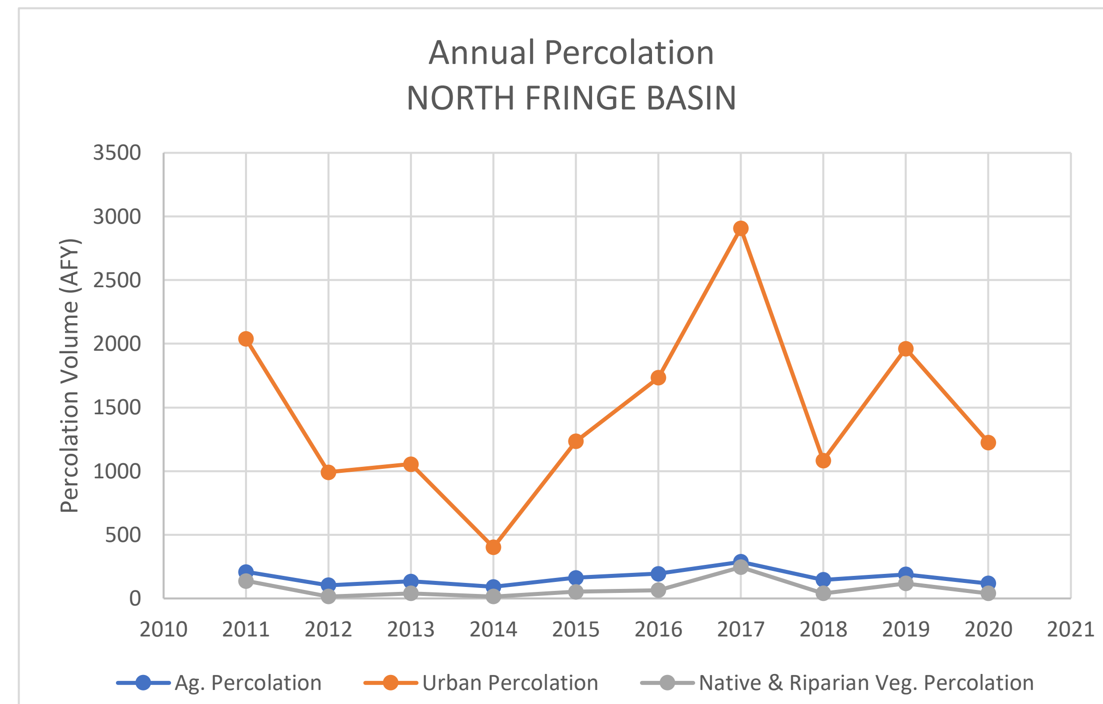

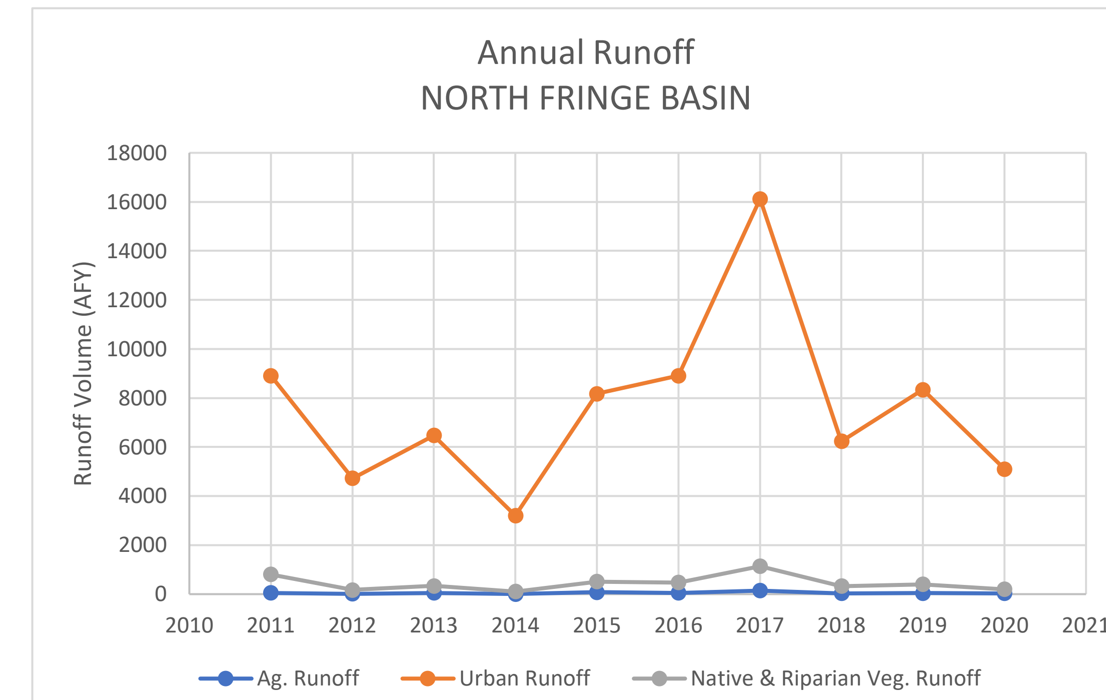

TABLE 5
IDC RESULTS BY WATER YEAR
NORTHEAST FRINGE MANAGEMENT AREA

	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
Water Year	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	149	215	268	82	19	5,700	5,500	588	4,551	1,221	3,447	8,805	699	7,771	775	2,166	14,654	5,715	12,590	2,078	5,633
2012	193	732	733	159	9	3,042	5,042	518	4,167	408	1,734	4,562	757	4,200	217	854	7,798	5,774	9,100	784	2,596
2013	235	794	787	205	33	3,680	5,123	449	3,833	596	2,363	5,559	767	4,112	367	1,720	9,474	5,917	8,732	1,169	4,115
2014	97	670	689	75	3	2,180	5,024	382	3,760	247	1,203	3,305	796	3,451	189	479	5,582	5,693	7,900	511	1,685
2015	193	646	671	123	43	4,341	4,918	313	3,622	654	2,959	6,579	774	4,359	482	2,588	11,113	5,563	8,652	1,260	5,589
2016	131	273	317	74	15	5,629	4,723	315	4,215	918	3,419	7,879	774	6,002	572	2,051	13,640	4,996	10,533	1,564	5,484
2017	214	252	308	112	46	9,228	4,565	318	4,208	1,538	6,167	12,787	749	7,096	1,556	4,875	22,228	4,817	11,612	3,207	11,088
2018	93	276	307	52	10	4,014	4,630	320	3,775	524	2,424	5,562	748	4,627	326	1,362	9,670	4,907	8,708	903	3,796
2019	125	261	307	67	12	5,432	4,489	325	3,851	959	3,265	7,466	740	5,777	730	1,619	13,024	4,751	9,935	1,756	4,897
2020	93	201	212	45	11	3,411	4,284	327	3,444	576	2,003	4,477	765	4,061	317	930	7,981	4,485	7,717	938	2,944
AVERAGE	**152**	**432**	**460**	**100**	**20**	**4,666**	**4,830**	**385**	**3,943**	**764**	**2,898**	**6,698**	**757**	**5,146**	**553**	**1,864**	**11,516**	**5,262**	**9,548**	**1,417**	**4,783**
in/yr	*11.2*	*31.7*	*33.7*	*7.3*	*1.5*	*12.2*	*12.6*	*1.0*	*10.3*	*2.0*	*7.6*	*12.9*	*1.5*	*9.9*	*1.1*	*3.6*	*12.5*	*5.7*	*10.4*	*1.5*	*5.2*

Abbreviations:
- Ag. = Agricultural
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- IDC = Integrated Water Flow Demand Calculator
- in/yr = inches per year
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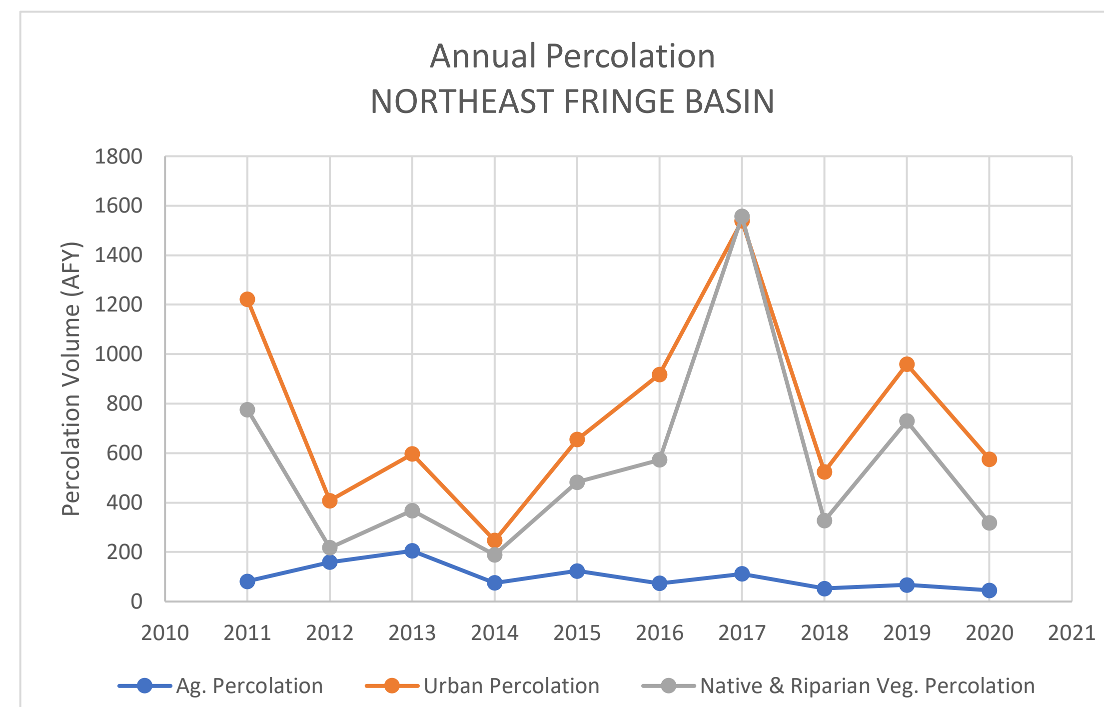
Notes:
1) All values listed in units of acre-feet per year (AFY) unless specified otherwise.



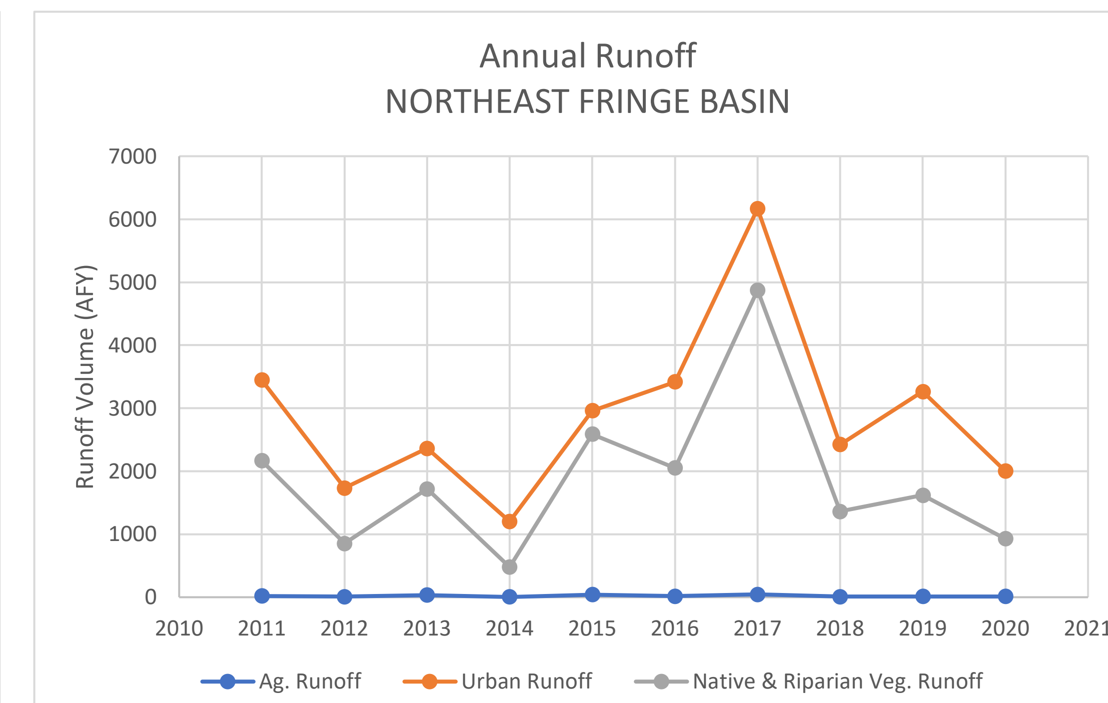
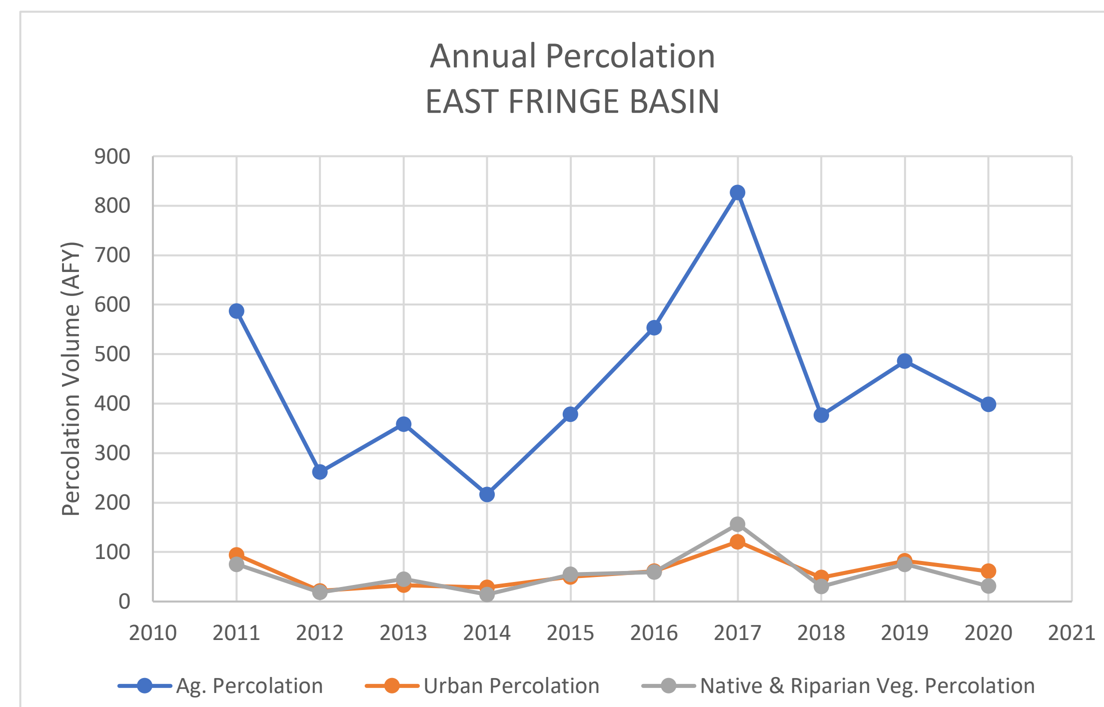


TABLE 6
IDC RESULTS BY WATER YEAR
EAST FRINGE MANAGEMENT AREA

	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
Water Year	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	894	640	863	587	139	295	331	17	305	95	102	504	0	401	75	91	1,693	971	1,569	757	333
2012	476	746	914	261	46	111	208	16	186	22	30	314	0	238	19	38	901	954	1,338	302	115
2013	578	774	875	359	117	135	193	16	167	33	53	382	0	234	45	95	1,094	967	1,276	437	264
2014	341	818	921	217	21	99	221	15	192	28	23	206	0	174	14	19	645	1,039	1,288	259	63
2015	678	774	892	379	181	196	205	15	181	50	90	409	0	225	55	134	1,284	979	1,298	484	405
2016	811	770	896	554	132	241	224	18	238	62	80	523	0	369	59	99	1,576	994	1,502	675	311
2017	1,322	733	888	826	341	426	248	22	273	121	191	820	0	417	156	246	2,568	981	1,577	1,104	778
2018	575	767	880	377	85	185	269	26	240	48	65	357	0	263	30	64	1,117	1,036	1,383	456	214
2019	775	710	899	486	100	249	290	29	266	82	83	480	0	323	76	76	1,504	1,001	1,489	644	260
2020	471	954	981	399	53	161	323	33	258	61	54	290	0	221	31	42	922	1,277	1,460	491	148
AVERAGE	**692**	**769**	**901**	**444**	**122**	**210**	**251**	**21**	**231**	**60**	**77**	**428**	**0**	**286**	**56**	**90**	**1,330**	**1,020**	**1,418**	**561**	**289**
in/yr	*11.9*	*13.2*	*15.5*	*7.7*	*2.1*	*12.0*	*14.4*	*1.2*	*13.2*	*3.4*	*4.4*	*11.8*	*0.0*	*7.9*	*1.5*	*2.5*	*11.9*	*9.1*	*12.7*	*5.0*	*2.6*

Abbreviations:
Ag. = Agricultural
ET = Evapotranspiration
IDC = Integrated Water Flow Demand Calculator
in/yr = inches per year
Veg. = Vegetation

Notes:
1) All values listed in units of acre-feet per year (AFY) unless specified otherwise.



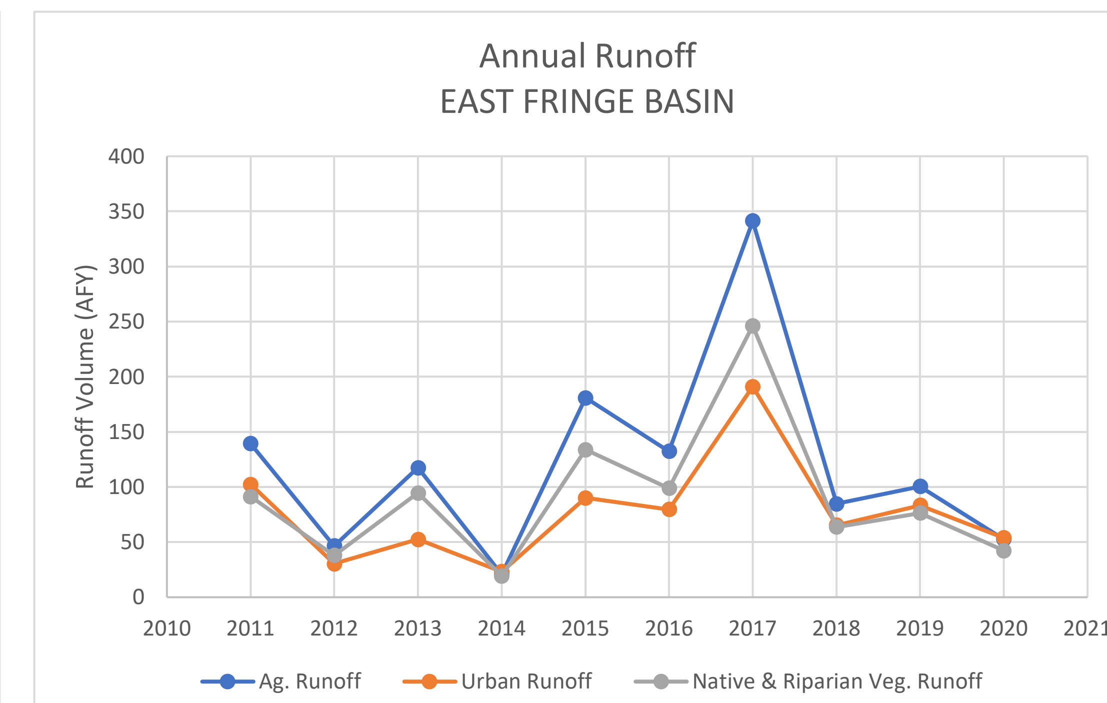
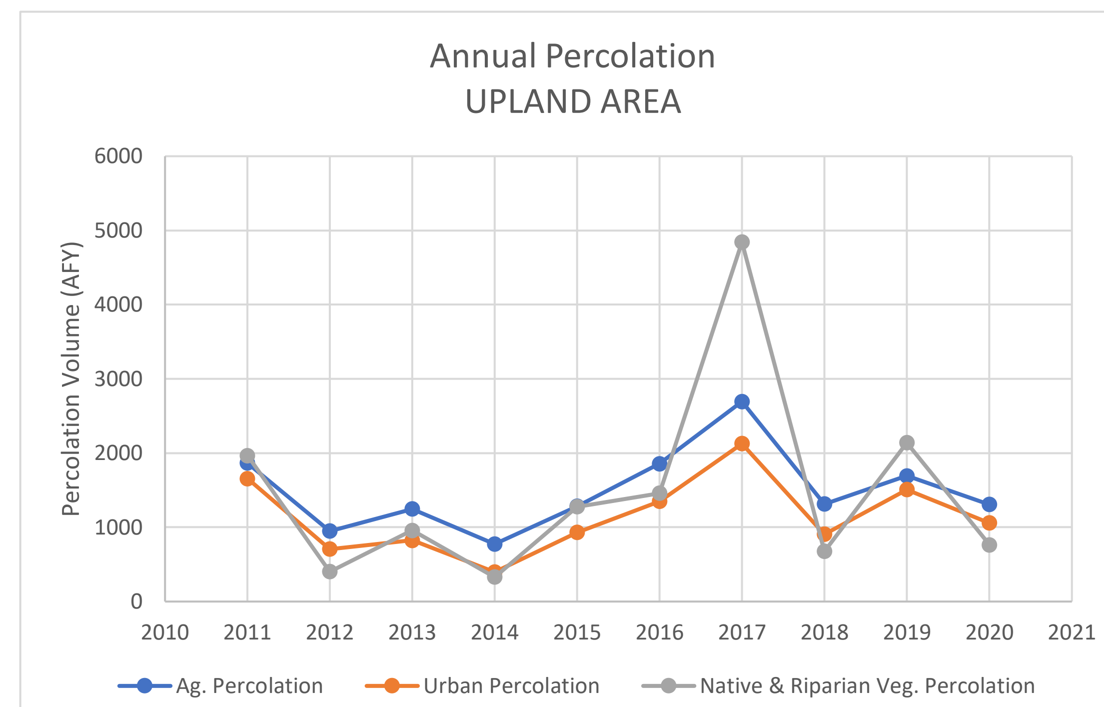


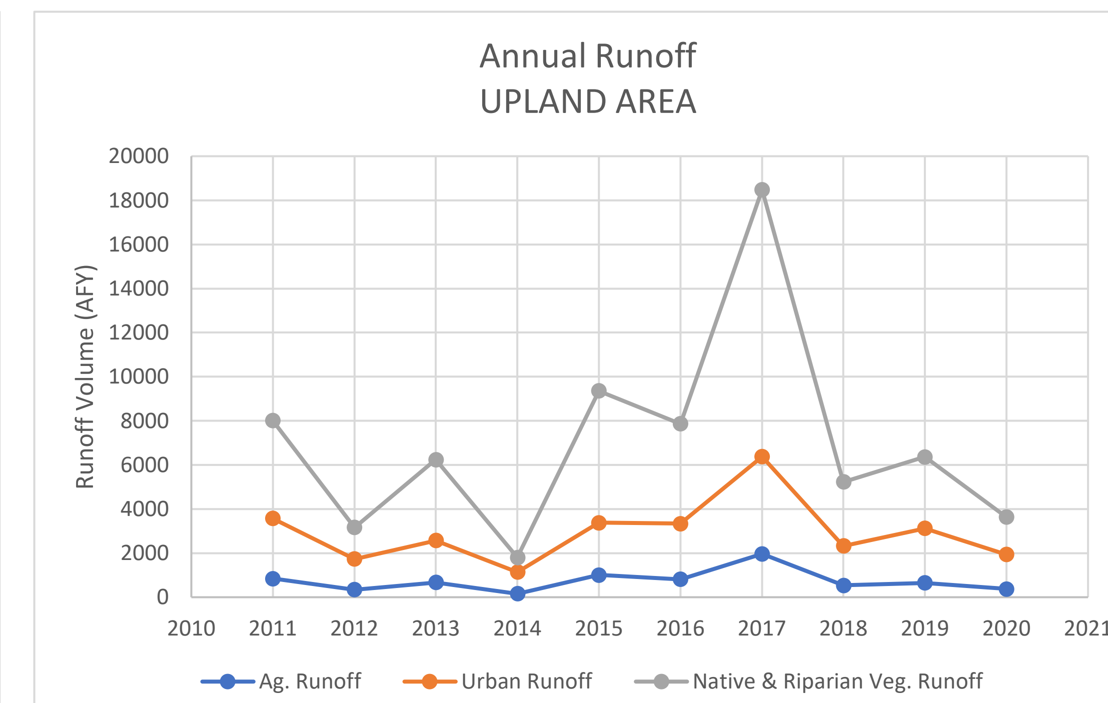
TABLE 7
IDC RESULTS BY WATER YEAR
UPLAND MANAGEMENT AREA

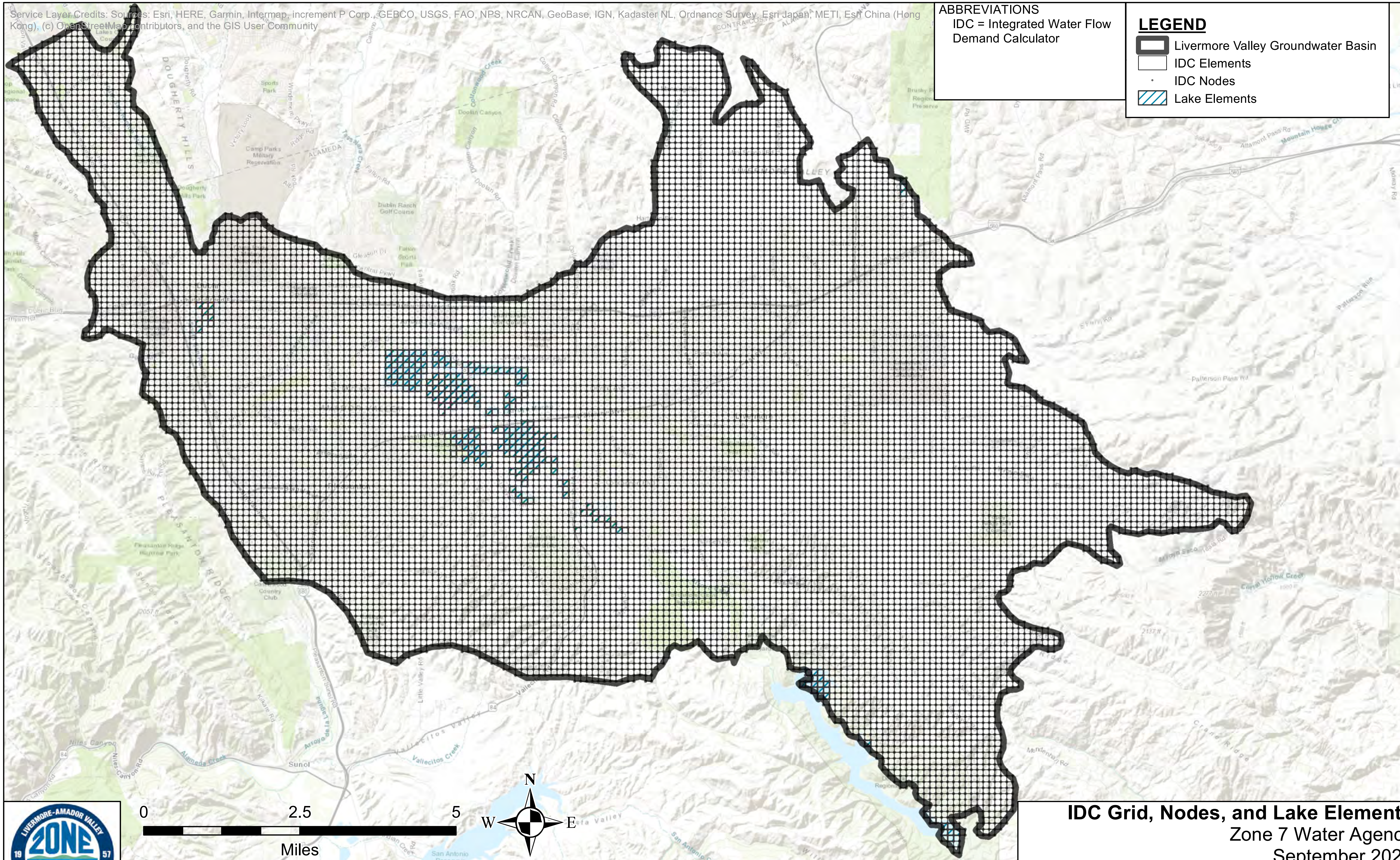
	NON-PONDED AGRICULTURAL AREAS					URBAN AREAS						NATIVE & RIPARIAN AREAS					TOTAL				
Water Year	Ag. Precipitation	Ag. Applied Water	Ag. Actual ET	Ag. Percolation	Ag. Runoff	Urban Precipitation	Urban Applied Water	Generic Soil Moisture:	Urban Actual ET	Urban Percolation	Urban Runoff	Native&Riparian Veg. Precipitation	Native & Riparian Veg. Groundwater Inflow	Native & Riparian Veg. Actual ET	Native & Riparian Veg. Percolation	Native & Riparian Veg. Runoff	Total Precipitation	Total Applied Water	Total Actual ET	Total Percolation	Total Runoff
2011	3,548	3,194	4,195	1,865	846	6,813	5,533	386	5,183	1,658	3,577	30,465	159	23,667	1,966	8,013	40,826	8,727	33,046	5,489	12,436
2012	2,072	3,949	4,690	950	339	3,830	5,219	382	5,067	705	1,735	15,823	171	12,341	402	3,165	21,725	9,168	22,098	2,056	5,240
2013	2,491	4,056	4,609	1,246	676	4,640	4,926	376	4,468	825	2,574	19,263	173	11,889	959	6,243	26,394	8,982	20,965	3,029	9,492
2014	1,431	4,240	4,728	775	156	2,756	4,610	372	4,326	397	1,138	11,364	113	9,377	328	1,806	15,552	8,849	18,430	1,500	3,100
2015	2,849	4,036	4,600	1,282	1,010	5,498	4,359	367	4,119	931	3,378	22,612	160	12,376	1,275	9,355	30,960	8,395	21,095	3,488	13,742
2016	3,408	4,011	4,738	1,857	815	6,493	4,442	388	4,792	1,349	3,337	28,100	175	18,849	1,460	7,870	38,000	8,453	28,378	4,666	12,022
2017	5,572	3,733	4,648	2,695	1,965	10,513	4,604	410	4,991	2,126	6,374	45,842	169	22,656	4,843	18,483	61,927	8,336	32,295	9,663	26,822
2018	2,424	4,028	4,594	1,314	539	4,566	4,826	432	4,445	908	2,331	19,949	169	14,219	676	5,233	26,940	8,854	23,257	2,898	8,104
2019	3,265	3,727	4,648	1,694	651	6,150	5,143	454	4,821	1,508	3,128	26,869	167	18,317	2,139	6,363	36,283	8,870	27,787	5,341	10,142
2020	2,069	4,347	4,680	1,307	373	3,947	5,443	475	4,576	1,059	1,931	16,217	173	12,178	765	3,635	22,233	9,790	21,434	3,131	5,938
AVERAGE	**2,913**	**3,932**	**4,613**	**1,498**	**737**	**5,521**	**4,911**	**404**	**4,679**	**1,147**	**2,950**	**23,650**	**163**	**15,587**	**1,481**	**7,017**	**32,084**	**8,843**	**24,879**	**4,126**	**10,704**
in/yr	*13.1*	*17.7*	*20.7*	*6.7*	*3.3*	*14.6*	*13.0*	*1.1*	*12.3*	*3.0*	*7.8*	*14.0*	*0.1*	*9.2*	*0.9*	*4.1*	*13.9*	*3.8*	*10.8*	*1.8*	*4.6*

<u>Abbreviations:</u>
Ag. = Agricultural
ET = Evapotranspiration
IDC = Integrated Water Flow Demand Calculator
in/yr = inches per year
Veg. = Vegetation

<u>Notes:</u>
1) All values listed in units of acre-feet per year (AFY) unless specified otherwise.







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IDC Grid, Nodes, and Lake Elements

Zone 7 Water Agency

September 2021

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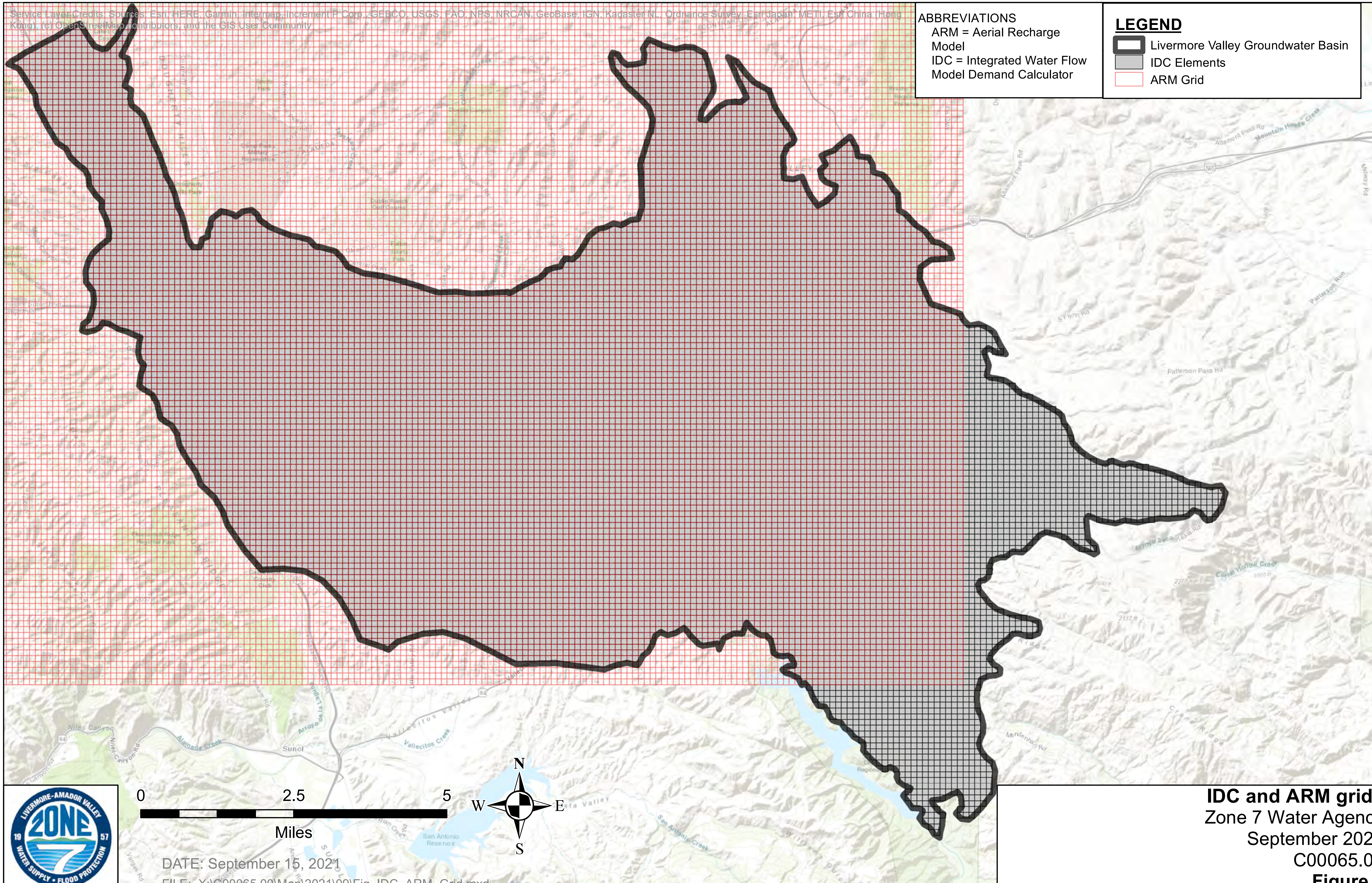
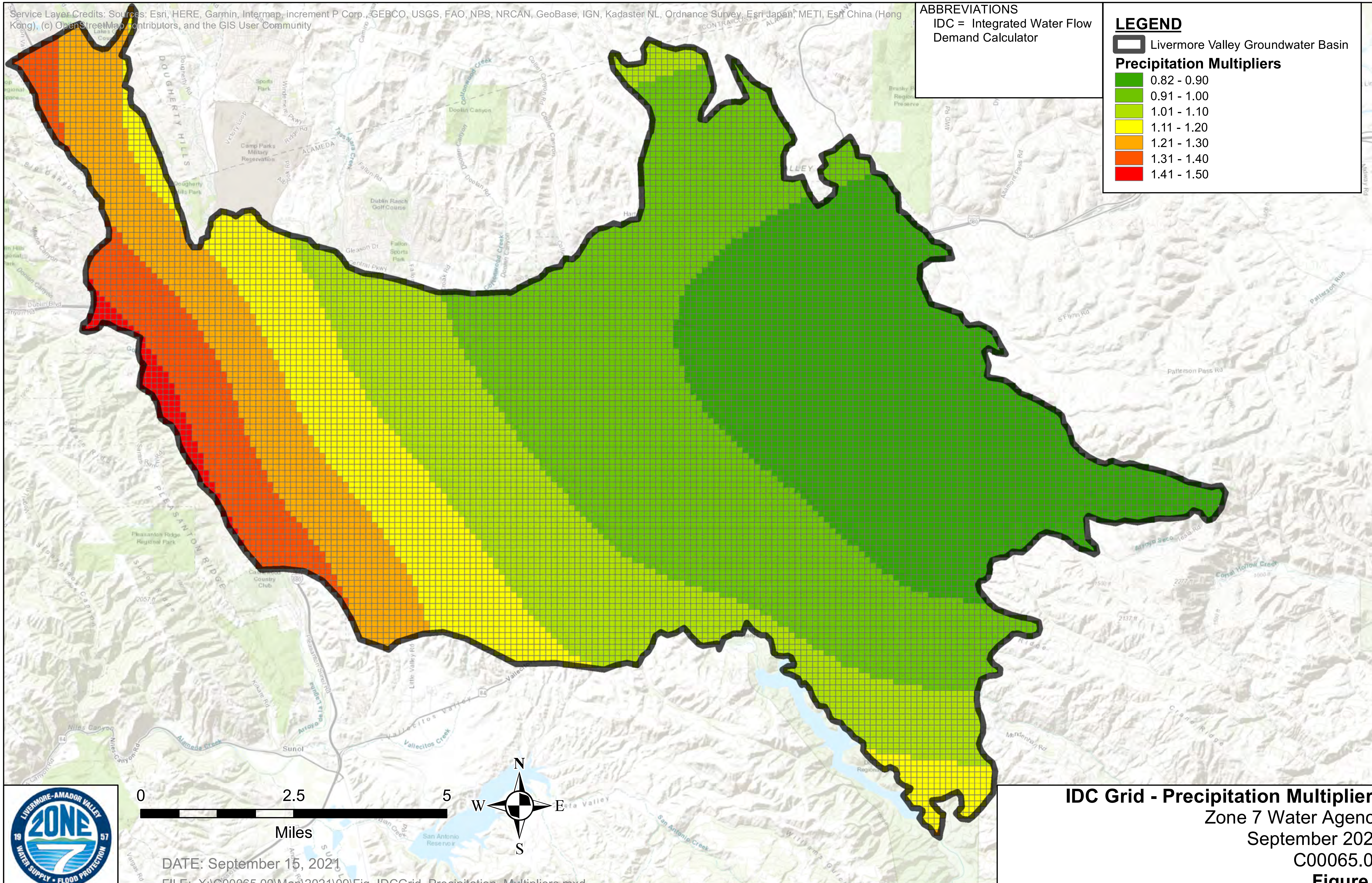
Figure 2



IDC and ARM grids
Zone 7 Water Agency
September 2021
C00065.00
Figure 3


Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
ABBREVIATIONS
IDC = Integrated Water Flow Demand Calculator
LEGEND
Livermore Valley Groundwater Basin
Precipitation Multipliers
0.82 - 0.90
0.91 - 1.00
1.01 - 1.10
1.11 - 1.20
1.21 - 1.30
1.31 - 1.40
1.41 - 1.50
0
2.5
5
Miles
N
W
E
S
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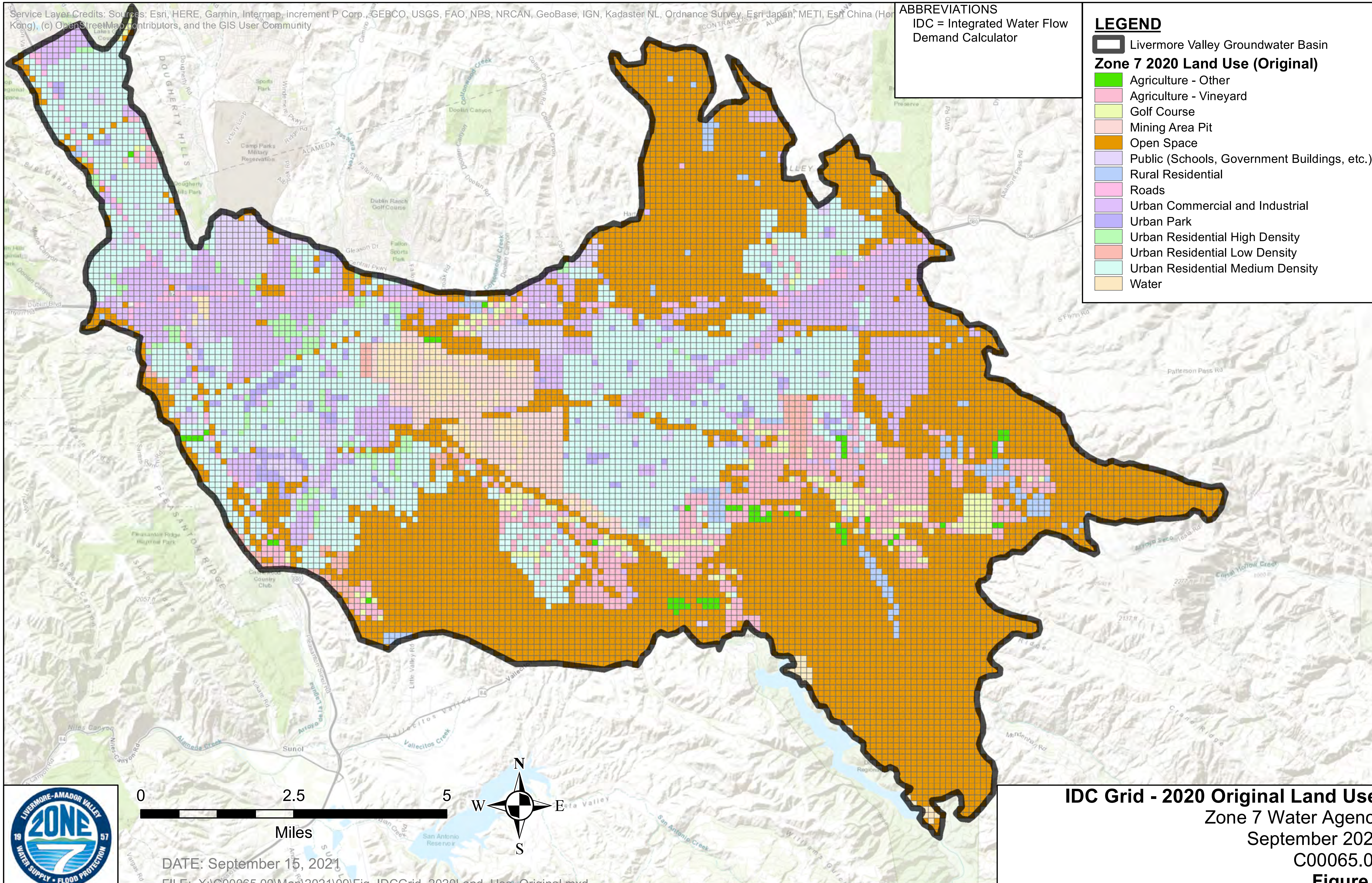
IDC Grid - Precipitation Multipliers
Zone 7 Water Agency
September 2021
C00065.00
Figure 4


Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
ABBREVIATIONS
IDC = Integrated Water Flow Demand Calculator
LEGEND
Livermore Valley Groundwater Basin
Zone 7 2020 Land Use (Original)
Agriculture - Other
Agriculture - Vineyard
Golf Course
Mining Area Pit
Open Space
Public (Schools, Government Buildings, etc.)
Rural Residential
Roads
Urban Commercial and Industrial
Urban Park
Urban Residential High Density
Urban Residential Low Density
Urban Residential Medium Density
Water
0
2.5
5
Miles
N
W
E
S
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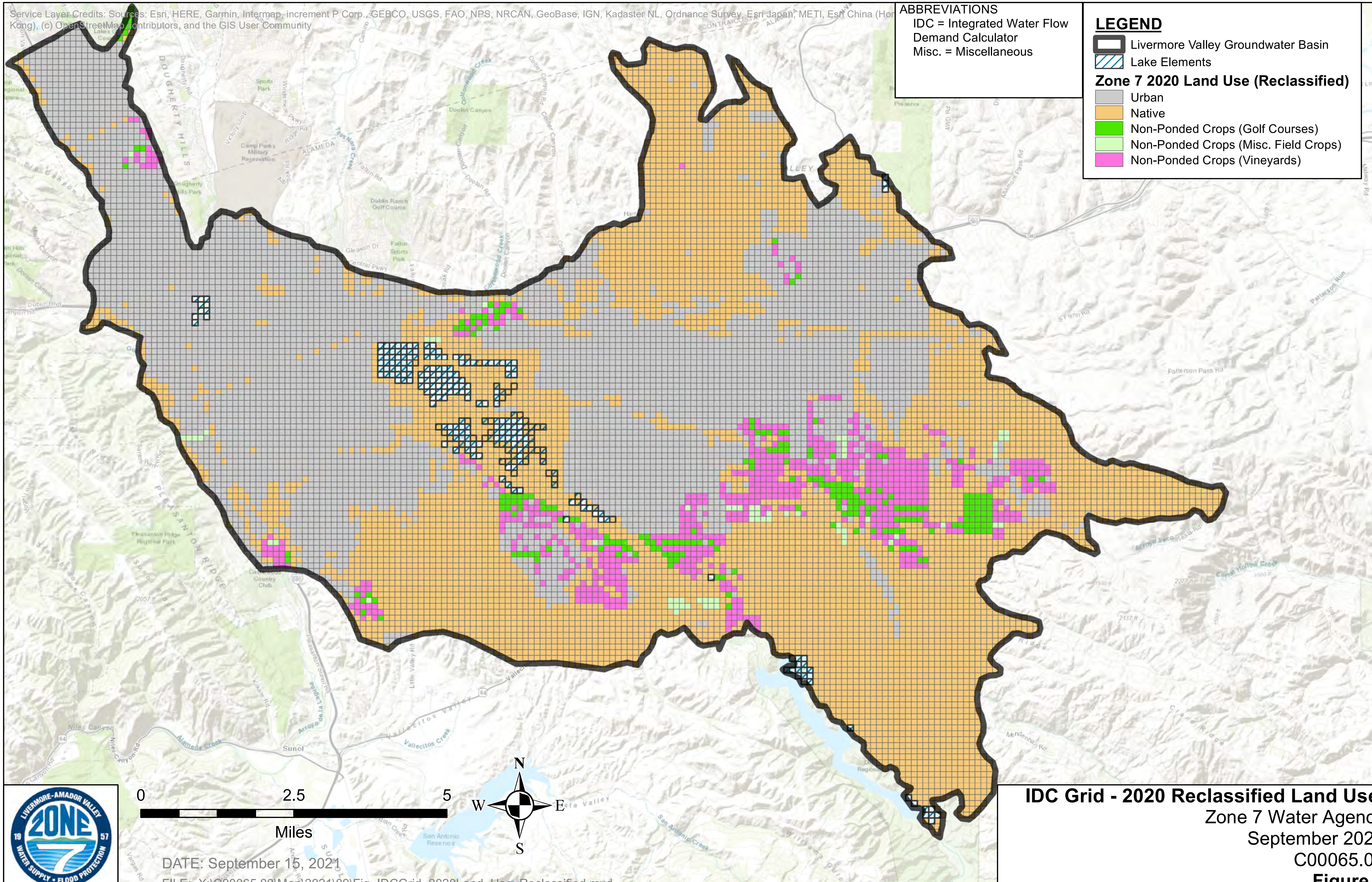
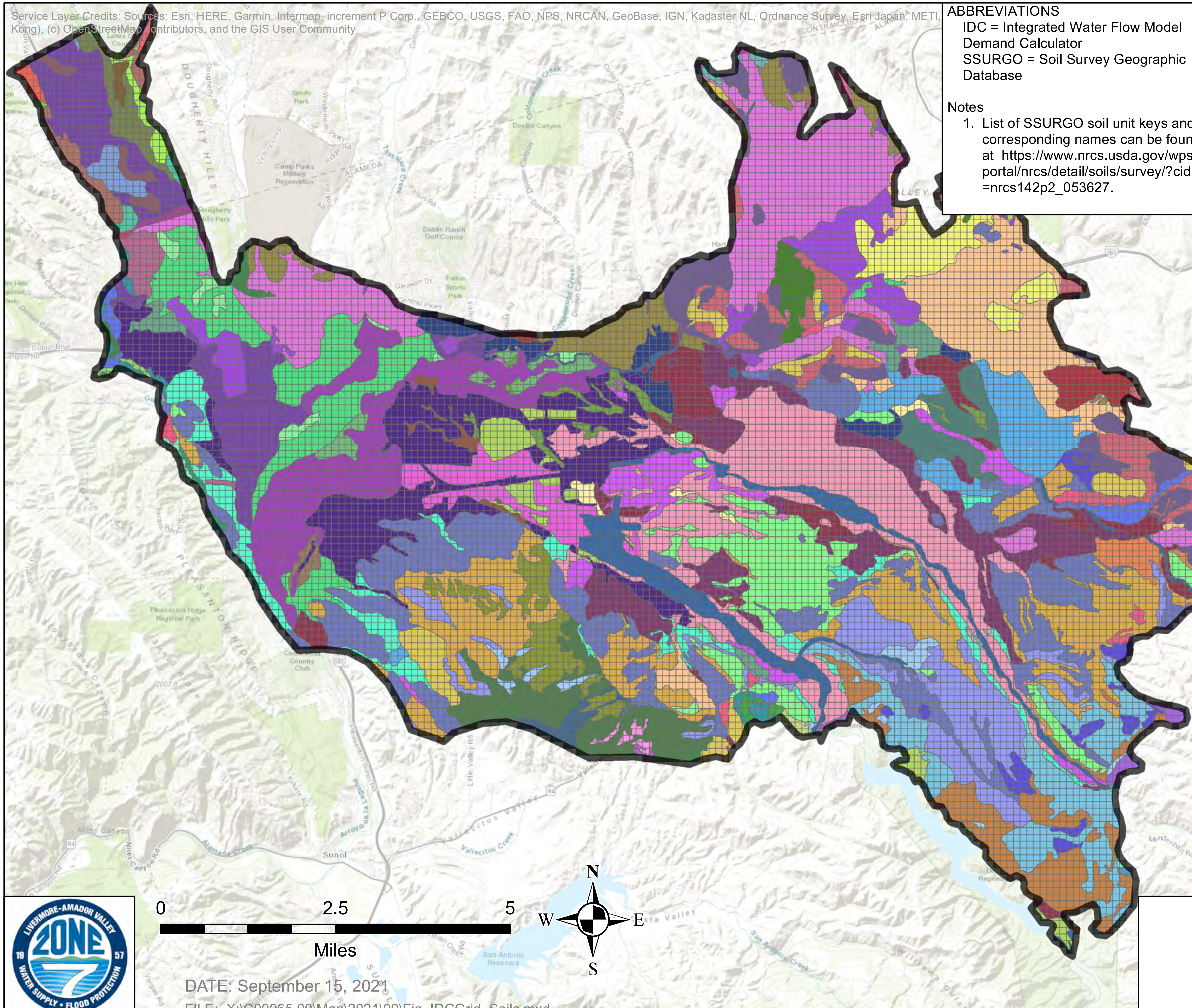
IDC Grid - 2020 Original Land Use
Zone 7 Water Agency
September 2021
C00065.00
Figure 5



IDC Grid - 2020 Reclassified Land Use
Zone 7 Water Agency
September 2021
C00065.00
Figure 7



ABBREVIATIONS

IDC = Integrated Water Flow Model Demand Calculator
SSURGO = Soil Survey Geographic Database

Notes

1. List of SSURGO soil unit keys and corresponding names can be found at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627.

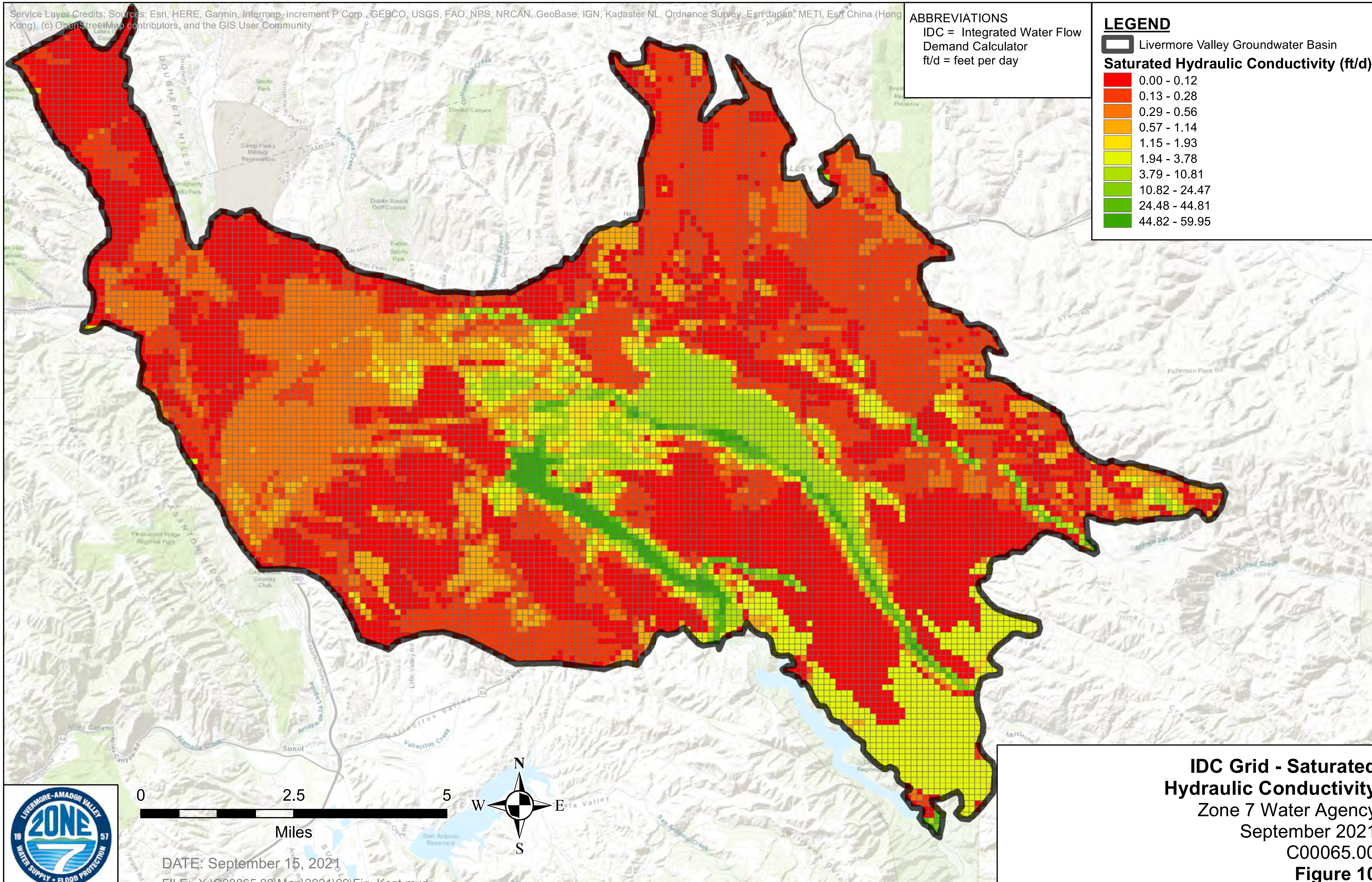
LEGEND

Livermore Valley Groundwater Basin

SSURGO Soil Types

<all other values>
AaC
AaD
AmE2
AmF2
AzD
AzE2
AzF2
BaA
Cc
CdA
CdAaa
CdB
CeA
ChA
CkB
DaA
DaB
DbC
DbD
DbE2
DdD
DdDcc
DdE
DdF
DmF2
DvC
DvD2
DvE2
DvF2
GaE2
GaF2
Gp
LaC
LaD
LaE2
LcF2
Lg
LhE
LhF
Lm
LpF2
LtE2
LuD
LuE2
MeF
MhE2
MhF2
Pb
PcD
PcF2
Pd
PgA
PgB
PoC2
PoE2
PoF2
PtB2
Rc
RdA
RdB
Rh
RoF
Sa
SdD2
SdE2
SdF3
Sf
Sl
Sm
Sn
So
Sy
TaC
TaCcc
VaE2
VaF2
W
YmA
Yo
Yr
Ys
Za
Zc

IDC Grid - SSURGO Soil Types
Zone 7 Water Agency
September 2021
C00065.00
Figure 9



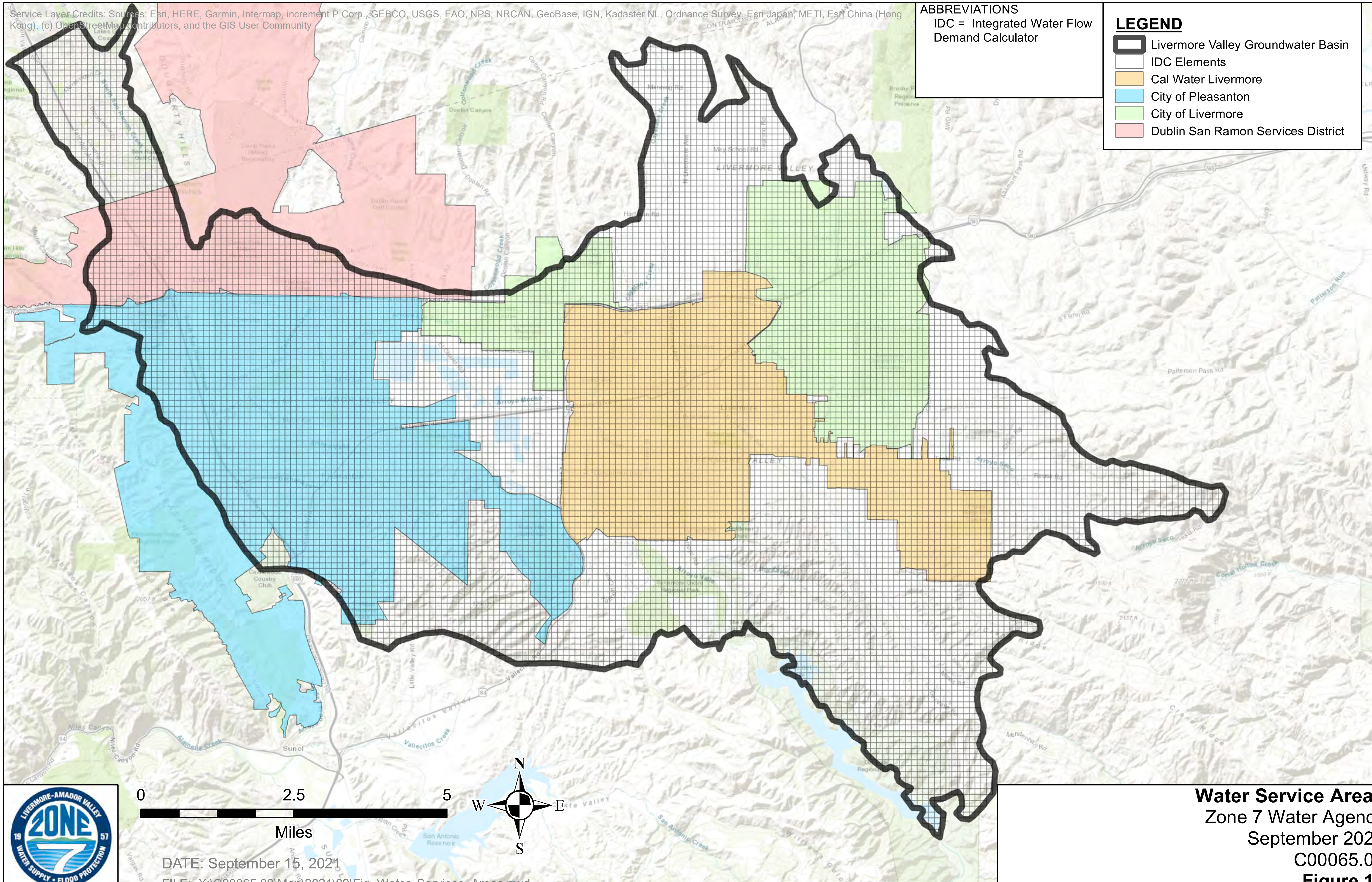
IDC Grid - Saturated Hydraulic Conductivity

Zone 7 Water Agency

September 2021

C00065.00

Figure 10



Water Service Areas
Zone 7 Water Agency
September 2021
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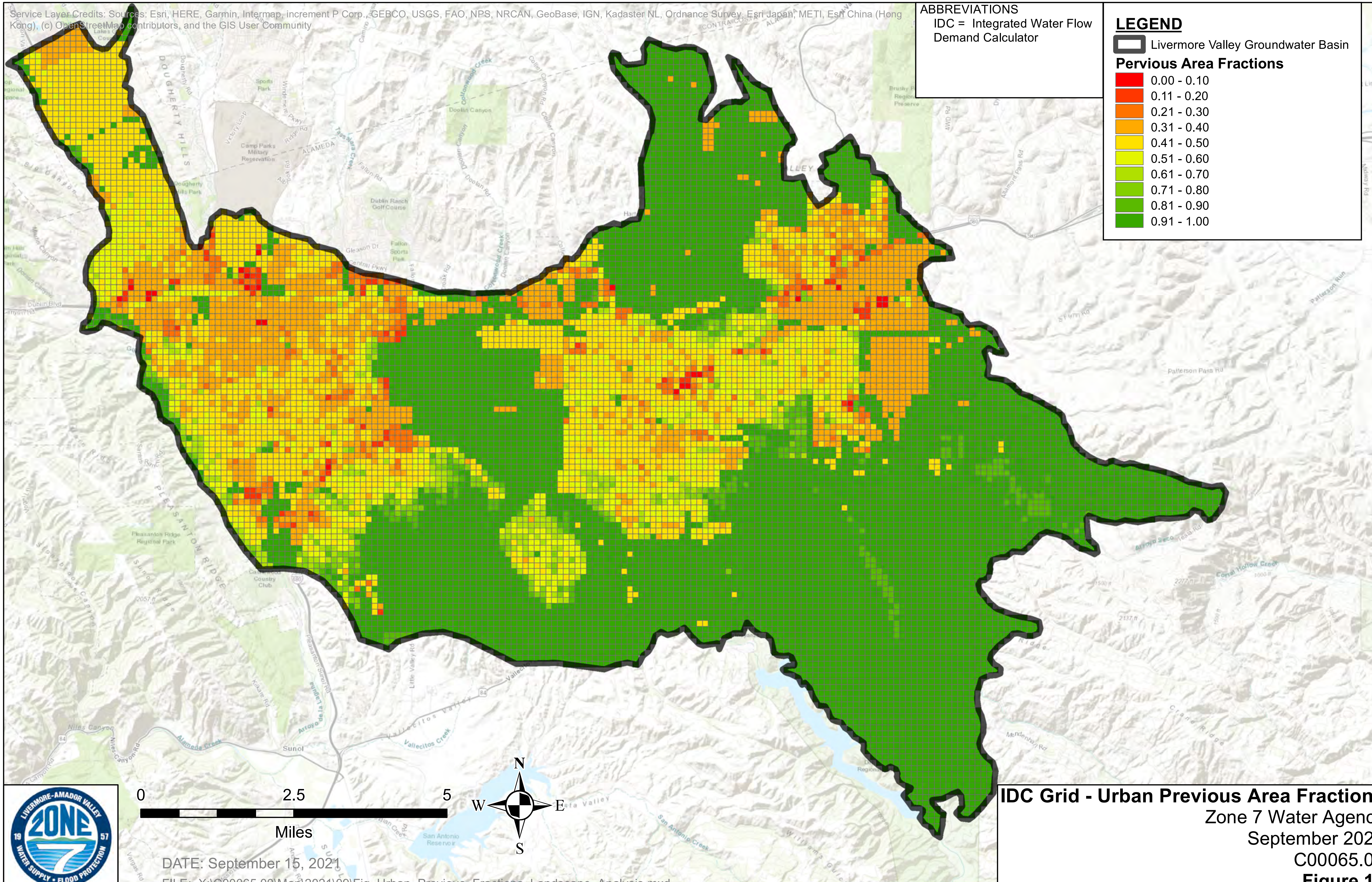
Figure 11



IDC Grid - Urban Previous Area Fractions

Zone 7 Water Agency

September 2021

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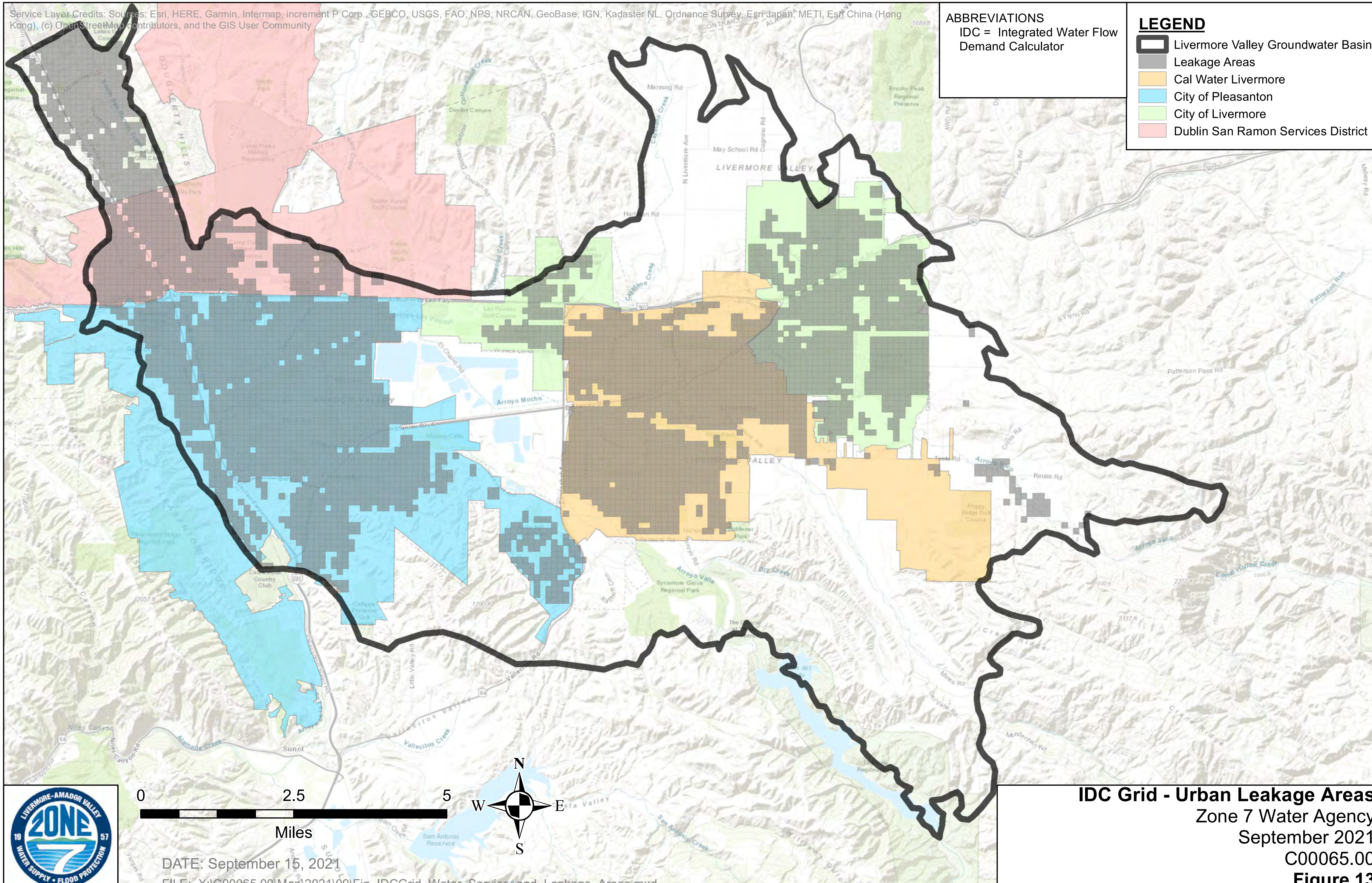
Figure 12



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ABBREVIATIONS
IDC = Integrated Water Flow Demand Calculator
LEGEND
Livermore Valley Groundwater Basin
Leakage Areas
Cal Water Livermore
City of Pleasanton
City of Livermore
Dublin San Ramon Services District
0
2.5
5
Miles
N
S
W
E
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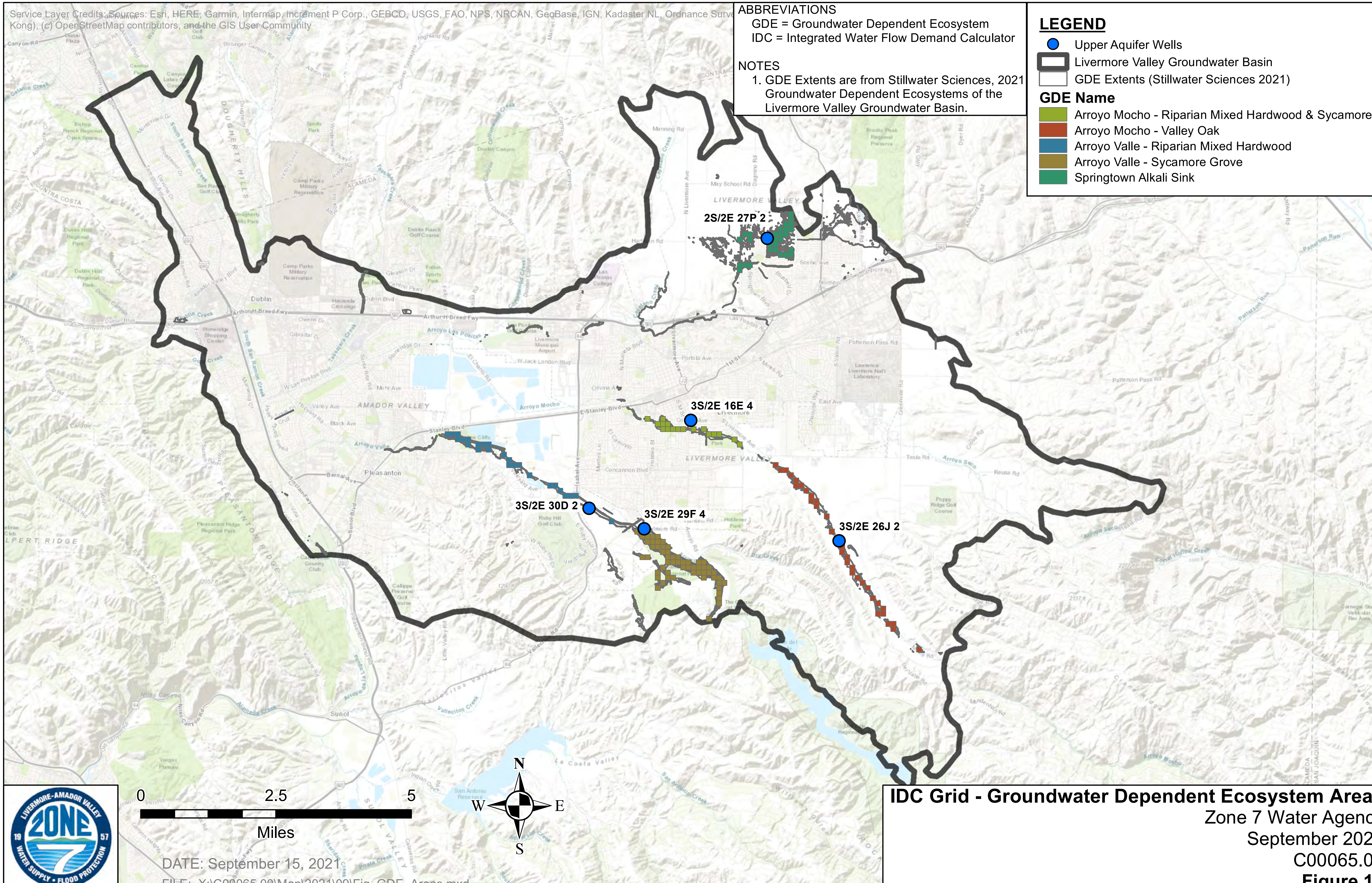
IDC Grid - Urban Leakage Areas
Zone 7 Water Agency
September 2021
C00065.00
Figure 13



IDC Grid - Groundwater Dependent Ecosystem Areas
Zone 7 Water Agency
September 2021
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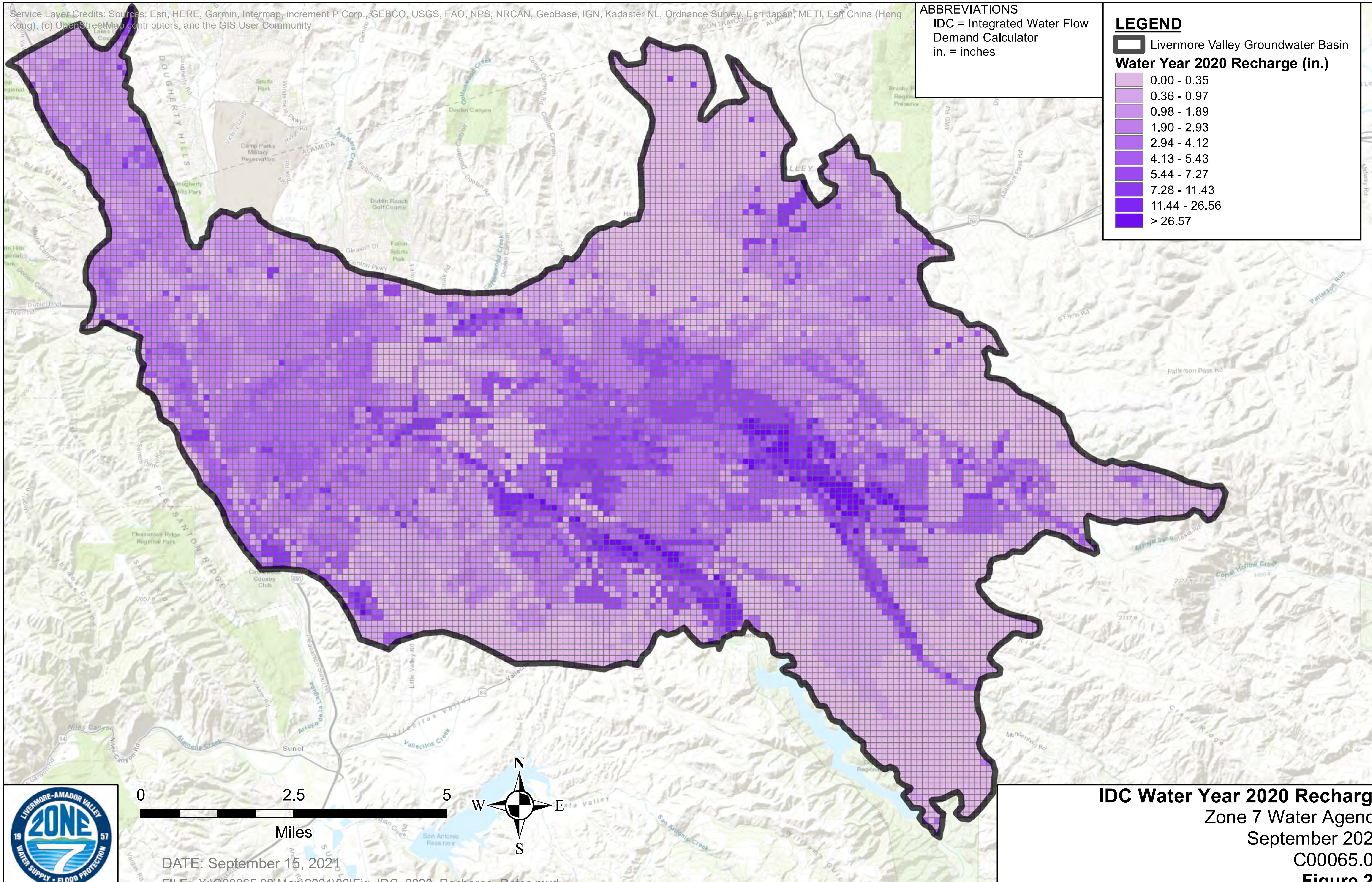
Figure 14



IDC Water Year 2020 Recharge

Zone 7 Water Agency

September 2021

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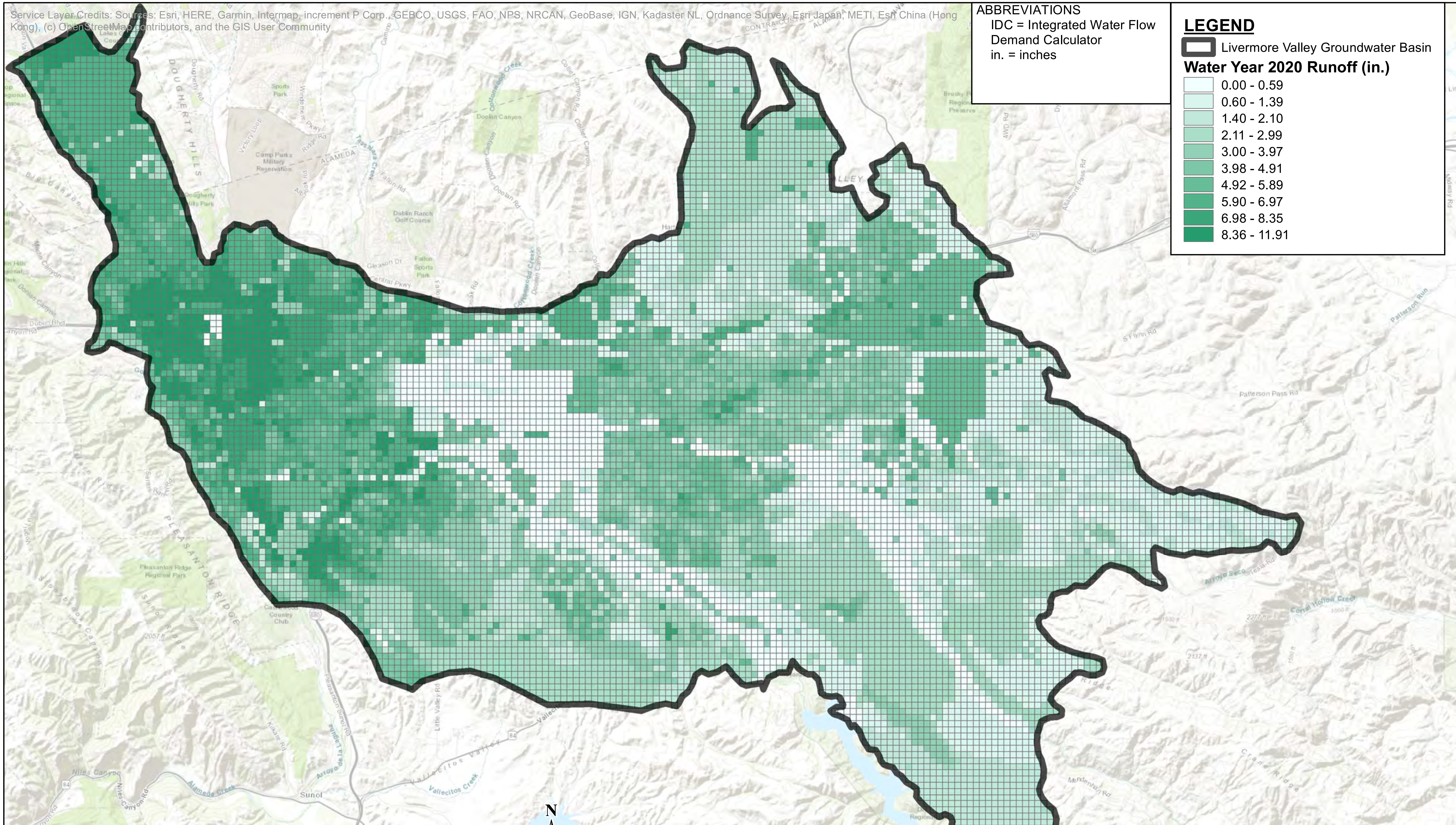
Figure 21



0 2.5 5
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IDC Water Year 2020 Runoff
Zone 7 Water Agency
September 2021
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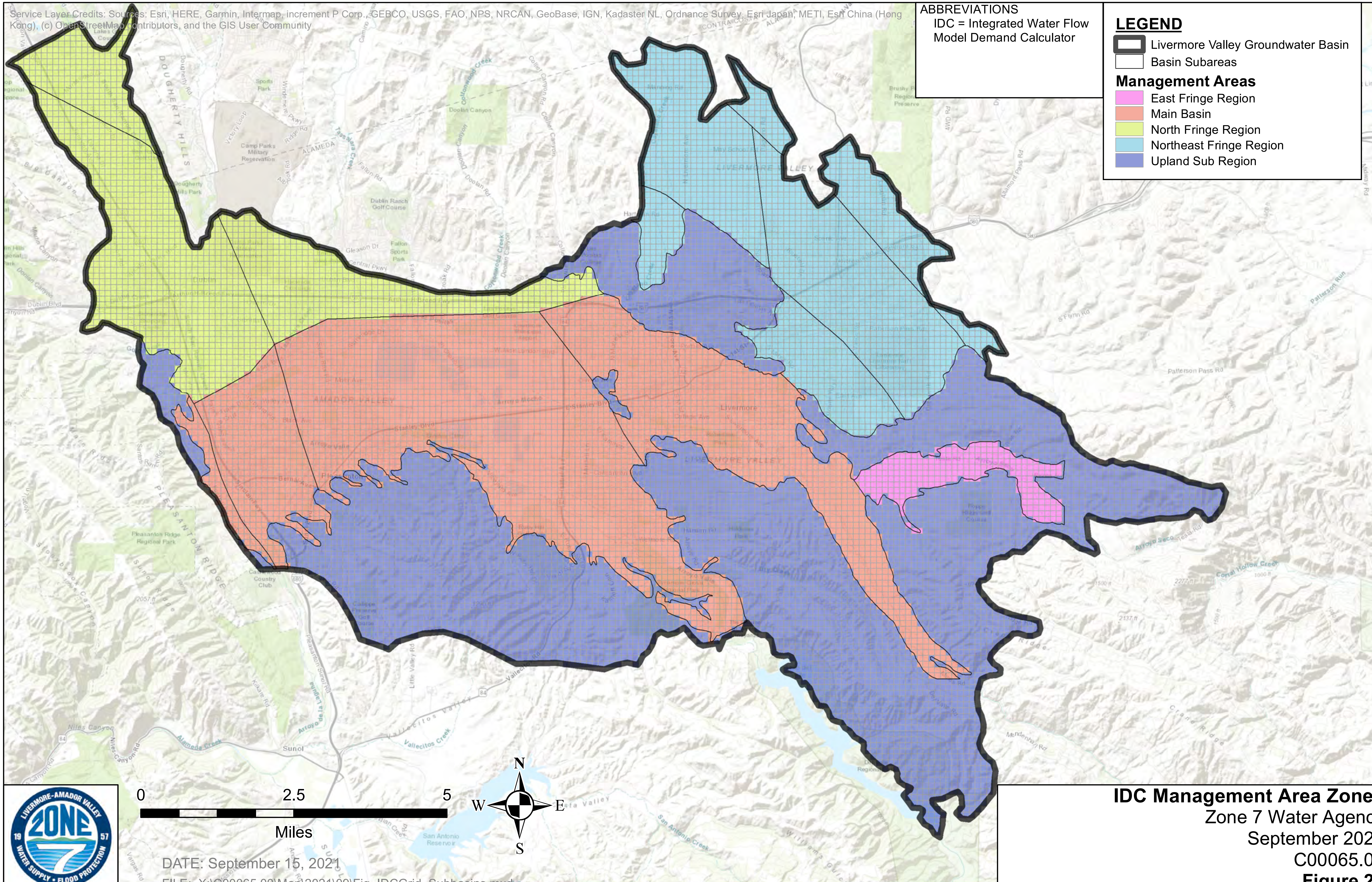
Figure 22



IDC Management Area Zones
Zone 7 Water Agency
September 2021
C00065.00
Figure 23

Attachment A

IDC Theoretical Documentation and User's Manual

DWR Technical Memorandum

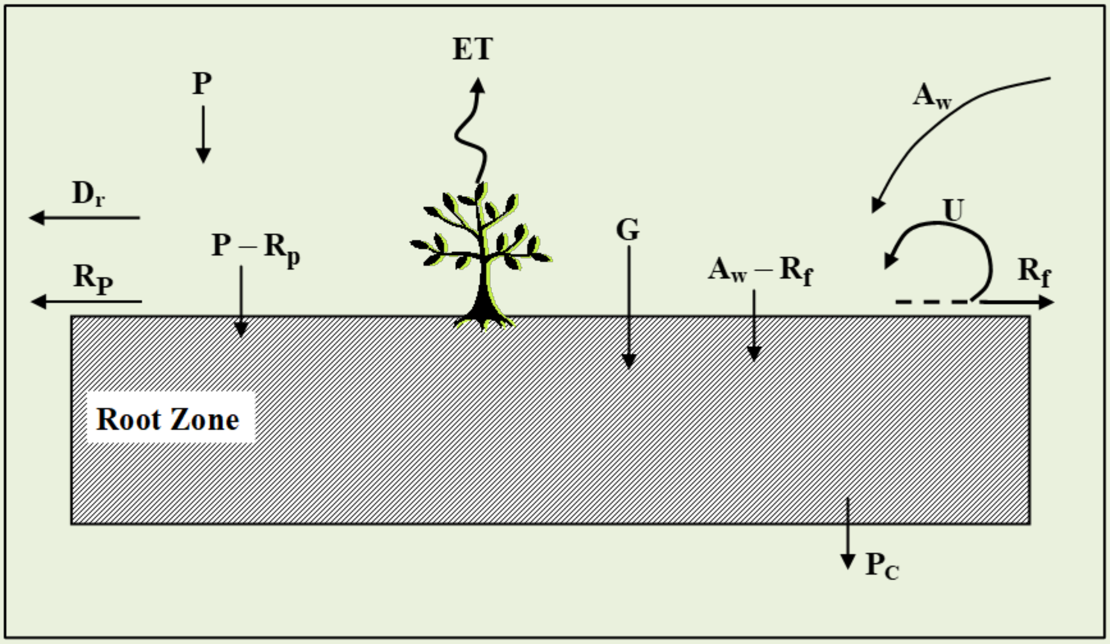
IWFM Demand Calculator

IDC-2015

Revision 102

Theoretical Documentation and User's Manual

Emin C. Dogrul and Tariq N. Kadir



Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814

May 2021

DWR Technical Memorandum

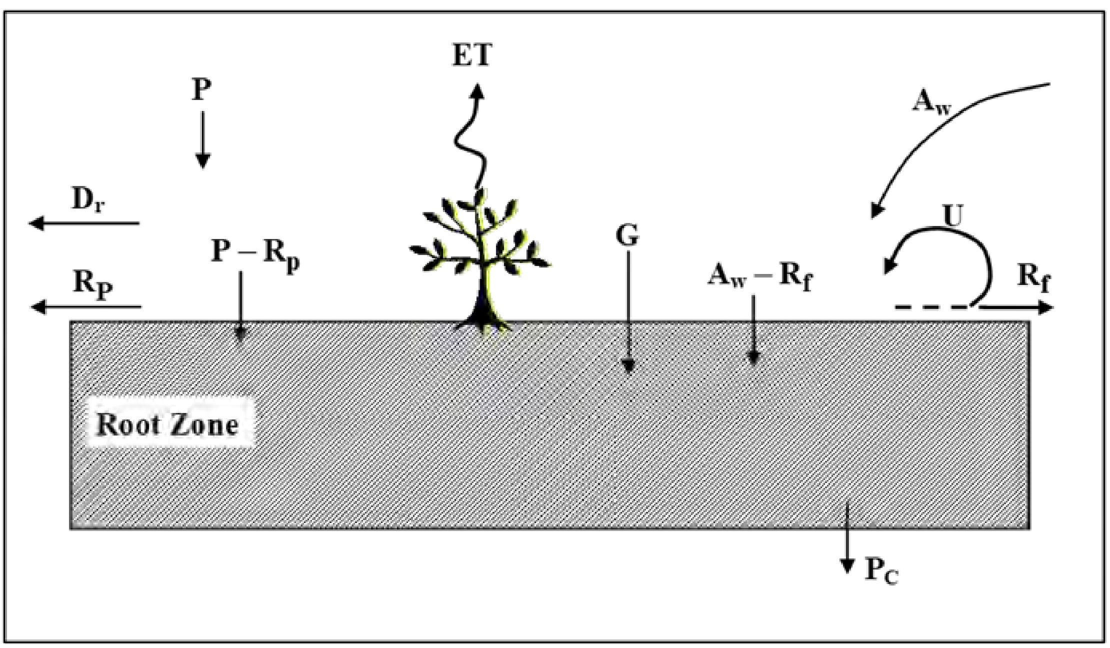
IWFM Demand Calculator

IDC-2015

Revision 102

Theoretical Documentation and User's Manual

Emin C. Dogrul and Tariq N. Kadir



Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814

May 2021

DWR Technical Memorandum: Theoretical Documentation and User's Manual for IWFM Demand Calculator (IDC-2015), Revision 102
Authors: Emin C. Dogrul and Tariq N. Kadir
Modeling software and documentation originated and maintained by the Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814
https://www.water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model-Demand-Calculator
This report describes methods and files used in IDC-2015 Revision 102, released in May 2021.

Table of Contents

List of Figures

List of Tables

Summary of Features of the Root Zone Component Versions

IWFM Demand Calculator 2015 (IDC-2015) provides access to several different versions of the root zone flow computation schemes. For a given application, the user is supposed to choose one of these versions.

To aid the user in choosing the right component version, below is a summary of the simulation capabilities these root zone component versions offer.

Version	Capabilities
4.0	• Simulation of non-ponded and ponded (rice and managed refuges) crops, urban lands, native and riparian vegetation at each element • Simulation of generic moisture (seepage from extra source of water, fog, etc.) • Ability to deliver water to an element, group of elements or a subregion to meet water demand • Ability to compute physical crop water demand dynamically based on crop, irrigation management, soil and atmospheric conditions or to pre-specify water demand to represent contractual demand
4.01	• All features listed for version 4.0 above • Optional Z-Budget output for root zone as well as land and water use budgets for zone budget generation
4.1	• All features listed for version 4.0 above • Simulation of riparian vegetation access to stream water to meet all or part of their evapotranspirative water demand • Simulation of root water uptake from groundwater that meets part or all of the plant evapotranspirative demand
4.11	• All features listed for version 4.1 above • Optional Z-Budget output for root zone as well as land and water use budgets for zone budget generation
5.0	• Simulation for agricultural water demand, root zone and land surface flow processes for an average, representative crop • Agricultural and urban water demand simulated at subregion level • Ability to compute physical crop water demand dynamically based on crop, irrigation management, soil and atmospheric conditions or to pre-specify water demand to represent contractual demand

1. Introduction

In developed watersheds, the stresses on surface and subsurface water resources are generally created by groundwater pumping and surface water deliveries to satisfy agricultural and urban water requirements. The application of pumping and surface water deliveries to meet these requirements also affects the surface and subsurface water system through recharge of the aquifer and surface runoff back into the streams. The agricultural crop water requirement is a function of climate, soil and land surface physical properties as well as land use management practices which are spatially distributed and evolve in time. In almost all integrated hydrologic models pumping and surface water deliveries are specified as predefined stresses and are not included in the simulation as an integral and dynamic component of the hydrologic cycle that depend on other hydrologic components as well as water resources operational practices. On the other hand, in irrigation scheduling models that route the moisture through the root zone and compute the irrigation water requirement based on the moisture content, the root zone is completely detached from the rest of the hydrologic cycle. These models generally assume that the water demand is always met and they cannot simulate the effect of extreme hydrologic and operational conditions that may limit the pumping and surface water deliveries. Therefore, both integrated hydrologic models and irrigation scheduling models can be coupled to benefit from each other's features. This document discusses a new model developed by the California Department of Water Resources (CADWR) that estimates the irrigation water requirements and route the soil moisture through root zone in the context of integrated hydrologic modeling.

Integrated hydrologic modeling has received much attention in the last few decades. Models such as PRMS (Leavesley et al. 1983), MIKE SHE (DHI 1999), SWATMOD (Sophocleous et al. 1999), WEHY (Kavvas et al. 2004), GSFLOW (Markstrom et al. 2008), IWFM (Dogrul 2021a), HydroGeoSphere (Therrien et al. 2009) and Modflow with Farm Process (Schmid et al. 2009) are developed to route the water through the components of the hydrologic cycle and to simulate the interactions between them. Integrated hydrologic models include the simulation of the land use based runoff processes and the plant consumptive use, and their effects on surface and subsurface flow dynamics. However, except for IWFM, Modflow with Farm Process and SWATMOD, they do not simulate agricultural and urban water demands and the conjunctive use of surface and subsurface water resources to meet these demands. Essentially, they are descriptive models; i.e. given all the stresses on the hydrologic system modeled, they describe where and how fast the water flows.

However, having to pre-specify the stresses such as pumping and surface water deliveries may pose difficulties in a modeling study. For instance, in the State of California pumping records are proprietary or not measured and often are unavailable. Therefore, for a historical or a calibration model run, the modeler is required to estimate the historical pumping rates to meet an externally computed demand. For instance, Williamson et al. (1989) used electric power records to estimate the historical groundwater pumping in the Central Valley of California. However, such approaches may introduce additional uncertainties to the simulation. On the other hand, in a projection model run where future hydrologic and water resources operational conditions are simulated, pre-specifying pumping and surface water deliveries is almost impossible. First, the agricultural and urban water requirements that pumping and surface water deliveries are used to meet are not known until after the future conditions are actually simulated. Second, amount of pumping and surface water deliveries may be limited by physical (aquifer storage, stream flow capacity, etc.) and contractual limitations which will affect agricultural and urban water requirements, in turn affecting the flow dynamics. This suggests that pumping and surface water deliveries in a projection model run are dynamic and depend on other components of hydrologic cycle simulated. They cannot be pre-specified and can only be simulated as an integral part of the evolving hydrologic cycle, and irrigation and urban water requirements that depend on the cycle.

Another type of modeling tool, irrigation-scheduling-type models, treats the root zone component of the hydrologic cycle as detached from other components. Given the climatic, soil and crop properties, these models simulate the evolution of the soil moisture in the root zone and the agricultural water requirement that depends on the soil moisture content (Kincaid and Heerman 1974, Camp et al. 1988, Smith 1991, George et al. 2000, Orang et al. 2004, Snyder et al. 2004, Raes et al. 2009). Generally, these models include a complex representation of the flow dynamics in the root zone and solve a soil moisture balance equation. Some of these models can also be used in evaluating the effect of different farm management scenarios such as regulated deficit irrigation on crops and in computing leaching requirements (Tayfur et al. 1995, Corwin et al. 2007, Heng et al. 2009).

Because of the treatment of the root zone as a component disconnected from the rest of the hydrologic cycle, irrigation-scheduling-type models cannot address situations where applied water is different than the crop irrigation water requirement in a dynamic sense. Similar to the integrated hydrologic models, they require applied water to be pre-defined. The pre-defined applied water can be assumed equal to the crop irrigation requirement, it can be pre-defined as being less than the irrigation requirement to simulate deficit irrigation conditions, or it can be defined to be greater than the irrigation requirement. However, it is not possible to simulate conditions where, throughout the simulation period, aquifer storage or stream flows are depleted such that the pre-defined applied water cannot be met. Another drawback of irrigation-scheduling-type models is that they cannot be calibrated or verified when they are used in regional scale applications. Since they are not connected to the stream network or the underlying aquifer system, it is generally not possible to verify the accuracy of the simulated percolation or the simulated surface runoff due to irrigation and precipitation.

In general, the two types of modeling approaches, integrated hydrologic and the irrigation-scheduling-type models, can benefit from each other's capabilities if they are coupled. Integrated hydrologic models need a root zone component that is developed in an irrigation-scheduling-type approach that responds to the hydrologic and farm operational conditions, and compute corresponding water demands. On the other hand, irrigation-scheduling-type models need to be connected to the rest of the hydrologic cycle through coupling with an integrated hydrologic model to receive feedback from the aquifer system and the stream network in terms of simulated pumping and surface water deliveries that are actually available.

CADWR has been developing and maintaining the Integrated Water Flow Model (IWFM), a surface-subsurface hydrologic model that couples the integrated hydrologic modeling approach with a root zone component that uses the irrigation-scheduling-type approach (CADWR 2018). Over the years, both IWFM as a whole and its root zone component have evolved to incorporate accurate simulation techniques and to address the issues CADWR have been facing. The root zone simulation engine of IWFM is designed such that it can either be used as a stand-alone irrigation-scheduling-type model or can easily be linked to integrated hydrologic models other than IWFM.

The stand-alone root zone modeling tool is named as IWFM Demand Calculator (IDC). As a stand-alone modeling tool, IDC assumes that the applied water is equal to the computed irrigation water requirements. When IDC's underlying root zone simulation engine is linked to IWFM or any other integrated hydrologic model, applied water is defined as the sum of simulated pumping and surface water deliveries computed by the integrated hydrologic model. In this case, depending on the state of the aquifer and the stream flows, the applied water can be equal or less than the water demand computed by the root zone simulation engine. The percolation, surface runoff due to precipitation and irrigation return flow computed by the root zone simulation engine are passed to the integrated hydrologic model as stresses to the aquifer and the stream network.

This document describes the methods used in IDC (the stand-alone version of the root zone simulation engine) to solve the soil moisture balance in the root zone and to compute agricultural and urban water demands. However, this document should also serve as a guide for the simulation engine when linked to integrated hydrologic models since the methods as well as the input and output data files remain exactly the same.

2. Computational Framework

A computational grid is required when using IDC to compute irrigation water requirements and route moisture through the root zone. This computational grid can be a regular grid (such as a finite difference grid) or an irregular grid (e.g. a finite element grid). However, IDC expects the computational grid to be defined in a manner similar to a finite element grid; i.e. cells and the node numbers that surround each cell should be listed along with the coordinates of the nodes (it should be noted that finite difference grids can easily be defined in this manner). Grid cells are grouped into subregions that are defined by the user. These subregions may represent different types of boundaries and scales (e.g. hydrologic regions, water districts, counties, regions where irrigation and water management data are collected, etc.) depending on the requirements of the IDC application. Although IDC requires a computational grid to be defined, it does not use the finite element or the finite difference approach to solve the conservation equation for the soil moisture in the root zone. The reasons for and benefits of using a computational grid are explained later in this section.

Each grid cell area is distributed between native and riparian vegetation, urban, rice, refuge (specifically wetland refuges for waterfowl) and user-specified number of non-ponded agricultural crop lands. Rice lands are further distributed between lands where rice residue is decomposed by flooding (flooded decomp), where it is decomposed without any flooding (non-flooded decomp) and where it is not decomposed at all. Refuges are divided into two groups of seasonal and permanent refuges. Rice and refuge lands are collectively referred to as ponded crop lands. Even though refuges are not agricultural crops, the refuge ponds are managed in a way that is similar to rice ponds, allowing the simulation methods for rice fields to be used for refuges as well. For this reason, refuges are included in the ponded-crop category in IDC. Non-ponded crops are agricultural crops that are not grown in standing water like rice. The number of non-ponded crops simulated in an IDC application is specified by the user. Therefore, in an IDC application where there are N number of non-ponded crops, the total number of land use types that are simulated at each grid cell will be equal to N+8 (N for non-ponded crops, 5 for ponded crops, 1 for urban, 1 for native vegetation and 1 for riparian vegetation). Even though N+8 land use types are simulated, a grid cell can have the area of one or more land use types set to zero. This tells IDC that those land use types do not exist in that grid cell and the simulation of these land use types is skipped. IDC allows time series land use areas defined for each grid cell, so a particular land use type that does not exist in a grid cell in earlier times of the simulation period can exist in the same cell in the later times, or an existing land use type can disappear from a cell (this feature allows, for instance, to simulate the effects of agricultural lands and native vegetation areas being converted into urban lands).

IDC computes applied water demands for ponded and non-ponded crops at each grid cell under user-specified climatic and irrigation management settings. Urban water demand is computed based on user-specified population and per-capita water usage. Native and riparian vegetations are not irrigated; therefore applied water demands for these land use types are not computed.

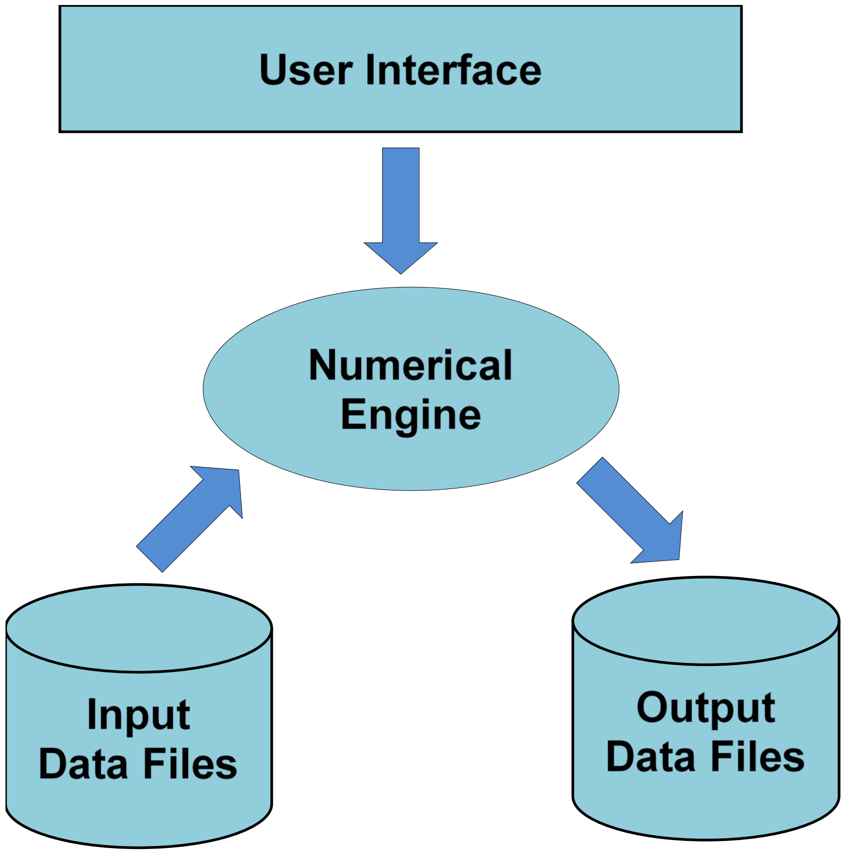
For all land-use types precipitation as well as applied water, if any, is routed through the root zone. Any surface runoff due to precipitation and irrigation generated at each cell is routed to a subregion, to another grid cell or to outside the model area, depending on the choice of the user. Any surface runoff that is routed to a subregion or grid cell becomes part of the applied water in that subregion or cell.

IDC is written in Fortran 2003 using an object-oriented programming approach. It consists of i) input data files, ii) output data files, iii) the numerical engine that reads data from input files, computes applied water demands, routes water through the root zone and prints out the results to output files, and iv) a user interface that utilizes an ASCII text file that allows the user to define input and output files and simulation control data for the numerical engine (Figure 1).

Although IDC does not use finite difference or finite element methods to solve the conservation equation in the root zone, being able to operate on a grid as well as its object-oriented design brings several advantages:

i. The computational grid allows better representation of spatially-distributed data such as potential evapotranspiration, precipitation, soil characteristics, etc.
ii. Being able to operate on computational grids allows IDC to easily couple with other numerical engines that operate on computational grids such as groundwater models.

Figure 1. *Software components of IDC*



iii. The object-oriented design allows easy re-compilation of the numerical engine into a dynamic link library (DLL) which allows easy coupling to other hydrologic, biological and environmental numerical engines such as those that comply with Open Modeling Interface (OpenMI) standards (Gregersen et al. 2007, Goodall et al. 2007).

iv. Easy coupling to numerical engines that simulate other components of the hydrologic cycle allows calibration of model parameters (e.g. soil hydraulic conductivity, soil and irrigation management parameters that play a role in the generation of surface runoff, etc.) through the use of widely available observation data (e.g. groundwater elevations and stream flows).

The methods used by IDC to compute water demand and route moisture through root zone at a regional level, and the design of the computational framework make IDC a unique tool.

Table 1. *Version numbers and simulation capabilities for the root zone component*

Version	Capabilities
4.0	• Simulation of non-ponded and ponded (rice and managed refuges) crops, urban lands, native and riparian vegetation at each element • Simulation of generic moisture (seepage from extra source of water, fog, etc.) • Ability to deliver water to an element, group of elements or a subregion to meet water demand • Ability to compute physical crop water demand dynamically based on crop, irrigation management, soil and atmospheric conditions or to pre-specify water demand to represent contractual demand
4.01	• All features listed for version 4.0 above • Optional Z-Budget output for root zone as well as land and water use budgets for zone budget generation
4.1	• All features listed for version 4.0 above • Simulation of riparian vegetation access to stream water to meet all or part of their evapotranspirative water demand • Simulation of root water uptake from groundwater that meets part or all of the plant evapotranspirative demand
4.11	• All features listed for version 4.1 above • Optional Z-Budget output for root zone as well as land and water use budgets for zone budget generation
5.0	• Simulation for agricultural water demand, root zone and land surface flow processes for an average, representative crop • Agricultural and urban water demand simulated at subregion level • Ability to compute physical crop water demand dynamically based on crop, irrigation management, soil and atmospheric conditions or to pre-specify water demand to represent contractual demand

IDC provides several different versions of root zone component with slightly different simulation features. Table 1 lists the simulation capabilities included with each version of the root zone components. It is expected that as the need for different simulation capabilities arises in the future, IDC will be extended to provide more versions of root zone components with the desired features. It should be noted that some of the features listed in Table 1 are available only when IDC is linked to an integrated hydrologic model such as IWFM (CADWR 2018).

In the following sections, flow routing and water demand calculations as well as the input and output data files in each version of root zone component will be explained.

3. Root Zone Component Version 4.0

3.1. Soil Moisture Routing

Precipitation is generally the natural source for the soil moisture in the root zone. Precipitation that falls on the ground surface infiltrates into the soil at a rate dictated by the type of ground cover, physical characteristics of the soil and the moisture that is already available in the soil. The portion of the precipitation that is in excess of the infiltration rate generates a surface flow. In IDC, this surface flow is termed as *direct runoff*. Irrigation of agricultural lands and urban outdoors such as lawns and parks can also generate surface flows. Surface flows due to irrigation are termed as *return flows* in IDC. Part of the precipitation and irrigation evaporate before infiltrating into the soil. Infiltration due to precipitation and irrigation replenish the soil moisture in the root zone which is also depleted through plant root uptake for transpiration and additional evaporation from the top layers of the soil. The transpiration through the plants and evaporation from the land surface as well as the top layers of the soil are all simulated as a single *evapotranspiration* term in IDC. In general, moisture in the root zone can move in horizontal as well as the vertical directions. In IDC, it is assumed that the horizontal movement of the moisture is negligible compared to the vertical movement. Therefore only the flow of the moisture in the vertical direction is addressed. The moisture that leaves the root zone through its bottom boundary is termed as *percolation*.

IDC uses a physically-based approach to compute the flow terms mentioned above and to route the soil moisture through the root zone. For a particular land use type at a grid cell, the conservation equation for the soil moisture discretized in time is

$$\begin{aligned}\theta^{t+1}Z^{t+1} &= \theta^{t}Z^{t} \\ &+\Delta t\left(P^{t+1}-R_P^{t+1}+A_w^{t+1}-R_f^{t+1}+G^{t+1}Z^{t+1}-D_r^{t+1}-P_C^{t+1}-ET^{t+1}\right) \\ &+\Delta\theta_a^{t+1}\end{aligned} \tag{1}$$

and

$$\theta^{t+1} = \theta_P^{t+1} + \theta_{A_w}^{t+1} + \theta_G^{t+1} \quad (2)$$

$$\theta^{t} = \theta_P^{t} + \theta_{A_w}^{t} + \theta_G^{t} \quad (3)$$

$$R_f^{t+1} = R_{f,ini}^{t+1} - U^{t+1} \quad (4)$$

where

θ_P = soil moisture content due to precipitation (L/L),

θ_{A_w} = soil moisture content due to applied water (L/L),

θ_G = soil moisture content due to a generic, user-defined moisture inflow (L/L),

θ = total soil moisture content (L/L),

Z = rooting depth (L);

P = rate of precipitation (L/T),

R_P = direct runoff (L/T),

A_w = applied water, i.e. irrigation (L/T),

$R_{f,ini}$ = initial return flow (L/T),

U = re-used portion of the initial return flow (L/T),

R_f = net return flow after re-use takes place (L/T),

G = a generic, user-defined moisture inflow to represent any source of moisture other than precipitation or irrigation (L/L/T),

D_r = outflow due to the draining of rice and refuge ponds (L/T),

P_C = percolation (L/T),

ET = evapotranspiration (L/T),

$\Delta\theta_a$ = change in soil moisture due to change in land use area (L),

t = the time step index (dimensionless),

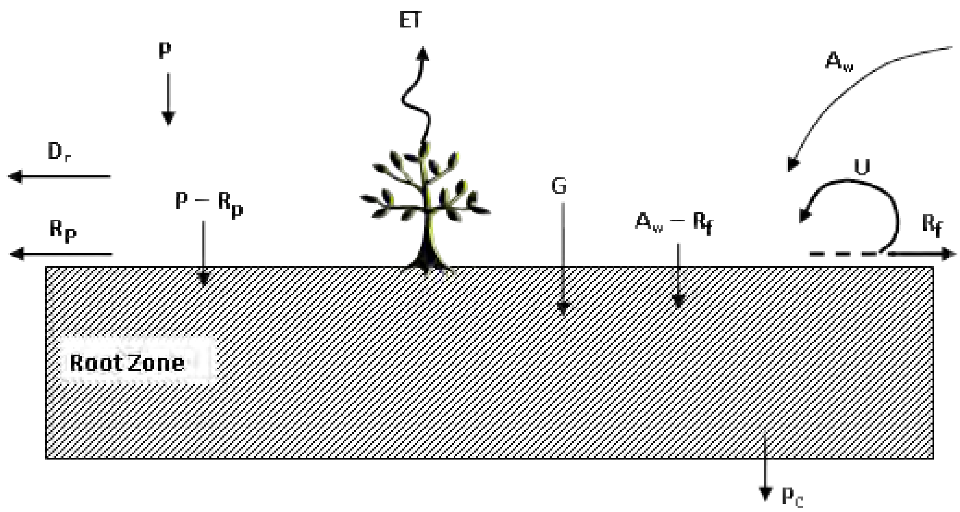
Δt = simulation time step length (T).

These flow terms are depicted in Figure 2. The soil moisture in equation (1) is represented as a summation of moisture due to precipitation and applied water in order to keep track of the contribution of applied water to crop evapotranspiration which is termed as ET of applied water (ETaw) by irrigation practitioners.

Equation (1) is solved for each land use type at each grid cell. In equation (1), θ^{t+1} and θ^t are generally less than the total porosity, θ_T, except for rice and refuge lands where ponding is possible. In these areas, it is assumed that the rooting depth is constant $(Z^{t+1} = Z^t)$, that θ can be computed to be greater than θ_T, and the difference between the θ and θ_T represents the depth of the pond. Therefore, for rice and refuge areas, θZ is not truly the stored soil moisture in the root zone; it represents the sum of the soil moisture and the depth of the ponded water.

In the following sections, the simulation of the flow processes illustrated in Figure 2 will be discussed. For simplicity, time indices t and t+1 are dropped, when appropriate, from the flow notations in the rest of this document.

Figure 2. *Schematic representation of root zone flow processes simulated by IDC*



3.1.1. Precipitation, P

Precipitation is a user-input time series data for each grid cell.

3.1.2. Direct Runoff, R_P

IDC uses a modified version of SCS curve number (SCS-CN) method (USDA 2004) described by Schroeder et al. (1994):

$$R_p = \frac{1}{\Delta t} \frac{(P\Delta t - 0.2S)}{P\Delta t + 0.8S} \qquad (5)$$

$$S = \begin{cases} S_{max}\left[1 - \dfrac{\theta^t - \dfrac{\theta_f}{2}}{\theta_T - \dfrac{\theta_f}{2}}\right] & \text{for } \theta^t > \dfrac{\theta_f}{2} \\ S_{max} & \text{for } \theta^t \leq \dfrac{\theta_f}{2} \end{cases} \tag{6}$$

$$S_{max} = \frac{1000}{CN} - 10 \tag{7}$$

where CN is the curve number specified for a combination of land use type, soil type and management practice (dimensionless), S_{max} is the soil retention parameter for dry antecedent moisture conditions (L), S is the soil retention parameter at a given moisture content (L), θ_f is the field capacity (L/L) and θ_T is the total porosity (L/L). Equations (5) - (7) state that when root zone moisture is below half of field capacity direct runoff is at a minimum as computed by the SCS-CN method. As the soil moisture increases above half of field capacity the retention capacity of the soil decreases and direct runoff increases.

Equations (5) - (7) are not used for areas such as rice and refuge ponds, and impervious urban areas (parking lots, roof tops, etc) where the infiltration of precipitation is not possible. For these areas entire precipitation becomes direct runoff. For rice lands and seasonal refuges, the ponds are temporary. Therefore, equations (5) - (7) are used during the period when ponds do not exist whereas the entire precipitation is converted into direct runoff during ponding season.

The total direct runoff that leaves a grid cell is the summation of direct runoff from all the agricultural and urban areas at the cell.

3.1.3. Applied Water, A_w

The main purpose of IDC is to compute dynamically the applied water for agricultural lands that will meet the crop evapotranspirative requirements in climatic and agricultural management settings defined by user-input parameters. The detailed discussion for the computation of applied water is given later in this document. Aside from being able to calculate it, IDC also allows the user to specify applied water. For instance, the amount of applied water may be dictated by contractual agreements rather than the crop evapotranspirative requirements. In a historical simulation, the amount of applied water may be available as historical records whereas in a projection run it will need to be computed. To be able to address such situations, IDC allows the user to specify some or all of the applied water amounts for each agricultural land use at each grid cell as time series input data. Applied water for any agricultural land use that is not assigned user specified values is computed by IDC.

In general, urban applied water to meet municipal and industrial water demand as well as demand for urban outdoors is calculated in terms of rate of water use per capita (e.g. CADWR 2005). For this reason, IDC does not attempt to compute the applied water for urban lands; instead, it is always a user-specified time series input data for urban lands at each grid cell. Urban areas are divided into pervious (lawns, parks and any unpaved outdoor areas) and impervious (roof tops, paved areas such as parking lots) areas. Applied water for urban areas is divided into two parts through user-specified time series fractions to meet the urban outdoors water demand at pervious urban lands, and municipal and industrial water demand at impervious urban lands.

Native and riparian vegetation rely on precipitation alone (the contribution of groundwater to ET of riparian vegetation is not simulated in IDC). Therefore, applied water for these areas is always taken to be zero.

Applied water is computed by IDC or specified by the user for each agricultural and urban land use at each grid cell. It consists of two components: i) surface runoff (combination of return flows due to irrigation, direct runoff due to precipitation, and drainage from rice and refuge ponds) that is generated at an upstream grid cell and used as irrigation water at the grid cell in consideration, and ii) water acquired from other sources such as streams and groundwater (stream flows and groundwater system are not simulated by IDC since IDC only considers the domain that consists of the root zone and the land surface that is separated from the rest of the hydrologic cycle). Another component that can be used to meet the crop evapotranspirative requirements as well as the urban indoors and outdoors water requirements is the re-use of captured return flow, U, in a grid cell (see Figure 2). This component is not included in the definition of the applied water to properly satisfy the statement of conservation of mass. To make a distinction between applied water with and without the re-use component, the applied water without the re-use component, U, is termed as *prime applied water* (i.e. A_w as discussed in this section), and the applied water that includes U is termed as the *total applied water*.

3.1.4. Initial Return Flow, $R_{f,ini}$

Initial return flow is specified by the user as a time series fraction of the prime applied water, A_w, for each non-ponded agricultural crop and urban land use area at each grid cell:

$$R_{f,ini} = A_w f_{R_{f,ini}} \tag{8}$$

where $f_{R_{f,ini}}$ is the initial return flow fraction (dimensionless). For urban lands, the initial return flow fraction only applies to the portion of the applied water that is allocated for the urban outdoors. The applied water that is allocated for urban indoors usage is assumed to become return flow completely.

For rice and refuge areas initial return flow is specified by the user as a time series unit flow rate. Generally, irrigation methods for rice require an additional amount of water to be applied to sustain flow-through type irrigation systems (Williams 2004) where water supplied to the top-most rice field sequentially floods each successive field as it makes its way to the lowermost basin. For refuges, additional water may be necessary to keep the water in the refuge ponds moving to control water quality and algae growth.

For areas with native and riparian vegetation, $R_{f,ini}$ is zero since applied water for these areas is zero.

3.1.5. Re-use of Return Flow, U

Re-use of return flow is specified by the user as a time series fraction of the prime applied water, A_w, for each non-ponded agricultural crop and urban land use area at each grid cell:

$$U = A_w f_U \tag{9}$$

where f_U is the re-used return flow fraction (dimensionless). Since re-used amount of return flow cannot be larger than the return flow itself, the re-use fraction must be less than or equal to the initial return flow fraction.

Similar to initial return flow, re-use is specified as time series unit flow rate for rice and refuge areas.

U simulates the re-use that occurs in a single grid cell. In an IDC application, a single grid cell can be large enough to cover multiple farms. In this case, U represents the total return flow from upstream farms that is captured and re-used by the downstream farms in the same grid cell. Another type of re-use occurs when the return flow from a grid cell crosses the cell boundary and flows into a downstream grid cell where it is captured and re-used. This type of re-use is not included in the term U. Instead, as discussed earlier, it becomes part of the prime applied water, A_w, for the downstream grid cell.

3.1.6. Net Return Flow, R_f

As shown in equation (4), the net return flow, R_f, is the difference between the initial return flow, $R_{f,ini}$ and the re-used return flow, U. Substituting equations (8) and (9) into equation (4), R_f can also be represented as

$$R_f = A_w \left(f_{R_{f,ini}} - f_U \right) \tag{10}$$

Equation (10) is valid for non-ponded agricultural lands as well as urban areas. Equation (10) is not used for ponded crops since re-use and initial return flows are specified explicitly.

The total net return flow that leaves a grid cell is the summation of all return flows from all the agricultural and urban land areas at that cell.

3.1.7. Generic Moisture Inflow, G

Generic moisture inflow, G, is included in equation (1) to represent any moisture inflow into the root zone due to a source other than precipitation or irrigation. It is a user-defined time-series data set specified for each computational grid cell. It is given as a unit rate of inflow per unit length of the rooting depth (L/L/T) of the land use type that is being considered. IDC multiplies G by the rooting depth and the length of the simulation time step to convert it into units of length.

It is expected that G will be set to zero in most IDC applications. However, it can be used in cases where the user has estimates of moisture inflow into the root zone from sources other than precipitation and irrigation. For instance, seepage through the levees into the islands of California's Sacramento-San Joaquin Delta can be represented through G. Another possibility to utilize G is to simulate the effects of fog on meeting the evapotranspirative crop demands.

3.1.8. Drainage of Rice and Refuge Ponds, D_r

Rice ponds and seasonal refuges are drained during certain periods of the year. Rice ponds are drained for harvesting at the end of the growing season. Some rice fields may be re-flooded to decompose the rice residue as well as to create habitat for wildlife. Before the growing season begins, these fields are drained again. Similarly, seasonal refuge ponds can be periodically drained to create space for other types of land usage such as farming during growing season. IDC allows the user to simulate such land management practices by requiring time series ponding depths for rice and refuge areas. Any time the ponding depth specified for a time step is less than that specified for the previous time step, IDC computes a unit rate of pond drainage as

$$D_r^{t+1} = \frac{P_D^t - P_D^{t+1}}{\Delta t} \geq 0 \qquad (11)$$

For land use types other than rice and refuges, pond drainage is equal to zero.

3.1.9. Percolation, P_C

Percolation is the amount of vertical moisture flow that leaves the root zone through its lower boundary. IDC uses a one-dimensional physically-based routing approach to compute P_C:

$$P_C^{t+1} = K\left(\theta^{t+1}Z^{t+1}\right)\frac{dh\left(\theta^{t+1}Z^{t+1}\right)}{dz} \tag{12}$$

where K is the unsaturated hydraulic conductivity as a function of soil moisture (L/T), h is the pressure head (L), and z is the vertical distance measured from land surface (L). Assuming that the vertical head gradient is unity, using van Genuchten-Mualem equation (Mualem 1976, van Genuchten 1980) and assuming residual moisture content is negligible, equation (12) can be re-written as

$$P_C^{t+1} = P_{Crdc}^{t+1} + K_s\left(\frac{\theta^{t+1}}{\theta_T}\right)^{1/2}\left\{1-\left[1-\left(\frac{\theta^{t+1}}{\theta_T}\right)^{1/m}\right]^m\right\}^2 \tag{13}$$

and

$$m = \frac{\lambda}{\lambda+1} \tag{14}$$

$$P_{Crdc}^{t+1} = \begin{cases} \theta^t\left(Z^t - Z^{t+1}\right) & \text{if } \; Z^t > Z^{t+1} \\ 0 & \text{otherwise} \end{cases} \tag{15}$$

where K_s is the saturated hydraulic conductivity (L/T) and λ is the pore size distribution index (dimensionless).

Equation (15) shows that when the rooting depth is decreasing, generally at the harvest time, any moisture that falls outside the rooting depth is converted into percolation. However, it should be noted that setting the rooting depth, Z, to zero outside of cropping season will cause incorrect results as IDC will assume that soil has zero storage capacity and will convert all precipitation to either percolation or direct runoff. Therefore, it is important to specify a non-zero rooting depth even outside the growing season to properly represent the moisture storage capacity of the soil. Alternatively, one can assume constant rooting depth throughout the entire simulation period. Preliminary tests have shown that although changing rooting depth has an impact on the flow terms as well as the computed water demands at short time periods that are on the order of a few days, over the entire cropping season its cumulative impact is small.

As an alternative to the van Genuchten-Mualem equation, IDC can use Campbell's approach (Campbell 1974) to represent the unsaturated hydraulic conductivity:

$$P_C^{t+1} = P_{Crdc}^{t+1} + K_s \left(\frac{\theta^{t+1}}{\theta_T} \right)^{3+\frac{2}{\lambda}} \tag{16}$$

where the assumption of negligible residual moisture content is applied.

3.1.10. Evapotranspiration, ET

Calculations of ET are based on the potential ET, ET_{pot}, values specified by the user as time series data for each land use and grid cell combination. Although ET_{pot} values can be taken as the crop ET under standard conditions, ET_c, described by Allen et al. (1998), they can also be taken as the crop ET under non-standard conditions, ET_{cadj}, also described by Allen et al. (1998), to incorporate conditions such as non-uniform irrigation, low soil fertility, salt toxicity, pests, diseases, etc (except the case where the plants are water stressed because of lack of sufficient water; this situation is simulated dynamically in IDC as discussed below).

IDC computes ET as a function of the soil moisture in the root zone:

$$ET^{t+1} = \begin{cases} ET_{pot}^{t+1} & \text{if} \quad \dfrac{\theta^{t+1} - \theta_{wp}}{\left(\dfrac{\theta_f - \theta_{wp}}{2}\right)} > 1 \\ \dfrac{\theta^{t+1} - \theta_{wp}}{\left(\dfrac{\theta_f - \theta_{wp}}{2}\right)} ET_{pot}^{t+1} & \text{if} \quad 0 \le \dfrac{\theta^{t+1} - \theta_{wp}}{\left(\dfrac{\theta_f - \theta_{wp}}{2}\right)} \le 1 \\ 0 & \text{if} \quad \dfrac{\theta^{t+1} - \theta_{wp}}{\left(\dfrac{\theta_f - \theta_{wp}}{2}\right)} < 0 \end{cases} \tag{17}$$

where θ_{wp} is the wilting point (L/L) and $\theta_f - \theta_{wp}$ is the total available water (TAW) (Allen et al. 1998). Equation (17) suggests that if the soil moisture at a given time step is greater than half of TAW, ET will be equal to ET_{pot}. If the soil moisture falls below half of TAW, plants will start experiencing water stress and ET will be less than ET_{pot}. Below wilting point, the ET rate will be zero. The method described by equation (17) is similar to the method described in Allen et al. (1998) to compute a non-standard crop ET under water stress conditions. In Allen et al. (1998), a water stress parameter, p, is defined for each crop which represents the soil moisture content below which the crop starts experiencing water stress. In equation (17), p is taken as 0.5 regardless of the plant type.

3.1.11. Change in Soil Moisture due to Change in Land Use Area, $\Delta\theta_a$

IDC allows the user to specify areas for each land use type at each grid cell as time series data. Equation (1) is solved and soil moisture is tracked for each land use type at each cell. Due to different crop characteristics and management practices for each land use, soil moisture will be different for different land use types. To satisfy the global conservation of mass at the modeled domain, it is necessary to keep track of the soil moisture that is exchanged between different land use types as the areas change through the simulation period. $\Delta\theta_a$ is the term that represents this exchange of soil moisture between different land use types.

As an example consider a total of n land use types defined for a grid cell with corresponding areas defined at time step t and t+1 as A_i^t and A_i^{t+1}, respectively, where i=1,…,n. For land use types whose areas decline or stay the same $\Delta\theta_a$ will be zero (volumetric soil moisture storage will be less for land use types whose areas decrease, but soil moisture depth will be the same for these land use types). On the other hand, land use types whose areas increase will adopt new soil moisture from land use types whose areas diminish. For a land use type j whose area increases by

$$A_j^e = A_j^{t+1} - A_j^t > 0 \tag{18}$$

the change in soil moisture due to area change, $\Delta\theta_{a,j}$, is computed as

$$\Delta\theta_{a,j} = \frac{A_j^t \theta_j^t Z_j^t + A_j^e \dfrac{\sum_i A_i^r \theta_i^t Z_i^t}{\sum_i A_i^r}}{A_j^{t+1}} - \theta_j^t Z_j^t \tag{19}$$

where A_i^r is the decrease in the area of land use i:

$$A_i^r = A_i^t - A_i^{t+1} > 0 \tag{20}$$

Equation (19) suggests that after adopting the soil moisture from land use types whose areas decrease, the new soil moisture computed for the land use j is uniformly distributed over the land use area.

In certain situations, the new soil moisture with the adopted moisture from reduced land use areas can be numerically greater than the total porosity. For instance such a case can occur when the area of a crop with short rooting depth extends into the area of a crop with much deeper rooting depth. In this case the new soil moisture is set to total porosity and the moisture above total porosity is converted into percolation.

3.1.12. Solution of the Root Zone Conservation Equation

Equation (1) is non-linear with respect to θ^{t+1}. IDC uses an iterative method that is a combination of bisection and Newton's methods (Gerald and Wheatley 1994) to solve equation (1). The iterative solution methodology starts and continues with Newton iterations until the estimate for the soil moisture goes above total porosity less 10% of the user-defined convergence tolerance for the iterative solver. At this point, bisection method is used as the iterative method. The reason for this switch between the two methods is that the gradient of the van Genuchten-Mualem equation near saturation becomes very large and this causes problems for Newton's method. Bisection method has slower convergence but is more robust; therefore it is preferred when soil moisture is close to or above saturation. The switch between Newton's and bisection methods occurs mostly for rice and refuge areas where soil moisture can be at or numerically above total porosity (representing the ponding conditions).

3.2. Water Demand

From a plants perspective, water demand (also referred to as the physical water demand in this document) is the amount of irrigation water to satisfy the crop's evapotranspirative requirement under a specified irrigation management setting that is not met by precipitation. From a water management perspective, it is the amount of irrigation water that needs to be delivered to farms dictated by contractual agreements. This amount may or may not be the same as the physical water demand of the crops.

IDC is designed to address both types of water demands under user-specified climatic and irrigation management settings in regional scale applications. The physical water demand is computed by utilizing the root zone conservation equation (1), whereas the contractual water demands are specified by the user. Physical water demand is calculated only for agricultural crops, refuges and urban lands; water demand is zero for native and riparian vegetation since they are not irrigated.

Below, the methods used by IDC to compute applied water demand for non-ponded and ponded (rice and refuge lands) land use areas are explained.

3.2.1. Water Demand for Non-Ponded Crops

IDC utilizes an irrigation-scheduling-type approach in computing the water demand for non-ponded crops. Each non-ponded crop at each grid cell is associated with a time series data of irrigation period flag, irrigation trigger minimum soil moisture, irrigation target soil moisture, minimum percolation requirement as a fraction of infiltrated applied water, return flow fraction and re-use fraction. IDC also requires the user to specify if the soil moisture at the beginning or at the end of a time step will be used to compute irrigation water demand. For a short simulation time step such as a day using the soil moisture at the beginning of the time step is appropriate, whereas for a long time step such as a month, it is better to use the soil moisture at the end of the time step. The real-world analogy is that a farmer may check the soil moisture conditions in the morning and decide if the crops need irrigation, while he never bases his decision of irrigating over an entire month on the moisture conditions at the beginning of that month.

The irrigation period flag tells IDC when to compute irrigation water demand for a non-ponded crop. An irrigation period flag of 0 means that it is outside the cropping season and IDC will not compute the irrigation water demand, whereas 1 means that it is growing season and the irrigation water demand will be computed.

First, the water demand calculations in the case when the soil moisture at the beginning of a time step is used will be explained.

At the beginning of a time step, if irrigation period flag is 1, IDC checks if the soil moisture, $\theta^t Z^t$, is less than the irrigation trigger minimum soil moisture, $\theta_{min}^{t+1} Z^{t+1}$, where θ_{min}^{t+1} is represented in terms of the Total Available Water (TAW):

$$\theta_{min}^{t+1} = \theta_{wp} + f_{\theta min}^{t+1} TAW \tag{21}$$

$$TAW = \theta_f - \theta_{wp} \tag{22}$$

where $f_{\theta min}^{t+1}$ is a fraction of TAW specified as time series data by the user. θ_{min}^{t+1} is the soil moisture content that corresponds to the maximum allowable depletion (Allen et al. 1998). If $\theta^t Z^t$ is less than $\theta_{min}^{t+1} Z^{t+1}$, the irrigation amount to raise the soil moisture up to irrigation target moisture, $\theta_{trg}^{t+1} Z^{t+1}$ is computed by setting θ^{t+1}

in equation (1) to θ_{trg}^{t+1} and re-writing it for A_w (in IDC irrigation water demand is equivalent to the applied water since IDC assumes that water is available to meet the irrigation water demand at all times):

$$A_w^{t+1} = \begin{cases} \dfrac{\dfrac{\theta_{trg}^{t+1} Z^{t+1} - \theta^t Z^t - \Delta\theta_a^{t+1}}{\Delta t} - P^{t+1} + R_p^{t+1} - G^{t+1} Z^{t+1} + P_{Ctrg}^{t+1} + ET_{trg}^{t+1}}{1 - \left(f_{R_{f,ini}}^{t+1} - f_U^{t+1} \right)} & \text{if} \quad \theta^t Z^t < \theta_{min}^{t+1} Z^{t+1} \\ 0 & \text{if} \quad \theta^t Z^t \geq \theta_{min}^{t+1} Z^{t+1} \end{cases} \quad (23)$$

Several points need to be highlighted for equation (23):

1. Pond drainage flow, Dr, is set to zero since equation (23) is written for non-ponded crops.
2. ET_{trg}^{t+1} and P_{Ctrg}^{t+1} represent the ET and percolation rates, respectively, at the target soil moisture.
3. Equation (10) is substituted for return flow, Rf.

Equation (23) is the expression for the amount of applied water that will raise the soil moisture up to target soil moisture while taking into account the contribution of precipitation, irrigation efficiency measures $f_{R_{f,ini}}$ and f_U as well as the moisture depleting effects of percolation and ET.

By default, IDC uses field capacity as the target soil moisture. However, the user can optionally specify a fraction of the field capacity as the target soil moisture during irrigation to simulate the effects of deficit irrigation (Fereres and Soriano, 2007; Kirda, 2002). By setting the irrigation trigger minimum soil moisture and the irrigation target soil moisture to values that are lower than those for optimal irrigation, the user can simulate the deficit irrigation practices.

In the case where the soil moisture at the end of a time step is used for water demand calculations, IDC initially assumes that A_w^{t+1} is zero, and solves equation (1) for θ^{t+1}. If $\theta^{t+1} Z^{t+1}$ is less than $\theta_{min}^{t+1} Z^{t+1}$, there is irrigation water demand and IDC uses equation (23) to compute this demand.

It is common practice to apply additional irrigation water on the fields to flush the salts from the soil. To simulate this practice, IDC allows the user to specify an optional time-series minimum percolation factor for each non-ponded crop at each grid cell. The percolation factor is defined as a fraction of the infiltrated applied water:

$$P_{Cmin} = f_D\left(A_w - R_f\right) \tag{24}$$

where P_{Cmin} is the minimum percolation required (L/T) and f_D is the minimum percolation fraction (dimensionless). It should be noted that f_D is different than leaching fraction in that leaching fraction is defined for a set of irrigation events after which the soil salinity and water flow in the root zone reaches an equilibrium (Ayers and Westcot, 1985; Dudley et al., 2008) whereas f_D in IDC is valid only for the time step when the irrigation event takes place.

After water demand is computed using equation (23), IDC checks if percolation is greater than the minimum percolation, if f_D is supplied. If minimum percolation is not achieved, it computes a new water demand that will raise the soil moisture to the irrigation target soil moisture while generating minimum percolation. This is achieved by writing equation (24) for $A_w - R_f$, substituting it into equation (1), and solving the resulting non-linear equation for θ^{t+1}:

$$\begin{aligned}\theta^{t+1}Z^{t+1} &= \theta^t Z^t \\ &+\Delta t\left[P^{t+1} - R_p^{t+1} + G^{t+1}Z^{t+1} - P_{Cmin}^{t+1}\left(1-\frac{1}{f_D^{t+1}}\right) - ET^{t+1}\right] \\ &+\Delta\theta_a^{t+1}\end{aligned} \tag{25}$$

In writing equation (25), pond drainage, D_r, is set to zero since the equation is written for non-ponded crops only and ET^{t+1} is the ET rate at θ^{t+1}. It should also be noted that P_{Cmin} is a function of θ^{t+1} in equation (25).

Equation (25) is solved for θ^{t+1} iteratively using Newton's method. Once the solution is obtained, the water demand is computed as

$$A_w^{t+1} = \frac{P_{Cmin}^{t+1}}{f_D^{t+1}\left[1-\left(f_{R_{f,ini}}^{t+1} - f_U^{t+1}\right)\right]} \tag{26}$$

where P_{Cmin}^{t+1} is computed at θ^{t+1} that is obtained by solving equation (25).

Percolation has an upper limit that is equal in magnitude to the saturated hydraulic conductivity, K_s, of the soil (see equation (13)). Therefore, P_{Cmin} is limited by K_s. If it is computed to be larger than K_s, it is adjusted down to K_s and the user-specified minimum percolation factor, f_D, is overridden.

Alternatively, IDC allows the user to specify water demand to address the contractual rather than the physical water demands. In this case, equations (23) and (26) are bypassed and user-specified water demands are used. However, it is likely that the specified water demands will be less than or greater than the physical water demands. In either case, IDC uses the specified values in equation (1) to route the moisture through the root zone. In the case that the specified demands are less than their physical counterparts, IDC will allow ET to fall below ET_{pot}, assuming that the target irrigation soil moisture is equal to the field capacity. If they are greater than the physical demands, IDC computes increased soil moisture, percolation and return flow, again by the use of equation (1).

The inclusion of percolation in equation (23) shows that the water demand, among other factors, depends also on the soil type where the crops are planted. The same crop under the same management factors and for the same yield will require more water if it was planted on a sandy soil than it was planted on a clayey soil.

3.2.2. Water Demand for Ponded Crops

The water demand computations for ponded crops are driven by the pond depths specified by the user except during decomposition periods for rice lands where non-flooded decomposition practices are followed. For the periods when a non-zero ponding depth is specified, IDC computes the applied water demand that will completely saturate the soil and crate a pond with the specified depth after taking into account the contribution of precipitation in a user-specified crop management setting. First an initial estimate of water demand is computed by setting drainage flow and net return flow to zero, percolation to saturated hydraulic conductivity, ET to ET_{pot}, θ^{t+1} to total porosity plus the pond depth in equation (1) and rearranging the equation for A_w:

$$A_{w,ini}^{t+1} = \frac{\theta_T Z + P_D^{t+1} - \theta^t Z - \Delta\theta_a^{t+1}}{\Delta t} - P^{t+1} + R_p^{t+1} - G^{t+1}Z + K_s + ET_{pot}^{t+1} + D_r^{t+1} > 0 \quad (27)$$

where $A_{w,ini}$ is the initial estimate of the applied water demand (L/T) and P_D is the pond depth (L). As stated previously, IDC assumes constant rooting depth for ponded crops, therefore the time index for Z in equation (27) does not appear. There is water demand only if the result of equation (27) is greater than zero. As the second step, the drainage flow is computed using equation (11). Then, the final applied water demand is computed as

$$A_w^{t+1} = A_{w,ini}^{t+1} + R_{f,ini}^{t+1} - U^{t+1} \quad > \quad 0 \quad (28)$$

where, as mentioned earlier, $R_{f,ini}$ and U are specified as unit flow rates for rice lands and refuges.

Equations (27) and (28) are used for seasonal and permanent refuge areas as well as for rice lands where flooded decomposition practices are followed. For rice lands where non-flooded decomposition practices are followed, the same approach is used during growing season; during decomposition period user specified water application amounts are utilized.

As with non-ponded crops, if the user specifies water demand IDC bypasses its computation and substitutes the specified value into equation (1).

3.2.3. Evapotranspiration of Applied Water, ETaw

The portion of the crop evapotranspiration that is satisfied by irrigation water is referred to as the evapotranspiration of applied water (ETaw). The crop evapotranspiration can be satisfied by moisture storage already available in the soil, precipitation, applied water, and if available, other sources of moisture, G. Moisture storage is comprised of previous precipitation events and irrigation activities as well as moisture inflows from other sources. Therefore, one can view ETaw as having two components: one where the irrigation satisfies the crop ET requirement almost instantaneously (e.g. over a period of few minutes or hours), and one where a portion of the applied water is stored in the soil and satisfies the crop ET over an extended period of time (e.g. over a period of few days or weeks).

For proper prediction, IDC keeps track of the portion of soil moisture that is supplied by irrigation and effectively simulates both components of ETaw. After equation (1) is solved and all flow components are calculated, ETaw and the soil moisture storage due to irrigation are computed using the following set of expressions:

$$\alpha_{A_w} = \frac{\theta_{A_w}^t Z^t + \Delta t\left(A_w^{t+1} - R_f^{t+1}\right)}{\left(\theta_P^t + \theta_{A_w}^t + \theta_G^t\right)Z^t + \Delta t\left(P^{t+1} - R^{t+1} + A_w^{t+1} - R_f^{t+1} + G^{t+1}Z^{t+1}\right)} \qquad (29)$$

$$ETaw^{t+1} = \alpha_{A_w} ET^{t+1} \qquad (30)$$

$$\theta_{A_w}^{t+1} Z^{t+1} = \theta_{A_w}^t Z^t + \Delta t\left[A_w^{t+1} - R_f^{t+1} - \alpha_{A_w}\left(D_r^{t+1} + P_C^{t+1}\right) - ETaw^{t+1}\right] + \Delta\theta_{a,A_w}^{t+1} \qquad (31)$$

where α_{A_w} is the ratio of stored applied water plus the infiltrated applied water to the total moisture storage plus total infiltration, and $\Delta\theta_{a,A_w}$ is the moisture storage due to irrigation that is acquired from adjacent land use areas because of change in land use area. Equations (29) - (31) suggest that all root zone flow components are proportioned between flow due to precipitation, flow due to applied water and flow due to other sources of moisture using the fraction defined in equation (29), which are used to compute the moisture storage due to irrigation.

α_{A_w} represents both the instantaneous and the long-term contributions of irrigation to ETaw and other flow terms. The part with $\Delta t\left(A_w^{t+1} - R_f^{t+1}\right)$ at the numerator represents the instantaneous contribution, whereas the part with $\theta_{A_w}^t Z^t$ represents its contribution that takes place over an extended period of time. Here, the term “instantaneous” refers to any event that takes place over a single simulation time step, Δt.

When irrigation period flag is 0 representing out-of-growing-season, ETaw is still computed to track θ_{A_w} (see equation (31)). This is because evapotranspiration continues to occur outside the irrigation period due to soil evaporation and transpiration from non-agricultural crops such as weeds.

3.2.4. Effective Precipitation, ETp

Effective precipitation, ETp, is the portion of precipitation that is available to meet crop evapotranspiration. It does not include direct runoff, percolation or evaporation before the crop can use it (USDA 1997). Similar to ETaw, ETp represents the instantaneous contribution of precipitation to satisfy the crop evapotranspiration as well as its contribution over an extended period of time. IDC uses the following expressions to compute ETp:

$$\alpha_P = \frac{\theta_P^t Z^t + \Delta t\left(P^{t+1} - R^{t+1}\right)}{\left(\theta_P^t + \theta_{A_w}^t + \theta_G^t\right)Z^t + \Delta t\left(P^{t+1} - R^{t+1} + A_w^{t+1} - R_f^{t+1} + G^{t+1}Z^{t+1}\right)} \quad (32)$$

$$ETp^{t+1} = \alpha_P ET^{t+1} \quad (33)$$

$$\theta_P^{t+1} Z^{t+1} = \theta_P^t Z^t + \Delta t\left[P^{t+1} - R^{t+1} - \alpha_P\left(D_r^{t+1} + P_C^{t+1}\right) - ETp^{t+1}\right] + \Delta\theta_{a,P}^{t+1} \quad (34)$$

where α_P is the ratio of stored precipitation plus the infiltration of precipitation to the total moisture storage plus the total infiltration, and $\Delta\theta_{a,P}$ is the moisture storage due to precipitation that is acquired from adjacent land use areas because of change in land use area.

3.2.5. Evapotranspiration due to Other Sources, ET_G

ET_G is the portion of the generic, user-defined source of moisture that is available to meet the evapotranspirative demand. Similar to ETaw and ETp, it represents the instantaneous contribution of the generic source of moisture to satisfy the crop evapotranspiration as well as its contribution over an extended period of time. IDC uses the following set of expressions to compute ET_G:

$$\alpha_G = \frac{\theta_G^t Z^t + \Delta t\left(G^{t+1} Z^{t+1}\right)}{\left(\theta_P^t + \theta_{A_w}^t + \theta_G^t\right)Z^t + \Delta t\left(P^{t+1} - R^{t+1} + A_w^{t+1} - R_f^{t+1} + G^{t+1}Z^{t+1}\right)} \quad (35)$$

$$ET_G^{t+1} = \alpha_G ET^{t+1} \quad (36)$$

$$\theta_G^{t+1} Z^{t+1} = \theta_G^t Z^t + \Delta t \left[G^{t+1} Z^{t+1} - \alpha_G \left(D_r^{t+1} + P_C^{t+1} \right) - ET_G^{t+1} \right] + \Delta\theta_{a,G}^{t+1} \quad (37)$$

where α_G is the ratio of stored moisture due to generic source plus the infiltration of the generic moisture to the total moisture storage plus the total infiltration, and $\Delta\theta_{a,G}$ is the moisture storage due to the generic moisture source that is acquired from adjacent land use areas because of change in land use area.

3.3. Example 1: Hypothetical Scenario

To test and analyze its results, IDC was run for a hypothetical case where tomatoes were the irrigated crop. Additionally, to test the irrigation scheduling logic built into IDC, it was compared, when applicable, to the CUP model developed jointly by DWR and UC Davis (Orang et al. 2004). CUP is a graphical user interface driven spreadsheet application that was developed to improve the dissemination of crop evapotranspiration (ET_c) information to California growers and water purveyors. The program uses monthly means of solar radiation, maximum and minimum temperature, dew point temperature, wind speed, and daily rainfall data to compute and apply ET_c values on a daily basis to determine crop water requirements.

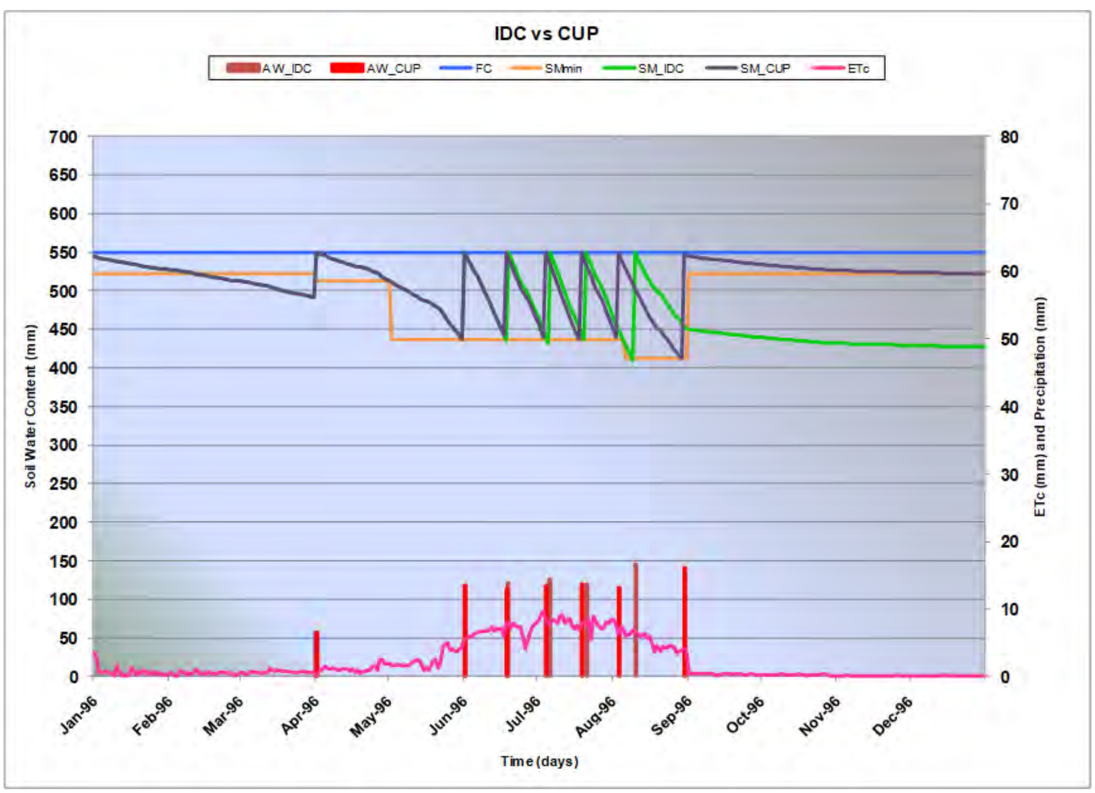
The testing and analysis of IDC results were performed in several stages. The first stage included a very simple test case with minimum amount of IDC features included. In each consecutive stage another feature of IDC was included in the test and the effects of the feature on the results were analyzed.

For this example, tomatoes were chosen as the crop for which irrigation water requirements were calculated from January 1, 1996 to December 31, 1996. The growing season for tomatoes was April 1 to August 31. The generic source of moisture was set to zero. For a specified set of weather data, CUP computed daily ET_c values that were input into IDC. Available water holding capacity (the difference between field capacity and wilting point) was 0.14 mm/mm, the rooting depth was set to 1524 mm and the maximum allowable soil moisture depletion was set to 50% of the field capacity. Using soil properties and crop specific information, CUP computed yield threshold depletion and the corresponding allowable moisture depletion (Snyder et al. 2004). The moisture content that corresponded to the allowable soil moisture depletion computed by CUP was input as the irrigation trigger moisture content into IDC. In IDC, the wilting point, field capacity, total porosity and pore size distribution index are taken to be 0.000 mm/mm, 0.270 mm/mm, 0.463 mm/mm and 0.418, respectively. These values were taken from data published by Rawls et al. (1982) for a loam soil. The initial soil moisture content was set equal to field capacity. It was also assumed in IDC that 50% of the initial soil moisture was due to precipitation.

3.3.1. Zero Precipitation, Percolation and Return Flow

CUP computes runoff due to precipitation differently than IDC. It also doesn't incorporate percolation and agricultural return flow into the computation of applied water. To simulate the similar processes, the precipitation in both programs, and saturated hydraulic conductivity and return flow factor in IDC were all set to zero. Figure 3 shows a comparison of IDC and CUP results for this case.

Figure 3. *Comparison of IDC results to CUP results for zero precipitation, percolation and return flow*



In Figure 3, FC is the field capacity, SMmin is the irrigation trigger minimum soil moisture computed by CUP and used as input to IDC, AW_IDC is the applied water computed by IDC, AW_CUP is the applied water computed by CUP, SM_IDC is the soil moisture computed by IDC, SM_CUP is the soil moisture computed by CUP, and ET_c is the crop ET that is computed by CUP and used as input to IDC.

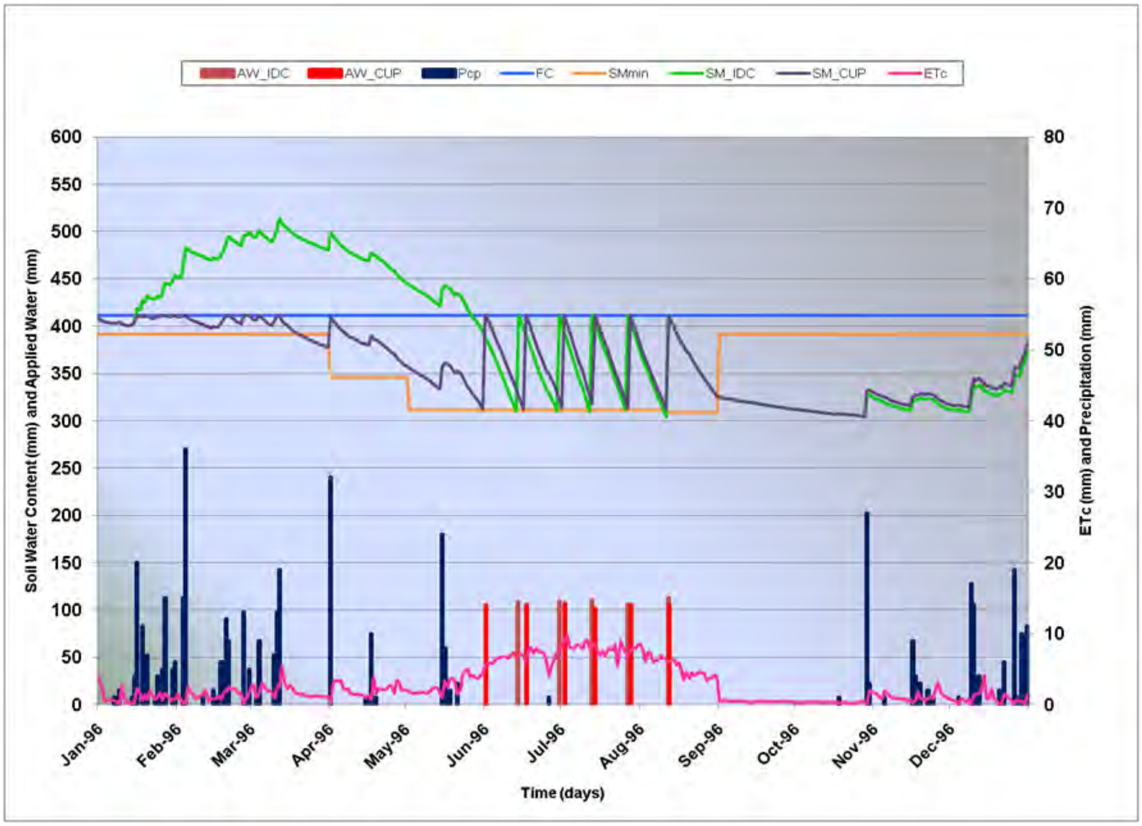
In both models, initial soil moisture is at field capacity. Until April 1, ET_c for bare soil and non-agricultural plants deplete the soil moisture below the irrigation trigger minimum soil moisture. However, since growing season does not start until April 1, irrigation is not triggered. On April 1, when the growing season starts, the first irrigation event is triggered and both models raise the soil moisture up to field capacity. Soil moisture and the magnitude of applied water are almost exactly the same until the second irrigation event towards the end of May. Here, a difference between IDC and CUP becomes apparent. The second irrigation event occurs on May 28 for CUP and on May 29 for IDC. At the beginning of May 28 both models have soil moisture that is above the irrigation trigger minimum soil moisture. CUP predicts that soil moisture at the end of the day will be less than the minimum moisture and initiates an irrigation event. IDC, on the other hand, initiates an irrigation event only based on the soil moisture at the beginning of the day. At the begging of May 29, the soil moisture is less than the minimum moisture in IDC and this is when IDC initiates an irrigation event. The effect of this difference between the two models in deciding when to irrigate accumulates throughout the growing season until the simulated soil moistures are visibly different. In fact, CUP initiates a total of 8 irrigation events that amounts to 774 mm of applied water throughout the growing season whereas IDC initiates 7 events that amounts to 712 mm.

Although there are some differences between IDC and CUP results, in general, this comparison shows that the irrigation scheduling logic built into IDC works properly. IDC allows the depletion of soil moisture until it becomes less than the irrigation trigger moisture. This is when it initiates an irrigation event to raise the moisture up to the target moisture level (field capacity, in this case).

3.3.2. Zero Percolation and Return Flow

At this stage of testing IDC, daily precipitation data for calendar year 1996 was used. With the inclusion of this data, CUP computed a new set of ET_c and irrigation trigger minimum soil moisture which were used as input to IDC. The results for this stage are shown in Figure 4.

Figure 4. *Comparison of IDC results to CUP results for zero percolation and return flow*



In this stage, another difference between IDC and CUP is shown. CUP never allows the soil moisture to go above field capacity; the infiltration of precipitation is adjusted so that soil moisture stays below or at the field capacity. IDC uses SCS curve number method (USDA 2004) to compute the direct runoff and, consequently, infiltration from precipitation (a curve number of 82 was used for this example). It also allows soil moisture to go above field capacity. This is because past CADWR experiences in coupled root zone, groundwater and stream flow modeling showed that forcing the soil moisture to be at or below field capacity at every time step required increasing direct runoff or percolation. This approach had adverse effects on the timing of recharge into groundwater and surface runoff into the streams. Furthermore, it has been observed in the field that considerable root zone drainage can occur beyond three days (Ritchie, 1981) suggesting that the soil moisture stays above field capacity for as long as the drainage continues.

Figure 4 shows that the soil moisture in IDC rises above field capacity with the winter rains whereas CUP limits it with field capacity by decreasing the infiltration of precipitation. For the entire year, IDC and CUP generate 69 mm and 141 mm of direct runoff, respectively, out of 465 mm of precipitation. Although, with different values for curve number, the direct runoff can be changed in IDC, this example shows the effect of allowing the soil moisture to rise above field capacity. With the higher moisture content at the beginning of the growing season, IDC does not initiate an irrigation until June 14, whereas CUP initiates the first irrigation on June 1. For the entire season, the application water for IDC and CUP are 547 mm and 628 mm, respectively.

3.3.3. Zero Return Flow

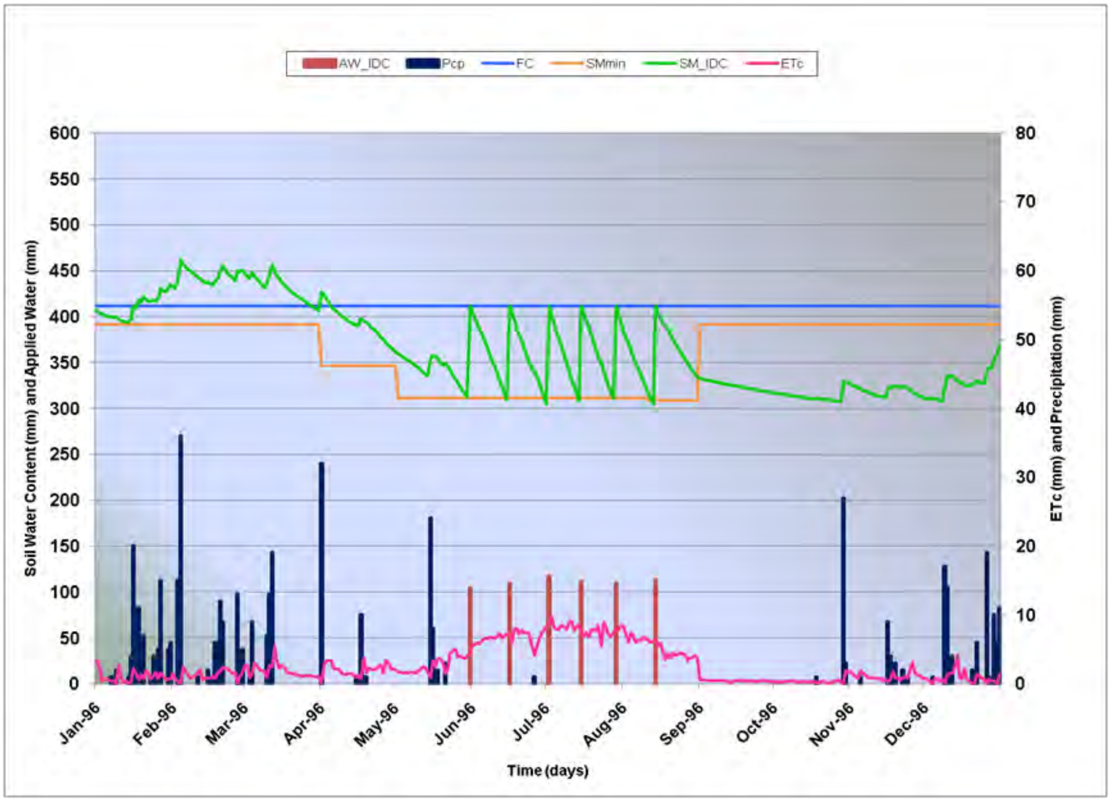
At this stage of testing, hydraulic conductivity of the loam soil was set to 1.32 cm/hour (Rawls et al. 1982) to simulate the percolation from the root zone. Since percolation is not simulated in CUP, the IDC results were compared to the IDC results from previous stage.

Figure 5 shows the results for this test case. The annual percolation is 135 mm. When compared to Figure 4, it can be seen that the soil moisture increase during the winter months is less due to the moisture depleting effects of percolation.

Inclusion of the percolation in the simulation also decreases the direct runoff from precipitation; 57 mm annually in this case versus 69 mm with zero percolation. This result is expected since depleting the soil moisture through percolation leads to increased empty storage to be filled by precipitation.

The annual applied water in this case is 666 mm compared to 547 mm with no percolation. This result is also in line with expectations that increasing the percolation should also increase the amount of applied water to achieve the same crop yield. In this case, when raising the moisture to field capacity, applied water not only counter-balances the moisture depleting effect of evapotranspiration but also that of percolation.

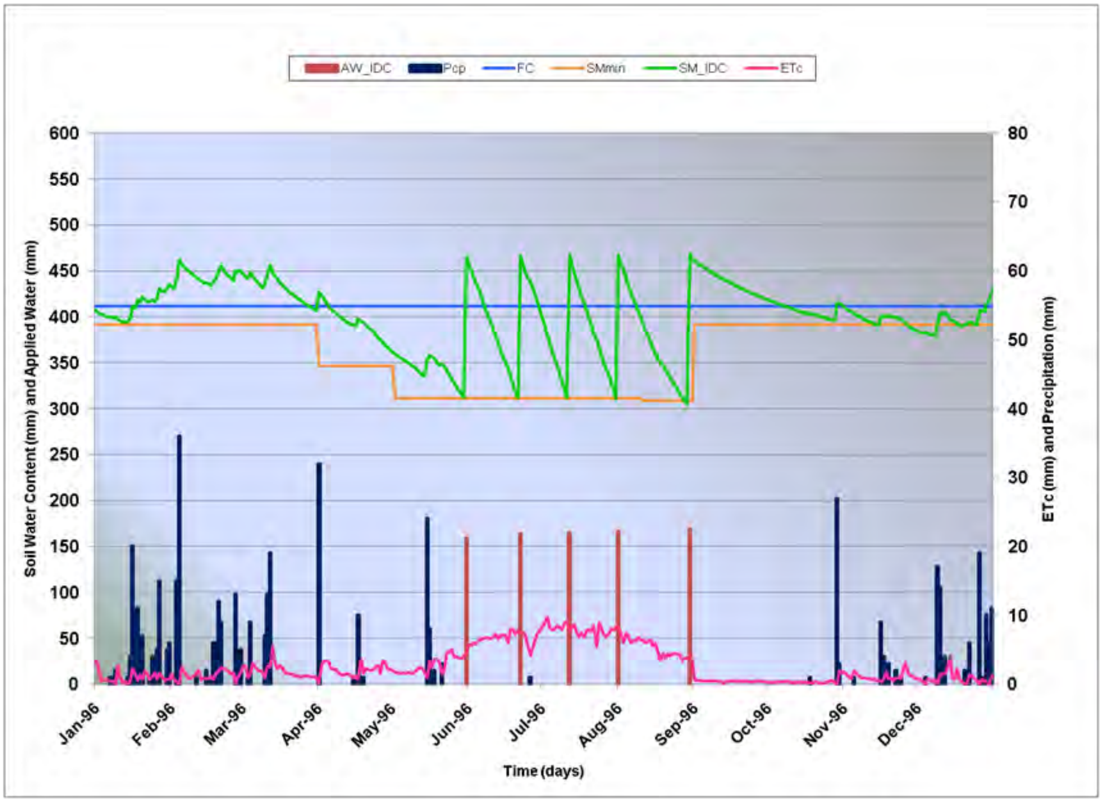
Figure 5. *IDC results for zero return flow*



3.3.4. Zero Return Flow and 1% Minimum Percolation Fraction

In this stage, a minimum percolation of 1% of infiltrated applied water is imposed. Figure 6 shows that every time an irrigation event is triggered, the soil moisture is raised above field capacity to a moisture that will create a percolation that is equal to 1% of the infiltrated applied water on that day. Since the percolation continues beyond the day of the irrigation, the total percolation from irrigation is larger than 1%. During the growing season, the total percolation amounts to 70 mm with 822 mm of applied water. Assuming that the percolation is entirely due to irrigation during the growing season, this leads to a leaching fraction of 9%.

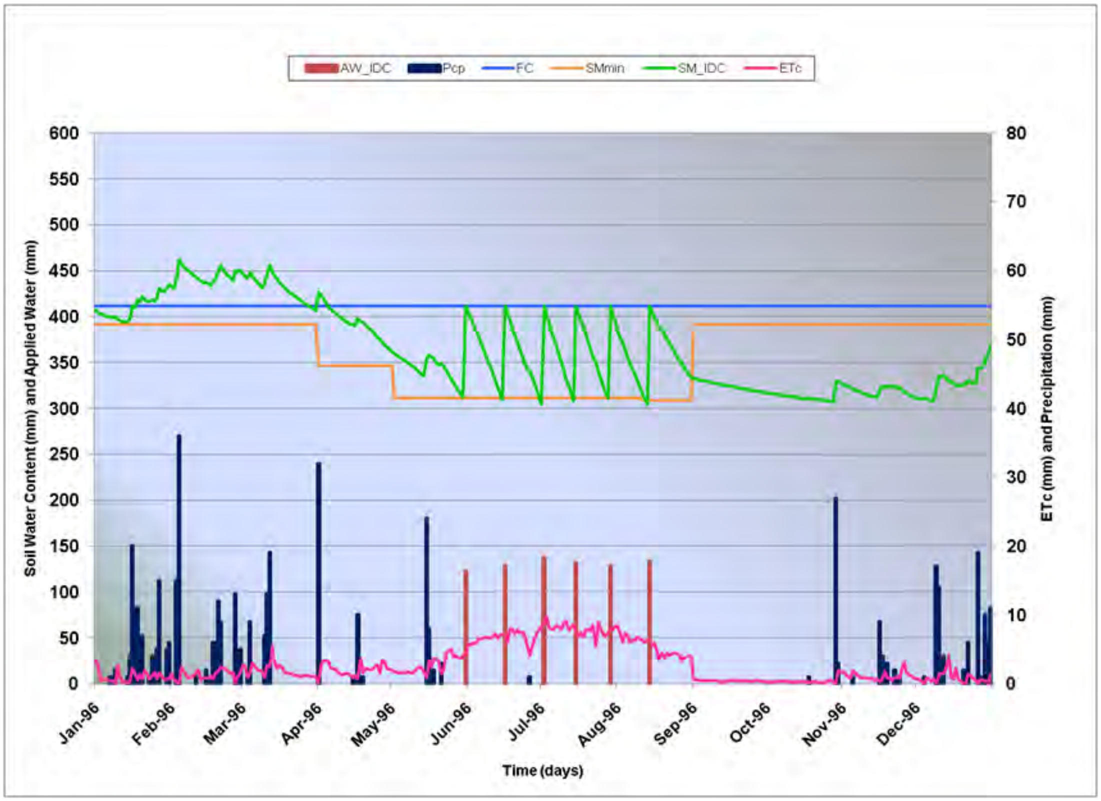
Figure 6. *IDC results for zero return flow with 1% minimum percolation requirement*



3.3.5. 15% Return Flow Fraction

In this case, the minimum percolation fraction was set to zero but the return flow fraction was set to 15% of applied water. The results for this case are shown in Figure 7. When compared to Figure 5 of section 3.3.3 (zero return flow with zero minimum percolation fraction), it can be seen that the only difference is in the amount of applied water. The total applied water in this case was 783 mm compared to 666 mm in the case with zero return flow and minimum percolation fraction (see section 3.3.3). The return flow amount was 117 mm, equal to the difference between the applied water in two test cases. The return flow is taken out of the total applied water and it does not affect the soil moisture dynamics.

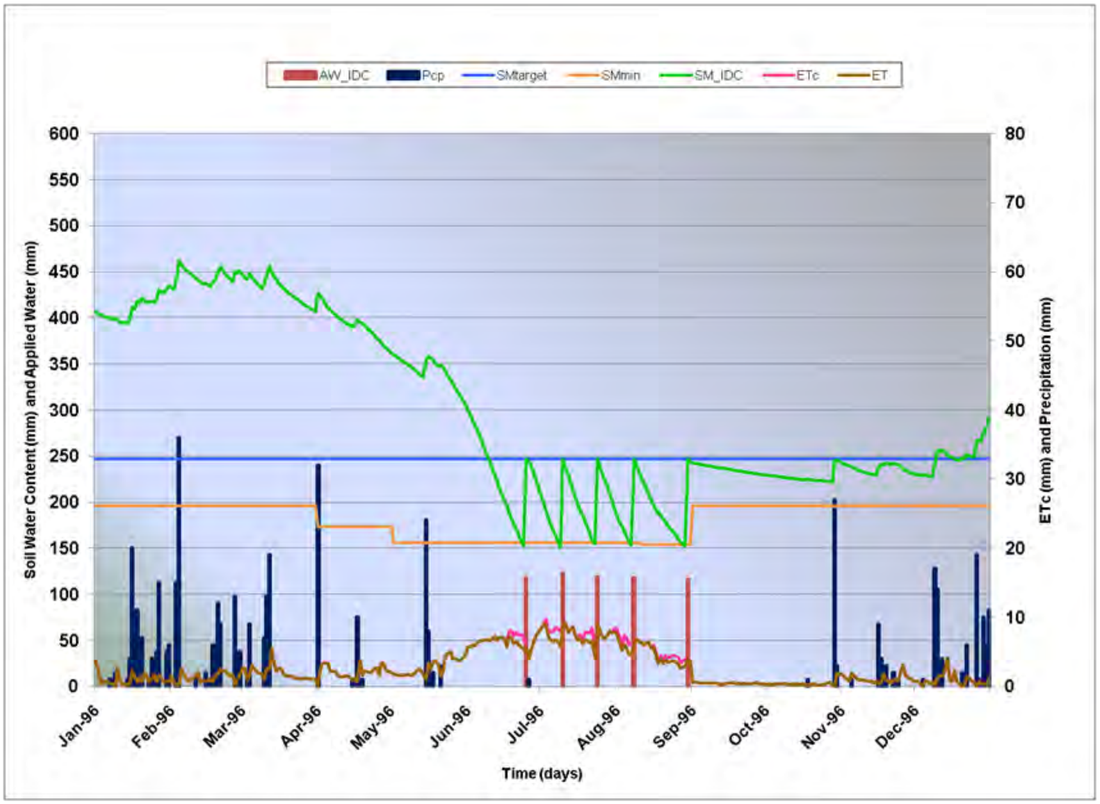
Figure 7. *IDC results for 15% return flow*



3.3.6. Deficit Irrigation

As a final test case, deficit irrigation conditions were simulated by setting the irrigation target moisture to 60% of field capacity and the irrigation trigger minimum soil moisture to 50% of those used in previous test case (see section 3.3.5). The results for this case are shown in Figure 8. SMtarget and ET in Figure 8 represent the irrigation target soil moisture and the actual ET, respectively. Deficit irrigation is generally recommended when the losses due to the decrease in the crop yield because of unmet crop ET is surpassed by the gains from conserving irrigation water (Kirda, 2002). In this test case, the total applied water and crop ET were 594 mm and 718 mm, respectively, compared to 783 mm and 764 mm, respectively, in the non-deficit irrigation scenario simulated in section 3.3.5. These results show that a 24% reduction in applied water only caused a 6% reduction in the crop ET.

Figure 8. *IDC results for deficit irrigation scenario*



3.3.7. Additional Comments on Test Cases

Some of the important seasonal (values on the left) and annual (values on the right in parentheses) flow terms from each simulated scenario are listed in Table 2. The scenario simulated in section 3.3.1 (zero precipitation, percolation and return flow) is not included in the table since the crop ET is different than the other scenarios and it would be difficult to make meaningful comparisons with other scenarios. In Table 2, AW is the applied water, ET is the actual ET, R_P is the direct runoff, R_f is the net return flow, P_C is the percolation, ETaw is the ET of applied water, ETp is the effective precipitation and IE is the irrigation efficiency expressed as ETaw divided by AW.

The following are several comments and conclusions based on the values listed in Table 2:

Table 2. *Summary of IDC results for the simulated scenarios (first values are for the growing season, second values (i.e. values in parentheses) are for the entire calendar year; all values except IE are in mm.*

Flow Term	**Scenario 1** (section 3.3.2) P_C=0 ; R_f=0	**Scenario 2** (section 3.3.3) R_f=0	**Scenario 3** (section 3.3.4) R_f=0 ; P_{Cmin}=1%	**Scenario 4** (section 3.3.5) R_f=15%	**Scenario 5** (section 3.3.6) Deficit Irrigation
AW	546 (546)	666 (666)	822 (822)	783 (783)	594 (594)
ET	764 (983)	764 (983)	764 (983)	764 (983)	718 (936)
R_P	21 (69)	16 (57)	16 (62)	16 (57)	16 (53)
R_f	0 (0)	0 (0)	0 (0)	117 (117)	89 (89)
P_C	0 (0)	43 (135)	69 (226)	43 (135)	19 (100)
ETaw	428 (428)	475 (475)	484 (484)	475 (475)	397 (397)
ETp	336 (336)	289 (289)	280 (280)	289 (289)	321 (321)
IE	78%	71%	59%	61%	67%

1. Percolation has a direct impact on the irrigation requirement, higher the percolation more applied water is needed to meet the crop ET (see AW values for scenarios simulated in sections 3.3.2, 3.3.3 and 3.3.4). However, percolation and applied water are not linearly related since a portion of the applied water is stored in the soil.
2. Direct runoff from precipitation decreases as percolation increases (see Rp values for sections 3.3.2 and 3.3.3). This is because percolation depletes the soil moisture storage allowing more precipitation to infiltrate. However, as more water is applied to increase the soil moisture above field capacity, increasing the percolation for leaching of salts, higher values of direct runoff are observed due to soil moisture being above field capacity at the end of growing season (see Figure 6 and annual Rp values for sections 3.3.3 and 3.3.4).
3. Return flow affects the irrigation requirement but not the ET, percolation, ETaw and ETp (see relevant flow terms for sections 3.3.3 and 3.3.5). As expected, increasing return flow decreases irrigation efficiency.
4. Comparing IE values for sections 3.3.3 and 3.3.4, it can be seen that applying more irrigation water for the purposes of leaching decreases the irrigation efficiency. However, an alternative definition of irrigation efficiency includes not only ETaw but also the losses if they are beneficial such as percolation for leaching (Burt et al., 1997). Although beneficial

percolation cannot immediately be quantified through IDC output values, IE would be higher for section 3.3.4 when the alternative definition of the irrigation efficiency is considered. As a rough estimate, it can be assumed that the difference between the annual percolation values from sections 3.3.3 and 3.3.4 is the beneficial percolation triggered by additional applied water. Then the IE expressed by Burt et al. (1997) can be computed as

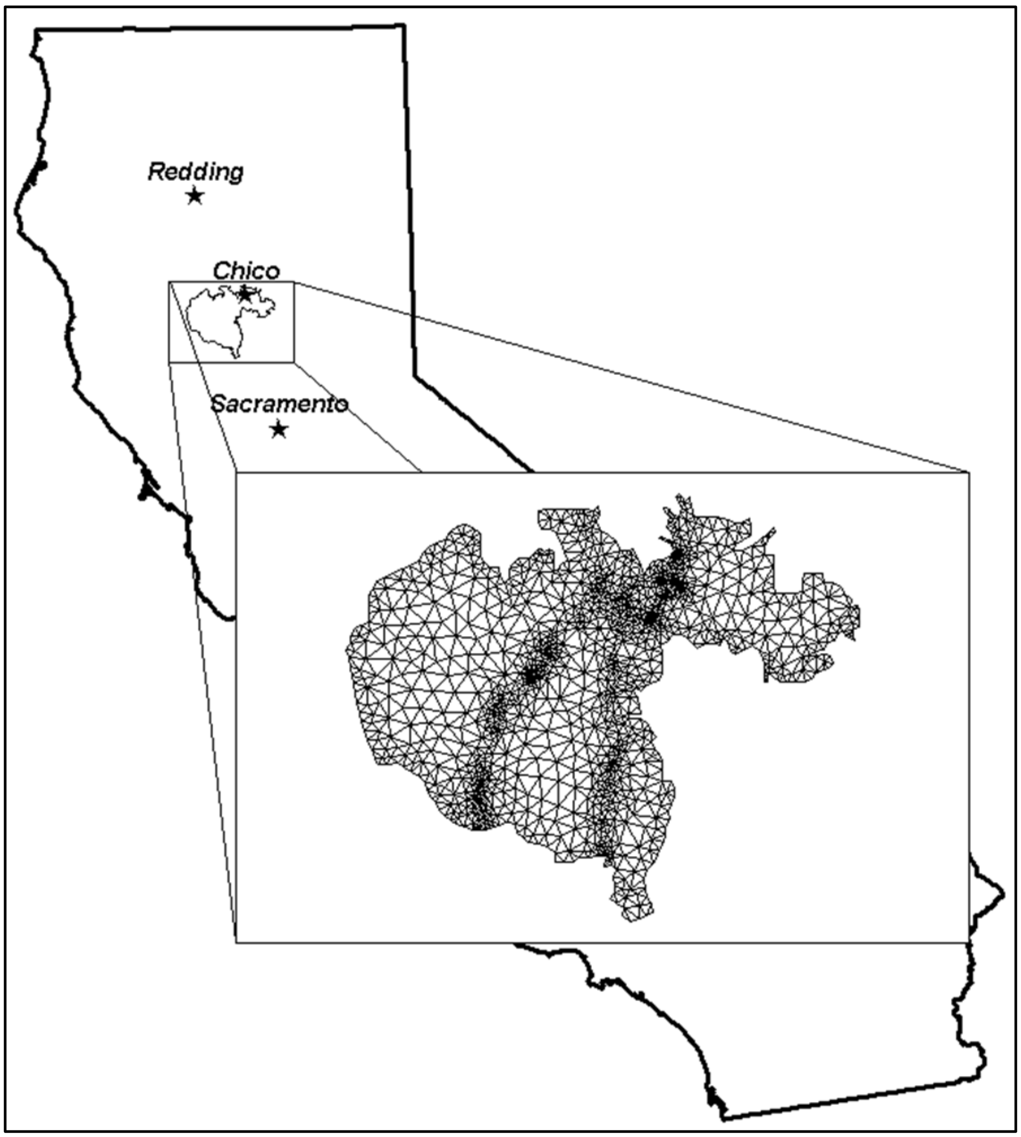
$$IE = \frac{ETaw + P_{Cbeneficial}}{AW} = \frac{484 + 226 - 135}{822} \times 100 = 70\% \qquad (38)$$

5. Deficit irrigation is one way of increasing the irrigation efficiency (Kirda, 2002). Table 2 shows a 6% increase in the IE (see IE values for scenarios 3.3.5 and 3.3.6) when a deficit irrigation scenario is simulated.
6. IDC uses the ratio of the soil moisture due to irrigation to the total soil moisture storage in computing the ETaw (see equation (30)) and hence the IE. IDC allows the user to input initial soil moisture content due to irrigation and precipitation. The ETaw values at the early stages of the simulation period are largely impacted by the user-defined initial proportioning of the moisture between precipitation and irrigation. Therefore, for a modeling study that addresses a short simulation period such as this example, IE values will be affected by the initial soil moisture estimates. Since the true portioning of the moisture between irrigation and precipitation is hard to estimate, it is advisable to include a “spin-up” period of a few years in IDC runs to achieve a more realistic mixture of stored moisture due to precipitation and applied water. This spin-up period will minimize the adverse effects of incorrect estimates of initial proportioning of the soil moisture storage on the IE calculations.

3.4. Example 2: A Real-World Application

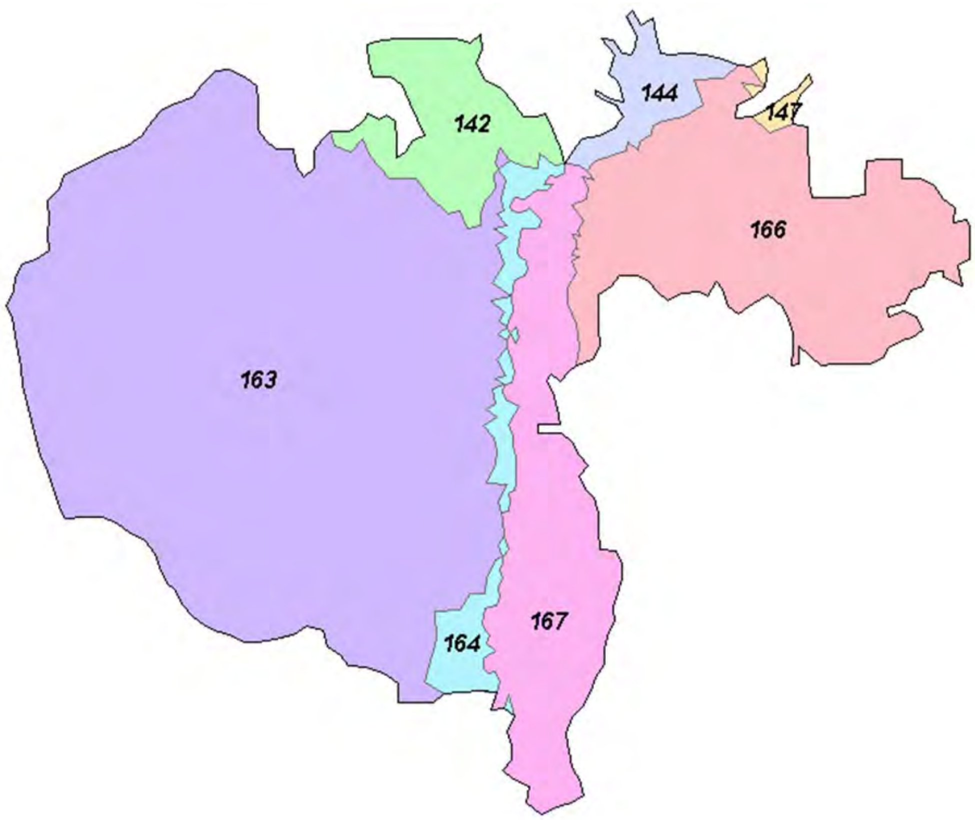
For this example IDC was used to simulate the irrigation water requirements and root zone flow terms over a period of four water years (October 1, 1997 to September 30, 2001) at a section of California's Central Valley (Figure 9) using field data as input. The reason for the selection of this area was that another project, CalSim 3.0 hydrology development, also addressed the same area.

Figure 9. *Model area and the simulation grid for Example 2*



CalSim is the CADWR's model used to simulate California State Water Project (SWP) and the Central Valley Project (CVP) operations. An earlier version of IDC was used during the CalSim 3.0 project so a large portion of the input data for this example was already developed. Furthermore, the modeled area intersected with seven Detailed Analysis Units (DAUs) (Figure 10). DAUs are the smallest study areas used by CADWR for analyses of water demand and supply, generally defined by hydrologic features or boundaries of organized water service agencies. CADWR has collected and developed extensive data sets for these regions. To test their accuracy, IDC results were compared to data developed for the seven DAUs that the model area intersects.

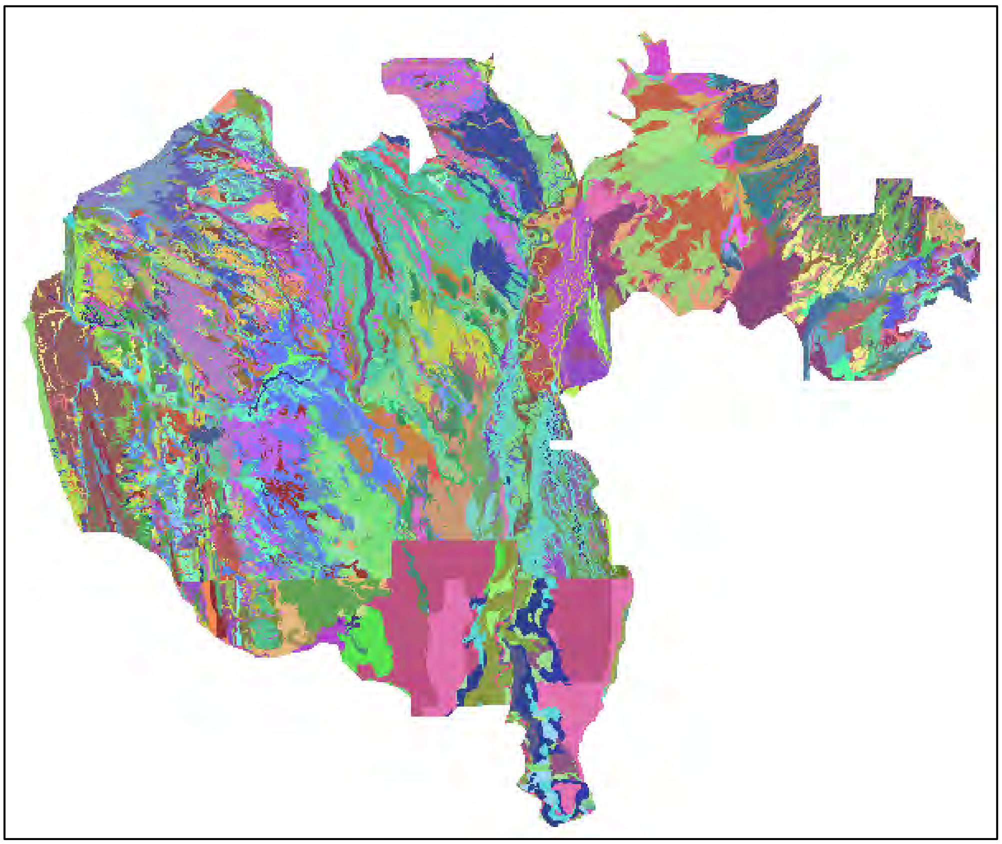
Figure 10. *DAUs in modeled area in Example 2*



The 2805 km^2 model area and the finite element grid for this example are shown in Figure 9. The simulation grid, which includes 2622 cells, was created using a mesh generator developed by CADWR as an add-on for ESRI's ArcGIS software. The part of each DAU that intersected with the model area was designated as an individual subregion (Figure 10) where subregions in IDC are used for aggregation and reporting of the simulation results.

The soil physical properties were compiled using the Natural Resources Conservation Service's (NRCS) Soil Survey Geographic Database (SSURGO). The soils map for the modeled area is shown in Figure 11 without the legend due to highly complex soil structure.

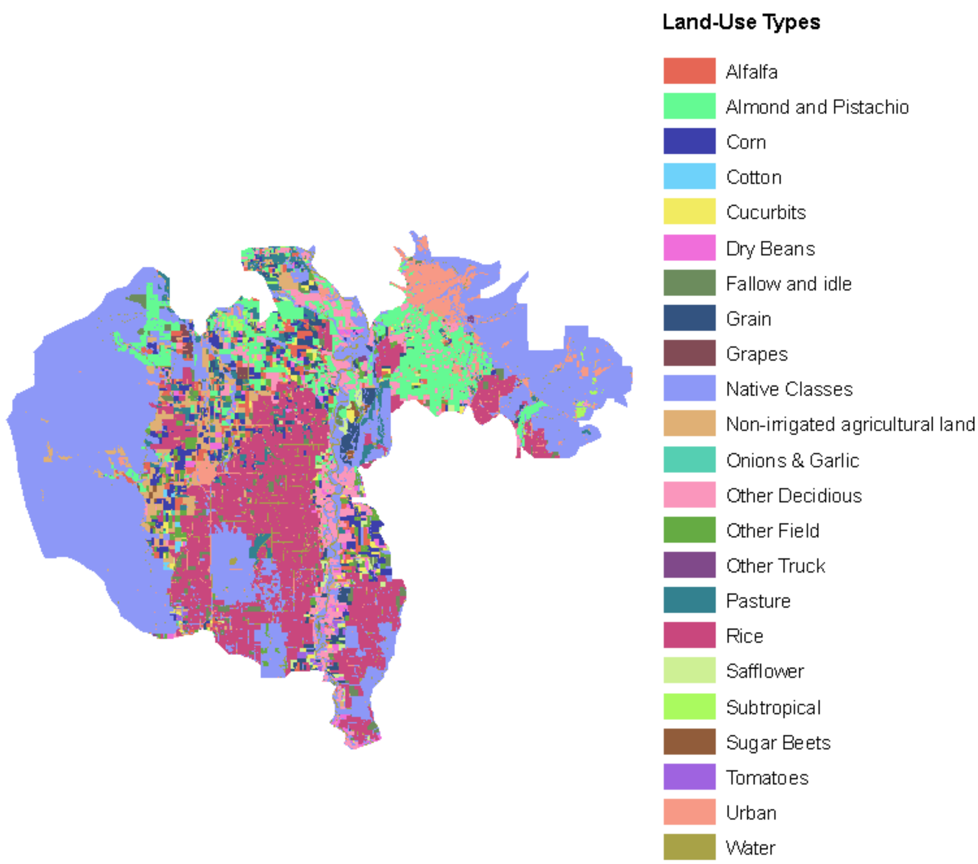
Figure 11. *Soils map for the model area*



Using the Soil Data Viewer software available from NRCS, the soil physical properties (field capacity, total porosity, saturated hydraulic conductivity and soil hydrologic group) were first averaged over soil horizons for each soil component. Properties defined for each component were then averaged for each soil map unit. Finally, properties defined for map units were intersected with simulation grid cells. Since each grid cell intersected with multiple map units, the physical soil properties were further area-averaged over grid cells to end up with a single value for each soil property for each element. The dominant surface soil texture for each grid cell was also identified and the arithmetic mean values for pore size distribution index listed in Rawls et al. (1982) were assigned to matching soil textures. Wilting point for each cell was set to zero.

The land-use map for the model area was available as a Geographic Information System (GIS) layer (Figure 12). The agricultural crops were grouped into 20 non-ponded crop types including fallow or idle areas, and rice fields. The modeled area also included urban areas, wildlife refuges and native vegetation. Total area of water and non-irrigated agricultural lands were minor, 2% and 4% of the total modeled area, respectively. Therefore these land-use types were incorporated into the lands with native vegetation (Figure 12). The land-use map was intersected with the finite element grid and the area of each land-use type over every grid cell was computed.

Figure 12. *Land-use types in the modeled area*



Precipitation data that was developed for Calsim 3.0 project using the PRISM climate data (PRISM, 2009) was utilized in this example.

ET data for each crop at each DAU obtained from DPLA changed from month to another and from year to year. However, it was zero for particular crops when they were not planted in certain years. On the other hand, the land-use areas used in this test was constant and did not change from year to year. Therefore, matching ET data from DPLA with constant land-use areas created a problem: in some years zero ET was assumed for land-use types whose area was not zero. To avoid this problem, ET data for each land use at each grid cell was obtained from the Calsim 3.0 project on a monthly basis. It changed from one month to another but the same monthly values were used for each water year.

Rice operations data such as ponding depths and return flow depths were all taken from CalSim 3.0 study whose source was the Northern District of CADWR.

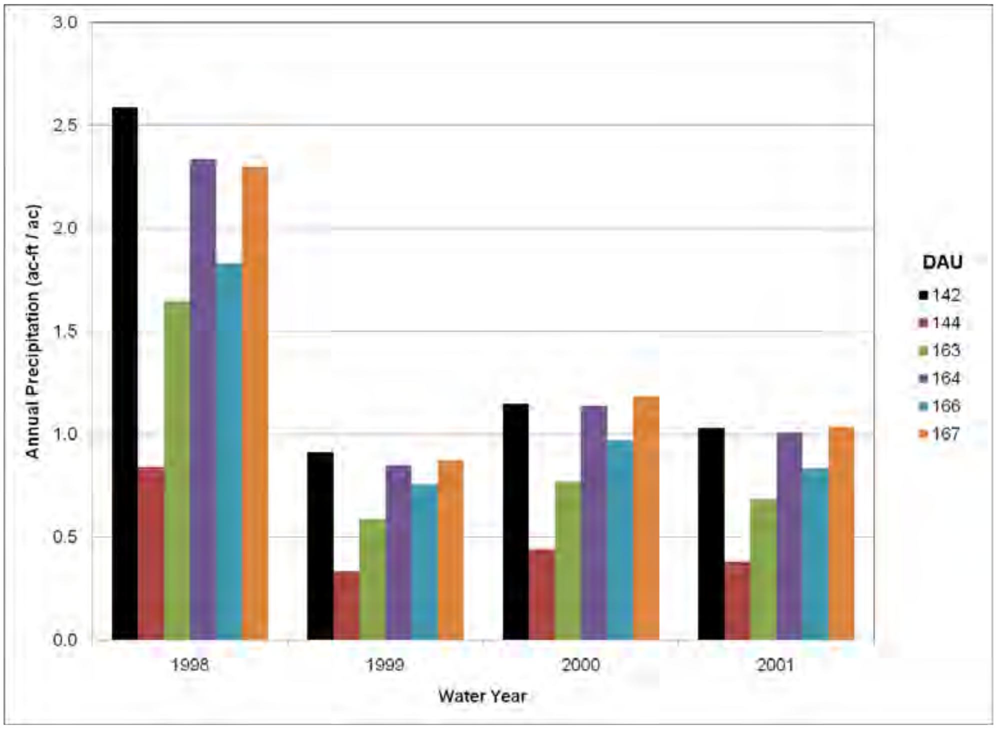
Even though the irrigation water demand data for modeled DAUs obtained from DPLA was for water years 1998 to 2001, IDC run was started from October 1, 1990; i.e. a spin-up period of eight years was used to ensure that the mixture of soil moisture storage due to irrigation and precipitation was realistic.

3.4.1. Results and Discussion

The data obtained from DPLA listed crop irrigation requirements for non-ponded agricultural crops and rice as well as ET_c for each DAU as unit rates in terms of acre-feet/acre. To be able to compare to DPLA values, IDC results were also converted to unit rates. Instead of comparing results for individual crops, the total irrigation requirements for each DAU for non-ponded crops computed by IDC were compared to total irrigation requirements for non-ponded crops obtained from DPLA. Irrigation requirement for rice from IDC and DPLA was compared individually since rice irrigation requires much more water than non-ponded crops.

Precipitation is one of the major drivers of the flow processes in IDC. Figure 13 shows the annual precipitation for each DAU.

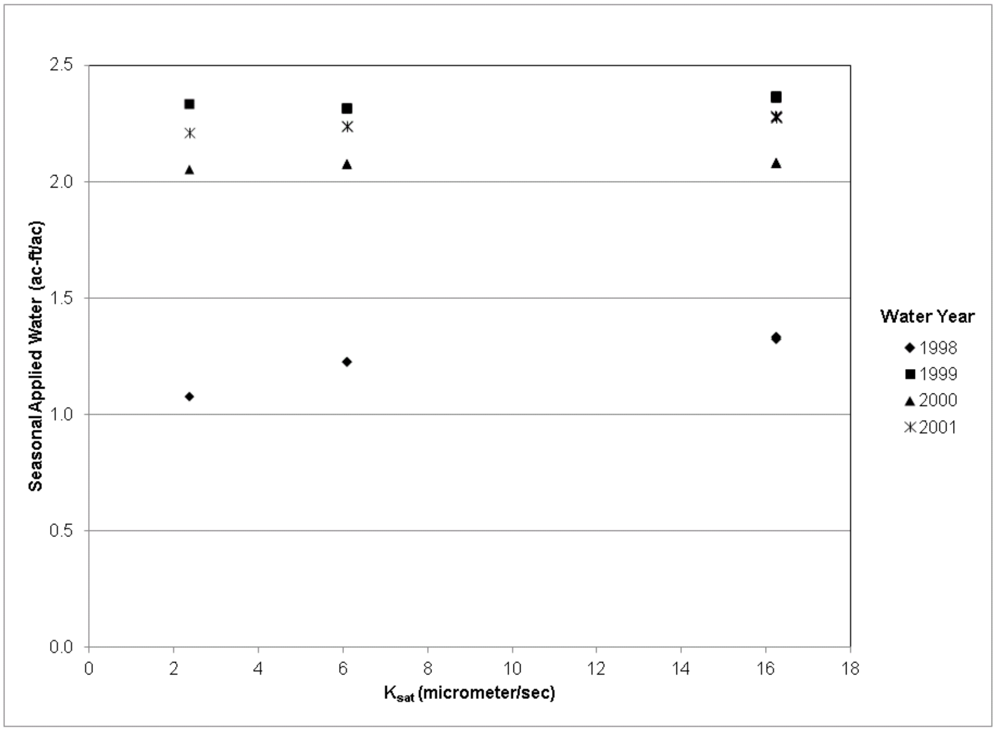
Figure 13. *Annual precipitation for each DAU*



The Soil Data Viewer from NRCS allows different ways of averaging of the soil physical properties. Also each soil physical property is assigned a lower and upper limit as well as a representative value. Combining the lower, upper and representative values with different averaging methods, one can obtain different values for each soil map unit. Figure 14 and Figure 15 show the simulated irrigation water requirements for non-ponded crops at DAU 142 and for rice in DAU 163, respectively, for varying average saturated hydraulic conductivities (K_{sat}). These DAUs were selected for analysis because DAU 142 had the largest percent non-ponded crop acreage (88% of the total modeled area of the DAU) and DAU 163 had the largest percent rice acreage (24% of the total modeled area of the DAU). Figure 14 shows results for four water years whereas Figure 15 shows those only for water year 2000 because there was no visible difference in the results from one year to another for rice irrigation requirements.

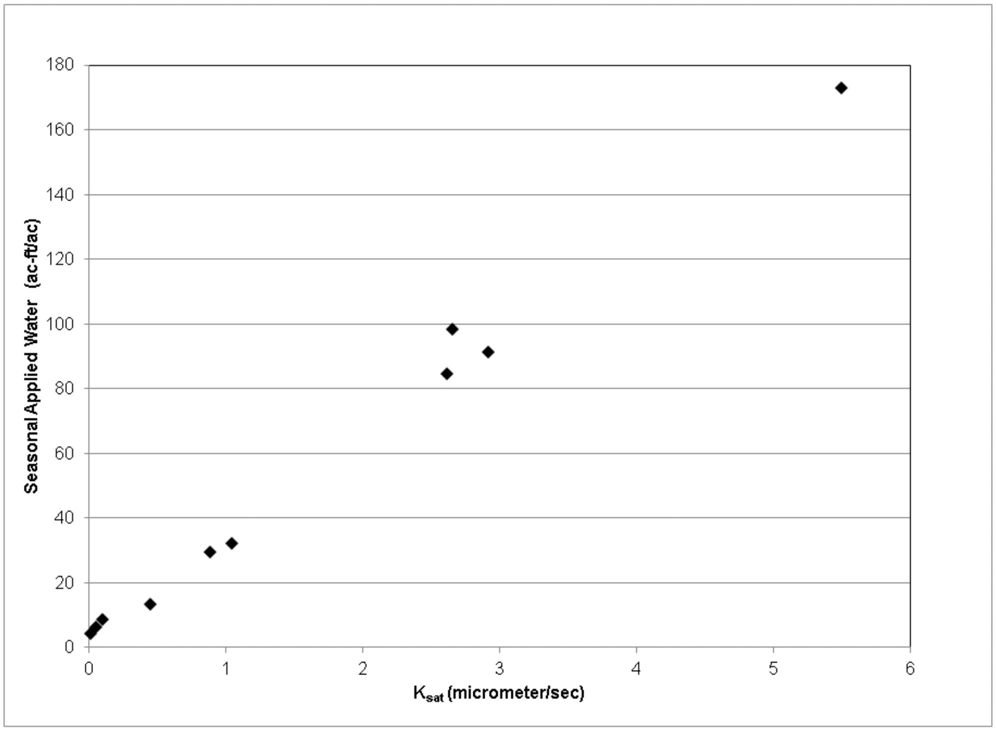
It can be seen that while irrigation water requirement for non-ponded crops is not extremely sensitive to K_{sat} (Figure 14), it is very sensitive in the case of rice (Figure 15).

Figure 14. *Seasonal irrigation water requirement versus saturated hydraulic conductivity for non-ponded crops at DAU 142*



This is expected since rice is grown under saturated conditions. However, even though K_{sat} values shown in Figure 15 were computed using the NRCS data, larger K_{sat} values lead to unreasonably high values of irrigation requirements for rice. In fact, using different averaging techniques featured in the NRCS Soil Data Viewer on upper, lower and representative K_{sat} values listed in the SSURGO database, the smallest average K_{sat} value obtained was 0.45 micrometers/sec. By contrast, DPLA assumes an average of 0.01 micrometer/sec (equivalent to 1 inch/month) percolation from rice fields in their analysis. This value is in line with other sources. For instance, Williams (2004) reports percolation at rice fields between 0.012 to 0.048 micrometers/sec (1.2 to 4.8 inches/month). Assuming that these rates represent the K_{sat} values, the smallest value obtained by averaging the data from SSURGO is one order of magnitude larger leading to large simulated irrigation requirements for rice. Although a visual inspection of SSURGO data showed that there were K_{sat} values as low as 0.001 micrometers/sec, this example shows that one needs to exercise caution when assigning K_{sat} values to grid elements where rice is grown.

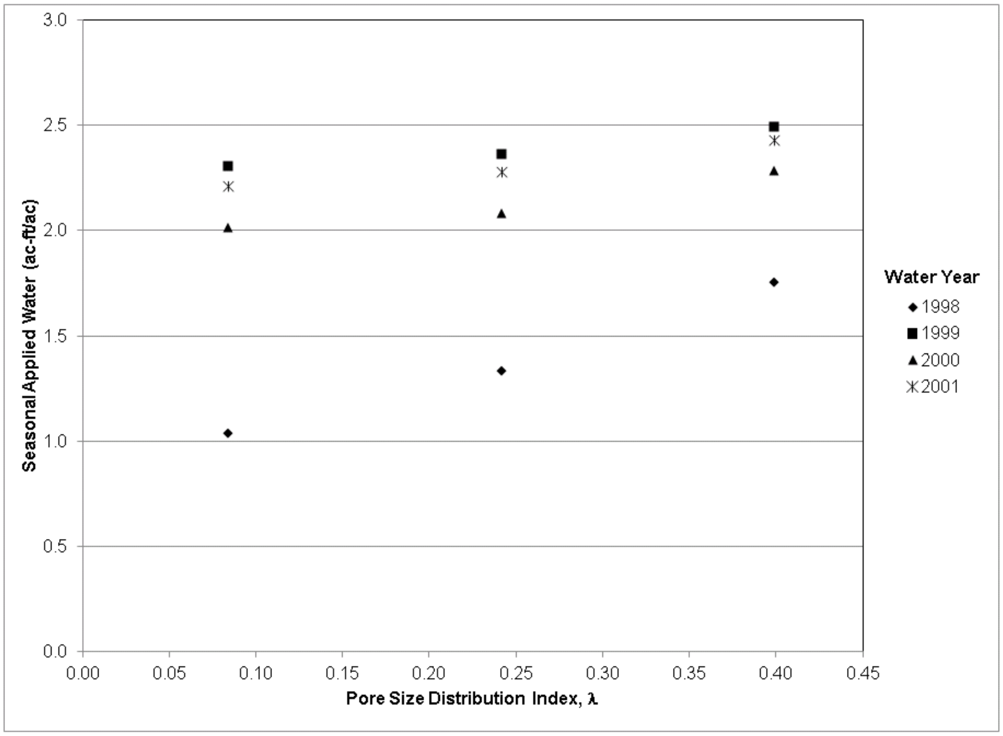
Figure 15. *Seasonal irrigation water requirement versus saturated hydraulic conductivity for rice at DAU 163 for water year 2000*



To test how IDC performs for rice fields with soil properties suggested by other sources, grid cells that had rice fields were assigned K_{sat} values of 0.01, 0.05 and 0.1 micrometers/sec. The irrigation requirement for rice computed by IDC for water year 2000 was 4.6, 6.4 and 8.7 ac-ft/ac for K_{sat} values of 0.01, 0.05 and 0.1 micrometers/sec, respectively. For comparison purposes, DPLA reports 5.8 ac-ft/ac and Williams (2004) reports an average value of 6 to 6.5 ac-ft/ac which can vary from 4 to 8 ac-ft/ac or more. This comparison suggests that IDC is capable of producing reasonable values for irrigation requirements at rice fields when grid cell K_{sat} values are set properly. In contrast, the rice irrigation requirement computed by IDC with the K_{sat} value at grid cells with rice set to the minimum values obtained by averaging the SSURGO data (0.45 micrometers/sec on average) was 13.6 ac-ft/ac.

As mentioned earlier, irrigation water requirement for non-ponded crops is not very sensitive to the changes in K_{sat} values (Figure 14). Figure 16 shows the seasonal irrigation water requirement (i.e. applied water) versus pore size distribution index, λ, for DAU 142 at different water years. For each soil texture, Rawls et al. (1982) list lower and upper limits as well as a representative value for λ.

Figure 16. *Seasonal irrigation water requirement versus pore size distribution index for non-ponded crops at DAU 142*



To generate Figure 16, IDC was run with the K_{sat} values computed by averaging representative values from SSURGO database combined with low, representative and high values of λ listed by Rawls et al. (1982). To gage the sensitivity of irrigation requirement to K_{sat} and λ values, linear best-fit curves were computed for simulation results shown in Figure 14 and Figure 16, respectively; high gradient of the best-fit curve represented high sensitivity. The gradient of the best-fit line for K_{sat} versus irrigation requirement varied from 0.0007 for year 2000 to 0.014 for year 1998, whereas for λ versus irrigation requirement it varied from 0.505 for year 2001 to 2.169 for year 1998.

As a summary, one needs to choose K_{sat} values carefully for grid cells where rice is grown. K_{sat} values will not affect the irrigation requirements for non-ponded crops in these cells because they are insensitive to changes in K_{sat} values. On the other hand, to change the irrigation requirement for non-ponded crops one can modify λ with minimal effect on the values computed for rice.

Table 3 shows a general comparison of simulation results for non-ponded crops compared to DPLA values when K_{sat} at grid cells with rice was set to 0.01

micrometers/sec. Percolation from DPLA was not available so these values are shown as n/a (not applicable). One can see in Table 3 that the annual ET rates from DPLA change from one year to another, whereas IDC values are constant. This difference is likely to cause other values to be different as well.

Table 3. *Comparison of IDC results for non-ponded crops to the values obtained from DPLA with K_{sat} values at cells with rice set to 0.01 micrometers/sec (all values are in ac-ft/ac; n/a = not applicable)*

DAU (Water Year)	ET IDC	ET DPLA	A_W IDC	A_W DPLA	ETaw IDC	ETaw DPLA	ETp IDC	ETp DPLA	P_C IDC	P_C DPLA
142 (1998)	2.65	2.18	1.74	1.66	1.16	1.24	1.49	0.94	0.63	n/a
144 (1998)	2.71	2.68	2.10	1.91	1.23	1.50	1.48	1.17	1.09	n/a
163 (1998)	2.34	2.19	1.50	2.04	1.02	1.47	1.32	0.72	0.33	n/a
164 (1998)	2.51	2.38	1.20	2.05	0.85	1.52	1.66	0.87	0.40	n/a
166 (1998)	2.80	2.54	1.91	2.11	1.13	1.56	1.67	0.98	0.91	n/a
167 (1998)	2.01	1.98	1.28	1.47	0.75	1.09	1.26	0.89	0.62	n/a
142 (1999)	2.65	2.56	2.49	2.57	1.76	1.92	0.89	0.64	0.02	n/a
144 (1999)	2.71	2.65	2.78	2.56	1.79	2.01	0.92	0.65	0.12	n/a
163 (1999)	2.33	2.49	2.26	3.28	1.55	2.04	0.78	0.45	0.02	n/a
164 (1999)	2.50	2.74	2.26	3.47	1.50	2.19	1.00	0.55	0.01	n/a
166 (1999)	2.80	2.88	2.56	3.11	1.65	2.29	1.15	0.59	0.16	n/a
167 (1999)	2.01	2.17	1.89	2.32	1.15	1.56	0.86	0.60	0.06	n/a
142 (2000)	2.65	2.60	2.28	2.49	1.64	1.87	1.00	0.74	0.07	n/a
144 (2000)	2.71	3.22	2.52	2.86	1.65	2.26	1.07	0.96	0.27	n/a
163 (2000)	2.33	2.53	2.07	2.63	1.44	1.92	0.90	0.61	0.04	n/a
164 (2000)	2.51	2.77	1.93	2.71	1.36	2.00	1.14	0.76	0.02	n/a
166 (2000)	2.80	2.97	2.30	2.96	1.57	2.24	1.23	0.74	0.29	n/a
167 (2000)	2.01	2.33	1.63	2.13	1.04	1.57	0.97	0.76	0.11	n/a
142 (2001)	2.65	2.67	2.42	2.66	1.76	2.01	0.89	0.66	0.05	n/a
144 (2001)	2.71	3.32	2.68	3.23	1.75	2.53	0.96	0.79	0.20	n/a
163 (2001)	2.33	2.60	2.17	2.88	1.55	2.10	0.78	0.50	0.03	n/a
164 (2001)	2.51	2.88	2.09	2.95	1.50	2.20	1.01	0.68	0.01	n/a
166 (2001)	2.80	3.08	2.61	3.19	1.66	2.40	1.14	0.68	0.20	n/a
167 (2001)	2.01	2.37	1.84	2.29	1.14	1.70	0.87	0.67	0.08	n/a

Furthermore, precipitation data used in DPLA analysis was not available. It was also observed that some crops that were present in some subregions in IDC had zero acreage in DPLA's data. The likelihood of precipitation data being different from IDC data along with different ET rates and different crop areas is responsible for some of the differences among other values such as applied water. Also, ETaw is constantly lower in IDC than in DPLA data, whereas ETp is higher. This means that DPLA values will lead to a higher irrigation efficiency than IDC values. This difference is likely due to different methods used for computing ETaw and ETp as well as different ET and precipitation input data. It also appears that since applied water is generally lower in IDC (see Table 3), it is likely that the infiltration of precipitation in IDC is estimated higher compared with those in DPLA. By increasing the curve numbers in IDC, the infiltration of precipitation can be decreased which will lead to increased applied water with increased ETaw and decreased ETp. Overall, however, the values from IDC and DPLA are reasonably close given the fact that there was no effort to calibrate IDC to match values from DPLA.

Similarly, Table 4 shows the comparison of IDC and DPLA values for rice. As for Table 3, IDC results were obtained by setting the K_{sat} values for grid cells that include rice fields to 0.01 micrometers/sec. It can be seen that ET values are generally lower in IDC than DPLA, with the exception of 1998. For 1998, ET values are closer to each other. It appears that due to different ET rates, applied water and ETaw are also lower in IDC for years 1999 through 2001. Since ET rates are similar for 1998, these values are also close to each other for 1998. Overall, the results match relatively well compared to the results for non-ponded crops.

Table 4. *Comparison of IDC results for rice to the values obtained from DPLA with Ksat values at cells with rice set to 0.01 micrometers/sec (all values are in ac-ft/ac; n/a = not applicable)*

DAU (Water Year)	**ET** IDC	**ET** DPLA	**A_w** IDC	**A_w** DPLA	**ETaw** IDC	**ETaw** DPLA	**ETp** IDC	**ETp** DPLA	**P_c** IDC	**P_c** DPLA
142 (1998)	3.32	2.50	5.27	4.36	2.93	2.48	0.37	0.02	0.55	n/a
144 (1998)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a
163 (1998)	2.78	2.50	4.49	4.22	2.47	2.40	0.29	0.10	0.51	n/a
164 (1998)	2.94	2.55	4.75	4.29	2.61	2.44	0.30	0.12	0.50	n/a
166 (1998)	3.49	2.53	5.87	4.25	3.16	2.42	0.30	0.12	0.66	n/a
167 (1998)	3.49	2.50	5.85	4.21	3.16	2.40	0.30	0.10	0.65	n/a
142 (1999)	3.32	3.30	5.40	7.73	3.02	3.19	0.27	0.12	0.53	n/a
144 (1999)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a
163 (1999)	2.78	3.30	4.59	6.18	2.54	3.10	0.22	0.20	0.47	n/a
164 (1999)	2.94	3.26	4.85	5.98	2.68	3.06	0.23	0.20	0.49	n/a
166 (1999)	3.49	3.30	5.97	7.76	3.23	3.09	0.23	0.21	0.65	n/a
167 (1999)	3.49	3.30	5.94	6.18	3.22	3.10	0.23	0.20	0.65	n/a
142 (2000)	3.32	3.23	5.38	5.34	2.99	3.05	0.30	0.19	0.53	n/a
144 (2000)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a
163 (2000)	2.78	3.39	4.58	5.78	2.53	3.29	0.23	0.10	0.47	n/a
164 (2000)	2.94	3.31	4.85	5.62	2.67	3.19	0.24	0.13	0.49	n/a
166 (2000)	3.49	3.37	5.96	5.73	3.21	3.26	0.25	0.11	0.65	n/a
167 (2000)	3.48	3.40	5.95	5.79	3.21	3.30	0.24	0.10	0.65	n/a
142 (2001)	3.32	3.45	5.43	5.71	3.03	3.25	0.26	0.20	0.53	n/a
144 (2001)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a
163 (2001)	2.78	3.60	4.62	5.96	2.56	3.40	0.20	0.20	0.47	n/a
164 (2001)	2.94	3.54	4.89	5.90	2.70	3.34	0.21	0.20	0.49	n/a
166 (2001)	3.49	3.59	5.97	5.96	3.22	3.39	0.24	0.20	0.65	n/a
167 (2001)	3.49	3.60	5.99	5.96	3.24	3.40	0.21	0.20	0.65	n/a

4. Root Zone Component Version 4.01

This version is exactly the same as version 4.0 except that it allows the user to print out Z-Budget data files for Land and Water Use as well as the Root Zone budgets. These files can then be post-processed using the Z-Budget tool to analyze the water demand, water supply and the root zone water budget for elements grouped into zones by the user. Land and Water Use Z-Budget and Root Zone Z-Budget outputs will be discussed later in this document. The input files to run the Z-Budget post-processing tool are described in the *User's Manual for IWFM-2015* (Dogrul 2021b).

5. Root Zone Component Version 4.1

This version is very similar to version 4.0 as described in the previous chapter. In addition to all the features of version 4.0, it includes two new capabilities, namely the riparian vegetation access to stream flow to meet the evapotranspirative demands and the root water uptake from groundwater. The root water uptake from groundwater requires depth-to-groundwater information which can be specified by the user as a time series data. However, IDC, when executed on its own, has no information about the stream flows. Therefore, riparian vegetation access to stream flow to meet the evapotranspirative demands is only effective when IDC is linked to an integrated hydrologic model such as IWFM that simulates both stream flows. When IDC is executed on its own, this feature will simply be ignored.

Since all the flow routing and demand calculations that are explained for version 4.0 are the same in version 4.1, these simulation methods will not be iterated here. Instead, only the new features will be detailed in the following sections.

5.1. Riparian Vegetation Access to Stream Flows

In version 4.0 of the root zone component, the only sources of moisture to meet the evapotranspirative demand of riparian vegetation are precipitation, any moisture that is already stored in the root zone and user-specified generic sources, if any. In the real-world, riparian vegetation grows near streams and part of the evapotranspirative demand is met by stream flow, either directly or by the moisture in the root zone that is due to stream flow seepage.

In IDC, the user specifies the stream node for each grid cell from which riparian vegetation in that cell will meet part or all of its evapotraspirative demand. Any grid cell that is away from streams with no riparian vegetation is assigned a stream node number of zero.

IDC uses the stream flow to meet the riparian water demand after considering the contribution of moisture that is already available in the root zone, precipitation, and any moisture from generic sources. First, equation (1) is solved to calculate the actual evapotranspiration at the end of the time step, ET^{t+1}, to check if it is less than the potential evapotranspiration specified by the user for riparian vegetation.

The required amount of water from the stream to meet the unmet riparian demand is calculated as

$$ET_{strm,pot}^{t+1} = ET_{pot}^{t+1} - ET^{t+1} \geq 0 \tag{39}$$

where $ET_{strm,pot}^{t+1}$ is the potential rate of evapotranspiration to be taken out of the stream (L/T). The actual amount, ET_{strm}^{t+1}, depends on the actual stream flow that is available at the stream node that the grid cell is connected to and it is found only after the entire integrated hydrologic system is simulated (as mentioned earlier, riparian evapotranspiration from streams is only simulated when IDC is linked to an integrated hydrologic model):

$$ET_{strm}^{t+1} = \frac{\min\left(ET_{strm,pot}^{t+1} A_{rip}^{t+1} \, , \, Q_{strm}^{t+1}\right)}{A_{rip}^{t+1}} \tag{40}$$

where ET_{strm}^{t+1} is the actual evapotranspiration from the stream (L/T), A_{rip}^{t+1} is the area of the riparian vegetation at the grid cell for which root zone flow processes are simulated (L^2),and Q_{strm}^{t+1} is the simulated stream flow (L^3/T). Once ET_{strm}^{t+1} is calculated, the total riparian vegetation evapotranspiration is calculated as

$$ET_{total}^{t+1} = ET_{strm}^{t+1} + ET^{t+1} \tag{41}$$

where ET_{total}^{t+1} is the total riparian vegetation evapotranspiration (L/T).

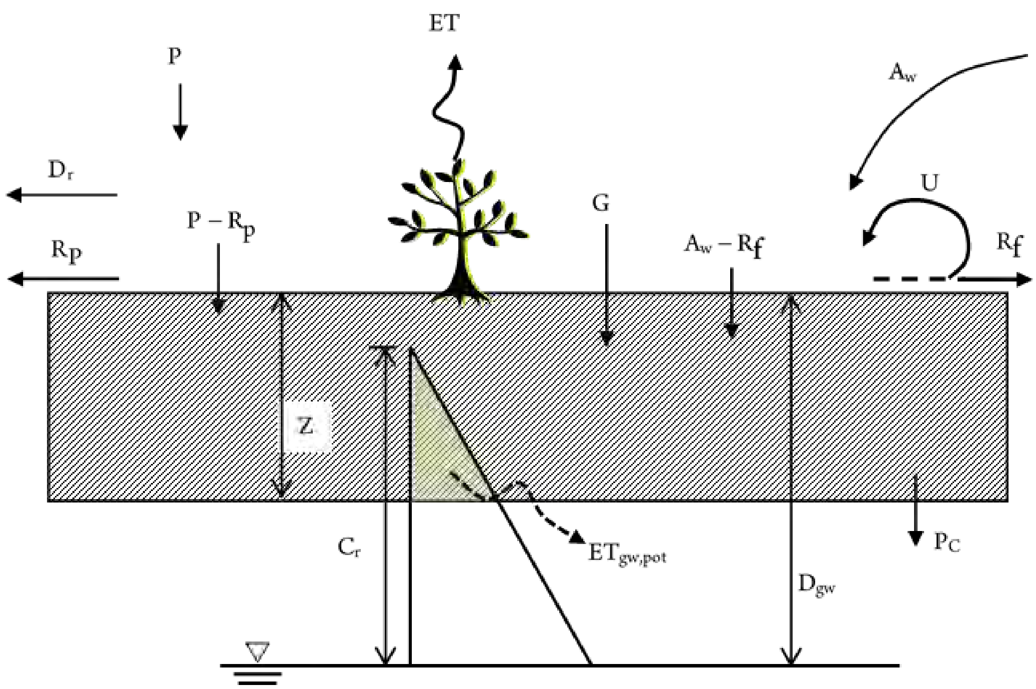
IDC assumes that all stream flow contribution to evapotranspiration of riparian vegetation is direct; i.e. the mechanism of the stream flow first seeping into the root zone before meeting the evapotranspiration is ignored. This is because of the conceptual set-up used in IDC where the flow exchange between the root zone and the stream system is not considered in order to minimize the computer run-times. On the other hand, the next section discusses the optional simulation of root water uptake from groundwater which can implicitly handle the case where the stream flow first seeps into the groundwater before potentially contributing to the riparian evapotranspiration through root water uptake.

5.2. Root Water Uptake from Groundwater

Shallow groundwater can meet part or all of the plant evapotranspirative demand. In IDC, groundwater contribution to evapotranspiration is considered as the first source of moisture that is available to the plants. As will be explained later, one of the information IDC requires to compute the root water uptake from groundwater is the depth-to-groundwater. When IDC is run as a stand-alone program the user can specify time series depth-to-groundwater data at each finite element cell. This data can be obtained either from field measurements or from separate groundwater models. If IDC is executed as a linked component of an integrated hydrologic model such as IWFM, depth-to-groundwater is calculated dynamically by the integrated hydrologic model and passed to IDC.

Figure 17 shows a schematic representation of the root zone and root water uptake from groundwater as simulated by IDC.

Figure 17. *Schematic representation of root zone and root water uptake from groundwater*



At each grid cell the user specifies a capillary rise above the saturated groundwater table. IDC assumes that the soil moisture content at the groundwater table is at total porosity (assumed equal to the specific yield of the aquifer material) and declines linearly to zero at a height equal to the capillary rise above the groundwater table. The maximum potential root water uptake from groundwater is calculated as the part of the capillary rise and the saturated groundwater that intersect with the root zone:

$$ET_{gw,pot}^{t+1} = \begin{cases} 0 & \text{if} \quad C_r + Z^{t+1} \le D_{gw}^t \\ \dfrac{S_y\left(Z^{t+1} - D_{gw}^t + C_r\right)^2}{2\Delta t C_r} & \text{if} \quad D_{gw}^t > C_r \quad ; \quad D_{gw}^t > Z^{t+1} \\ \dfrac{S_y Z^{t+1}}{\Delta t C_r}\left(\dfrac{Z^{t+1}}{2} + C_r - D_{gw}^t\right) & \text{if} \quad D_{gw}^t \le C_r \quad ; \quad D_{gw}^t > Z^{t+1} \\ \dfrac{S_y}{\Delta t}\left(Z^{t+1} - D_{gw}^t\right) & \text{if} \quad C_r = 0 \quad ; \quad D_{gw}^t \le Z^{t+1} \\ \dfrac{S_y C_r}{2\Delta t} + \dfrac{S_y}{\Delta t}\left(Z^{t+1} - D_{gw}^t\right) & \text{if} \quad C_r > 0 \quad ; \quad D_{gw}^t > C_r \quad ; \quad D_{gw}^t \le Z^{t+1} \\ \dfrac{S_y}{2\Delta t C_r}\left[2C_r Z^{t+1} - \left(D_{gw}^t\right)^2\right] & \text{if} \quad C_r > 0 \quad ; \quad D_{gw}^t \le C_r \quad ; \quad D_{gw}^t \le Z^{t+1} \end{cases} \tag{42}$$

where $ET_{gw,pot}^{t+1}$ is the maximum potential root water uptake from groundwater (L/T), S_y is the aquifer specific yield (dimensionless), D_{gw}^t is the depth-to-groundwater (computed as the ground surface elevation less the groundwater head) at the beginning of time step (L), C_r is the height of capillary rise above the groundwater table (L), and Δt is the simulation time step length (T). In equation (42), already known value of the depth-to-groundwater at the beginning of the time step is used to avoid additional iterations between IDC and the groundwater simulation component of the integrated hydrologic model that would arise if the unknown head at the current time step were used.

The actual root water uptake from groundwater is calculated as

$$ET_{gw}^{t+1} = \min\left(ET_{pot}^{t+1} \ , \ ET_{gw,pot}^{t+1}\right) \tag{43}$$

If IDC is linked to an integrated hydrologic model, then ET_{gw}^{t+1} in (43) becomes a sink term for the groundwater component of the model.

When simulated, root water uptake from groundwater also affects the demand for irrigation water for ponded and non-ponded crops. For non-ponded crops, IDC uses either equation (23) or equation (26) to calculate the irrigation water demand, depending on if IDC is asked to maintain a minimum percolation, whereas for ponded crops it uses equation (28). To calculate the effect of groundwater on irrigation water demand, IDC uses a modified potential ET, $ET_{pot,mod}$, in equations (23), (26) or (28) by considering the ability of groundwater to meet part or all of the potential crop ET. Therefore, the irrigation water demand when root water uptake from groundwater is considered is calculated by using the modified potential ET instead of the original potential ET:

$$A_w^{t+1} = f\left(ET_{pot,mod}^{t+1}\right) \tag{44}$$

where

$$ET_{pot,mod}^{t+1} = \max\left(0 \ , \ ET_{pot}^{t+1} - ET_{gw,pot}^{t+1}\right) \tag{45}$$

6. Root Zone Component Version 4.11

This version is exactly the same as version 4.1 except that it allows the user to print out Z-Budget data files for Land and Water Use as well as the Root Zone budgets. These files can then be post-processed using the Z-Budget tool to analyze the water demand, water supply and the root zone water budget for elements grouped into zones by the user. Land and Water Use Z-Budget and Root Zone Z-Budget outputs will be discussed later in this document. The input files to run the Z-Budget post-processing tool are described in the *User's Manual for IWFM-2015* (Dogrul 2021b).

7. Root Zone Component Version 5.0

This version of the root zone component uses similar methods as in version 4.0 to compute water demands and route the water through the root zone, but for an average agricultural crop, and for each land use and soil type combination.

The user specifies as many soil types as is necessary for the application along with their soil parameters (wilting point, field capacity, total porosity, saturated hydraulic conductivity and pore size distribution index) and each grid cell is associated with one of these soil types. The user also specifies as many agricultural cops as required by the application along with the crop and irrigation management parameters as well as the evapotranspiration. Additionally, the individual crop areas are specified at each subregion (subregions are groups of elements that represent sub-areas within the model domain) while total agricultural areas are specified for each grid cell. Based on the subregional crop areas IDC calculates area-weighted average crop characteristics that are then used in calculating average agricultural water demand and in routing water through the agricultural root zone at each soil type.

The urban and average agricultural water demands as well as the root zone flow terms for agricultural, urban, native and riparian vegetation areas are computed in unit rates at each soil type. By multiplying these values with the area of each of the four land use type in a cell leads to cell-level volumetric water demands and root zone flows.

Root zone component version 5.0 is developed mainly to provide backward compatibility to the older versions of IDC prior to version 4.0. Although it is not as accurate as versions 4.0 through 4.11, mainly because it simulates agricultural flows for an average crop, it can be used as a screening tool to quickly analyze the effects of management alternatives.

8. Running IDC

IDC can be executed as a stand-alone model or it can be linked to other simulation models that operate on finite-element or finite-difference type computational grids. Both the source code and the compiled executables are available for download from the IDC web site at https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model-Demand-Calculator. IDC, either executed as a stand-alone model or linked to other simulation models, requires a main control input file that lists the names of data files used for the simulation, the simulation period and length of time step, as well as the output options. Depending on the specifications listed in the input data files, one or more output files are generated. These files store simulated water budget information at each subregion or each grid cell and they are in HDF5 file format. Another program, Budget.exe, is required to process the subregional files and generate water budget tables in ASCII text format. Z-Budget.exe program is used to process cell-level water budget information and aggregate them for user-defined zones which are groups of cells. Budget.exe and Z-Budget.exe are also available for download from IWFM web site. Next, the IDC's time-tracking feature as well as input files that are used and output files that are generated by IDC are discussed.

8.1. Simulation Time Tracking

To better represent the temporal distribution of input and output data, IDC keeps track of the actual date and time of each time step in a simulation period. Each data entry in input time series data files is required to have a date and time stamp which allows IDC to retrieve time series data correctly. This, in return, allows the user to maintain a single set of time series input data files for applications where the starting and ending date and time of the simulation may change. For example, during the calibration stage of a project, the simulation is run for two periods: calibration period and the verification period. In a time tracking simulation, time series input data files can be prepared so that the data covers both the calibration and verification periods. Then the same time series data files can be used for both calibration and verification runs without the need for modification. Since a time tracking simulation keeps track of actual date and time of each of the simulation time steps, IDC can retrieve the correct data from the time series data files.

Time tracking simulations allow usage of HEC-DSS files as well as ASCII text files for time series data input and output. HEC-DSS is a database format designed by Hydrologic Engineering Center (HEC) of U.S. Army Corps of Engineers specifically for time-series data encountered in hydrologic applications. These files allow efficient storage and retrieval of hydrologic time series data, and HEC offers free utilities (HEC-DSSVue and DSS Excel add-in) for manipulation, visualization and analysis of data stored in DSS files. These utilities and instructions on how to use DSS files can be downloaded from HEC web site at www.hec.usace.army.mil.

Another advantage of time tracking simulations is that results that are printed to output files have date and time stamps associated with them. This allows easy comparison of simulation results to observed values which generally come with the date and time of observation.

8.1.1. Length of Simulation Time Step

In order to be consistent with the standards of HEC-DSS database files, IDC restricts the length of simulation time step that can be used in an application. The allowable time step lengths are listed in Table 5.

Table 5. *List of allowable time step lengths in IDC simulations*

Time Step Length	IDC Notation
1 minute	1MIN
2 minutes	2MIN
3 minutes	3MIN
4 minutes	4MIN
5 minutes	5MIN
10 minutes	10MIN
15 minutes	15MIN
20 minutes	20MIN
30 minutes	30MIN

Time Step Length	IDC Notation
1 hour	1HOUR
2 hours	2HOUR
3 hours	3HOUR
4 hours	4HOUR
6 hours	6HOUR
8 hours	8HOUR
12 hours	12HOUR

Time Step Length	IDC Notation
1 day	1DAY
1 week	1WEEK
1 month	1MON
1 year	1YEAR

8.1.2. Time Step Format

In IDC, start and end date and time of simulation period as well as the date and time of each data entry in time series data input files are required to be specified by using a time stamp. The format of the time stamp is as follows:

MM/DD/YYYY_hh:mm

where

MM	=	two digit month index;
DD	=	two digit day index;
YYYY	=	four digit year;
hh	=	two digit hour in terms of military time (e.g. 1:00pm is represented as 13:00);
mm	=	two digit minute.

The time is represented in military time and midnight is referred to as 24:00. For instance, 05/28/1973_24:00 represents the midnight on the night of May 28, 1973. Another example is the starting date and time of a simulation period: if the initial conditions for a daily simulation is given for the end of September 30, 1975, then the time stamp for the starting date and time of the simulation will be 09/30/1975_24:00. The first simulation result will be printed for October 1, 1975 at midnight with the time stamp 10/01/1975_24:00.

8.1.3. Preparation of Time Series Data Input Files

The user is allowed to use a mixture of ASCII text and DSS files for time series input data. In preparing these files, the rules listed below should be followed:

1. The data should have a regular interval. Gaps in the data are not allowed. For instance, if the data is monthly a value for every month should be entered.
2. The time stamp of the data represents the end of the interval for which the data is valid. For instance, in monthly time series evapotranspiration data, a data point time stamped with 08/31/1995_24:00 represents the evapotranspiration that occurred in August of 1995. As another example, if the starting date and time of the simulation period is 12/31/1970_24:00 (i.e. initial conditions are given at the midnight of December 31, 1970) in a daily simulation, then IDC will search for the time series data time-stamped as 01/01/1971_24:00 (data for January 1st in 1971) in the time series input files.
3. The smallest interval that can be used for time series data is 1 minute.

4. A time series input data can be constant throughout the simulation period. If an ASCII text file is used for data input, the time stamp for the constant value can be set to a date and time that is greater than the ending date and time of the simulation period. For instance, if the simulation period ends at 06/15/2003_18:00 (6:00pm on June 15, 2003), then the constant value can have a time stamp 12/31/2100_24:00 (midnight on the night of December 31, 2100). IDC reads the constant value for the midnight of December 31, 2100 and uses this value for all simulation times before this date and time. Generally, time series input files include conversion factors to convert only the "spatial" component of the input data unit. The temporal unit is deduced from the time interval of the input data. In the case of constant time series data, IDC is not able to obtain the time interval and, hence, the temporal unit. If a constant value for time series data is used, the user should make sure that appropriate conversion factors are supplied so that the temporal and spatial units of the input data are consistent with those used internally during the simulation. Time series data that is constant can also be represented in DSS files but this is not suggested.
5. For rate-type time series data (e.g. evapotranspiration data), the time unit is assumed to be the interval of data. For instance, if the evapotranspiration data is entered monthly, IDC assumes that the time unit of the evapotranspiration rates is 1 month. When time series data is a constant value for the entire simulation period IDC has no way to figure out the time unit of the input data. In this case the user should make sure that the time unit of data is the same as the consistent time unit of simulation.
6. For recycled time series data (e.g. fraction of total urban water that is used indoors given for each month but do not change from one year to the other), the year of the time stamp can be set to 4000. Year 4000 is a special flag for IDC such that it replaces year 4000 with the simulation year to retrieve the appropriate data from the input file. As an example, consider the time series data in Table 6 for the fraction of total urban water that is used indoors. This data set represents that for the initial third of each simulation year the urban water indoors usage fraction is 0.7, for the second third it is 0.5 and for the last third it is 0.35. Recycled time series data can be used in both ASCII text and DSS files.

Table 6. *Example for the representation of recycled time series data*

Time Stamp	Fraction of Urban Indoors Water
04/30/4000_24:00	0.70
08/31/4000_24:00	0.50
12/31/4000_24:00	0.35

If a monthly time series data is to be recycled the user should enter the time stamp for the last day of February as 02/29/4000_24:00 to address both the leap and non-leap years.

The interval of time series data is required to be synchronized with the simulation time step. Table 7 shows examples of accepted and unaccepted situations. It should be noted that IDC will continue to read data from the input files even if the data interval is not properly synchronized with the simulation time step. However, in such cases there is no guarantee that the correct data will be retrieved from the input file. Therefore, it is up to the user to ensure correct synchronization between the input data and the simulation time step.

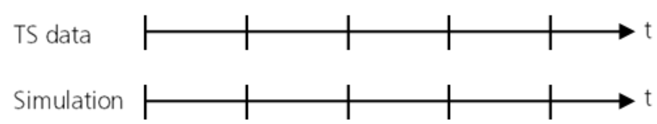
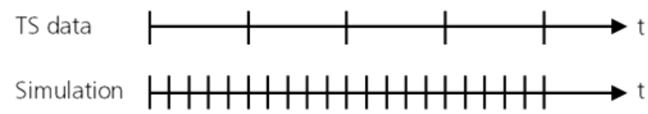
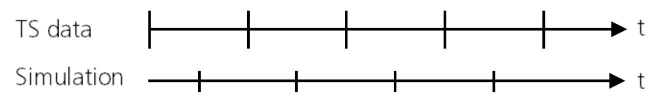
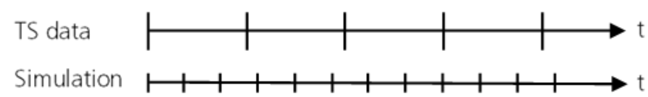
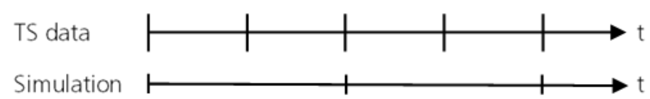
8.2. Input and Output Data File Types

IDC can access multiple file formats: (i) ASCII text, (ii) HDF5 and (iii) HEC-DSS files. The user can use several file formats in a single application. For instance, some of the input time series data can be read from HEC-DSS files whereas the rest can be read from ASCII text files. Some of the time series simulation results can be printed out to ASCII text files and the others can be printed out to HEC-DSS files.

Although IDC allows usage of several file formats in a single application, some of the input and output files are required to be in specific formats. For instance, all budget output files generated by IDC and read in by Budget post-processors are required to be in HDF5 format. Another example is the main control input file for all IDC: this file is required to be in ASCII text file format.

IDC recognizes the file formats from the file name extensions. Table 8 lists the extensions that are recognized by IDC for each of the file formats.

Table 7. *Examples for acceptable and unacceptable cases for the synchronization of time series data interval and the simulation time step*

Situation	Graphical Representation	Accepted
Monthly time series data, monthly simulation		Yes
Monthly time series data, daily simulation		Yes
Monthly time series data, monthly simulation (TS data times don't match simulation times)		No
Monthly time series data, weekly simulation		No
Monthly time series data, yearly simulation		No

8.3. Input Files

Input files in IDC include comment lines as well as the input data itself. A line with one of "C", "c" or "*" at the first column is identified as a comment line. The inclusion of comment lines allows IDC files to be self-documenting. The purpose of each file along with the description of each input data are already included in IDC input file templates, and the user can include explanations for the data development directly in the input files using the comment lines.

A schematic representation of IDC input file structure is given in Figure 18. A Main Input File serves as the starting point for an IDC simulation.

Table 8. *Filename extensions recognized by IDC*

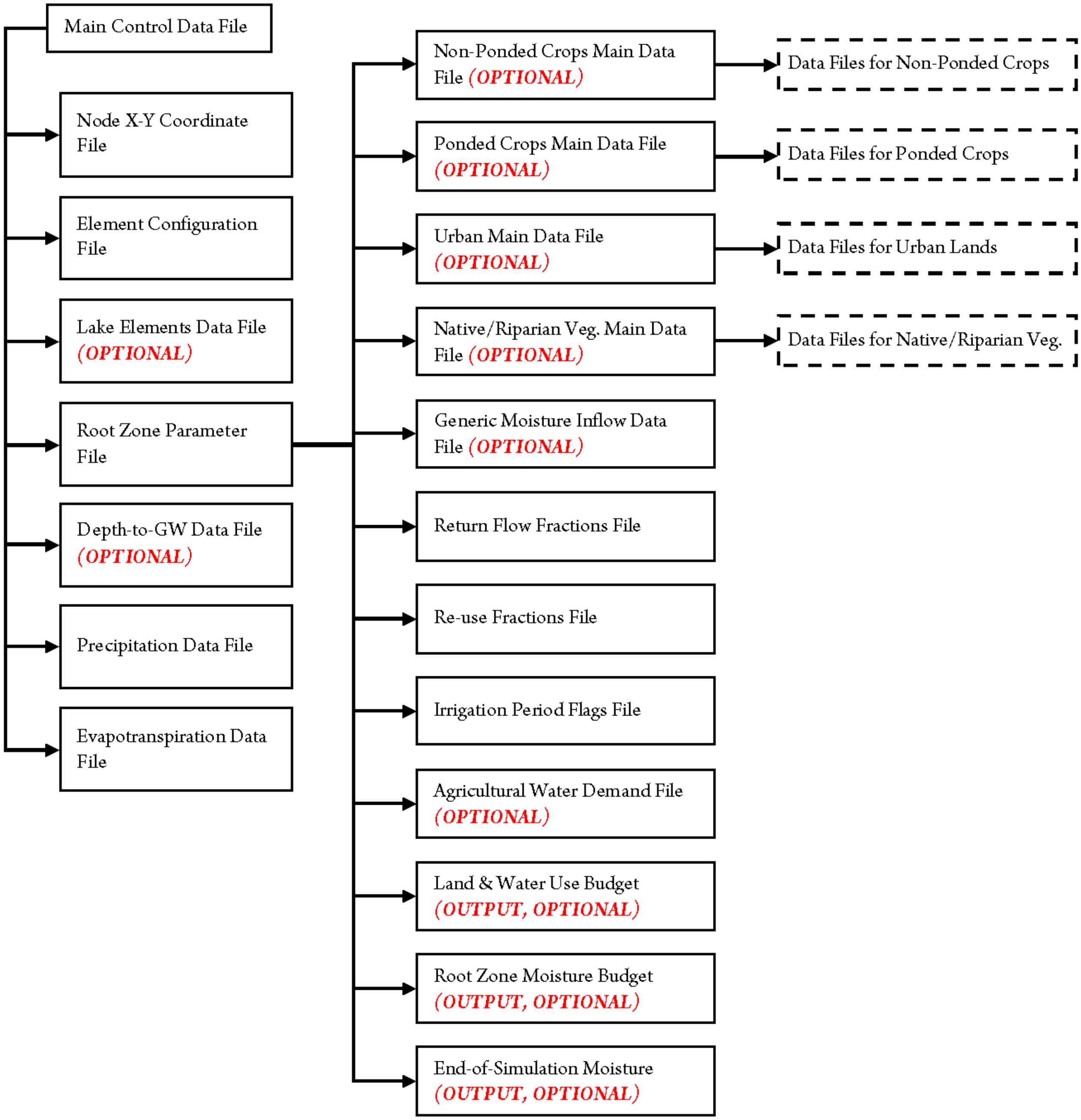
File Type	Recognized Filename Extensions
ASCII	.DAT .TXT .OUT .IN .IN1 .IN2 .BUD
HDF5	.HDF .HDF5 .H5 .HE5
HEC-DSS	.DSS

The IDC Main Input File lists the names of the data files that include grid nodal x-y coordinates, element configuration data, precipitation and evaporation data, list of elements that are covered by lakes or reservoirs where root zone flow processes are not simulated, and the root zone parameters.

The IDC Main Input File also lists the beginning and ending date and time of the simulation as well as the simulation time step length. Factors to convert IDC simulation units into desired units of output are also listed in this file.

Root Zone Parameter File that is listed in the IDC Main Input File acts as a gateway to all the parameters and data files required for the simulation of the root zone flow processes and water demand computations. The first line of data entry in this file lists the version number of the root zone component (e.g. 4.0 or 4.1). Once IDC reads this version number it knows what additional parameters it should read and what flow processes it should simulate. The Root Zone Parameter File also includes names of gateway data files required for the simulation of non-ponded crops, ponded crops, urban lands, and lands with native and riparian vegetation. Additionally, it includes file names for simulation output, soil parameters at each cell and the destination for the surface runoff generated at each cell. Gateway files for non-ponded crops, ponded-crops, urban lands and lands with native and riparian vegetation act as containers for additional data file names and parameters that are necessary to simulate the flow processes and water demands (if applicable) for these land-use types.

Figure 18. *Schematic representation of the IDC input file structure*



These gateway files provide a structure for the user to group related data files as well as turn on or off the simulation of particular land use types in an application. For instance, by leaving blank the name of the gateway file for non-ponded crops in the Root Zone Parameter File, the user can easily omit the simulation of flow processes for non-ponded crops. This feature allows easy implementation of scenario studies where a particular land-use type is assumed to be non-existent with respect to a base-case scenario.

Each land-use type (non-ponded crops, ponded-crops, urban or native and riparian vegetation) include a data file that lists the area of each land-use type at a grid cell. These areas can be entered either as absolute areas or as fractions of the total cell area. In either case, IDC normalizes all areas (given as absolute areas or crops, urban lands and lands with native and riparian vegetation should also be specified as fractions. Otherwise, the total cell area will be incorrectly divided into the land-use types.

The following sections describe in detail the variables to be populated in each of the input file and display sample files.

8.3.1. IDC Main Input File

The IDC Main Input File serves as the starting point for an IDC simulation. The names of the data files for the IDC simulation are listed in this file as well as the beginning and ending date and time of the simulation, the simulation time step length and output control options.

The following is a list of the variables used in this data file:

BDT	Beginning simulation date and time; use MM/DD/YYYY_hh:mm format
EDT	Ending simulation date and time; use MM/DD/YYYY_hh:mm format
UNITT	Time step length and unit; choose one of the options listed in the IDC Main Input File which are time steps that are recognized by HEC-DSS database system
CACHE	This is the minimum number of simulation results for each time series output data that is stored in the computer memory before saved onto the hard disk; a large value (e.g. 50000 or more) that is permissible by the memory resources may have a substantial effect on decreasing the simulation run-times
KDEB	Switch for simulation progress monitoring (1 = print detailed messages on the screen; 0 = print only simulation timesteps on the screen; −1 = do not print any messages on the screen)

```
C*****************************************************************************
C
C                          IWFM DEMAND CALCULATOR (IDC)
C                              *** Version ### ***
C
C*****************************************************************************
C
C                            MAIN INPUT FILE
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: IDC_MAIN.in
C
C*****************************************************************************
C                              File Description
C
C    This file contains the control data for IDC that includes the names and
C    descriptions of all simulation files; simulation period and output control
C    options.
C
C***************************************************************************
C                            File Description
C
C  *Listed below are all input and output file names used when running the
C   utility.
C  *Each file name has a maximum length of 1000 characters
C  *If an optional file does not exist for a project, leave the filename blank
C
C-----------------------------------------------------------------------------
C    FILE NAME                                      DESCRIPTION
C-------------------------------------------------------------------------------------------
     Grid\Element.dat                               / 1: ELEMENT CONFIGURATION FILE (INPUT, REQUIRED)
     Grid\NodeXY.dat                                / 2: NODE X-Y COORDINATE FILE (INPUT, REQUIRED)
                                                    / 3: LAKE ELEMENTS DATA FILE (INPUT, OPTIONAL)
     RootZone\ROOTZONE_MAIN.dat                     / 4: ROOT ZONE PARAMETER DATA FILE (INPUT, REQUIRED)
     DepthToGW.dat                                  / 5: DEPTH-TO-GROUNDWATER DATA FILE (INPUT, OPTIONAL)
     Precip_ET\Precip.dat                           / 6: PRECIPITATION DATA FILE (INPUT, REQUIRED)
     Precip_ET\ET.dat                               / 7: EVAPOTRANSPIRATION DATA FILE (INPUT, REQUIRED)
C*****************************************************************************
C                         Model Simulation Period
C
C   The following lists the simulation beginning time, ending time and time step length.
C
C   BDT    ; Beginning simulation date and time. Use MM/DD/YYYY_hh:mm format.
C            * Midnight is 24:00
C   EDT   ; Ending simulation date and time.  Use MM/DD/YYYY_hh:mm format.
C           * Midnight is 24:00
C   UNITT  ; Time step length and unit. Choose one of the following:
C                  1MIN
C                  2MIN
C                  3MIN
C                  4MIN
C                  5MIN
C                  10MIN
C                  15MIN
C                  20MIN
C                  30MIN
C                  1HOUR
C                  2HOUR
C                  3HOUR
C                  4HOUR
C                  6HOUR
C                  8HOUR
C                  12HOUR
C                  1DAY
C                  1WEEK
C                  1MON
C                  1YEAR
C
C-----------------------------------------------------------------------------
C       VALUE                   DESCRIPTION
C-----------------------------------------------------------------------------
      09/30/1997_24:00          / BDT
      09/30/2001_24:00          / EDT
      1day                      / UNITT
C****************************************************************************
C                     Output Control Options
C
C    CACHE   ; Cache size in terms of number of values stored for time series data output
C    KDEB    ; Enter  1 - to print messages on the screen to monitor execution
C              Enter  0 - otherwise
C              Enter -1 - to supress printing of timesteps on the screen
C
C---------------------------------------------------------------------------
C       VALUE                   DESCRIPTION
C---------------------------------------------------------------------------
        5000000                 / CACHE
        0                       / KDEB
```

8.3.2. Element Configuration File

The Element Configuration File details the element configuration for each element represented in the finite element mesh, number of subregions that the model domain is divided into, the name of the subregions and the subregion number that each element belongs to. Each element is configured using three or four nodal points. All elements that represent the model domain are either triangular or quadrilateral. A zero value for IDE(4) indicates that the element is triangular. Nodes corresponding to each element are specified in a counterclockwise manner. IWFM Mesh Generator that is available for download from the IWFM web site can be used to quickly generate the finite element grid. The following variables are required as input in Element Configuration File:

NE	Number of elements within the model domain
NREGN	Number of subregions the model domain is divided into
RNAME	Name of each subregion (maximum 50 characters long)
IE	Element number
IDE	Nodes corresponding to each element number; 3 nodes are associated with each triangular element (4^{th} node should be set to zero) and 4 nodes are associated with each quadrilateral element
IRGE	Subregion number that element IE belongs to

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                        ELEMENT CONFIGURATION FILE
C                         Discretization Component
C                           *** Version ### ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Element.dat
C
C*******************************************************************************
C                            File Description
C
C   This file  contains the element configuration for each element.
C   The nodes that make a finite element are listed for each element in
C   a counter-clock wise fashion starting with any node. For triangular elements,
C   the fourth node is specified as zero.
C
C
C   For example,
C
C                   13-------------14----------17
C                    I             I         I
C                    I      2      I   3   I
C                    I             I     I
C                    I             I   I
C                   15------------- 16
C
C
C   The configuration for elements 2 and 3 will be listed as,
C
C           element   node 1    node 2    node 3   node 4
C              2        13        15        16       14
C              3        14        16        17        0
C
C*******************************************************************************
C                     Element Configuration Data
C
C    NE    ;   Number of elements within the model domain
C    NREGN ;   Number of subregions
C
C-------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    400                           / NE
    4                             / NREGN
C*******************************************************************************
C                         Sub-region Names
C
C   The following lists the names for each sub-region in an ascending order of
C   the subregion numbers.
C
C--------------------------------------------------------------------------------
C
C   RNAME; Sub-region name (max. 50 characters)
C
C--------------------------------------------------------------------------------
C   VALUE                        DESCRIPTION
C--------------------------------------------------------------------------------
    Region1                      / RNAME1
    Region2                      / RNAME2
    Region3                      / RNAME3
    Region4                      / RNAME4
C*******************************************************************************
C
C   The data listed below represents all elements and corresponding nodes
C   within the model domain.
C
C   IE;      Element number
C   IDE;     Nodes corresponding to each element
C            *Note* IDE(4) is zero for all triangular elements
C   IRGE;    Subregion number to which element IE belongs to
C
C-------------------------------------------------------------------------------
C   Element     ------------Corresponding Nodes-------------------      Subregion
C   IE          IDE(1)        IDE(2)        IDE(3)       IDE(4)          IRGE
C-------------------------------------------------------------------------------
     1           1             2            23            22              1
     2           2             3            24            23              1
     3           3             4            25            24              1
     4           4             5            26            25              1
     5           5             6            27            26              1
     .           .             .             .             .              .
     .           .             .             .             .              .
     .           .             .             .             .              ,
     397         416           417          438           437             4
     398         417           418          439           438             4
     399         418           419          440           439             4
     400         419           420          441           440             4
```

8.3.3. Nodal X-Y Coordinate File

The nodal coordinate file contains node numbers and corresponding x and y coordinates. Any coordinate units may be used as long as the appropriate conversion factor is given. This file sets up the spatial orientation of the finite element mesh nodes in the model domain. The finite element mesh is generated from the nodal coordinates, as well as relationship between elements and corresponding nodes (refer to the Element Configuration File).

ND	Number of nodes
FACT	Factor to convert nodal coordinates to simulation unit of length
ID	Node identification number
X	x-coordinate of node location
Y	y-coordinate of node location

```
C*******************************************************************************
C
C                    INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                        NODAL X-Y COORDINATE FILE
C                         Discretization Component
C                            *** Version ### ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: NodeXY.dat
C
C*******************************************************************************
C                            File Description
C
C   *This file includes all groundwater nodes that represent the model domain,
C    as well as the x and y coordinates that correspond with each node.
C
C   *The coordinates can be specified for any reference point and coordinate
C    system
C
C*******************************************************************************
C                    Groundwater Node Specifications
C
C   ND;    Number of groundwater nodes
C   FACT;  Conversion factor for nodal coordinates
C-------------------------------------------------------------------------------
C   VALUE                        DESCRIPTION
C-------------------------------------------------------------------------------
    441                          /ND
    1.0                          /FACT
C-------------------------------------------------------------------------------
C*******************************************************************************
C                      Groundwater Node Locations
C   The following lists the node number and x & y coordinate of each node
C
C   ID;   Groundwater node number
C   X,Y;  Coordinates of groundwater node location; [L]
C
C-------------------------------------------------------------------------------
C   Node     ----------Coordinates----------
C    ID            X                 Y
C-------------------------------------------------------------------------------
      1         0.0               0.0
      2         2000.0            0.0
      3         4000.0            0.0
      4         6000.0            0.0
      5         8000.0            0.0
      .         .                 .
      .         .                 .
      .         .                 .
    437         32000.0           40000.0
    438         34000.0           40000.0
    439         36000.0           40000.0
    440         38000.0           40000.0
    441         40000.0           40000.0
```

8.3.4. Lake Elements Data File

The Lake Elements Data File lists the grid cells that are lake elements and will be excluded from land surface and root zone flow computations. It should be noted that lakes in IDC are different then the ponded areas for rice and refuges. Rice and refuge ponding operations are explicitly simulated in IDC and the grid cells with such ponds should not be listed in the Lake Elements Data File.

The following variables are used in this data file:

NTELAKE Total number of lake elements

IELAKE List of lake elements

```
C*******************************************************************************
C
C                          IWFM DEMAND CALCULATOR (IDC)
C                              *** Version ### ***
C
C*******************************************************************************
C
C                     LAKE ELEMENTS DATA FILE
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: LakeElems.dat
C
C*******************************************************************************
C
C                             File Description:
C
C   This data file lists the lake elements that will be excluded from root zone
C   flow routing.
C
C*******************************************************************************
C                  Lake Elements Data
C
C   NTELAKE ;  Total number of lake elements
C   IELAKE  ;  Lake element number
C
C-------------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
    7                           / NTELAKE
C-------------------------------------------------------------------------------
C   IELAKE
C-------------------------------------------------------------------------------
    12
    13
    56
    57
    58
    102
    103
```

8.3.5. Depth-to-Groundwater Data File

To simulate the contribution of groundwater to plant evapotranspiration, the Depth-to-Groundwater data file must be specified. This data file lists the specific yield for the underlying aquifer material and time series depth-to-groundwater at each finite element cell. This information can be obtained deduced from field measurements or from a groundwater model. When IDC is linked to an integrated hydrologic model such as IWFM, the depth-to-groundwater data is computed dynamically by the hydrologic model and passed to IDC. It should be noted that if the contribution of groundwater to evapotranspiration is to be simulated, then Root Zone Component Version 4.1 must be used.

The following variables are used in this file:

NDGW	Number of depth-to-groundwater time series data columns
FACTDGW	Conversion factor for depth-to-groundwater
NSPDGW	Number of time steps to update the depth-to-groundwater data; if time tracking simulation, enter any number
NFQDGW	Repetition frequency of the depth-to-groundwater data (enter zero if full time series data is supplied); if time tracking simulation, enter any number
DSSFL	If the time series data is stored in a DSS file, name of the file; leave blank if the data is listed in the Depth-to-Groundwater Data File

Aquifer Specific Yield and Cell-Data Connections

In this section, specific yield of the underlying aquifer material and the depth-to-groundwater data column pointer are listed for each finite element cell:

IE	Finite element identification number
SY	Specific yield of the underlying aquifer material at element IE; [L/L]
IDGW	Column number for the depth-to-groundwater time series data to be used at element IE

Data Input from Depth-to-Groundwater Data File

If the time series data is listed in the Depth-to-Groundwater Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITDGW	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
DGW	Depth-to-groundwater time series data, [L]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                            IWFM DEMAND CALCULATOR (IDC)
C                                *** Version ### ***
C
C*******************************************************************************
C
C                       DEPTH-TO-GROUNDWATER DATA FILE
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: DepthToGW.dat
C
C*******************************************************************************
C
C                             File Description:
C
C   This data file lists the specific yield of underlying aquifer material and
C   time-series depth-to-groundwater data at each element to be used in water
C   demand calculations and root zone flow routing.
C
C*******************************************************************************
C              Depth-to-Groundwater Time Series Data Specifications
C
C   NDGW   ;  Number of data columns (or pathnames if DSS files are used)
C   FACTDGW;  Conversion factor for depth-to-groundwater data
C   NSPDGW ;  Number of time steps to update the depth-to-groundwater data
C              * Enter any number if time-tracking option is on
C   NFQDGW ;  Repetition frequency of the depth-to-groundwater data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ;  The name of the DSS file for data input (maximum 50 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------
          1                                           / NDGW
          1.0                                         / FACTDGW
          1                                           / NSPDGW
          0                                           / NFQDGW
                                                      / DSSFL
C*******************************************************************************
C             Specific Yield and Element-Data-Column Connections
C
C   IE     ;  Element ID
C   SY     ;  Specific yield of the underlying aquifer material to be used in computing root
C               water uptake from groundwater; [L/L]
C   IDGW   ;  Depth-to-groundwater data column to be used for element IE
C
C-------------------------------------------------------------------------------
C   IE      SY     IDGW
C-------------------------------------------------------------------------------
   1        0.2     1
   2        0.2     1
   3        0.2     1
   .        .       .
   .        .       .
   .        .       .
   397      0.2     1
   398      0.2     1
   399      0.2     1
   400      0.2     1
C*******************************************************************************
C                         Depth-to-Groundwater Data
C                           (READ FROM THIS FILE)
C
C   List depth-to-groundwater data below, if it will
C   not be read from a DSS file (i.e. DSSFL is left blank above).
C
C   ITDGW ;   Time
C   DGW   ;   Depth-to-groundwater; [L]
C
C-------------------------------------------------------------------------------
C ITDGW               DGW[1]  DGW[2]  DGW[3] ... DGW[NDGW]
C-------------------------------------------------------------------------------
   12/31/2500_24:00   10.0
*
C-------------------------------------------------------------------------------
C                    Pathnames for Depth-to-Groundwater Data
C                           (READ FROM DSS FILE)
C
C   List the pathnames for the depth-to-groundwater data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   REC    ;  Time series record number
C   PATH   ;  Pathname for the time series record
C
C-------------------------------------------------------------------------------
C   REC        PATH
C-------------------------------------------------------------------------------
*
*
```

8.3.6. Precipitation File

The Precipitation File contains the time series rainfall values for each of the rainfall stations used in the simulation. Each element is associated with a rainfall station in the Root Zone Component Main File as described later in this document. The factors that convert the precipitation at rainfall stations to the precipitation over the elements are also listed in the Root Zone Component Main File. The rainfall data for a station associated with an element is multiplied by the corresponding factor to obtain the rainfall rate over an element.

In non-time tracking simulations a time-series precipitation data set of any frequency can be used as the precipitation data in IDC. NSPRN and NFQRN must be specified according to the frequency of the data entered. If the precipitation data is specified for the entire simulation period, NFQRN should be set to zero. In time tracking simulations the time series precipitation data can be either listed in this file or in a DSS file. If a DSS file is used for data input, then the name of the DSS file and the pathnames corresponding to each of the time series data are required.

The following variables are used:

NRAIN	Number of rainfall stations used in the model
FACTRN	Conversion factor for the spatial component of the unit for the rainfall rate
NSPRN	Number of time steps to update the precipitation data; if time tracking simulation, enter any number
NFQRN	Repetition frequency of the precipitation data (enter zero if full time series data is supplied); if time tracking simulation, enter any number
DSSFL	If the time series data is stored in a DSS file, name of the file; leave blank if the data is listed in the Precipitation File

Data Input from Precipitation File

If the time series data is listed in the Precipitation File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITRN	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
ARAIN	Rainfall rate at the corresponding rainfall station, [L/T]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                         PRECIPITATION DATA FILE
C               Precipitation and Evapotranspiration Component
C                           *** Version ### ***
C
C
C             Project : IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Precip.dat
C
C*******************************************************************************
C                             File Description:
C
C   This data file contains the time-series rainfall at each rainfall station used
C   in the model.
C
C*******************************************************************************
C                         Rainfall Data Specifications
C
C   NRAIN ;  Number of rainfall stations (or pathnames if DSS files are used)
C             used in the model
C   FACTRN;  Conversion factor for rainfall rate
C             It is used to convert only the spatial component of the unit;
C             DO NOT include the conversion factor for time component of the unit.
C             * e.g. Unit of rainfall rate listed in this file = INCHES/MONTH
C                    Consistent unit used in simulation        = FEET/DAY
C                    Enter FACTRN (INCHES/MONTH -> FEET/MONTH) = 8.33333E-02
C                     (conversion of MONTH -> DAY is performed automatically)
C   NSPRN ;  Number of time steps to update the precipitation data
C             * Enter any number if time-tracking option is on
C   NFQRN ;  Repetition frequency of the precipitation data
C             * Enter 0 if full time series data is supplied
C             * Enter any number if time-tracking option is on
C   DSSFL ;  The name of the DSS file for data input (maximum 50 characters);
C             * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          2                                          / NRAIN
          8.33333E-2                                 / FACTRN   (in -> ft)
          1                                          / NSPRN
          0                                          / NFQRN
          TSDATA_IN.DSS                              / DSSFL
C-------------------------------------------------------------------------------
C                             Rainfall Data
C                         (READ FROM THIS FILE)
C
C   List the rainfall rates for each of the rainfall station below, if it will
C   not be read from a DSS file (i.e. DSSFL is left blank above).
C
C   ITRN ;   Time
C   ARAIN;   Rainfall rate at the corresponding rainfall station; [L/T]
C
C-------------------------------------------------------------------------------
C ITRN    ARAIN(1)  ARAIN(2)  ARAIN(3) ...
C-------------------------------------------------------------------------------
*
*
C-------------------------------------------------------------------------------
C                       Pathnames for Rainfall Data
C                         (READ FROM DSS FILE)
C
C   List the pathnames for the rainfall data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   REC    ;  Time series record number
C   PATH   ;  Pathname for the time series record
C
C---------------------------------------------------------------------------------
C   REC        PATH
C---------------------------------------------------------------------------------
     1         /SAMPLE_PROBLEM/GAGE1/PRECIP//1MON/PRECIPITATION/
     2         /SAMPLE_PROBLEM/GAGE2/PRECIP//1MON/PRECIPITATION/
```

8.3.7. Evapotranspiration File

The Evapotranspiration File contains time series ET data for all crop types and non-agricultural land use types. The ET rates listed in this file are associated with individual land-use types in each element using the related Root Zone Component files as described later in this document. The conversion factor for the ET rates is a required input, as well as the number of time steps to update the data and the repetition frequency of the data. In time tracking simulations the time series evapotranspiration data can be either listed in this file or in a DSS file. If a DSS file is used for data input, then the name of the DSS file and the pathnames corresponding to each of the time series data are required. The ET rates listed in this file are associated with individual land-use types in each element using the related root zone component files as described later in this document.

The example file given below shows how recycled time series data in a time tracking simulation can be specified using the special year 4000 flag. The following is a list of the variables that need to be specified:

NCOLET	Number of evapotranspiration data columns
FACTET	Conversion factor for the spatial component of the unit for the evapotranspiration rate
NSPET	Number of time steps to update the ET data; if time tracking simulation, enter any number
NFQET	Repetition frequency of the ET data (enter zero if full time series data is supplied); if time tracking simulation, enter any number
DSSFL	If the time series data is stored in a DSS file, name of the file; leave blank if the data is listed in the Evapotranspiration File

Data Input from Evapotranspiration File

If the time series data is listed in the Evapotranspiration File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITEV	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.

AEVAP	Evapotranspiration rate, [L/T]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                     INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                          EVAPOTRANSPIRATION DATA FILE
C                  Precipitation and Evapotranspiration Component
C                              *** Version ### ***
C
C
C
C              Project : IDC Version ### Release
C                        California Department of Water Resources
C              Filename: ET.dat
C
C*******************************************************************************
C                            File Description:
C
C    This data file contains sets of evapotranspiration values that are used in
C    root zone, lake and small watershed components of Simulation.
C
C*******************************************************************************
C                        Evapotranspiration Data Specifications
C
C    NCOLET;  Number of ET columns (or pathnames if DSS files are used)
C    FACTET:  Conversion factor for evapotranspiration rate
C              It is used to convert only the spatial component of the unit;
C              DO NOT include the conversion factor for time component of the unit.
C              * e.g. Unit of ET rate listed in this file       = INCHES/MONTH
C                     Consistent unit used in simulation        = FEET/DAY
C                     Enter FACTET (INCHES/MONTH -> FEET/MONTH) = 8.33333E-02
C                      (conversion of MONTH -> DAY is performed automatically)
C    NSPET ;  Number of time steps to update the ET data
C              * Enter any number if time-tracking option is on
C    NFQET ;  Repetition frequency of the ET data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C    DSSFL ;  The name of the DSS file for data input (maximum 50 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------
          5                                           / NCOLET
          0.083333                                    / FACTET  (in/month -> ft/month)
          1                                           / NSPET
          0                                           / NFQET
                                                      / DSSFL
C-------------------------------------------------------------------------------
C                               Evapotranspiration Data
C                                (READ FROM THIS FILE)
C
C    ITEV ;   Time
C    AEVAP;   Evapotranspiration rate; [L/T]
C
C-------------------------------------------------------------------------------
C ITEV   AEVAP[1]  AEVAP[2]  AEVAP[3] ...  AEVAP[NCOLET]
C-------------------------------------------------------------------------------
C                     Tomatoes  Alfalfa     Rice    Urban    Native
  10/31/4000_24:00      3.4       3.5        2.2      3.4       3.4
  11/30/4000_24:00      1.6       1.6        1.6      1.6       1.6
  12/31/4000_24:00      1.0       1.0        1.0      0.5       1.0
  01/31/4000_24:00      1.0       1.0        1.0      0.5       1.0
  02/29/4000_24:00      1.8       1.8        1.8      1.8       1.8
  03/31/4000_24:00      3.0       3.0        3.0      3.0       3.0
  04/30/4000_24:00      4.5       4.1        8.0      4.5       4.5
  05/31/4000_24:00      5.9       5.4        9.1      5.9       5.9
  06/30/4000_24:00      7.3       6.8       10.4      7.3       7.3
  07/31/4000_24:00      7.9       7.7        9.7      7.9       7.9
  08/31/4000_24:00      6.6       6.8        7.0      6.6       6.6
  09/30/4000_24:00      5.2       5.4        1.9      5.2       5.2
C-------------------------------------------------------------------------------
C                          Pathnames for Evapotranspiration Data
C                                (READ FROM DSS FILE)
C
C    List the pathnames for evapotranspiration  data below, if it will
C    be read from a DSS file (i.e. DSSFL is specified above).
C
C    REC  ;  Time series record number
C    PATH ;  Pathname for the time series record
C
C-------------------------------------------------------------------------------------
C    REC      PATH
C-------------------------------------------------------------------------------------
*
*
```

8.3.8. Input Files for Root Zone Component Version 4.0

The root zone component is the main simulation part of IDC. Root Zone Component Main File is the gateway to additional data files that are used in simulating land surface and root zone flow processes at agricultural, urban, native vegetation and riparian vegetation lands. Agricultural and urban water demands are also computed in the root zone component. Root zone component version 4.0 files are described in detail in the following sections.

8.3.8.1. Root Zone Component Main File

The Root Zone Component Main File includes the convergence criteria for the iterative solution of the non-linear soil moisture mass balance equation, names of additional input files that are used to simulate land surface and root zone flow processes for agricultural, urban and natural lands, and agricultural and urban water demands. Subregional Land and Water Use as well as Subregional Root Zone Moisture Budget output filenames are also listed in this file. Soil properties at each grid cell and the destination for the surface flow generated at each cell are listed in the last section of the Root Zone Component Main File.

First data line of the Root Zone Component Main File lists the version number (i.e. 4.0) of the root zone component that will be used in simulating the land surface and root zone flow processes. IDC first reads this data line to figure out what other parameters will be read and what flow processes are to be simulated. This first line of data entry must not be modified.

The following sections and variables are defined in the rest of this file:

Root Zone Simulation Scheme Control and Filenames

In this section convergence criteria for the iterative solution methodology and names of additional input and output files are listed.

RZCONV	Convergence criteria for iterative soil moisture accounting as a fraction of total porosity; [L/L]
RZITERMX	Maximum number of iterations for iterative soil moisture accounting
FACTCN	Conversion factor to convert inches to the simulation unit of length

AGNPFL	Filename for the Non-Ponded Crops Main File (maximum 1000 characters); leave blank if non-ponded crops are not simulated
PFL	Filename for the Ponded Crops Main File (maximum 1000 characters); leave blank if rice and/or refuge lands are not simulated
URBFL	Filename for the Urban Lands Main File (maximum 1000 characters); leave blank if urban lands are not simulated
NVRVFL	Filename for the Natural Lands Main File (maximum 1000 characters); leave blank if native and/or riparian vegetation lands are not simulated
RFFL	File that lists the return flow fractions (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
RUFL	File that lists the irrigation water re-use factors (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
IPFL	File that lists the irrigation periods for each ponded and non-ponded crop (maximum 1000 characters); this is a required file even if ponded and non-ponded crops are not simulated
MSRCFL	File that lists generic source of moisture rates other than precipitation and irrigation (maximum 1000 characters); leave blank if there are no generic sources of moisture simulated
AGWDFL	File that lists agricultural water supply requirement (maximum 1000 characters); leave blank if agricultural water supply requirement for all crops will be computed dynamically
LWUBUDFL	HDF5 output file for subregional land and water use budget (maximum 1000 characters); leave blank if this output is not required
RZBUDFL	HDF5 output file for subregional root zone moisture (maximum 1000 characters); leave blank if this output is not required

FNSMFL	Output file for end-of-simulation soil moisture (maximum 1000 characters); leave blank if this output is not required

Soil Parameters and Surface Flow Destinations

In this section, soil parameters, precipitation rates, generic soil moisture sources (if any) and surface runoff destinations are listed for each finite element.

FACTK	Conversion factor for the spatial component of the root zone hydraulic conductivity
TUNITK	Time unit of root zone hydraulic conductivity this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File
IE	Element identification number
WP	Wilting point; [L/L]
FC	Field capacity; [L/L]
TN	Total porosity; [L/L]
LAMBDA	Pore size distribution index
K	Saturated hydraulic conductivity; [L/T]
RHC	Method to represent hydraulic conductivity versus moisture content curve (1 = Campbell's equation, 2 = van Genucten-Mualem equation)
IRNE	Precipitation rate; this number corresponds to the appropriate data column in the Precipitation File
FRNE	Factor to convert rainfall at the precipitation data column IRNE to rainfall at element IE
IMSRC	Generic source of moisture; this number corresponds to the appropriate data column in the Generic Moisture Source File that applies to element IE (enter any number if the Generic Moisture Source File, MSRCFL, is not defined)
TYPDEST	Destination type for the surface flow from element IE (0 = surface flow goes outside of model area, 1 = surface flow goes to a stream node, 3 = surface flow goes to a lake, 5 = surface flow recharges the groundwater)
DEST	Destination identification number for the surface flow from element IE; enter any number if surface flow from the element

	goes outside the model area (TYPDEST = 0) or recharges the groundwater (TYPDEST = 5)
KPonded	Saturated hydraulic conductivity to be used for ponded crops in the element (enter −1.0 if KPonded is the same as K); [L/T]

```
#4.0
C***  DO NOT DELETE ABOVE LINE ***
C
C*****************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*****************************************************************************
C
C                     ROOT ZONE PARAMETERS DATA FILE
C                          Root Zone Component
C                          *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: ROOTZONE_MAIN.dat
C
C*****************************************************************************
C                            File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes.
C
C*****************************************************************************
C                Root Zone Simulation Scheme Control and File Names
C
C   RZCONV   ;  Convergence criteria for iterative soil moisture accounting as a
C                fraction of total porosity; [L/L]
C   RZITERMX ;  Maximum number of iterations for iterative soil moisture accounting
C   FACTCN   ;  Conversion factor to convert inches to the simulation unit of length
C   AGNPFL   ;  Non-ponded agricultural crop data file (max. 1000 characters)
C                * Leave blank if non-ponded crops are not simulated
C   PFL      ;  Rice/refuge data file (max. 1000 characters)
C                * Leave blank if rice and/or refuge lands are not simulated
C   URBFL    ;  Urban lands data file (max. 1000 characters)
C                * Leave blank if urban lands are not simulated
C   NVRVFL   ;  Native/riparian vegetation lands data file (max. 1000 characters)
C                * Leave blank if native and/or riparion veg. lands are not simulated
C   RFFL     ;  File that lists the return flow fractions (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   RUFL     ;  File that lists the irrigation water re-use factors (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   IPFL     ;  File that lists the irrigation periods for each ponded and
C                non-ponded crop (max. 1000 characters)
C                * Leave blank if both ponded and non-ponded crops are not simulated
C   MSRCFL   ;  File that lists generic source of moisture rates other than precipitation
C                and irrigation (max. 1000 characters)
C                * Leave blank if there are no generic sources of moisture simulated
C   AGWDFL   ;  File that lists agricultural water supply requirement (max. 1000 characters)
C                * Leave blank if agricultural water supply requirement will be computed
C                  dynamically
C   LWUBUDFL ;  HDF5 output file for land and water use budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   RZBUDFL  ;  HDF5 output file for root zone moisture budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   FNSMFL   ;  Output file for end-of-simulation soil moisture (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-------------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------------
          0.0001                                      / RZCONV
          200                                         / RZITERMX
          0.08333                                     / FACTCN  (in -> ft)
          RootZone\NonPondedAg\NonPondedAg.dat        / AGNPFL
          RootZone\PondedAg\PondedAg.dat              / PFL
          RootZone\Urban\Urban.dat                    / URBFL
          RootZone\NVRV\NVRV.dat                      / NVRVFL
          RootZone\ReturnFlowFrac.dat                 / RFFL
          RootZone\ReuseFrac.dat                      / RUFL
          RootZone\IrrigPeriod.dat                    / IPFL
                                                      / MSRCFL
          RootZone\AgWaterDemand.dat                  / AGWDFL
          Budget\LWU.hdf                              / LWUBUDFL
          Budget\RZ.hdf                               / RZBUDFL
                                                      / FNSMFL
C*****************************************************************************
C             Parameters for Soil, Precipitation and Runoff Destination
C
C   Enter conversion factors.
C
C   FACTK  ;  Conversion factor for root zone hydraulic conductivity
C              It is used to convert only the spatial component of the unit;
C              DO NOT include the conversion factor for time component of the unit.
C              * e.g. Unit of hydraulic conductivity listed in this file = IN/DAY
C                     Consistent unit used in simulation                = FT/MONTH
C                     Enter FACT (IN/MONTH -> FT/MONTH)                 = 8.33333E-02
C                     (conversion of DAY -> MONTH is performed automatically)
C   TUNITK ;  Time unit of root zone hydraulic conductivity.  This should be one of the
C             units recognized by HEC-DSS that are listed in the Main Control File.
C
C-------------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------------
          0.283464                                    / FACTK (micrometers/sec -> ft/day)
          1day                                        / TUNITK
C-------------------------------------------------------------------------------------
C
C   Enter soil parameters, precipitaion and surface flow destination data below for each
C   grid element.
C
C   IE     ;  Element ID
C   WP     ;  Wilting point; [L/L]
C   FC     ;  Field capacity; [L/L]
C   TN     ;  Total porosity; [L/L]
C   LAMBDA ;  Pore size distribution index; [dimensionless]
C   K      ;  Saturated hydraulic conductivity; [L/T]
C   RHC    ;  Method to represent hydraulic conductivity vs. moisture content curve
C               1 = Campbell's equation
```

```
C               2 = van Genucten-Mualem equation
C   IRNE   ;  Precipitation data column in the Precipitation file that applies to element IE
C   FRNE   ;  Factor to convert rainfall at the precipitation data column to
C               rainfall at element IE
C   IMSRC  ;  Generic source of moisture data column in the Generic Moisture Source file (MSRCFL
C               file listed above) that applies to element IE
C               * Note: Enter any number if MSRCFL above is left blank
C   TYPDEST;  Destination type for the surface flow from element IE
C               0 = Surface flow goes outside of model area
C               1 =   "       "    "  to a stream node
C               3 =   "       "    "   " a lake
C               5 =   "       "    "   " groundwater
C   DEST   ;  Destination for the surface flow from element IE
C               * Note: Enter any number if TYPDEST is set to 0 or 5
C   KPonded;  Saturated hydraulic conductivity to be used for ponded crops in the element; [L/T]
C               * Note: Enter -1.0 if KPonded is the same as K
C
C--------------------------------------------------------------------------------------------------------------
C  IE      WP        FC        TN        LAMBDA    K        RHC   IRNE  FRNE   IMSRC   TYPDEST  DEST   KPonded
C--------------------------------------------------------------------------------------------------------------
   1       0.0000    0.1370    0.4530    0.378     5.0E-02  2     1     1.0      0       0       3      -1.0
   2       0.0000    0.1571    0.4640    0.242     5.1E+01  2     1     1.0      0       0       3      -1.0
   3       0.0000    0.1053    0.4630    0.252     5.0E-02  2     1     1.0      0       0       3      -1.0
   .         .         .         .         .         .      .     .     .        .       .       .        .
   .         .         .         .         .         .      .     .     .        .       .       .        .
   .         .         .         .         .         .      .     .     .        .       .       .        .
   220     0.0000    0.1210    0.4300    0.223     5.0E-02  2     3     1.0      0       0       3      1.0E-03
   221     0.0000    0.0485    0.4530    0.378     5.0E-02  2     3     1.0      0       0       0      1.0E-03
   222     0.0000    0.2322    0.5010    0.234     1.9E+01  2     3     1.0      0       0       0      1.0E-03
   223     0.0000    0.1210    0.4300    0.223     5.0E-02  2     3     1.0      0       0       3      1.0E-03
```

8.3.8.2. Return Flow Fractions Data File

The Return Flow Fractions Data File lists return flows specified as time series fractions of applied water. Non-ponded crops, ponded crops and urban lands at each element are associated with data columns in this file through pointers specified in the Non-Ponded Crops Main File, Ponded Crops Main File and Urban Lands Main File, respectively.

The following variables are used in this file:

NCOLRT	Number of return flow fractions data columns
NSPRT	Number of time steps to update the return flow fractions; enter any number if time-tracking simulation
NFQRT	Repetition frequency of the return flow fractions data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Return Flow Fractions Data File

If the time series data is listed in the Return Flow Fractions Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using “C”, “c” or “*”, and the variables in the “Data Input from DSS File” section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
RTRNF	Return flows as a fraction of applied water

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                 RETURN FLOW FRACTIONS DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: ReturnFlowFrac.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains a set of return flows given as fractions of irrigation
C   water.
C
C*******************************************************************************
C               Return Flow Fractions Data Specifications
C
C   NCOLRT ; Number of return flow fractions data columns
C   NSPRT  ; Number of time steps to update the return flow fractions
C              * Enter any number if time-tracking option is on
C   NFQRT  ; Repetition frequency of the return flow fractions data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          2                                          / NCOLRT
          1                                          / NSPRT
          0                                          / NFQRT
                                                     / DSSFL
C-------------------------------------------------------------------------------------
C                            Return Flow Fractions
C                            (READ FROM THIS FILE)
C
C   List the return flow fractions data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   RTRNF;  Return flows as a fraction of applied water; [dimensionless]
C
C-------------------------------------------------------------------------------------
C  TIME              RTRNF_AG    RTRNF_URB  RTRNF[3] ... RTRNF[NCOLRT]
C-------------------------------------------------------------------------------------
   12/31/2500_24:00    0.2         0.2
*
C-------------------------------------------------------------------------------
C                  Pathnames for Return Flow Fractions Data
C                            (READ FROM DSS FILE)
C
C   List the pathnames for return flow fractions data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C-------------------------------------------------------------------------------------
C   REC     PATH
C-------------------------------------------------------------------------------------
*
*
```

8.3.8.3. Re-use Fractions Data File

The Re-use Fractions Data File lists re-used portion of the captured return flow from agricultural and urban lands. It is specified as time series fractions of applied water. The difference between the return flow and re-use is the net return flow from agricultural and urban lands. Non-ponded crops, ponded crops and urban lands at each element are associated with data columns in this file through pointers specified in the Non-Ponded Crops Main File, Ponded Crops Main File and Urban Lands Main File, respectively.

The following variables are used in this file:

NCOLRUF	Number of re-use fractions data columns
NSPRUF	Number of time steps to update the re-use fractions; enter any number if time-tracking simulation
NFQRUF	Repetition frequency of the re-use fractions data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Re-use Fractions Data File

If the time series data is listed in the Re-use Fractions Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
RUF	Re-use as a fraction of applied water

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data

PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                    RE-USE FRACTIONS DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: ReuseFrac.dat
C
C*******************************************************************************
C                             File Description
C
C   This data file contains a set of re-use data given as fractions of irrigation
C   water.
C
C*******************************************************************************
C               Re-Use Fractions Data Specifications
C
C   NCOLRUF ; Number of re-use fractions data columns
C   NSPRUF  ; Number of time steps to update the re-use fractions
C              * Enter any number if time-tracking option is on
C   NFQRUF  ; Repetition frequency of the re-use fractions data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL   ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
           2                                         / NCOLRUF
           1                                         / NSPRUF
           0                                         / NFQRUF
                                                     / DSSFL
C---------------------------------------------------------------------------------
C                              Re-Use Fractions
C                            (READ FROM THIS FILE)
C
C   List the re-use fractions data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   RUF  ;  Re-use as a fraction of applied water; [dimensionless]
C
C---------------------------------------------------------------------------------
C  TIME                RUF_AG  RUF_URB  RUF[3] ... RUF[NCOLRUF]
C---------------------------------------------------------------------------------
   12/31/2500_24:00    0.05     0.0
*
C-------------------------------------------------------------------------------
C                       Pathnames for Re-Use Fractions Data
C                             (READ FROM DSS FILE)
C
C   List the pathnames for re-use fractions data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C---------------------------------------------------------------------------------
C   REC     PATH
C---------------------------------------------------------------------------------
*
*
```

8.3.8.4. Irrigation Period Data File

The Irrigation Period Data File includes time series flags that represent cropping seasons for ponded and non-ponded crops. A value of 0 represents a non-cropping period so IDC does not compute agricultural water demand for that period; a value of 1 represents cropping period and IDC calculates water demand for that period. The ponded and non-ponded crops in each element are associated with data columns in this file through pointers specified in the Ponded Crops Main File and the Non-Ponded Crops Main File.

The following variables are used in this file:

NCOLIP	Number of data columns for irrigation period
NSPIP	Number of time steps to update the irrigation period data; enter any number if time-tracking option is on
NFQIP	Repetition frequency of the irrigation period data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Irrigation Period Data File

If the time series data is listed in the Irrigation Period Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
IP	Irrigation period indicator (0 = it is out of cropping season and IDC will not compute a water demand; 1 = cropping season and IDC will compute a water demand)

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                   IRRIGATION PERIOD DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: IrrigPeriod.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains a set of irrigation period indicators (1 for irrigation
C   season and 0 for non-irrigation season).  These values are correlated to
C   individual ponded and non-ponded crops through the Ponded Crops Main File and
C   the Non-Ponded Crops Main File.
C
C*******************************************************************************
C               Irrigation Period Data Specifications
C
C   NCOLIP  ; Number of irrigation period data columns
C   NSPIP   ; Number of time steps to update the irrigation period data
C              * Enter any number if time-tracking option is on
C   NFQIP   ; Repetition frequency of the irrigation period data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL   ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-------------------------------------------------------------------------------
          22                                        / NCOLIP
          1                                         / NSPIP
          0                                         / NFQIP
          Example_Data.dss                          / DSSFL
C-----------------------------------------------------------------------------------------------
C                            Irrigation Period Indicators
C                               (READ FROM THIS FILE)
C
C   List the irrigtaion period data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   IP   ;  Irrigation period indicator;
C             0 = non-irrigation period (i.e. agricultural water demand will not be computed)
C             1 = irrigation period (i.e. agricultural water demand will be computed)
C
C-----------------------------------------------------------------------------------------------
C  TIME  IP[1]  IP[2]  IP[3] ... IP[NCOLIP]
C-----------------------------------------------------------------------------------------------
*
*
C-------------------------------------------------------------------------------
C                       Pathnames for Irrigation Period Data
C                              (READ FROM DSS FILE)
C
C   List the pathnames for irrigation period indicators below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C-----------------------------------------------------------------------------------------------
C   REC     PATH
C-----------------------------------------------------------------------------------------------
    1         /IWFM/GR_IP/FLAG//1MON/IRRIG_PERIOD/
    2         /IWFM/CO_IP/FLAG//1MON/IRRIG_PERIOD/
    3         /IWFM/SB_IP/FLAG//1MON/IRRIG_PERIOD/
    4         /IWFM/CR_IP/FLAG//1MON/IRRIG_PERIOD/
    5         /IWFM/DB_IP/FLAG//1MON/IRRIG_PERIOD/
    6         /IWFM/SF_IP/FLAG//1MON/IRRIG_PERIOD/
    7         /IWFM/FI_IP/FLAG//1MON/IRRIG_PERIOD/
    8         /IWFM/AL_IP/FLAG//1MON/IRRIG_PERIOD/
    9         /IWFM/PA_IP/FLAG//1MON/IRRIG_PERIOD/
    10        /IWFM/TM_IP/FLAG//1MON/IRRIG_PERIOD/
    11        /IWFM/CU_IP/FLAG//1MON/IRRIG_PERIOD/
    12        /IWFM/OG_IP/FLAG//1MON/IRRIG_PERIOD/
    13        /IWFM/TR_IP/FLAG//1MON/IRRIG_PERIOD/
    14        /IWFM/AP_IP/FLAG//1MON/IRRIG_PERIOD/
    15        /IWFM/OR_IP/FLAG//1MON/IRRIG_PERIOD/
    16        /IWFM/SO_IP/FLAG//1MON/IRRIG_PERIOD/
    17        /IWFM/FL_IP/FLAG//1MON/IRRIG_PERIOD/
    18        /IWFM/RICE_FL_IP/FLAG//1MON/IRRIG_PERIOD/
    19        /IWFM/RICE_NFL_IP/FLAG//1MON/IRRIG_PERIOD/
    20        /IWFM/RICE_NDC_IP/FLAG//1MON/IRRIG_PERIOD/
    21        /IWFM/RFG_SL_IP/FLAG//1MON/IRRIG_PERIOD/
    22        /IWFM/RFS_PR_IP/FLAG//1MON/IRRIG_PERIOD/
```

8.3.8.5. Generic Moisture Source File

The Generic Moisture Source File lists time series moisture inflow into the root zone from sources other than irrigation and precipitation. Possible sources of moisture are fog and lateral seepage through levees in places such as California's Sacramento-San Joaquin River Delta. The inflow rate is given in terms of unit rate per rooting depth of a land-use type. All land-use types can have access to generic sources of moisture. Each land-use type at each element is associated to a data column in this file through pointers in the respective main input file of a particular land-use.

The following variables are used in this file:

NCOLSRC	Number of generic moisture data columns
FACTSRC	Conversion factor for the spatial component of the generic moisture data
NSPSRC	Number of time steps to update the generic moisture data; enter any number if time-tracking simulation
NFQSRC	Repetition frequency of the generic moisture data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Generic Moisture Source File

If the time series data is listed in the Generic Moisture Source File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
MSRC	Generic moisture inflow rate; [(L/L)/T]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C              GENERIC MOISTURE SOURCE DATA FILE
C                     Root Zone Component
C                     *** Version 4.0 ***
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: GenericMoist.dat
C
C*******************************************************************************
C                              File Description:
C
C    This file contains a set of moisture time-series data to be used as generic
C    source of water for the root zone. This additional source of moisture can be
C    used to represent any source of water other then precipitation and irrigation.
C    The unit of the generic moisture is specified as [(L/L)/T], for instance
C    inches per foot per month. These values will be converted to unit rate of inflow
C    by the Root Zone Component by multiplying them with the rooting depth for each
C    land use. The generic moisture data are correlated to individual grid cells
C    through the Root Zone Parameter file.
C
C*******************************************************************************
C                    Generic Moisture Source Data Specifications
C
C    NCOLSRC; Number of generic moisture data columns (or pathnames if DSS files are used)
C    FACTSRC; Conversion factor for generic moisture data
C              It is used to convert only the spatial component of the unit;
C              DO NOT include the conversion factor for time component of the unit.
C              * e.g. Unit of generic moisture listed in this file          = INCHES/FOOT/MONTH
C                     Consistent unit used in simulation                    = FOOT/FOOT/DAY
C                     Enter FACTSRC (INCHES/FOOT//MONTH -> FOOT/FOOT/MONTH) = 8.33333E-02
C                      (conversion of MONTH -> DAY is performed automatically)
C    NSPSRC ; Number of time steps to update the generic moisture data
C              * Enter any number if time-tracking option is on
C    NFQSRC ; Repetition frequency of the generic moisture data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C    DSSFL ;  The name of the DSS file for data input (maximum 50 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C          VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------
           3                                           / NCOLSRC
           0.083333                                    / FACTSRC   (in -> ft)
           1                                           / NSPSRC
           0                                           / NFQSRC
           INPUT_DATA.DSS                              / DSSFL
C-------------------------------------------------------------------------------
C                          Generic Moisture Data
C                          (READ FROM THIS FILE)
C
C    List the generic moisture rates below in units of L/L/T, if it will
C    not be read from a DSS file (i.e. DSSFL is left blank above).
C
C    TIME ;   Time
C    MSRC ;   Generic moisture rate; [L/L/T]
C
C-------------------------------------------------------------------------------
C   TIME      MSRC[1]  MSRC[2]  MSRC[3]  ...  MSRC[NCOLSRC] ...
C-------------------------------------------------------------------------------
*
*
C-------------------------------------------------------------------------------
C                     Pathnames for Generic Moisture Data
C                          (READ FROM DSS FILE)
C
C    List the pathnames for the generic moisture data below, if it will be read
C    from a DSS file (i.e. DSSFL is specified above).
C
C    REC    ;  Time series record number
C    PATH   ;  Pathname for the time series record
C
C----------------------------------------------------------------------------------------------
C    REC        PATH
C----------------------------------------------------------------------------------------------
     1          /DELTA/SOUTH_LEVEE/SEEP//1DAY/SEEPAGE/
     2          /DELTA/NORTH_LEVEE/SEEP//1DAY/SEEPAGE/
     3          /DELTA/EAST_LEVEE/SEEP//1DAY/SEEPAGE/
```

8.3.8.6. Agricultural Supply Requirement Data File

IDC allows time-series agricultural water demands to be specified for some or all of the crops rather than dynamically computing them. This feature is useful in planning studies when the water demand is dictated by the contractual limits rather than crop evapotranspirative requirements. This feature can also be used when the historical surface water deliveries are known and the part or all of the deliveries are used for artificial recharge of the groundwater. The non-ponded and ponded crops in each element can optionally be associated with a data column in this file through the pointers in the Non-Ponded Crops Main File and the Ponded Crops Main File, respectively.

The following variables are used in this file:

NDMAG	Number of agricultural supply requirement data columns
FACTDMAG	Conversion factor for the spatial component of the agricultural supply requirement data
NSPDMAG	Number of time steps to update the agricultural supply requirement data; enter any number if time-tracking simulation
NFQDMAG	Repetition frequency of the agricultural supply requirement data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Agricultural Supply Requirement Data File

If the time series data is listed in the Agricultural Supply Requirement Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITDA	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
RDMAG	Agricultural water supply requirement; $[L^3/T]$

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

I	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C         AGRICULTURAL WATER SUPPLY REQUIREMENT DATA FILE
C                        Root Zone Component
C                        *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: AgWaterDemand.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains a set of agricultural water supply requirement data.
C   These data are correlated to individual crops through Non-Ponded and Ponded
C   Crop Data Files.
C
C*******************************************************************************
C              Agricultural Water Supply Requirement Data Specifications
C
C   NDMAG   ;  Number of agricultural water supply requirement data columns
C   FACTDMAG;  Conversion factor for the agricultural supply requirement
C               It is used to convert only the spatial component of the unit;
C               DO NOT include the conversion factor for time component of the unit.
C               * e.g. Unit of flow listed in this file           = AC-FT/MONTH
C                      Consistent unit used in simulation         = CU.FT/DAY
C                      Enter FACTDMAG (AC-FT/MONTH -> CU.FT/MONTH) = 43560.0
C                     (conversion of MONTH -> DAY is performed automatically)
C   NSPDMAG ;  Number of time steps to update the agricultural supply requirement data
C               * Enter any number if time-tracking option is on
C   NFQDMAG ;  Repetition frequency of the agricultural supply requirement data
C               * Enter 0 if full time series data is supplied
C               * Enter any number if time-tracking option is on
C   DSSFL   ;  The name of the DSS file for data input
C               * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C        VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          31                                        / NDMAG
          43560.0                                   / FACTDMAG (ac.ft -> cu.ft)
          1                                         / NSPDMAG
          0                                         / NFQDMAG
                                                    / DSSFL
C-------------------------------------------------------------------------------
C               Agricultural Water Supply Requirement Data
C                          (READ FROM THIS FILE)
C
C   List the agricultural water supply requirement data below, if it will not
C   be read from a DSS file (i.e. DSSFL is left blank above).
C
C   ITDA;    Time
C   RDMAG;   Agricultural water supply requirement; [L^3/T]
C
C-------------------------------------------------------------------------------
C ITDA                    RDMAG(1)  RDMAG(2)
C-------------------------------------------------------------------------------
C                            1        2        3      ...    29       30      31
  10/31/4000_24:00        26.02     8.88     0.34     ...    4.06     6.71  213.58
  11/30/4000_24:00        18.24     6.22     0.24     ...    2.85     4.70  149.75
  12/31/4000_24:00        17.34     5.92     0.23     ...    2.71     4.47  142.39
  01/31/4000_24:00         9.87     3.37     0.13     ...    1.54     2.54   81.01
  02/29/4000_24:00         7.77     2.65     0.10     ...    1.21     2.00   63.83
  03/31/4000_24:00         2.69     0.92     0.04     ...    0.42     0.69   22.09
  04/30/4000_24:00         0.60     0.20     0.01     ...    0.09     0.15    4.91
  05/31/4000_24:00         2.69     0.92     0.04     ...    0.42     0.69   22.09
  06/30/4000_24:00         5.38     1.84     0.07     ...    0.84     1.39   44.19
  07/31/4000_24:00         9.27     3.16     0.12     ...    1.45     2.39   76.10
  08/31/4000_24:00        13.16     4.49     0.17     ...    2.05     3.39  108.02
  09/30/4000_24:00        18.24     6.22     0.24     ...    2.85     4.70  149.75
C-------------------------------------------------------------------------------
C                 Pathnames for Agricultural Water Supply Requirement Data
C                               (READ FROM DSS FILE)
C
C   List the pathnames for the agricultural water supply requirement data below,
C   if it will be read from a DSS file (i.e. DSSFL is specified above).
C
C   I    ;  Pathname number
C   PATH ;  Pathname for the time series record
C
C---------------------------------------------------------------------------------------
C   I       PATH
C---------------------------------------------------------------------------------------
*
*
```

8.3.8.7. Non-Ponded-Crops Component Files

8.3.8.7.a Non-Ponded Crops Main File

The Non-Ponded Crops Main File is the gateway file for all data that is necessary to simulate non-ponded crops and generate non-ponded-crop related budget files.

The file is divided into several sections and uses the following variables:

General Data

Number of non-ponded crops simulated, crop codes and filename for the non-ponded crop acreage data are defined in this section:

NCROP	Number of agricultural crops excluding ponded crops (i.e. rice and refuge)
FLDMD	Flag for the root zone moisture to be used for the computation of agricultural water demand and the timing of irrigation (0 = use the soil moisture at the beginning of time step, 1 = use the soil moisture at the end of time step); setting FLDMD to 0 works well when the simulation time step is small (e.g. 1 day) while it should be set to 1 when the simulation time step is longer (e.g. 1 month)
CCODE	Crop codes; enter 2-character crop codes for each of the non-ponded crops modeled (following codes are reserved and should not be used: UR = Urban, RI = Rice, RF = Refuge, NV = Native vegetation, RV = Riparian vegetation)
LUFLNP	File that lists the crop areas (maximum 1000 characters)

Budget Output Files

To generate crop-specific land and water use and root zone budgets, the following variables must be specified:

NBCROP	Number of non-ponded crops for water budget output; enter 0 if crop specific budget output is not required
BCCODE	Crop codes (from above) for which water budget output is required
CLWUBUDFL	HDF5 output file for crop-specific land and water use budget at each subregion for selected crops (maximum 1000 characters); leave blank if this output is not required

CRZBUDFL	HDF5 output file for root zone moisture budget at each subregion for selected crops (maximum 1000 characters); leave blank if this output is not required

Rooting Depths

RZFRACFL	File that lists fraction of maximum root depths to represent root growth (maximum 1000 characters)
FACT	Conversion factor for maximum crop root zone depths
IC	Crop identification number; enter 1 through NCROP, sequentailly
ROOT	Maximum crop root zone depth; [L]
ICROOT	Root depth as a fraction of maximum root depth; this number corresponds to the appropriate data column in the Root Depth Fractions Data File

Curve Numbers for Rainfall Runoff Simulation

Curve numbers for each element and crop combination are entered in this section.

IE	Element identification number entered sequentially; enter 0 if curve numbers defined for each crop are to be used for all elements
CN	Curve number for each non-ponded agricultural crop

Crop Evapotranspiration

Crop evapotranspiration for each element and crop combination is listed here by specifying a column number in the Evapotranspiration File:

IE	Element identification number entered sequentially; enter 0 if following values are to be used for all elements
ICET	Crop ET; this number corresponds to the appropriate data column the Evapotranspiration File

Agricultural Water Supply Requirement

If, for any crop at an element, the agricultural water supply requirement is pre-specified instead of being computed dynamically, they are specified in this section:

IE	Element identification number; enter 0 if following values are to be used for all elements

ICAW	Agricultural water supply requirement; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically

Irrigation Periods

Time series irrigation period data is listed in this section for each crop and element combination:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICIP	Irrigation period; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL) listed in the Root Zone Parameters Data File.

Minimum Soil Moisture

The minimum soil moisture that is used to trigger an irrigation event for each crop and element combination is listed in this section:

MINSMFL	File that lists the minimum soil moisture for each crop (maximum 1000 characters)
IE	Element identification number; enter 0 if following values are to be used for all elements
ICMSM	Minimum soil moisture as a fraction of field capacity; this corresponds to the appropriate data column in the Minimum Soil Moisture Data File (MINSMFL)

Target Soil Moisture for Irrigation

The moisture level which is targeted to be achieved by the irrigation event is listed for each crop and element combination in this section:

TRGSMFL	File that lists the target soil moisture for each crop during irrigation (maximum 1000 characters); leave blank if target soil moisture is the field capacity
IE	Element identification number; enter 0 if following values are to be used for all elements

ICTRGSM	Target soil moisture as a fraction of total available water (i.e. field capacity less wilting point); this number corresponds to the appropriate data column in the Target Soil Moisture Data File (TRGSMFL)

Return Flow Fractions

The return flow fractions for each crop and element combination are listed in this section:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICRTRNF	Fraction of the applied water that becomes return flow; this number corresponds to the appropriate data column in the Return Flow Fractions Data File given in the Root Zone Component Main File

Re-use Fractions

The re-use fractions for each crop and element combination are listed in this section:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICRUF	Fraction of the applied water that becomes re-used water; this number corresponds to the appropriate data column in the Re-use Fractions Data File given in the Root Zone Component Main File

Minimum Percolation Fractions

If a minimum percolation amount needs to be specified, it is listed in this section for each crop and element combination:

DPFL	File that lists the minimum percolation fractions (maximum 1000 characters); leave blank if minimum percolation is not imposed
IE	Element identification number; enter 0 if following values are to be used for all elements
ICDPF	Fraction of the "infiltrated" applied water that is going to be percolation; this number corresponds to the appropriate data

	column in the Minimum Percolation Fractions Data File (DPFL)

Initial Soil Moisture Conditions

IE	Element identification number; enter 0 if following values are to be used for all elements
FSOILMP	Fraction of initial soil moisture at element IE that is due to precipitation
SOILM	Initial root zone moisture content; [L/L]

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C               NON-PONDED AGRICULTURAL CROPS DATA FILE
C                        Root Zone Component
C                        *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: NonPondedAg_MAIN.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes and managament of non-ponded agricultural crops.
C
C*******************************************************************************
C             Number of Non-Ponded Agricultural Crops and Crop Codes
C
C   NCROP    ;  Number of agricultural crops excluding ponded crops (i.e. rice and refuge)
C   FLDMD    ;  Flag for the root zone moisture to be used for the computation of
C                agricultural water demand and the timing of irrigation
C                * 0: Use the soil moisture at the beginning of time step
C                * 1: Use the soil moisture at the end of time step
C   CCODE    ;  Crop codes (max. 2 characters)
C               (1 to NCROP)
C             * Note: The following codes are reserved and should not be used:
C                UR : Urban
C                RI : Rice
C                RF : Refuge
C                NV : Native vegetation
C                RV : Riparian vegetation
C   LUFLNP   ;  File that lists the crop areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------------
    17                                                      / NCROP
    0                                                       / FLDMD
    GR                                                      / CCODE1     GRAIN
    CO                                                      / CCODE2     COTTON
    SB                                                      / CCODE3     SUGAR BEETS
    CR                                                      / CCODE4     CORN
    DB                                                      / CCODE5     DRY BEANS
    SF                                                      / CCODE6     SAFFLOWER
    FI                                                      / CCODE7     OTHER FIELD
    AL                                                      / CCODE8     ALFALFA
    PA                                                      / CCODE9     PASTURE
    TM                                                      / CCODE10    TOMATOES
    CU                                                      / CCODE11    CUCURBITS
    OG                                                      / CCODE12    ONIONS AND GARLIC
    TR                                                      / CCODE13    OTHER TRUCK
    AP                                                      / CCODE14    ALMONDS AND PISTACHIO
    OR                                                      / CCODE15    OTHER DECID.
    SO                                                      / CCODE16    SUBTROPICAL
    FL                                                      / CCODE17    FALLOW AND IDLE
    RootZone\NonPondedAg\NonPondedAgArea.dat                / LUFLNP
C*******************************************************************************
C                       Water Budget Output Files
C
C   NBCROP   ;  Number of non-ponded crops for water budget output
C                * Enter 0 if crop specific budget output is not required
C   BCCODE   ;  Crop codes (from above) for which water budget output is required
C                (1 to NBCROP)
C   CLWUBUDFL;  HDF5 output file for land and water use budget at each
C                  subregion for selected crops (max. 1000 characters)
C                * Leave blank if this output is not required
C   CRZBUDFL ;  HDF5 output file for root zone moisture budget at each
C                  subregion for selected crops (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-------------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------------
    17                                         / NBCROP
    GR                                         / BCCODE1    GRAIN
    CO                                         / BCCODE2    COTTON
    SB                                         / BCCODE3    SUGAR BEETS
    CR                                         / BCCODE4    CORN
    DB                                         / BCCODE5    DRY BEANS
    SF                                         / BCCODE6    SAFFLOWER
    FI                                         / BCCODE7    OTHER FIELD
    AL                                         / BCCODE8    ALFALFA
    PA                                         / BCCODE9    PASTURE
    TM                                         / BCCODE10   TOMATOES
    CU                                         / BCCODE11   CUCURBITS
    OG                                         / BCCODE12   ONIONS AND GARLIC
    TR                                         / BCCODE13   OTHER TRUCK
    AP                                         / BCCODE14   ALMONDS AND PISTACHIO
    OR                                         / BCCODE15   OTHER DECID.
    SO                                         / BCCODE16   SUBTROPICAL
    FL                                         / BCCODE17   FALLOW AND IDLE
    Budget\NonPondedAgLWU.hdf                  / CLWUBUDFL
    Budget\NonPondedAgRZ.hdf                   / CRZBUDFL
C*******************************************************************************
C                              Rooting Depths
C
C   RZFRACFL ;  File that lists fraction of maximum root depths to represent
C                root growth (max. 1000 characters)
C   FACT     ;  Conversion factor for maximum crop root zone depths
C   IC       ;  Crop type number (1 to NCROP);
C   ROOT     ;  Maximum crop root zone depth; [L]
C   ICROOT   ;  Root depth as a fraction of maximum root depth - this number
C                corresponds to the appropriate data column in the root depth
C                fractions data file (RZFRACFL).
C
*   Crop/Land Use No.          Name
```

```
*    ----------------            ------
*        1                         GR  grain
*        2                         CO  cotton
*        3                         SB  sugar beets
*        4                         CR  corn
*        5                         DB  dry beans
*        6                         SF  safflower
*        7                         FI  other field
*        8                         AL  alfalfa
*        9                         PA  pasture
*        10                        TM  processed tomatoes
*        11                        CU  cucurbits
*        12                        OG  onions & garlic
*        13                        TR  other truck
*        14                        AP  almonds & pistachios
*        15                        OR  other deciduous
*        16                        SO  subtropical
*        17                        FL  fallow and idle
*
C-------------------------------------------------------------------------------
C   VALUE                                  DESCRIPTION
C-------------------------------------------------------------------------------
    RootZone\NonPondedAg\RootDepthFrac.dat    / RZFRACFL
    1.0                                       / FACT
C-------------------------------------------------------------------------------
C   IC    ROOT      ICROOT
C-------------------------------------------------------------------------------
    1     4.0       1
    2     6.0       2
    3     5.0       3
    4     4.0       4
    5     4.0       5
    6     4.0       6
    7     4.0       7
    8     6.0       8
    9     2.0       9
    10    5.0       10
    11    3.0       11
    12    3.0       12
    13    3.0       13
    14    6.0       14
    15    6.0       15
    16    4.0       16
    17    1.0       17
C******************************************************************************
C                    Curve Numbers for Rainfall Runoff Simulation
C
C   Enter curve numbers for each grid element and crop combination.
C
C   IE     ;  Element ID (Enter 0 if following values are to be used for all element
C               and non-ponded agricultural crop combinations)
C   CN     ;  Curve number for each non-ponded agricultural crop (1 to NCROP)
C
C-------------------------------------------------------------------------------
C                                                      CN BY CROP
C IE   -------------------------------------------------------------------------------------------
C          GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C-----------------------------------------------------------------------------------------------------
    1      81    82    82    85    81    81    81    81    74    82    85    85    85    82    72    72    91
    2      81    82    82    85    81    81    81    81    74    82    85    85    85    82    72    72    91
    3      73    75    75    78    72    72    72    72    61    75    78    78    78    75    58    58    86
    .      .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
    .      .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
    .      .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
    221    81    82    82    85    81    81    81    81    74    82    85    85    85    82    72    72    91
    222    73    75    75    78    72    72    72    72    61    75    78    78    78    75    58    58    86
    223    73    75    75    78    72    72    72    72    61    75    78    78    78    75    58    58    86
C******************************************************************************
C                         Crop Evapotranspiration (ETc)
C
C   The following lists the ETc column pointers for each finite element and non-ponded
C   agricultural crop combination.
C
C   IE       ;  Element ID (Enter 0 if following values are to be used for all element
C                 and non-ponded agricultural crop combinations)
C   ICET     ;  Crop ET (ETc) - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Input File.  List for each
C                 non-ponded agricultural crop (1 to NCROP).
C
C-------------------------------------------------------------------------------
C                                                           ICET BY CROP
C   IE   -------------------------------------------------------------------------------------------
C          GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C-----------------------------------------------------------------------------------------------------
    0      1     2     3     4     5     6     7     8     9     10    11    12    13    14    15    16    17
C******************************************************************************
C                         Agricultural Water Supply Requirement
C
C   The following lists the agricultural water supply requirement column pointers
C   for each finite element and non-ponded agricultural crop combination.
C
C   IE       ;  Element ID (Enter 0 if following values are to be used for all element
C                 and non-ponded agricultural crop combinations)
C   ICAW     ;  Agricultural water supply requirement - this number corresponds to the
C                 appropriate data column in the agricultural water supply requirement data
C                 file (AGWDFL) listed in the Root Zone Parameters Data File.  List for each
C                 non-ponded agricultural crop (1 to NCROP).
C                 *** Note: Enter 0 if agricultural water supply requirement will be computed
C                           internally.
C
C-------------------------------------------------------------------------------
C                                                           ICAW BY CROP
C   IE   -------------------------------------------------------------------------------------------
C          GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C-----------------------------------------------------------------------------------------------------
    0      0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
C******************************************************************************
C                         Irrigation Periods
C
C   The following lists the irrigation period column pointers for each
C   finite element and non-ponded agricultural crop combinations.
C
```

```
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                  and non-ponded agricultural crop combinations)
C   ICIP      ;  Irrigation period - this number corresponds to the appropriate data
C                  column in the irrigation period data file (IPFL) listed in the Root
C                  Zone Parameters Data File.  List for each non-ponded crop (1 to NCROP).
C
C-------------------------------------------------------------------------------
C                                                                     ICIP BY CROP
C   IE  ------------------------------------------------------------------------------------------
C         GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C---------------------------------------------------------------------------------------------------
    0     1     2     3     4     5     6     7     8     9     10    11    12    13    14    15    16    17
C*******************************************************************************
C                         Minimum Soil Moisture
C
C   The following lists the minimum soil moisture column pointers for
C   each finite element and non-ponded agricultural crop combinations.
C
C   MINSMFL  ;  File that lists the minimum soil moisture for each crop
C                 (max. 1000 characters)
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                  and non-ponded agricultural crop combinations)
C   ICMSM     ;  Minimum soil moisture as a fraction of Total Available Water
C                 (TAW = field capacity - wilting point) - this number corresponds to
C                  the appropriate data column in the minimum soil moisture
C                  data file (MINSMFL).  List for each non-ponded crop (1 to NCROP).
C
C-------------------------------------------------------------------------------
C         VALUE                                  DESCRIPTION
C-------------------------------------------------------------------------------
          RootZone\NonPondedAg\MinMoist.dat          / MINSMFL
C-------------------------------------------------------------------------------
C                                                                     ICMSM BY CROP
C IE  --------------------------------------------------------------------------------------------
C         GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C---------------------------------------------------------------------------------------------------
   0      1     2     3     4     5     6     7     8     9     10    11    12    13    14    15    16    17
C*******************************************************************************
C                         Target Soil Moisture for Irrigation
C
C   The following lists the target soil moisture column pointers for
C   each finite element and non-ponded agricultural crop combinations.
C
C   TRGSMFL  ;  File that lists the target soil moisture for each crop during irrigation
C                 (max. 1000 characters)
C                 * Leave blank if target soil moisture is field capacity
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                  and non-ponded agricultural crop combinations)
C   ICTRGSM  ;  Target soil moisture as a fraction of field capacity - this number
C                  corresponds to the appropriate data column in the target soil moisture
C                  data file (TRGSMFL).  List for each non-ponded crop (1 to NCROP).
C
C-------------------------------------------------------------------------------
C         VALUE                                  DESCRIPTION
C-------------------------------------------------------------------------------
                                                     / TRGSMFL
C-------------------------------------------------------------------------------
C   IE     ICTRGSM[1]  ICTRGSM[2] ... ICTRGSM[NCROP]
C-------------------------------------------------------------------------------
*
*
C*******************************************************************************
C                          Irrigation Water Return Flow Fractions
C
C   The following lists the irrigation water return flow fraction column pointers
C   for each finite element and non-ponded agricultural crop combinations.
C
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                   and non-ponded agricultural crop combinations)
C   ICRTRNF  ;  Fraction of the applied water that becomes return flow - this number
C                   corresponds to the appropriate data column in irrigation water
C                   return flow factor data file (RFFL) given in the Root Zone
C                   Parameters Data File.  List for each non-ponded crop (1 to NCROP)
C
C-------------------------------------------------------------------------------
C                                                                     ICRTRNF BY CROP
C IE  --------------------------------------------------------------------------------------------
C         GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C---------------------------------------------------------------------------------------------------
  0       1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1
C*******************************************************************************
C                          Irrigation Water Re-Use Fractions
C
C   The following lists the irrigation water re-use fraction column pointers
C   for each finite element and non-ponded agricultural crop combinations.
C
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                   and non-ponded agricultural crop combinations)
C   ICRUF     ;  Fraction of the applied water that is re-used - this number
C                   corresponds to the appropriate data column in irrigation water
C                   re-use factor data file (RUFL) given in the Root Zone
C                   Parameters Data File.  List for each non-ponded crop (1 to NCROP)
C
C-------------------------------------------------------------------------------
C                                                                     ICRUF BY CROP
C IE  --------------------------------------------------------------------------------------------
C         GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C---------------------------------------------------------------------------------------------------
    0     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1
C*******************************************************************************
C                             Minimum Deep Percolation Fractions
C
C   The following lists the fractions for minimum deep percolation at each finite element.
C
C   DPFL      ;  File that lists the minimum deep percolation fractions (max. 1000 characters)
C                   * Leave blank if minimum deep percolation is not imposed
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                 and non-ponded agricultural crop combinations)
C   ICDPF     ;  Fraction of the "infiltrated" applied water that is going to be deep
C                 percolation - this number corresponds to the appropriate data column in
C                 minimum deep percolation factor data file (DPFL).  List for each non-ponded
C                 crop (1 to NCROP).
```

```
C-------------------------------------------------------------------------------
C        VALUE                                           DESCRIPTION
C-------------------------------------------------------------------------------
                                                         / DPFL
C-------------------------------------------------------------------------------
C   IE    ICDPF[1]  ICDPF[2] ... ICDPF[NCROP]
C-------------------------------------------------------------------------------
*
*
C*******************************************************************************
C                           Initial Soil Moisture Condition
C                          For Non-Ponded Agricultural Lands
C
C   IE     ; Element ID (Enter 0 if following values are to be used for all element
C              and non-ponded agricultural crop combinations)
C   FSOILMP; Fraction of initial soil moisture at element IE that is due to precipitation
C   SOILM  ; Initial root zone moisture content; [L/L]
C              (1 to NCROP)
C
C-----------------------------------------------------------------------------------------------------------------
C IE   FSOILMP  GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C-----------------------------------------------------------------------------------------------------------------
  1      0.5    0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13  0.13
  2      0.5    0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15  0.15
  3      0.5    0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10  0.10
  .       .       .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
  .       .       .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
  .       .       .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
  221    0.5    0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04  0.04
  222    0.5    0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23  0.23
  223    0.5    0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12  0.12
```

8.3.8.7.b Non-Ponded Crops Area Data File

Areas of each non-ponded crop at every element are listed in this file:

FACTLNNP	Conversion factor for land use areas; enter 0.0 if land use distribution is given as a fraction of element area
NSPLNNP	Number of time steps to update the land use data; enter any number if time-tracking option is on
NFQLNNP	Repetition frequency of the crop area data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Non-Ponded Crops Area Data File

If the time series data is listed in the Non-Ponded Crops Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using “C”, “c” or “*”, and the variables in the “Data Input from DSS File” section below should be populated.

ITLN	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
IE	Element identification number
ALAND	Area (or fraction of area) corresponding to non-ponded crops over an element; $[L^2]$ or $[L^2/L^2]$ based on FACTLNNP above.

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IE	Element identification number
LUTYPE	Crop identification number entered sequentially
PATH	Pathname corresponding to element and non-ponded crop type combination

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                        NON-PONDED CROP AREA FILE
C                           Root Zone Component
C                           *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: NonPondedCropArea.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains the land use distribution of non-ponded crops for
C   each element for the simulation period.
C
C*******************************************************************************
C                            Land Use Data Specifications
C
C   FACTLNNP;   Conversion factor for land use area
C                 * Enter 0.0 if land use distribution is given as a fraction of element area
C   NSPLNNP ;   Number of time steps to update the land use data
C                 * Enter any number if time-tracking option is on
C   NFQLNNP ;   Repetition frequency of the land use data
C                 * Enter 0 if full time series data is supplied
C                 * Enter any number if time-tracking option is on
C   DSSFL   ;   The name of the DSS file for data input
C                 * Leave blank if DSS file is not used for data input
C
C-----------------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-----------------------------------------------------------------------------------------
          10.763910417                                / FACTLNNP  (sq.m. -> sq.ft.)
          1                                           / NSPLNNP
          0                                           / NFQLNNP
                                                      / DSSFL
C-----------------------------------------------------------------------------------------
C                              Land Use Data
C                          (READ FROM THIS FILE)
C
C   List the land use data below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN ;   Time
C   IE   ;   Element number
C   ALAND;   Area (or fraction of area) corresponding to non-ponded crops over an
C             element; [L^2] or [L^2/L^2] (based on FACTLNNP above)
C             (1 to NCROP)
C               1      : Non-ponded crop 1
C               2      : Non-ponded crop 2
C                             .
C                             .
C               NCROP  : Non-ponded crop NCROP
C            * Note: Crop areas over elements that are designated as lake elements
C                    will be ignored
C
C-----------------------------------------------------------------------------------------------------------
C                                                                  ALAND
C                            -------------------------------------------------------------------------------
C   ITLN             IE            GR            CO            SB    ...   OR            SO             FL
C-----------------------------------------------------------------------------------------------------------
 12/31/2500_24:00    1            0.00          0.00          0.00  ...  0.00          0.00       52162.85
                     2            0.00          0.00          0.00  ...  0.00          0.00           0.00
                     3            0.00          0.00          0.00  ...  0.00          0.00           0.00
                     .             .             .             .    ...   .             .              .
                     .             .             .             .    ...   .             .              .
                     221          0.00     705478.12          0.00  ...  0.00          0.00         452.45
                     222          0.00          0.00          0.00  ...  0.00          0.00           0.00
                     223          0.00          0.00          0.00  ...  0.00          0.00           0.00
C-----------------------------------------------------------------------------------------
C                               Pathnames for Land Use Data
C                                 (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   The pathnames should be listed for each element and non-ponded crop combination.
C   They should be listed in an order such that, the crop type changes first.
C
C   * Example with 3 non-ponded agricultural crops (i.e. NCROP=3):
C
C       IE     LUTYPE      PATH
C        1        1       (pathname[1])
C        1        2       (pathname[2])
C        1        3       (pathname[3])
C        2        1       (pathname[4])
C        2        2       (pathname[5])
C        2        3       (pathname[6])
C        .        .            .
C        .        .            .
C       NE        1       (pathname[(NCROP)*NE - 2])
C       NE        2       (pathname[(NCROP)*NE - 1])
C       NE        3       (pathname[(NCROP)*NE])
C
C   IE     ;  Element number
C   LUTYPE ;  Land use type
C               1       = Non-ponded agricultural crop 1
C               2       = Non-ponded agricultural crop 2
C                            .
C                            .
C               NCROP   = Non-ponded agricultural crop NCROP
C   PATH   ;  Pathname corresponding to element and non-ponded crop type combination
C
C-----------------------------------------------------------------------------------------
C   IE        LUTYPE        PATH
C-----------------------------------------------------------------------------------------
*
```

8.3.8.7.c Root Depth Fractions Data File

This file includes the time series rooting depths as a fraction of the maximum rooting depths listed in the Non-Ponded Crops Main File. The non-ponded crops are associated with data columns in this file through pointers specified in the Non-Ponded Crops Main File.

The following variables are listed in this file:

NCOLRDF	Number of data columns for the rooting depth fractions
NSPRDF	Number of time steps to update the rooting depth fractions; enter any number if time-tracking option is on
NFQRDF	Repetition frequency of the rooting depth fractions; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Root Depth Fractions Data File

If the time series data is listed in the Root Depth Fractions Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
RDFRC	Root depths as a fraction of the maximum rooting depth

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                   ROOT DEPTH FRACTIONS DATA FILE
C                        Root Zone Component
C                        *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: RootDepthFrac.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains a set of rooting depths given as a fraction of the
C   maximum rooting depth to represent the root growth for non-ponded and ponded
C   crops.
C
C*******************************************************************************
C               Root Depth Fractions Data Specifications
C
C   NCOLRDF ; Number of root depth fractions data columns
C   NSPRDF  ; Number of time steps to update the root depth fractions
C              * Enter any number if time-tracking option is on
C   NFQRDF  ; Repetition frequency of the root depth fractions data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL   ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C        VALUE                                     DESCRIPTION
C-------------------------------------------------------------------------------
         17                                        / NCOLRDF
         1                                         / NSPRDF
         0                                         / NFQRDF
                                                   / DSSFL
C-----------------------------------------------------------------------------------------------
C                            Root Depth Fractions
C                            (READ FROM THIS FILE)
C
C   List the root depth fractions (between 0.0 and 1.0) data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   RDFRC;  Root depths as a fraction of the maximum rooting depth; [dimensionless]
C
C-----------------------------------------------------------------------------------------------
C  TIME               RDFRC[1]  RDFRC[2]  RDFRC[3] ... RTRNF[NCOLRDF]
C----------------------------------------------------------------------------------------------------------------------
C                     GR    CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C                     1     2     3     4     5     6     7     8     9     10    11    12    13    14    15    16    17
C----------------------------------------------------------------------------------------------------------------------
  12/31/2500_24:00    1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
*
C-------------------------------------------------------------------------------
C                     Pathnames for Root Depth Fractions Data
C                             (READ FROM DSS FILE)
C
C   List the pathnames for root depth fractions data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C---------------------------------------------------------------------------------------------------------
C   REC     PATH
C---------------------------------------------------------------------------------------------------------
*
*
```

8.3.8.7.d Minimum Soil Moisture Data File

This file includes the time series minimum soil moisture data that is used by IDC as an irrigation event trigger. The data is specified as a fraction of the total available water which is defined as the field capacity less the wilting point. In a given time step, if the root zone moisture falls below the minimum soil moisture IDC computes the agricultural supply requirement that is going to raise the moisture up to irrigation target moisture (field capacity, by default) after the losses due to percolation and return flow are taken into account. Each non-ponded crop at each grid cell is associated with a data column in this file through pointers listed in the Non-Ponded Crops Main File.

The following variables must be specified in this data file:

NCOLSM	Number of minimum soil moisture data columns
NSPSM	Number of time steps to update the minimum soil moisture data; enter any number if time-tracking option is on
NFQSM	Repetition frequency of the minimum soil moisture data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Minimum Soil Moisture Data File

If the time series data is listed in the Minimum Soil Moisture Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using “C”, “c” or “*”, and the variables in the “Data Input from DSS File” section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
SMMIN	Minimum soil moisture as a fraction of the total available water (i.e. field capacity less wilting point)

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                  MINIMUM SOIL MOISTURE DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: MinMoist.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains a set of minimum soil moistures as a fraction of the
C   Total Available Water (TAW = field capacity - wilting point) that are used
C   as triggers for irrigation events. These values are correlated to individual
C   crops through the Agricultural Lands Main Data File.
C
C*******************************************************************************
C                Minimum Soil Moisture Data Specifications
C
C   NCOLSM ; Number of minimum soil moisture data columns
C   NSPSM  ; Number of time steps to update the minimum soil moisture data
C              * Enter any number if time-tracking option is on
C   NFQSM  ; Repetition frequency of the minimum soil moisture data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                        DESCRIPTION
C-------------------------------------------------------------------------------
          17                                      / NCOLSM
          1                                       / NSPSM
          0                                       / NFQSM
                                                  / DSSFL
C-----------------------------------------------------------------------------------------------
C                          Minimum Soil Moisture Data
C                              (READ FROM THIS FILE)
C
C   List the minimum soil moisture data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   SMMIN;  Minimum soil moisture as a fraction of the Total Available Water
C             (TAW = field capacity - wilting point)
C
*   Crop/Land Use No.           Name
*   ----------------            ------
*       1                         GR  grain
*       2                         CO  cotton
*       3                         SB  sugar beets
*       4                         CR  corn
*       5                         DB  dry beans
*       6                         SF  safflower
*       7                         FI  other field
*       8                         AL  alfalfa
*       9                         PA  pasture
*       10                        TM  tomatoes
*       11                        CU  cucurbits
*       12                        OG  onions & garlic
*       13                        TR  other truck
*       14                        AP  almonds & pistachios
*       15                        OR  other deciduous
*       16                        SO  subtropical
*       17                        FL  fallow and bare soil
*
C---------------------------------------------------------------------------------------------------------------------
C TIME              GR     CO     SB     CR     DB     SF     FI     AL     PA     TM     CU     OG     TR     AP     OR     SO     FL
C---------------------------------------------------------------------------------------------------------------------
  12/31/2500_24:00  0.55   0.5    0.45   0.5    0.5    0.4    0.7    0.4    0.5    0.6    0.5    0.7    0.5    0.6    0.5    0.5    0.5
*
C-------------------------------------------------------------------------------
C                     Pathnames for Minimum Soil Moisture Data
C                              (READ FROM DSS FILE)
C
C   List the pathnames for minimum soil moisture data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C----------------------------------------------------------------------------------------------------
C   REC     PATH
C----------------------------------------------------------------------------------------------------
*
*
```

8.3.8.7.e Irrigation Target Moisture Data File

The Irrigation Target Moisture Data File is optional and lists the target moisture that IDC uses to compute the agricultural water supply requirement. This is the moisture level that will be achieved when the irrigation amount is equal to the IDC-computed water demand. The irrigation target moisture is specified as a fraction of the field capacity. A value that is less than 1.0 may represent deficit irrigation conditions (along with proper values of evapotranspiration rate and minimum soil moisture data) while a value that is larger than 1.0 may represent additional irrigation for leaching salts. If this file is omitted, then IDC uses field capacity as the irrigation target moisture. Each non-ponded crop at each element is associated with a data column in this file through pointers specified in the Non-Ponded Crops Data File.

The following variables are used in this file:

NCOLTSM	Number of irrigation target soil moisture data columns
NSPTSM	Number of time steps to update the irrigation target soil moisture data; enter any number if time-tracking option is on
NFQTSM	Repetition frequency of the irrigation target soil moisture data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Irrigation Target Moisture Data File

If the time series data is listed in the Irrigation Target Moisture Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
SMTRG	Irrigation target soil moisture as a fraction of field capacity

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C              IRRIGATION TARGET SOIL MOISTURE DATA FILE
C                        Root Zone Component
C                        *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: TargetMoist.dat
C
C*******************************************************************************
C                             File Description
C
C   This data file contains a set of irrigation target soil moistures as a fraction of
C   field capacity that are used in computing irrigation water demand. During an
C   irrigation event the soil moisture is raised to the target soil moisture.  Target
C   soil mositure cannot be less than minimum soil moisture specified in the Minimum
C   Soil Moisture data file. These values are correlated to individual crops through
C   the Non-Ponded Crop Data File.
C
C*******************************************************************************
C               Irrigation Target Soil Moisture Data Specifications
C
C   NCOLTSM ; Number of irrigation target soil moisture data columns
C   NSPTSM  ; Number of time steps to update the irrigation target soil moisture data
C              * Enter any number if time-tracking option is on
C   NFQTSM  ; Repetition frequency of the irrigation target soil moisture data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL   ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                    DESCRIPTION
C-------------------------------------------------------------------------------
          17                                       / NCOLTSM
          1                                        / NSPTSM
          0                                        / NFQTSM
                                                   / DSSFL
C----------------------------------------------------------------------------------------------
C                      Irrigation Target Soil Moisture Data
C                            (READ FROM THIS FILE)
C
C   List the irrigation target soil moisture data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   SMTRG;  Irrigation target soil moisture as a fraction of field capacity; [L/L]
C
*   Crop/Land Use No.            Name
*   ----------------             ------
*       1                          GR  grain
*       2                          CO  cotton
*       3                          SB  sugar beets
*       4                          CR  corn
*       5                          DB  dry beans
*       6                          SF  safflower
*       7                          FI  other field
*       8                          AL  alfalfa
*       9                          PA  pasture
*       10                         TM  tomatoes
*       11                         CU  cucurbits
*       12                         OG  onions & garlic
*       13                         TR  other truck
*       14                         AP  almonds & pistachios
*       15                         OR  other deciduous
*       16                         SO  subtropical
*       17                         FL  fallow and bare soil
*
C--------------------------------------------------------------------------------------------------------------------------
C                                                      SMTRG
C                  --------------------------------------------------------------------------------------------------------
C TIME              GR     CO    SB    CR    DB    SF    FI    AL    PA    TM    CU    OG    TR    AP    OR    SO    FL
C--------------------------------------------------------------------------------------------------------------------------
  12/31/2500_24:00  1.0    1.0   0.7   1.1   1.0   1.0   1.1   1.0   1.0   1.0   1.0   0.7   1.0   1.0   1.0   1.0   0.0
*
C-------------------------------------------------------------------------------
C                Pathnames for Irrigation Target Soil Moisture Data
C                             (READ FROM DSS FILE)
C
C   List the pathnames for irrigation target soil moisture data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C-----------------------------------------------------------------------------------------------------
C   REC     PATH
C-----------------------------------------------------------------------------------------------------
*
*
```

8.3.8.7.f Minimum Percolation Fractions Data File

The Minimum Percolation Fractions Data File is optional and lists the minimum percolation values that IDC uses to compute the agricultural water supply requirement. This is the percolation level that IDC will try to achieve with the applied water during an irrigation event. However, the percolation is limited with the saturated hydraulic conductivity of the root zone and IDC may not be able to achieve the user-specified minimum percolation if it is greater than the saturated hydraulic conductivity. The minimum percolation is specified as a fraction of the infiltrated applied water (i.e. total applied water less the net return flow). This minimum percolation data can be used to simulate the irrigation practices to facilitate the leaching of salts. If this file is omitted, then IDC will not try to increase the applied water to achieve a minimum percolation. Each non-ponded crop at each element is associated with a data column in this file through pointers specified in the Non-Ponded Crops Data File.

The following variables are used in this file:

NCOLDPF	Number of minimum percolation data columns
NSPDPF	Number of time steps to update the minimum percolation data; enter any number if time-tracking option is on
NFQDPF	Repetition frequency of the minimum percolation data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Minimum Percolation Fractions Data File

If the time series data is listed in the Minimum Percolation Fractions Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
LF	Minimum percolation as a fraction of the infiltrated applied water

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                 MINIMUM PERCOLATION FACTORS DATA FILE
C                         Root Zone Component
C                         *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: MinPerc.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains a set of minimum percolation factors given as
C   fractions of infiltrated irrigation water.  These values are correlated to
C   individual crops through the Non-Ponded Crop Data File.
C
C*******************************************************************************
C            Minimum Percolation Factors Data Specifications
C
C   NCOLDPF ; Number of minimum percolation factors data columns
C   NSPDPF  ; Number of time steps to update the minimum percolation
C              * Enter any number if time-tracking option is on
C   NFQDPF  ; Repetition frequency of the minimum percolation factors data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL   ; The name of the DSS file for data input
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          2                                        / NCOLDPF
          1                                        / NSPDPF
          0                                        / NFQDPF
                                                   / DSSFL
C-----------------------------------------------------------------------------------------------
C                           Minimum Percolation Factors
C                              (READ FROM THIS FILE)
C
C   List the minimum percolation factors data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   LF   ;  Minimum percolation factors as a fraction of infiltrated irrigation water; [dimensionless]
C
C-----------------------------------------------------------------------------------------------
C  TIME               DPF[1]  DPF[2]  DPF[3] ... DPF[NCOLLF]
C-----------------------------------------------------------------------------------------------
   12/31/2500_24:00   0.10    0.15
*
C-------------------------------------------------------------------------------
C                 Pathnames for Minimum Percolation Factors Data
C                             (READ FROM DSS FILE)
C
C   List the pathnames for minimum percolation factors data below, if it
C   will be read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C-------------------------------------------------------------------------------------------------------
C   REC     PATH
C-------------------------------------------------------------------------------------------------------
*
*
```

8.3.8.8. Ponded-Crops Component Files

There are 5 pre-specified ponded crops simulated by IDC: i) rice with flooded decomposition, ii) rice with non-flooded decomposition, iii) rice with no decomposition, iv) seasonal refuges, and v) permanent refuges. Even though refuges are not agricultural lands, their ponding operations are very similar to those of rice fields. Therefore, they are grouped and simulated as ponded crops in IDC.

The following sections describe in detail the input data files that are used to simulated ponded crops.

8.3.8.8.a Ponded Crops Main File

The Ponded Crops Main File is the gateway file for all data that is necessary to simulate ponded crops and generate ponded-crop related budget files.

The file is divided into several sections and uses the following variables:

Land-Use Areas

The filename for the ponded crop areas data file is listed in this section:

LUFLP	File that lists the ponded crop areas (maximum 1000 characters)

Budget Output Files

To generate crop-specific land and water use and root zone budgets, the following variables must be specified:

NBCROP	Number of ponded crops for water budget output; enter 0 if crop specific budget output is not required
BCCODE	Crop codes for which water budget output is required (RICE_FL = rice with flooded decomposition, RICE_NFL = rice with non-flooded decomposition, RICE_NDC = rice with no decomposition, REFUGE_SL = seasonal refuges, REFUGE_PR = permanent refuges)
CLWUBUDFL	HDF5 output file for crop-specific land and water use budget at each subregion for selected crops (maximum 1000 characters); leave blank if this output is not required

CRZBUDFL	HDF5 output file for root zone moisture budget at each subregion for selected crops (maximum 1000 characters); leave blank if this output is not required

Rooting Depths

FACT	Conversion factor for rice and refuge root zone depths
ROOTRI_FL	Root zone depth for rice with flooded decomposition; [L]
ROOTRI_NFL	Root zone depth for rice with non-flooded decomposition; [L]
ROOTRI_NDC	Root zone depth for rice with no decomposition; [L]
ROOTRF_SL	Root zone depth for seasonal refuges; [L]
ROOTRF_PR	Root zone depth for permanent refuges; [L]

Curve Numbers for Rainfall Runoff Simulation

Curve numbers for each element and ponded-crop combination are entered in this section. The curve numbers listed in this section are used only outside the ponding season; during ponding season a value of 100 is used.

IE	Element identification number entered sequentially; enter 0 if curve numbers defined for each ponded-crop are to be used for all elements
CNRI_FL	Curve number for rice lands with flooded decomposition
CNRI_NFL	Curve number for rice lands with non-flooded decomposition
CNRI_NDC	Curve number for rice lands with no decomposition
CNRF_SL	Curve number for seasonal refuge lands
CNRF_PR	Curve number for permanent refuge lands

Crop Evapotranspiration

Crop evapotranspiration for each element and ponded-crop combination is listed here by specifying a column number in the Evapotranspiration File:

IE	Element identification number entered sequentially; enter 0 if following values are to be used for all elements
ICETRI_FL	Evapotranspiration rate for rice with flooded decomposition; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the Root Zone Component Main File

ICETRI_NFL	Evapotranspiration rate for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the Root Zone Component Main File
ICETRI_NDC	Evapotranspiration rate for rice with no decomposition; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the Root Zone Component Main File
ICETRI_SL	Evapotranspiration rate for seasonal refuges; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the Root Zone Component Main File
ICETRI_PR	Evapotranspiration rate for permanent refuges; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the Root Zone Component Main File

Agricultural Water Supply Requirement

If, for any ponded-crop at an element, the agricultural water supply requirement is pre-specified instead of being computed dynamically, they are specified in this section:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICAWRI_FL	Agricultural water supply requirement for rice with flooded decomposition; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically
ICAWRI_NFL	Agricultural water supply requirement for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically

ICAWRI_NDC	Agricultural water supply requirement for rice with no decomposition; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically
ICAWRF_SL	Water supply requirement for seasonal refuges; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically
ICAWRF_PR	Water supply requirement for permanent refuges; this number corresponds to the appropriate data column in the Agricultural Supply Requirement Data File (AGWDFL) listed in the Root Zone Component Main File (enter 0 if agricultural water supply requirement will be computed dynamically

Irrigation Periods

Time series irrigation period data is listed in this section for each ponded crop and element combination:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICIP_FL	Irrigation period for rice with flooded decomposition; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL) listed in the Root Zone Parameters Data File.
ICIP_NFL	Irrigation period for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL) listed in the Root Zone Parameters Data File.
ICIP_NDC	Irrigation period for rice with no decomposition; this number corresponds to the appropriate data column in the Irrigation

	Period Data File (IPFL) listed in the Root Zone Parameters Data File.
ICIP_SL	Irrigation period for seasonal refuges; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL) listed in the Root Zone Parameters Data File.
ICIP_PR	Irrigation period for permanent refuges; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL) listed in the Root Zone Parameters Data File.

Rice and Refuge Operations Input Files

In this section filenames for input data files that list time series ponding depths and pond operation flows are listed:

PNDTHFL	File that lists the ponding depths for rice and refuge operations (maximum 1000 characters)
FLOWFL	File that lists rice and refuge pond operation flows that include water application depths for non-flooded decomposition of rice, re-use and return flow depths (maximum 1000 characters)

Ponding Depths

Time series ponding depths for each element and ponded-crop combination are listed in this section.

IE	Element identification number; enter 0 if following values are to be used for all element and ponded-crop combinations
ICPDRI_FL	Ponding depth for rice with flooded decomposition including depths for decomposition operations; this number corresponds to the appropriate data column in the Ponding Depth Data File (PNDTHFL)
ICPDRI_NFL	Ponding depth for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Ponding Depth Data File (PNDTHFL)

ICPDRI_NDC	Ponding depth for rice with no decomposition; this number corresponds to the appropriate data column in the Ponding Depth Data File (PNDTHFL)
ICPDRF_SL	Ponding depth for seasonal refuge ponds; this number corresponds to the appropriate data column in the Ponding Depth Data File (PNDTHFL)
ICPDRF_PR	Ponding depth for permanent refuge ponds; this number corresponds to the appropriate data column in the Ponding Depth Data File (PNDTHFL)

Application Depths for Non-Flooded Decomposition of Rice

For rice with non-flooded decomposition, the water application rates for the decomposition of rice are listed here.

IE	Element identification number; enter 0 if following values are to be used for all element and ponded-crop combinations
ICDWRI_NFL	Water application depth for non-flooded decomposition of rice; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL).

Return Flow Depths

The return flow depths for each crop and element combination are listed in this section. The return flows for rice and refuges include circulation depths as well as lateral subsurface flows (i.e. seepage) into the return flow collection ditches.

IE	Element identification number; enter 0 if following values are to be used for all elements
ICRTRI_FL	Depth of return flow for rice with flooded decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRTRI_NFL	Depth of return flow for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRTRI_NDC	Depth of return flow for rice with no decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)

ICRTRF_SL	Depth of return flow for seasonal refuges; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRTRF_PR	Depth of return flow for permanent refuges; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)

Re-use Flow Depth

The re-use flow depths for each crop and element combination are listed in this section:

IE	Element identification number; enter 0 if following values are to be used for all elements
ICRUFRI_FL	Depth of re-used water for rice with flooded decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRUFRI_NFL	Depth of re-used water for rice with non-flooded decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRUFRI_NDC	Depth of re-used water for rice with no decomposition; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRUFRF_SL	Depth of re-used water at seasonal refuges; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)
ICRUFRF_PR	Depth of re-used water at permanent refuges; this number corresponds to the appropriate data column in the Pond Operation Flows Data File (FLOWFL)

Initial Soil Moisture Conditions

The initial soil moisture content for each ponded crop and element combination is listed in this section. For ponded crops, soil moisture content can be greater 1.0; in this case the portion of the soil moisture above 1.0 represents the ponding depth.

IE	Element identification number; enter 0 if following values are to be used for all elements

FSOILMP	Fraction of initial soil moisture at element IE that is due to precipitation
SOILM_RI_FL	Initial root zone moisture content for rice with flooded decomposition; [L/L]
SOILM_RI_NFL	Initial root zone moisture content for rice with non-flooded decomposition; [L/L]
SOILM_RI_NDC	Initial root zone moisture content for rice with no decomposition; [L/L]
SOILM_RF_SL	Initial root zone moisture content for seasonal refuges; [L/L]
SOILM_RF_PR	Initial root zone moisture content for permanent refuges; [L/L]

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                     RICE AND REFUGE LANDS DATA FILE
C                          Root Zone Component
C                          *** Version 4.0 ***
C
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: PondedAg_MAIN.dat
C
C*******************************************************************************
C                           File Description
C
C    This data file contains the parameters and data file names for the simulation
C    of root zone processes and managament of lands with rice and refuge.
C
C*******************************************************************************
C                          Land Use Areas
C
C    LUFLP   ;  File that lists the crop areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    RootZone\PondedAg\PondedAgArea.dat                      / LUFLP
C*******************************************************************************
C                       Water Budget Output Files
C
C    NBCROP   ;  Number of ponded crops for water budget output
C                 * Enter 0 if crop specific budget output is not required
C    BCCODE   ;  Crop codes for which water budget output is required
C                 (1 to NBCROP)
C                 * Use the following crop codes:
C                   RICE_FL  : Rice with flooded decomposition
C                   RICE_NFL : Rice with non-flooded decomposition
C                   RICE_NDC : Rice with no decomposition
C                   REFUGE_SL: Seasonal refuges
C                   REFUGE_PR: Permanent refuges
C    CLWUBUDFL;  HDF5 output file for land and water use budget at each
C                   subregion for selected crops (max. 1000 characters)
C                 * Leave blank if this output is not required
C    CRZBUDFL ;  HDF5 output file for root zone moisture budget at each
C                   subregion for selected crops (max. 1000 characters)
C                 * Leave blank if this output is not required
C
C-------------------------------------------------------------------------------
C    VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
      2                             / NBCROP
      RICE_FL                       / BCCODE[1]
      REFUGE_PR                     / BCCODE[2]
      Budget\PondedAgLWU.hdf        / CLWUBUDFL
      Budget\PondedAgRZ.hdf         / CRZBUDFL
C*******************************************************************************
C                             Rooting Depths
C
C    FACT       ;    Conversion factor for rice and refuge root zone depths
C    ROOTRI_FL ;     Root zone depth for rice with flooded decomposition; [L]
C    ROOTRI_NFL;     Root zone depth for rice with non-flooded decomposition; [L]
C    ROOTRI_NDC;     Root zone depth for rice with no decomposition; [L]
C    ROOTRF_SL ;     Root zone depth for seasonal refuges; [L]
C    ROOTRF_PR ;     Root zone depth for permanent refuges; [L]
C
C-------------------------------------------------------------------------------
C    VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                     / FACT
    2.0                     / ROOTRI_FL
    2.0                     / ROOTRI_NFL
    2.0                     / ROOTRI_NDC
    2.0                     / ROOTRF_SL
    2.0                     / ROOTRF_PR
C*******************************************************************************
C                   Curve Numbers for Rainfall Runoff Simulation
C
C    Enter curve numbers for each grid element and rice/refuge combination.
C
C    IE        ;  Element ID (Enter 0 if following values are to be used for all
C                 element and ponded agricultural crop combinations)
C    CNRI_FL   ;  Curve number for rice lands with flooded decomposition
C    CNRI_NFL ;   Curve number for rice lands with non-flooded decomposition
C    CNRI_NDC ;   Curve number for rice lands with no decomposition
C    CNRF_SL   ;  Curve number for seasonal refuge lands
C    CNRF_PR   ;  Curve number for permanent refuge lands
C               * Note: CN for rice and refuge should be entered for the type of
C                       soil and land cover during non-ponding season. During the
C                       ponding season CN=100 will be used.
C
C-------------------------------------------------------------------------------
C   IE      CNRI_FL    CNRI_NFL     CNRI_NDC    CNRF_SL    CNRF_PR
C-------------------------------------------------------------------------------
    1            78          78           78         65         65
    2            78          78           78         65         65
    3            71          71           71         48         48
    .            .           .            .          .          .
    .            .           .            .          .          .
    .            .           .            .          .          .
    221          78          78           78         65         65
    222          71          71           71         48         48
    223          71          71           71         48         48
C*******************************************************************************
C                     Crop Evapotranspiration (ETc)
C
C    The following lists the ETc column pointers for each finite element, rice and
C    refuge combination.
C
C    IE          ;  Element ID (Enter 0 if following values are to be used for all element
C                     and ponded crop combinations)
C    ICETRI_FL  ;  ETc for rice with flooded decomposition - this number corresponds to the
```

```
C                appropriate data column in the ET data file listed in the Main Control
C                Data file.
C   ICETRI_NFL ; ETc for rice with non-flooded decomposition - this number corresponds to
C                the appropriate data column in the ET data file listed in the Main Control
C                Data file.
C   ICETRI_NDC ; ETc for rice with no decomposition - this number corresponds to
C                the appropriate data column in the ET data file listed in the Main Control
C                Data file.
C   ICETRF_SL  ; ETc for seasonal refuge - this number corresponds to the appropriate data
C                column in the ET data file listed in the Main Control Data file.
C   ICETRF_PR  ; ETc for permanent refuge - this number corresponds to the appropriate data
C                column in the ET data file listed in the Main Control Data file.
C
C-------------------------------------------------------------------------------
C   IE    ICETRI_FL    ICETRI_NFL    ICETRI_NDC    ICETRF_SL    ICETRF_PR
C-------------------------------------------------------------------------------
    1          18            18            18           19       19
    2          18            18            18           19       19
    3          18            18            18           19       19
    .          .             .             .            .        .
    .          .             .             .            .        .
    .          .             .             .            .        .
    221        18            18            18           19       19
    222        18            18            18           19       19
    223        18            18            18           19       19
C*******************************************************************************
C                      Water Supply Requirement
C
C   The following lists the water supply requirement column pointers for each finite
C   element and ponded crop combination.
C
C   IE         ; Element ID (Enter 0 if following values are to be used for all element
C                and ponded crop combinations)
C   ICAWRI_FL  ; Water supply requirement for rice with flooded decomposition - this
C                number corresponds to the appropriate data column in the agricultural
C                water supply requirement data file (AGWDFL) listed in the Root Zone
C                Parameters Data File.
C                *** Note: Enter 0 if water supply requirement will be computed
C                          internally.
C   ICAWRI_NFL ; Water supply requirement for rice with non-flooded decomposition - this
C                number corresponds to the appropriate data column in the agricultural
C                water supply requirement data file (AGWDFL) listed in the Root Zone
C                Parameters Data File.
C                *** Note: Enter 0 if water supply requirement will be computed
C                          internally.
C   ICAWRI_NDC ; Water supply requirement for rice with no decomposition - this
C                number corresponds to the appropriate data column in the agricultural
C                water supply requirement data file (AGWDFL) listed in the Root Zone
C                Parameters Data File.
C                *** Note: Enter 0 if water supply requirement will be computed
C                          internally.
C   ICAWRF_SL  ; Water supply requirement for seasonal refuge - this number corresponds
C                to the appropriate data column in the agricultural water supply
C                requirement data file (AGWDFL) listed in the Root Zone Parameters
C                Data File.
C                *** Note: Enter 0 if water supply requirement will be computed
C                          internally.
C   ICAWRF_PR  ; Water supply requirement for permanentl refuge - this number corresponds
C                to the appropriate data column in the agricultural water supply
C                requirement data file (AGWDFL) listed in the Root Zone Parameters
C                Data File.
C                *** Note: Enter 0 if water supply requirement will be computed
C                          internally.
C
C-------------------------------------------------------------------------------
C   IE    ICAWRI_FL    ICAWRI_NFL    ICAWRI_NDC    ICAWRF_SL    ICAWRF_PR
C-------------------------------------------------------------------------------
    1          0             0             0            0        0
    2          0             0             0            0        0
    3          0             0             0            0        0
    .          .             .             .            .        .
    .          .             .             .            .        .
    .          .             .             .            .        .
    221        0             0             0            0        0
    222        0             0             0            0        31
    223        0             0             0            0        0
C*******************************************************************************
C                      Irrigation Periods
C
C   The following lists the irrigation period column pointers for each
C   finite element and ponded crop combinations.
C
C   IE       ; Element ID (Enter 0 if following values are to be used for all element
C               and ponded crop combinations)
C   ICIP_FL  ; Irrigation period for rice with flooded decomposition - this number
C               corresponds to the appropriate data column in the irrigation period
C               data file (IPFL) listed in the Root Zone Parameters Data File.
C   ICIP_NFL ; Irrigation period for rice with non-flooded decomposition - this number
C               corresponds to the appropriate data column in the irrigation period
C               data file (IPFL) listed in the Root Zone Parameters Data File.
C   ICIP_NDC ; Irrigation period for rice with no decomposition - this number
C               corresponds to the appropriate data column in the irrigation period
C               data file (IPFL) listed in the Root Zone Parameters Data File.
C   ICIP_SL  ; Irrigation period for seasonal refuge - this number corresponds to
C               the appropriate data column in the irrigation period data file
C               (IPFL) listed in the Root Zone Parameters Data File.
C   ICIP_PR  ; Irrigation period for permanent refuge - this number corresponds to
C               the appropriate data column in the irrigation period data file
C               (IPFL) listed in the Root Zone Parameters Data File.
C
C-------------------------------------------------------------------------------
C   IE    ICIP_FL   ICIP_NFL   ICIP_NDC   ICIP_SL   ICIP_PR
C-------------------------------------------------------------------------------
    0       18         19         20         21        22
C*******************************************************************************
C                  Rice and Refuge Operations Input Files
C
C   The following lists the rice and refuge operations related data files.
C
C   PNDTHFL   ; File that lists the ponding depths for rice and refuge operations
C                (max. 1000 characters)
C   FLOWFL    ; File that lists rice/refuge pond operation flows (water application
```

```
C               depths for non-flooded decomposition of rice, re-use and return
C               flow depths (max. 1000 characters)
C
C-------------------------------------------------------------------------------
C        VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
    RootZone\PondedAg\PondDepth.dat                 / PNDTHFL
    RootZone\PondedAg\PondOperationFlows.dat        / FLOWFL
C*******************************************************************************
C                                    Ponding Depths
C
C   IE        ; Element ID (Enter 0 if following values are to be used for all element
C               and ponded crop combinations)
C   ICPDRI_FL ; Ponding depth for rice with flooded decomposition including depths for
C               decomposition operations - this number corresponds to the appropriate
C               data column in the rice/refuge ponding depth data file (PNDTHFL).
C   ICPDRI_NFL; Ponding depth for rice with non-flooded decomposition - this number
C               corresponds to the appropriate data column in the rice/refuge
C               ponding depth data file (PNDTHFL).
C   ICPDRI_NDC; Ponding depth for rice with no decomposition - this number
C               corresponds to the appropriate data column in the rice/refuge
C               ponding depth data file (PNDTHFL).
C   ICPDRF_SL ; Ponding depth for seasonal refuge ponds - this number corresponds to the
C               appropriate data column in the rice/refuge ponding depth data file (PNDTHFL).
C   ICPDRF_PR ; Ponding depth for permanent refuge ponds - this number corresponds to the
C               appropriate data column in the rice/refuge ponding depth data file (PNDTHFL).
C
C-------------------------------------------------------------------------------
C   IE     ICPDRI_FL   ICPDRI_NFL   ICPDRI_NDC   ICPDRF_SL   ICPDRF_PR
C-------------------------------------------------------------------------------
     0       1            1            1            2           2
C*******************************************************************************
C              Application Depths for Non-Flooded Rice Decomposition
C
C   IE        ; Element ID (Enter 0 if following values are to be used for all elements)
C   ICDWRI_NFL; Water application depth for non-flooded decomposition of rice - this number
C               corresponds to the appropriate data column in the rice/refuge flows
C               data file (FLOWFL).
C
C-------------------------------------------------------------------------------
C   IE     ICDWRI_NFL
C-------------------------------------------------------------------------------
    0       5
C*******************************************************************************
C                               Return Flow Depths
C
C   IE        ;  Element ID (Enter 0 if following values are to be used for all element
C                and ponded crop combinations)
C   ICRTRI_FL ;  Depth of return flow for rice with flooded decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge flows
C                data file (FLOWFL).
C   ICRTRI_NFL;  Depth of return flow for rice with non-flooded decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge flows
C                data file (FLOWFL).
C   ICRTRI_NDC;  Depth of return flow for rice with no decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge flows
C                data file (FLOWFL).
C   ICRTRF_SL ;  Depth of return flow for seasonal refuges - this number corresponds to the
C                appropriate data column in the rice/refuge flows data file (FLOWFL).
C   ICRTRF_PR ;  Depth of return flow for permanent refuges - this number corresponds to the
C                appropriate data column in the rice/refuge flows data file (FLOWFL).
C                *** Note: Return flow for rice and refuge includes circulation depths as well
C                          as lateral subsurface flow (i.e. seepage) to return flow collection
C                          ditches.
C
C-------------------------------------------------------------------------------
C   IE     ICRTRI_FL   ICRTRI_NFL   ICRTRI_NDC   ICRTRF_SL   ICRTRF_PR
C-------------------------------------------------------------------------------
    0       1           1            1            2           2
C*******************************************************************************
C                               Re-use Flow Depths
C
C   IE         ;  Element ID (Enter 0 if following values are to be used for all element
C                 and ponded crop combinations)
C   ICRUFRI_FL ; Depth of re-used water at rice with flooded decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge
C                flows data file (FLOWFL).
C   ICRUFRI_NFL; Depth of re-used water at rice with non-flooded decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge
C                flows data file (FLOWFL).
C   ICRUFRI_NDC; Depth of re-used water at rice with no decomposition - this number
C                corresponds to the appropriate data column in the rice/refuge
C                flows data file (FLOWFL).
C   ICRUFRF_SL ; Depth of re-used water at seasonal refuges - this number corresponds to the
C                appropriate data column in the rice/refuge flows data file (FLOWFL).
C   ICRUFRF_PR ; Depth of re-used water at permanent refuges - this number corresponds to the
C                appropriate data column in the rice/refuge flows data file (FLOWFL).
C
C-------------------------------------------------------------------------------
C   IE     ICRUFRI_FL   ICRUFRI_NFL   ICRUFRI_NDC   ICRUFRF_SL   ICRUFRF_PR
C-------------------------------------------------------------------------------
    0       3            3             3             4            4
C*******************************************************************************
C                          Initial Soil Moisture Condition
C                                For Ponded Lands
C
C   IE          ;   Element ID (0 if following values are to be used for all elements)
C   FSOILMP     ;   Fraction of initial soil moisture at element IE that is due to precipitation
C   SOILM_RI_FL ;   Initial root zone moisture content for rice with flooded decomposition; [L/L]
C   SOILM_RI_NFL;   Initial root zone moisture content for rice with non-flooded decomposition; [L/L]
C   SOILM_RI_NDC;   Initial root zone moisture content for rice with no decomposition; [L/L]
C   SOILM_RF_SL ;   Initial root zone moisture content for seasonal refuges; [L/L]
C   SOILM_RF_PR ;   Initial root zone moisture content for permanent refuges; [L/L]
C                   *** Note: SOILM can be greater than 1.0 to reflect
C                             ponding conditions for rice and refuge. When SOILM is
C                             greater than 1.0, the ponding depth will be computed as
C                             RootDepth x (SOILM-1)
C
C---------------------------------------------------------------------------------------
C   IE    FSOILMP    SOILM_RI_FL   SOILM_RI_NFL   SOILM_RI_NDC    SOILM_RF_SL   SOILM_RF_PR
C---------------------------------------------------------------------------------------
    1       0.5       0.1370        0.1370         0.1370          0.1370        0.1370
```

```
2       0.5     0.1571       0.1571       0.1571        0.1571       0.1571
3       0.5     0.1053       0.1053       0.1053        0.1053       0.1053
.       .       .            .            .             .            .
.       .       .            .            .             .            .
.       .       .            .            .             .            .
221     0.5     0.0485       0.0485       0.0485        0.0485       0.0485
222     0.5     0.2322       0.2322       0.2322        0.2322       0.2322
223     0.5     0.1210       0.1210       0.1210        0.1210       0.1210
```

8.3.8.8.b Ponded Crops Area Data File

Areas of each ponded crop at every element are listed in this file:

FACTLNP	Conversion factor for land use areas; enter 0.0 if land use distribution is given as a fraction of element area
NSPLNP	Number of time steps to update the land use data; enter any number if time-tracking option is on
NFQLNP	Repetition frequency of the crop area data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Ponded Crops Area Data File

If the time series data is listed in the Ponded Crops Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITLN	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
IE	Element identification number
ALANDRI_FL	Area (or fraction of area) of rice with flooded decomposition over element IE; [L^2] or [L^2/L^2] based on FACTLNP above
ALANDRI_NFL	Area (or fraction of area) of rice with non-flooded decomposition over element IE; [L^2] or [L^2/L^2] based on FACTLNP above
ALANDRI_NDC	Area (or fraction of area) of rice with no decomposition over element IE; [L^2] or [L^2/L^2] based on FACTLNP above
ALANDRF_SL	Area (or fraction of area) of seasonal refuges over element IE; [L^2] or [L^2/L^2] based on FACTLNP above
ALANDRF_PR	Area (or fraction of area) of rice with permanent refuges over element IE; [L^2] or [L^2/L^2] based on FACTLNP above

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IE	Element identification number
LUTYPE	Land-use identification number entered sequentially (1 = rice with flooded decomposition, 2 = rice with non-flooded decomposition, 3 = rice with no decomposition, 4 = seasonal refuges, 5 = permanent refuges)
PATH	Pathname corresponding to element and ponded crop type combination

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                         PONDED CROP AREA FILE
C                          Root Zone Component
C                          *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: PondedAgArea.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the land use distribution of ponded crops for
C   each element for the simulation period.
C
C*******************************************************************************
C                           Land Use Data Specifications
C
C   FACTLNP;   Conversion factor for land use area
C                * Enter 0.0 if land use distribution is given as a fraction of element area
C   NSPLNP ;   Number of time steps to update the land use data
C                * Enter any number if time-tracking option is on
C   NFQLNP ;   Repetition frequency of the land use data
C                * Enter 0 if full time series data is supplied
C                * Enter any number if time-tracking option is on
C   DSSFL   ;   The name of the DSS file for data input
C                * Leave blank if DSS file is not used for data input
C
C-----------------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-----------------------------------------------------------------------------------------
          10.763910417                              / FACTLNP  (sq.m. -> sq.ft.)
          1                                         / NSPLNP
          0                                         / NFQLNP
                                                    / DSSFL
C-----------------------------------------------------------------------------------------
C                              Land Use Data
C                          (READ FROM THIS FILE)
C
C   List the land use data below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN        ;  Time
C   IE          ;  Element number
C   ALANDRI_FL ;  Rice area (or fraction of area) over an element with flooded
C                   decomposition; [L^2] or [L^2/L^2] (based on FACTLNP above)
C   ALANDRI_NFL;  Rice area (or fraction of area) over an element with non-flooded
C                   decomposition; [L^2] or [L^2/L^2] (based on FACTLNP above)
C   ALANDRI_NDC;  Rice area (or fraction of area) over an element with no
C                   decomposition; [L^2] or [L^2/L^2] (based on FACTLNP above)
C   ALANDRF_SL ;  Seasonal refuge area (or fraction of area) over an
C                   element; [L^2] or [L^2/L^2] (based on FACTLNP above)
C   ALANDRF_PR ;  Permanent refuge area (or fraction of area) over an
C                   element; [L^2] or [L^2/L^2] (based on FACTLNP above)
C                 * Note: Crop areas over elements that are designated as lake elements
C                         will be ignored
C
C---------------------------------------------------------------------------------------------------------------------
C   ITLN      IE              ALANDRI_FL      ALANDRI_NFL     ALANDRI_NDC         ALANDRF_SL      ALANDRF_PR
C---------------------------------------------------------------------------------------------------------------------
 12/31/2500_24:00    1             311.19          0.0000          0.0000              0.0000            0.00
                     2               0.00          0.0000          0.0000              0.0000            0.00
                     3          409749.34          0.0000          0.0000              0.0000            0.00
                     4         1155717.27          0.0000          0.0000              0.0000            0.00
                     5               0.00          0.0000          0.0000              0.0000            0.00
                     .                  .          .               .                   .                 .
                     .                  .          .               .                   .                 .
                     .                  .          .               .                   .                 .
                     219        505008.16          0.0000          0.0000              0.0000        27976.28
                     220       1607496.62          0.0000          0.0000              0.0000        46201.79
                     221         13063.29          0.0000          0.0000              0.0000            0.00
                     222             0.00          0.0000          0.0000              0.0000      1471081.66
                     223        958187.12          0.0000          0.0000              0.0000            0.00
C-----------------------------------------------------------------------------------------
C                               Pathnames for Land Use Data
C                                 (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   The pathnames should be listed for each element and ponded crop combination.
C   They should be listed in an order such that, the crop type changes first.
C
C   * Example:
C
C       IE     LUTYPE      PATH
C        1        1       (pathname[1])
C        1        2       (pathname[2])
C        1        3       (pathname[3])
C        1        4       (pathname[4])
C        1        5       (pathname[5])
C        2        1       (pathname[6])
C        2        2       (pathname[7])
C        2        3       (pathname[8])
C        2        4       (pathname[9])
C        2        5       (pathname[10])
C        .        .            .
C        .        .            .
C        .        .            .
C       NE        1       (pathname[5*NE - 4])
C       NE        2       (pathname[5*NE - 3])
C       NE        3       (pathname[5*NE - 2])
C       NE        4       (pathname[5*NE - 1])
C       NE        5       (pathname[5*NE    ])
C
C   IE     ;  Element number
```

```
C   LUTYPE ;  Land use type
C               1 = Rice with flooded decomposition
C               2 = Rice with non-flooded decomposition
C               3 = Rice with no decomposition
C               4 = Seasonal refuge
C               5 = Permanent refuge
C   PATH   ;  Pathname corresponding to element and ponded crop type combination
C
C-----------------------------------------------------------------------------------------
C   IE        LUTYPE        PATH
C-----------------------------------------------------------------------------------------
*
*
```

8.3.8.8.c Ponding Depth Data File

This file includes the time series pond depths for rice and refuges. The ponded crops are associated with data columns in this file through pointers specified in the Ponded Crops Main File.

The following variables are listed in this file:

NCOLPND	Number of pond depth data columns
FACTPND	Conversion factor pond depths
NSPPND	Number of time steps to update the pond depths; enter any number if time-tracking option is on
NFQPND	Repetition frequency of the pond depths; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Ponding Depth Data File

If the time series data is listed in the Ponding Depth Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using “C”, “c” or “*”, and the variables in the “Data Input from DSS File” section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
PND	Pond depth; [L]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                 RICE/REFUGE POND DEPTH DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: PondDepth.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains a set of ponding depths for rice fields and refuges.
C   These values are correlated to individual grid elements through the Rice/Refuge
C   Data File.
C
C*******************************************************************************
C                 Rice/Refuge Pond Depth Data Specifications
C
C   NCOLPND  ; Number of pond depth data columns
C   FACTPND  ; Conversion factor for pond depths
C   NSPPND   ; Number of time steps to update the pond depths
C                * Enter any number if time-tracking option is on
C   NFQPND   ; Repetition frequency of the pond depth data
C                * Enter 0 if full time series data is supplied
C                * Enter any number if time-tracking option is on
C   DSSFL    ; The name of the DSS file for data input
C                * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-------------------------------------------------------------------------------
          2                                         / NCOLPND
          0.08333                                   / FACTPND (in -> ft)
          1                                         / NSPPND
          0                                         / NFQPND
                                                    / DSSFL
C-----------------------------------------------------------------------------------
C                           Rice/Refuge Pond Depth Data
C                              (READ FROM THIS FILE)
C
C   List the rice/refuge pond depths below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   PND  ;  Pond depths; [L]
C
*   Column 1: Growing season and decomp ponding depths for flooded-decomp rice
*   Column 2: Ponding depth for permanent refuges
C
C-----------------------------------------------------------------------------------
C  TIME                PND[1]   PND[2]    PND[3] ... PND[NCOLPND]
C-----------------------------------------------------------------------------------
C                       1        2
   01/31/4000_24:00    0.0      2.5
   02/29/4000_24:00    0.0      2.5
   03/31/4000_24:00    0.0      2.5
   04/30/4000_24:00    0.0      2.5
   05/31/4000_24:00    3.0      2.5
   06/30/4000_24:00    5.0      2.5
   07/31/4000_24:00    8.0      2.5
   08/31/4000_24:00    0.0      2.5
   09/30/4000_24:00    0.0      2.5
   10/31/4000_24:00    3.0      2.5
   11/30/4000_24:00    6.0      2.5
   12/31/4000_24:00    0.0      2.5
C-------------------------------------------------------------------------------
C                             Pathnames for Pond Depths
C                               (READ FROM DSS FILE)
C
C   List the pathnames for pond depths below, if it will be
C   read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C-----------------------------------------------------------------------------------
C   REC     PATH
C-----------------------------------------------------------------------------------
*
*
```

8.3.8.8.d Pond Operation Flows Data File

This file lists unit flow rates that represent the pond and decomposition operations such as return flows, amounts of re-used return flows and the application rates for the non-flooded rice decomposition. The data columns in this file are associated with specific ponded crops through pointers specified in the Ponded Crops Main File.

The following variables are used:

NCOLFLW	Number of data columns for pond operation flow rates
FACTFLW	Conversion factor for the spatial component of the pond operation flow rates
NSPFLW	Number of time steps to update the pond operation flow rates; enter any number if time-tracking option is on
NFQFLW	Repetition frequency of the pond operation flow rates; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Pond Operation Flows Data File

If the time series data is listed in the Pond Operation Flows Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

TIME	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
FLW	Pond operation flow rates; [L/T]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C             RICE/REFUGE OPERATION FLOW RATE DATA FILE
C                        Root Zone Component
C                        *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: PondOperationFlows.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains a set of flow rates (in units of L/T) to be used for
C   simulating the rice and refuge return flows, re-use and water application rates
C   for non-flooded rice decomposition. These values are correlated to individual
C   grid elements through the Rice/Refuge Data File.
C
C*******************************************************************************
C              Rice/Refuge Operation Flow Rate Data Specifications
C
C   NCOLFLW  ; Number of data columns
C   FACTFLW  ; Conversion factor for operation flow rates
C               It is used to convert only the spatial component of the unit;
C               DO NOT include the conversion factor for time component of the unit.
C               * e.g. Unit of depth listed in this file        = INCHES/MONTH
C                      Consistent unit used in simulation       = FT/DAY
C                      Enter FACTOPS (INCHES/MONTH -> FT/MONTH) = 8.333333E-02
C                       (conversion of MONTH -> DAY is performed automatically)
C   NSPFLW   ; Number of time steps to update the operation flow rates
C               * Enter any number if time-tracking option is on
C   NFQFLW   ; Repetition frequency of the operation flow rate data
C               * Enter 0 if full time series data is supplied
C               * Enter any number if time-tracking option is on
C   DSSFL    ; The name of the DSS file for data input
C               * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-------------------------------------------------------------------------------
          5                                         / NCOLFLW
          0.08333                                   / FACTFLW  (in/mon -> ft/mon)
          1                                         / NSPFLW
          0                                         / NFQFLW
                                                    / DSSFL
C----------------------------------------------------------------------------------------------
C                      Rice/Refuge Operation Flow Rate Data
C                            (READ FROM THIS FILE)
C
C   List the rice/refuge operation flow rates below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   TIME ;  Time
C   FLW  ;  Operation flow rates; [L/T]
C
*   Column 1: Flow-thru (return flow) depth for entire year for flooded-decomp rice
*   Column 2: Return flow depth for permanent refuges
*   Column 3: Re-use depth for flooded decomp rice
*   Column 4: Re-use depth for refuges
*   Column 5: Application depth for non-ponded decomp rice
C
C----------------------------------------------------------------------------------------------
C  TIME    FLW[1]    FLW[2]    FLW[3] ... FLW[NCOLFLW]
C----------------------------------------------------------------------------------------------
C                     1        2        3        4        5
   01/31/4000_24:00   2.0      0.0      0.0      0.0      0.0
   02/29/4000_24:00   1.0      0.0      0.0      0.0      0.0
   03/31/4000_24:00   0.0      0.0      0.0      0.0      0.0
   04/30/4000_24:00   0.0      0.0      0.0      0.0      0.0
   05/31/4000_24:00   3.0      0.0      0.0      0.0      0.0
   06/30/4000_24:00   0.0      0.0      0.0      0.0      0.0
   07/31/4000_24:00   1.9      0.0      0.0      0.0      0.0
   08/31/4000_24:00   1.9      0.0      0.0      0.0      0.0
   09/30/4000_24:00   0.95     0.0      0.0      0.0      0.0
   10/31/4000_24:00   0.0      0.0      0.0      0.0      0.0
   11/30/4000_24:00   2.0      0.0      0.0      0.0      0.0
   12/31/4000_24:00   2.0      0.0      0.0      0.0      0.0
C-------------------------------------------------------------------------------
C                         Pathnames for Operation Flow Rates
C                              (READ FROM DSS FILE)
C
C   List the pathnames for operation flow rates below, if it will be
C   read from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C----------------------------------------------------------------------------------------------
C   REC     PATH
C----------------------------------------------------------------------------------------------
*
*
```

8.3.8.9. Urban Component Files

8.3.8.9.a Urban Lands Main File

The Urban Lands Main File is the gateway file for all data that is necessary to simulate land surface and root zone flow processes in urban lands.

The file is divided into several sections and uses the following variables:

Land-Use Areas

The filename for the urban areas data file is listed in this section:

LUFLU	File that lists the urban areas (maximum 1000 characters)

Rooting Depth

FACT	Conversion factor for urban outdoors root zone depth
ROOTURB	Root zone depth for urban outdoors; [L]

Urban Water Use, Management and Simulation Parameters

POPULFL	File that lists the time series urban population data (maximum 1000 characters)
WTRUSEFL	File that lists the rates of per capita water use (maximum 1000 characters)
URBSPECFL	File that lists the urban water use specifications (maximum 1000 characters)
IE	Element identification number
PERV	Fraction of pervious area to total urban areas
CNURB	Curve number for urban lands
ICPOPUL	Population; this number corresponds to the appropriate data column in the Population Data File (POPULFL)
ICWTRUSE	Per capita water use; this number corresponds to the appropriate data column in the Per Capita Water Use Data File (WTRUSEFL)
FRACDM	Relative proportion of the urban demand computed by multiplying population with per capita water use to be applied to element IE; enter -1.0 for all elements if relative proportion will be computed with respect to urban area at each element

ICETURB	Urban evapotranspiration; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File
ICRTFURB	Fraction of the urban applied water that becomes return flow; this number corresponds to the appropriate data column in the Return Flow Fractions Data File (RFFL) specified in the Root Zone Component Main File; for urban lands (return flow fraction applies only to pervious (lawns, parks, etc) urban areas; all water delivered to urban indoor areas becomes return flow)
ICRUFURB	Fraction of the urban applied water that is re-used; this number corresponds to the appropriate data column in the Re-use Fractions Data File (RUFL) specified in the Root Zone Component Main File
ICURBSPEC	Urban water use specification data as a fraction of total urban water that is used indoors; this number corresponds to the appropriate data column in the Urban Water Use Specifications Data File (URBSPECFL)

Initial Soil Moisture Conditions

The initial soil moisture content for urban outdoors at each element is listed in this section.

IE	Element identification number; enter 0 if following values are to be used for all elements
FSOILMP	Fraction of initial soil moisture at element IE that is due to precipitation
SOILM	Initial root zone moisture content for urban outdoors; [L/L]

```
C*******************************************************************************
C
C                    INTEGRATED WATER FLOW MODEL (IWFM)
C                           *** Version ### ***
C
C*******************************************************************************
C
C                          URBAN LANDS DATA FILE
C                           Root Zone Component
C                           for IWFM Simulation
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Urban_MAIN.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes and managament of urban lands.
C
C*******************************************************************************
C                           Land Use Areas
C
C   LUFLU   ;  File that lists the urban areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    RootZone\Urban\UrbanArea.dat                      / LUFLU
C*******************************************************************************
C                                Rooting Depth
C
C   FACT   ;    Conversion factor for urban root zone depth
C   ROOTURB;    Urban root zone depth; [L]
C
C-------------------------------------------------------------------------------
C   VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                    / FACT
    2.0                    / ROOTURB
C*******************************************************************************
C                    Urban Water Use, Management and Simulation Parameters
C
C   POPULFL  ;  File that lists the urban population (max. 1000 characters)
C   WTRUSEFL ;  File that lists the per capita water use (max. 1000 characters)
C   URBSPECFL;  File that lists the urban water use specifications (max. 1000 characters)
C   IE       ;  Element ID (Enter 0 if following values are to be used for all elements)
C   PERV     ;  Fraction of pervious area to total urban areas
C   CNURB    ;  Curve number for urban lands
C   ICPOPUL  ;  Population - this number corresponds to the appropriate data
C                 column in the Population file (POPULFL)
C   ICWTRUSE ;  Per capita water use - this number corresponds to the appropriate data
C                 column in the Per Capita Water Use file (WTRUSEFL)
C   FRACDM   ;  Relative proportion of the urban demand computed by multiplying population
C                 with per capita water use to be applied to element IE
C                 * Note: Enter -1.0 for all FRACDM if relative proportion will be computed
C                         with respect to urban area at each element
C   ICETURB  ;  Urban ETc - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Control Data file.
C   ICRTFURB ;  Fraction of the urban applied water that becomes return flow - this
C                 number corresponds to the appropriate data column in irrigation
C                 water return flow factor data file (RFFL).
C                 * Note: For urban lands, return flow fraction applies only to
C                         pervious (lawns, parks, etc) urban areas. All water
C                         delivered to urban indoor areas becomes return flow.
C   ICRUFURB ;  Fraction of the applied water that is re-used - this number corresponds
C                 to the appropriate data column in irrigation water re-use factor data
C                  file (RUFL).
C   ICURBSPEC;  Urban water use specification data as a fraction of total urban water that
C                is used indoors - this number corresponds to the appropriate data column
C                in the urban water use specifications data file (URBSPECFL).
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          RootZone\Urban\Population.dat              / POPULFL
          RootZone\Urban\WaterUse.dat                / WTRUSEFL
          RootZone\Urban\UrbanSpecs.dat              / URBSPECFL
C-----------------------------------------------------------------------------------------------------------
C   IE      PERV   CNURB   ICPOPUL  ICWTRUSE     FRACDM     ICETURB   ICRTFURB   ICRUFURB     ICURBSPEC
C-----------------------------------------------------------------------------------------------------------
    1       0.62    79       1         4          -1.0          20        2           2             1
    2       0.62    79       1         4          -1.0          20        2           2             1
    3       0.62    69       1         4          -1.0          20        2           2             1
    .        .       .       .         .            .            .        .           .             .
    .        .       .       .         .            .            .        .           .             .
    .        .       .       .         .            .            .        .           .             .
    221     0.62    79       1         2          -1.0          20        2           2             1
    222     0.62    69       1         1          -1.0          20        2           2             1
    223     0.62    69       1         4          -1.0          20        2           2             1
C*******************************************************************************
C                            Initial Soil Moisture Condition
C                                    For Urban Lands
C
C   IE     ; Element ID (0 if following values are to be used for all elements)
C   FSOILMP; Fraction of initial soil moisture at element IE that is due to precipitation
C   SOILM  ; Initial root zone moisture content for urban land; [L/L]
C
C----------------------------------------------------------------------------
C   IE     FSOILMP    SOILM
C----------------------------------------------------------------------------
  1        0.5        0.1370
  2        0.5        0.1571
  3        0.5        0.1053
  .         .           .
  .         .           .
  .         .           .
  221      0.5        0.0485
  222      0.5        0.2322
  223      0.5        0.1210
```

8.3.8.9.b Urban Area Data File

Area of urban lands at every element are listed in this file:

FACTLNU	Conversion factor for land use areas; enter 0.0 if land use distribution is given as a fraction of element area
NSPLNU	Number of time steps to update the land use data; enter any number if time-tracking option is on
NFQLNU	Repetition frequency of the land use data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Urban Area Data File

If the time series data is listed in the Urban Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITLN	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
IE	Element identification number
ALANDU	Urban area (or fraction of area) over element IE; $[L^2]$ or $[L^2/L^2]$ based on FACTLNU above

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IE	Element identification number
PATH	Pathname corresponding to urban area at element IE

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                           URBAN AREA FILE
C                          Root Zone Component
C                          *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: UrbanArea.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the land use distribution of urban lands for
C   each element for the simulation period.
C
C*******************************************************************************
C                           Land Use Data Specifications
C
C   FACTLNU;   Conversion factor for land use area
C                * Enter 0.0 if land use distribution is given as a fraction of element area
C   NSPLNU ;   Number of time steps to update the land use data
C                * Enter any number if time-tracking option is on
C   NFQLNU ;   Repetition frequency of the land use data
C                * Enter 0 if full time series data is supplied
C                * Enter any number if time-tracking option is on
C   DSSFL   ;   The name of the DSS file for data input
C                * Leave blank if DSS file is not used for data input
C
C-----------------------------------------------------------------------------------------
C         VALUE                                        DESCRIPTION
C-----------------------------------------------------------------------------------------
          10.763910417                                 / FACTLNU    (sq. m. -> sq. ft.)
          1                                            / NSPLNU
          0                                            / NFQLNU
                                                       / DSSFL
C-----------------------------------------------------------------------------------------
C                             Land Use Data
C                          (READ FROM THIS FILE)
C
C   List the land use data below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN   ;   Time
C   IE     ;   Element number
C   ALANDU ;   Urban area (or fraction of area) over an element; [L^2] or [L^2/L^2] (based on FACTLNU above)
C              * Note: Urban areas over elements that are designated as lake elements
C                     will be ignored
C
C-------------------------------------------------------------------------------------------------------------
C   ITLN             IE             ALANDU
C-------------------------------------------------------------------------------------------------------------
 12/31/2500_24:00    1               633.00
                     2                 0.00
                     3              8771.34
                     4             60486.76
                     5                 0.00
                     .                  .
                     .                  .
                     .                  .
                     219           99096.04
                     220          110491.22
                     221            2989.20
                     222               0.00
                     223           23114.89
C-----------------------------------------------------------------------------------------
C                               Pathnames for Land Use Data
C                                 (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   IE     ;  Element number
C   PATH   ;  Pathname corresponding to urban area at element IE
C
C-----------------------------------------------------------------------------------------
C   IE        PATH
C-----------------------------------------------------------------------------------------
*
*
```

8.3.8.9.c Population Data File

This file lists urban population. Urban land in each element is associated with a data column in this file through pointers specified in the Urban Main File.

The following variables are listed in this file:

NCOLPOP	Number of population data columns
NSPPOP	Number of time steps to update the population data; enter any number if time-tracking option is on
NFQPOP	Repetition frequency of the population data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Population Data File

If the time series data is listed in the Population Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITPOP	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
POPUL	Population; [people]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

I	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                     POPULATION DATA FILE
C                      Root Zone Component
C                      *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Population.dat
C
C*******************************************************************************
C                                File Description
C
C   This data file contains a set of population data on a time-series basis
C
C*******************************************************************************
C                      Population Data Specifications
C
C   NCOLPOP;  Number of population data columns
C   NSPPOP ;  Number of time steps to update the population data
C              * Enter any number if time-tracking option is on
C   NFQPOP ;  Repetition frequency of the population data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ;  The name of the DSS file for data input (maximum 50 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
           1                                         / NCOLPOP
           1                                         / NSPPOP
           0                                         / NFQPOP
                                                     / DSSFL
C-------------------------------------------------------------------------------
C                           Population Data
C                         (READ FROM THIS FILE)
C
C   List the population data below, if it will not be read from a
C   DSS file (i.e. DSSFL is left blank above).
C
C   ITPOP;   Time
C   POPUL;   Population; [People]
C
C-------------------------------------------------------------------------------
C ITPOP                 POPUL(1)  POPUL(2)  POPUL(3) ...
C-------------------------------------------------------------------------------
   12/31/2500_24:00     100000
*
C-------------------------------------------------------------------------------
C                       Pathnames for Population Data
C                           (READ FROM DSS FILE)
C
C   List the pathnames for the population data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   I    ;  Pathname number
C   PATH ;  Pathname for the time series record
C
C--------------------------------------------------------------------------------
C   I       PATH
C--------------------------------------------------------------------------------
*
*
```

8.3.8.9.d Per Capita Water Use Data File

Time series per-capita water use rates are listed in this file. The urban areas at each element are associated with a data column in this file through pointers specified in the Urban Lands Main File.

The following variables are used in this file:

NCOLWU	Number of per capita water use data columns
FACTWU	Conversion factor for the spatial component of the per capita water use data
NSPWU	Number of time steps to update the per capita water use data; enter any number if time-tracking option is on
NFQWU	Repetition frequency of the per capita water use data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Per Capita Water Use Data File

If the time series data is listed in the Per Capita Water Use Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITWU	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
WU	Per capita water use; $[(L^3/T)/\text{person}]$

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                  PER CAPITA WATER USE DATA FILE
C                       Root Zone Component
C                       *** Version 4.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: WaterUse.dat
C
C*******************************************************************************
C                               File Description
C
C   This data file contains a set of per capita water use data on a time-series
C   basis.  Water use includes both indoors (M&I) and outdoors water.
C
C*******************************************************************************
C                      Per Capita Water Use Data Specifications
C
C   NCOLWU ;  Number of water use data columns
C   FACTWU ;  Conversion factor for the water use data
C               It is used to convert only the spatial component of the unit;
C               DO NOT include the conversion factor for time component of the unit.
C               * e.g. Unit of flow listed in this file          = AC-FT/MONTH
C                      Consistent unit used in simulation        = CU.FT/DAY
C                      Enter FACTWU (AC-FT/MONTH -> CU.FT/MONTH) = 43560.0
C                     (conversion of MONTH -> DAY is performed automatically)
C   NSPWU  ;  Number of time steps to update the water use data
C              * Enter any number if time-tracking option is on
C   NFQWU  ;  Repetition frequency of the water use data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ;  The name of the DSS file for data input (maximum 50 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------
          4                                           / NCOLWU
          43560.0                                     / FACTWU   (ac.ft. -> cu.ft.)
          1                                           / NSPWU
          0                                           / NFQWU
                                                      / DSSFL
C-------------------------------------------------------------------------------
C                       Per Capita Water Use Data
C                         (READ FROM THIS FILE)
C
C   List the per capita water use data below, if it will not be read from a
C   DSS file (i.e. DSSFL is left blank above).
C
C   ITWU;   Time
C   WU  ;   Per capita water use; [L^3/T/PERSON]
C
C-------------------------------------------------------------------------------
C ITWU    WU(1)  WU(2)  WU(3) ...
C-------------------------------------------------------------------------------
 01/31/4000_24:00   0.0014928   0.0013725       0.0000844       0.0059222
 02/29/4000_24:00   0.0014928   0.0013725       0.0000844       0.0059222
 03/31/4000_24:00   0.0018247   0.0016776       0.0001032       0.0072382
 04/30/4000_24:00   0.0028199   0.0025926       0.0001595       0.0111864
 05/31/4000_24:00   0.0036492   0.0033551       0.0002064       0.0144765
 06/30/4000_24:00   0.0041468   0.0038126       0.0002346       0.0164505
 07/31/4000_24:00   0.0046444   0.0042701       0.0002627       0.0184246
 08/31/4000_24:00   0.0043127   0.0039651       0.0002440       0.0171086
 09/30/4000_24:00   0.0034834   0.0032026       0.0001970       0.0138185
 10/31/4000_24:00   0.0021564   0.0019826       0.0001220       0.0085543
 11/30/4000_24:00   0.0016587   0.0015250       0.0000938       0.0065802
 12/31/4000_24:00   0.0014928   0.0013725       0.0000844       0.0059222
C-------------------------------------------------------------------------------
C                   Pathnames for Per Capita Water Use Data
C                           (READ FROM DSS FILE)
C
C   List the pathnames for the per capita water use data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C------------------------------------------------------------------------------------
C   REC       PATH
C------------------------------------------------------------------------------------
*
*
```

8.3.8.9.e Urban Water Use Specifications Data File

Time series urban water use specifications in terms of the fraction of indoor water use to total urban water use are listed in this file. The urban areas at each element are associated with a data column in this file through pointers specified in the Urban Lands Main File.

The following variables are used in this file:

NURBSP	Number of urban water use specifications data columns
NSPURBSP	Number of time steps to update the urban water use specifications data; enter any number if time-tracking option is on
NFQURBSP	Repetition frequency of the urban water use specifications data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Urban Water Use Specifications Data File

If the time series data is listed in the Urban Water Use Specifications Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITUSP	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
URINDR	Fraction of total urban water that is used indoors

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                     INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                   URBAN WATER USAGE SPECIFICATION DATA FILE
C                             Root Zone Component
C                             *** Version 4.0 ***
C
C
C               Project:  IDC Version ### Release
C                         California Department of Water Resources
C               Filename: UrbanSpecs.dat
C
C*******************************************************************************
C                               File Description
C
C   This data file contains a set of urban water usage specification data as the
C   fraction of total urban water that is used indoors.
C
C*******************************************************************************
C                             Urban Water Use Data Specifications
C
C   NURBSP   ;   Number of urban water use specifications data columns
C   NSPURBSP ;   Number of time steps to update the urban water use specification data
C                 * Enter any number if time-tracking option is on
C   NFQURBSP ;   Repitition frequency of the urban water use sepcification data
C                 * Enter 0 if full time series data is supplied
C                 * Enter any number if time-tracking option is on
C   DSSFL    ;   The name of the DSS file for data input (maximum 50 characters);
C                 * Leave blank if DSS file is not used for data input
C
C------------------------------------------------------------------------------
C         VALUE                                         DESCRIPTION
C------------------------------------------------------------------------------
           1                                           / NURBSP
           1                                           / NSPURBSP
           0                                           / NFQURBSP
                                                       / DSSFL
C--------------------------------------------------------------------------------------
C                             Urban Water Use Data
C                             (READ FROM THIS FILE)
C
C   List the urban water use data below, if it will not be read from
C   a DSS file (i.e. DSSFL is left blank above).
C
C   ITUSP ;  Time
C   URINDR;  Fraction of total urban water that is used indoors
C
C--------------------------------------------------------------------------------------
C   ITUSP         URINDR[1]  URINDR[2]  URINDR[3] ...
C--------------------------------------------------------------------------------------
10/31/4000_24:00     0.5
11/30/4000_24:00     0.7
12/31/4000_24:00     0.8
01/31/4000_24:00    1.00
02/29/4000_24:00    1.00
03/31/4000_24:00     0.6
04/30/4000_24:00     0.5
05/31/4000_24:00    0.45
06/30/4000_24:00     0.4
07/31/4000_24:00     0.4
08/31/4000_24:00     0.4
09/30/4000_24:00     0.4
C-------------------------------------------------------------------------------
C                        Pathnames for Urban Water Use Data
C                              (READ FROM DSS FILE)
C
C   List the pathnames for urban water use data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C--------------------------------------------------------------------------------------
C   REC       PATH
C--------------------------------------------------------------------------------------
*
*
```

8.3.8.10. Native and Riparian Vegetation Component Files

8.3.8.10.a Native and Riparian Vegetation Lands Main File

The Native and Riparian Vegetation Lands Main File is the gateway file for all data that is necessary to simulate land surface and root zone flow processes in areas that are covered with native and riparian vegetation.

The file is divided into several sections and uses the following variables:

Land-Use Areas

The filename for the native and riparian areas data file is listed in this section:

LUFLNVRV	File that lists the urban areas (maximum 1000 characters)

Rooting Depths

FACT	Conversion factor for native and riparian vegetation root zone depths
ROOTNV	Root zone depth for native vegetation; [L]
ROOTRV	Root zone depth for riparian vegetation; [L]

Native and Riparian Vegetation Simulation Parameters

IE	Element identification number entered sequentially; enter 0 if the following values are to be used for all elements
CNNV	Curve number for native vegetation lands
CNRV	Curve number for riparian vegetation lands
ICETNV	Native vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File
ICETRV	Riparian vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File

Initial Soil Moisture Conditions

The initial soil moisture contents for native and riparian vegetation at each element are listed in this section.

IE	Element identification number; enter 0 if following values are to be used for all elements

SOILM_NV	Initial root zone moisture content for native vegetation at element IE; [L/L]
SOILM_RV	Initial root zone moisture content for riparian vegetation at element IE; [L/L]

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                  NATIVE AND RIPARIAN VEGETATION DATA FILE
C                          Root Zone Component
C                          *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: NVRV_MAIN.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes for native and riparian vegetation.
C
C*******************************************************************************
C                         Land Use Areas
C
C   LUFLNVRV   ;  File that lists the land use areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    RootZone\NVRV\NVRVArea.dat                      / LUFLNVRV
C*******************************************************************************
C                             Rooting Depths
C
C   FACT  ;  Conversion factor for root zone depths
C   ROOTNV;  Native veg. root zone depth; [L]
C   ROOTRV;  Riparian veg. root zone depth; [L]
C
C-------------------------------------------------------------------------------
C   VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                    / FACT
    3.0                    / ROOTNV
    3.0                    / ROOTNV
C*******************************************************************************
C         Native and Riparian Vegetation Root Zone Simulation Parameters
C
C   IE       ;  Element ID (0 if following values are to be used for all elements)
C   CNNV     ;  Curve number for native vegetation lands
C   CNRV     ;  Curve number for riparian vegetation lands
C   ICETNV   ;  Native vegetation ETc - this number corresponds to the appropriate
C                 data column in the ET data file listed in the Main Control Data file.
C   ICETRV   ;  Riparian vegetation ETc - this number corresponds to the appropriate
C                 data column in the ET data file listed in the Main Control Data file.
C
C-------------------------------------------------------------------------------
C   IE       CNNV   CNRV    ICETNV    ICETRV
C-------------------------------------------------------------------------------
    1        71     71      21        22
    2        71     71      21        22
    3        58     58      21        22
    .        .      .       .         .
    .        .      .       .         .
    .        .      .       .         .
    221      71     71      21        22
    222      58     58      21        22
    223      58     58      21        22
C*******************************************************************************
C                          Initial Soil Moisture Condition
C                      For Native and Riparian Vegetation Areas
C
C   IE      ;   Element ID (0 if following values are to be used for all elements)
C   SOILM_NV;   Initial root zone moisture content for native vegetation area; [L/L]
C   SOILM_RV;   Initial root zone moisture content for riparian vegetation area; [L/L]
C
C----------------------------------------------------------------------------
C   IE      SOILM_NV    SOILM_RV
C----------------------------------------------------------------------------
    1       0.1370      0.1370
    2       0.1571      0.1571
    3       0.1053      0.1053
    .        .           .
    .        .           .
    .        .           .
    221     0.0485      0.0485
    222     0.2322      0.2322
    223     0.1210      0.1210
```

8.3.8.10.b Native and Riparian Vegetation Area Data File

Areas of native and riparian vegetation at every element are listed in this file:

FACTLNVRV	Conversion factor for land use areas; enter 0.0 if land use distribution is given as a fraction of element area
NSPLNVRV	Number of time steps to update the land use data; enter any number if time-tracking option is on
NFQLNVRV	Repetition frequency of the land use data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Native and Riparian Vegetation Area Data File

If the time series data is listed in the Native and Riparian Vegetation Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITLN	Time. For time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number.
IE	Element identification number
ALANDNV	Native vegetation area (or fraction of area) over element IE; $[L^2]$ or $[L^2/L^2]$ based on FACTLNVRV above
ALANDRV	Riparian vegetation area (or fraction of area) over element IE; $[L^2]$ or $[L^2/L^2]$ based on FACTLNVRV above

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IE	Element identification number
LUTYPE	Land-use type entered sequentially (1 = native vegetation, 2 = riparian vegetation)
PATH	Pathname corresponding to element and land-use type combination

```
C*******************************************************************************
C
C                    INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                  NATIVE AND RIPARIAN VEGETATION AREA FILE
C                            Root Zone Component
C                            *** Version 4.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: NVRVArea.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains the land use distribution of native and riparian vegetation
C   for each element for the simulation period.
C
C*******************************************************************************
C                            Land Use Data Specifications
C
C   FACTLNVRV;   Conversion factor for land use area
C                  * Enter 0.0 if land use distribution is given as a fraction of element area
C   NSPLNVRV ;   Number of time steps to update the land use data
C                  * Enter any number if time-tracking option is on
C   NFQLNVRV ;   Repetition frequency of the land use data
C                  * Enter 0 if full time series data is supplied
C                  * Enter any number if time-tracking option is on
C   DSSFL    ;   The name of the DSS file for data input
C                  * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-------------------------------------------------------------------------------------------
          10.763910417                                / FACTLNNRV     (sq. m. -> sq. ft.)
          1                                           / NSPLNVRV
          0                                           / NFQLNVRV
                                                      / DSSFL
C-------------------------------------------------------------------------------------------
C                             Land Use Data
C                         (READ FROM THIS FILE)
C
C   List the land use data below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN   ;   Time
C   IE     ;   Element number
C   ALANDNV;   Native vegetation area (or fraction of area) over an element;
C                 [L^2] or [L^2/L^2] (based on FACTLNVRV above)
C   ALANDRV;   Riparian vegetation area (or fraction of area) over an element;
C                 [L^2] or [L^2/L^2] (based on FACTLNVRV above)
C              * Note: Areas over elements that are designated as lake elements
C                      will be ignored
C
C--------------------------------------------------------------------------------------------------------
C   ITLN            IE            ALANDNV                  ALANDRV
C--------------------------------------------------------------------------------------------------------
 12/31/2500_24:00    1            964286.26                 0.0001
                     2           2414291.17                 0.0001
                     3            400223.27                 0.0001
                     4            380287.64                 0.0001
                     5           2113855.82                 0.0001
                     .                 .                      .
                     .                 .                      .
                     .                 .                      .
                     219         1391742.52                 0.0001
                     220          136979.26                 0.0001
                     221         1080191.08                 0.0001
                     222               0.00                 0.0001
                     223          190938.21                 0.0001
C-------------------------------------------------------------------------------------------
C                              Pathnames for Land Use Data
C                                 (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   The pathnames should be listed for each element and native and riparian vegetation combination.
C   They should be listed in an order such that, the land use type changes first.
C
C   * Example:
C
C       IE     LUTYPE      PATH
C        1        1       (pathname[1])
C        1        2       (pathname[2])
C        2        1       (pathname[3])
C        2        2       (pathname[4])
C        .        .           .
C        .        .           .
C        .        .           .
C       NE        1       (pathname[2*NE - 1])
C       NE        2       (pathname[2*NE])
C
C   IE     ;  Element number
C   LUTYPE ;  Land use type
C               1 = Native veg.
C               2 = Riparian veg.
C   PATH   ;  Pathname corresponding to element and land use type combination
C
C-------------------------------------------------------------------------------------------
C   IE       LUTYPE        PATH
C-------------------------------------------------------------------------------------------
*
*
```

8.3.9. Input Files for Root Zone Component Version 4.01

All input files for the root zone component version 4.01 except the Root Zone Component Main File are the same as those for the component version 4.0. Therefore, only the Root Zone Component Main File for version 4.01 will be explained in this section. For a detailed description of the other input files, please refer to section 8.3.8.

8.3.9.1. Root Zone Component Main File

This file is exactly the same as that for the root zone component version 4.0, except that it allows the specification of two additional filenames to print out cell-level Land and Water Use as well as the Root Zone budget data. These output files are optional and are generated as HDF5 files. They can later be post-processed using the Z-Budget post-processor to generate water budgets for "*zones*" which are groups of cells defined by the user.

The following sections and variables are defined in the rest of this file:

Root Zone Simulation Scheme Control and Filenames
In this section convergence criteria for the iterative solution methodology and names of additional input and output files are listed.

RZCONV	Convergence criteria for iterative soil moisture accounting as a fraction of total porosity; [L/L]
RZITERMX	Maximum number of iterations for iterative soil moisture accounting
FACTCN	Conversion factor to convert inches to the simulation unit of length
AGNPFL	Filename for the Non-Ponded Crops Main File (maximum 1000 characters); leave blank if non-ponded crops are not simulated
PFL	Filename for the Ponded Crops Main File (maximum 1000 characters); leave blank if rice and/or refuge lands are not simulated
URBFL	Filename for the Urban Lands Main File (maximum 1000 characters); leave blank if urban lands are not simulated

NVRVFL	Filename for the Natural Lands Main File (maximum 1000 characters); leave blank if native and/or riparian vegetation lands are not simulated
RFFL	File that lists the return flow fractions (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
RUFL	File that lists the irrigation water re-use factors (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
IPFL	File that lists the irrigation periods for each ponded and non-ponded crop (maximum 1000 characters); this is a required file even if ponded and non-ponded crops are not simulated
MSRCFL	File that lists generic source of moisture rates other than precipitation and irrigation (maximum 1000 characters); leave blank if there are no generic sources of moisture simulated
AGWDFL	File that lists agricultural water supply requirement (maximum 1000 characters); leave blank if agricultural water supply requirement for all crops will be computed dynamically
LWUBUDFL	HDF5 output file for subregional land and water use budget (maximum 1000 characters); leave blank if this output is not required
RZBUDFL	HDF5 output file for subregional root zone moisture (maximum 1000 characters); leave blank if this output is not required
ZLWUBUDFL	HDF5 output file for land and water use zone budget post-processor (maximum 1000 characters); leave blank if this output is not required
ZRZBUDFL	HDF5 output file for root zone zone budget post-processor (maximum 1000 characters); leave blank if this output is not required
FNSMFL	Output file for end-of-simulation soil moisture (maximum 1000 characters); leave blank if this output is not required

Soil Parameters and Surface Flow Destinations

In this section soil parameters, precipitation rates, generic soil moisture sources (if any) and surface runoff destinations are listed for each finite element.

FACTK	Conversion factor for the spatial component of the root zone hydraulic conductivity
TUNITK	Time unit of root zone hydraulic conductivity this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File
IE	Element identification number
WP	Wilting point; [L/L]
FC	Field capacity; [L/L]
TN	Total porosity; [L/L]
LAMBDA	Pore size distribution index
K	Saturated hydraulic conductivity; [L/T]
RHC	Method to represent hydraulic conductivity versus moisture content curve (1 = Campbell's equation, 2 = van Genucten-Mualem equation)
IRNE	Precipitation rate; this number corresponds to the appropriate data column in the Precipitation File
FRNE	Factor to convert rainfall at the precipitation data column IRNE to rainfall at element IE
IMSRC	Generic source of moisture; this number corresponds to the appropriate data column in the Generic Moisture Source File that applies to element IE (enter any number if the Generic Moisture Source File, MSRCFL, is not defined)
TYPDEST	Destination type for the surface flow from element IE (0 = surface flow goes outside of model area, 1 = surface flow goes to a stream node, 3 = surface flow goes to a lake, 5 = surface flow recharges the groundwater)
DEST	Destination identification number for the surface flow from element IE; enter any number if surface flow from the element goes outside the model area (TYPDEST = 0) or recharges the groundwater (TYPDEST = 5)

KPonded	Saturated hydraulic conductivity to be used for ponded crops in the element (enter −1.0 if KPonded is the same as K); [L/T]

```
#4.01
C***  DO NOT DELETE ABOVE LINE ***
C
C*****************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*****************************************************************************
C
C                   ROOT ZONE PARAMETERS DATA FILE
C                        Root Zone Component
C                        *** Version 4.01 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: ROOTZONE_v401_MAIN.dat
C
C*****************************************************************************
C                         File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes.
C
C*****************************************************************************
C                Root Zone Simulation Scheme Control and File Names
C
C   RZCONV   ;  Convergence criteria for iterative soil moisture accounting as a
C                fraction of total porosity; [L/L]
C   RZITERMX ;  Maximum number of iterations for iterative soil moisture accounting
C   FACTCN   ;  Conversion factor to convert inches to the simulation unit of length
C   AGNPFL   ;  Non-ponded agricultural crop data file (max. 1000 characters)
C                 * Leave blank if non-ponded crops are not simulated
C   PFL      ;  Rice/refuge data file (max. 1000 characters)
C                * Leave blank if rice and/or refuge lands are not simulated
C   URBFL    ;  Urban lands data file (max. 1000 characters)
C                * Leave blank if urban lands are not simulated
C   NVRVFL   ;  Native/riparian vegetation lands data file (max. 1000 characters)
C                * Leave blank if native and/or riparion veg. lands are not simulated
C   RFFL     ;  File that lists the return flow fractions (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   RUFL     ;  File that lists the irrigation water re-use factors (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   IPFL     ;  File that lists the irrigation periods for each ponded and
C                non-ponded crop (max. 1000 characters)
C                * Leave blank if both ponded and non-ponded crops are not simulated
C   MSRCFL   ;  File that lists generic source of moisture rates other than precipitation
C                and irrigation (max. 1000 characters)
C                * Leave blank if there are no generic sources of moisture simulated
C   AGWDFL   ;  File that lists agricultural water supply requirement (max. 1000 characters)
C                * Leave blank if agricultural water supply requirement will be computed
C                  dynamically
C   LWUBUDFL ;  HDF5 output file for land and water use budget at each
C                  subregion (max. 1000 characters)
C                 * Leave blank if this output is not required
C   RZBUDFL  ;  HDF5 output file for root zone moisture budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   ZLWUBUDFL;  HDF5 output file for land and water use zone budget
C                  post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   ZRZBUDFL ;  HDF5 output file for root zone zone budget
C                  post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   FNSMFL   ;  Output file for end-of-simulation soil moisture (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-----------------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.0001                                    / RZCONV
          200                                       / RZITERMX
          0.08333                                   / FACTCN  (in -> ft)
          RootZone\NonPondedAg\NonPondedAg.dat      / AGNPFL
          RootZone\PondedAg\PondedAg.dat            / PFL
          RootZone\Urban\Urban.dat                  / URBFL
          RootZone\NVRV\NVRV.dat                    / NVRVFL
          RootZone\ReturnFlowFrac.dat               / RFFL
          RootZone\ReuseFrac.dat                    / RUFL
          RootZone\IrrigPeriod.dat                  / IPFL
                                                    / MSRCFL
          RootZone\AgWaterDemand.dat                / AGWDFL
          Budget\LWU.hdf                            / LWUBUDFL
          Budget\RZ.hdf                             / RZBUDFL
          ZBudget\LWU_ZBud.hdf                      / ZLWUBUDFL
          ZBudget\RZ_ZBud.hdf                       / ZRZBUDFL
                                                    / FNSMFL
C*****************************************************************************
C            Parameters for Soil, Precipitation and Runoff Destination
C
C   Enter conversion factors.
C
C   FACTK  ;  Conversion factor for root zone hydraulic conductivity
C              It is used to convert only the spatial component of the unit;
C              DO NOT include the conversion factor for time component of the unit.
C              * e.g. Unit of hydraulic conductivity listed in this file = FT/MONTH
C                     Consistent unit used in simulation                = IN/DAY
C                     Enter FACT (FT/MONTH -> IN/MONTH)                 = 8.33333E-02
C                     (conversion of MONTH -> DAY is performed automatically)
C   TUNITK ;  Time unit of root zone hydraulic conductivity.  This should be one of the
C             units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.283464                                  / FACTK (micrometers/sec -> ft/day)
          1day                                      / TUNITK
C-----------------------------------------------------------------------------------------
C
C   Enter soil parameters, precipitaion and surface flow destination data below for each
C   grid element.
C
```

```
C   IE     ;  Element ID
C   WP     ;  Wilting point; [L/L]
C   FC     ;  Field capacity; [L/L]
C   TN     ;  Total porosity; [L/L]
C   LAMBDA ;  Pore size distribution index; [dimensionless]
C   K      ;  Saturated hydraulic conductivity; [L/T]
C   RHC    ;  Method to represent hydraulic conductivity vs. moisture content curve
C               1 = Campbell's equation
C               2 = van Genucten-Mualem equation
C   IRNE   ;  Precipitation data column in the Precipitation file that applies to element IE
C   FRNE   ;  Factor to convert rainfall at the precipitation data column to
C               rainfall at element IE
C   IMSRC  ;  Generic source of moisture data column in the Generic Moisture Source file (MSRCFL
C               file listed above) that applies to element IE
C               * Note: Enter any number if MSRCFL above is left blank
C   TYPDEST;  Destination type for the surface flow from element IE
C               0 = Surface flow goes outside of model area
C               1 =   "       "    "  to a stream node
C               3 =   "       "    "   " a lake
C               5 =   "       "    "   " groundwater
C   DEST   ;  Destination for the surface flow from element IE
C               * Note: Enter any number if TYPDEST is set to 0 or 5
C   KPonded;  Saturated hydraulic conductivity to be used for ponded crops in the element; [L/T]
C               * Note: Enter -1.0 if KPonded is the same as K
C
C-----------------------------------------------------------------------------------------------------------
C  IE      WP        FC        TN        LAMBDA    K        RHC    IRNE  FRNE   IMSRC   TYPDEST  DEST   KPonded
C-----------------------------------------------------------------------------------------------------------
   1       0.0000    0.1370    0.4530    0.378     5.0E-02   2      1    1.0      0       0       3      -1.0
   2       0.0000    0.1571    0.4640    0.242     5.1E+01   2      1    1.0      0       0       3      -1.0
   3       0.0000    0.1053    0.4630    0.252     5.0E-02   2      1    1.0      0       0       3      -1.0
   .         .         .         .         .         .       .      .     .       .       .       .        .
   .         .         .         .         .         .       .      .     .       .       .       .        .
   .         .         .         .         .         .       .      .     .       .       .       .        .
   220     0.0000    0.1210    0.4300    0.223     5.0E-02   2      3    1.0      0       0       3      1.0E-03
   221     0.0000    0.0485    0.4530    0.378     5.0E-02   2      3    1.0      0       0       0      1.0E-03
   222     0.0000    0.2322    0.5010    0.234     1.9E+01   2      3    1.0      0       0       0      1.0E-03
   223     0.0000    0.1210    0.4300    0.223     5.0E-02   2      3    1.0      0       0       3      1.0E-03
```

8.3.10. Input Files for Root Zone Component Version 4.1

Most of the input data files required by the root zone component version 4.1 and the parameters required to be specified are the same as those for root zone component version 4.0. Therefore, only those input files that are different than the ones in version 4.0 will be explained in this section. For a detailed description of the other input files, please refer to section 8.3.8.

8.3.10.1. Root Zone Component Main File

Similar to the Root Zone Component Main File for version 4.0, this file includes the convergence criteria for the iterative solution of the non-linear soil moisture mass balance equation, names of additional input files that are used to simulate land surface and root zone flow processes for agricultural, urban and natural lands, and agricultural and urban water demands. Subregional Land and Water Use as well as Subregional Root Zone Moisture Budget output filenames are also listed in this file. Data to simulate root water uptake from groundwater and riparian vegetation access to stream flows are also listed in this file. Soil properties at each grid cell and the destination for the surface flow generated at each cell are listed in the last section of the Root Zone Component Main File.

First data line of the Root Zone Component Main File lists the version number (i.e. 4.1) of the root zone component that will be used in simulating the land surface and root zone flow processes. IDC first reads this data line to figure out what other parameters will be read and what flow processes are to be simulated. This first line of data entry must not be modified.

The following sections and variables are defined in the rest of this file:

Root Zone Simulation Scheme Control and Filenames

In this section convergence criteria for the iterative solution methodology and names of additional input and output files are listed.

RZCONV	Convergence criteria for iterative soil moisture accounting as a fraction of total porosity; [L/L]
RZITERMX	Maximum number of iterations for iterative soil moisture accounting

FACTCN	Conversion factor to convert inches to the simulation unit of length
GWUPTK	Flag to turn on or off the root water uptake from groundwater (0 = root water uptake from groundwater is NOT simulated; 1 = root water uptake from groundwater is simulated); this flag is effective only when IDC is executed when linked to an integrated hydrologic model such as IWFM
AGNPFL	Filename for the Non-Ponded Crops Main File (maximum 1000 characters); leave blank if non-ponded crops are not simulated
PFL	Filename for the Ponded Crops Main File (maximum 1000 characters); leave blank if rice and/or refuge lands are not simulated
URBFL	Filename for the Urban Lands Main File (maximum 1000 characters); leave blank if urban lands are not simulated
NVRVFL	Filename for the Natural Lands Main File (maximum 1000 characters); leave blank if native and/or riparian vegetation lands are not simulated
RFFL	File that lists the return flow fractions (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
RUFL	File that lists the irrigation water re-use factors (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
IPFL	File that lists the irrigation periods for each ponded and non-ponded crop (maximum 1000 characters); this is a required file even if ponded and non-ponded crops are not simulated
MSRCFL	File that lists generic source of moisture rates other than precipitation and irrigation (maximum 1000 characters); leave blank if there are no generic sources of moisture simulated
AGWDFL	File that lists agricultural water supply requirement (maximum 1000 characters); leave blank if agricultural water supply requirement for all crops will be computed dynamically

LWUBUDFL	HDF5 output file for subregional land and water use budget (maximum 1000 characters); leave blank if this output is not required
RZBUDFL	HDF5 output file for subregional root zone moisture (maximum 1000 characters); leave blank if this output is not required
FNSMFL	Output file for end-of-simulation soil moisture (maximum 1000 characters); leave blank if this output is not required

Soil Parameters and Surface Flow Destinations

In this section soil parameters, precipitation rates, generic soil moisture sources (if any) and surface runoff destinations are listed for each finite element.

FACTK	Conversion factor for the spatial component of the root zone hydraulic conductivity
FACTCPRISE	Conversion factor for capillary rise
TUNITK	Time unit of root zone hydraulic conductivity this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File
IE	Element identification number
WP	Wilting point; [L/L]
FC	Field capacity; [L/L]
TN	Total porosity; [L/L]
LAMBDA	Pore size distribution index
K	Saturated hydraulic conductivity; [L/T]
RHC	Method to represent hydraulic conductivity versus moisture content curve (1 = Campbell's equation, 2 = van Genucten-Mualem equation)
CPRISE	Capillary rise; [L]
IRNE	Precipitation rate; this number corresponds to the appropriate data column in the Precipitation File
FRNE	Factor to convert rainfall at the precipitation data column IRNE to rainfall at element IE
IMSRC	Generic source of moisture; this number corresponds to the appropriate data column in the Generic Moisture Source File

	that applies to element IE (enter any number if the Generic Moisture Source File, MSRCFL, is not defined)
TYPDEST	Destination type for the surface flow from element IE (0 = surface flow goes outside of model area, 1 = surface flow goes to a stream node, 3 = surface flow goes to a lake, 5 = surface flow recharges the groundwater)
DEST	Destination identification number for the surface flow from element IE; enter any number if surface flow from the element goes outside the model area (TYPDEST = 0) or recharges the groundwater (TYPDEST = 5)
KPonded	Saturated hydraulic conductivity to be used for ponded crops in the element (enter −1.0 if KPonded is the same as K); [L/T]

```
#4.1
C***  DO NOT DELETE ABOVE LINE ***
C
C*****************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*****************************************************************************
C
C                     ROOT ZONE PARAMETERS DATA FILE
C                          Root Zone Component
C                          *** Version 4.1 ***
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: ROOTZONE_MAIN.dat
C
C*****************************************************************************
C                             File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes.
C
C*****************************************************************************
C                 Root Zone Simulation Scheme Control and File Names
C
C   RZCONV   ;  Convergence criteria for iterative soil moisture accounting as a
C                fraction of total porosity; [L/L]
C   RZITERMX ;  Maximum number of iterations for iterative soil moisture accounting
C   FACTCN   ;  Conversion factor to convert inches to the simulation unit of length
C   GWUPTK   ;  Flag to turn on or off the root water uptake from groundwater
C                0 = DO NOT allow root water uptake from groundwater
C                1 = Allow root water uptake from groundwater
C   AGNPFL   ;  Non-ponded agricultural crop data file (max. 1000 characters)
C                * Leave blank if non-ponded crops are not simulated
C   PFL      ;  Rice/refuge data file (max. 1000 characters)
C                * Leave blank if rice and/or refuge lands are not simulated
C   URBFL    ;  Urban lands data file (max. 1000 characters)
C                * Leave blank if urban lands are not simulated
C   NVRVFL   ;  Native/riparian vegetation lands data file (max. 1000 characters)
C                * Leave blank if native and/or riparion veg. lands are not simulated
C   RFFL     ;  File that lists the return flow fractions (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   RUFL     ;  File that lists the irrigation water re-use factors (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   IPFL     ;  File that lists the irrigation periods for each ponded and
C                non-ponded crop (max. 1000 characters)
C                * Leave blank if both ponded and non-ponded crops are not simulated
C   MSRCFL   ;  File that lists generic source of moisture rates other than precipitation
C                and irrigation (max. 1000 characters)
C                * Leave blank if there are no generic sources of moisture simulated
C   AGWDFL   ;  File that lists agricultural water supply requirement (max. 1000 characters)
C                * Leave blank if agricultural water supply requirement will be computed
C                  dynamically
C   LWUBUDFL ;  HDF5 output file for land and water use budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   RZBUDFL  ;  HDF5 output file for root zone moisture budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   FNSMFL   ;  Output file for end-of-simulation soil moisture (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-----------------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.0001                                    / RZCONV
          200                                       / RZITERMX
          0.08333                                   / FACTCN
          1                                         / GWUPTK
          RootZone\NonPondedAg\NonPondedAg.dat      / AGNPFL
          RootZone\PondedAg\PondedAg.dat            / PFL
          RootZone\Urban\Urban.dat                  / URBFL
          RootZone\NVRV\NVRV.dat                    / NVRVFL
          RootZone\ReturnFlowFrac.dat               / RFFL
          RootZone\ReuseFrac.dat                    / RUFL
          RootZone\IrrigPeriod.dat                  / IPFL
                                                    / MSRCFL
          RootZone\AgWaterDemand.dat                / AGWDFL
          Budget\LWU.hdf                            / LWUBUDFL
          Budget\RZ.hdf                             / RZBUDFL
                                                    / FNSMFL
C*****************************************************************************
C              Parameters for Soil, Precipitation and Runoff Destination
C
C   Enter conversion factors.
C
C   FACTK      ;  Conversion factor for root zone hydraulic conductivity
C                  It is used to convert only the spatial component of the unit;
C                  DO NOT include the conversion factor for time component of the unit.
C                  * e.g. Unit of hydraulic conductivity listed in this file = IN/DAY
C                         Consistent unit used in simulation                = FT/MONTH
C                         Enter FACT (IN/MONTH -> FT/MONTH)                 = 8.33333E-02
C                         (conversion of DAY -> MONTH is performed automatically)
C   FACTCPRISE;  Conversion factor for capillary rise
C   TUNITK     ;  Time unit of root zone hydraulic conductivity.  This should be one of the
C                  units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.283464                                  / FACTK          (micrometers/sec -> ft/day)
          1.0                                       / FACTCPRISE
          1day                                      / TUNITK
C-----------------------------------------------------------------------------------------
C
C   Enter soil parameters, precipitaion and surface flow destination data below for each
C   grid element.
C
C   IE     ;  Element ID
C   WP     ;  Wilting point; [L/L]
```

```
C   FC     ;  Field capacity; [L/L]
C   TN     ;  Total porosity; [L/L]
C   LAMBDA ;  Pore size distribution index; [dimensionless]
C   K      ;  Saturated hydraulic conductivity; [L/T]
C   RHC    ;  Method to represent hydraulic conductivity vs. moisture content curve
C               1 = Campbell's equation
C               2 = van Genucten-Mualem equation
C   CPRISE ;  Capillary rise; [L]
C   IRNE   ;  Precipitation data column in the Precipitation file that applies to element IE
C   FRNE   ;  Factor to convert rainfall at the precipitation data column to
C               rainfall at element IE
C   IMSRC  ;  Generic source of moisture data column in the Generic Moisture Source file (MSRCFL
C               file listed above) that applies to element IE
C               * Note: Enter any number if MSRCFL above is left blank
C   TYPDEST;  Destination type for the surface flow from element IE
C               0 = Surface flow goes outside of model area
C               1 =   "        "    "  to a stream node
C               3 =   "        "    "   " a lake
C               5 =   "        "    "   " groundwater
C   DEST   ;  Destination for the surface flow from element IE
C               * Note: Enter any number if TYPDEST is set to 0 or 5
C   KPonded;  Saturated hydraulic conductivity to be used for ponded crops in the element; [L/T]
C               * Note: Enter -1.0 if KPonded is the same as K
C
C---------------------------------------------------------------------------------------------------------------
C  IE      WP      FC      TN      LAMBDA   K        RHC    CPRISE  IRNE    FRNE    IMSRC  TYPDEST  DEST    KPonded
C---------------------------------------------------------------------------------------------------------------
   1       0.00    0.137   0.453   0.378    5.0E-02   2     10.0    1       1.0       0      0       3      -1.0
   2       0.00    0.157   0.464   0.242    5.1E+01   2     10.0    1       1.0       0      0       3      -1.0
   3       0.00    0.105   0.463   0.252    5.0E-02   2     10.0    1       1.0       0      0       3      -1.0
   .        .       .       .       .        .        .     .       .        .        .      .       .        .
   .        .       .       .       .        .        .     .       .        .        .      .       .        .
   .        .       .       .       .        .        .     .       .        .        .      .       .        .
   220     0.00    0.121   0.430   0.223    5.0E-02   2     10.0    3       1.0       0      0       3      1.0E-03
   221     0.00    0.048   0.453   0.378    5.0E-02   2     10.0    3       1.0       0      0       0      1.0E-03
   222     0.00    0.232   0.501   0.234    1.9E+01   2     10.0    3       1.0       0      0       0      1.0E-03
   223     0.00    0.121   0.430   0.223    5.0E-02   2     10.0    3       1.0       0      0       3      1.0E-03
```

8.3.10.2. Native and Riparian Vegetation Component Files

8.3.10.2.a Native and Riparian Vegetation Lands Main File

The Native and Riparian Vegetation Lands Main File is the gateway file for all data that is necessary to simulate land surface and root zone flow processes in areas that are covered with native and riparian vegetation.

The file is divided into several sections and uses the following variables:

Land-Use Areas

The filename for the native and riparian areas data file is listed in this section:

LUFLNVRV	File that lists the urban areas (maximum 1000 characters)

Rooting Depths

FACT	Conversion factor for native and riparian vegetation root zone depths
ROOTNV	Root zone depth for native vegetation; [L]
ROOTRV	Root zone depth for riparian vegetation; [L]

Native and Riparian Vegetation Simulation Parameters

IE	Element identification number entered sequentially; enter 0 if the following values are to be used for all elements
CNNV	Curve number for native vegetation lands
CNRV	Curve number for riparian vegetation lands
ICETNV	Native vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File
ICETRV	Riparian vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File
ISTRMRV	Stream node at which water will be used to satisfy unmet riparian evapotranspirative demand in element IE; enter 0 if riparian vegetation in element IE has no access to a stream node

Initial Soil Moisture Conditions

The initial soil moisture contents for native and riparian vegetation at each element are listed in this section.

IE	Element identification number; enter 0 if following values are to be used for all elements
SOILM_NV	Initial root zone moisture content for native vegetation at element IE; [L/L]
SOILM_RV	Initial root zone moisture content for riparian vegetation at element IE; [L/L]

```
C*******************************************************************************
C
C                    INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                  NATIVE AND RIPARIAN VEGETATION DATA FILE
C                          Root Zone Component
C                          *** Version 4.1 ***
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: NVRV_MAIN.dat
C
C*******************************************************************************
C                           File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes for native and riparian vegetation.
C
C*******************************************************************************
C                          Land Use Areas
C
C   LUFLNVRV   ;  File that lists the land use areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    RootZone\NVRV\NVRVArea.dat                       / LUFLNVRV
C*******************************************************************************
C                               Rooting Depths
C
C   FACT  ;  Conversion factor for root zone depths
C   ROOTNV;  Native veg. root zone depth; [L]
C   ROOTRV;  Riparian veg. root zone depth; [L]
C
C-------------------------------------------------------------------------------
C   VALUE                DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                  / FACT
    3.0                  / ROOTNV
    3.0                  / ROOTRV
C*******************************************************************************
C         Native and Riparian Vegetation Root Zone Simulation Parameters
C
C   IE       ;  Element ID (0 if following values are to be used for all elements)
C   CNNV     ;  Curve number for native vegetation lands
C   CNRV     ;  Curve number for riparian vegetation lands
C   ICETNV   ;  Native vegetation ETc - this number corresponds to the appropriate
C                 data column in the ET data file listed in the Main Control Data file.
C   ICETRV   ;  Riparian vegetation ETc - this number corresponds to the appropriate
C                 data column in the ET data file listed in the Main Control Data file.
C   ISTRMRV  ;  Stream node at which water will be used to satisfy unmet riparain ET
C                 requirement in element IE
C                 * Enter 0 if riparian vegetation in element IE has no access to a
C                   stream node
C
C-------------------------------------------------------------------------------
C   IE    CNNV    CNRV    ICETNV    ICETRV    ISTRMRV
C-------------------------------------------------------------------------------
    1        71      71      21        22        23
    2        71      71      21        22        23
    3        58      58      21        22        0
    .        .       .       .         .         .
    .        .       .       .         .         .
    .        .       .       .         .         .
    221      71      71      21        22        78
    222      58      58      21        22        0
    223      58      58      21        22        0
C*******************************************************************************
C                          Initial Soil Moisture Condition
C                      For Native and Riparian Vegetation Areas
C
C   IE       ;  Element ID (0 if following values are to be used for all elements)
C   SOILM_NV;   Initial root zone moisture content for native vegetation area; [L/L]
C   SOILM_RV;   Initial root zone moisture content for riparian vegetation area; [L/L]
C
C-----------------------------------------------------------------------------
C   IE     SOILM_NV     SOILM_RV
C-----------------------------------------------------------------------------
    1       0.1370       0.1370
    2       0.1571       0.1571
    3       0.1053       0.1053
    .         .            .
    .         .            .
    .         .            .
    221     0.0485       0.0485
    222     0.2322       0.2322
    223     0.1210       0.1210
```

8.3.11. Input Files for Root Zone Component Version 4.11

All input files for the root zone component version 4.11 except the Root Zone Component Main File are the same as those for the component version 4.1. Therefore, only the Root Zone Component Main File for version 4.11 will be explained in this section. For a detailed description of the other input files, please refer to section 8.3.10.

8.3.11.1. Root Zone Component Main File

This file is exactly the same as that for the root zone component version 4.1, except that it allows the specification of two additional filenames to print out cell-level Land and Water Use as well as the Root Zone budget data. These output files are optional and are generated as HDF5 files. They can later be post-processed using the Z-Budget post-processor to generate water budgets for "*zones*" which are groups of cells defined by the user.

The following sections and variables are defined in the rest of this file:

Root Zone Simulation Scheme Control and Filenames

In this section convergence criteria for the iterative solution methodology and names of additional input and output files are listed.

RZCONV	Convergence criteria for iterative soil moisture accounting as a fraction of total porosity; [L/L]
RZITERMX	Maximum number of iterations for iterative soil moisture accounting
FACTCN	Conversion factor to convert inches to the simulation unit of length
GWUPTK	Flag to turn on or off the root water uptake from groundwater (0 = root water uptake from groundwater is NOT simulated; 1 = root water uptake from groundwater is simulated); this flag is effective only when IDC is executed when linked to an integrated hydrologic model such as IWFM
AGNPFL	Filename for the Non-Ponded Crops Main File (maximum 1000 characters); leave blank if non-ponded crops are not simulated

PFL	Filename for the Ponded Crops Main File (maximum 1000 characters); leave blank if rice and/or refuge lands are not simulated
URBFL	Filename for the Urban Lands Main File (maximum 1000 characters); leave blank if urban lands are not simulated
NVRVFL	Filename for the Natural Lands Main File (maximum 1000 characters); leave blank if native and/or riparian vegetation lands are not simulated
RFFL	File that lists the return flow fractions (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
RUFL	File that lists the irrigation water re-use factors (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
IPFL	File that lists the irrigation periods for each ponded and non-ponded crop (maximum 1000 characters); this is a required file even if ponded and non-ponded crops are not simulated
MSRCFL	File that lists generic source of moisture rates other than precipitation and irrigation (maximum 1000 characters); leave blank if there are no generic sources of moisture simulated
AGWDFL	File that lists agricultural water supply requirement (maximum 1000 characters); leave blank if agricultural water supply requirement for all crops will be computed dynamically
LWUBUDFL	HDF5 output file for subregional land and water use budget (maximum 1000 characters); leave blank if this output is not required
RZBUDFL	HDF5 output file for subregional root zone moisture (maximum 1000 characters); leave blank if this output is not required
ZLWUBUDFL	HDF5 output file for land and water use zone budget post-processor (maximum 1000 characters); leave blank if this output is not required

ZRZBUDFL	HDF5 output file for root zone zone budget post-processor (maximum 1000 characters); leave blank if this output is not required
FNSMFL	Output file for end-of-simulation soil moisture (maximum 1000 characters); leave blank if this output is not required

Soil Parameters and Surface Flow Destinations

In this section soil parameters, precipitation rates, generic soil moisture sources (if any) and surface runoff destinations are listed for each finite element.

FACTK	Conversion factor for the spatial component of the root zone hydraulic conductivity
FACTCPRISE	Conversion factor for capillary rise
TUNITK	Time unit of root zone hydraulic conductivity this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File
IE	Element identification number
WP	Wilting point; [L/L]
FC	Field capacity; [L/L]
TN	Total porosity; [L/L]
LAMBDA	Pore size distribution index
K	Saturated hydraulic conductivity; [L/T]
RHC	Method to represent hydraulic conductivity versus moisture content curve (1 = Campbell's equation, 2 = van Genucten-Mualem equation)
CPRISE	Capillary rise; [L]
IRNE	Precipitation rate; this number corresponds to the appropriate data column in the Precipitation File
FRNE	Factor to convert rainfall at the precipitation data column IRNE to rainfall at element IE
IMSRC	Generic source of moisture; this number corresponds to the appropriate data column in the Generic Moisture Source File that applies to element IE (enter any number if the Generic Moisture Source File, MSRCFL, is not defined)
TYPDEST	Destination type for the surface flow from element IE (0 = surface flow goes outside of model area, 1 = surface flow goes

	to a stream node, 3 = surface flow goes to a lake, 5 = surface flow recharges the groundwater)
DEST	Destination identification number for the surface flow from element IE; enter any number if surface flow from the element goes outside the model area (TYPDEST = 0) or recharges the groundwater (TYPDEST = 5)
KPonded	Saturated hydraulic conductivity to be used for ponded crops in the element (enter –1.0 if KPonded is the same as K); [L/T]

```
#4.11
C***  DO NOT DELETE ABOVE LINE ***
C
C*****************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*****************************************************************************
C
C                     ROOT ZONE PARAMETERS DATA FILE
C                          Root Zone Component
C                          *** Version 4.11 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: ROOTZONE_v411_MAIN.dat
C
C*****************************************************************************
C                          File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes.
C
C*****************************************************************************
C                Root Zone Simulation Scheme Control and File Names
C
C   RZCONV   ;  Convergence criteria for iterative soil moisture accounting as a
C                fraction of total porosity; [L/L]
C   RZITERMX ;  Maximum number of iterations for iterative soil moisture accounting
C   FACTCN   ;  Conversion factor to convert inches to the simulation unit of length
C   GWUPTK   ;  Flag to turn on or off the root water uptake from groundwater
C                0 = DO NOT allow root water uptake from groundwater
C                1 = Allow root water uptake from groundwater
C   AGNPFL   ;  Non-ponded agricultural crop data file (max. 1000 characters)
C                * Leave blank if non-ponded crops are not simulated
C   PFL      ;  Rice/refuge data file (max. 1000 characters)
C                * Leave blank if rice and/or refuge lands are not simulated
C   URBFL    ;  Urban lands data file (max. 1000 characters)
C                * Leave blank if urban lands are not simulated
C   NVRVFL   ;  Native/riparian vegetation lands data file (max. 1000 characters)
C                * Leave blank if native and/or riparion veg. lands are not simulated
C   RFFL     ;  File that lists the return flow fractions (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   RUFL     ;  File that lists the irrigation water re-use factors (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   IPFL     ;  File that lists the irrigation periods for each ponded and
C                non-ponded crop (max. 1000 characters)
C                * Leave blank if both ponded and non-ponded crops are not simulated
C   MSRCFL   ;  File that lists generic source of moisture rates other than precipitation
C                and irrigation (max. 1000 characters)
C                * Leave blank if there are no generic sources of moisture simulated
C   AGWDFL   ;  File that lists agricultural water supply requirement (max. 1000 characters)
C                * Leave blank if agricultural water supply requirement will be computed
C                  dynamically
C   LWUBUDFL ;  HDF5 output file for land and water use budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   RZBUDFL  ;  HDF5 output file for root zone moisture budget at each
C                  subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   ZLWUBUDFL;  HDF5 output file for land and water use zone budget
C                  post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   ZRZBUDFL ;  HDF5 output file for root zone zone budget
C                  post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   FNSMFL   ;  Output file for end-of-simulation soil moisture (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-----------------------------------------------------------------------------------------
C         VALUE                                         DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.0001                                        / RZCONV
          200                                           / RZITERMX
          0.08333                                       / FACTCN
          1                                             / GWUPTK
          RootZone\NonPondedAg\NonPondedAg.dat          / AGNPFL
          RootZone\PondedAg\PondedAg.dat                / PFL
          RootZone\Urban\Urban.dat                      / URBFL
          RootZone\NVRV\NVRV.dat                        / NVRVFL
          RootZone\ReturnFlowFrac.dat                   / RFFL
          RootZone\ReuseFrac.dat                        / RUFL
          RootZone\IrrigPeriod.dat                      / IPFL
                                                        / MSRCFL
          RootZone\AgWaterDemand.dat                    / AGWDFL
          Budget\LWU.hdf                                / LWUBUDFL
          Budget\RZ.hdf                                 / RZBUDFL
          ZBudget\LWU_ZBud.hdf                          / ZLWUBUDFL
          ZBudget\RZ_ZBud.hdf                           / ZRZBUDFL
                                                        / FNSMFL
C*****************************************************************************
C             Parameters for Soil, Precipitation and Runoff Destination
C
C   Enter conversion factors.
C
C   FACTK     ;  Conversion factor for root zone hydraulic conductivity
C                 It is used to convert only the spatial component of the unit;
C                 DO NOT include the conversion factor for time component of the unit.
C                 * e.g. Unit of hydraulic conductivity listed in this file = IN/DAY
C                        Consistent unit used in simulation                = FT/MONTH
C                        Enter FACT (IN/MONTH -> FT/MONTH)                 = 8.33333E-02
C                        (conversion of DAY -> MONTH is performed automatically)
C   FACTCPRISE;  Conversion factor for capillary rise
C   TUNITK    ;  Time unit of root zone hydraulic conductivity.  This should be one of the
C                 units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------------------
C         VALUE                                         DESCRIPTION
C-----------------------------------------------------------------------------------------
          0.283464                                      / FACTK          (micrometers/sec -> ft/day)
          1.0                                           / FACTCPRISE
```

```
         1day                                         / TUNITK
C-------------------------------------------------------------------------------------------
C
C   Enter soil parameters, precipitaion and surface flow destination data below for each
C   grid element.
C
C   IE     ;  Element ID
C   WP     ;  Wilting point; [L/L]
C   FC     ;  Field capacity; [L/L]
C   TN     ;  Total porosity; [L/L]
C   LAMBDA ;  Pore size distribution index; [dimensionless]
C   K      ;  Saturated hydraulic conductivity; [L/T]
C   RHC    ;  Method to represent hydraulic conductivity vs. moisture content curve
C               1 = Campbell's equation
C               2 = van Genucten-Mualem equation
C   CPRISE ;  Capillary rise; [L]
C   IRNE   ;  Precipitation data column in the Precipitation file that applies to element IE
C   FRNE   ;  Factor to convert rainfall at the precipitation data column to
C               rainfall at element IE
C   IMSRC  ;  Generic source of moisture data column in the Generic Moisture Source file (MSRCFL
C               file listed above) that applies to element IE
C               * Note: Enter any number if MSRCFL above is left blank
C   TYPDEST;  Destination type for the surface flow from element IE
C               0 = Surface flow goes outside of model area
C               1 =   "       "    "  to a stream node
C               3 =   "       "    "   " a lake
C               5 =   "       "    "   " groundwater
C   DEST   ;  Destination for the surface flow from element IE
C               * Note: Enter any number if TYPDEST is set to 0 or 5
C   KPonded;  Saturated hydraulic conductivity to be used for ponded crops in the element; [L/T]
C               * Note: Enter -1.0 if KPonded is the same as K
C
C-------------------------------------------------------------------------------------------------------------------
C  IE      WP      FC      TN      LAMBDA   K       RHC    CPRISE  IRNE   FRNE   IMSRC  TYPDEST  DEST   KPonded
C-------------------------------------------------------------------------------------------------------------------
   1       0.00    0.137   0.453   0.378    5.0E-02   2    10.0    1      1.0      0      0       3     -1.0
   2       0.00    0.157   0.464   0.242    5.1E+01   2    10.0    1      1.0      0      0       3     -1.0
   3       0.00    0.105   0.463   0.252    5.0E-02   2    10.0    1      1.0      0      0       3     -1.0
   .         .       .       .       .        .       .    .       .       .       .      .       .       .
   .         .       .       .       .        .       .    .       .       .       .      .       .       .
   .         .       .       .       .        .       .    .       .       .       .      .       .       .
   220     0.00    0.121   0.430   0.223    5.0E-02   2    10.0    3      1.0      0      0       3     1.0E-03
   221     0.00    0.048   0.453   0.378    5.0E-02   2    10.0    3      1.0      0      0       0     1.0E-03
   222     0.00    0.232   0.501   0.234    1.9E+01   2    10.0    3      1.0      0      0       0     1.0E-03
   223     0.00    0.121   0.430   0.223    5.0E-02   2    10.0    3      1.0      0      0       3     1.0E-03
```

8.3.12. Input Files for Root Zone Component Version 5.0

Root zone component version 5.0 simulates root zone flow processes for each land-use and soil type combinations for user-defined number of soil types. Additionally, agricultural water demand and agricultural root zone flow processes are calculated for an average crop over each soil type defined by the user. The average agricultural crop characteristics are calculated with respect to the area of each crop in a subregion. In other words, it is assumed that each model subregion has a different average crop with different crop characteristics. The following sections describe the input files used for the root zone component version 5.0.

8.3.12.1. Root Zone Component Main File

The Root Zone Component Main File includes the convergence criteria for the iterative solution of the non-linear soil moisture mass balance equation, names of additional input files that are used to simulate land surface and root zone flow processes for agricultural, urban and natural lands, and agricultural and urban water demands. Subregional and cell-level Land and Water Use as well as the Root Zone Moisture budget output filenames are also listed in this file. Number of soil types that are simulated, soil parameters for the soil types at each subregion and a list of grid cells specifying the soil type that each cell belongs to and the destination of surface runoff from each cell are included in this file.

First data line of the Root Zone Component Main File lists the version number (i.e. 5.0) of the root zone component that will be used in simulating the land surface and root zone flow processes. IDC first reads this data line to figure out what other parameters will be read and what flow processes are to be simulated. This first line of data entry must not be modified.

The following sections and variables are defined in the rest of this file:

Root Zone Simulation Scheme Control and Filenames

In this section convergence criteria for the iterative solution methodology and names of additional input and output files are listed.

RZCONV	Convergence criteria for iterative soil moisture accounting as a fraction of total porosity; [L/L]

RZITERMX	Maximum number of iterations for iterative soil moisture accounting
NSOIL	Number of simulated soil types
FACTCN	Conversion factor to convert inches to the simulation unit of length
AGFL	Filename for the agricultural Lands Main File (maximum 1000 characters); leave blank if non-ponded crops are not simulated
URBFL	Filename for the Urban Lands Main File (maximum 1000 characters); leave blank if urban lands are not simulated
NVRVFL	Filename for the Natural Lands Main File (maximum 1000 characters); leave blank if native and/or riparian vegetation lands are not simulated
RFFL	File that lists the return flow fractions (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
RUFL	File that lists the irrigation water re-use factors (maximum 1000 characters); leave blank if only native and/or riparian vegetation lands are simulated
MSRCFL	File that lists generic source of moisture rates other than precipitation and irrigation (maximum 1000 characters); leave blank if there are no generic sources of moisture simulated
LWUBUDFL	HDF5 output file for subregional land and water use budget (maximum 1000 characters); leave blank if this output is not required
RZBUDFL	HDF5 output file for subregional root zone moisture (maximum 1000 characters); leave blank if this output is not required
ZLWUBUDFL	HDF5 output file for land and water use zone budget post-processor (maximum 1000 characters); eave blank if this output is not required
ZRZBUDFL	HDF5 output file for root zone zone budget post-processor (maximum 1000 characters); leave blank if this output is not required

FNSMFL	Output file for end-of-simulation soil moisture (maximum 1000 characters); leave blank if this output is not required

Soil Parameters

In this section soil parameters and generic soil moisture sources (if any) are listed for each subregion and soil type combination.

FACTK	Conversion factor for the spatial component of the root zone hydraulic conductivity
TUNITK	Time unit of root zone hydraulic conductivity; this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File
IR	Subregion identification number
WP	Wilting point; [L/L]
FC	Field capacity; [L/L]
TN	Total porosity; [L/L]
LAMBDA	Pore size distribution index
K	Saturated hydraulic conductivity; [L/T]
RHC	Method to represent hydraulic conductivity versus moisture content curve (1 = Campbell's equation, 2 = van Genucten-Mualem equation)
IMSRC	Generic source of moisture; this number corresponds to the appropriate data column in the Generic Moisture Source File that applies to element IE (enter any number if the Generic Moisture Source File, MSRCFL, is not defined)

Element Soil Type, Precipitation and Flow Destination Characteristics

This section lists the soil type at each element, precipitation rate and the surface flow destination for each element.

IE	Element identification number
ISLID	Soil type at element IE
IRNE	Precipitation rate; this number corresponds to the appropriate data column in the Precipitation File
FRNE	Factor to convert rainfall at the precipitation data column IRNE to rainfall at element IE

TYPDEST	Destination type for the surface flow from element IE (0 = surface flow goes outside of model area, 1 = surface flow goes to a stream node, 3 = surface flow goes to a lake, 5 = surface flow recharges the groundwater)
DEST	Destination identification number for the surface flow from element IE; enter any number if surface flow from the element goes outside the model area (TYPDEST = 0) or recharges the groundwater (TYPDEST = 5)

```
#5.0
C***  DO NOT DELETE ABOVE LINE ***
C
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                    ROOT ZONE PARAMETERS DATA FILE
C                         Root Zone Component
C                         *** Version 5.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: ROOTZONE_v50_MAIN.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes.
C
C*******************************************************************************
C                Root Zone Simulation Scheme Control and File Names
C
C   RZCONV   ;  Convergence criteria for iterative soil moisture accounting as a
C                fraction of total porosity; [L/L]
C   RZITERMX ;  Maximum number of iterations for iterative soil moisture accounting
C   NSOIL    ;  Number of simulated soil types
C   FACTCN   ;  Conversion factor to convert inches to the simulation unit of length
C   AGFL     ;  Agricultural lands data file (max. 1000 characters)
C                * Leave blank if agricultural lands are not simulated
C   URBFL    ;  Urban lands data file (max. 1000 characters)
C                * Leave blank if urban lands are not simulated
C   NVRVFL   ;  Native/riparian vegetation lands data file (max. 1000 characters)
C                * Leave blank if native and/or riparion veg. lands are not simulated
C   RFFL     ;  File that lists the return flow fractions (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   RUFL     ;  File that lists the irrigation water re-use factors (max. 1000 characters)
C                * Leave blank if only native/riparian vegetation lands are simulated
C   MSRCFL   ;  File that lists generic source of moisture rates other than precipitation
C                and irrigation (max. 1000 characters)
C                * Leave blank if there are no generic sources of moisture simulated
C   LWUBUDFL ;  HDF5 output file for land and water use budget at each
C                 subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   RZBUDFL  ;  HDF5 output file for root zone moisture budget at each
C                 subregion (max. 1000 characters)
C                * Leave blank if this output is not required
C   ZLWUBUDFL;  HDF5 output file for land and water use zone budget
C                 post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   ZRZBUDFL ;  HDF5 output file for root zone zone budget
C                 post-processor (max. 1000 characters)
C                 * Leave blank if this output is not required
C   FNSMFL   ;  Output file for end-of-simulation soil moisture (max. 1000 characters)
C                * Leave blank if this output is not required
C
C-----------------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-----------------------------------------------------------------------------------------
      0.0001                                         / RZCONV
      200                                            / RZITERMX
      4                                              / NSOIL
      0.083333                                       / FACTCN
      Ag_MAIN.dat                                    / AGFL
      Urban_MAIN.dat                                 / URBFL
      NativeVeg_MAIN.dat                             / NVRVFL
      ReturnFlowFrac.dat                             / RFFL
      ReuseFrac.dat                                  / RUFL
                                                     / MSRCFL
      ..\Results\LWU.hdf                             / LWUBUDFL
      ..\Results\RZ.hdf                              / RZBUDFL
      ..\Results\LWU_ZBud.hdf                        / ZLWUBUDFL
      ..\Results\RZ_ZBud.hdf                         / ZRZBUDFL
      FinRootZone.out                                / FNSMFL
C*******************************************************************************
C                                  Soil Parameters
C
C   Enter conversion factors.
C
C   FACTK  ;  Conversion factor for root zone hydraulic conductivity
C              It is used to convert only the spatial component of the unit;
C              DO NOT include the conversion factor for time component of the unit.
C              * e.g. Unit of hydraulic conductivity listed in this file = IN/DAY
C                     Consistent unit used in simulation                = FT/MONTH
C                     Enter FACT (IN/MONTH -> FT/MONTH)                 = 8.33333E-02
C                     (conversion of DAY -> MONTH is performed automatically)
C   TUNITK ;  Time unit of root zone hydraulic conductivity.  This should be one of the
C             units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-----------------------------------------------------------------------------------------
          1.9685e-4                                  / FACTK    (micrometer/sec -> ft/min)
          1min                                       / TUNITK
C-----------------------------------------------------------------------------------------
C
C   Enter soil parameters for each soil-subregion combination.
C
C   IR     ;  Subregion ID
C   WP     ;  Wilting point (1 to NSOIL); [L/L]
C   FC     ;  Field capacity (1 to NSOIL); [L/L]
C   TN     ;  Total porosity (1 to NSOIL); [L/L]
C   LAMBDA ;  Pore size distribution index (1 to NSOIL); [dimensionless]
C   K      ;  Saturated hydraulic conductivity (1 to NSOIL); [L/T]
C   RHC    ;  Method to represent hydraulic conductivity vs. moisture content curve (1 to NSOIL)
C               1 = Campbell's equation
C               2 = van Genucten-Mualem equation
C   IMSRC  ;  Generic source of moisture data column in the Generic Moisture Source file, MSRCFL,
```

```
C             listed above (1 to NSOIL)
C             * Note: Enter any number if MSRCFL above is left blank
C
C-----------------------------------------------------------------------------------------------
C  IR    WP[1]       FC[1]       TN[1]       LAMBDA[1]      K[1]       RHC[1]       IMSRC[1]
C        WP[2]       FC[2]       TN[2]       LAMBDA[2]      K[2]       RHC[2]       IMSRC[2]
C         .           .           .           .             .           .            .
C         .           .           .           .             .           .            .
C        WP[NSOIL]   FC[NSOIL]   TN[NSOIL]   LAMBDA[NSOIL]  K[NSOIL]   RHC[NSOIL]   IMSRC[NSOIL]
C-----------------------------------------------------------------------------------------------
    1      0.000       0.067        0.477       0.755         0.250        1            0
           0.000       0.473        0.483       0.755         0.014        1            0
           0.000       0.303        0.385       0.755         0.250        1            0
           0.000       0.333        0.343       0.755         0.250        1            0
    2      0.000       0.089        0.440       0.755         0.500        1            0
           0.000       0.110        0.481       0.755         1.000        1            0
           0.000       0.239        0.477       0.755         0.402        1            0
           0.000       0.111        0.500       0.755         1.000        1            0
    3      0.000       0.119        0.438       0.755         0.620        1            0
           0.000       0.033        0.471       0.755         0.632        1            0
           0.000       0.490        0.500       0.755         0.394        1            0
           0.000       0.031        0.281       0.755         0.053        1            0
             .           .            .           .             .          .            .
             .           .            .           .             .          .            .
             .           .            .           .             .          .            .
   19      0.000       0.080        0.440       0.755         1.000        1            0
           0.000       0.208        0.478       0.755         0.873        1            0
           0.000       0.065        0.389       0.755         0.956        1            0
           0.000       0.322        0.460       0.755         0.993        1            0
   20      0.000       0.081        0.440       0.755         0.850        1            0
           0.000       0.131        0.482       0.755         0.584        1            0
           0.000       0.127        0.389       0.755         0.783        1            0
           0.000       0.094        0.459       0.755         0.843        1            0
   21      0.000       0.080        0.440       0.755         1.000        1            0
           0.000       0.418        0.478       0.755         0.914        1            0
           0.000       0.390        0.400       0.755         0.997        1            0
           0.000       0.234        0.462       0.755         1.000        1            0
C*******************************************************************************
C           Soil Type, Precipitation and Runoff Destination for Elements
C
C   Enter soil type, precipitation and surface runoff destination data for each element.
C
C   IE     ;  Element ID
C   ISLID  ;  Soil type ID number
C   IRNE   ;  Precipitation data column in the Precipitation file that applies to element IE
C   FRNE   ;  Factor to convert rainfall at the precipitation data column to
C               rainfall at element IE
C   TYPDEST;  Destination type for the surface flow from element IE
C               0 = Surface flow goes outside of model area
C               1 =   "       "    "  to a stream node
C               3 =   "       "    "   " a lake
C               5 =   "       "    "   " groundwater
C   DEST   ;  Destination for the surface flow from element IE
C               * Note: Enter any number if TYPDEST is set to 0 or 5
C
C----------------------------------------------------------------------------------------------
C    IE   ISLID   IRNE     FRNE   TYPDEST    DEST
C----------------------------------------------------------------------------------------------
      1     3       1       1.0      1       207
      2     3       2       1.0      1       206
      3     3       3       1.0      1       206
      4     3       4       1.0      1       206
      5     4       5       1.0      1       207
      .     .       .        .       .       .
      .     .       .        .       .       .
      .     .       .        .       .       .
   1387     3    1387       1.0      1       9
   1388     2    1388       1.0      1       4
   1389     2    1389       1.0      1       4
   1390     3    1390       1.0      1       9
   1391     2    1391       1.0      1       4
   1392     2    1392       1.0      1       4
```

8.3.12.2. Return Flow Fractions Data File

This file is exactly the same as the Return Flow Fractions Data File for root zone component version 4.0. Refer to section 8.3.8.2 for a detailed explanation of the variables used in this file.

8.3.12.3. Re-use Fractions Data File

This file is exactly the same as the Re-use Fractions Data File for root zone component version 4.0. Refer to section 8.3.8.3 for a detailed explanation of the variables used in this file.

8.3.12.4. Agricultural Lands Component Files

8.3.12.4.a Agricultural Lands Main File

The Agricultural Crops Main File is the gateway file for all data that is necessary to simulate agricultural water demands as well as the land surface and root zone flow processes for the agricultural lands.

The file is divided into several sections and uses the following variables:

General Data

Number of agricultural crops simulated, input files that list the subregional crop and cell-level total agricultural land areas, and the output file to print the average crop characteristics are specified in this section.

NCROP	Number of simulated agricultural crops
LUFLAGSR	File that lists the crop areas at each subregion (maximum 1000 characters)
LUFLAG	File that lists the total agricultural area at each element (maximum 1000 characters)
FACTLTOU	Factor to convert simulation unit of length into the intended output unit to be used in printing average crop characteristics
UNITLTOU	Output length unit for the average crop characteristics (maximum 10 characters)

AVGCRPFL	Output file for the average crop characteristics (maximum 1000 characters); leave blank if this output is not required

Rooting Depths

This section lists the rooting depths for each of the simulated agricultural crop

FACT	Conversion factor for crop root zone depth
ROOTCP	Root zone depth for each of the simulated crops; [L]

Curve Numbers for Rainfall Runoff Simulation

Curve numbers for each subregion and soil type combination are entered in this section.

IR	Subregion identification number entered sequentially; enter 0 if curve numbers defined for each soil type are to be used for all subregions
CNAG	Curve number for each soil type

Crop Evapotranspiration

Crop evapotranspiration for each subregion and crop combination is listed here by specifying a column number in the Evapotranspiration File:

IR	Subregion identification number entered sequentially; enter 0 if following values are to be used for all subregions
ICET	Crop ET; this number corresponds to the appropriate data column the Evapotranspiration File

Irrigation Periods

Time series irrigation period data is listed in this section for each subregion and crop combination:

IPFL	Irrigation period data file (maximum 1000 characters)
IR	Subregion identification number; enter 0 if following values are to be used for all subregions
ICIP	Irrigation period; this number corresponds to the appropriate data column in the Irrigation Period Data File (IPFL)

Minimum Soil Moisture

The minimum soil moisture that is used to trigger an irrigation event for each crop and subregion combination is listed in this section:

MINSMFL	File that lists the minimum soil moisture (maximum 1000 characters)
IR	Subregion identification number; enter 0 if following values are to be used for all subregions
ICMSM	Minimum soil moisture as a fraction of total available water (i.e. field capacity less wilting point); this corresponds to the appropriate data column in the Minimum Soil Moisture Data File (MINSMFL)

Target Soil Moisture for Irrigation

The moisture level which is targeted to be achieved by the irrigation event is listed for each crop and subregion combination in this section:

TRGSMFL	File that lists the target soil moisture during irrigation (maximum 1000 characters); leave blank if target soil moisture is the field capacity
IR	Subregiont identification number; enter 0 if following values are to be used for all subregions
ICTRGSM	Target soil moisture as a fraction of field capacity; this number corresponds to the appropriate data column in the Target Soil Moisture Data File (TRGSMFL)

Agricultural Water Supply, Return Flow and Re-Use Fractions

If the agricultural water supply requirement is pre-specified instead of being computed dynamically, they are specified in this section. Irrigation water return flow and re-use fractions are also listed.

AGWDFL	File that lists the agricultural water supply requirement (maximum 1000 characters); leave blank if agricultural water demand is simulated dynamically
FLDMD	Flag for the root zone moisture to be used for the computation of agricultural water demand and the timing of irrigation (0 = use the soil moisture at the beginning of time step, 1 = use the soil moisture at the end of time step); setting FLDMD to 0 works well when the simulation time step is

	small (e.g. 1 day) while it should be set to 1 when the simulation time step is longer (e.g. 1 month)
IR	Subregion identification number; enter0 if the following values are to be used for all subregions
ICAGWD	Water supply requirement for subregion IR; this number corresponds to the appropriate data column in the Agricultural Water Supply Requirement file (AGWDFL); enter any number if AGWDFL is not specified or enter 0 if agricultural water supply requirement will be computed internally for the subregion
ICRTFAG	Fraction of the agricultural applied water that becomes return flow; this number corresponds to the appropriate data column in Return Flow Factor Data File (RFFL) listed in the Root Zone Main File
ICRUFAG	Fraction of the applied water that is re-used; this number corresponds to the appropriate data column in the Re-use Factor Data File (RUFL) listed in the Root Zone Main File.

Initial Soil Moisture Conditions

IR	Subregion identification number; enter 0 if following values are to be used for all subregions
FSOILMP	Fraction of initial soil moisture at subregion IR that is due to precipitation for each soil type
SOILM	Initial root zone moisture content for agricultural area for each soil type; [L/L]

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                     AGRICULTURAL LANDS DATA FILE
C                        Root Zone Component
C                        *** Version 5.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Ag_MAIN.dat
C
C*******************************************************************************
C                              File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes and crop water managament of agricultural lands.
C
C*******************************************************************************
C                       Number of Crops and Land Use Areas
C
C   NCROP    :  Number of simulated agricultrural crops
C   LUFLAGSR ;  File that lists the crop areas at each subregion (max. 1000 characters)
C   LUFLAG   ;  File that lists the total agricultural area at each element (max. 1000 characters)
C   FACTLTOU ;  Factor to convert simulation unit of length into the intended output unit
C                 to be used in printing average crop characteristics
C   UNITLTOU ;  Output length unit for the average crop characteristics (max. 10 characters)
C   AVGCRPFL ;  Output file for the average crop characteristics (max. 1000 characters)
C                 * Leave blank if this output is not required
C
C-------------------------------------------------------------------------------
*     Crop No.                    Name
*   --------------              ----------
*         1                    PA = Pasture
*         2                    AL = Alfalfa
*         3                    SB = Sugar Beets
*         4                    FI = Field Crops
*         5                    RI = Rice
*         6                    TR = Truck Crops
*         7                    TO = Tomato
*         8                    TH = Tomato (Hand)
*         9                    TM = Tomato (Machine)
*        10                    OR = Orchard
*        11                    GR = Grains
*        12                    VI = Vineyards
*        13                    CO = Cotton
*        14                    SO = Citrus and Olives
C-------------------------------------------------------------------------------
C   VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
    14                        / NCROP
    CVCropArea.dat            / LUFLAGSR
    CVAgElemArea.dat          / LUFLAG
    12.0                      / FACTLTOU   (ft -> in)
    inches                    / UNITLTOU
    ..\Results\AvgCrop.out    / AVGCRPFL
C*******************************************************************************
C                                Rooting Depths
C
C   FACT    ;    Conversion factor for crop root zone depth
C   ROOTCP ;     Crop root zone depths (1 to NCROP); [L]
C
C-------------------------------------------------------------------------------
C   VALUE                  DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                    / FACT
    2.0                    / ROOTCP[1]      Pasture
    6.0                    / ROOTCP[2]      Alfalfa
    5.0                    / ROOTCP[3]      Sugar Beets
    4.0                    / ROOTCP[4]      Field Crops
    2.0                    / ROOTCP[5]      Rice
    3.0                    / ROOTCP[6]      Truck Crops
    5.0                    / ROOTCP[7]      Tomato
    5.0                    / ROOTCP[8]      Tomato (Hand)
    5.0                    / ROOTCP[9]      Tomato (Machine)
    6.0                    / ROOTCP[10]     Orchard
    4.0                    / ROOTCP[11]     Grains
    5.0                    / ROOTCP[12]     Vineyards
    6.0                    / ROOTCP[13]     Cotton
    4.0                    / ROOTCP[14]     Citrus and Olives
C*******************************************************************************
C                     Curve Numbers for Rainfall Runoff Simulation
C
C   Enter curve numbers for each subregion and soil-type combination for
C   agricultural areas.
C
C   IR       ;  Subregion ID (0 if following values are to be used for all subregions)
C   CNAG     ;  Curve number for agricultural lands for each simulated
C                 soil type (1 to NSOIL)
C
C-------------------------------------------------------------------------------
C   IR    CNURB[1]   CNURB[2]   CNURB[3]   CNURB[4]
C-------------------------------------------------------------------------------
    1     79.0       84.0       92.0       94.0
    2     83.0       86.0       93.0       95.9
    3     83.0       86.0       93.0       96.1
    4     83.0       86.0       93.0       96.0
    .      .          .          .          .
    .      .          .          .          .
    .      .          .          .          .
   18     87.0       90.0       94.0       97.0
   19     92.0       93.0       96.0       97.0
   20     89.0       91.0       94.0       97.0
   21     89.0       91.0       94.0       97.0
C*******************************************************************************
C                       Crop Evapotranspiration (ETc)
C
C   The following lists the ETc column pointers for each subregion and agricultural
C   crop combination.
```

```
C
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all
C                 subregion and agricultural crop combinations)
C   ICETAG   ;  Crop ET (ETc) - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Input File.  List for each
C                 agricultural crop (1 to NCROP).
C
C-----------------------------------------------------------------------------
C   IR    ICETAG[1]  ICETAG[2] ... ICETAG[NCROP]
C-----------------------------------------------------------------------------
C          PA      AL      SB      FI      RI      TR      TO      TH      TM      OR      GR      VI      CO      SO
    1       1       2       3       4       5       6       7       8       9      10      11      12      13      14
    2      18      19      20      21      22      23      24      25      26      27      28      29      30      31
    3      35      36      37      38      39      40      41      42      43      44      45      46      47      48
    4      52      53      54      55      56      57      58      59      60      61      62      63      64      65
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
   18     290     291     292     293     294     295     296     297     298     299     300     301     302     303
   19     307     308     309     310     311     312     313     314     315     316     317     318     319     320
   20     324     325     326     327     328     329     330     331     332     333     334     335     336     337
   21     341     342     343     344     345     346     347     348     349     350     351     352     353     354
C*****************************************************************************
C                         Irrigation Periods
C
C   The following lists the irrigation period column pointers for each
C   subregion and agricultural crop combination.
C
C   IPFL     ;  Irrigation period data file (max. 1000 characters)
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all subregion
C                 and agricultural crop combinations)
C   ICIP     ;  Irrigation period - this number corresponds to the appropriate data
C                 column in the Irrigation Period Data File (IPFL). List for each
C                 crop (1 to NCROP).
C
C-----------------------------------------------------------------------------
C   VALUE                                      DESCRIPTION
C-----------------------------------------------------------------------------
    CVAgIrrigPeriod.dat                        / IPFL
C-----------------------------------------------------------------------------
C   IR    ICIP[1]  ICIP[2] ... ICIP[NCROP]
C-----------------------------------------------------------------------------
C          PA      AL      SB      FI      RI      TR      TO      TH      TM      OR      GR      VI      CO      SO
    1       1       2       3       4       5       6       7       8       9      10      11      12      13      14
    2      15      16      17      18      19      20      21      22      23      24      25      26      27      28
    3      29      30      31      32      33      34      35      36      37      38      39      40      41      42
    4      43      44      45      46      47      48      49      50      51      52      53      54      55      56
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
    .       .       .       .       .       .       .       .       .       .       .       .       .       .       .
   18     239     240     241     242     243     244     245     246     247     248     249     250     251     252
   19     253     254     255     256     257     258     259     260     261     262     263     264     265     266
   20     267     268     269     270     271     272     273     274     275     276     277     278     279     280
   21     281     282     283     284     285     286     287     288     289     290     291     292     293     294
C*****************************************************************************
C                         Minimum Soil Moisture
C
C   The following lists the minimum soil moisture column pointers for
C   each subregion and agricultural crop combination.
C
C   MINSMFL  ;  File that lists the minimum soil moisture requirements (max. 1000 characters)
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all subregion
C                 and crop combinations)
C   ICMSM    ;  Minimum soil moisture as a fraction of Total Available Water
C                 (TAW = field capacity - wilting point) - this number corresponds to
C                 the appropriate data column in the Minimum Soil Moisture Requirement
C                 Data File (MINSMFL).  List for each crop (1 to NCROP).
C
C-----------------------------------------------------------------------------
C   VALUE                                      DESCRIPTION
C-----------------------------------------------------------------------------
    CVAgMinMoist.dat                           / MINSMFL
C-----------------------------------------------------------------------------
C   IR    ICMSM[1]  ICMSM[2] ... ICMSM[NCROP]
C-----------------------------------------------------------------------------
C          PA      AL      SB      FI      RI      TR      TO      TH      TM      OR      GR      VI      CO      SO
    0       1       2       3       4       5       6       7       8       9      10      11      12      13      14
C*****************************************************************************
C                      Target Soil Moisture for Irrigation
C
C   The following lists the target soil moisture column pointers for
C   each subregion and agricultural crop combination. If irrigtaion target soil
C   moisture is field capacity, then leave TRGSMFL variable blank and comment out
C   the section where IR and ICTRGSM variables are specified.
C
C   TRGSMFL  ;  File that lists the target soil moisture for each crop during irrigation
C                 (max. 1000 characters)
C                 * Leave blank if target soil moisture is field capacity
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all subregion
C                 and agricultural crop combinations)
C   ICTRGSM  ;  Target soil moisture as a fraction of field capacity - this number
C                 corresponds to the appropriate data column in the target soil moisture
C                 data file (TRGSMFL).  List for each agricultural crop (1 to NCROP).
C
C-----------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-----------------------------------------------------------------------------
                                                     / TRGSMFL
C-----------------------------------------------------------------------------
C   IR    ICTRGSM[1]  ICTRGSM[2] ... ICTRGSM[NCROP]
C-----------------------------------------------------------------------------
*
*
C*****************************************************************************
C              Specified Water Supply Requirement, Return Flow and Re-use Factors
C
C   AGWDFL   ;  File that lists the agricultural water supply requirement (max. 1000 characters)
C                * Leave blank if agricultural water demand is simulated dynamically
C   FLDMD    ;  Flag for the root zone moisture to be used for the computation of
C                agricultural water supply requirement and the timing of irrigation
C                * 0: Use the soil moisture at the beginning of time step
C                * 1: Use the soil moisture at the end of time step
```

```
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all subregions)
C   ICAGWD   ;  Water supply requirement - this number corresponds to the appropriate data
C                 column in the Agricultural Water Supply Requirement file (AGWDFL)
C                 * Enter any number if AGWDFL is not specified
C                 * Enter 0 if agricultural water supply requirement will be computed
C                   internally for the subregion
C   ICRTFAG  ;  Fraction of the agricultural applied water that becomes return flow - this
C                 number corresponds to the appropriate data column in Return Flow Factor
C                 Data File (RFFL) listed in the Root Zone Main Data File.
C   ICRUFAG  ;  Fraction of the applied water that is re-used - this number corresponds
C                 to the appropriate data column in Re-use Factor Data File (RUFL) listed
C                 in the Root Zone Data File.
C
C-------------------------------------------------------------------------------
C         VALUE                                         DESCRIPTION
C-------------------------------------------------------------------------------
                                                        / AGWDFL
          1                                             / FLDMD
C---------------------------------------------------------------------------------------
C   IR    ICAGWD    ICRTFAG   ICRUFAG
C---------------------------------------------------------------------------------------
    1      0          1         1
    2      0          2         2
    3      0          3         3
    4      0          4         4
    .      .          .         .
    .      .          .         .
    .      .          .         .
   18      0         18        18
   19      0         19        19
   20      0         20        20
   21      0         21        21
C******************************************************************************
C                          Initial Soil Moisture Condition
C                               For Agricultural Lands
C
C   IR     ; Subregion ID (0 if following values are to be used for all subregions)
C   FSOILMP; Fraction of initial soil moisture due to precipitation for each soil
C              type (1 to NSOIL)
C   SOILM  ; Initial root zone moisture content for agricultural area for each
C              soil type (1 to NSOIL); [L/L]
C
C-------------------------------------------------------------------------------------------
C   IR    FSOILMP[1]       SOILM[1]
C         FSOILMP[2]       SOILM[2]
C            .                .
C            .                .
C         FSOILMP[NSOIL]   SOILM[NSOIL]
C-------------------------------------------------------------------------------------------
    1      0.5          0.067
           0.5          0.473
           0.5          0.303
           0.5          0.333
    2      0.5          0.089
           0.5          0.110
           0.5          0.239
           0.5          0.111
    3      0.5          0.119
           0.5          0.033
           0.5          0.490
           0.5          0.031
    4      0.5          0.121
           0.5          0.286
           0.5          0.382
           0.5          0.243
    .       .            .
            .            .
            .            .
            .            .
    .       .            .
            .            .
            .            .
            .            .
    .       .            .
            .            .
            .            .
            .            .
   18      0.5          0.199
           0.5          0.109
           0.5          0.119
           0.5          0.116
   19      0.5          0.080
           0.5          0.208
           0.5          0.065
           0.5          0.322
   20      0.5          0.081
           0.5          0.131
           0.5          0.127
           0.5          0.094
   21      0.5          0.080
           0.5          0.418
           0.5          0.390
           0.5          0.234
```

8.3.12.4.b Subregional Crop Area Data File

Areas of each crop at every subregion are listed in this file:

FACTLNCR	Conversion factor for crop areas; enter 0.0 if crop areas are given as fractions of the subregion areas
NSPLNCR	Number of time steps to update the subregional crop area; enter any number if time-tracking option is on
NFQLNCR	Repetition frequency of the subregional crop area data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Subregional Crop Area Data File

If the time series data is listed in the Subregional Crop Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITLN	Time; for time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number
IR	Subregion identification number
ALAND	Area (or fraction of subregion area) corresponding to the crops over a subregion; $[L^2]$ or $[L^2/L^2]$ based on FACTLNCR above

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IR	Subregion identification number
LUTYPE	Crop identification number entered sequentially
PATH	Pathname corresponding to subregion and crop type combination

```
C*******************************************************************************
C
C                 INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                      SUBREGIONAL CROP AREA FILE
C                         Root Zone Component
C                         *** Version 5.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: SubregionCropArea.dat
C
C*******************************************************************************
C                         File Description
C
C   This data file contains the individual crop areas for each subregion
C   for the simulation period.
C
C*******************************************************************************
C                          Land Use Data Specifications
C
C   FACTLNCR;   Conversion factor for crop area
C                 * Enter 0.0 if crop area is given as a fraction of subregion area
C   NSPLNCR ;   Number of time steps to update the land use data
C                 * Enter any number if time-tracking option is on
C   NFQLNCR ;   Repetition frequency of the land use data
C                 * Enter 0 if full time series data is supplied
C                 * Enter any number if time-tracking option is on
C   DSSFL   ;   The name of the DSS file for data input
C                 * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------------------
          43560.0                                    / FACTLNCR
          1                                          / NSPLNCR
          0                                          / NFQLNCR
                                                     / DSSFL
C-------------------------------------------------------------------------------------------
C                              Land Use Data
C                          (READ FROM THIS FILE)
C
C   List the crop areas below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN    ;   Time
C   IR      ;   Subregion number
C   ALANDCR;    Crop area (or fraction of area) over a subregion; [L^2] or
C               [L^2/L^2] (based on FACTLNCR above). List for each
C               crop (1 to NCROP)
C
C----------------------------------------------------------------------------------------------------------------------------------
C                                                                ALANDCR
C                      ------------------------------------------------------------------------------------------------------------
C   ITLN            IR       PA        AL        SB        FI        RI   ...        OR        GR        VI        CO        SO
C----------------------------------------------------------------------------------------------------------------------------------
09/30/1922_24:00     1    12692       765         0       393         0   ...       674         0         0         0         0
                     2    22800     11100         0      2700         0   ...     16900         0         0         0         0
                     3    22400      8600         0      6200     40000   ...     11400         0         0         0         0
                     4     5100      2600         0     31900     22000   ...      6800         0         0         0         0
                     5    27200     15800       600     11400     31800   ...     42700         0         0         0         0
                     6     6200      5300       600      3400      6000   ...      5500         0       400         0         0
                     7    19800      5200      1200      8600      1200   ...     22200         0         0         0         0
                     8    40000      7800       500     10300      3100   ...     15500         0     22700         0         0
                     9    23200     40100     19500     79900      2900   ...     29200     74100         0         0         0
                    10     8937     44348      1012     51482      5844   ...      7817         0       298     17808         0
                    11    25709     11311       163     27674      3708   ...     16379         0      7185       386         0
                    12    12672     16298        33     39301        22   ...     16612         0      8890         0         0
                    13    31982     61743       794     35543      5826   ...     22284         0     36926     12206         0
                    14      741     27419      3281     56059       637   ...      2410         0      1610     76990         0
                    15    13456     94550      2300     77785      1890   ...      7221         0     17160     76273         0
                    16    16986      9140        96     11873         0   ...      9241         0     22302      5579         0
                    17     9604      7972       285     12821         0   ...     18987         0     37128      5018         0
                    18    21473     54838       990     84272      1869   ...     18482         0     17310     50558         0
                    19     2621     43917      1634     30845       223   ...     11766         0      3320     48002         0
                    20      643     11943       180      8537         1   ...     14061         0     11681     10972         0
                    21     4376     42223      1233     23837       381   ...      6450         0     14290     38277         0
09/30/1923_24:00     1    12692       765         0       393         0   ...       674         0         0         0         0
                     2    22300     10900         0      2700         0   ...     16600         0         0         0         0
                     3    22400      8600         0      6200     40000   ...     11400         0         0         0         0
                     4     5200      2600         0     32600     22000   ...      6900         0         0         0         0
                     5    27600     15900       700     11600     31800   ...     42900         0         0         0         0
                     6     6600      5700       600      3600      7000   ...      5900         0       400         0         0
                     7    20500      5300      1200      8800      1200   ...     23000         0         0         0         0
                     8    41800      8100       600     10800      3200   ...     16300         0     23700         0         0
                     9    24000     40100     20900     80700      2900   ...     30100     69500       100         0         0
                    10     9016     44780      1012     50646      5427   ...      8065         0       312     19214         0
                    11    25936     11421       163     27225      3443   ...     16898         0      7522       417         0
                    12    12784     16457        33     38663        20   ...     17139         0      9307         0         0
                    13    32264     62343       794     34966      5410   ...     22991         0     38658     13169         0
                    14      744     27550      3281     56279       637   ...      2421         0      1618     77484         0
                    15    13514     95003      2300     78090      1890   ...      7254         0     17243     76762         0
                    16    17059      9183        96     11919         0   ...      9283         0     22409      5615         0
                    17     9645      8010       285     12872         0   ...     19073         0     37307      5051         0
                    18    21565     55101       990     84603      1869   ...     18565         0     17393     50882         0
                    19     2633     44127      1634     30966       223   ...     11819         0      3336     48310         0
                    20      646     12000       180      8571         1   ...     14124         0     11737     11042         0
                    21     4395     42426      1233     23931       381   ...      6479         0     14358     38522         0
        .            .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
        .            .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
                     .        .         .         .         .         .   ...         .         .         .         .         .
09/30/2009_24:00     1    24516       715         0       204         0   ...      2868      1328       102         0       919
```

```
                     2    35071      7256     302     8969    2016  ...    86469    6047       0       0   22373
                     3    13844     14902    3269    34419  165364  ...    59896   26439    7211   13556    2115
                     4     1999      5298    1000    53682  110763  ...    30890   14695       0    1100   12796
                     5    20235      5403       0     8644  185259  ...   138011    5992      98     491    4911
                     6     8768     50170       0    43819   16452  ...    28724   51571    1551     969    8919
                     7    22160      3393     636     9012   72842  ...    11981    9118       0       0     318
                     8    41769     15028    2902    48091    3317  ...    56901   24149   92658       0     311
                     9    15224     50403    5381   131936     625  ...    10707   40758   21588       0     104
                    10    10927     76582    4296    53701    5977  ...    38478   37544    1681   90778     654
                    11    48341      9304       0    32766    5764  ...    88692   12237   12742       0     303
                    12    18556     21418     185    54376       0  ...    94627   12094   14309       0     185
                    13    30394     61061    2548    55419    3640  ...   136682   57239   95186   42042    5096
                    14     1088     10791    4534    18681       0  ...    43257   38088   10066  170578     453
                    15     5270    107990    2311    71654       0  ...    54827   73965   53163  179644     647
                    16     6961      9076       0     5375       0  ...    25554    2291   63621    5375   10574
                    17     5917      7027       0     8321       0  ...    74150    8876   99299    2866   34856
                    18     3557     91713    3172   129975       0  ...    83638   77677   49702   83061   98154
                    19     1223     36601    2258    14772       0  ...    77247   40835    8938   72543    2258
                    20       97     17332     484     9005       0  ...    69618   10457   40570   10554   27111
                    21     1129     53066     282    54101       0  ...    25875   35378   36130   62569   17971
C-----------------------------------------------------------------------------------------
C                             Pathnames for Land Use Data
C                               (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   The pathnames should be listed for each subregion and crop combination.
C   They should be listed in an order such that, the crop type changes first.
C
C   * Example with 3 agricultural crops (i.e. NCROP=3):
C
C       IR     LUTYPE      PATH
C        1        1       (pathname[1])
C        1        2       (pathname[2])
C        1        3       (pathname[3])
C        2        1       (pathname[4])
C        2        2       (pathname[5])
C        2        3       (pathname[6])
C        .        .            .
C        .        .            .
C        .        .            .
C    NREGN        1       (pathname[(NCROP)*NREGN - 2])
C    NREGN        2       (pathname[(NCROP)*NREGN - 1])
C    NREGN        3       (pathname[(NCROP)*NREGN])
C
C   IR     ;  Subregion number
C   LUTYPE ;  Land use type
C               1       = Agricultural crop 1
C               2       = Agricultural crop 2
C                           .
C                           .
C                           .
C               NCROP   = Agricultural crop NCROP
C   PATH   ;  Pathname corresponding to subregion and crop type combination
C
C-----------------------------------------------------------------------------------------
C   IR        LUTYPE        PATH
C-----------------------------------------------------------------------------------------
*
*
```

8.3.12.4.c Elemental Total Agricultural Area Data File

Total agricultural area at each element are listed in this file:

FACTLNA	Conversion factor for agricultural areas; enter 0.0 if areas are given as fractions of the element areas
NSPLNA	Number of time steps to update the total agricultural areas at each element; enter any number if time-tracking option is on
NFQLNA	Repetition frequency of the element-level total agricultural area data; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Elemental Total Agricultural Area Data File

If the time series data is listed in the Elemental Total Agricultural Area Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITLN	Time; for time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number
IE	Element identification number
ALANDA	Agricultural area (or fraction of element area) over an element; $[L^2]$ or $[L^2/L^2]$ based on FACTLNA above

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

IE	Element identification number
PATH	Pathname corresponding to the total agricultural area at element IE

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                      ELEMENTAL AGRICULTRAL AREA FILE
C                           Root Zone Component
C                           *** Version 5.0 ***
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: ElemAgArea.dat
C
C*******************************************************************************
C                            File Description
C
C   This data file contains the total agricultural area for each element
C   for the simulation period.
C
C*******************************************************************************
C                             Land Use Data Specifications
C
C   FACTLNA;   Conversion factor for land use area
C                * Enter 0.0 if land use distribution is given as a fraction of element area
C   NSPLNA ;   Number of time steps to update the land use data
C                * Enter any number if time-tracking option is on
C   NFQLNA ;   Repetition frequency of the land use data
C                * Enter 0 if full time series data is supplied
C                * Enter any number if time-tracking option is on
C   DSSFL   ;   The name of the DSS file for data input
C                * Leave blank if DSS file is not used for data input
C
C-----------------------------------------------------------------------------------------
C         VALUE                                       DESCRIPTION
C-----------------------------------------------------------------------------------------
          43560.0                                     / FACTLNA
          1                                           / NSPLNA
          0                                           / NFQLNA
                                                      / DSSFL
C-----------------------------------------------------------------------------------------
C                               Land Use Data
C                            (READ FROM THIS FILE)
C
C   List the land use data below, if it will not be read from a DSS file
C   (i.e. DSSFL is left blank above).
C
C   ITLN    ;   Time
C   IE      ;   Element number
C   ALANDA ;    Agricultural area (or fraction of area) over an element; [L^2] or
C               [L^2/L^2] (based on FACTLNA above)
C               * Note: Agricultural areas over elements that are designated as lake elements
C                       will be ignored
C
C--------------------------------------------------------------------------------------------
C   ITLN             IE          ALANDA
C--------------------------------------------------------------------------------------------
09/30/1922_24:00      1            812.39
                      2              0.00
                      3              0.00
                      4              0.00
                      .              .
                      .              .
                      .              .
                   1389           1615.33
                   1390              0.00
                   1391              0.00
                   1392              0.00
09/30/1923_24:00      1            806.27
                      2              0.00
                      3              0.00
                      4              0.00
                      .              .
                      .              .
                      .              .
                   1389           1654.52
                   1390              0.00
                   1391              0.00
                   1392              0.00
                      .              .
                      .              .
                      .              .
                      .              .
                      .              .
                      .              .
09/30/2009_24:00      1             89.96
                      2            180.79
                      3           1379.60
                      4            781.58
                      .              .
                      .              .
                      .              .
                   1389           5536.55
                   1390           5945.77
                   1391           6233.13
                   1392           1375.83
C-----------------------------------------------------------------------------------------
C                            Pathnames for Land Use Data
C                               (READ FROM DSS FILE)
C
C   List the pathnames for the land use data below, if it will be read from a DSS file
C   (i.e. DSSFL is specified above).
C
C   IE     ;  Element number
C   PATH   ;  Pathname corresponding to agricultrural area at element IE
C
C-----------------------------------------------------------------------------------------
C   IE        PATH
C-----------------------------------------------------------------------------------------
*
*
```

8.3.12.4.d Irrigation Period Data File

This file is exactly the same as the Irrigation Period Data File for the root zone component version 4.0. Refer to section 8.3.8.4 for a detailed explanation of this file.

8.3.12.4.e Minimum Soil Moisture Data File

This file is exactly the same as the Minimum Soil Moisture Data File for the root zone component version 4.0. Refer to section 8.3.8.7.d for a detailed explanation of this file.

8.3.12.4.f Irrigation Target Moisture Data File

This file is exactly the same as the Irrigation Target Moisture Data File for the root zone component version 4.0. Refer to section 8.3.8.7.e for a detailed explanation of this file.

8.3.12.4.g Agricultural Supply Requirement Data File

This file is exactly the same as the Agricultural Supply Requirement Data File for the root zone component version 4.0. Refer to section 8.3.8.6 for a detailed explanation of this file.

8.3.12.5. Urban Component Files

8.3.12.5.a Urban Lands Main File

The Urban Lands Main File is the gateway file for all data that is necessary to simulate land surface and root zone flow processes in urban lands.

The file is divided into several sections and uses the following variables:

Land-Use Areas
The filename for the urban areas data file is listed in this section:

LUFLU File that lists the urban areas (maximum 1000 characters)

Rooting Depth

FACT	Conversion factor for urban outdoors root zone depth
ROOTURB	Root zone depth for urban outdoors; [L]

Curve Numbers

IR	Subregion identification number; enter 0 if following values are to be used for all subregions
CNURB	Curve number for urban lands for each simulated soil in subregion IR

Urban Water Use, Management and Simulation Parameters

WTRDMDFL	File that lists the urban water demand (maximum 1000 characters)
URBSPECFL	File that lists the urban water use specifications (maximum 1000 characters)
IR	Subregion identification number; enter 0 if following values are to be used for all subregions
PERV	Fraction of pervious area to total urban areas
ICWTRDMD	Water demand in surgeion IR; this number corresponds to the appropriate data column in the Urban Water Demand File, WTRDMDFL, listed above
ICURBSPEC	Urban water use specification data as a fraction of total urban water that is used indoors; this number corresponds to the appropriate data column in the Urban Water Use Specifications File, URBSPECFL, listed above
ICETURB	Urban evapotranspiration; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File
ICRTFURB	Fraction of the urban applied water that becomes return flow; this number corresponds to the appropriate data column in the Return Flow Fractions Data File (RFFL) specified in the Root Zone Component Main File; for urban lands (return flow fraction applies only to pervious (lawns, parks, etc) urban areas; all water delivered to urban indoor areas becomes return flow)

ICRUFURB	Fraction of the urban applied water that is re-used; this number corresponds to the appropriate data column in the Re-use Fractions Data File (RUFL) specified in the Root Zone Component Main File

Destination for Urban Surface Flow

In this section, the destination for surface flow generated in urban lands at each grid cell is listed.

IE	Element identification number
TYPDESTUR	Destination type for the urban surface flow from element IE (0 = surface flow goes outside of model area; 1= surface flow goes to a stream node; 3 = surface flow goes to a lake; 4 = surface flow goes to a subregion; 5 = surface flow goes to groundwater)
DESTUR	Destination identification number for the urban surface flow from element IE; enter any number if TYPDESTUR is set to 0 or 5

Initial Soil Moisture Conditions

The initial soil moisture content for urban outdoors at each subregiont is listed in this section.

IR	Subregion identification number; enter 0 if following values are to be used for all subregions
FSOILMP	Fraction of initial soil moisture in subregion IR at each soil type that is due to precipitation
SOILM	Initial root zone moisture content for urban outdoors for each type at each subregion; [L/L]

```
C*******************************************************************************
C
C                    INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                          URBAN LANDS DATA FILE
C                           Root Zone Component
C                           *** Version 5.0 ***
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: Urban_MAIN.dat
C
C*******************************************************************************
C                             File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes and managament of urban lands.
C
C*******************************************************************************
C                            Land Use Areas
C
C   LUFLU   ;  File that lists the urban areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    UrbanArea.dat                          / LUFLU
C*******************************************************************************
C                                 Rooting Depth
C
C   FACT    ;    Conversion factor for urban root zone depth
C   ROOTURB;     Urban root zone depth; [L]
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                        / FACT
    2.0                        / ROOTURB
C*******************************************************************************
C                    Curve Numbers for Rainfall Runoff Simulation
C
C   Enter curve numbers for each subregion and soil-type combination for
C   urban areas.
C
C   IR        ;  Subregion ID (0 if following values are to be used for all subregions)
C   CNURB     ;  Curve number for urban lands lands for each simulated
C                  soil type (1 to NSOIL)
C
C-------------------------------------------------------------------------------
C   IR     CNURB[1]   CNURB[2]   CNURB[3]   CNURB[4]
C-------------------------------------------------------------------------------
    1      83.0        86.0        94.0       97.0
    2      85.0        87.0        94.0       97.0
    3      86.0        87.0        94.0       97.0
    .       .           .           .          .
    .       .           .           .          .
    .       .           .           .          .
   19      93.0        94.0        97.0       97.0
   20      91.0        93.0        96.0       97.0
   21      91.0        93.0        96.0       97.0
C*******************************************************************************
C                   Urban Water Use, Management and Simulation Parameters
C
C   WTRDMDFL ;  File that lists the urban water demand (max. 1000 characters)
C   URBSPECFL;  File that lists the urban water use specifications (max. 1000 characters)
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all elements)
C   PERV     ;  Fraction of pervious area to total urban areas
C   ICWTRDMD ;  Water demand - this number corresponds to the appropriate data
C                 column in the Urban Water Demand file (WTRDMDFL)
C   ICURBSPEC;  Urban water use specification data as a fraction of total urban water that
C                is used indoors - this number corresponds to the appropriate data column
C                in the Urban Water Use Specifications file (URBSPECFL).
C   ICETURB  ;  Urban ETc - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Control Data file.
C   ICRTFURB ;  Fraction of the urban applied water that becomes return flow - this
C                 number corresponds to the appropriate data column in irrigation
C                 water return flow factor data file (RFFL).
C                 * Note: For urban lands, return flow fraction applies only to
C                         pervious (lawns, parks, etc) urban areas. All water
C                         delivered to urban indoor areas becomes return flow.
C   ICRUFURB ;  Fraction of the applied water that is re-used - this number corresponds
C                 to the appropriate data column in irrigation water re-use factor data
C                  file (RUFL).
C
C-------------------------------------------------------------------------------
C         VALUE                                     DESCRIPTION
C-------------------------------------------------------------------------------
   UrbanWaterDemand.dat                             / WTRDMDFL
   UrbanWaterUseSpecs.dat                           / URBSPECFL
C---------------------------------------------------------------------------------------
C   IR     PERV    ICWTRDMD    ICURBSPEC    ICETURB   ICRTFURB   ICRUFURB
C---------------------------------------------------------------------------------------
    1      0.62       1            1           15         22         22
    2      0.62       2            2           32         22         22
    3      0.62       3            3           49         22         22
    .       .         .            .            .          .          .
    .       .         .            .            .          .          .
    .       .         .            .            .          .          .
   19      0.62      19           19          321         22         22
   20      0.62      20           20          338         22         22
   21      0.62      21           21          355         22         22
C*******************************************************************************
C                   Destination for Urban Surface Flow
C
C   List the destination type and number for urban surface flow from each element.
C   Destinations for urban surface flow can be different than those for surface
C   flows generated on other land use areas as listed in the Root Zone Component
C   Main Input File.
C
C   IE         ;  Element ID
C   TYPDESTUR ;  Destination type for the urban surface flow from element IE
```

```
C                   0 = Surface flow goes outside of model area
C                   1 =   "       "    "  to a stream node
C                   3 =   "       "    "   " a lake
C                   4 =   "       "    "   " a subregion
C                   5 =   "       "    "   " groundwater
C   DESTUR    ;  Destination for the urban surface flow from element IE
C                   * Note: Enter any number if TYPDESTUR is set to 0 or 5
C
C-------------------------------------------------------------------------------
C    IE     TYPDESTUR     DESTUR
C-------------------------------------------------------------------------------
      1         1          207
      2         1          206
      3         1          206
      4         1          206
      .         .           .
      .         .           .
      .         .           .
   1389         5           0
   1390         5           0
   1391         5           0
   1392         5           0
C******************************************************************************
C                             Initial Soil Moisture Condition
C                                     For Urban Lands
C
C   IR      ; Subregion ID (0 if following values are to be used for all subregions)
C   FSOILMP; Fraction of initial soil moisture due to precipitation for each soil
C                type (1 to NSOIL)
C   SOILM   ; Initial root zone moisture content for urban area for each
C                soil type (1 to NSOIL); [L/L]
C
C---------------------------------------------------------------------------------
C   IR     FSOILMP[1]   SOILM[1]
C          FSOILMP[2]   SOILM[2]
C          FSOILMP[3]   SOILM[3]
C          FSOILMP[4]   SOILM[4]
C---------------------------------------------------------------------------------
    1      0.5          0.067
           0.5          0.473
           0.5          0.303
           0.5          0.333
    2      0.5          0.089
           0.5          0.110
           0.5          0.239
           0.5          0.111
    3      0.5          0.119
           0.5          0.033
           0.5          0.490
           0.5          0.031
    .       .             .
            .             .
            .             .
    .       .             .
            .             .
            .             .
    .       .             .
            .             .
            .             .
   19      0.5          0.080
           0.5          0.208
           0.5          0.065
           0.5          0.322
   20      0.5          0.081
           0.5          0.131
           0.5          0.127
           0.5          0.094
   21      0.5          0.080
           0.5          0.418
           0.5          0.390
           0.5          0.234
```

8.3.12.5.b Urban Area Data File

This file is exactly the same as the Urban Area Data File for the root zone component version 4.0. Refer to section 8.3.8.9.b for a detailed explanation of this file.

8.3.12.5.c Urban Water Demand Data File

This file lists total urban water demand. Urban land in each subregion is associated with a data column in this file through pointers specified in the Urban Lands Main File.

The following variables are listed in this file:

NCOLWD	Number of urban water demand data columns
FACTWD	Conversion factor for the spatial component of the urban water demand data
NSPWD	Number of time steps to update the urban water demand data; enter any number if time-tracking option is on
NFQWD	Repetition frequency of the urban water demand; a value of zero indicates that a full time series data set is supplied; if time tracking simulation, enter any number
DSSFL	The name of the DSS file for data input; leave blank if DSS file is not used for data input

Data Input from Urban Water Demand Data File

If the time series data is listed in the Urban Water Demand Data File, then the following variables need to be populated. Otherwise, these variables should be commented out using "C", "c" or "*", and the variables in the "Data Input from DSS File" section below should be populated.

ITWD	Time; for time tracking simulations use MM/DD/YYYY_hh:mm format, for non-time tracking simulations enter an integer number
WD	Urban water demand; [L^3/T]

Data Input from DSS File

If time series data is stored in a DSS file then the following variables should be populated:

REC	Record number that coincides with the data column number for the time series data
PATH	Pathname for the time series record that will be used for data retrieval

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C                    URBAN WATER DEMAND DATA FILE
C                        Root Zone Component
C                        *** Version 5.0 ***
C
C
C              Project:  IDC Version ### Release
C                        California Department of Water Resources
C              Filename: UrbanWaterDemand.dat
C
C*******************************************************************************
C                               File Description
C
C   This data file contains urban water demand data on a time-series
C   basis.
C
C*******************************************************************************
C                     Urban Water Demand Data Specifications
C
C   NCOLWD ;  Number of urban water demand data columns
C   FACTWD ;  Conversion factor for urban water demand
C               It is used to convert only the spatial component of the unit;
C               DO NOT include the conversion factor for time component of the unit.
C               * e.g. Unit of flow listed in this file           = AC-FT/MONTH
C                      Consistent unit used in simulation         = CU.FT/DAY
C                      Enter FACTDWD (AC-FT/MONTH -> CU.FT/MONTH) = 43560.0
C                     (conversion of MONTH -> DAY is performed automatically)
C   NSPWD  ;  Number of time steps to update the water demand data
C              * Enter any number if time-tracking option is on
C   NFQWD  ;  Repetition frequency of the water demand data
C              * Enter 0 if full time series data is supplied
C              * Enter any number if time-tracking option is on
C   DSSFL  ;  The name of the DSS file for data input (maximum 1000 characters);
C              * Leave blank if DSS file is not used for data input
C
C-------------------------------------------------------------------------------
C         VALUE                                      DESCRIPTION
C-------------------------------------------------------------------------------
          21                                         / NCOLWD
          43560000.0                                 / FACTWD (TAF/mon --> ft^3/month)
          1                                          / NSPWD
          0                                          / NFQWD
                                                     / DSSFL
C-------------------------------------------------------------------------------
C                         Urban Water Demand Data
C                          (READ FROM THIS FILE)
C
C   List the water demand data below, if it will not be read from a
C   DSS file (i.e. DSSFL is left blank above).
C
C   ITWD;   Time
C   WD  ;   Water demand; [L^3/T]
C
C-------------------------------------------------------------------------------
C ITWD    WD(1)  WD(2)  WD(3) ...
C-------------------------------------------------------------------------------
C                     1       2       3       4       5    ...    18      19      20      21
 10/31/1921_24:00    0.2     0.4     0.2     0.1     0.7   ...    1.1     0.2     0.3     1.1
 11/30/1921_24:00    0.2     0.3     0.1     0.1     0.5   ...    0.8     0.1     0.2     0.7
 12/31/1921_24:00    0.2     0.3     0.2     0.1     0.5   ...    0.7     0.1     0.2     0.7
 01/31/1922_24:00    0.2     0.3     0.2     0.1     0.5   ...    0.7     0.1     0.2     0.7
 02/28/1922_24:00    0.1     0.3     0.1     0.1     0.5   ...    0.6     0.1     0.2     0.6
 03/31/1922_24:00    0.2     0.4     0.2     0.1     0.5   ...    0.8     0.1     0.2     0.8
        .             .       .       .       .       .    ...     .       .       .       .
        .             .       .       .       .       .    ...     .       .       .       .
        .             .       .       .       .       .    ...     .       .       .       .
 04/30/2009_24:00    2.8     2.5     1.0     0.5     6.0   ...   12.7     1.7     5.7    16.7
 05/31/2009_24:00   11.5     5.2     1.5     0.7    11.1   ...   16.9     2.4     7.9    22.2
 06/30/2009_24:00   16.6     6.9     2.0     0.8    13.7   ...   18.5     2.7     8.9    24.3
 07/31/2009_24:00   17.7     7.4     2.1     0.9    14.8   ...   19.3     2.8     9.2    25.3
 08/31/2009_24:00   15.2     6.4     1.8     0.8    12.8   ...   17.8     2.6     8.4    23.4
 09/30/2009_24:00   13.1     5.7     1.6     0.7    11.5   ...   14.4     2.0     6.6    19.0
C-------------------------------------------------------------------------------
C                    Pathnames for Urban Water Demand Data
C                            (READ FROM DSS FILE)
C
C   List the pathnames for the urban water demand data below, if it will be read
C   from a DSS file (i.e. DSSFL is specified above).
C
C   REC  ;  Time series record number
C   PATH ;  Pathname for the time series record
C
C----------------------------------------------------------------------------------------------
C   REC       PATH
C----------------------------------------------------------------------------------------------
*
*
```

8.3.12.5.d Urban Water Use Specifications Data File

This file is exactly the same as the Urban Water Use Specifications Data File for the root zone component version 4.0. Refer to section 8.3.8.9.e for a detailed explanation of this file.

8.3.12.6. Native and Riparian Vegetation Component Files

8.3.12.6.a Native and Riparian Vegetation Lands Main File

The Native and Riparian Vegetation Lands Main File is the gateway file for all data that is necessary to simulate land surface and root zone flow processes in areas that are covered with native and riparian vegetation.

The file is divided into several sections and uses the following variables:

Land-Use Areas

The filename for the native and riparian areas data file is listed in this section:

LUFLNVRV	File that lists the urban areas (maximum 1000 characters)

Rooting Depths

FACT	Conversion factor for native and riparian vegetation root zone depths
ROOTNV	Root zone depth for native vegetation; [L]
ROOTRV	Root zone depth for riparian vegetation; [L]

Native and Riparian Vegetation Simulation Parameters

IR	Subregion identification number entered sequentially; enter 0 if the following values are to be used for all subregions
CNNV	Curve number for native vegetation lands for each soil type simulated
CNRV	Curve number for riparian vegetation lands for each soil type simulated
ICETNV	Native vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File

ICETRV	Riparian vegetation evapotranspiration rate; this number corresponds to the appropriate data column in the Evapotranspiration File listed in the IDC Main Input File

Initial Soil Moisture Conditions

The initial soil moisture contents for native and riparian vegetation at each subregion and soil type combination are listed in this section.

IR	Subregion identification number; enter 0 if following values are to be used for all elements
SOILM_NV	Initial root zone moisture content for native vegetation at subregion IR for each of the simulated soil types; [L/L]
SOILM_RV	Initial root zone moisture content for riparian vegetation at subregion IR for each of the simulated soil types; [L/L]

```
C*******************************************************************************
C
C                INTEGRATED WATER FLOW MODEL (IWFM)
C
C*******************************************************************************
C
C               NATIVE AND RIPARIAN VEGETATION DATA FILE
C                       Root Zone Component
C                       *** Version 5.0 ***
C
C
C            Project:  IDC Version ### Release
C                      California Department of Water Resources
C            Filename: NativeVeg_MAIN.dat
C
C*******************************************************************************
C                          File Description
C
C   This data file contains the parameters and data file names for the simulation
C   of root zone processes for native and riparian vegetation.
C
C*******************************************************************************
C                         Land Use Areas
C
C   LUFLNVRV   ;  File that lists the land use areas (max. 1000 characters)
C
C-------------------------------------------------------------------------------
    NativeVegArea.dat   / LUFLNVRV
C*******************************************************************************
C                              Rooting Depths
C
C   FACT  ;  Conversion factor for root zone depths
C   ROOTNV;  Native veg. root zone depth; [L]
C   ROOTRV;  Riparian veg. root zone depth; [L]
C
C-------------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                   / FACT
    5.0                   / ROOTNV
    5.0                   / ROOTRV
C*******************************************************************************
C                    Curve Numbers for Rainfall Runoff Simulation
C
C   Enter curve numbers for each subregion and soil-type combination for native
C   and riparian vegetation.
C
C   IR       ;  Subregion ID (0 if following values are to be used for all subregions)
C   CNNV     ;  Curve number for native vegetation lands for each simulated
C                 soil type (1 to NSOIL)
C   CNRV     ;  Curve number for riparian vegetation lands for each simulated
C                 soil type (1 to NSOIL)
C
C-------------------------------------------------------------------------------
C   IR    CNNV[1]  CNNV[2]  CNNV[3]  CNNV[4]  CNRV[1]  CNRV[2]  CNRV[3]  CNRV[4]
C-------------------------------------------------------------------------------
    1     81       84       90       94       81       84       90       94
    2     84       86       91       94       84       86       91       94
    3     84       86       92       94       84       86       92       94
    .     .        .        .        .        .        .        .        .
    .     .        .        .        .        .        .        .        .
    .     .        .        .        .        .        .        .        .
   19     92       93       96       97       92       93       96       97
   20     90       92       94       96       90       92       94       96
   21     90       92       94       96       90       92       94       96
C*******************************************************************************
C                          Evapotranspiration (ETc)
C
C   The following lists the ETc column pointers for each subregion for native and
C   riparian vegetation.
C
C   IR       ;  Subregion ID (Enter 0 if following values are to be used for all subregions)
C   ICETNV   ;  Native vegetation ETc - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Control Data file.
C   ICETRV   ;  Riparian vegetation ETc - this number corresponds to the appropriate data column
C                 in the ET data file listed in the Main Control Data file.
C
C-------------------------------------------------------------------------------
C   IR    ICETNV    ICETRV
C-------------------------------------------------------------------------------
    1       16         17
    2       33         34
    3       50         51
    .        .          .
    .        .          .
    .        .          .
   19      322        323
   20      339        340
   21      356        357
C*******************************************************************************
C                           Initial Soil Moisture Condition
C                       For Native and Riparian Vegetation Areas
C
C   IR      ;   Subregion ID (0 if following values are to be used for all subregions)
C   SOILM_NV;   Initial root zone moisture content for native vegetation area for
C                 each soil type (1 to NSOIL); [L/L]
C   SOILM_RV;   Initial root zone moisture content for riparian vegetation area for
C                 each soil type (1 to NSOIL); [L/L]
C
C-----------------------------------------------------------------------------------------------
C   IR     SOILM_NV[1]     SOILM_RV[1]
C          SOILM_NV[2]     SOILM_RV[2]
C          SOILM_NV[3]     SOILM_RV[3]
C          SOILM_NV[4]     SOILM_RV[4]
C-----------------------------------------------------------------------------------------------
    1      0.067           0.067
           0.473           0.473
           0.303           0.303
           0.333           0.333
    2      0.089           0.089
           0.110           0.110
           0.239           0.239
```

```
           0.111          0.111
  3        0.119          0.119
           0.033          0.033
           0.490          0.490
           0.031          0.031
  .          .              .
             .              .
             .              .
  .          .              .
             .              .
             .              .
  .          .              .
             .              .
             .              .
 19        0.080          0.080
           0.208          0.208
           0.065          0.065
           0.322          0.322
 20        0.081          0.081
           0.131          0.131
           0.127          0.127
           0.094          0.094
 21        0.080          0.080
           0.418          0.418
           0.390          0.390
           0.234          0.234
```

8.3.12.6.b Native and Riparian Vegetation Area Data File

This file is exactly the same as the Native and Riparian Vegetation Area Data File for the root zone component version 4.0. Refer to section 8.3.8.10.b for a detailed explanation of this file.

8.4. Output Files

IDC produces several optional output files. In the Root Zone Component Main File, the user can specify file names to which soil moisture as well as land and water use budgets are printed for 4 main land-use types at each subregion. These files are created in HDF5 file format for run-time efficiency and to save computer storage space. A post-processing tool, Budget, which is available for download from the IDC web site and discussed later in this document is required to process these HDF5 files and create tables in ASCII text file format.

Root zone component versions 4.01, 4.11 and 5.0 also allow optional soil moisture and land and water use budgets to be printed at each grid cell to HDF5 files. These files can then be post-processed using the Z-Budget tool for user-defined cell groups, called zones, to generate budget tables for regions other than the pre-defined subregions of the model domain. The Z-Budget tool, which is also available for download from the IDC web site and discussed later in this document, creates tables in ASCII text file format.

Alternatively, *IWFM Tools Add-in for Excel 2016* can be downloaded from IWFM Support Tools page (https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model). This add-in allows quick transfer of data stored in the IDC HDF5 output files into Excel for further analysis.

Optionally, IDC can generate an end-of-simulation moisture content output file that is already in ASCII text format. This file lists soil moisture for each land-use type at each element for root zone component versions 4.0 through 4.11, and at each subregion for version 5.0. The name for this file is specified in the Root Zone Component Main File.

The soil moisture and land and water use budget files specified in the Root Zone Component Main File stores information for 4 main land-use types at each subregion. Budget information for individual crops is not stored in these files.

Optionally, for versions 4.0 through 4.11, IDC can generate budget files for specific non-ponded and ponded crops at each subregion. This can be achieved by specifying crop codes and output file names in non-ponded and ponded parameter files. As mentioned earlier, the generated files will be in HDF5 file format and the user will need either the Budget post-processor to process these files and generate tables in ASCII text format or the *IWFM Tools Add-in for Excel 2007-2013* to transfer the data stored in these files to MS Excel. The usage of Budget post-processor is explained later in this document. The user's manual for the *IWFM Tools Add-in for Excel 2007-2013* is included with the tool itself.

In the following sections, a detailed explanation of the budget tables that are produced by IDC and post-processed by the Budget post-processor is given.

8.4.1. Output Files for Root Zone Component Version 4.0

8.4.1.1. Subregional Land and Water Use Budget

The subregional land and water use budget HDF5 file is generated by specifying a proper filename in the Root Zone Component Main File. A budget table is produced for each subregion listed for the LPRNT variable in the Budget Main Input File. The title printed for each subregional land and water use budget includes root zone component version number, subregion name given by the user, the unit of data columns and the area of the subregion. All land and water use budget columns are in volumetric units except *Time*, *Agricultural Area* and *Urban Area*. The output units and conversion factors for area (UNITAROU and FACTAROU) and volume (UNITVLOU and FACTVLOU) are specified by the user in the Budget Main Input File.

The total agricultural and urban areas, as well as the agricultural potential consumptive use of applied water and the water supply requirements are reported in the output, followed by the components that the land and water use budget is comprised of. For agricultural lands, potential consumptive use is the amount of water needed to bring the soil moisture up to the irrigation target moisture (field capacity, by default) after the effects of precipitation and generic moisture sources, excluding the net return flow, are taken into account. The agricultural supply requirement is the potential consumptive use of applied water plus the net return flow.

A positive or negative sign is given for each column that is a component of the subregional land and water use. The *Shortage* column is the resulting balance, based on water use components. A value of zero in this column indicates that the available water supply (surface water deliveries, groundwater pumping and surface runoff from upstream elements) meets the agricultural or urban supply requirements. A positive value indicates that the supply is not a large enough quantity to satisfy water requirements. Conversely, a negative value in the *Shortage* column signifies a water supply surplus. The last three columns for agricultural areas are informational and show the sources of water that are used in meeting the crop evapotranspirative requirement.

The following table defines each column in the subregional land and water use budget table printed out to a text file:

SUBREGIONAL LAND AND WATER USE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
4	Agricultural Supply Requirement	If agricultural water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If agricultural water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events

10	Effective Precip	Amount of crop evapotranspiration that is met by current and previous precipitation events
11	ET from Other Sources	Amount of crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
12	Area	Urban area
13	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
14	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement
15	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
16	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
17	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_L&W_USE_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional land and water use budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)

ii. *AG_POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *AG_SUP_REQ* (corresponds to column 4 in text output file)
iv. *AG_PUMPING* (corresponds to column 5 in text output file)
v. *AG_DELIVERY* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_SHORTAGE* (corresponds to column 8 in text output file)
viii. *AG_ETAW* (corresponds to column 9 in text output file)
ix. *AG_EFF_PRECIP* (corresponds to column 10 in text output file)
x. *AG_ET_OTH* (corresponds to column 11 in text output file)
xi. *URB_AREA* (corresponds to column 12 in text output file)
xii. *URB_SUP_REQ* (corresponds to column 13 in text output file)
xiii. *URB_PUMPING* (corresponds to column 14 in text output file)
xiv. *URB_DELIVERY* (corresponds to column 15 in text output file)
xv. *URB_SR_INFLOW* (corresponds to column 16 in text output file)
xvi. *URB_SHORTAGE* (corresponds to column 17 in text output file)

8.4.1.2. Crop-Specific Land and Water Use Budget

The crop-specific land and water use budget HDF5 files are generated by specifying the individual crops and proper filenames in the non-ponded and ponded crops section of the Root Zone Component Main File.

A budget table is produced for each subregion and crop combination listed for the LPRNT variable in the Budget Main Input File. The indices for subregion and crop combinations are arranged in the Root Zone Component such that crops are listed first and subregions second. For instance, if 5 non-ponded crops are specified for crop-specific land and water use budget output in a model with 2 subregions, indices 1 through 5 represent crops 1 through 5 in subregion 1, indices 6 through 10 represent crops 1 through 5 in subregion 2, and indices 11 through 15 represent crops 1 through 5 in the entire model domain. So, if LPRNT variable is set to {1, 7, 9}, budget tables for crop 1 in subregion 1 (index 1), crop 2 in subregion 2 (index 7) and crop 4 in subregion 2 (index 9) will be printed.

The generated budget table is similar to that generated for the subregional land and water use budget except that there is no information for urban lands. The title printed for each crop-specific land and water use budget includes root zone component version number, subregion name given by the user, the crop code, the unit of data columns and the area of the subregion. All land and water use budget columns are in volumetric units except *Time and Area*. The output units and conversion factors for area (UNITAROU and FACTAROU) and volume (UNITVLOU and FACTVLOU) are specified by the user in the Budget Main Input File.

The crop area, potential consumptive use of applied water and the supply requirement are reported in the output, followed by the components that the crop-specific land and water use budget is comprised of. A positive or negative sign is given for each column that is a component of the crop-specific land and water use. The *Shortage* column is the resulting balance, based on water use components. A value of zero in this column indicates that the available water supply (surface water deliveries, groundwater pumping and surface runoff from upstream elements) meets the agricultural or urban supply requirements. A positive value indicates that the supply is not a large enough quantity to satisfy water requirements. Conversely, a negative value in the *Shortage* column signifies a water supply surplus. The last three columns are informational and show the sources of water that are used in meeting the crop evapotranspirative requirement. The following table defines each column in the crop-specific land and water use budget table printed out to a text file:

CROP-SPECIFIC LAND AND WATER USE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
2	Area	Crop area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
4	Agricultural Supply Requirement	If crop water demand is computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If crop water demand is specified, then this term equals the pre-specified crop water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the crop water supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the crop water supply requirement

7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the crop water supply requirement
8	Shortage (=)	Resulting water balance with respect to the crop water supply requirement and actual water supply specified in preceding columns
9	ETAW	Amount of crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of crop evapotranspiration that is met by current and previous precipitation events
11	ET from Other Sources	Amount of crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_L&W_USE_BUD

Part B:

TTT (SR*XXX*)_*YY* where *TTT* is the name of the subregion, *XXX* is the subregion number and *YY* is the user-specified crop code

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the crop-specific land and water use budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AREA* (corresponds to column 2 in text output file)
ii. *POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *SUP_REQ* (corresponds to column 4 in text output file)
iv. *PUMPING* (corresponds to column 5 in text output file)

v. *DELIVERY* (corresponds to column 6 in text output file)
vi. *SR_INFLOW* (corresponds to column 7 in text output file)
vii. *SHORTAGE* (corresponds to column 8 in text output file)
viii. *ETAW* (corresponds to column 9 in text output file)
ix. *EFF_PRECIP* (corresponds to column 10 in text output file)
x. *ET_OTHER* (corresponds to column 11 in text output file)

8.4.1.3. Subregional Root Zone Moisture Budget

The subregional root zone moisture budget is produced for each subregion listed for processing in the Budget Main Input File. The title printed for each subregional root zone moisture budget includes root zone component version number, subregion name given by the user, the unit of data columns and the area of the subregion. The output units are specified by the user in the Budget Main Input File.

The root zone moisture budget provides information on processes that are used to compute soil moisture in the root zone. Agricultural areas represent the areas where crops are located. Urban area includes indoor and outdoor urban areas and the native and riparian lands represent the undeveloped area in the subregion. For each area type (agricultural, urban, and native and riparian vegetation) precipitation and irrigation (except for native and riparian vegetation areas) along with direct runoff and return flows are listed. The *Infiltration* column is computed by adding the *Precipitation*, *Prime Applied Water* and *Inflow as Surface Runoff* columns and subtracting the *Runoff* and *Net Return Flow* columns. The following table describes the columns in the subregional root zone moisture budget when printed out to a text file:

SUBREGIONAL ROOT ZONE MOISTURE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for agricultural lands
4	Precipitation	Precipitation that falls on agricultural lands
5	Runoff	Direct runoff of precipitation that falls on agricultural lands

6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of agricultural lands increase (a negative value represents loss of moisture due to the decrease of agricultural area)
12	Infiltration (+)	Total infiltration on the agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
14	Pond Drain (–)	Drainage of rice and refuge ponds
15	Actual ET (–)	Actual evapotranspiration in agricultural lands
16	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in agricultural areas
17	Ending Storage (–)	Root zone moisture in agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
18	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of agricultural lands
Urban Area		
19	Area	Urban area
20	Potential ET	Potential evapotranspiration for urban lands
21	Precipitation	Precipitation that falls on urban lands
22	Runoff	Direct runoff of precipitation that falls on urban lands
23	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
24	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand

25	Reused Water	The amount of return flow that is captured and re-used on urban lands
26	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
27	Beginning Storage (+)	Root zone moisture at the beginning of time step
28	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
29	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
30	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
31	Actual ET (–)	Actual evapotranspiration in urban lands
32	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
33	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
34	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native and Riparian Vegetation Area		
35	Area	Native and riparian vegetation area
36	Potential ET	Potential evapotranspiration for native and riparian vegetation
37	Precipitation	Precipitation that falls on areas with native and riparian vegetation
38	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
39	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
40	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
41	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
42	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff

43	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
44	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
45	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
46	Ending Storage (+)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
47	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ROOTZN_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional root zone moisture budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POT_ET* (corresponds to column 3 in text output file)
iii. *AG_PRECIP* (corresponds to column 4 in text output file)
iv. *AG_RUNOFF* (corresponds to column 5 in text output file)
v. *AG_PRM_H2O* (corresponds to column 6 in text output file)

vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_RE-USE* (corresponds to column 8 in text output file)
viii. *AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *AG_INFILTR* (corresponds to column 12 in text output file)
xii. *AG_OTHER_INFLOW* (corresponds to column 13 in text output file)
xiii. *AG_DRAIN* (corresponds to column 14 in text output file)
xiv. *AG_ET* (corresponds to column 15 in text output file)
xv. *AG_PERC* (corresponds to column 16 in text output file)
xvi. *AG_END_STOR* (corresponds to column 17 in text output file)
xvii. *AG_DISCREPANCY* (corresponds to column 18 in text output file)
xviii. *URB_AREA* (corresponds to column 19 in text output file)
xix. *URB_POT_ET* (corresponds to column 20 in text output file)
xx. *URB_PRECIP* (corresponds to column 21 in text output file)
xxi. *URB_RUNOFF* (corresponds to column 22 in text output file)
xxii. *URB_PRM_H2O* (corresponds to column 23 in text output file)
xxiii. *URB_SR_INFLOW* (corresponds to column 24 in text output file)
xxiv. *URB_RE-USE* (corresponds to column 25 in text output file)
xxv. *URB_NT_RTRN_FLOW* (corresponds to column 26 in text output file)
xxvi. *URB_BEGIN_STOR* (corresponds to column 27 in text output file)
xxvii. *URB_GAIN_EXP* (corresponds to column 28 in text output file)
xxviii. *URB_INFILTR* (corresponds to column 29 in text output file)
xxix. *URB_OTHER_INFLOW* (corresponds to column 30 in text output file)
xxx. *URB_ET* (corresponds to column 31 in text output file)
xxxi. *URB_PERC* (corresponds to column 32 in text output file)
xxxii. *URB_END_STOR* (corresponds to column 33 in text output file)
xxxiii. *URB_DISCREPANCY* (corresponds to column 34 in text output file)

xxxiv. *NRV_AREA* (corresponds to column 35 in text output file)
xxxv. *NRV_POT_ET* (corresponds to column 36 in text output file)
xxxvi. *NRV_PRECIP* (corresponds to column 37 in text output file)
xxxvii. *NRV_SR_INFLOW* (corresponds to column 38 in text output file)
xxxviii. *NRV_RUNOFF* (corresponds to column 39 in text output file)
xxxix. *NRV_BEGIN_STOR* (corresponds to column 40 in text output file)
xl. *NRV_GAIN_EXP* (corresponds to column 41 in text output file)
xli. *NRV_INFILTR* (corresponds to column 42 in text output file)
xlii. *NRV_OTHER_INFLOW* (corresponds to column 43 in text output file)
xliii. *NRV_ET* (corresponds to column 44 in text output file)
xliv. *NRV_PERC* (corresponds to column 45 in text output file)
xlv. *NRV_END_STOR* (corresponds to column 46 in text output file)
xlvi. *NRV_DISCREPANCY* (corresponds to column 47 in text output file)

8.4.1.4. Crop-Specific Root Zone Moisture Budget

The crop-specific root zone moisture budget HDF5 files are generated by specifying the individual crops and proper filenames in the non-ponded and ponded crops section of the Root Zone Component Main File.

A budget table is produced for each subregion and crop combination listed for the LPRNT variable in the Budget Main Input File. The indices for subregion and crop combinations are arranged in the Root Zone Component such that crops are listed first and subregions second. For instance, if 5 non-ponded crops are specified for crop-specific root zone moisture budget HDF5 output in a model with 2 subregions, indices 1 through 5 represent crops 1 through 5 in subregion 1, indices 6 through 10 represent crops 1 through 5 in subregion 2, and indices 11 through 15 represent crops 1 through 5 in the entire model domain. So, if LPRNT variable is set to {1, 7, 9}, budget tables for crop 1 in subregion 1 (index 1), crop 2 in subregion 2 (index 7) and crop 4 in subregion 2 (index 9) will be printed.

The generated budget table is similar to that generated for the subregional root zone moisture budget except that there is no information for urban lands, and areas with native and riparian vegetation. The title printed for each crop-specific root zone moisture budget includes root zone component version number, subregion name given by the user, the crop code, the unit of data columns and the area of the subregion.

The following table describes the columns in the crop-specific root zone moisture budget when printed out to a text file:

CROP-SPECIFIC ROOT ZONE MOISTURE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
2	Area	Crop area
3	Potential ET	Potential evapotranspiration for the specified crop
4	Precipitation	Precipitation that falls on areas with the specified crop
5	Runoff	Direct runoff of precipitation that falls on areas with the specified crop
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on areas with the specified crop (after re-use)
10	Beginning Storage (+)	Root zone moisture in areas with the specified crop at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of the specified crop increases (a negative value represents loss of moisture due to the decrease of the crop area)
12	Infiltration (+)	Total infiltration on areas with the specified crop; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
14	Pond Drain (–)	Drainage of rice and refuge ponds; this column is non-zero only if the specified crop is a ponded crop
15	Actual ET (–)	Actual evapotranspiration of the specified crop

16	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the crop root zone
17	Ending Storage (–)	Root zone moisture in areas with the specified crop at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
18	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of the specified crop

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ROOTZN_BUD

Part B:

TTT (SR*XXX*)_*YY* where *TTT* is the name of the subregion, *XXX* is the subregion number and *YY* is the crop code specified by the user

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the crop-specific root zone moisture budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AREA* (corresponds to column 2 in text output file)
ii. *POT_ET* (corresponds to column 3 in text output file)
iii. *PRECIP* (corresponds to column 4 in text output file)
iv. *RUNOFF* (corresponds to column 5 in text output file)
v. *PRM_H2O* (corresponds to column 6 in text output file)
vi. *SR_INFLOW* (corresponds to column 7 in text output file)
vii. *RE-USE* (corresponds to column 8 in text output file)
viii. *NET_RTRN_FLOW* (corresponds to column 9 in text output file)

ix. *BEGIN_STOR* (corresponds to column 10 in text output file)
x. *GAIN_EXP* (corresponds to column 11 in text output file)
xi. *INFILTR* (corresponds to column 12 in text output file)
xii. *OTHER_INFLOW* (corresponds to column 13 in text output file)
xiii. *DRAIN* (corresponds to column 14 in text output file)
xiv. *ET* (corresponds to column 15 in text output file)
xv. *PERC* (corresponds to column 16 in text output file)
xvi. *END_STOR* (corresponds to column 17 in text output file)
xvii. *DISCREPANCY* (corresponds to column 18 in text output file)

8.4.2. Output Files for Root Zone Component Version 4.01

Root zone component version 4.01 can generate the same output files as version 4.0. Refer to section 8.4.1 for a description of these files. Additionally it can generate the land and water use as well as the root zone Z-Budget output files for element-level budgets which can then be aggregated for groups of elements, called zones, using the Z-Budget post-processing tool.

8.4.2.1. Land and Water Use Z-Budget

The Z-Budget tool allows printing of the land and water use budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The land and water use budget for each zone provides water demand and supply information for non-ponded crops, rice, refuges and urban areas. The portions of the evapotranspiration that are met by irrigation, source of water that meets the evapotranspiration are also listed.

The following table defines each column in the land and water use budget table printed out to a text file:

LAND AND WATER USE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Non-Ponded Agricultural Area		
2	Area	Non-ponded agricultural area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture for non-ponded crops before taking into account the net return flow
4	Agricultural Supply Requirement	If non-ponded crop water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow for non-ponded crops. If non-ponded water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the non-ponded agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the non-ponded agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the non-ponded agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the non-ponded agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of non-ponded crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of non-ponded crop evapotranspiration that is met by current and previous precipitation events
11	ET from Other Sources	Amount of non-ponded crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Rice Area		
12	Area	Total rice area
13	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
14	Agricultural Supply Requirement	If rice water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If rice water demands are specified,

		then this term equals the pre-specified water demand.
15	Pumping (–)	Portion of groundwater pumping that is used to meet the rice water supply requirement
16	Deliveries (–)	Portion of the stream diversions that is used to meet the rice water supply requirement
17	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the rice water supply requirement
18	Shortage (=)	Resulting water balance with respect to the rice water supply requirements and actual water supply specified in preceding columns
19	ETAW	Amount of rice evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
20	Effective Precip	Amount of rice evapotranspiration that is met by current and previous precipitation events
21	ET from Other Sources	Amount of rice evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Refuge Area		
22	Area	Total refuge area
23	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture in refuges before taking into account the net return flow
24	Agricultural Supply Requirement	If refuge water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If refuge water demands are specified, then this term equals the pre-specified water demand.
25	Pumping (–)	Portion of groundwater pumping that is used to meet the refuge water supply requirement
26	Deliveries (–)	Portion of the stream diversions that is used to meet the refuge water supply requirement
27	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the refuge water supply requirement
28	Shortage (=)	Resulting water balance with respect to the refuge water supply requirements and actual water supply specified in preceding columns
29	ETAW	Amount of refuge evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events

30	Effective Precip	Amount of refuge evapotranspiration that is met by current and previous precipitation events
31	ET from Other Sources	Amount of refuge evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
32	Area	Urban area
33	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
34	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement
35	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
36	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
37	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal land and water use budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *NP_AG_AREA* (corresponds to column 2 in text output file)

ii. *NP_AG_POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *NP_AG_SUP_REQ* (corresponds to column 4 in text output file)
iv. *NP_AG_PUMPING* (corresponds to column 5 in text output file)
v. *NP_AG_DELIVERY* (corresponds to column 6 in text output file)
vi. *NP_AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *NP_AG_SHORTAGE* (corresponds to column 8 in text output file)
viii. *NP_AG_ETAW* (corresponds to column 9 in text output file)
ix. *NP_AG_EFF_PRECIP* (corresponds to column 10 in text output file)
x. *NP_AG_ET_OTH* (corresponds to column 11 in text output file)
xi. *RICE_AREA* (corresponds to column 12 in text output file)
xii. *RICE_POTNL_CUAW* (corresponds to column 13 in text output file)
xiii. *RICE_SUP_REQ* (corresponds to column 14 in text output file)
xiv. *RICE_PUMPING* (corresponds to column 15 in text output file)
xv. *RICE_DELIVERY* (corresponds to column 16 in text output file)
xvi. *RICE_SR_INFLOW* (corresponds to column 17 in text output file)
xvii. *RICE_SHORTAGE* (corresponds to column 18 in text output file)
xviii. *RICE_ETAW* (corresponds to column 19 in text output file)
xix. *RICE_EFF_PRECIP* (corresponds to column 20 in text output file)
xx. *RICE_ET_OTH* (corresponds to column 21 in text output file)
xxi. *REFUGE_AREA* (corresponds to column 22 in text output file)
xxii. *REFUGE_POTNL_CUAW* (corresponds to column 23 in text output file)
xxiii. *REFUGE_SUP_REQ* (corresponds to column 24 in text output file)
xxiv. *REFUGE_PUMPING* (corresponds to column 25 in text output file)
xxv. *REFUGE_DELIVERY* (corresponds to column 26 in text output file)
xxvi. *REFUGE_SR_INFLOW* (corresponds to column 27 in text output file)

xxvii. *REFUGE_SHORTAGE* (corresponds to column 28 in text output file)
xxviii. *REFUGE_ETAW* (corresponds to column 29 in text output file)
xxix. *REFUGE_EFF_PRECIP* (corresponds to column 30 in text output file)
xxx. *REFUGE_ET_OTH* (corresponds to column 31 in text output file)
xxxi. *URB_AREA* (corresponds to column 32 in text output file)
xxxii. *URB_SUP_REQ* (corresponds to column 33 in text output file)
xxxiii. *URB_PUMPING* (corresponds to column 34 in text output file)
xxxiv. *URB_DELIVERY* (corresponds to column 35 in text output file)
xxxv. *URB_SR_INFLOW* (corresponds to column 36 in text output file)
xxxvi. *URB_SHORTAGE* (corresponds to column 37 in text output file)

8.4.2.2. Root Zone Moisture Z-Budget

The Z-Budget tool allows printing of the root zone budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The root zone moisture budget for each zone provides detailed inflow and outflow terms to and from the root zone for non-ponded crops, rice, refuges and urban areas as well as native and riparian vegetation araes. It also includes precipitation, rainfall runoff, applied water and return flow for each zone.

The following table defines each column in the land and water use budget table printed out to a text file:

ROOT ZONE MOISTURE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Non-Ponded Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for non-ponded crops
4	Precipitation	Precipitation that falls on non-ponded agricultural lands

5	Runoff	Direct runoff of precipitation that falls on non-ponded agricultural lands
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on non-ponded agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in non-ponded agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of non-ponded agricultural lands increase (a negative value represents loss of moisture due to the decrease of non-ponded agricultural area)
12	Infiltration (+)	Total infiltration on the non-ponded agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
14	Actual ET (–)	Actual non-ponded crop evapotranspiration
15	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in non-ponded agricultural areas
16	Ending Storage (–)	Root zone moisture in non-ponded agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
17	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of non-ponded agricultural lands
Rice Area		
18	Area	Rice area
19	Potential ET	Potential evapotranspiration for rice
20	Precipitation	Precipitation that falls on rice lands
21	Runoff	Direct runoff of precipitation that falls on rice lands
22	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
23	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes

24	Reused Water	Amount of return flow that is captured and re-used for irrigation
25	Net Return Flow	Net return flow of irrigation on rice lands (after re-use)
26	Beginning Storage (+)	Root zone moisture in rice lands at the beginning of time step
27	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of rice lands increase (a negative value represents loss of moisture due to the decrease of rice area)
28	Infiltration (+)	Total infiltration on the rice lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
29	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
30	Pond Drain (–)	Drainage of rice ponds
31	Actual ET (–)	Actual rice evapotranspiration
32	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in rice lands
33	Ending Storage (–)	Root zone moisture in rice lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
34	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of rice lands
Refuge Area		
35	Area	Refuge area
36	Potential ET	Potential evapotranspiration for refuges
37	Precipitation	Precipitation that falls on refuges
38	Runoff	Direct runoff of precipitation that falls on refuges
39	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
40	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
41	Reused Water	Amount of return flow that is captured and re-used for irrigation
42	Net Return Flow	Net return flow of irrigation on refuges (after re-use)
43	Beginning Storage (+)	Root zone moisture in refuges at the beginning of time step

44	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of refuges increase (a negative value represents loss of moisture due to the decrease of refuge area)
45	Infiltration (+)	Total infiltration in the refuges; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
46	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
47	Pond Drain (–)	Drainage of refuge ponds
48	Actual ET (–)	Actual refuge evapotranspiration
49	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in refuges
50	Ending Storage (–)	Root zone moisture in refuges at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
51	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of refuges
Urban Area		
52	Area	Urban area
53	Potential ET	Potential evapotranspiration for urban lands
54	Precipitation	Precipitation that falls on urban lands
55	Runoff	Direct runoff of precipitation that falls on urban lands
56	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
57	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand
58	Reused Water	The amount of return flow that is captured and re-used on urban lands
59	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
60	Beginning Storage (+)	Root zone moisture at the beginning of time step
61	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
62	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow

63	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
64	Actual ET (–)	Actual evapotranspiration in urban lands
65	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
66	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
67	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native and Riparian Vegetation Area		
68	Area	Native and riparian vegetation area
69	Potential ET	Potential evapotranspiration for native and riparian vegetation
70	Precipitation	Precipitation that falls on areas with native and riparian vegetation
71	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
72	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
73	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
74	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
75	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff
76	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
77	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
78	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
79	Ending Storage (+)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
80	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal root zone budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *NP_AG_AREA* (corresponds to column 2 in text output file)
ii. *NP_AG_POT_ET* (corresponds to column 3 in text output file)
iii. *NP_AG_PRECIP* (corresponds to column 4 in text output file)
iv. *NP_AG_RUNOFF* (corresponds to column 5 in text output file)
v. *NP_AG_PRM_H2O* (corresponds to column 6 in text output file)
vi. *NP_AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *NP_AG_RE-USE* (corresponds to column 8 in text output file)
viii. *NP_AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *NP_AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *NP_AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *NP_AG_INFILTR* (corresponds to column 12 in text output file)

xii. *NP_AG_OTHER_INFLOW* (corresponds to column 13 in text output file)
xiii. *NP_AG_ET* (corresponds to column 14 in text output file)
xiv. *NP_AG_PERC* (corresponds to column 15 in text output file)
xv. *NP_AG_END_STOR* (corresponds to column 16 in text output file)
xvi. *NP_AG_DISCREPANCY* (corresponds to column 17 in text output file)
xvii. *RICE_AREA* (corresponds to column 18 in text output file)
xviii. *RICE_POT_ET* (corresponds to column 19 in text output file)
xix. *RICE_PRECIP* (corresponds to column 20 in text output file)
xx. *RICE_RUNOFF* (corresponds to column 21 in text output file)
xxi. *RICE_PRM_H2O* (corresponds to column 22 in text output file)
xxii. *RICE_SR_INFLOW* (corresponds to column 23 in text output file)
xxiii. *RICE_RE-USE* (corresponds to column 24 in text output file)
xxiv. *RICE_NT_RTRN_FLOW* (corresponds to column 25 in text output file)
xxv. *RICE_BEGIN_STOR* (corresponds to column 26 in text output file)
xxvi. *RICE_GAIN_EXP* (corresponds to column 27 in text output file)
xxvii. *RICE_INFILTR* (corresponds to column 28 in text output file)
xxviii. *RICE_OTHER_INFLOW* (corresponds to column 29 in text output file)
xxix. *RICE_DRAIN* (corresponds to column 30 in text output file)
xxx. *RICE_ET* (corresponds to column 31 in text output file)
xxxi. *RICE_PERC* (corresponds to column 32 in text output file)
xxxii. *RICE_END_STOR* (corresponds to column 33 in text output file)
xxxiii. *RICE_DISCREPANCY* (corresponds to column 34 in text output file)
xxxiv. *REFUGE_AREA* (corresponds to column 35 in text output file)
xxxv. *REFUGE_POT_ET* (corresponds to column 36 in text output file)
xxxvi. *REFUGE_PRECIP* (corresponds to column 37 in text output file)
xxxvii. *REFUGE_RUNOFF* (corresponds to column 38 in text output file)

xxxviii. *REFUGE_PRM_H2O* (corresponds to column 39 in text output file)
xxxix. *REFUGE_SR_INFLOW* (corresponds to column 40 in text output file)
xl. *REFUGE_RE-USE* (corresponds to column 41 in text output file)
xli. *REFUGE_NT_RTRN_FLOW* (corresponds to column 42 in text output file)
xlii. *REFUGE_BEGIN_STOR* (corresponds to column 43 in text output file)
xliii. *REFUGE_GAIN_EXP* (corresponds to column 44 in text output file)
xliv. *REFUGE_INFILTR* (corresponds to column 45 in text output file)
xlv. *REFUGE_OTHER_INFLOW* (corresponds to column 46 in text output file)
xlvi. *REFUGE_DRAIN* (corresponds to column 47 in text output file)
xlvii. *REFUGE_ET* (corresponds to column 48 in text output file)
xlviii. *REFUGE_PERC* (corresponds to column 49 in text output file)
xlix. *REFUGE_END_STOR* (corresponds to column 50 in text output file)
l. *REFUGE_DISCREPANCY* (corresponds to column 51 in text output file)
li. *URB_AREA* (corresponds to column 52 in text output file)
lii. *URB_POT_ET* (corresponds to column 53 in text output file)
liii. *URB_PRECIP* (corresponds to column 54 in text output file)
liv. *URB_RUNOFF* (corresponds to column 55 in text output file)
lv. *URB_PRM_H2O* (corresponds to column 56 in text output file)
lvi. *URB_SR_INFLOW* (corresponds to column 57 in text output file)
lvii. *URB_RE-USE* (corresponds to column 58 in text output file)
lviii. *URB_NT_RTRN_FLOW* (corresponds to column 59 in text output file)
lix. *URB_BEGIN_STOR* (corresponds to column 60 in text output file)
lx. *URB_GAIN_EXP* (corresponds to column 61 in text output file)
lxi. *URB_INFILTR* (corresponds to column 62 in text output file)

lxii. *URB_OTHER_INFLOW* (corresponds to column 63 in text output file)
lxiii. *URB_ET* (corresponds to column 64 in text output file)
lxiv. *URB_PERC* (corresponds to column 65 in text output file)
lxv. *URB_END_STOR* (corresponds to column 66 in text output file)
lxvi. *URB_DISCREPANCY* (corresponds to column 67 in text output file)
lxvii. *NRV_AREA* (corresponds to column 68 in text output file)
lxviii. *NRV_POT_ET* (corresponds to column 69 in text output file)
lxix. *NRV_PRECIP* (corresponds to column 70 in text output file)
lxx. *NRV_SR_INFLOW* (corresponds to column 71 in text output file)
lxxi. *NRV_RUNOFF* (corresponds to column 72 in text output file)
lxxii. *NRV_BEGIN_STOR* (corresponds to column 73 in text output file)
lxxiii. *NRV_GAIN_EXP* (corresponds to column 74 in text output file)
lxxiv. *NRV_INFILTR* (corresponds to column 75 in text output file)
lxxv. *NRV_OTHER_INFLOW* (corresponds to column 76 in text output file)
lxxvi. *NRV_ET* (corresponds to column 77 in text output file)
lxxvii. *NRV_PERC* (corresponds to column 78 in text output file)
lxxviii. *NRV_END_STOR* (corresponds to column 79 in text output file)
lxxix. *NRV_DISCREPANCY* (corresponds to column 80 in text output file)

8.4.3. Output Files for Root Zone Component Version 4.1

Since root zone component version 4.1 simulates root water uptake from groundwater and riparian vegetation access to stream flows in addition to other flow processes simulated in version 4.1, budget output files for version 4.1 have several additional data columns. Other data columns are the same as those in version 4.0 and are already explained in detail in section 8.4.1. Therefore, only the additional data columns that appear in version 4.1 will be explained in the following sections.

8.4.3.1. Subregional Land and Water Use Budget

In root zone component version 4.1, groundwater can meet all or a portion of the plant evapotranspirative demand. For agricultural areas, the portion of the total evapotranspiration that is met by groundwater is listed along with the other possible moisture sources; namely, irrigation, precipitation and generic moisture source.

The following table defines each column in the subregional land and water use budget table for root zone component version 4.1 when printed out to a text file:

SUBREGIONAL LAND AND WATER USE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
4	Agricultural Supply Requirement	If agricultural water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If agricultural water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of crop evapotranspiration that is met by current and previous precipitation events
11	ET from Groundwater	Amount of crop evapotranspiration that is met by groundwater

12	ET from Other Sources	Amount of crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
13	Area	Urban area
14	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
15	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement
16	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
17	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
18	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_L&W_USE_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional land and water use budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POTNL_CUAW* (corresponds to column 3 in text output file)

iii. *AG_SUP_REQ* (corresponds to column 4 in text output file)
iv. *AG_PUMPING* (corresponds to column 5 in text output file)
v. *AG_DELIVERY* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_SHORTAGE* (corresponds to column 8 in text output file)
viii. *AG_ETAW* (corresponds to column 19 in text output file)
ix. *AG_EFF_PRECIP* (corresponds to column 10 in text output file)
x. *AG_ET_GW* (corresponds to column 11 in text output file)
xi. *AG_ET_OTH* (corresponds to column 12 in text output file)
xii. *URB_AREA* (corresponds to column 13 in text output file)
xiii. *URB_SUP_REQ* (corresponds to column 14 in text output file)
xiv. *URB_PUMPING* (corresponds to column 15 in text output file)
xv. *URB_DELIVERY* (corresponds to column 16 in text output file)
xvi. *URB_SR_INFLOW* (corresponds to column 17 in text output file)
xvii. *URB_SHORTAGE* (corresponds to column 18 in text output file)

8.4.3.2. Crop-Specific Land and Water Use Budget

In addition to the output columns listed and explained for root zone component version 4.0 in section 8.4.1.2, the portion of plant evapotranspirative demand that is met by groundwater is listed for user-specified ponded and non-ponded crops. The following table defines each column in the crop-specific land and water use budget table printed out to a text file:

CROP-SPECIFIC LAND AND WATER USE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
2	Area	Crop area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
4	Agricultural Supply Requirement	If crop water demand is computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If crop water demand is specified, then this term equals the pre-specified crop water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the crop water supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the crop water supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the crop water supply requirement
8	Shortage (=)	Resulting water balance with respect to the crop water supply requirement and actual water supply specified in preceding columns
9	ETAW	Amount of crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of crop evapotranspiration that is met by current and previous precipitation events
11	ET from Groundwater	Amount of crop evapotranspiration that is met by groundwater
12	ET from Other Sources	Amount of crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_L&W_USE_BUD

Part B:

TTT (SR*XXX*)_*YY* where *TTT* is the name of the subregion, *XXX* is the subregion number and *YY* is the user-specified crop code

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the crop-specific land and water use budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AREA* (corresponds to column 2 in text output file)
ii. *POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *SUP_REQ* (corresponds to column 4 in text output file)
iv. *PUMPING* (corresponds to column 5 in text output file)
v. *DELIVERY* (corresponds to column 6 in text output file)
vi. *SR_INFLOW* (corresponds to column 7 in text output file)
vii. *SHORTAGE* (corresponds to column 8 in text output file)
viii. *ETAW* (corresponds to column 9 in text output file)
ix. *EFF_PRECIP* (corresponds to column 10 in text output file)
x. *ET_GW* (corresponds to column 11 in text output file)
xi. *ET_OTHER* (corresponds to column 12 in text output file)

8.4.3.3. Subregional Root Zone Moisture Budget

In addition to the output columns listed in section 8.4.1.3, several additional data columns appear in the budget output tables for root zone component version 4.1 to account for the effects of root water uptake from groundwater and riparian vegetation access to stream flow to meet part or all of the riparian evapotranspirative demand. The following table describes the columns in the subregional root zone moisture budget when printed out to a text file:

SUBREGIONAL ROOT ZONE MOISTURE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for agricultural lands
4	Precipitation	Precipitation that falls on agricultural lands
5	Runoff	Direct runoff of precipitation that falls on agricultural lands
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of agricultural lands increase (a negative value represents loss of moisture due to the decrease of agricultural area)
12	Infiltration (+)	Total infiltration on the agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Groundwater Inflow (+)	Portion of the actual agricultural evapotranspiration that is met by groundwater
14	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
15	Pond Drain (–)	Drainage of rice and refuge ponds
16	Actual ET (–)	Actual evapotranspiration in agricultural lands
17	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in agricultural areas
18	Ending Storage (–)	Root zone moisture in agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
19	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of agricultural lands

Urban Area		
20	Area	Urban area
21	Potential ET	Potential evapotranspiration for urban lands
22	Precipitation	Precipitation that falls on urban lands
23	Runoff	Direct runoff of precipitation that falls on urban lands
24	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
25	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand
26	Reused Water	The amount of return flow that is captured and re-used on urban lands
27	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
28	Beginning Storage (+)	Root zone moisture at the beginning of time step
29	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
30	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
31	Groundwater Inflow (+)	Portion of the actual urban evapotranspiration that is met by groundwater
32	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
33	Actual ET (–)	Actual evapotranspiration in urban lands
34	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
35	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
36	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native & Riparian Vegetation Area		
37	Area	Native and riparian vegetation area
38	Potential ET	Total potential evapotranspiration for native and riparian vegetation

39	Precipitation	Precipitation that falls on areas with native and riparian vegetation
40	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
41	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
42	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
43	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
44	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff
45	Groundwater Inflow (+)	Portion of the actual native and riparian vegetation evapotranspiration that is met by groundwater
46	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
47	Stream Inflow for ET (+)	Portion of the actual riparian vegetation evapotranspiration that is met by stream flows
48	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
49	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
50	Ending Storage (–)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
51	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ROOTZN_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional root zone moisture budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POT_ET* (corresponds to column 3 in text output file)
iii. *AG_PRECIP* (corresponds to column 4 in text output file)
iv. *AG_RUNOFF* (corresponds to column 5 in text output file)
v. *AG_PRM_H2O* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_RE-USE* (corresponds to column 8 in text output file)
viii. *AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *AG_INFILTR* (corresponds to column 12 in text output file)
xii. *AG_GW_INFLOW* (corresponds to column 13 in text output file)
xiii. *AG_OTHER_INFLOW* (corresponds to column 14 in text output file)
xiv. *AG_DRAIN* (corresponds to column 15 in text output file)
xv. *AG_ET* (corresponds to column 16 in text output file)
xvi. *AG_PERC* (corresponds to column 17 in text output file)
xvii. *AG_END_STOR* (corresponds to column 18 in text output file)
xviii. *AG_DISCREPANCY* (corresponds to column 19 in text output file)
xix. *URB_AREA* (corresponds to column 20 in text output file)

xx. *URB_POT_ET* (corresponds to column 21 in text output file)
xxi. *URB_PRECIP* (corresponds to column 22 in text output file)
xxii. *URB_RUNOFF* (corresponds to column 23 in text output file)
xxiii. *URB_PRM_H2O* (corresponds to column 24 in text output file)
xxiv. *URB_SR_INFLOW* (corresponds to column 25 in text output file)
xxv. *URB_RE-USE* (corresponds to column 26 in text output file)
xxvi. *URB_NT_RTRN_FLOW* (corresponds to column 27 in text output file)
xxvii. *URB_BEGIN_STOR* (corresponds to column 28 in text output file)
xxviii. *URB_GAIN_EXP* (corresponds to column 29 in text output file)
xxix. *URB_INFILTR* (corresponds to column 30 in text output file)
xxx. *URB_GW_INFLOW* (corresponds to column 31 in text output file)
xxxi. *URB_OTHER_INFLOW* (corresponds to column 32 in text output file)
xxxii. *URB_ET* (corresponds to column 33 in text output file)
xxxiii. *URB_PERC* (corresponds to column 34 in text output file)
xxxiv. *URB_END_STOR* (corresponds to column 35 in text output file)
xxxv. *URB_DISCREPANCY* (corresponds to column 36 in text output file)
xxxvi. *NRV_AREA* (corresponds to column 37 in text output file)
xxxvii. *NRV_POT_ET* (corresponds to column 38 in text output file)
xxxviii. *NRV_PRECIP* (corresponds to column 39 in text output file)
xxxix. *NRV_SR_INFLOW* (corresponds to column 40 in text output file)
xl. *NRV_RUNOFF* (corresponds to column 41 in text output file)
xli. *NRV_BEGIN_STOR* (corresponds to column 42 in text output file)
xlii. *NRV_GAIN_EXP* (corresponds to column 43 in text output file)
xliii. *NRV_INFILTR* (corresponds to column 44 in text output file)
xliv. *NRV_GW_INFLOW* (corresponds to column 45 in text output file)

xlv. *NRV_OTHER_INFLOW* (corresponds to column 46 in text output file)
xlvi. *NRV_STRM_ET* (corresponds to column 47 in text output file)
xlvii. *NRV_ET* (corresponds to column 48 in text output file)
xlviii. *NRV_PERC* (corresponds to column 49 in text output file)
xlix. *NRV_END_STOR* (corresponds to column 50 in text output file)
l. *NRV_DISCREPANCY* (corresponds to column 51 in text output file)

8.4.3.4. Crop-Specific Root Zone Moisture Budget

Contribution of groundwater to the evapotranspiration for user-specified ponded and non-ponded crops is listed in addition to the data columns listed for root zone component version 4.0 in section 8.4.1.4. The following table describes the columns in the crop-specific root zone moisture budget when printed out to a text file:

CROP-SPECIFIC ROOT ZONE MOISTURE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
2	Area	Crop area
3	Potential ET	Potential evapotranspiration for the specified crop
4	Precipitation	Precipitation that falls on areas with the specified crop
5	Runoff	Direct runoff of precipitation that falls on areas with the specified crop
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on areas with the specified crop (after re-use)
10	Beginning Storage (+)	Root zone moisture in areas with the specified crop at the beginning of time step

11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of the specified crop increases (a negative value represents loss of moisture due to the decrease of the crop area)
12	Groundwater Inflow (+)	Portion of the actual evapotranspiration for the user-specified crop that is met by groundwater
13	Infiltration (+)	Total infiltration on areas with the specified crop; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
14	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
15	Pond Drain (–)	Drainage of rice and refuge ponds; this column is non-zero only if the specified crop is a ponded crop
16	Actual ET (–)	Actual evapotranspiration of the specified crop
17	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the crop root zone
18	Ending Storage (–)	Root zone moisture in areas with the specified crop at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
19	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of the specified crop

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ROOTZN_BUD

Part B:

TTT (SR*XXX*)_*YY* where *TTT* is the name of the subregion, *XXX* is the subregion number and *YY* is the crop code specified by the user

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the crop-specific root zone moisture budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AREA* (corresponds to column 2 in text output file)
ii. *POT_ET* (corresponds to column 3 in text output file)
iii. *PRECIP* (corresponds to column 4 in text output file)
iv. *RUNOFF* (corresponds to column 5 in text output file)
v. *PRM_H2O* (corresponds to column 6 in text output file)
vi. *SR_INFLOW* (corresponds to column 7 in text output file)
vii. *RE-USE* (corresponds to column 8 in text output file)
viii. *NET_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *BEGIN_STOR* (corresponds to column 10 in text output file)
x. *GAIN_EXP* (corresponds to column 11 in text output file)
xi. *INFILTR* (corresponds to column 12 in text output file)
xii. *GW_INFLOW* (corresponds to column 13 in text output file)
xiii. *OTHER_INFLOW* (corresponds to column 14 in text output file)
xiv. *DRAIN* (corresponds to column 15 in text output file)
xv. *ET* (corresponds to column 16 in text output file)
xvi. *PERC* (corresponds to column 17 in text output file)
xvii. *END_STOR* (corresponds to column 18 in text output file)
xviii. *DISCREPANCY* (corresponds to column 19 in text output file)

8.4.4. Output Files for Root Zone Component Version 4.11

Root zone component version 4.11 can generate the same output files as version 4.1. Refer to section 8.4.3 for a description of these files. Additionally it can generate the land and water use as well as the root zone Z-Budget output files for element-level budgets which can then be aggregated for groups of elements, called zones, using the Z-Budget post-processing tool.

8.4.4.1. Land and Water Use Z-Budget

The Z-Budget tool allows printing of the land and water use budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The land and water use budget for each zone provides water demand and supply information for non-ponded crops, rice, refuges and urban areas. The portions of the evapotranspiration that are met by irrigation, source of water that meets the evapotranspiration are also listed.

The following table defines each column in the land and water use budget table printed out to a text file:

LAND AND WATER USE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Non-Ponded Agricultural Area		
2	Area	Non-ponded agricultural area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture for non-ponded crops before taking into account the net return flow
4	Agricultural Supply Requirement	If non-ponded crop water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow for non-ponded crops. If non-ponded water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the non-ponded agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the non-ponded agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the non-ponded agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the non-ponded agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of non-ponded crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events

10	Effective Precip	Amount of non-ponded crop evapotranspiration that is met by current and previous precipitation events
11	ET from Groundwater	Amount of non-ponded crop evapotranspiration that is met by groundwater
12	ET from Other Sources	Amount of non-ponded crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Rice Area		
13	Area	Total rice area
14	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
15	Agricultural Supply Requirement	If rice water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If rice water demands are specified, then this term equals the pre-specified water demand.
16	Pumping (–)	Portion of groundwater pumping that is used to meet the rice water supply requirement
17	Deliveries (–)	Portion of the stream diversions that is used to meet the rice water supply requirement
18	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the rice water supply requirement
19	Shortage (=)	Resulting water balance with respect to the rice water supply requirements and actual water supply specified in preceding columns
20	ETAW	Amount of rice evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
21	Effective Precip	Amount of rice evapotranspiration that is met by current and previous precipitation events
22	ET from Groundwater	Amount of rice evapotranspiration that is met by groundwater
23	ET from Other Sources	Amount of rice evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Refuge Area		
24	Area	Total refuge area
25	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture in refuges before taking into account the net return flow
26	Agricultural Supply Requirement	If refuge water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If refuge water

		demands are specified, then this term equals the pre-specified water demand.
27	Pumping (–)	Portion of groundwater pumping that is used to meet the refuge water supply requirement
28	Deliveries (–)	Portion of the stream diversions that is used to meet the refuge water supply requirement
29	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the refuge water supply requirement
30	Shortage (=)	Resulting water balance with respect to the refuge water supply requirements and actual water supply specified in preceding columns
31	ETAW	Amount of refuge evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
32	Effective Precip	Amount of refuge evapotranspiration that is met by current and previous precipitation events
33	ET from Groundwater	Amount of refuge evapotranspiration that is met by groundwater
34	ET from Other Sources	Amount of refuge evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
35	Area	Urban area
36	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
37	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement
38	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
39	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
40	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*

ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal land and water use budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *NP_AG_AREA* (corresponds to column 2 in text output file)

ii. *NP_AG_POTNL_CUAW* (corresponds to column 3 in text output file)

iii. *NP_AG_SUP_REQ* (corresponds to column 4 in text output file)

iv. *NP_AG_PUMPING* (corresponds to column 5 in text output file)

v. *NP_AG_DELIVERY* (corresponds to column 6 in text output file)

vi. *NP_AG_SR_INFLOW* (corresponds to column 7 in text output file)

vii. *NP_AG_SHORTAGE* (corresponds to column 8 in text output file)

viii. *NP_AG_ETAW* (corresponds to column 9 in text output file)

ix. *NP_AG_EFF_PRECIP* (corresponds to column 10 in text output file)

x. *NP_AG_ET_GW* (corresponds to column 11 in text output file)

xi. *NP_AG_ET_OTH* (corresponds to column 12 in text output file)

xii. *RICE_AREA* (corresponds to column 13 in text output file)

xiii. *RICE_POTNL_CUAW* (corresponds to column 14 in text output file)

xiv. *RICE_SUP_REQ* (corresponds to column 15 in text output file)

xv. *RICE_PUMPING* (corresponds to column 16 in text output file)

xvi. *RICE_DELIVERY* (corresponds to column 17 in text output file)

xvii. *RICE_SR_INFLOW* (corresponds to column 18 in text output file)

xviii. *RICE_SHORTAGE* (corresponds to column 19 in text output file)
xix. *RICE_ETAW* (corresponds to column 20 in text output file)
xx. *RICE_EFF_PRECIP* (corresponds to column 21 in text output file)
xxi. *RICE_ET_GW* (corresponds to column 22 in text output file)
xxii. *RICE_ET_OTH* (corresponds to column 23 in text output file)
xxiii. *REFUGE_AREA* (corresponds to column 24 in text output file)
xxiv. *REFUGE_POTNL_CUAW* (corresponds to column 25 in text output file)
xxv. *REFUGE_SUP_REQ* (corresponds to column 26 in text output file)
xxvi. *REFUGE_PUMPING* (corresponds to column 27 in text output file)
xxvii. *REFUGE_DELIVERY* (corresponds to column 28 in text output file)
xxviii. *REFUGE_SR_INFLOW* (corresponds to column 29 in text output file)
xxix. *REFUGE_SHORTAGE* (corresponds to column 30 in text output file)
xxx. *REFUGE_ETAW* (corresponds to column 31 in text output file)
xxxi. *REFUGE_EFF_PRECIP* (corresponds to column 32 in text output file)
xxxii. *REFUGE_ET_GW* (corresponds to column 33 in text output file)
xxxiii. *REFUGE_ET_OTH* (corresponds to column 34 in text output file)
xxxiv. *URB_AREA* (corresponds to column 35 in text output file)
xxxv. *URB_SUP_REQ* (corresponds to column 36 in text output file)
xxxvi. *URB_PUMPING* (corresponds to column 37 in text output file)
xxxvii. *URB_DELIVERY* (corresponds to column 38 in text output file)
xxxviii. *URB_SR_INFLOW* (corresponds to column 39 in text output file)
xxxix. *URB_SHORTAGE* (corresponds to column 40 in text output file)

8.4.4.2. Root Zone Moisture Z-Budget

The Z-Budget tool allows printing of the root zone budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The root zone moisture budget for each zone provides detailed inflow and outflow terms to and from the root zone for non-ponded crops, rice, refuges and urban areas as well native and riparian vegetation areas. It also includes precipitation, rainfall runoff, applied water and return flow for each zone.

The following table defines each column in the land and water use budget table printed out to a text file:

ROOT ZONE MOISTURE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Non-Ponded Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for non-ponded crops
4	Precipitation	Precipitation that falls on non-ponded agricultural lands
5	Runoff	Direct runoff of precipitation that falls on non-ponded agricultural lands
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on non-ponded agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in non-ponded agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of non-ponded agricultural lands increase (a negative value represents loss of moisture due to the decrease of non-ponded agricultural area)

12	Infiltration (+)	Total infiltration on the non-ponded agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Groundwater Inflow (+)	Portion of the actual non-ponded crops evapotranspiration that is met by groundwater
14	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
15	Actual ET (–)	Actual non-ponded crop evapotranspiration
16	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in non-ponded agricultural areas
17	Ending Storage (–)	Root zone moisture in non-ponded agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
18	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of non-ponded agricultural lands
Rice Area		
19	Area	Rice area
20	Potential ET	Potential evapotranspiration for rice
21	Precipitation	Precipitation that falls on rice lands
22	Runoff	Direct runoff of precipitation that falls on rice lands
23	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
24	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
25	Reused Water	Amount of return flow that is captured and re-used for irrigation
26	Net Return Flow	Net return flow of irrigation on rice lands (after re-use)
27	Beginning Storage (+)	Root zone moisture in rice lands at the beginning of time step
28	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of rice lands increase (a negative value represents loss of moisture due to the decrease of rice area)
29	Infiltration (+)	Total infiltration on the rice lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
30	Groundwater Inflow (+)	Portion of the actual rice evapotranspiration that is met by groundwater

31	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
32	Pond Drain (–)	Drainage of rice ponds
33	Actual ET (–)	Actual rice evapotranspiration
34	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in rice lands
35	Ending Storage (–)	Root zone moisture in rice lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
36	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of rice lands
Refuge Area		
37	Area	Refuge area
38	Potential ET	Potential evapotranspiration for refuges
39	Precipitation	Precipitation that falls on refuges
40	Runoff	Direct runoff of precipitation that falls on refuges
41	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
42	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
43	Reused Water	Amount of return flow that is captured and re-used for irrigation
44	Net Return Flow	Net return flow of irrigation on refuges (after re-use)
45	Beginning Storage (+)	Root zone moisture in refuges at the beginning of time step
46	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of refuges increase (a negative value represents loss of moisture due to the decrease of refuge area)
47	Infiltration (+)	Total infiltration in the refuges; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
48	Groundwater Inflow (+)	Portion of the actual refuge evapotranspiration that is met by groundwater
49	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
50	Pond Drain (–)	Drainage of refuge ponds
51	Actual ET (–)	Actual refuge evapotranspiration

52	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in refuges
53	Ending Storage (–)	Root zone moisture in refuges at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
54	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of refuges
Urban Area		
55	Area	Urban area
56	Potential ET	Potential evapotranspiration for urban lands
57	Precipitation	Precipitation that falls on urban lands
58	Runoff	Direct runoff of precipitation that falls on urban lands
59	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
60	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand
61	Reused Water	The amount of return flow that is captured and re-used on urban lands
62	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
63	Beginning Storage (+)	Root zone moisture at the beginning of time step
64	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
65	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
66	Groundwater Inflow (+)	Portion of the actual urban evapotranspiration that is met by groundwater
67	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
68	Actual ET (–)	Actual evapotranspiration in urban lands
69	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
70	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone

71	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native and Riparian Vegetation Area		
72	Area	Native and riparian vegetation area
73	Potential ET	Potential evapotranspiration for native and riparian vegetation
74	Precipitation	Precipitation that falls on areas with native and riparian vegetation
75	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
76	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
77	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
78	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
79	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff
80	Groundwater Inflow (+)	Portion of the actual evapotranspiration of native and riparian vegetation that is met by groundwater
81	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
82	Stream Inflow for ET (+)	Portion of the actual riparian vegetation evapotranspiration that is met by stream flows
83	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
84	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
85	Ending Storage (+)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
86	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal root zone budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *NP_AG_AREA* (corresponds to column 2 in text output file)
ii. *NP_AG_POT_ET* (corresponds to column 3 in text output file)
iii. *NP_AG_PRECIP* (corresponds to column 4 in text output file)
iv. *NP_AG_RUNOFF* (corresponds to column 5 in text output file)
v. *NP_AG_PRM_H2O* (corresponds to column 6 in text output file)
vi. *NP_AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *NP_AG_RE-USE* (corresponds to column 8 in text output file)
viii. *NP_AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *NP_AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *NP_AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *NP_AG_INFILTR* (corresponds to column 12 in text output file)
xii. *NP_AG_GW_INFLOW* (corresponds to column 13 in text output file)
xiii. *NP_AG_OTHER_INFLOW* (corresponds to column 14 in text output file)

xiv. *NP_AG_ET* (corresponds to column 15 in text output file)
xv. *NP_AG_PERC* (corresponds to column 16 in text output file)
xvi. *NP_AG_END_STOR* (corresponds to column 17 in text output file)
xvii. *NP_AG_DISCREPANCY* (corresponds to column 18 in text output file)
xviii. *RICE_AREA* (corresponds to column 19 in text output file)
xix. *RICE_POT_ET* (corresponds to column 20 in text output file)
xx. *RICE_PRECIP* (corresponds to column 21 in text output file)
xxi. *RICE_RUNOFF* (corresponds to column 22 in text output file)
xxii. *RICE_PRM_H2O* (corresponds to column 23 in text output file)
xxiii. *RICE_SR_INFLOW* (corresponds to column 24 in text output file)
xxiv. *RICE_RE-USE* (corresponds to column 25 in text output file)
xxv. *RICE_NT_RTRN_FLOW* (corresponds to column 26 in text output file)
xxvi. *RICE_BEGIN_STOR* (corresponds to column 27 in text output file)
xxvii. *RICE_GAIN_EXP* (corresponds to column 28 in text output file)
xxviii. *RICE_INFILTR* (corresponds to column 29 in text output file)
xxix. *RICE_GW_INFLOW* (corresponds to column 30 in text output file)
xxx. *RICE_OTHER_INFLOW* (corresponds to column 31 in text output file)
xxxi. *RICE_DRAIN* (corresponds to column 32 in text output file)
xxxii. *RICE_ET* (corresponds to column 33 in text output file)
xxxiii. *RICE_PERC* (corresponds to column 34 in text output file)
xxxiv. *RICE_END_STOR* (corresponds to column 35 in text output file)
xxxv. *RICE_DISCREPANCY* (corresponds to column 36 in text output file)
xxxvi. *REFUGE_AREA* (corresponds to column 37 in text output file)
xxxvii. *REFUGE_POT_ET* (corresponds to column 38 in text output file)
xxxviii. *REFUGE_PRECIP* (corresponds to column 39 in text output file)
xxxix. *REFUGE_RUNOFF* (corresponds to column 40 in text output file)

xl. *REFUGE_PRM_H2O* (corresponds to column 41 in text output file)
xli. *REFUGE_SR_INFLOW* (corresponds to column 42 in text output file)
xlii. *REFUGE_RE-USE* (corresponds to column 43 in text output file)
xliii. *REFUGE_NT_RTRN_FLOW* (corresponds to column 44 in text output file)
xliv. *REFUGE_BEGIN_STOR* (corresponds to column 45 in text output file)
xlv. *REFUGE_GAIN_EXP* (corresponds to column 46 in text output file)
xlvi. *REFUGE_INFILTR* (corresponds to column 47 in text output file)
xlvii. *REFUGE_GW_INFLOW* (corresponds to column 48 in text output file)
xlviii. *REFUGE_OTHER_INFLOW* (corresponds to column 49 in text output file)
xlix. *REFUGE_DRAIN* (corresponds to column 50 in text output file)
l. *REFUGE_ET* (corresponds to column 51 in text output file)
li. *REFUGE_PERC* (corresponds to column 52 in text output file)
lii. *REFUGE_END_STOR* (corresponds to column 53 in text output file)
liii. *REFUGE_DISCREPANCY* (corresponds to column 54 in text output file)
liv. *URB_AREA* (corresponds to column 55 in text output file)
lv. *URB_POT_ET* (corresponds to column 56 in text output file)
lvi. *URB_PRECIP* (corresponds to column 57 in text output file)
lvii. *URB_RUNOFF* (corresponds to column 58 in text output file)
lviii. *URB_PRM_H2O* (corresponds to column 59 in text output file)
lix. *URB_SR_INFLOW* (corresponds to column 60 in text output file)
lx. *URB_RE-USE* (corresponds to column 61 in text output file)
lxi. *URB_NT_RTRN_FLOW* (corresponds to column 62 in text output file)
lxii. *URB_BEGIN_STOR* (corresponds to column 63 in text output file)
lxiii. *URB_GAIN_EXP* (corresponds to column 64 in text output file)

lxiv. *URB_INFILTR* (corresponds to column 65 in text output file)
lxv. *URB_GW_INFLOW* (corresponds to column 66 in text output file)
lxvi. *URB_OTHER_INFLOW* (corresponds to column 67 in text output file)
lxvii. *URB_ET* (corresponds to column 68 in text output file)
lxviii. *URB_PERC* (corresponds to column 69 in text output file)
lxix. *URB_END_STOR* (corresponds to column 70 in text output file)
lxx. *URB_DISCREPANCY* (corresponds to column 71 in text output file)
lxxi. *NRV_AREA* (corresponds to column 72 in text output file)
lxxii. *NRV_POT_ET* (corresponds to column 73 in text output file)
lxxiii. *NRV_PRECIP* (corresponds to column 74 in text output file)
lxxiv. *NRV_SR_INFLOW* (corresponds to column 75 in text output file)
lxxv. *NRV_RUNOFF* (corresponds to column 76 in text output file)
lxxvi. *NRV_BEGIN_STOR* (corresponds to column 77 in text output file)
lxxvii. *NRV_GAIN_EXP* (corresponds to column 78 in text output file)
lxxviii. *NRV_INFILTR* (corresponds to column 79 in text output file)
lxxix. *NRV_GW_INFLOW* (corresponds to column 80 in text output file)
lxxx. *NRV_OTHER_INFLOW* (corresponds to column 81 in text output file)
lxxxi. *NRV_STRM_ET* (corresponds to column 82 in text output file)
lxxxii. *NRV_ET* (corresponds to column 83 in text output file)
lxxxiii. *NRV_PERC* (corresponds to column 84 in text output file)
lxxxiv. *NRV_END_STOR* (corresponds to column 85 in text output file)
lxxxv. *NRV_DISCREPANCY* (corresponds to column 86 in text output file)

8.4.5. Output Files for Root Zone Component Version 5.0

Output files for root zone component version 5.0 are similar to those of versions 4.01 and 4.11 except that there are no budget output files for crop-specific land and water use and root zone data. This is because root zone version 5.0 computes the water demands, and land surface and root zone flow processes for an agricultural crop with average parameters based on crop areas in each subregion. Additionally, element-level Z-Budget output does not distinguish information between non-ponded crops, rice and refuge lands.

8.4.5.1. Subregional Land and Water Use Budget

The subregional land and water use budget HDF5 file is generated by specifying a proper filename in the Root Zone Component Main File. A budget table is produced for each subregion listed for the LPRNT variable in the Budget Main Input File. The title printed for each subregional land and water use budget includes root zone component version number, subregion name given by the user, the unit of data columns and the area of the subregion. All land and water use budget columns are in volumetric units except *Time*, *Agricultural Area* and *Urban Area*. The output units and conversion factors for area (UNITAROU and FACTAROU) and volume (UNITVLOU and FACTVLOU) are specified by the user in the Budget Main Input File.

The total agricultural and urban areas, as well as the agricultural potential consumptive use of applied water and the water supply requirements are reported in the output, followed by the components that the land and water use budget is comprised of. For agricultural lands, potential consumptive use is the amount of water needed to bring the soil moisture up to the irrigation target moisture (field capacity, by default) after the effects of precipitation and generic moisture sources, excluding the net return flow, are taken into account. The agricultural supply requirement is the potential consumptive use of applied water plus the net return flow.

A positive or negative sign is given for each column that is a component of the subregional land and water use. The *Shortage* column is the resulting balance, based on water use components. A value of zero in this column indicates that the available water supply (surface water deliveries, groundwater pumping and surface runoff from upstream elements) meets the agricultural or urban supply requirements. A positive value indicates that the supply is not a large enough quantity to satisfy water requirements. Conversely, a negative value in the *Shortage* column signifies a water supply surplus. The last three columns for agricultural areas are informational and show the sources of water that are used in meeting the crop evapotranspirative requirement.

The following table defines each column in the subregional land and water use budget table printed out to a text file:

SUBREGIONAL LAND AND WATER USE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture before taking into account the net return flow
4	Agricultural Supply Requirement	If agricultural water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow. If agricultural water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of crop evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of crop evapotranspiration that is met by current and previous precipitation events
11	ET from Other Sources	Amount of crop evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
12	Area	Urban area
13	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
14	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement

15	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
16	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
17	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_L&W_USE_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional land and water use budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *AG_SUP_REQ* (corresponds to column 4 in text output file)
iv. *AG_PUMPING* (corresponds to column 5 in text output file)
v. *AG_DELIVERY* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_SHORTAGE* (corresponds to column 8 in text output file)
viii. *AG_ETAW* (corresponds to column 9 in text output file)

ix. *AG_EFF_PRECIP* (corresponds to column 10 in text output file)
x. *AG_ET_OTH* (corresponds to column 11 in text output file)
xi. *URB_AREA* (corresponds to column 12 in text output file)
xii. *URB_SUP_REQ* (corresponds to column 13 in text output file)
xiii. *URB_PUMPING* (corresponds to column 14 in text output file)
xiv. *URB_DELIVERY* (corresponds to column 15 in text output file)
xv. *URB_SR_INFLOW* (corresponds to column 16 in text output file)
xvi. *URB_SHORTAGE* (corresponds to column 17 in text output file)

8.4.5.2. Subregional Root Zone Moisture Budget

The subregional root zone moisture budget is produced for each subregion listed for processing in the Budget Main Input File. The title printed for each subregional root zone moisture budget includes root zone component version number, subregion name given by the user, the unit of data columns and the area of the subregion. The output units are specified by the user in the Budget Main Input File.

The root zone moisture budget provides information on processes that are used to compute soil moisture in the root zone. Agricultural areas represent the areas where crops are located. Urban area includes indoor and outdoor urban areas and the native and riparian lands represent the undeveloped area in the subregion. For each area type (agricultural, urban, and native and riparian vegetation) precipitation and irrigation (except for native and riparian vegetation areas) along with direct runoff and return flows are listed. The *Infiltration* column is computed by adding the *Precipitation*, *Prime Applied Water* and *Inflow as Surface Runoff* columns and subtracting the *Runoff* and *Net Return Flow* columns. The following table describes the columns in the subregional root zone moisture budget when printed out to a text file:

SUBREGIONAL ROOT ZONE MOISTURE BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for agricultural lands
4	Precipitation	Precipitation that falls on agricultural lands

5	Runoff	Direct runoff of precipitation that falls on agricultural lands
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of agricultural lands increase (a negative value represents loss of moisture due to the decrease of agricultural area)
12	Infiltration (+)	Total infiltration on the agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
14	Actual ET (–)	Actual evapotranspiration in agricultural lands
15	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in agricultural areas
16	Ending Storage (–)	Root zone moisture in agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
17	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of agricultural lands
Urban Area		
18	Area	Urban area
19	Potential ET	Potential evapotranspiration for urban lands
20	Precipitation	Precipitation that falls on urban lands
21	Runoff	Direct runoff of precipitation that falls on urban lands
22	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
23	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand

24	Reused Water	The amount of return flow that is captured and re-used on urban lands
25	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
26	Beginning Storage (+)	Root zone moisture at the beginning of time step
27	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
28	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
29	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
30	Actual ET (–)	Actual evapotranspiration in urban lands
31	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
32	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
33	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native and Riparian Vegetation Area		
34	Area	Native and riparian vegetation area
35	Potential ET	Potential evapotranspiration for native and riparian vegetation
36	Precipitation	Precipitation that falls on areas with native and riparian vegetation
37	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
38	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
39	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
40	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
41	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff

42	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
43	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
44	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
45	Ending Storage (+)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
46	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ROOTZN_BUD

Part B:

TTT (SR*XXX*) where *TTT* is the name of the subregion and *XXX* is the subregion number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the subregional root zone moisture budget as specified in the Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POT_ET* (corresponds to column 3 in text output file)
iii. *AG_PRECIP* (corresponds to column 4 in text output file)
iv. *AG_RUNOFF* (corresponds to column 5 in text output file)
v. *AG_PRM_H2O* (corresponds to column 6 in text output file)

vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_RE-USE* (corresponds to column 8 in text output file)
viii. *AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *AG_INFILTR* (corresponds to column 12 in text output file)
xii. *AG_OTHER_INFLOW* (corresponds to column 13 in text output file)
xiii. *AG_ET* (corresponds to column 14 in text output file)
xiv. *AG_PERC* (corresponds to column 15 in text output file)
xv. *AG_END_STOR* (corresponds to column 16 in text output file)
xvi. *AG_DISCREPANCY* (corresponds to column 17 in text output file)
xvii. *URB_AREA* (corresponds to column 18 in text output file)
xviii. *URB_POT_ET* (corresponds to column 19 in text output file)
xix. *URB_PRECIP* (corresponds to column 20 in text output file)
xx. *URB_RUNOFF* (corresponds to column 21 in text output file)
xxi. *URB_PRM_H2O* (corresponds to column 22 in text output file)
xxii. *URB_SR_INFLOW* (corresponds to column 23 in text output file)
xxiii. *URB_RE-USE* (corresponds to column 24 in text output file)
xxiv. *URB_NT_RTRN_FLOW* (corresponds to column 25 in text output file)
xxv. *URB_BEGIN_STOR* (corresponds to column 26 in text output file)
xxvi. *URB_GAIN_EXP* (corresponds to column 27 in text output file)
xxvii. *URB_INFILTR* (corresponds to column 28 in text output file)
xxviii. *URB_OTHER_INFLOW* (corresponds to column 29 in text output file)
xxix. *URB_ET* (corresponds to column 30 in text output file)
xxx. *URB_PERC* (corresponds to column 31 in text output file)
xxxi. *URB_END_STOR* (corresponds to column 32 in text output file)
xxxii. *URB_DISCREPANCY* (corresponds to column 33 in text output file)
xxxiii. *NRV_AREA* (corresponds to column 34 in text output file)

xxxiv. *NRV_POT_ET* (corresponds to column 35 in text output file)
xxxv. *NRV_PRECIP* (corresponds to column 36 in text output file)
xxxvi. *NRV_SR_INFLOW* (corresponds to column 37 in text output file)
xxxvii. *NRV_RUNOFF* (corresponds to column 38 in text output file)
xxxviii. *NRV_BEGIN_STOR* (corresponds to column 39 in text output file)
xxxix. *NRV_GAIN_EXP* (corresponds to column 40 in text output file)
xl. *NRV_INFILTR* (corresponds to column 41 in text output file)
xli. *NRV_OTHER_INFLOW* (corresponds to column 42 in text output file)
xlii. *NRV_ET* (corresponds to column 43 in text output file)
xliii. *NRV_PERC* (corresponds to column 44 in text output file)
xliv. *NRV_END_STOR* (corresponds to column 45 in text output file)
xlv. *NRV_DISCREPANCY* (corresponds to column 46 in text output file)

8.4.5.3. Land and Water Use Z-Budget

The Z-Budget tool allows printing of the land and water use budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The land and water use budget for each zone provides water demand and supply information for agricultural and urban areas. The portions of the evapotranspiration that are met by irrigation, source of water that meets the evapotranspiration are also listed.

The following table defines each column in the land and water use budget table printed out to a text file:

LAND AND WATER USE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area

3	Potential CUAW	Applied water needed to increase the soil moisture to irrigation target moisture for agricultural crops before taking into account the net return flow
4	Agricultural Supply Requirement	If agricultural water demands are computed internally, this is the total amount of applied water needed to increase the soil moisture to irrigation target moisture plus the net return flow for non-ponded crops. If non-ponded water demands are specified, then this term equals the pre-specified water demand.
5	Pumping (–)	Portion of groundwater pumping that is used to meet the agricultural supply requirement
6	Deliveries (–)	Portion of the stream diversions that is used to meet the agricultural supply requirement
7	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the agricultural supply requirement
8	Shortage (=)	Resulting water balance with respect to the agricultural supply requirements and actual water supply specified in preceding columns
9	ETAW	Amount of agricultural evapotranspiration that is met by applied water (summation of pumping, deliveries and captured surface runoff from upstream elements) through current and previous irrigation events
10	Effective Precip	Amount of agricultural evapotranspiration that is met by current and previous precipitation events
11	ET from Other Sources	Amount of agricultural evapotranspiration that is met by generic water sources (e.g. lateral seepage, fog)
Urban Area		
12	Area	Urban area
13	Urban Supply Requirement	Sum of indoor and outdoor urban water demand
14	Pumping (–)	Portion of groundwater pumping that is used to meet the urban supply requirement
15	Deliveries (–)	Portion of stream diversions that is used to meet the urban supply requirement
16	Inflow as Srfc. Runoff (–)	Surface runoff (combination of rainfall runoff, and agricultural and urban return flow) from upstream elements and subregions that is captured and used to meet part of the urban supply requirement
17	Shortage (=)	Resulting water balance with respect to the urban supply requirements and actual water supply specified in preceding columns

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal land and water use budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POTNL_CUAW* (corresponds to column 3 in text output file)
iii. *AG_SUP_REQ* (corresponds to column 4 in text output file)
iv. *AG_PUMPING* (corresponds to column 5 in text output file)
v. *AG_DELIVERY* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_SHORTAGE* (corresponds to column 8 in text output file)
viii. *AG_ETAW* (corresponds to column 9 in text output file)
ix. *AG_EFF_PRECIP* (corresponds to column 10 in text output file)
x. *AG_ET_OTH* (corresponds to column 11 in text output file)
xi. *URB_AREA* (corresponds to column 12 in text output file)
xii. *URB_SUP_REQ* (corresponds to column 13 in text output file)
xiii. *URB_PUMPING* (corresponds to column 14 in text output file)
xiv. *URB_DELIVERY* (corresponds to column 15 in text output file)
xv. *URB_SR_INFLOW* (corresponds to column 16 in text output file)
xvi. *URB_SHORTAGE* (corresponds to column 17 in text output file)

8.4.5.4. Root Zone Moisture Z-Budget

The Z-Budget tool allows printing of the root zone budget tables to either an ASCII text file or to a DSS file for each of the zones defined by the user. The budget table for each zone includes a title that lists the version of the root zone component that was used in the IDC run, the units of the budget flow terms as well as the name and area of the zone.

The root zone moisture budget for each zone provides detailed inflow and outflow terms to and from the root zone for agricultural, urban and natural (native and riparian vegetation) areas. It also includes precipitation, rainfall runoff, applied water and return flow for each zone.

The following table defines each column in the land and water use budget table printed out to a text file:

ROOT ZONE MOISTURE Z-BUDGET		
Column No.	Column Name	Description
1	Time	Simulation date and time
Agricultural Area		
2	Area	Agricultural area
3	Potential ET	Potential evapotranspiration for agricultural lands
4	Precipitation	Precipitation that falls on agricultural lands
5	Runoff	Direct runoff of precipitation that falls on agricultural lands
6	Prime Applied Water	Amount of water applied as a summation of surface water deliveries and pumping for irrigation purposes
7	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used for irrigation purposes
8	Reused Water	Amount of return flow that is captured and re-used for irrigation
9	Net Return Flow	Net return flow of irrigation on agricultural lands (after re-use)
10	Beginning Storage (+)	Root zone moisture in agricultural lands at the beginning of time step
11	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of agricultural lands increase (a negative value represents loss of moisture due to the decrease of agricultural area)

12	Infiltration (+)	Total infiltration on the agricultural lands; computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
13	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
14	Actual ET (–)	Actual evapotranspiration in agricultural lands
15	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in agricultural areas
16	Ending Storage (–)	Root zone moisture in agricultural lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
17	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of agricultural lands
Urban Area		
18	Area	Urban area
19	Potential ET	Potential evapotranspiration for urban lands
20	Precipitation	Precipitation that falls on urban lands
21	Runoff	Direct runoff of precipitation that falls on urban lands
22	Prime Applied Water	Total amount of pumping and surface water deliveries that is used to meet urban indoors and outdoors water demand
23	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that is captured and used to meet urban water demand
24	Reused Water	The amount of return flow that is captured and re-used on urban lands
25	Net Return Flow	Net return flow of applied water used for urban indoors and outdoors usage (after re-use)
26	Beginning Storage (+)	Root zone moisture at the beginning of time step
27	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of urban lands increase (a negative value represents loss of moisture due to the decrease of urban area)
28	Infiltration (+)	Total infiltration on the urban lands computed as the summation of precipitation, prime applied water and inflow as surface runoff less runoff and net return flow
29	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
30	Actual ET (–)	Actual evapotranspiration in urban lands

31	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in urban areas
32	Ending Storage (–)	Root zone moisture in urban lands at the end of the time step computed as the summation of the beginning storage and the net inflow into the root zone
33	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of urban lands
Native and Riparian Vegetation Area		
34	Area	Native and riparian vegetation area
35	Potential ET	Potential evapotranspiration for native and riparian vegetation
36	Precipitation	Precipitation that falls on areas with native and riparian vegetation
37	Inflow as Surface Runoff	Surface runoff (sum of rainfall runoff and return flow from agricultural and urban lands) from upstream elements and subregions that flows into the lands with native and riparian vegetation
38	Runoff	Direct runoff of precipitation that falls on areas with native and riparian vegetation
39	Beginning Storage (+)	Root zone moisture in areas with native and riparian vegetation at the beginning of time step
40	Net Gain from Land Expansion (+)	The net moisture gained from other land use areas as the area of native and riparian vegetation increase (a negative value represents loss of moisture due to the decrease of native and riparian vegetation area)
41	Infiltration (+)	Total infiltration on areas with native and riparian vegetation; computed as the sum of precipitation and inflow as surface runoff less runoff
42	Other Inflow (+)	Moisture inflow from other generic moisture sources such as lateral seepage
43	Actual ET (–)	Actual evapotranspiration in areas with native and riparian vegetation
44	Percolation (–)	Percolation from the root zone which is the vertical moisture outflow from the bottom of the root zone in areas with native and riparian vegetation
45	Ending Storage (+)	Root zone moisture in areas with native and riparian vegetation at the end of the time step; computed as the summation of the beginning storage and the net moisture inflow
46	Discrepancy (=)	Mass balance error check for the moisture storage in the root zone of lands with native and riparian vegetation

If a DSS file is used for print-out, the following pathnames are used:

Part A:

IWFM_ZBUD

Part B:

ZONE:*XXX* where *XXX* is the zone number

Part C:

One of the following, depending on the output data:

i. *AREA*
ii. *VOLUME*

Part D:

Start date of the time series depending on the values of the BDT and EDT variables (starting and ending date and time of budget print-out)

Part E:

Print-out interval for the zonal root zone budget as specified in the Z-Budget Main Input File

Part F:

One of the following, depending on the output data (refer to the table above for further details):

i. *AG_AREA* (corresponds to column 2 in text output file)
ii. *AG_POT_ET* (corresponds to column 3 in text output file)
iii. *AG_PRECIP* (corresponds to column 4 in text output file)
iv. *AG_RUNOFF* (corresponds to column 5 in text output file)
v. *AG_PRM_H2O* (corresponds to column 6 in text output file)
vi. *AG_SR_INFLOW* (corresponds to column 7 in text output file)
vii. *AG_RE-USE* (corresponds to column 8 in text output file)
viii. *AG_NT_RTRN_FLOW* (corresponds to column 9 in text output file)
ix. *AG_BEGIN_STOR* (corresponds to column 10 in text output file)
x. *AG_GAIN_EXP* (corresponds to column 11 in text output file)
xi. *AG_INFILTR* (corresponds to column 12 in text output file)
xii. *AG_OTHER_INFLOW* (corresponds to column 13 in text output file)
xiii. *AG_ET* (corresponds to column 14 in text output file)
xiv. *AG_PERC* (corresponds to column 15 in text output file)
xv. *AG_END_STOR* (corresponds to column 16 in text output file)

xvi. *AG_DISCREPANCY* (corresponds to column 17 in text output file)
xvii. *URB_AREA* (corresponds to column 18 in text output file)
xviii. *URB_POT_ET* (corresponds to column 19 in text output file)
xix. *URB_PRECIP* (corresponds to column 20 in text output file)
xx. *URB_RUNOFF* (corresponds to column 21 in text output file)
xxi. *URB_PRM_H2O* (corresponds to column 22 in text output file)
xxii. *URB_SR_INFLOW* (corresponds to column 23 in text output file)
xxiii. *URB_RE-USE* (corresponds to column 24 in text output file)
xxiv. *URB_NT_RTRN_FLOW* (corresponds to column 25 in text output file)
xxv. *URB_BEGIN_STOR* (corresponds to column 26 in text output file)
xxvi. *URB_GAIN_EXP* (corresponds to column 27 in text output file)
xxvii. *URB_INFILTR* (corresponds to column 28 in text output file)
xxviii. *URB_OTHER_INFLOW* (corresponds to column 29 in text output file)
xxix. *URB_ET* (corresponds to column 30 in text output file)
xxx. *URB_PERC* (corresponds to column 31 in text output file)
xxxi. *URB_END_STOR* (corresponds to column 32 in text output file)
xxxii. *URB_DISCREPANCY* (corresponds to column 33 in text output file)
xxxiii. *NRV_AREA* (corresponds to column 34 in text output file)
xxxiv. *NRV_POT_ET* (corresponds to column 35 in text output file)
xxxv. *NRV_PRECIP* (corresponds to column 36 in text output file)
xxxvi. *NRV_SR_INFLOW* (corresponds to column 37 in text output file)
xxxvii. *NRV_RUNOFF* (corresponds to column 38 in text output file)
xxxviii. *NRV_BEGIN_STOR* (corresponds to column 39 in text output file)
xxxix. *NRV_GAIN_EXP* (corresponds to column 40 in text output file)
xl. *NRV_INFILTR* (corresponds to column 41 in text output file)
xli. *NRV_OTHER_INFLOW* (corresponds to column 42 in text output file)
xlii. *NRV_ET* (corresponds to column 43 in text output file)
xliii. *NRV_PERC* (corresponds to column 44 in text output file)

xliv. *NRV_END_STOR* (corresponds to column 45 in text output file)

xlv. *NRV_DISCREPANCY* (corresponds to column 46 in text output file)

9. Budget Post-Processor

IDC prints out its results into HDF5 files to decrease the computer run times as well as the size of the output files. The information in these HDF5 files need to be processed to generate understandable information in a table format. The Budget post-processor is created for this purpose and it is available for download from the IDC's web site at https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model-Demand-Calculator.

Budget post-processor can process multiple HDF5 files at the same time. The user specifies the number of HDF5 files to be processed, the names of these files and the output files where the processed results will be printed out.

For each HDF5 file to be processed the user can choose the "locations" for which the IDC results will be listed in a tabulated form. A location can either be a subregion or a set of specified land-uses at a subregion. For instance, the user can specify names for root zone moisture, and land and water use budget files in the Root Zone Parameter File. For these files, a location is a subregion. If the model has 20 subregions, then the user can choose in the Budget post-processor to process these two HDF5 files and generate tabulated data for all or some of the subregions.

Similar output file names can also be specified for non-ponded and ponded crops as well as urban, native vegetation and riparian vegetation lands. In this case, a location will be a land-use and subregion combination. For instance, if the user chooses to generate HDF5 soil moisture budget file for 4 crops (e.g. grain, alfalfa, corn and sugar beets), the first location for the processed and tabulated data will be grain in the first subregion, second location will be alfalfa in the first subregion, third location will be corn in the first subregion, etc. Fifth location will be grain in the second subregion.

By using the output features of IDC and Budget post-processor the user can obtain detailed land and water use as well as soil moisture budgets for total agriculture, urban, and native and riparian vegetation lands as well as for specific crops in each subregion.

When executed, Budget post-processor asks for the name of the Budget Main Input File which is described below.

9.1. Budget Main Input File

The Budget Main Input File contains output unit controls, beginning and ending simulation times for the budget print-out, names of the HDF5 files to be processed, budget print-out locations and the print-out interval of the budget data.

The values stored in the HDF5 files have units used in the IDC run. The output unit control information allows the user to print out the budget data in a different set of units. The user is required to enter the beginning date and time, BDT, and the ending date and time, EDT for the budget outputs. The user can process as many budget files as needed. A single HDF5 file can be processed multiple times with different output intervals. For each HDF5 file to be processed, the user is required to enter the name of the HDF5 file, the name of the output file, output interval, number of *locations* for budget print-out and a list of the location indices. If the output interval is greater than the simulation time step, the budget flow terms will be accumulated over the output interval.

The meaning of *location* depends on the type of the budget file being processed. For instance, for subregional root zone budget, *location* represents a subregion. For crop specific root zone budget a *location* represents agricultural lands occupied by a specific crop at a subregion. When location is specified as −1, Budget post-processor prints out budget tables for all locations in that particular budget class. If a value of 0 is specified for the location, then Budget suppresses the processing of the budget tables.

The following is a list of variables that need to be defined in this file:

FACTLTOU	Factor to convert simulation unit of length to output unit of length
UNITLTOU	Output unit of length (maximum of 8 characters)
FACTAROU	Factor to convert simulation unit of area to output unit of area
UNITAROU	Output unit of area (maximum of 8 characters)
FACTVLOU	Factor to convert simulation unit of volume to output unit of volume
UNITVLOU	Output unit of volume (maximum of 8 characters)
CACHE	Cache size in terms of number of output values stored in the memory before being printed to the output file; a large CACHE value (e.g. 50000 or more depending on the memory resources of the computer where Budget runs are taking

	place) can drastically decrease the program run-time especially when the budget tables are printed out to a DSS file.
TBEGIN	Beginning time step for the budget tables; used only for non-time-tracking simulations (note that IDC only performs time-tracking simulations)
TLAST	Ending time step for the budget tables; used only for non-time-tracking simulations (note that IDC only performs time-tracking simulations)
BDT	Beginning date and time for the budget tables; used only for time-tracking simulations
EDT	Ending date and time for the budget tables; used only for time-tracking simulations
NBUDGET	Number of budget files to be processed

NBUDGET, described above, informs the Budget post-processor about the number of budget files that will be processed. For each of the budget files to be processed the following variables need to be set:

HDFFILE	Name of the HDF5 budget file (maximum 1000 characters)
OUTFILE	Name of the budget output file (maximum 1000 characters); the filename extension dictates if the output file will be text file or a DSS file (see section 8.2 for file types and corresponding filename extensions)
INTPRNT	Interval for budget print-out (budget flow terms will be accumulated over the output interval); this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File. If left blank, the print-out interval will be the same as the simulation time step.
NLPRNT	Number of *locations* for budget table print-out; a *location* corresponds to different spatial attributes depending on the type of the budget table being processed (e.g. a subregion for subregional root zone budgets, lands that are occupied by a specific crop in a subregion for crop specific root zone budget, etc.)
LPRNT	Index for locations for which a budget table will be generated; for budget tables at subregions, the index for the entire

domain is the number of subregions plus 1 (−1 = print budget tables for all locations, 0 = suppress printing of all budget tables)

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C                         *** Version ### ***
C
C*******************************************************************************
C
C                           BUDGET INPUT FILE
C                       for IWFM Post-Processing
C
C
C             Project:  IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Budget.in
C
C*******************************************************************************
c
C                            File Description
C
C    This file contains the names of all HDF5 input files,
C    conversion factors and output control options for running the post-processor.
C
C*******************************************************************************
C                    Output Unit Control
C
C    FACTLTOU; Factor to convert simulation unit of length to output unit of length
C    UNITLTOU; Output unit of length (8 characters max.)
C    FACTAROU; Factor to convert simulation unit of area to output unit of area
C    UNITAROU; Output unit of area (8 characters max.)
C    FACTVLOU; Factor to convert simulation unit of volume to output unit of volume
C    UNITVLOU; Output unit of volume (8 characters max.)
C
C-----------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-----------------------------------------------------------------------------
    1.0                           / FACTLTOU
    FT.                           / UNITLTOU
    2.295684114e-5                / FACTAROU  (sq.ft. -> ac)
    AC.                           / UNITAROU
    2.295684114e-5                / FACTVLOU  (cu.ft. -> ac.ft.)
    AC.FT.                        / UNITVLOU
C*******************************************************************************
C                    Output Cache Size
C
C    CACHE;   Cache size in terms of number of values stored for time series
C             data output
C
C-----------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    500000                        / CACHE
C*******************************************************************************
C                        Budget Output Control Options
C                    (Simulation Date and Time NOT Tracked)
C
C    If the actual simulation date and time is NOT tracked enter the following
C    variables. Otherwise, comment out the following variables and use the
C    "Simulation Date and Time NOT Tracked" option below.
C
C    TBEGIN ; Beginning time for the budget tables
C               * Use ##.# format
C    TLAST  ; Ending time for the budget tables
C               * Use ##.# format
C
C-------------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
*                               / TBEGIN
*                               / TLAST
C-------------------------------------------------------------------------------
C                        Budget Output Control Options
C                     (Simulation Date and Time Tracked)
C
C    If the actual simulation date and time is tracked enter the following
C    variables. Otherwise, comment out the following variables and use the
C    "Simulation Date and Time NOT Tracked" option above.
C
C    BDT    ; Begining date and time for the budget output
C                * Use MM/DD/YYYY_HH:MM format
C                * Midnight is 24:00
C    EDT    ; Ending date and time for the budget output
C                * Use MM/DD/YYYY_HH:MM format
C                * Midnight is 24:00
C
C-------------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
    09/30/1980_24:00            / BDT
    09/30/2006_24:00            / EDT
C*******************************************************************************
C                            Budget Output Data
C
C   List below the number of budget classes (i.e. groundwater budget, stream
C   budget, small watershed budget, etc.), and for each budget class list the
C   input file, output file and the locations for which a budget table will
C   be generated.
C
C   NBUDGET ;  Number of budget classes to be printed
C   HDFFILE ;  Name of the input budget file (max. 1000 characters)
C   OUTFILE ;  Name of the budget output file (max. 1000 characters)
C   INTPRNT ;  Interval for budget print out (e.g. 1DAY, 1MONTH, etc.). The interval
C                must be a one of those listed in the Main Input File for the
C                executable that generated the HDF5 input files.
C                * Leave blank to use the same interval as the data.
C                * This interval will only be used for simulation with
C                  date and time tracked
C   NLPRNT  ;  Number of location indices for budget table print-out
C   LPRNT   ;  Index for locations (i.e. subregions, lakes, stream reaches, etc.
C                depending on the budget class) for which a budget table will be
C                generated.  For budget tables at subregions, the index for the
C                entire domain is the number of subregions plus 1.
C                * Enter -1: to print budget tables for all locations
```

```
C                          0: to suppress printing of any budget tables
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
     4                         / NBUDGET
C*******************************************************************************
C                          Data for Budget Class 1
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
   LWU.HDF                     / HDFFILE
   LWU.BUD                     / OUTFILE
   1mon                        / INTPRNT
   1                           / NLPRNT
   -1                          / LPRNT[1]
C*******************************************************************************
C                          Data for Budget Class 2
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
   RZ.HDF                      / HDFFILE
   RZ.BUD                      / OUTFILE
                               / INTPRNT
   1                           / NLPRNT
   -1                          / LPRNT[1]
C*******************************************************************************
C                          Data for Budget Class 3
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
    NonPondedAgLWU.hdf         / HDFFILE
    NonPondedAgLWU.bud         / OUTFILE
                               / INTPRNT
    3                          / NLPRNT
    1                          / LPRNT[1]
    7                          / LPRNT[2]
    14                         / LPRNT[3]
C*******************************************************************************
C                          Data for Budget Class 4
C
C-------------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
    NonPondedAgLWU.hdf         / HDFFILE
    NonPondedAgLWU_ANNUAL.bud  / OUTFILE
    1year                      / INTPRNT
    1                          / NLPRNT
    -1                         / LPRNT[1]
```

10. Z-Budget Post-Processor

While Budget post-processor tabulates simulation results for predefined subregions, Z-Budget post-processor allows the user to group selected elements into *zones*, and compiles and tabulates water budgets for these zones. This post-processing approach allows the user to zoom in on areas within the model boundary to examine the flow processes in these areas.

All output files the Z-Budget post-processor generates are text files that include tabular data. To perform any analysis, these data are generally needed to be imported into other software such as Microsoft Excel. Alternatively, the user can download and install the IWFM Tools Add-in for Excel 2016 from IWFM's web site (https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model). This tool allows easy import of the data stored in the HDF5 Z-Budget files into Microsoft Excel.

This chapter describes the input files and provides file samples for the Z-Budget post-processor.

10.1. Z-Budget Main Input File

The Z-Budget Main Input File contains output unit controls, beginning and ending simulation times for the Z-Budget print-out, names of the HDF5 files to be processed, zones for which tabulated data will be generated and the print-out interval of the tabulated data.

The values stored in the HDF5 files have units used in the Simulation. The output unit control information allows the user to print out the tabulated data in a different set of units. Beginning and ending date of the Z-Budget output are required to be specified. The output begin date can be later than the beginning date of the model simulation period and the output end date can be earlier than the ending date of the simulation period, allowing the user to zoom in on short time periods within the simulation period for analysis.

The user can process as many Z-Budget HDF5 files as needed. A single HDF5 file can be processed multiple times with different output intervals or for different zone definitions. For each HDF5 file to be processed, the user is required to enter the name of the HDF5 file, the name of the file that includes the zone definitions, the name of the output file, output interval for time-tracking simulations, number of zones for print-out and a list of the zone indices for the print-out. If the output interval is greater than the simulation time step, the Z-Budget flow terms will be accumulated over the output interval.

The following is a list of variables that need to be defined in this file:

FACTAROU	Factor to convert simulation unit of area to output unit of area
UNITAROU	Output unit of area (maximum of 8 characters)
FACTVLOU	Factor to convert simulation unit of volume to output unit of volume
UNITVLOU	Output unit of volume (maximum of 8 characters)
CACHE	Cache size in terms of number of output values stored in the memory before being printed to the output file; a large CACHE value (e.g. 50000 or more depending on the memory resources of the computer where Z-Budget runs are taking place) can drastically decrease the program run-time especially when the tabulated data are printed out to a DSS file.
BDT	Beginning date and time for the Z-Budget tables
EDT	Ending date and time for the Z-Budget tables
NZBUDGET	Number of Z-Budget HDF5 files to be processed

NZBUDGET, described above, informs the Z-Budget post-processor about the number of HDF5 files that will be processed. For each of the HDF5 files to be processed the following variables need to be set:

ZDEFFILE	Name of the zone definition file (maximum 1000 characters); the contents of this file are described in the next section
HDFFILE	Name of the input HDF5 Z-Budget file (maximum 1000 characters)
OUTFILE	Name of the Z-Budget output file (maximum 1000 characters); the filename extension dictates if the output file will be text file or a DSS file (see section 8.2 for file types and corresponding filename extensions)
INTPRNT	Interval for Z-Budget print-out (flow terms will be accumulated over the output interval); this should be one of the units recognized by HEC-DSS that are listed in the IDC Main Input File. If left blank, the print-out interval will be the same as the IDC model time step.

NZPRNT	Number of zones for which tabulated output is required; enter 1 if ZPRNT is set to −1 or 0 (see below)
ZPRNT	Index for zones for which tabulated data will be generated (−1 = print tabulated data for all zones; 0 = suppress printing of tabulated data for all zones)

```
C*******************************************************************************
C
C                   INTEGRATED WATER FLOW MODEL (IWFM)
C                          *** Version 2015 ***
C
C*******************************************************************************
C
C                         Z-BUDGET MAIN INPUT FILE
C                         for IWFM Post-Processing
C
C
C              Project : IDC Version ### Release
C                        California Department of Water Resources
C              Filename: ZBudget.in
C
C*******************************************************************************
C
C                             File Description
C
C    This file contains the names of all HDF5 Z-Budget input files, conversion
C    factors and output control options for running the post-processor.
C
C*******************************************************************************
C                          Z-Budget Output Control
C
C    FACTAROU; Factor to convert simulation unit of area to output unit of area
C    UNITAROU; Output unit of area (8 characters max.)
C    FACTVLOU; Factor to convert simulation unit of volume to output unit of volume
C    UNITVLOU; Output unit of volume (8 characters max.)
C    CACHE   ; Cache size in terms of number of values stored for time series
C                data output
C
C-----------------------------------------------------------------------------
C   VALUE                           DESCRIPTION
C-----------------------------------------------------------------------------
    0.000022957                     / FACTAROU     (sq.ft. -> ac.)
    AC.                             / UNITAROU
    0.000022957                     / FACTVLOU     (cu.ft. -> ac.ft.)
    AF.                             / UNITVLOU
    500000                          / CACHE
C*******************************************************************************
C                         Z-Budget Output Period
C
C    BDT    ; Begining date and time for the Z-Budget output
C              * Use MM/DD/YYYY_HH:MM format
C              * Midnight is 24:00
C    EDT    ; Ending date and time for the Z-Budget output
C              * Use MM/DD/YYYY_HH:MM format
C              * Midnight is 24:00
C
C-------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    09/30/1921_24:00            / BDT
    09/30/2015_24:00            / EDT
C*******************************************************************************
C                          Z-Budget Output Data
C
C   List below the number of Z-Budget types (i.e. groundwater Z-Budget, root zone
C   Z-Budget, land & water use Z-Budget, etc.), and for each Z-Budget type list the
C   zone definition file, input HDF5 file, output file and the locations for which a
C   Z-Budget table will be generated.
C
C   NZBUDGET;  Number of Z-Budget types to be printed
C   ZDEFFILE;  Name of the zone definition file (max. 1000 characters)
C   HDFFILE ;  Name of the input Z-Budget file (max. 1000 characters)
C   OUTFILE ;  Name of the Z-Budget output file (max. 1000 characters)
C   INTPRNT ;  Interval for Z-Budget print out (e.g. 1DAY, 1MONTH, etc.). The interval
C                must be a one of those listed in the Main Input File for the
C                executable that generated the input HDF5 files.
C                * Leave blank to use the same interval as the data.
C   NZPRNT  ;  Number of zones for Z-Budget print-out (not all the zones listed above
C                need to be processed)
C   ZPRNT   ;  Zone numbers for which a Z-Budget table will be generated
C                * Enter -1: to print Z-Budget tables for all zones
C                         0: to suppress printing of any Z-Budget tables
C
C-------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    4                              / NZBUDGET
C*******************************************************************************
C                           Data for Z-Budget Type 1
C
C-------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    Zones_Subregions.dat        / ZDEFFILE
    LandWater_ZBudget.hdf       / HDFFILE
    LandWater_ZBud_SR.bud       / OUTFILE
                                / INTPRNT
    1                           / NZPRNT
    -1                          / ZPRNT[1]
C*******************************************************************************
C                           Data for Z-Budget Type 2
C
C-------------------------------------------------------------------------------
C   VALUE                         DESCRIPTION
C-------------------------------------------------------------------------------
    Zones_Subregions.dat        / ZDEFFILE
    LandWater_ZBudget.hdf       / HDFFILE
    LandWater_ZBud_SR.bud       / OUTFILE
    1YEAR                       / INTPRNT
    4                           / NZPRNT
    6                           / ZPRNT[1]
    7                           / ZPRNT[2]
    8                           / ZPRNT[3]
    9                           / ZPRNT[4]
C*******************************************************************************
C                           Data for Z-Budget Type 3
C
C-------------------------------------------------------------------------------
```

```
C   VALUE                           DESCRIPTION
C-------------------------------------------------------------------------------
    Zones_DAUs.dat                  / ZDEFFILE
    LandWater_ZBudget.hdf           / HDFFILE
    LandWater_ZBud_DAU.bud          / OUTFILE
                                    / INTPRNT
    1                               / NZPRNT
    -1                              / ZPRNT[1]
C*******************************************************************************
C                        Data for Z-Budget Type 4
C
C-------------------------------------------------------------------------------
C   VALUE                           DESCRIPTION
C-------------------------------------------------------------------------------
    Zones_Elements.dat              / ZDEFFILE
    RootZone_ZBudget.hdf            / HDFFILE
    RootZone_ZBud_Elems.bud         / OUTFILE
    1MON                            / INTPRNT
    7                               / NZPRNT
    567                             / ZPRNT[1]
    1002                            / ZPRNT[2]
    568                             / ZPRNT[3]
    573                             / ZPRNT[4]
    1003                            / ZPRNT[5]
    574                             / ZPRNT[6]
    1006                            / ZPRNT[7]
```

10.2. Zone Definition File

In the Zone Definition File one or more elements are grouped into zones. Each zone is identified with an integer number. Zone numbers don't have to start from 1 and they don't need to be sequential. A single element cannot be associated with more than one zone. Not all elements need to be associated with a zone; by default each element is assigned the *undefined zone number*, –99. However, at least one element must be listed in the Zone Definition File with a zone number that is different than –99. Since –99 is a special zone number for the Z-Budget post-processor, it is not allowed to assign elements with this zone number explicitly.

In theory, zones can be defined both in horizontal and vertical directions. Zone definition in the vertical requires flow processes that operate on three-dimensional space (such as the groundwater or the unsaturated zone processes simulated in IWFM). The root zone process simulated by IDC is only two-dimensional; the root zone flows vary in the horizontal but the system is represented with a single root zone layer in the vertical. Therefore, for Z-Budget outputs produced by IDC zones can only be defined by grouping elements in the horizontal.

Below is a list of the variables that need to be populated in the Zone Definition File:

ZEXTENT	Extent of the zone numbering (1 = zone numbering is defined for horizontal plane and will be used for all layers in the vertical; 0 = different zone numbering is specified for each layer in the vertical); this variable must be set to 1 always to process IDC-generated Z-Budget files
ZID	Zone number for which a name is defined
ZNAME	Name of each zone (maximum 50 characters)
IE	Element number
LAYER	Layer number at which element is located; this variable must always be left blank to process IDC-generated Z-Budget files
ZONE	Zone number; any integer number except –99 is allowed

```
C*******************************************************************************
C
C                  INTEGRATED WATER FLOW MODEL (IWFM)
C                         *** Version 2015 ***
C
C*******************************************************************************
C
C                        ZONE DEFINITION INPUT FILE
C                     for IWFM Z-Budget Post-Processing
C
C
C             Project : IDC Version ### Release
C                       California Department of Water Resources
C             Filename: Zones_DAUs.dat
C
C*******************************************************************************
C
C                            File Description
C
C    This file contains zone definitions to be used with the Z-Budget post-processor.
C
C*******************************************************************************
C                            Zone Information
C
C    The following lists the zone numbers that the elements of the finite element
C    mesh belong to.  Element number, layer number (this information is
C    optional depending on the value of ZEXTENT above) and the zone number that
C    the element belongs to are required information. It is not necessary to list
C    all elements at all layers and assign a zone number to each of them.
C    By default, each element is given a zone number of -99.  Therefore, any elements
C    that are not listed below will constitute zone -99.
C
C    ** Note: If variable ZEXTENT below is set to 1, do not specify LAYER below. If
C             ZEXTENT is set to 0, it is required that LAYER for each element below
C             is specified.
C
C    ZEXTENT ; Extent of the the zone numbering
C                1 = Zone numbering is defined for horizontal plane and will be
C                     used for all layers
C                0 = Different zone numbering is specified for each layer
C    ZID     ; Zone number for which a name is defined
C    ZNAME   ; Name of each zone (maximum 50 characters)
C    IE      ; Element number
C    LAYER   ; Layer number at which element is located
C                *Leave blank if ZEXTENT = 1
C    ZONE    ; Zone number
C
C-------------------------------------------------------------------------------
C    VALUE                     DESCRIPTION
C-------------------------------------------------------------------------------
     1                         / ZEXTENT
C-------------------------------------------------------------------------------
C    ZID       ZNAME
C-------------------------------------------------------------------------------
       1       DAU_41
       2       DAU_139
       3       DAU_141
       .         .
       .         .
       .         .
      57       DAU_259
      58       DAU_260
      59       DAU_261
C-------------------------------------------------------------------------------
C     IE        LAYER       ZONE
C-------------------------------------------------------------------------------
      1                     3
      2                     5
      3                     5
      4                     5
      5                     5
      6                     5
      7                     3
      8                     5
      .                     .
      .                     .
      .                     .
   1385                    56
   1386                    59
   1387                    59
   1388                    56
   1389                    56
   1390                    59
   1391                    56
   1392                    56
```

11. Linking IDC to Other Models

The source code of IDC has been compiled into a dynamic link library (DLL) which is the IDC Application Programing Interface (API). The API exposes the procedures necessary to link IDC to other models.

When IDC is linked to other models it still requires the same input data files that are utilized when IDC is used as a stand-alone model. This means that some information that is used by the linking model may need to be re-structured in a format that IDC expects. For instance, the linking model may already be using precipitation data for other processes it simulates. Since IDC also requires precipitation as input the same or additional precipitation data needs to be re-structured into the format that IDC expects. Another information that needs to be redefined in a format that IDC requires is the configuration of the computational grid. If the linking model utilizes a finite-element grid, it is likely that the format of the grid configuration data for the linking model is in a different format than IDC requires. In this case, the grid configuration needs to be redefined in the format that IDC expects to read. Similarly, if the linking model utilizes a finite-difference grid, the grid configuration should be redefined as if it is a finite-element grid in the format that IDC expects.

To successfully link IDC to other models, the modeler needs to know the interfaces to the exported procedures in the IDC API. Next, the calling convention used in the IDC API, exported procedures and their interfaces are given.

11.1. Calling Conventions

IDC API is written using Fortran 2008 programming language. It is compiled for both 32-bit and 64-bit Microsoft Windows OS. The following approach and data standards are used in the API:

1. *stdcall* calling convention is used to allow the API procedures to be called from code written in Visual Basic for Applications (VBA). For instance, this is the case when the API procedures are called from MS Excel.

2. All procedure arguments are expected to be passed by reference.

3. To avoid possible stack overflows, heap memory is used.

4. All procedure arguments are C data types.

5. All real number arguments that appear in procedure interfaces are defined as C `double` type; i.e. as 64-bit (8-byte) arguments. In this document, a real type is denoted by **`REAL(C_DOUBLE)`**.

6. All integer arguments that appear in procedure interfaces are defined as C `int` type; i.e. as 32-bit (4-byte) arguments. In this document, an integer type is denoted by **`INTEGER(C_INT)`**.

7. The API allows passing arrays of real and integer arguments. This is accomplished by passing a reference to the first element of the array along with its size. Note that Fortran uses 1-based arrays and it uses column-major order (i.e. first array index changes the fastest) when ordering multi-dimensional arrays. Care must be taken when the API is called from languages that use 0-based arrays and row-major ordering.

8. When a scalar string argument is passed to an API procedure, it is received as an array of C `char` data type. Both the name of the argument and the number of characters in the string must be passed. In this document, a character type is denoted by **`CHARACTER(C_CHAR)`**.

11.2. Language-Specific Calling Mechanisms

In this section, mechanisms specific to different programming languages to call IDC API procedures will be explained. For this purpose, the following dummy procedures will be used to demonstrate how arguments with different data types are defined in the client programming language and how the API procedure is called. These procedures are included in the IDC API to test calling mechanisms with other programming languages. Please refer to section 11.4 for the description of these procedures and how to check if the tested calling mechanism works properly.

i. Scalar integer and real numbers (passed to or retrieved from API procedure):

```
SUBROUTINE fooScalar(iArg,dArg)
   INTEGER(C_INT) :: iArg
```

```
    REAL(C_DOUBLE) :: dArg
END SUBROUTINE fooScalar
```

ii. 1-dimensional integer and real arrays (passed to or retrieved from API procedure):

```
SUBROUTINE foo1DArray(iArrayDim,iArray,idArrayDim,dArray)
    INTEGER(C_INT) :: iArrayDim,idArrayDim
    INTEGER(C_INT) :: iArray(iArrayDim)
    REAL(C_DOUBLE) :: dArray(idArrayDim)
END SUBROUTINE foo1DArray
```

iii. 2-dimensional integer and real arrays (passed to or retrieved from API procedure):

```
SUBROUTINE foo2DArray(iDim1,iDim2,iArray,idDim1,idDim2,dArray)
    INTEGER(C_INT) :: iDim1,iDim2,idDim1,idDim2
    INTEGER(C_INT) :: iArray(iDim1,iDim2)
    REAL(C_DOUBLE) :: dArray(idDim1,idDim2)
END SUBROUTINE foo2DArray
```

iv. String scalar passed to API procedure:

```
SUBROUTINE fooStrPassed(iLen,cStrPassed)
    INTEGER(C_INT) :: iLen
    CHARACTER(C_CHAR),INTENT(IN) :: cStrPassed(iLen)
END SUBROUTINE fooStrPassed
```

v. String scalar received from the API procedure:

```
SUBROUTINE fooStrReceived(iLen,cStrRecvd)
    INTEGER(C_INT) :: iLen
    CHARACTER(C_CHAR),INTENT(OUT) :: cStrRecvd(iLen)
END SUBROUTINE fooStrReceived
```

11.2.1. Python

IDC API procedures are called from Python using the `ctypes` foreign function library. `windll` object exposed by `ctypes` is used to gain access to the API procedures using the *stdcall* calling convention.

```
import ctypes
IWFM_dll = ctypes.windll.LoadLibrary("D:\\IDC\\Bin\\IDC2015_x64.dll")
```

i. Scalar integer and real numbers:

```
iArg = ctypes.c_int(5)
dArg = ctypes.c_double(3.2)
```

```
IWFM_dll.fooScalar(ctypes.byref(iArg), ctypes.byref(dArg))
```

ii. 1-dimensional integer and real arrays:

```
iArrayDim = ctypes.c_int(10)
idArrayDim = ctypes.c_int(15)
iArray = (ctypes.c_int*iArrayDim.value)()
dArray = (ctypes.c_double*idArrayDim.value)()
IWFM_dll.foo1DArray(ctypes.byref(iArrayDim), iArray,  \
    ctypes.byref(idArrayDim), dArray)
```

iii. 2-dimensional integer and real arrays:

```
iDim1 = ctypes.c_int(5)
iDim2 = ctypes.c_int(10)
idDim1 = iDim1
idDim2 = iDim2
i2DArray = ((ctypes.c_int*iDim1.value)*iDim2.value)()
d2DArray = ((ctypes.c_double*idDim1.value)*idDim2.value)()
IWFM_dll.foo2DArray(ctypes.byref(iDim1), ctypes.byref(iDim2),  \
    i2DArray, ctypes.byref(idDim1), ctypes.byref(idDim2), d2DArray)
```

iv. String scalar passed to API procedure:

```
sString = ctypes.create_string_buffer(b"This is a test!")
iLen = ctypes.c_int(ctypes.sizeof(sString))
IWFM_dll.fooStrPassed(ctypes.byref(iLen), sString)
```

v. String scalar received from the API procedure:

```
iLen = ctypes.c_int(50)
sString = ctypes.create_string_buffer(iLen.value)
IWFM_dll.fooStrReceived(ctypes.byref(iLen), sString)
print(sString.value)
```

11.2.2. Java

IDC API procedures are accessed from Java using the Java Native Access (JNA) API. JNA provides two types of library mapping: direct and interface mapping. For efficiency, direct mapping is suggested. Individual procedures from the IDC API are accessed by mapping their signatures directly to a Java native method:

```
import com.sun.jna.Native;
import com.sun.jna.ptr.IntByReference;

public class IDC {

    static {
```

```
        Native.register("IDC2015_x64.dll");
    }

    public static native void fooScalar(IntByReference iArg,
                                        DoubleByReference dArg);
}
```

i. Scalar integer and real numbers (`IntByReference` and `DoubleByReference` classes from the JNA API are used):

```
public static native void fooScalar(IntByReference iArg,
                DoubleByReference dArg);

IntByReference iArg = new IntByReference(5);
DoubleByReference dArg = new DoubleByReference(3.2);
IWFM.fooScalar(iArg, dArg);
```

ii. 1-dimensional integer and real arrays (`IntByReference` class from the JNA API is used):

```
public static native void foo1DArray(IntByReference iArrayDim,
                                     int[] iArray,
                                     IntByReference idArrayDim,
                                     double[] dArray);

int[] iArray = new int[10];
double[] dArray = new double[15];
IntByReference iArrayDim = new IntByReference(iArray.length);
IntByReference idArrayDim = new IntByReference(dArray.length);
IWFM.foo1DArray(iArrayDim, iArray, idArrayDim, dArray);
```

iii. 2-dimensional integer and real arrays (the easiest way to pass a 2-dimensional array from Java to Fortran is to flatten it to a 1-dimensional array, keeping in mind that Fortran stores the arrays in column-major order; similarly, a 2-dimensional array can be received from Fortran as a 1-dimensional array and mapped to a 2-dimensional array):

```
public static native void foo2DArray(IntByReference iDim1,
                IntByReference iDim2,
                int[] iArray,
                IntByRference idDim1,
                IntByReference idDim2,
                double[] dArray);

int iDim1 = 5;
int iDim2 = 10;
int idDim1 = iDim1;
```

```
int idDim2 = iDim2;

IntByReference iRefDim1 = new IntByReference(iDim1);
IntByReference iRefDim2 = new IntByReference(iDim2);
IntByReference idRefDim1 = new IntByReference(idDim1);
IntByReference idRefDim2 = new IntByReference(idDim2);
int[] iArray = new int[iDim1*iDim2];
double[] dArray = new double[idDim1*idDim2];
IWFM.foo2DArray(iRefDim1, iRefDim2, iArray,
                idRefDim1, idRefDim2,dArray);

int iRow, iCol, indx;
int[][] i2DArray=new int[iDim1][iDim2];
indx = 0;
for (iCol=0; iCol < iDim2; iCol++)
     for (iRow=0; iRow < iDim1; iRow++) {
          i2DArray[iRow][iCol]=iArray[indx];
          indx++;
}

double[][] d2DArray =  new double[idDim1][idDim2];
indx = 0;
for (iCol=0; iCol < idDim2; iCol++)
     for (iRow=0; iRow < idDim1; iRow++) {
          d2DArray[iRow][iCol]=dArray[indx];
          indx++;
}
```

iv. String scalar passed to API procedure (`IntByReference` class from the JNA API is used):

```
public static native void fooStrPassed(IntByReference iLen,
                String sString);

String sString = "This is a test!";
IntByReference iLen = new IntByReference(sString.length());
IWFM.fooStrPassed(iLen, sString);
```

v. String scalar received from the API procedure (`IntByReference` class from the JNA API is used, the string is received as an array of `byte` and converted to Java String; make sure the string length parameter, `iLen`, is large enough to hold all the characters received):

```
public static native void fooStrReceived(IntByReference iLen,
                byte[] bStrRecvd);

IntByReference iLen = new IntByReference(50);
byte[] bss = new byte[iLen.getValue()];
IWFM.fooStrReceived(iLen, bss);
String ss = Native.toString(bss);
```

11.2.3. C#

IDC API procedures are accessed from C# using the `DllImportAttribute` class from the `System.Runtime.InteropServices` namespace.

```
using System.Runtime.InteropServices;
```

An example declaration of an IDC API procedure to be called from C# code is as follows:

```
const string cIDC2015_DLL = "D:\\IDC\\Bin\\IDC2015_x64.dll";
[DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "fooScalar",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void fooScalar(ref int iArg, ref double dArg);
```

i. Scalar integer and real numbers:

```
[DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "fooScalar",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void fooScalar(ref int iArg, ref double dArg);

int iArg = 5;
double dArg = 3.2;
fooScalar(ref iArg, ref dArg);
```

ii. 1-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure):

```
[DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "foo1DArray",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void foo1DArray(ref int iArrayDim, ref int iArray,
    ref int idArrayDim, ref double dArray);

int iArrayDim = 10;
int idArrayDim = 15;
int[] iArray = new int[iArrayDim];
double[] dArray = new double[idArrayDim];
```

```
foo1DArray(ref iArrayDim, ref iArray[0], ref idArrayDim, ref dArray[0]);
```

iii. 2-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure. Additionally, since the 2-dimensional arrays below are defined in row-major order, the dimensions must be reversed for proper operation with the IDCAPI; i.e. a 10×5 array in C# is transposed and represented as a 5×10 array in IDC API):

```
[DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "foo2DArray",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void foo2DArray(ref int iDim2, ref int iDim1,
    ref int i2DArray, ref int idDim2, ref int idDim1,
    ref double d2DArray);

int iDim1 = 5;
int iDim2 = 10;
int idDim1 = iDim1;
int idDim2 = iDim2;
int[,] i2DArray = new int[iDim2, iDim1];
double[,] d2DArray = new double[idDim2, idDim1];
foo2DArray(ref iDim1, ref iDim2, ref i2DArray[0,0], ref idDim1,
    ref idDim2, ref d2DArray[0,0]);
```

iv. String scalar passed to API procedure (note that when a `StringBuilder` argument that is already assigned a value is passed to an API procedure, the `Length` property is used to obtain its length in characters):

```
 [DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "fooStrPassed",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void fooStrPassed(ref int iLen,
    StringBuilder sString);

StringBuilder sString = new StringBuilder("This is a test!");
int iLen = sString.Length;
fooStrPassed(ref iLen, sString);
```

v. String scalar received from the API procedure (note that when a string argument is received from the API procedure, a `StringBuilder` variable with a long enough capacity is created and the `Capacity` property is used to define its length in characters):

```
[DllImport(cIDC2015_DLL,
    CallingConvention = CallingConvention.StdCall,
    EntryPoint = "fooStrReceived",
    CharSet = CharSet.Ansi,
    SetLastError = true,
    ExactSpelling = true)]
public static extern void fooStrReceived(ref int iLen,
    StringBuilder sString);

StringBuilder sString = new StringBuilder(50)
int iLen = sString.Capacity;
fooStrReceived(ref iLen, sString);
```

11.2.4. Visual Basic

IDC API procedures are accessed from Visual Basic using the `DllImportAttribute` class from the `System.Runtime.InteropServices` namespace.

```
Imports System.Runtime.InteropServices
```

An example declaration of an IDC API procedure to be called from Visual Basic code is as follows:

```
Const cIDC2015_DLL As String = "D:\IDC\Bin\IDC2015_x64.dll"
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="fooScalar",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling:=True)>
Sub fooScalar(ByRef iArg As Integer, ByRef dArg As Double)
End Sub
```

i. Scalar integer and real numbers:

```
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="fooScalar",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling:=True)>
Public Sub fooScalar(ByRef iArg As Integer, ByRef dArg As Double)
End Sub
```

```
Dim iArg As Integer = 5
Dim dArg As Double = 3.2
fooScalar(iArg, dArg)
```

ii. 1-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure):

```
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="foo1DArray",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling:=True)>
Public Sub foo1DArray(ByRef iArrayDim As Integer,
    ByRef iArray As Integer, ByRef idArrayDim As Integer,
    ByRef dArray As Double)
End Sub

Dim iArrayDim As Integer = 10
Dim idArrayDim As Integer = 15
Dim iArray(iArrayDim - 1) As Integer
Dim dArray(idArrayDim - 1) As Double
foo1DArray(iArrayDim, iArray(0), idArrayDim, dArray(0))
```

iii. 2-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure. Additionally, since the 2-dimensional arrays below are defined in row-major order, the dimensions must be reversed for proper operation with the IDC API; i.e. a 10×5 array in Visual Basic is transposed and represented as a 5×10 array in IDC API):

```
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="foo2DArray",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling:=True)>
Public Sub foo2DArray(ByRef iDim2 As Integer, ByRef iDim1 As Integer,
    ByRef i2DArray As Integer, ByRef idDim2 As Integer,
    ByRef idDim1 As Integer, ByRef d2DArray As Double)
End Sub

Dim iDim1 As Integer = 5
Dim iDim2 As Integer = 10
Dim idDim1 As Integer = iDim1
Dim idDim2 As Integer = iDim2
Dim i2DArray(iDim2 - 1, iDim1 - 1) As Integer
Dim d2DArray(idDim2 - 1, idDim1 - 1) As Double
foo2DArray(iDim1, iDim2, i2DArray(0, 0), idDim1, idDim2, d2DArray(0, 0))
```

iv. String scalar passed to API procedure (note that when a **StringBuilder** argument that is already assigned a value is passed to an API procedure, the `Length` property is used to obtain its length in characters):

```
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="fooStrPassed",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling=True)>
Public Sub fooStrPassed(ByRef iLen As Integer, sString As StringBuilder)
End Sub

Dim sString As New StringBuilder("This is a test!")
Dim iLen As Integer = sString.Length
fooStrPassed(iLen, sString)
```

v. String scalar received from the API procedure (note that when a string argument is received from the API procedure, a **StringBuilder** variable with a long enough capacity is created and the `Capacity` property is used to define its length in characters):

```
<DllImport(cIDC2015_DLL,
    CallingConvention:=CallingConvention.StdCall,
    EntryPoint:="fooStrReceived",
    CharSet:=CharSet.Ansi,
    SetLastError:=True,
    ExactSpelling:=True)>
Public Sub fooStrReceived(ByRef iLen As Integer, sString As StringBuilder)
End Sub

Dim sString As New StringBuilder(50)
Dim iLen As Integer = sString.Capacity
fooStrReceived(iLen, sString)
```

11.2.5. Visual Basic for Applications (VBA)

IDC API procedures are accessed from VBA using the `Declare` statement. An example declaration of an IDC API procedure to be called from VBA code is as follows:

```
Public Declare PtrSafe Sub fooScalar Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iArg As Long, ByRef dArg As Double)
```

i. Scalar integer and real numbers:

```
Public Declare PtrSafe Sub fooScalar Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iArg As Long, ByRef dArg As Double)
```

```
Dim iArg As Long
Dim dArg As Double
iArg = 5
dArg = 3.2
Call fooScalar(iArg, dArg)
```

ii. 1-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure):

```
Public Declare PtrSafe Sub foo1DArray Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iArrayDim As Long, ByRef iArray As Long, _
     ByRef idArrayDim As Long, ByRef dArray As Double)

Dim iArrayDim As Long
Dim idArrayDim As Long
Dim iArray() As Long
Dim dArray() As Double
iArrayDim = 10
idArrayDim = 15
ReDim iArray(iArrayDim - 1)
ReDim dArray(idArrayDim - 1)
Call foo1DArray(iArrayDim, iArray(0), idArrayDim, dArray(0))
```

iii. 2-dimensional integer and real arrays (note that only the reference to the first item of each array is passed to the API procedure):

```
Public Declare PtrSafe Sub foo2DArray Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iDim2 As Long, ByRef iDim1 As Long, ByRef i2DArray As Long, _
     ByRef idDim2 As Long, ByRef idDim1 As Long, _
     ByRef d2DArray As Double)

Dim iDim1 As Long
Dim iDim2 As Long
Dim idDim1 As Long
Dim idDim2 As Long
Dim i2DArray() As Long
Dim d2DArray() As Double
iDim1 = 5
iDim2 = 10
idDim1 = iDim1
idDim2 = iDim2
ReDim i2DArray(iDim1 - 1, iDim2 - 1)
ReDim d2DArray(idDim1 - 1, idDim2 - 1)
Call foo2DArray(iDim1, iDim2, i2DArray(0, 0), idDim1, _
                idDim2, d2DArray(0, 0)
```

iv. String scalar passed to API procedure:

```
Public Declare PtrSafe Sub fooStrPassed Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iLen As Long, ByVal sString As String)
```

```
Dim sString As String
Dim iLen As Long
sString = "This is a test!"
iLen = Len(sString)
Call fooStrPassed(iLen, sString)
```

v. String scalar received from the API procedure (note that when a string argument is received from the API procedure, a `String` variable with a long enough capacity is created):

```
Public Declare PtrSafe Sub fooStrReceived Lib "D:\IDC\Bin\IDC2015_x64.dll" _
    (ByRef iLen As Long, ByVal sString As String)

Dim sString As String
Dim iLen As Long
iLen = 50
sString = String(iLen, " ")
Call fooStrReceived(iLen, sString)
```

11.3. Pseudocode to Link a Model to IDC

For IDC to execute properly when linked to other models, it is necessary to invoke the procedures in the IDC API in a specific order. Below is a pseudocode describing the steps to instantiate, run and interact with an IDC model from a generic integrated hydrologic model (IHM) that simulates groundwater, lakes and stream flows. It is assumed that IDC and IHM are linked using an iterative approach until the flows between the two models converge within a given timestep. Although not mentioned in the following pseudocode, it is recommended that the error code returned with each IDC API procedure call is checked and, if the call was unsuccessful, `IDC_GetLastMessage` procedure is called to retrieve the error message.

i) Specify a text log file that IDC will use to print out messages during model execution (call `IDC_SetLogFile` procedure)

ii) Retrieve codes IDC uses to describe different model features (e.g. stream nodes, lakes, outside model domain, etc.) to be used in distributing IDC-computed land surface flows within the linked model domain (call `IDC_GetFlowDestTypeIDs` procedure)

iii) Retrieve codes IDC uses to describe different water supplies (i.e. groundwater pumping and stream diversions) to be used in meeting the computed water demands (call IDC_GetSupplyTypeIDs procedure)

iv) Initialize the IDC model by providing the filename for the IDC Main Input File (call IDC_New procedure)

v) Retrieve destination types and destination indices for land surface flows generated at each grid cell (call IDC_GetSurfaceFlowDestinations procedure)

vi) If needed, adjust the simulation timestep of the IDC model so that it is consistent with the simulation timestep of the calling model (call IDC_SetTimeStep procedure)

vii) Retrieve the number of demand calculation locations (call procedure IDC_GetNDemandLocations) and allocate memory for arrays that will hold agricultural and urban water demand calculated by IDC

viii) Turn the simulation of root water uptake from groundwater on or off (call IDC_SetSimulateGWUptake procedure); note that this procedure will overwrite the setting defined in the IDC model input parameters

ix) If root water uptake from groundwater will be simulated, specify the aquifer specific yield parameters at each IDC model cell (call IDC_SetSpecificYields procedure); note that this procedure will overwrite any specific yield values that are already specified through the IDC model input data files

x) Advance IDC simulation time one timestep forward (call IDC_AdvanceTime procedure)

xi) Read timeseries input data (call IDC_ReadTSData procedure)

xii) If root water uptake from groundwater is simulated, calculate the depth-to-groundwater values at each IDC grid cell and pass them to the IDC model (call IDC_SetDepthToGW procedure); note that this procedure will overwrite any depth-to-groundwater values that are already specified through the IDC model input data files

xiii) Compute agricultural and urban water demand (call IDC_ComputeWaterDemand procedure)

xiv) Retrieve agricultural and urban water demands (call IDC_GetWaterDemand_Ag and IDC_GetWaterDemand_Urb procedures)

xv) Retrieve flows that will affect stream flows in IHM (call IDC_GetFlowsToStreams procedure), lakes (call IDC_GetFlowsToLakes procedure) and the groundwater system (call IDC_GetPercAll and IDC_GetElementGWUptake procedures)

xvi) In IHM, simulate groundwater, stream flows, lakes as well as groundwater pumping and stream diversions that will be used to meet the water demand in the IDC model

xvii) Specify agricultural and urban water supplies for the IDC model based on the simulated groundwater pumping and stream diversions (call IDC_ZeroSupply procedure first, then call IDC_SetSupply_Ag and IDC_SetSupply_Urb procedures as many times as needed)

xviii) Specify the actual riparian evapotranspiration that the stream flows were able to provide (call IDC_SetActualRiparianET_AtStrmNodes procedure)

xix) Simulate land surface and root zone flows (call IDC_Simulate procedure)

xx) Retrieve flows computed by IDC that will affect streams, lakes and groundwater; compare them to those obtained in step *xiv*; if they are close enough (based on a predefined convergence criteria) go to next step, otherwise go to step *xiv*

xxi) Print out IDC simulation results (call IDC_PrintResults procedure)

xxii) Check if the end of the simulation period reached (call IDC_IsEndOfSimulation procedure); if end of simulation period is not reached, advance state of the IDC model in time (call IDC_AdvanceState procedure) and go to step *x*

xxiii) Clear memory and close all IDC-related files (call IDC_Kill and IDC_CloseLogFile procedures)

11.4. Procedure Interfaces

11.4.1. IDC_New

Given the name of the Main Control Data File, this procedure instantiates an IDC model.

```
SUBROUTINE IDC_New(iLenFileName,cMainFileName,iStat)
   INTEGER(C_INT),INTENT(IN) :: iLenFileName
   CHARACTER(C_CHAR),INTENT(IN) :: cMainFileName(iLenFileName)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_New
```

iLenFileName	:	Length of the name for the Main Control Data file.
cMainFileName	:	Name of the Main Control Data File
iStat	:	Error code; returns 0 if the procedure call was successful

11.4.2. IDC_Kill

This subroutine clears the memory associated with IDC and resets all IDC-related parameters.

```
SUBROUTINE IDC_Kill(iStat)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_Kill
```

iStat	:	Error code; returns 0 if the procedure call was successful

11.4.3. IDC_GetSupplyTypeIDs

This procedure returns the codes that IDC uses to define water supply types, pumping or diversions.

```
SUBROUTINE IDC_GetSupplyTypeIDs(iSupplyType_Pump,iSupplyType_Div,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iSupplyType_Pump,iSupplyType_Div,iStat
END SUBROUTINE IDC_GetSupplyTypeIDs
```

iSupplyType_Pump	:	Code that indicates that water supply is from groundwater pumping

`iSupplyType_Div` : Code that indicates that water supply is from stream diversions

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.4. IDC_GetFlowDestTypeIDs

This procedure retrieves all the codes that are used to indicate different types of model features as the destination of surface flows computed by IDC.

```
SUBROUTINE IDC_GetFlowDestTypeIDs(iFlowDestTypeID_Outside,             &
                      iFlowDestTypeID_StrmNode,                        &
                      iFlowDestTypeID_Element,iFlowDestTypeID_Lake,    &
                      iFlowDestTypeID_Subregion,iFlowDestTypeID_GWElement, &
                      iFlowDestTypeID_ElementSet,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iFlowDestTypeID_StrmNode,     &
                                 iFlowDestTypeID_Element,      &
                                 iFlowDestTypeID_Lake,         &
                                 iFlowDestTypeID_Subregion,    &
                                 iFlowDestTypeID_GWElement,    &
                                 iFlowDestTypeID_ElementSet,   &
                                 iStat
END SUBROUTINE IDC_GetFlowDestTypeIDs
```

`iFlowDestTypeID_Outside` : Code that indicates outside the model domain as the destination of flow from a hydrologic feature

`iFlowDestTypeID_StrmNode` : Code that indicates a stream node as the destination of flow from a hydrologic feature

`iFlowDestTypeID_Element` : Code that indicates a grid cell as the destination of flow from a hydrologic feature

`iFlowDestTypeID_Lake` : Code that indicates a lake as the destination of flow from a hydrologic feature

`iFlowDestTypeID_Subregion` : Code that indicates a subregion as the destination of flow from a hydrologic feature

`iFlowDestTypeID_GWElement` : Code that indicates groundwater at a grid cell as the destination of flow from a hydrologic feature

`iFlowDestTypeID_ElementSet` : Code that indicates a group of grid cells as the destination of flow from a hydrologic feature

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.5. IDC_GetCurrentDateAndTime

This procedure retrieves the date and time for which land surface and root zone flow processes are being simulated.

```
SUBROUTINE IDC_GetCurrentDateAndTime(iLen,cDateAndTime,iStat)
   INTEGER(C_INT),INTENT(IN) :: iLen
   CHARACTER(C_CHAR),INTENT(OUT) :: cDateAndTime(iLen)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetCurrentDateAndTime
```

`iLen` : Character length of the simulation date and time; a value of 16 is appropriate

`cDateAndTime` : Date and time for which land surface and root zone flow processes are being simulated; the format is MM/DD/YYY_hh:mm

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.6. IDC_GetNElements

This procedure returns the number of grid cells in the IDC model.

```
SUBROUTINE IDC_GetNElements(iNElements,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iNElements,iStat
END SUBROUTINE IDC_GetNElements
```

`iNElements` : Number of grid cells in the IDC model

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.7. IDC_GetElementIDs

This procedure returns the grid cell identification numbers in the IDC model.

```
SUBROUTINE IDC_GetElementIDs(iNElements,iElemIDs,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNElements
    INTEGER(C_INT),INTENT(OUT) :: iElemIDs(iNElements),iStat
END SUBROUTINE IDC_GetNElements
```

`iNElements`	:	Number of grid cells in the IDC model; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)
`iElemIDs`	:	Array of grid cell identification numbers
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.8. IDC_GetRatio_DestSupplyToRegionSupply_Ag

This procedure returns the ratio of the agricultural water demand at each demand location to the total agricultural water demand at the subregion that each demand location belongs to. These ratios can then be used to distribute subregional water supplies to specific demand locations within those subregions.

```
SUBROUTINE IDC_GetRatio_DestSupplyToRegionSupply_Ag(iNLocs,rRatio,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNLocs
    REAL(C_DOUBLE),INTENT(OUT) :: rRatio(iNLocs)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetRatio_DestSupplyToRegionSupply_Ag
```

`iNLocs`	:	Number of demand locations; this number can be obtained by calling `IDC_GetNDemandLocations` procedure (see section 11.4.15)
`rRatio`	:	Ratio of agricultural water demand at each demand location to the total agricultural water demand at the subregion that the demand location belongs to
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.9. IDC_GetRatio_DestSupplyToRegionSupply_Urb

This procedure returns the ratio of the urban water demand at each demand location to the total urban water demand at the subregion that each demand location belongs to. These ratios can then be used to distribute subregional water supplies to specific demand locations within those subregions.

```
SUBROUTINE IDC_GetRatio_DestSupplyToRegionSupply_Urb(iNLocs,rRatio,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNLocs
   REAL(C_DOUBLE),INTENT(OUT) :: rRatio(iNLocs)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetRatio_DestSupplyToRegionSupply_Urb
```

`iNLocs`	:	Number of demand locations; this number can be obtained by calling `IDC_GetNDemandLocations` procedure (see section 11.4.15)
`rRatio`	:	Ratio of urban water demand at each demand location to the total urban water demand at the subregion that the demand location belongs to
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.10. IDC_GetFlowsToStreams

This procedure returns the surface flows into each stream node in terms of return flows and rainfall runoff as well as the required outflow (actual amount is limited by the amount of actual flow in the stream) from each stream node due to riparian evapotranspiration at each stream node.

```
SUBROUTINE IDC_GetFlowsToStreams(iNStrmNodes,rRunoff,rReturnFlow, &
              rRipETReq,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNStrmNodes
   REAL(C_DOUBLE),INTENT(OUT) :: rRunoff(iNStrmNodes),     &
                                 rReturnFlow(iNStrmNodes), &
                                 rRipETReq(iNStrmNodes)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetFlowsToStreams
```

`iNStrmNodes`	:	Number of stream nodes simulated in the system
`rRunoff`	:	Rainfall runoff into each stream node as calculated by IDC
`rReturnFlow`	:	Sum of agricultural and urban return flow into each stream node as calculated by IDC

`rRipETReq` : Required outflow from each stream node to meet the riparian evapotranspirative demand

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.11. IDC_GetFlowsToLakes

This procedure returns the surface flows into each lake in terms of return flows and rainfall runoff.

```
SUBROUTINE IDC_GetFlowsToLakes(iNLakes,rRunoff,rReturnFlow,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNLakes
   REAL(C_DOUBLE),INTENT(OUT) :: rRunoff(iNLakes),     &
                                 rReturnFlow(iNLakes)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetFlowsToLakes
```

`iNLakes` : Number of lakes simulated in the system

`rRunoff` : Rainfall runoff into each lake as calculated by IDC

`rReturnFlow` : Sum of agricultural and urban return flow into each lake as calculated by IDC

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.12. IDC_GetPercElement

This procedure is used to retrieve percolation at a specific cell of the computational grid.

```
SUBROUTINE IDC_GetPercElement(iElem,rPerc,iStat)
   INTEGER(C_INT),INTENT(IN) :: iElem
   REAL(C_DOUBLE),INTENT(OUT) :: rPerc
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetPercElement
```

`iElem` : Index of the grid cell for which the percolation is retrieved; note that grid cell identification (ID) number defined in an IDC model can be different than the index within the array used by IDC to store grid cell information; procedure `IDC_GetElementIDs` (see section 11.4.7) can be used to retrieve the list of cell ID numbers and to convert a cell ID number to its corresponding index

`rPerc` : Percolation at grid cell iElem computed by IDC

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.13. IDC_GetPercAll

This procedure is used to retrieve the percolation computed at all elements of the computational grid. These values can be used by the calling simulation model as the recharge to the groundwater.

```
SUBROUTINE IDC_GetPercAll(iNElements,rPerc,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNElements
   REAL(C_DOUBLE),INTENT(OUT) :: rPerc(iNElements)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetPercAll
```

`iNElements` : Number of cells in the computational grid; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.511.4.4)

`rPerc` : Percolation at every cell computed by IDC

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.14. IDC_GetElementGWUptake

This procedure returns the actual amount of groundwater that is used to meet the plant evapotranspirative demand at each grid cell. These values can be used as sink terms in groundwater simulations.

```
SUBROUTINE IDC_GetElementGWUptake(iNElements,rGWUptake,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNElements
   REAL(C_DOUBLE),INTENT(OUT) :: rGWUptake(iNElements)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetElementUptake
```

`iNElements` : Number of cells in the computational grid; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)

`rGWUptake` : Actual amount of groundwater that is used to meet the plant evapotranspirative need at each cell

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.15. IDC_GetNDemandLocations

This function returns the number of computational locations where demand is calculated. This procedure will currently return either the number of subregions or the number of finite element cells used in the model, depending on the Root Zone simulation component used.

```
SUBROUTINE IDC_GetNDemandLocations(iNLocs,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iNLocs,iStat
END SUBROUTINE IDC_GetNDemandLocations
```

`iNLocs` : Number of locations (number of cells or subregions) where water demand is computed

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.16. IDC_GetWaterDemand_Ag

This procedure retrieves the agricultural water demand at each demand location (grid cell or subregion, depending on the version of the Root Zone simulation component used). These demands can be used by the linking model to compute diversions and groundwater pumping.

```
SUBROUTINE IDC_GetWaterDemand_Ag(iNLocations,rDemand,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNLocations
   REAL(C_DOUBLE),INTENT(OUT) :: rDemand(iNLocations)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetWaterDemand_Ag
```

`iNLocations` : Number of water demand calculation locations; this value can be retreived by calling procedure `IDC_GetNDemandLocations` (see section 11.4.15)

`rDemand` : Agricultural water demand at each demand location computed by IDC

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.17. IDC_GetWaterDemand_Urb

This procedure retrieves the urban water demand at each demand location (grid cell or subregion, depending on the version of the Root Zone simulation component used). These demands can be used by the linking model to compute diversions and groundwater pumping.

```
SUBROUTINE IDC_GetWaterDemand_Urb(iNLocations,rDemand,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNLocations
   REAL(C_DOUBLE),INTENT(OUT) :: rDemand(iNLocations)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetWaterDemand_Urb
```

`iNLocations` : Number of water demand calculation locations; this value can be retreived by calling procedure `IDC_GetNDemandLocations` (see section 11.4.15)

`rDemand` : Urban water demand at each demand location computed by IDC

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.18. IDC_GetElementAreas_Ag

This procedure retrieves the agricultural areas at each grid cell.

```
SUBROUTINE IDC_GetElementAreas_Ag(iNElements,rAreas,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNElements
   REAL(C_DOUBLE),INTENT(OUT) :: rAreas(iNElements)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetElementAreas_Ag
```

`iNElements`	:	Number of cells in the computational grid; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)
`rAreas`	:	Agricultural areas at each grid cell
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.19. IDC_GetElementAreas_Urb

This procedure retreives the urban areas at each grid cell.

```
SUBROUTINE IDC_GetElementAreas_Urb(iNElements,rAreas,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNElements
    REAL(C_DOUBLE),INTENT(OUT) :: rAreas(iNElements)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetElementAreas_Urb
```

`iNElements`	:	Number of cells in the computational grid; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)
`rAreas`	:	Urban areas at each grid cell
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.20. IDC_GetSurfaceFlowDestinations

This procedure returns the destination type IDs and the indices for the destination of surface flows generated at each grid cell.

```
SUBROUTINE IDC_GetSurfaceFlowDestinations(iNElements,iDestTypes,iDest,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNElements
    INTEGER(C_INT),INTENT(OUT) :: iDestTypes(iNElements),  &
                                  iDest(iNElements),iStat
END SUBROUTINE IDC_GetSurfaceFlowDestinations
```

`iNElements`	:	Number of cells in the computational grid; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)

`iDestTypes` : Codes for the surface flow destinations for each grid cell; codes used by iDC to identify different flow destination types can be obtained by calling `IDC_GetFlowDestTypeIDs` (see section 11.4.4)

`iDest` : Indices for surface flow destinations for each grid cell

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.21. IDC_GetLastMessage

This procedure is used to retrieve the error message in case a procedure call from IDC API returns an error code (`iStat`) other than 0.

```
SUBROUTINE IDC_GetLastMessage(iLen,cErrorMessage,iStat)
    INTEGER(C_INT),INTENT(IN) :: iLen
    CHARACTER(C_CHAR),INTENT(INOUT) :: cErrorMessage(iLen)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetLastMessage
```

`iLen` : Character length of the error message; a value of 500 is appropriate

`cErrorMessage` : Error message that is generated by the IDC API procedure that was unsuccessfully called last

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.22. IDC_GetVersion

This subroutine returns the version number of IDC as well as the version numbers all components it is linked to.

```
SUBROUTINE IDC_GetVersion(iLenVersion,cVersion,iStat)
    INTEGER(C_INT),INTENT(IN) :: iLenVersion
    CHARACTER(C_CHAR),INTENT(OUT) :: cVersion(iLenVersion)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_GetVersion
```

`iLenVersion` : Maximum length of the version number in terms of characters; a value of 1000 is recomended `cVersion` : Version number of IDC and all of its components

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.23. IDC_GetActiveRootZoneVersion

This function returns the version number of the active root zone component that is being used in the simulation as an integer (e.g. it returns 40 if root zone component version 4.0 is being used).

```
SUBROUTINE IDC_GetActiveRootZoneVersion(iVersion,iStat)
    INTEGER(C_INT),INTENT(OUT) :: iVersion,iStat
END SUBROUTINE IDC_GetActiveRootZoneVersion
```

`iVersion` : Version number of the active root zone component being used for the simulation

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.24. IDC_SetTimeStep

This subroutine sets the timestep to be used in IDC model and adjusts the time units initially defined for IDC parameters. It can be used when IDC is linked to another model and that model's simulation timestep is different than that of IDC's, which was initially defined in the Main Control Data File. This procedure must be called right after the IDC model is initiated with the `IDC_New` (see section 11.4.1) procedure.

```
SUBROUTINE IDC_SetTimeStep(iLenNewUnit,cNewUnit,iStat)
    INTEGER(C_INT),INTENT(IN) :: iLenNewUnit
    CHARACTER(C_CHAR),INTENT(IN) :: cNewUnit(iLenNewUnit)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetTimeStep
```

`iLenNewUnit` : Character length of the simulation timestep; for instance, if simulation timestep is '`1DAY`', then `iLenNewUnit` is 4 (i.e. number of characters in '`1DAY`')

`cNewUnit` : Simulation timestep; allowbale timesteps are

i. "1MIN"

ii. “2MIN”

iii. “3MIN”

iv. “4MIN”

v. “5MIN”

vi. “10MIN”

vii. “15MIN”

viii. “20MIN”

ix. “30MIN”

x. “1HOUR”

xi. “2HOUR”

xii. “3HOUR”

xiii. “4HOUR”

xiv. “6HOUR”

xv. “8HOUR”

xvi. “12HOUR”

xvii. “1DAY”

xviii. “1WEEK”

xix. “1MON”

xx. “1YEAR”

iStat : Error code; returns 0 if the procedure call was successful

11.4.25. IDC_SetSimulateGWUptake

This procedure informs the IDC model if groundwater uptake in meeting part or all of the water demand will be simulated or not. If groundwater uptake will be simulated, either the relevant input data (aquifer specific yield, depth-to-groundwater timeseries data, etc.) must be provided as part of the IDC model or must be supplied to the IDC model via relevant procedure calls.

```
SUBROUTINE IDC_SetSimulateGWUptake(iSimGWUptake,iStat)
   INTEGER(C_INT),INTENT(IN) :: iSimGWUptake
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetSimulateGWUptake
```

`iSimGWUptake` : Flag to specify if groundwater uptake will be simulated; 0 = groundwater uptake will not be simulated, 1= groundwater uptake will be simulated

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.26. IDC_SetSpecificYields

This procedure sets the value of aquifer specific yield at each model cell to be used in simulating the groundwater uptake. If these values are already supplied through the Depth-to-Groundwater input data file of the IDC model, they will be overwritten by the values provided with this procedure. Note that simulation of groundwater uptake is optional, so this procedure needs to be called only when groundwater uptake is simulated.

```
SUBROUTINE IDC_SetSpecificYields(iNElements,rSys,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNElements
   REAL(C_DOUBLE),INTENT(IN) :: rSys(iNElements)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetSimulateGWUptake
```

`iNElements` : Number of grid cells in the IDC model; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)

`rSys` : Specific yield values at each model cell; these values will overwrite those that are specified, if at all, through the Depth-to-Groundwater input data file

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.27. IDC_SetDepthToGW

This procedure sets the value of depth-to-groundwater-table at each model cell to be used in simulating the groundwater uptake. If these values are already supplied through the Depth-to-Groundwater input data file of the IDC model, they will be overwritten by the values provided with this procedure. Note that simulation of groundwater uptake is optional, so this procedure needs to be called only when groundwater uptake is simulated.

```
SUBROUTINE IDC_SetDepthToGW(iNElements,rDepthToGW,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNElements
    REAL(C_DOUBLE),INTENT(IN) :: rDepthToGW(iNElements)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetDepthToGW
```

`iNElements`	:	Number of grid cells in the IDC model; this value can be obtained by calling procedure `IDC_GetNElements` (see section 11.4.5)
`rDepthToGW`	:	Depth-to-groundwater-table at each model cell; these values will overwrite those that are specified, if at all, through the Depth-to-Groundwater input data file
`iStat`	:	Error code; returns 0 if the procedure call was successful

11.4.28. IDC_SetSupply_Ag

This procedure sets the agricultural water supply to each demand location (element or subregion, based on the version of the Root Zone simulation component used). The source of water supply can be either stream diversions or groundwater pumping. Water supply can be assigned to each element or to each subregion. If the supply is assigned to each subregion than IDC distributes the subregional water supply to individual elements in proportion to the agricultural water demand at each element in the subregion. This procedure can be called multiple times to represent a mixture of pumping and diversions to elements or subregions. When the procedure is called multiple times, IDC accumulates supplies to elements.

```
SUBROUTINE IDC_SetSupply_Ag(iNLocs,rSupply,iSupplyType,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNLocs,iSupplyType
    REAL(C_DOUBLE),INTENT(IN) :: rSupply(iNLocs)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetSupply_Ag
```

`iNLocs`	:	Number of demand calculation locations;this value can be obtained by calling procedure `IDC_GetNDemandLocations` (see section 11.4.15)

`rSupply` : Agricultural water supply to each element or subregion

`iSupplyType` : Supply type (pumping or diversions) identification number; supply identification numbers for diversions and pumping used by IDC can be obtained by calling procedure `IDC_GetSupplyTypeIDs` (see section 11.4.3)

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.29. IDC_SetSupply_Urb

This procedure sets the urban water supply to each demand location (element or subregion, based on the version of the Root Zone simulation component used). The source of water supply can be either stream diversions or groundwater pumping. Water supply can be assigned to each element or to each subregion. If the supply is assigned to each subregion, then IDC distributes the subregional water supply to individual elements in proportion to the urban water demand at each element in the subregion. This procedure can be called multiple times to represent a mixture of pumping and diversions to elements or subregions. When the procedure is called multiple times, IDC accumulates supplies to elements.

```
SUBROUTINE IDC_SetSupply_Urb(iNLocs,rSupply,iSupplyType,iStat)
   INTEGER(C_INT),INTENT(IN) :: iNLocs,iSupplyType
   REAL(C_DOUBLE),INTENT(IN) :: rSupply(iNLocs)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetSupply_Urb
```

`iNLocs` : Number of demand calculation locations;this value can be obtained by calling procedure `IDC_GetNDemandLocations` (see section 11.4.15)

`rSupply` : Urban water supply to each element or subregion

`iSupplyType` : Supply type (pumping or diversions) identification number; supply identification numbers for diversions and pumping used by IDC can be obtained by calling procedure `IDC_GetSupplyTypeIDs` (see section 11.4.3)

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.30. IDC_SetActualRiparianET_AtStrmNodes

This procedure specifies the actual outflow from each stream node to meet riparian evapotranspirative demand after stream flows are simulated.

```
SUBROUTINE IDC_SetActualRiparianET_AtStrmNodes(iNStrmNodes,rRipETFrac,iStat)
    INTEGER(C_INT),INTENT(IN) :: iNStrmNodes
    REAL(C_DOUBLE),INTENT(IN) :: rRipETFrac(iNStrmNodes)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_SetActualRiparianET_AtStrmNodes
```

iNStrmNodes	:	Number of stream nodes simulated in the system
rRipETFrac	:	Ratio of the actual riparian evapotranspiration from each stream node to the required riparian evapotranspiration
iStat	:	Error code; returns 0 if the procedure call was successful

11.4.31. IDC_SetLogFile

This procedure creates a text log file for IDC API to print out error and warning messages.

```
SUBROUTINE IDC_SetLogFile(iLen,cFileName,iStat)
    INTEGER(C_INT),INTENT(IN) :: iLen
    CHARACTER(C_CHAR),INTENT(IN) :: cFileName(iLen)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END FUNCTION IDC_SetLogFile
```

iLen	:	Character length of the log filename
cFileName	:	Log filename
iStat	:	Error code; returns 0 if the procedure call was successful

11.4.32. IDC_CloseLogFile

This procedure closes the log file opened for IDC API to print out error and warning messages.

```
SUBROUTINE IDC_CloseLogFile(iStat)
    INTEGER(C_INT),INTENT(OUT) :: iStat
```

```
END SUBROUTINE IDC_CloseLogFile
```

iStat : Error code; returns 0 if the procedure call was successful

11.4.33. IDC_AdvanceTime

This procedure advances the time step for IDC and generates the new time stamp using the simulation time interval. The new time stamp is used to locate and read data from the time-series input data files and to decide if end of simulation period has been reached.

```
SUBROUTINE IDC_AdvanceTime(iStat)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_AdvanceTime
```

iStat : Error code; returns 0 if the procedure call was successful

11.4.34. IDC_ReadTSData

This procedure reads data from time-series input files for the corresponding time step in the simulation.

```
SUBROUTINE IDC_ReadTSData(iStat)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_ReadTSData
```

iStat : Error code; returns 0 if the procedure call was successful

11.4.35. IDC_ComputeWaterDemand

This procedure computes applied water demand for ponded and non-ponded agricultural crops as well as for urban areas. It also incorporates the effect of groundwater uptake, if simulated, on the water demand.

```
SUBROUTINE IDC_ComputeWaterDemand(iStat)
   INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_ComputeWaterDemand
```

iStat : Error code; returns 0 if the procedure call was successful

11.4.36. IDC_ZeroSupply

This procedure resets the water supply to each element to zero.

```
SUBROUTINE IDC_ZeroSupply(iStat)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_ZeroSupply
```

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.37. IDC_Simulate

This procedure simulates the root zone and land surface flow processes.

```
SUBROUTINE IDC_Simulate(iStat)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_Simulate
```

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.38. IDC_PrintResults

This procedure prints out the simulation results at the end of each timestep to the ouput files.

```
SUBROUTINE IDC_PrintResults(iStat)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_PrintResults
```

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.39. IDC_AdvanceState

This procedure advances the state of the root zone in time. The flow rates that are computed at the end of the time step are labeled as flow rates at the beginning of the next time step.

```
SUBROUTINE IDC_AdvanceState(iStat)
    INTEGER(C_INT),INTENT(OUT) :: iStat
END SUBROUTINE IDC_AdvanceState
```

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.40. IDC_IsEndOfSimulation

This procedure checks if the end of simulation period has been reached.

```
SUBROUTINE IDC_IsEndOfSimulation(iEndOfSimulation,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iEndOfSimulation,iStat
END SUBROUTINE IDC_IsEndOfSimulation
```

`iEndOfSimulation` : 1 if end of simulation period has been reached; 0 otherwise

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.41. IDC_IsLandUseUpdated

This procedure checks if the land-use areas have already been read from the input data file and updated.

```
SUBROUTINE IDC_IsLandUseUpdated(iUpdated,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iUpdated,iStat
END SUBROUTINE IDC_IsLandUseUpdated
```

`iUpdated` : 1 if the land-use areas are already updated; 0 if they are not yet updated

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.42. IDC_IsRootZoneDefined

This function checks if the root zone component has been instantiated.

```
SUBROUTINE IDC_IsRootZoneDefined(iDefined,iStat)
   INTEGER(C_INT),INTENT(OUT) :: iDefined,iStat
END SUBROUTINE IDC_IsRootZoneDefined
```

`iDefined` : Flag to check if the root zone has been instantiated; a value of 0 means it has not been instantiated and a value of 1 means it has been instantiated

`iStat` : Error code; returns 0 if the procedure call was successful

11.4.43. fooScalar

This procedure can be used to test the calling mechanisms used by a client software in passing or retrieving scalar integer and real numbers to and from the IDC API.

```
SUBROUTINE fooScalar(iArg,dArg)
   INTEGER(C_INT),INTENT(INOUT) :: iArg
   REAL(C_DOUBLE),INTENT(INOUT) :: dArg
END SUBROUTINE fooScalar
```

`iArg` : Integer argument; if calling of this procedure from a client software is successful, `iArg` will be modified by multiplying its original value by 2 (i.e. if passed `iArg` = 2, retrieved `iArg` = 4)

`dArg` : Real argument; if calling of this procedure from a client software is successful, `dArg` will be modified by multiplying its original value by 2 (i.e. if passed `dArg` = 2.0, retrieved `dArg` = 4.0)

11.4.44. foo1DArray

This procedure can be used to test the calling mechanisms used by a client software in passing or retrieving one-dimensional integer and real arrays to and from the IDC API.

```
SUBROUTINE foo1DArray(iArrayDim,iArray,idArrayDim,dArray)
   INTEGER(C_INT),INTENT(IN) :: iArrayDim,idArrayDim
   INTEGER(C_INT),INTENT(INOUT) :: iArray(iArrayDim)
   REAL(C_DOUBLE),INTENT(INOUT) :: dArray(idArrayDim)
END SUBROUTINE foo1DArray
```

`iArrayDim` : Dimension of the integer array, `iArray`

`iArray` : Integer array; if calling of this procedure from a client software is successful, all components of the integer array will have a value of 5 `dArrayDim` : Dimension of the real array, `dArray`

`dArray` : Real array; if calling of this procedure from a client software is successful, all components of the real array will have a value of 3.2

11.4.45. foo2DArray

This procedure can be used to test the calling mechanisms used by a client software in passing or retrieving two-dimensional integer and real arrays to and from the IDC API. When calling this procedure, care must be taken if the client software uses row-major ordering of multi-dimensional arrays (Fortran uses column-major ordering).

```
SUBROUTINE foo2DArray(iDim1,iDim2,iArray,idDim1,idDim2,dArray)
    INTEGER(C_INT),INTENT(IN) :: iDim1,iDim2,idDim1,idDim2
    INTEGER(C_INT),INTENT(INOUT) :: iArray(iDim1,iDim2)
    REAL(C_DOUBLE),INTENT(INOUT) :: dArray(idDim1,idDim2)
END SUBROUTINE foo2DArray
```

`iDim1` : Number of rows of the integer array, `iArray`; i.e. the size of its first dimension

`iDim2` : Number of columns of the integer array, `iArray`; i.e. the size of its second dimension

`iArray` : Integer array; if calling of this procedure from a client software is successful, all columns will have the associated row number (e.g. all columns in the first row will have the value 1, all columns in the second row will have the value 2, etc.)

`idDim1` : Number of rows of the real array, `dArray`; i.e. the size of its first dimension

`idDim2` : Number of columns of the real array, `dArray`; i.e. the size of its second dimension

`dArray` : Real array; if calling of this procedure from a client software is successful, all columns will have the associated row number (e.g. all columns in the first row will have the value 1.0, all columns in the second row will have the value 2.0, etc.)

11.4.46. fooStrPassed

This procedure can be used to test the calling mechanisms used by a client software in passing a string variable to the IDC API. The API does not modify the value of this variable.

```
SUBROUTINE fooStrPassed(iLen,cStrPassed)
   INTEGER(C_INT),INTENT(IN) :: iLen
   INTEGER(C_CHAR),INTENT(IN) :: cStrPassed(iLen)
END SUBROUTINE fooStrPassed
```

`iLen` : Character length of the passed string variable, `cStrPassed`

`cStrPassed` : String variable with a character length of `iLen` that is passed to the API; if calling of this procedure from a client software is successful, the API creates a new text file with the name *IW_API_Test.txt* and prints the value of `cStrPassed` to this file

11.4.47. fooStrReceived

This procedure can be used to test the calling mechanisms used by a client software in retrieving a string variable to the IDC API.

```
SUBROUTINE fooStrReceived(iLen,cStrRecvd)
   INTEGER(C_INT),INTENT(IN) :: iLen
   INTEGER(C_CHAR),INTENT(OUT) :: cStrRecvd(iLen)
END SUBROUTINE fooStrReceived
```

`iLen` : Character length of the string variable, `cStrRecvd`; its value should be 21 or more

`cStrRecvd` : String variable with a character length of `iLen` that is returned to the client software; if calling of this procedure from a client software is successful, this variable will return with a value `'This is another test!'`

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APPENDIX E

GROUNDWATER STORAGE TECHNICAL MEMORANDUM

14 October 2021

TECHNICAL MEMORANDUM

To: Tom Rooze, PG, Zone 7 Water Agency (Zone 7)
Ken Minn, PE, Zone 7
Colleen Winey, PG, Zone 7
Carol Mahoney, PG, Zone 7

From: Anona Dutton, PG, CHg, EKI Environment & Water, Inc. (EKI)
Aaron Lewis, EIT, EKI
Nigel Chen, PhD, EKI

Subject: **Evaluation of Groundwater Storage Depletion Under Water Level Sustainability Criteria**
(EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to provide to Zone 7 Water Agency (Zone 7) with this technical memorandum (TM) presenting: (1) estimates of the total, baseline, and recent (Fall 2015 – Fall 2020) usable groundwater storage in the Livermore Valley Groundwater Basin (Basin); and (2) an evaluation of the protectiveness of Zone 7's proposed Sustainable Management Criteria (SMCs) for the Chronic Lowering of Groundwater Levels Sustainability Indicator (SI) and for use as a proxy for the Reduction of Groundwater Storage SI. The sole purpose of the estimates and evaluation is to verify the effectiveness of use of the groundwater level as the proxy for these SMCs. It should be noted that considering the generalization and included assumptions, these calculated values are meant for relative comparison but not to be considered as absolute values. The most accurate storage values should be calculated using a properly calibrated numerical groundwater flow model.

BACKGROUND AND METHODOLOGY

Pursuant to Title 23, Section 358.2(a) of the California Code of Regulations (23-CCR §358.2(a)), Groundwater Sustainability Agencies (GSAs) with an approved Alternative Groundwater Sustainability Plan (Alt GSP or Plan) must resubmit an updated Plan to the California Department of Water Resources (DWR) every five years. As part of the five-year update process to the 2016 Alt GSP, Zone 7 contracted with EKI to evaluate and develop SMCs for the Reduction of Groundwater Storage SI.

Pursuant to the GSP Emergency Regulations (23 CCR § 354.28(d)) and as further described in the DWR Sustainable Management Criteria Best Management Practices #6[1], Minimum Thresholds (MTs) for the Reduction of Groundwater Storage SI may be set using groundwater levels as a proxy if it is demonstrated

[1] DWR 2017, Sustainable Management Criteria Best Management Practices, dated November 2017, 38 pp.

that a correlation exists between the two metrics and if the MTs for Chronic Lowering of Groundwater Levels are sufficiently protective to ensure prevention of significant and unreasonable occurrences.

To demonstrate that the updated MTs for Chronic Lowering of Groundwater Levels developed by Zone 7 as part of the 2022 Alt GSP are sufficiently protective, a calculation was performed to estimate the volume of groundwater that would be removed from storage in the Principal Aquifer units if groundwater levels were to decline from SGMA Baseline (i.e., Fall 2015) levels to their respective MTs for Chronic Lowering of Groundwater Levels. This volume is then compared to the volume of Total Usable Storage within applicable Management Areas of the Basin, which is defined as the available groundwater storage calculated at historic high water level conditions.[2] Based on the analysis presented herein, the Total Usable Storage in the Basin will not be significantly impacted, even at the MTs, indicating that the MTs for Chronic Lowering of Groundwater Levels are protective for the Reduction of Groundwater Storage SI.

EVALUATION OF TOTAL USABLE GROUNDWATER STORAGE

As described in EKI's TM entitled *Progress Update on Extending Existing Hydrogeologic Framework* (dated 02 April 2021), EKI developed a three-dimensional (3D) representation of the Principal Aquifer units within the Basin using the Rockworks[3] geologic software program. The Principal Aquifer units within the Basin are described in detail in EKI's TM entitled *Geologic Cross-Sections for 2022 Alternative Groundwater Sustainability Plan* (dated 07 June 2021). As described in that TM, the Rockworks model extends to the base of the "usable" aquifer system (i.e., where the deepest wells in the Basin are constructed within the Upper Livermore Formation).

As part of the current effort, EKI extracted a series of rasters delineating the top and bottom elevations of each Principal Aquifer unit mapped in the Rockworks model. The base of each Principal Aquifer unit was compared to surfaces of historic high groundwater elevations previously created by Zone 7 staff to define the maximum saturated aquifer thicknesses historically encountered within the Basin. These saturated aquifer thicknesses were then multiplied by spatially variable storage coefficients previously developed by Zone 7 staff (for the Main Basin)[4] or otherwise estimated based on best available information (for the Fringe Management Area)[5] to support calculations of "Total Usable Storage" volumes within each Management Area of the Basin. Here the Total Usable Storage is defined as the available groundwater storage at historic high water level conditions observed within the Basin. This calculation is shown in the equation below:

$$Total\_Usable\_Storage_{i,j} = \sum_{k=1}^{n} Sat\_Aq\_thickness_{Historic\ High_{i,j,k}} * A_k * S_k$$

---

[2] The Basin is divided into three Management Areas (Main, Fringe, and Upland). The Upland Management area is not considered in this analysis as there are insufficient monitoring wells and groundwater elevation data available to inform comparisons of water level surfaces over time.

[3] RockWorks 2020 Standard Level License from RockWare is downloaded and installed on 15 October 2020: https://www.rockware.com/product/rockworks/

[4] Storage coefficients were provided by Zone 7 at a node level based on the nodes included in DWR's Bulletin 118 groundwater model of the Basin (DWR 1974).

[5] Given the uncertainty in aquifer properties in the Fringe Management Areas, both upper and lower bound storage coefficients were used to present a reasonable range in available groundwater storage.

where:

$Total\_Usable\_Storage_{i,j}$ is the Total Usable Storage (in acre-feet [AF]) for aquifer unit "i" in Management Area "j" based on historic high water level conditions

$Sat\_Aq\_thickness_{Historic\ High_{i,j,k}} = GWE_{Historic\ High_{i,j,k}} - Aq\_bottom_{i,j,k}$

$GWE_{Historic\ High_{i,j,k}}$ is the historic high groundwater elevation in aquifer unit "i" and Management Area "j" at node "k"

$Aq\_bottom_{i,j,k}$ the bottom elevation of aquifer unit "i" in Management Area "j" at node "k"

A_k is the area (acres) of node "k", and

S_k is the storage coefficient (dimensionless) at node "k"

A summary of the Total Usable Storage estimates (in units of thousand acre-feet [TAF]) for each Principal Aquifer unit and applicable Management Area is presented in **Table 1** below. Here the Upper Livermore Formation portion of the Lower Aquifer Principal Aquifer unit is presented distinctly (herein referred to as the "Livermore Aquifer") in order to maintain consistency with the delineation of the Lower Aquifer in the Zone 7's existing storage estimation method (i.e., the "Nodal method", see **Attachments A and B**).

Table 1. Total Usable Groundwater Storage Estimates

Management Area	Principal Aquifer Unit	Total Usable Storage (TAF)
Main Basin	Upper Aquifer[6]	94 - 157 TAF
	Lower Aquifer[7]	102 - 127 TAF
	Livermore Aquifer[8,9]	87 – 174 TAF
North Fringe	Fringe Aquifer[9]	75 – 134 TAF
Northeast Fringe	Fringe Aquifer[9]	24 – 47 TAF
East Fringe	Fringe Aquifer[9]	0.3 – 0.6 TAF
TOTAL		382 – 640 TAF

The raster-based groundwater storage estimation method described above is subject to certain limitations, including: (1) uncertainty in Principal Aquifer unit extents and thicknesses; (2) uncertainty in aquifer storage properties (i.e., specific yield and storativity) and their spatial variability within each Principal Aquifer unit; and (3) lack of ability to calculate groundwater storage reserves in recharge ponds (e.g., the Chain of Lakes mining pits). As such, the estimated groundwater storage volumes are presented as a range that reflects: (1) in the Main Basin, the lower and upper bound estimates of groundwater storage calculated from the Rockworks surfaces versus Zone 7's Nodal method; or (2) in the Fringe

[6] The upper end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B.**
[7] The lower end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B**.
[8] The range reflects a variability in the specific yield storage coefficient of 0.025 – 0.05.
[9] Here the Upper Livermore Formation portion of the Lower Aquifer unit is presented distinctly (i.e., "Livermore Aquifer") in order to maintain consistency with the delineation of the Lower Aquifer in the Nodal method.

Management Areas, the lower and upper bounds of uncertainty in storage coefficients based on the best available information regarding aquifer lithologies and grain size distributions and applicable methodologies. The resultant volumes are intended to provide a relative comparison of available groundwater storage at different water level conditions and do not represent absolute values. A comparison of this method to other methods historically applied by Zone 7 (i.e., the Nodal method and the Hydrologic Inventory method) is provided as **Attachment A**. The full dataset of historical groundwater storage volumes calculated from Zone 7's Nodal method is provided as **Attachment B**.

EVALUATION OF "SGMA BASELINE" GROUNDWATER STORAGE

As specified in California Water Code (CWC) Section 10727.2(b)(4) a GSP or Alt GSP "may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015". As such, groundwater conditions in 2015 may serve as an effective "SGMA Baseline" to evaluate any further reductions in groundwater storage that would occur at the MTs and MOs defined for Chronic Lowering of Groundwater Levels.

The Rockworks rasters of the top and bottom elevations of the Principal Aquifer units were subsequently compared to Fall 2015 water level surfaces provided by Zone 7 to estimate the "SGMA Baseline" groundwater storage within each Principal Aquifer unit and Management Area. The calculation of SGMA Baseline Storage uses the same equation provided above for Total Usable Storage, except now the saturated aquifer thickness is informed by the Fall 2015 groundwater elevation surfaces as opposed to the historic high surfaces:

$$Current\_Storage_{i,j} = \sum_{k=1}^{n} Sat\_Aq\_thickness_{SGMA\ Baseline_{i,j,k}} * A_k * S_k$$

where:

$$Sat\_Aq\_thickness_{SGMA\ Baseline_{i,j,k}} = GWE_{Fall\ 2015_{i,j,k}} - Aq\_bottom_{i,j,k}$$

A summary of the SGMA Baseline Storage estimates for each Principal Aquifer unit and Management Area is presented in **Table 2** below. Also provided is an estimate of the percentage of storage available in each Principal Aquifer unit at the SGMA Baseline relative to the Total Usable Storage volumes provided in **Table 1**.

Table 2. "SGMA Baseline" (Fall 2015) Available Groundwater Storage Estimates

Management Area	Principal Aquifer Unit	SGMA Baseline Groundwater Storage (TAF)	Percentage Relative to Total Usable Storage[10] (%)
Main Basin	Upper Aquifer[11]	59 – 113 TAF	68%
	Lower Aquifer[12]	102 – 120 TAF	97%
	Livermore Aquifer[13,14]	85 – 170 TAF	98%
North Fringe	Fringe Aquifer[14]	74 – 133 TAF	99%
Northeast Fringe	Fringe Aquifer[14]	23 – 46 TAF	97%
East Fringe	Fringe Aquifer[14]	0.3 – 0.6 TAF	100%
TOTAL		343 – 583 TAF	91%

Based on the above, it appears that approximately 91% of Total Usable Storage is available under the SGMA Baseline (i.e., Fall 2015) condition. As of Fall 2015, Upper Aquifer and Lower Aquifer units of the Main Basin were 68% and 97% full, respectively, relative to historic highs, while the Upper Livermore Formation portion of the Lower Aquifer (i.e., the "Livermore Aquifer") and Fringe Aquifer units remained close to or at historic highs.

EVALUATION OF RECENT GROUNDWATER STORAGE TRENDS

As part of this exercise, EKI also calculated total available groundwater storage volumes for each Principal Aquifer unit and applicable Management Area over the past five years in attempts to conduct relative comparisons of annual changes in groundwater storage observed within the Basin post-SGMA adoption. The same equations used to calculate the Total Usable and SGMA Baseline Storage apply, except now the saturated thickness is informed by recent annual (Fall) water level surfaces previously developed by Zone 7. **Table 3** presents a summary of recent groundwater storage volumes as well as annual and cumulative changes in storage based on water level rasters obtained from Zone 7 for Fall 2015 – Fall 2020.

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[10] Percentages are based on the average of the lower and upper bound ranges in Total Usable Storage volumes calculated for each Principal Aquifer unit in **Table 1**.
[11] The upper end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B**.
[12] The lower end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B**.
[13] The range reflects a variability in the specific yield storage coefficient of 0.025 – 0.05.
[14] Here the Upper Livermore Formation portion of the Lower Aquifer unit is presented distinctly (i.e., the "Livermore Aquifer") in order to maintain consistency with the delineation of the Lower Aquifer in the Nodal method.

Table 3. Recent (Fall 2015 – 2020) Groundwater Storage Estimates

Management Area	Principal Aquifer Unit	Fall 2015 Groundwater Storage (TAF)	Fall 2016 Groundwater Storage (TAF)	Fall 2017 Groundwater Storage (TAF)	Fall 2018 Groundwater Storage (TAF)	Fall 2019 Groundwater Storage (TAF)	Fall 2020 Groundwater Storage (TAF)
Main Basin	Upper Aquifer[15]	59 – 113 TAF	66 - 124 TAF	77 – 143 TAF	76 – 144 TAF	78 – 147 TAF	70 – 129 TAF
	Lower Aquifer[16]	102 - 120 TAF	102 - 122 TAF	102 - 124 TAF	102 - 123 TAF	102 - 123 TAF	102 - 121 TAF
	Livermore Aquifer[17,18]	85 – 170 TAF	85 – 170 TAF	85 – 170 TAF	85 – 170 TAF	85 – 170 TAF	85 – 170 TAF
North Fringe	Fringe Aquifer[18]	74 – 133 TAF	74 – 133 TAF	74 – 133 TAF	74 – 133 TAF	74 – 133 TAF	74 – 133 TAF
Northeast Fringe	Fringe Aquifer[18]	23 – 46 TAF	23 – 46 TAF	23 – 46 TAF	23 – 46 TAF	23 – 46 TAF	23 – 46 TAF
East Fringe	Fringe Aquifer[18]	0.3 – 0.6 TAF	0.3 – 0.5 TAF	0.3 – 0.5 TAF	0.3 – 0.5 TAF	0.3 – 0.5 TAF	0.3 – 0.5 TAF
TOTAL		343 – 583 TAF	350 – 596 TAF	361 – 617 TAF	360 – 617 TAF	362 – 620 TAF	354 – 600 TAF
Average Annual Change in Groundwater Storage		-	+10 TAF	+16 TAF	-1 TAF	+3 TAF	-14 TAF
Cumulative Change in Groundwater Storage		0 TAF	+10 TAF	+26 TAF	+25 TAF	+28 TAF	+14 TAF

Based on the above, it appears that total groundwater storage in the Basin has increased by +14 TAF since the SGMA Baseline period (Fall 2015). Annual changes in groundwater storage ranged from +16 TAF (2016-2017) to -14 TAF (2019 – 2020). All storage changes were observed within the Upper Aquifer and Lower Aquifer units of the Main Basin, while storage in the Upper Livermore Formation portion of the Lower Aquifer (i.e., the "Livermore Aquifer") and remained close to or at historic highs and storage in the Fringe Aquifers remained stable throughout the recent five-year period.

EVALUATION OF AVAILABLE GROUNDWATER STORAGE AT WATER LEVEL MINIMUM THRESHOLDS AND MEASURABLE OBJECTIVES

As mentioned above and described in Section 354.36(b)(1) of the GSP Emergency Regulations (23 CCR § 354.36(b)(1)), "groundwater elevations may be used as a proxy for monitoring [Reduction of Groundwater Storage] if the Agency demonstrates [that] significant correlation exists between groundwater elevations and [Reduction of Groundwater Storage]." In various GSP comment letters submitted to DWR by the State

[15] The upper end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B.**

[16] The lower end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B**.

[17] The range reflects a variability in the specific yield storage coefficient of 0.025 – 0.05.

[18] Here the Upper Livermore Formation portion of the Lower Aquifer unit is presented distinctly (i.e., the "Livermore Aquifer") in order to maintain consistency with the delineation of the Lower Aquifer in the Nodal method.

Water Resources Control Board (SWRCB)[19], SWRCB consistently identifies the need for Groundwater Sustainability Agencies (GSAs) to "provide technical support for the argument of correlation between groundwater levels and groundwater storage and justifying the use of MTs for Chronic Lowering of Groundwater Levels as a proxy for Reduction of Groundwater Storage, with specific consideration of the metrics associated with the definitions of MTs and Undesirable Results." As such, in order to effectively demonstrate that the use of groundwater elevations can be as a reasonable proxy for Reduction in Groundwater Storage, it is necessary to quantify the estimated groundwater storage depletion that would occur under Chronic Lowering of Groundwater Level MTs and to assess if it would constitute an Undesirable Result for Reduction of Groundwater Storage as defined in the 2022 Alt GSP[20].

As further described in the SMC section of the 2022 Alt GSP, groundwater level MTs and Measurable Objectives (MOs) are defined at specific representative monitoring site (RMS) locations, thus making a comprehensive spatial evaluation of Basin-wide groundwater storage at the MTs/MOs challenging. However, given that water level MOs are generally tied to historic lows in the Basin[21], raster surfaces of historic low groundwater elevations previously created by Zone 7 staff can serve as a reasonable proxy for estimating associated groundwater storage availability at water level MO conditions. Similarly, as water level MTs are generally tied to historic lows with an additional allowable decline informed by seasonal ranges in water levels at the RMSs[22], modified historic low raster surfaces can serve as a reasonable proxy for estimating associated groundwater storage availability at water level MT conditions. The same equations used to calculate the Total Usable, SGMA Baseline, and recent groundwater storage apply, except now the saturated thickness is informed by the historic low water level surface (for MOs) or the modified historic low water level surface (for MTs).

Table 4 and **Table 5** present a summary of estimated available groundwater storage volumes for each Principal Aquifer unit and Management Area at MO and MT water level conditions, respectively, along with their comparative SGMA Baseline Storage volumes (see **Table 2).** Also provided is an estimate of the percentage of storage available in each Principal Aquifer unit at MO and MT water levels relative to the Total Usable and SGMA Baseline Storage volumes provided in **Table 1** and **Table 2**, respectively.

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[19] EKI, 2021. *Key Excerpts from SWRCB's August 2021 GSP Comment Letters in comparison to DWR's 3 June 2021 GSP Determination and Notification Letters, and Suggested Clarifications for the Northern and Central Delta-Mendota Region GSP.*

[20] Zone 7 2022 Alt GSP, Section 13.2.1. *Undesirable Results for Reduction of Groundwater Storage*

[21] Zone 7 2022 Alt GSP, Section 13.1.3 *Measurable Objectives and Interim Milestones for Chronic Lowering of Groundwater Levels*

[22] Zone 7 2022 Alt GSP, Section 13.1.2 *Minimum Thresholds for Chronic Lowering of Groundwater Levels*

Table 4. Available Groundwater Storage Estimates at Measurable Objective Water Levels

Management Area	Principal Aquifer Unit	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at Measurable Objective (TAF)	Percentage Relative to Total Usable Storage[23] (%)	Percentage Relative to SGMA Baseline Storage[24] (%)
Main Basin	Upper Aquifer[25]	59 – 113 TAF	47 - 67 TAF	45%	67%
	Lower Aquifer[26]	102 - 120 TAF	102 - 110 TAF	93%	95%
	Livermore Aquifer[27,28]	85 – 170 TAF	85 – 170 TAF	98%	100%
North Fringe	Fringe Aquifer[25]	74 – 133 TAF	73 – 131 TAF	98%	99%
Northeast Fringe	Fringe Aquifer[25]	23 – 46 TAF	21 – 43 TAF	90%	91%
East Fringe	Fringe Aquifer[25]	0.3 – 0.6 TAF	0.2 – 0.4 TAF	67%	67%
TOTAL		343 – 583 TAF	328 – 521 TAF	83%	92%

Table 5. Available Groundwater Storage Estimates at Minimum Threshold Water Levels

Management Area	Principal Aquifer Unit	SGMA Baseline Groundwater Storage (TAF)	Available Groundwater Storage at Minimum Threshold (TAF)	Percentage Relative to Total Usable Storage[23] (%)	Percentage Relative to SGMA Baseline Storage[24] (%)
Main Basin	Upper Aquifer[25]	59 - 113 TAF	36 – 47 TAF	33%	48%
	Lower Aquifer[26]	102 - 120 TAF	102 TAF	89%	92%
	Livermore Aquifer[27,28]	85 – 170 TAF	85 – 170 TAF	98%	100%
North Fringe	Fringe Aquifer[25]	74 – 133 TAF	72 – 128 TAF	96%	97%
Northeast Fringe	Fringe Aquifer[25]	23 – 46 TAF	20 – 40 TAF	85%	87%
East Fringe	Fringe Aquifer[25]	0.3 – 0.6 TAF	0.2 – 0.4 TAF	67%	67%
TOTAL		343 – 583 TAF	315 – 487 TAF	78%	87%

As a whole, the Basin would remain no less than 87% full under MT water levels relative to SGMA Baseline conditions, corresponding to a total reduction in groundwater storage of approximately 28 – 96 TAF. A

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[23] Percentages are based on the average of the lower and upper bound ranges in Total Usable Storage volumes calculated for each Principal Aquifer unit in **Table 1**.
[24] Percentages are based on the average of the lower and upper bound ranges in SGMA Baseline Storage volumes calculated for each Principal Aquifer unit in **Table 2**.
[25] The upper end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B.**
[26] The lower end of the range is based on the Nodal method that has historically been used by Zone 7 to estimate basin storage, see **Attachment A** and **Attachment B**.
[27] The range reflects a variability in the specific yield storage coefficient of 0.025 – 0.05.
[28] Here the Upper Livermore Formation portion of the Lower Aquifer unit is presented distinctly (i.e., the "Livermore Aquifer") in order to maintain consistency with the delineation of the Lower Aquifer in the Nodal method.

large majority of this storage loss would occur within the Upper Aquifer (23 – 66 TAF) and Lower Aquifer (0 - 18 TAF) units of the Main Basin.

While groundwater storage in the Upper Aquifer unit appears to be most affected by groundwater level declines, it is important to note that groundwater production in this unit is de minimis, and that water level MTs and MOs are specifically designed to protect groundwater dependent ecosystems and prevent depletion of interconnected surface waters in the areas of the Basin where shallow groundwater conditions are known to occur[29]. Within the Lower Aquifer unit, an 18 TAF storage decline at MT water levels would still leave 92% of usable storage available relative to SGMA Baseline conditions. Meanwhile, the underlying Upper Livermore Formation portion of the Lower Aquifer unit (i.e., "Livermore Aquifer") retains 100% saturation at the MT water levels relative to SGMA Baseline conditions, demonstrating that this portion of the Lower Aquifer unit is at virtually no risk of desaturation.

The North Fringe, Northeast Fringe, and East Fringe Management Areas will remain at least 97%, 87%, and 67% full at MT water levels, respectively, relative to SGMA Baseline conditions, demonstrating that the SMCs defined for Chronic Lowering of Groundwater Levels will also be sufficiently protective of Reduction of Groundwater Storage within these areas of de minimis groundwater use.

The above calculations serve to demonstrate that the SMCs defined for the Chronic Lowering of Groundwater Levels SI are sufficiently protective of Undesirable Results for Reduction of Groundwater Storage and thus can serve as an effective proxy for defining Reduction of Groundwater Storage SMCs in the 2022 Alt GSP. It is also important to note that an UR for Chronic Lowering of Groundwater Levels would be triggered well before the entire basin reached the MT water level conditions defined in this analysis[30], and thus the available storage volumes defined in **Table 5** are inherently conservative.

[29] Zone 7 2022 Alt GSP, Section 13.1.2 *Minimum Threshold for Chronic Lowering of Groundwater Levels*
[30] Zone 7 2022 Alt GSP, Section 13.1.1. *Undesirable Results for Chronic Lowering of Groundwater Levels*

ATTACHMENT A

Comparison of Rockworks and "Nodal" Model Aquifer Volumes

EKI's development of the Rockworks stratigraphy model of the Livermore Valley Groundwater Basin (Basin) provides for a refined, high resolution (200 x 200 feet) representation of Principal Aquifer unit extents and geometries within the Basin. As described in EKI's TM entitled *Progress Update on Extending Existing Hydrogeologic Framework* (dated 02 April 2021), the Rockworks model was developed using the best available information regarding Basin hydrogeology and incorporates lithologic and geophysical data from 1,053 unique boreholes within the Basin as well as key data and representations of Basin hydrogeology from various existing studies (e.g., DWR 1974, Norfleet 2004, Zone 7 2011).

Given that the Rockworks stratigraphy model reflects an updated hydrogeologic conceptualization of the Basin, migrating from Zone 7's existing "Nodal" model of the Basin (which originated from the DWR 1974 Bulletin 118 study) to the Rockworks model was expected to, and did, result in different estimates of Total Groundwater Storage volumes for the Basin. These differences are attributable to:

1) Differences in spatial resolution (i.e., 22 zones in the Nodal model versus a 200 x 200-foot Rockworks grid);
2) Differences in representation of Principal Aquifer thicknesses (i.e., uniform thickness for each zone in the Nodal Model vs varying thickness in Rockworks grid);
3) Differences in representation of Principal Aquifer spatial extents; and,
4) Differences in Principal Aquifer definitions (i.e., Upper and Lower Aquifer in the Nodal model versus Upper, Lower and Upper Livermore Aquifers in the Rockworks grid).

As part of the current effort to evaluate groundwater storage volumes in the Basin under planned Sustainable Management Criteria (SMC), a detailed comparison of aquifer volumetrics between the Rockworks and Nodal models was completed for the Main Basin Management Area (Main Basin)[1]. Total aquifer volumes were extracted from the Rockworks model for each Principal Aquifer unit and compared to analogous aquifer volumes from each node of the Nodal model, and a weighted difference between the Nodal-based and Rockworks-based aquifer volumes was calculated for each node and Principal Aquifer unit as follows:

$$\%\ Impact\ on\ Aquifer\ Volume_{i,k} = \frac{Rockworks\ Aquifer\ Volume_{i,k} - Nodal\ Aquifer\ Volume_{i,k}}{\sum_{i=1}^{n} Nodal\ Aquifer\ Volume_{i,k}}$$

where *"i"* is the node number and *"k"* is the Principal Aquifer unit.

This metric helps to identify areas of the Main Basin where the differences between Rockworks vs. Nodal aquifer volumes results in the greatest impacts to the total groundwater storage calculation for each Principal Aquifer unit. Results of the comparative analysis are shown on **Figures 1 through 8,** and key findings are summarized by Principal Aquifer unit below.

[1] The Nodal model does not include a complete mapping of Principal Aquifer units in the Fringe Basin and Upland Management Areas. Therefore, this comparison is limited to the Main Basin.

Upper Aquifer

As shown on **Figure 1** and **Table 1**, the Rockworks model depicts a smaller Upper Aquifer unit than the Nodal model in most areas of the Main Basin. Some of the key discrepancies in Upper Aquifer representation between the two models include:

- **Central Main Basin** (Bernal, Amador subareas) – As shown on **Figure 2**, the Rockworks model depicts a slightly thinner Upper Aquifer unit than the Nodal model within the central portion of the Main Basin and includes a more spatially resolved representation of land surface elevations. Upper Aquifer thicknesses in the Bernal and Central Amador areas averaged ~88 feet in the Nodal model, compared to ~63 feet in the Rockworks model. Additionally, as shown on **Figure 3**, the Rockworks model depicts the overlying Overburden Unit as extending into the western portion of the Amador subarea, whereas the Nodal model only includes the Overburden unit within the Bernal subarea. Also, as shown on **Figure 4**, the Rockworks Upper Aquifer surface does not extend all the way to the Basin boundary in some areas (e.g., Nodes 25 and 19 along the southern boundary of the Amador subarea), whereas the Nodal model assumes a constant aquifer thickness in each node up to the Basin boundary. Finally, Zone 7 has added a calculation of groundwater storage within the Chain of Lakes mining pits to the Nodal estimates of Upper Aquifer storage beginning in 2014, which is not directly accounted for in the Rockworks storage calculations. Based on Zone 7's calculations, storage in the Chain of Lakes mining pits could result in as much as 14 thousand acre-feet (TAF) of additional Upper Aquifer storage that is not being included in the Rockworks estimates.

- **Northern Mocho II Subarea** – As shown on **Figure 2,** the Rockworks model shows the Upper Aquifer thinning from ~50 feet to ~30 feet thickness at the northeastern edge of the Mocho II subarea before reaching "The Gap" (i.e., the boundary between Mocho II [Main Basin] and Mocho I [Fringe Basin]). The Nodal model assumes the Upper Aquifer is ~83 feet thick on average within the entirety of the northern portion of the Mocho II subarea.

- **Arroyo Valle and Arroyo Mocho stream corridors** – As shown on **Figure 5** and **Figure 6,** the Rockworks model represents the Upper Aquifer as a progressively thinning sequence of shallow alluvial fill materials moving up the Arroyo Valle and Arroyo Mocho stream corridors. The Upper Aquifer thins to ~30 feet thickness in the stream corridors and is directly underlain by the Livermore Aquifer. The Nodal model, in comparison, only includes one node for each of the Arroyo Mocho (Node 36) and Arroyo Valle (Node 41) stream corridors and assumes the Upper Aquifer is the only Principal Aquifer unit in these areas. The Nodal model maps the Upper Aquifer thickness at 105 feet in the Arroyo Valle stream corridor, and 112 feet in the Arroyo Mocho stream corridor. Additionally, as shown on **Figure 4**, the Rockworks Upper Aquifer surface does not extend all the way to the edges of the Basin along these stream corridors, whereas Nodes 36 and 41 extend to the Basin boundary.

Lower Aquifer

As shown on **Figure 7** and **Table 1**, the Rockworks model depicts a larger Lower Aquifer unit than the Nodal model in most areas of the Main Basin. Some of the key discrepancies in Lower Aquifer representation between the two models include:

- **Central Main Basin** (Bernal, Amador subareas) – As shown on **Figure 2**, the Rockworks model depicts a thicker Lower Aquifer unit than the Nodal model within the central portion of the Main Basin. Lower Aquifer thicknesses in the Bernal and Central Amador areas averaged ~148 feet in the Nodal model, compared to ~297 feet in the Rockworks model. As seen on **Figure 2** and **Figure 5**, it appears the Nodal model does not include the deepest stratigraphic sequence of the Lower Aquifer (characterized as the "Purple" sequence in the Norfleet 2004 study) within the Bernal and central Amador subareas, thus excluding as much as 50% of the total thickness of the Lower Aquifer in the central Main Basin.

- **Near the Concannon Boundary** – As shown on **Figure 7**, Node 35 in the southern-central portion of the Amador subarea shows the largest discrepancy between the Rockworks and Nodal model depictions of the Lower Aquifer (a -16% impact on total aquifer volume). As shown on **Figure 8**, the Rockworks model depicts an abrupt end to the Lower Aquifer at the Concannon Boundary in this area. As described in the Norfleet 2004 study, the Concannon Boundary delineates the southern extent of the ancestral Arroyo Mocho paleochannel that comprise the alluvial materials of the Lower Aquifer, and thus represents the de-facto southern edge of the Lower Aquifer. As such, in the Rockworks model the Lower Aquifer only extends through the northern portion of Node 35 at an average thickness of ~87 feet, whereas the Nodal model assumes a constant Lower Aquifer thickness of 112 feet throughout Node 35 before terminating the Lower Aquifer in Node 36 to the south.

Livermore Aquifer

The Rockworks model includes the Livermore Aquifer in its delineation of Principal Aquifer units. The Livermore Aquifer underlies the Lower Aquifer in the Main Basin and comprises a majority of the Fringe Aquifer in the Fringe Management Area. The Nodal model currently does not include the underlying Livermore Aquifer, thus defining the Basin bottom at the base of the Lower Aquifer, even though many production wells in the Basin are screened in this unit (see **Figures 2 and 5**). Based on the Rockworks model, it is estimated that an additional 87 – TAF of Total Usable Groundwater Storage exists in the Livermore Aquifer which is not being accounted for in the Nodal model. This represents ~28 – 44% of the Total Usable Groundwater Storage calculated for the Main Basin as further outlined below.

Net Impacts on Total Usable Groundwater Storage Estimates

As demonstrated above, differences in groundwater storage estimates from the Rockworks and Nodal stratigraphy models can be attributed to differences in the spatial resolution, thicknesses, extents, and definitions of Principal Aquifer units between the two models. **Table 1** below presents a comparison in Total Usable Groundwater Storage[2] estimates for the Main Basin between these two methods.

[2] Here "Total Usable Groundwater Storage" is defined as total available groundwater storage at historic high water level conditions. Note this is not equivalent to total aquifer volume, as some areas of the Basin were not fully saturated at historic high conditions.

Table 1. Total Usable Groundwater Storage Estimates (Main Basin)

Principal Aquifer Unit	Total Usable Storage from Nodal Model (TAF)	Total Usable Storage from Rockworks Model (TAF)	Percent Difference [Rockworks vs. Nodal] (%)
Upper Aquifer	157 TAF	94 TAF	-40%
Lower Aquifer	102 TAF	127 TAF	+25%
Livermore Aquifer	-	87 – 174 TAF	+100%
TOTAL	259 TAF	308 – 395 TAF	+19% to +52%

As seen from **Table 1** above, the Rockworks stratigraphy model calculates between 19% to 52% greater estimates of Total Usable Groundwater Storage within the Main Basin compared to the Nodal model. While storage in the Upper Aquifer is decreased by 40% relative to the Nodal model, storage in the Lower Aquifer is increased by 25% and storage in the Livermore Aquifer is now included in the estimate.

Limitations

While the above analysis explains some of the differences that are observed between the Rockworks and Nodal methods, this analysis does not explain the observed discrepancies between both of these methods and the storage estimates derived from the Hydrologic Inventory (HI) method. As shown in **Figure 9**, both the Rockworks and Nodal methods underestimate storage increases and overestimate storage decreases relative to the HI method estimates over the past five years. Adjusting the assumed storativity parameters does not appear to address the issue, as it simply scales the results. As mentioned above, the discrepancy between the Rockworks and Nodal methods is further exacerbated by Zone 7's inclusion of groundwater storage volumes within the Chain of Lakes mining pits into the Nodal storage change calculations beginning in 2014. Additional analysis beyond the scope of this effort (e.g., update and re-calibration of the Basin numerical groundwater model) will be required to better refine the estimates of total and year-over-year changes in storage in the Basin, using the Rockworks, Nodal and HI methods.

Figures

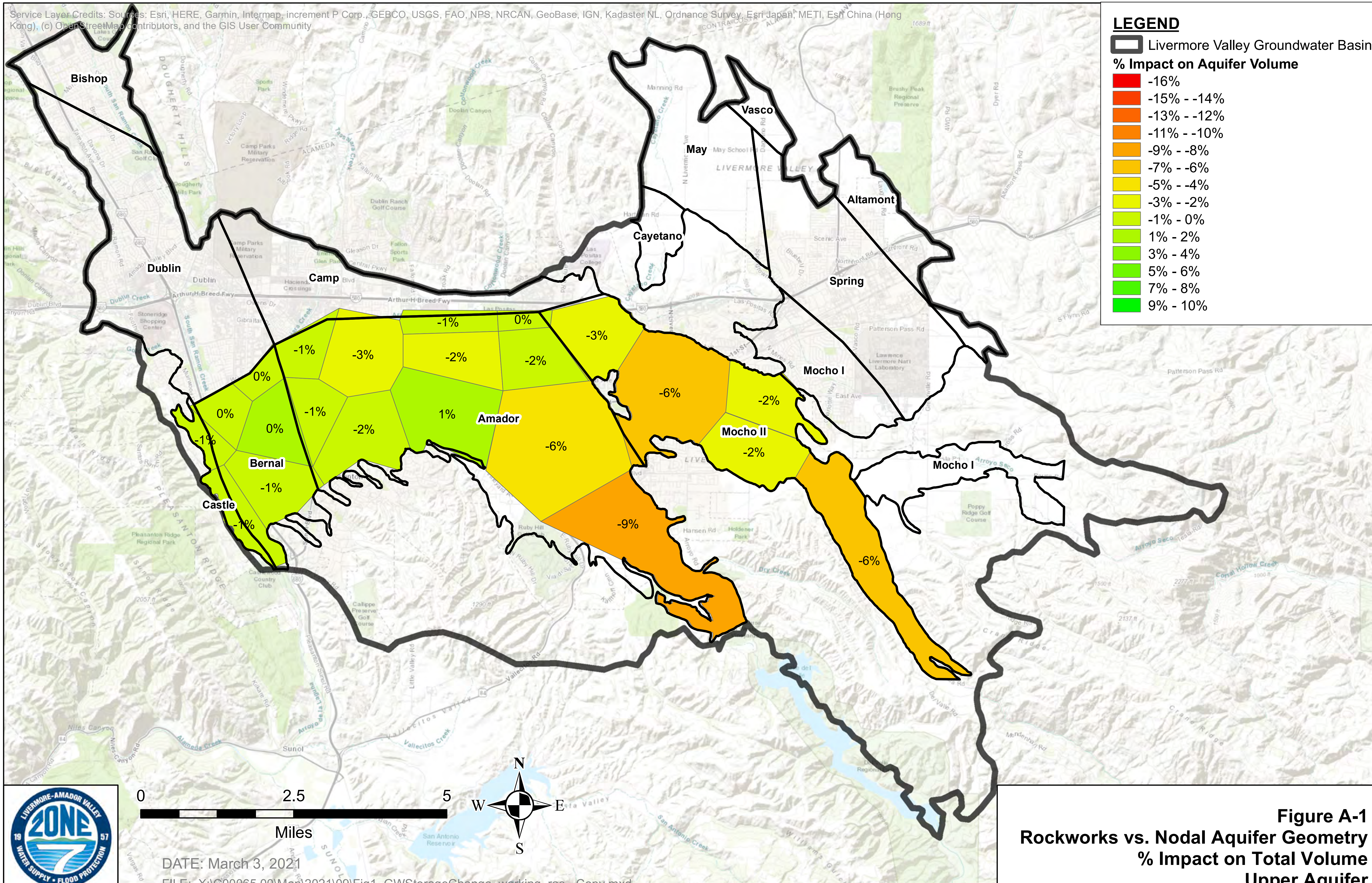
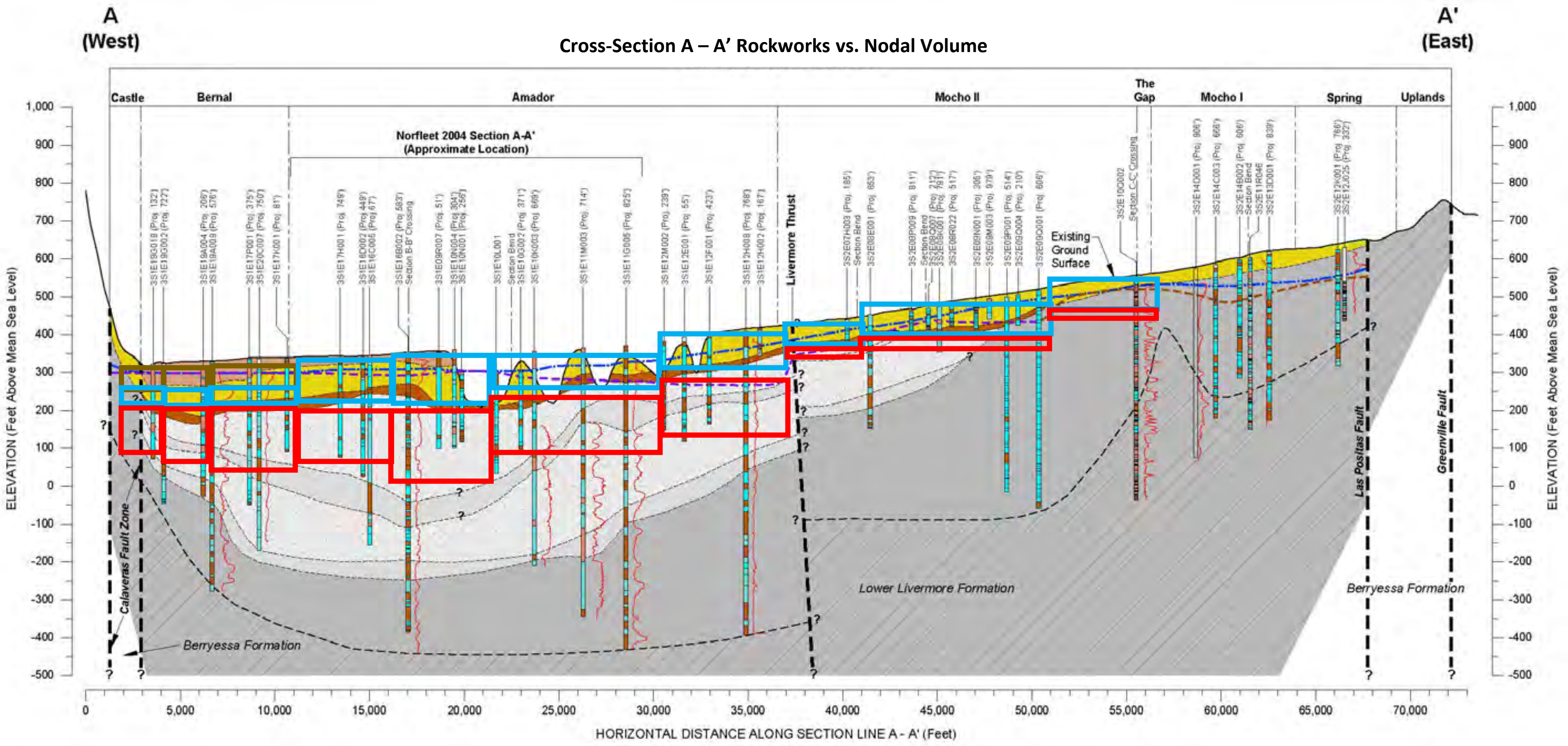


Figure A-1
Rockworks vs. Nodal Aquifer Geometry
% Impact on Total Volume
Upper Aquifer

Principal Aquifer Units in Nodal Model

- Upper Aquifer
- Lower Aquifer
- Overburden



Cross-Section A - A'

(Vertical Scale in Feet) 300 200 100 0

(20X Vertical Exaggeration)

0 6,000 12,000

(Horizontal Scale in Feet)

Legend:

Stratigraphy

- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

- Long-Normal Resistivity

Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area

Cross-Section A – A'
Rockworks vs. Nodal

Zone 7 2022 Alternative GSP
Livermore, CA
June 2021
EKI C00065.00
Figure A-2

eki environment & water

20210603.092158 G:\C00065.00\2021-06\Cross Section A-A.dwg Section A-A'

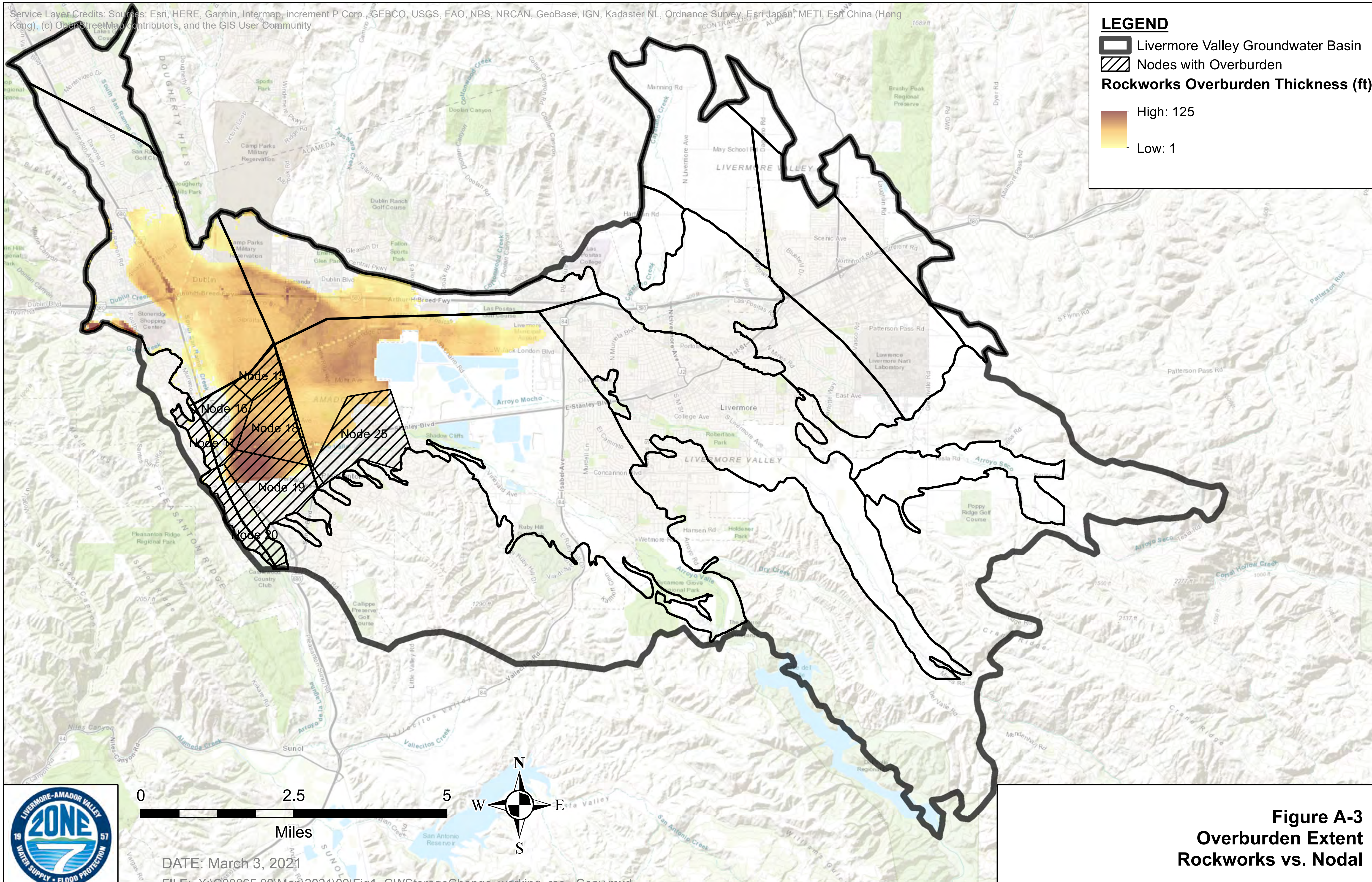


Figure A-3
Overburden Extent
Rockworks vs. Nodal

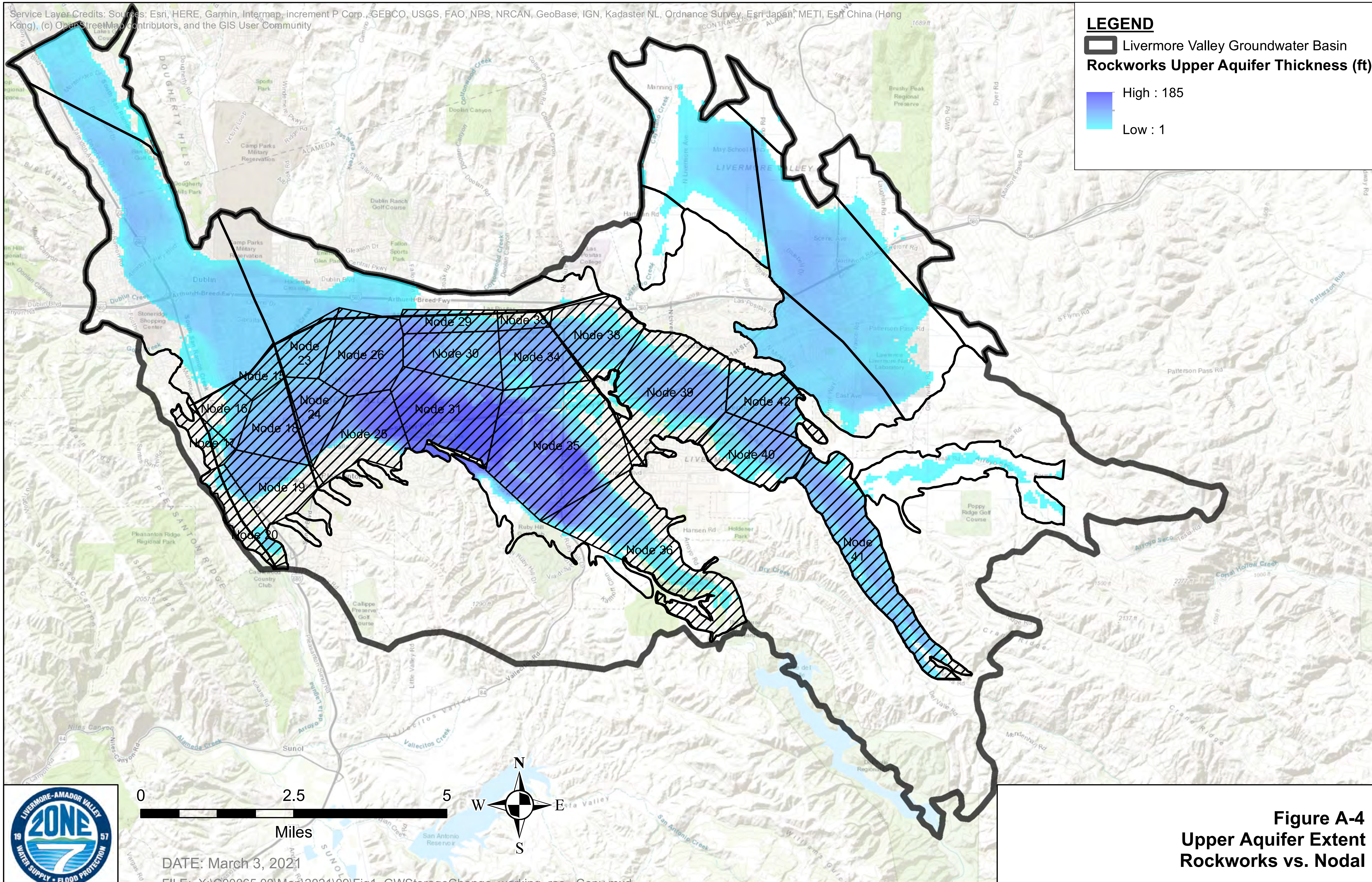
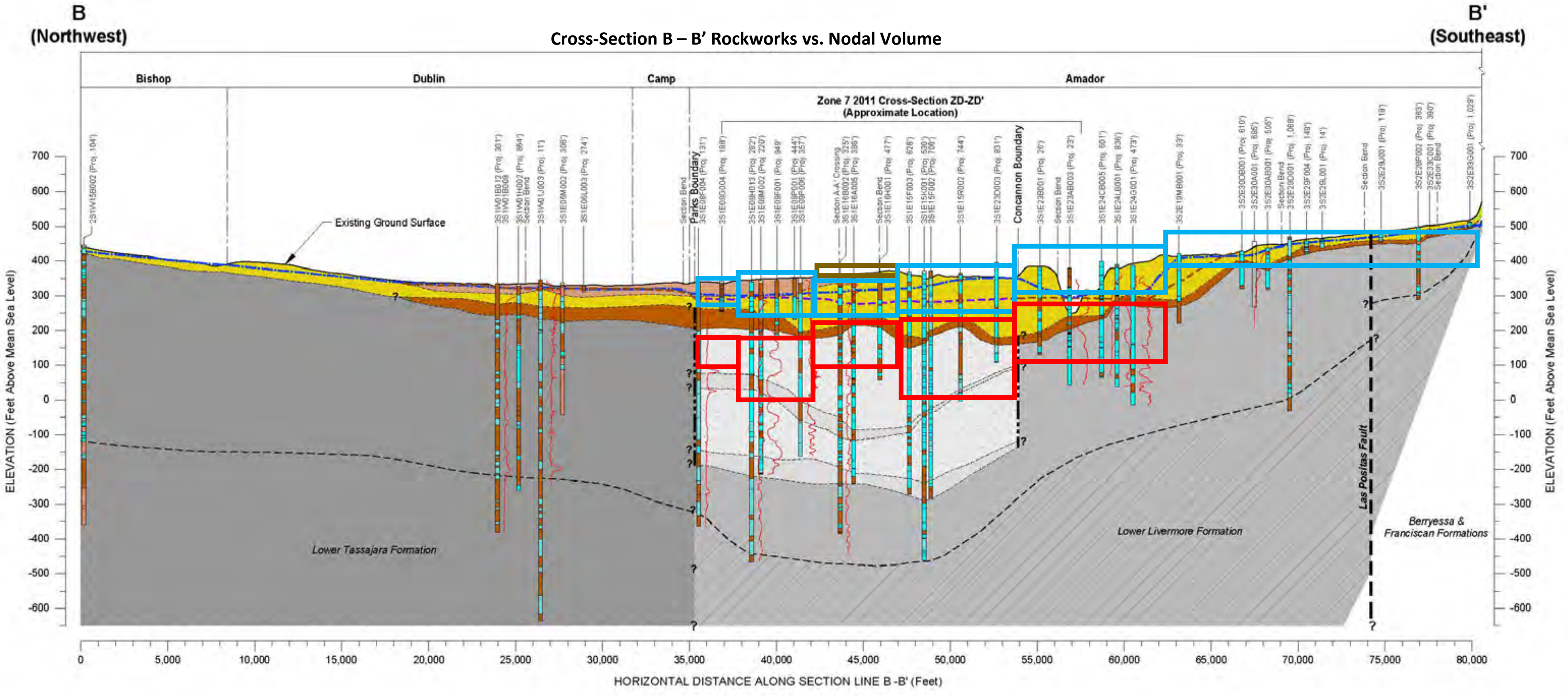


Figure A-4
Upper Aquifer Extent
Rockworks vs. Nodal

Principal Aquifer Units in Nodal Model

- Upper Aquifer
- Lower Aquifer
- Overburden



Cross-Section B - B'

Legend:

Stratigraphy

- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

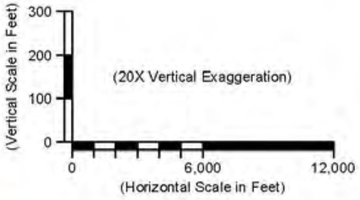
- Long-Normal Resistivity

Map Elements

- A —— A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



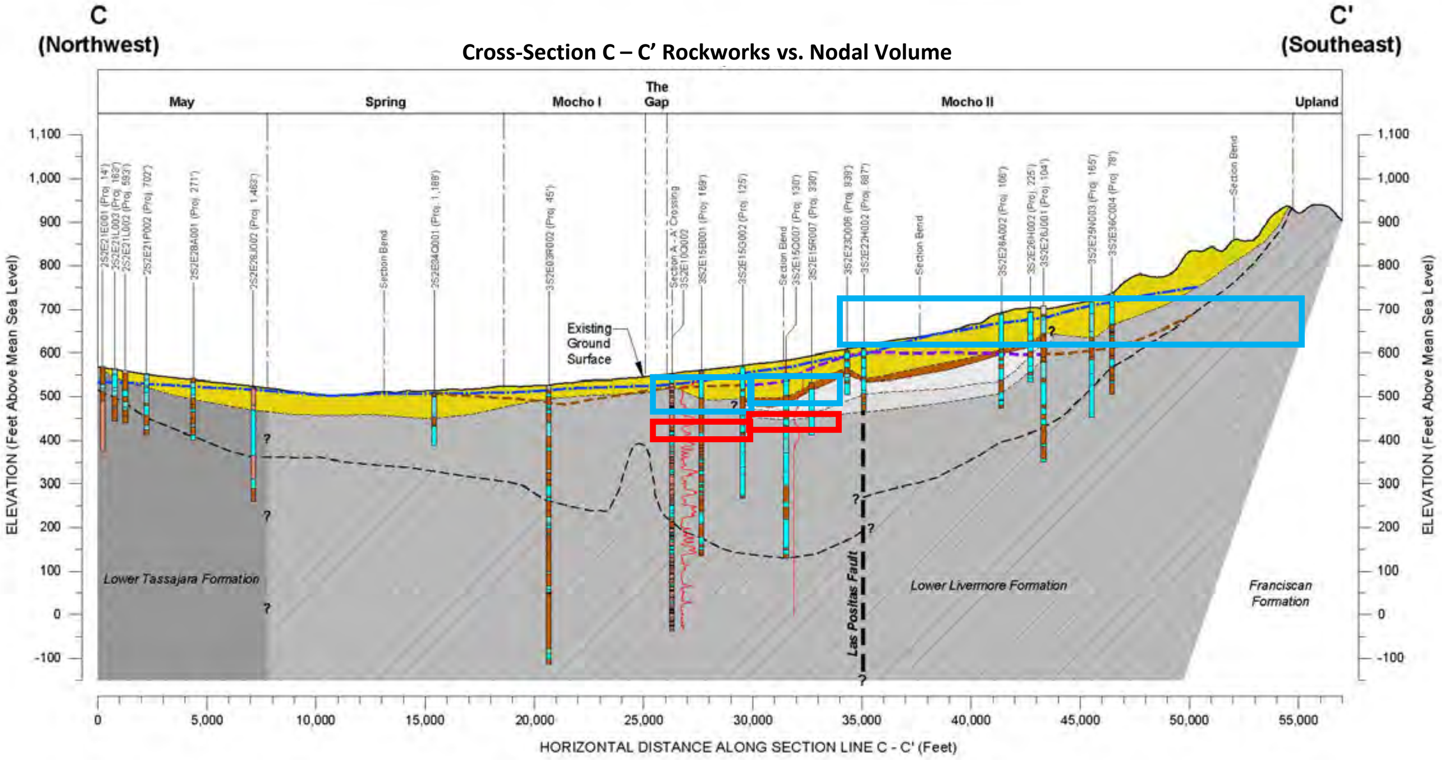
Cross-Section B – B'
Rockworks vs. Nodal

Zone 7 2022 Alternative GSP
Livermore, CA
June 2021
EKI C00065.00
Figure A-5

20210603.085738 G:\C00065.00\2021-06\Cross Section B-B.dwg Section B-B'

Principal Aquifer Units in Nodal Model

- Upper Aquifer
- Lower Aquifer
- Overburden



Cross-Section C - C'

Legend:

Stratigraphy

- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

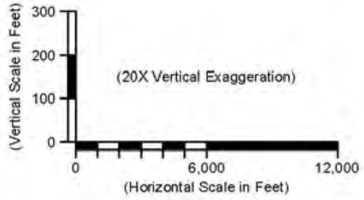
- Long-Normal Resistivity

Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Cross-Section C – C' Rockworks vs. Nodal

Zone 7 2022 Alternative GSP
Livermore, CA
June 2021
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Figure A-6

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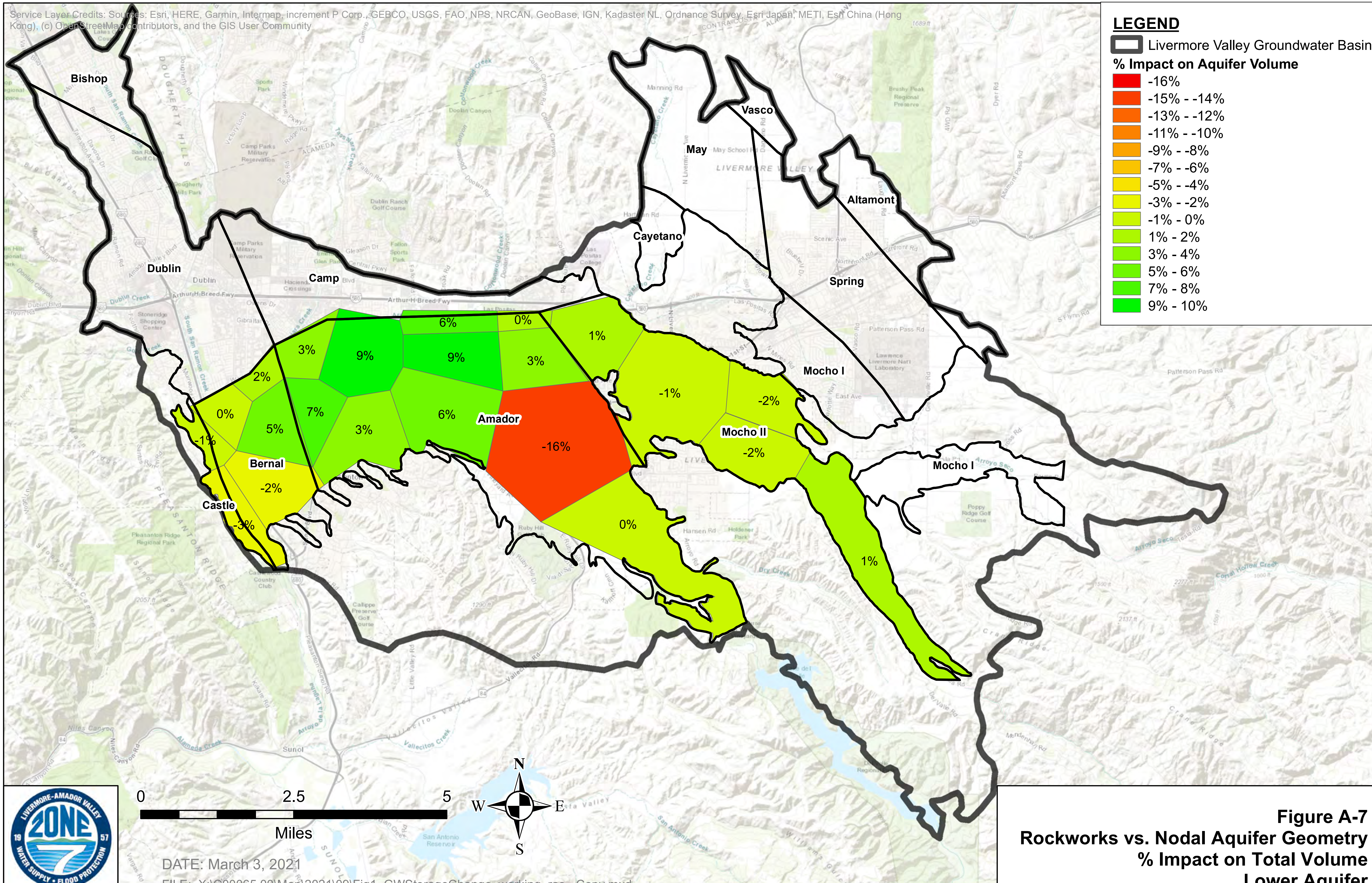


Figure A-7
Rockworks vs. Nodal Aquifer Geometry
% Impact on Total Volume
Lower Aquifer

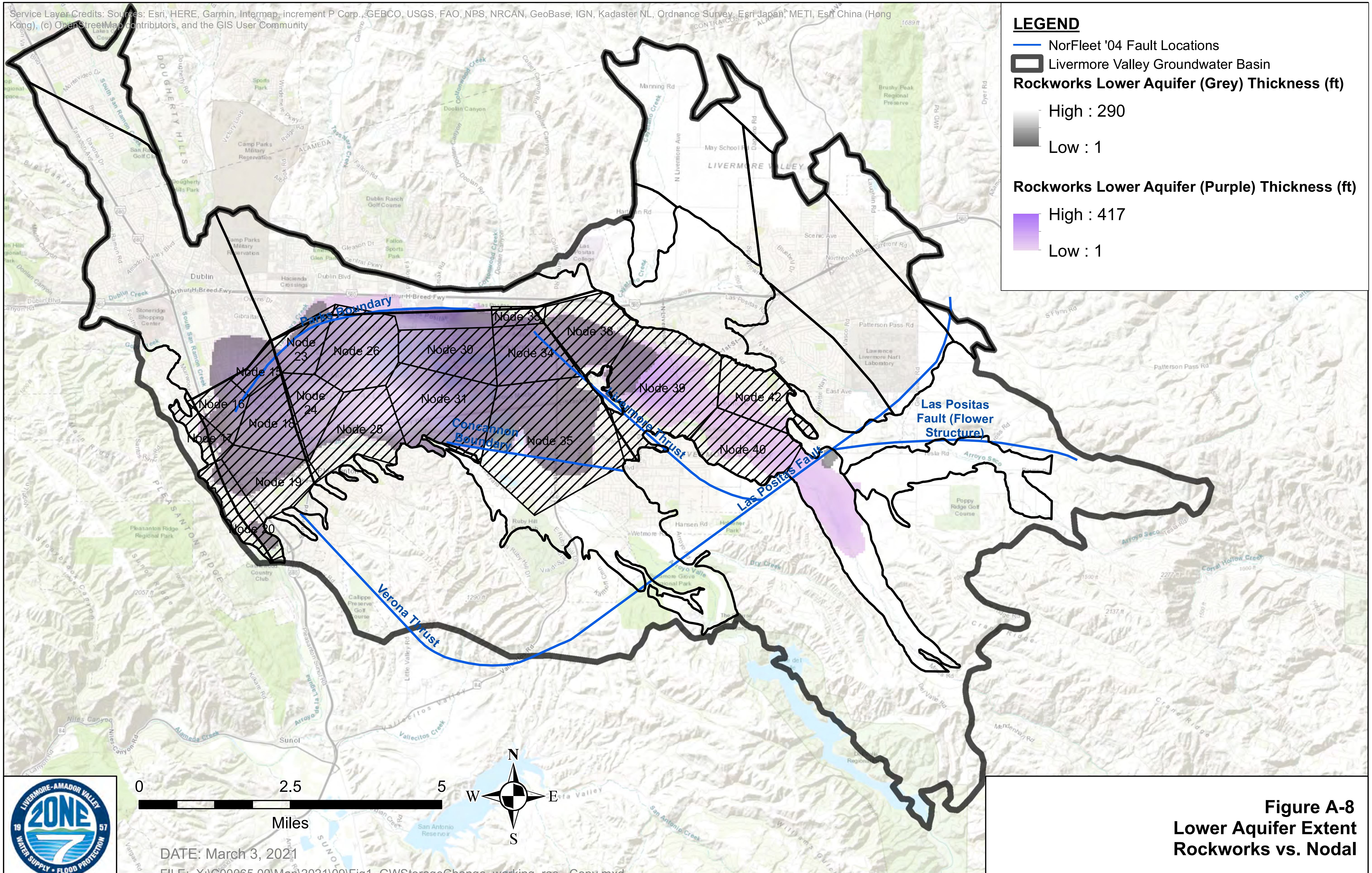
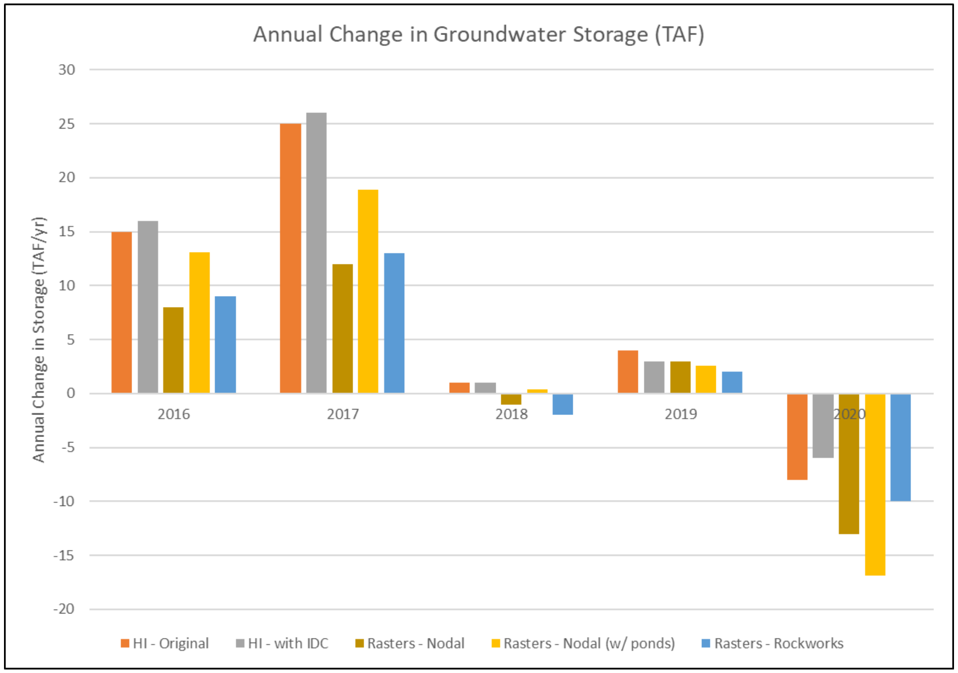
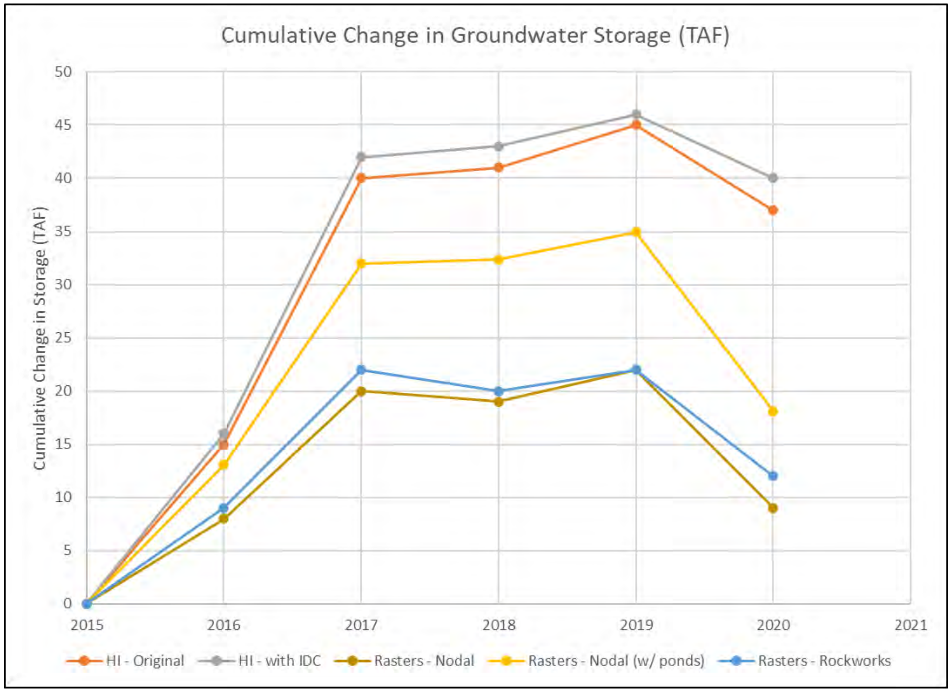


Figure A-8
Lower Aquifer Extent
Rockworks vs. Nodal





Abbreviations:
HI = Hydrologic Inventory
IDC = Integrated Water Flow Model Demand Calculator
TAF = thousand acre-feet
yr = Year

DRAFT

Comparison of Annual and Cumulative Change in Storage Estimates

Zone 7 Water Agency
Alameda County, California
September 2021
EKI C00065.00

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Figure A-9

ATTACHMENT B

ZONE 7 NODAL STORAGE VOLUMES

(ALL VALUES IN ACRE-FEET)

WATER YEAR / CONDITION	UPPER AQUIFER (ROUNDED)	LOWER AQUIFER (ROUNDED)	POND STORAGE (ROUNDED)	**TOTAL (without ponds)**	**TOTAL (with ponds)**
Historical High	157,000	102,000		259,000	259,000
Historical Low	67,000	102,000		169,000	169,000
1992	82,000	102,000		184,000	184,000
1993	109,000	102,000		211,000	211,000
1994	114,000	102,000		216,000	216,000
1995	123,000	102,000		225,000	225,000
1996	121,000	102,000		223,000	223,000
1997	120,000	102,000		222,000	222,000
1998	123,000	102,000		225,000	225,000
1999	120,000	102,000		222,000	222,000
2000	120,000	102,000		222,000	222,000
2001	101,000	102,000		203,000	203,000
2002	110,000	102,000		212,000	212,000
2003	118,000	102,000		220,000	220,000
2004	111,000	102,000		213,000	213,000
2005	134,000	102,000		236,000	236,000
2006	136,000	102,000		238,000	238,000
2007	130,000	102,000		232,000	232,000
2008	132,000	102,000		234,000	234,000
2009	131,000	102,000		233,000	233,000
2010	132,000	102,000		234,000	234,000
2011	133,000	102,000		235,000	235,000
2012	126,000	102,000		228,000	228,000
2013	119,000	102,000		221,000	221,000
2014	107,000	102,000	1,000	209,000	210,000
2015	111,000	102,000	2,000	213,000	215,000
2016	119,000	102,000	5,000	221,000	226,000
2017	131,000	102,000	12,000	233,000	245,000
2018	130,000	102,000	14,000	232,000	246,000
2019	133,000	102,000	14,000	235,000	249,000
2020	120,000	102,000	9,000	222,000	231,000

APPENDIX F

GROUNDWATER DEPENDENT ECOSYSTEMS AND SURFACE WATER TECHNICAL MEMORANDUM

14 September 2021

TECHNICAL MEMORANDUM

To: Tom Rooze, PG, Zone 7 Water Agency (Zone 7)
Ken Minn, PE, Zone 7
Carol Mahoney, PG, Zone 7
Colleen Winey, PG, Zone 7

From: Anona Dutton, PG, CHg, EKI Environment & Water, Inc. (EKI)
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Subject: **Groundwater Dependent Ecosystems and Surface Water – Groundwater Interaction Program Update**
Zone 7 Water Agency Alternative Groundwater Sustainability Plan
(EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to present to Zone 7 Water Agency (Zone 7) a memorandum documenting the update the groundwater dependent ecosystems (GDEs) and surface water – groundwater interaction program within the Livermore Valley Groundwater Basin (Basin) as part of Zone 7's 2022 Alternative Groundwater Sustainability Plan (Alt GSP or Plan) Update.

Pursuant to our approved scope of work, EKI's work efforts included: (1) identification of GDEs and other areas of potential interconnected surface water (ICSW), (2) evaluation of the need for and identification of new monitoring locations, (3) assessment of groundwater demands from GDEs, (4) development of sustainability criteria (i.e., Measurable Objectives [MOs] and Minimum Thresholds [MTs]) for Depletion of Interconnected Surface Water.

A final version of this memorandum is anticipated to be included as an attachment to the 2022 Alt GSP and/or to inform selected chapters of the Plan.

1. UPDATE TO GROUNDWATER DEPENDENT ECOSYSTEMS AND INTERCONNECTED SURFACE WATER PROGRAM

The following section describes the process used to update the GDE and ICSW program.

1.1. Identification of Groundwater Dependent Ecosystems

EKI (supported by Stillwater Sciences [Stillwater]) performed a preliminary identification of likely GDEs within the Basin based on the available data and tools, field and aerial photo surveys, and analysis conducted in general accordance with the process laid out in The Nature Conservancy (TNC) guidance[1]. A summary of the work effort is presented below and in **Attachments A and B**.

1.1.1. Preliminary Screening

Based on the available data, EKI conducted a preliminary screening to identify potential GDE areas in the Basin as described below.

Data Sources

Primary data sources that were incorporated into the screening analyses or otherwise supported the GDE field investigation and identification include the following:

- GDE information from the California Department of Water Resources' (DWR) Natural Communities Commonly Associated with Groundwater (NCCAG) dataset and TNC guidance documents[2,3,4];
- GDE health indices from the TNC GDE Pulse tool[5], including the Normalized Derived Moisture Index (NDMI) and the Normalized Derived Vegetation Index (NDVI), which indicate the vegetation moisture and vegetation greenness, respectively;
- Additional resources regarding the presence of GDEs in the Basin provided by Zone 7, including GDE geospatial data and Sycamore alluvial woodland data;
- United States Geological Survey (USGS) ground surface elevation data;
- Well information, including locations and well construction details as provided by Zone 7; and
- Groundwater elevation and depth to water data provided by Zone 7.

Depth to Groundwater Analysis

The NCCAG dataset identifies land areas by vegetation or wetland categories that potentially indicate the presence of GDEs, as shown on **Figure 1**. The NCCAG dataset also assigns the potential GDEs a polygon number. An additional GDE area (i.e., the Springtown Alkali Sink[6]) was not identified in the NCCAG dataset, but was included in this analysis and on **Figure 1** for completeness.

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[1] Rohde et al., 2018. *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans.* The Nature Conservancy. Dated January 2018.

[2] Ibid.

[3] Klausmeyer et al., *GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data*. The Nature Conservancy. Dated January 2019.

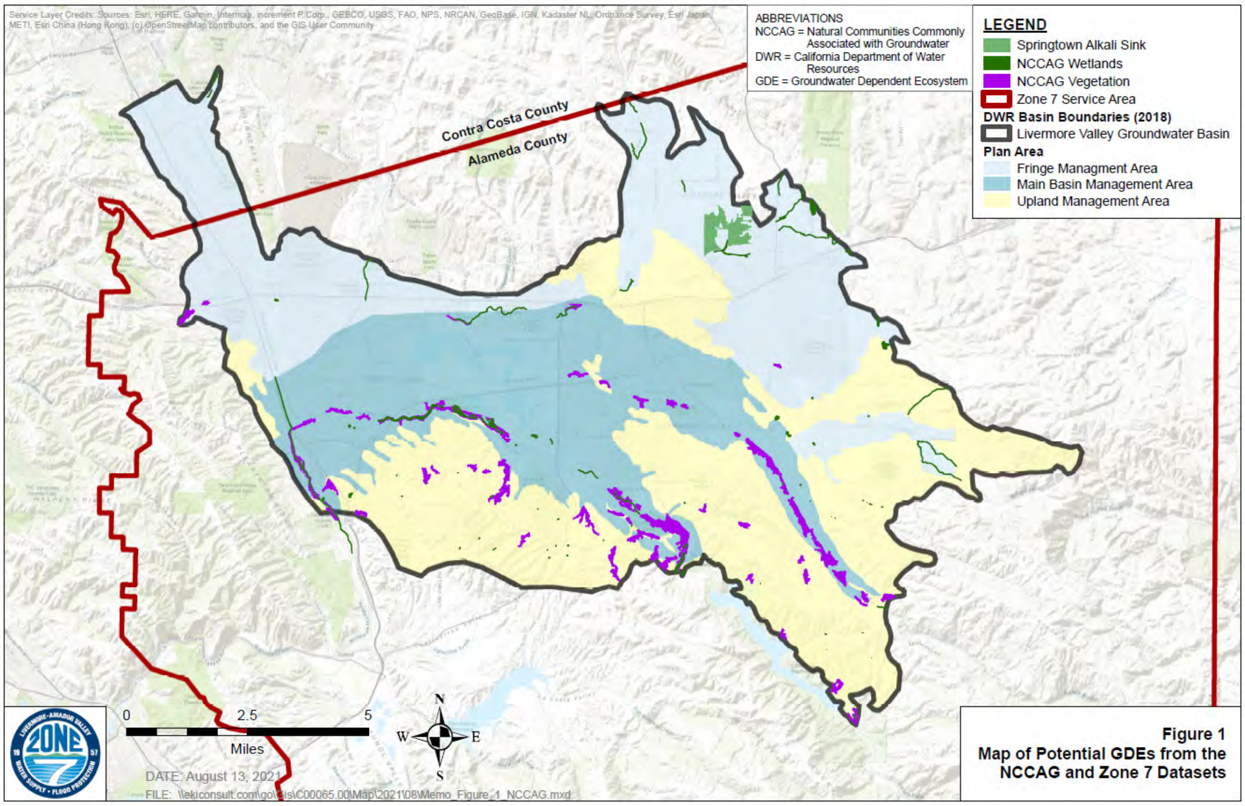
[4] TNC, 2019. *Identifying GDEs Under SGMA: Best Practices for using the NC Dataset*. The Nature Conservancy. Dated July 2019.

[5] https://gde.codefornature.org/#/methodology; The GDE Pulse interactive map developed by The Nature Conservancy provides users easy access to satellite data to view long term temporal trends of vegetation metrics. These vegetation metrics serve as an indicator of vegetation health for GDEs. In addition, the GDE Pulse web app provides long-term temporal trends of groundwater depth and regional precipitation data. This provides users with a platform to infer relationships between groundwater levels, precipitation, and GDE vegetation metrics to monitor and sustainably manage groundwater and GDEs.

[6] The 2016 Alt GSP identified the Springtown Alkali Sink as a GDE in Section 2.1.4.

Based on review of the NCCAG dataset, the maximum rooting depth of various plant species associated with potential GDEs within the Basin is approximately 30 feet below ground surface (ft bgs).[7] As such, if the minimum depth to groundwater between 2015 and 2020 in the vicinity of the mapped potential GDEs was greater than 30 ft bgs,[8] it is unlikely that the mapped vegetation or wetland areas in the NCCAG dataset were accessing the principal aquifer[9] as their source of supply. Rather, these mapped vegetative communities are likely supplied by a surface water, perched groundwater, or other source (e.g., runoff or a man-made water feature) and are therefore not GDEs in the context of SGMA.

Figure 1. Map of Potential GDEs from the NCCAG and Zone 7 Datasets



To further clarify whether the mapped vegetative communities from the NCCAG and Zone 7 datasets are likely GDEs that are dependent on the principal aquifer, the depth to groundwater for each potential GDE polygon (and the area of the Springtown Alkali Sink) was estimated by comparing the potential max GDE rooting depth (30 ft bgs) to the measured depth to groundwater from nearby Upper Aquifer wells within the Basin. Upper Aquifer wells within a one-kilometer (km) radius of the mapped potential GDEs were

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[7] https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/

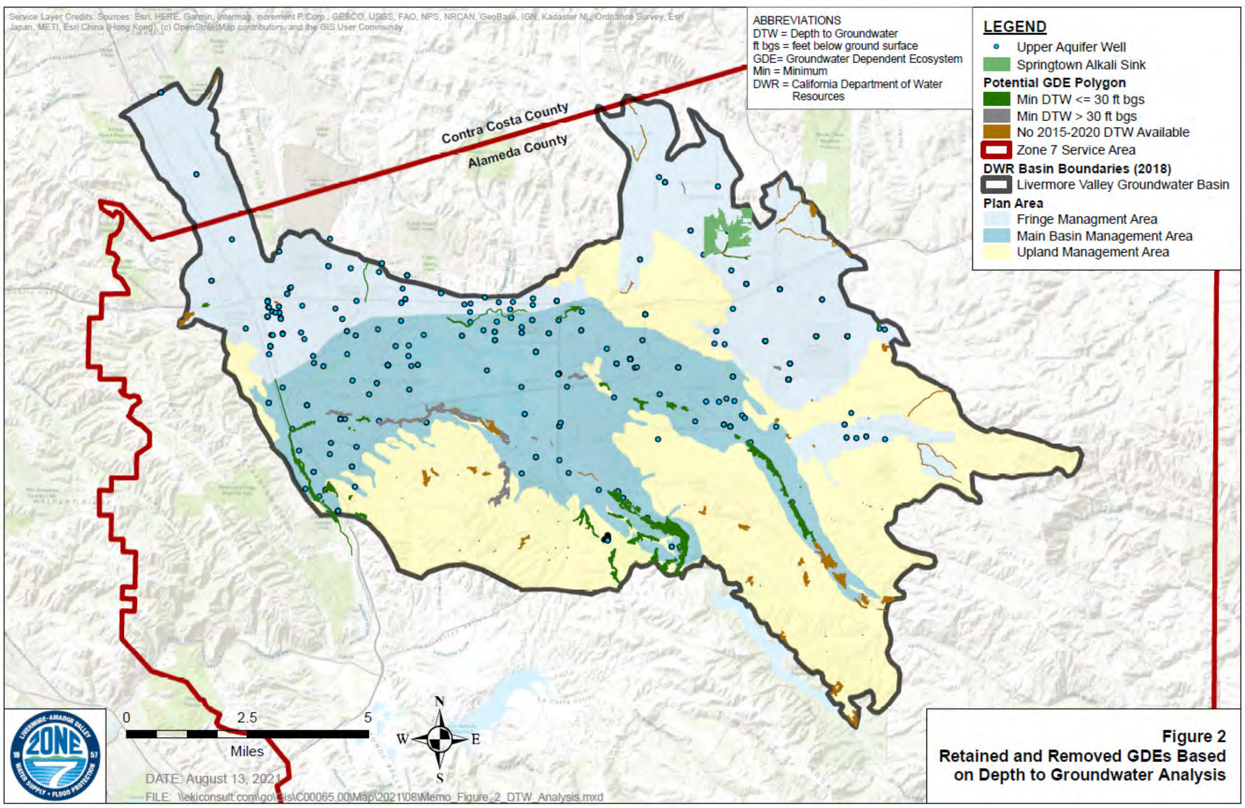
[8] Since the Plan is not required to address undesirable results that occurred before, and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2015 is selected as the start of the analysis timeframe.

[9] Per § 351.(aa), "Principal aquifers" refer to aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. The Main Basin includes a single principal aquifer that includes two hydraulically connect zones with varying degrees of connectivity: the Upper Aquifer and Lower Aquifer.

assumed to be representative of groundwater conditions within those areas[10]. The locations of Upper Aquifer wells within the Basin that were used to evaluate shallow groundwater conditions are shown on **Figure 2.** If multiple wells were within one km of a GDE polygon, the minimum depth to groundwater between 2015 and 2020 from these wells was calculated.

If the minimum depth to water between 2015 and 2020 was greater than 30 ft bgs, then that respective GDE polygon was determined to likely not be a GDE that was dependent on the principal aquifer and was "removed" from further consideration. If the minimum depth to groundwater between 2015 and 2020 was less than 30 ft bgs or if no proximate groundwater data were available, the potential GDE polygon was preliminarily "retained" for further review. The retained and removed GDE polygons are shown on **Figure 2.**

Figure 2. Retained and Removed GDEs Based on Depth to Groundwater Analysis



Application of the TNC GDE Pulse Tool Methodology

The TNC GDE Pulse tool provides time series data for two remote sensing indices that are used to monitor a vegetation's health: (1) the Normalized Derived Moisture Index (NDMI), and (2) the Normalized Derived Vegetation Index (NDVI), which indicate the vegetation moisture and vegetation greenness, respectively. Higher NDMI and NDVI values are associated with "healthier" vegetation. In the TNC GDE Pulse tool the

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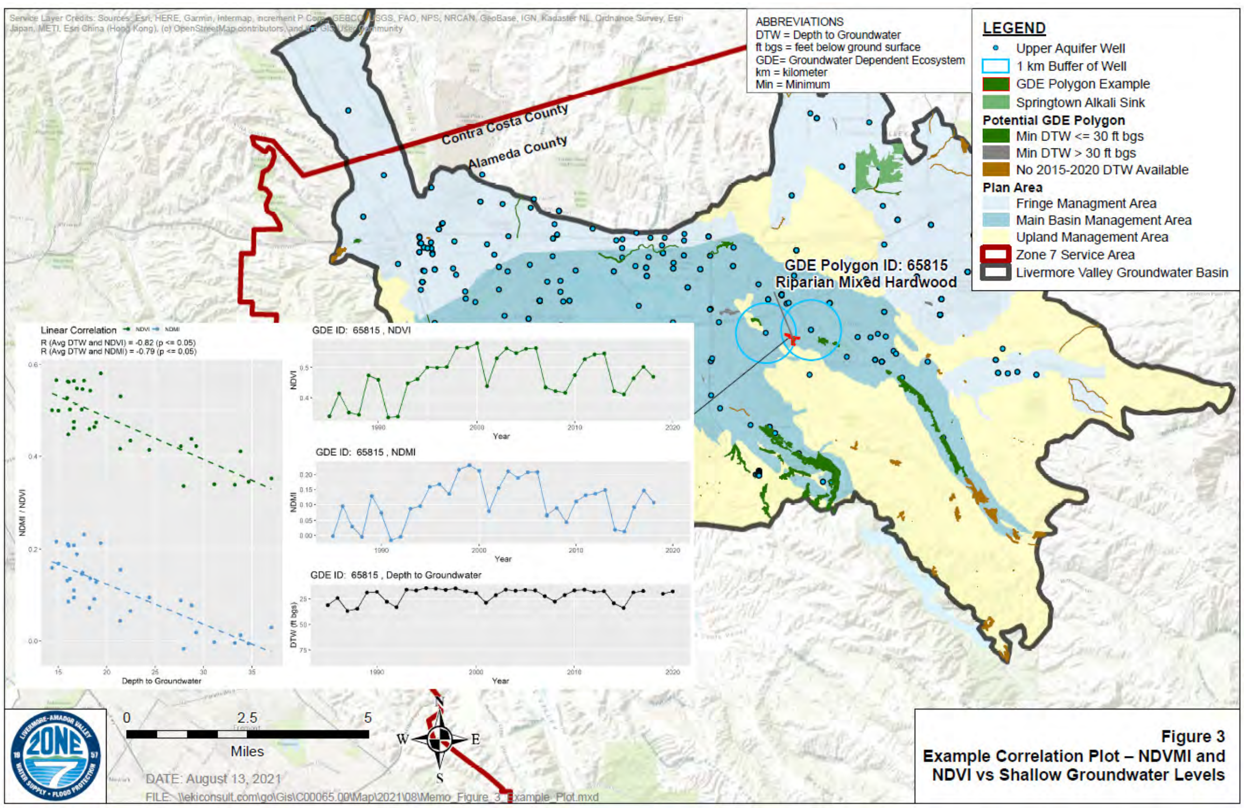
[10] Klausmeyer et al., *GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data*. The Nature Conservancy. Dated January 2019.

NDMI and NDVI data are indexed to the same GDE polygon numbers included in the NCCAG dataset[11].

The premise of the TNC GDE Pulse tool is that, since the NDMI and NDVI indices can quantify changes in the rates and patterns of vegetation growth and moisture levels in plants over time, the relationship between these two indices and the depth to shallow groundwater can be evaluated to examine whether these measures of GDE "health" have a relationship to shallow groundwater conditions. Since limited depth to groundwater data are provided in the TNC GDE Pulse tool, depth to groundwater data provided by Zone 7 were used to supplement this analysis.

Time series data of these two indices and the nearby (i.e., within one km) depth to groundwater data were plotted for each retained GDE polygon, as shown on **Figure 3** and **Attachment A**. A linear correlation between the two indices and the local depth to groundwater data was then evaluated for each polygon. A negative correlation would mean that, when the depths to groundwater increase, the NDMI and NDVI indices decrease, indicating that the GDEs are less healthy when conditions are such that local groundwater elevations decrease, and vice versa.

Figure 3. Example Correlation Plot – NDMI and NDVI vs Shallow Groundwater Levels

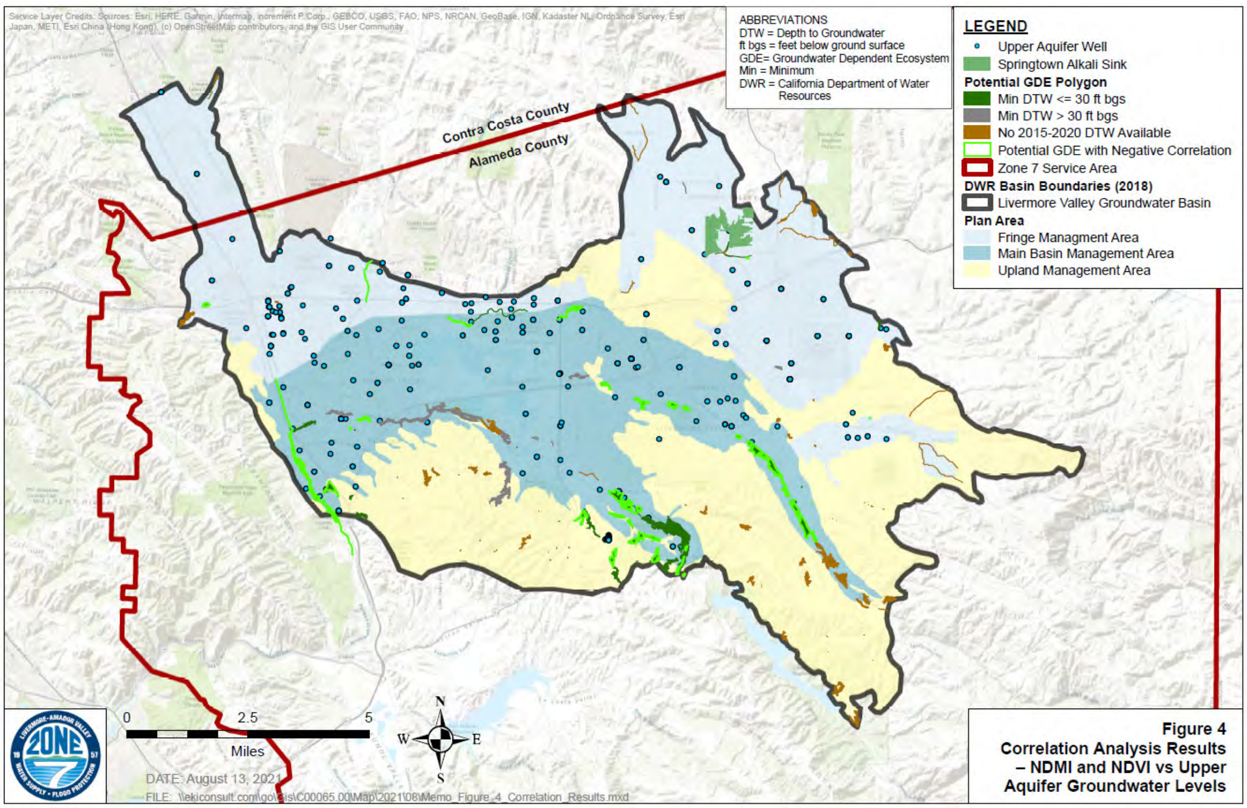


Among the preliminarily retained GDEs (i.e., those GDE polygons where the minimum depth to groundwater in the Upper Aquifer between 2015 and 2020 was less than 30 ft bgs), 84% exhibited a negative correlation between NDMI and depth to groundwater, and 71% exhibited a negative correlation

[11] There are no TNC GDE Pulse data for Springtown Alkali Sink, so the analysis of groundwater level trends and the NDMI and NDVI indices could not be conducted for this GDE.

between NDVI and depth to groundwater. For the purpose of this analysis, correlation with a p-value that is less or equal to 0.05 is considered to be significant. Among the potential GDEs that have negative correlations, 46% of them have a significant correlation between NDMI and depth to groundwater, and 38% of them have a significant correlation between NDVI and depth to groundwater. The potential GDE areas that exhibited negative correlations for both NDMI and NDVI are shown on **Figure 4**. These data indicate that one factor impacting vegetative health in the retained GDE area could be the depth to groundwater.

Figure 4. Correlation Analysis Results – NDMI and NDVI vs Upper Aquifer Groundwater Levels



It should be noted, however, that correlation is not the same as causation and a negative correlation does not necessarily confirm the presence of a GDE that would be impacted by changes in Upper Aquifer groundwater levels. Rather, what this analysis confirms is that GDEs are objectively less healthy when conditions are such that local groundwater elevations decrease, and vice versa. However, significant uncertainties remain. For example, the Overburden layer extent in the Fringe Management Area is uncertain, and therefore while vegetation along the Tassajara Creek and near Dublin (northeastern portion of the Basin) are retained as potential GDEs, they may be disconnected from the underlying Upper Aquifer and any apparent correlation would be meaningless.

1.1.2. <u>Field Investigation & Verification</u>

As described in **Attachment B**, Stillwater Sciences integrated the aforementioned screening analysis and other available local data to conduct a refined mapping of the potential GDEs within the Basin, including: the Classification and Assessment with Landsat of Visible Ecology Groupings (CalVeg) dataset; Urban Creeks Council (UCC) 2014 CalVeg update for third-order and higher channels; Aerial Information Systems

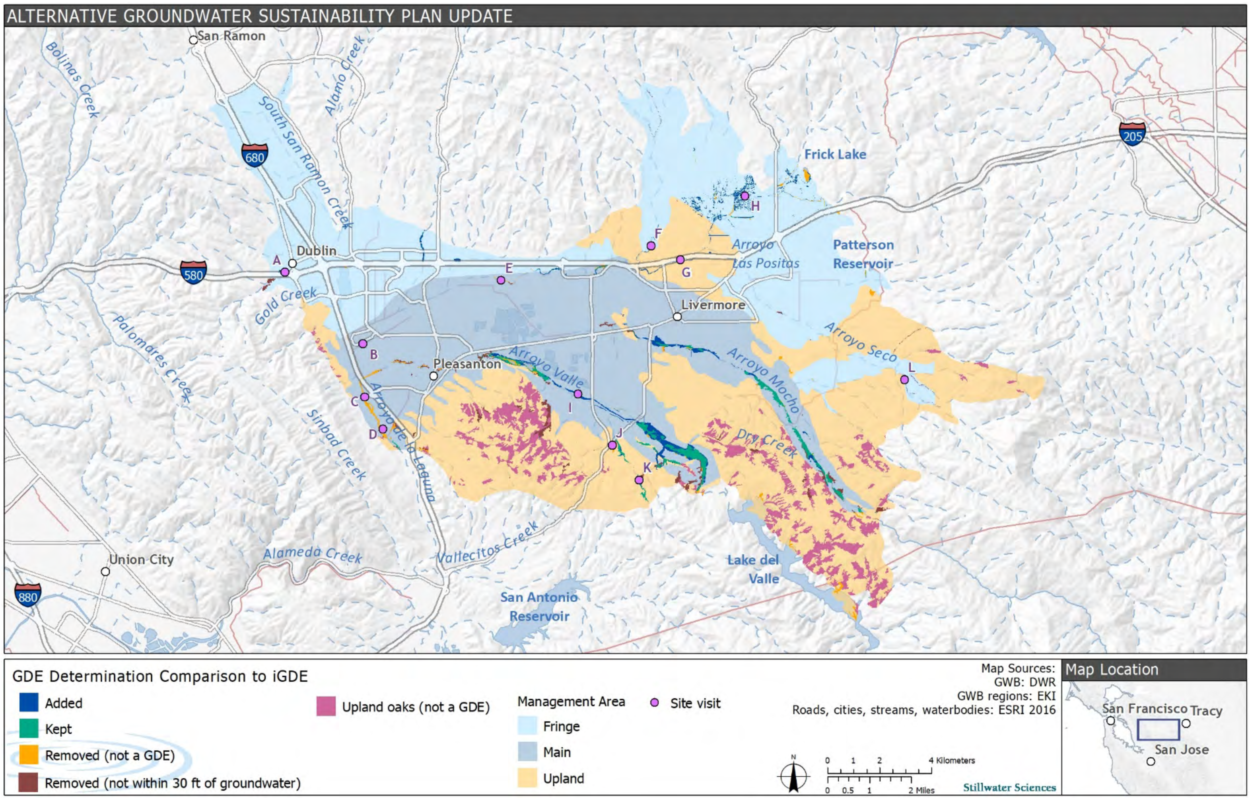
(AIS) Springtown Alkali Sink Preserve Wetlands Mapping; and Sycamore Alluvial Woodland Tree Survey in Arroyo Mocho and Arroyo Valley. Man-made open water areas (e.g., the Chain of Lakes and golf course ponds) were removed from the refined vegetation map. As part of the ecological inventory, special-status species and sensitive natural communities that are potentially associated with GDEs in the Basin were also identified using regional and local databases.[12]

On 31 March 2021, Stillwater conducted field studies and surveyed aerial photography to verify the presence of GDEs at 12 unique sites throughout the Basin (Sites A through L as shown on **Figure 5**). These sites included areas where there were: (1) apparent "gaps" in the potential GDE map shown on **Figure 1** (i.e., where vegetation similar to GDEs occurred immediately upstream and downstream of the mapped site but was not identified as a GDE); (2) where the riparian vegetation was mapped along stream channels (i.e., where the mapped GDEs are potentially supported by surface water, not groundwater); and (3) where the mapped GDEs are underlain by thick clay layers (i.e., where perched groundwater, not the principal aquifer, could be the source). Additionally, Stillwater scientists assessed potential GDEs at sites where groundwater data are sparse (e.g., near Sycamore Park and Springtown). Likely groundwater dependence of these sites was determined by assessing various local water sources and the width of the riparian zone. Where riparian zones were narrow and relatively sparse, other water sources likely support the vegetation. Where existing vegetation and wetland areas extend beyond a narrow strip along the channel, groundwater dependence was considered likely.[13]

[12] Databases used by Stillwater to identify special-status species include: (1) California Natural Diversity Database, (2) California Native Plant Society (CNPS) Manual of California Vegetation, (3) eBird, and (4) TNC freshwater species lists generated from the California Freshwater Species Database (CAFSD).

[13] Stillwater 2021, Technical Memorandum: Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin, dated 17 May 2021.

Figure 5. Comparison of the Likely GDE Map (Figure 6) with the NCCAG Dataset (Figure 1)



Based on the totality of the above analysis, a final determination was made on the presence of likely GDEs within the Basin. The primary differences in GDE mapping relative to the initial NCCAG map of potential GDEs are summarized below and shown on **Figure 5**:

- Additional GDEs were identified in the northeast portion of the Basin where the AIS mapping occurred (Site H, **Figure 5**).
- Potential GDEs mapped in the NCCAG dataset that occur adjacent to man-made open water features along Chain of Lakes (in the Arroyo Valle corridor) and near the City of Dublin were removed.
- Some further changes in GDE mapping reflect differences between the UCC update to the CalVeg map along Arroyo Mocho and Arroyo Valle. In particular, the width of the riparian vegetation along both streams increased in places, as seen in **Figure 5**.
- The reclassification of vegetation near Lake Boris on Arroyo Valle (downstream of Site I, **Figure 5**) reduced the extent of GDEs downstream of the lake.
- The vegetation was removed along Arroyo de la Laguna and west of Pleasanton (Sites B, C, and D, **Figure 5**) after conducting field investigations. These sites occur above a thick clay layer (known colloquially as the Overburden layer) that precludes connection to the principal aquifer. Observations during the field visit suggested that the riparian vegetation at Sites B, C, and D was likely dependent on surface water rather than groundwater due to the relatively narrow riparian zone.

- The potential GDE community near Site L was also removed since the very sparse riparian vegetation suggested the area was not connected to groundwater.
- Wetlands mapped within man-made lakes and ponds (e.g., Frick Lake in the eastern part of the basin) were also removed.[14]

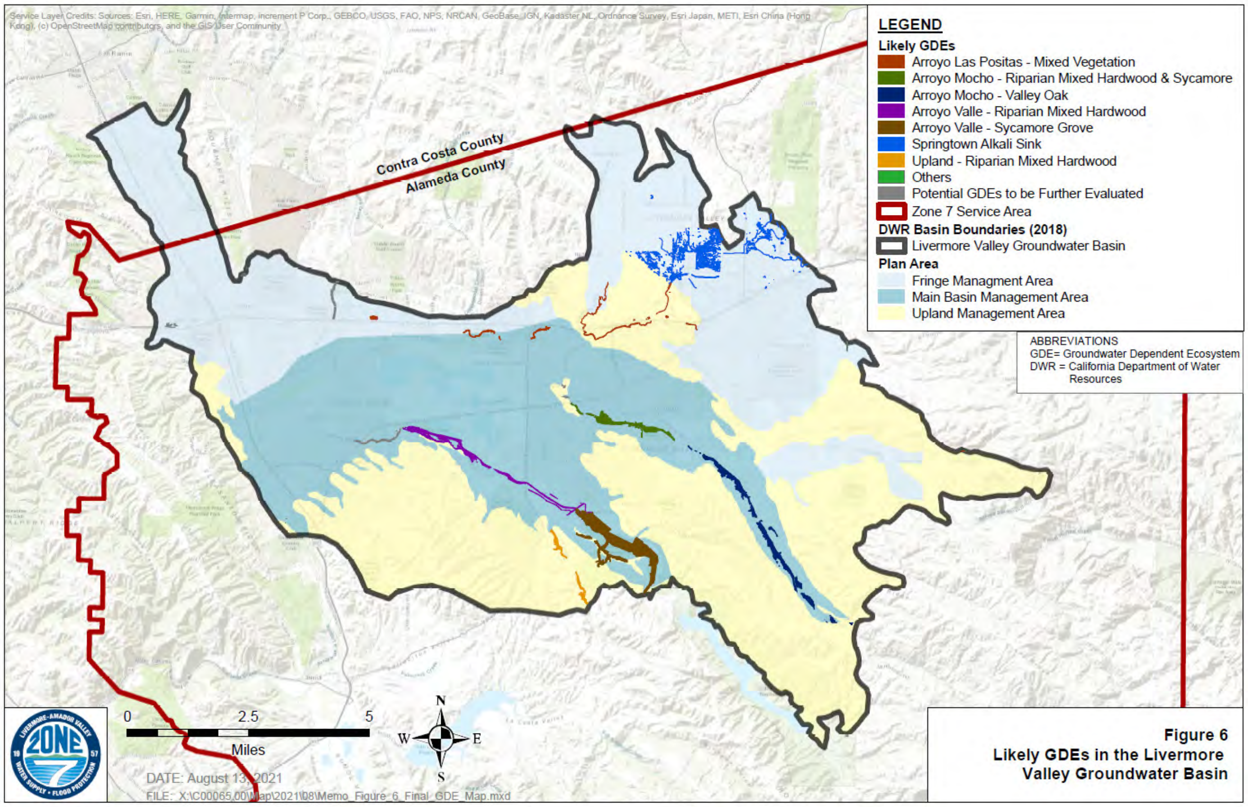
The final likely GDE map is presented on **Figure 6**. Likely GDEs are grouped and named based on their location and major vegetation types, as shown on **Figure 6** and in **Table 1.** However, significant uncertainties remain. For example, the Overburden layer extent in the Fringe Management Area is uncertain, and therefore while vegetation along the Tassajara Creek and near Dublin (northeastern portion of the Basin) are retained as potential GDEs, they may be disconnected from the Upper Aquifer. Other areas retained as potential GDEs include areas of non-native vegetation (such as Eucalyptus trees) or that are adjacent to shallow bedrock outcrops in the center of the Basin (e.g., the "Oak Knoll" area). These GDE areas have been preliminarily retained, but will be further evaluated through monitoring and periodic visual inspections as discussed in **Section 2** below.

Table 1. GDE Region and Major Vegetative Composition

Management Area	Likely GDE Name	Acreages
Main Basin Management Area	Arroyo Valle – Riparian Mixed Hardwood	137
	Arroyo Valle – Sycamore Grove	343
	Arroyo Mocho – Riparian Mixed Hardwood & Sycamore	94
	Arroyo Mocho – Valley Oak	178
Fringe Management Area	Springtown Alkali Sink	173
	Arroyo Las Positas – Mixed Vegetation	56
Upland Management Area	Upland – Riparian Mixed Hardwood	35
Basin-Wide	Potential GDEs to be Further Evaluated	37
	Total Acreages	1,052

[14] Ibid.

Figure 6. Likely GDEs in the Livermore Valley Groundwater Basin



In total, the Basin includes approximately 1,052 acres of likely GDEs, approximately 2% of the total Basin area. The Main Basin Management Area contains approximately 69% of the total likely GDE area, the Fringe Management Area contains approximately 20%, and the Upland Management Area contains the remaining 11% of the likely GDEs. The most prevalent vegetation communities across all likely GDE units are the riparian mixed hardwood alliance and California sycamore alliance, which respectively comprise 40% and 30% of the likely GDE areas in the Basin and are located almost entirely in the Main Basin Management Area. The Alkaline mixed grasses and forbs alliance comprises 10% of total likely GDE area and is located almost entirely in the Fringe Management Area.[15]

The Basin includes United States Fish and Wildlife Service (USFWS) designated critical habitat for four federally listed species: the Alameda whipsnake, California red-legged frog, California tiger salamander, and vernal pool fairy shrimp. As described in **Attachment B**, of the designated critical habitat, most of the habitat for the vernal pool fairy shrimp is co-located with mapped GDEs, but this species relies on vernal pools, which are dependent on rainfall, rather than groundwater and is therefore unlikely to be groundwater dependent. Most of the critical habitat for California red-legged frogs and Alameda whipsnake occurs outside of the defined GDEs, with approximately two acres of their critical habitat overlapping with a riparian GDE at the upstream end of Arroyo Mocho.[16] Zone 7 adheres to the East

[15] Ibid.
[16] Ibid.

Alameda County Conservation Strategy (EACCS) that was developed to preserve endangered species by developing a shared vision for long term habitat protection.[17]

As described in **Attachment B**, 22 special-status plants occur within the Basin, including Alkali milk-vetch, Heartscale, Brittlescale, Livermore tarplant, and Jepson's coyote-thistle. Of these, 12 plant types were likely dependent upon groundwater, four were possibly dependent on groundwater, one was unlikely to be groundwater dependent, and five were not groundwater dependent. All 12 special-status plants likely dependent on groundwater occurred in the Fringe Management Area, and three of the 12 occurred in the Upland Management Area. The likely groundwater dependent special-status plants in the Fringe Management Area mostly were observed in or around the Springtown Alkali Sink.[18]

Thirty-one special-status terrestrial and aquatic wildlife species were identified as having the potential to occur within the Basin, including the Crotch bumble bee, Southwestern pond turtle, and American peregrine falcon. Of these, 14 were potentially groundwater dependent species: two amphibian species, two reptile species, seven bird species, and three mammal species. Additional information on these groundwater dependent species, including regulatory status and habitat associations, is provided in **Attachment B**. Ten of the groundwater dependent special status species are likely to occur in the Main Basin Management Area, eight of the groundwater-dependent special status species are likely to occur in the Fringe Management Area, and 13 of the groundwater-dependent special status species are likely to occur in the Upland Management Area.[19]

1.2. Identification of Interconnected Surface Water Locations

EKI performed various statistical and geospatial analyses to identify locations in the Basin where surface water bodies (e.g., streams) are likely interconnected to shallow groundwater. A summary of this work effort is presented below and in **Attachments C and D**.

1.2.1. Preliminary Screening

Information regarding the locations of streams within the Basin was provided by Zone 7 and are shown on **Figure 7**. EKI conducted a preliminary screening of potential ICSW locations as further described below.

Data Sources

The primary data sources that were incorporated into the analyses include the following:

- Stream mapping provided by Zone 7;
- Stream daily flow data and gauge height between 2015 and 2020 provided by Zone 7;
- Stream recharge rates shapefile provided by Zone 7 based on synoptic surveys;
- Groundwater elevation and depth to water data provided by Zone 7;
- Stream cross sections provided by Zone 7; and

[17] EACCS website, http://eastalco-conservation.org/about.html.
[18] Stillwater 2021, Technical Memorandum: Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin, dated 17 May 2021.
[19] Ibid.

- Guidance document from Environmental Defense Fund (EDF),[20] USGS,[21] and UC Berkeley.[22]

Physical and Operational Exemptions

Artificial stream sections (i.e., those that have been channelized and lined with concrete) were excluded from the depth to groundwater analysis discussed below that was used to identify potential ICSW. Similarly, stream sections that overlie the Overburden layer were excluded. The Overburden layer consists of a thick, continuous surficial lens of clay reaching up to 70 feet thickness that precludes connection to the Upper Aquifer, and mainly exists in the Main Basin Management Area and extends from the north central portion of the Basin to the western edge of the Basin.

Although in its comment letter the DWR identified the Chain of Lakes (COL) as a potential ICSW feature, as stated in the 2016 Alt GSP, "Ongoing mining and reclamation are changing to some degree the connection between upper and lower aquifers and surface water, as some areas are capped or filled (thus reducing connection), and as excavation of wet pits effectively creates surface water ponds. However, no GDEs exist in the mining area and the surface water pits are not identified for specific beneficial uses in the Basin Plan. Releases of water for recharge along the arroyos have resulted in dry season flows in the arroyos; however, these are flows are relatively warm and not equivalent to cool pre-mining flows that could support some native species." Therefore, COL is also excluded from ICSW consideration.

Depth to Groundwater Analysis

The relationship between groundwater and surface water largely depends upon the depth to groundwater relative to the streambed depth. For groundwater to be interconnected with a stream channel, the depth to groundwater in the vicinity of the stream must be less than the streambed depth. Conversely, for surface water to seep to groundwater, which indicates disconnectivity between surface water and groundwater, the depth to groundwater in the vicinity of the stream must be deeper than the streambed depth.

Based on review of the stream cross section profiles provided by Zone 7, the maximum streambed depth of the streams within the Basin is approximately 30 feet. As such, if the minimum depth to groundwater between 2015 and 2020 in the vicinity of the stream sections is more than 30 ft bgs, it is unlikely that the mapped stream sections are interconnected with groundwater. Conversely, if the depth to groundwater is less than 30 ft bgs along the stream sections, the groundwater and stream sections are likely to be interconnected. Upper Aquifer groundwater elevation rasters between 2015 and 2020 were provided by Zone 7, and the depth to groundwater rasters were generated by subtracting the groundwater elevation rasters from the ground surface elevation raster. Depth to groundwater estimates in the vicinity of the mapped streams were made at 500 foot intervals along the length of the mapped streams.

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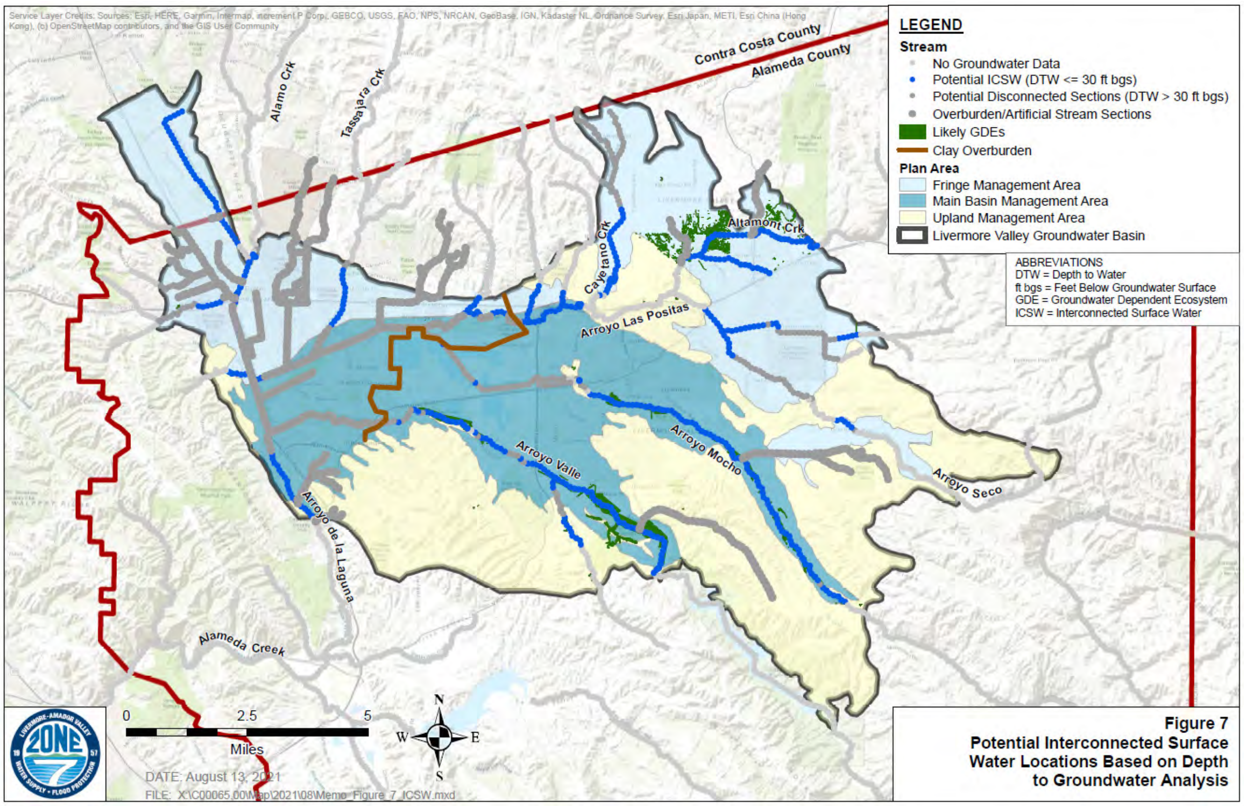
[20] EDF, 2018. *Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act*, dated August 2018.
[21] Winter et al., 1998. *Ground Water and Surface Water: A Single Resource*. USGS. Dated 1998.
[22] Cantor et al., 2018. *Navigating Groundwater-Surface Water Interactions under the Sustainable Groundwater Management Act*. Center for Law, Energy & the Environment, UC Berkeley School of Law. Dated March 2018.

Additionally, Zone 7 has conducted synoptic surveys to identify the reaches of major streams in the Basin and whether they are gaining or losing, and what the respective rates are, as shown on Figure 2-4 of the 2016 Alt GSP (**Attachment C**).

Based on the above data and analysis, locations of potential ICSW locations are shown on **Figure 7**.

Figure 7. Potential Interconnected Surface Water Locations Based on Depth to Groundwater Analysis



Correlation Analysis

SGMA requires that the sustainability criteria of the ICSW Sustainability Indicator be developed based on the "…rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water..."[23] Alternatively, groundwater levels can be used as a proxy.[24]

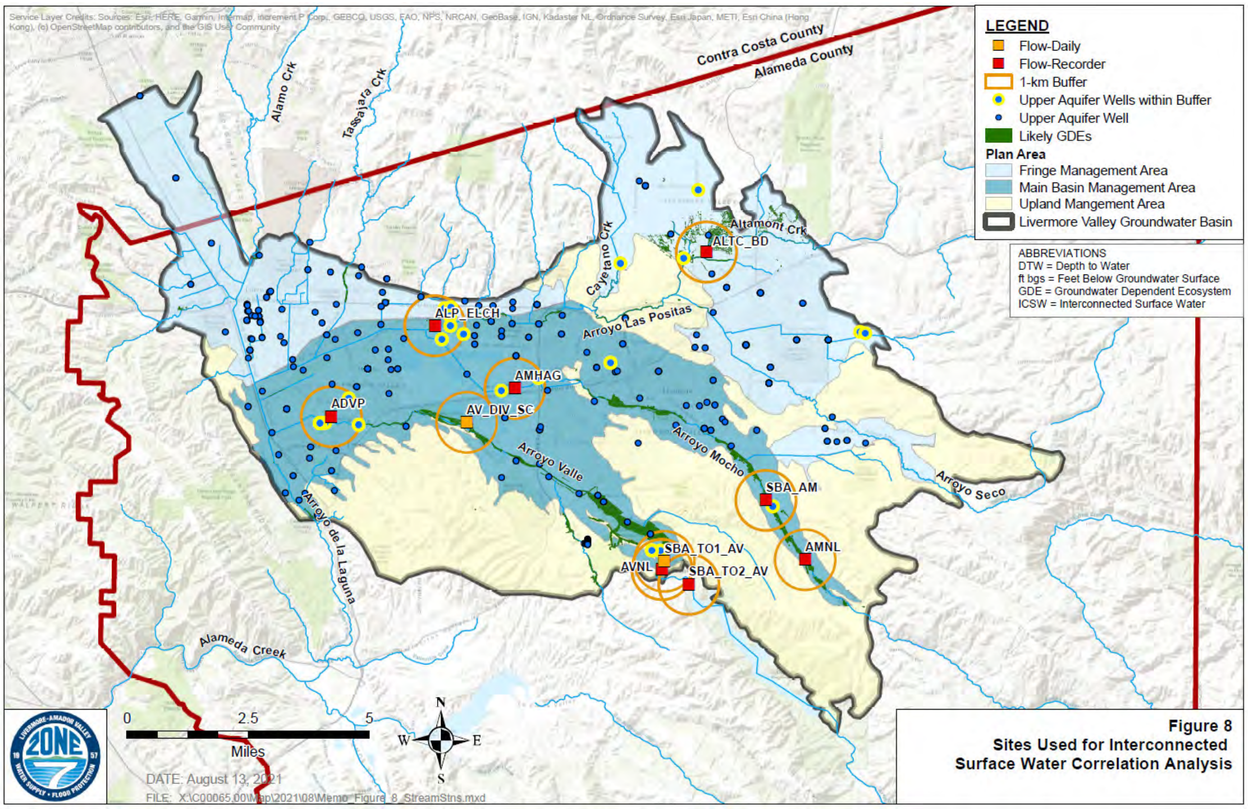
Based on the above, the potential correlation between Upper Aquifer groundwater elevation and streamflow data, including gauge height and flow rate, were evaluated to examine whether the portions of the streams that were identified as likely ICSW have a quantifiable relationship to the principal aquifer. Stream gauging stations along potential ICSW sections and near likely GDEs (from **Figure 7** and

[23] § 354.28(b)(6)

[24] § 354.28(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence

Attachment C) were selected for the correlation analysis, as shown on **Figure 8**. Zone 7 provided daily flow data and gauge height between 2015 and 2020 for the selected stations.

Figure 8. Sites Used for Interconnected Surface Water Correlation Analysis

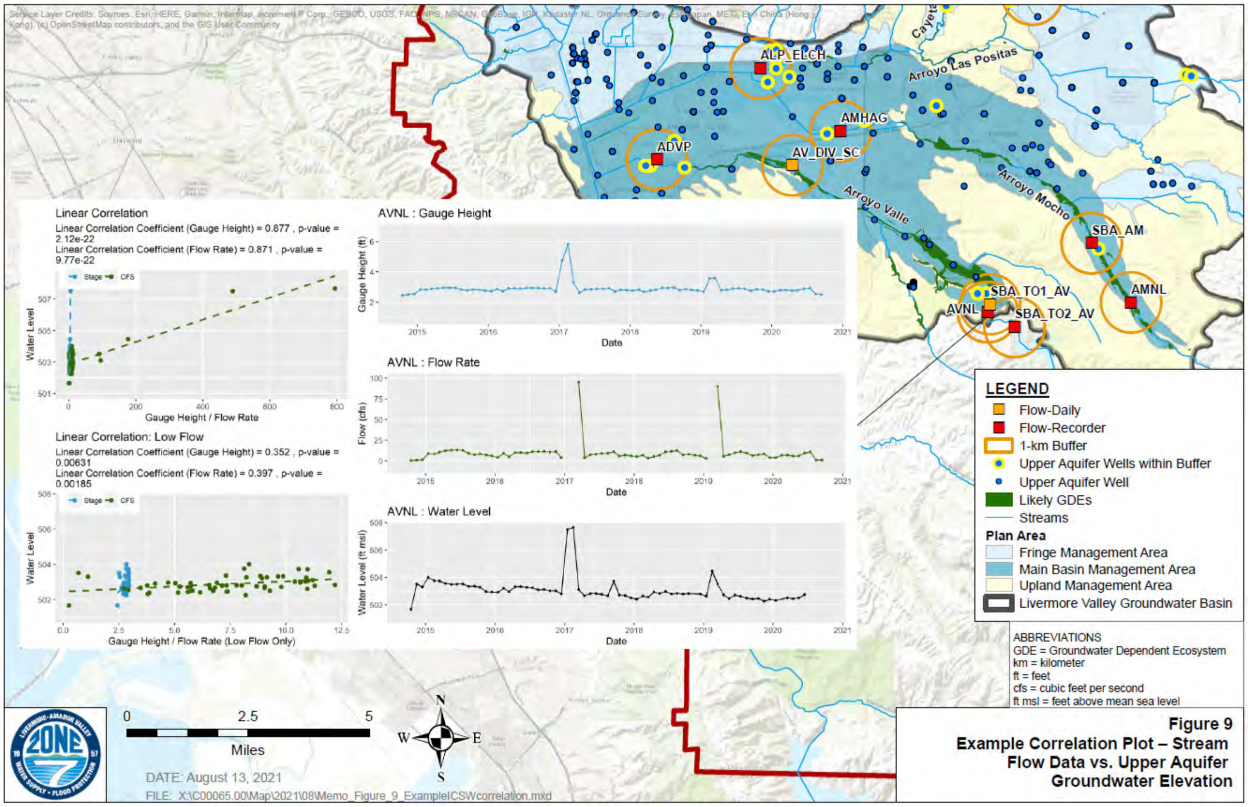


Upper Aquifer wells within a one km radius of the selected stream gauging stations were assumed to be representative of groundwater conditions in vicinity of the stations. If multiple wells were associated with (i.e., within one km of) a stream gauging station, average groundwater elevations from these wells were calculated. The Upper Aquifer wells within the one km buffer of each selected stream gauging station are shown on **Figure 8**. Since most of the groundwater elevations were measured monthly, monthly average flow data and gauge height were calculated.

Time series data of the gauge height and flow rate were plotted for each stream gauging station, as shown on **Figure 9** and in **Attachment D**. A linear correlation between the stream flow data (gauge height and flow rate) and the local groundwater elevation was then evaluated for each station. A positive correlation would mean that, when the gauge height or flow rate increases, the groundwater elevation also increases, indicating that there is potential interconnectivity between the stream and groundwater, and vice versa.

As part of its active management of the Basin, Zone 7 imports surface water from the State Water Project (SWP) through the South Bay Aqueduct (SBA) for treatment, storage, and groundwater recharge. Since the streams within the Basin are also used for artificial recharge, correlation between low flow, which better represents the natural streamflow conditions, and Upper Aquifer groundwater elevation was also performed. Low flow data for each stream gauging station were obtained by removing the gauge height and flow rate data that fell outside of the 90th percentile[25]. The low flow correlation result for each stream gauging station is also shown on **Figure 9** and in **Attachment D**.

Figure 9. Example Correlation Plot – Stream Flow Data vs. Upper Aquifer Groundwater Elevation



Among the selected stream gauging stations (i.e., stations located along potential ICSW and near likely GDEs), only the AVNL station exhibited statistically significant positive correlations between streamflow data (gauge height and flow rate) and groundwater elevation data.[26] The ADVP station also showed a low but statistically significant positive correlation for low flow conditions only. Groundwater elevation measurements from the wells located close to the other stream gauging stations are generally collected biannually, and thus there is insufficient groundwater elevation data to support statistically significant correlation between groundwater levels and monthly average stream flow data. This data gap is addressed further under **Section 2**.

For the AVNL station, the correlation using all stream flow data has a larger correlation coefficient and smaller p-value than those for the correlation using low flow data only (i.e., for all stream flow data, correlation coefficients and p-values are 0.88 and 2.1e-22 for gauge height, 0.87 and 9.8e-22 for flow rate; for low flow data, the correlation coefficients and p-values are 0.35 and 0.006 for gauge height, 0.40 and 0.002 for flow rate). The AVNL station is located along Arroyo Valle and near the location where imported

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[25] Ratio of high flow events to low flow events is approximately 1:9 in most of the stream stations, and therefore 90th percentile is used as a threshold to retain low flow data.

[26] For the purpose of this analysis, correlation with a p-value that is less or equal to 0.05 is considered to be significant.

SWP water is released into the stream. Nearby likely GDEs (Sycamore Grove located in the southeastern portion of the Basin) have been documented to rely on the released imported water for artificial recharge,[27] which is also reflected in the higher correlation for all flow data (i.e., during active Zone 7 recharge operations).

Additionally, cross-correlation was performed for the AVNL station data to examine whether a time lag exists between the stream flow data and shallow groundwater elevations.[28] The cross-correlation result shows that maximum correlation is reached when time lag equals zero months and the correlation is significant, which indicates that limited time lag exists between the stream flow data and groundwater elevations for the AVNL station.

1.3. GDE and ICSW Program Update

Based on the above analyses and field investigation, the Basin includes approximately 1,052 acres of likely GDEs, which encompass approximately 2% of the total Basin area. The most prevalent vegetation communities across all likely GDE units are the riparian mixed hardwood alliance, California sycamore alliance, and the Alkaline mixed grasses and forbs alliance. Most of the likely GDEs are located along the Arroyo Valle and Arroyo Mocho creeks in the Main Basin Management Area and around Altamont Creek in the Fringe Management Area.

Likely ICSW sections have also been identified along several reaches of the major surface water features within the Basin, including Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, and Altamont Creek. Unsurprisingly, most of the areas where potential ICSW sections occur also support likely GDEs, as these stream corridors consistently encounter some of the shallowest groundwater elevations observed within the Basin, see **Figure 7**.

Where sufficient data and ICSW conditions exist, groundwater levels in the Upper Aquifer can be correlated to ICSW conditions and GDE locations. As such, Upper Aquifer wells and the selected stream gauging stations can serve as the representative monitoring sites for purposes of SGMA implementation, and sustainability criteria that are protective of both GDEs and ICSW can be developed using groundwater levels as a proxy.

2. GDE AND ICSW MONITORING NETWORK

This section describes the existing and proposed Monitoring Network for areas of the Basin that have likely GDEs and/or ICSW reaches. As mentioned above, the locations of likely GDE communities within the Basin are largely coincident with the presence of ICSW reaches, given that both GDEs and ICSW are supported by shallow local groundwater conditions. As such, the proposed ICSW Monitoring Network presented in this section is designed to provide a "dual benefit" of: (1) assessing ongoing surface water - shallow groundwater connectivity within ICSW reaches, as well as (2) supporting monitoring of groundwater conditions that are one of the factors that can contribute to the health of nearby GDE communities.

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[27] Zone 7, 2009. Phase 2 Technical Report: Sycamore Grove Recovery Program, Sycamore Grove Park, Livermore, California, dated December 2009.

[28] Cross-correlation is a measurement that tracks the movements of two or more sets of time series data relative to one another.

2.1. Existing Monitoring Locations

Zone 7 has about 240 program wells for the groundwater elevation monitoring program in order to track groundwater levels and flow, identify short- and long-term trends, estimate subsurface flow between Management Areas, and support water budget and storage analyses.[29] Among the 240 program wells, about 110 wells are Upper Aquifer wells, as shown on **Figure 10**. The program wells are measured at least biannually. Water level measurements are also taken monthly in several wells to track performance of recharge and pumping operations and groundwater conditions. Figure 2-17 and Appendix C-1 of the 2016 Alt GSP show the location and well construction information of the program wells. Two wells (2S2E34E001 and 2S2E27P002) are currently used for monitoring of Springtown Alkali Sink, which is one of the likely GDE areas (see **Table 1** and **Figure 6**).

Zone 7 monitors also streamflow within the Basin and has a stream monitoring program that includes 15 stream gauging stations that record flow data at 15-minute intervals. Figure 4-2 and Table 4-3 of the 2016 Alt GSP show the location and detail of the stations.

In addition to the existing network, as part of the development of the 2022 Plan, Zone 7 has identified and secured access to additional well sites. Several of these new wells have been identified as candidates for the ICSW Monitoring Network; selected others will become program wells.

2.2. Proposed ICSW Monitoring Network

The objective of a SGMA Representative Monitoring Network is to collect sufficient data for the correct assessment of the Sustainability Indicators relevant to the Basin, and the impacts to the beneficial uses and users of groundwater.[30] The proposed SGMA Representative Monitoring Network for Depletions of Interconnected Surface Water (RMN-ICSW) is therefore comprised of selected Upper Aquifer program wells, new wells, and stream gauging stations along the ICSW reaches and near the likely GDEs identified in **Section 1.1.2**.

In developing the RMW-ICSW, the EDF guidance, which recommends a monitoring location every four to six miles along an ICSW stream for a "reasonable balance between rigor and practicality" was considered.[31] Upper Aquifer wells with a long period of record and located in close proximity to a stream gauging station were preferentially selected and a higher density of monitoring wells was selected in some likely ICSW reaches to sufficiently cover nearby likely GDEs within the Basin.

Figure 10 shows the RMN-ICSW, including both representative monitoring wells and representative stream gauging stations. **Table 2** shows the monitoring network details, including the nearby likely GDEs, nearby stream gauging stations, monitoring methods, monitoring frequency, and well construction information. In total 14 wells and 10 stream gauging stations have been selected as part of the RMN-ICSW, where data will be collected manually every month, semi-annually, or using data loggers every 15 minutes, depending on the site.[32] These data will be evaluated annually to assess the correlation between

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[29] Zone 7, 2016. Alternative Groundwater Sustainability Plan for the Livermore Valley Groundwater Basin, dated December 2016.
[30] Pursuant to § 354.32
[31] Hall et al., 2018. *Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act. Environmental Defense Fund.* Dated 2018.
[32] Two of the wells (3S1E16P005 and 3S2E30D002) currently have data loggers installed.

shallow groundwater levels and GDE health and ICSW flow rates to confirm that groundwater levels can serve as an appropriate proxy for purposes of developing and applying sustainability criteria. Monitoring frequency will be re-evaluated if groundwater levels decline below their Minimum Thresholds (MT) in the RMN-ICSW monitoring wells.

In addition to monitoring the proposed RMN-ICSW, Zone 7 plans to perform periodic visual inspections to monitor the health of likely GDEs and ICSW conditions. Visual inspections will be either examination of areal images or field investigation, or a combination thereof. Bi-annual or monthly monitoring of the remaining Upper Aquifer program wells will also continue, which will provide additional data and perspective on shallow aquifer conditions within the Basin.

Figure 10. Proposed Representative Monitoring Network for Depletions of Interconnected Surface Water

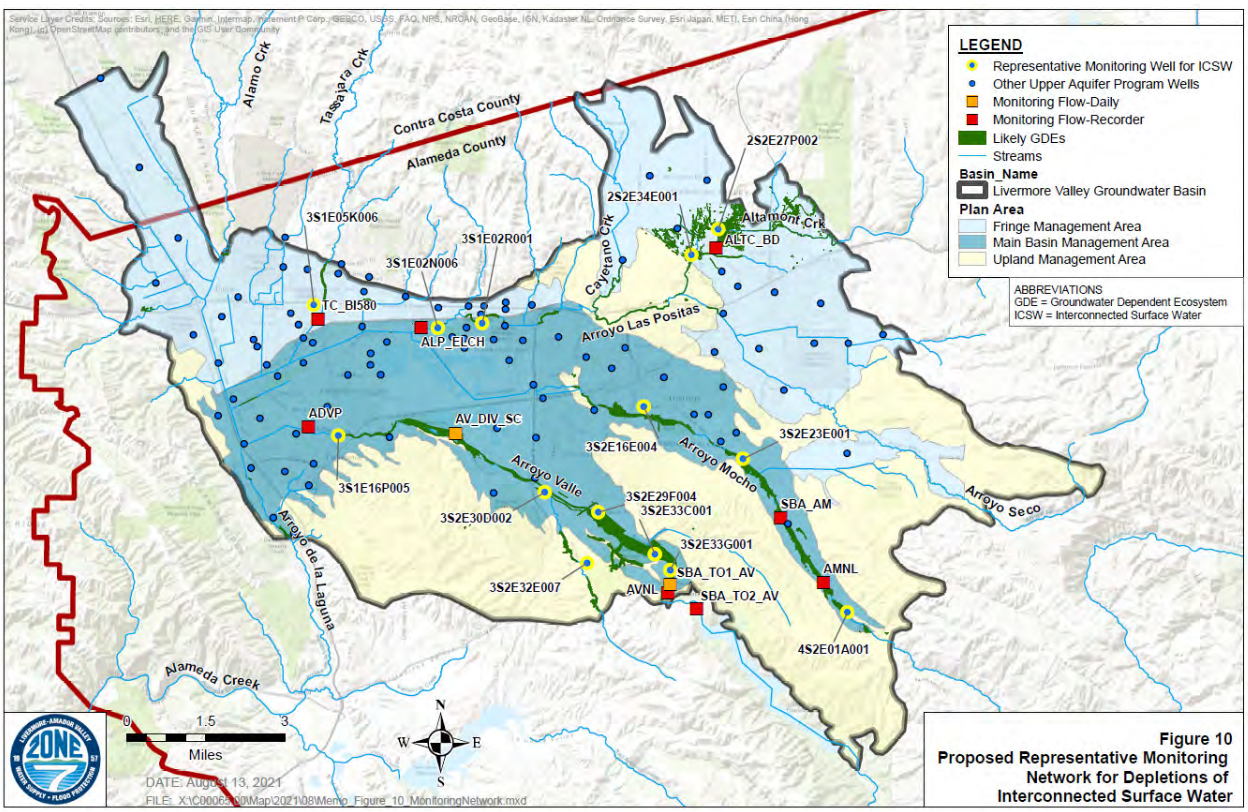

Table 2. Proposed Representative Monitoring Network for Depletions of Interconnected Surface Water Details

Well Name	Well Type	Nearby GDE	Nearby ICSW	Nearby Stream Station (<=1km)	Monitoring Method	Monitoring Frequency	RP Elev (ft msl)	Top Perf (ft bgs)	Bot Perf (ft bgs)	Well Depth (ft bgs)
2S2E27P002	Program Well	Springtown Alkali Sink	Altamont Creek	ALTC_BD	Collect Manually	SemiAnnual	505.43	35	63	68
2S2E34E001	Program Well	Springtown Alkali Sink	Altamont Creek	ALTC_BD	Collect Manually	SemiAnnual	499.73	40	45	49
3S1E05K006	Program Well	TC-Riparian Mixed Hardwood	Tassajara Creek	TC_BI580	Collect Manually	SemiAnnual	346.05	40	70	75
3S2E30D002	Program Well	AV-Riparian Mixed Hardwood	Arroyo Valle	--	Logger (existing)	15 Minutes	431.6	24	39	44
3S1E16P005	Program Well	AV-Riparian Mixed Hardwood	Arroyo Valle	ADVP	Logger (existing)	15 Minutes	354.51	64	69	75
3S2E33G001	Program Well	AV-Sycamore Grove	Arroyo Valle	AVNL, SBA_TO1_AV, SBA_TO2_AV	Collect Manually	Monthly	511.52	9	14	17
3S2E29F004	Program Well	AV-Sycamore Grove	Arroyo Valle	--	Collect Manually	Monthly	457.50	26	31	36
3S2E33C001	New Program Well (Monitoring)	AV-Sycamore Grove	Arroyo Valle	--	Collect Manually	SemiAnnual	493.23	5	20	20
3S1E02R001	Program Well	ALP-Mixed Vegetation	Arroyo Las Positas	--	Collect Manually	SemiAnnual	376.29	21	26	33
3S1E02N006	Program Well	ALP-Mixed Vegetation	Arroyo Las Positas	ALP_ELCH	Collect Manually	SemiAnnual	366.14	40	55	55
3S2E16E004	Program Well	AM-Riparian Mixed Hardwood & Sycamore	Arroyo Mocho	--	Collect Manually	SemiAnnual	506.26	35	40	45
3S2E23E001	Program Well	AM-Valley Oak	Arroyo Mocho	--	Logger (to be added)	15 Minutes	613.36	20	35	40
4S2E01A001	New Program Well (Ag)	AM-Valley Oak	Arroyo Mocho	AMNL	Collect Manually	SemiAnnual	819.76	45	130	150
3S2E32E007	Program Well	Upland-Riparian Mixed Hardwood	Vineyard Creek	--	Collect Manually	SemiAnnual	610.94	19	34	37

Table 2. Proposed Representative Monitoring Network for Depletions of Interconnected Surface Water (Cont.)

Station ID	Measures	Nearby GDE	Nearby ICSW	Flow Frequency	Gauge Height	Flow Rate
ALTC_BD	Streamflow	Springtown Alkali Sink	Altamont Creek	15 Min	x	x
ALP_ELCH	Streamflow	ALP-Mixed Vegetation	Arroyo Las Positas	15 Min	x	x
ADVP	Streamflow	AV-Riparian Mixed Hardwood	Arroyo Valle	15 Min	x	x
AV_DIV_SC	Diversion From AV	AV-Riparian Mixed Hardwood	Arroyo Valle	Daily	-	x
AVNL	Streamflow	AV-Sycamore Grove	Arroyo Valle	15 Min	x	x
SBA_TO1_AV	Release into AV	AV-Sycamore Grove	Arroyo Valle	15 Min	-	x
SBA_TO2_AV	Release into AV	AV-Sycamore Grove	Arroyo Valle	15 Min	-	x
SBA_AM	Release into AM	AM-Valley Oak	Arroyo Mocho	15 Min	-	x
AMNL	Streamflow	AM-Valley Oak	Arroyo Mocho	15 Min	x	x
TC_BI580	Streamflow	Tassajara Creek - Riparian Mixed Hardwood	Tassajara Creek	15 Min	x	x

2.3. Data Gap Filling Activities

Zone 7 uses Arroyo Valle and Arroyo Mocho for artificial recharge of the Basin using imported SWP water. Currently two representative monitoring wells, 3S2E30D002 and 3S1E16P005 along Arroyo Valle, have automatic dataloggers installed that collect data at 15-minute intervals. In addition, to better evaluate the relationship between the Upper Aquifer groundwater elevations and the stream flow data collected along the Arroyo Mocho, Zone 7 plans to install dataloggers in well 3S2E23E001.

Additional analyses that may help further characterize the degree of connectivity between stream reaches and the underlying principal aquifer system include installation of additional data loggers, pumping tests, geophysical investigations, and tracer studies within potential ICSW reaches and nearby GDE communities. Zone 7 will evaluate these data gap filling activities prior to the 2027 Alt GSP update.

3. GROUNDWATER DEPENDENT ECOSYSTEM DEMANDS

Quantifying groundwater consumptive use from GDEs can be estimated using a soil moisture balance model. Evapotranspiration (ET) uptake from groundwater occurs when the saturated groundwater table is accessible by the root zone of a GDE or is within a small enough depth below the root zone such that groundwater can be accessed via capillary rise. As part of this work effort, EKI has utilized DWR's Integrated Water Flow Model Demand Calculator (IDC) soil moisture balance model to provide initial estimates of ET uptake from groundwater for the GDE communities identified in the above analyses. The IDC employs the "Root Water Uptake" package to simulate shallow groundwater uptake by GDE communities to meet ET demands[33]. In its current form, the Zone 7 IDC model explicitly simulates shallow groundwater uptake from the five largest and most contiguous GDE communities identified in the Basin, including:

- Arroyo Valle - Riparian Mixed Hardwood
- Arroyo Valle - Sycamore Grove
- Arroyo Mocho - Riparian Mixed Hardwood & Sycamore
- Arroyo Mocho - Valley Oak
- Springtown Alkali Sink

These GDE communities collectively comprise approximately 925 acres, or roughly 90% of the total mapped GDE areas within the Basin.

Based on IDC model outputs for DWR Water Years 2011 – 2020, approximately 2,900 acre-feet per year (AFY) of shallow groundwater are consumed by GDE communities to help meet ET demands, equating to approximately 3.0 AF/acre. This represents roughly 70% of the total potential ET demand estimated for GDEs within the Basin (~4.3 AFY/acre) [34]. Given the considerable uncertainties in soil properties, shallow groundwater availability, and plant-specific groundwater uptake rates embedded in this calculation, a

[33] Dogrul, E.C., Kadir, T.N. (DWR). 2020. *IWFM Demand Calculator, IDC-2015. Theoretical Documentation and User's Manual.*

[34] Based on local CIMIS station reference evapotranspiration (ETo) data and monthly riparian/native vegetation ET coefficients provided by DWR's Cal-SIMETAW model for the Livermore study area.

more reasonable range of average GDE groundwater demands within the Basin is likely somewhere between 2,000 AFY (~2 AFY/acre) and 4,000 AFY (~4 AFY/acre).

4. SUSTAINABLE MANAGEMENT CRITERIA

The SGMA legislation defines a "Sustainability Goal" as "the existence and implementation of one or more groundwater sustainability plans [GSPs] that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield".[35] The SGMA requires Groundwater Sustainability Agencies (GSAs) to develop and implement GSPs to meet the Sustainability Goal[36] and defines terms related to achievement of the Sustainability Goal, including:

- Measurable Objective (MO) – "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin";[37]
- Minimum Threshold (MT) – "a numeric value for each sustainability indicator used to define undesirable results";[38] and
- Interim Milestone (IM) – "a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan".[39]

Collectively, the Sustainability Goal, IMs, MOs, and MTs are referred to herein as Sustainable Management Criteria (SMCs).

This section describes the proposed SMCs for Depletions of Interconnected Surface Water, including the Undesirable Results (URs), MOs and MTs for areas of the Basin that have confirmed GDEs and/or ICSW. These SMCs were developed in consideration of the California Water Code (CWC) §10727.2(b)(4) which states that the Plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015. It is further noted that the GSP Emergency Regulations (23-CCR § 354.28(c)) state that the SMCs for a given Sustainability Indicator can be set by using groundwater levels as a proxy, which is the approach utilized herein.

4.1. Undesirable Results

Undesirable Results are defined in the SGMA as "when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin". For Depletions of Interconnected Surface water, SGMA defines an UR as "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water".[40]

[35] CWC § 10721(u)
[36] CWC § 10727(a)
[37] 23 CCR § 351(s)
[38] 23 CCR § 351(t)
[39] 23 CCR § 351(q)
[40] CWC § 10721(x) (6)

As shown in **Attachment E**, based on information provided by TNC,[41] the area-weighted average change in the size of the GDE areas between 2014 and 2018 within the Basin was approximately 40% (i.e., the mapped GDE area in 2014 was 40% smaller than the GDE areas mapped in 2018).[42] Based on this change in GDE area analysis, a 40% reduction in GDE area is within the historical range of GDE area fluctuation under recently-observed, post-SGMA hydrologic conditions.

As such, the URs for Depletions of ICSW would be experienced in the Basin when groundwater extractions in the Basin cause significant and unreasonable depletions of hydrologically connected surface water, such that beneficial uses and users of the surface water (including the likely GDEs and protected species) are significantly and unreasonably harmed. Specifically, a significant and unreasonable negative effect would be experienced if the health of the GDE areas in the Basin are adversely impacted by mechanisms that can be directly attributed to pumping-related lowering of groundwater levels over time, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions or land use changes.

This Undesirable Result definition is preliminary pending the collection of additional data. At this time, as described above, the relationship between ICSW, GDE health and groundwater conditions has not been definitively determined and the ability of Zone 7 to manage the ICSW and GDE areas is limited given the significant other factors that impact their occurrence and health (e.g., climate, hydrology, invasive species, land development, etc.). Furthermore, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs. Zone 7 will continue to monitor the ICSW and GDE areas and may refine the definition of URs once the information regarding the relationship between the occurrence of ICSW and GDEs and the management of the Basin is better understood.

4.1.1. Potential Causes of Undesirable Results

Depletions of Interconnected Surface Water are generally correlated to Chronic Lowering of Groundwater Levels in a system of ICSW and groundwater. Therefore, the potential causes of URs for the Depletions of Interconnected Surface Water are generally the same as the potential causes for URs due to Chronic Lowering of Groundwater Levels, including increased groundwater pumping and reduced recharge. Additional causes directly related to surface water bodies can also influence depletions including, but not limited to, hydrology, increased diversions, reduced return flows, and water consumption by riparian vegetation. Additional causes related to GDEs can include hydrology, land use changes and the occurrence of invasive species, among other things. Currently there are little to no quantitative data regarding the impacts from these potentially contributing causes to ICSW and GDEs within the Basin.

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[41] Statewide raster data that show NDVI trends are provided by TNC on 30 August 2021. Since NDVI is used to estimate vegetation greenness and provides a proxy for vegetation growth, change in GDE area can be estimated using TNC GDE Pulse raster data that shows the NDVI trends between 2014 and 2018. Moderate to large increases in NDVI trends represent an increase in the GDE area and moderate to large decreases in NDVI trends represent a decrease in the GDE area. Therefore, the change in GDE area can be estimated by subtracting GDE area with decreasing NDVI trends from GDE area with increasing NDVI trends.

[42] Since the Plan is not required to address undesirable results that occurred before, and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2014 is selected as the start of the analysis timeframe. 2018 is selected as the end of the analysis timeframe since it is a recent wet year when GDE conditions might be above average.

4.1.2. Criteria Used to Define Undesirable Results

Per Section 354.26(b)(2) of the GSP Emergency Regulations, the description of Undesirable Results must include a quantitative description of the combination of MT exceedances that constitute an UR. The MTs for Depletions of Interconnected Surface Water are described below in **Section 4.2.1**.

Based on application of the MTs at the Representative Monitoring Network for Interconnected Surface Water (RMN-ICSW) and the significant and unreasonable negative effect discussed above, URs will be experienced if and when Depletions of Interconnected Surface Water occur as a result of unsustainable groundwater extraction such that groundwater levels decline below their MTs in the Representative Monitoring Sites (RMSs) for more than two consecutive years.

This UR criteria is preliminary pending the collection of additional data. At this time, as described above, the relationship between ICSW, GDE health and groundwater conditions has not been definitively determined and the ability of Zone 7 to manage the ICSW and GDE areas is limited given the significant other factors that impact their occurrence and health (e.g., climate, hydrology, invasive species, land development, etc.). Furthermore, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs. Zone 7 will continue to monitor the ICSW and GDE areas and may refine the criteria used to determine URs once the data gaps are filled, additional information are gathered and the relationship between the occurrence of ICSW and GDEs and the management of the Basin is better understood.

4.1.3. Potential Effects of Undesirable Results

Potential effects of URs for Depletion of Interconnected Surface Water may include impacts to environmental users, such as likely GDEs, critical habitat for federally listed species, special-status plants, and special-status terrestrial and aquatic wildlife species, as discussed in **Section 1.1.2**. Furthermore, there may be reduced surface water flows to support downstream or in-stream uses. Conversely, if groundwater levels in the vicinity of ICSW (and the co-located GDEs) remain too high, Zone 7's ability to actively manage the Basin through recharge operations will be negatively impacted. Consideration of all the above was included as part of the development of the SMCs.

4.2. Minimum Threshold, Measurable Objective, and Interim Milestones Development

The sections below discussed the development of MOs, IMs, and MTs for Depletions of Interconnected Surface Water.

The GSP Emergency Regulations (23 CCR 354.28(c)) state that the MT for Depletions of Interconnected Surface Water "shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial users of the surface water and may lead to undesirable results". Based on the analysis presented in **Sections 1.1** and **1.2**, where sufficient data are available and ICSW conditions exist, a reasonable correlation exists between groundwater levels in the monitoring wells included in the RMW-ICSW. As such, for the purposes of developing SMCs, water levels in those monitoring wells are used as a proxy for developing the MTs.

4.2.1. Minimum Threshold

MTs are the numeric criteria for each Sustainability Indicator that, if exceeded, may cause URs for that indicator or for other indicators by proxy. This section describes the MTs that have been developed to avoid URs related to the of Depletions of Interconnected Surface Water in the Basin.

Water levels are considered reasonably effective (and the best available) criteria because they can be utilized to help maintain conditions and instream flows that support environmental water users and, in the case of Zone 7, Basin recharge operations. A composite map of historic lows observed in the Upper Aquifer, as shown on Figure 3-1 of the Alt GSP, has been prepared by Zone 7. For several decades, Zone 7 has operated the Basin to maintain water levels above historic low levels throughout the Main Basin Management Area [without causing URs].[43] Water levels outside of the Main Basin Management Area have not fluctuated significantly over time, and no areas of significant downward trends [or areas with URs] have been identified.[44]

Generally consistent with the definition used for the MT for the Chronic Lowering of Groundwater Levels, the MT for the Depletions of Interconnected Surface Water is defined as the historic low water level at the wells included in the RMN-ICSW. The resultant MTs for the RMN-ICSW within the Basin are shown in **Table 3**. Where historical water level measurements are not available, estimated values at the RMWs are sourced from the groundwater elevation rasters developed by Zone 7 as discussed in **Section 1.2.1**. **Attachment F** shows the hydrograph and SMC for the Depletions of Interconnected Surface Water for each RMW-ICSW.

Currently there are no significant quantitative data representing negative impacts from the contributing causes identified in **Section 4.1.1** to ICSW and GDEs within the Basin. Therefore, historical groundwater conditions are concluded to be sufficient to sustain ICSW and GDEs within the Basin.

As discussed above, the 10 stream stations located along the potential ICSW within the Basin (as shown in **Table 1**) that are included in the RMN-ICSW will record either flow rates and/or gauge heights. These data, combined with water level measurements from the monitoring wells in the RMN-ICSW, will better quantify relationships between measured changes in groundwater levels and surface water flows that can help ensure that these MTs are protective and will allow for refinement of the SMC approach over time.

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[43] Zone 7, 2016. Alternative Groundwater Sustainability Plan for the Livermore Valley Groundwater Basin, dated December 2016.
[44] Ibid.

Table 3. Sustainable Management Criteria for Depletions of Interconnected Surface Water

Well Name	Minimum Thresholds (ft msl)	Interim Milestones (ft msl)			Measurable Objectives (ft msl)
		IM-5	*IM-10*	*IM-15*	
2S2E27P002	501.0	501.0	501.0	501.0	501.0
2S2E34E001	491.2	492.1	492.4	492.7	493.0
3S1E05K006	326.0	328.2	328.2	328.2	328.2
3S2E30D002	401.0	403.8	404.7	405.6	406.5
3S1E16P005	285.2	285.2	285.2	285.2	285.2
3S2E33G001	501.0	501.1	501.2	501.2	501.3
3S2E29F004	437.8	441.2	442.3	443.5	444.6
3S2E33C001	482.1	484.2	484.8	485.5	486.2
3S1E02R001	345.3	349.4	350.8	352.2	353.6
3S1E02N006	331.5	333.9	333.9	333.9	333.9
3S2E16E004	466.9	466.9	466.9	466.9	467.0
3S2E23E001	595.4	595.4	595.4	595.4	595.4
4S2E01A001	781.2 (a)	781.2 (a)	781.2 (a)	781.2 (a)	781.2 (a)
3S2E32E007	591.4	591.4	591.4	591.4	591.4

Notes:

(a) RMW 4S2E01A001 is a new well and there are insufficient water level data to establish an MT, MO, and IM based on historical water levels. As such, initial MT, MO, and IM for these RMW are based on the minimum water level values sourced from 2014 to 2020 groundwater elevation rasters developed by Zone 7 for the Basin.

4.2.2. Measurable Objective and Interim Milestones

MO Determination

As described in the Sustainable Management Criteria BMP document, "Measurable Objectives should be set such that there is a reasonable margin of operation flexibility (or 'margin of safety'), between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities".[45]

The MOs for Depletion of Interconnected Surface Water were similarly developed based on measured groundwater levels in the monitoring wells included in the RMN-ICSW. Specifically, the MOs are equal to the minimum water levels measured between 2014 and 2020 at each RMN-ICSW, which represents the recent groundwater conditions that are protective of ICSW and GDEs following the adoption of SGMA. Where water level measurements between 2014 and 2020 are not available, estimated values at the RMWs are sourced from the groundwater elevation rasters developed by Zone 7 as discussed in **Section**

[45] DWR, 2017. Best Management Practices for the Sustainable Management of Groundwater, dated November 2017.

1.2.1. The hydrographs and SMCs for the Depletions of Interconnected Surface Water at each RMW-ICSW are shown in **Attachment F**.

Based on the defined MOs and MTs (**Table 3**), Zone 7 considers there to be a sufficient Margin of Operational Flexibility at each RMN-ICSW. Data collected regularly from the RMN-ICSW will better quantify relationships between measured changes in groundwater levels, surface water flows and GDE areas that can help ensure that these MOs are protective and will allow for refinement of the SMC approach over time.

IM Determination

Interim Milestones for Depletion of Interconnected Surface Water are defined herein based on a trajectory for groundwater levels informed by the groundwater level trends since 2015, MOs, and MTs. If the RMN-ICSWs have decreasing groundwater level trends since 2015, the IM for the first 5-year period is set as the average between MOs and MTs, and the IMs for the following three 5-year periods are set as groundwater elevations that are linearly interpolated between IM for the first 5-year period and the MO. This trajectory allows for and assumes a continuation of current groundwater level trends for the first 5-year period, and recovery towards the MOs over the following three 5-year periods. Conversely, if the RMN-ICSWs have increasing groundwater level trends since 2015, the subsequent IMs are all equal to the MOs. The IMs are presented in **Table 3** and the methodology used to develop them is shown in **Table 4**.

Table 4. Interim Milestone Trajectory for Depletion of Interconnected Surface Water

Calendar Year	Interim Milestone for Depletion of Interconnected Surface Water	Basis for Interim Milestone
2022	Not applicable	Not applicable
2027	IM-5	½ * (MO_{GWL}+ MT_{GWL})
2032	IM-10	$IM\text{-}5_{GWL}$ + 1/3 * (MO_{GWL}-$IM\text{-}5_{GWL}$)
2037	IM-15	$IM\text{-}5_{GWL}$ + 2/3 * (MO_{GWL}-$IM\text{-}5_{GWL}$)
2045	MO	MO_{GWL}

Where:

IM-5, IM-10, and IM-15 are the IM for Depletion of Interconnected Surface Water after 5 years, 10 years and 15 years respectively; and

MO and MT are the MO and MT for Depletion of Interconnected Surface Water defined previously.

ATTACHMENTS

Attachment A: Time Series Data and Correlation Plots by GDE Polygon

Attachment B: Technical Memorandum from Stillwater: Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin

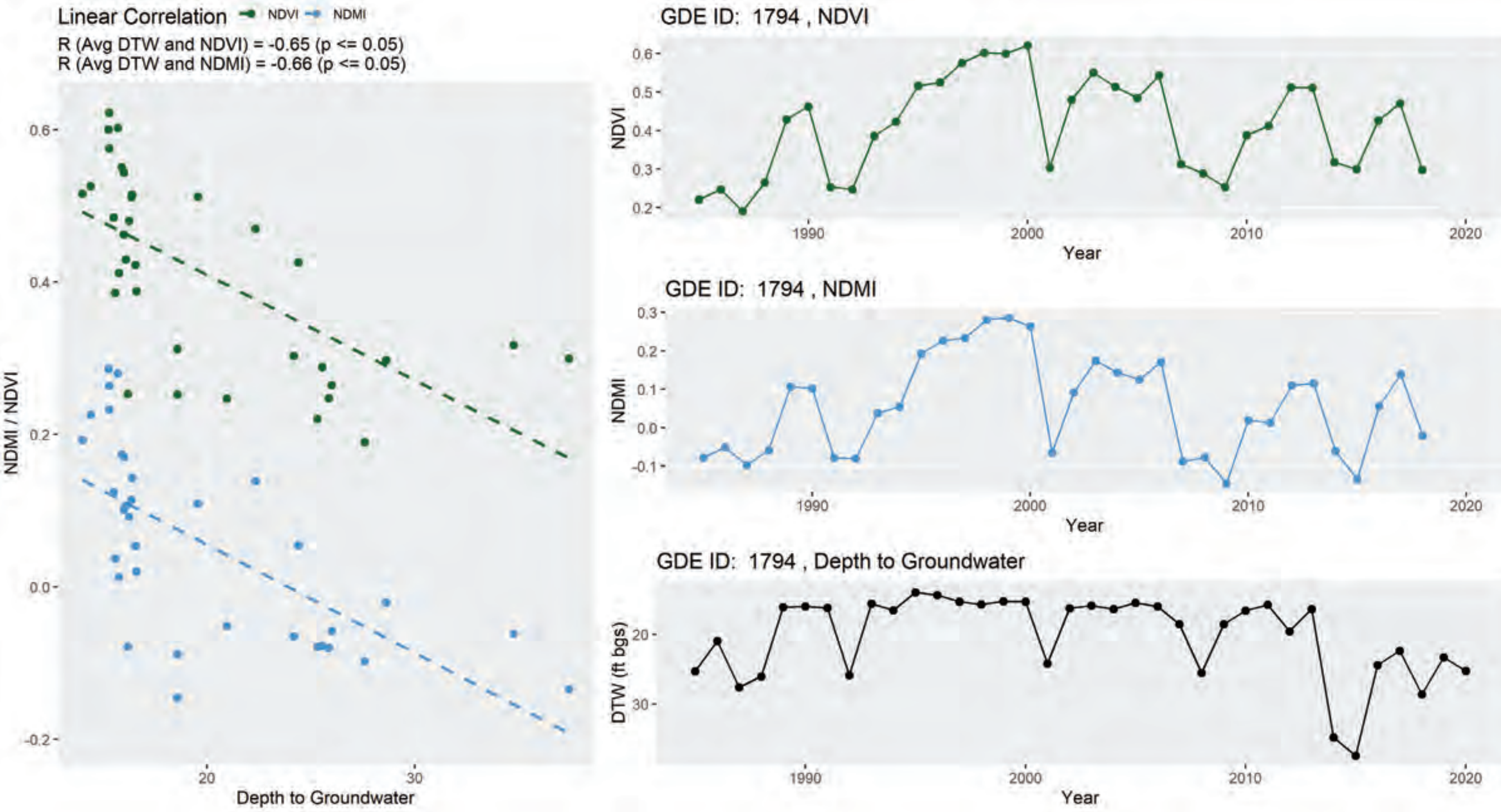
Attachment C: Surface Water Bodies and Monitoring Sites

Attachment D: Time Series Data and Correlation Plots by Stream Station

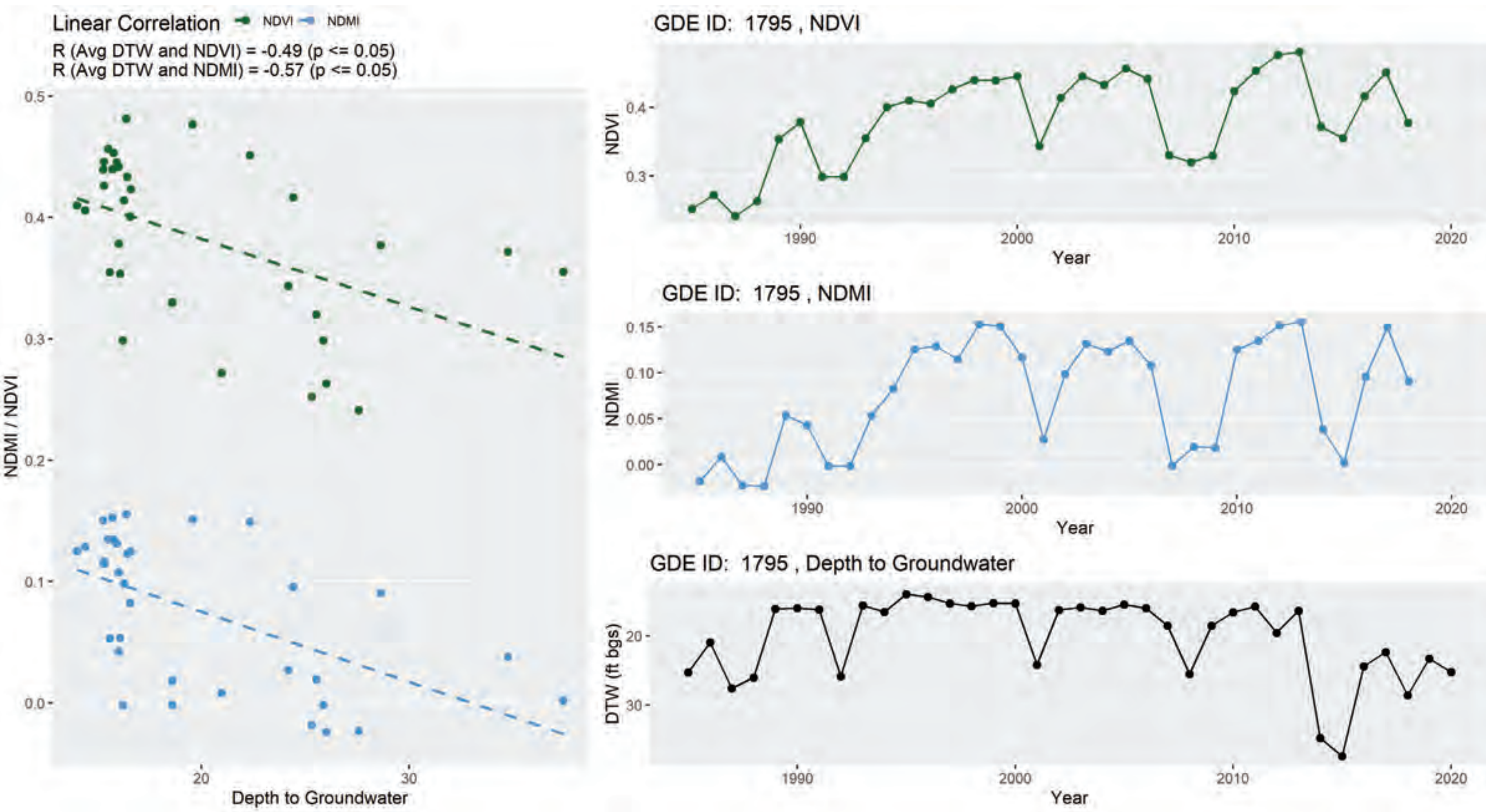
Attachment E: Change in GDE Area Analysis

Attachment F: Water Levels and SMC Plots by RMW-ICSW

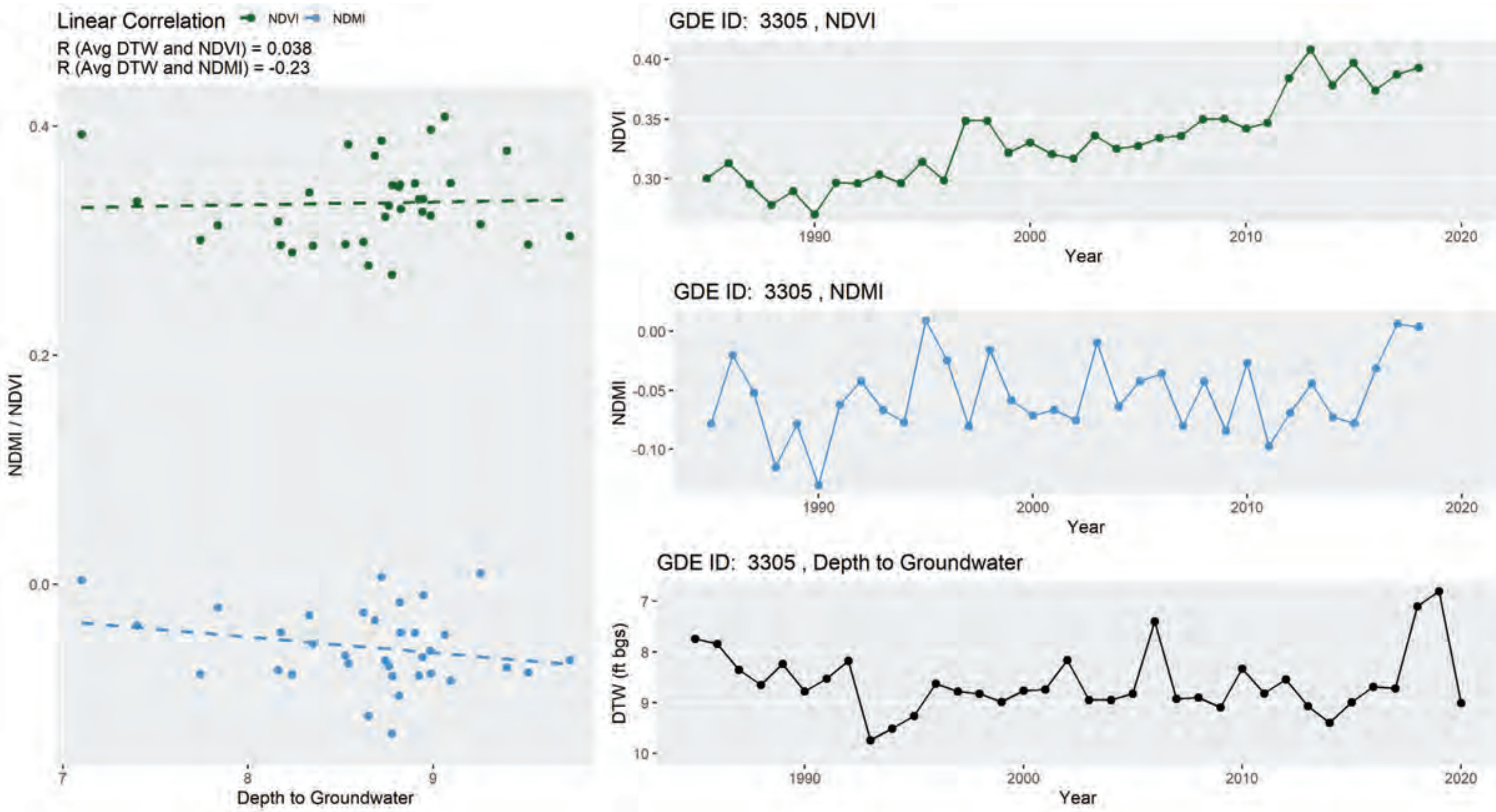
Attachment A: Time Series Data and Correlation Plots by GDE Polygon



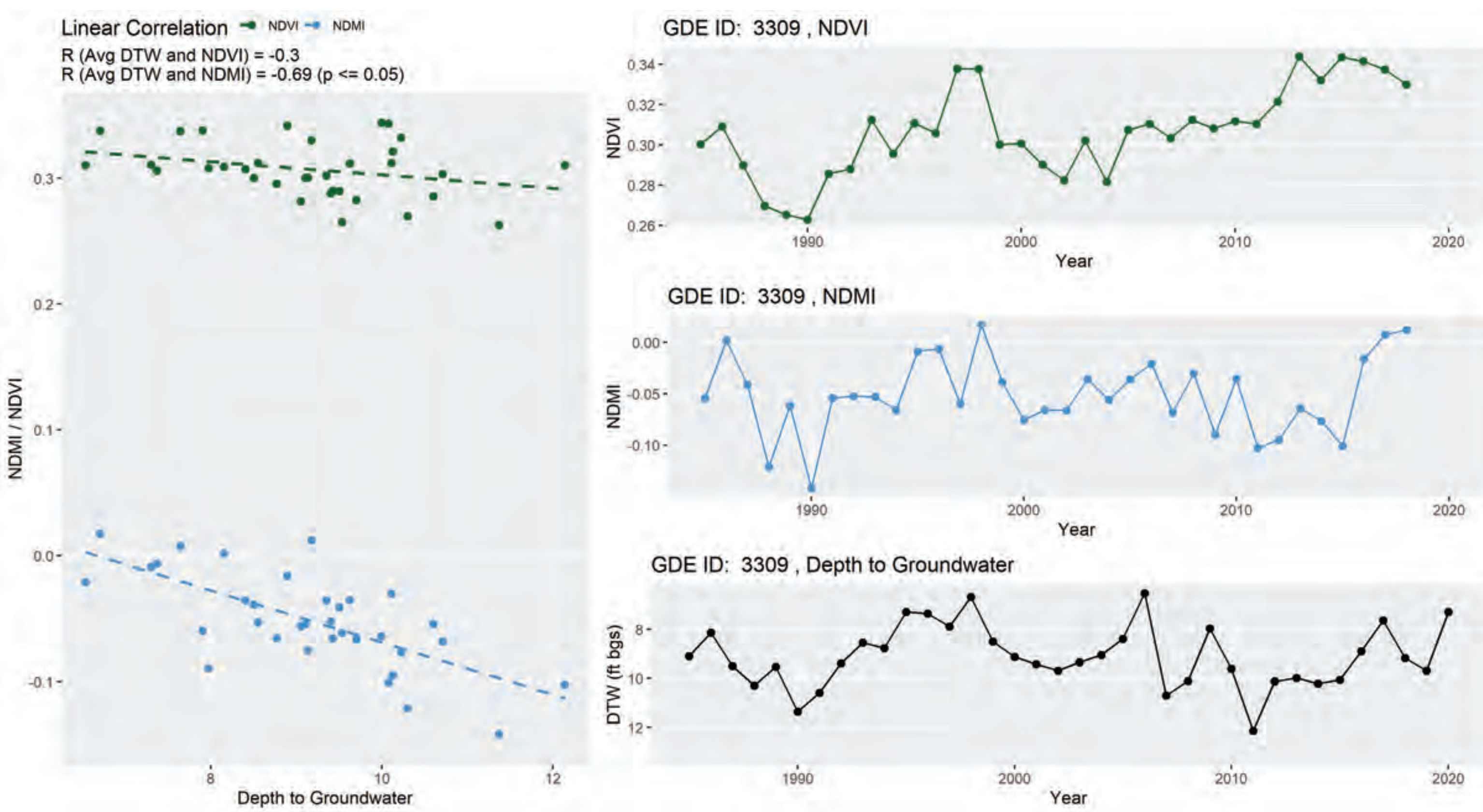
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.65 (p <= 0.05)
R (Avg DTW and NDMI) = -0.66 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 1794 , NDVI
NDVI
Year
GDE ID: 1794 , NDMI
NDMI
Year
GDE ID: 1794 , Depth to Groundwater
DTW (ft bgs)
Year



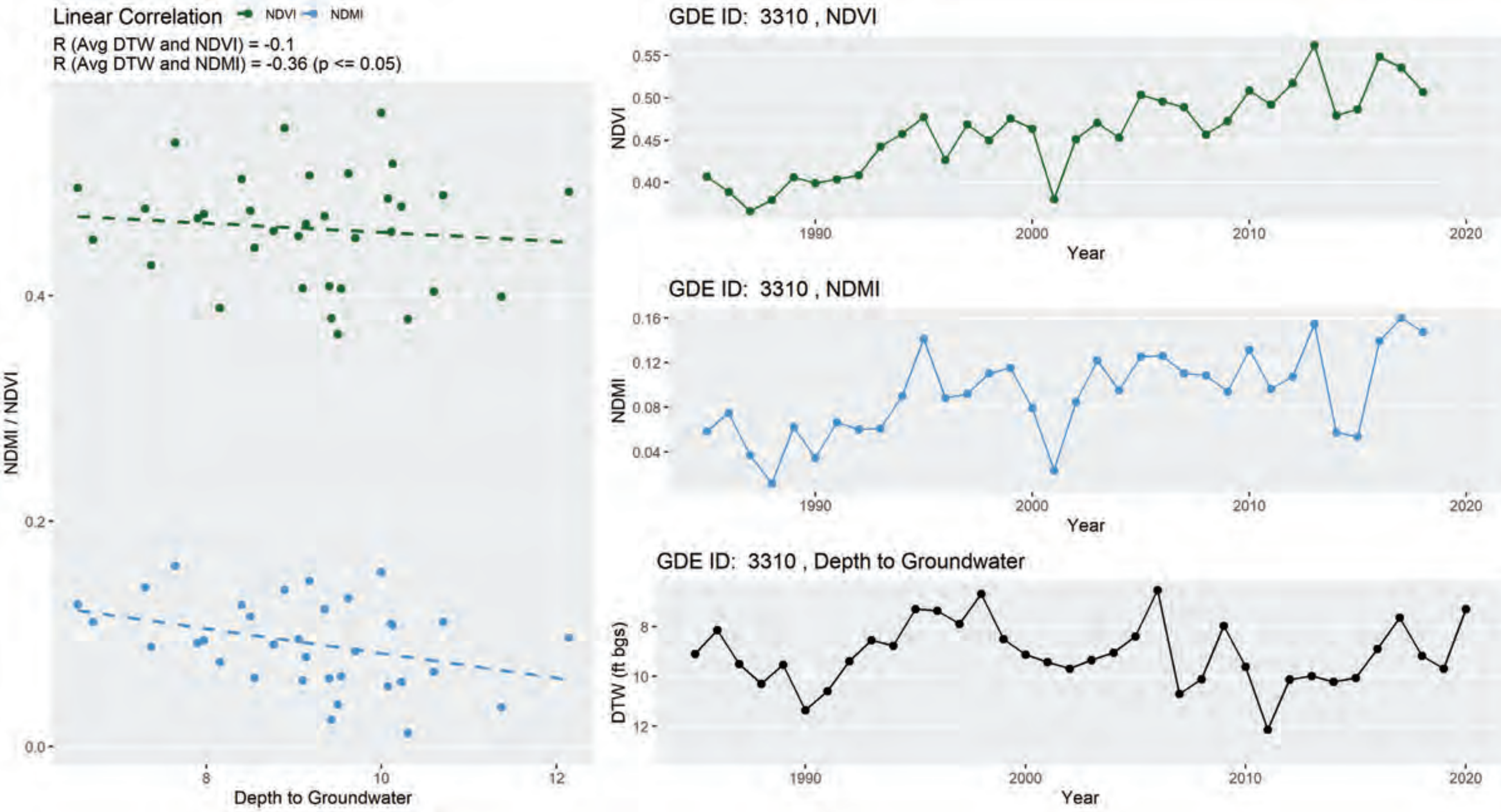
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.49 (p <= 0.05)
R (Avg DTW and NDMI) = -0.57 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 1795 , NDVI
NDVI
Year
GDE ID: 1795 , NDMI
NDMI
Year
GDE ID: 1795 , Depth to Groundwater
DTW (ft bgs)
Year

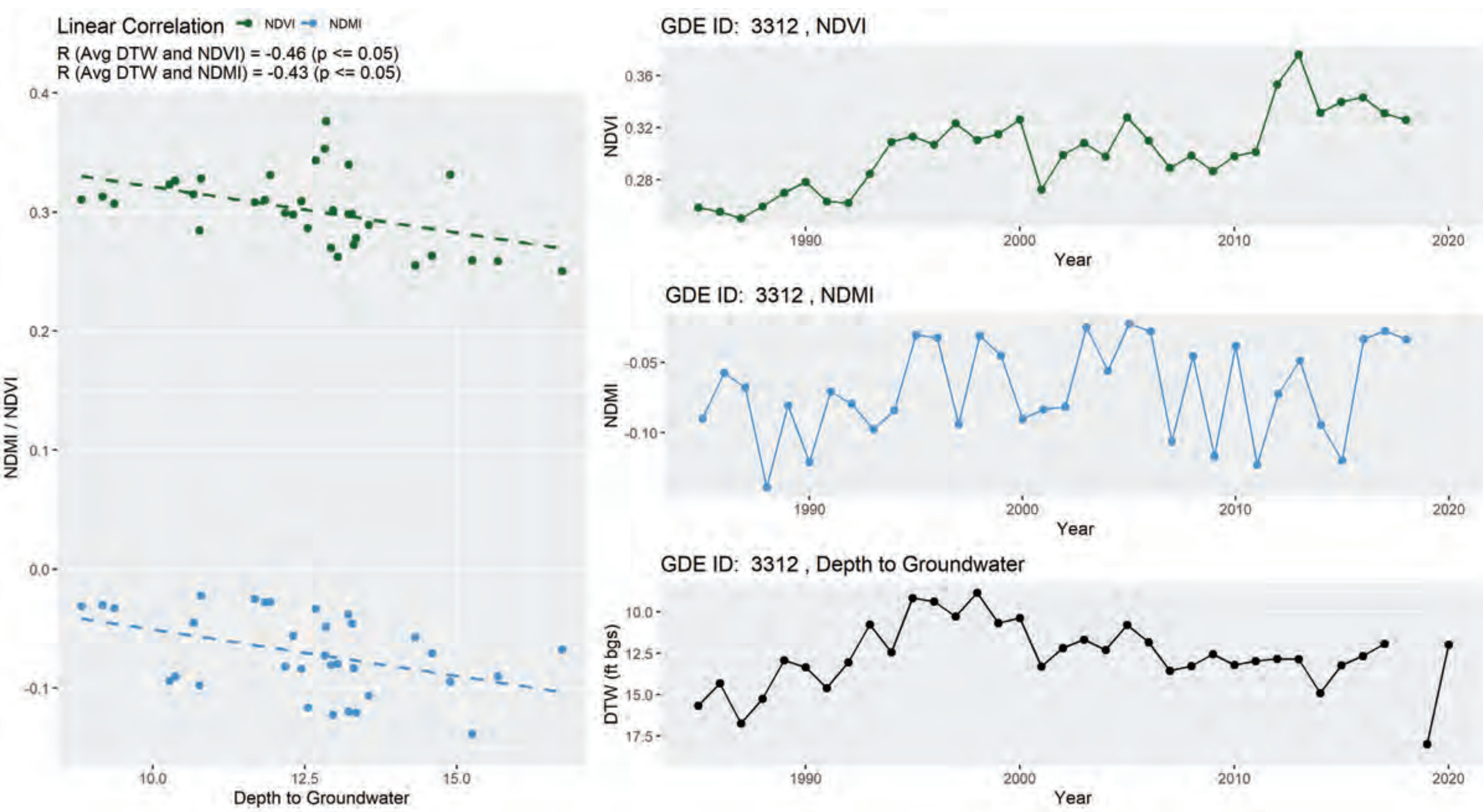


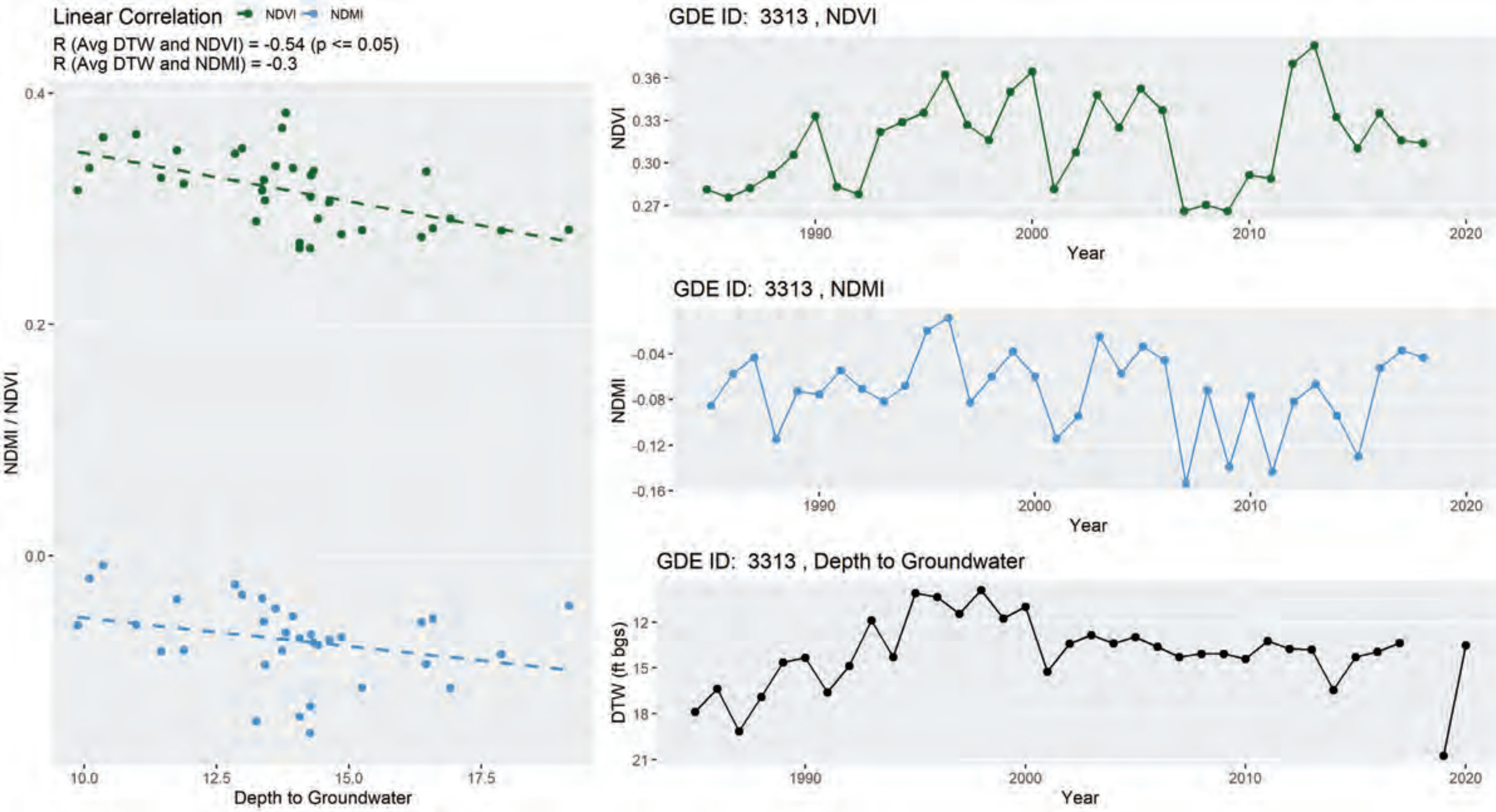
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.038
R (Avg DTW and NDMI) = -0.23
NDMI / NDVI
Depth to Groundwater
GDE ID: 3305 , NDVI
NDVI
Year
GDE ID: 3305 , NDMI
NDMI
Year
GDE ID: 3305 , Depth to Groundwater
DTW (ft bgs)
Year

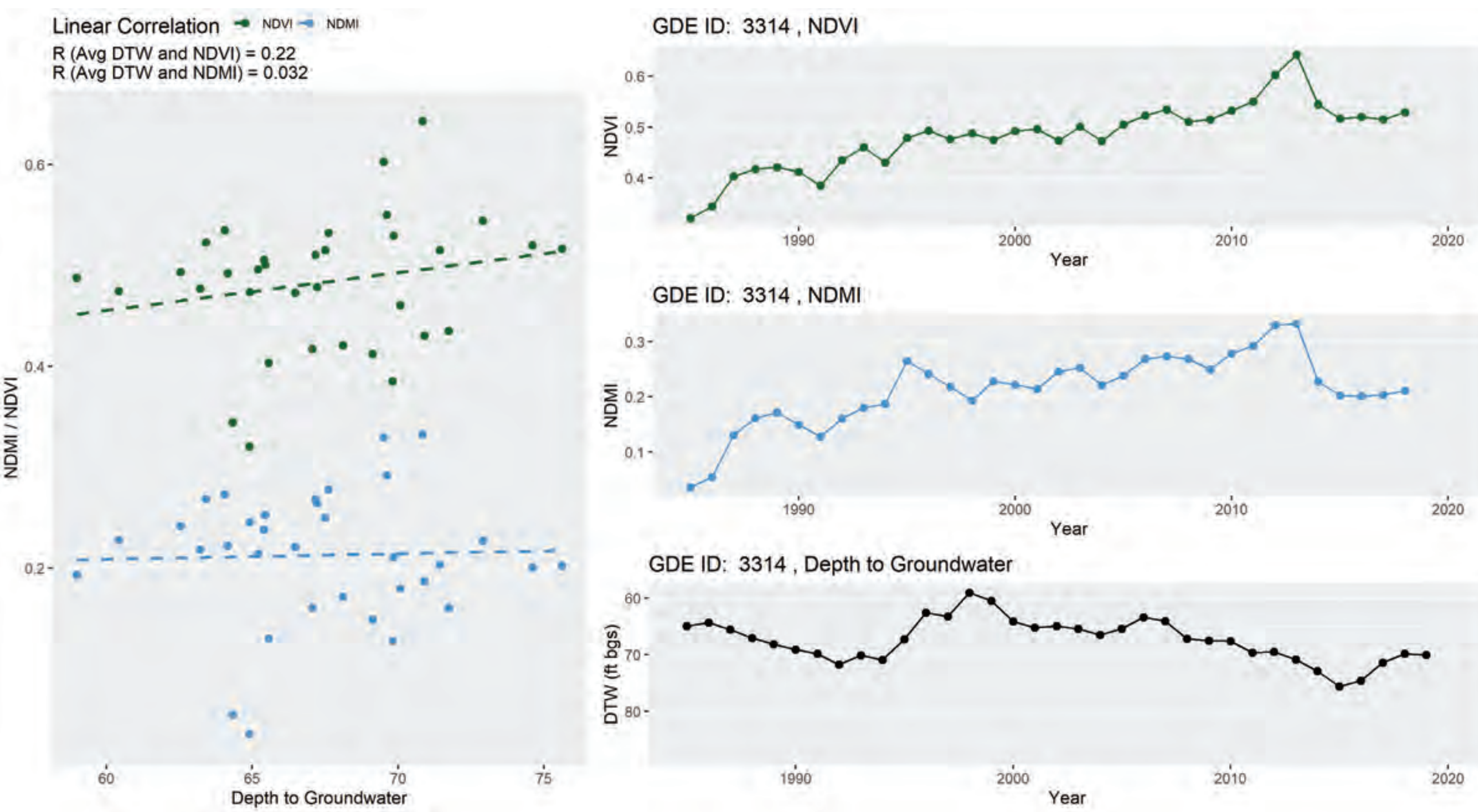


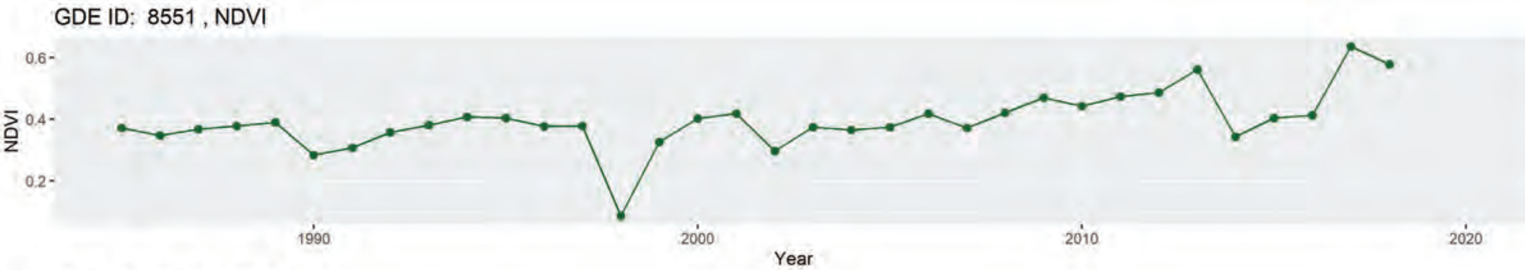
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.3
R (Avg DTW and NDMI) = -0.69 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 3309 , NDVI
NDVI
Year
GDE ID: 3309 , NDMI
NDMI
Year
GDE ID: 3309 , Depth to Groundwater
DTW (ft bgs)
Year

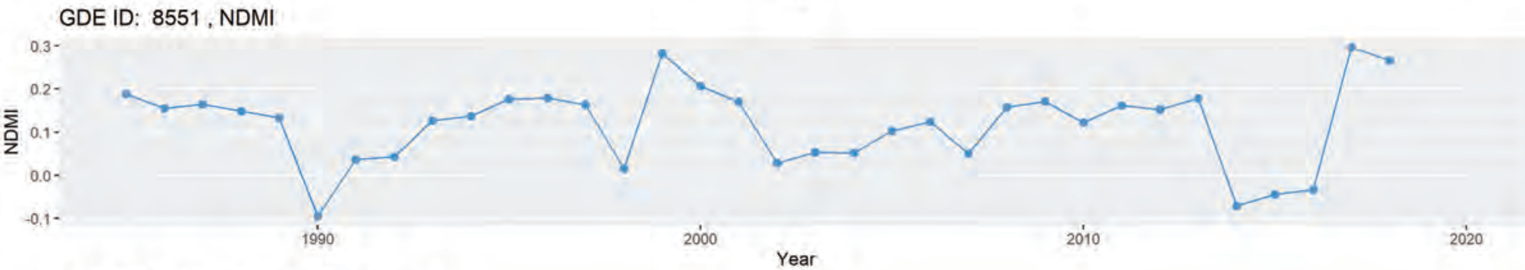

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.1
R (Avg DTW and NDMI) = -0.36 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 3310 , NDVI
NDVI
Year
GDE ID: 3310 , NDMI
NDMI
Year
GDE ID: 3310 , Depth to Groundwater
DTW (ft bgs)
Year

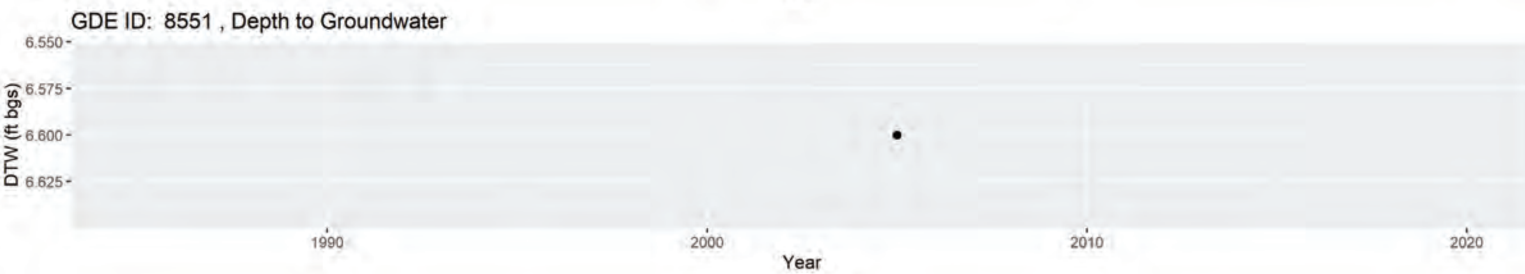

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.46 (p <= 0.05)
R (Avg DTW and NDMI) = -0.43 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 3312 , NDVI
NDVI
Year
GDE ID: 3312 , NDMI
NDMI
Year
GDE ID: 3312 , Depth to Groundwater
DTW (ft bgs)
Year

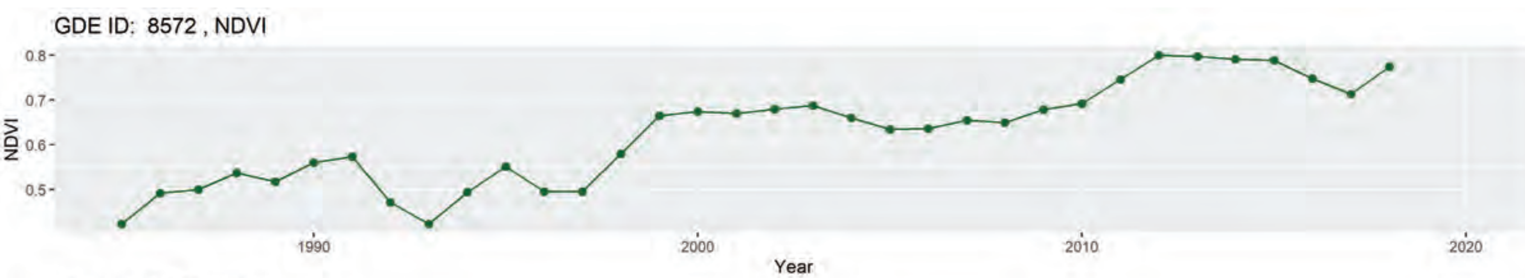

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.54 (p <= 0.05)
R (Avg DTW and NDMI) = -0.3
NDMI / NDVI
Depth to Groundwater
GDE ID: 3313 , NDVI
NDVI
Year
GDE ID: 3313 , NDMI
NDMI
Year
GDE ID: 3313 , Depth to Groundwater
DTW (ft bgs)
Year

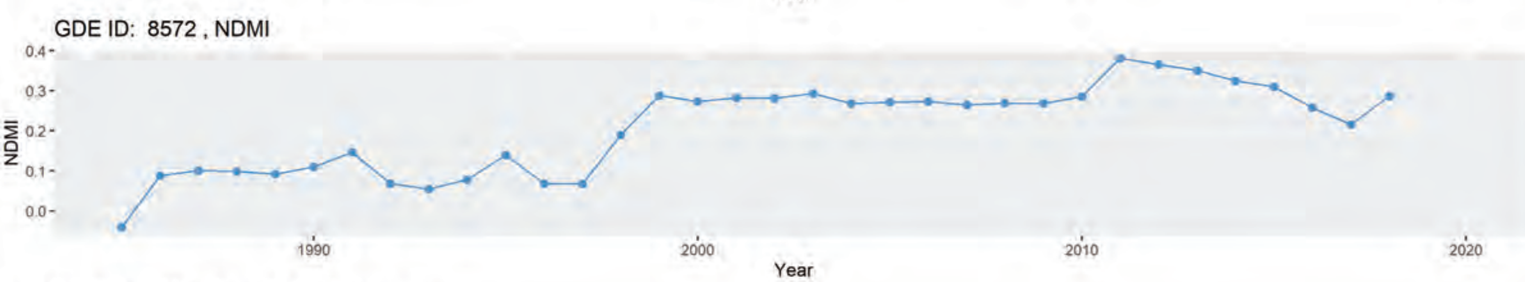

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.22
R (Avg DTW and NDMI) = 0.032
NDMI / NDVI
Depth to Groundwater
GDE ID: 3314 , NDVI
NDVI
Year
GDE ID: 3314 , NDMI
NDMI
Year
GDE ID: 3314 , Depth to Groundwater
DTW (ft bgs)
Year

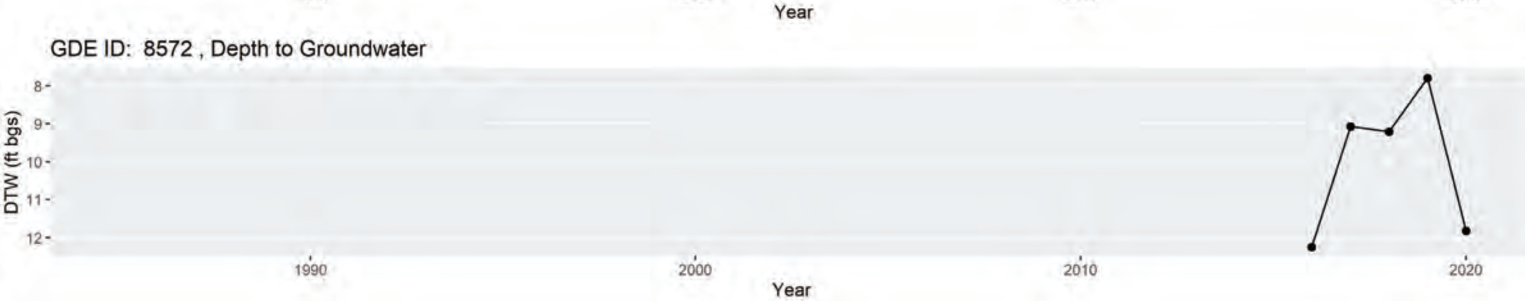

GDE ID: 8551 , NDVI
NDVI
0.6
0.4
0.2
1990
2000
2010
2020
Year

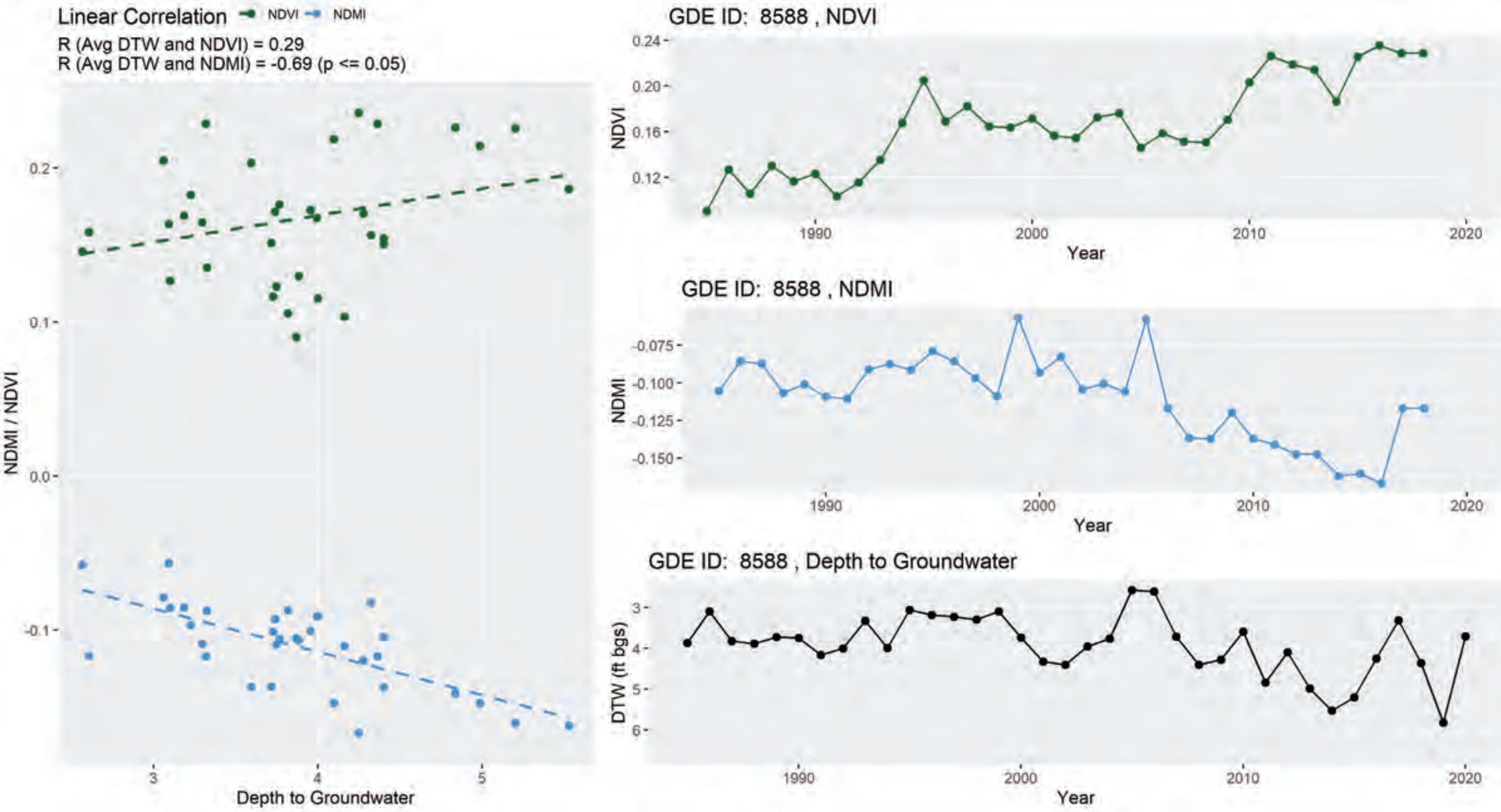

GDE ID: 8551 , NDMI
NDMI
0.3
0.2
0.1
0.0
-0.1
1990
2000
2010
2020
Year


GDE ID: 8551 , Depth to Groundwater
DTW (ft bgs)
6.550
6.575
6.600
6.625
1990
2000
2010
2020
Year

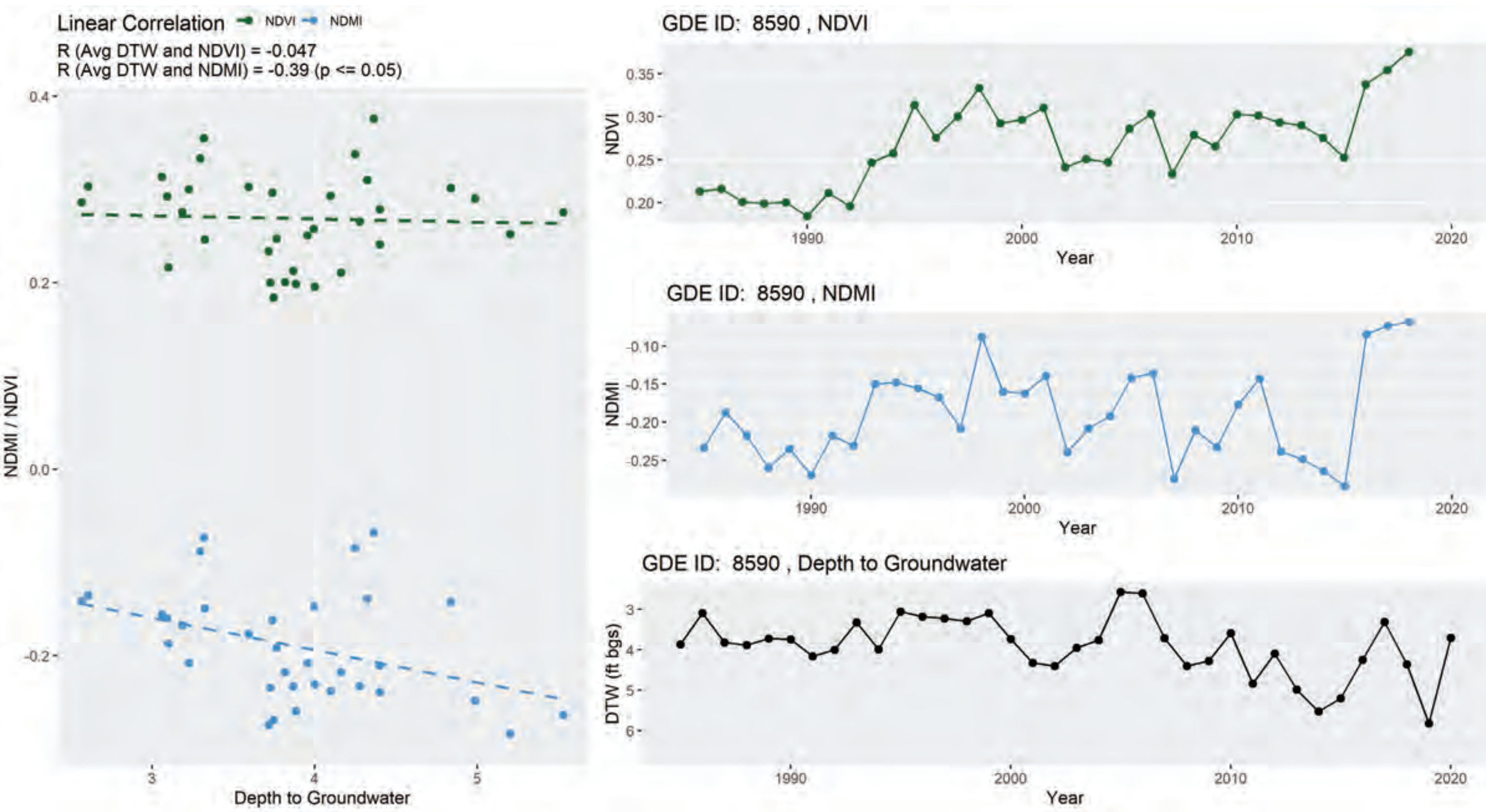

GDE ID: 8572 , NDVI
NDVI
0.8
0.7
0.6
0.5
1990
2000
2010
2020
Year


GDE ID: 8572 , NDMI
NDMI
0.4
0.3
0.2
0.1
0.0
1990
2000
2010
2020
Year

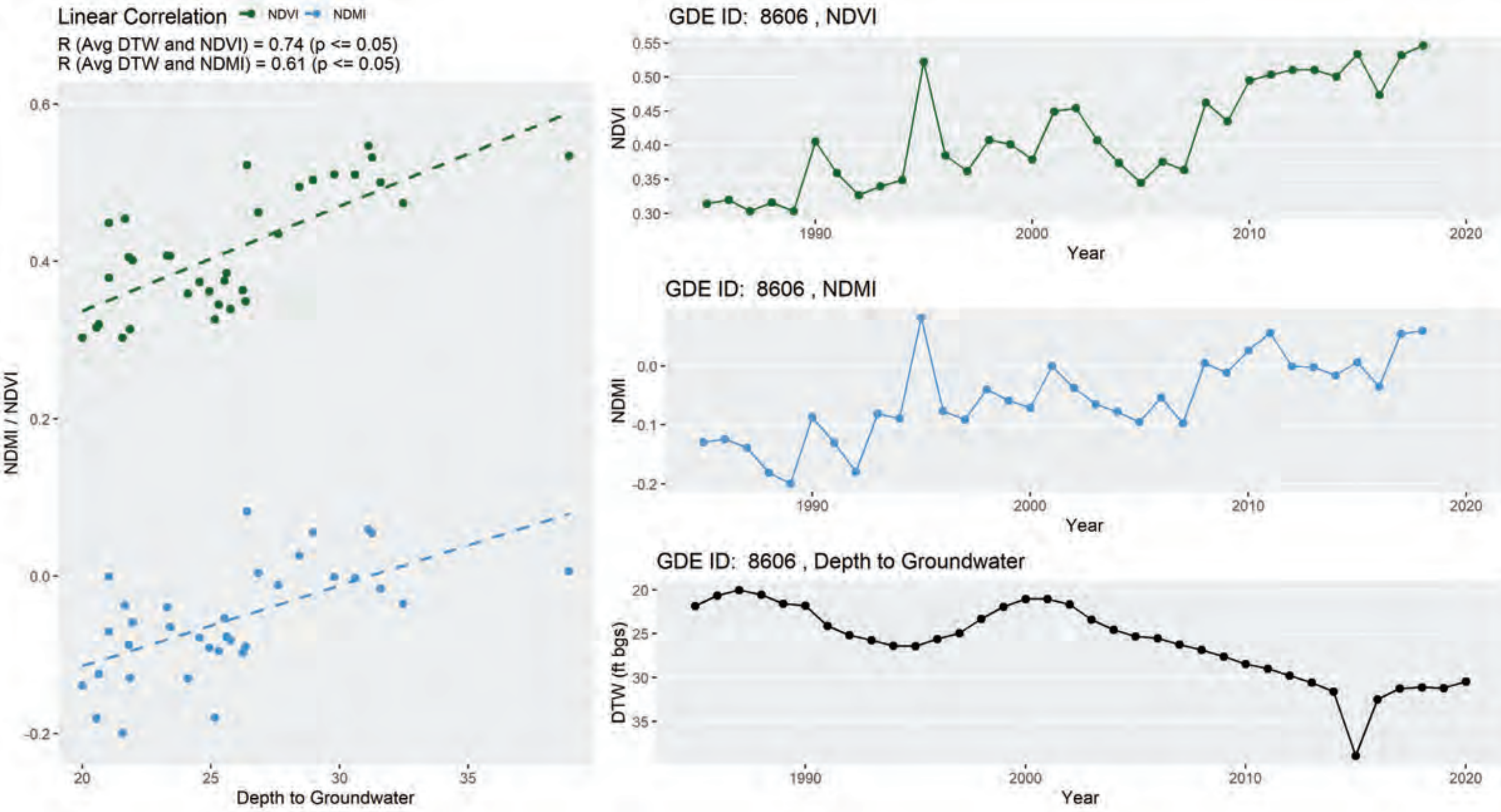

GDE ID: 8572 , Depth to Groundwater
DTW (ft bgs)
8
9
10
11
12
1990
2000
2010
2020
Year

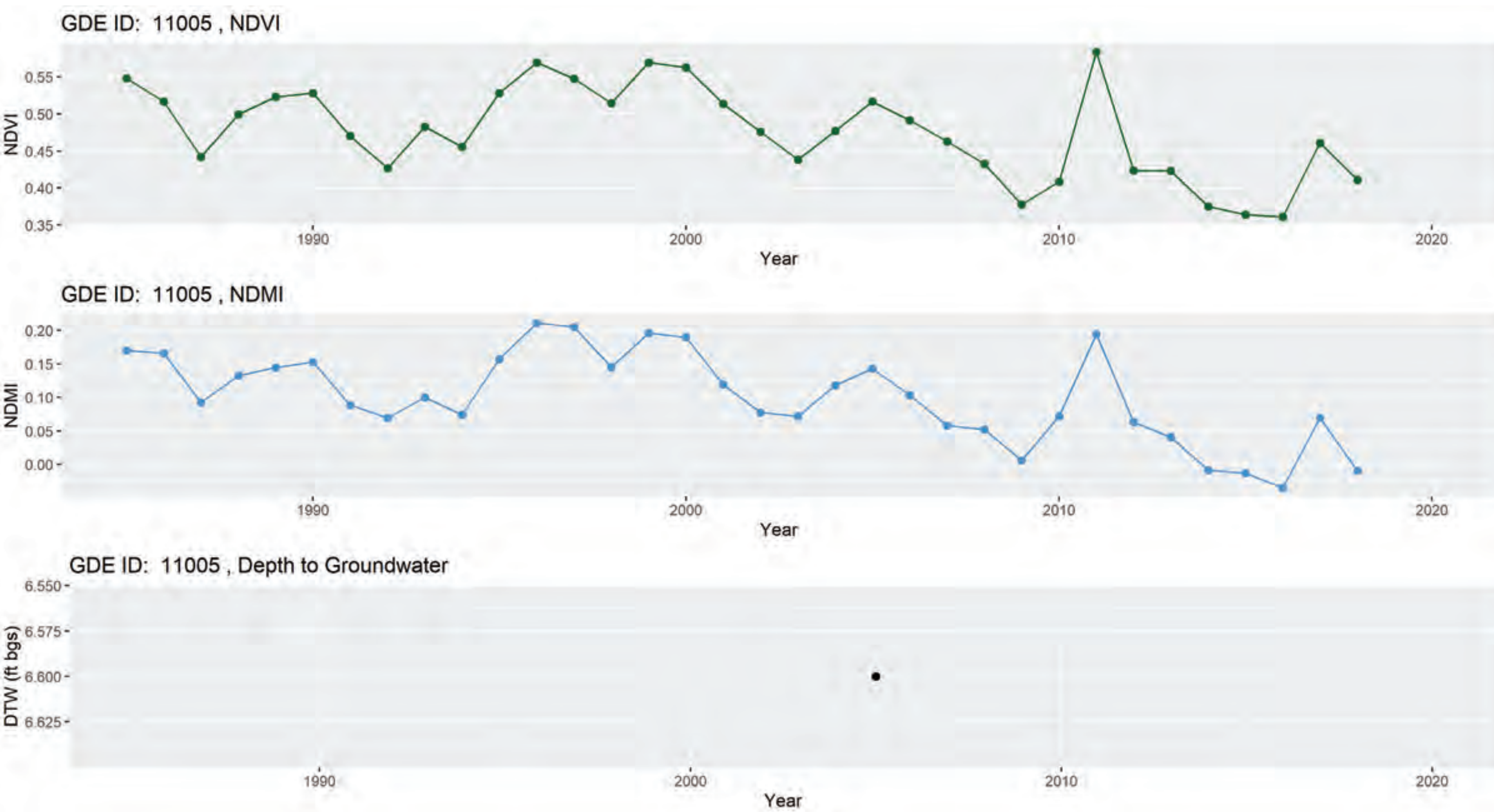


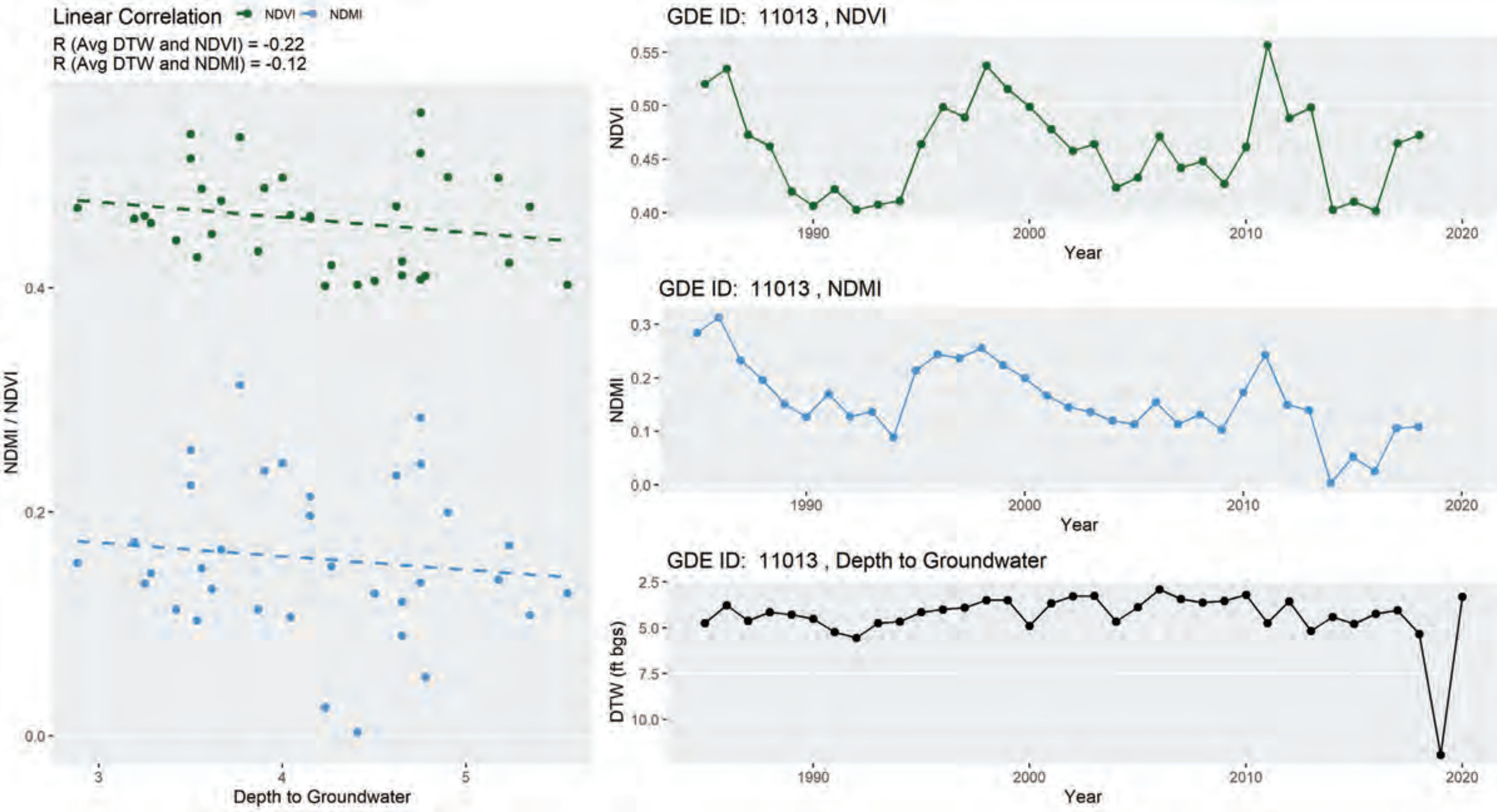
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.29
R (Avg DTW and NDMI) = -0.69 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 8588 , NDVI
NDVI
Year
GDE ID: 8588 , NDMI
NDMI
Year
GDE ID: 8588 , Depth to Groundwater
DTW (ft bgs)
Year

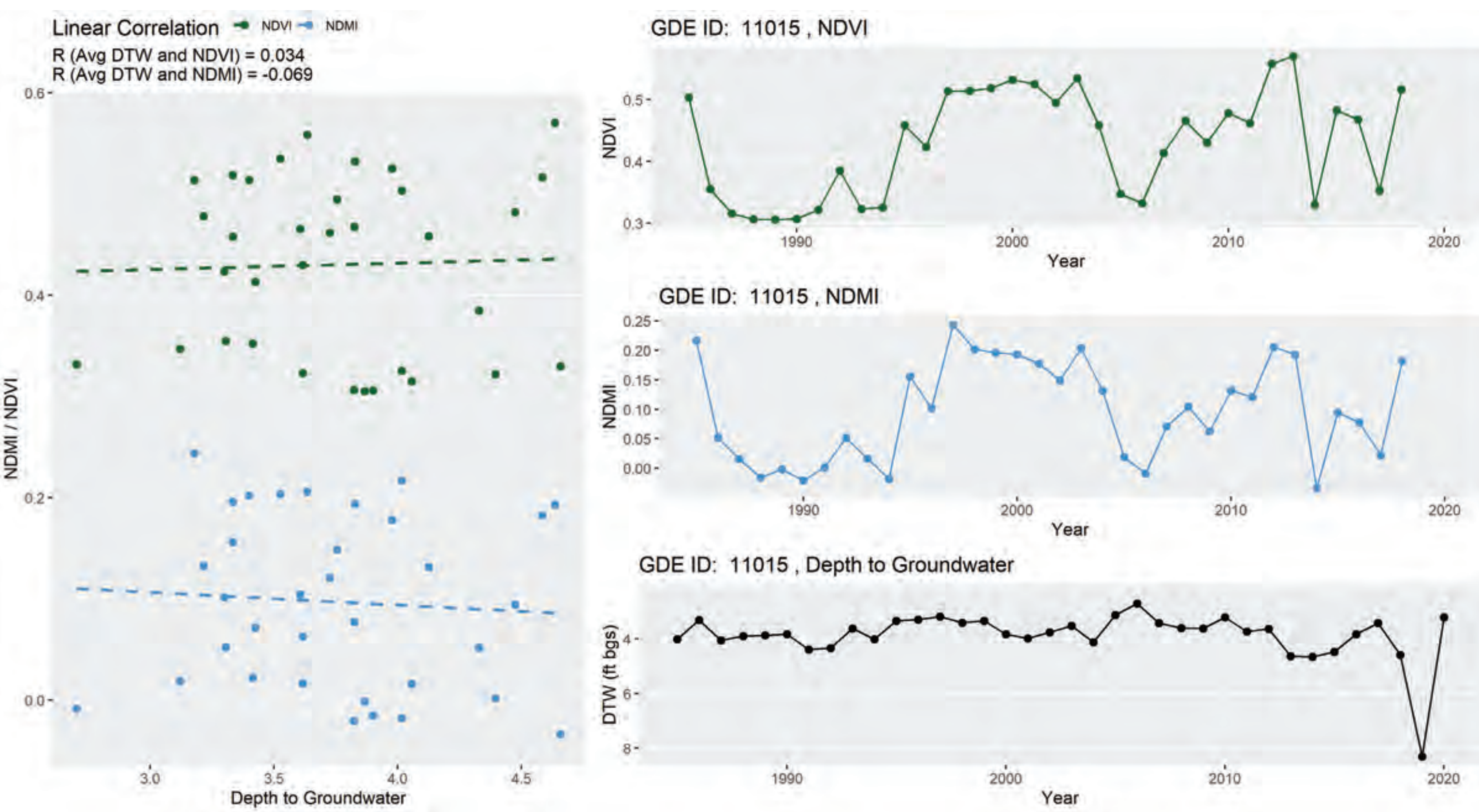


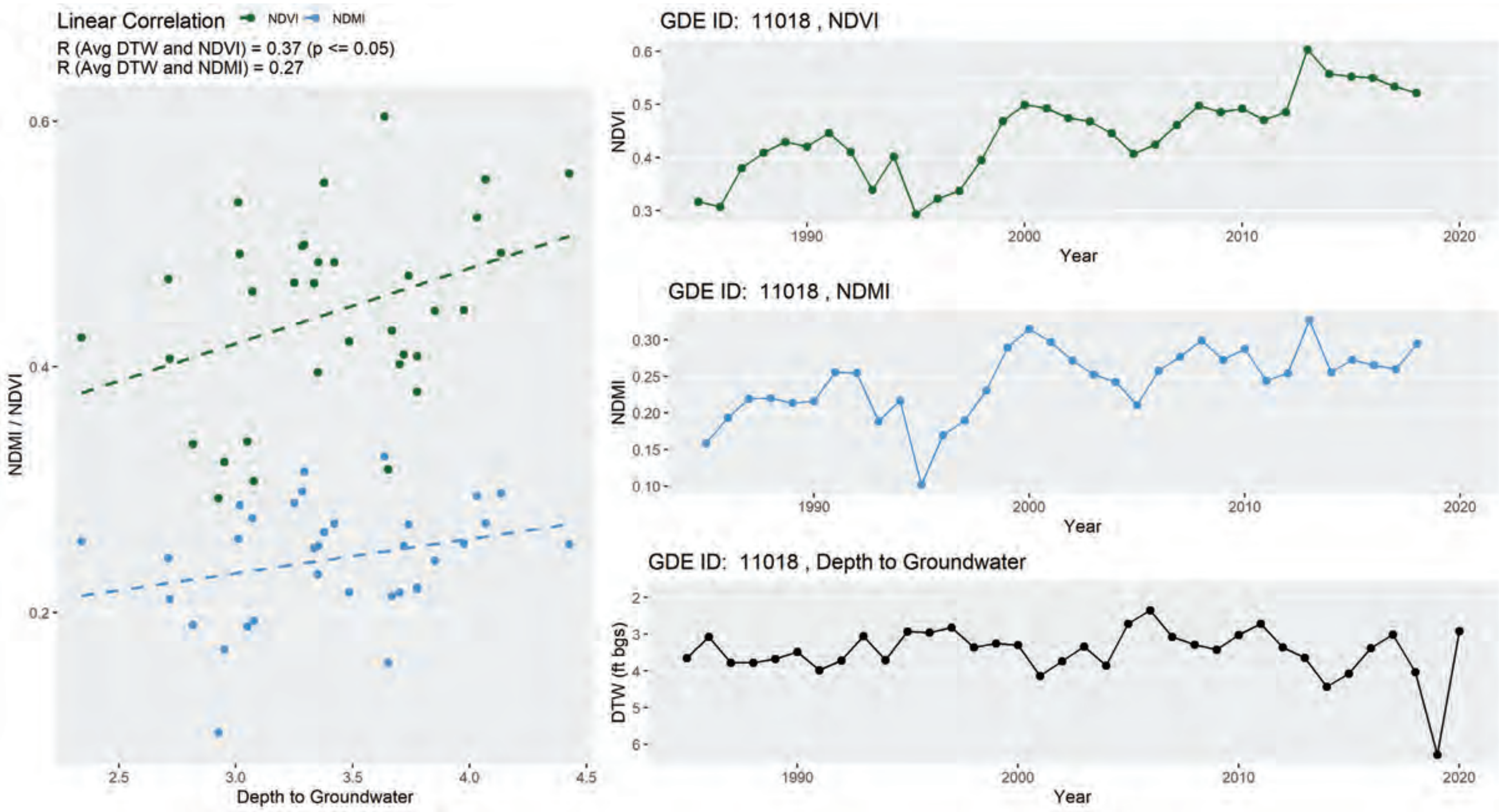
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.047
R (Avg DTW and NDMI) = -0.39 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 8590 , NDVI
NDVI
Year
GDE ID: 8590 , NDMI
NDMI
Year
GDE ID: 8590 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.74 (p <= 0.05)
R (Avg DTW and NDMI) = 0.61 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 8606 , NDVI
NDVI
Year
GDE ID: 8606 , NDMI
NDMI
Year
GDE ID: 8606 , Depth to Groundwater
DTW (ft bgs)
Year

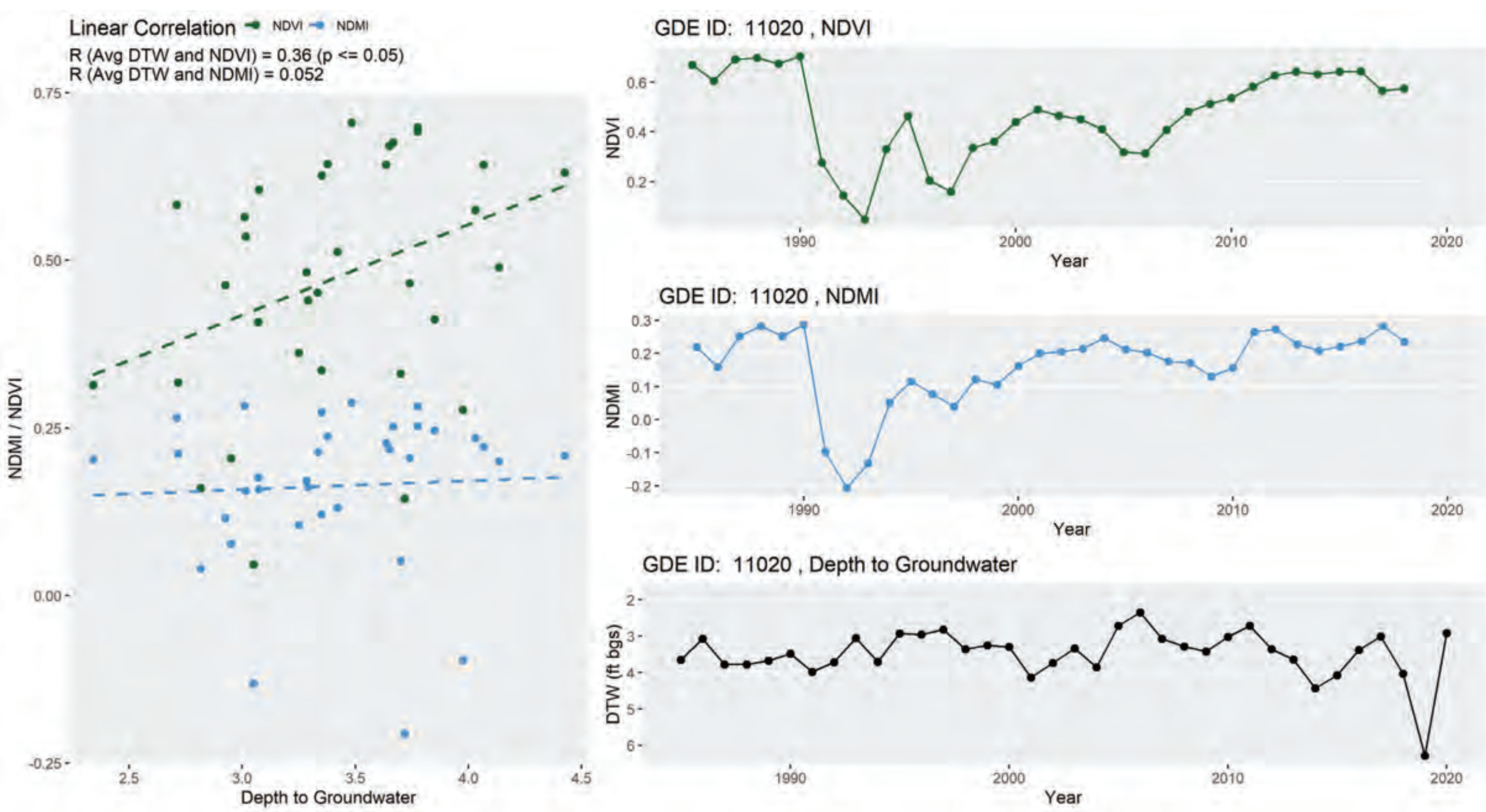

GDE ID: 11005 , NDVI
NDVI
Year
GDE ID: 11005 , NDMI
NDMI
Year
GDE ID: 11005 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.22
R (Avg DTW and NDMI) = -0.12
NDMI / NDVI
Depth to Groundwater
GDE ID: 11013 , NDVI
NDVI
Year
GDE ID: 11013 , NDMI
NDMI
Year
GDE ID: 11013 , Depth to Groundwater
DTW (ft bgs)
Year

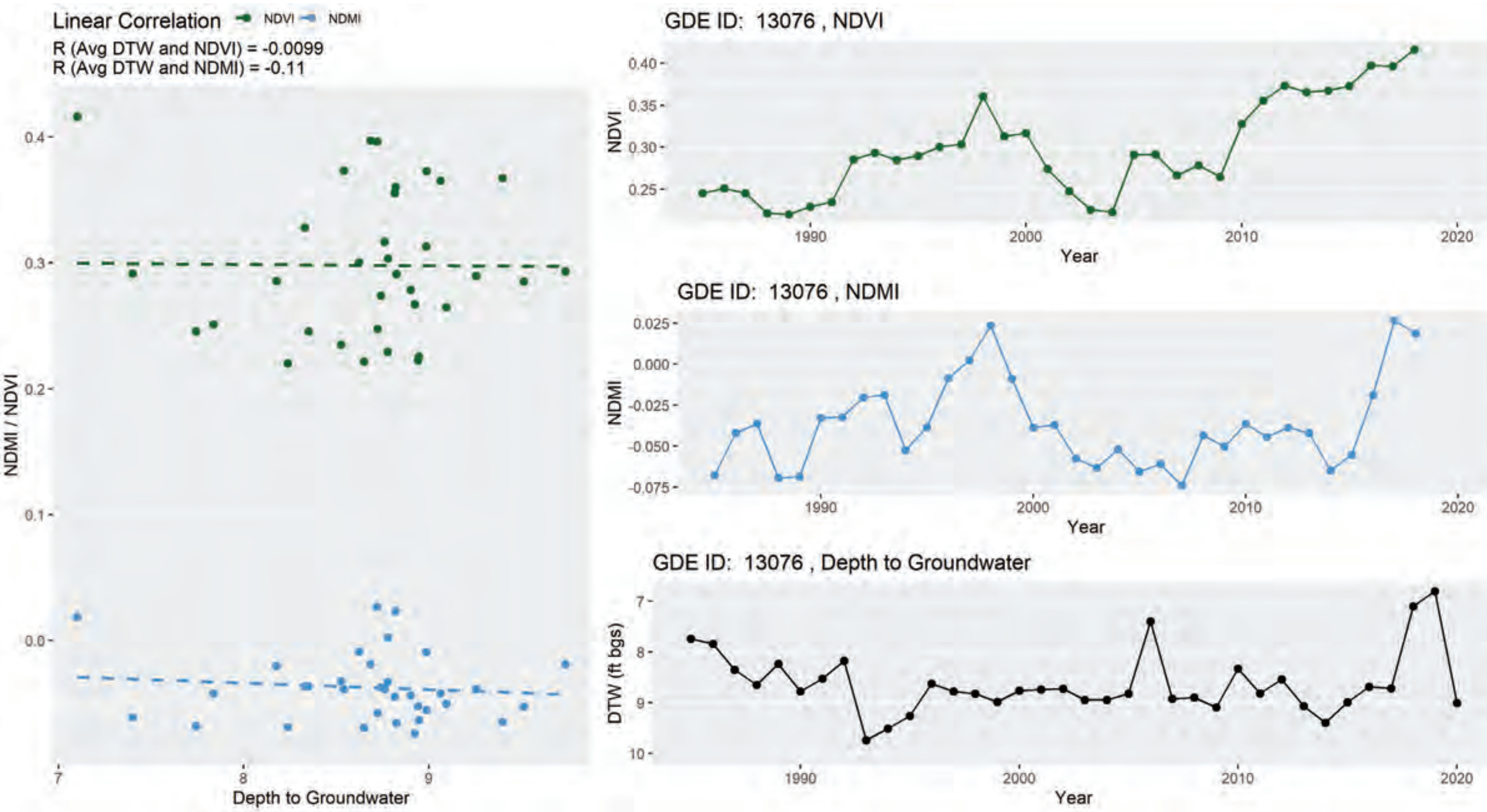

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.034
R (Avg DTW and NDMI) = -0.069
NDMI / NDVI
Depth to Groundwater
GDE ID: 11015 , NDVI
NDVI
Year
GDE ID: 11015 , NDMI
NDMI
Year
GDE ID: 11015 , Depth to Groundwater
DTW (ft bgs)
Year

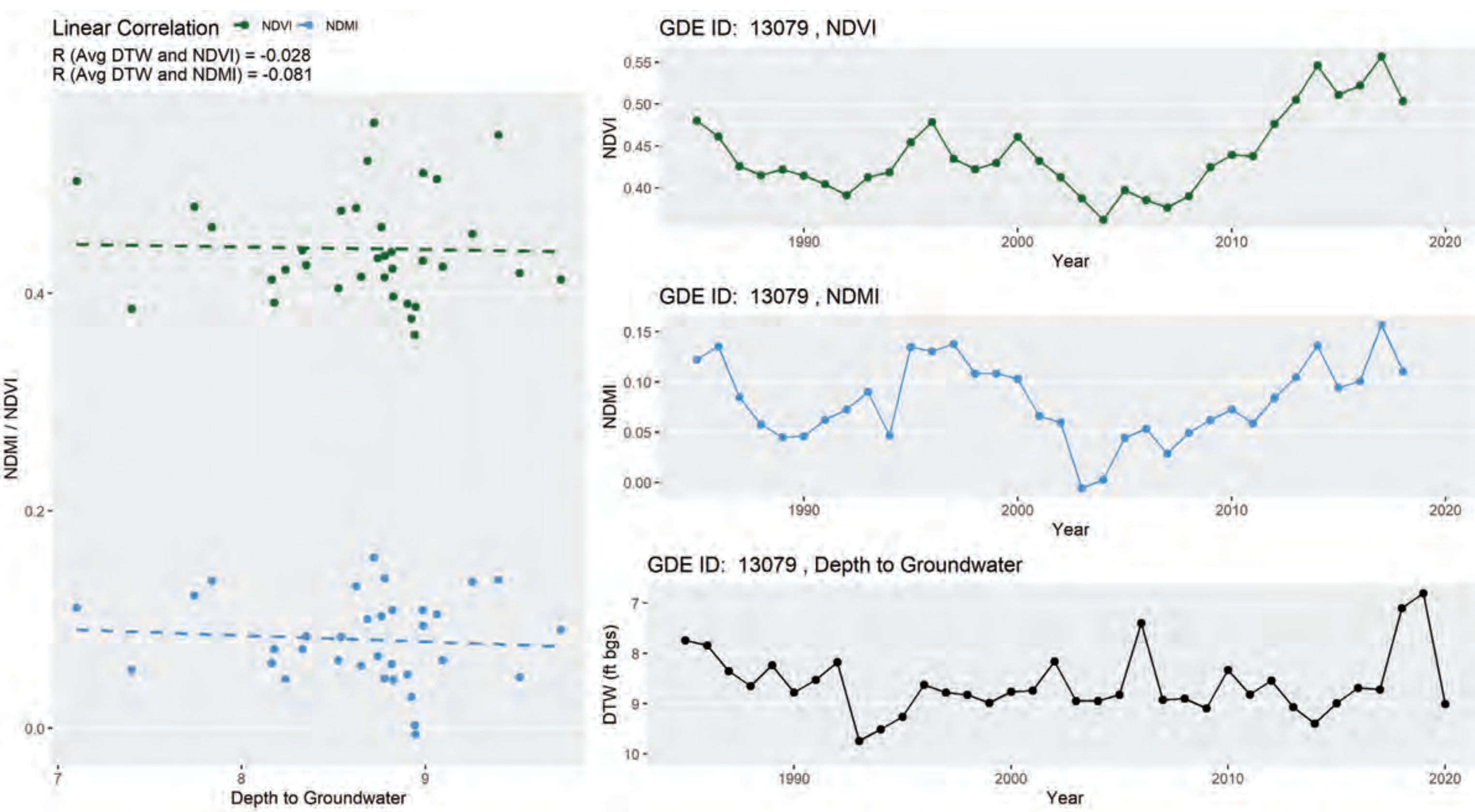


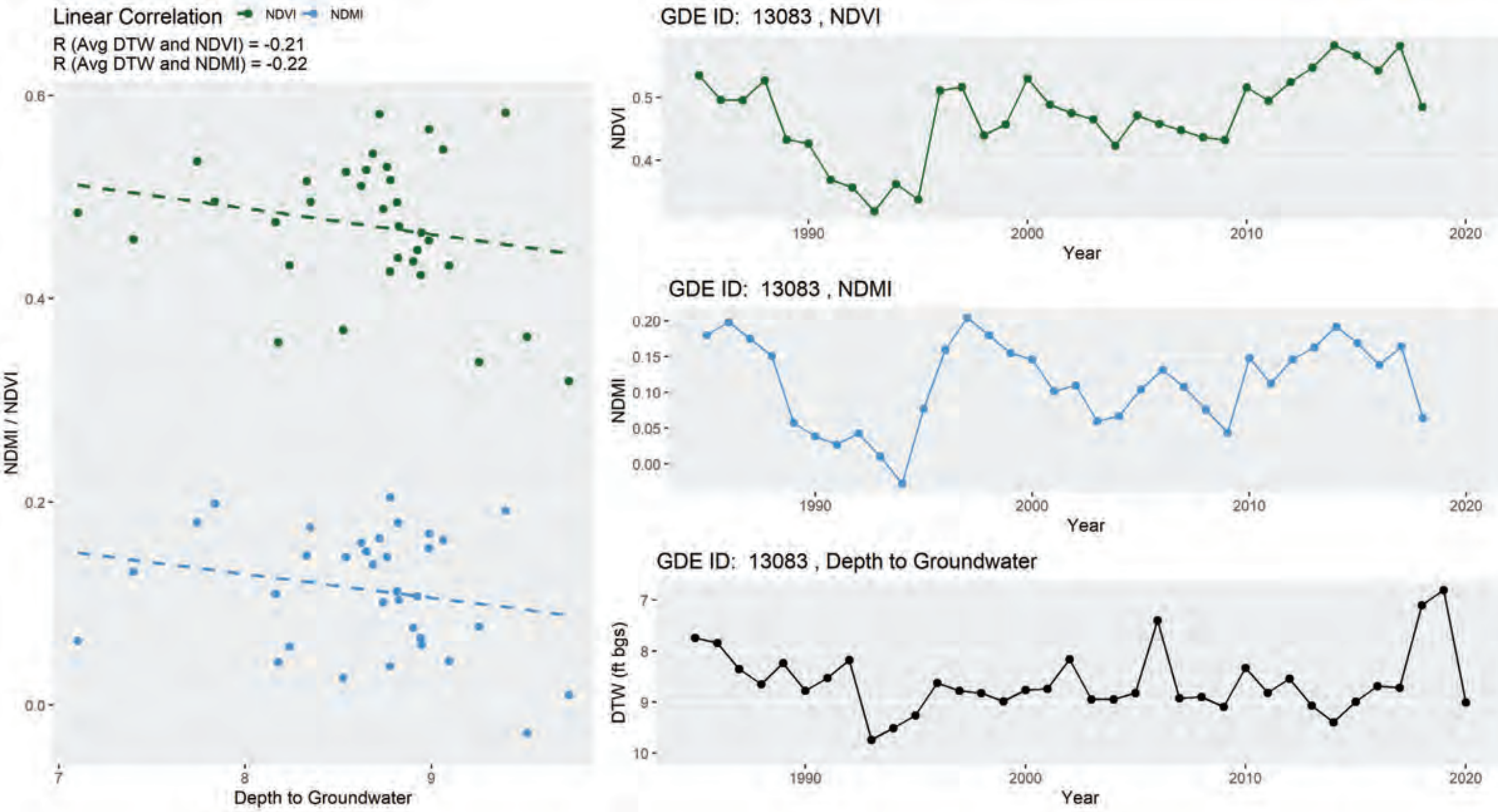
Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = 0.37 (p <= 0.05)
R (Avg DTW and NDMI) = 0.27
NDMI / NDVI
Depth to Groundwater
GDE ID: 11018 , NDVI
NDVI
Year
GDE ID: 11018 , NDMI
NDMI
Year
GDE ID: 11018 , Depth to Groundwater
DTW (ft bgs)
Year



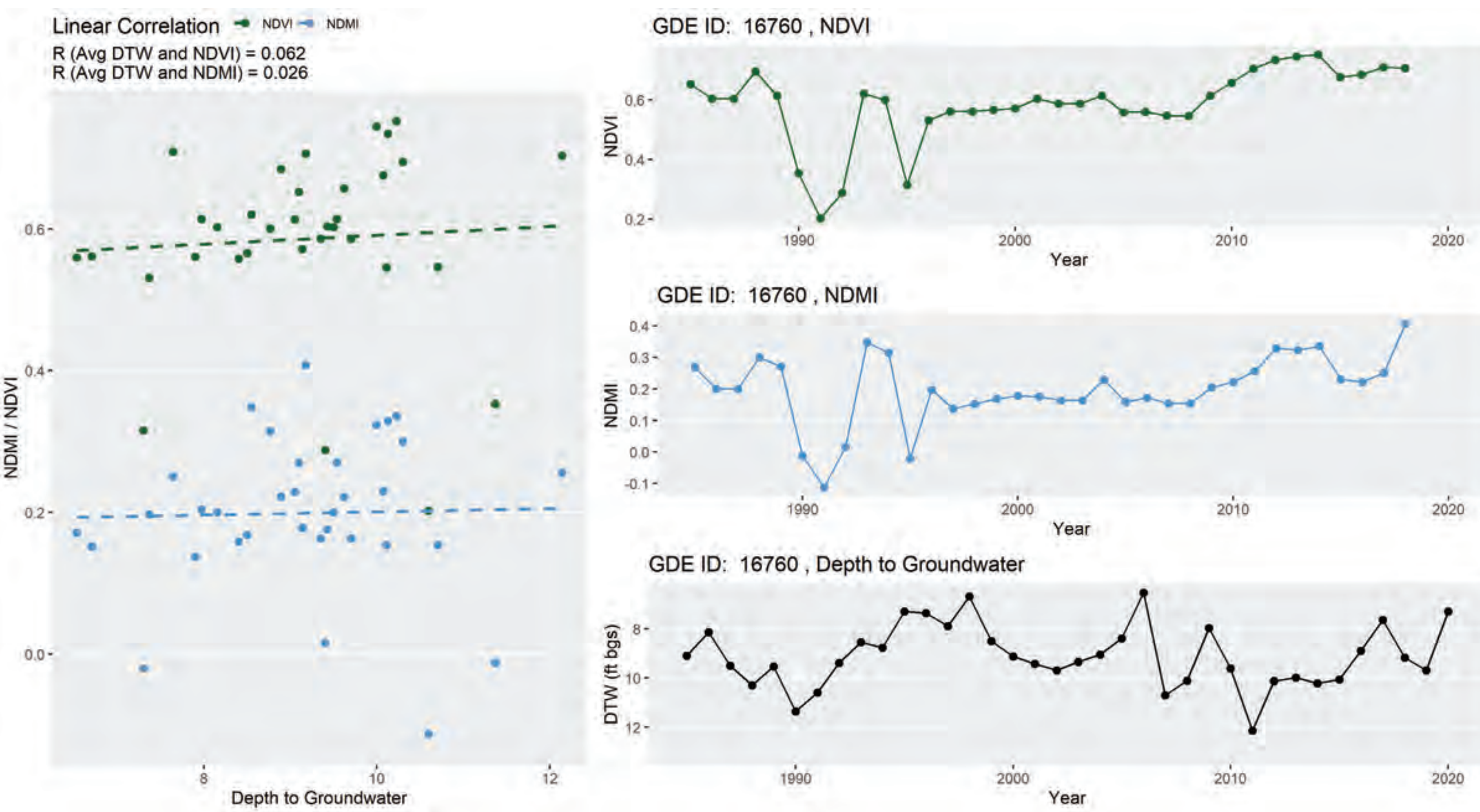
Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = 0.36 (p <= 0.05)
R (Avg DTW and NDMI) = 0.052
NDMI / NDVI
Depth to Groundwater
GDE ID: 11020 , NDVI
NDVI
Year
GDE ID: 11020 , NDMI
NDMI
Year
GDE ID: 11020 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.0099
R (Avg DTW and NDMI) = -0.11
NDMI / NDVI
Depth to Groundwater
GDE ID: 13076 , NDVI
NDVI
Year
GDE ID: 13076 , NDMI
NDMI
Year
GDE ID: 13076 , Depth to Groundwater
DTW (ft bgs)
Year

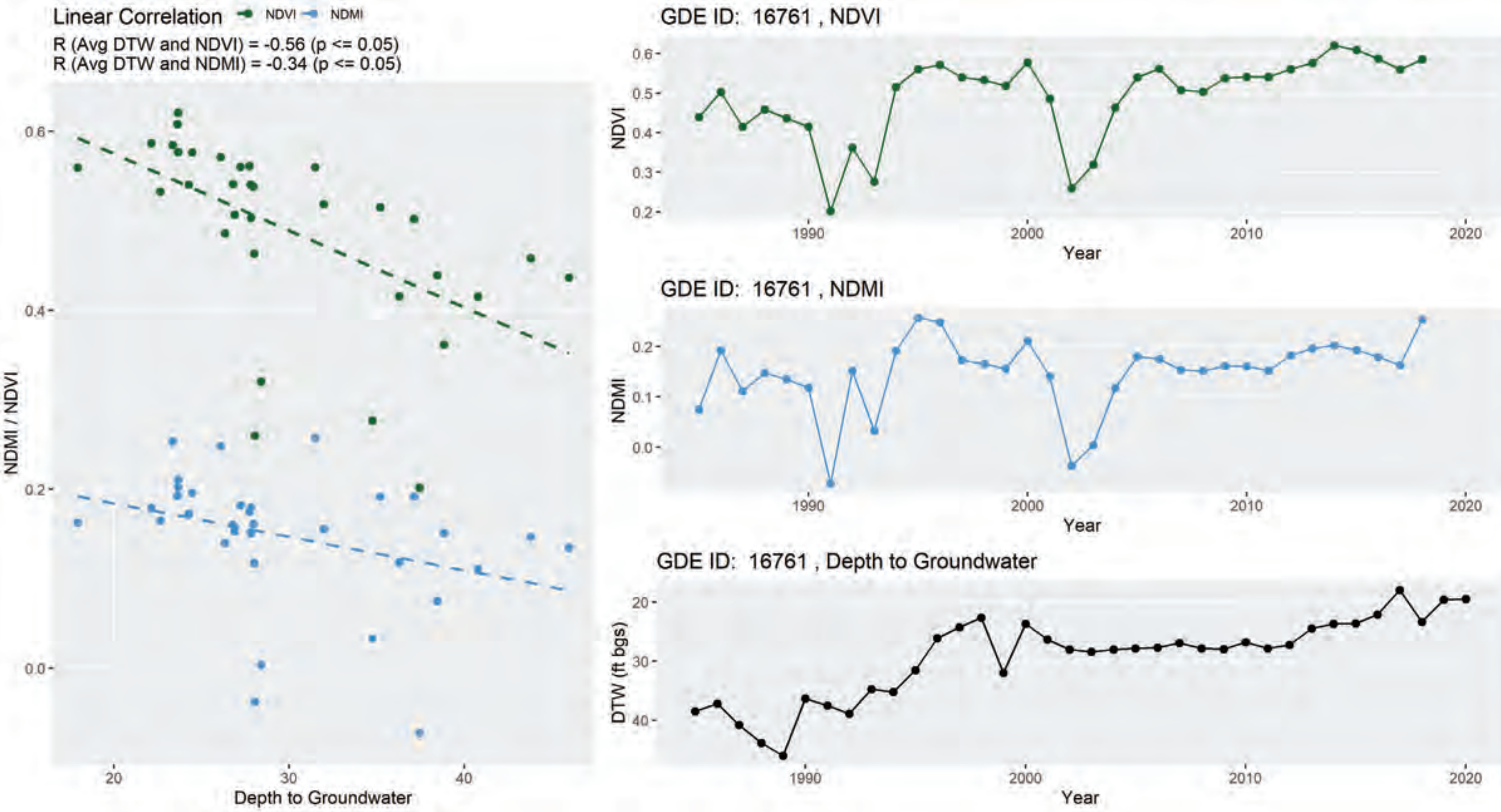

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.028
R (Avg DTW and NDMI) = -0.081
NDMI / NDVI
Depth to Groundwater
GDE ID: 13079 , NDVI
NDVI
Year
GDE ID: 13079 , NDMI
NDMI
Year
GDE ID: 13079 , Depth to Groundwater
DTW (ft bgs)
Year



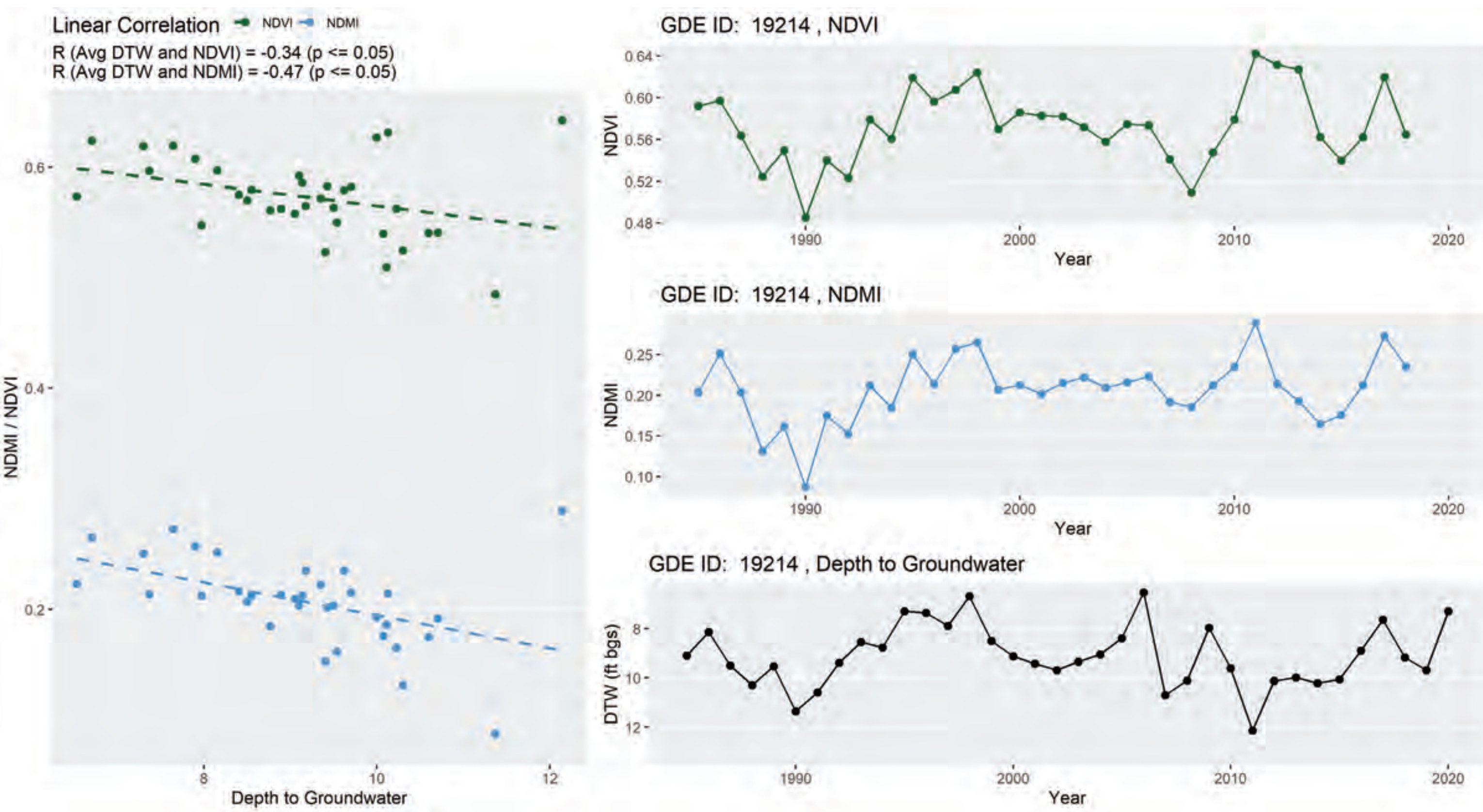
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.21
R (Avg DTW and NDMI) = -0.22
NDMI / NDVI
Depth to Groundwater
GDE ID: 13083 , NDVI
NDVI
Year
GDE ID: 13083 , NDMI
NDMI
Year
GDE ID: 13083 , Depth to Groundwater
DTW (ft bgs)
Year



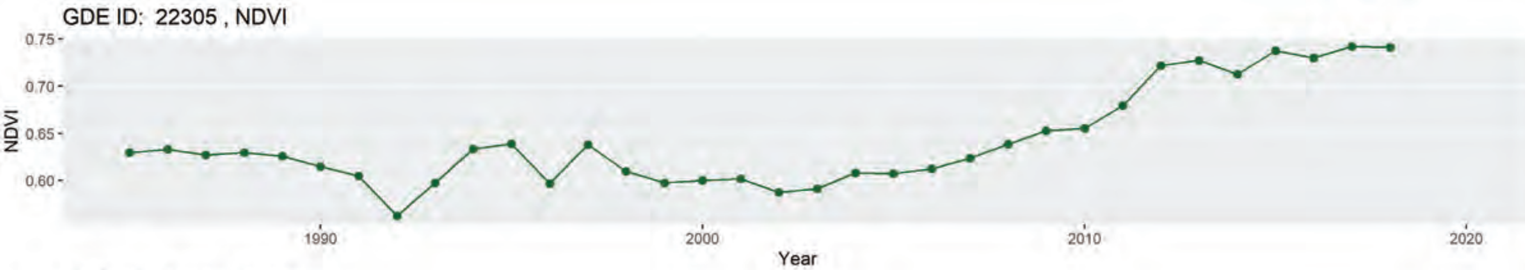
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.062
R (Avg DTW and NDMI) = 0.026
NDMI / NDVI
Depth to Groundwater
GDE ID: 16760 , NDVI
NDVI
Year
GDE ID: 16760 , NDMI
NDMI
Year
GDE ID: 16760 , Depth to Groundwater
DTW (ft bgs)
Year

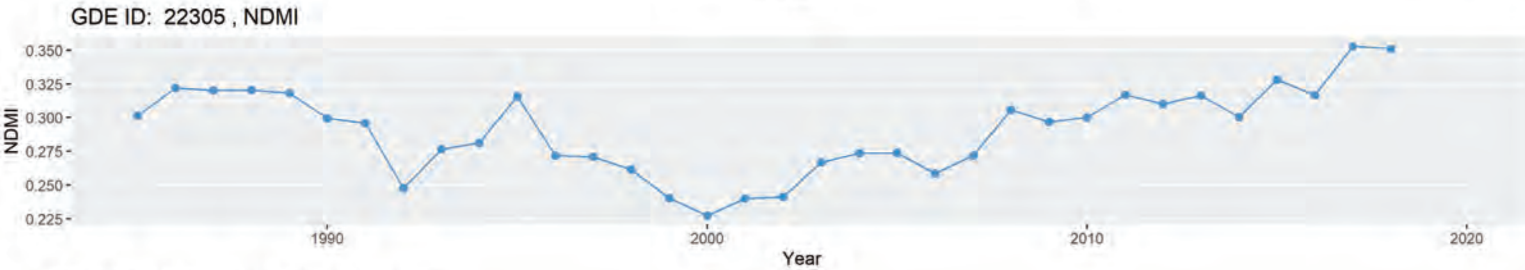


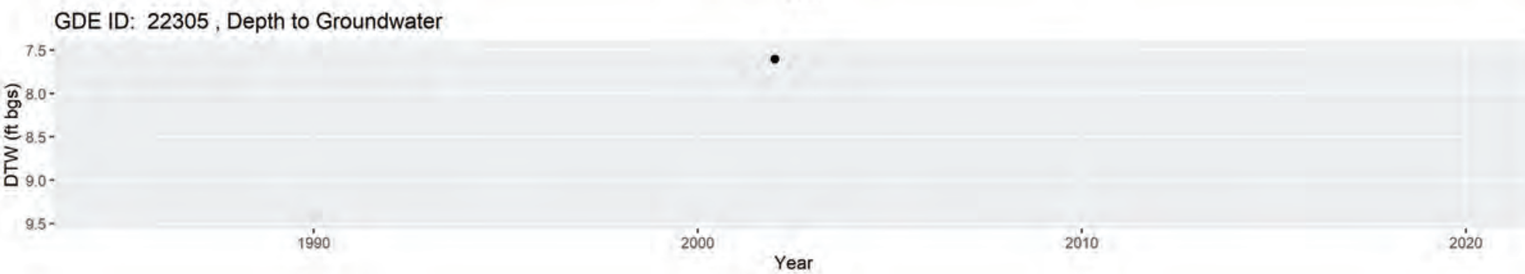
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.56 (p <= 0.05)
R (Avg DTW and NDMI) = -0.34 (p <= 0.05)
NDMI / NDVI
0.6
0.4
0.2
0.0
20
30
40
Depth to Groundwater
GDE ID: 16761 , NDVI
NDVI
0.6
0.5
0.4
0.3
0.2
1990
2000
2010
2020
Year
GDE ID: 16761 , NDMI
NDMI
0.2
0.1
0.0
1990
2000
2010
2020
Year
GDE ID: 16761 , Depth to Groundwater
DTW (ft bgs)
20
30
40
1990
2000
2010
2020
Year

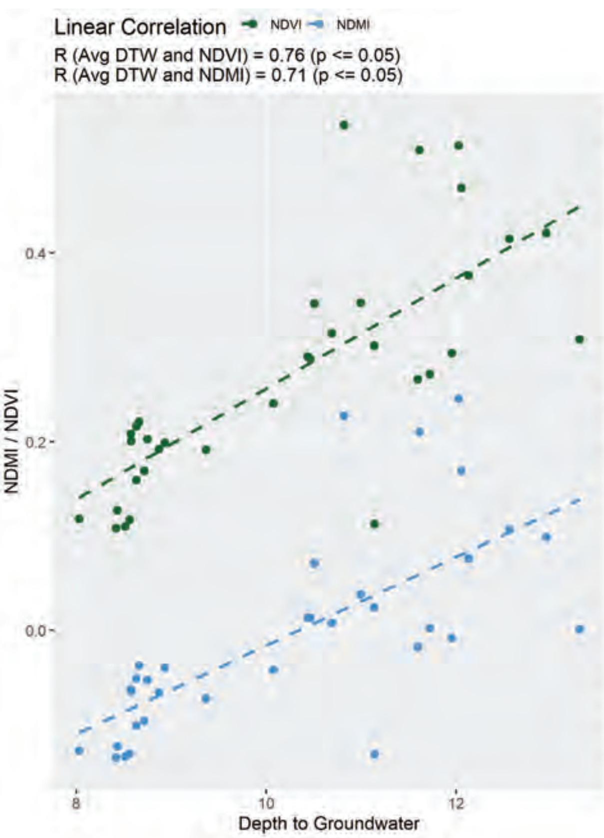


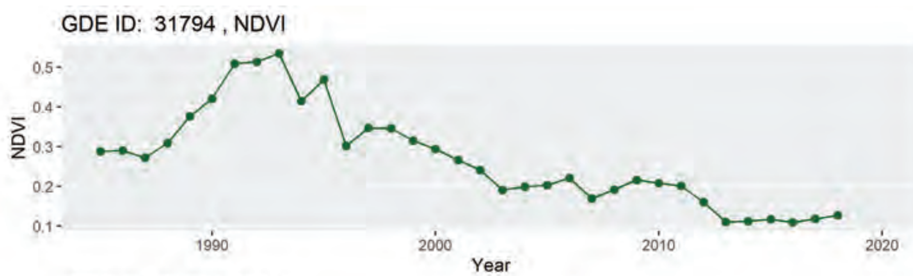
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.34 (p <= 0.05)
R (Avg DTW and NDMI) = -0.47 (p <= 0.05)
NDMI / NDVI
0.6
0.4
0.2
8
10
12
Depth to Groundwater
GDE ID: 19214 , NDVI
NDVI
0.64
0.60
0.56
0.52
0.48
1990
2000
2010
2020
Year
GDE ID: 19214 , NDMI
NDMI
0.25
0.20
0.15
0.10
1990
2000
2010
2020
Year
GDE ID: 19214 , Depth to Groundwater
DTW (ft bgs)
8
10
12
1990
2000
2010
2020
Year

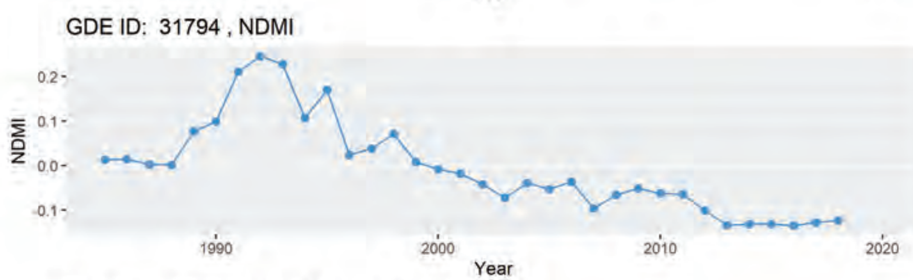

GDE ID: 22305 , NDVI
NDVI
Year

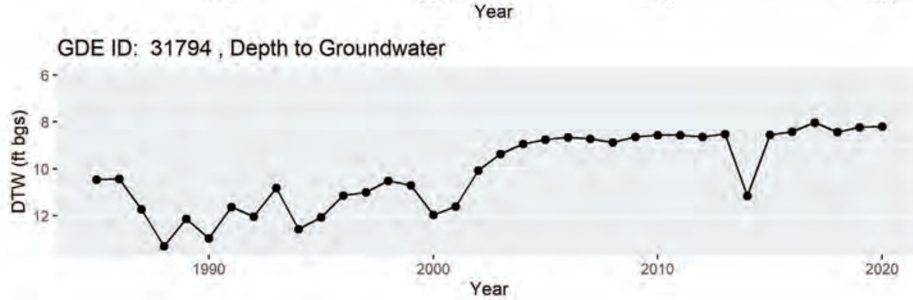

GDE ID: 22305 , NDMI
NDMI
Year

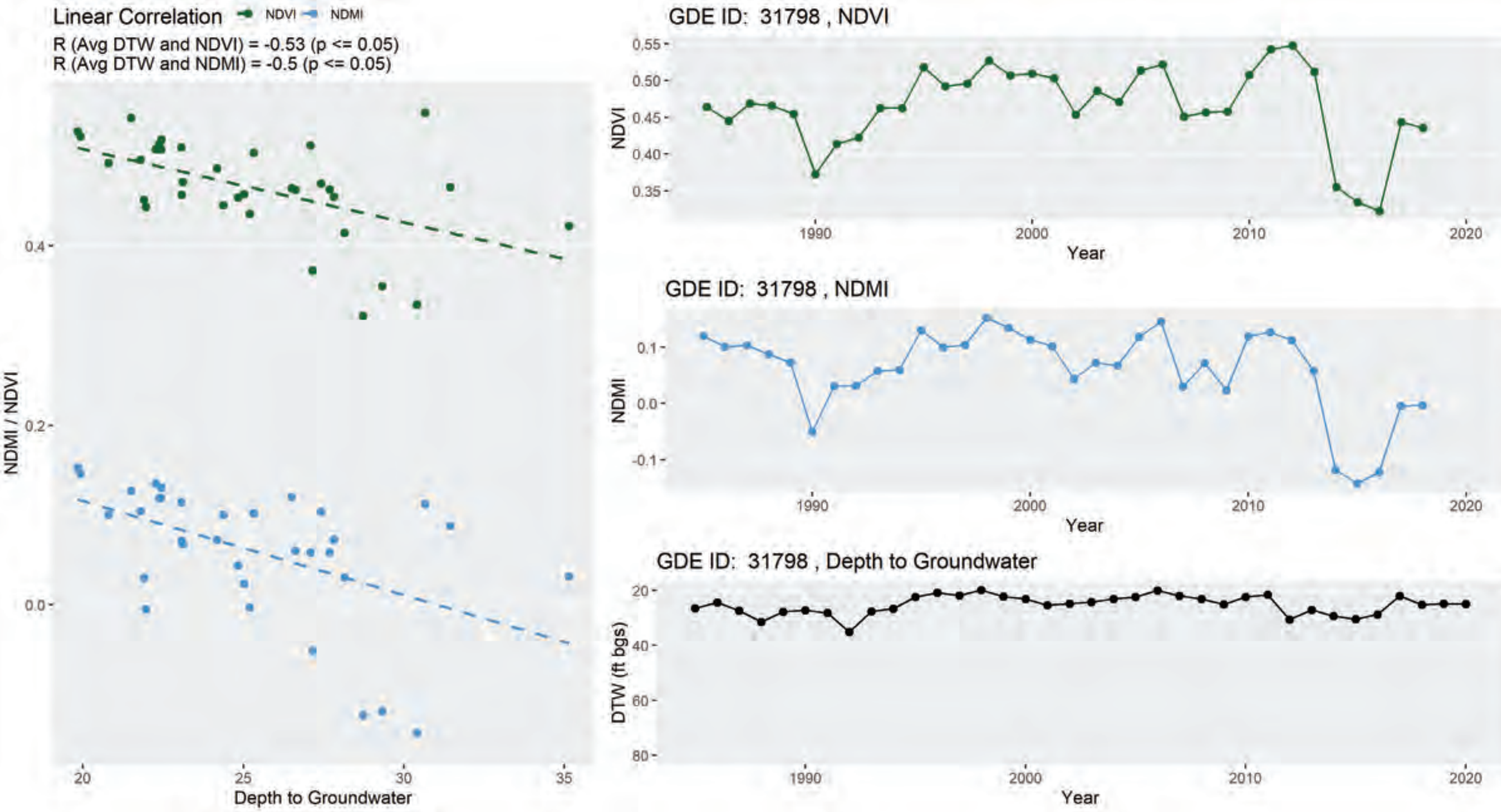

GDE ID: 22305 , Depth to Groundwater
DTW (ft bgs)
Year

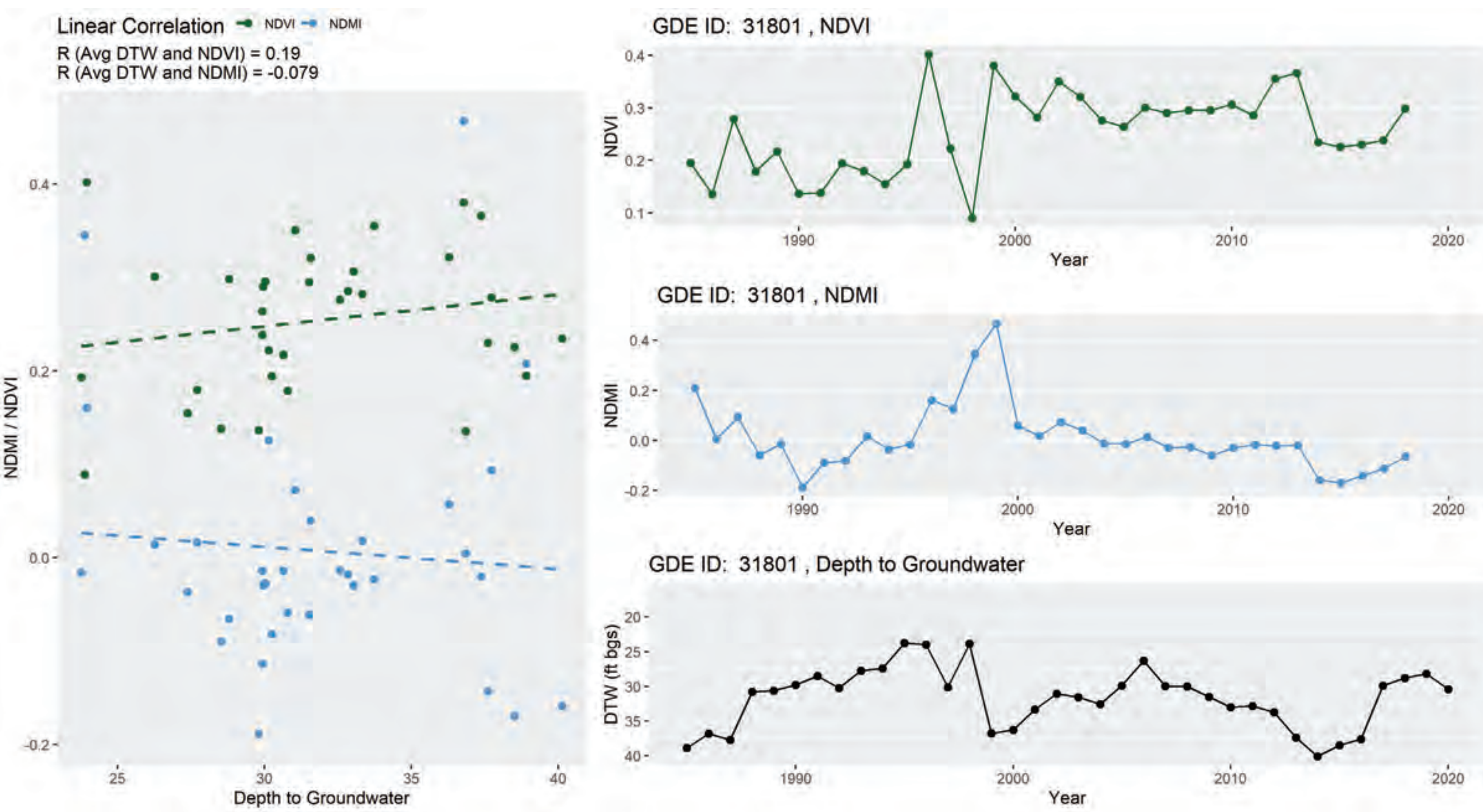

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.76 (p <= 0.05)
R (Avg DTW and NDMI) = 0.71 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater

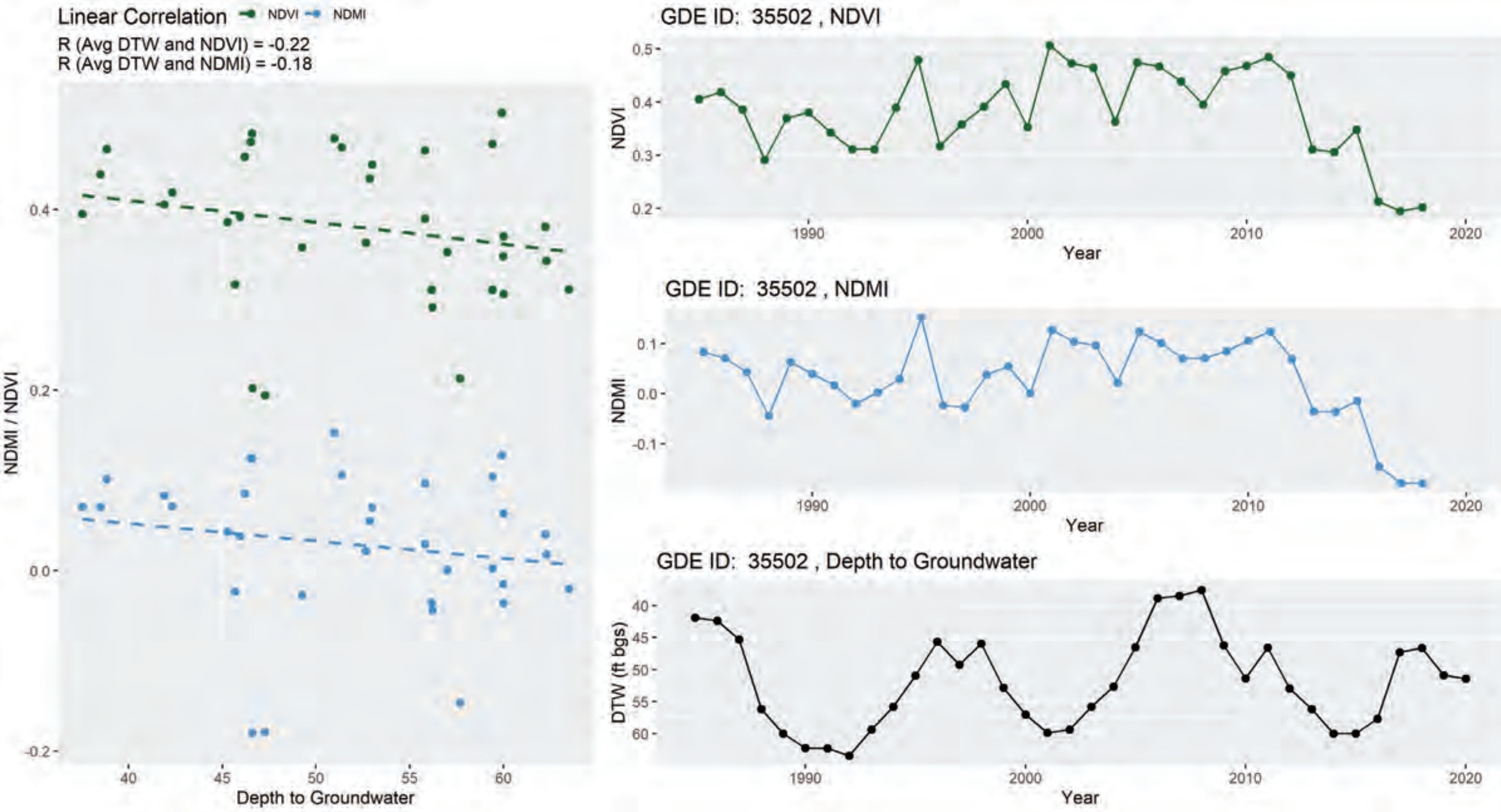

GDE ID: 31794 , NDVI
NDVI
Year

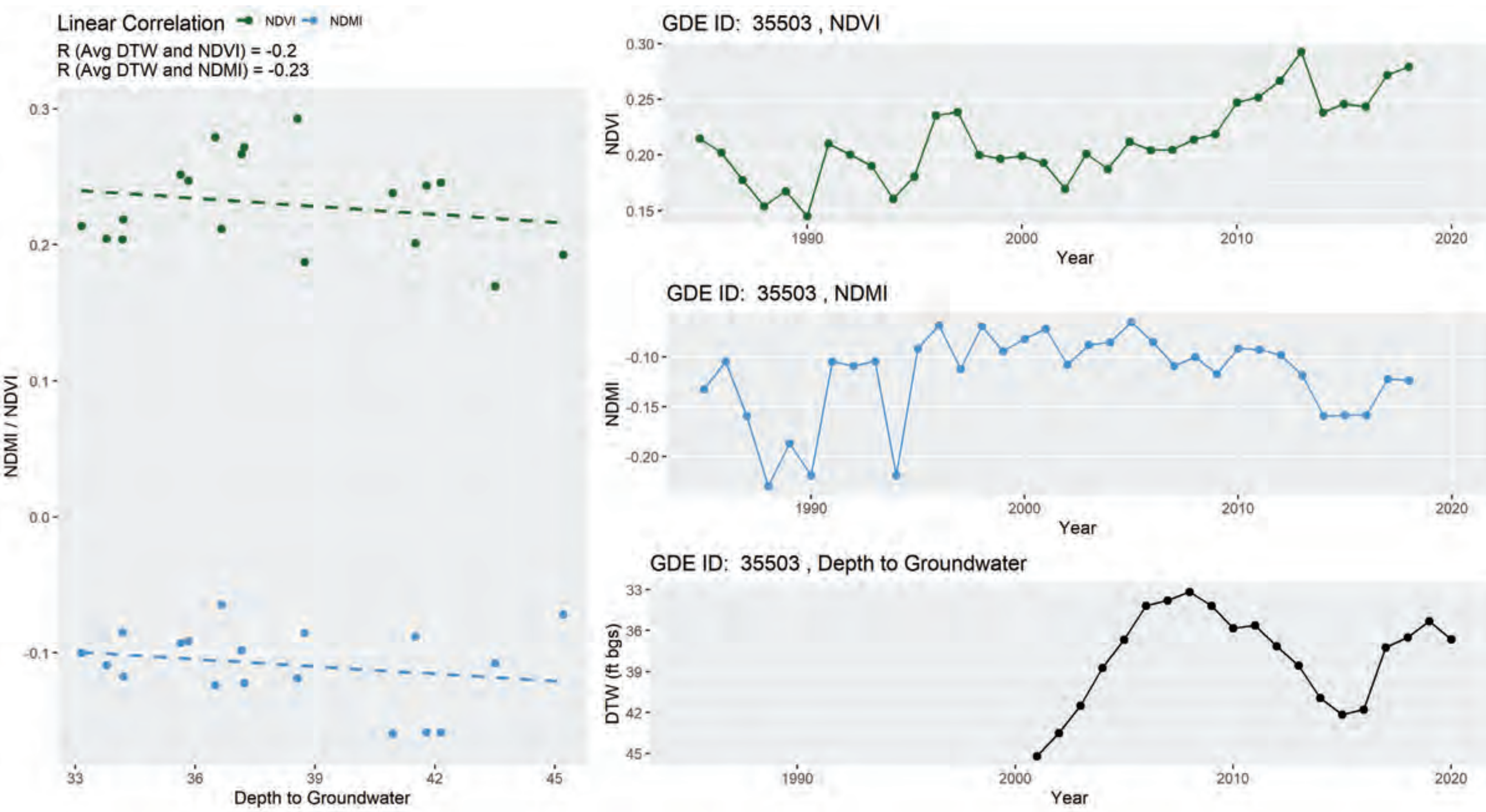

GDE ID: 31794 , NDMI
NDMI
Year

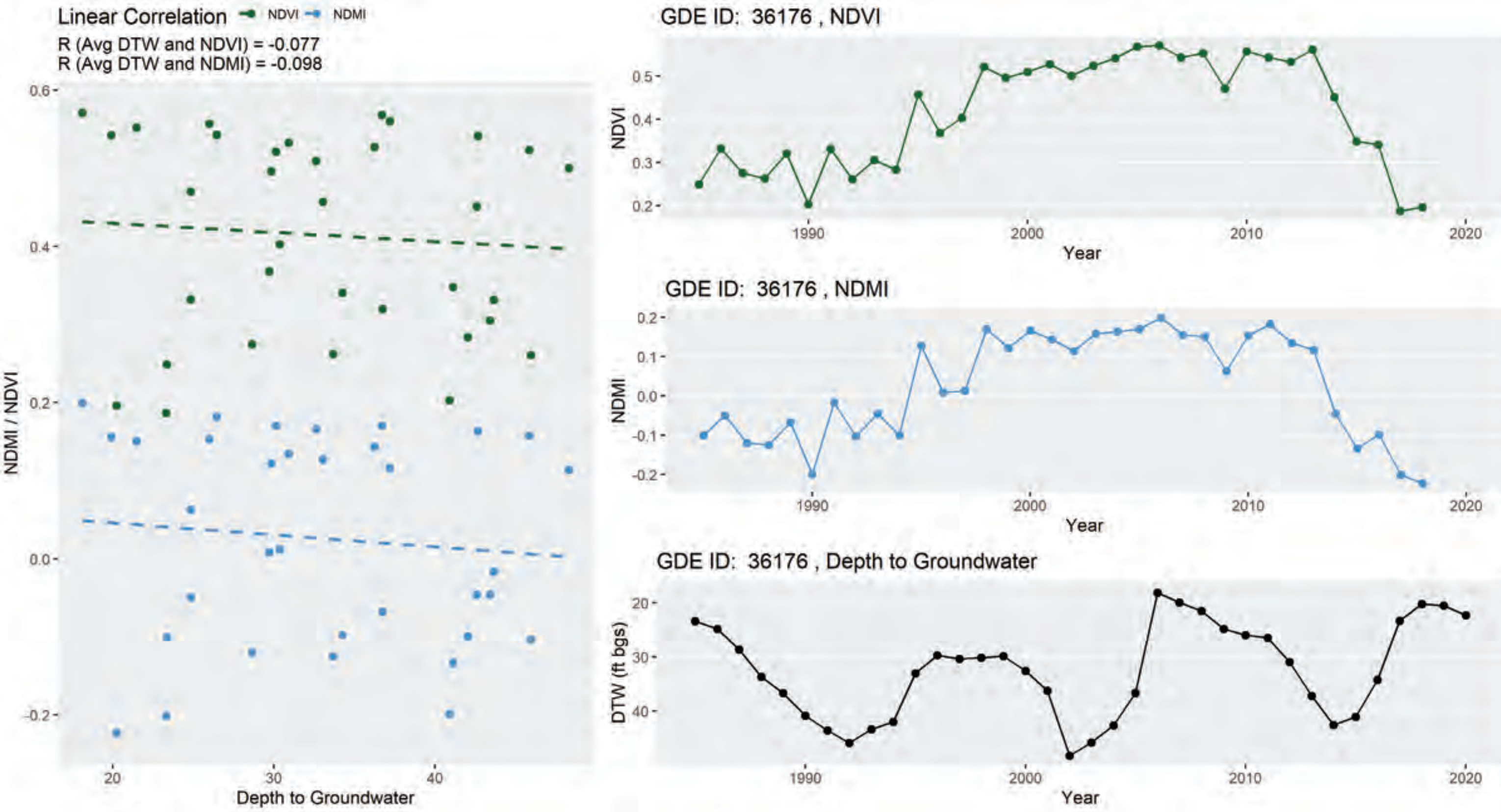

GDE ID: 31794 , Depth to Groundwater
DTW (ft bgs)
Year

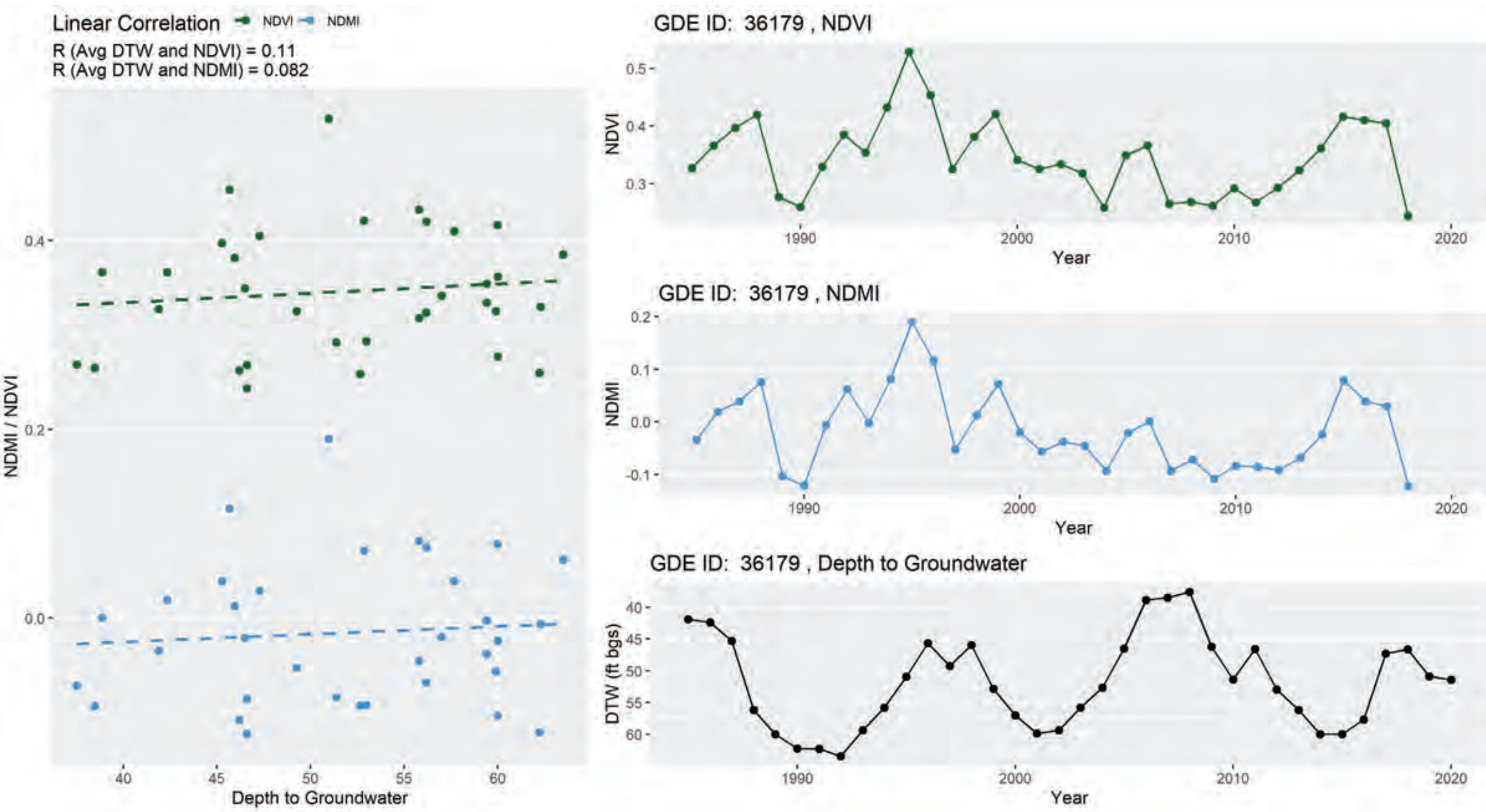

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.53 (p <= 0.05)
R (Avg DTW and NDMI) = -0.5 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 31798 , NDVI
NDVI
Year
GDE ID: 31798 , NDMI
NDMI
Year
GDE ID: 31798 , Depth to Groundwater
DTW (ft bgs)
Year

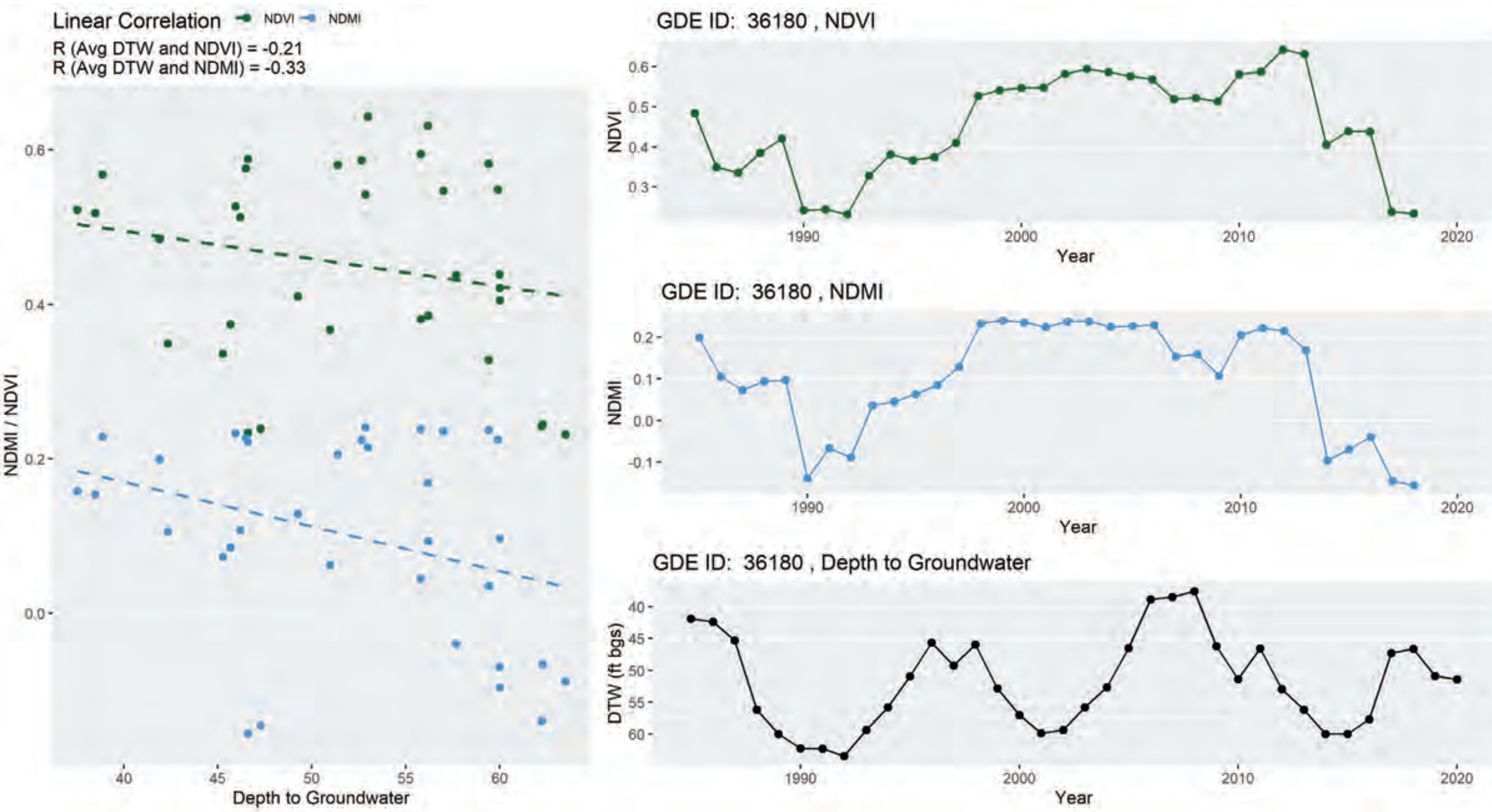

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.19
R (Avg DTW and NDMI) = -0.079
NDMI / NDVI
Depth to Groundwater
GDE ID: 31801 , NDVI
NDVI
Year
GDE ID: 31801 , NDMI
NDMI
Year
GDE ID: 31801 , Depth to Groundwater
DTW (ft bgs)
Year

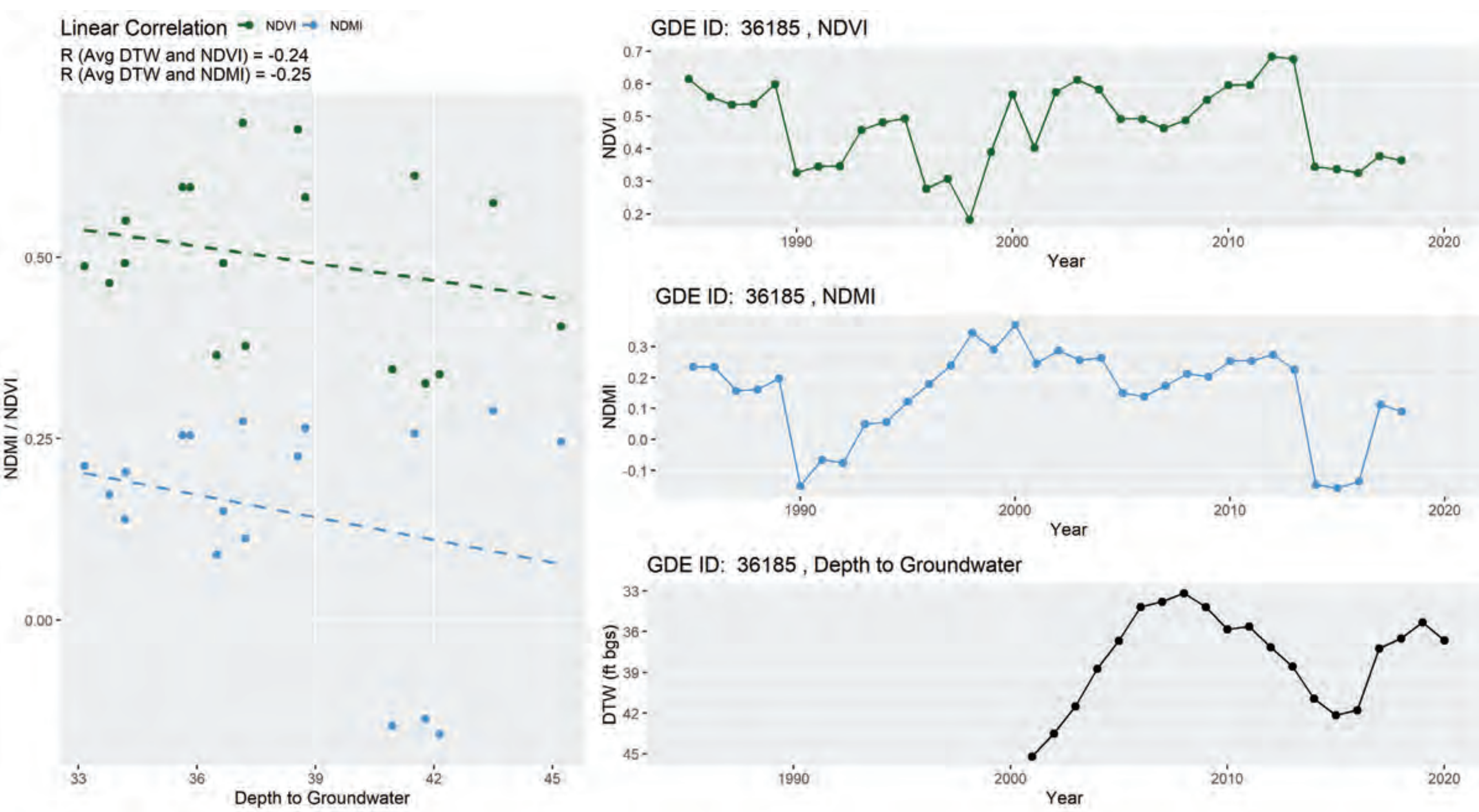

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.22
R (Avg DTW and NDMI) = -0.18
NDMI / NDVI
Depth to Groundwater
GDE ID: 35502 , NDVI
NDVI
Year
GDE ID: 35502 , NDMI
NDMI
Year
GDE ID: 35502 , Depth to Groundwater
DTW (ft bgs)
Year

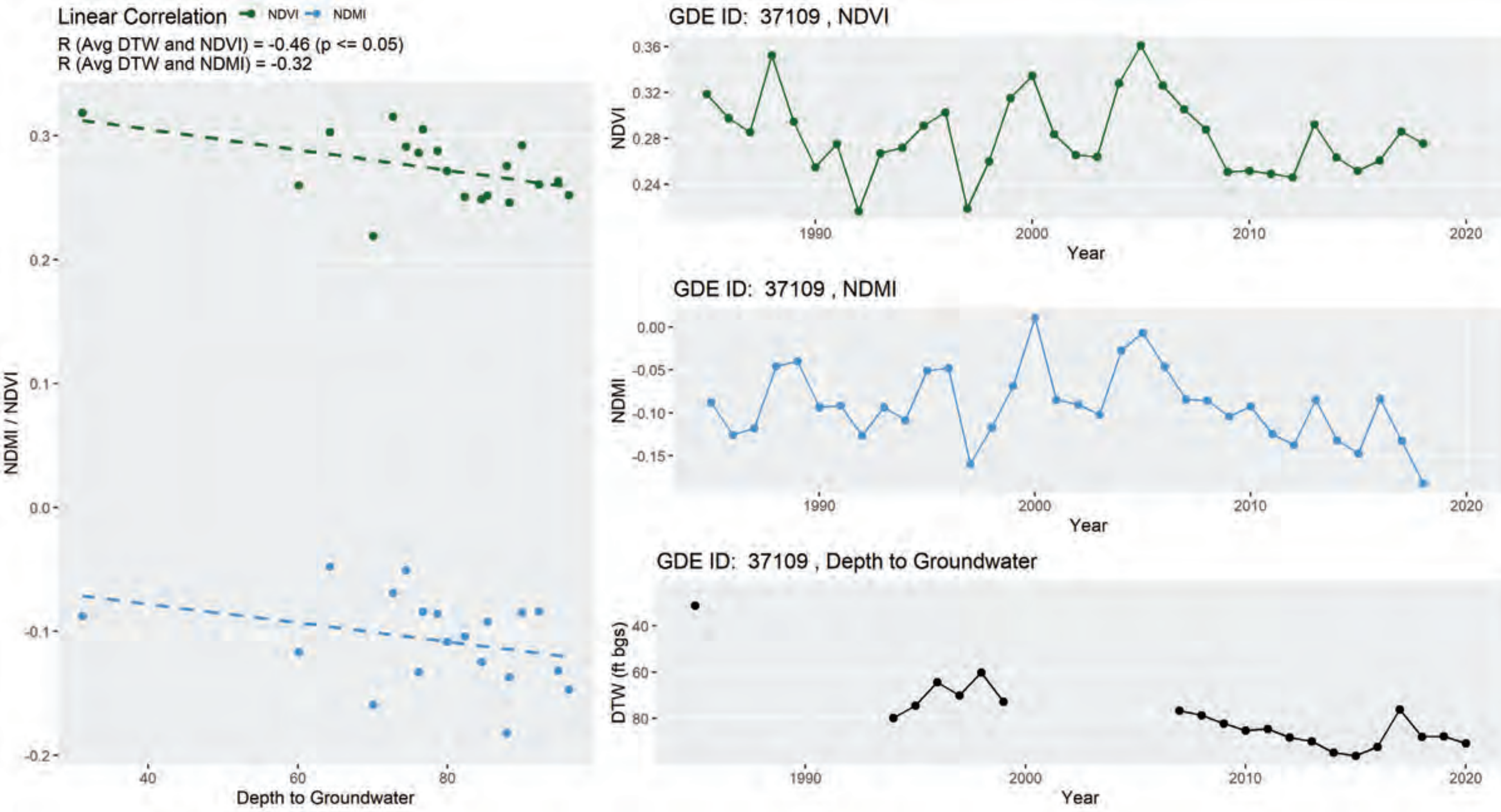

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.2
R (Avg DTW and NDMI) = -0.23
NDMI / NDVI
Depth to Groundwater
GDE ID: 35503 , NDVI
NDVI
Year
GDE ID: 35503 , NDMI
NDMI
Year
GDE ID: 35503 , Depth to Groundwater
DTW (ft bgs)
Year

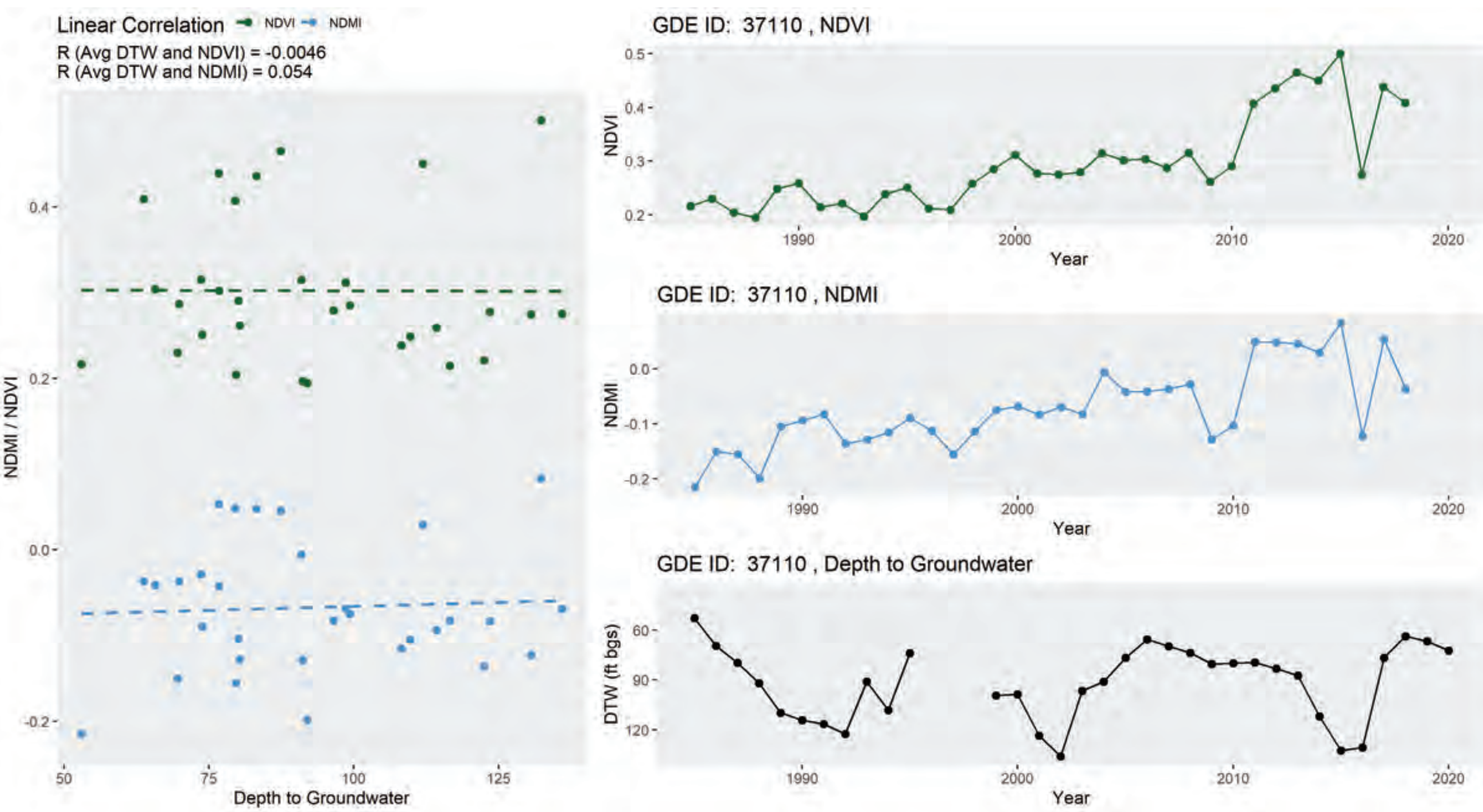

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.077
R (Avg DTW and NDMI) = -0.098
NDMI / NDVI
Depth to Groundwater
GDE ID: 36176 , NDVI
NDVI
Year
GDE ID: 36176 , NDMI
NDMI
Year
GDE ID: 36176 , Depth to Groundwater
DTW (ft bgs)
Year

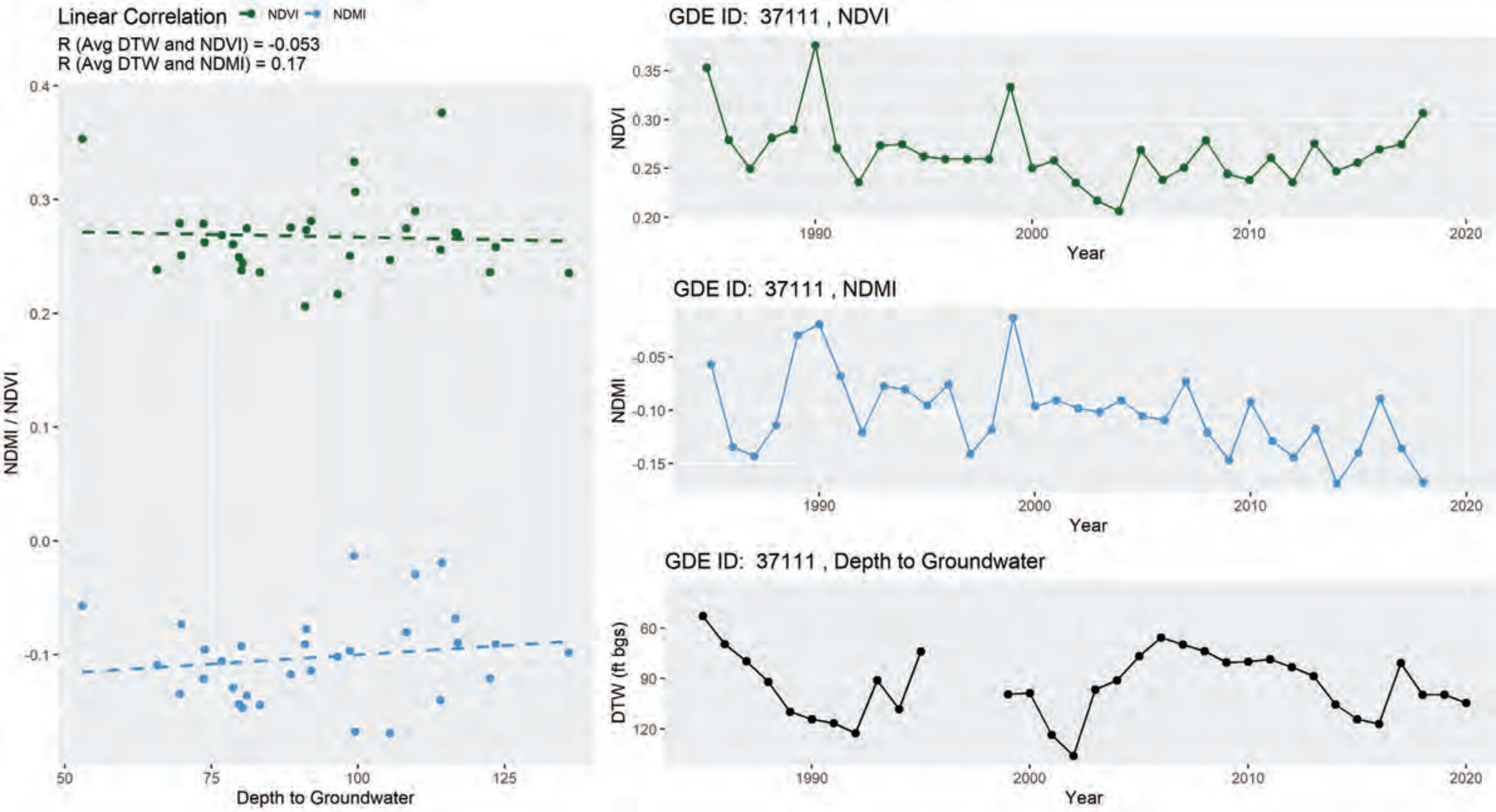

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.11
R (Avg DTW and NDMI) = 0.082
NDMI / NDVI
Depth to Groundwater
GDE ID: 36179 , NDVI
NDVI
Year
GDE ID: 36179 , NDMI
NDMI
Year
GDE ID: 36179 , Depth to Groundwater
DTW (ft bgs)
Year

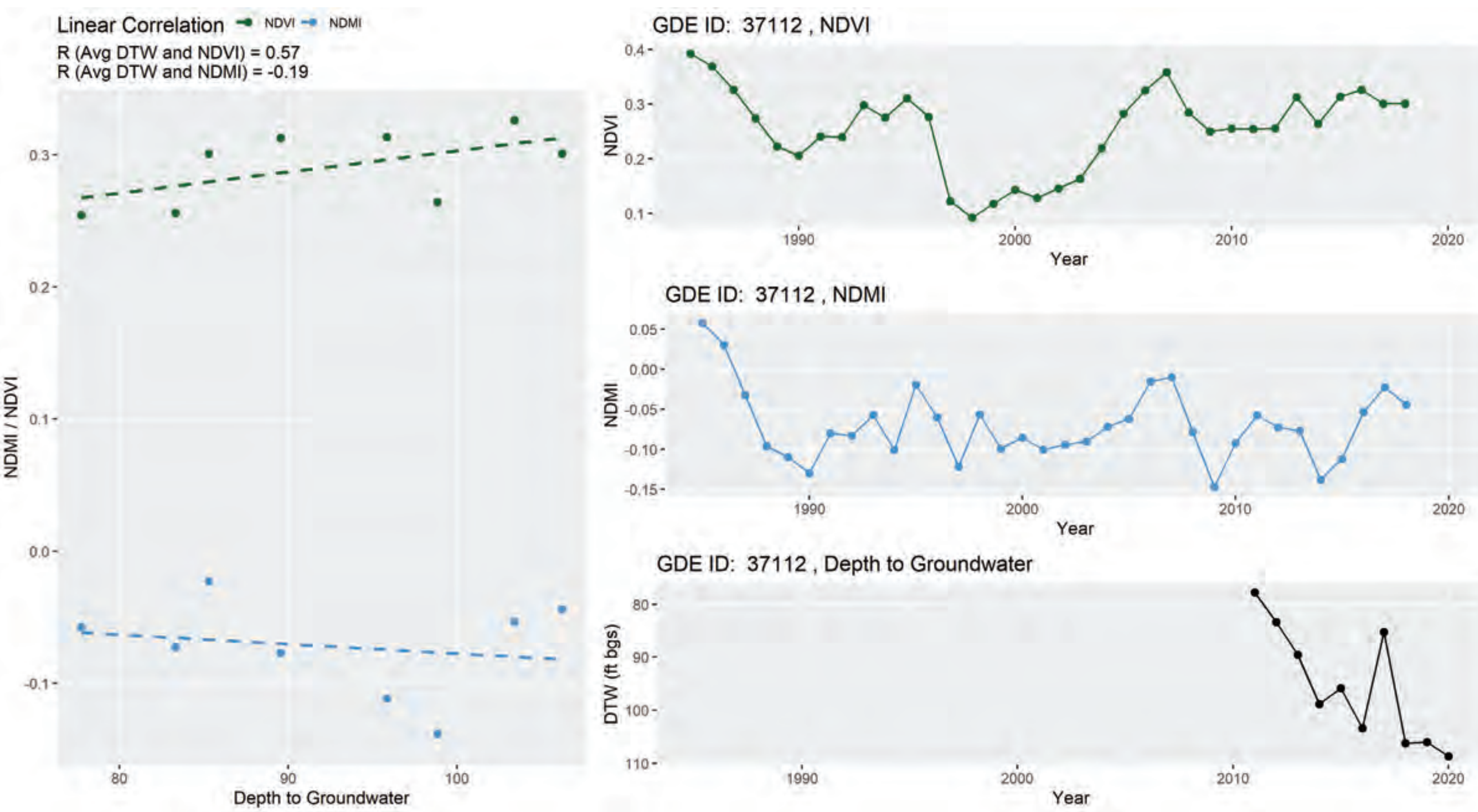

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.21
R (Avg DTW and NDMI) = -0.33
NDMI / NDVI
Depth to Groundwater
GDE ID: 36180 , NDVI
NDVI
Year
GDE ID: 36180 , NDMI
NDMI
Year
GDE ID: 36180 , Depth to Groundwater
DTW (ft bgs)
Year

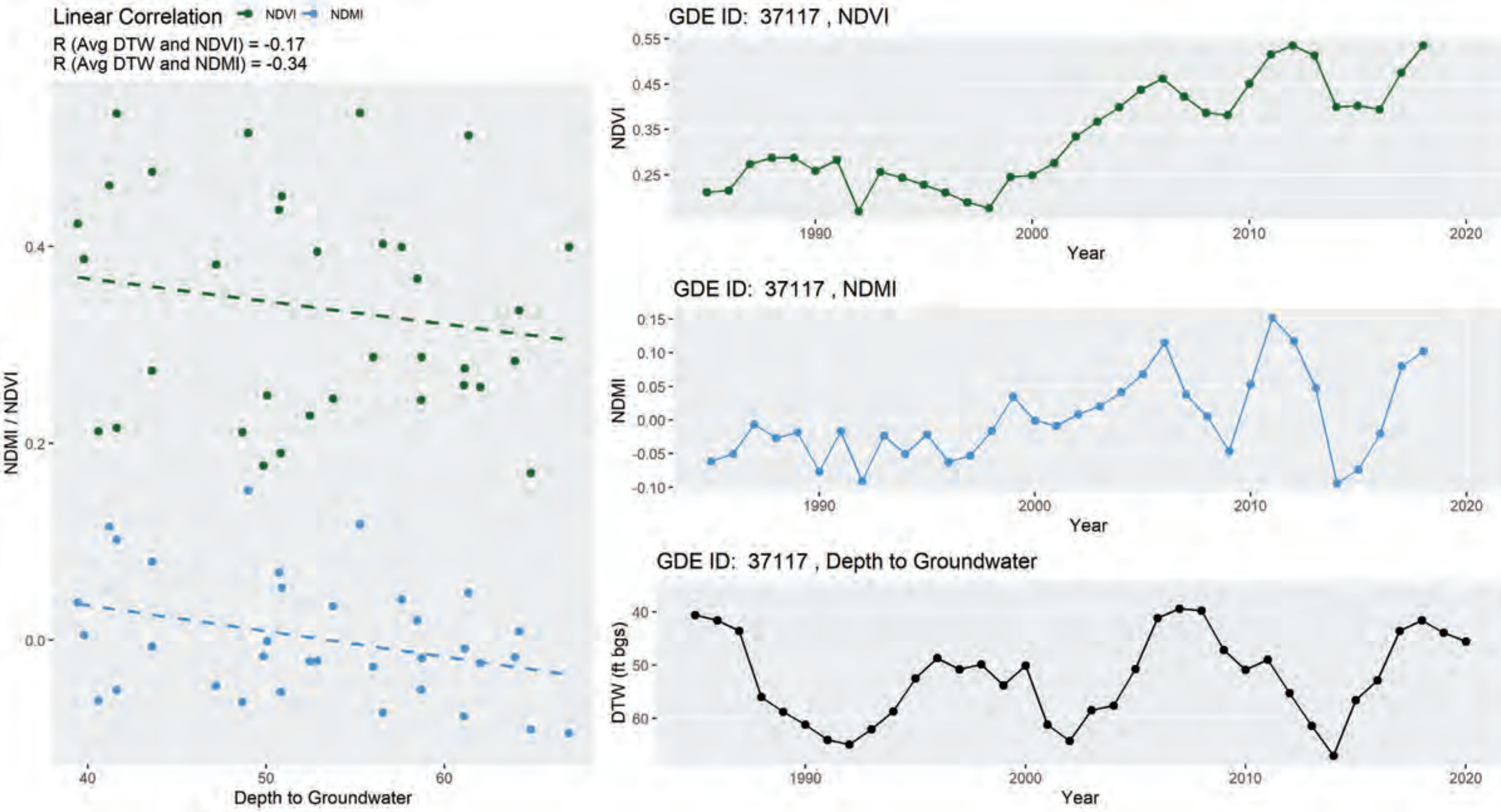

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.24
R (Avg DTW and NDMI) = -0.25
NDMI / NDVI
Depth to Groundwater
GDE ID: 36185 , NDVI
NDVI
Year
GDE ID: 36185 , NDMI
NDMI
Year
GDE ID: 36185 , Depth to Groundwater
DTW (ft bgs)
Year

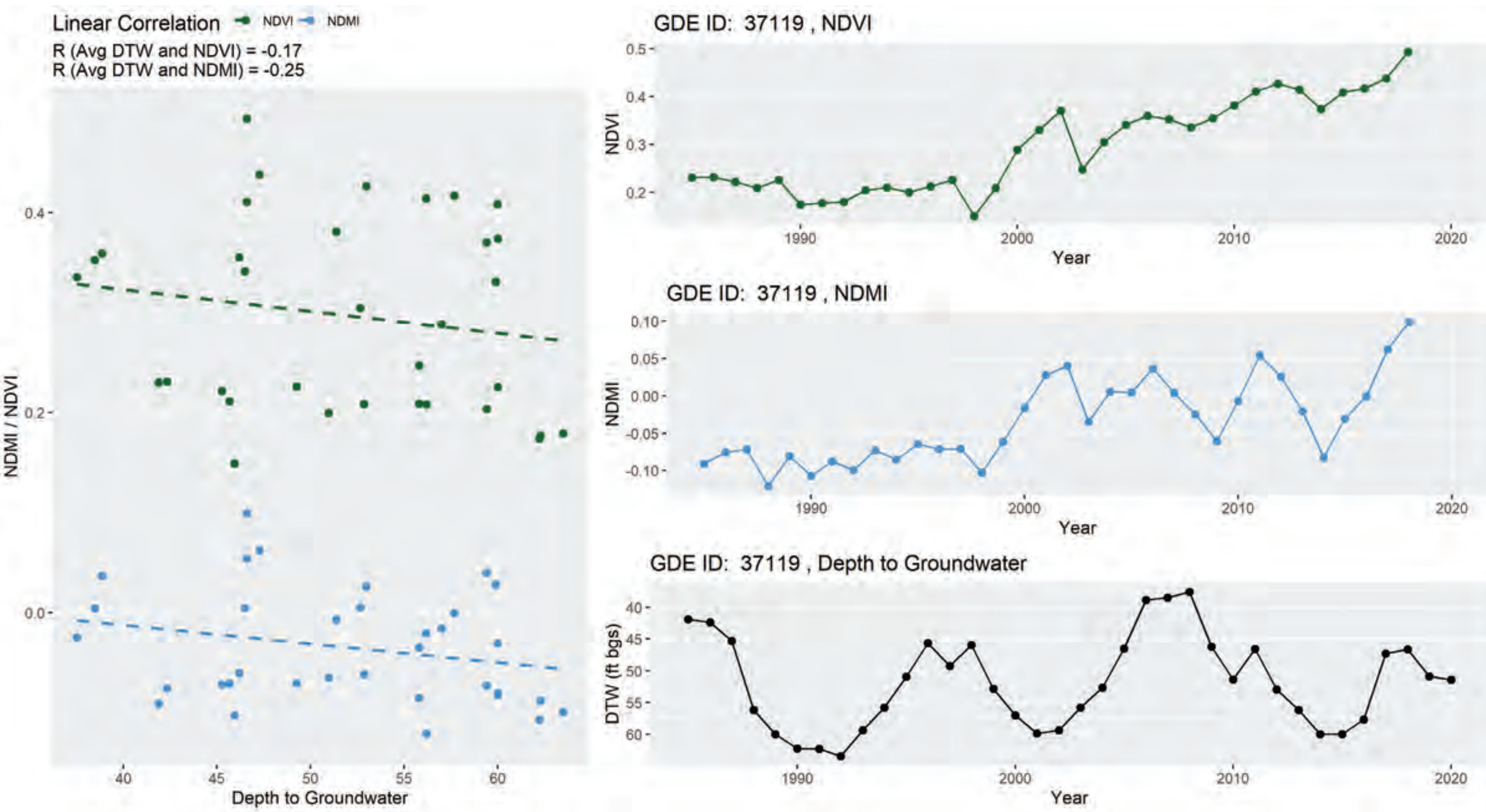

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.46 (p <= 0.05)
R (Avg DTW and NDMI) = -0.32
NDMI / NDVI
Depth to Groundwater
GDE ID: 37109 , NDVI
NDVI
Year
GDE ID: 37109 , NDMI
NDMI
Year
GDE ID: 37109 , Depth to Groundwater
DTW (ft bgs)
Year

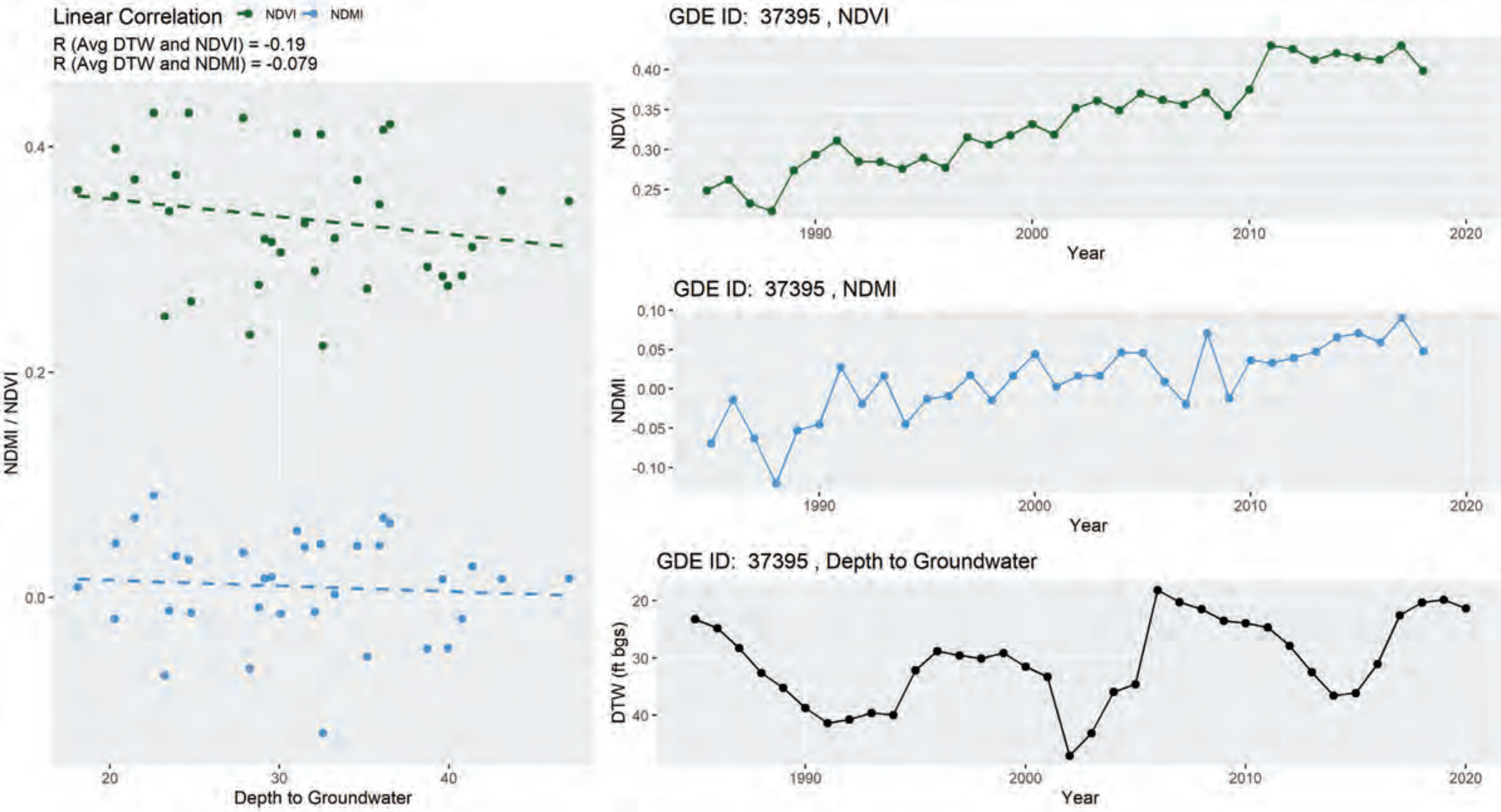

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.0046
R (Avg DTW and NDMI) = 0.054
NDMI / NDVI
Depth to Groundwater
GDE ID: 37110 , NDVI
NDVI
Year
GDE ID: 37110 , NDMI
NDMI
Year
GDE ID: 37110 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.053
R (Avg DTW and NDMI) = 0.17
NDMI / NDVI
Depth to Groundwater
GDE ID: 37111 , NDVI
NDVI
Year
GDE ID: 37111 , NDMI
NDMI
Year
GDE ID: 37111 , Depth to Groundwater
DTW (ft bgs)
Year

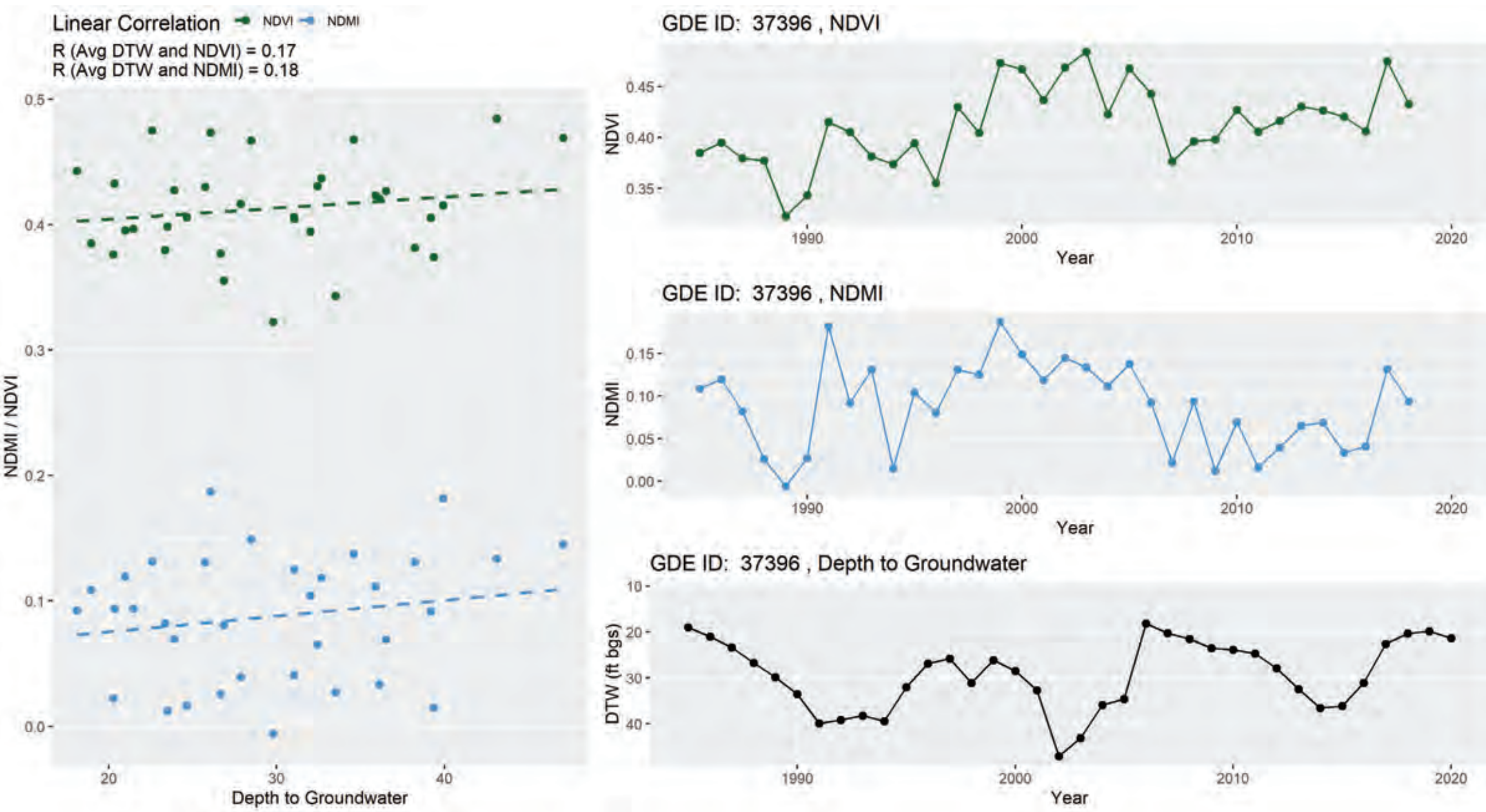

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.57
R (Avg DTW and NDMI) = -0.19
NDMI / NDVI
Depth to Groundwater
GDE ID: 37112 , NDVI
NDVI
Year
GDE ID: 37112 , NDMI
NDMI
Year
GDE ID: 37112 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.17
R (Avg DTW and NDMI) = -0.34
NDMI / NDVI
Depth to Groundwater
GDE ID: 37117 , NDVI
NDVI
Year
GDE ID: 37117 , NDMI
NDMI
Year
GDE ID: 37117 , Depth to Groundwater
DTW (ft bgs)
Year

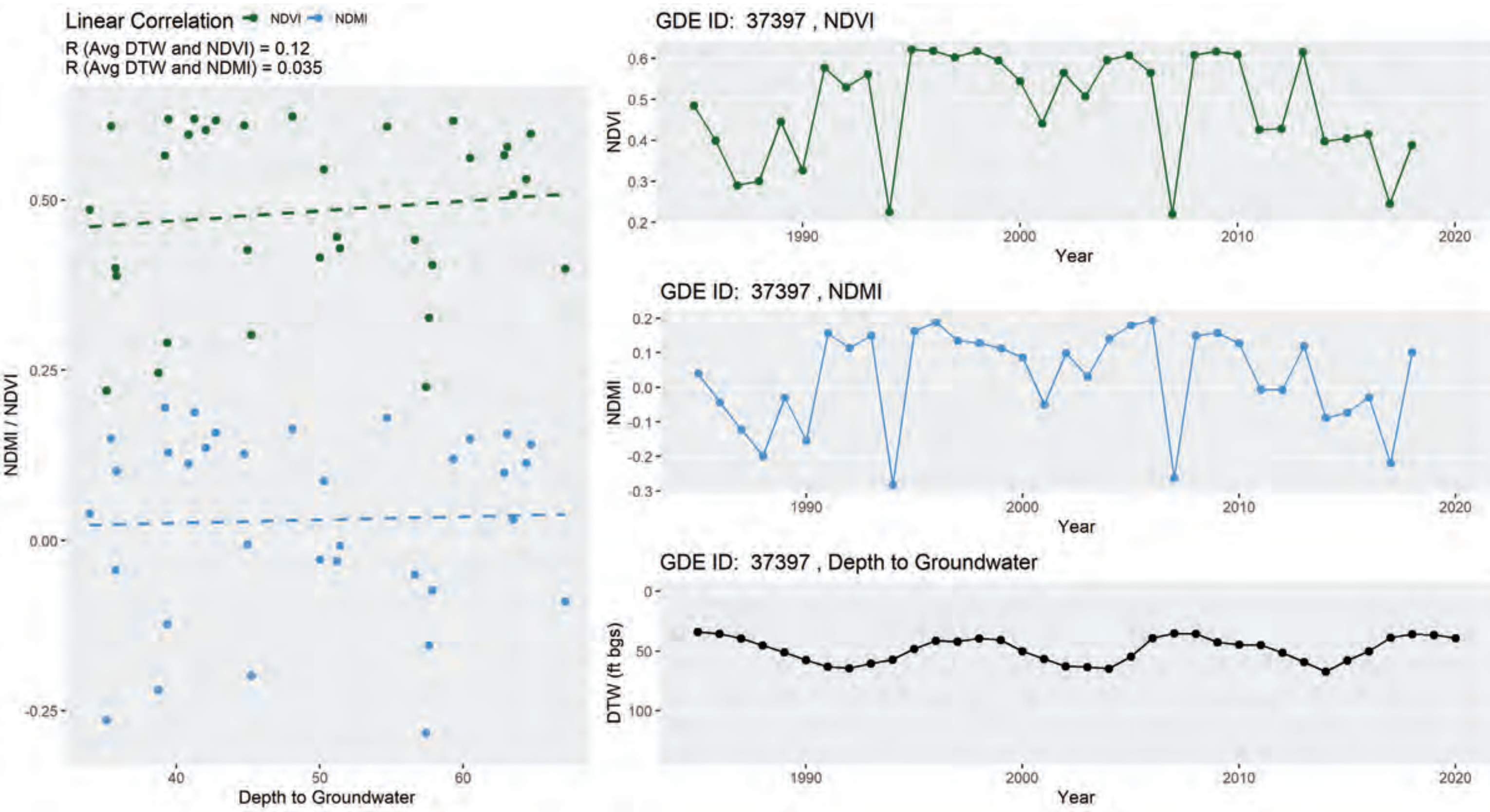

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.17
R (Avg DTW and NDMI) = -0.25
NDMI / NDVI
Depth to Groundwater
GDE ID: 37119 , NDVI
NDVI
Year
GDE ID: 37119 , NDMI
NDMI
Year
GDE ID: 37119 , Depth to Groundwater
DTW (ft bgs)
Year

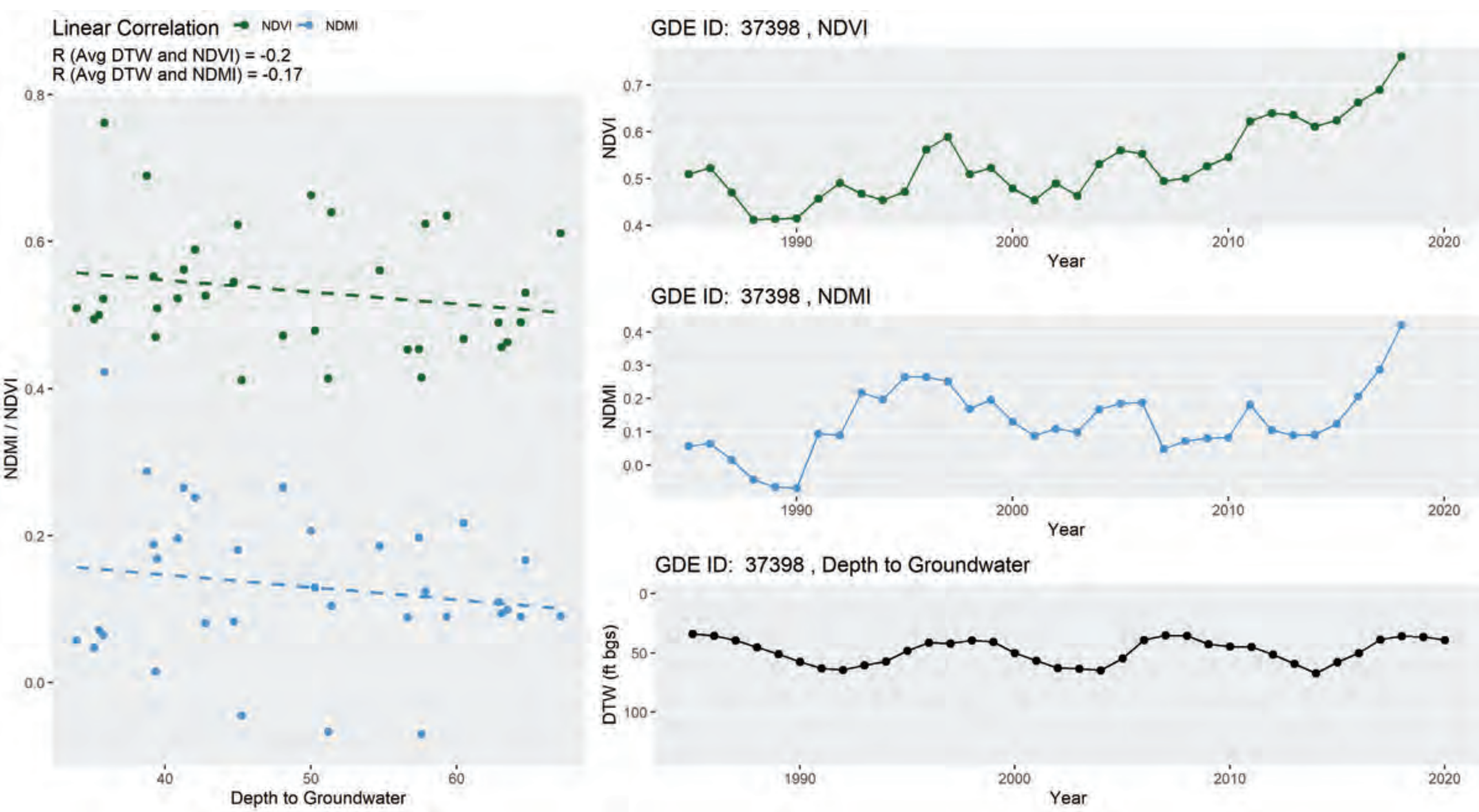


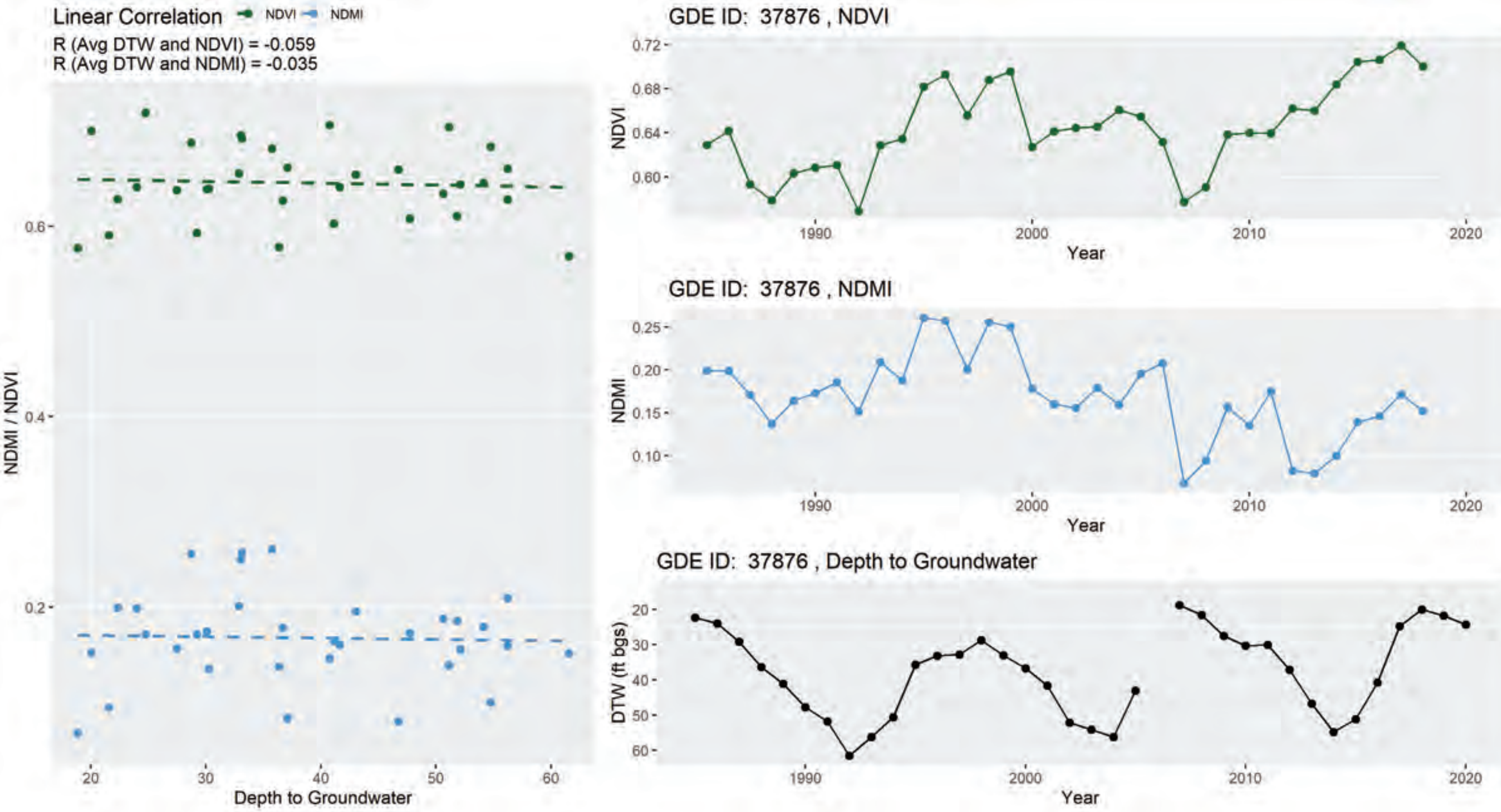
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.19
R (Avg DTW and NDMI) = -0.079
NDMI / NDVI
Depth to Groundwater
GDE ID: 37395 , NDVI
NDVI
Year
GDE ID: 37395 , NDMI
NDMI
Year
GDE ID: 37395 , Depth to Groundwater
DTW (ft bgs)
Year

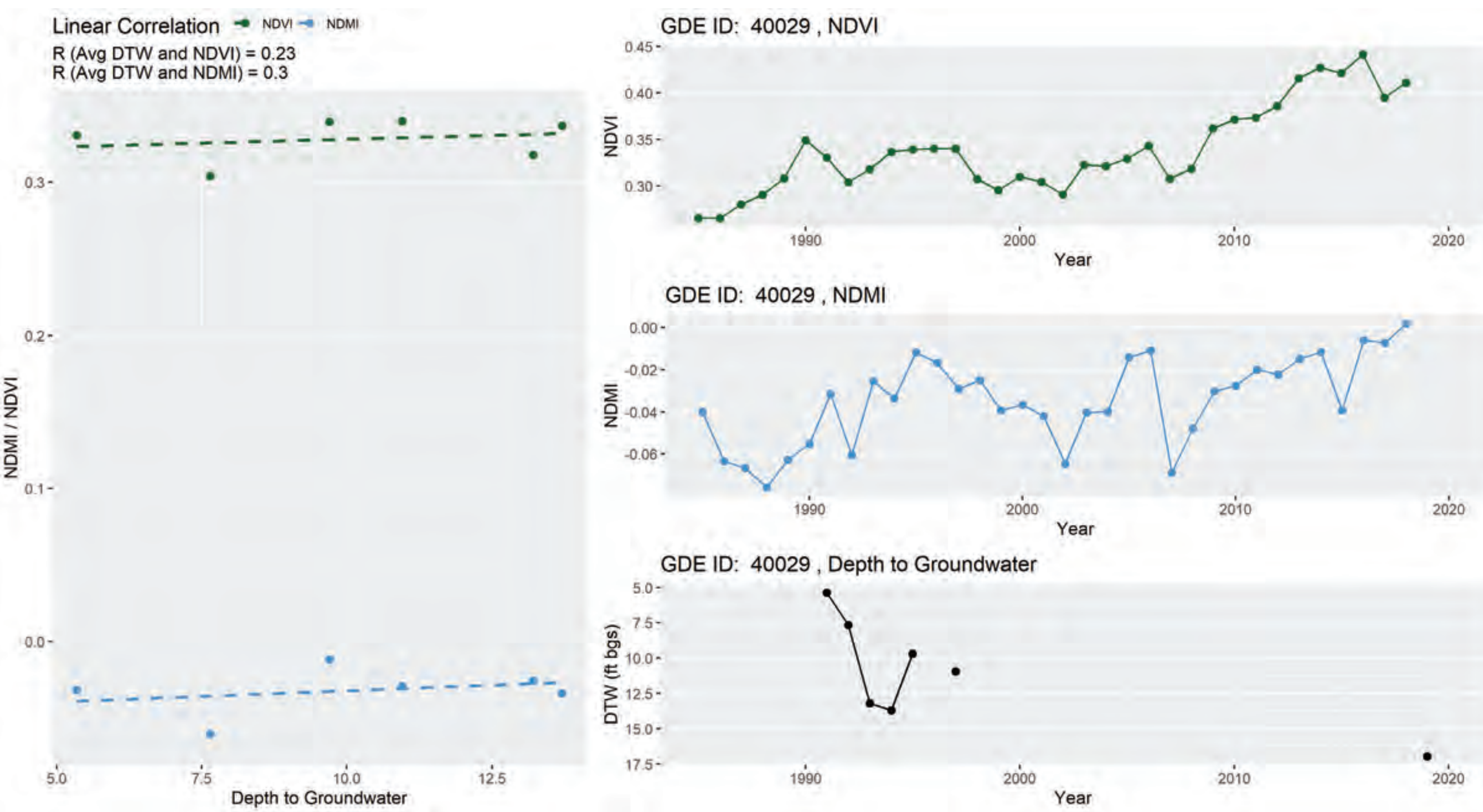


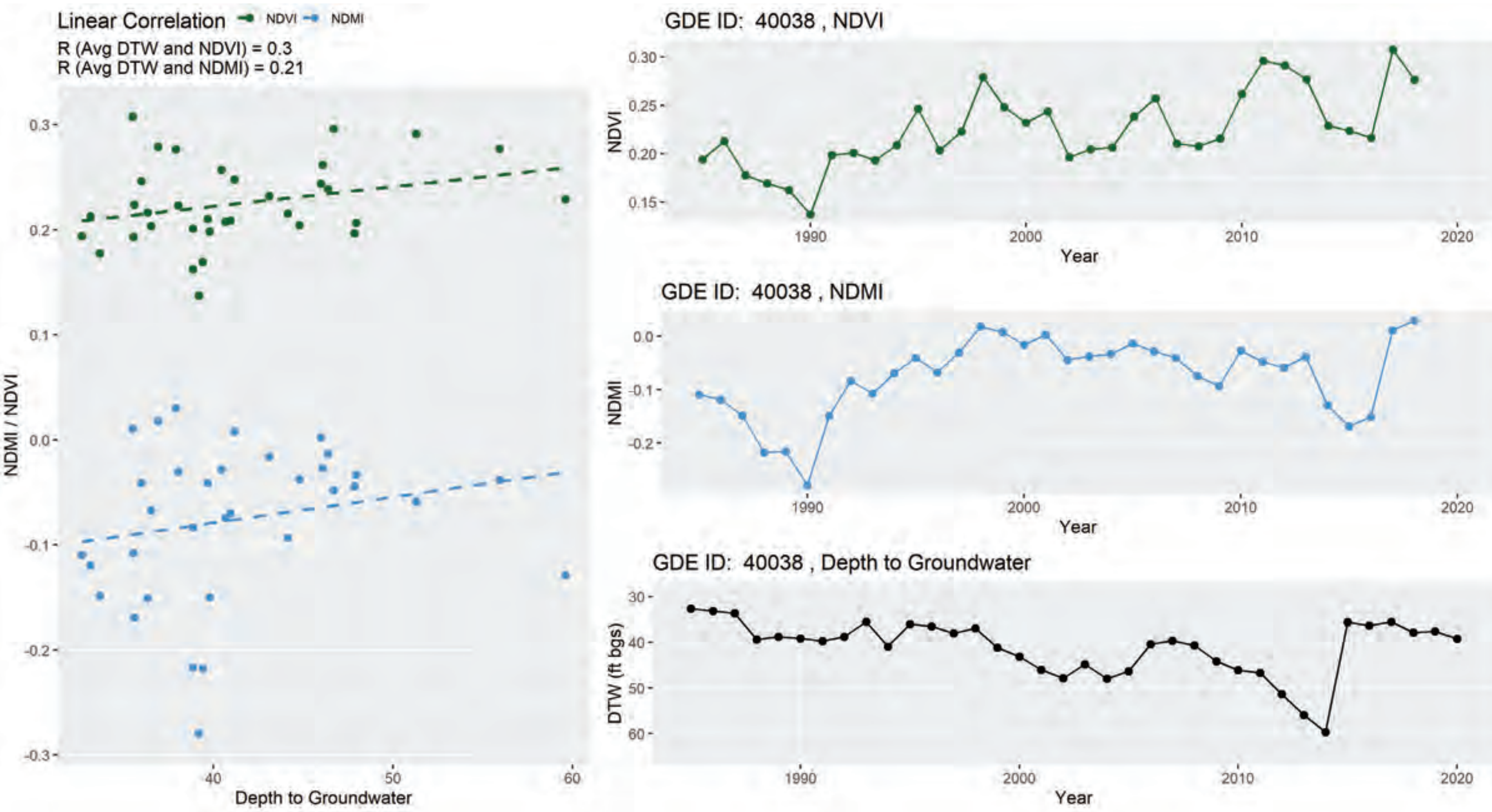
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.17
R (Avg DTW and NDMI) = 0.18
NDMI / NDVI
Depth to Groundwater
GDE ID: 37396 , NDVI
NDVI
Year
GDE ID: 37396 , NDMI
NDMI
Year
GDE ID: 37396 , Depth to Groundwater
DTW (ft bgs)
Year

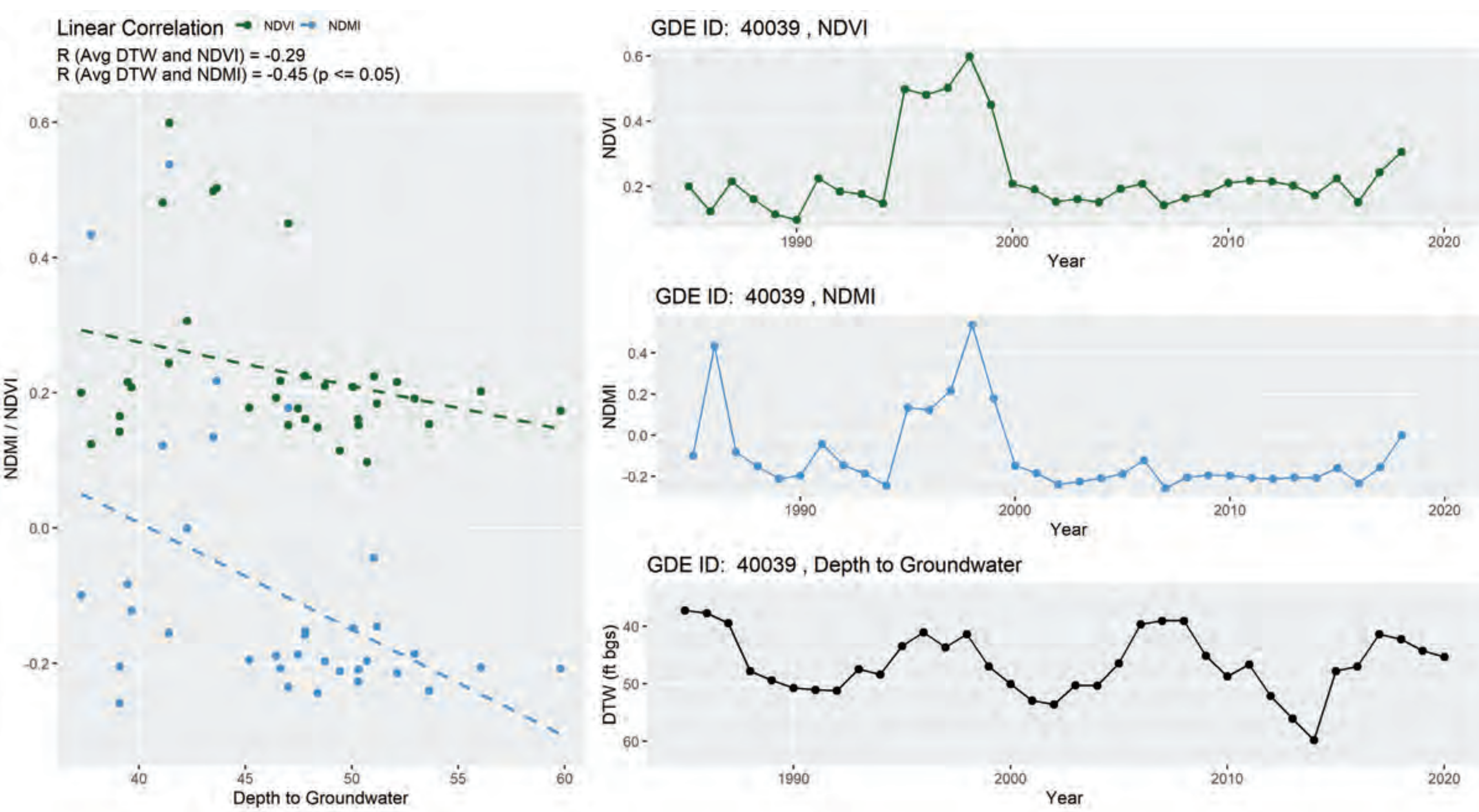

Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = 0.12
R (Avg DTW and NDMI) = 0.035
NDMI / NDVI
Depth to Groundwater
GDE ID: 37397 , NDVI
NDVI
Year
GDE ID: 37397 , NDMI
NDMI
Year
GDE ID: 37397 , Depth to Groundwater
DTW (ft bgs)
Year

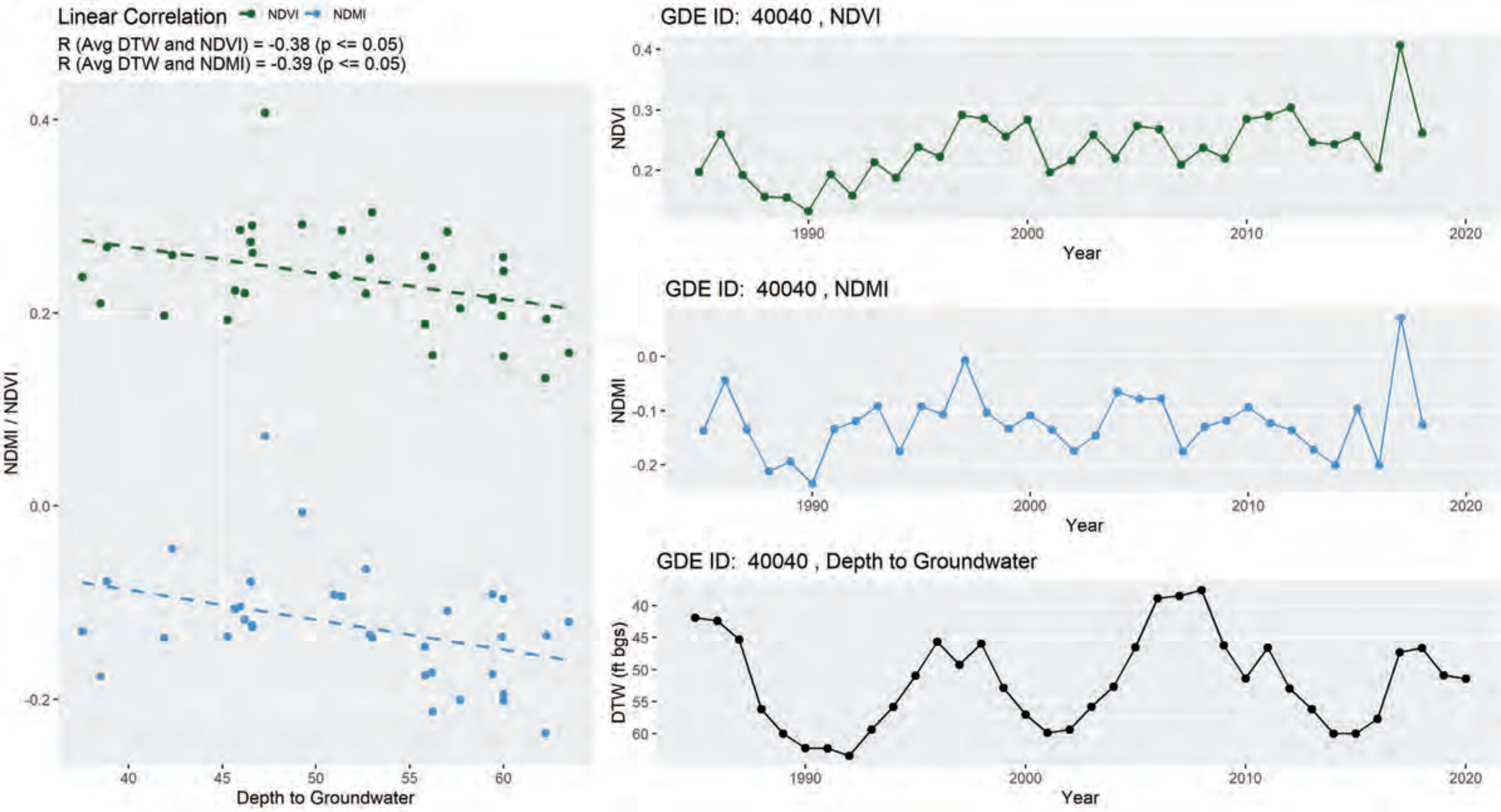

Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = -0.2
R (Avg DTW and NDMI) = -0.17
NDMI / NDVI
Depth to Groundwater
GDE ID: 37398 , NDVI
NDVI
Year
GDE ID: 37398 , NDMI
NDMI
Year
GDE ID: 37398 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.059
R (Avg DTW and NDMI) = -0.035
NDMI / NDVI
Depth to Groundwater
GDE ID: 37876 , NDVI
NDVI
Year
GDE ID: 37876 , NDMI
NDMI
Year
GDE ID: 37876 , Depth to Groundwater
DTW (ft bgs)
Year

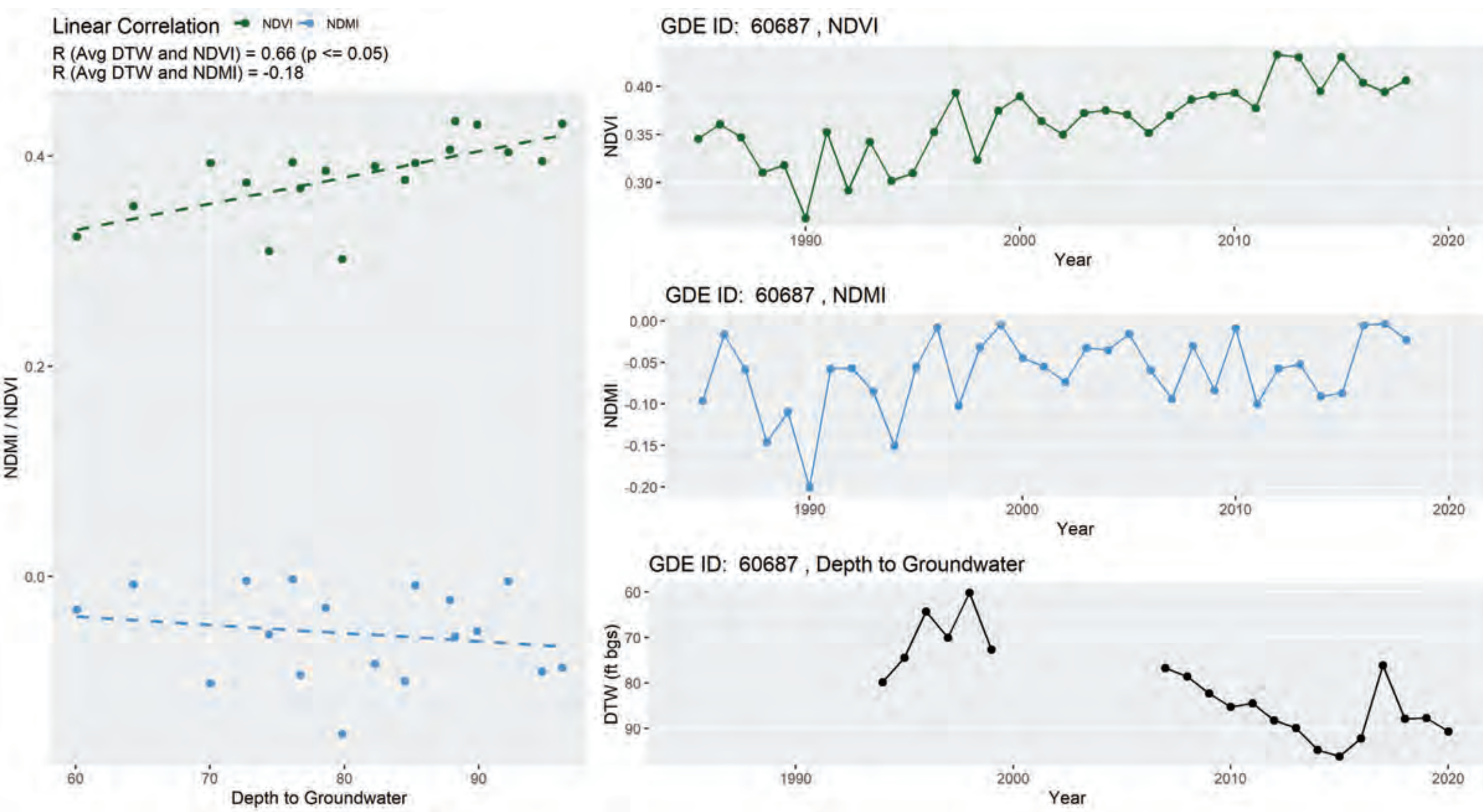

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.23
R (Avg DTW and NDMI) = 0.3
NDMI / NDVI
Depth to Groundwater
GDE ID: 40029 , NDVI
NDVI
Year
GDE ID: 40029 , NDMI
NDMI
Year
GDE ID: 40029 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.3
R (Avg DTW and NDMI) = 0.21
NDMI / NDVI
Depth to Groundwater
GDE ID: 40038 , NDVI
NDVI
Year
GDE ID: 40038 , NDMI
NDMI
Year
GDE ID: 40038 , Depth to Groundwater
DTW (ft bgs)
Year

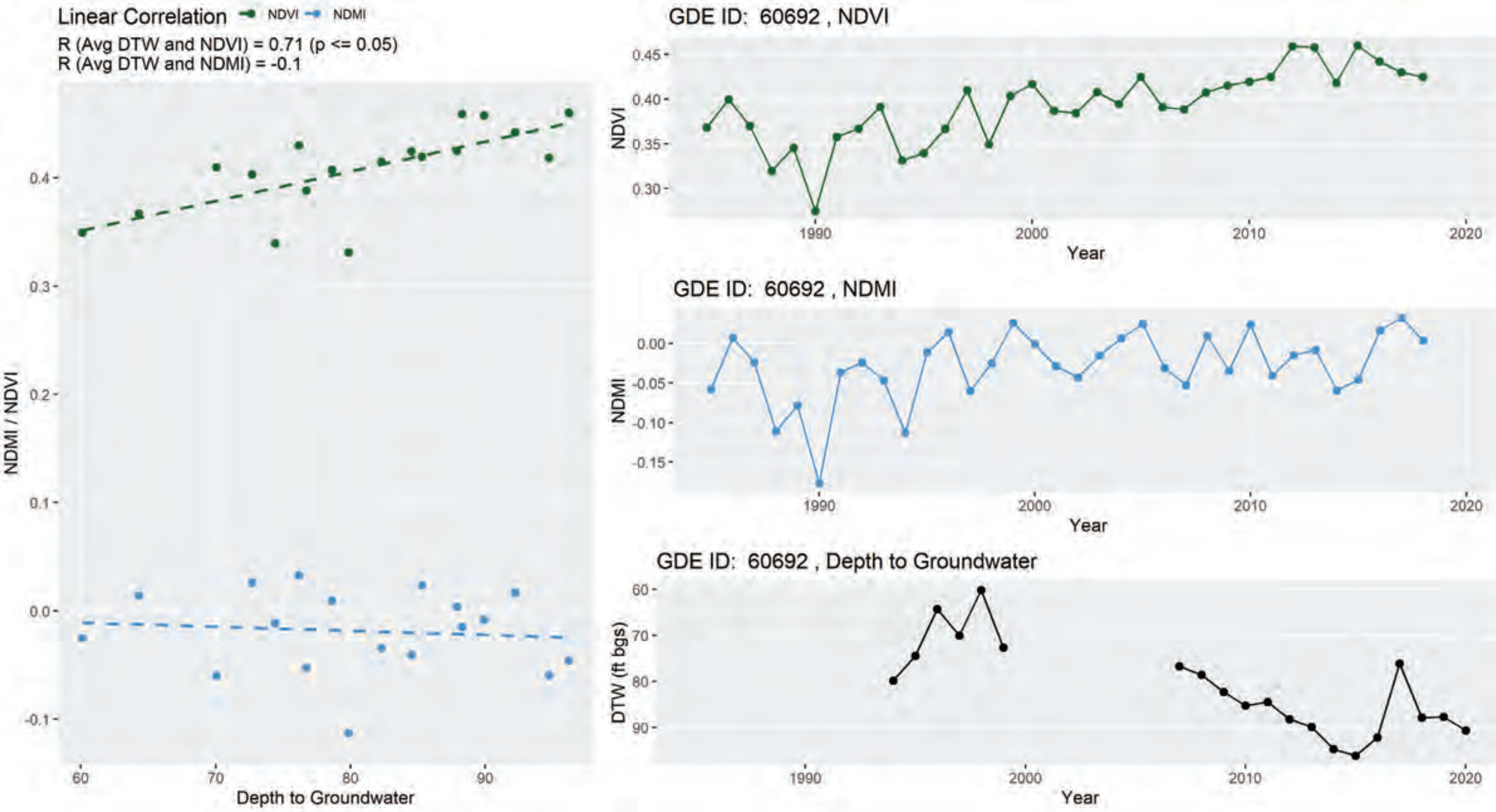

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.29
R (Avg DTW and NDMI) = -0.45 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 40039 , NDVI
NDVI
Year
GDE ID: 40039 , NDMI
NDMI
Year
GDE ID: 40039 , Depth to Groundwater
DTW (ft bgs)
Year

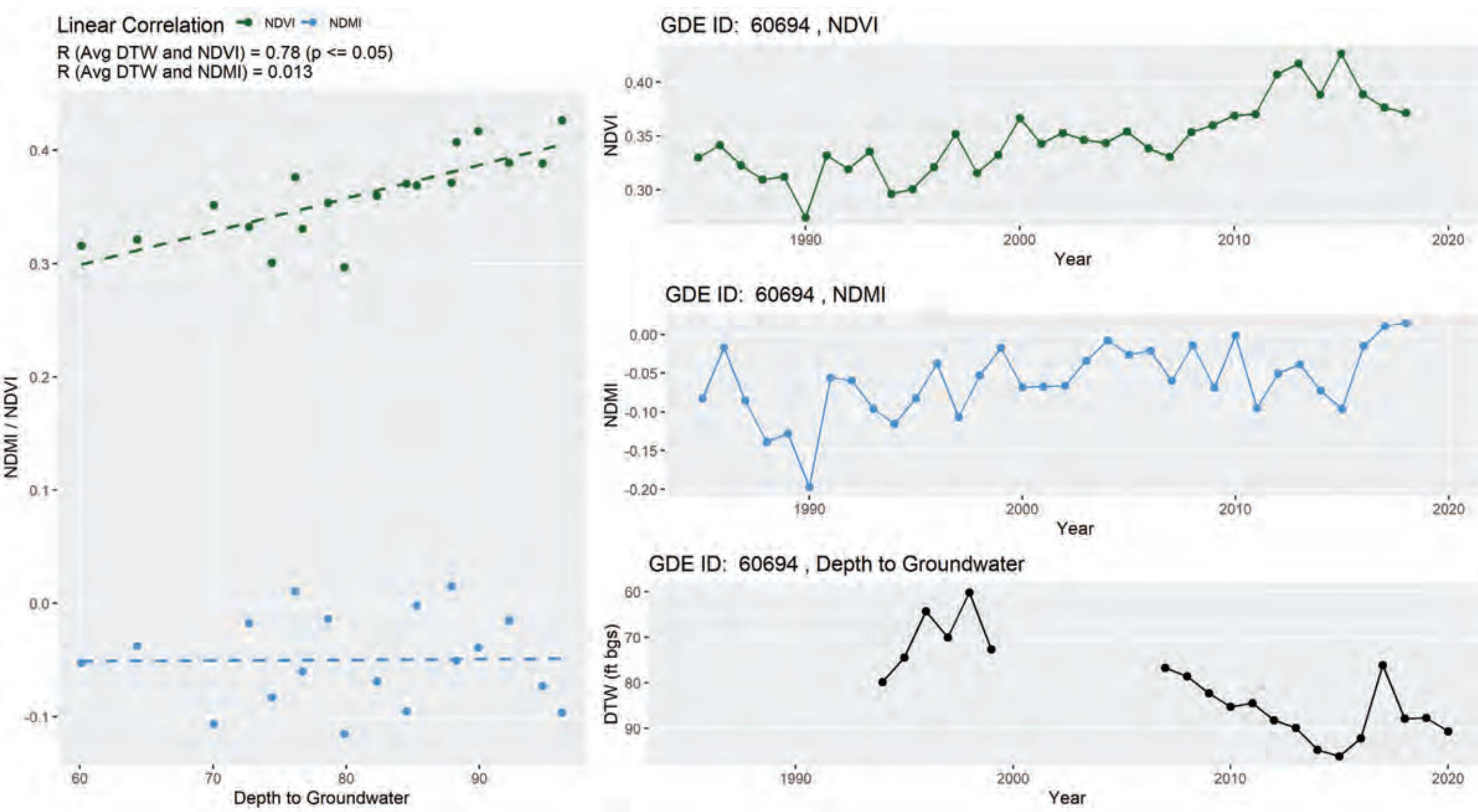


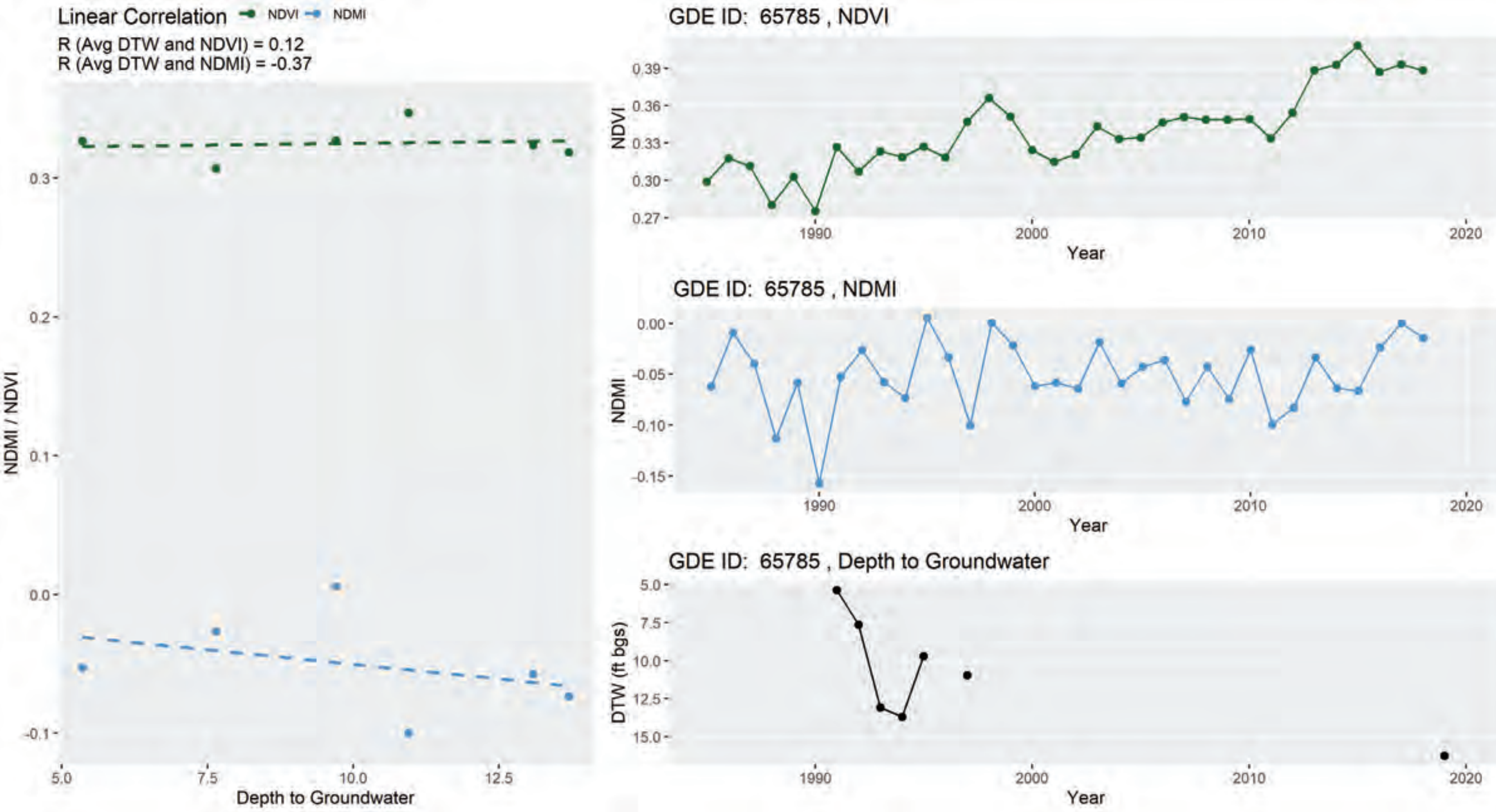
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.38 (p <= 0.05)
R (Avg DTW and NDMI) = -0.39 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 40040 , NDVI
NDVI
Year
GDE ID: 40040 , NDMI
NDMI
Year
GDE ID: 40040 , Depth to Groundwater
DTW (ft bgs)
Year

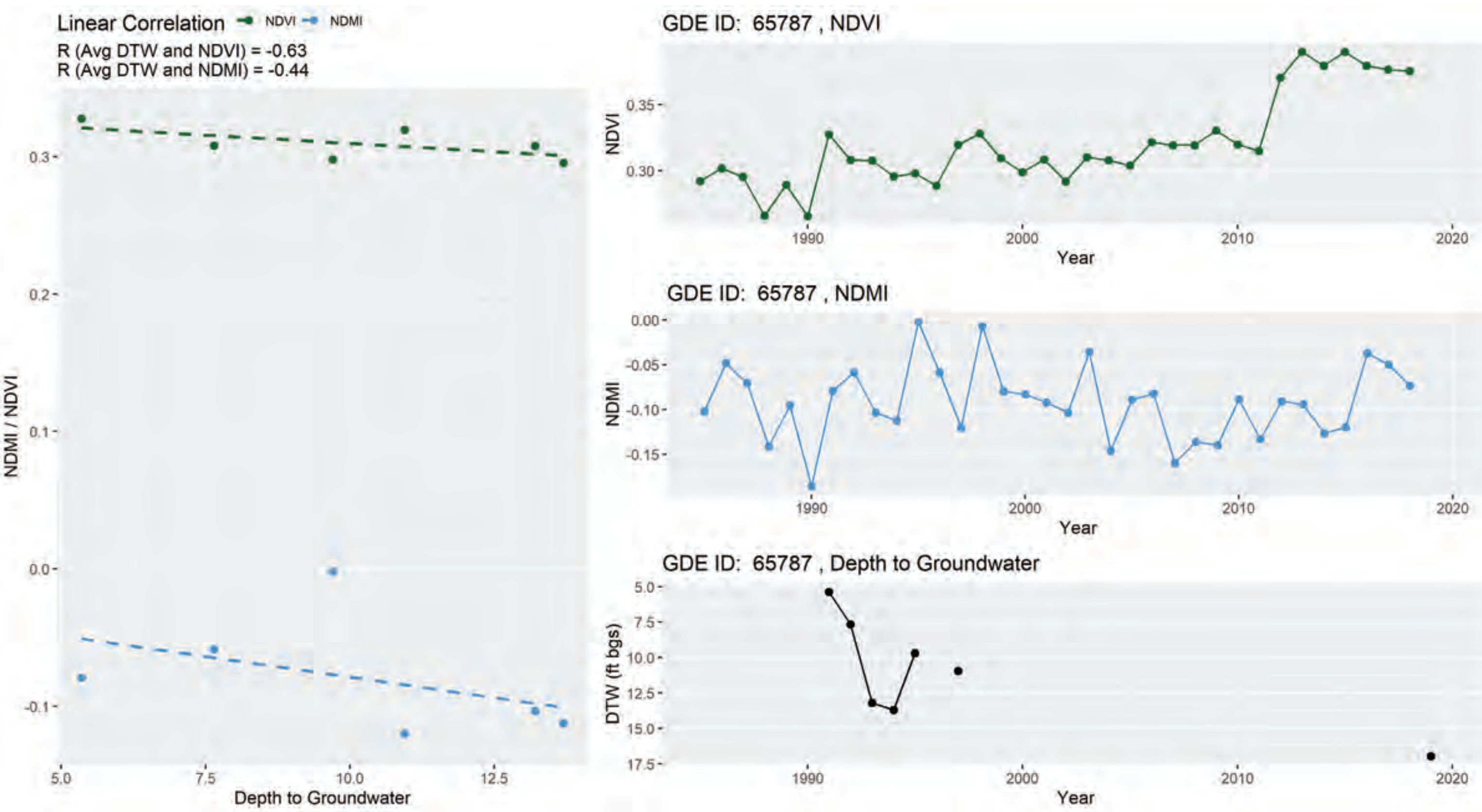


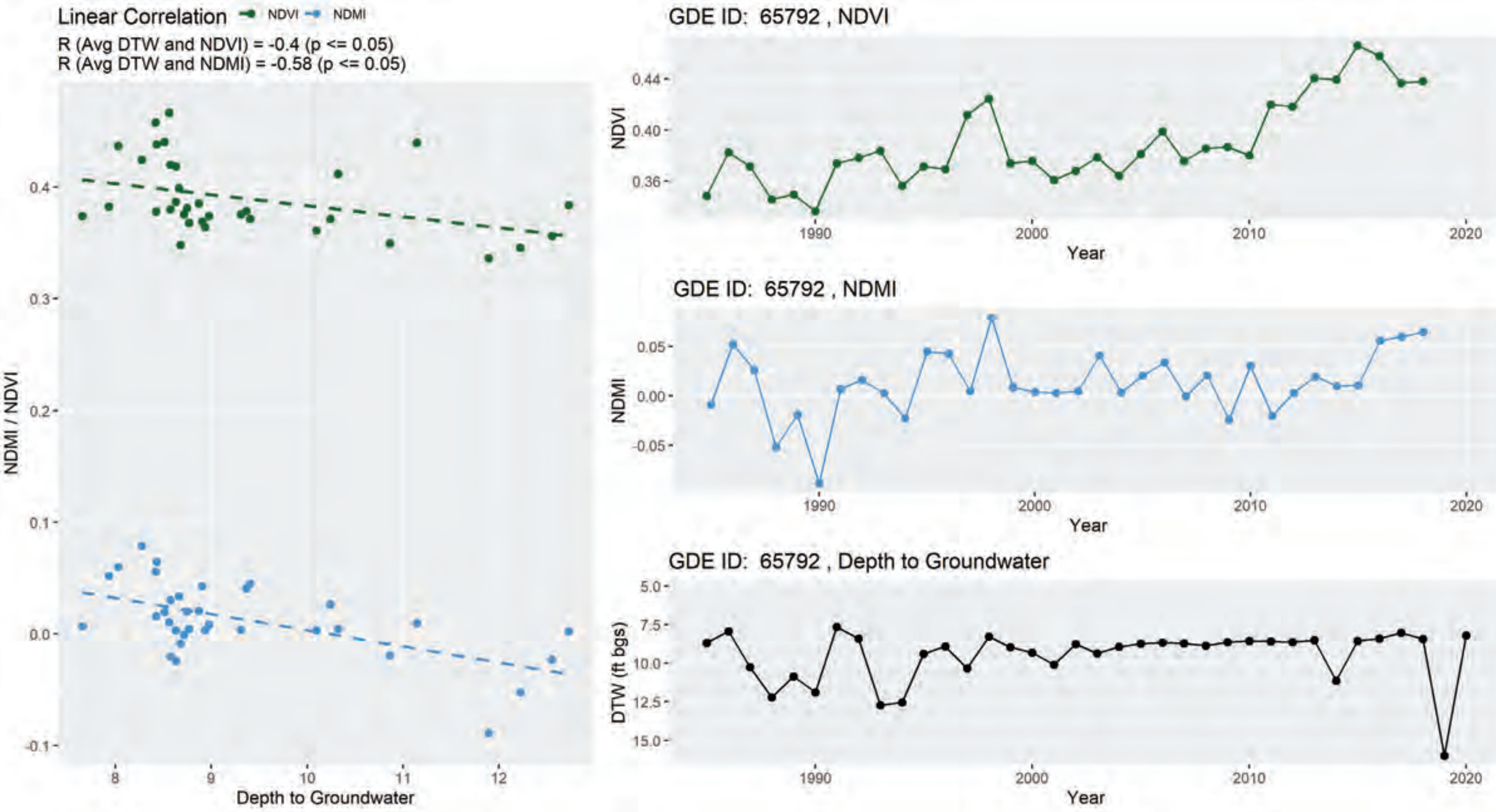
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.66 (p <= 0.05)
R (Avg DTW and NDMI) = -0.18
NDMI / NDVI
Depth to Groundwater
GDE ID: 60687 , NDVI
NDVI
Year
GDE ID: 60687 , NDMI
NDMI
Year
GDE ID: 60687 , Depth to Groundwater
DTW (ft bgs)
Year

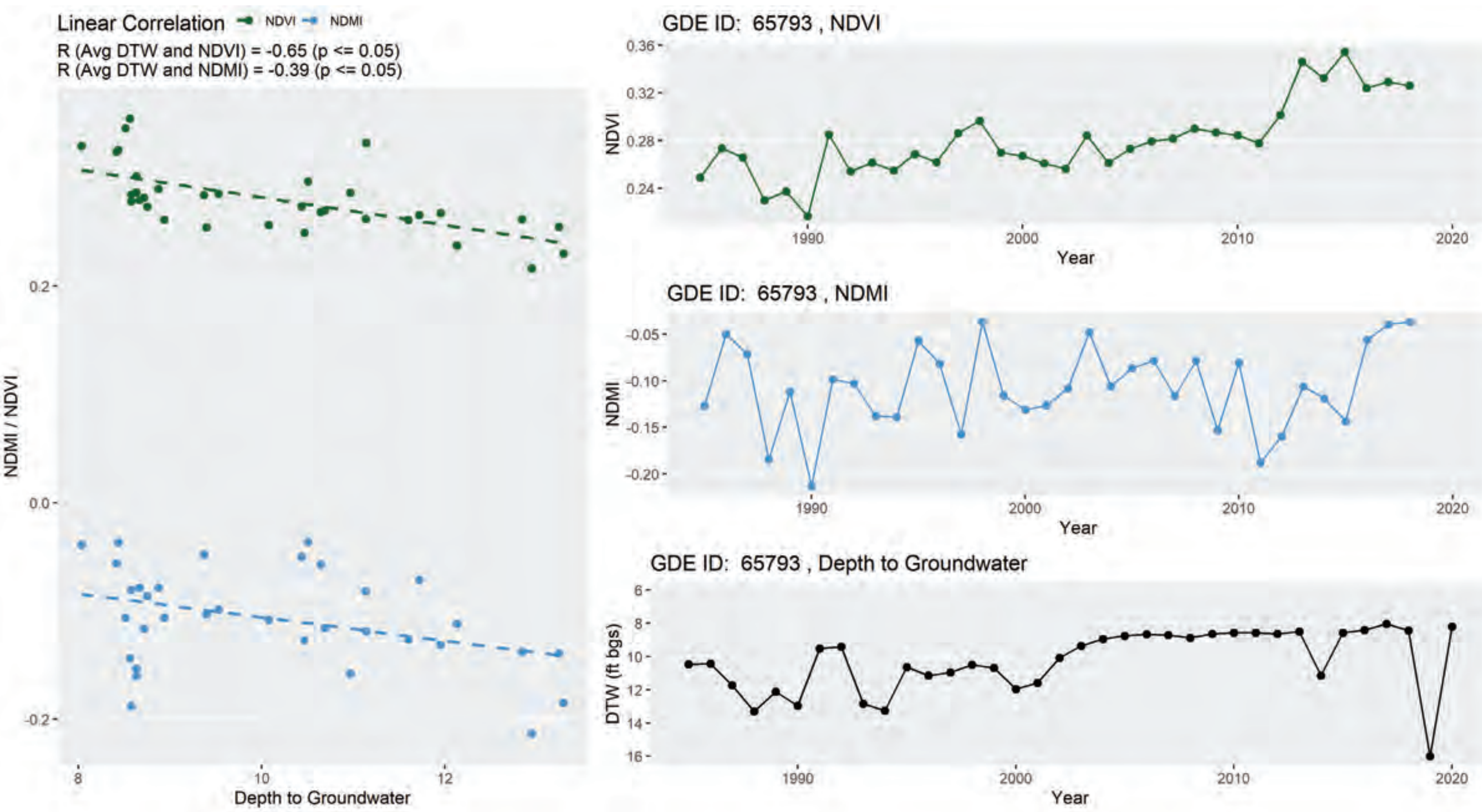

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.71 (p <= 0.05)
R (Avg DTW and NDMI) = -0.1
NDMI / NDVI
Depth to Groundwater
GDE ID: 60692 , NDVI
NDVI
Year
GDE ID: 60692 , NDMI
NDMI
Year
GDE ID: 60692 , Depth to Groundwater
DTW (ft bgs)
Year

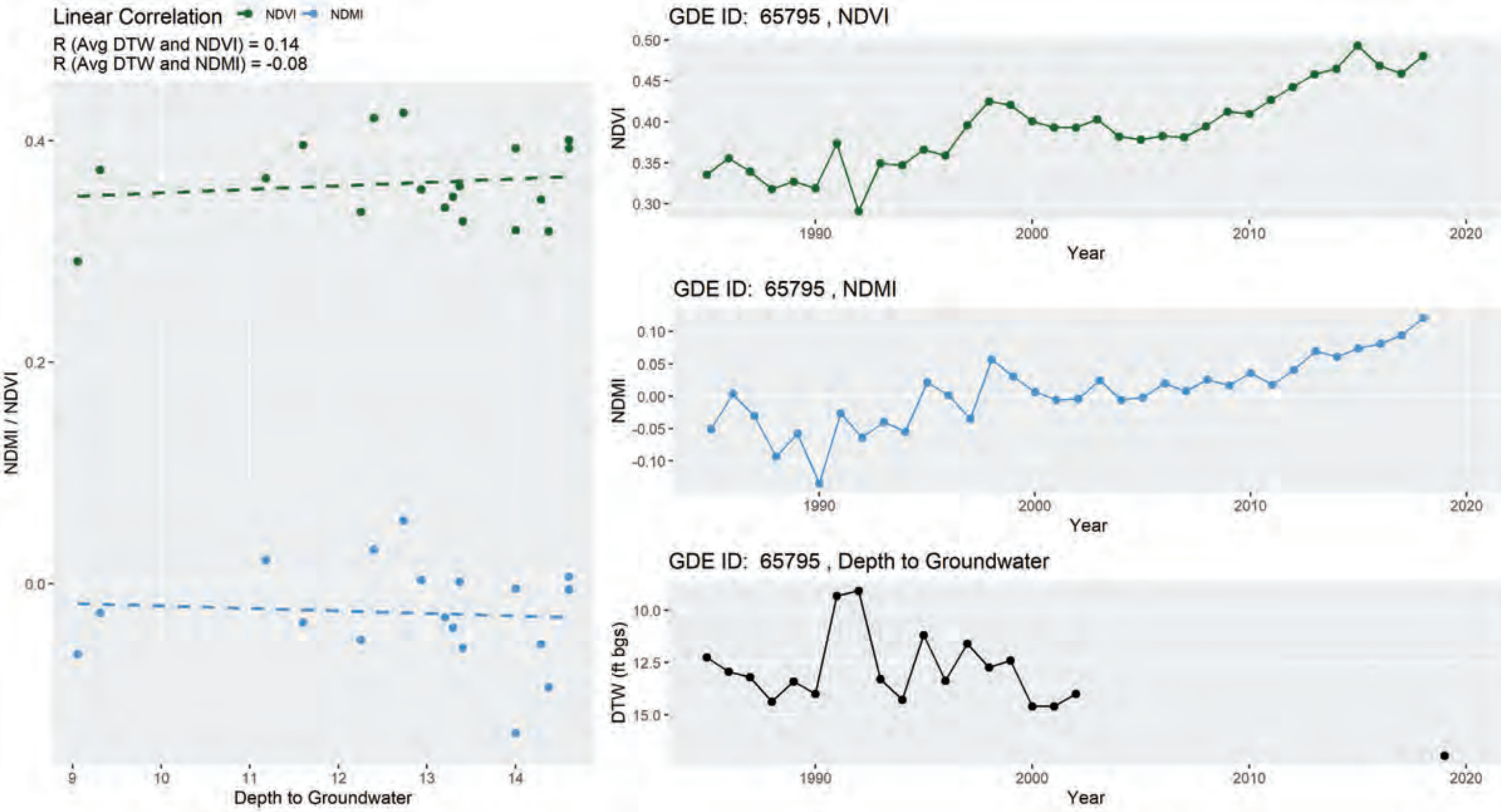

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.78 (p <= 0.05)
R (Avg DTW and NDMI) = 0.013
NDMI / NDVI
Depth to Groundwater
GDE ID: 60694 , NDVI
NDVI
Year
GDE ID: 60694 , NDMI
NDMI
Year
GDE ID: 60694 , Depth to Groundwater
DTW (ft bgs)
Year

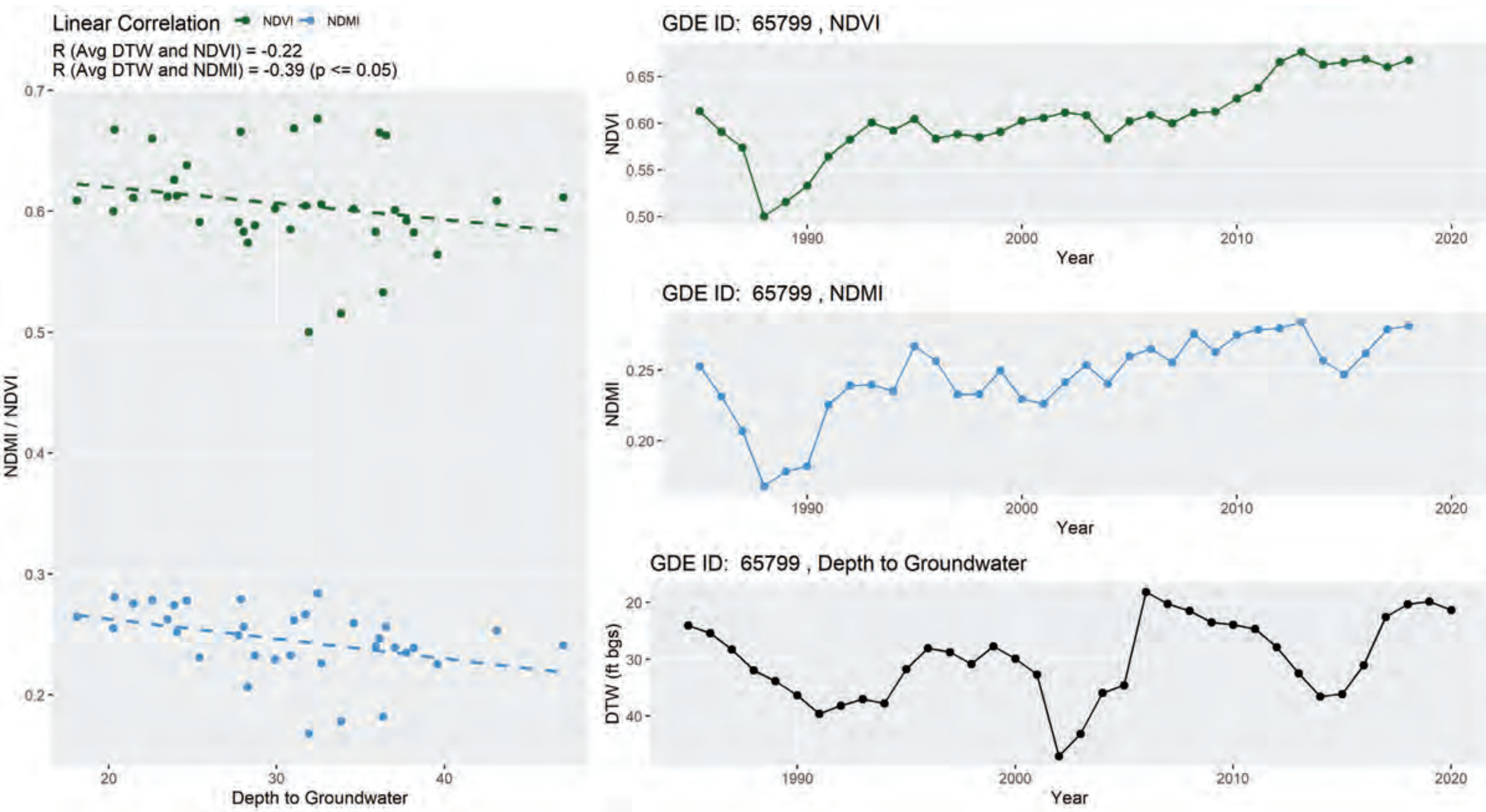

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.12
R (Avg DTW and NDMI) = -0.37
NDMI / NDVI
Depth to Groundwater
GDE ID: 65785 , NDVI
NDVI
Year
GDE ID: 65785 , NDMI
NDMI
Year
GDE ID: 65785 , Depth to Groundwater
DTW (ft bgs)
Year

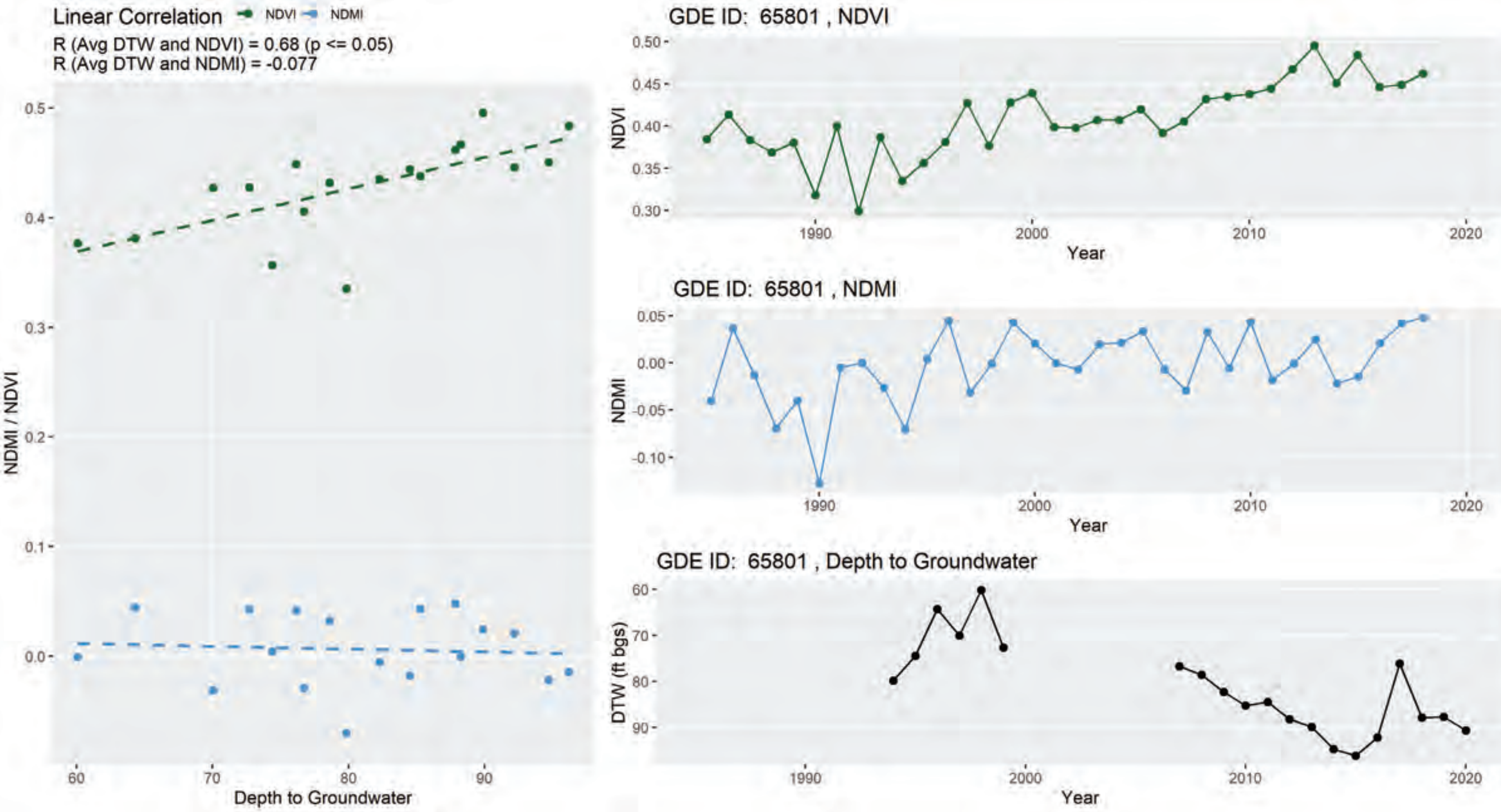

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.63
R (Avg DTW and NDMI) = -0.44
NDMI / NDVI
Depth to Groundwater
GDE ID: 65787 , NDVI
NDVI
Year
GDE ID: 65787 , NDMI
NDMI
Year
GDE ID: 65787 , Depth to Groundwater
DTW (ft bgs)
Year

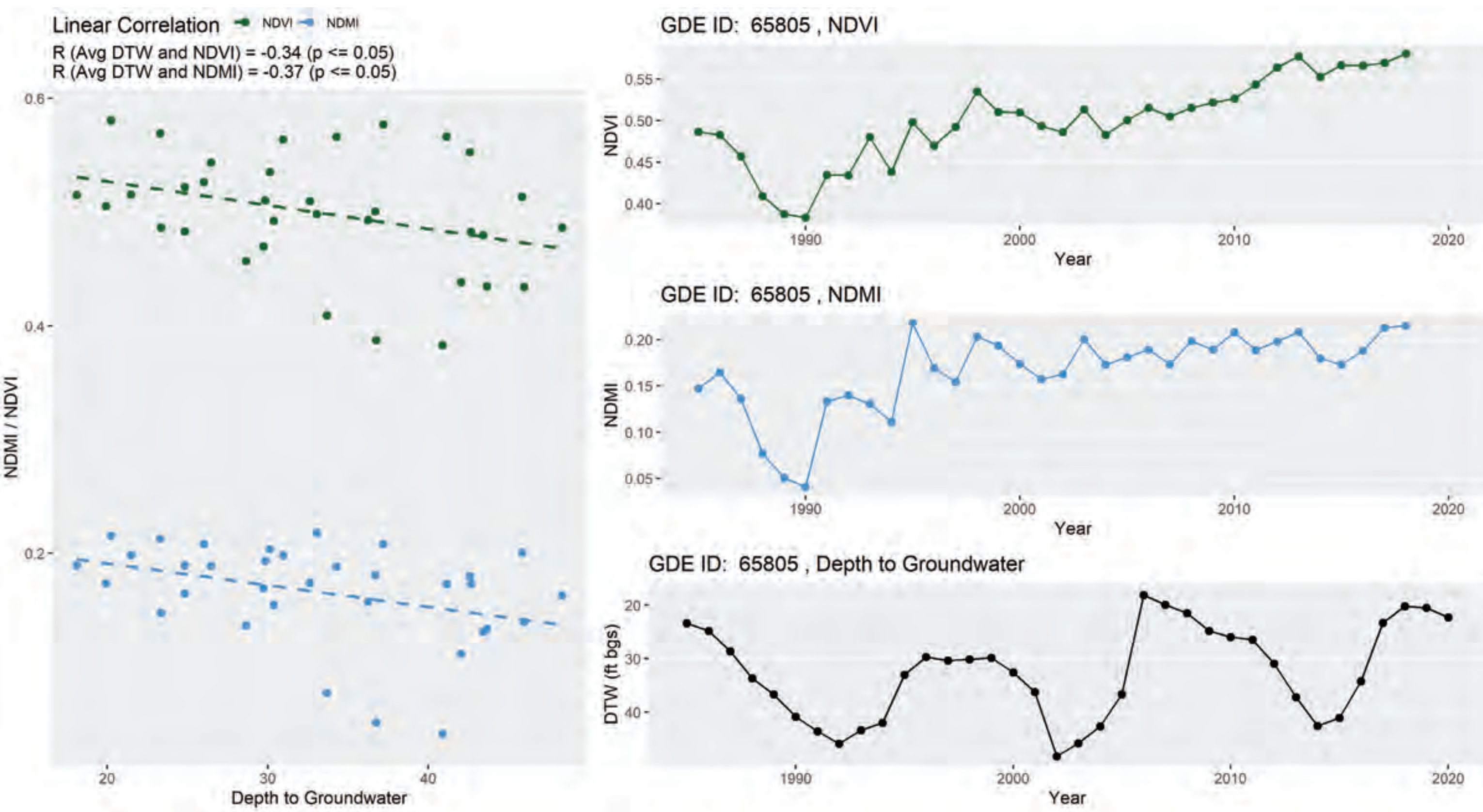

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.4 (p <= 0.05)
R (Avg DTW and NDMI) = -0.58 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65792 , NDVI
NDVI
Year
GDE ID: 65792 , NDMI
NDMI
Year
GDE ID: 65792 , Depth to Groundwater
DTW (ft bgs)
Year

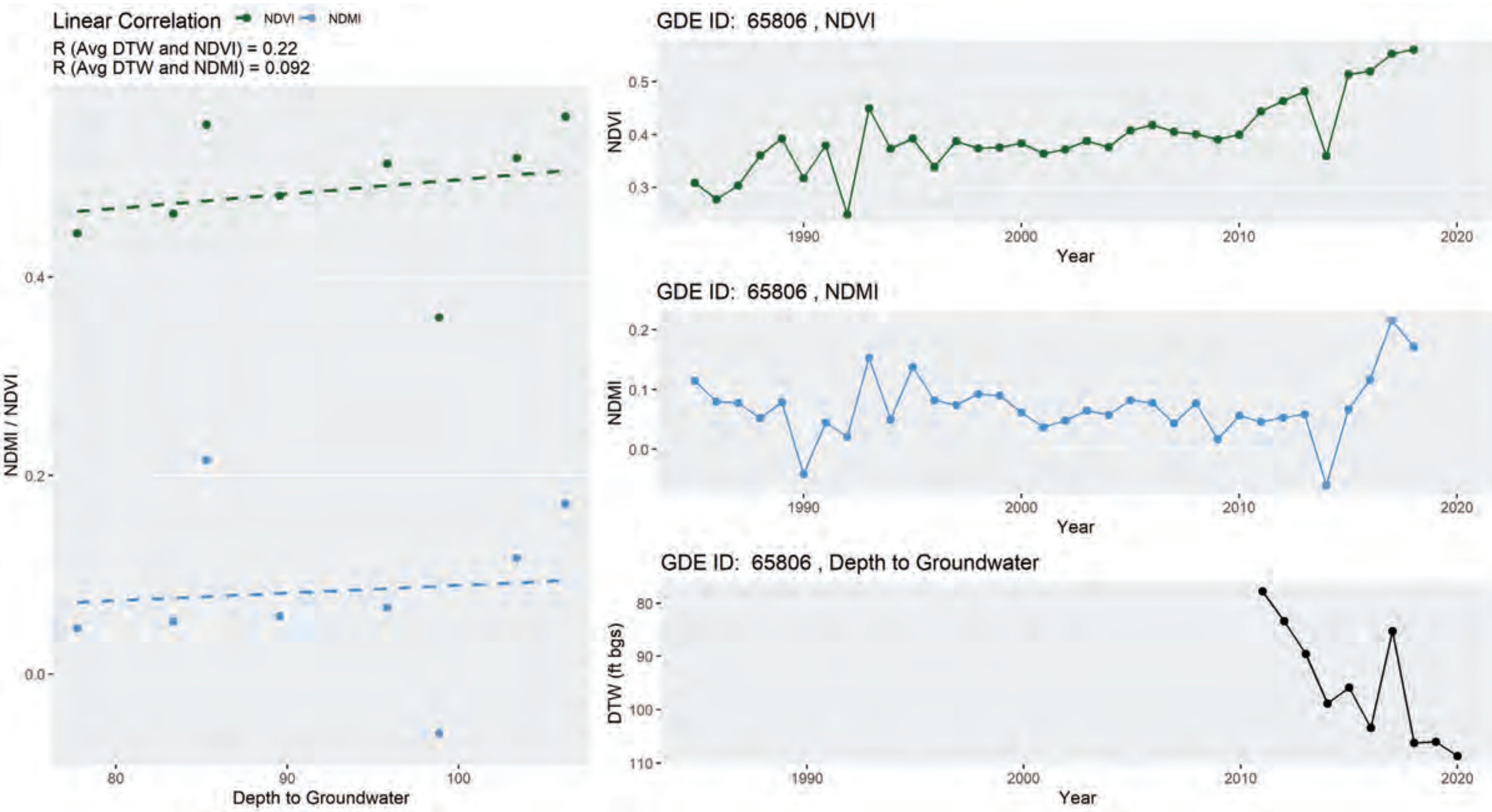

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.65 (p <= 0.05)
R (Avg DTW and NDMI) = -0.39 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65793 , NDVI
NDVI
Year
GDE ID: 65793 , NDMI
NDMI
Year
GDE ID: 65793 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.14
R (Avg DTW and NDMI) = -0.08
NDMI / NDVI
Depth to Groundwater
GDE ID: 65795 , NDVI
NDVI
Year
GDE ID: 65795 , NDMI
NDMI
Year
GDE ID: 65795 , Depth to Groundwater
DTW (ft bgs)
Year

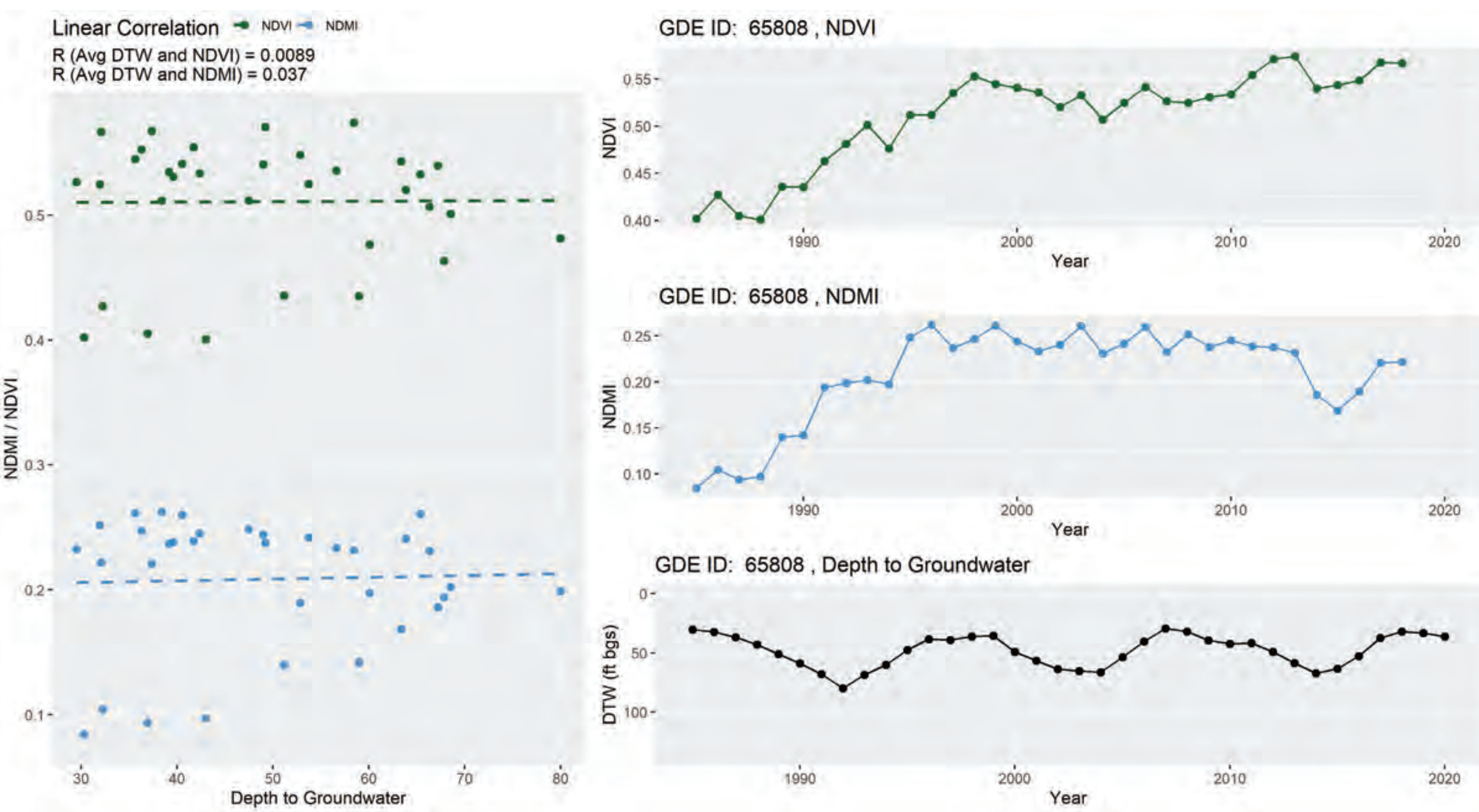

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.22
R (Avg DTW and NDMI) = -0.39 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65799 , NDVI
NDVI
Year
GDE ID: 65799 , NDMI
NDMI
Year
GDE ID: 65799 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.68 (p <= 0.05)
R (Avg DTW and NDMI) = -0.077
NDMI / NDVI
Depth to Groundwater
GDE ID: 65801 , NDVI
NDVI
Year
GDE ID: 65801 , NDMI
NDMI
Year
GDE ID: 65801 , Depth to Groundwater
DTW (ft bgs)
Year

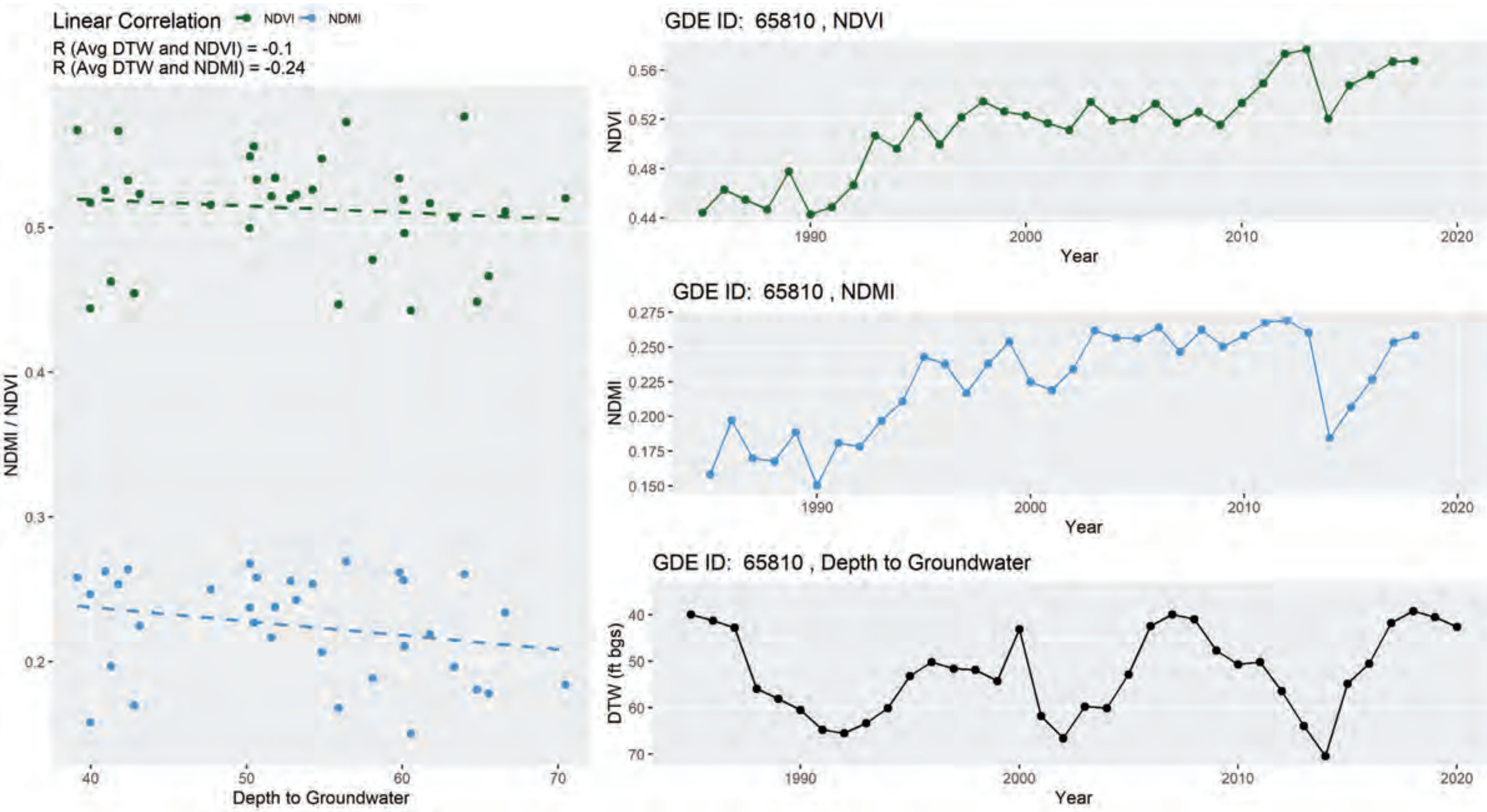

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.34 (p <= 0.05)
R (Avg DTW and NDMI) = -0.37 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65805 , NDVI
NDVI
Year
GDE ID: 65805 , NDMI
NDMI
Year
GDE ID: 65805 , Depth to Groundwater
DTW (ft bgs)
Year



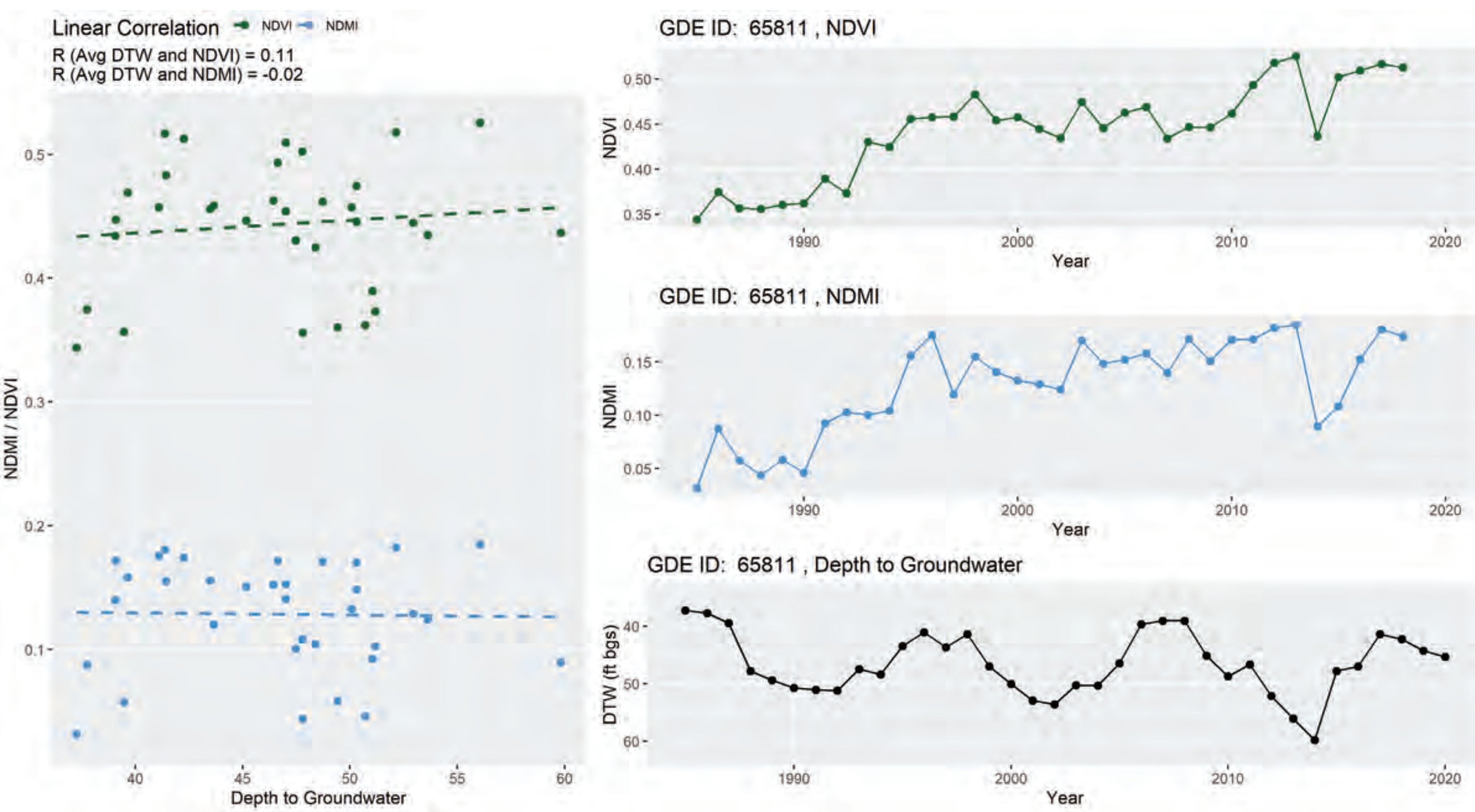
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.22
R (Avg DTW and NDMI) = 0.092
NDMI / NDVI
Depth to Groundwater
GDE ID: 65806 , NDVI
NDVI
Year
GDE ID: 65806 , NDMI
NDMI
Year
GDE ID: 65806 , Depth to Groundwater
DTW (ft bgs)
Year



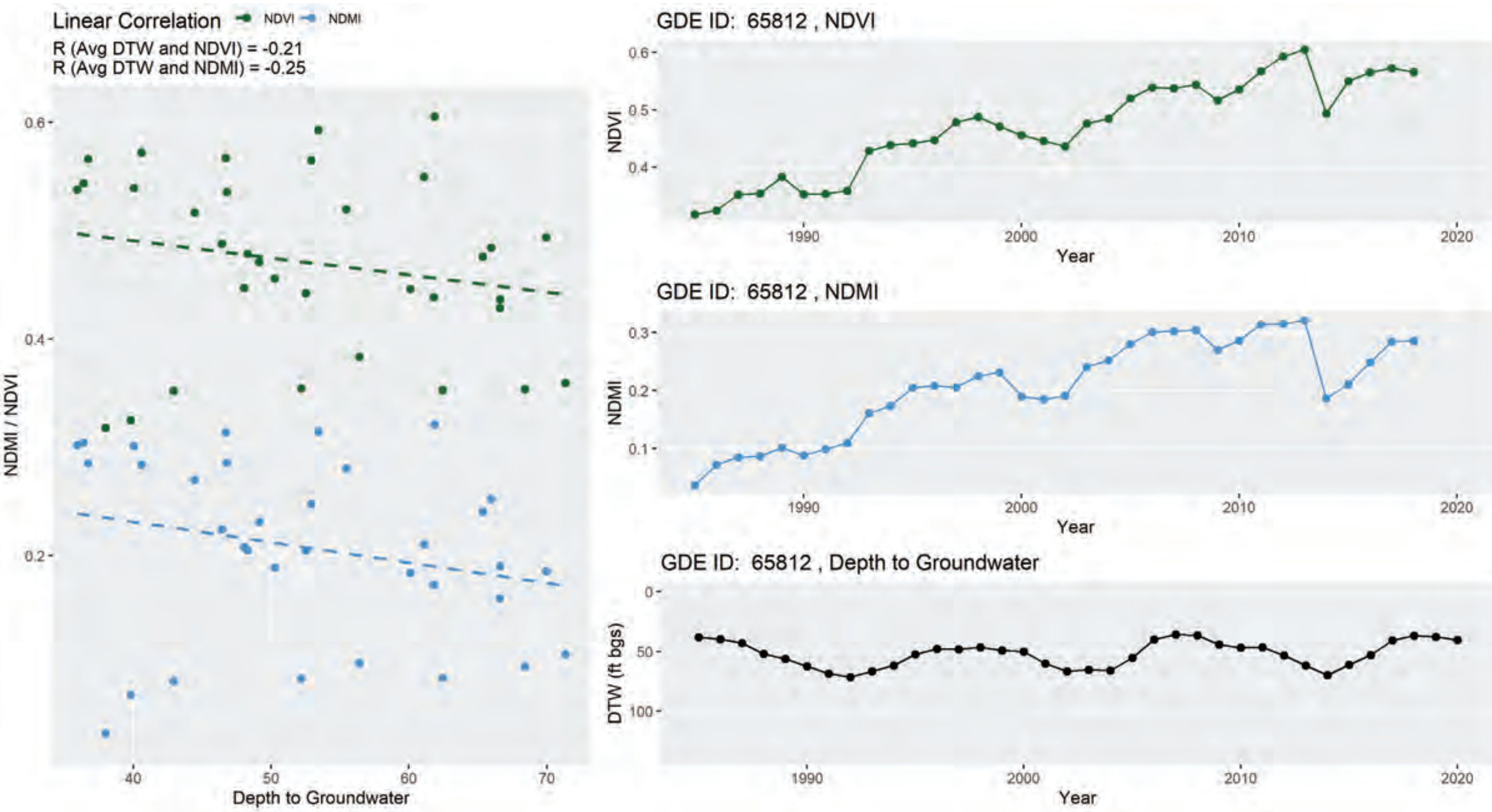
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.0089
R (Avg DTW and NDMI) = 0.037
NDMI / NDVI
Depth to Groundwater
GDE ID: 65808 , NDVI
NDVI
Year
GDE ID: 65808 , NDMI
NDMI
Year
GDE ID: 65808 , Depth to Groundwater
DTW (ft bgs)
Year

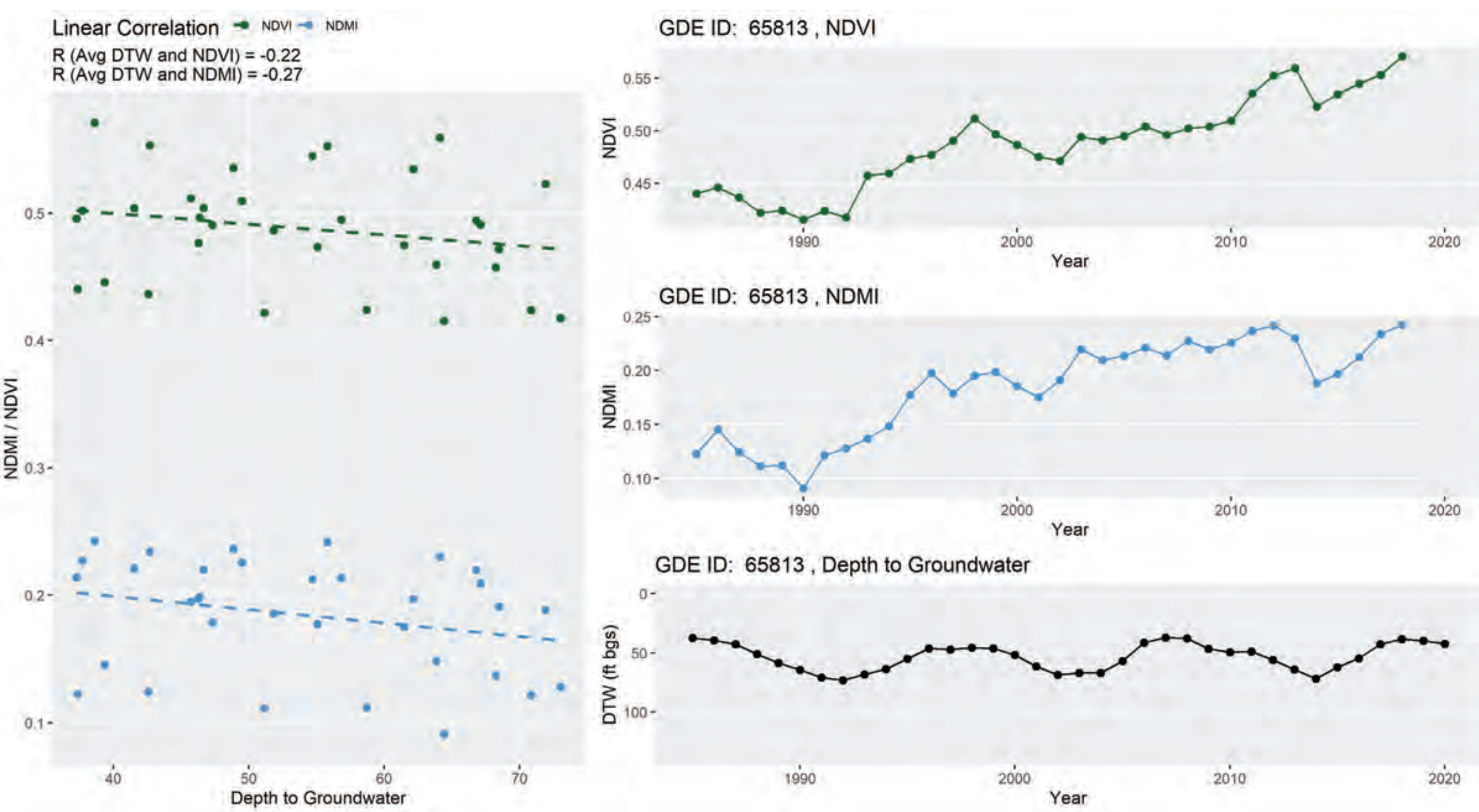


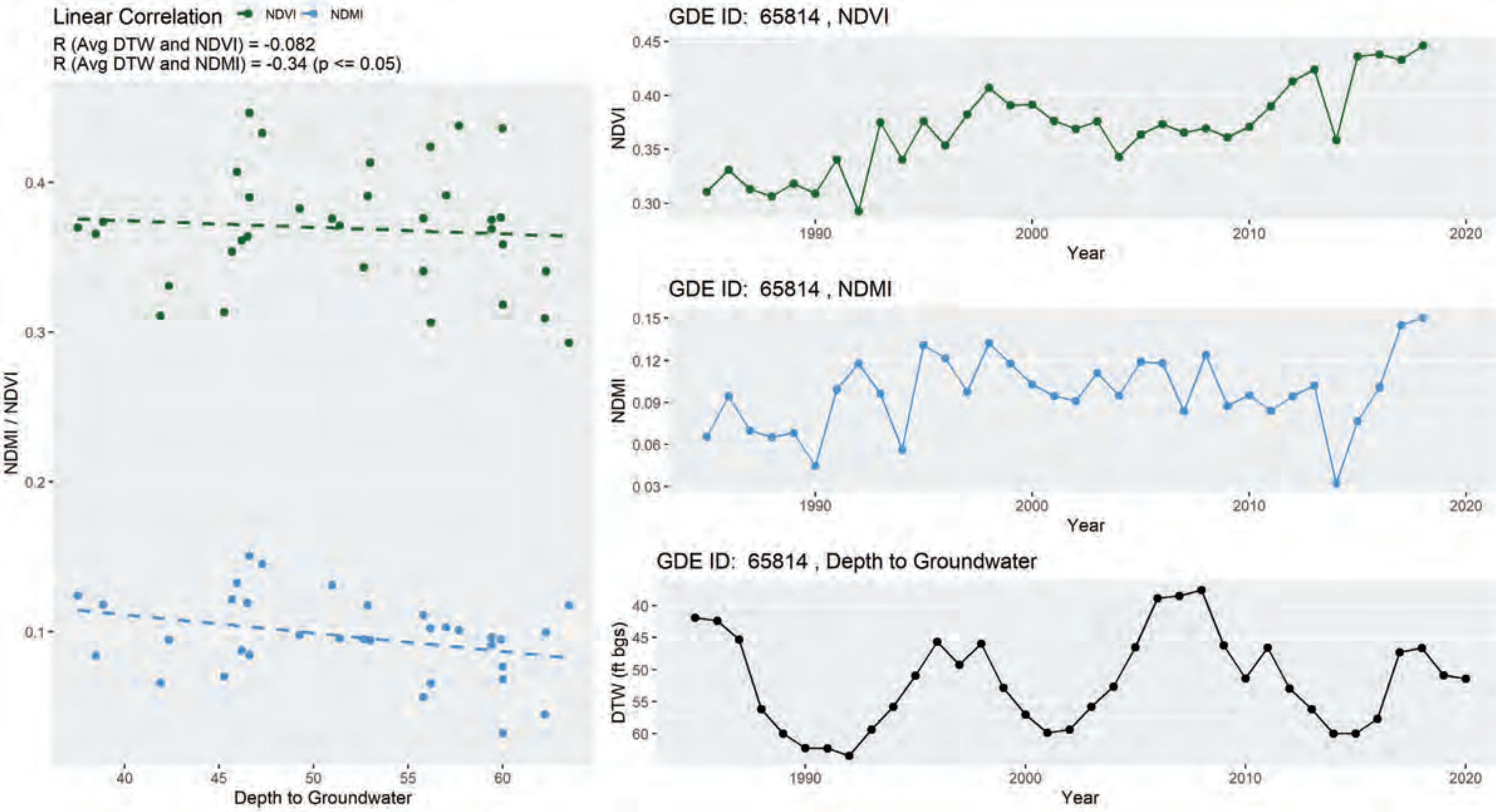
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.1
R (Avg DTW and NDMI) = -0.24
NDMI / NDVI
0.5
0.4
0.3
0.2
40
50
60
70
Depth to Groundwater
GDE ID: 65810 , NDVI
NDVI
0.56
0.52
0.48
0.44
1990
2000
2010
2020
Year
GDE ID: 65810 , NDMI
NDMI
0.275
0.250
0.225
0.200
0.175
0.150
1990
2000
2010
2020
Year
GDE ID: 65810 , Depth to Groundwater
DTW (ft bgs)
40
50
60
70
1990
2000
2010
2020
Year



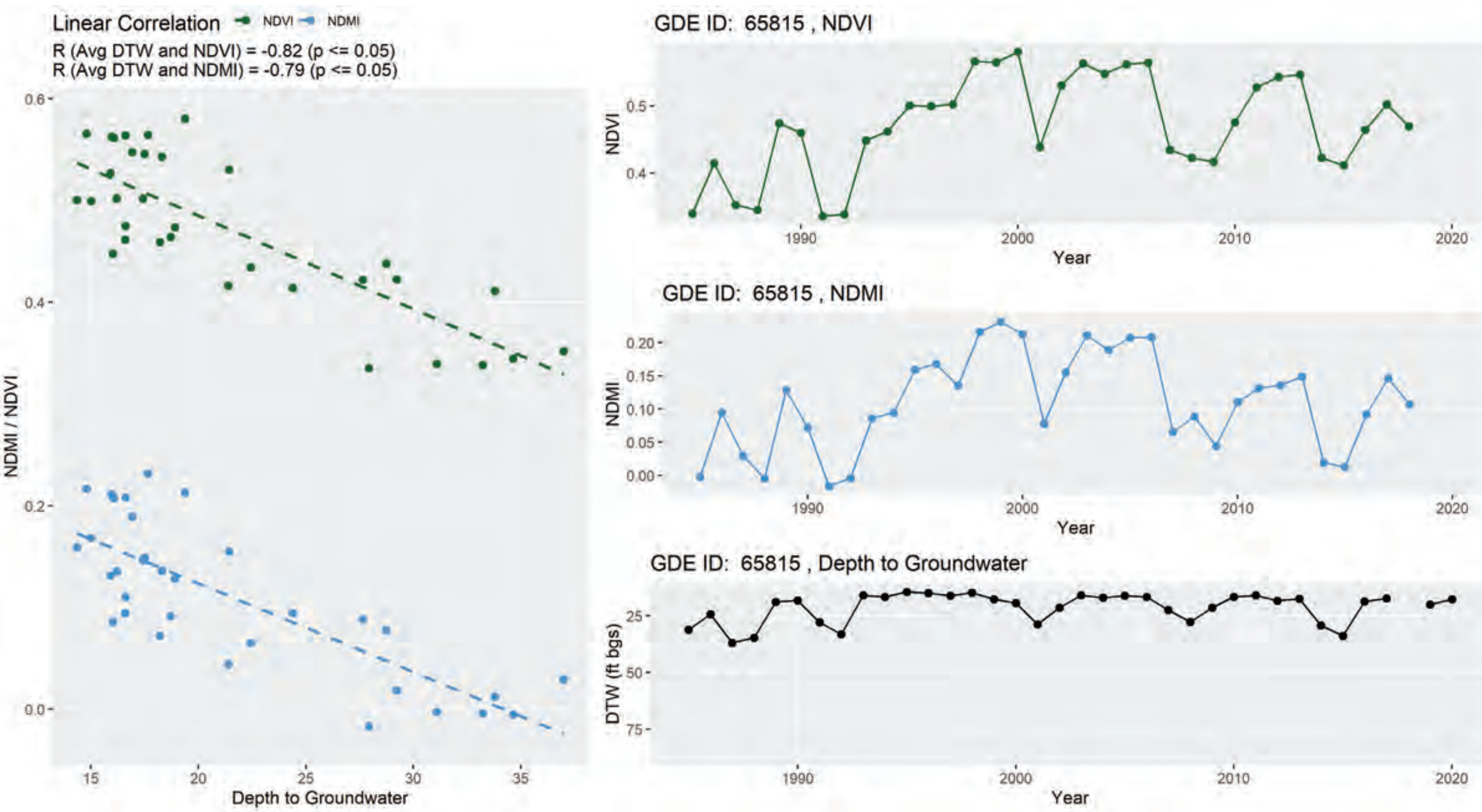
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.11
R (Avg DTW and NDMI) = -0.02
NDMI / NDVI
0.5
0.4
0.3
0.2
0.1
40
45
50
55
60
Depth to Groundwater
GDE ID: 65811 , NDVI
NDVI
0.50
0.45
0.40
0.35
1990
2000
2010
2020
Year
GDE ID: 65811 , NDMI
NDMI
0.15
0.10
0.05
1990
2000
2010
2020
Year
GDE ID: 65811 , Depth to Groundwater
DTW (ft bgs)
40
50
60
1990
2000
2010
2020
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.21
R (Avg DTW and NDMI) = -0.25
NDMI / NDVI
Depth to Groundwater
GDE ID: 65812 , NDVI
NDVI
Year
GDE ID: 65812 , NDMI
NDMI
Year
GDE ID: 65812 , Depth to Groundwater
DTW (ft bgs)
Year

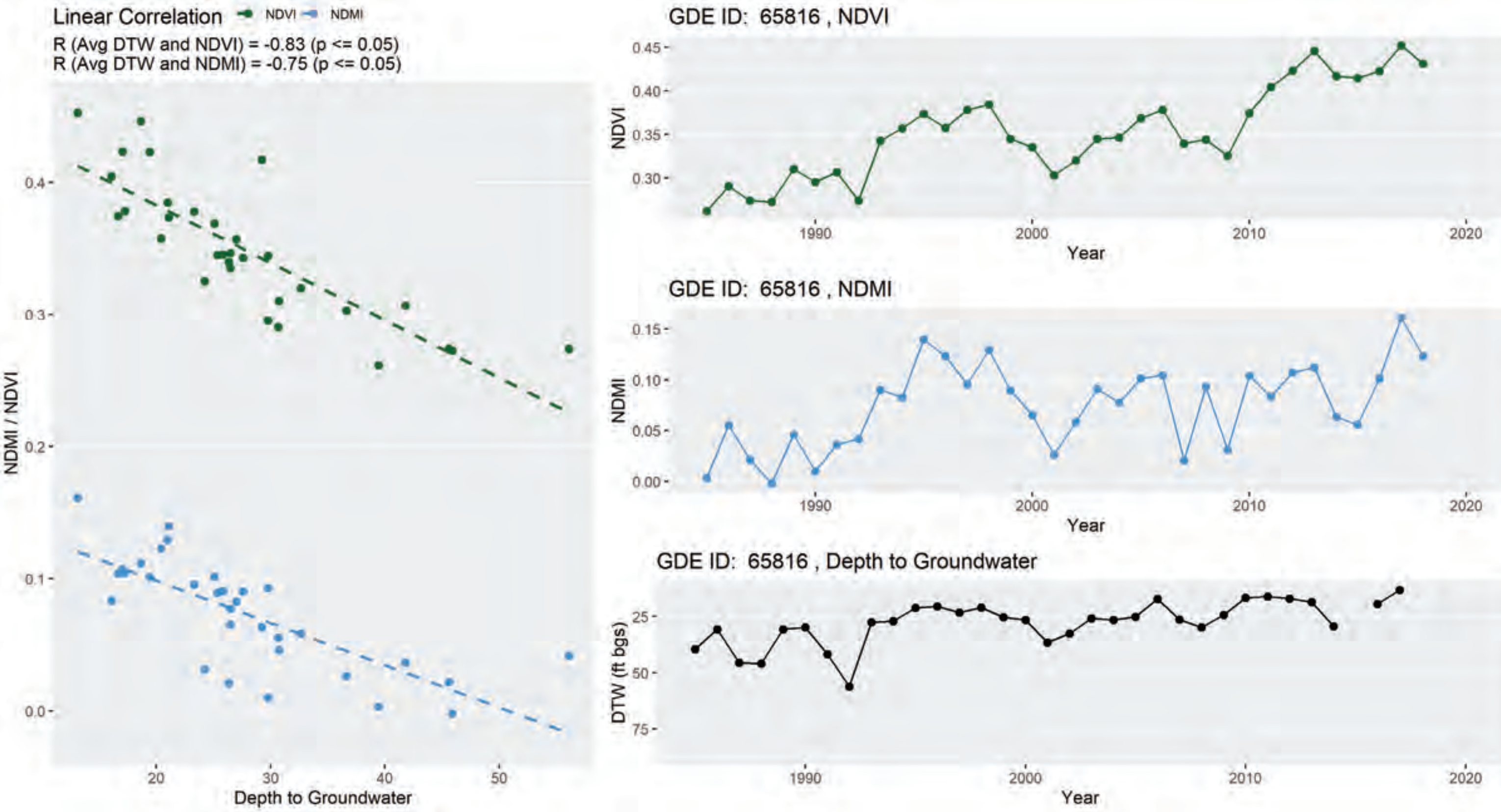

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.22
R (Avg DTW and NDMI) = -0.27
NDMI / NDVI
Depth to Groundwater
GDE ID: 65813 , NDVI
NDVI
Year
GDE ID: 65813 , NDMI
NDMI
Year
GDE ID: 65813 , Depth to Groundwater
DTW (ft bgs)
Year



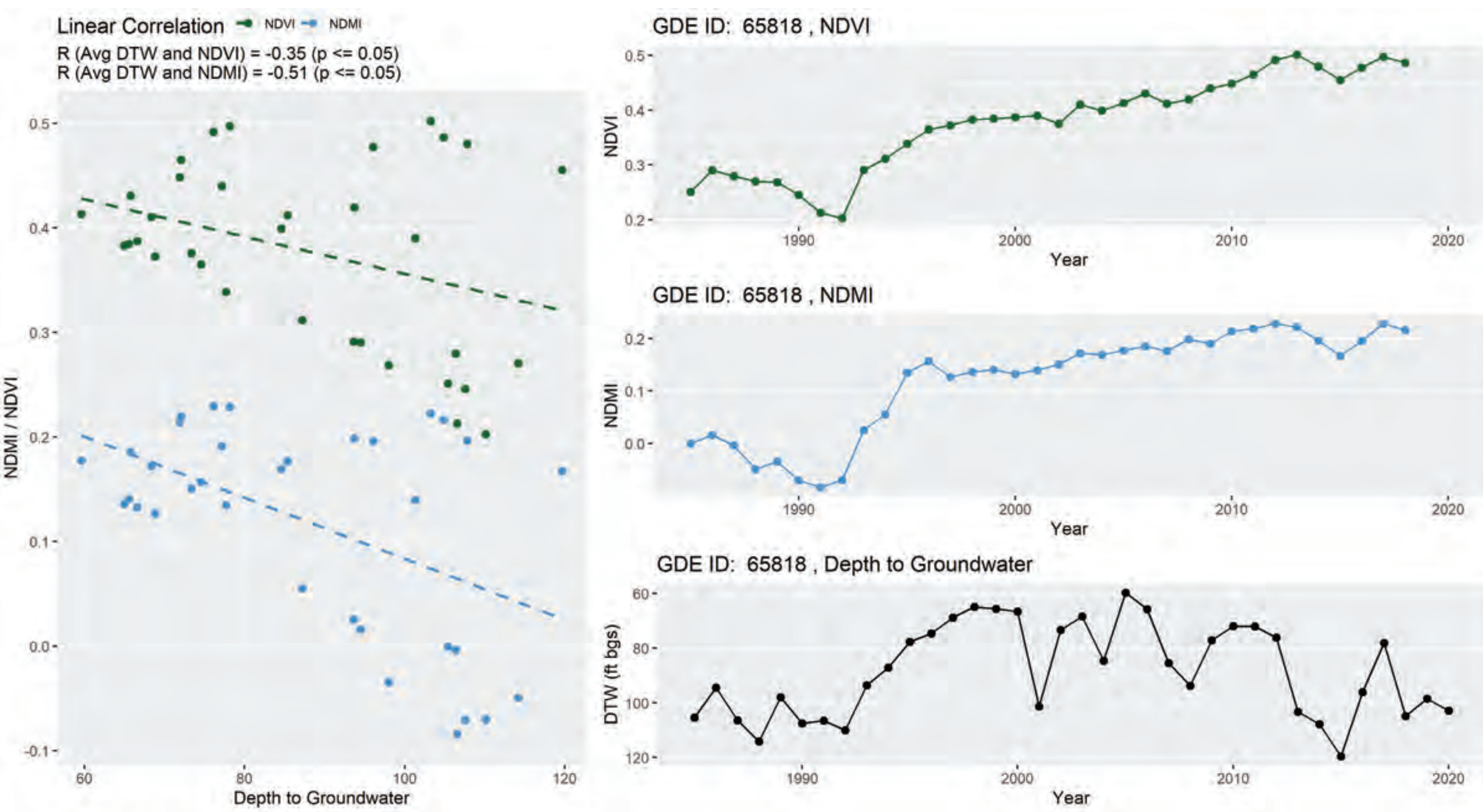
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.082
R (Avg DTW and NDMI) = -0.34 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65814 , NDVI
NDVI
Year
GDE ID: 65814 , NDMI
NDMI
Year
GDE ID: 65814 , Depth to Groundwater
DTW (ft bgs)
Year



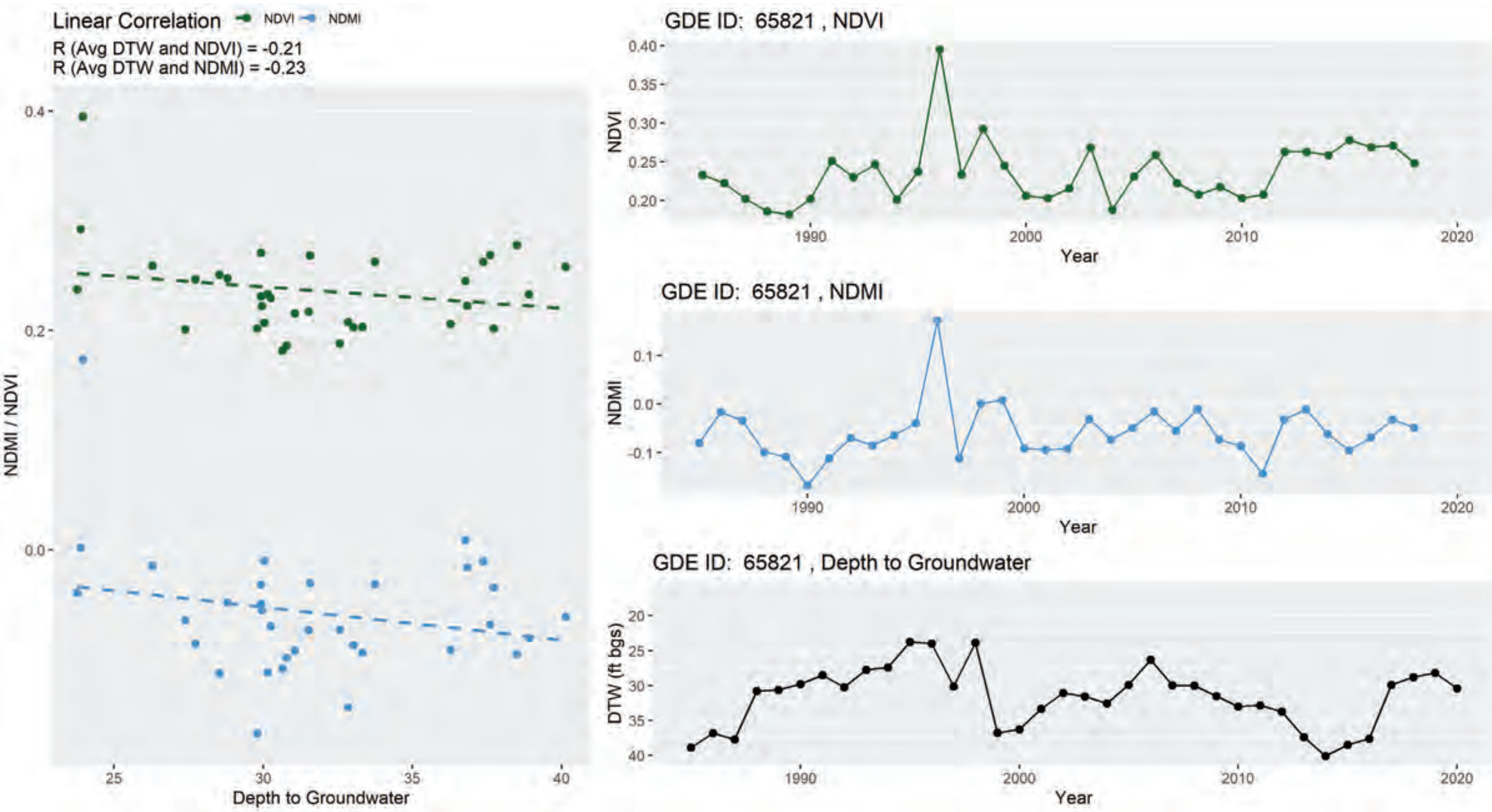
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.82 (p <= 0.05)
R (Avg DTW and NDMI) = -0.79 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65815 , NDVI
NDVI
Year
GDE ID: 65815 , NDMI
NDMI
Year
GDE ID: 65815 , Depth to Groundwater
DTW (ft bgs)
Year

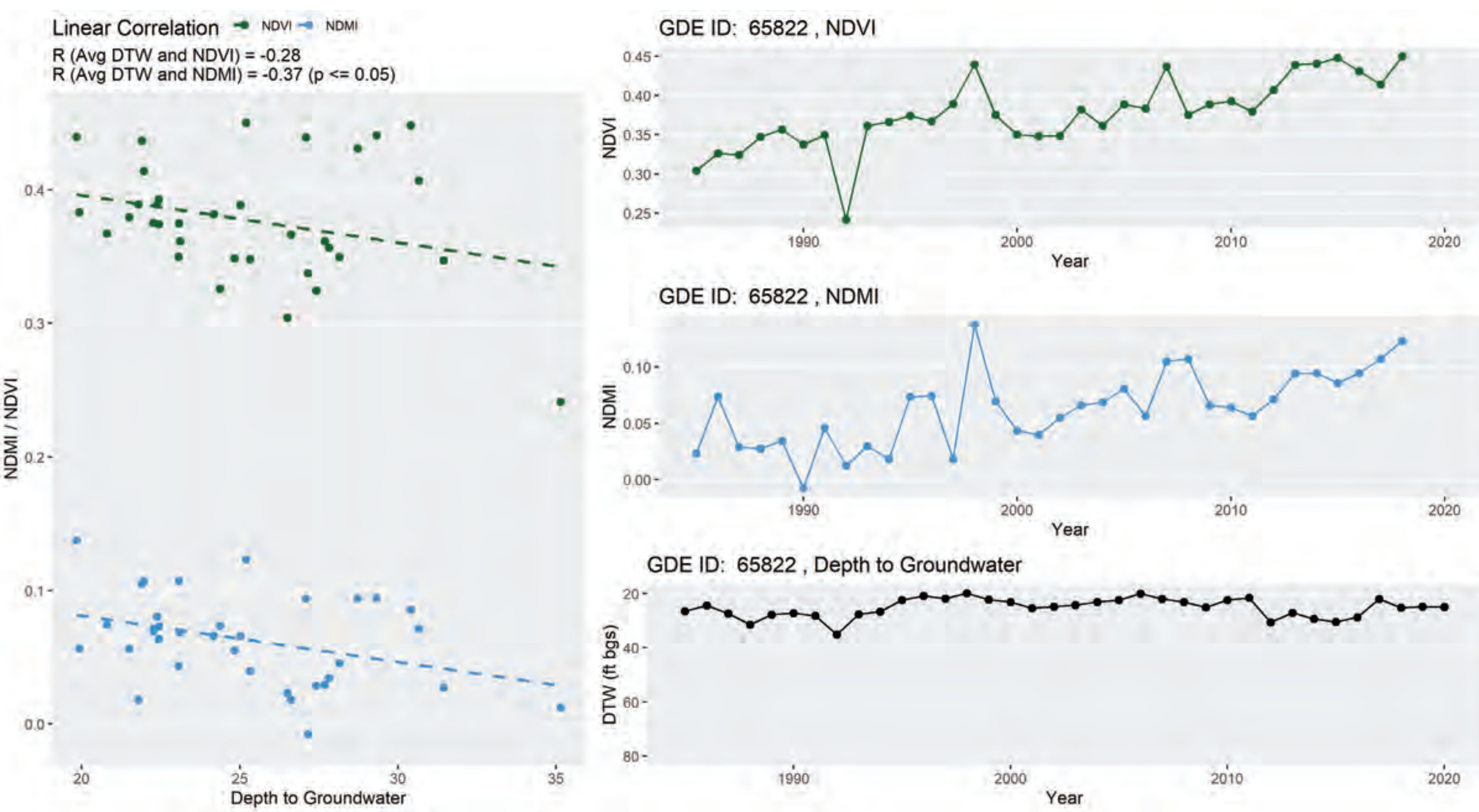


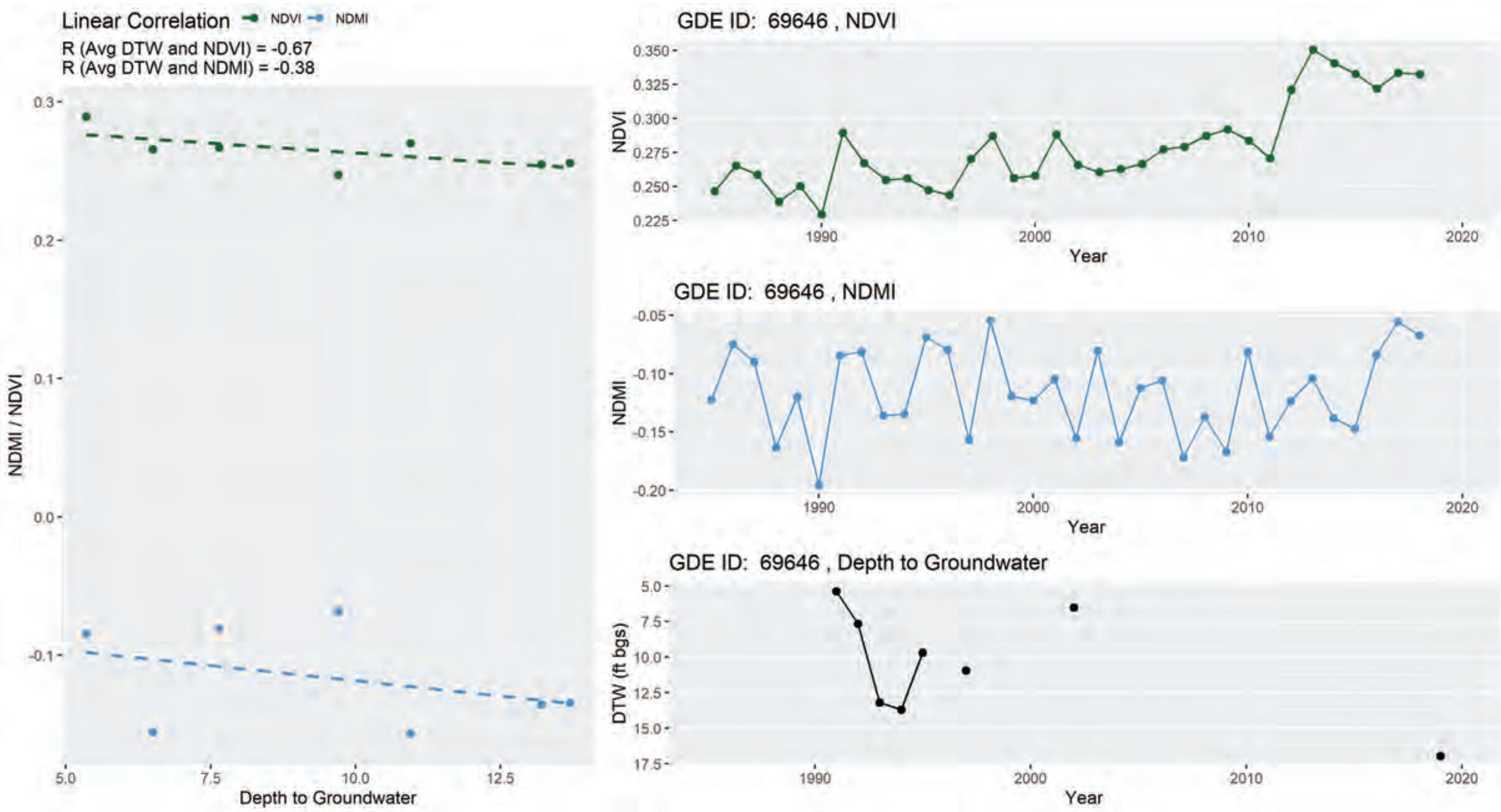
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.83 (p <= 0.05)
R (Avg DTW and NDMI) = -0.75 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65816 , NDVI
NDVI
Year
GDE ID: 65816 , NDMI
NDMI
Year
GDE ID: 65816 , Depth to Groundwater
DTW (ft bgs)
Year

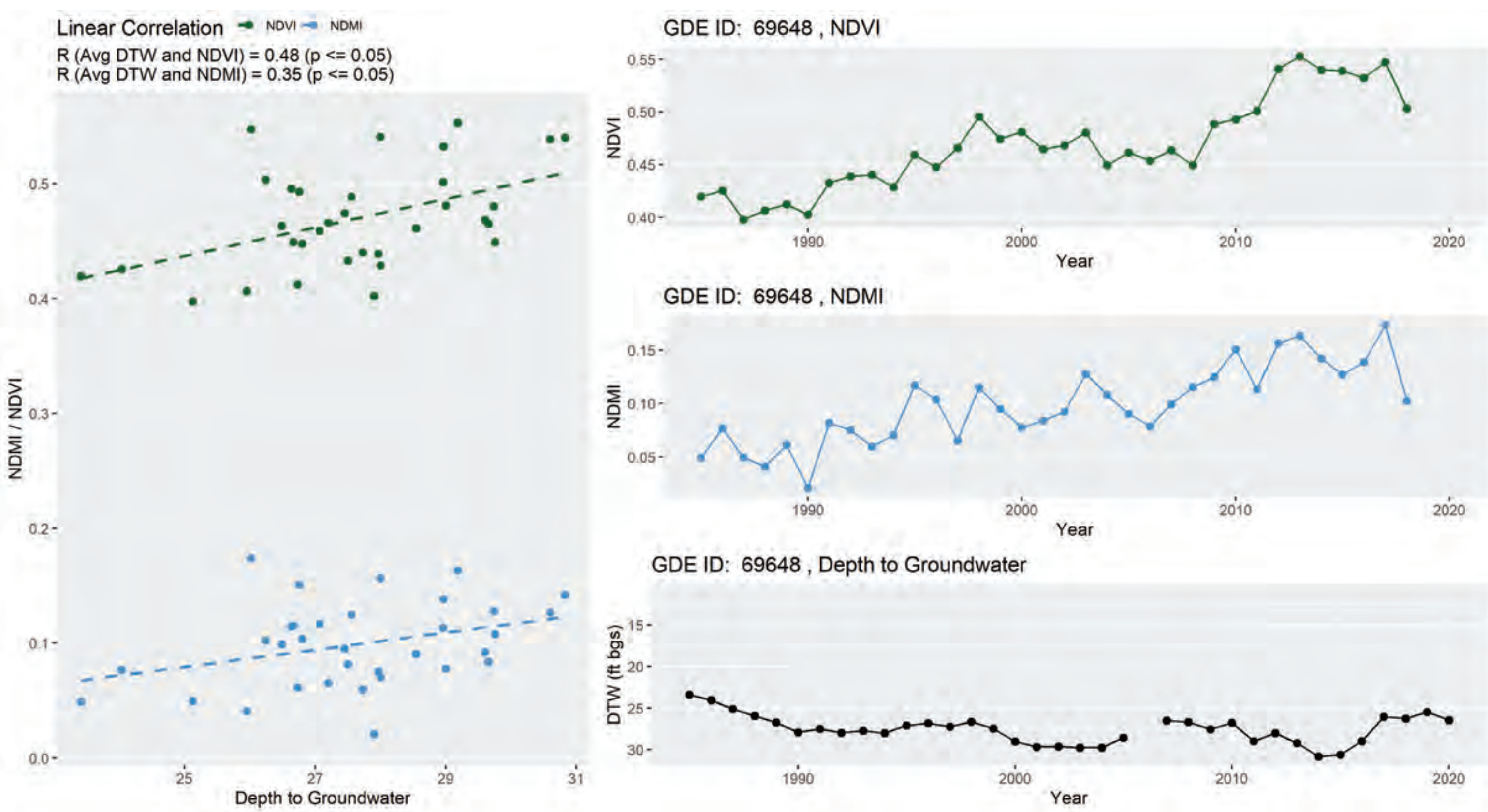


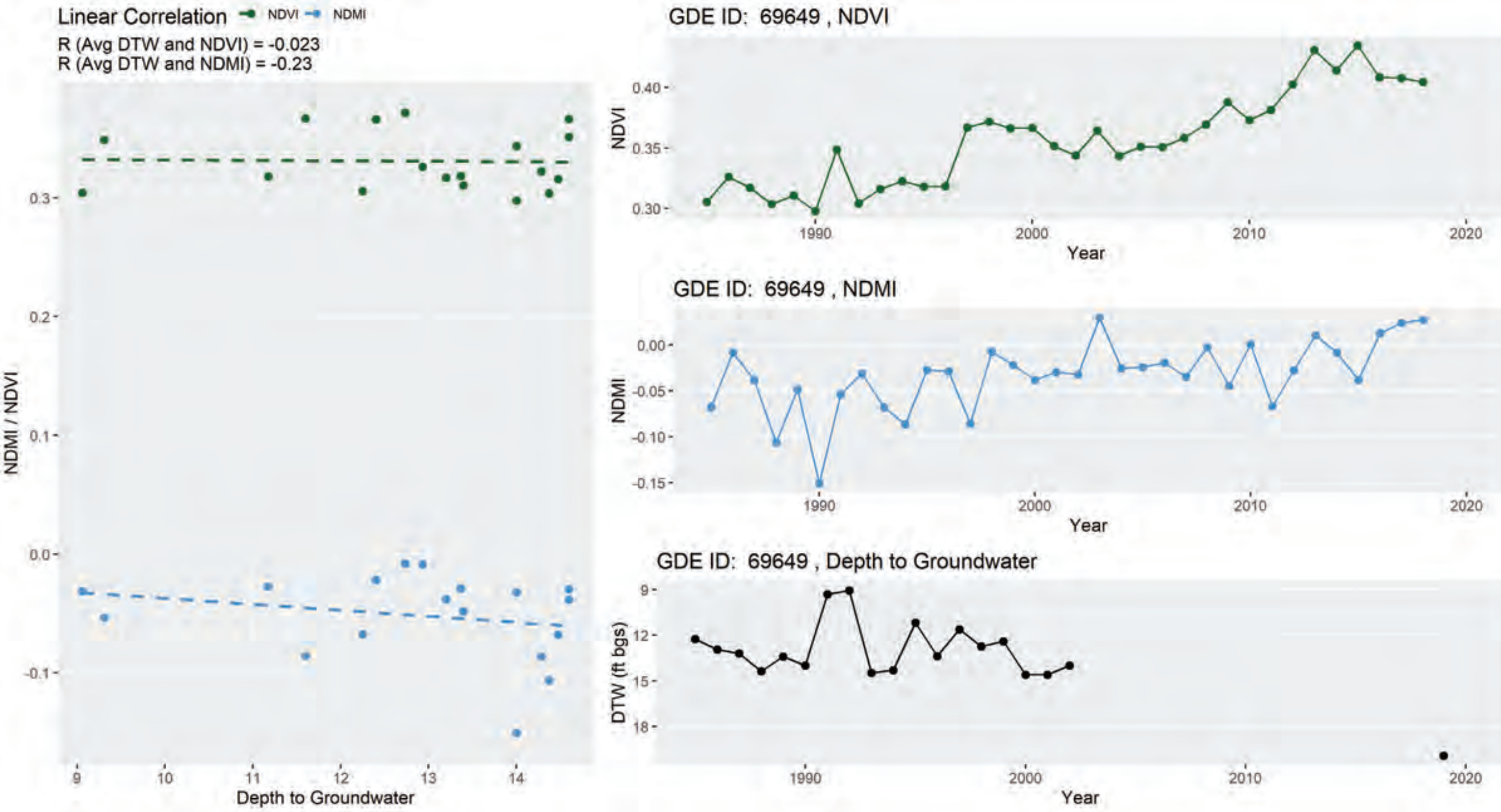
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.35 (p <= 0.05)
R (Avg DTW and NDMI) = -0.51 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65818 , NDVI
NDVI
Year
GDE ID: 65818 , NDMI
NDMI
Year
GDE ID: 65818 , Depth to Groundwater
DTW (ft bgs)
Year

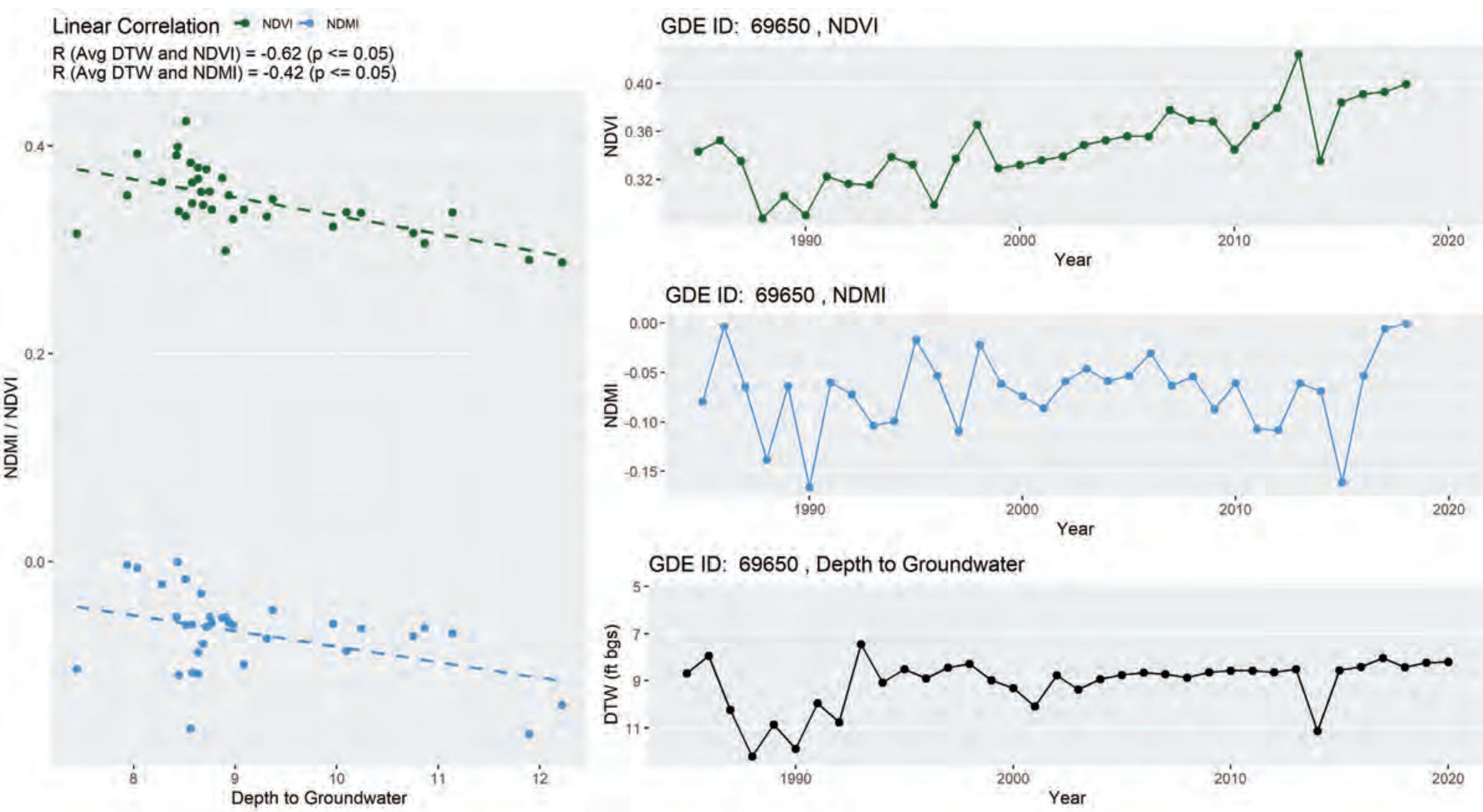

Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = -0.21
R (Avg DTW and NDMI) = -0.23
NDMI / NDVI
Depth to Groundwater
GDE ID: 65821 , NDVI
NDVI
Year
GDE ID: 65821 , NDMI
NDMI
Year
GDE ID: 65821 , Depth to Groundwater
DTW (ft bgs)
Year

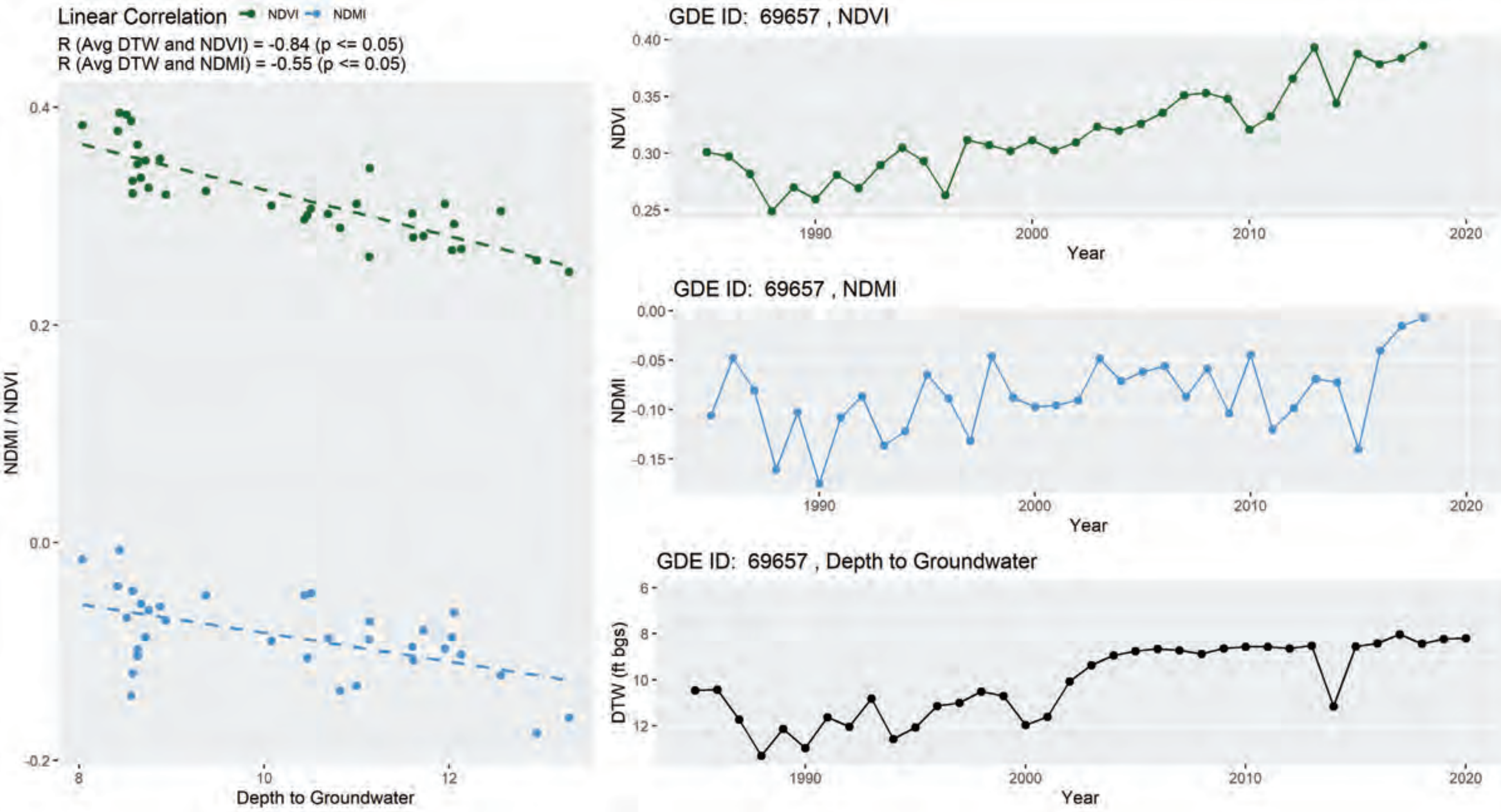

Linear Correlation NDVI NDMI
R (Avg DTW and NDVI) = -0.28
R (Avg DTW and NDMI) = -0.37 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 65822 , NDVI
NDVI
Year
GDE ID: 65822 , NDMI
NDMI
Year
GDE ID: 65822 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.67
R (Avg DTW and NDMI) = -0.38
NDMI / NDVI
Depth to Groundwater
GDE ID: 69646 , NDVI
NDVI
Year
GDE ID: 69646 , NDMI
NDMI
Year
GDE ID: 69646 , Depth to Groundwater
DTW (ft bgs)
Year

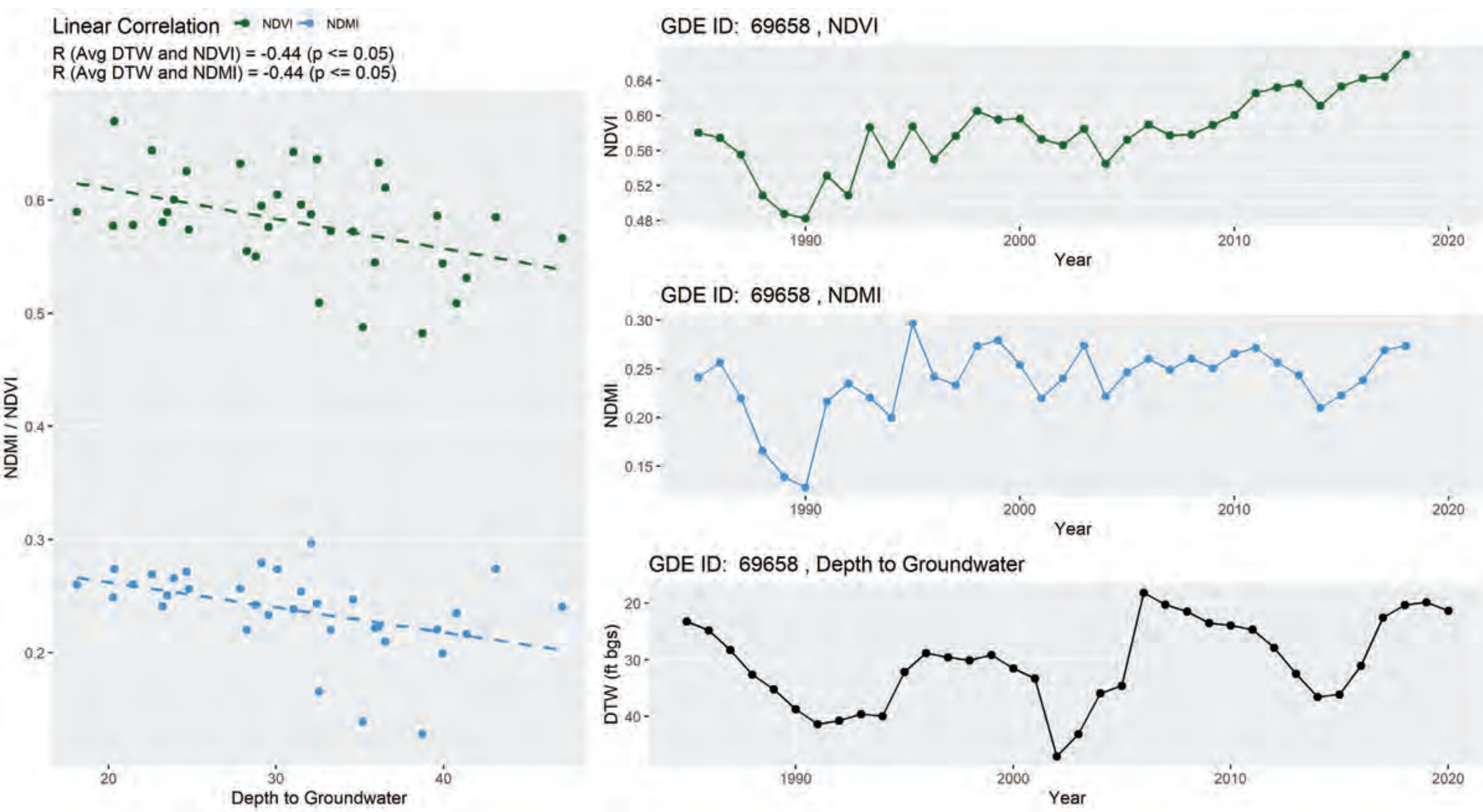

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.48 (p <= 0.05)
R (Avg DTW and NDMI) = 0.35 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 69648 , NDVI
NDVI
Year
GDE ID: 69648 , NDMI
NDMI
Year
GDE ID: 69648 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.023
R (Avg DTW and NDMI) = -0.23
NDMI / NDVI
Depth to Groundwater
GDE ID: 69649 , NDVI
NDVI
Year
GDE ID: 69649 , NDMI
NDMI
Year
GDE ID: 69649 , Depth to Groundwater
DTW (ft bgs)
Year

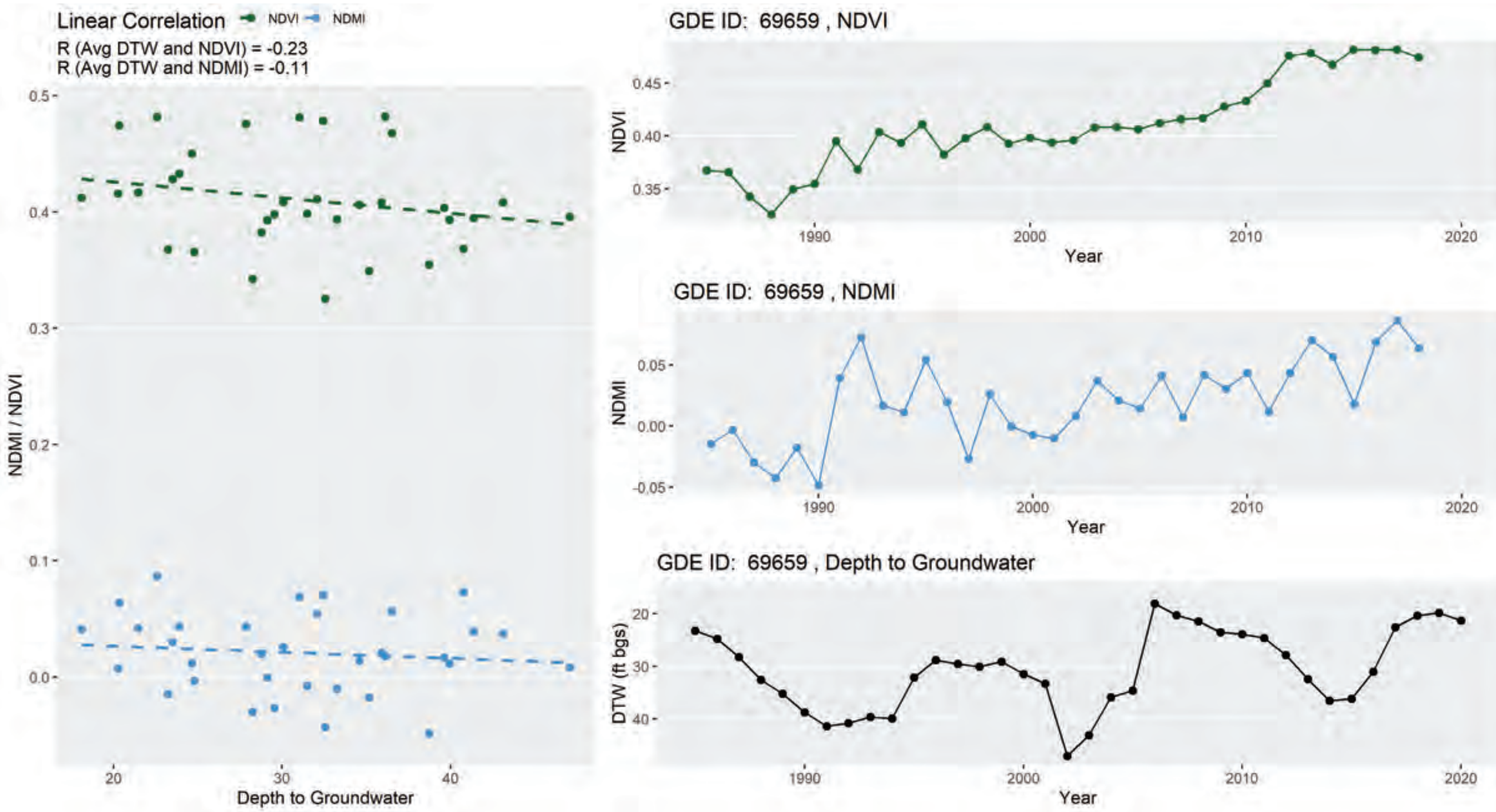

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.62 (p <= 0.05)
R (Avg DTW and NDMI) = -0.42 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 69650 , NDVI
NDVI
Year
GDE ID: 69650 , NDMI
NDMI
Year
GDE ID: 69650 , Depth to Groundwater
DTW (ft bgs)
Year

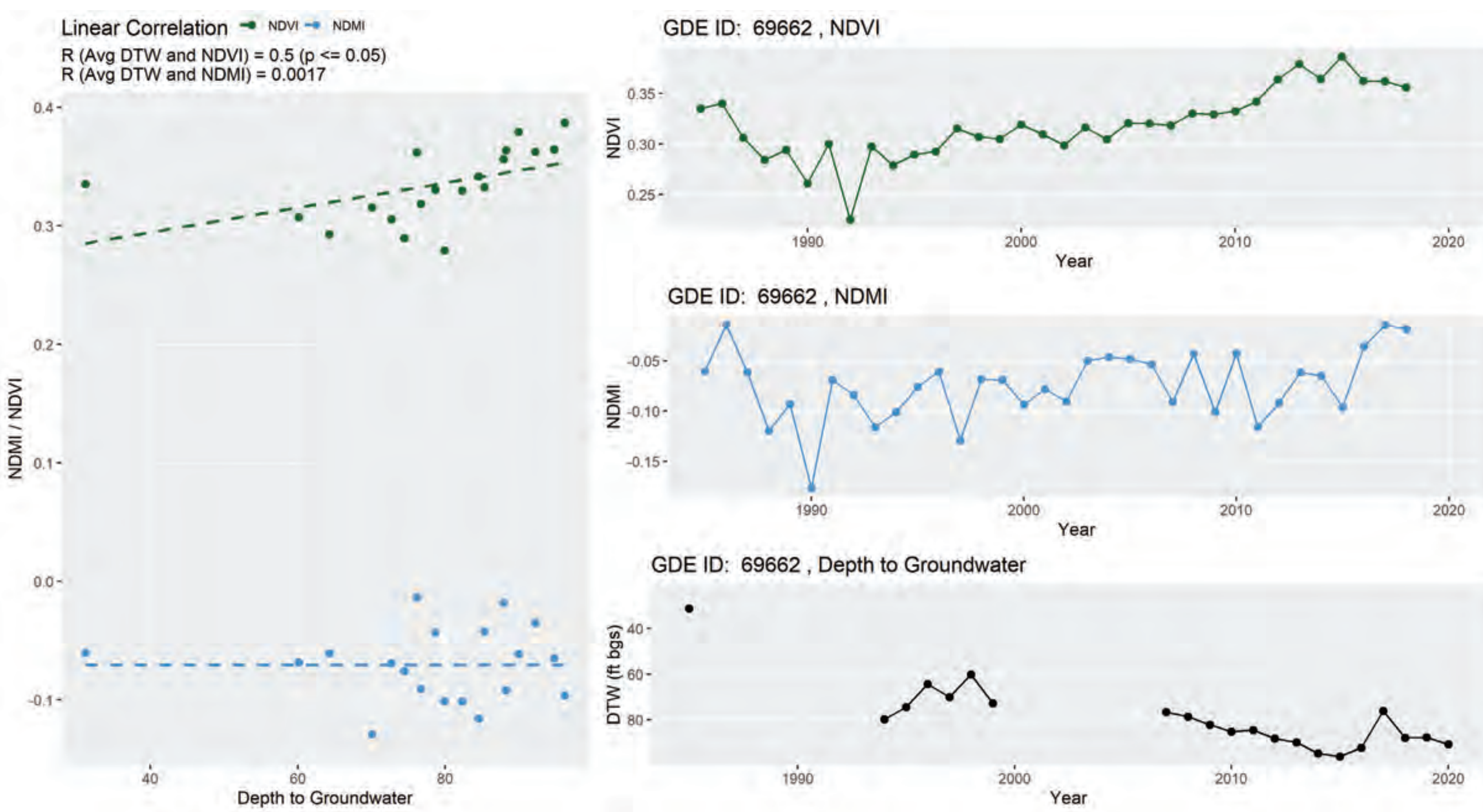


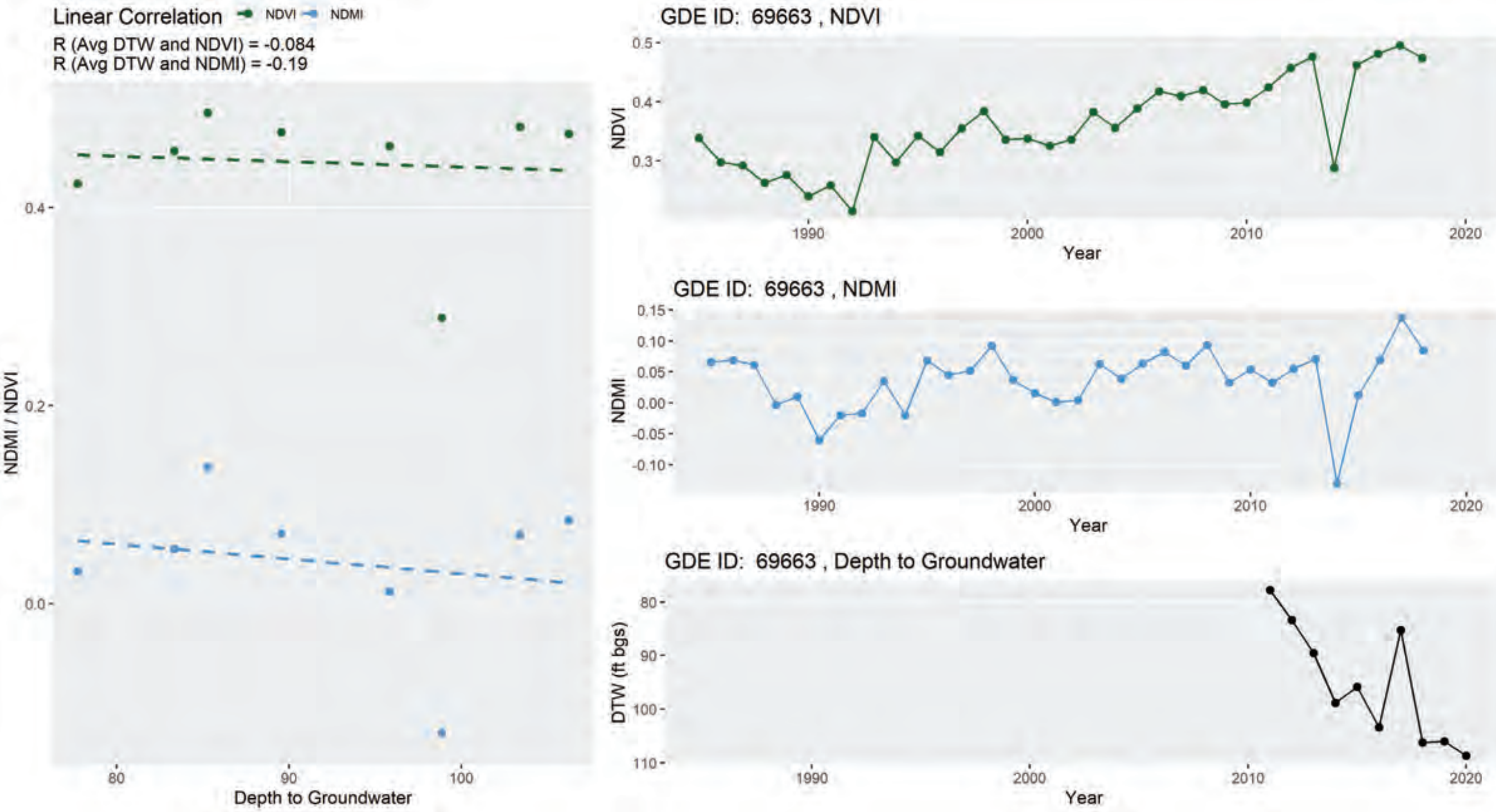
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.84 (p <= 0.05)
R (Avg DTW and NDMI) = -0.55 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 69657 , NDVI
NDVI
Year
GDE ID: 69657 , NDMI
NDMI
Year
GDE ID: 69657 , Depth to Groundwater
DTW (ft bgs)
Year

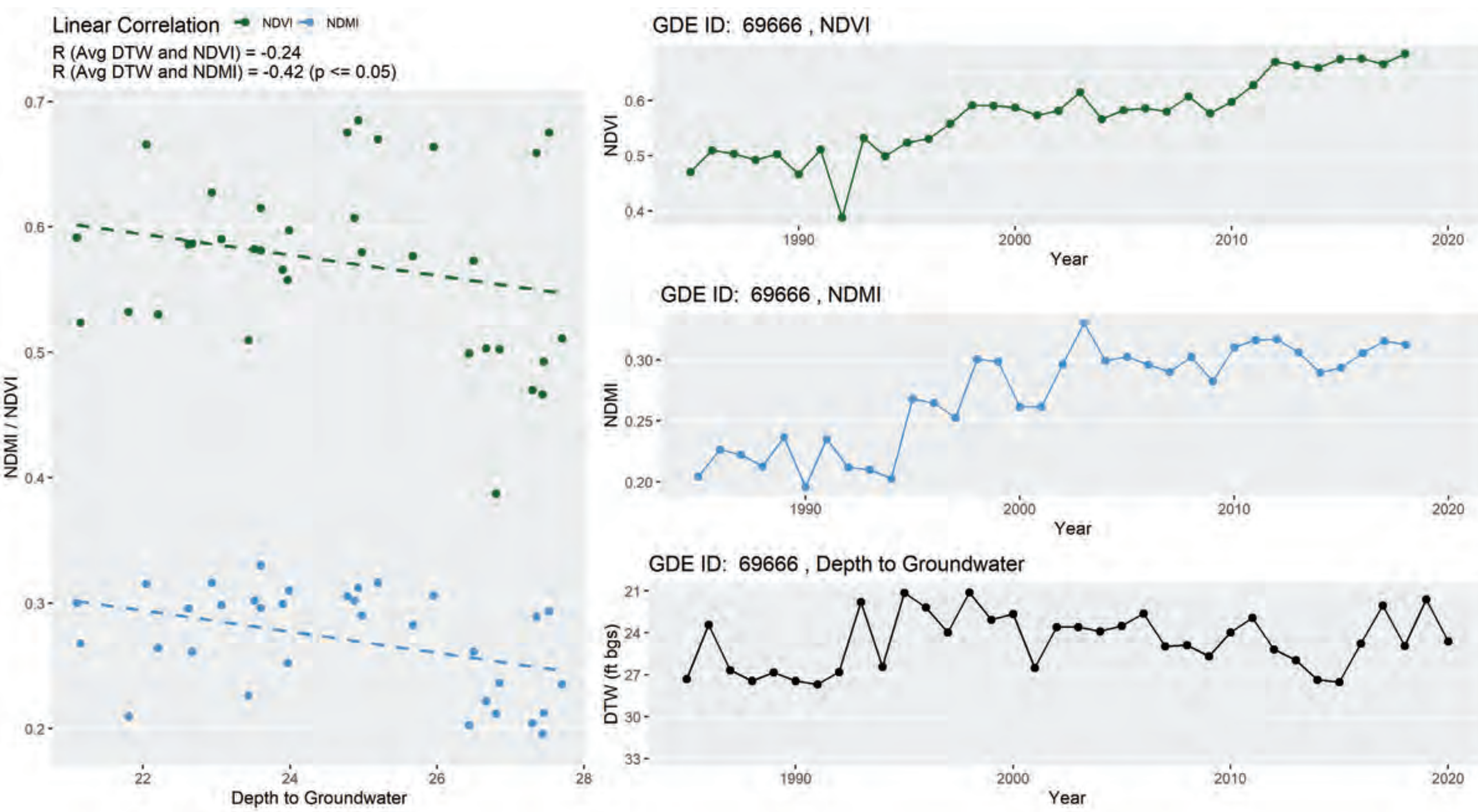


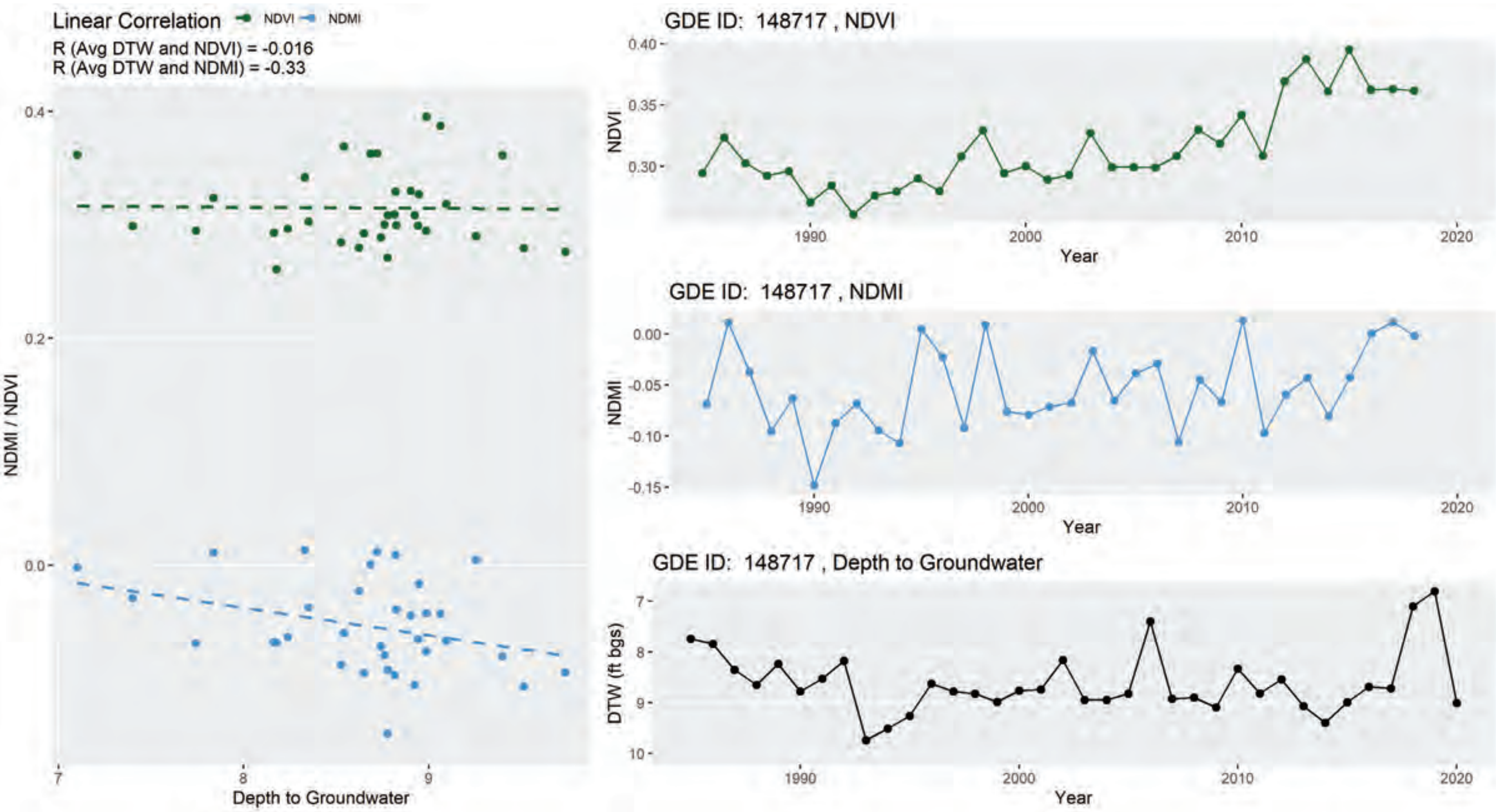
Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.44 (p <= 0.05)
R (Avg DTW and NDMI) = -0.44 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 69658 , NDVI
NDVI
Year
GDE ID: 69658 , NDMI
NDMI
Year
GDE ID: 69658 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.23
R (Avg DTW and NDMI) = -0.11
NDMI / NDVI
Depth to Groundwater
GDE ID: 69659 , NDVI
NDVI
Year
GDE ID: 69659 , NDMI
NDMI
Year
GDE ID: 69659 , Depth to Groundwater
DTW (ft bgs)
Year

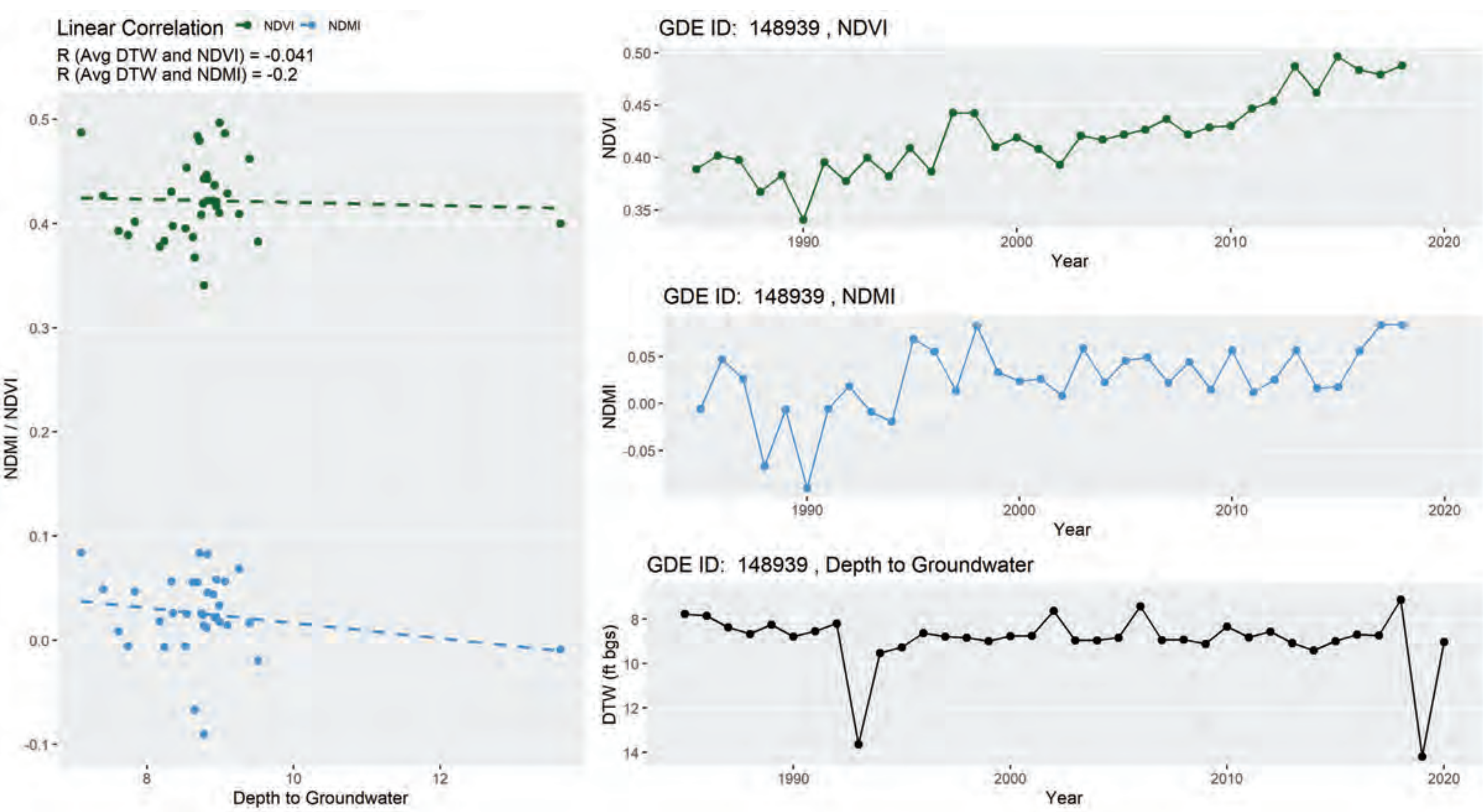

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.5 (p <= 0.05)
R (Avg DTW and NDMI) = 0.0017
NDMI / NDVI
Depth to Groundwater
GDE ID: 69662 , NDVI
NDVI
Year
GDE ID: 69662 , NDMI
NDMI
Year
GDE ID: 69662 , Depth to Groundwater
DTW (ft bgs)
Year


Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.084
R (Avg DTW and NDMI) = -0.19
NDMI / NDVI
Depth to Groundwater
GDE ID: 69663 , NDVI
NDVI
Year
GDE ID: 69663 , NDMI
NDMI
Year
GDE ID: 69663 , Depth to Groundwater
DTW (ft bgs)
Year

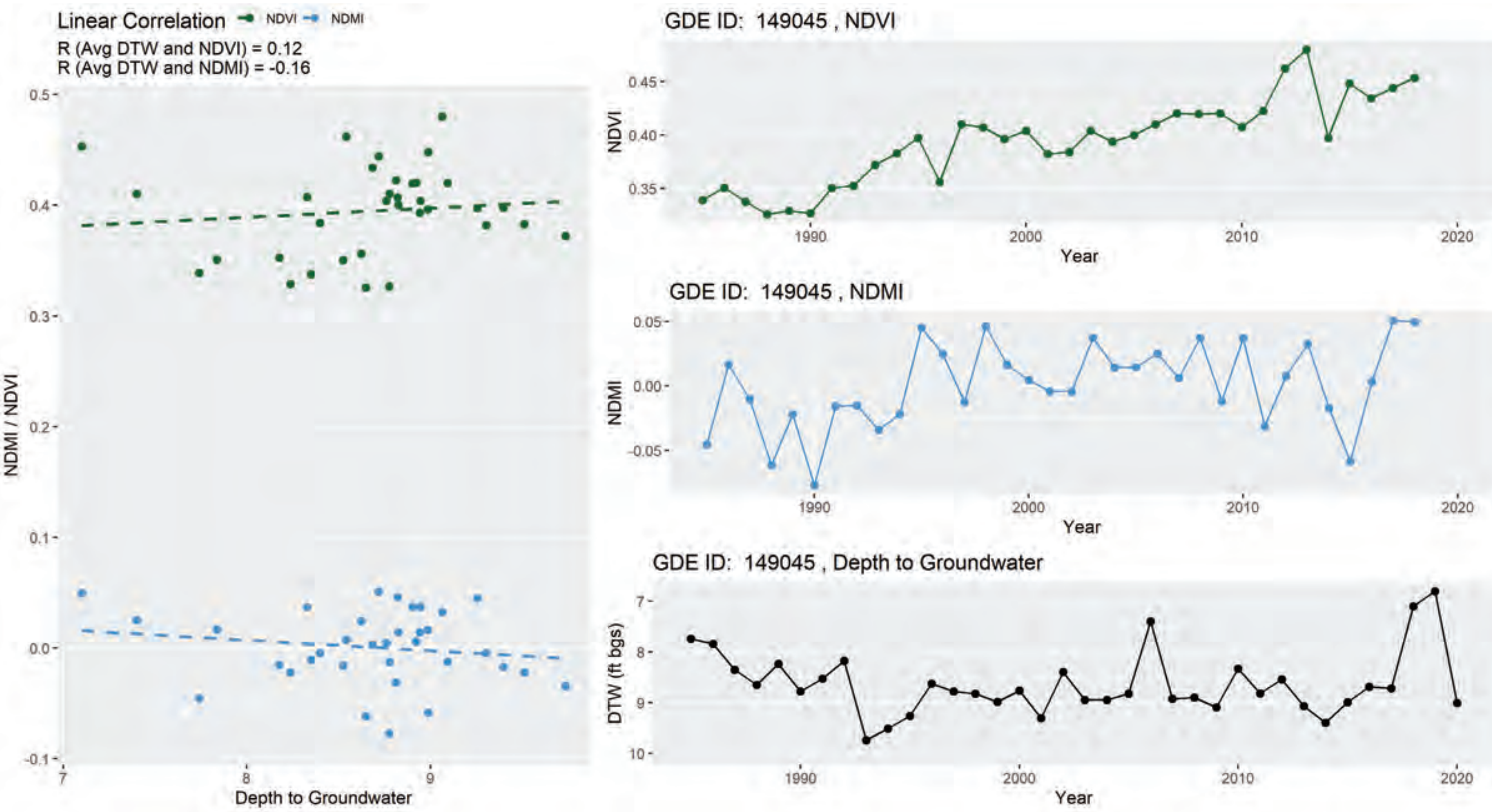

Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.24
R (Avg DTW and NDMI) = -0.42 (p <= 0.05)
NDMI / NDVI
Depth to Groundwater
GDE ID: 69666 , NDVI
NDVI
Year
GDE ID: 69666 , NDMI
NDMI
Year
GDE ID: 69666 , Depth to Groundwater
DTW (ft bgs)
Year



Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.016
R (Avg DTW and NDMI) = -0.33
NDMI / NDVI
Depth to Groundwater
GDE ID: 148717 , NDVI
NDVI
Year
GDE ID: 148717 , NDMI
NDMI
Year
GDE ID: 148717 , Depth to Groundwater
DTW (ft bgs)
Year



Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = -0.041
R (Avg DTW and NDMI) = -0.2
NDMI / NDVI
Depth to Groundwater
GDE ID: 148939 , NDVI
NDVI
Year
GDE ID: 148939 , NDMI
NDMI
Year
GDE ID: 148939 , Depth to Groundwater
DTW (ft bgs)
Year



Linear Correlation
NDVI
NDMI
R (Avg DTW and NDVI) = 0.12
R (Avg DTW and NDMI) = -0.16
NDMI / NDVI
Depth to Groundwater
GDE ID: 149045 , NDVI
NDVI
Year
GDE ID: 149045 , NDMI
NDMI
Year
GDE ID: 149045 , Depth to Groundwater
DTW (ft bgs)
Year

Attachment B: Technical Memorandum from Stillwater: Groundwater Dependent Ecosystems of Livermore Valley Groundwater Basin

DRAFT TECHNICAL MEMORANDUM ◦ MAY 2021

Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin

PREPARED FOR

Zone 7 Water Agency
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PREPARED BY

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Stillwater Sciences

Suggested citation:
Stillwater Sciences. 2021. Groundwater Dependent Ecosystems of the Livermore Valley Groundwater Basin. Prepared by Stillwater Sciences, Berkeley, California for EKI Environment & Water, Inc., Burlingame, California

Cover photo: Riparian vegetation along Arroyo Las Positas, Livermore, CA.

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1 INTRODUCTION

This technical memorandum is anticipated to be included as an attachment to the 2022 Alternative Groundwater Sustainability Plan (Alt GSP) for the Livermore Valley Groundwater Basin. This memorandum identifies groundwater dependent ecosystems (GDEs) in the Livermore Valley Groundwater Basin. The Livermore Valley Groundwater Basin is managed by the Zone 7 Water Agency, which is the exclusive Groundwater Sustainability Agency (GSA) within its boundaries. Under the California Sustainable Groundwater Management Act (SGMA), GSAs are required to identify GDEs and other beneficial uses and users of groundwater and consider impacts to GDEs and beneficial users when developing their GSPs as codified in the California Code of Regulations (CCR) sections 23 CCR § 354.16(g), Water Code § 10723.2(e), and Water Code § 10727.4 (State of California 2021). SGMA defines GDEs as “ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR § 351(m)). As described in The Nature Conservancy’s (TNC) guidance for GDE analysis (Rohde et al. 2018), a GDE’s dependence on groundwater refers to reliance of GDE species and/or ecological communities on groundwater for all or a portion of their water needs. Mapping GDEs requires mapping vegetation that can tap groundwater through their root systems, assessing where the depth of groundwater is within the rooting depth of that vegetation, and mapping the extent of surface water that is interconnected with groundwater (Rohde et al. 2018). Once the GDEs are mapped, the occurrence of special-status species can be used to assess the sensitivity of GDEs in the basin.

Based on the 2016 Alternative Groundwater Sustainability Plan (Zone 7 Water Agency 2016), the Livermore Valley Groundwater Basin is divided into three management areas (Figure 1):

- **The Main Basin Management Area** includes the major aquifer in the Livermore Valley Groundwater Basin and is comprised of deep alluvial sediments (Zone 7 Water Agency 2016).
- **The Fringe Management Area** makes up the northern and eastern portions of the Livermore Valley Groundwater Basin and does not provide a large source of groundwater to the basin due to poor water quality and low well yields (Zone 7 Water Agency 2016). The Fringe Management Area contains the Springtown Alkali Sink which supports several special status species and GDEs (Zone 7 Water Agency 2016).
- **The Upland Management Area** primarily makes up the southern portion of the groundwater basin and is underlain by the Livermore Formation, which is not extensively used for groundwater pumping due to poor water yields (Zone 7 Water Agency 2016).

Although groundwater pumping volumes in the Fringe and Upland Management Areas are small, potential GDEs were identified in these areas to provide a baseline inventory of GDEs in the basin and to inform future monitoring efforts rather than to develop sustainable management criteria for the 2022 Alt GSP Update.

This assessment was conducted in coordination with EKI Environment & Water, Inc. (EKI) and the Zone 7 Water Agency, as described below.

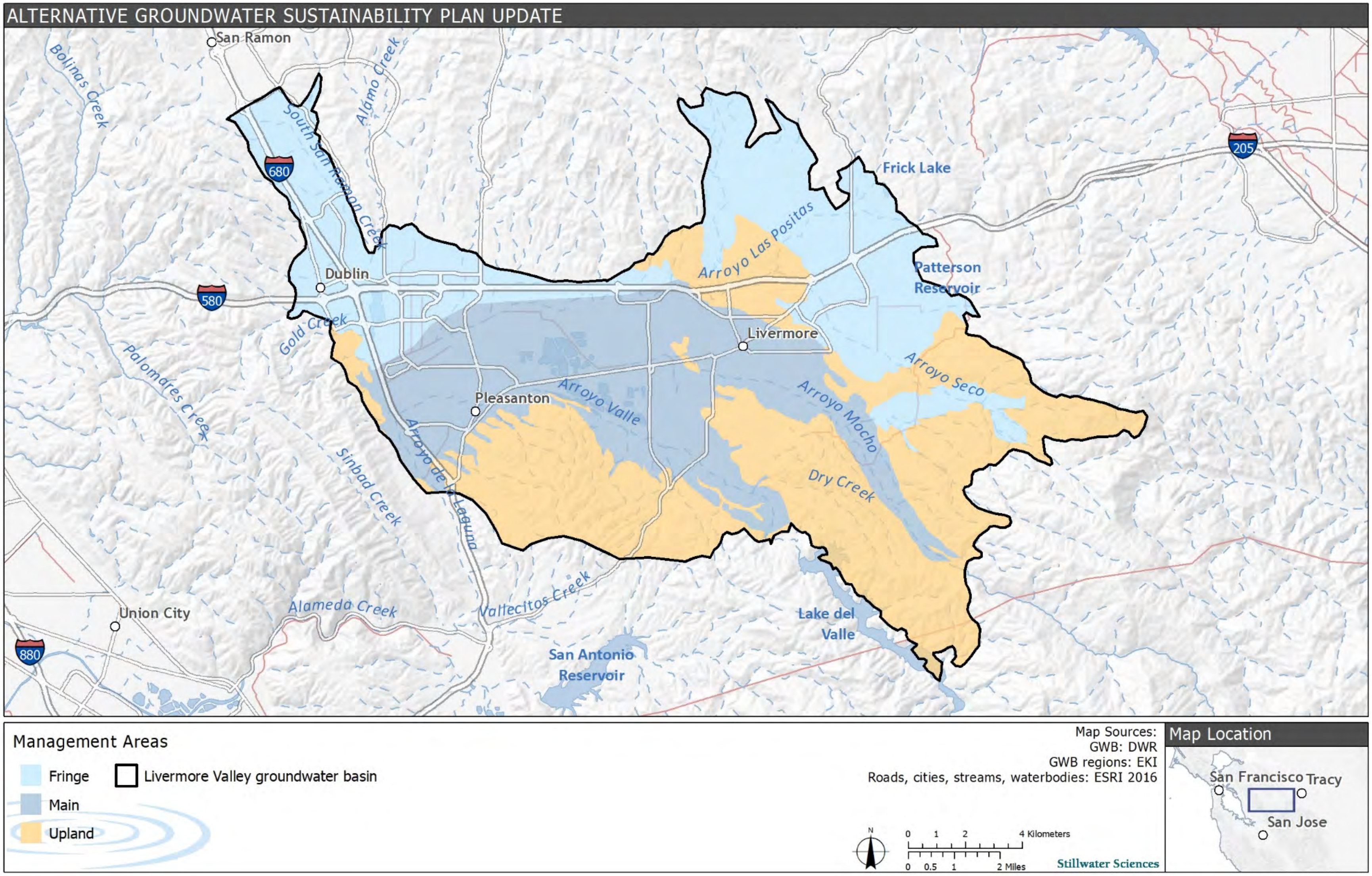

Figure 1. Livermore Valley Groundwater Basin Management Areas.

2 METHODS

2.1 GDE Identification

The procedure used for identifying GDEs is summarized below, and the steps are described in detail in the following sections.

1. **Data sources**: Potential GDEs in the Livermore Valley Groundwater Basin were identified using the California Department of Water Resources' (DWR) indicators of groundwater dependent ecosystems (iGDE) database. The database, which is published online[1] and referred to as the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (Klausmeyer et al. 2018), includes the location and spatial extent of vegetation and wetland natural communities. This database uses statewide vegetation and wetland mapping coupled with information on the potential groundwater dependence of those communities to identify potential GDEs. This map can be refined by including additional or updated vegetation map sources. The vegetation data sources must then be prioritized (based on data resolution, quality and age) to produce an initial vegetation map of the groundwater basin.
2. **Procedure**: Once the maps are assembled, groundwater dependent vegetation communities are identified through a decision tree based on literature review and wetland status (Lichvar et al. 2016) of dominant species.
3. **Refine potential GDE map**: Potential groundwater dependent vegetation communities were initially identified where depths to groundwater were less than 30 feet (ft) anytime between 2015-2020. Where groundwater depth was unknown (e.g., in portions of the Fringe and Upland Management Areas) the vegetation community was not removed. Where potential GDEs did not reflect current conditions, obvious errors in the vegetation mapping (i.e., polygon boundaries) were corrected using aerial imagery. In addition, the potential GDE map incorporated results of a correlation analysis on depth to groundwater and GDE health-indicating indices provided by EKI. The potential GDE maps were further revised based on input from Zone 7 and EKI.
4. **Field visit**: Where the presence of potential GDE communities was uncertain, Stillwater botanists visited several sites to assess groundwater dependence in the field. Updates based on field observations were incorporated into the final GDE assessment.

2.1.1 Data sources

This section includes brief descriptions of the vegetation community data and other information sources used to identify and aggregate potential GDEs into final GDE units. The Indicators of Groundwater Dependent Ecosystems (iGDE) database (Klausmeyer et al. 2018) was reviewed in a geographic information system (GIS) and used to generate a preliminary map to serve as a guide for initial identification of potential GDEs in the Livermore Valley Groundwater Basin.

For more precise identification of potential GDEs, we developed a refined vegetation map by combining the Classification and Assessment with Landsat of Visible Ecology Groupings (CalVeg) dataset with several more recent datasets. Our refined vegetation map incorporates the following datasets:

[1] https://gis.water.ca.gov/app/NCDatasetViewer/ [Accessed April 28, 2021]

- Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg) – United States Department of Agriculture - Forest Service (USDA 2014). *Central Coast region: Imagery date: 1997–2013; Minimum mapping unit (MMU): 2.5-acre.*
- Urban Creeks Council 2014 CalVeg update for third-order and higher channels. *Minimum mapping unit (MMU): ~0.5 acre.* Urban Creeks Council (2014).
- Springtown Alkali Sink Preserve Wetlands Mapping Project, Aerial Information Systems, Inc. (AIS 2009). *Minimum mapping unit (MMU): as low as 200 ft sq in wetland areas, 1.2-acre in general study area.*
- Sycamore Alluvial Woodland Tree Survey in Arroyo Mocho and Arroyo Valley, Alameda County, CA, Zone 7 Water Agency, San Francisco Estuary Institute, H.T. Harvey & Associates (SFEI and H.T. Harvey 2017).

AIS (2009) was considered the highest quality vegetation mapping due to its high resolution. The sycamore woodland mapping was also considered high quality but is of limited extent. Because of the recent date, we next used the UCC (2014) along the channels underlain by the original CalVeg mapping (Figure 2).

Table 1 and Figure 2 show, respectively, the acreage and extent of each dataset.

Table 1. Vegetation and wetland data sources for the Livermore Valley Groundwater Basin.

Data source	Mapped area (acres)
CalVeg	36,254
CalVeg – UCC updates	22,906
AIS Springtown Mapping	10,329
Zone 7 Sycamore Survey	40
Total[1]	**69,531**

[1] Totals may not appear to sum exactly due to rounding error.

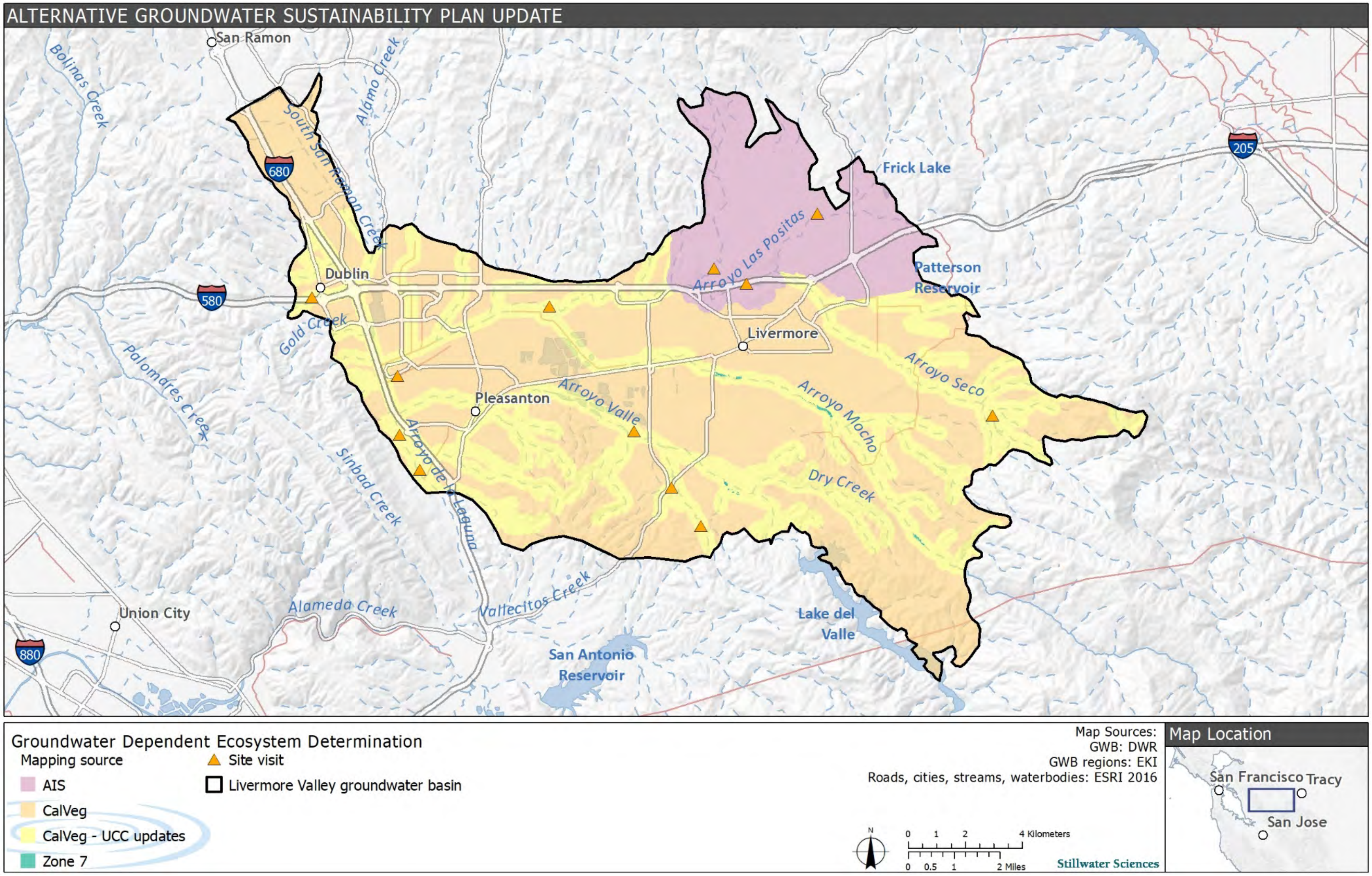

Figure 2. Extent of vegetation mapping data sources.

2.1.2 Procedure

The steps for defining and mapping GDEs outlined in Rohde et al. (2018) were used as a guideline for this process. A decision tree was applied to determine when species or biological communities were considered groundwater dependent based on definitions found in 23 CCR § 351(m) (State of California 2021) and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below; the term "unit" refers to an area with consistent vegetation and hydrology:

The unit is a GDE if groundwater is likely:

1. An important hydrologic input to the unit during some time of the year, AND
2. Important to survival and/or natural history of inhabiting species, AND
3. Associated with a regional aquifer used as a regionally important source of groundwater.

The unit is not a GDE if its hydrologic regime is primarily controlled by:

1. Surface discharge or drainage from a(n) upslope human-made structure(s), such as a mining pit, irrigation canal, irrigated fields, reservoir, cattle pond, or water treatment pond/facility.
2. Precipitation inputs directly to the unit surface. This excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area.

Rohde et al. (2018) recommend that maps of potential GDEs be compared with local groundwater elevations to determine where groundwater is within the rooting depth of potential GDEs. Given uncertainties in extrapolating well measurements to GDEs and differences in surface elevation of wells and GDEs, Rohde et al. (2018) recommend assigning GDE status to vegetation communities either where groundwater is within 30 ft of the ground surface or where interconnected surface waters are observed.

2.1.3 Refine potential GDE map

The basin-wide vegetation and wetland map was reviewed, and each community was assigned a groundwater dependence category based on rankings for likelihood of connection to groundwater (i.e., unlikely or likely). This determination was based on species composition and the groundwater dependency of dominant species, whether they were considered groundwater dependent by the iGDE database (DWR 2021), and wetland indicator status (Lichvar et al. 2016).

These potential GDEs were then compared with groundwater depth (where known). Depth to groundwater contours for the Main Basin and Fringe Management Areas were provided by Zone 7 and EKI. In the Main Basin and Fringe Management Areas, phreatophytes that occur where groundwater is within 30 ft of the ground surface were identified as likely GDEs. Initial GDE maps used areas with groundwater depth less than 30 ft in a wet period, Spring 2019, using data provided by Zone 7 (Zone 7 2020). The map was revised to include areas where groundwater depths are less than 30 ft anytime between 2015-2020 using raster data of groundwater depth subsequently provided by EKI (EKI 2021).

Groundwater contours or rasters were not available for the Upland Management Area of the Livermore Valley Groundwater Basin due to the general lack of monitoring and production wells in this portion of the Basin. Where well data was available in the Upland Management Area, EKI evaluated potential groundwater dependence for GDEs that occurred within one kilometer (approximately 0.6 miles) of the well and had minimum depth to water observations less than 30 ft between 2015 and 2020. These potential GDEs were evaluated in the field to assess groundwater dependence.

The southern portion of the Upland Management Area contains extensive valley oak (*Quercus lobata*) and blue oak (*Quercus douglasii*) communities (Figure 3). Valley oaks are included as phreatophytes in California by Klausmeyer et al. (2018) suggesting that they can rely on groundwater for part of their water needs. Klausmeyer et al. (2018) did not include blue oaks in their list of phreatophytes, but focused studies in blue oak woodlands suggest they can depend on groundwater to meet their water needs (e.g., Miller et al. 2010). Though these oaks are deep-rooted (maximum rooting depths range from 30-80 ft, depending on the species) and occur where depth to groundwater is unknown, they are unlikely to be affected by groundwater management because they occur in hillslopes, where hydraulic gradients are steep and groundwater production is de minimis as evidenced by the lack of wells in the area (Zone 7 Water Agency 2016). As such, these communities were not included in the final GDE map presented in Figure 4.

Zone 7 made additional comments on the preliminary GDE map, noting discrepancies between mapped GDEs and current vegetation as well as recent stream restoration projects which may be connected to groundwater. The vegetation map was subsequently adjusted to ensure that mapped polygons aligned with the current extent of vegetation, with a focus on the restoration project areas identified in comments provided by Zone 7.

EKI performed a correlation analysis between depth to groundwater and two remote sensing indices that indicate GDE's health by GDE unit, the Normalized Derived Moisture Index (NDMI) and the Normalized Derived Vegetation Index (NDVI), which indicate the vegetation moisture and vegetation greenness, respectively. The premise of the analysis is that, since the NDMI and NDVI indices can quantify changes in the rates and patterns of vegetation growth and moisture levels in plants over time, the relationship between these two indices and the depth to groundwater can be evaluated to examine whether these measures of GDE "health" have a relationship to shallow groundwater conditions. The preliminary GDE map was subsequently revised based on the results of the correlation analysis provided by EKI.

The occurrence and extent of interconnected surface water is uncertain in the Livermore Valley Groundwater Basin. Potential reaches of interconnected surface water were identified by EKI based on analysis of streambed elevations relative to recent depth to groundwater observations. These reaches generally overlapped with mapped GDEs and were not evaluated separately. Man-made open water areas (e.g., Chain of Lakes and golf course ponds) were removed from the final GDE map.

2.1.4 Field visit

Stillwater Sciences and EKI identified 12 sites to examine in the field based on uncertainties in the preliminary GDE maps, as shown on Figure 2. These sites included gaps in the GDE map where vegetation appeared similar to GDEs that occurred immediately upstream and downstream of the site, riparian vegetation along channels, and mapped GDEs underlain by thick clay layers. Additionally, Stillwater scientists assessed potential GDEs where groundwater data was sparse (near Sycamore Park) and near Springtown. Groundwater dependence of these sites was determined by assessing various local water sources and the width of the riparian zone. Where riparian zones were narrow and relatively sparse, other water sources likely support the vegetation. Where existing vegetation and wetland areas extend beyond a narrow strip along the channel, groundwater dependence was considered likely. The results of the field investigation are shown in Table 2 and Figure 3, and the Final likely GDE map is presented in Figure 4.

2.2 Special-status Species

As part of the ecological inventory, special-status species and sensitive natural communities that are potentially associated with GDEs in the Livermore Valley Groundwater Basin were identified. For the purposes of this document, special-status species are defined as those:

- Listed, proposed, or under review as endangered or threatened under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA);
- Designated by California Department of Fish and Wildlife (CDFW) as a Species of Special Concern;
- Designated by CDFW as Fully Protected under the California Fish and Game Code (Sections 3511, 4700, 5050, and 5515);
- Designated as Bureau of Land Management (BLM) sensitive;
- Designated as rare under the California Native Plant Protection Act (CNPPA); and/or
- Included on CDFW's most recent Special Vascular Plants, Bryophytes, and Lichens List (CDFW 2020b) with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4.

2.2.1 Data sources

Stillwater ecologists queried databases on regional and local occurrences and spatial distributions of special-status species within the Livermore Valley Groundwater Basin. Spatial database queries included potential GDEs plus a 1-mile buffer. Databases queried include:

- California Natural Diversity Database (CNDDB) (CDFW 2020);
- California Native Plant Society (CNPS) Manual of California Vegetation (2020);
- eBird (2021); and
- TNC freshwater species lists generated from the California Freshwater Species Database (CAFSD) (TNC 2020).

2.2.2 Procedure

Stillwater reviewed the database query results and identified special-status species and vegetation communities that may occur within or be associated with the vegetation and aquatic communities in or immediately adjacent to potential GDEs. Stillwater ecologists then consolidated these special-status species and sensitive community types into a list, along with summaries of habitat preferences, potential groundwater dependence, and reports of any known occurrences.

Wildlife species were evaluated for potential groundwater dependence using determinations from the Critical Species Lookbook (Rohde et al. 2019) or by evaluating known habitat preferences, life histories, and diets. Species GDE associations were assigned one of three categories:

- Direct—species directly dependent on groundwater for some or all water needs (e.g., cottonwood with roots in groundwater, juvenile steelhead in dry season)
- Indirect—species dependent upon other species that rely on groundwater for some or all water needs (e.g., riparian birds)

- No known reliance on groundwater

Sensitive natural communities were classified as either likely or unlikely to depend on groundwater based on species composition using the same methodology as vegetation communities (Section 2.1.3). Plant species were evaluated for potential groundwater dependence based on their habitat (Jepson Flora Project 2020) and association with vegetation communities classified as GDEs. Special-status plant GDE associations were assigned one of three categories: likely, possible, or unlikely. The "possible" category was included to classify plant species with limited habitat data or where a species may have an association with a vegetation community identified as a GDE (e.g., Coast live oak, California sagebrush).

Database query results for local and regional special-status species occurrences were combined with their known habitat requirements to develop a list of groundwater dependent special-status species (Section 3.2) that satisfy the following criteria: (1) documented to occur within the GDE unit, or (2) known to occur in the region and suitable habitat present in the GDE unit.

3 RESULTS

3.1 Comparison with iGDE Database

The differences between the iGDE map (DWR 2021) and the final GDE map are shown in Figure 3. The primary differences are the addition of GDEs in the northeast portion of the basin where the AIS mapping occurred and removal of man-made open water polygons along Chain of Lakes (along Arroyo Valle) and near Dublin. Some changes reflect differences between the UCC update to the CalVeg map and Stillwater's edits to the map along Arroyo Mocho and Arroyo Valle. In particular, the width of the riparian vegetation along both rivers increased in places. The reclassification near Lake Boris on Arroyo Valle (downstream of Site I) reduced the extent of GDEs downstream of the lake. In addition, several changes were made based on the site visit (Figure 3, Table 2). The vegetation was removed along Arroyo Del Laguna and west of Pleasanton (Sites B, C, and D). These sites occur above a thick clay layer (known colloquially as the Overburden layer) that precludes connection to the aquifer. Observations during the field visit suggested that the riparian vegetation at Sites B–D was likely dependent on surface water rather than groundwater due to the relatively narrow riparian zone. Site L (Figure 3) was also removed since the very sparse riparian vegetation suggested the area was not connected to groundwater. Wetlands mapped within man-made lakes and ponds (e.g., Frick Lake in the eastern part of the basin) were also removed. The final GDE map is presented in Figure 4.

Table 2. Likely groundwater dependence of field sites.

Site	Site description	Groundwater dependence
A	Mature trees including oaks (*Quercus* spp.), redwood (*Sequoia sempervirens*), tree of heaven (*Ailanthus altissima*), eucalyptus (*Eucalyptus* spp.)	Likely, kept
B	Flood control channel with planted willows (*Salix* spp.)	Unlikely, removed
C	Narrow band of willows, cottonwoods (*Populus* spp.), and oaks; channel incised up to 30 ft	Unlikely, removed
D	Narrow band of willows, cottonwoods, and valley oaks (*Quercus lobata*)	Unlikely, removed
E	Narrow band of sparse riparian vegetation	Unlikely, removed
F	Valley oak, live oak (*Quercus agrifolia*) and willow	Likely, kept
G	Willows, live oak, eucalyptus; may have perennial flow	Likely, kept
H	Near Springtown; likely groundwater dependent	Likely, added
I	Similar to upstream and downstream GDEs	Likely, added
J	Mature riparian trees, little surface water	Likely, added
K	Sycamore Park; closed canopy, mature riparian trees	Likely, added
L	Sparse valley oaks along incised, intermittent channel	Unlikely, removed

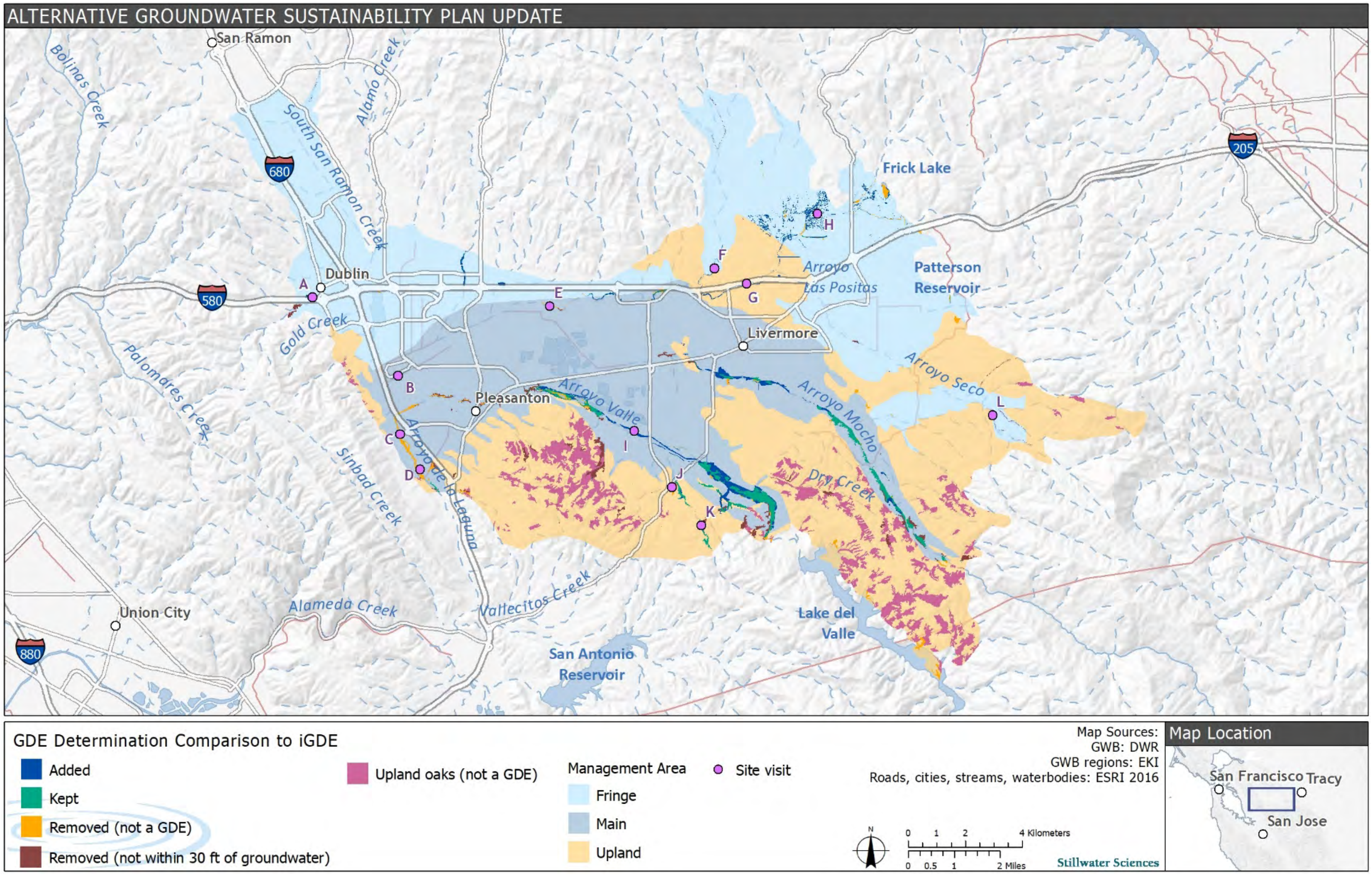

Figure 3. Comparison of the GDE map with the iGDE database (DWR 2021).

Note: The reasons for GDE removal are discussed in Section 3.1 and Table 2.

3.2 GDEs in the Livermore Valley Groundwater Basin

The Livermore Valley Groundwater Basin contains 1062 acres of likely GDEs, approximately 2% of the total basin area (Figure 4). The Main Basin Management Area contains approximately 69% of the total likely GDE area, the Fringe Management Area approximately 20%, and the Upland Management Area contains the remaining 11% of the GDEs. The most prevalent vegetation communities across all likely GDE units are the riparian mixed hardwood alliance and California sycamore alliance, which respectively comprise 40% and 30% of likely GDE area in the basin and are located almost entirely in the Main Basin Management Area. The Alkaline mixed grasses and forbs alliance comprises 10% of total likely GDE area and is located almost entirely in the Fringe Management Area.

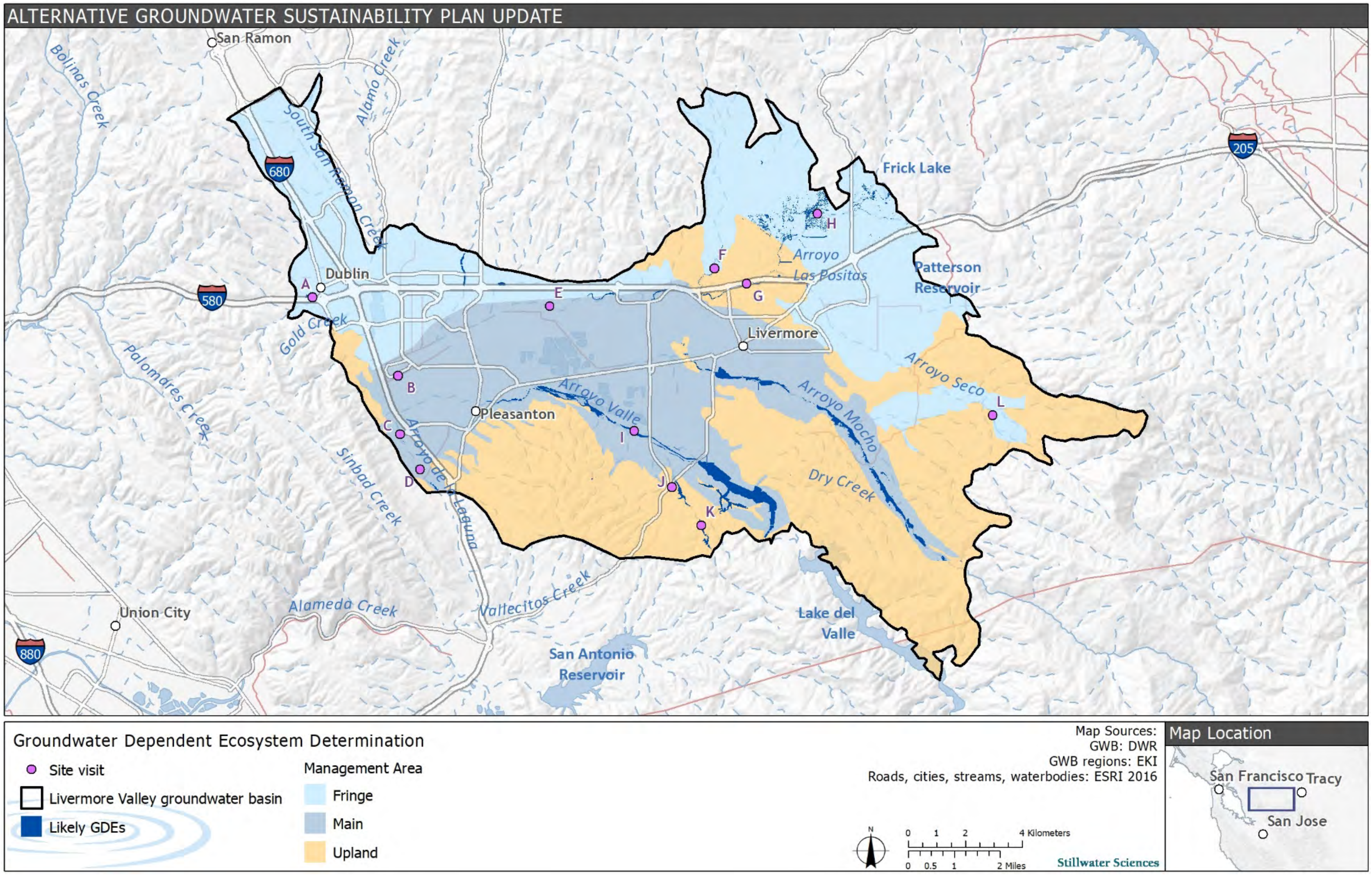

Figure 4. Groundwater dependent ecosystems in the Livermore Basin.

The Main Basin Management Area contains 737 acres of likely GDEs. The most prevalent vegetation communities are the California sycamore alliance (250 acres), riparian mixed hardwood alliance (239 acres), and valley oak alliance (212 acres) (Figure 5). GDEs typically occur along riparian zones, particularly Arroyo Mocho, Arroyo Valle, and Arroyo Las Positas. Additional GDEs occur in Sycamore Park in the upper extent of Arroyo Valle. The valley oak alliance is mostly found in the upstream portions of Arroyo Mocho within the main basin.

The riparian mixed hardwood alliance is comprised of willows (*Salix* spp.) and Fremont cottonwoods (*Populus fremontii*), which have maximum reported rooting depths in the literature of about 7 ft (The Nature Conservancy 2018) but can occur at relative elevations of 10–15 ft in some cases (Stillwater Sciences 2007). Maximum rooting depths for California sycamore (*Platanus racemosa*) are not reported in the literature, but American sycamore (*Platanus occidentalis*) has a maximum reported rooting depth of about 9 ft (The Nature Conservancy 2018). The valley oaks (Quercus lobata) that make up the valley oak alliance have the deepest rooting depth of the riparian vegetation found in the main basin measured maximum rooting depths up to 24 ft (The Nature Conservancy 2018).

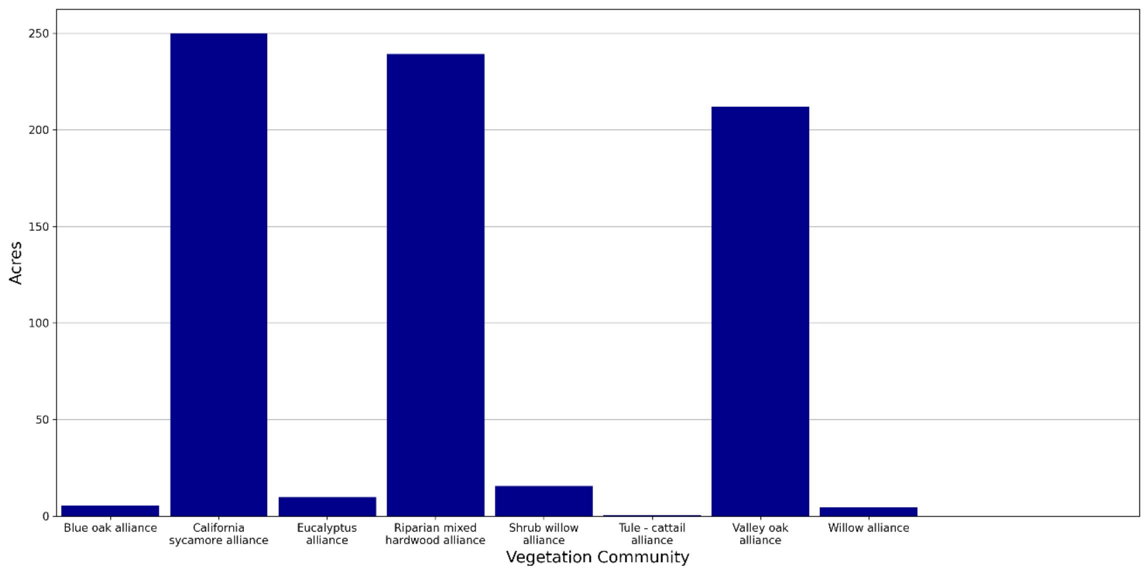

Figure 5. Likely GDE vegetation communities in the Main Basin Management Area, by acreage. Only eight likely GDE vegetation communities occur in the management area.

The Fringe Management Area contains 210 acres of likely GDEs. The most prevalent vegetation community is the alkaline mixed grasses and forbs alliance (100 acres). Other alkaline communities are also prevalent: alkaline mixed scrub alliance (29 acres) and alkaline flats (15 acres) (Figure 6). The GDEs in the Fringe Management Area occur along Arroyo Las Positas and the smaller spring-fed channels and wetlands in the northeast portion of the Fringe Management Area near Springtown (the northeasternmost site visit marker in Figure 4). Of the 144 acres of alkaline likely GDE vegetation communities, 54 acres occur in the Springtown Alkali Sink, as defined in the Zone 7 Alternative GSP (2016). The rooting depth of species in the alkaline mixed grasses and forbs alliance is unknown but is likely shallow (< 2 ft). The dominant species of the alkaline mixed scrub alliance is iodine bush (*Allenrolfea occidentalis*), which has reported maximum rooting depths of 2 ft. The dominant species of the tule-cattail alliance include sedges (*Carex* spp.), tules (*Scirpus* spp.), cattails (*Typha* spp.), and spikerushes (*Eleocharis* spp.). The rooting depth of these genera is typically less than 1 ft. The riparian mixed hardwood alliance has maximum rooting depths of about 7 ft (see above).

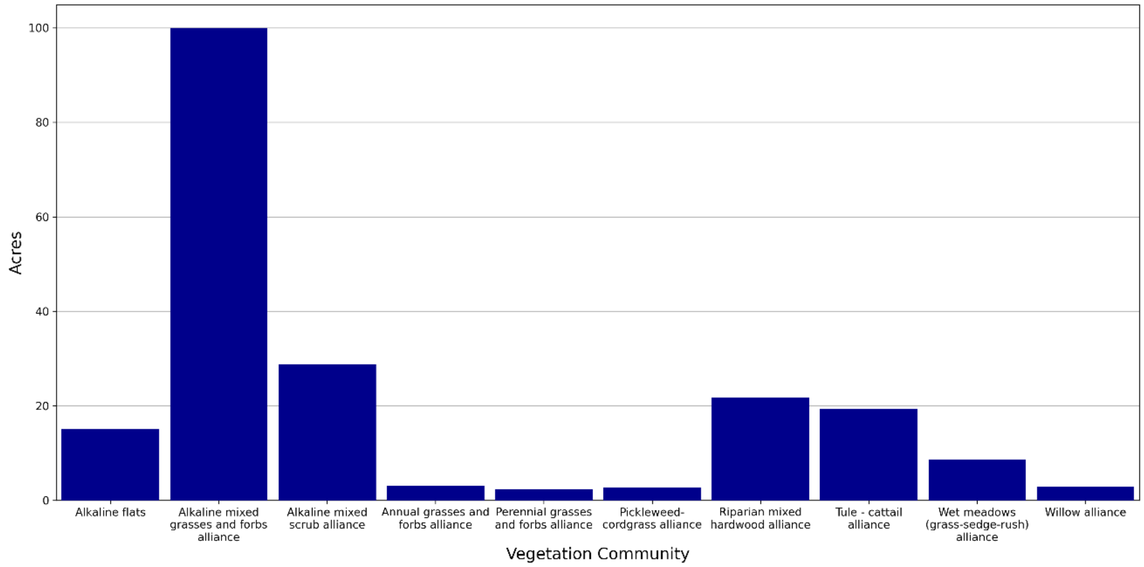

Figure 6. Ten most common likely GDE vegetation communities in the Fringe Management Area, by acreage.

The Upland Management Area contains 101 acres of likely GDEs. The most prevalent vegetation community is the riparian mixed hardwood alliance (74 acres) (Figure 7). GDEs in this unit occur in the riparian zones of smaller tributaries. The riparian mixed hardwood alliance is comprised of willows (*Salix* spp.) and Fremont cottonwoods (*Populus fremontii*), which have maximum reported rooting depths in the literature of about 7 ft (The Nature Conservancy 2018) but can occur at relative elevations of 10–15 ft in some cases (Stillwater Sciences 2007).

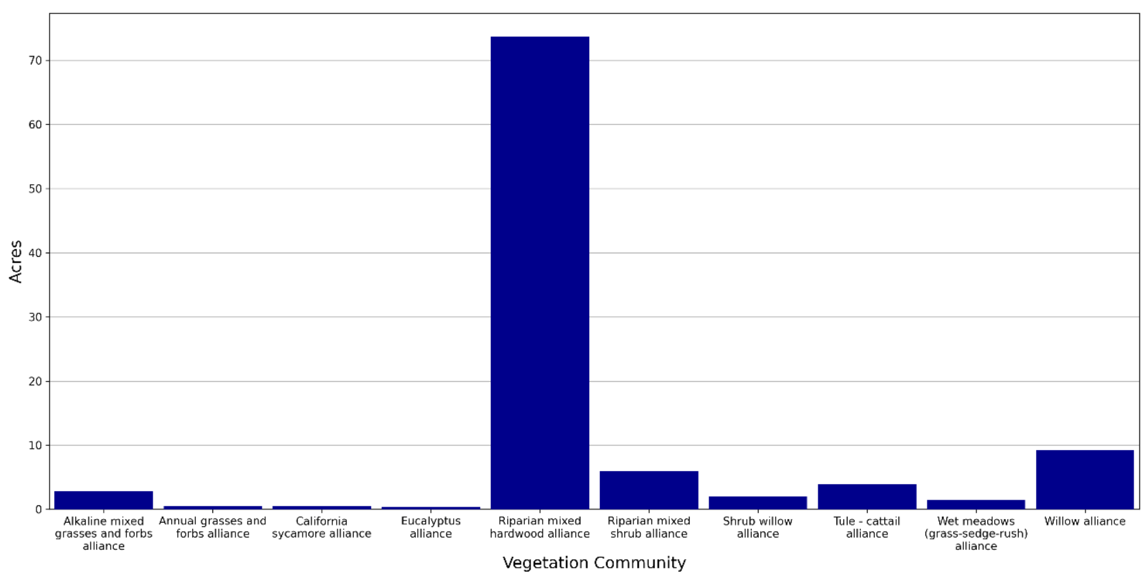

Figure 7. Ten most common likely GDE vegetation communities in the Upland Management Area, by acreage.

3.3 Special-status Species

3.3.1 Critical habitat

The Livermore Valley Groundwater Basin includes United States Fish and Wildlife Service (USFWS) designated critical habitat for four federally listed species: Alameda whipsnake (*Masticophis lateralis euryxanthus*) (936 acres), California red-legged frog (*Rana draytonii*) (7,273 acres), California tiger salamander (*Ambystoma californiense*) (0.5 acres), and vernal pool fairy shrimp (*Branchinecta lynchi*) (1,337 acres) (USFWS 2006a, USFWS 2010, USFWS 2005, USFWS 2006b). The locations of critical habitat for each species within the Livermore Valley Groundwater Basin are shown in Figure 8. Of the designated critical habitat, most of the habitat for the vernal pool fairy shrimp is co-located with mapped GDEs, but this species relies on vernal pools, which are dependent on rainfall, rather than groundwater and is therefore unlikely to be groundwater dependent. Most of the critical habitat for California red-legged frogs and Alameda whipsnake occurs outside of the defined GDEs, with approximately 2 acres of their critical habitat overlapping with a riparian GDE at the upstream end of Arroyo Mocho.

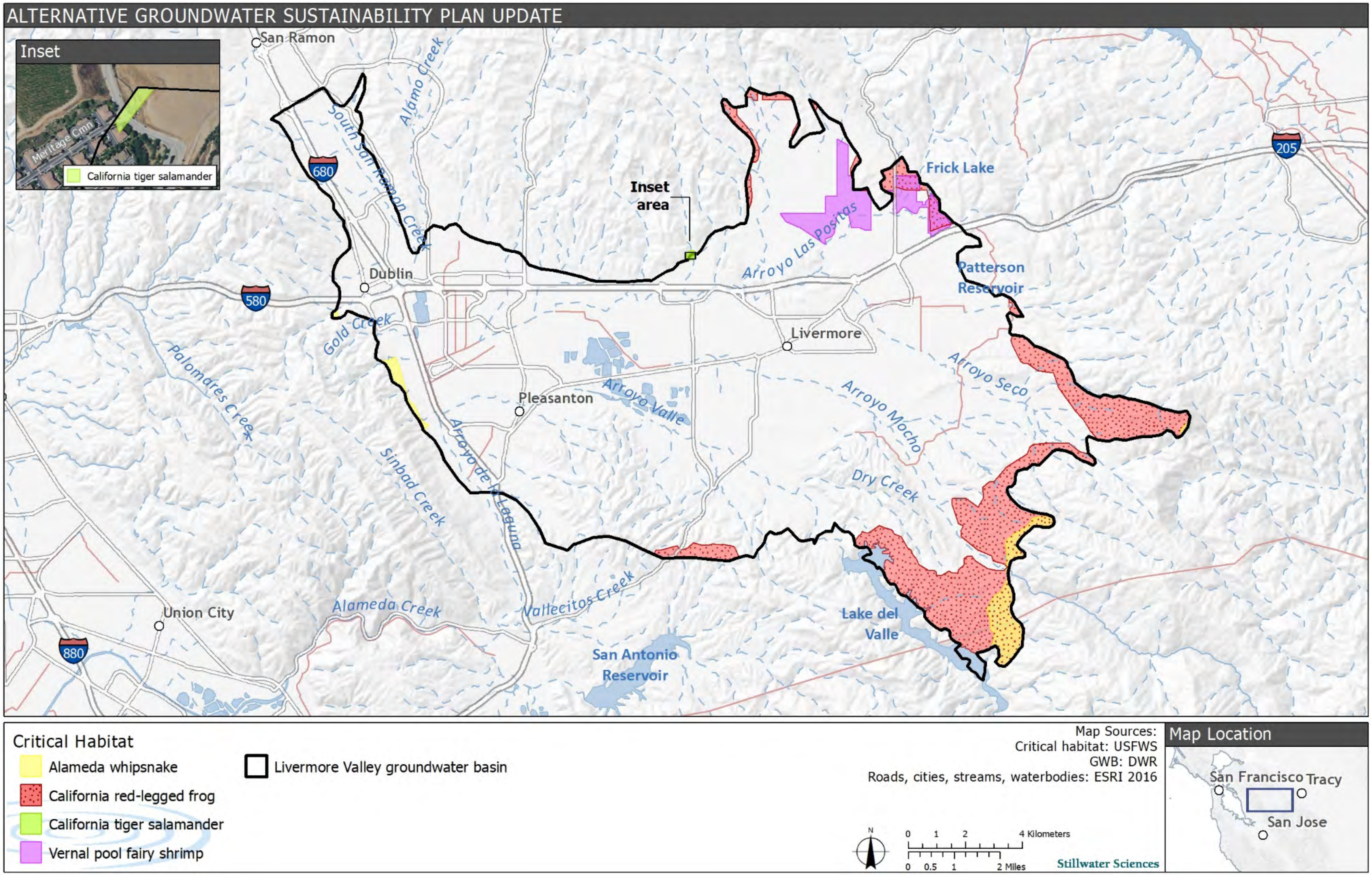

Figure 8. Designated critical habitat within the Livermore Valley Groundwater Basin.

3.3.2 Plants

Twenty-two special-status plants occur within the basin (Table 3). Of these, 12 were likely dependent upon groundwater, four were possibly dependent on groundwater, one was unlikely to be groundwater dependent, and five were not groundwater dependent (Table 3). All 12 special-status plants likely dependent on groundwater occurred in the Fringe Management Area, and three of the 12 also occurred in the Upland Management Area. The likely groundwater dependent special-status plants in the Fringe Area mostly were observed in or around the Springtown Alkali Sink.

Table 3. Groundwater dependance of special-status plant species in the Livermore Valley Groundwater Basin.

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Documented occurrence location**	**Query source**[2]
Alkali milk-vetch *Astragalus tener* var. *tener*	G2T1, S1, 1B.2	Likely	Fringe	CNDDB
Heartscale *Atriplex cordulata* var. *cordulata*	G3T2, S2, 1B.2	Likely	Fringe	CNDDB
Brittlescale *Atriplex depressa*	G2, S2, 1B.2	Likely	Fringe	CNDDB
Lesser saltscale *Atriplex minuscula*	G2, S2, 1B.1	Possible	Fringe	CNDDB
Big-scale balsamroot *Balsamorhiza macrolepis*	G2, S2, 1B.2	Not a GDE	Uplands	CNDDB
Big tarplant *Blepharizonia plumosa*	G1G2, S1S2, 1B.1	Not a GDE	Outside of basin	CNDDB
Congdon's tarplant *Centromadia parryi* subsp. *congdonii*	G3T1T2, S1S2, 1B.1	Possible	Fringe, Uplands	CNDDB
Hispid salty bird's-beak *Chloropyron molle* subsp. *hispidum*	G2T1, S1, 1B.1	Likely	Fringe	CNDDB
Palmate-bracted bird's-beak *Chloropyron palmatum*	G1, S1, 1B.1	Likely	Fringe, Uplands	CNDDB
Livermore tarplant *Deinandra bacigalupii*	G1, S1, 1B.1	Likely	Fringe	CNDDB
Hospital Canyon larkspur *Delphinium californicum* subsp. *interius*	G3T3, S3, 1B.2	Not a GDE	Main, Uplands	CNDDB

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Documented occurrence location**	**Query source**[2]
Jepson's coyote-thistle *Eryngium jepsonii*	G2, S2, 1B.2	Likely	Fringe	CNDDB
San Joaquin spearscale *Extriplex joaquinana*	G2, S2, 1B.2	Possible	Fringe	CNDDB
Stinkbells *Fritillaria agrestis*	G3, S3, 4.2	Unlikely	Fringe	CNDDB
Diablo helianthella *Helianthella castanea*	G2, S2, 1B.2	Possible	Fringe, on the edge of basin	CNDDB
Prostrate vernal pool navarretia *Navarretia prostrata*	G2, S2, 1B.2	Likely	Fringe	CNDDB
Hairless popcornflower *Plagiobothrys glaber*	GX, SX, 1A	Likely	Fringe, Uplands	CNDDB
California alkali grass *Puccinellia simplex*	G3, S2, 1B.2	Likely	Fringe, Uplands	CNDDB
Chaparral ragwort *Senecio aphanactis*	G3, S2, 2B.2	Not a GDE	Outside of Basin	CNDDB
Long-styled sand-spurrey *Spergularia macrotheca* var. *longistyla*	G5T2, S2, 1B.2	Likely	Fringe	CNDDB
Saline clover *Trifolium hydrophilum*	G2, S2, 1B.2	Likely	Fringe	CNDDB

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Documented occurrence location**	**Query source**[2]
Caper-fruited tropidocarpum *Tropidocarpum capparideum*	G1, S1, 1B.1	Not a GDE	Outside of Basin	CNDDB

[1] **Status codes:**

G = Global
T = Subspecies or variety
Federal
FT = Listed as threatened under the federal Endangered Species Act
FPT = Proposed as threatened under the federal Endangered Species Act
FD = Federally delisted

State
S = Sensitive
SE = Listed as Endangered under the California Endangered Species Act
ST = Listed as Threatened under the California Endangered Species Act
SSC = CDFW species of special concern
SFP = CDFW fully protected species

Rank
1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
2 Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
3 Vulnerable—At moderate risk of extinction or elimination due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
5 Demonstrably Secure—Common; widespread and abundant.
Q Taxonomic questions associated with this name
Ranks such as S2S3 indicate a ranking between S2 and S3

California Rare Plant Rank (CRPR)
1B Plants rare, threatened, or endangered in California and elsewhere
2B Plants rare, threatened, or endangered in California, but more common elsewhere
4 More information needed about this plant, a review list
4 Plants of limited distribution, a watch list

CRPR Threat Ranks:
0.1 Seriously threatened in California (high degree/immediacy of threat)
0.2 Fairly threatened in California (moderate degree/immediacy of threat)
0.3 Not very threatened in California (low degree/immediacy of threats or no current threats known

GDE Likelihood
Likely Species habitat includes multiple GDE habitats and the species has a wetland plant rating in the USACE Arid West Regional Supplement (FAC, FACW, or OBL)
Possible Species habitat range includes at least some GDE habitats (per CNPS and/or Jepson), however the species has an upland plant rating in the USACE Arid West Regional Supplement (FACU, UPL, or NL/UPL [i.e., not listed therefore considered upland])
Unlikely Species habitat associations do not include a potential GDE and it is associated with upland habitats. However, it has a plant rating in the USACE Arid West Regional Supplement of sometimes occurring in wetlands (e.g., FAC).
Not a GDE Species habitat associations do not include a potential GDE and it is associated with upland habitats. Also, it has an upland plant rating in the USACE Arid West Regional Supplement.

[2]**Query source:** CNDDB: California Natural Diversity Database (CDFW 2020a)

3.3.3 Terrestrial and aquatic wildlife

Thirty-one special-status terrestrial and aquatic wildlife species were identified as having the potential to occur within the Livermore Valley Groundwater Basin. Of these, 14 were potentially groundwater dependent species: two amphibian species, two reptile species, seven bird species, and three mammal species. Additional information on these groundwater dependent species, including regulatory status and habitat associations, is provided in Table 4. Ten of the groundwater dependent special status species are likely to occur in the Main Basin, eight of the groundwater-dependent special status species are likely to occur in the Fringe Management Area, and 13 of the groundwater-dependent special status species are likely to occur in the Upland Management Area.

Table 4. Groundwater-dependence of special-status terrestrial and aquatic wildlife species with potential to occur or suitable habit in the Livermore Valley Groundwater Basin.

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in the Livermore Valley Groundwater Basin[2]**	**Documented occurrence location**	**Query source[3]**	**GDE . association[4]**	**Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin**
Invertebrates						
Longhorn fairy shrimp *Branchinecta longiantenna*	FE/–	Likely	Main, Fringe, Uplands	CNDDB, CAFSD	No known reliance on groundwater	Vernal pools; also found in sandstone rock outcrop pools, grass-bottomed pools, and claypan pools.
Vernal pool fairy shrimp *Branchinecta lynchi*	FT/–	Likely (critical habitat)	Fringe	CNDDB, CAFSD	No known reliance on groundwater	Vernal pools; also found in sandstone rock outcrop pools. The Livermore Valley Groundwater Basin includes 1,337 acres of USFWS designated critical habitat.
Crotch bumble bee *Bombus crotchii*	–/SCE	Likely	Fringe, Uplands	CNDDB	No known reliance on groundwater	Inhabits open grassland and scrub habitats in Coastal California east towards the Sierra-Cascade Crest. Nests are often located underground in abandoned rodent burrows, or above ground in tufts of grass, rock piles, or tree cavities.
Western bumble bee *Bombus occidentalis*	–/SCE	Likely	Fringe, Uplands	CNDDB	No known reliance on groundwater	Uses flowering plants in meadows and forested openings; abandoned rodent burrows are used for nest and hibernation sites for queens.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the Livermore Valley Groundwater Basin[2]	Documented occurrence location	Query source[3]	GDE . association[4]	Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin
Amphibian						
California red-legged frog *Rana draytonii*	FT/SSC	Likely (Critical Habitat)	Main, Fringe, Uplands	CNDDB, CAFSD	Direct	Breeds in still or slow-moving water with emergent and overhanging vegetation, including wetlands, wet meadows, ponds, lakes, and low-gradient, slow moving stream reaches with permanent pools; uses adjacent uplands for dispersal and summer retreat. Relies on surface water that may be supported by groundwater (Rohde et al. 2019). The Livermore Valley Groundwater Basin includes 7,273 acres of USFWS designated critical habitat.
California tiger salamander *Ambystoma californiense*	FT/ST	Likely (Critical Habitat)	Fringe, Uplands	CNDDB, CAFSD	No known reliance on groundwater	Grassland, oak savannah, or edges of woodland that provide subterranean refuge (typically mammal burrows); breeds in nearby temporary ponds, vernal pools, or slow-moving parts of streams. The Livermore Valley Groundwater Basin includes 0.5 acres of USFWS designated critical habitat.
Foothill yellow-legged frog *Rana boylii*	BLMS/SE	Likely	Main, Uplands	CNDDB	Direct	Shallow tributaries and mainstems of perennial streams and rivers, typically associated with cobble or boulder substrate; occasionally found in isolated pools, vegetated backwaters, and deep, shaded, spring-fed pools. The frog is reliant on surface water that may be fed by groundwater.
Western spadefoot *Spea hammondii*	BLMS/SSC	Likely	Fringe, Uplands	CNDDB, CAFSD	No known reliance on groundwater	Areas with sparse vegetation and/or short grasses in sandy or gravelly soils; primarily in washes, river floodplains, alluvial fans, playas, alkali flats, among grasslands, chaparral, or pine-oak woodlands; breeds in ephemeral rain pools with no predators.

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in the Livermore Valley Groundwater Basin[2]**	**Documented occurrence location**	**Query source[3]**	**GDE . association[4]**	**Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin**
Reptile						
Alameda whipsnake *Masticophis lateralis euryxanthus*	FT/ST	Likely (Critical Habitat)	Uplands	CNDDB	Indirect	Chaparral (northern coastal sage scrub and coastal sage) and rocky outcrops; may venture into adjacent habitats, including grassland, oak savanna, and woodlands. Relies on native vegetation that may be groundwater dependent vegetation (e.g., *Quercas* spp.) (Rohde et al. 2019). The Livermore Valley Groundwater Basin includes 936 acres of USFWS designated critical habitat.
Coast horned lizard *Phrynosoma blainvillii*	BLMS/SSC	Likely	Main, Fringe	CNDDB	No known reliance on groundwater	Open areas with sandy soil and/or patches of loose soil and low/scattered vegetation in scrublands, grasslands, conifer forests, and woodlands; frequently found near ant hills. Feeds on ants and other small invertebrates (e.g., spiders, beetles, and grasshoppers).
Northern California legless lizard *Anniella pulchra*	–/SSC	Possible	Outside of basin	CNDDB	No known reliance on groundwater	Occurs in moist, warm, loose soil with plant cover and in sparsely vegetated areas of chaparral, pine-oak woodlands, desert scrub, and stream terraces with sycamores, cottonwoods, or oaks. Forages in loose soil, sand, and leaf litter for larval insects, beetles, termites, and spiders.
San Joaquin coachwhip *Masticophis flagellum ruddocki*	–/SSC	Likely	Uplands	CNDDB	No known reliance on groundwater	Open, dry, treeless areas, including grassland and saltbush scrub; uses rodent burrows, shaded vegetation, and surface objects as refuge.
Southwestern pond turtle *Actinemys pallida*	BLMS/SSC	Likely	Main, Fringe, Uplands	CNDDB, CAFSD	Direct	Ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with basking sites. Feeds on aquatic plants, invertebrates, worms, frog and salamander eggs and larvae, crayfish, and occasionally frogs and fish. Relies on surface water that may be supported by groundwater (Rhode et al. 2019).

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the Livermore Valley Groundwater Basin[2]	Documented occurrence location	Query source[3]	GDE . association[4]	Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin
Bird						
American peregrine falcon *Falco peregrinus anatum*	–/SFP	Likely	Main, Fringe, Uplands	CNDDB, eBird	No known reliance on groundwater	Wetlands, woodlands, cities, agricultural lands, and coastal area with cliffs (and rarely broken-top, predominant trees) for nesting; often forages near water. Prey includes birds (e.g., shorebirds, ducks, grebes, gulls, pigeons, and songbird) and bats.
American White Pelican *Pelecanus erythrorhynchos*	–/SSC	Likely	Main, Fringe, Uplands	CAFSD, eBird	Indirect	Salt ponds, large lakes, and estuaries; loafs on open water during the day; roosts along water's edge at night. Forages for small fish in shallow water on inland marshes.
Bald eagle *Haliaeetus leucocephalus*	BGEPA, BLMS/SE, SFP	Likely	Main, Fringe, Uplands	CNDDB, CAFSD, eBird	Indirect	Large bodies of water or rivers with abundant fish, uses snags or other perches; nests in advanced-successional conifer forest near open water (e.g., lakes, reservoirs, rivers). Bald eagles are reliant on surface water that may be supported by groundwater and/or groundwater-dependent vegetation (Rhode et al. 2019).
Burrowing owl *Athene cunicularia*	BLMS/SSC	Likely	Main, Fringe, Uplands	CNDDB	No known reliance on groundwater	Level, open, dry, heavily grazed or low-stature grassland or desert vegetation with available burrows. Preys on invertebrates and vertebrates.
Golden eagle *Aquila chrysaetos*	BGEPA, BLMS/SFP	Likely	Main, Fringe, Uplands	CNDDB, eBird	No known reliance on groundwater	Open woodlands and oak savannahs, grasslands, chaparral, sagebrush flats; nests on steep cliffs or medium to tall trees. Primary prey are small to medium mammals and birds; also scavenges and catches fish.
Grasshopper sparrow *Ammodramus savannarum*	–/SSC	Likely	Main, Uplands	CNDDB	No known reliance on groundwater	Grasslands. Ground forager that feeds on insects, including grasshoppers.

Common name ***Scientific name***	**Status[1] Federal/State**	**Potential to occur in the Livermore Valley Groundwater Basin[2]**	**Documented occurrence location**	**Query source[3]**	**GDE . association[4]**	**Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin**
Loggerhead shrike *Lanius ludovicianus*	–/SSC	Likely	Main, Fringe, Uplands	CNDDB, eBird	No known reliance on groundwater	Open shrubland or woodlands with short vegetation and and/or bare ground for hunting; some tall shrubs, trees, fences, or power lines for perching; typically nests in isolated trees or large shrubs. Feeds on insects, amphibians, reptiles, small mammals, and birds.
Redhead *Aythya americana*	–/SSC	Likely	Main, Fringe, Uplands	CAFSD, eBird	Indirect	Freshwater emergent wetlands with dense stands of cattails (*Typha* spp.) and bulrush (*Schoenoplectus* spp.) interspersed with areas of deep, open water; forages and rests on large, deep bodies of water. Summer resident in southern California.
Swainson's hawk *Buteo swainsoni*	–/ST	Likely	Main, Fringe, Uplands	CNDDB, eBird	Indirect	Nests in oaks or cottonwoods in or near riparian habitats; forages in grasslands, irrigated pastures, and grain fields. Swainson's hawks rely on groundwater-dependent vegetation in riparian woodland areas for nesting (Rohde et al 2019). Preys on mammals and insects.
Tricolored blackbird *Agelaius tricolor*	–/ST	Likely	Main, Fringe, Uplands	CNDDB, CAFSD, eBird	Indirect	Feeds in grasslands and agriculture fields; nesting habitat components include open accessible water with dense, tall emergent vegetation, a protected nesting substrate (including flooded or thorny vegetation), and a suitable nearby foraging space with adequate insect prey.
White-tailed kite *Elanus leucurus*	BLMS/SFP	Likely	Main, Fringe, Uplands	CNDDB, eBird	Indirect	Lowland grasslands and wetlands with open areas; nests in trees near open foraging area. Predominately preys on small mammals, but its diet also includes birds and lizards.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the Livermore Valley Groundwater Basin[2]	Documented occurrence location	Query source[3]	GDE . association[4]	Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin
Willow Flycatcher *Empidonax traillii*	–/SE	Likely	Main, Uplands	CAFSD, eBird	Indirect	Dense brushy thickets within riparian woodland often dominated by willows and/or alder, near permanent standing water. Reliant on groundwater-dependent riparian vegetation, including for nest sites that are typically located near slow-moving streams, or side channels and marshes with standing water and/or wet soils (Rohde et al 2019). Feeds on insects, fruits, and berries.
Mammals						
American badger *Taxidea taxus*	–/SSC	Likely	Fringe, Uplands	CNDDB	No known reliance on groundwater	Shrubland, open grasslands, fields, and alpine meadows with friable soils.
Pallid bat *Antrozous pallidus*	BLMS/SSC	Likely	Fringe, Main, Uplands	CNDDB	No known reliance on groundwater	Roosts in rock crevices, tree hollows, mines, caves, and a variety of vacant and occupied buildings; feeds in a variety of open woodland habitats. Habitat and prey (e.g., insects and arachnids) not associated with aquatic ecosystems.
San Joaquin kit fox *Vulpes macrotis mutica*	FE, BLMS/ST	Likely	Outside of Basin	CNDDB	No known reliance on groundwater	Annual grasslands or open areas dominated by scattered brush, shrubs, and scrub.
San Joaquin pocket mouse *Perognathus inornatus*	BLMS/–	Possible	Outside of Basin	CNDDB	Indirect	Open grasslands, savanna, and desert shrub communities; often in areas with sandy washes and finely textured soils. Birthing dens are in burrows near the base of shrubs. Predominantly granivorous, eating seeds of annual and perennial grasses, shrubs, and forbs. Also feeds on soft-bodied insects, cutworms, earthworms, and even grasshoppers.

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in the Livermore Valley Groundwater Basin[2]	Documented occurrence location	Query source[3]	GDE . association[4]	Habitat and documented occurrences in Livermore Valley Groundwater Basin Groundwater Basin
Townsend's big-eared bat *Corynorhinus townsendii*	BLMS/SSC	Likely	Main, Uplands	CNDDB	Indirect	Most abundant in mesic habitats, also found in oak woodlands, desert, vegetated drainages, caves or cave-like structures (including basal hollows in large trees, mines, tunnels, and buildings) and riparian communities. Feeds on moths, beetles, and soft-bodied insects and drinks water.
Yuma myotis *Myotis yumanensis*	BLMS/–	Likely	Main, Uplands	CNDDB	Indirect	Uses a variety of habitats, including riparian, agriculture, shrub, urban, desert, open forests, and woodlands. Distribution is strongly associated with water; drinks water and forages near or over waterbodies.

[1] **Status codes:**

Federal
FE = Listed as endangered under the federal Endangered Species Act
FT = Listed as threatened under the federal Endangered Species Act
FPE = Federally proposed as endangered
BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
BLMS = Bureau of Land Management Sensitive Species

State
SE = Listed as Endangered under the California Endangered Species Act
ST = Listed as Threatened under the California Endangered Species Act
SCE = State Candidate Endangered
SSC = CDFW Species of Special Concern
SFP = CDFW Fully Protected species

[2] **Potential to Occur:**
Likely: the species *has* documented occurrences and the habitat is high quality or quantity
Possible: no documented occurrences and the species' required habitat is moderate to high quality or quantity
Unlikely: no documented occurrences and the species' required habitat is of low to moderate quality or quantity

[3] **Query source:**
CAFSD: California Freshwater Species Database (TNC 2021)
CNDDB: California Natural Diversity Database (CDFW 2020a)
eBird: (eBird 2021)

[4] **Groundwater Dependent Ecosystem (GDE) association:**
Direct: Species directly dependent on groundwater for some or all water needs
Indirect: species dependent upon other species that rely on groundwater for some or all water needs (e.g., riparian birds).
No known reliance on groundwater: Species is not known to rely on groundwater. For species associated with vernal pools, it is assumed that the seasonal water in the vernal pools originates from rainfall rather than groundwater.

4 SUMMARY

In the Livermore Valley Groundwater Basin, likely GDEs occur in all three management areas. Likely GDEs in the Main Basin Management Area typically occur along riparian zones along major channels (e.g., Arroyo Valle, Arroyo Mocho, and Arroyo Las Positas). Likely GDEs in the Fringe Management Area include riparian vegetation (willows and cottonwoods) and alkaline-tolerant plants that occur along spring-fed channels and wetlands in Springtown Alkali Sink in the northeast corner of the basin. Likely GDEs in the Upland Management Area occur in riparian zones along smaller tributaries.

Twelve special status plants identified in the basin are likely dependent on groundwater. Groundwater dependent special-status plant species occur primarily in the Fringe and Upland Management Areas. There are 14 groundwater dependent special-status wildlife species likely to occur in the basin. Groundwater dependent special-status wildlife are likely to occur in all three management areas.

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Zone 7. 2020. Spring 2019 depth to groundwater contours for the Main Basin and Fringe Area in the Livermore Valley Groundwater Basin.

Attachment C: Surface Water Bodies and Monitoring Sites

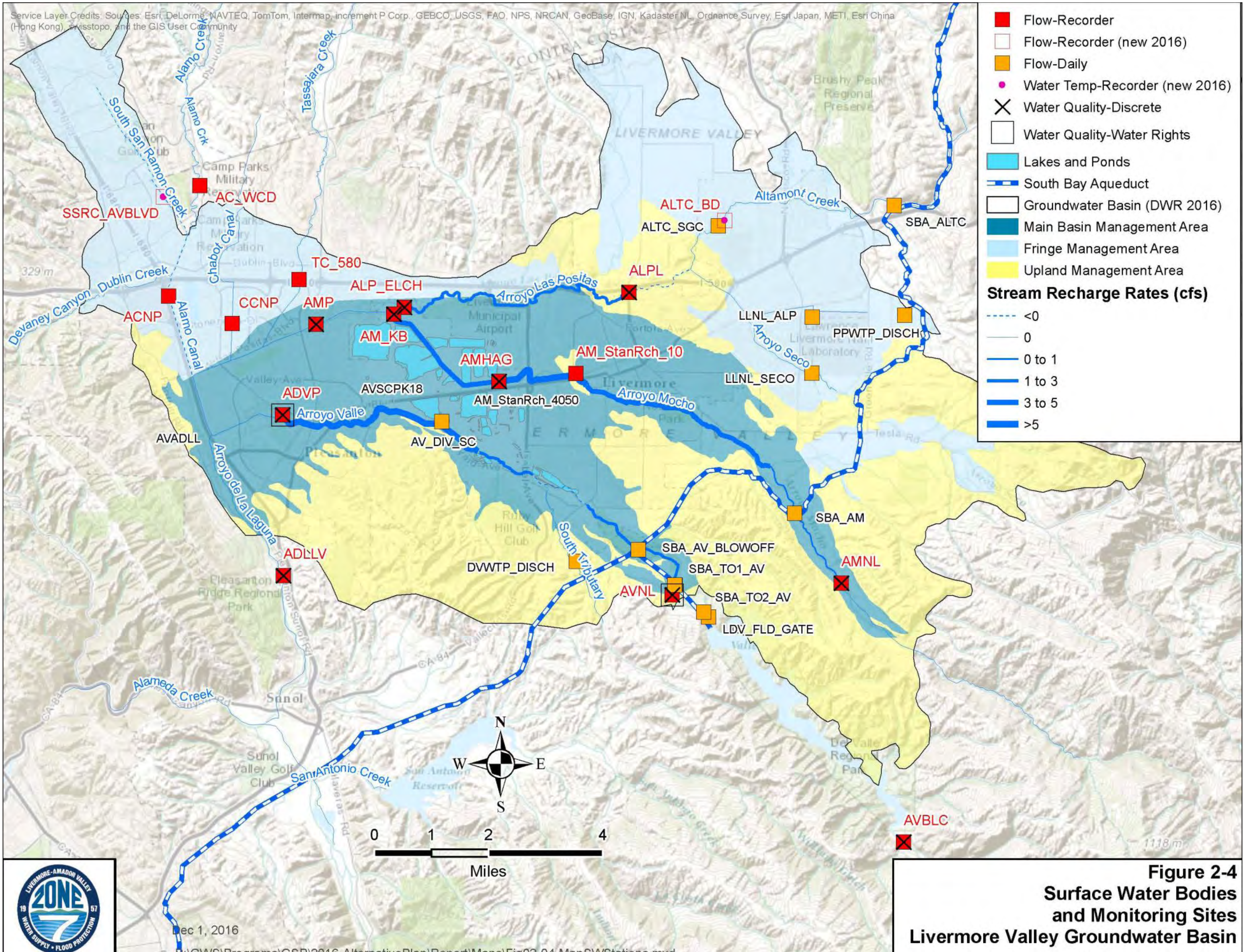
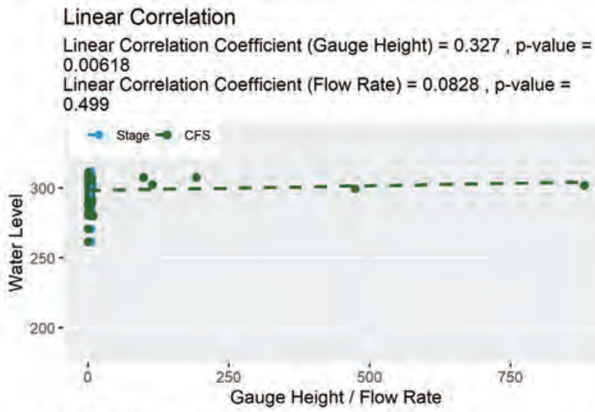


Figure 2-4
Surface Water Bodies and Monitoring Sites
Livermore Valley Groundwater Basin

Attachment D: Time Series Data and Correlation Plots by Stream Station


Linear Correlation
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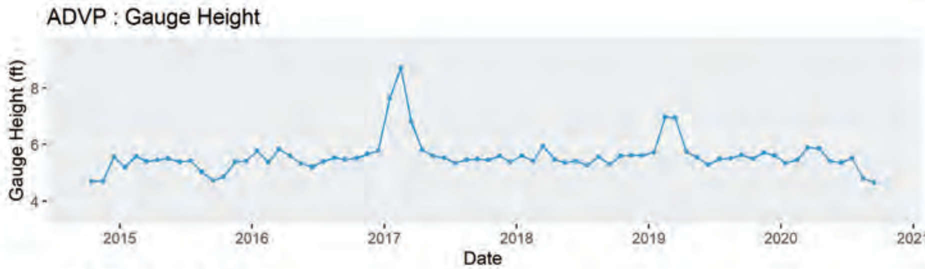
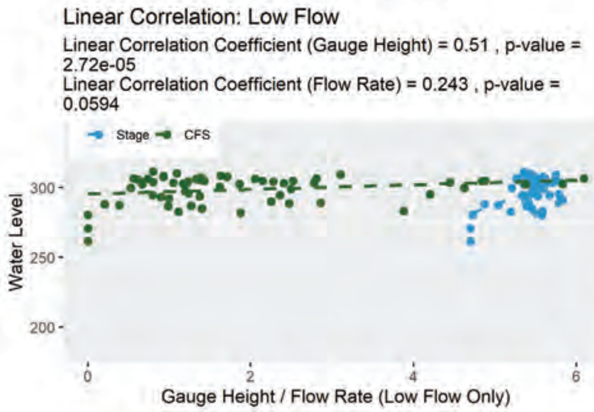
Stage
CFS
Water Level
Gauge Height / Flow Rate


ADVP : Gauge Height
Gauge Height (ft)
Date


ADVP : Flow Rate
Flow (cfs)
Date


Linear Correlation: Low Flow
Linear Correlation Coefficient (Gauge Height) = 0.51 , p-value = 2.72e-05
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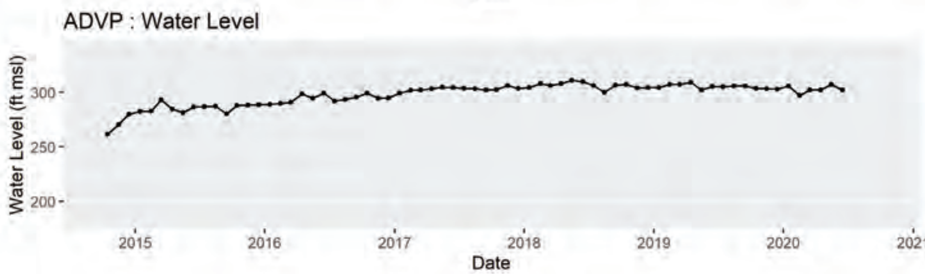
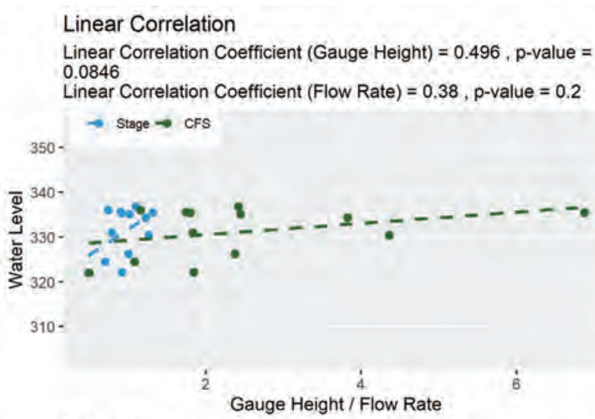
Stage
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)


ADVP : Water Level
Water Level (ft msl)
Date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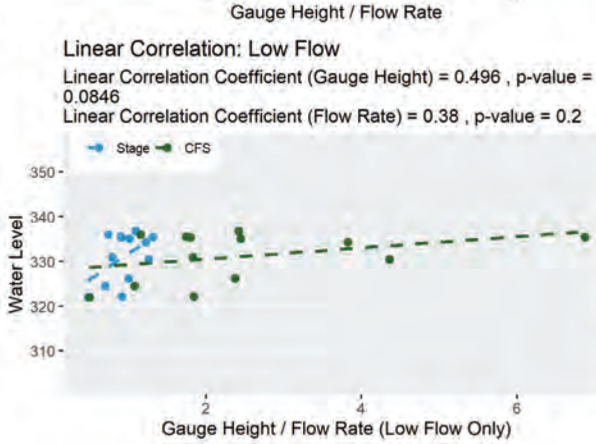
Linear Correlation Coefficient (Flow Rate) = 0.38 , p-value = 0.2
Stage
CFS
Water Level
Gauge Height / Flow Rate


ALP_ELCH : Gauge Height
Gauge Height (ft)
Date


ALP_ELCH : Flow Rate
Flow (cfs)
Date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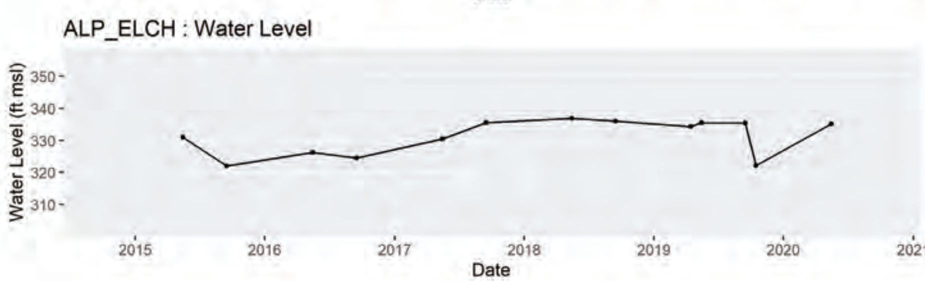
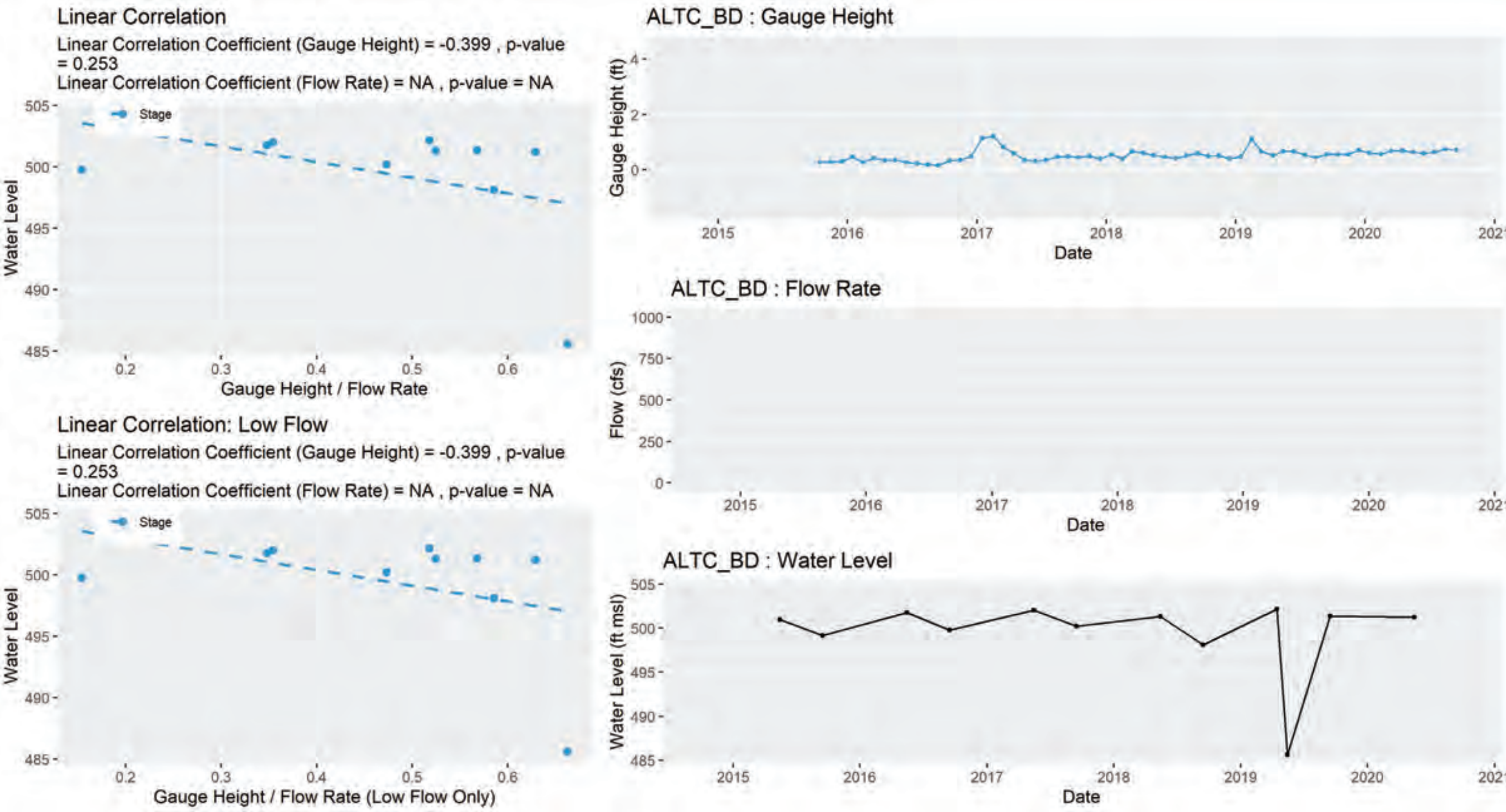
Stage
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)


ALP_ELCH : Water Level
Water Level (ft msl)
Date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Stage
Water Level
Gauge Height / Flow Rate
Linear Correlation: Low Flow
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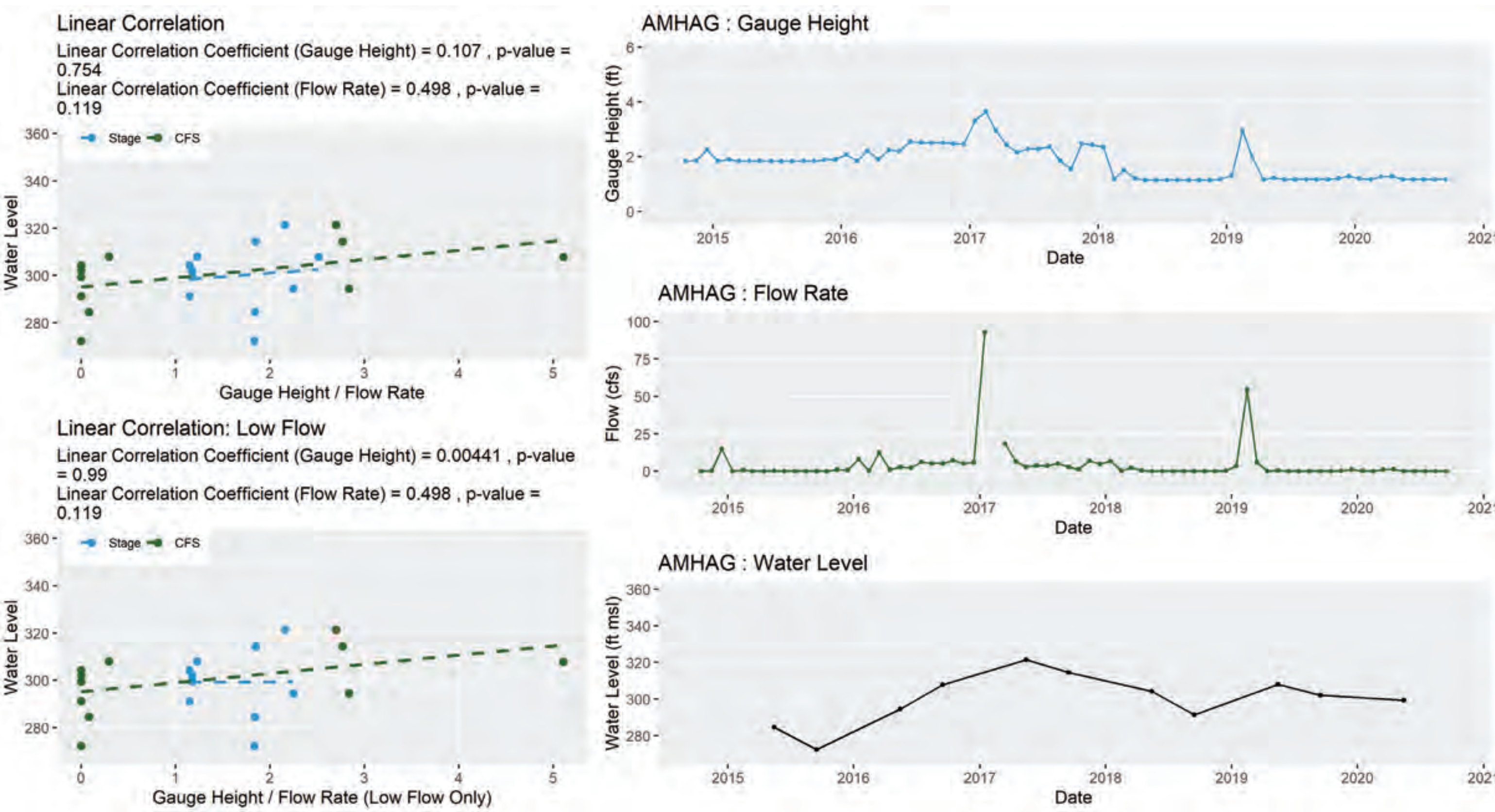
Linear Correlation Coefficient (Flow Rate) = NA , p-value = NA
Stage
Water Level
Gauge Height / Flow Rate (Low Flow Only)
ALTC_BD : Gauge Height
Gauge Height (ft)
Date
ALTC_BD : Flow Rate
Flow (cfs)
Date
ALTC_BD : Water Level
Water Level (ft msl)
Date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Stage
CFS
Water Level
Gauge Height / Flow Rate
Linear Correlation: Low Flow
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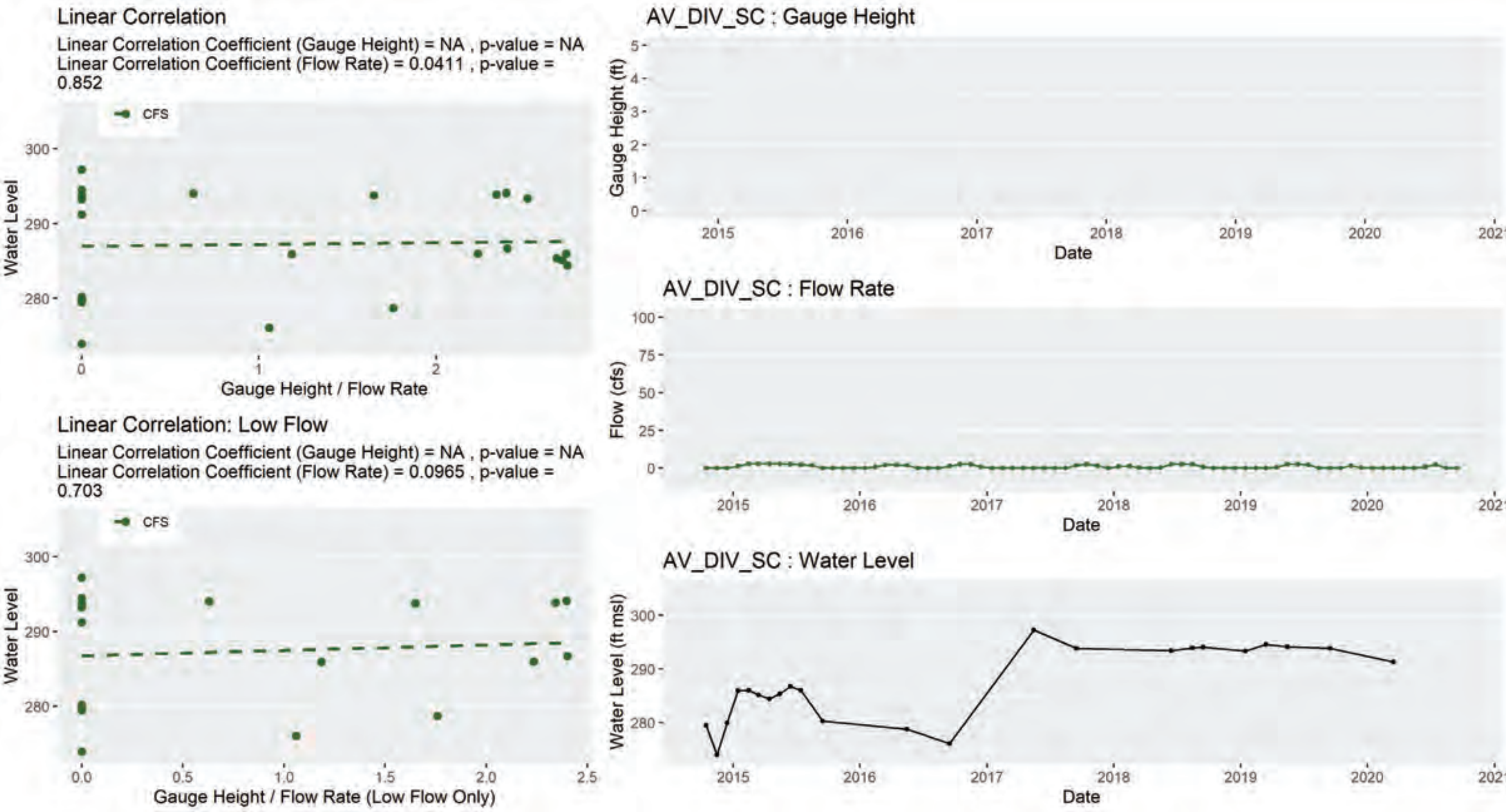
Linear Correlation Coefficient (Flow Rate) = 0.498 , p-value = 0.119
Stage
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)
AMHAG : Gauge Height
Gauge Height (ft)
Date
AMHAG : Flow Rate
Flow (cfs)
Date
AMHAG : Water Level
Water Level (ft msl)
Date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CFS
Water Level
Gauge Height / Flow Rate
Linear Correlation: Low Flow
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Linear Correlation Coefficient (Flow Rate) = 0.0965 , p-value = 0.703
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)
AV_DIV_SC : Gauge Height
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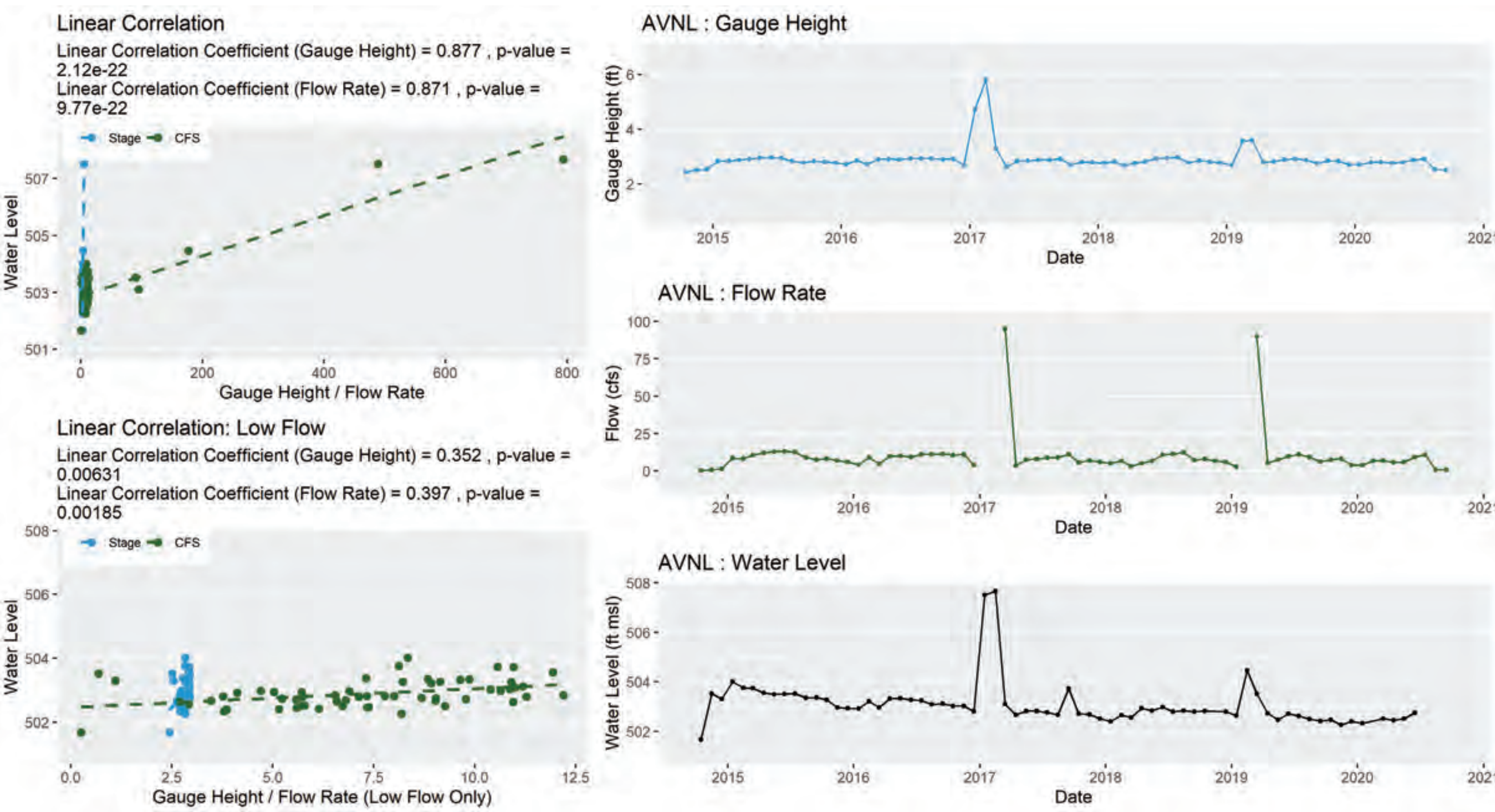
Date
AV_DIV_SC : Flow Rate
Flow (cfs)
Date
AV_DIV_SC : Water Level
Water Level (ft msl)
Date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Linear Correlation Coefficient (Flow Rate) = 0.871 , p-value = 9.77e-22
Stage
CFS
Water Level
Gauge Height / Flow Rate
Linear Correlation: Low Flow
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Linear Correlation Coefficient (Flow Rate) = 0.397 , p-value = 0.00185
Stage
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)
AVNL : Gauge Height
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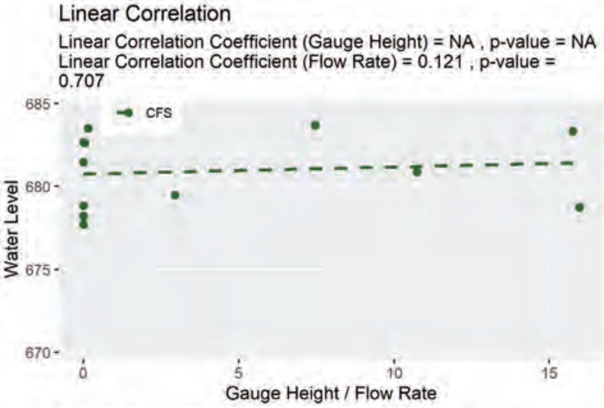
Date
AVNL : Flow Rate
Flow (cfs)
Date
AVNL : Water Level
Water Level (ft msl)
Date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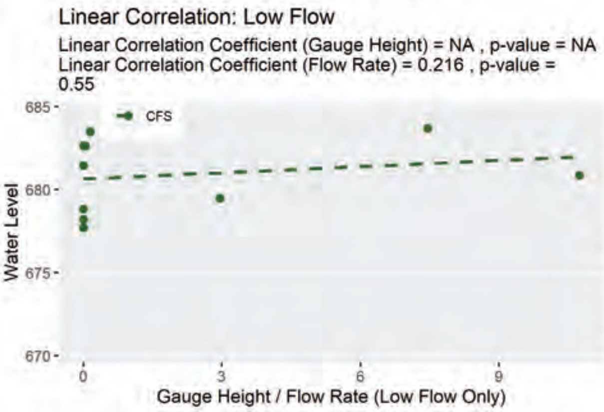
CFS
Water Level
Gauge Height / Flow Rate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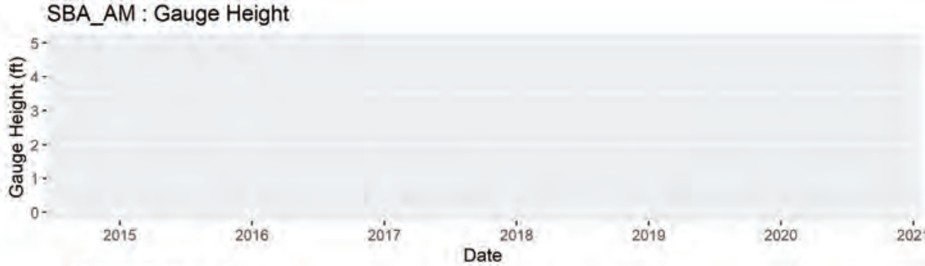
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)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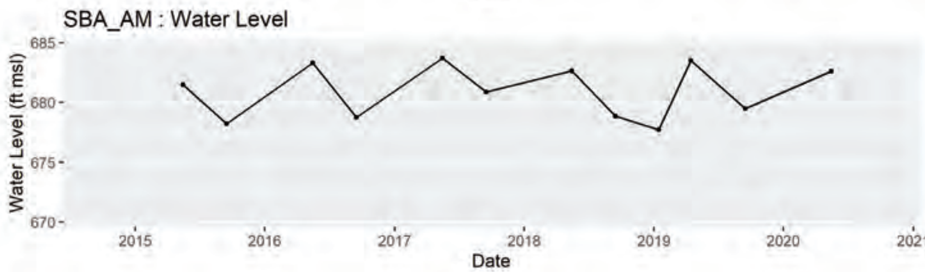
Gauge Height (ft)
Date


SBA_AM : Flow Rate
Flow (cfs)
Date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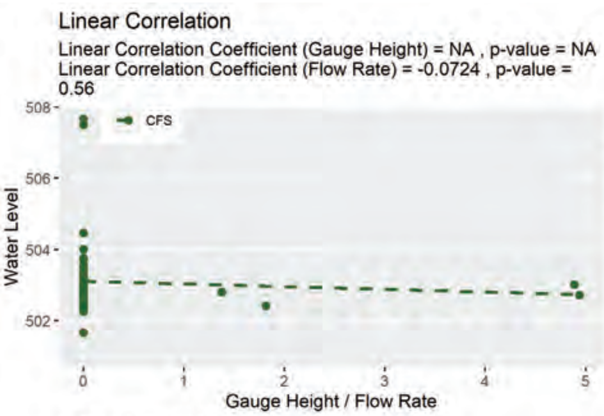
Water Level (ft msl)
Date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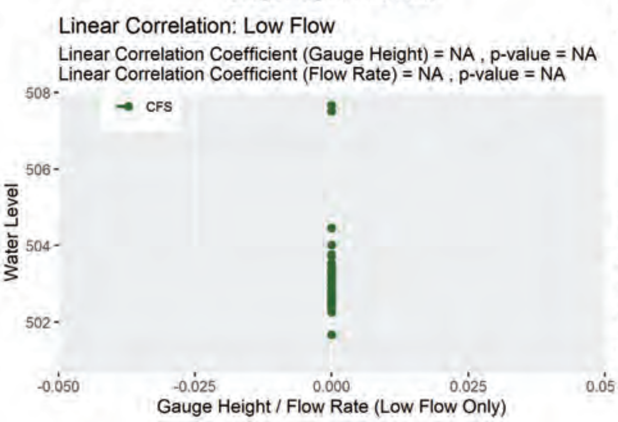
CFS
Water Level
Gauge Height / Flow Rate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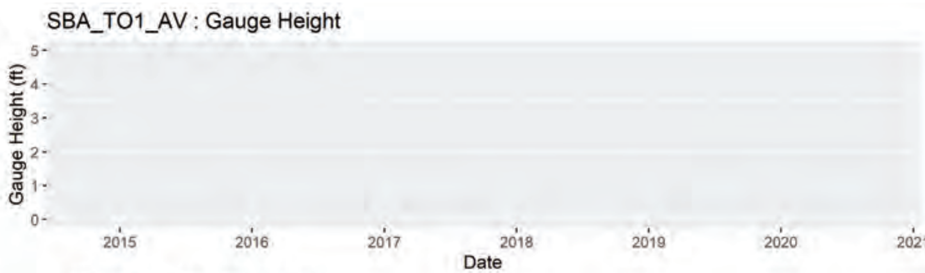
CFS
Water Level
Gauge Height / Flow Rate (Low Flow Only)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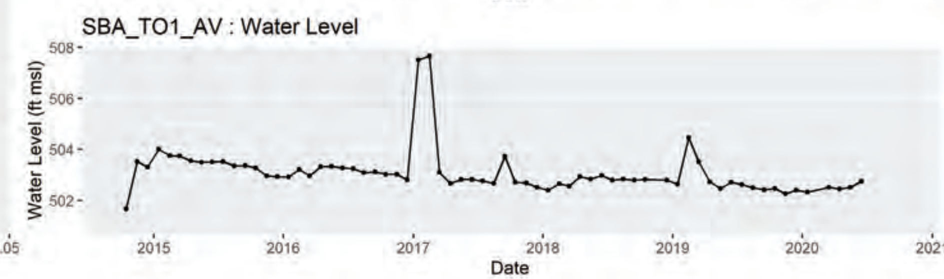
Gauge Height (ft)
Date


SBA_TO1_AV : Flow Rate
Flow (cfs)
Date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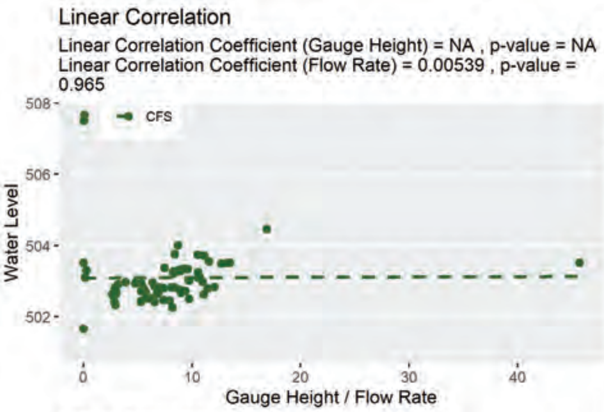
Water Level (ft msl)
Date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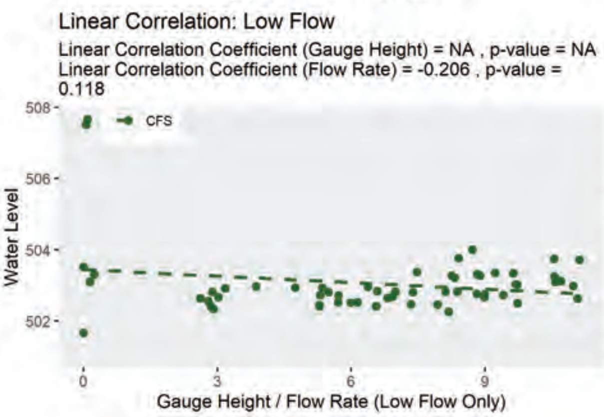
CFS
Water Level
Gauge Height / Flow Rate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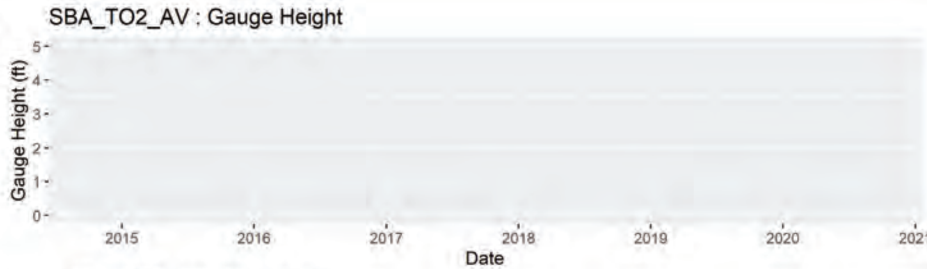
Water Level
Gauge Height / Flow Rate (Low Flow Only)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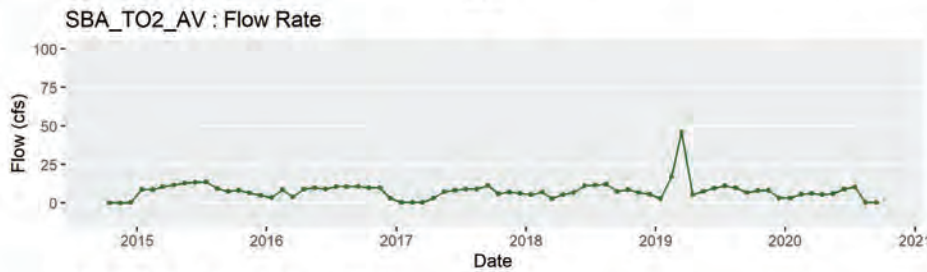
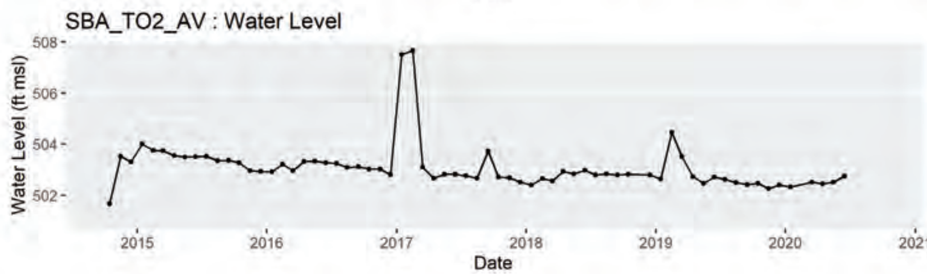
Gauge Height (ft)
Date


SBA_TO2_AV : Flow Rate
Flow (cfs)
Date


SBA_TO2_AV : Water Level
Water Level (ft msl)
Date

Attachment E: Change in GDE Area Analysis

Change in GDE Area Analysis

Normalized Derived Vegetation Index (NDVI) is the most widely used vegetation metric in the literature and is a reliable measure of the photosynthetic chlorophyll content in leaves and vegetation cover.[1] The Nature Conservancy (TNC) Groundwater Dependent Ecosystem (GDE) Pulse calculated annual NDVI from surface reflectance corrected multispectral Landsat imagery, and applied a linear fit to the NDVI time series data to estimate the NDVI trends over specific timespan of interest. The NDVI trends can be viewed on the TNC GDE Pulse website (https://gde.codefornature.org/#/map).

Since NDVI is used to estimate vegetation greenness and provides a proxy for vegetation growth, change in GDE area can be estimated using TNC GDE Pulse raster data that shows the NDVI trends between 2014 and 2018.[2,3] Moderate to large increases in NDVI trends represent an increase in the GDE area and moderate to large decreases in NDVI trends represent a decrease in the GDE area. Therefore, the change in GDE area can be estimated by subtracting GDE area with decreasing NDVI trends from GDE area with increasing NDVI trends.

This analysis was performed in ArcGIS.[4] The statewide raster data that show NDVI trends between 2014 and 2018 were clipped using the likely GDEs' polygon within the Livermore Valley Groundwater Basin (Basin). Raster values of zero mean no change in NDVI trends. Positive and negative raster values mean increasing and decreasing NDVI trends respectively. For the purpose of this analysis, raster values that range from -628 to 628 were assumed to represent little or no change in NDVI trends.[5] For each likely GDE area within the Basin, the total number of raster pixels that fall within the GDE polygon boundary, the number of pixels that show increasing NDVI trends, and the number of pixels that show decreasing NDVI trends were summarized, as shown in **Table 1**. Change in area for each likely GDE was then calculated by dividing the difference between the increasing and decreasing NDVI trends' pixel counts by the total pixel count.

Percentages of GDE area reduction in 2014 compared to 2018 by likely GDEs are shown in **Table 1**. Figures included below show the raster data of NDVI trends by likely GDEs within the Basin. Compared to the 2018 GDE area, reductions in GDE area that range from -14% to 63% were observed, with an area weighted average of 40% (i.e., on average the GDE area in 2014 was 40% less than the GDE area in 2018).

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[1] https://gde.codefornature.org/#/methodology

[2] Statewide raster data that show NDVI trends are provided by TNC on 30 August 2021.

[3] Since the Plan is not required to address undesirable results that occurred before, and have not been corrected by January 1, 2015 (Water Code Section 10727.2 (b)(4)), 2014 is selected as the start of the analysis timeframe. 2018 is selected as the end of the analysis timeframe since it is a recent wet year when GDE conditions might be above average.

[4] https://www.esri.com/en-us/arcgis/about-arcgis/overview

[5] The range of -628 to 628 is approximately two percent of the raster values' total range. It was selected by visually comparing raster pixels that fall within this range with the "little or no change" NDVI trend category from the TNC GDE Pulse website. Therefore, raster values larger than 628 represent moderate or large increase in NDVI trends, and raster values smaller than -628 represent moderate or large decreasing in NDVI trends.

Table 1. Change in GDE Area (2014-2018)

Likely GDEs	Total Pixel Count	Pixel Count of Increasing NDVI Trends	Pixel Count of Decreasing NDVI Trends	GDE Area Reduction in 2014 (a)
Arroyo Mocho - Riparian Mixed Hardwood & Sycamore	529	349	33	60%
Arroyo Mocho - Valley Oak	999	185	290	-11%
Arroyo Valle - Riparian Mixed Hardwood	769	527	46	63%
Arroyo Valle - Sycamore Grove	1954	1134	94	53%
Springtown Alkali Sink	971	633	42	61%
Upland - Riparian Mixed Hardwood	210	41	71	-14%
Arroyo Las Positas - Mixed Vegetation	303	88	86	1%
Potential GDEs to be Further Evaluated	203	127	20	53%
Area Weighted Average (%)				**40%**

Abbreviations:

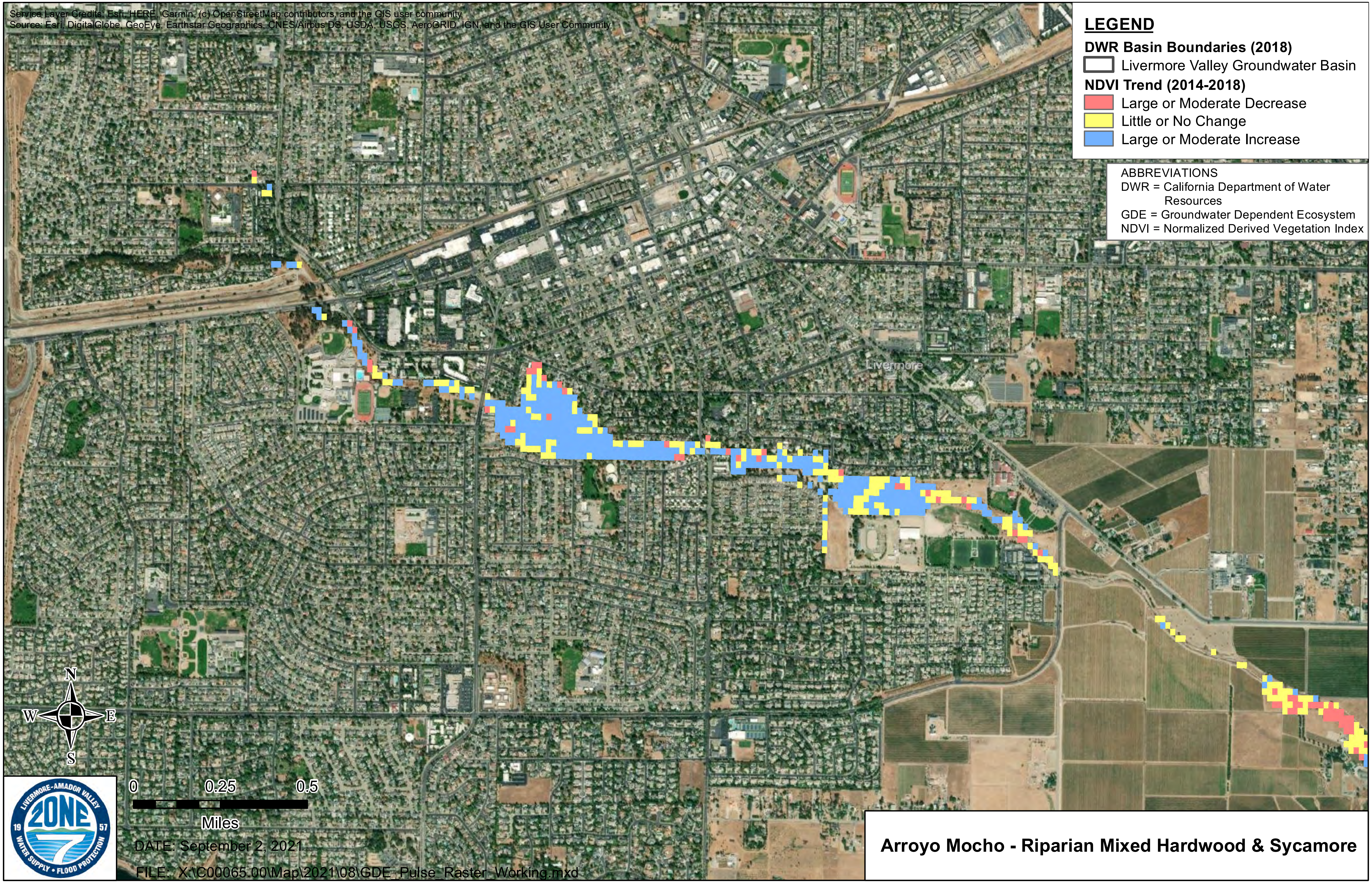
GDE = Groundwater Dependent Ecosystem

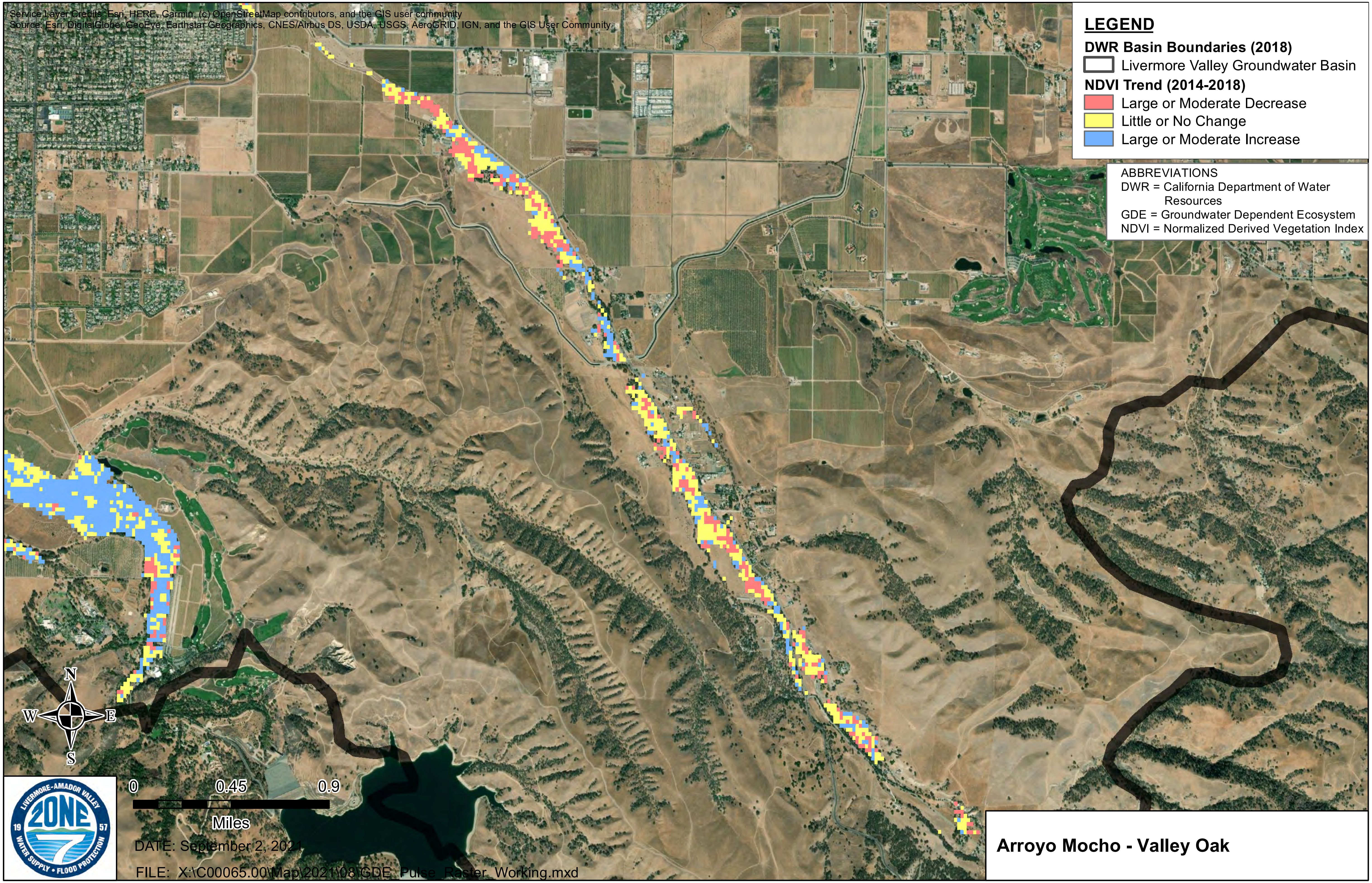
NDVI = Normalized Derived Vegetation Index

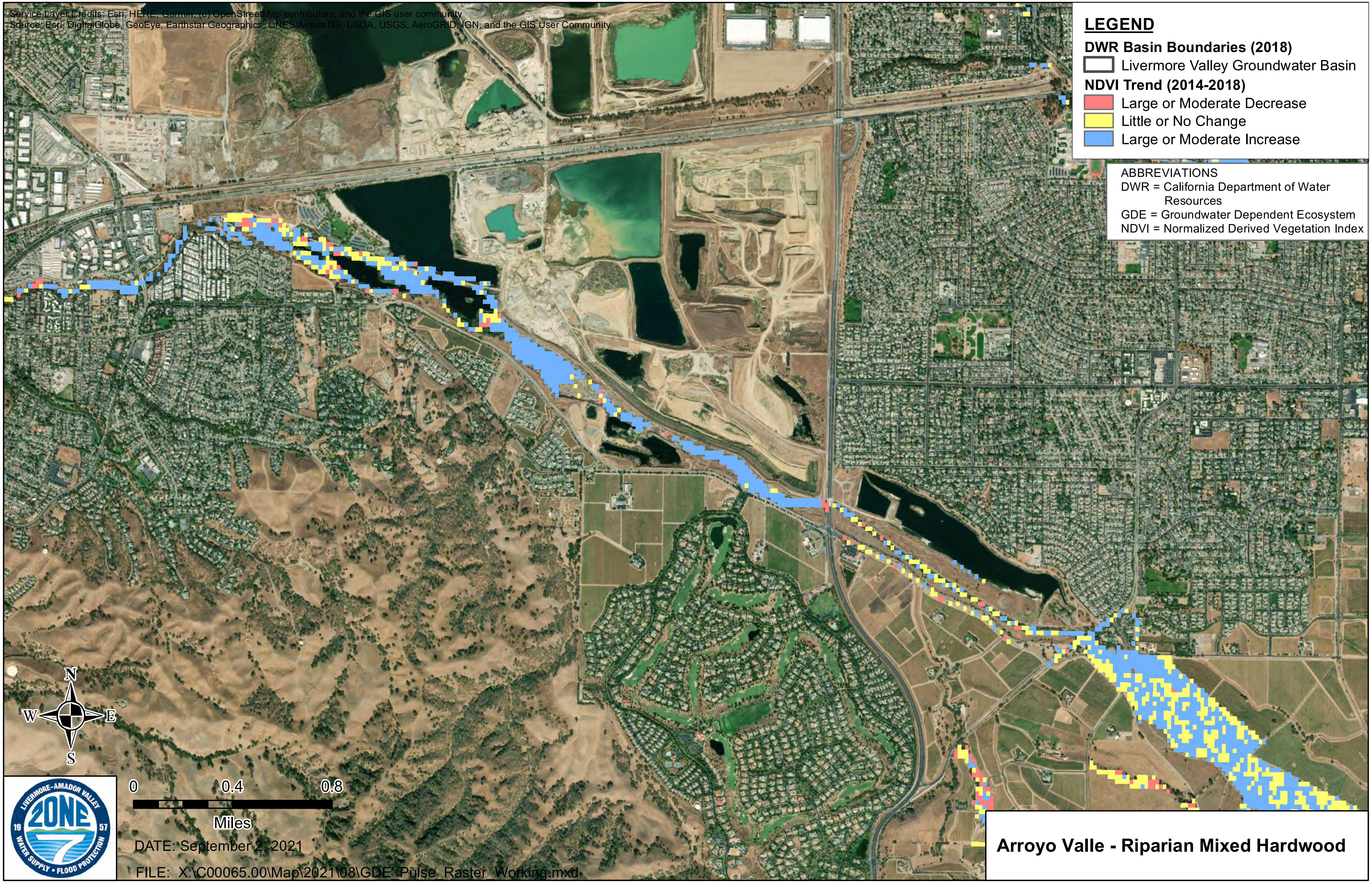
TNC = The Nature Conservancy

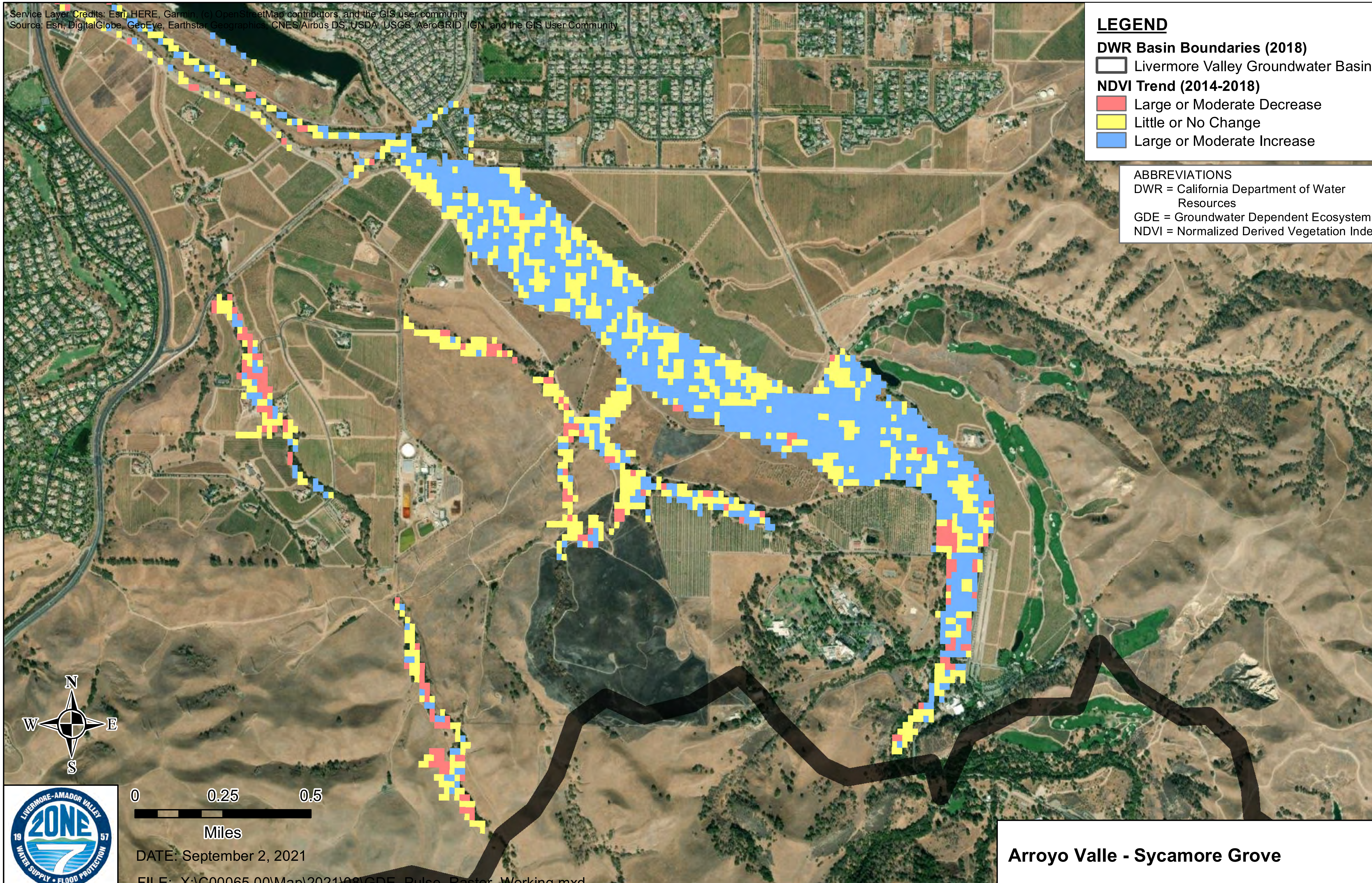
Notes:

(a) Positive percentages represent net reduction in GDE area and negative percentages represent net increase in GDE area in 2014 relative to 2018.

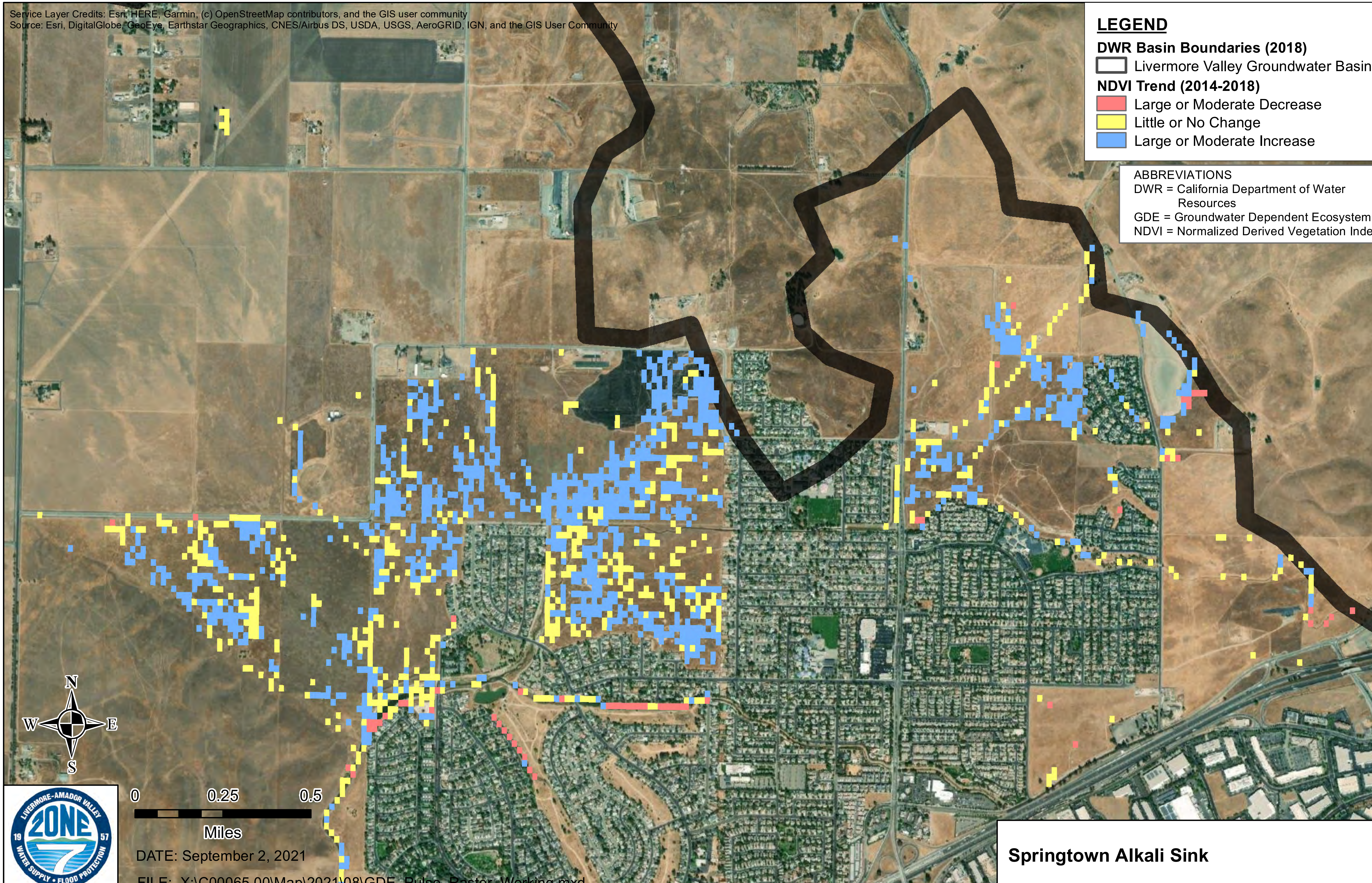

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
Livermore
N
W
E
S
0
0.25
0.5
Miles
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Arroyo Mocho - Riparian Mixed Hardwood & Sycamore


Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
N
W
E
S
0
0.45
0.9
Miles
LIVERMORE-AMADOR VALLEY
ZONE 7
19
57
WATER SUPPLY • FLOOD PROTECTION
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Arroyo Mocho - Valley Oak

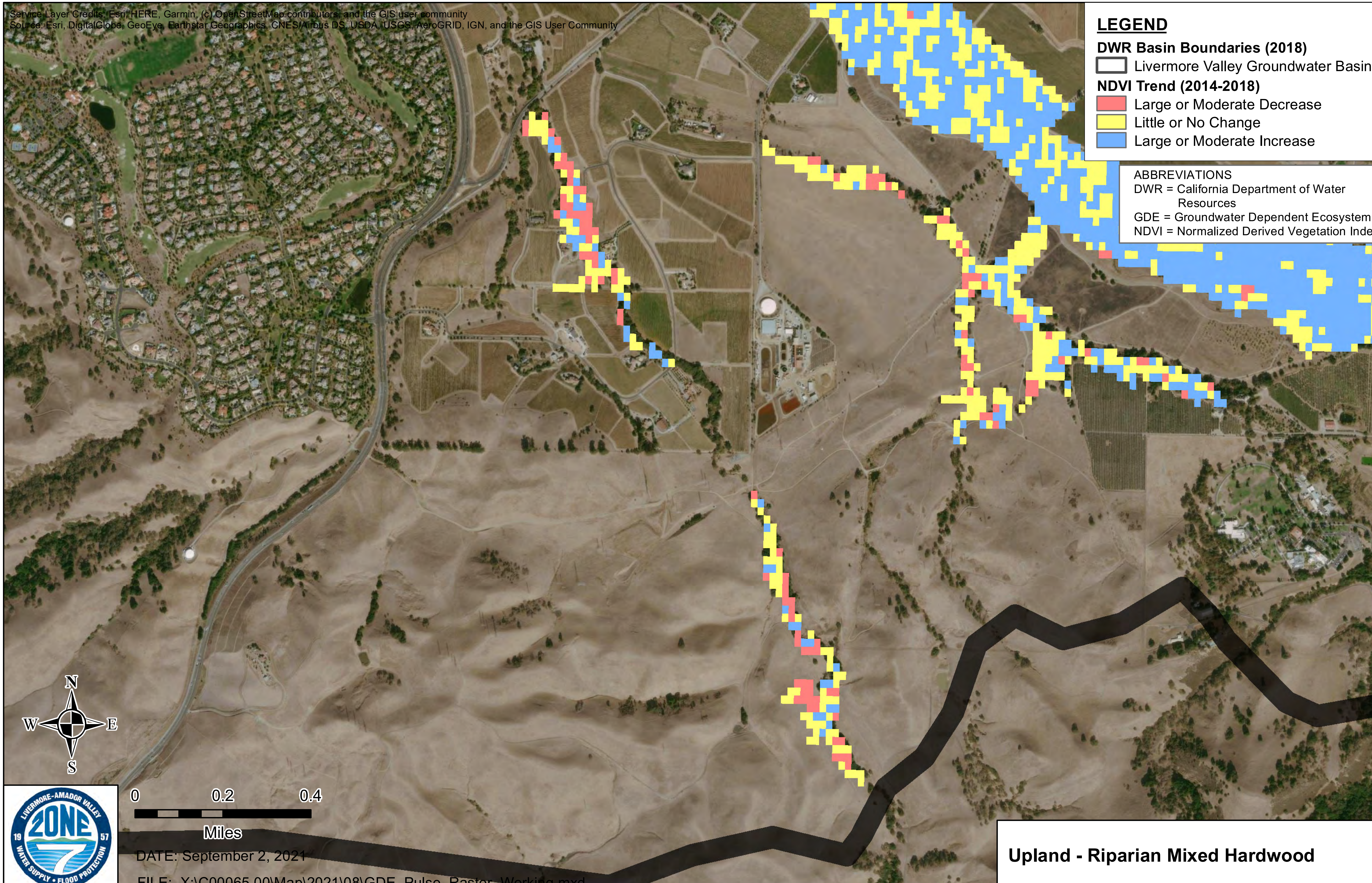

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
N
W
E
S
0
0.4
0.8
Miles
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Arroyo Valle - Riparian Mixed Hardwood



Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
N
W
E
S
0
0.25
0.5
Miles
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Arroyo Valle - Sycamore Grove

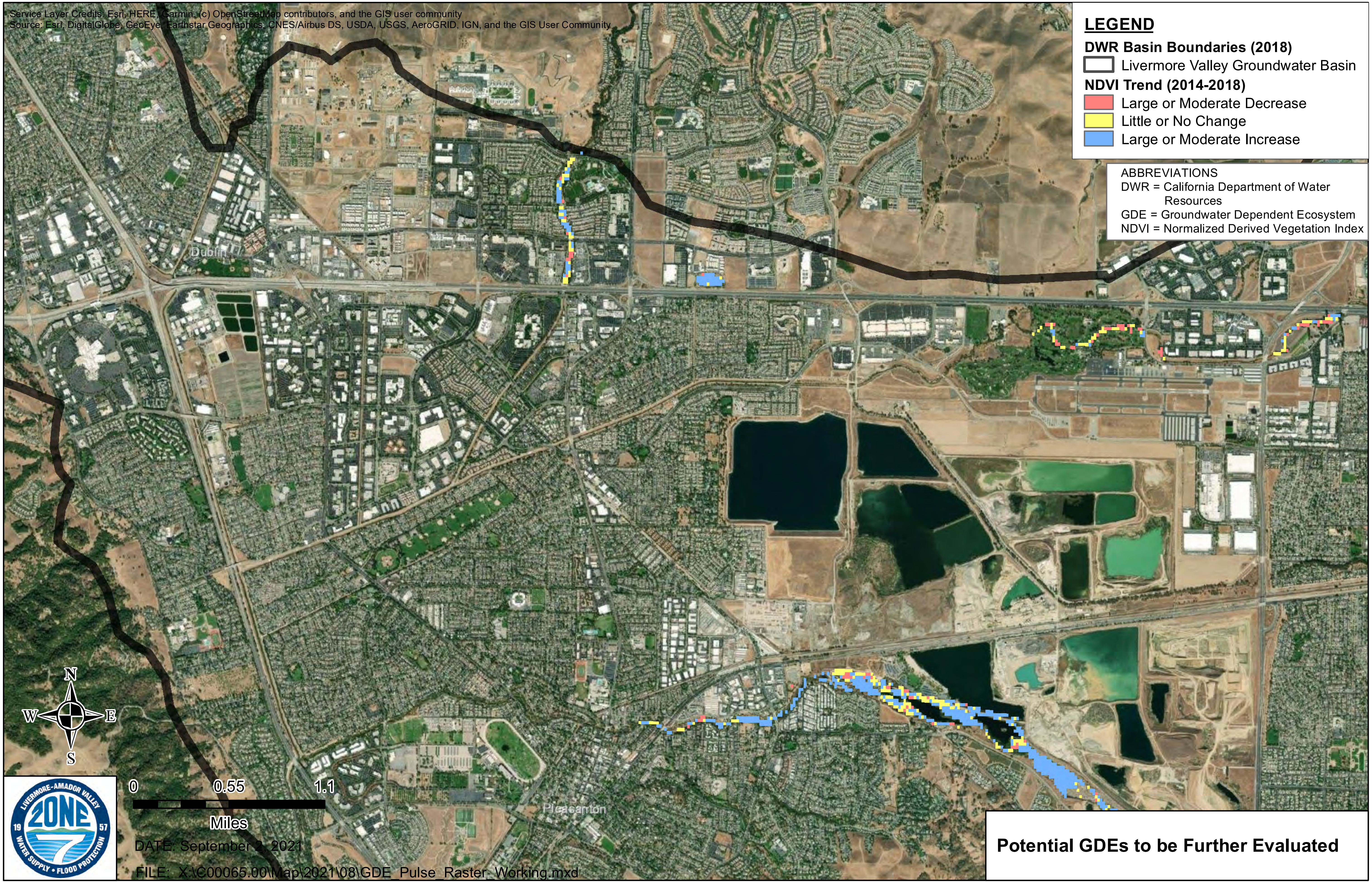


Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
N
W
E
S
0
0.25
0.5
Miles
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Springtown Alkali Sink

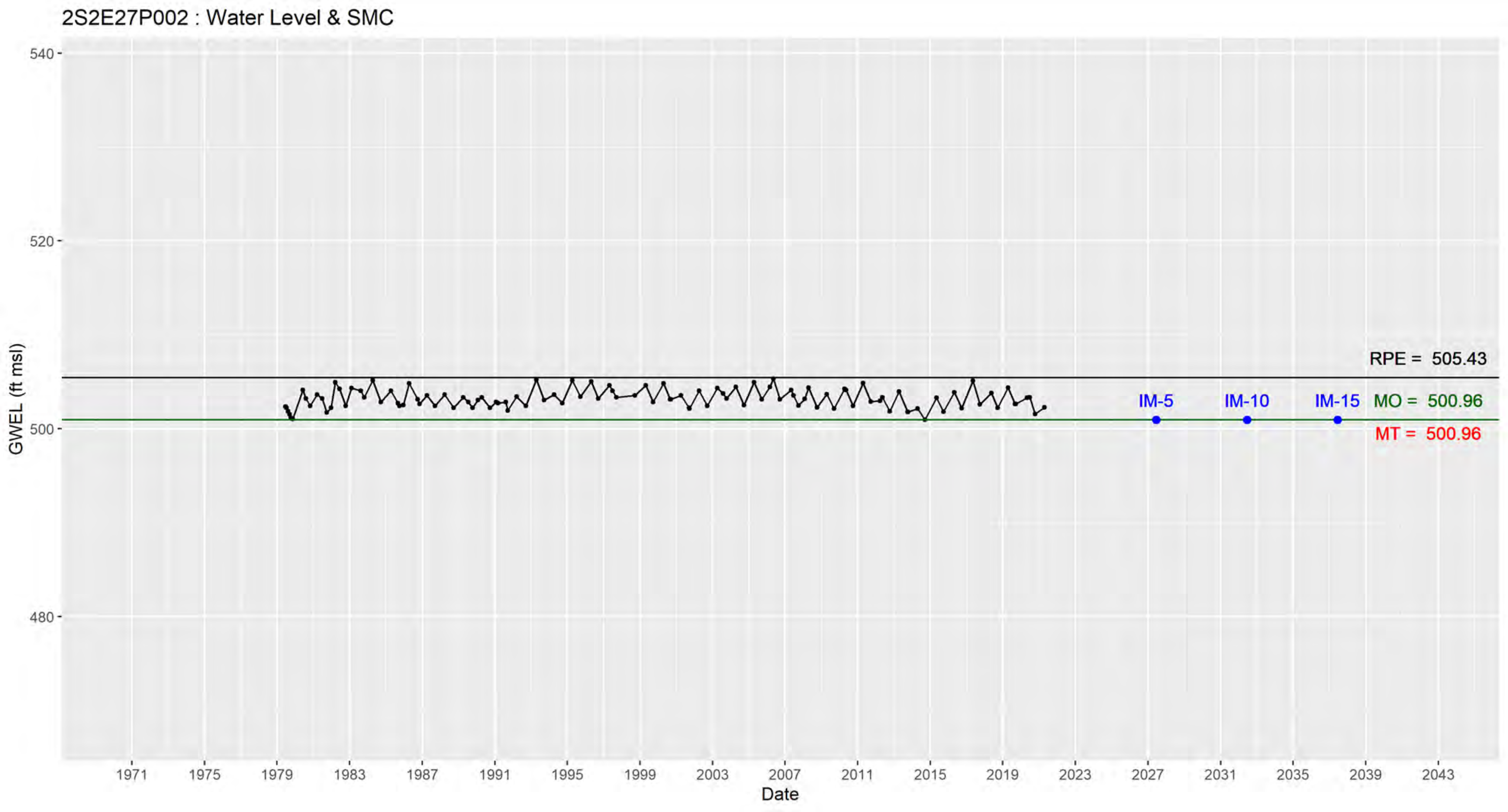


Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
N
W
E
S
0
0.2
0.4
Miles
LIVERMORE-AMADOR VALLEY
ZONE 7
19
57
WATER SUPPLY • FLOOD PROTECTION
DATE: September 2, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Upland - Riparian Mixed Hardwood

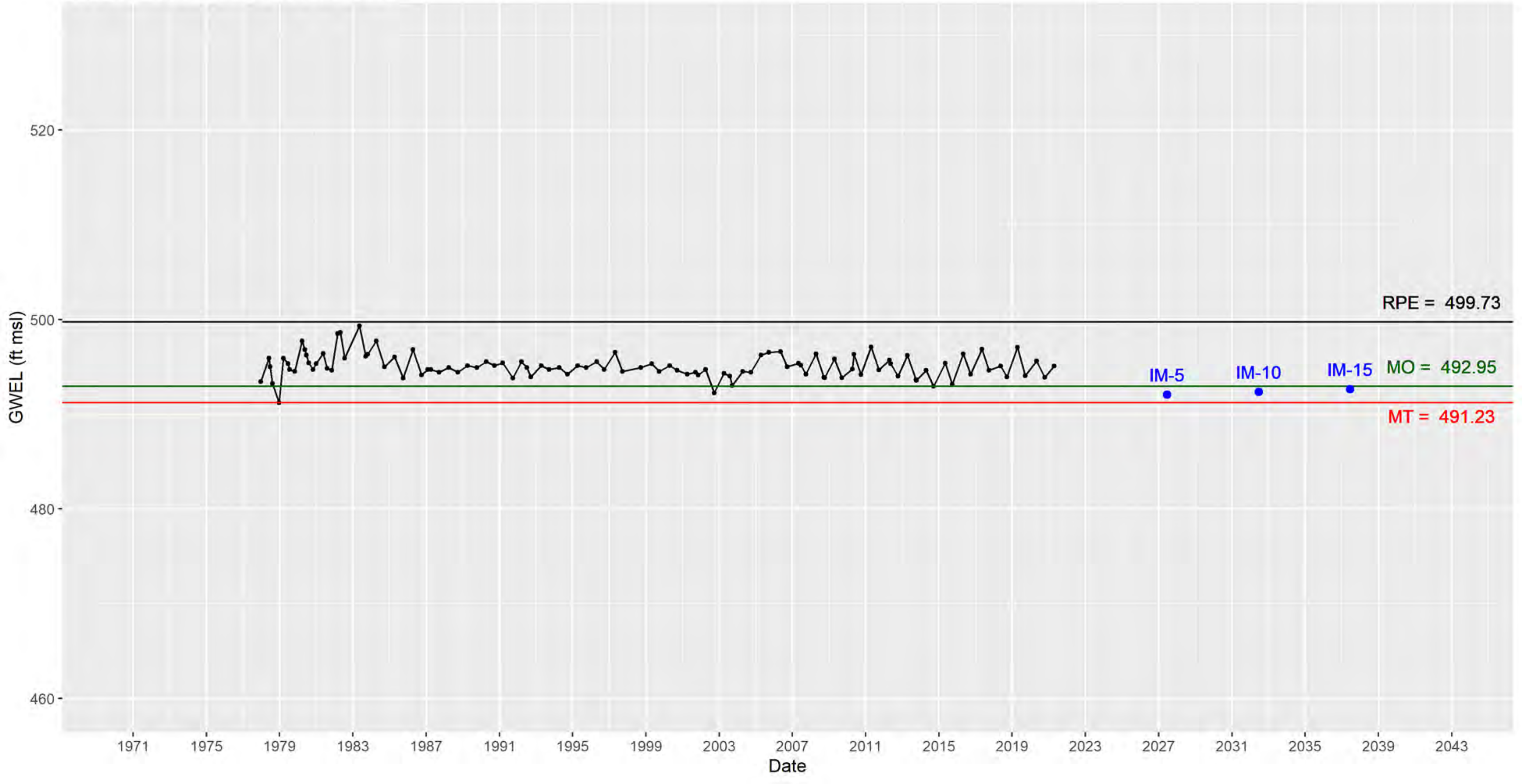
Arroyo Las Positas -- Mixed Vegetation


Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
LEGEND
DWR Basin Boundaries (2018)
Livermore Valley Groundwater Basin
NDVI Trend (2014-2018)
Large or Moderate Decrease
Little or No Change
Large or Moderate Increase
ABBREVIATIONS
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
Dublin
Pleasanton
N
W
E
S
0
0.55
1.1
Miles
LIVERMORE-AMADOR VALLEY
ZONE 7
19
57
WATER SUPPLY • FLOOD PROTECTION
DATE: September 3, 2021
FILE: X:\C00065.00\Map\2021\08\GDE_Pulse_Raster_Working.mxd
Potential GDEs to be Further Evaluated

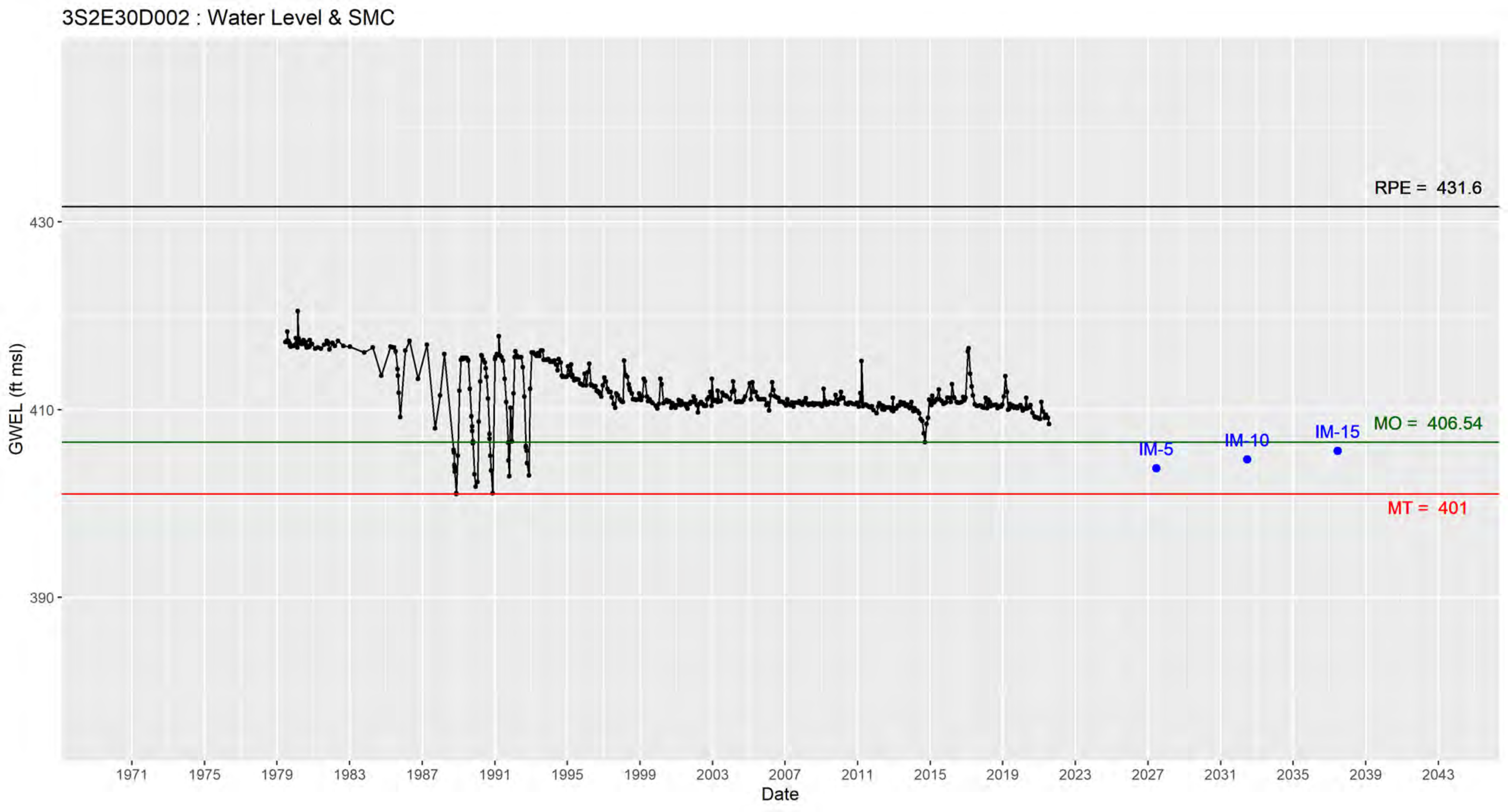
Attachment F: Water Levels and SMC Plots by RMW-ICSW


2S2E27P002 : Water Level & SMC
GWEL (ft msl)
540
520
500
480
RPE = 505.43
MO = 500.96
MT = 500.96
IM-5
IM-10
IM-15
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date

2S2E34E001 : Water Level & SMC

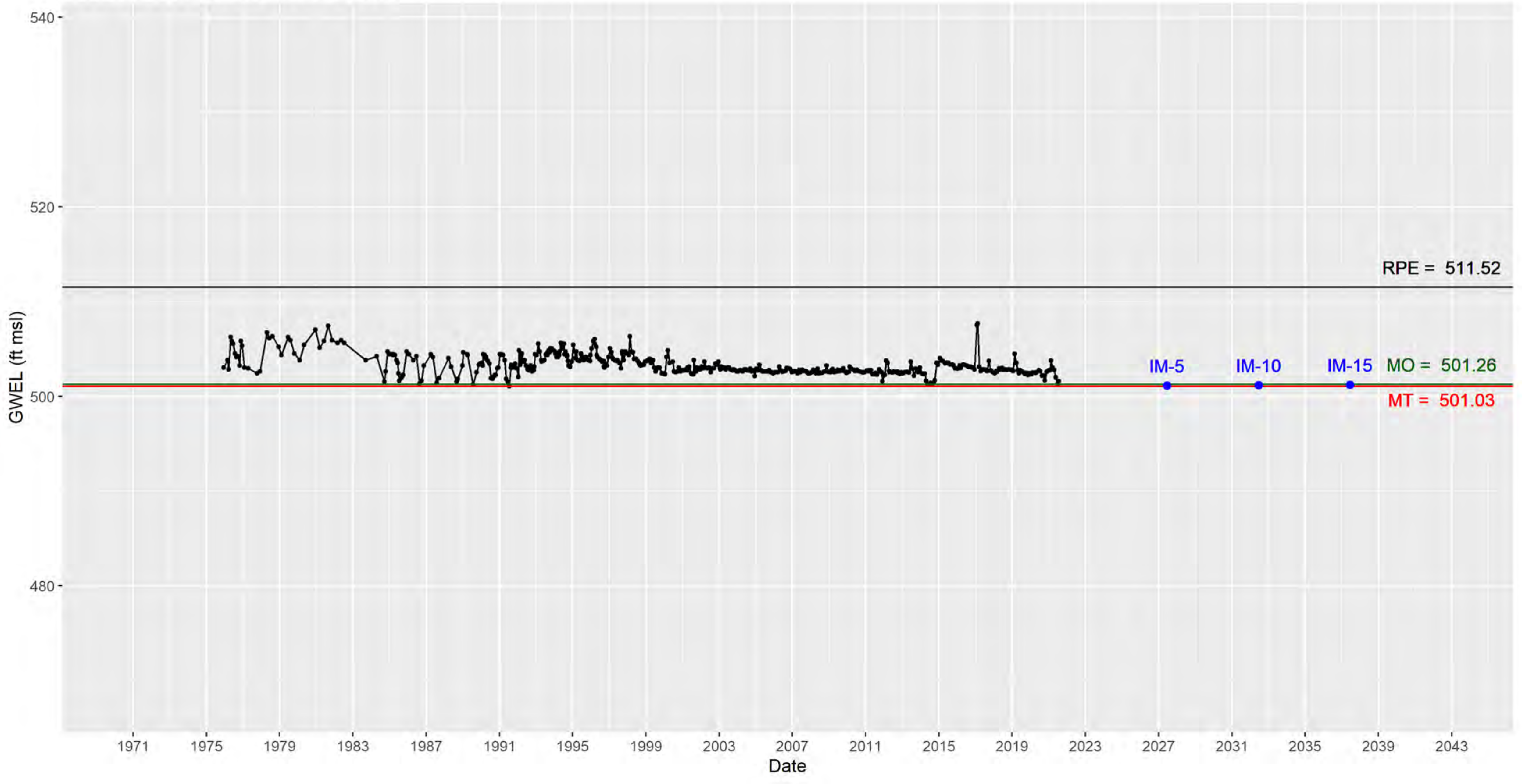



3S1E05K006 : Water Level & SMC
370
350
330
310
GWEL (ft msl)
RPE = 346.05
IM-5
IM-10
IM-15
MO = 328.18
MT = 325.95
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date

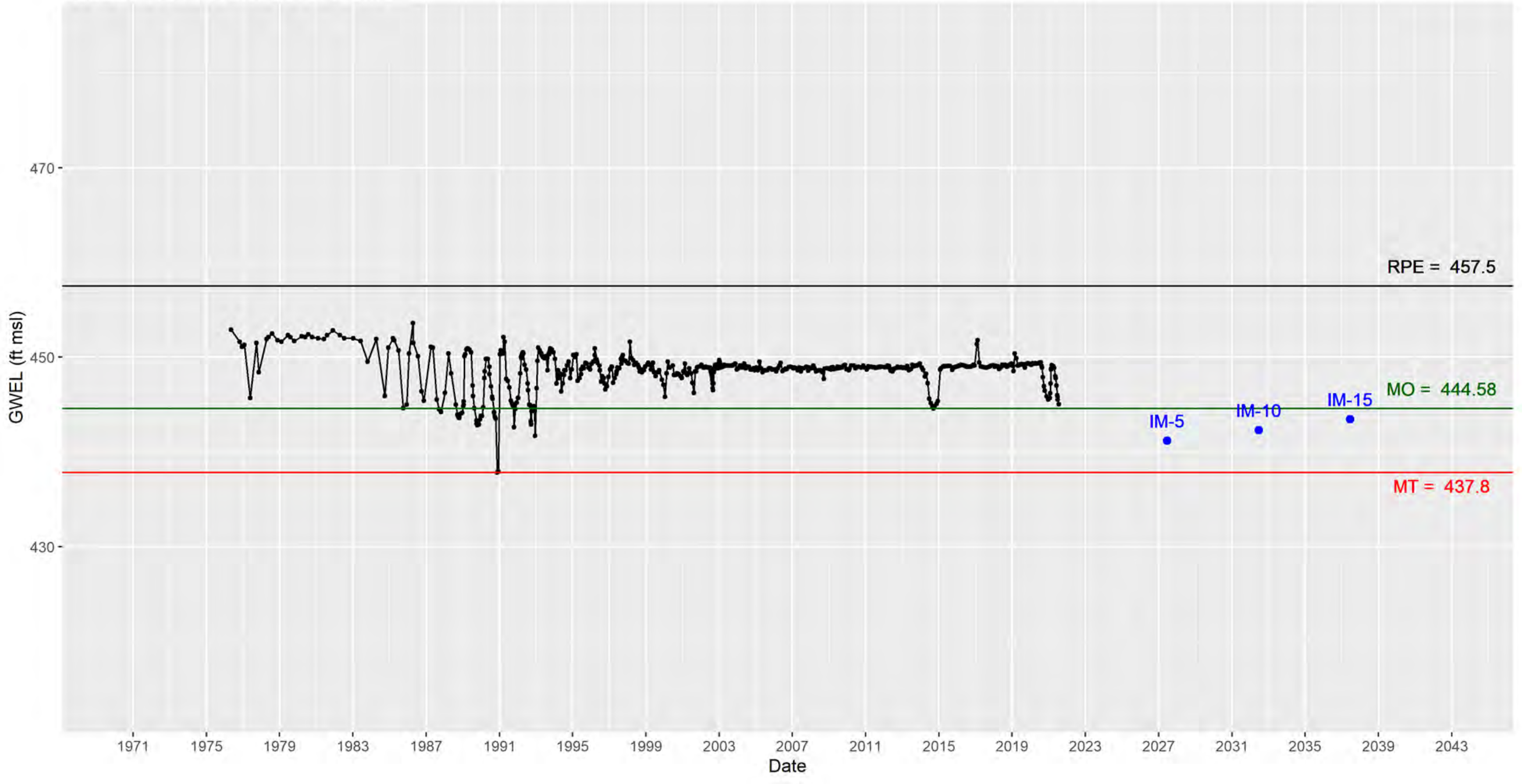

3S2E30D002 : Water Level & SMC
RPE = 431.6
MO = 406.54
MT = 401
IM-5
IM-10
IM-15
GWEL (ft msl)
430
410
390
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date

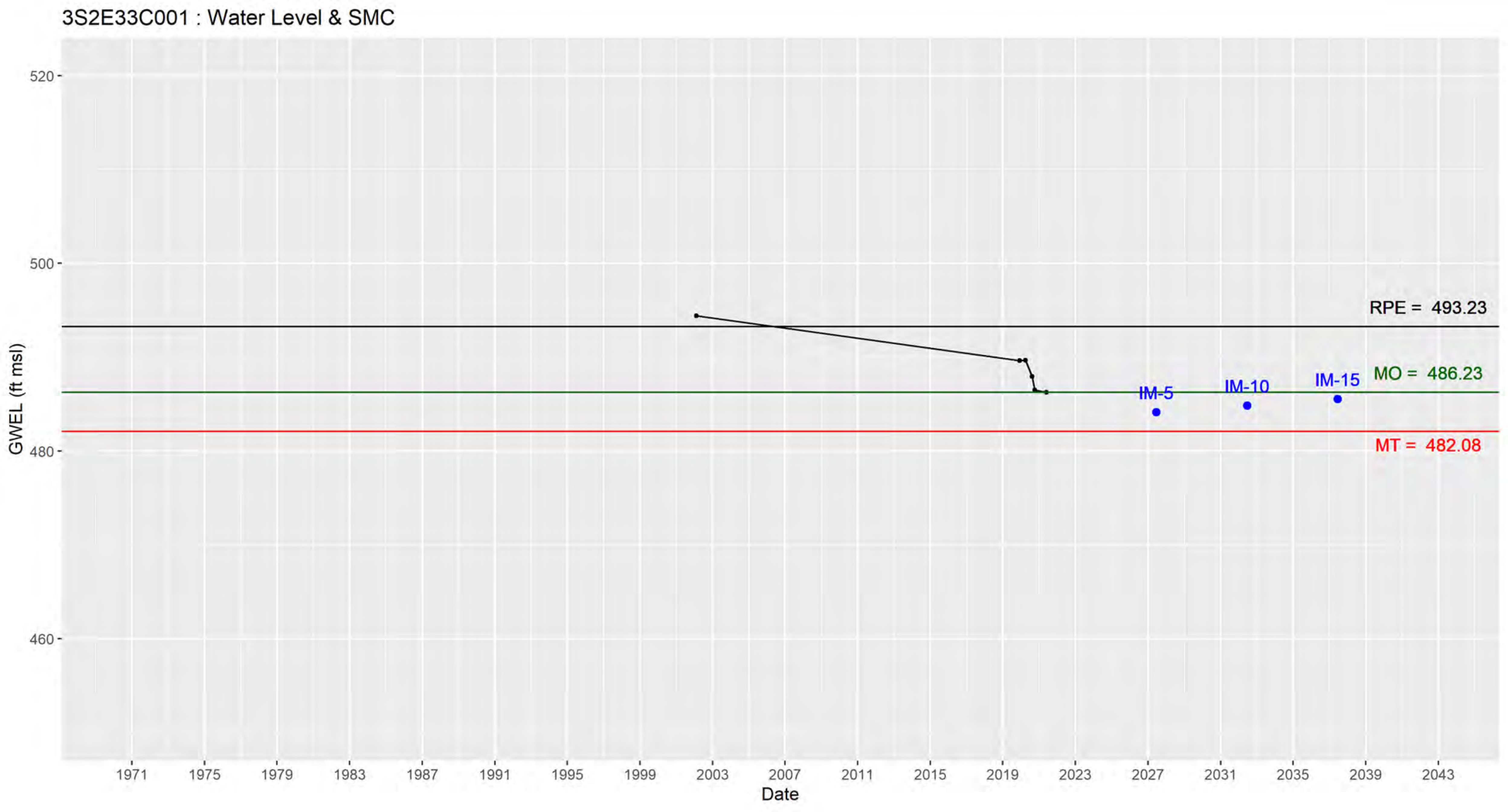
3S1E16P005 : Water Level & SMC

3S2E33G001 : Water Level & SMC

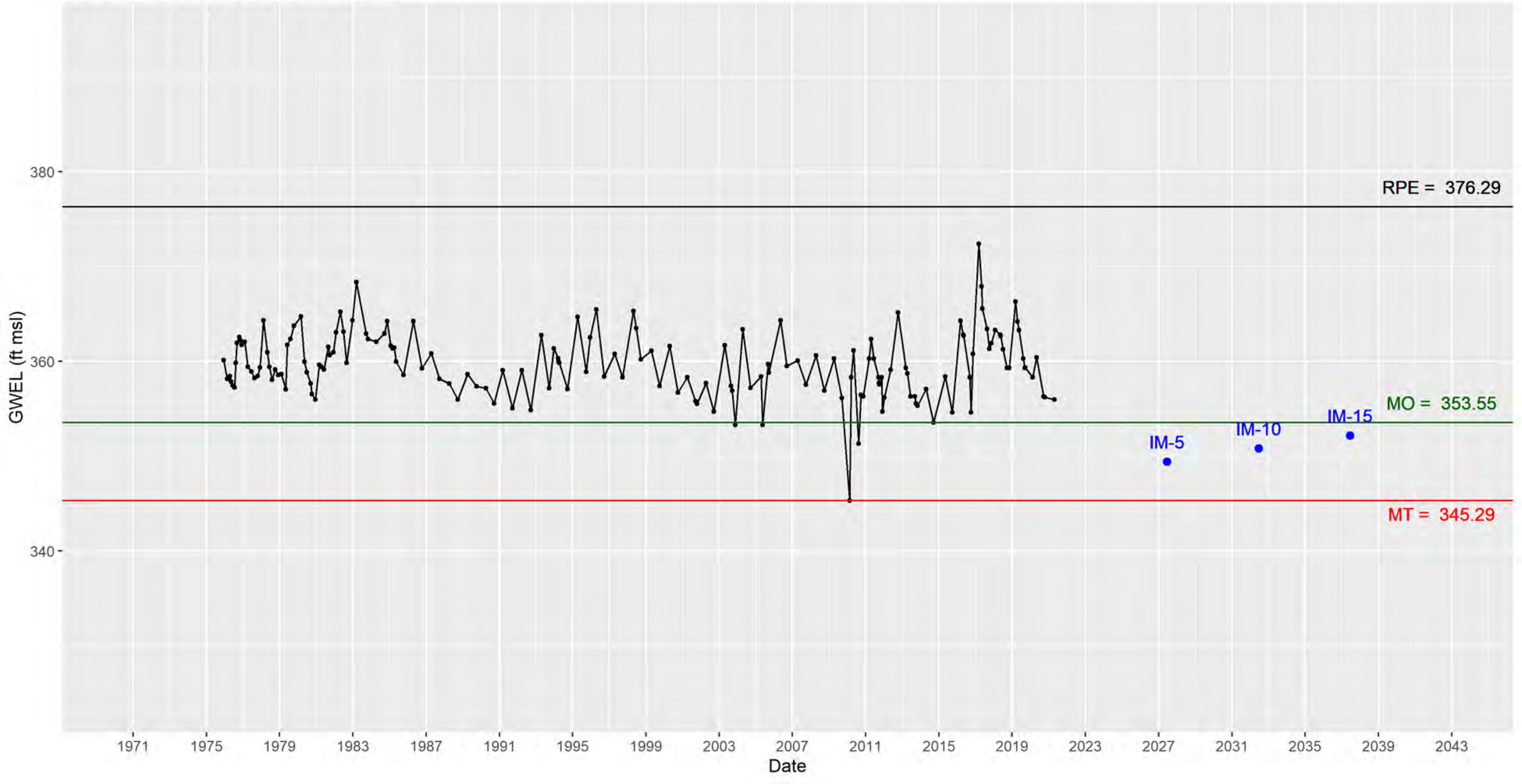


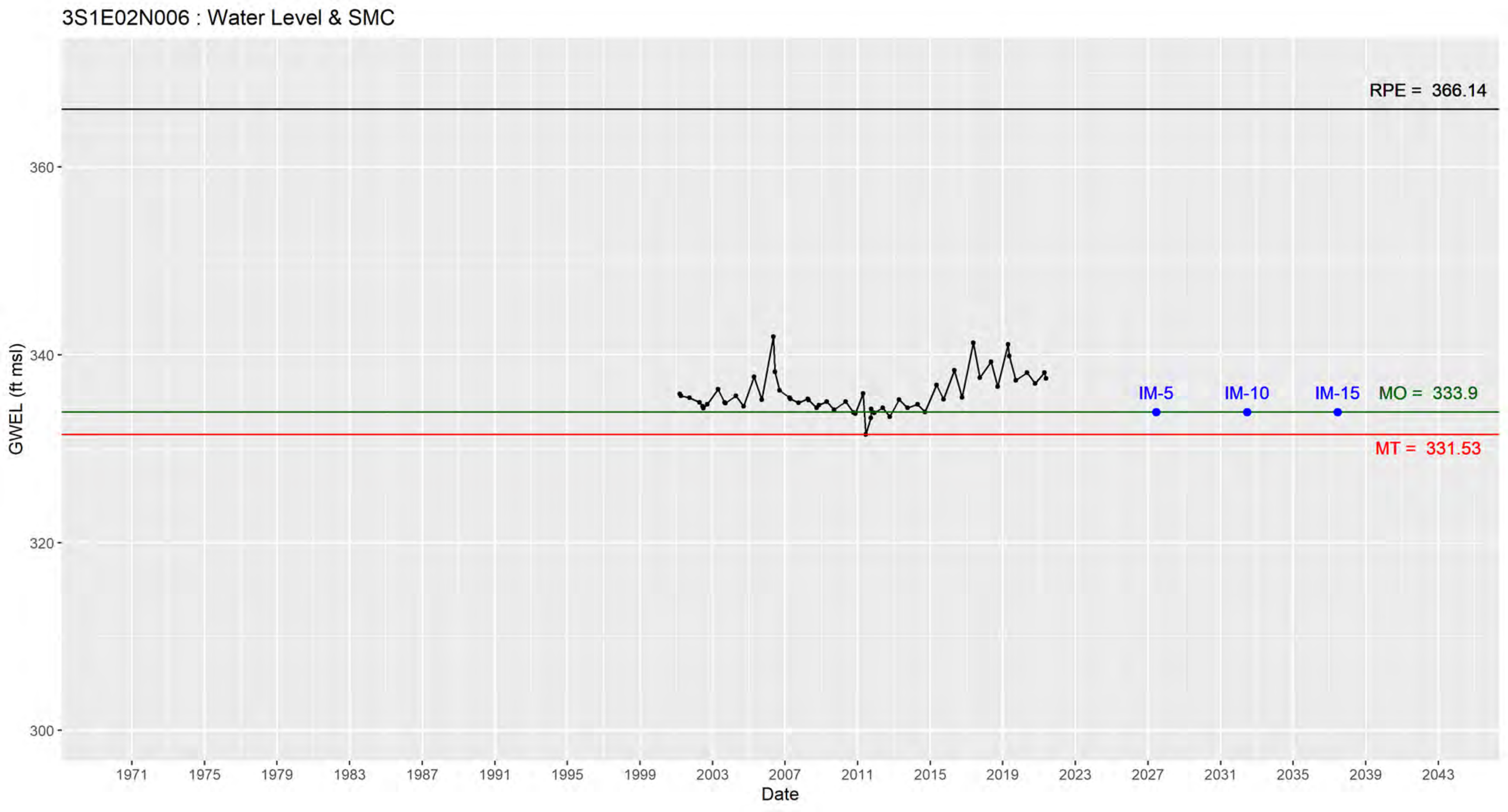
3S2E29F004 : Water Level & SMC

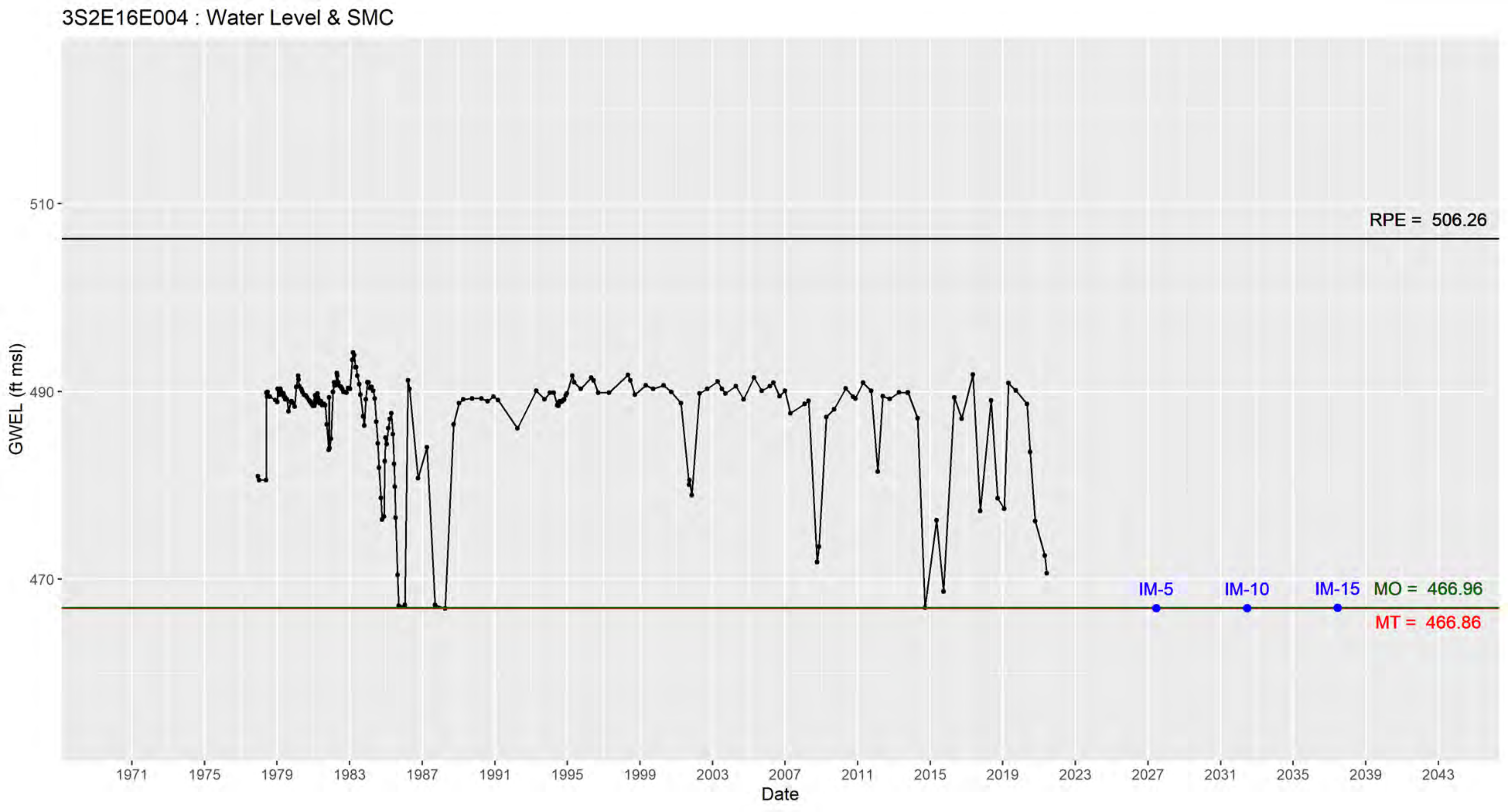


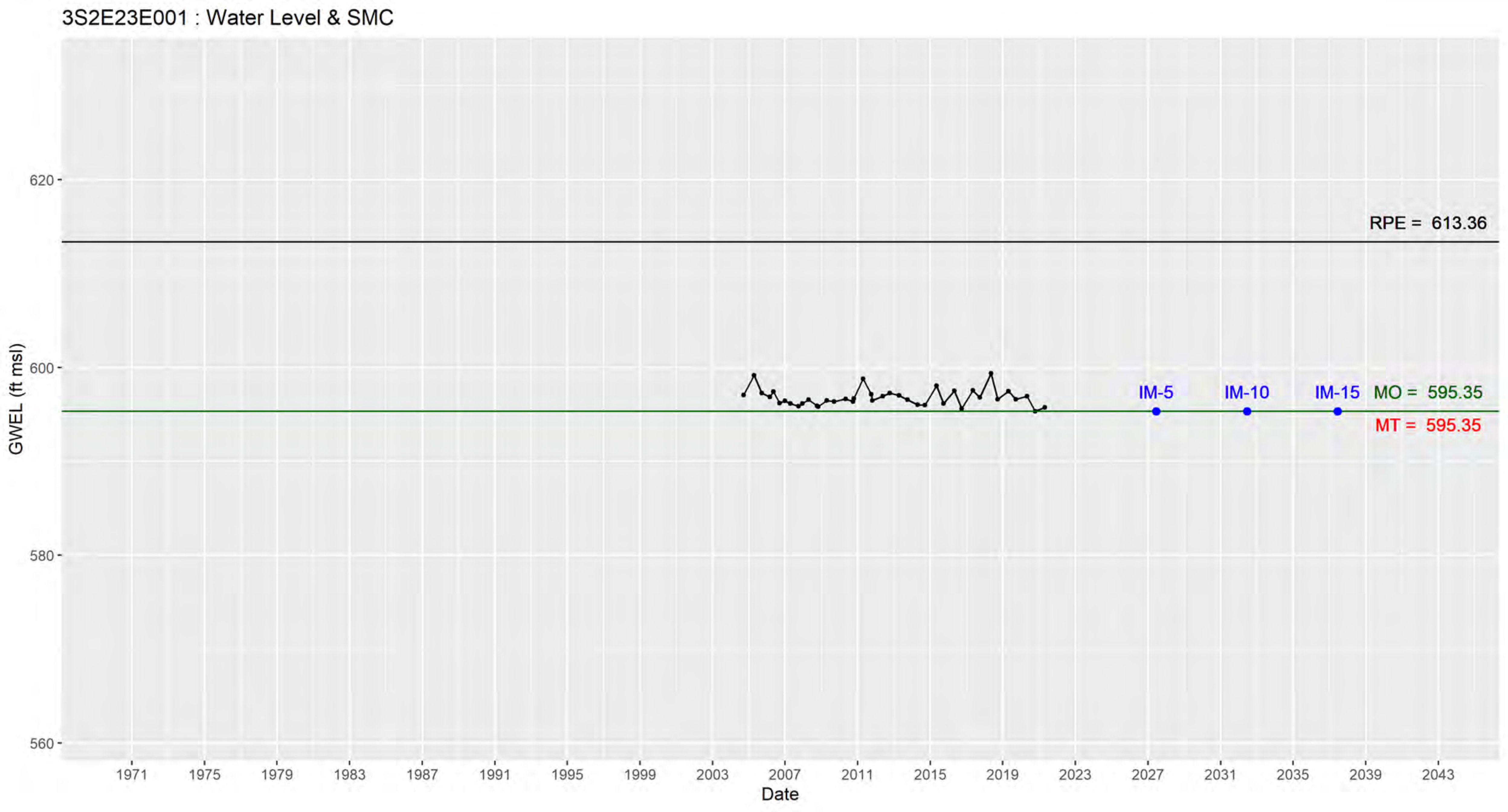

3S2E33C001 : Water Level & SMC
GWEL (ft msl)
520
500
480
460
RPE = 493.23
MO = 486.23
MT = 482.08
IM-5
IM-10
IM-15
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date

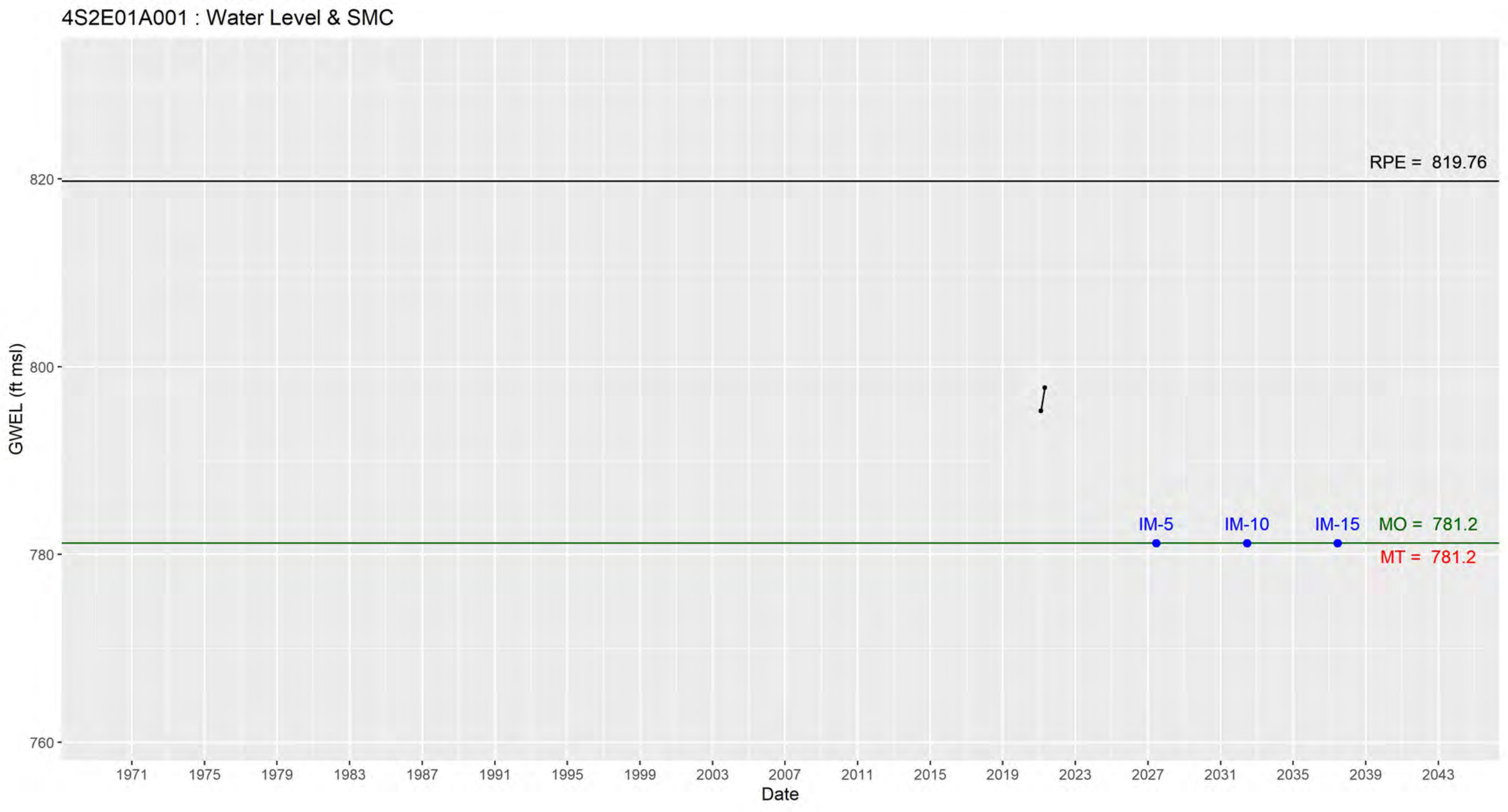
3S1E02R001 : Water Level & SMC

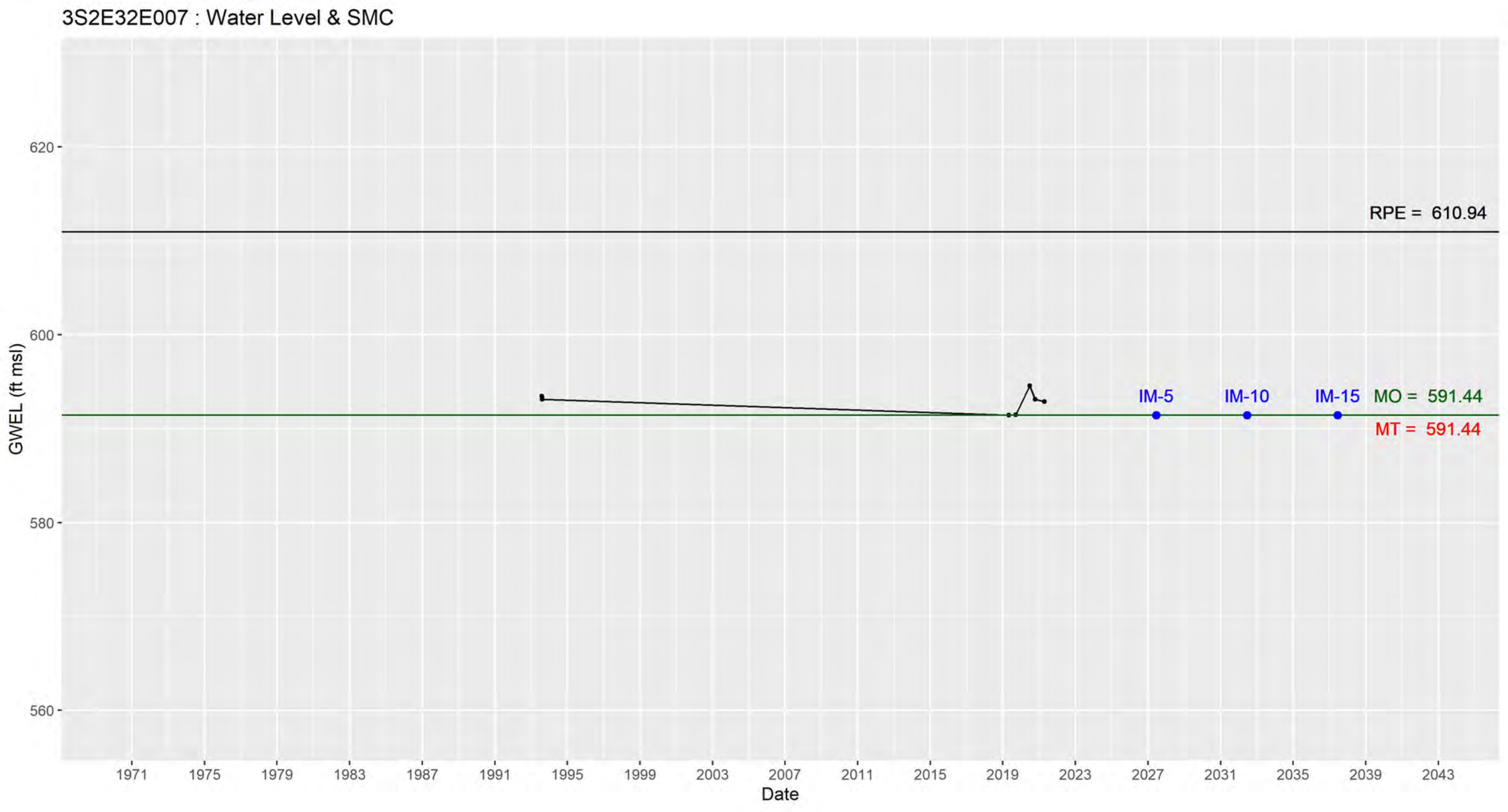



3S1E02N006 : Water Level & SMC
RPE = 366.14
IM-5
IM-10
IM-15
MO = 333.9
MT = 331.53
GWEL (ft msl)
360
340
320
300
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date


3S2E16E004 : Water Level & SMC
GWEL (ft msl)
510
490
470
RPE = 506.26
IM-5
IM-10
IM-15
MO = 466.96
MT = 466.86
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date


3S2E23E001 : Water Level & SMC
GWEL (ft msl)
620
600
580
560
RPE = 613.36
IM-5
IM-10
IM-15
MO = 595.35
MT = 595.35
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date


4S2E01A001 : Water Level & SMC
RPE = 819.76
IM-5
IM-10
IM-15
MO = 781.2
MT = 781.2
GWEL (ft msl)
820
800
780
760
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date



3S2E32E007 : Water Level & SMC
RPE = 610.94
IM-5
IM-10
IM-15
MO = 591.44
MT = 591.44
GWEL (ft msl)
620
600
580
560
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
Date

APPENDIX G

STANDARD OPERATING PROCEDURES

Appendix G

Standard Operating Procedures

Prepared by
Zone 7 Water Agency

PUBLIC REVIEW DRAFT
October 2021

TABLE OF CONTENTS

1 GROUNDWATER ELEVATION MEASUREMENT PROCEDURES

1.1 GENERAL

The common datum for all water and land surface elevations is in Mean Sea Level (MSL) in feet (ft), using the North American Vertical Datum of 1988 (NAVD88). To calculate the water elevation, Zone 7 measures the depth-to-water relative to a known reference point, or measures it directly using Zone 7's Real Time Kinematic (RTK) Global Positioning System (GPS) Unit (Sokkia GRX1).

For each field measurement event, Zone 7 completes a field sheet that includes the following columns:

- Site
- Sample Date
- Sample Time
- Reference Point
- Previous Measurement
- Depth To Water
- Groundwater Elevation
- Equipment Used
- Notes

All water elevation field measurements are compared to the previous measurement shown on the field sheet. Wells with suspicious levels are re-measured to check the elevation. Back in the office, groundwater elevation data are graphed and/or contoured to check the general accuracy of the data. Suspi-cious water levels are investigated and, if deemed invalid or questionable, are then (1) re-measured, if possible, or (2) noted as suspect in the database and are deleted from graphs and reports.

1.2 GROUNDWATER ELEVATIONS IN WELLS

1.2.1 Reference Points

For groundwater elevations in wells, Zone 7 measures depth-to-water from a surveyed reference point in each well, usually on the north side of the top of the well casing. These reference points are typically marked with a sharpie and/or a notch on the well casing. Whenever possible, reference point elevations are surveyed to 0.01' NAVD88 (or better) by a licensed surveyor or measured using Zone 7's GPS Unit (accurate to about 0.05 ft). When not possible, Zone 7 estimates the reference point elevation from the following (in order of preference):

ES.1. Pictometry
ES.2. Lidar
ES.3. Topographic Maps

1.2.2 Depth to Water Measurements

Zone 7 uses Solinst or Heron Water Level Meters to measure the depth to water. The elevation of the water surface in the well is computed by subtracting the depth-to-water from the reference point elevation. The field data is then entered into a database (**Section 1.5**) and made available to staff for further analysis.

Water levels are measured under static (or semi-static) conditions. Productions wells are typically turned off and allowed to equalize (same reading for one minute) prior to recording water levels. For those wells not controlled by Zone 7, or when a Zone 7 well cannot be switched off, no water levels measurements are taken for that measurement event. On the field sheet, a note (including the date and time) is made indicating that the well was pumping during the field visit. Pumping water levels are sometimes submitted by other agencies and are so noted in the database, but are not used to create groundwater elevation maps and contours.

1.3 GROUNDWATER ELEVATIONS IN SURFACE WATER BODIES

Zone 7 uses a GPS Unit to measure groundwater elevation in static surface water bodies, (e.g., mining area ponds). The GPS Unit is localized at the beginning of each field event using a known benchmark. In the field the GPS Unit is operated as per the manufacturers specifications and set so that the base of the unit represents the average water surface (i.e., on a rock or on the bank). The GPS reading is noted on a field sheet along with the date/time of the measurement and the equipment used. The accuracy of Zone 7's current GPS unit (Sokkia GRX1) is approximately 0.05 ft.

1.4 GROUNDWATER ELEVATION DATA FROM OTHERS

In some cases, other agencies or individuals (e.g., CWS and the City of Pleasanton) provide monthly water level data to Zone 7. Water levels measured by others are received a month or more after the actual measurement so a field-check measurement is usually not possible. However, the data is compared to previous measurements for accuracy, and if inconsistent, Zone 7 will contact the measurer for clarification or will flag the dataset as questionable.

1.5 GROUNDWATER ELEVATION DATA MANAGEMENT

Groundwater elevation data is transferred from the field sheets and imported into HydroGeoAnalst (HGA), a proprietary environmental database designed for storing and reporting chemistry, hydrology, and geologic data. The program includes a detailed QA/QC module that checks data integrity during import. Once imported into the database, Zone 7 uses the reporting and mapping tools within HGA to view and report the datasets. Zone 7 also exports datasets from HGA for use in other programs such as Microsoft Excel, Microsoft Access, and ArcGIS.

2 GROUNDWATER QUALITY SAMPLING PROCEDURES

2.1 GENERAL

Groundwater samples are collected from all wells, mining area ponds, and surface water stations in Zone 7's programs provided a suitable sample can be obtained. Zone 7 staff typically samples water from municipal wells, various mining area ponds, and arroyos that communicate with groundwater. Zone 7 employs a contractor (Contractor, currently Blaine Tech Services) to perform groundwater sampling from the majority of the non-municipal wells in the program. Both Zone 7 staff and Contractor must follow the procedures below.

2.2 FIELD PREPARATION

Prior to sampling, field personnel perform the following:

- ES.4. Zone 7 prepares well data sheets of all wells to be sampled for the year. Well data sheets include a map, coordinates, photographs, well depth, well diameter, screen interval, and any sampling notes or instructions specific to that well.
- ES.5. For contracted sampling events, the contractor contacts Zone 7s' Laboratory at least a week prior to desired sampling dates to schedule sample delivery and to confirm that the laboratory can analyze the anticipated number of samples in a timely manner. The contractor delivers all samples on Monday through Thursday in consideration of holding times for certain analyses.
- ES.6. Zone 7 obtains and/or provides sample containers, sample labels, chain of custody sheet, and parameter stability sheets for purging.
- ES.7. If indicated on the well data sheets, field personnel contact the owner to pre-arrange schedule and to access the property and well.

2.3 FIELD INSTRUMENT CALIBRATION

Upon arrival to the first well of each sampling day, the sampler performs a field instrument calibration for pH and specific conductance.

- ES.8. Accuracy of pH meters should be +/- 0.1 pH unit of the standard.
- ES.9. Accuracy of specific conductance (SC) should be within 5% of the standard.
- ES.10. Calibrations are recorded in instrument log books as well as on the chain of custody for that sample day.

2.4 WATER SAMPLING

2.4.1 General

Static depth to water level (for wells) or water elevation (for surface water bodies) are measured and recorded prior to pumping/sampling. In the case of nested wells, static water levels for all associated nested wells are measured before any of them are pumped.

All sampling and purge water stability records are logged and stored in a binder specifically for that purpose. Samples are typically filtered through a single use 0.45-micron filter in the field, except when not appropriate for the analytes being tested (e.g., for VOC sampling, see **Section 2.5.3**). If field-filtering is not possible, the field personnel indicate on the Chain of Custody that the sample is to be filtered by the lab prior to sampling.

Sample labels are filled out completely and placed on all sample bottles.

2.4.2 Wells with No Dedicated Pump

For wells without dedicated pumps, the most appropriate/efficient sampling method for each well, either *Well-Volume Purge and Sample* or *Low Flow Sampling*, is indicated on Zone 7's stability sheets. Detailed instructions for each sampling method are provided below.

2.4.2.1 Well-Volume Purge and Sample

This method involves purging static groundwater from the well so that the water in the well is representative of groundwater. During the purging period, the purged groundwater is monitored for specific conductance, pH, and temperature to determine stability. The stabilization criteria are listed below in **Section 2.4.4**. Samples are collected after the parameters have stabilized.

No purge water is discharged to storm drains; however since groundwater from all wells are believed to be uncontaminated, purge water can be discharged to a permeable ground surface at the well site as long as the discharge does not cause excessive erosion and does not enter a storm drain. If there are no permeable surfaces at the well site, the purge water is containerized and transported to a Zone 7-approved location for surface discharge.

- ES.11. Samples are collected after the parameter stabilization criteria specified below have been met.
- ES.12. A minimum of three casing volumes are purged. If stability is not reached prior to five casing volumes purged, then a sample is collected when five casings have been purged.
- ES.13. The sample SC, pH, and temperature readings are measured in the field and recorded on a field data sheet provided by Zone 7.
- ES.14. Readings are taken at every ½ well volume purged or every three to five minutes.
- ES.15. If a well purges dry, it must recover to 80% of original water column before the sample is collected. If recovery time takes more than one hour, the sample is collected at end of the day or the following morning (within 24 hours from drying of well).

2.4.2.2 Low Flow Sampling

ES.16. A bladder pump is lowered to specified depth, which is typically halfway down the well screen interval. If there are multiple screen intervals, then the shallowest screen interval is used.
ES.17. The pumping rate is adjusted so that it is less than natural recovery rate of the well (usually between 0.1L and 0.5L/minute), and so that drawdown is no more than 0.33 feet (ft).
ES.18. Water quality readings and water level readings (to monitor drawdown) are taken every three to five minutes. The sample is collected when the parameter stabilization criteria (**Section 2.4.4**) are met.

2.4.3 Wells with Dedicated Pumps

Several wells in Zone 7's program have dedicated submersible pumps, most of which are active pumping wells. The sample is collected when the parameter stabilization criteria (**Section 2.4.4**) are met.

ES.19. For active wells, the sampler opens the sample tap and purge water for five minutes and then collects the sample.
ES.20. Inactive wells are purged for five minutes. After five minutes have passed, the sampler then begins recording water quality parameters every three to five minutes until parameter stabilization occurs.

2.4.4 Parameter Stabilization Criteria

Samples are collected after the specific conductance (SC) and pH have stabilized as follows:

ES.21. **SC** - the difference between the maximum and minimum values of the last three readings must be no more than 5%.
ES.22. **pH** - the difference between the maximum and minimum values of the last three readings must be less than or equal to 0.1 units.

2.4.5 Grab Sampling from Surface Water Bodies

When collecting water samples from surface water bodies, the field personnel avoid sampling water that has been stirred up. Field personnel collect samples choosing Option 1 or 2, below, as appropriate while standing on the edge of the water body or on a rock. The field personnel:

OPTION 1

ES.23. Hold the uncapped bottle upside down and submerse it,
ES.24. Tip bottle upright and allow water to fill bottle, and
ES.25. Remove bottle from water and screw on cap.

OPTION 2 (recommended for soft-sediment water bodies)

ES.26. Use a large, clean dip sampler to collect water,
ES.27. Rinse sampler in stream water three times,
ES.28. Collect stream water, and
ES.29. Fill sample bottles with water from the dip sampler.

2.5 SAMPLING CONTAINERS

2.5.1 General

The field personnel avoid touching the inside or lip of all sample bottles or caps. Each sample container is labeled with the site name/number, sample date, and sample time. Sample containers are selected as required by the EPA Method regulations.

2.5.2 Metals and Minerals

The majority of the water samples taken as part of Zone 7's water quality program are analyzed for metals and minerals. For these analyses, field personnel fill both a 1L bottle (no preservatives) and a 0.5L bottle (no preservatives).

2.5.3 VOC Sampling

Occasionally, Zone 7 samples water for volatile organic compound (VOC) analyses. VOC samples are collected with as little agitation or disturbance as possible.

ES.30. Stainless steel or Teflon bailers are used to collect VOC samples after purging and sampling.
ES.31. Unfiltered groundwater samples for VOC analysis are collected in three 40 ml glass VOA vials supplied by Zone 7. The vials are preserved with hydrochloric acid to allow for a two-week holding time.
ES.32. The vial is filled so that there is a meniscus above the top of the vial and absolutely no bubbles or headspace are present in the vial after it is capped. After the cap is tightened, the vial is inverted and tapped to dislodge any hidden air bubbles. If bubbles are present, the vial is topped off using a minimal amount of sample to re-establish the meniscus. Care is taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial is obtained and the sample re-collected.

2.6 SAMPLE STORAGE AND DELIVERY

Samples are stored in a cooler with ice or icepacks so that the cooler temperature is approximately four degrees Celsius. Field personnel complete a Chain of Custody for each sample day. Samples are then delivered within the analyte holding times, along with the Chain of Custody and water quality instrument calibration logs, to Zone 7's laboratory.

2.7 WATER QUALITY DATA MANAGEMENT

Zone 7's laboratory generates an electronic data deliverable (EDD) file that contains the sample results. This data is imported into HGA, a proprietary environmental database designed for storing chemistry, hydrology, and geologic information. The program includes a detailed QA/QC module that checks data integrity during import. Once imported into the database, Zone 7 uses the reporting and mapping tools within HGA to view and report the datasets. Zone 7 also exports datasets from HGA for use in other programs such as Microsoft Excel, Microsoft Access, and ArcGIS.

3 SURFACE WATER FLOW

3.1 GENERAL

All relevant information is recorded in a gauge house log sheet and on field note sheets.

3.2 FIELD VISIT

Upon arrival at the site, field personnel:

- ES.33. Look for evidence of vandalism/theft/high water destruction to gauge house, solar panels, cellular antennas, outside staff gauges, crest stage gauges, gauge height sensor conduit, and electronics within gauge house.
- ES.34. Verify recorder powers on and is recording data, wires are connected and in good order, and battery is not leaking acid.
- ES.35. Check battery voltage and replace battery if below 12.1 volts.
- ES.36. Check solar panel and clean if dirty.
- ES.37. Check channel banks and path to outside staff gauge to make sure they are clean, clear, stabile, and safe to approach. If not, field personnel use appropriate tools to clear (rake, shovel, broom, pruners, etc.).

Upon completion of the field visit, the gauge house is locked up.

3.3 GAUGE MEASUREMENT

During field visits, the field personnel often read the outside staff gauge and compare it to the recorder stage. During low flow, the field personnel reset the recorder stage if it differs from outside staff gauge by 0.02 ft or more. If there is a difference during high flow, field personnel try to observe what may be causing the difference and reset the recorder stage if appropriate.

Field personnel clean excess debris or algae from the control, and then allow time for stage to stabilize before taking another outside staff gauge reading for comparison to the recorder stage.

3.4 DISCHARGE MEASUREMENTS

For discharge measurements, field personnel look at the flow and mentally determine if it is safe to perform a wading discharge measurement. A general rule of thumb is that if the following condition is true:

Stream Depth (ft) x Stream Velocity (ft/s) > 10

Then the field personnel do not wade into the stream and perform the discharge measurement from the nearest bridge.

Discharge measurements and computations are performed in accordance with guidelines set forth in *United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1 and 2*. After the discharge measurement, field personnel recheck the outside staff gauge and recorder readings.

3.5 SURFACE WATER FLOW DATA MANAGEMENT

Zone 7 uses a proprietary program called Aquarius Time-Series (Aquarius) for managing surface water time-series datasets. The program allows Zone 7 to build rating curves, apply corrections, create comparison graphs, derive statistics, and report datasets.

4 SURFACE WATER QUALITY

4.1 GENERAL

Water quality samples are collected at most of Zone 7's surface water stations. Stream water sampling procedures are the same as those presented in **Section 2** except for the procedures described below.

4.2 SURFACE WATER SAMPLE COLLECTION

When collecting water samples from streams, the field personnel avoid sampling water that has been stirred up. The field personnel collect samples (choosing Option 1 or 2, below, as appropriate) while standing on the edge of the water body or on a rock. If this is not possible, the field personnel reach upstream as far as possible to avoid collecting stirred up water. The field personnel:

OPTION 1

ES.38. Hold the uncapped bottle upside down and submerse it,
ES.39. Tip bottle upright and allow water to fill bottle near top, and
ES.40. Remove bottle from water and screw on cap.

OPTION 2 (recommended for soft-sediment water bodies and low-flow streams)

ES.41. Use a large, clean dip sampler to collect water,
ES.42. Rinse sampler in stream water three times,
ES.43. Collect stream water, and
ES.44. Fill sample bottles with water from the dip sampler.

5 MUNICIPAL GROUNDWATER PRODUCTION DATA

Zone 7 records its groundwater production using its own SCADA system. As part of Zone 7's agreements with its retailers, Zone 7's retailer agencies provide their own groundwater production data to Zone 7. Zone 7 and Pleasanton production data are available in a daily format. CWS provides monthly totals.

Zone 7 staff does not collect groundwater production data from domestic, industrial, or agricultural wells in the valley. These volumes are estimated using Zone 7's Areal Recharge Model, IDC, or typical pumping rates.

6 CLIMATOLOGICAL

6.1 TIPPING BUCKET

Once a month Zone 7 staff visits the rain tipping buckets to download 15-minute rainfall data. The rain gauges are visually inspected to ensure there is no debris clogging the rain gage. Field personnel inspect the associated rainfall data logger and using a field sheet, then record date, time, total rainfall accumulation and battery voltage. The 15-minute rainfall data is then downloaded from the logger to a Zone 7 laptop.

At the end of the water year, field personnel perform a standard monthly check and download the 15-minute rainfall data. Then for annual maintenance, field personnel
ES.45. open up the tipping bucket,
ES.46. check the bubble level to ensure a level surface,
ES.47. manually tip the rain gage,
ES.48. confirm that the associated data logger is correctly recording the tips,
ES.49. reassemble the tipping bucket, and
ES.50. reset the data logger rainfall total is reset to 0.00" for the start of the new water year.

6.2 CIMIS

Zone 7 staff performs maintenance for the California Irrigation Management Information System (CIMIS) station in the City of Pleasanton. Maintenance standards for the station call for a maintenance visit every 3-4 weeks during the warmer months of the year and every 5-6 weeks in the cooler months. The maintenance visit includes checking the sensors for accuracy and/or operation and cleaning or replacing sensors as required.

7 LAND SURFACE ELEVATION MONITORING

Zone 7's Land Surface Elevation Monitoring Program involves conducting high precision spirit level surveys of benchmarks across the Bernal and Amador Sub-basins. These benchmark stations have been selected to represent generally stable features (e.g. bridge buttresses) founded in deeper soils so as not to be affected by shallow soils movement (e.g., expansive soils).

The main circuit (A1-1.0 and A1-17.0) starts and ends at stable bedrock elevation stations and passing through or near Zone 7 and City of Pleasanton wellfields. From this main circuit, several looped or branched circuits are also surveyed in the same manner to assess ground surface elevation changes within other Zone 7 wellfields. Elevations and vertical distances between certain wellhead features, such as concrete pads, floors, pedestals, casing flanges and water level reference points are also monitored for change.

The normal monitoring frequency is twice per year for Circuits A1, B1, B3 and B4 and the wellhead features, corresponding with the semi-annual groundwater level monitoring events (spring and fall), and only during the fall event for Circuit B5.

Zone 7 contracts out the level survey measurements to a California-licensed surveyor. The contractor typically utilizes a three-man survey crew that conducts a differential level loop to collect elevations using an Electronic digital/bar-code leveling system based on Federal Geodetic Control Subcommittee (FGCS) standards and Specifications for Third-Order Differential Leveling Surveys. The contractor supplies Zone 7 with a copy of all field notes, benchmark data sheets, and a map showing the approximate route for the level runs and points

APPENDIX H

STAKEHOLDER COMMUNICATION AND ENGAGEMENT PLAN

Zone 7 Water Agency

STAKEHOLDER COMMUNICATION & ENGAGEMENT PLAN

FOR THE LIVERMORE VALLEY GROUNDWATER BASIN

August 2020

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Glossary / Abbreviations

AB	Assembly Bill
ACCDA	Alameda County Community Development Agency
ACEH	Alameda County Environmental Health
ACWD	Alameda County Water District
AF	acre-feet
AFY	acre-feet per year
ARM	Areal Recharge Model
C&E	Communication & Engagement
CCE	California Conservation Easements
CCR	California Code of Regulation
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
COL	Chain of Lakes
CPA	California Protected Area
CWC	California Water Code
DAC	Disadvantaged Communities
DSRSD	Dublin San Ramon Service District
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utilities District
EBRPD	East Bay Regional Park District
ft	feet
GDE	Groundwater-Dependent Ecosystem
GPQ	Groundwater Pumping Quota
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
LARPD	Livermore Area Recreation and Park District
LAVQAR	Livermore Amador Valley Quarry Area Reclamation
LLNL	Lawrence Livermore National Laboratory
MOU	Memorandum of Understanding
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OWTS	Onsite Wastewater Treatment System
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SBA	South Bay Aqueduct
SCEP	Stakeholder Communication and Engagement Plan
SDWIS	Safe Drinking Water Information System
SFPUC	San Francisco Public Utilities Commission
SGM	Sustainable Groundwater Management
SGMA	Sustainable Groundwater Management Act
SLDMWA	San Luis & Delta-Mendota Water Authority

SWP	State Water Project
TDS	total dissolved solids
TVC	Tri-Valley Conservancy
TWRC	Tri-Valley Water Retailers Group

1. INTRODUCTION

The Zone 7 Water Agency Groundwater Sustainability Agency (Zone 7) has developed this Stakeholder Communication and Engagement Plan (SCEP) to describe its approach to Communication & Engagement (C&E) throughout the 2021 Alternative Groundwater Sustainability Plan (2021 Alt GSP) development and implementation process. This SCEP was prepared in accordance with the California Water Code (CWC), the GSP Regulations (Title 23 of the California Code of Regulations [CCR] §354.10 [see text boxes inserted below]), and was informed by the California Department of Water Resources (DWR) *Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement* (DWR, 2018).

1.1. SGMA Overview

The Sustainable Groundwater Management Act (SGMA) is a combination of three bills signed by the California Governor Jerry Brown in 2014: Assembly Bill (AB) 1739, Senate Bill (SB) 1168, and SB 1319[1]. This landmark legislation recognizes that groundwater is most effectively managed at the local level and provides local agencies with a framework and timeline to achieve or maintain groundwater sustainability.

In SGMA, sustainable groundwater management is defined as management of groundwater supplies in a manner that can be maintained in planning and implementation phases without causing "Undesirable Results". Undesirable Results include the "significant and unreasonable" chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and interconnected surface waters.

1.2. Communication & Engagement Plan Elements

The required elements of a SCEP and associated processes as documented in the GSP Regulations are summarized below.

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

  (1) An explanation of the Agency's decision-making process.

  (2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

  (3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

  (4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

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[1] Some minor changes of the legislation were made in SB 13 and AB 617 pertaining to Groundwater Sustainability Agency (GSA) formation, and AB 1390 and SB 226 pertaining to groundwater adjudication processes.

The C&E efforts described in this SCEP will help to ensure that beneficial uses and users of groundwater within the Livermore Valley Groundwater Basin (Basin) are adequately considered during the 2021 Alt GSP development and implementation process as required by GSP Regulations (23-CCR §354.10). Specifically, in this SCEP:

- **Section 2** includes a description of Zone 7's decision-making process (23-CCR §354.10(d)(1));
- **Section 3** identifies beneficial users within the Basin (23-CCR §354.10(a)) and describes how Zone 7 intends to engage with them, building upon its current understanding of stakeholders within the Basin (23-CCR §354.10(d)(3) and CWC §10723.4);
- **Section 4** includes a summary of information relating to communication by Zone 7 with other agencies and interested parties (23-CCR §354.10(d)(3));
- **Section 5** identifies and documents opportunities for public engagement and how public input and response will be incorporated into the 2021 Alt GSP development and implementation process (23-CCR §354.10(c); §354.10(d)(2) and §354.10(d)(4));
- **Section 6** describes the C&E implementation timeline, including when this SCEP will be updated to inform the public about the 2021 Alt GSP development and implementation progress, including the status of projects and management actions (23 CCR §354.10(d)(4)); and
- **Section 7** describes how Zone 7 will assess its C&E implementation during 2021 Alt GSP development and implementation.

2. GROUNDWATER SUSTAINABILITY AGENCY OVERVIEW

As shown in **Figure 1**, the "Plan Area" that is covered by the 2021 Alt GSP and managed by Zone 7 is the entire Livermore Valley Groundwater Basin. For the purposes of SGMA compliance, this SCEP is focused on the entirety of the Plan Area and outlines how Zone 7 intends to engage Basin stakeholders in the development and implementation of the 2021 Alt GSP.

2.1. GSA Description and Service Area Boundary

Zone 7 is one of the ten active zones of the Alameda County Flood Control and Water Conservation District (District). The Zone 7 service area encompasses approximately 425 square miles (272,000 acres) within the eastern portion of Alameda County and includes the Livermore-Amador Valley, the Sunol Valley, and portions of the Diablo Range (Zone 7, 2016a). Major cities within Zone 7 include the Cities of San Ramon, Dublin, Livermore, and Pleasanton.

The Zone 7 service area overlies almost all of the Livermore Valley Groundwater Basin (DWR 2-10), all of the Sunol Valley Groundwater Basin (DWR 2-11), and a small section of the Tracy Subbasin in the adjacent San Joaquin Valley Groundwater Basin (DWR 5-22.15). Consistent with its management responsibilities, duties, and powers, Zone 7 is designated in SGMA as the exclusive Groundwater Sustainability Agency (GSA) within its boundaries and, in electing to be the GSA for the Basin, will continue to exercise its groundwater management authority consistent with the District Act and with SGMA (Zone 7, 2016a).

A small portion of the Basin extends into Contra Costa County beyond the Zone 7 service area and into the service areas of the East Bay Municipal Utilities District (EBMUD), the City of San Ramon, and the Dublin San Ramon Service District (DSRSD). To provide management of this portion of the Basin, Zone 7 and the other overlying agencies have developed and adopted a Memorandum of Understanding (MOU) under which Zone 7 serves as the GSA for the Contra Costa portion of the Basin (Zone 7, 2016a).

The Sunol Valley Groundwater Basin is designated as very low priority and is therefore not subject to SGMA[2]. In the Tracy Subbasin, Zone 7 has executed a MOU with the San Luis & Delta-Mendota Water Authority (SLDMWA) to support SGMA compliance (Zone 7, 2016a), and a GSP for that subbasin is anticipated in January 2022.

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[2] Per CWC §10727 (a), "A groundwater sustainability plan shall be developed and implemented for each medium- or high priority basin by a groundwater sustainability agency to meet the sustainability goal established pursuant to this part." Per CWC §10720.7 (b), "The Legislature encourages and authorizes basins designated as low- and very low priority basins by the department to be managed under groundwater sustainability plans pursuant to this part. Chapter 11 (commencing with Section 10735) does not apply to a basin designated as a low- or very low priority basin."

2.2. GSA Structure and Decision-Making Process

> *§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:*
> *(d) A communication section of the Plan that includes the following:*
> *(1) An explanation of the Agency's decision-making process.*

Key decisions regarding the 2021 Alt GSP development and implementation will be made by the Zone 7 Board of Directors (Board), which is also the governing body of the Zone 7 GSA.

2.2.1. Zone 7 Board Structure and Meetings

Zone 7 is overseen by a seven-member Board that is elected by the community to provide strategic guidance and planning for Zone 7's policies, programs and finances. Board members serve four-year terms and represent the public throughout the Livermore-Amador Valley.

Zone 7 Board meetings are open to the public and are held on the third Wednesday of every month at 7:00 p.m. at Zone 7's offices, located at 100 North Canyons Parkway in Livermore. Due to the COVID-19 pandemic, and pursuant to the Governor's Executive Order (N-29-20), Board meetings have recently been held online. Video recordings of the meetings are open to the public and can be accessed through the Tri-Valley Community Television website (http://www.tri-valleytv.org/?q=node/59). Board meeting agendas and packets are posted to the Zone 7 website (http://www.zone7water.com/library/board-meetings).

2.2.2. Board Committee Structure and Meetings

Board decision making is supported by four Board Committees including the Administrative Committee, the Liaison Committee, the Finance Committee, and the Water Resources Committee. Each Board Committee is composed of three Board members. Committee meetings are open to public and held on an "as needed" basis (Zone 7, 2012). Board committee assignments can be found on the Zone 7 website (http://www.zone7water.com/about-us/board-of-directors). The Water Resources Committee addresses both water and flood protection matters and will have direct involvement in the 2021 Alt GSP development and implementation.

2.2.3. Zone 7 Organizational Structure

The Board provides direction to Zone 7 management and staff through the Zone 7 General Manager and general counsel (Zone 7, 2016a). The General Manager is assisted by two Assistant General Managers with respective responsibility for Engineering and Finance. Three other Core Managers oversee the core functions of the Agency: Engineering, Operations and Maintenance, and Integrated Water Resources. Groundwater management falls under the Integrated Water Resources function and coordinates within the group to also achieve stream management and flood protection, long-term planning, watershed and water quality protection, environmental planning, Asset Management and Capital Improvement Program planning (Zone 7, 2016a). Zone 7's organizational chart is included as **Appendix A**.

2.3. Desired Outcome of 2021 Alt GSP Development and Implementation

For more than 50 years, Zone 7 has managed imported and local surface and groundwater resources for beneficial uses in the Basin. Given Zone 7's ongoing sustainable management of the Basin, DWR determined that the 2016 Alt GSP adopted by Zone 7 satisfied the objectives of the SGMA and approved the Plan in 2019[3].

As part of its approval of the 2016 Alt GSP, DWR provided four suggestions for how the 2021 Alt GSP could be improved (see **Appendix B**). Zone 7 successfully applied for a Sustainable Groundwater Management (SGM) Grant funded by the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018 (Proposition 68) to support the suggested refinements. As such, Zone 7's goal in developing and implementing the 2021 Alt GSP is to respond to DWR's comments while continuing to demonstrate that: (1) the Basin is being operated within its Sustainable Yield;[4] and (2) Zone 7 is successfully managing the groundwater resources within the Basin to prevent Undesirable Results.

2.4. Challenges for the Plan Area

Zone 7 anticipates and plans to address the following challenges in its development of the 2021 Alt GSP:

- A small portion of the Basin extends into Contra Costa County and outside of Zone 7's statutory boundaries. Coordination efforts are required among multiple entities, including Contra Costa County, Contra Costa County Water Agency, the City of San Ramon, DSRSD, and EBMUD. Zone 7 entered into a MOU with each of the above entities and has assumed the GSA role for that portion of the Basin (see **Appendix C**). Zone 7 will continue to actively involve and work cooperatively with these local agencies in its SGMA-related planning and programs.
- Urban and irrigated agriculture are the primary land uses in the Plan Area, including a portion of the City of Livermore that is a Disadvantaged Community (DAC). Some stakeholders may be concerned regarding how SGMA compliance could impact that land and water use, or costs. Zone 7 aims to be open and transparent in any decisions that will have a substantial impact on beneficial users of groundwater in the Plan Area and to engage stakeholders in the decision-making process to consider their interests and concerns.
- Based on varying geologic, hydrogeologic, and groundwater conditions, the Basin has three different Management Areas (23 CCR §354.20(a)), including the Main Basin, Fringe Subareas, and Upland Area. Groundwater pumping in the Fringe and Uplands Management Areas is minor relative to the Main Basin. Groundwater levels and other data are routinely monitored in portions of the Fringe and Uplands Management Areas; however, there are some areas of the Basin that are not adequately monitored. As part of the 2021 Alt GSP development, Zone 7 will be working to fill these data gaps.

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[3] The DWR Approval Letter regarding the Zone 7 2016 Alt GSP is posted on the Zone 7 website (http://www.zone7water.com/library/groundwater), accessed August 2010.

[4] SGMA defines Sustainable Yield as the maximum quantity of water (calculated over a base period representative of long-term conditions in the basin and including any temporary surplus) that can be withdrawn annually from a groundwater supply without causing an undesirable result. In 1992, Zone 7 Water Agency calculated the natural sustainable yield for the Basin at 7,214 acre-feet per year (Zone 7, 2016a).

- Zone 7 supports the current and expanded use of recycled water in the Tri-Valley, which results in lower consumption of potable water supplies, by updating the Salt Management Plan to address nutrient management and supporting retailer grant applications for recycled water infrastructure funding. Zone 7 has also been working closely with the retailers in exploring potential options for expanding recycled water use beyond irrigation applications. Potable reuse offers the benefits of being local and drought-proof; however, some key implementation issues remain to be resolved, including the need for using multiple treatment technologies for reliable purification and the feasibility of groundwater injection. Portions of the 2021 Alt GSP work will provide additional data and tools that can help evaluate the feasibility of these potential options to expand recycled water use.

3. STAKEHOLDER IDENTIFICATION AND COMMUNICATION

> *§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:*
> *(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.*

Zone 7 cooperates with the Regional Water Quality Control Board (RWQCB) - San Francisco Bay Region in the implementation of the Water Quality Control Plan (Basin Plan; RWQCB, 2015). In the Basin Plan, the RWQCB identifies beneficial uses and water quality objectives for surface water and groundwater in the Livermore Valley. Consistent with the Basin Plan, and in accordance with the interests listed in CWC §10723.2[5], Zone 7 identified current beneficial uses and users of groundwater and cooperative programs with groundwater users in the Basin in the 2016 Alt GSP (Zone 7, 2016a). Those key cooperative programs is summarized in **Table 1**, and beneficial uses and users of groundwater are described further below and in **Table 2**. Zone 7 welcomes all of the beneficial users of groundwater in the Basin, and the parties representing those interests, to participate in the 2021 Alt GSP development and implementation process through the venues for engaging described in **Section 5.**

3.1. Holders of Overlying Groundwater Rights

3.1.1. Agricultural Users

Zone 7 maintains maps of agricultural use within its service area, the majority of which are developed as vineyards or grazing, and tracks agricultural well locations. Agricultural demand accounted for a major portion of Basin groundwater use prior to the 1970s, but decreased significantly once imported surface water became available in 1974 (Zone 7, 2016a). Zone 7 provides approximately 5,600 acre-feet per year (AFY) of untreated surface water to local agriculture while agricultural pumping averaged approximately 400 AFY between 1974 and 2015 (Zone 7, 2016a; 2016b). Individual groundwater users have been active

[5] § 10723.2. The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans. These interests include, but are not limited to, all of the following:
(a) Holders of overlying groundwater rights, including:
(1) Agricultural users, including farmers, ranchers, and dairy professionals.
(2) Domestic well owners.
(b) Municipal well operators.
(c) Public water systems.
(d) Local land use planning agencies.
(e) Environmental users of groundwater.
(f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.
(g) The federal government, including, but not limited to, the military and managers of federal lands.
(h) California Native American tribes.
(i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.
(j) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.

participants in prior Zone 7 groundwater-related planning efforts and numerous private well owners participate in Zone 7 groundwater monitoring programs.

3.1.2. Domestic Well Owners

As shown in the 2016 Alt GSP, there are numerous domestic wells located within the Plan Area. Individual groundwater users have been active participants in prior Zone 7 groundwater-related planning efforts and numerous private well owners participate in Zone 7 groundwater monitoring programs.

However, the actual quantity and distribution of active domestic wells within the Plan Area remains a source of uncertainty. Zone 7 seeks to compile additional information on the number, location and status of domestic wells, especially in the Fringe and Uplands Management Areas of the Basin. Zone 7 will be conducting direct outreach to land- and well-owners as part of the 2021 Alt GSP process to identify potential wells for future monitoring.

3.1.3. Commercial and Industrial Users

Groundwater is used for golf course irrigation; otherwise there is limited direct use of groundwater by commercial entities within the Basin.

A major industrial land use in the Plan Area is aggregate mining, conducted by various mining companies. Groundwater is extracted to dewater localized areas to facilitate the active mining of gravel. The extracted groundwater is stored in holding ponds and can be used for industrial mining purposes such as gravel washing and dust control. Zone 7 worked closely with Alameda County Planning Department and the mining companies in developing a quarry reclamation plan that recognizes the importance of groundwater recharge and conveyance through the mining area. This resulted in the Specific Plan for Livermore Amador Valley Quarry Area Reclamation (LAVQAR), wherein the mining area reclamation is being implemented to include a series of "lakes" (the Chain of Lakes [COL]) that will be owned and operated by Zone 7 for flood control and managed aquifer recharge (Alameda County Board of Supervisors, 1981).

3.2. Municipal Well Operators

Municipal pumpers constitute the majority of groundwater use within the Basin and include Zone 7, the City of Pleasanton, California Water Service (Cal Water), the San Francisco Public Utilities Commission (SFPUC), and the Alameda County Fairgrounds. In addition to Zone 7's ten municipal wells, Cal Water operates 12 wells in the Livermore area, the City of Pleasanton operates three wells, and SFPUC operates two wells (Zone 7, 2016a). The DSRSD receives pumped groundwater through Zone 7 (Zone 7, 2016a).

In 1992, Zone 7 calculated the natural sustainable yield for the basin at 7,214 AFY and collaborated with its retailers to allocate the yield (Zone 7, 2016a). As a result, each retailer is limited to an annual independent Groundwater Pumping Quota (GPQ), which is generally based on average historical use and is pro-rated based on the agreed upon natural sustainable yield. Together, the retailers are permitted to pump a total average of 7,214 AFY without paying recharge fees to Zone 7. Groundwater extraction is reported to Zone 7 on a monthly basis. Retailer-specific pumping averages are tracked by Zone 7, including a process of carry-overs (limited to 20% of the GPQ) and the assessment of recharge fees for all groundwater pumped in excess of the GPQ and carry-over credit (Zone 7, 2016a).

Zone 7 pumping is for municipal purposes, salt management, demand peaks, and to address any shortage or interruption in its surface water supply or treatment (Zone 7, 2016a). Zone 7 pumps only groundwater that has been stored in the Basin as part of its aquifer recharge program (i.e., over the long-term, Zone 7 only pumps groundwater in volumes equivalent to or less than its active recharge; Zone 7, 2016a). The timing and quantity of Zone 7's active recharge efforts are typically dependent upon available supply, available recharge capacities, source water quality, and regulatory requirements. Zone 7 pumping has ranged from zero (for example, in the wet years of the early 1980s) to significant pumping during the drought years, for example from 1987 to 1992 and from 2007 to 2009 (Zone 7, 2016a).

3.3. Public Water Systems

Zone 7 supplies the majority of the water within the Plan Area through its four retailers, including Cal Water, DSRSD, City of Livermore and City of Pleasanton. Three of these retailers (DSRSD, City of Livermore and City of Pleasanton) are public water supply agencies. The SFPUC supplies groundwater to the Castlewood Development in the western portion of Pleasanton (Zone 7, 2016a). Alameda County Fairgrounds, in Pleasanton, has a small water system that relies on groundwater.

The retailers and Zone 7 work together through various means of communication including the Tri-Valley Water Retailers Group (TWRG), consisting of staff from each retailer, and Liaison Committee meetings, consisting of both elected officials and staff (Zone 7, 2016a). Policy-level discussions related to water resources management is held through either the Water Resources Committee or Liaison Committee meetings. In addition to these formal meetings, the staff from operations and planning regularly meet to discuss annual operations, safety and emergency response, and long-term water supply planning (Zone 7, 2016a).

Zone 7 maintains close coordination with these public water systems within its service area. To the extent that additional public water systems are identified, they will be considered and engaged during the development and implementation of the 2021 Alt GSP.

3.4. Local Land Use Planning Agencies

The Basin is located mostly in Alameda County, with a northern extension into Contra Costa County. Cities overlying portions of the Basin include San Ramon, Dublin, Pleasanton, and Livermore. The Counties and Cities are responsible for land use planning in the Plan Area.

There are two Park Districts in the Valley: the East Bay Regional Park District (EBRPD) and the Livermore Area Recreation and Park District (LARPD). The Lake Del Valle State Recreation Area and Shadow Cliffs Regional Recreation Area located on the southern side of the Basin are operated by EBRPD (Zone 7, 2016a). In addition, the Tri-Valley Conservancy (TVC) protects open space for parks, farms, trails, ranches and wildlife habitat in the Tri-Valley. Most of the lands managed by TVC are in the Fringe and Upland Management Areas of the Basin (TVC, 2019).

Zone 7 maintains close coordination with the land use planning entities within its service area. To the extent that additional local land use planning agencies are identified, they will be considered and engaged during the development and implementation of the 2021 Alt GSP.

3.5. Environmental Users of Groundwater

Based on the 2016 Alt GSP and comments provide by DWR, there may be areas of the Basin that are considered a groundwater-dependent ecosystem (GDE), or where there is known surface water-groundwater interaction. These areas include, but are not necessarily limited to:

- The Springtown Alkali Sink (Sink) that is habitat for over a dozen Federally-listed, state-listed or state-listed-as-sensitive plant and animal taxa and includes plant communities that are globally or regionally rare or otherwise degraded. The Sink is also designated as Critical Habitat for vernal pools and some vernal pool species, and identified as predicted habitat for California red-legged frog, by the US Fish and Wildlife Service[6]. Recognized as such, most of the alkali sink and adjacent creeks are protected either as Preserves of the City of Livermore or conservation easements, or are owned and managed by Zone 7 or the Federal Communications Commission (Zone 7, 2016a).
- The prehistoric Pleasanton marsh complex extended over thousands of acres, including much of the Bernal and Castle Subareas and extending north into the Dublin Subarea and east into the Amador Subarea (Zone 7, 2016a). The existence of the marsh complex reflected the limited outlet of the Livermore-Amador Valley along Arroyo de la Laguna, resulting in shallow groundwater levels and ponding of floodwater. Arroyo de la Laguna is situated along the western edge of the Livermore-Amador Valley (and the former Pleasanton Marsh) and extends southward into the Sunol Valley Groundwater Basin, where it joins Alameda Creek (Zone 7, 2016a).

A significant focus of the 2021 Alt GSP is focused on improved delineation of GDEs in the Basin. To the extent that additional environmental users of groundwater are identified, they will be considered, and appropriate representatives will be engaged during the development and implementation of the 2021 Alt GSP.

3.6. Surface Water Users

Surface drainage features within the Basin include the Arroyo Valle, Arroyo Mocho, and Arroyo las Positas as principal streams, with Alamo Creek, South San Ramon Creek, and Tassajara Creek as minor streams draining from the north. All streams converge on the west side of the Basin to form Arroyo de la Laguna, which flows south, exiting the Livermore Valley and joining Alameda Creek in Sunol Valley. Both the Arroyo Valle and Arroyo Mocho originate in the woodland forests of the Burnt Hills region in Santa Clara County, in the sub-watershed above Lake Del Valle. These two streams and their tributaries cover the largest drainage areas within the Zone 7 service area. The Arroyo Las Positas mainly flows westerly along Interstate 580 and is fed by the Arroyo Seco, Altamont Creek, Cayetano Creek, Collier Canyon Creek, and Cottonwood Creek (Zone 7, 2016a).

As the water wholesaler for the Tri-Valley Area, Zone 7 imports surface water from the State Water Project (SWP) through the South Bay Aqueduct (SBA) for treatment, storage, and groundwater recharge. As part of Zone 7's managed recharge efforts, the imported water is discharged into the Arroyo Valley and Arroyo Mocho, where the underlying gravels allow the water to percolate into the Basin. Zone 7 supplies treated drinking water to its four retailers (i.e., Cal Water, Pleasanton, Livermore and DRSD), which deliver water

[6] See the California Department Fish and Wildlife interactive map https://apps.wildlife.ca.gov/bios/.

to customers in their specific service areas. Zone 7 also supplies untreated surface water for local industry and agriculture.

Numerous saline springs have been observed east of the Basin associated with upwelling along faults, especially those in the Greenville fault zone. Although minor springs contribute to the upper reaches of the Arroyo Mocho and Arroyo Valle above Lang Canyon, none of these springs contribute sufficient runoff to the arroyos to cause continuous flow in the streams (i.e., most are isolated and are subject to tectonic shifts and climatic conditions that impact the amount of flow emanating) (Zone 7, 2016a).

Other surface water bodies include the Chain of Lakes, which when completed will consist of ten quarry lakes in the western central Basin, and Lake Del Valle, a portion of which is located within the southern end of the Basin.

A significant focus of the 2021 Alt GSP is focused on improved delineation of surface water/groundwater interaction in the Basin. To the extent that additional areas of groundwater/surface water are identified, they will be considered and appropriate representatives will be engaged during the development and implementation of the 2021 Alt GSP.

3.7. The Federal Government

Based on application of DWR's SGMA Data Viewer, within the Plan Area there are several areas of California Department of Fish and Wildlife (CDFW) owned and operated lands and conservation easements, Nonprofit California Protected Area (CPA) holdings, and California Conservation Easements (CCE).

The Camp Parks Military Reservation/Reserve Forces Training Area is located on the northern boundary of the Basin and is operated by the Department of Defense/United States Army. The facility is a semi-active mobilization and training center for army reserve personnel to be used in case of war or natural disaster. The site also includes a federal correctional institution (Zone 7, 2016a).

To the extent that additional Federal and State landowners are identified, they will be also be considered and engaged during the development and implementation of the 2021 Alt GSP.

3.8. California Native American Tribes

There are no identified California Native American tribal lands within the Plan Area.

3.9. Disadvantaged Communities

There are three block groups identified as DACs based on an average household income less than 60% to 80% of the State median (U.S. Census, 2016). There are currently 2,598 disadvantaged households in the City of Livermore, with a total population of 6,678. Zone 7 will coordinate with the City of Livermore and community representative or groups, as appropriate, with respect to how to best engage with, and address the needs of, this DAC.

3.10. Groundwater Monitoring Entities

Zone 7 implements a groundwater elevation monitoring program within the Basin to track groundwater levels and flow, identify short- and long-term trends, estimate subsurface flows between Basin Management Areas, and support water budget and storage analyses. The groundwater elevation monitoring program consists of about 240 wells including 18 nested wells providing local information on vertical gradients (Zone 7, 2016a). These data will be incorporated into the 2021 Alt GSP.

3.11. Additional Stakeholders

As a water supply wholesaler, Zone 7 maintains close relationships with other groundwater users in the basin, and coordinates their actions with the groundwater monitoring and management activities of others (Zone 7, 2016a). **Table 1** below provides a summary of key cooperative programs.

Table 1. Summary of Cooperative Water Resource Management Programs

Water Resources Management Program	Other Local Agency	Zone 7 Cooperative Role
Onsite Wastewater Treatment System (OWTS)	Alameda County Environmental Health (ACEH)	Reviews permit applications; Zone 7 approval is required in some cases
Toxic Sites Surveillance (TSS)	RWQCB and ACEH	Tracks progress of site investigation/cleanup and provides input to lead agencies
Surface Mining Permits	Alameda County Community Development Agency (ACCDA)	Reviews permit changes and provides input as a future owner
Water Quality/Groundwater Elevation Monitoring	Retailers (City of Pleasanton, City of Livermore, DSRSD, Cal Water); Lawrence Livermore National Laboratory (LLNL)	Data sharing of water quality and elevation data
Referral Process (Development Reviews/ **California Environmental Quality Act** [CEQA] Reviews)	Cities of Pleasanton, Livermore, and Dublin, and Alameda County.	Review proposed site plans and comment on existing infrastructure as well as potential impacts
South Bay Contractors	Alameda County Water District (ACWD) and Santa Clara Valley Water District (SCVWD)	Work with other water agencies on allocating water supply available for recharge
Integrated Regional Water Management	San Francisco Bay Area water agencies	Local representative

Water Resources Management Program	Other Local Agency	Zone 7 Cooperative Role
Liaison Committee	Cities, retailers, DSRSD, Elected Officials	Local representative to provide input and information
Tri-Valley Potable Reuse Feasibility Study	Retailers	Evaluating feasibility of potable reuse for the Valley

Zone 7 has established positive ongoing working relationships with numerous other agencies involved in the basin including, but not limited to DWR, RWQCB, Alameda County, Contra Costa County, CDFW, U.S. Fish and Wildlife Service, National Marine Fisheries Service (NOAA-NMFS), and the U.S. Army Corps of Engineers. For example, Zone 7 was an early signatory to a Statement of Understanding for the development of NOAA-NMFS Multispecies Recovery Plan that explores responsible water management for the preservation of Oncorhynchus mykiss (steelhead trout) within the Alameda Creek watershed.

For development of the 2004 Salt Management Plan, Zone 7 assembled a Groundwater Management Advisory Committee including citizens and stakeholders and an independent Technical Advisory Group (including key stakeholders and water retailers). Similarly, the 2015 Nutrient Management Plan was developed with support and input from the RWQCB, ACEH, ACCDA, Zone 7 retailers, and other stakeholders and interested public. Most recently, the Tri-Valley Potable Reuse Feasibility Study was developed through a process involving a series of public Round Table discussions among representatives of Zone 7 and the retailers, along with extensive outreach to the public, including a survey (Zone 7, 2016a).

Table 2. Stakeholder Identification and Planned Engagement Summary

Organization/ Individual	Type of Stakeholder (a)	Anticipated Key Interests	Anticipated Key Issues (b)	Relevant Alt GSP Sections	Level of Engagement and Rationale (c)
Retailers (d)	Municipal Users and Public Water Systems	Preserving access to high quality groundwater for municipal uses	• Water quality degradation • 2021 Alternative Groundwater Sustainability plan (Alt GSP) development and implementation costs • Increased Recycled Water Use	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Agricultural Water Users	Agricultural Users	Preserving access to high quality groundwater for irrigation	• Potential curtailment of pumping • 2021 Alt GSP development and implementation costs	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Domestic Well Users	Domestic Well Owners	Preserving access to high quality groundwater for domestic users	• Water quality degradation • Declining water levels • 2021 Alt GSP development and implementation costs	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Industrial Well Users	Industrial Users	Continue to operate mining field	• Water quality degradation • Declining water levels from increased mining pit depths • 2021 Alt GSP development and implementation costs	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Commercial Well Users	Commercial Users	Continue to irrigate golf course	• Water quality degradation • 2021 Alt GSP development and implementation costs	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users

Organization/ Individual	Type of Stakeholder (a)	Anticipated Key Interests	Anticipated Key Issues (b)	Relevant Alt GSP Sections	Level of Engagement and Rationale (c)
SFPUC	Municipal Well Users	Preserving access to high quality groundwater for municipal uses	• Water quality degradation	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Alameda County Fairgrounds	Public Water System	Preserving access to high quality groundwater for municipal uses	• Water quality degradation	• Plan Area • Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Alameda County, Contra Costa County, City of San Ramon, City of Dublin, City of Pleasanton, and City of Livermore	Local Land Use Planning Agency	Managing County-wide or City-wide land use	• Implications for land use planning	• Plan Area • Projects and Management Actions	Inform and involve to avoid negative impact to these users
East Bay Regional Park District, Livermore Area Recreation and Park District, and Tri-Valley Conservancy	Local Land Use Planning Agency	Managing Regional-wide land use	• Implications for land use planning	• Plan Area • Projects and Management Actions	Inform and involve to avoid negative impact to these users
California Department of Fish and Wildlife, and Camp Parks Military Reservation / Reserve Forces Training Area	Federal Government	Managing Regional-wide land use	• Implications for land use planning	• Plan Area • Projects and Management Actions	Inform and involve to avoid negative impact to these users

Organization/ Individual	Type of Stakeholder (a)	Anticipated Key Interests	Anticipated Key Issues (b)	Relevant Alt GSP Sections	Level of Engagement and Rationale (c)
Groundwater Dependent Ecosystem (e)	Environmental Users	Preserving interconnected surface water and groundwater interactions	• Water quality degradation • Declining water levels	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Surface Drainage Features (f)	Surface Water Users	Preserving interconnected surface water and groundwater interactions	• Declining water levels	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Disadvantaged Communities	Disadvantaged Communities	Preserving access to high quality groundwater for domestic and municipal uses	• 2021 Alt GSP development and implementation costs	• Plan Area • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users

Notes:

(a) Type of stakeholder based on CWC §10723.2 (e.g., agricultural groundwater users, municipal well operators, etc.).
(b) Any documented issues (media coverage, statements, reports, etc.), specific issues such as past events, or issues that have been otherwise communicated to or are anticipated by Zone 7.
(c) Level of engagement based on the International Association of Public Participation Spectrum of Public Participation, as referenced in DWR's Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement (DWR, 2018).
(d) Retailers in the Basin include California Water Service, Dublin San Ramon Service District, City of Livermore, and City of Pleasanton.
(e) Known or suspected Groundwater Dependent Ecosystems within the Basin include the Springtown Alkali Sink and the prehistoric Pleasanton marsh complex.
(f) Surface drainage features within the Basin include the Arroyo Valle, Arroyo Mocho, and Arroyo las Positas as principal streams, with Alamo Creek, South San Ramon Creek, and Tassajara Creek as minor streams. Other surface drainage features include numerous saline springs and the South Bay Aqueduct.

4. STAKEHOLDER ENGAGEMENT AND FREQUENTLY ASKED QUESTIONS

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:
(d) A communication section of the Plan that includes the following:
(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

Zone 7 has developed objectives that support a basic philosophy of working cooperatively with groundwater stakeholders in the Basin including the public, irrigation and domestic well owners, gravel mining companies, TWRG, water purveyors, and planning agencies. These objectives include:

- develop information, policies, and procedures for the effective long-term management of the groundwater basin;
- inform the public and relevant governmental agencies of the Zone's water supply potential and management policies and to solicit their input and cooperation; and
- work cooperatively with the gravel mining industry to implement the Chain of Lakes reclamation plan.

Zone 7 involves the public, stakeholders and local agencies in its planning and programs through meetings, data sharing, and online media and has memorialized this approach as an operational policy in the Agency's 1987 Statement on Groundwater Management (Zone 7, 2016a)[7].

Zone 7's C&E efforts described herein specifically aim to provide beneficial uses and users of groundwater within the Basin with opportunities to engage in the 2021 Alt GSP development and implementation process. Zone 7 will provide on-going outreach opportunities through the specific communication venues discussed in **Section 5**.

Zone 7 further aims to convey consistent high-level messaging to all stakeholders throughout 2021 Alt GSP development and implementation. As such, Zone 7 has developed a summary of anticipated questions as well as responses. **Table 3** will be updated to add additional, frequently received questions as well as to build upon responses based on 2021 Alt GSP development progress.

Table 3. Likely Stakeholder Questions and Responses

Likely Questions	Responses
How can I participate in the 2021 Update of Alt GSP development and implementation process?	Zone 7 Board meetings are open to the public and held on the third Wednesday of every month. Board meeting agendas and packets are posted to the Zone 7 website: (http://www.zone7water.com/library/board-meetings).

[7] Objectives include: "To inform the public and relevant governmental agencies of the Zone's water supply potential and management policies, and to solicit their input and cooperation."

Likely Questions	Responses
What types of management actions or projects have been done or are going to occur in my area?	Zone 7 has implemented several management actions that are outlined in the Well Master Plan (2003), Salt Management Plan (2004), Nutrient Management Plan (2015), and 2016 Alt GSP. Additional management actions or projects have not been identified yet, as we are in the preliminary stages of the 2021 Alt GSP development.
Are pump meters going to be required?	At this point Zone 7 does not plan to require meters for single family residential, domestic, or agricultural wells.
Can groundwater management activities improve water challenges in DACs?	Zone 7 has implemented several long-term management actions (listed above) to improve the water quality and to ensure future water supply for DACs.
Who is paying for 2021 Alt GSP development and implementation?	Funding for the 2021 Alt GSP development is provided by Zone 7 and the DWR SGM Grant funded by Proposition 68.
How will Zone 7 resolve groundwater conflicts?	The Livermore Valley Groundwater Basin is not adjudicated; therefore, the State of California governs water rights and ownership. Zone 7 will work with landowners and the State to provide guidance and local data to resolve groundwater conflicts.
Why does my water taste funny/musty?	During the warm summer months, algae that produces a musty/muddy odor can grow in the surface waters of the South Bay Aqueduct (SBA), from which the Tri-Valley gets 80% of its water supply. DWR, which controls the SBA, treats the water periodically to minimize the growth of algae. Zone 7 is also in the process of building two ozone facilities that provide additional treatment to reduce the musty taste caused by algae. Consumer Confidence Report provided information on local drinking water quality can be accessed through the website here: http://www.zone7water.com/36-public/content/120-consumer-confidence-report.
Why is my water so hard? Why are there white spots on my glassware or car after washing?	In the late 1980s, total dissolved solids (TDS) concentrations increased in the Basin and have been relatively steady since that time. Zone 7 has been proactively addressing TDS concentrations, including implementing demineralization projects, both ongoing (Mocho Wellfield demineralization) and planned (Tri-Valley Recycled Water Project).
Is my water contaminated with Nitrate/Chromium/Boron/PFAS?	While these constituents of concern are present in the Basin, Zone 7 closely monitors the extent of these constituents and ensures that the concentrations of these constituents do not exceed any drinking water limits when introduced into the water distribution system.

Likely Questions	Responses
Does my well require CEQA compliance?	Currently CEQA compliance for supply wells is discretionary (i.e., at the discretion of the local agency); however, the California Supreme Court is currently evaluating whether or not this should be mandatory or not.
Is groundwater pumping causing land subsidence?	Zone 7 surveyed the land surface in the vicinity of our municipal wells in Pleasanton between 2002 and 2018 and has been monitoring the land surface over the entire Tri-Valley using InSAR since 2016. We have not seen any evidence of inelastic land subsidence from groundwater pumping.

5. VENUES FOR ENGAGING

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:
(b) A list of public meetings at which the Plan was discussed or considered by the Agency.
(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.
(d) A communication section of the Plan that includes the following:
(1) Identification of opportunities for public engagement and a discussion of how public input and response will be used.
(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

Zone 7 has historically provided, and will continue to provide, a variety of opportunities for engagement with stakeholders per (23-CCR §354.10(d)(1)). Stakeholder input received will inform and be incorporated into corresponding sections of the 2021 Alt GSP, as appropriate.

A list of public meetings at which the 2021 Alt GSP has been discussed or considered by Zone 7 is included as **Appendix D** and will be updated regularly (23-CCR §354.10(b)).

5.1. Zone 7 Board Meetings

Zone 7 Board meetings are open to the public and are held on the third Wednesday of every month at 7:00 p.m. at Zone 7's offices, located at 100 North Canyons Parkway in Livermore. Due to the COVID-19 pandemic, and pursuant to the Governor's Executive Order (N-29-20), Board meetings have recently been held online. Video recordings of the meetings are available to the public and can be accessed through the Tri-Valley Community Television website (http://www.tri-valleytv.org/?q=node/59). Board meeting agendas and packets are posted to the Zone 7 website (http://www.zone7water.com/library/board-meetings).

Zone 7 intends to inform its stakeholders of key updates and decisions regarding the 2021 Alt GSP during public Board meetings. These meetings provide a key venue for public engagement and discussion and will be where comments on the 2021 Alt GSP will be documented and addressed, as appropriate. Presentation materials will be posted on the SGMA website, discussed below.

As part of the Alt GSP implementation efforts, Zone 7 will continue to use the Board meetings as a venue to inform the public about 2021 Alt GSP implementation progress, including the status of projects and actions (23-CCR §354.10(d)(4)).

5.2. Website Communication

Zone 7 regularly updates its website (https://www.zone7water.com/) with Board meeting materials as described in **Section 2.2.1**. It also includes a webpage that includes significant reports related to its water resources and groundwater (https://www.zone7water.com/library/reports-planning-documents). Stakeholders can sign up to receive newsletters and other communications from Zone 7 directly from the website: https://www.zone7water.com/news/enewsletter-signups.

A new, dedicated webpage that briefly summarizes SGMA, the Alt GSP, Annual Reporting, and Five-Year Update process will be developed as part of the 2021 Alt GSP development effort. This updated webpage will provide information to the public and other agencies to encourage public involvement in the SGMA process.

5.3. Stakeholder Outreach

Zone 7 currently envisions directly engaging with key stakeholders throughout the development of the 2021 Alt GSP (e.g., Tri-Valley Retail Group and the local land use and regulatory agencies). Zone 7 will keep records of all stakeholder outreach efforts, which will also be included as **Appendix D**.

Zone 7 initiated an "Open House" event in October 2019, and intends to hold similar public engagement event annually to showcase Zone 7's facilities, operations, and projects, including SGMA and other groundwater management efforts. Website and radio advertisement links for the 2019 Open House Are shown in **Appendix D**. However, due to the COVID-19 pandemic, public engagement event for 2020 has not yet been decided.

5.4. Public Review of Draft Materials

Zone 7 plans to make a public draft version of the 2021 Alt GSP available for public review for a period of at least 30 days. A Public Hearing prior to the adoption of the Plan will also be held. Feedback received on the draft document will be noted and responses incorporated into the Final 2021 Alt GSP (23-CCR §354.10(c)). Public comments received on the 2021 Alt GSP are included in **Appendix E**.

5.5. Agencywide Annual Report

Every year, Zone 7 produces an agencywide annual report, which can be accessed directly from the website: http://www.zone7water.com/reports-a-planning-documents. The agencywide annual report includes information regarding Zone 7's key accomplishments, outreach and education events, supply and demand, and water quality.

6. IMPLEMENTATION TIMELINE

Zone 7's C&E implementation efforts will be aligned with the 2021 Alt GSP development timeline, as described in **Table 4** below.

Table 4. 2021 Update of Alternative Groundwater Sustainability Plan and Communication & Engagement Efforts by Phase

Alt GSP Element	Timeframe	2021 Alt GSP Efforts	C&E Efforts
Plan Stakeholder Engagement	July 2020 – December 2021	• Data collection and review	• Develop and begin to implement SCEP • Begin website update
Groundwater Level Program Update	July 2020 – December 2021	• Data collection and review • Revise Depth to Water and Historic Low Maps • Review/Develop Measurable Objectives, Minimum Thresholds	• Outreach to existing well owners • Conduct meetings with key stakeholders • Present progress update at one (1) Board meeting • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development
Groundwater Storage Program Update	July 2020 – September 2021	• Extend Existing Hydrogeologic Framework • Migrate and Extend Areal Recharge Model (ARM) • Review/Develop Measurable Objectives, Minimum Thresholds	• Conduct meetings with key stakeholders • Present progress update at one (1) Board meeting • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development
Groundwater Quality Program Update	July 2020 – December 2021	• Update TDS and Nitrate Projections • Evaluate Effectiveness of NMP • Review/Develop Measurable Objectives, Minimum Thresholds	• Conduct meetings with key stakeholders • Present progress update at one (1) Board meeting • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development
Land Subsidence Program Update	July 2020 – December 2021	• Evaluate Use of InSAR	• Conduct meetings with key stakeholders • Present progress update at one (1) Board meeting • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development

Surface Water - Groundwater Interaction / GDE Program Update	July 2020 – September 2021	• Confirm presence of GDEs • Assess Groundwater Needs for Sustainability • Review/Develop Measurable Objectives, Minimum Thresholds • Evaluate the Need for New Monitoring Locations and Protocols	• Conduct meetings with key stakeholders • Present progress update at one (1) Board meeting • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development
Prepare 2021 Alt GSP Report	July 2020 – December 2021	• Compile complete draft 2021 Update of Alt GSP • Revise draft 2021 Update of Alt GSP (if necessary) per stakeholder feedback • Finalize 2021 Update of Alt GSP Chapter and submit to DWR	• Distribute public review draft 2021 Alt GSPs for public review • Incorporate feedback from public review in 2021 Alt GSP • Present progress update at one (1) Board meeting • Hold Public Hearing to adopt 2021 Alt GSP • Update SCEP, as needed to reflect C&E efforts during 2021 Alt GSP development

7. EVALUATION AND ASSESSMENT

Zone 7 intends to assess its C&E implementation during the 2021 Alt GSP development process, as shown in **Table 4**. Zone 7 will also present brief summaries of C&E progress at Zone 7 Board meetings and will lead a discussion about lessons learned and what can be improved as part of future SGMA implementation. The following questions will guide C&E evaluation:

- What worked well?
  - What allowed us insight into stakeholder concerns?
  - What types of materials best communicated GSP development to stakeholders?
- What didn't work as planned?
  - Could materials (e.g., presentation slides, fact sheets, website pages) have been improved to better communicate 2021 Alt GSP development progress?
  - Are certain stakeholder groups less represented in the 2021 Update of Alt GSP development process than they should be?
- What do we plan on doing differently during the next phase based on what we have learned?
- How much of our C&E budget have we spent relative to work completed? Do we have enough remaining budget to complete our C&E plan?
- Are there any outreach venues that need to be added to the implementation timeline?
- What are the next steps?

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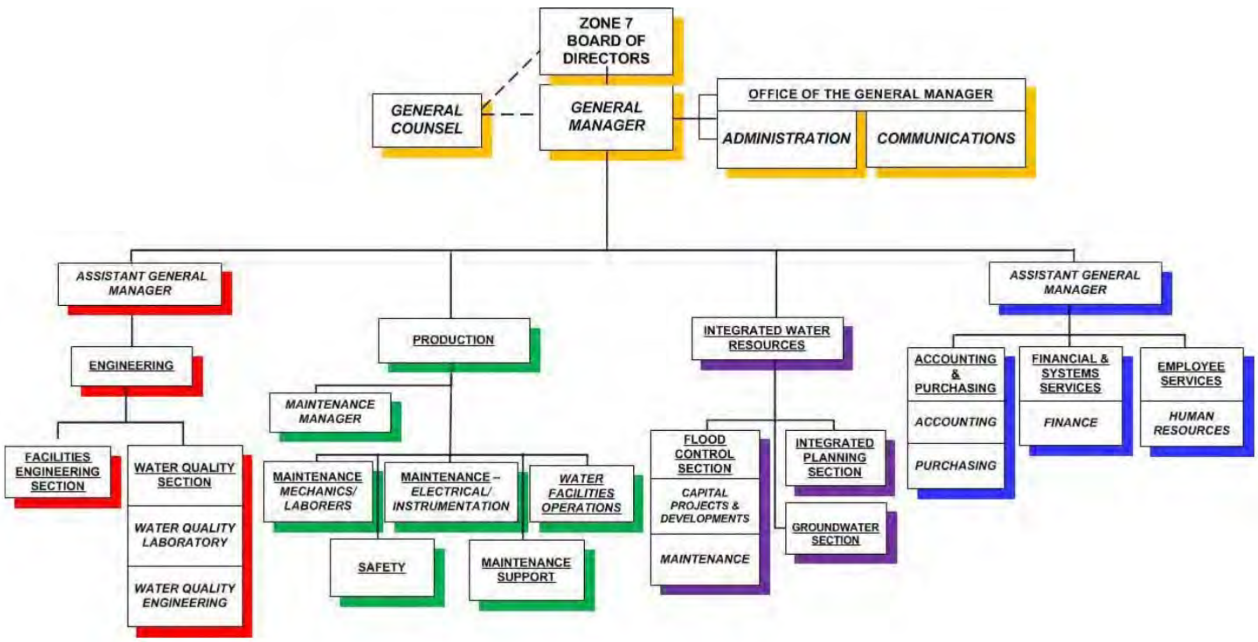
APPENDIX A

Zone 7 Organizational Chart



APPENDIX B

Summary of DWR Recommendations

The following recommended actions include information that the District may wish to include in the first five-year update of the Alternative to facilitate the Department's ongoing evaluation and assessment of the Alternative as well as recommendations for improvements to the Alternative.

Recommended Action 1.
Staff recommends that in the first update to the Alternative Report, the Agency identify those groundwater levels taken at representative monitoring sites, that are used to define the minimum threshold for the Basin, to facilitate the Department's ongoing responsibility to evaluate the Alternative Report.

Recommended Action 2.
Staff recommends that the Agency should develop quantitative minimum thresholds for the chronic lowering of groundwater levels for the Fringe and Upland management areas to better align with the requirements for management areas and definition of minimum thresholds, as defined in 23 CCR Sections 354.20(b)(2) and 354.28(b)(6).

Recommended Action 3.
Staff recommends that the Agency develop quantitative minimum thresholds for reduction of groundwater storage for the Fringe and Upland management areas to better align with the requirements for management areas and definition of minimum thresholds, as defined in 23 CCR Sections 354.20(b)(2) and 354.28(b)(6).

Recommended Action 4.
Staff recommends that the Agency include monitoring groundwater levels at additional locations in the Uplands Management Area to monitor changes in groundwater conditions and manage the groundwater resources to prevent undesirable results in future updates to the Alternative Report. The Agency should identify the frequency and timing when groundwater levels would be collected at new monitoring stations, and other relevant monitoring well construction information in accordance with the GSP Regulations.

APPENDIX C

Memorandums of Understanding with Other Agencies

MEMORANDUM OF UNDERSTANDING
AMONG
ZONE 7 OF THE ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT,
CONTRA COSTA COUNTY,
CONTRA COSTA COUNTY WATER AGENCY,
CITY OF SAN RAMON,
EAST BAY MUNICIPAL UTILITY DISTRICT
AND
DUBLIN SAN RAMON SERVICES DISTRICT

This memorandum of understanding (MOU) is made and entered among Contra Costa County (CCC), Contra Costa County Water Agency (CCCWA), the City of San Ramon (San Ramon), the East Bay Municipal Utility District (EBMUD) and the Dublin San Ramon Services District (DSRSD) (together, the Five Parties) and Zone 7 of the Alameda County Flood Control and Water Conservation District (Zone 7) in consideration of the factual recitals and mutual obligations contained herein.

W I T N E S S T H

WHEREAS, the Sustainable Groundwater Management Act of 2014 (SGMA) requires the formation of Local Groundwater Sustainability Agencies (GSAs) and the adoption of Groundwater Sustainability Plans for high- and medium-priority basins within five to seven years; and

WHEREAS, while the majority of the Livermore-Amador Valley Groundwater Basin (DWR Groundwater Basin No. 2-10, hereinafter referred to as "Basin No. 2-10"), a medium priority basin, lies within the boundaries of Alameda County and the jurisdiction of Zone 7, portions lie within the boundaries of Contra Costa County and the jurisdictions of CCC, CCCWA, San Ramon, DSRSD, and EBMUD; and

WHEREAS, SGMA identified Zone 7 as the exclusive local agency to be the GSA for managing groundwater within its statutory boundaries (Water Code, § 10723, subd. (c)(1)(A)), and those statutory boundaries include the portion of Basin No. 2-10 lying within Alameda County, which comprises the majority of the basin; and

WHEREAS, the Five Parties agree it would be prudent for Zone 7 to also manage the small remaining portion of Basin No. 2-10 that lies within the jurisdictions of CCC, CCCWA, San Ramon, DSRSD, and EBMUD to achieve effective groundwater management; and

WHEREAS, it is in the interests of the Five Parties and Zone 7 to maintain current levels of jurisdictional authority while striving for holistic, sustainable groundwater basin management; and

WHEREAS, it is mutually beneficial to create this agreement to establish a delegation of authority to allow Zone 7 to be the GSA for the remaining portion of Basin No. 2-10 within the jurisdictions of CCC, CCCWA, San Ramon, DSRSD, and EBMUD to assure sustainable groundwater management;

NOW, THEREFORE, the Five Parties and Zone 7 do hereby agree as follows:

1. Purposes of MOU. The purposes of this MOU are (1) for each of the Five Parties to agree to confer to Zone 7 certain Delegated Authority (as that term is defined in Paragraph 2.A below) within the Delegated Area (as that term is defined in Paragraph 3 below), and (2) for Zone 7 to agree to exercise the Delegated Authority within the Delegated Area.

2. Authority and Responsibility.

   A. Upon execution of this MOU, and upon final approval by California Department of Water Resources recognizing Zone 7 as the GSA responsible for the portion of Basin No. 2-10 lying within the area described in Paragraph 3 of this MOU, the Five Parties agree to delegate to Zone 7 all functions, powers, duties, and authority of a GSA conferred by SGMA. Notwithstanding any other provision of this MOU, the following authority shall not be delegated to Zone 7: (1) CCC shall continue to be the well permitting agency for all areas within its jurisdiction, (2) San Ramon and CCC shall continue to be the land use agencies for all areas within their respective jurisdictions, and (3) EBMUD and DSRSD shall continue to be the water supply agencies for all areas within their respective jurisdictions. The authority delegated by this Paragraph 2.A is referred to herein as the "Delegated Authority".

   B. Zone 7 agrees to assume and exercise all responsibilities required of a GSA, and to enforce all provisions and requirements contained in the Groundwater Sustainability Plan to be adopted for Basin No. 2-10 in accordance with SGMA. Zone 7 shall continue to monitor groundwater elevations within the Designated Area and to enter data into CASGEM as required in order to maintain grant eligibility.

3. Geographic Extent of Delegated Authority. The Delegated Authority shall have effect in that portion of Basin No. 2-10 which lies within the jurisdictional boundaries of each of the Five Parties, which portion is depicted in Exhibit A and is referred to herein as the "Delegated Area".

4. Records. Zone 7 shall provide each of the Five Parties copies of all documents, reports, studies and other records created in the course of its exercise of the Delegated Authority which affects or relates to groundwater management within the Delegated Area. CCC shall provide Zone 7 with copies of all well permits issued or environmental reports received (including well completion reports) and any water level measurements taken within the Delegated Area. Zone 7 and the Five Parties shall cooperate and coordinate in responding to requests made under the California Public Records Act regarding records related to groundwater management within the Delegated Area.

5. Term. This MOU becomes valid and effective immediately upon execution by each of the Five Parties and Zone 7 and shall remain in effect unless terminated pursuant to Paragraph 9, below.

6. Entire Agreement. This MOU shall constitute the entire agreement among the Five Parties and Zone 7 relating to the delegation of authority provided by SGMA as relates to Basin No. 2-10. This MOU supersedes and merges all previous understandings, and all other agreements, written or oral, between the parties and sets forth the entire

understanding of the parties regarding the subject matter thereof.

7. Counterparts and Copies. This MOU may be executed in any number of counterparts, each of which may be deemed an original and all of which collectively shall constitute a single instrument. Photocopies, facsimile copies, and PDF copies of this MOU shall have the same force and effect as a wet ink original signature on this MOU.

8. Amendment. This MOU may be amended at any time by a written agreement duly executed by each of the Five Parties and Zone 7.

9. Termination.

A. This MOU may be voluntarily terminated in full at any time by a writing signed by each of the Five Parties and Zone 7.

B. Any of the Five Parties may elect to terminate its participation in this MOU at any time. Termination of such party's participation in this MOU shall not become effective until after both of the following have occurred: (1) the terminating party provides written notice to all other signatories to this MOU of its intent to terminate its participation, and (2) one year has elapsed following the date of such written notice, during which time the terminating party may make efforts to assume the GSA role for the portion of the Delegated Area within the terminating party's jurisdiction. The termination of any of the Five Parties' participation in this MOU shall not affect the continuing validity of the MOU with respect to the remaining signatories.

C. Zone 7 may provide written notice to each of the Five Parties of its intent to terminate the Agreement, and the MOU shall cease to be of further effect one year following delivery of Zone 7's notice, during which time Zone 7 shall continue to exercise the Delegated Authority within the Delegated Area to allow adequate time for the Five Parties to address GSA related requirements for their respective portions of the Delegated Area.

10. Signatures. The individuals executing this MOU represent and warrant that they have the legal capacity and authority to do so on behalf of their respective legal entities.

IN WITNESS WHEREOF, the parties hereto have executed this MOU as follows:

CONTRA COSTA COUNTY

By:____________________
President, BOS Dated:

ZONE 7 OF THE ALAMEDA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

By: [signature] 21 Apr 2016
G.F. Duerig Dated:

understanding of the parties regarding the subject matter thereof.

7. Counterparts and Copies. This MOU may be executed in any number of counterparts, each of which may be deemed an original and all of which collectively shall constitute a single instrument. Photocopies, facsimile copies, and PDF copies of this MOU shall have the same force and effect as a wet ink original signature on this MOU.

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C. Zone 7 may provide written notice to each of the Five Parties of its intent to terminate the Agreement, and the MOU shall cease to be of further effect one year following delivery of Zone 7's notice, during which time Zone 7 shall continue to exercise the Delegated Authority within the Delegated Area to allow adequate time for the Five Parties to address GSA related requirements for their respective portions of the Delegated Area.

10. Signatures. The individuals executing this MOU represent and warrant that they have the legal capacity and authority to do so on behalf of their respective legal entities.

IN WITNESS WHEREOF, the parties hereto have executed this MOU as follows:

CONTRA COSTA COUNTY

By: [signature]
President, BOS Dated:12/22/16

ZONE 7 OF THE ALAMEDA COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

By:____________________________
G.F. Duerig Dated:

CONTRA COSTA WATER AGENCY

By:____________________________

CITY OF SAN RAMON

By:____________________________

DUBLIN SAN RAMON SERVICES DISTRICT

By:____________________________

EAST BAY MUNICIPAL UTILITY DISTRICT

By:____________________________ 8/19/16
Richard Sykes Dated:
Director of Water
and Natural Resources

CONTRA COSTA WATER AGENCY

By:______________________________

CITY OF SAN RAMON

By:______________________________

DUBLIN SAN RAMON SERVICES DISTRICT

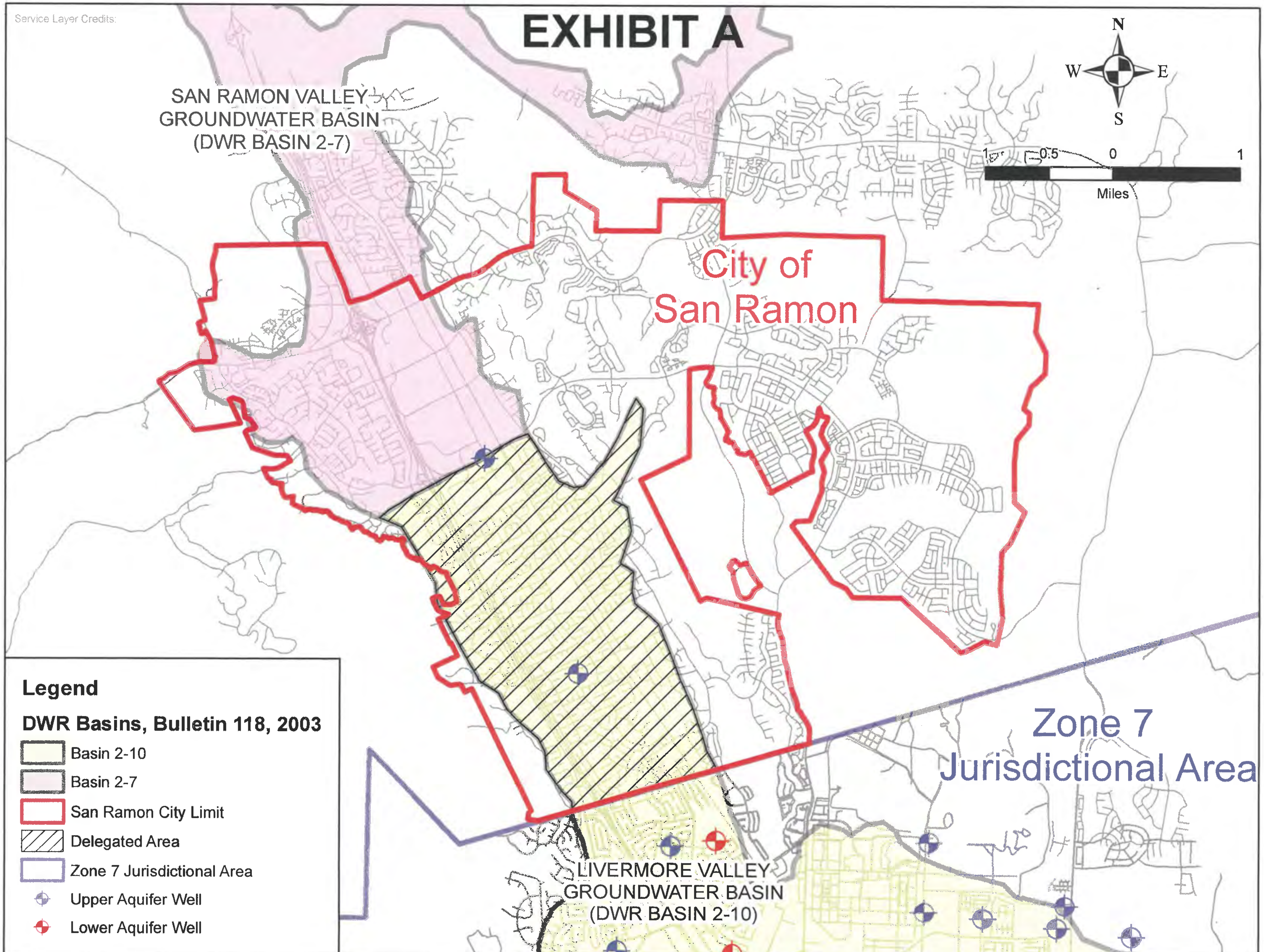
By: [signature] 10/20/16

Dan McIntyre Dated:
General Manager

EAST BAY MUNICIPAL UTILITY DISTRICT

By:______________________________

Richard Sykes Dated:
Director of Water
and Natural Resources


Service Layer Credits:
EXHIBIT A
SAN RAMON VALLEY
GROUNDWATER BASIN
(DWR BASIN 2-7)
N
W
E
S
0.5
0
1
Miles
City of
San Ramon
Zone 7
Jurisdictional Area
LIVERMORE VALLEY
GROUNDWATER BASIN
(DWR BASIN 2-10)
Legend
DWR Basins, Bulletin 118, 2003
Basin 2-10
Basin 2-7
San Ramon City Limit
Delegated Area
Zone 7 Jurisdictional Area
Upper Aquifer Well
Lower Aquifer Well

APPENDIX D

Stakeholder Outreach Efforts (updated 12/10/2021)

Date	Stakeholder	Outreach Efforts	Contacted	Outreach Response
Oct 12, 2019	Public	• Zone 7 Open House	• Public advertisements	Staff answered verbal questions from the public
June 17, 2020	Public	• Presentation at Board meetings: Grant Project 2021 Update to Alternative Groundwater Sustainability Plan for Livermore Valley Groundwater Basin	• Public	No comments or questions from the public
June 23, 2020	Public	• E Newsletter: Zone 7 Groundwater Management Efforts Supported with Half Million Dollar Grant	• Public	No comments or questions from the public
October 16, 2020	Public	• A dedicated webpage for the Alternative GSP is developed (www.zone7water.com/altgsp). This webpage will provide information to the public and other agencies to encourage public involvement in the SGMA process	• Public	No comments or questions from the public
January 21, 2021	RWQCB	• Presentation on the background of the 2021 Alternative GSP Update, and the salt and nutrient management tasks that will be included in the Alternative GSP update.	• RWQCB	No comments or questions from RWQCB
May 5, 2021	Public	• Presentation at Board meetings: Proposition 68 Grant Progress Alternative Groundwater Sustainability Plan 2021 Update	• Public	No comments or questions from the public
November 8, 2021	Public	• Zone 7 Board's Water Resources Committee in person meeting: summary of the draft 2021 Alternative GSP	• Public	No comments or questions from the public
November 18, 2021	Public	• Presentation on the public review draft of the 2021 Alternative GSP Update	• Public	No comments or questions from the public

APPENDIX E

Public Comments on the 2021 Update of Alternative GSP

Date	By	Comments/Questions	Response
11/4/2021	Lunn, Dave	Correct the spelling for "Stakeholders"	Made the spelling correction
11/4/2021	Lunn, Dave	Provide an enlarged map of Sycamore Grove area and numbers	The information was emailed to commenter.
11/4/2021	Lunn, Dave	Provide the estimated water use data	The information was emailed to commenter.
11/4/2021	Lunn, Dave	Include stationing along the Arroyo Valle to help identify features	Noted. May incorporate in future study.
11/4/2021	Lunn, Dave	It appears that the green line along the terrace boundary may not be properly mapped. It looks like it should be one of the purple areas excluded because the vegetation is primarily Oak, just like the pink line across the Crohare terrace.	The information was emailed to commenter.
11/4/2021	Lunn, Dave	The commenter provided the graph of groundwater levels from the well number 3s2e29f004 and documentation of flow through Sycamore Grove, and asked if he interpreted the Minimum Thresholds, IM and MO correctly for that well.	The MTs, IMs, and MOs for 29F4 are correct.
11/4/2021	Lunn, Dave	Well 3 and the Bobcat Pond is hoped to become part of a new Water Education element at Sycamore Grove	Noted.
11/8/2021	Figuers, Sandy	There isn't mention of groundwater age-dating, isotope analysis or something similar in the document as those are very common hydrogeologic analysis. The commenter thinks it is critical to look at the basin both laterally and vertically.	Zone 7 has completed several isotope studies prior to SGMA and is open to continue applying the technology as appropriate.
11/8/2021	Figuers, Sandy	Recommended removing the term "flower structure" from the figure since it is not accurate.	Completed.
11/8/2021	Figuers, Sandy	The USGS is working to purge references to all thrust faults in the Bay Area, and the USGS' current thinking is that the faults that appear to be thrust faults actually originated as strike-slip faults.	Noted
11/8/2021	Figuers, Sandy	The Norfleet study which is referenced in the Update is 15 years old and new theories on the geologic history of the basin may be available.	Zone 7 will consider newly available information and data in the future updates.
11/8/2021	Gambs, Dennis	What is Zone 7's groundwater storage goal? And why the plan doesn't include the idea of providing enough storage for a drought as a criterion in the report.	The key goals of the Update are to meet SGMA compliance requirements and address DWR's recommendations. Zone 7 has a separate planning process for water supply

Date	By	Comments/Questions	Response
			reliability and drought supply.
11/8/2021	Lunn, Dave	Recommended simplifying grid lines on Fig 8-21, and also noted that future storage exceeded max storage.	Fig 8-21 was modified as recommended.
11/8/2021	Lunn, Dave	Suggested using metric tons and cubic meter.	GSP Regulations standardizes the units.
11/9/2021	Lunn, Dave	As a technical Stakeholder, a discussion of the actual report would be appreciated.	Noted.
11/9/2021	Lunn, Dave	Asked for copies of the Figures 3A and 3B (cut off on the west side).	Sent to commenter.
11/9/2021	Lunn, Dave	Identify the source of base map geology on Figure 2	Completed.
11/18/2021	Lunn, Dave	Alt GSP should include actual metrics developed over decades by Zone 7. Undesirable Results would be running out of water, degrading water quality, high costs and low public trust.	SGMA and GSP regulations standardize sustainable management criteria.
11/18/2021	Lunn, Dave	The report does not appear to make this important point that the overall sustainability of the integrated water supply system (the entire portfolio) is the important indicator for Zone 7's Alternative GSP	Added text to reference Water Supply Eval or UWMP to convey the comment.
11/18/2021	Lunn, Dave	Include detailed Salt Management Plan annual report in the appendix. Add table similar to Table 9-2, 8-3,8-4 and 8-5. Monthly accounting is needed to evaluate salt export from pumped groundwater.	The calculations and tables initially created for the 2005 Salt Management Plan are updated each year; for brevity, results are summarized for the report. The background calculations do include monthly or quarterly data when available. Detailed calculations supporting the WY 2020 Salt Balance are now included in **Appendix L - Supporting Salt and Nutrient Loading Calculations**
11/18/2021	Lunn, Dave	The report does not appear to make the important point that the long-term mineral water quality of the municipal wells is dependent on the active management of the basin salt balance. It is important to state in the report that Zone 7 uses the long-term salt balance steady state calculation as the indicator and also that basin mineral water quality will not degrade.	As stated in Section 5.2.3, Zone 7's conjunctive use program includes recharging with low TDS water and groundwater pumping that "removes water with higher TDS, [which] can eventually improve the salinity of the

Date	By	Comments/Questions	Response
			Basin, helping achieve salt management objective." Zone 7 uses a variety of calculations (including the long-term steady-state salt balance; the actual salt balance calculated for each year since 1974; and expected future salt concentrations [see Figure 8-21]) as indicators for basin quality and for identifying appropriate salt management activities.
11/18/2021	Lunn, Dave	The Mocho demineralization table gives 100% credit for the exported brine which is not a correct calculation and other questions about salt calculations.	Edited test in 15.2.3.4 to clarify that the demineralization extracted salt from pumped groundwater.
11/18/2021	Lunn, Dave	On Figure 9-3: Suggested changing the name from Livermore-Amador to just Livermore, moving Pipe leakage to the left side, adding Applied water recharge to the left so that all supplies to the groundwater basin are included	Completed
11/18/2021	Lunn, Dave	The text describes the percolation of untreated wastewater from septic tanks and the VA hospital. Wastewater treatment includes the removal of Biological Oxygen Demand (BOD) before discharge. Both Septic tanks and water treatment plants remove BOD. The text should be corrected since the VA has a treatment plant and septic tanks treat wastewater and remove BOD. It should be noted that 40% of treated wastewater is recycled but 100% of the VA wastewater and septic tank wastewater is recycled. It is good to recycle water.	Removed "untreated" from Section 8.6.1.2.
11/18/2021	Lunn, Dave	On Table 8-3 Pipe leakage is only shown as 134 acre-feet but the inventory and Figure 9-3 show leakage of 1209 Acre-feet.	Table originally used IDC numbers. Updated to use Sustainable Yield numbers.
11/18/2021	Lunn, Dave	Think that the Zone 7 estimate is about 400 AF of leakage is from untreated sewer lines. In the discussion of Nitrate loading, the untreated wastewater from leaking sewer lines should include the estimated 400 AF. The nitrate loading from leaking sewer lines should be much larger than the nitrate loading from the rural residential septic tanks that may discharge only 50 -100 AF treated wastewater into the main basin.	Table originally used IDC volume estimate for pipe leakage. Updated to use Sustainable Yield numbers and recalculated average N concentration using a flow-weighted approach.

Date	By	Comments/Questions	Response
11/18/2021	Lunn, Dave	The nitrate loading from vineyards uses 4.86 pounds per acre as an application rate. I thought that the vineyards in Livermore that produce wine grapes did not use much nitrate. What is the source of this loading rate? Is this the loading rate from Wente?	Data started with a representative total applied N from ***Ransom, K.M., Bell, A.M., Barber, Q.E. et al. 2018. A Bayesian approach to infer nitrogen loading rates from crop and land-use types.*** The calculations then assumed a portion of that is taken by the plant and then a certain portion (23%) of the remainder is leachable N to GW. Detailed calculations and accompanying references supporting the Nitrogen Loading estimates are now included in **Appendix L - Supporting Salt and Nutrient Loading Calculations.**
11/18/2021	Lunn, Dave	The OWTS for large properties used an application rate per acre. Isn't the application based on the number of dwellings? For most properties, there is only one dwelling. If so, the calculation should be on the number of properties.	Recalculated using 1 RRE per property if < 7 acres and 1RRE x Number properties x Avg number of buildings per property on properties > 7 acres (using ACDEH GIS data). Assumes N loading of 34.8 lbs/yr for 1 RRE.
11/18/2021	Lunn, Dave	The groundwater pumping should include rural residential from areas like Buena Vista. Most of these properties have shallow wells with high nitrates. I believe the numbers indicate about 50 AF of pumping with a concentration of about 10 mg/l as N. The Asbury church is a good example. They have a community garden and lawns and use groundwater. Ever since they put in the well, they were able to discontinue the use of fertilization and have very green lawns.	The calculation took into account separate pumping and concentration rates for Ag, SFWD, Fairgrounds, Domestic, and golf courses. The numbers for GW Pumping - Others was represented on Table 8-3 as a weighted aggregate total. The concentration previously used for Domestic was 1.5 mg/L (an estimated total for the entire basin), but was updated. Now used GIS to calculate NO3N concentration at every

Date	By	Comments/Questions	Response
			active domestic well in MB. New average = 2.46 mg/L.
11/18/2021	Lunn, Dave	Figure 2 (Alt GSP Fig 7-2 and Section Memo Fig 2) comments: problem showing "faults" on an urban map.	The geology basemap includes the urban details, so the layers cannot be separated.
11/18/2021	Lunn, Dave	Section B-B' on the southern end could be improved if it included the monitoring wells in Sycamore Grove. 29F4 should be shown and I don't know if there is any evidence of a confining layer in Sycamore Grove. It would be helpful to have a more detailed and technical cross section from Isabel to the del Valle Dam for the educational programs at Sycamore Grove, but that is not an issue for this report. The section should include the groundwater levels in Lake A and B.	These current cross sections were developed for a high-level overview of the basin geology using Rockworks. More detailed cross-sections will be developed in the future for different purposes. 29F4 is included in the version of the cross section in memo Figure 4-A.
11/18/2021	Lunn, Dave	The groundwater Section A-A' should be compared to the earlier cross section. The new cross section does not show any aquifer offsets on the Pleasanton Fault. The earlier cross section was more realistic in the gravel mining area. It showed the vertical faces and the pits filled with clay. The new cross section shows Lake G and H excavating below the aquifer level. The Mining Area Monitoring program made observations of these pits and I don't recall that Lake G was excavated below the clay layer. This data is not in the Rockware file but the observations from the Mining Area monitoring of the gravel mining pits should be incorporated into the development of the cross sections. I was not able to observe the construction of Lake B. Is there evidence that the pit was excavated into the Livermore Formation?	Noted. The relevant cross-sections have been updated to show that G and H are not below the aquitard.
11/18/2021	Lunn, Dave	The PFAS "plume" should be shown on the A-A' cross section to better show the extent of this contamination.	The current scale of Rockworks cross sections developed for this Alt GSP are not suitable for a detailed analysis of PFAS concentrations in the western portion of the Main Basin. However, the PFAs report (Jacobs, 2020) referenced in the Alt GSP

Date	By	Comments/Questions	Response
			includes 2 cross sections with PFAS concentrations. Zone 7 intends to further develop and improve the Rockworks 3D model so that it can be used for future studies/reports (e.g., PFAS extent).
11/18/2021	Lunn, Dave	The groundwater monitoring maps should include data from the Pleasanton Dump monitoring wells	The referenced data is not currently available.
11/18/2021	Lunn, Dave	Evaluate PFAS in wastewater and recycled water	Noted
11/18/2021	Lunn, Dave	The PFAS “plume” has produced serious Undesirable Results. One of the Zone 7 wells has been shut down. The Zone 7 pumping capacity has been reduced 60%, Zone 7 was forced to purchase $7 million in water to replace the water that could not be pumped. The Risk model has probably not been updated to show this reduction in groundwater pumping capacity but the impact on the sustainable water supply is substantial	Noted
11/18/2021	Lunn, Dave	I encourage you to consider sharing the report and study information with the public at an earlier phase of the project	Noted
12/6/2021	Figuers, Sandy	General comments on Sections 6 and 7 (geologic??)	Comments are noted and/or addressed in the final report as appropriate.

APPENDIX I

ROCKWORKS TECHNICAL MEMORANDUM

02 April 2021

MEMORANDUM

To: Tom Rooze (Zone 7 Water Agency [Zone 7])
Colleen Winey (Zone 7)

From: Anona Dutton, PG, CHg (EKI Environment & Water, Inc. [EKI])
Aaron Lewis (EKI)
Susan Xie, EIT (EKI)

Subject: **Progress Update on Extending Existing Hydrogeologic Framework**
(EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to present to Zone 7 Water Agency (Zone 7) a summary of specific technical efforts related to extending the existing Hydrogeologic Conceptual Model (HCM) framework to encompass the entirety of the Livermore Valley Groundwater Basin (Basin). Pursuant to our approved scope of work, EKI's work efforts include application of 3D geologic modeling software to support development of three cross-sections for the Basin. This memorandum is anticipated to be included as an attachment to the 2022 Alternative Groundwater Sustainability Plan (Alt GSP).

GEOLOGIC MODELING SOFTWARE

The 3D geologic modeling software platform RockWorks[1] was selected by Zone 7 to support data integration, HCM representation, and cross-section development.

DATA SOURCES

The primary data sources that have been integrated into the RockWorks platform and are otherwise supporting development of the updated HCM framework include the following:

- Well information, including locations and well construction details as provided by Zone 7;
- Geologic and lithology data and resources as provided by Zone 7, including borehole geophysical (e-log) data, lithology intervals, aquifer layer (stratigraphy) depth intervals, prior hydrogeologic reports and studies, geologic maps, existing cross-sections, faults information, and other supporting resources;
- California Department of Water Resources (DWR) reports and information (e.g., from the SGMA data portal);

[1] RockWorks 2020 Standard Level License from RockWare is downloaded and installed on 15 October 2020: https://www.rockware.com/product/rockworks/

- Lawrence Livermore National Laboratory (LLNL) wells e-logs and lithology data;
- United States Geological Survey (USGS) ground surface elevation data;
- Groundwater elevation data provided by Zone 7; and
- Groundwater dependent ecosystem (GDE) resources, including GDE geospatial data and Sycamore alluvial woodland data.

MAJOR ASSUMPTIONS

Based on EKI's approved scope of work and further direction provided by Zone 7, the following key assumptions have informed the approach presented herein:

- ***On-going refinement of the Basin HCM is anticipated to be an evolving and iterative process that extends beyond the scope of this effort.*** As part of this scope of work, all currently available data have been processed and imported into the RockWorks framework to create a general 3D representation of the Basin. Additionally, detailed analysis and interpretations of the HCM framework are being made along the three proposed cross-section traces. It is anticipated that additional data can be added to RockWorks as available and that refined interpretations can be developed for additional areas of interest and/or to refine the Basin HCM as part of future work efforts by Zone 7 staff or consultants.
- ***For purposes of the 2022 Alt GSP, simplified Basin-scale Interpretations of the hydro-stratigraphic framework are appropriate.*** Multiple cross-sections have been developed by and for Zone 7 over time for different purposes. Previous interpretations of aquifer layer intervals contained as many as 10 stratigraphic units (i.e., overburden, perched aquifer, perched clay, cyan, gray clay, gray, purple clay, purple, red clay, and red) based on previous geological investigations within the Main Basin Management Area (MBMA) (Norfleet Consultant, 2004). However, given the considerable uncertainty involved in extending these stratigraphic units into the Fringe and Uplands management areas of the Basin, simplified stratigraphic units depicting only the overburden, upper aquifer, aquitard, lower aquifer, and the Lower Livermore Formation are used in the 3D modeling performed for the Basin for purposes of the 2022 Alt GSP. The original dataset of contact points between these more detailed stratigraphic units (cyan, gray, etc.) have been imported and are preserved as "I-Data" (interval data) in RockWorks to provide for future use and/or refinement, as applicable.

  Within the MBMA, the "upper aquifer" corresponds to the cyan unit (generally consisting of younger, unconsolidated Holocene to Quaternary alluvial deposits), the "aquitard" represents the gray clay unit, and the "lower aquifer" represents the combined gray-purple-red complex (generally consisting of older, semi-consolidated Quaternary alluvial deposits and the productive upper zone of the Plio-Pleistocene Livermore Formation [defined herein as the "Upper Livermore Formation"]). Where it exists outside the MBMA, the upper aquifer represents younger Quaternary alluvial deposits, while the lower aquifer represents older Quaternary terrace and alluvial deposits and the Upper Livermore Formation. The Basin bottom is defined at the top of the Lower Livermore Formation, i.e. the depth at which deposits become increasingly consolidated (transitioning from gravel beds lain with silts and clay to predominantly blue silts and clays) and well yields diminish considerably. In the Uplands area, it is assumed the Lower Livermore Formation is the dominant outcropping stratigraphic unit and therefore the upper and lower aquifers are not assumed to be present.

- ***Limited structural data can be directly incorporated into RockWorks.*** Given the RockWorks 2020 Standard Level license limitation, only three faults can be mapped and directly incorporated in the model. As such, three major faults[2] within the Basin were selected for modeling purposes, including the Livermore Thrust Fault, Las Positas Fault, and Verona Thrust Fault.

DATA INTEGRATION / APPLICATION OF ROCKWORKS

The following list summarizes the step-wise development process that was used to build the HCM framework in RockWorks. Graphical representations of the work effort to date are also included below:

1) ***Process and import borehole data provided by Zone 7 for 1,053 unique boreholes into the RockWorks Borehole Manager framework.*** As shown in Figure 1, these data included the location, borehole depth, borehole elevation, lithology, stratigraphy, and e-log data (gamma, short normal, long normal, spontaneous potential, single point resistivity, and lateral resistivity)[3].

    a. The lithology data were further refined to group the 19 Unified Soil Classification System (USCS) classifications included in the lithology dataset into six simplified types (i.e., clay, silt, gravel, sand, fill, and top soil).

    b. The stratigraphy data were further refined to group the 10 stratigraphic units included in the original Zone 7 stratigraphy dataset into five generalized units (overburden, upper aquifer, aquitard, lower aquifer, and Lower Livermore Foundation), as described below in more detail.

    c. To examine whether there were similar grain-size distribution patterns between wells in each aquifer layer, the lithological data were reclassified as either coarse or fine-grained sediments[4], and their coarse grain percentages within each aquifer layer were summarized by well. This classification was loaded into RockWorks as a separate attribute of the lithology dataset, but was ultimately not used for model development.

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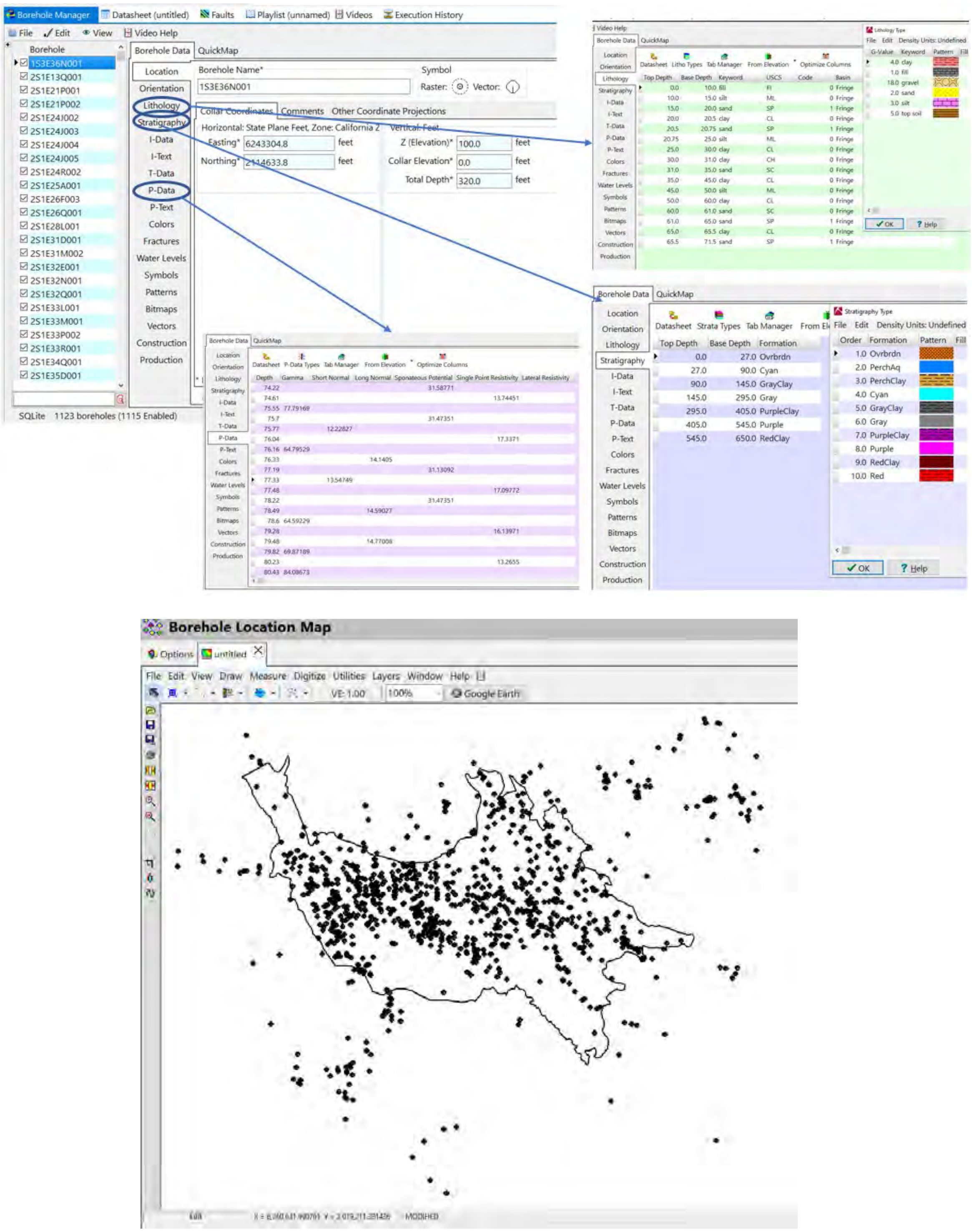
[2] Three faults are mapped in Figure 3-3 Preliminary Stratigraphy Evaluation, Main Basin, Norfleet Consultants, dated 15 January 2004.

[3] Data availability varies by borehole.

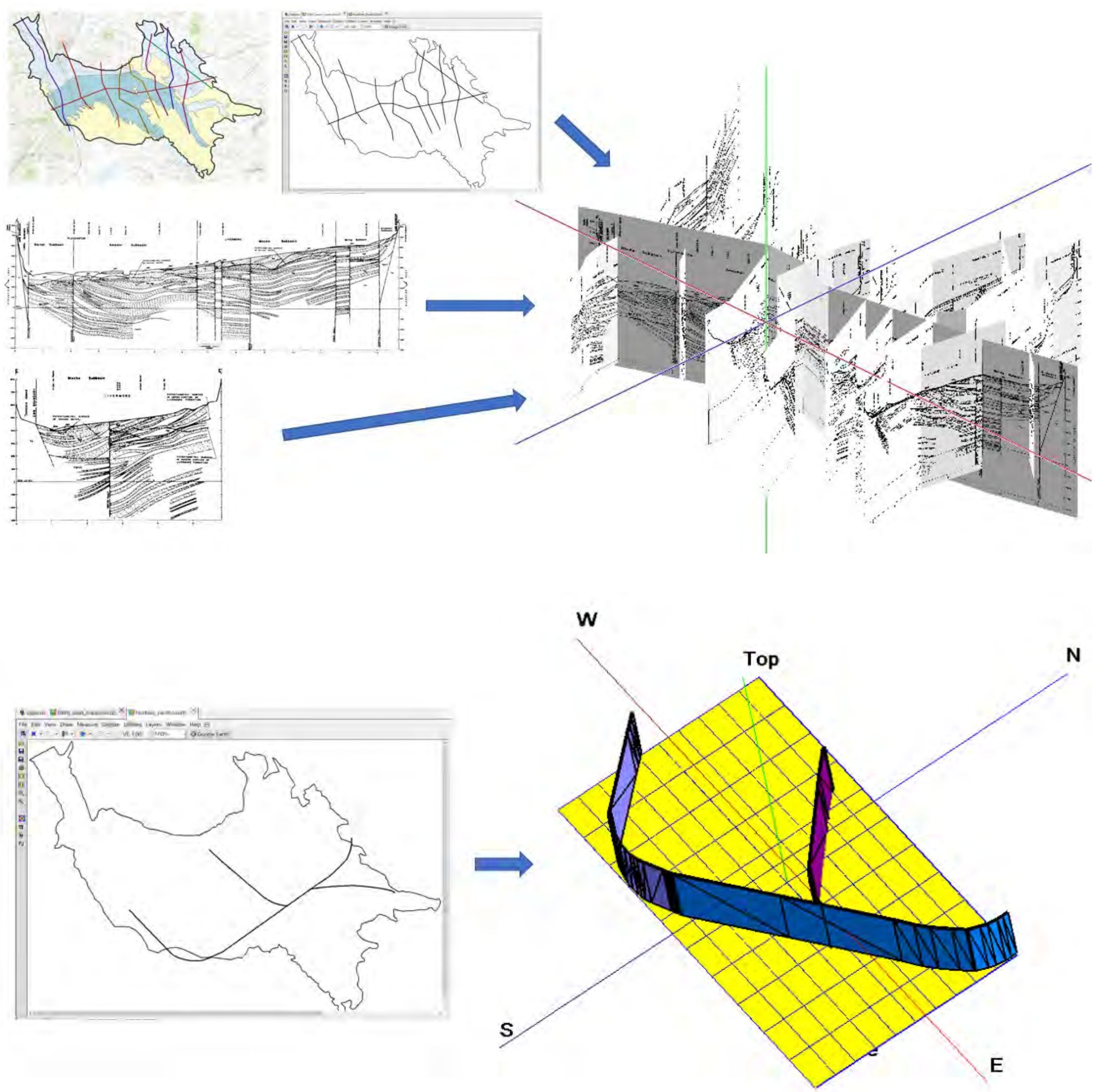
[4] Coarse/fine classification is based on Standard Practice for Classification of Soils for Engineering Purposes (USCS), American Society for Testing and Materials (ASTM) D2487-06.

Figure 1 - Processing of Well and Borehole Data



2) ***Process and import selected 2D shapefiles and imagery into the RockWorks framework.*** As shown in Figure 2, these files included the Basin boundary, the DWR (1974) cross-section traces[5] that were digitized by EKI, and three major faults within the Basin (Livermore Thrust, Las Positas Fault, and Verona Thrust) that were also digitized by EKI. EKI created georeferenced 3D RockWorks files for the 1974 DWR cross-section traces and three major faults.

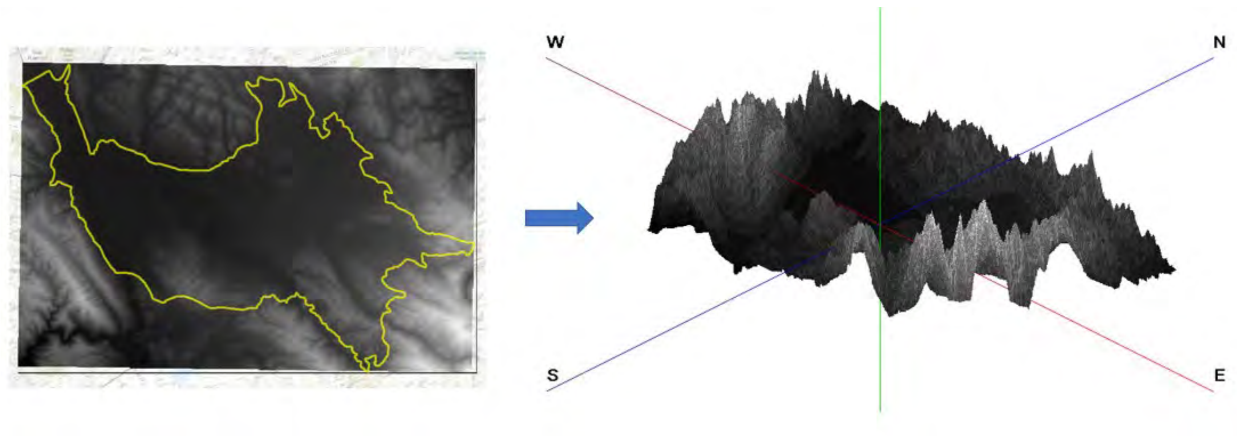
Figure 2 - Processing of Additional Basin Data and Structural Features



[5] California Department of Water Resources Bulletin 118-2, Evaluation of Ground Water Resources: Livermore and Sunol Valleys, dated June 1974.

3) ***Process and import USGS topography raster data and create 3D RockWorks file.*** As shown in Figure 3, the USGS dataset serves as an upper boundary (i.e., ground surface) to clip other RockWorks 3D models to. This dataset was resized and clipped to match the Basin dimensions as specified in RockWorks.

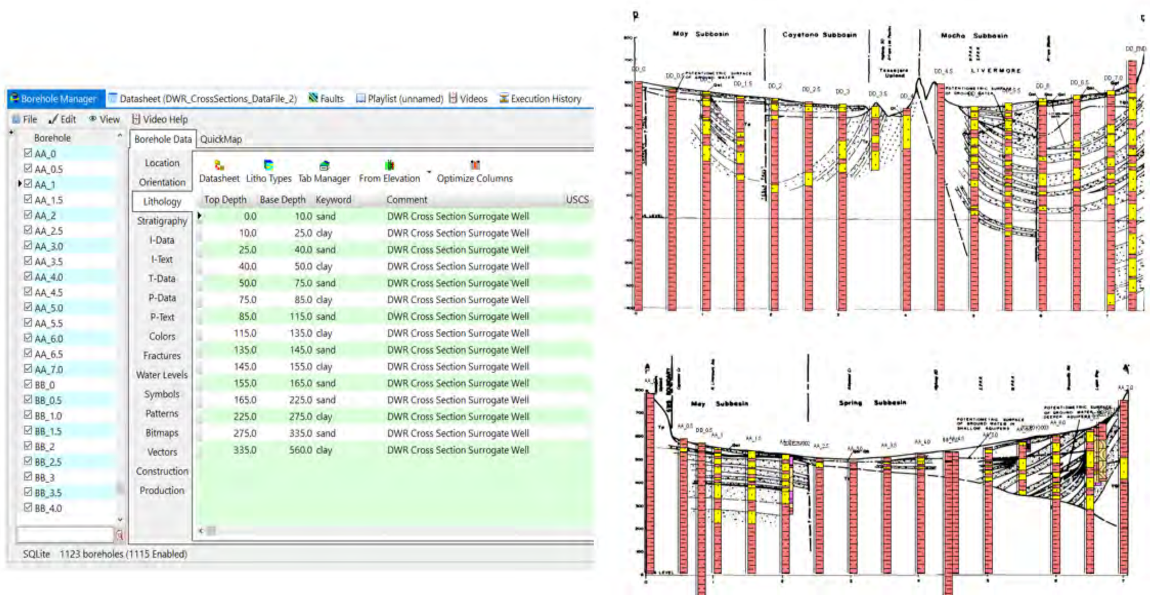
Figure 3 - Processing of Digital Elevation Model



4) ***Digitize and import lithology from select DWR (1974) cross-sections to fill data gaps***. Limited borehole data exist in certain portions of the Basin. To fill in data gaps, a total of 83 "surrogate" boreholes were developed and their generalized lithology profiles were characterized along the DWR (1974) cross-section traces A-A', B-B', C-C', D-D', E-E', and I-I'[6] to densify lithology information in the Fringe and Uplands management areas of the Basin. The DWR (1974) cross-sections approximate water bearing and non-water bearing units by elevation, which were then classified by EKI as either sand or clay in the surrogate boreholes. As shown in Figure 4, these surrogate boreholes were imported into RockWorks for subsequent use in developing the 3D lithology and stratigraphy models.

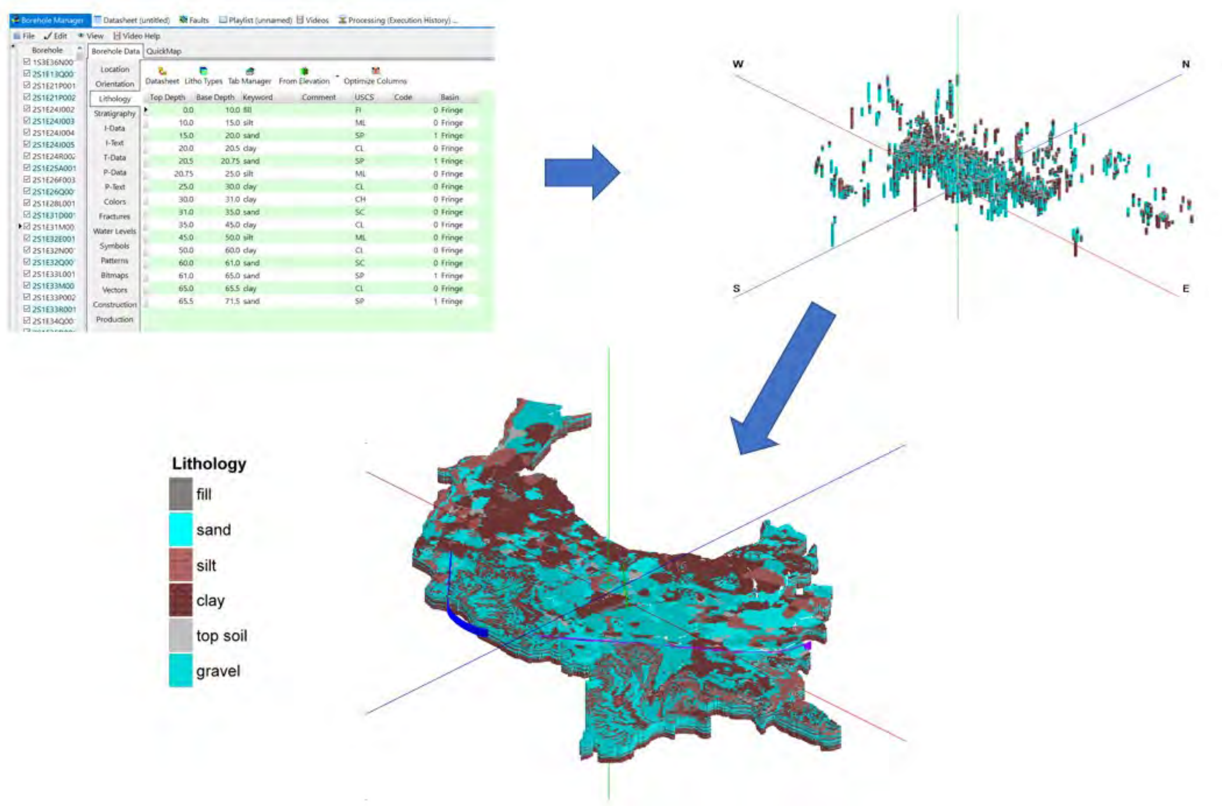
[6] *Ibid* [5].

Figure 4 – Development of Surrogate Boreholes to Fill Data Gaps



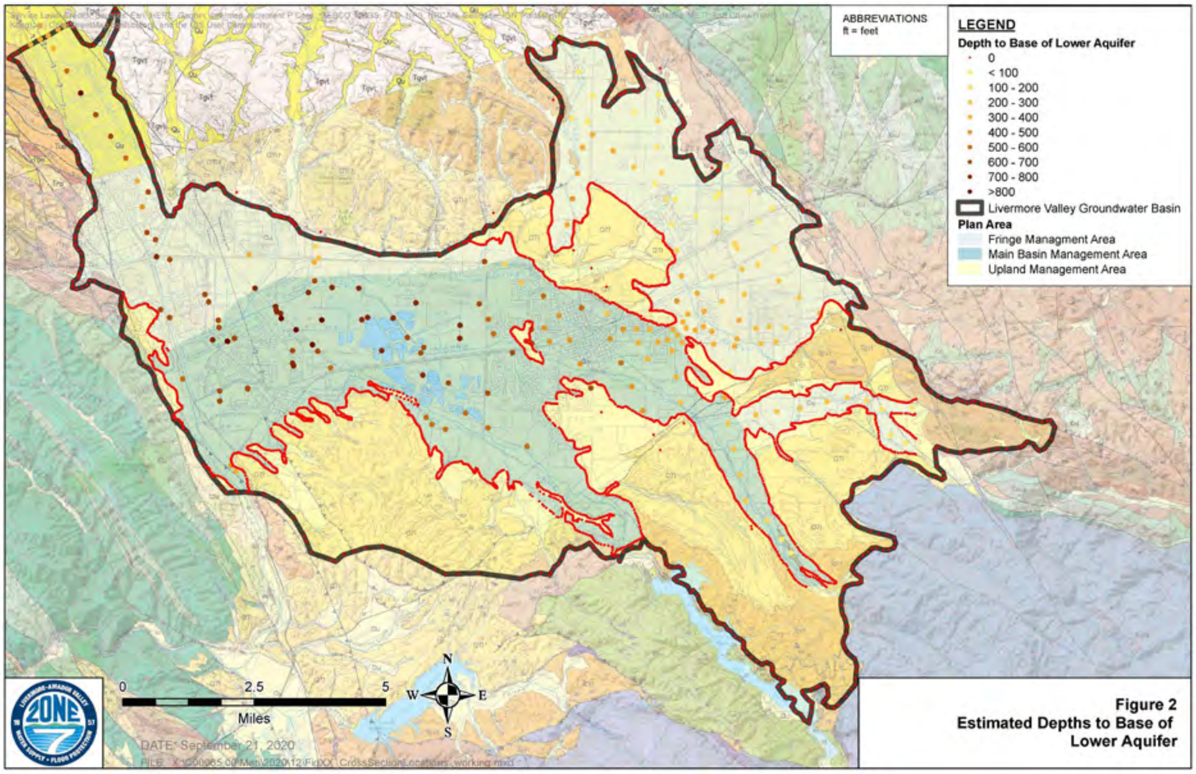
5) ***Create 3D RockWorks lithology model using the six simplified lithological classifications.*** As shown in Figure 5, a 3D gridded lithology model (200 x 200 x 20 ft resolution) was developed in RockWorks using the five simplified lithological classifications described in Step 1 to visualize the spatial distribution of lithology throughout the Basin. Discrete borehole lithology data from 991 wells were interpolated across the Basin to create a 3D gridded lithology model that extends from the ground surface down to the bottom of the Basin (i.e., the top of the Lower Livermore Formation).

Figure 5 – Development of a Basin Lithology Model



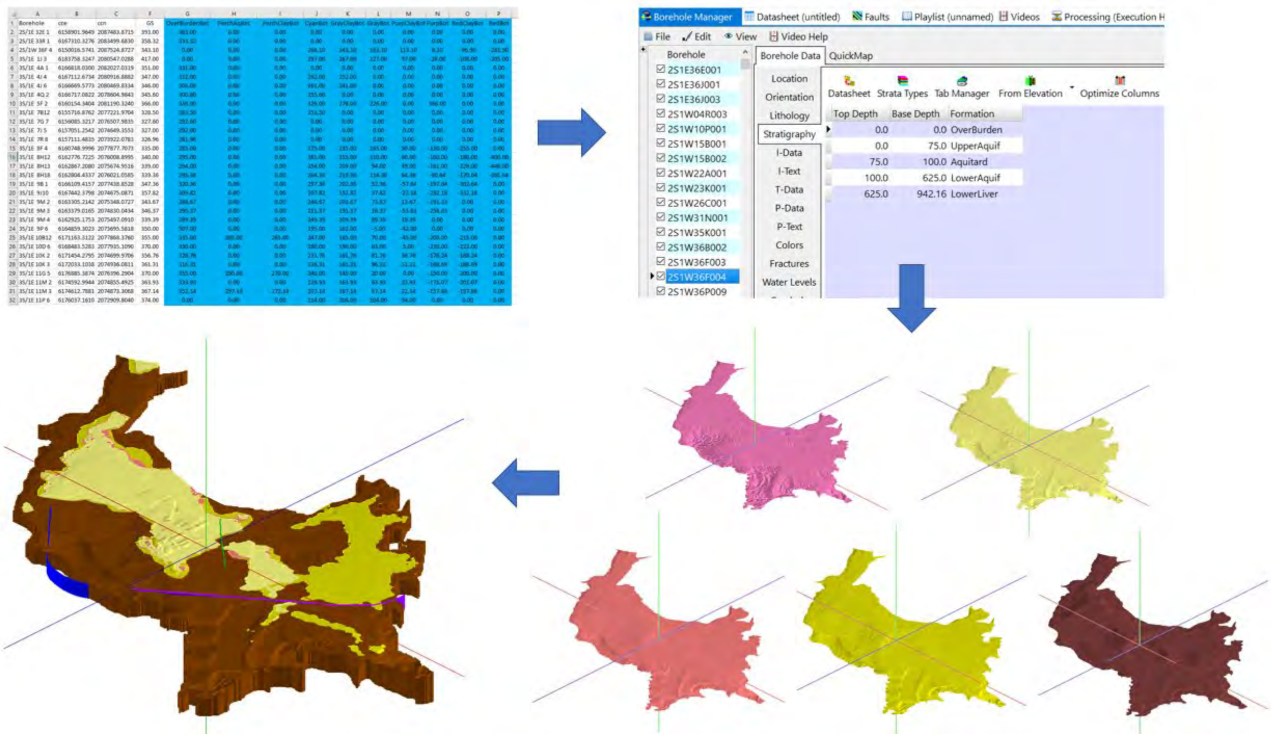
6) ***Refine stratigraphic contacts to inform 3D RockWorks stratigraphy model.*** The original "aquifer layers" dataset provided by Zone 7 only contained stratigraphy interval data for 72 boreholes, all of which were located in the MBMA and many of which only contained information for a few of the (10) stratigraphic units. To provide for a reasonable representation of Basin-wide geometry, these data were augmented with the "surrogate" boreholes used to densify the dataset of stratigraphic contact points within the Fringe and Upland areas and along the Basin boundaries (see Step 4). These "surrogate" boreholes included the 83 digitized DWR records mentioned above, the >6,000 vertices of Zone 7's Basin subareas shapefile used to delineate the Uplands and Fringe areas and the Basin boundaries, and several other locations within the MBMA, Fringe, and Upland management areas where aquifer depths were estimated based on nearby borehole (lithology, elog) information and other available geologic information (see Figure 6).

Figure 6 – Refine Stratigraphic Contacts Based on Additional Data



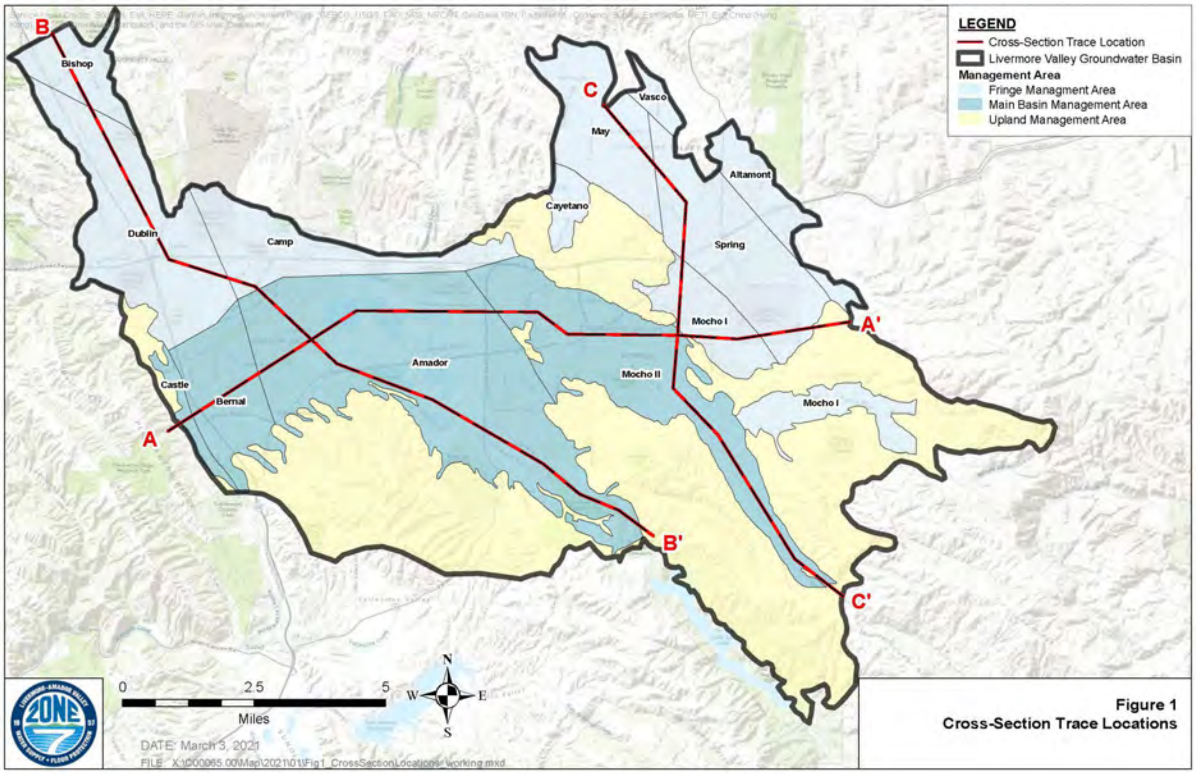
7) ***Create 3D RockWorks stratigraphy model.*** A 3D model of Basin stratigraphy was subsequently developed in RockWorks using the refined dataset of stratigraphic contacts described above (Step 6) along with other available lithology and e-log information (Step 1). As shown in Figure 7, the 3D stratigraphy model is a system of interpolated surfaces representing the top and base of the major aquifer units that have been “filled in” to produce a volumetric representations of each major aquifer unit across the Basin, and includes modeled hydrogeologic discontinuities resulting from the three major faults imported into RockWorks (Step 2).

Figure 7 – Development of a Basin Stratigraphic Model



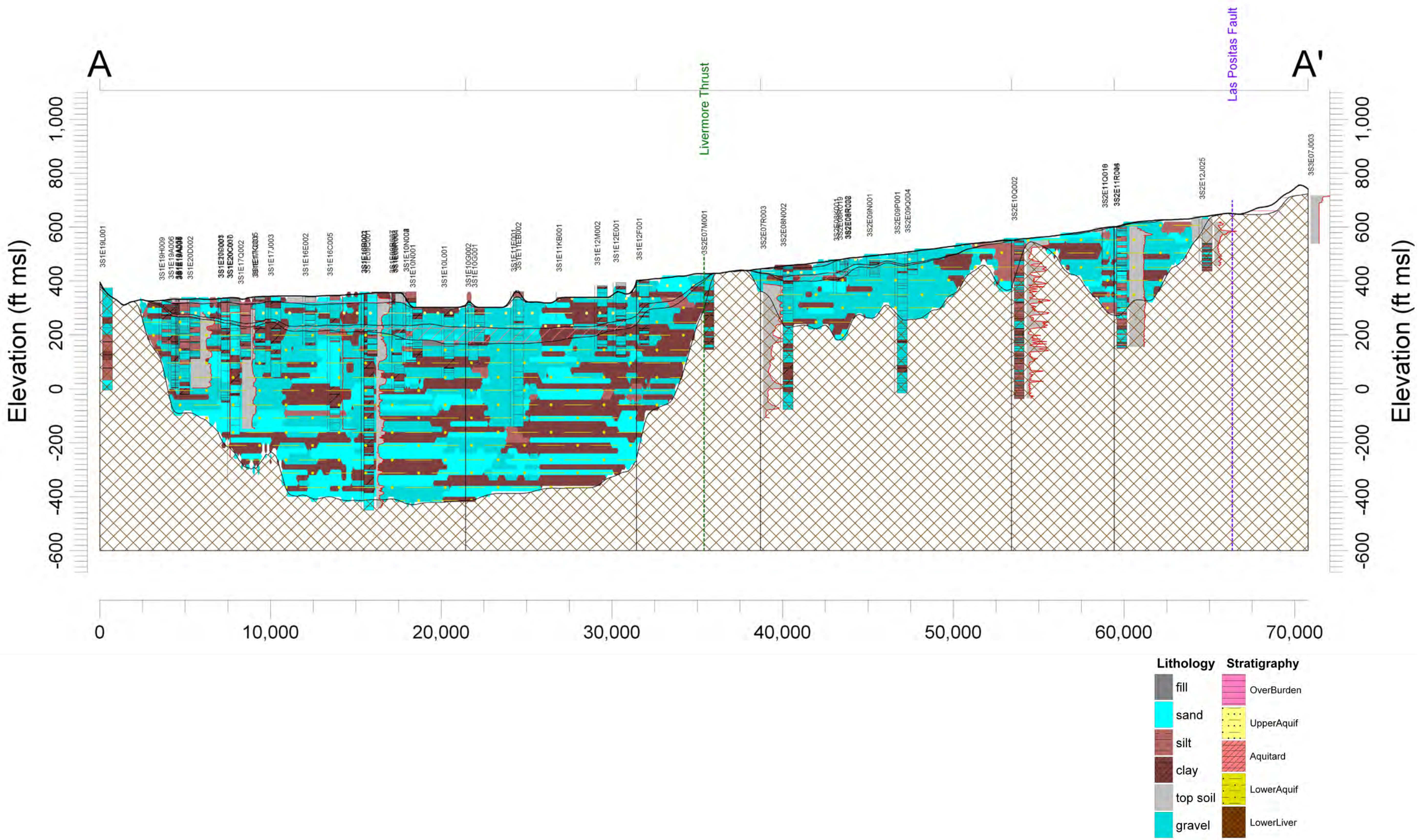
8) ***Develop cross-section traces.*** Various sources of available information, including well, lithology, and e-log dataset locations, surficial geology and fault maps, critical infrastructure facilities (e.g., Chain of Lakes recharge basins), potential GDE areas, and previous cross-section locations were assessed to develop proposed locations of three cross-section traces, A-A', B-B', and C-C', to be built in RockWorks for inclusion in the 2022 Alt GSP. These draft cross-section trace locations were reviewed and edited by Zone 7 technical staff to produce the final cross-section traces shown in Figure 8.

Figure 8 – Cross-Section Traces for the 2022 Alt GSP



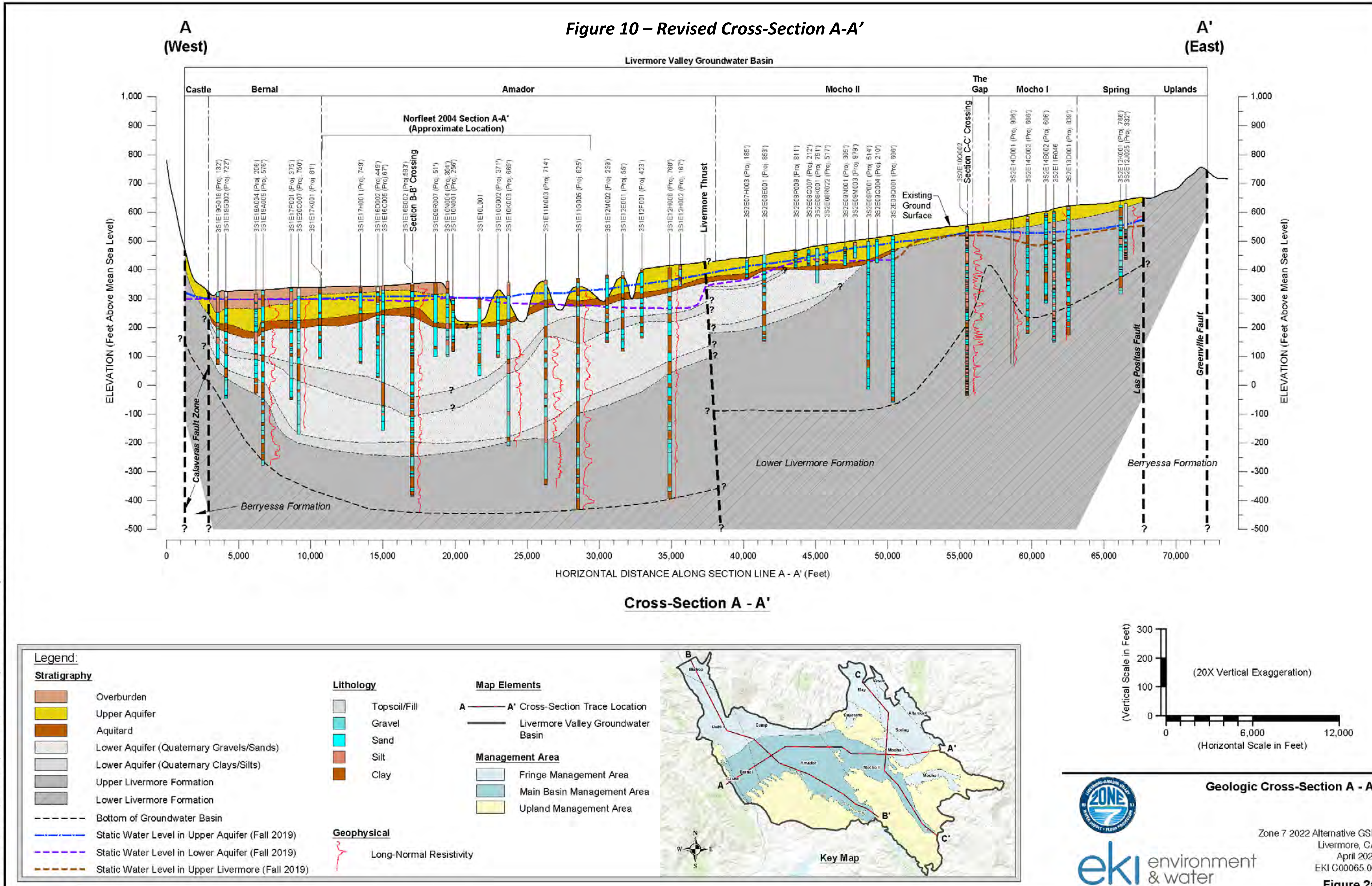
9) Develop preliminary cross-sections. The 3D stratigraphy model (Step 7) was subsequently "sliced" by the cross-section traces (Step 8) to produce cross-section profiles of the Basin. These cross-sections depict the major aquifer units represented in the stratigraphy model and also show projected lithology and e-log information from nearby wells along the traces. Depending on preference, the cross-sections can also be underlain by the interpolated lithology model produced from the bulk lithology dataset (Step 5). Figure 9 shows a "first-cut" example of cross-section A-A' as output from RockWorks.

Figure 9 – Draft Cross-Section A-A’



10) ***Export to AutoCAD and refine cross-sections.*** After receiving feedback from Zone 7 on the preliminary cross-section outputs from RockWorks, each cross-section was exported from Rockworks in .DXF format and imported into AutoCAD software. AutoCAD was ultimately employed for subsequent cross-section refinement as it allowed EKI to more efficiently modify stratigraphic contacts at individual borehole locations based on available lithology and e-log data, and to more accurately portray complex geological features such as the Livermore Thrust plate and Calaveras Fault deformation zone along the section traces. AutoCAD also provides for greater control of symbology, annotations, and formatting edits compared to RockWorks' Plot2D tool. Figure 10 presents the refined Cross-Section A-A' after subsequent editing in AutoCAD.

Figure 10 – Revised Cross-Section A-A'

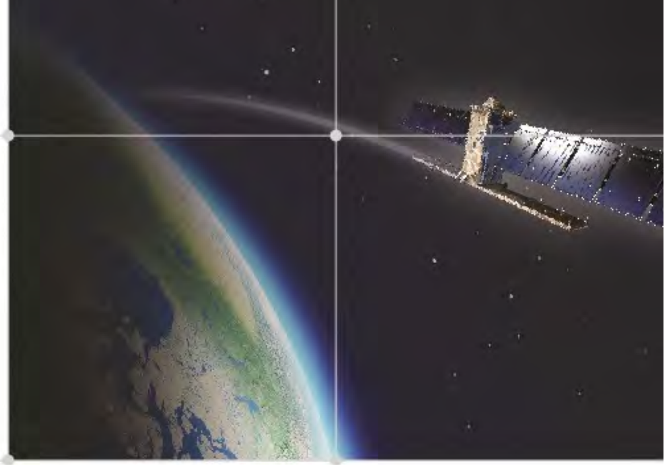


NEXT STEPS

As discussed previously, refining the Basin-wide stratigraphy model in RockWorks is an evolving and iterative process and can be routinely revisited as new information and/or borehole data becomes available. Under the current scope, EKI will reimport revisions to stratigraphic contacts made in AutoCAD into RockWorks in order to update the Basin-wide stratigraphy model. This updated stratigraphy model will subsequently be used to develop estimates of total available groundwater storage in each principal aquifer unit of the Basin for use in designing groundwater storage sustainability criteria for the 2022 Alt GSP. If desired, this updated Basin-wide stratigraphy model can also be used to inform future refinements to the layering and structure of Zone 7's MODFLOW groundwater flow model.

APPENDIX J

TRE ALTAMIRA 2020 REPORT



InSAR Analysis of Ground Displacement over Livermore for the period 2014 - 2020

Technical Report

February 2021

TRE ALTAMIRA
A CLS Group Company

Report Specifications

Client:	**Zone 7 Water Agency**
Attention:	Tom Rooze
Address:	100 N. Canyons Parkway Livermore, CA 94551-9486

Reference:	
Title:	InSAR Analysis of Ground Displacement over Livermore
TRE ALTAMIRA Delivery Reference:	JO20-1257-CA REP 1.0
Client Reference (PO):	

Prepared by:	**TRE ALTAMIRA Inc.**
Author(s):	Vicky Hsiao
Verified by:	Giacomo Falorni
Approved by:	Giacomo Falorni
Date:	19 Feb 2021
Version:	1.3

Executive Summary

This report describes the results of the InSAR ground displacement analysis over Livermore covering the period 13 March 2015 to 30 September 2020. TRE Altamira used its SqueeSAR® algorithm to process Sentinel satellite imagery and produce 2-D ground displacement measurements that were then calibrated using GNSS stations in the area. This report provides an update to the displacement measurements provided in 2019.

The following points summarize the key findings:

- Localized subsidence is detected in 2020
    - An interpolated map of annual (September to September) ground displacement shows over -0.25 inches of subsidence from 2019 to 2020 in the Main Basin.
- There appears to be a weak correlation between variations in groundwater levels at Key_AMW_U, Key_Bern_U and well 3S1E08H009, and ground displacement.
- Generalized westward movement is present throughout the AOI.

Confidentiality disclaimer

Table of Contents

Acronyms and Abbreviations

AOI	Area of Interest
ATS	Average Time Series
CS	Cross-Section
cRTS	Common Time Series of Residuals
DEM	Digital Elevation Model
DInSAR	Differential Interferometric SAR
DS	Distributed Scatterer(s)
ENVISAT	ENVISAT Satellite
ERS	European Remote Sensing Satellite
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
InSAR	Interferometric Synthetic Aperture Radar
LOS	Line of Sight
LTS	LOS Time Series
MP	Measurement Point
PS	Permanent Scatterer(s)
SAR	Synthetic Aperture Radar
SNT	Sentinel Satellite
SqueeSAR®	The most recent InSAR algorithm patented by TRE
TS	Time Series
UNAVCO	UNAVCO Data Center

1. Introduction

TRE ALTAMIRA Inc. (TRE) has been contracted by the Zone 7 Water Agency (Zone 7) to provide a 2-D SqueeSAR ground displacement update over the Livermore and Pleasanton areas. The InSAR study includes:

- A historical study using LOS ERS, Envisat and Sentinel satellite imagery covering the periods 1992 – 2000, 2003 – 2010, and 2015 – 2016, respectively [Completed in 2016].
- 2019 Annual InSAR monitoring using 2D Sentinel satellite imagery covering the periods 2015 – 2019 [Completed in 2019].
- 2020 Annual InSAR monitoring using 2D Sentinel satellite imagery covering the periods 2015 – 2020 [Current report].

1.1. Area of Interest

The AOI for Livermore comprises urban as well as very dry, sparsely vegetated areas and covers approximately 121 square miles (Figure 1). The terrain is flat with moderate hills and presents conditions suitable for the application of InSAR.

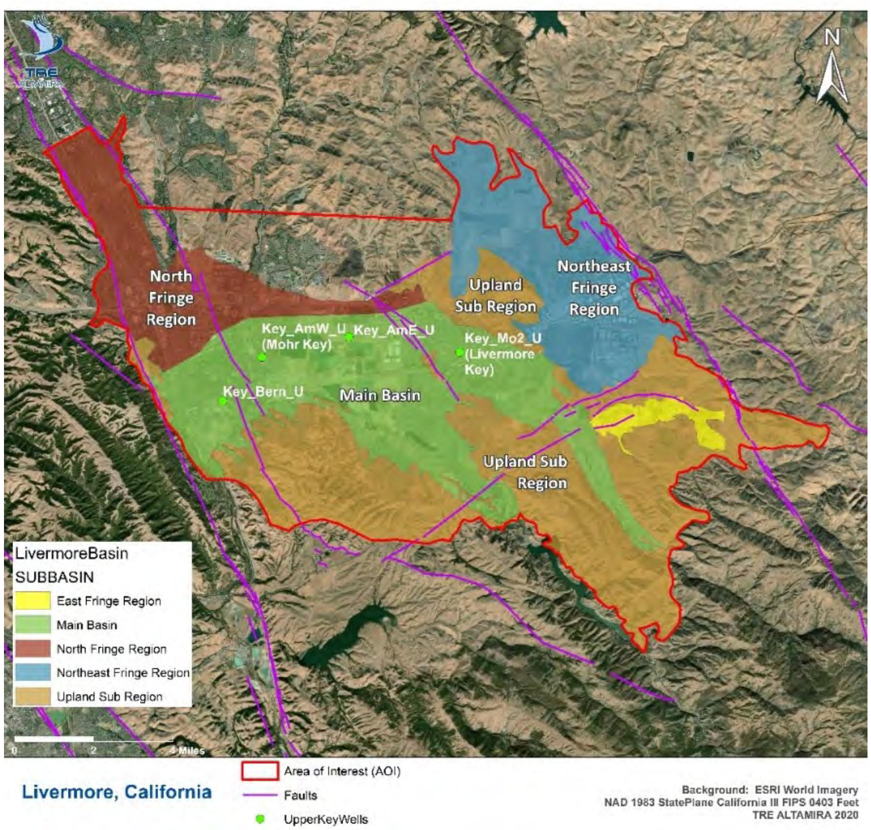


Figure 1: Livermore Area of Interest (AOI).

2. Radar Data

Radar images were acquired over Livermore by the Sentinel (SNT) satellite from both descending (satellite travelling from north to south and imaging to the west) and ascending orbits (satellite travelling from south to north and imaging to the east), with a 12-day revisit frequency. A total of 190 images from the descending orbit, covering the period 31 December 2014 - 30 September 2020, and 171 from the ascending orbit, spanning 13 March 2015 - 30 September 2020, were processed (Table 1). The temporal distribution of the radar imagery is shown in Figure 2. Appendix 2 provides additional information on the satellite acquisition data details.

Table 1: Satellite acquisition parameters and image acquisition information.

Satellite	Pixel Resolution	Orbit	LOS Angle (Θ)	Revisit Frequency	# of Images	Date Range
Sentinel	65 ft x 15 ft	Descending	42.3°	12 days (6-day since Aug 2019)	190	31 Dec 2014 – 30 Sep 2020
		Ascending	41.9°	12 days (6-day since Jan 2019)	171	13 Mar 2015 – 30 Sep 2020

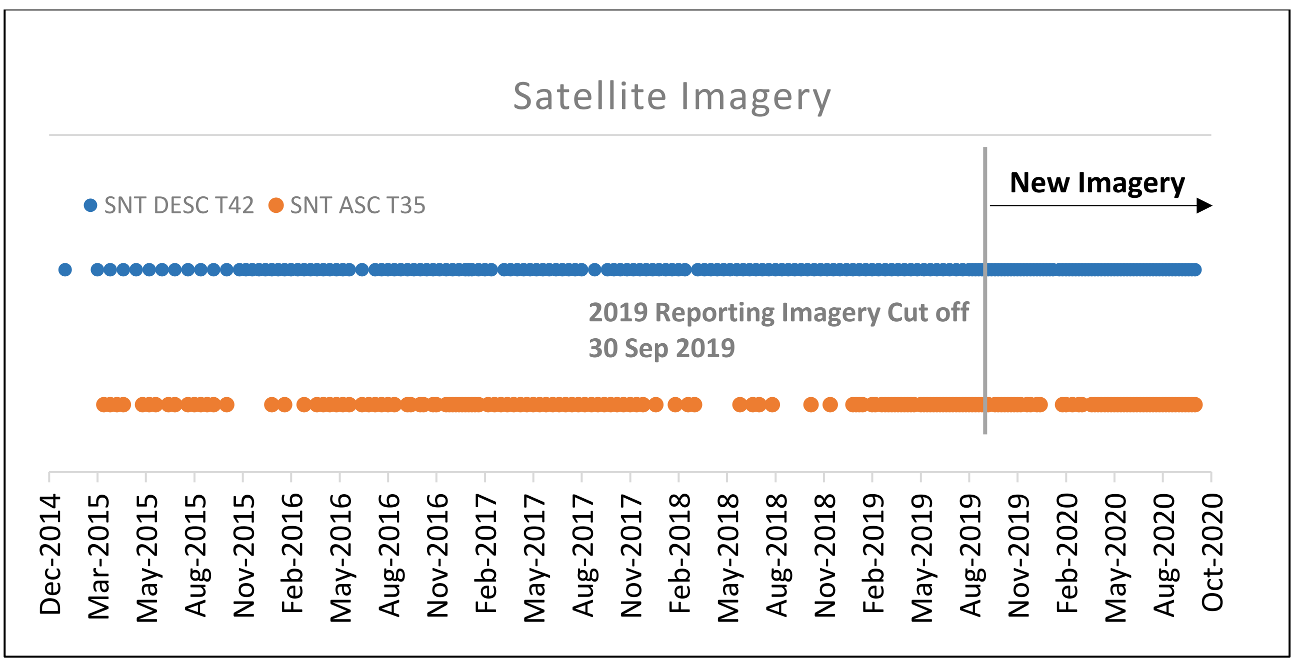


Figure 2: Temporal distribution of Sentinel ascending and descending radar images processed over Livermore.

3. Overview of Results

This section provides a summary of the techniques used and a general overview of the results, while Section 4 further describes areas of displacement in more detail. Refer to the Handbook for further details the technology and techniques used.

3.1. SqueeSAR Analysis

SqueeSAR identifies measurement points (MPs) from objects on the ground that display a stable return to the satellite in every image of an image archive. The MPs belong to two different families (Figure 3):

- Permanent Scatterers (PS): point-wise radar targets characterized by highly stable radar signal return (e.g. buildings, rocky outcrops, linear infrastructures, etc.)
- Distributed Scatterers (DS): patches of ground exhibiting a lower but homogenous radar signal return (e.g. rangeland, debris fields, arid areas, etc.). DS therefore refer to small areas covering several pixels rather than to a single target or object on the ground. For clarity of presentation and ease of interpretation, DS are represented as individual points.

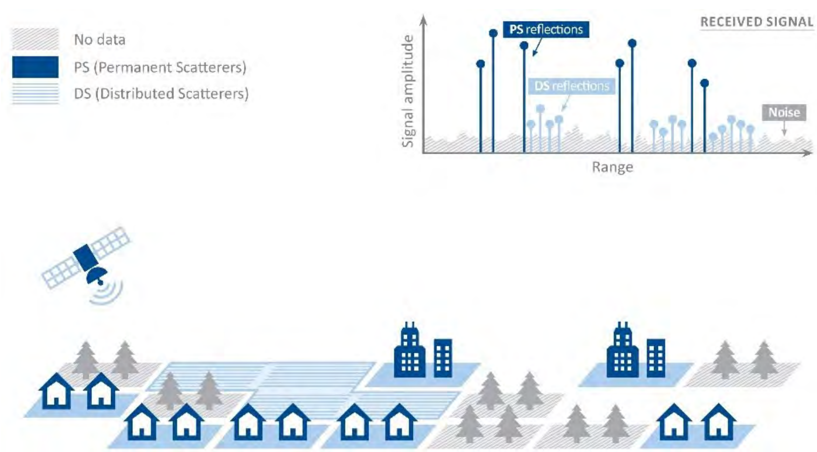


Figure 3: Schematic of PS and DS radar targets.

In InSAR analyses, all measurements are 1-D readings along the sensor's line-of-sight (LOS) as the true vector of displacement is projected onto the LOS. The same displacement will produce different readings when viewed from different angles (Figure 4). Negative values (red) indicate surface displacement away from the satellite, while positive values (blue) indicate surface displacement towards the satellite. The LOS displacement rates are calculated from a linear regression of the ground movement measured over the entire period covered by the satellite images. Each measurement point corresponds to a Permanent Scatterer (PS) or a distributed scatterer (DS), and is color-coded according to its annual rate of movement and direction:

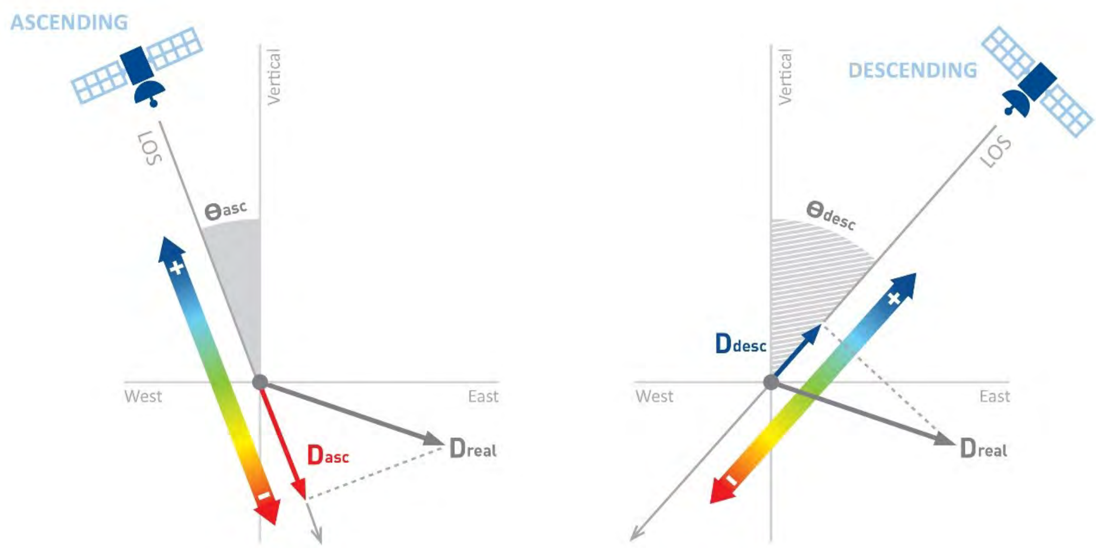


Figure 4: SqueeSAR measures the projection of real movement (D_{real}) onto the LOS. The same real movement (D_{real}) will produce a different value from a different LOS (different inclination or different acquisition geometry).

Displacement measurements obtained by the SqueeSAR algorithm are differential in space and time. Measurements are spatially related to the reference point, and temporally to the date of the first available satellite image. The reference point is assumed to be motionless and selected for its radar properties and motion behavior. Any seasonal trends present in the displacement data will be highlighted by the [SEASOM_AMP] field, which estimates amplitude of the average annual displacement.

The trigonometric combination of SqueeSAR results obtained from different orbits (i.e. ascending and descending), over the same area and overlapping period, produces 2-D (vertical and east-west) measurements of ground movement (Figure 5) in a gridded format, as different measurement points are identified from the two orbits. MPs contained within a same cell are averaged and a new unique, derived time series of displacement is obtained for each grid cell.

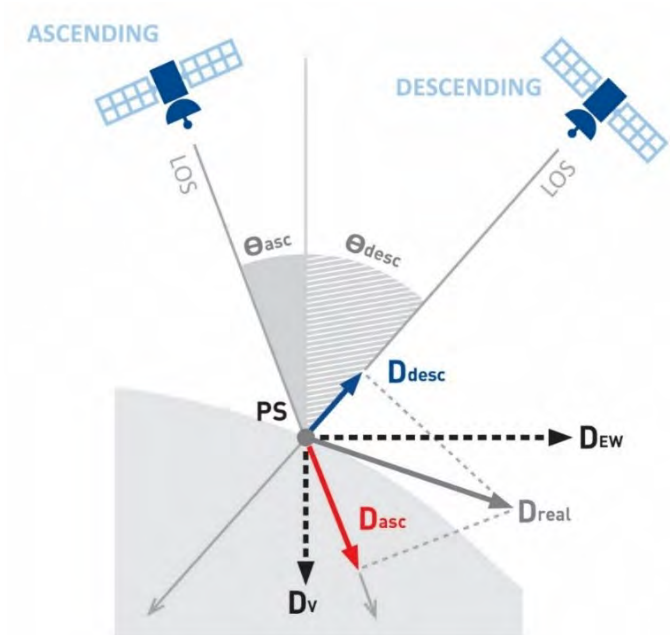


Figure 5: Example of motion decomposition combining ascending and descending acquisitions geometry.

As in the LOS analysis, average annual displacement rates in a 2-D analysis are calculated from a linear regression of the ground movement measured over the entire time interval covered by the analysis and all measurements are relative to a chosen reference point. Each point is color-coded according to the magnitude of movement:

- In a vertical data set, negative values (red) indicate downward surface displacement (i.e. subsidence), while positive values (blue) indicate upward surface displacement (i.e. uplift).
- In an east-west data set, negative values (red) indicate westward motion, while positive values (blue) indicate eastward motion.

The SqueeSAR data are calibrated using GNSS (Global Navigation Satellite System) stations P228 and P229 from UNAVCO. Appendix 3 provides additional information on the details for the calibration methodology.

3.2. 2-D and Line-of-Sight Results

The LOS displacement rates, measured in inches per year, were computed from the ascending archive (13 March 2015 to 30 September 2020) and the descending archive (31 December 2014 to 30 September 2020). These LOS results were calibrated using GPS stations located within the area of interest to account for regional ground displacement trends (Figure 6, uncalibrated results in Figure 7). The calibrated LOS (Ascending and Descending) results were then used to produce calibrated 2-D (East-West and Vertical) measurements (Figure 8, uncalibrated results in Figure 9). The calibrated 2-D output highlights an area of uplift in the western portion of the AOI and generalized westward movement throughout the AOI. Further observations are described in Section 4.

Various parameters of the analysis, including measurement point density and precision, are indicated in Table 2. Note that more heavily vegetated areas may produce a lower density of measurement points. Furthermore, as the radar signal in these areas is weaker the displacement readings may be noisier.

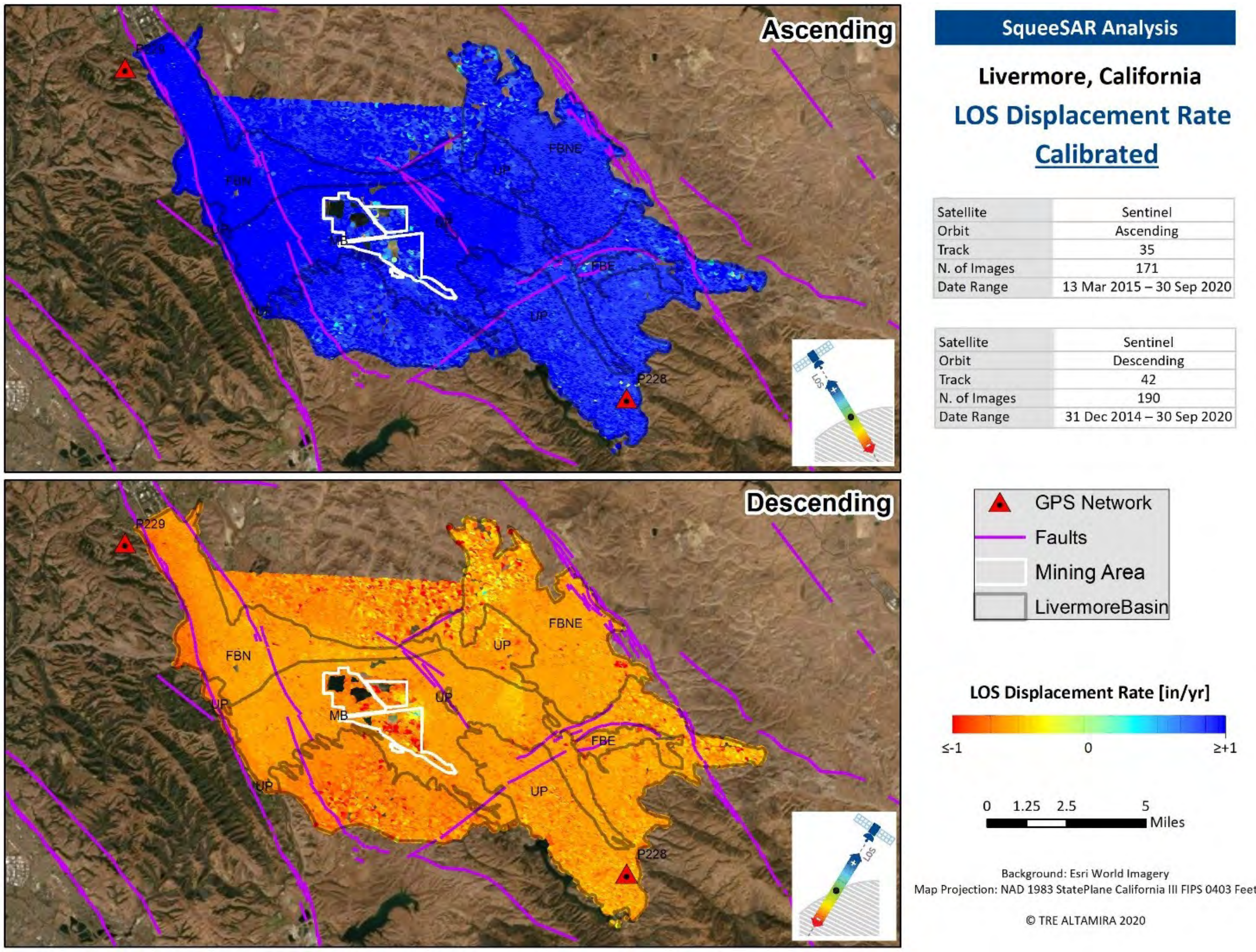


Figure 6: Ascending and Descending calibrated displacement rates over the AOI for the entire study period.

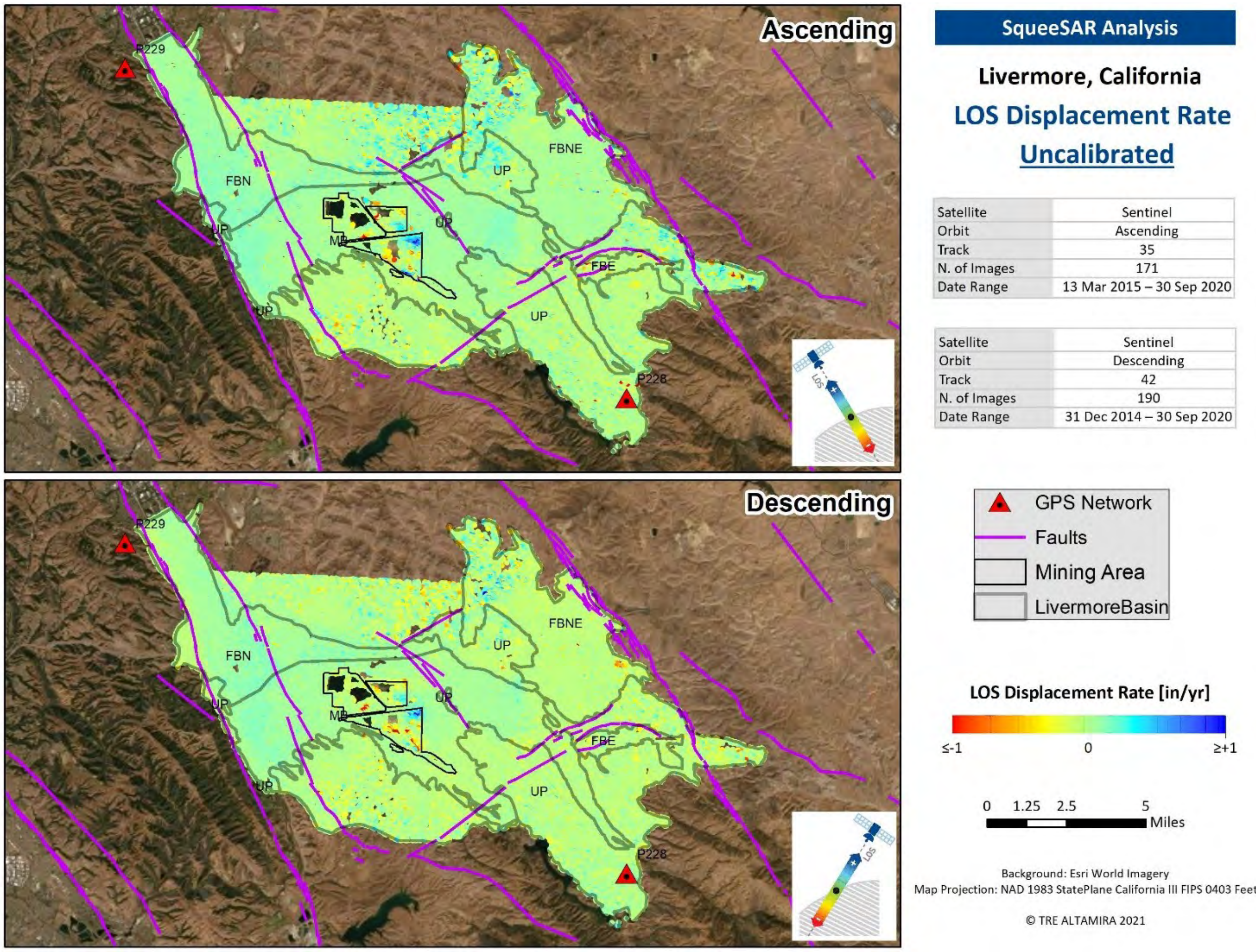


Figure 7: Ascending and Descending uncalibrated displacement rates over the AOI for the entire study period.

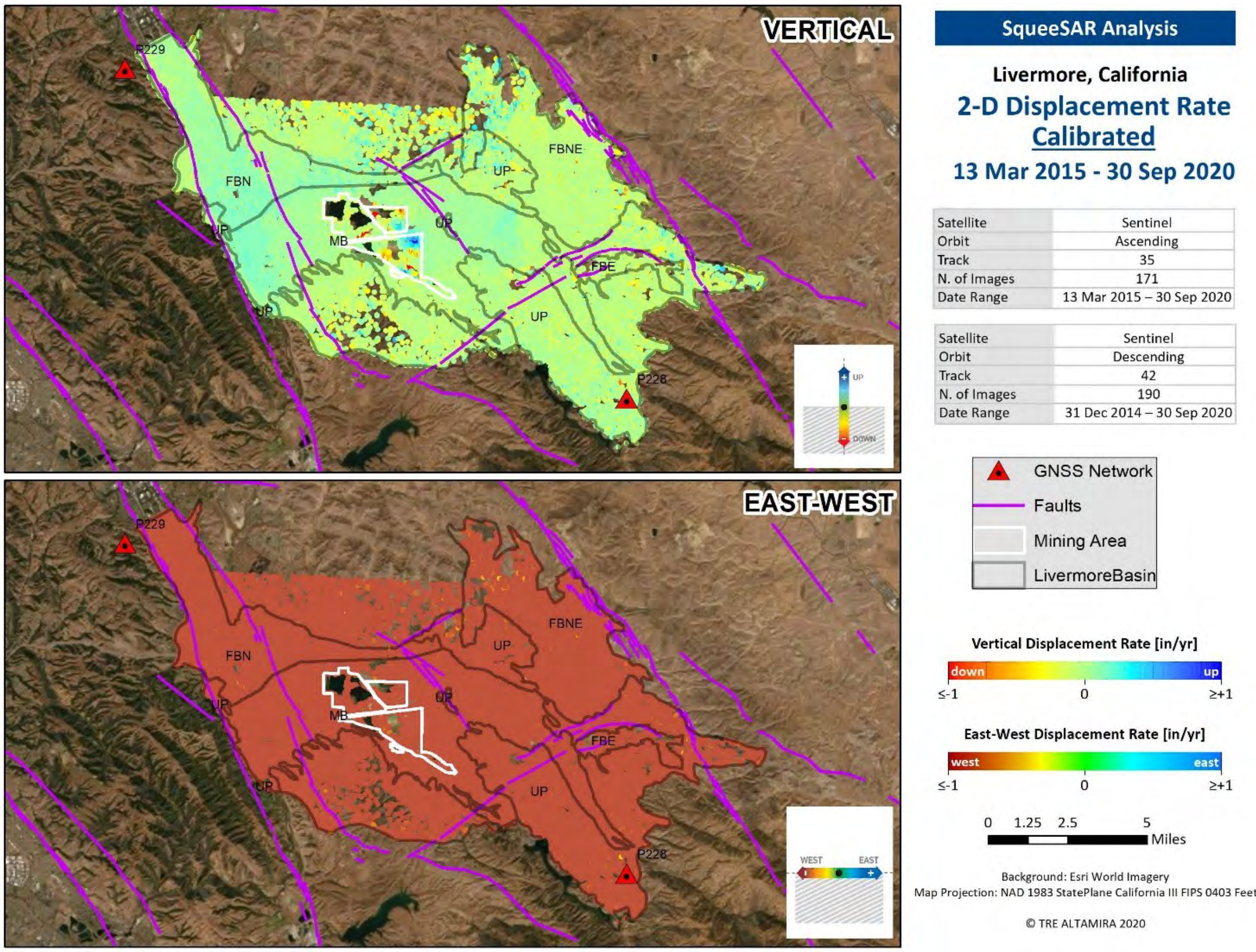


Figure 8: East-West and Vertical calibrated displacement rates over the AOI for the entire study period.

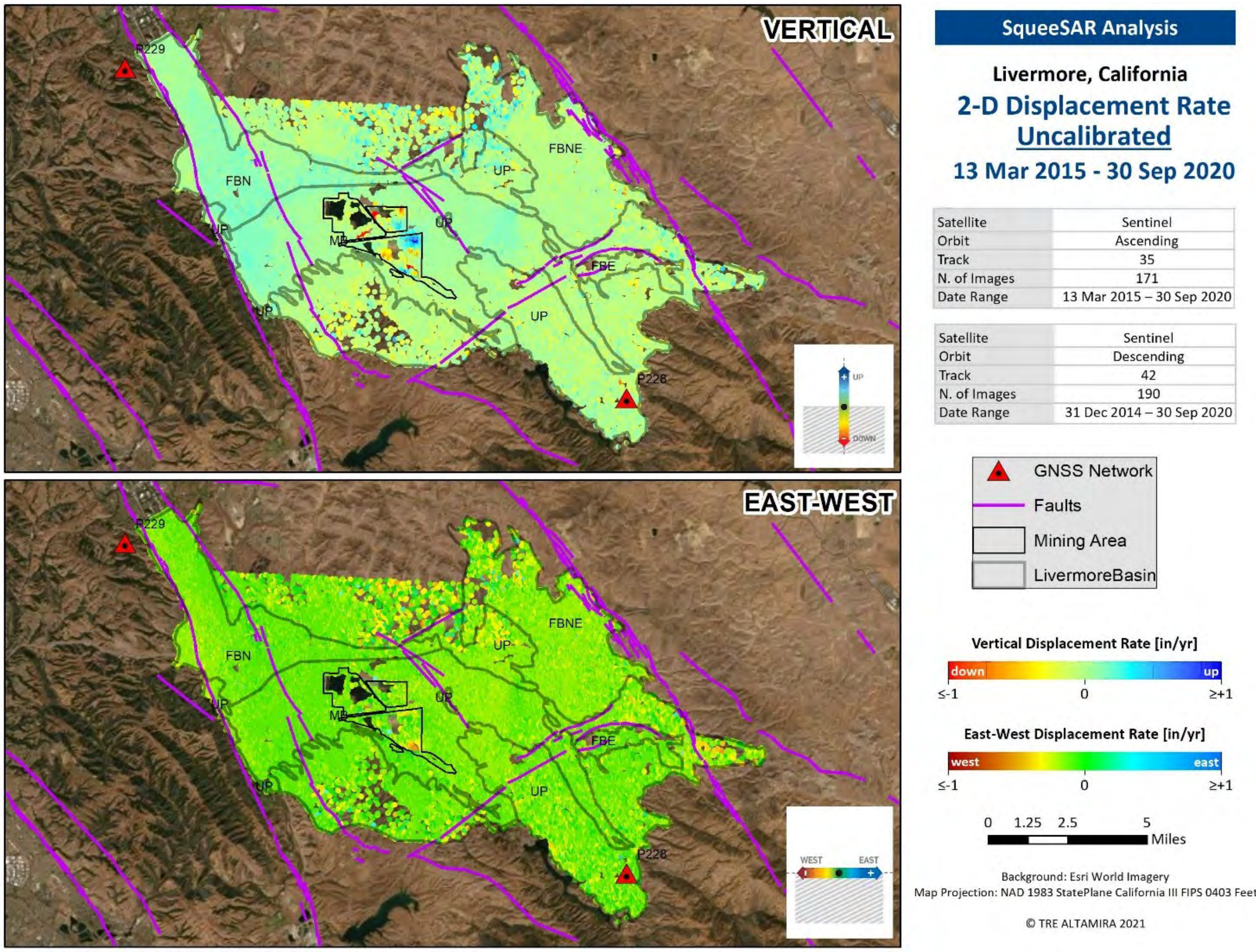


Figure 9: East-West and Vertical uncalibrated displacement rates over the AOI for the entire study period.

Table 2: Properties of the SqueeSAR analyses. *Based on uncalibrated LOS and 2D results.

Attribute	Ascending	Descending	Vertical	East-West
Date Range	13 Mar 2015 – 30 Sep 2020	31 Dec 2014 – 30 Sep 2020	13 Mar 2015– 30 Sep 2020	13 Mar 2015 – 30 Sep 2020
N. of Images	171	190	246	246
Total points (PS + DS) **Number of PS** **Number of DS**	120,467 82,924 37,543	124,723 86,639 38,084	41,665 / /	41,665 / /
Average Point Density (pts/mi^2)	996	1031	344	344
Average Displacement Rate Standard Deviation (in/yr)	±0.02	±0.01	±0.02	±0.02
Average Time Series Error Bar (in)	±0.15	±0.15	/	/

4. Observations

All data analyses in this section use uncalibrated vertical data, which is simply referred to as vertical data in the following.

4.1. Annual Ground Displacement

Figure 10 and Figure 11 outlines annual (September to September) cumulative displacement within the AOI. Within the North Fringe Region sub-basin (FBN) and the northwest Main Basin (MB), uplift is observed between 2016 to 2019, while up to -0.25 inches of subsidence is detected in the Main Basin (within the mining area) in 2020.

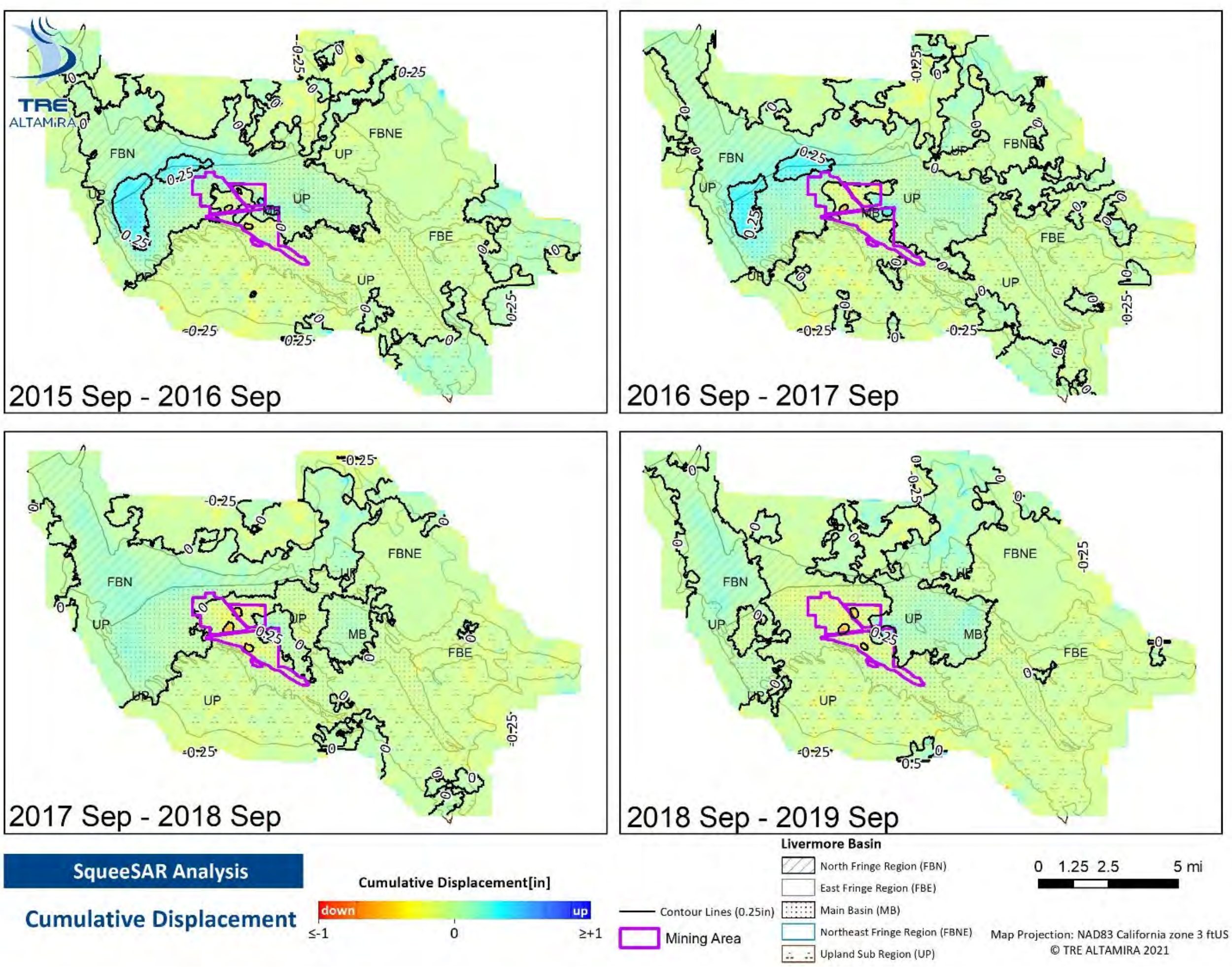


Figure 10: Interpolated map showing annual (September to September) ground displacement from 2015 to 2019. Contour lines have a 0.25-inch interval.

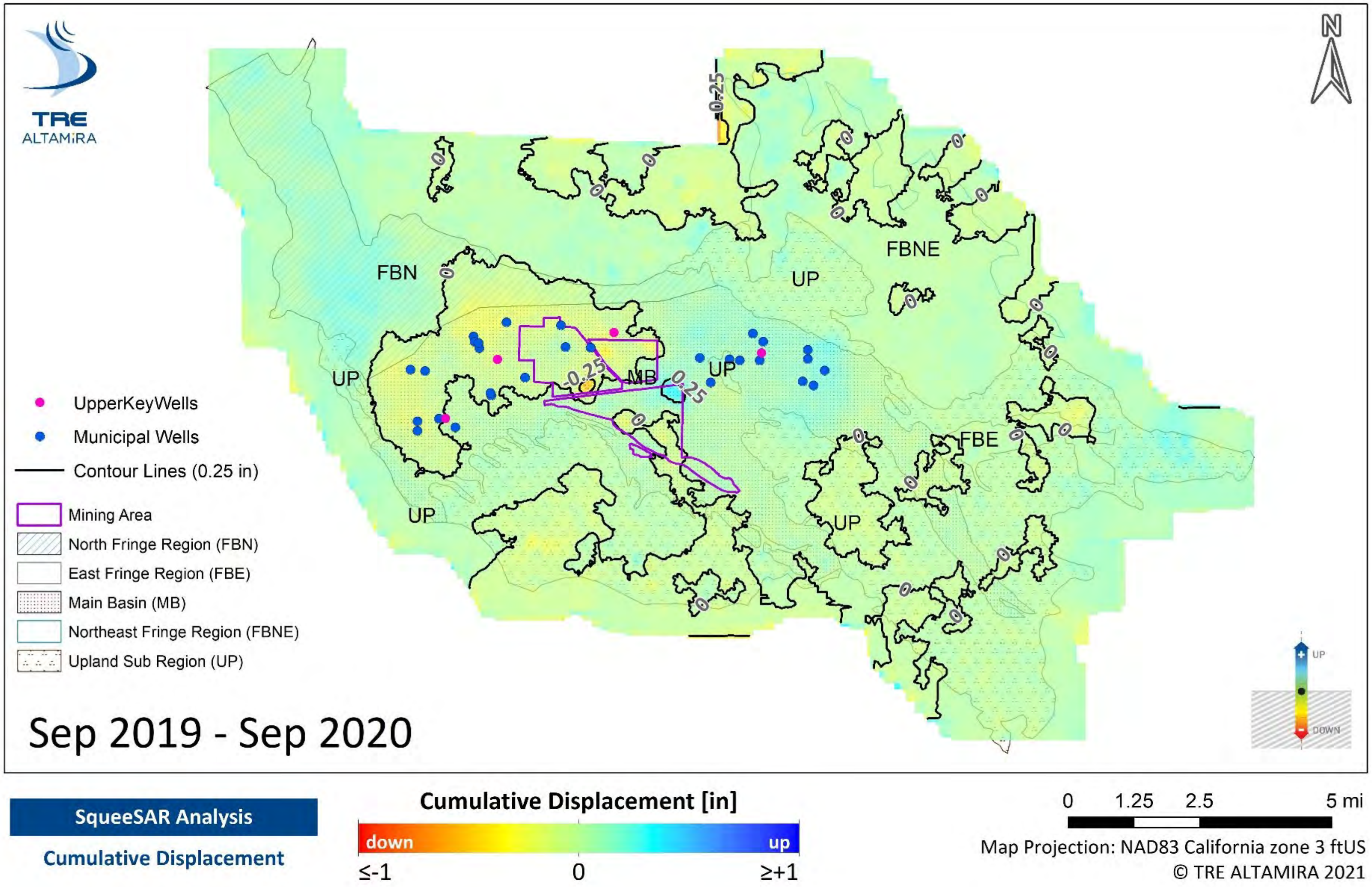


Figure 11: Interpolated map showing annual (September to September) ground displacement from 2019 to 2020. Contour lines have a 0.25-inch interval.

4.2. Comparison with Groundwater Levels

The relationship between groundwater levels and ground displacement was investigated by comparing vertical measurements (within a 500 foot buffer of four key wells and well 3S1E08H009) with groundwater levels (Figure 12). The results may be weakly correlated, including decreased groundwater levels matching minor ground subsidence (at Key_AMW_U, Key_Bern_U and well 3S1E08H009) in the last year (Figure 13 and Figure 14). The measurement points within 500 ft buffer to the wells are listed in Table 3.

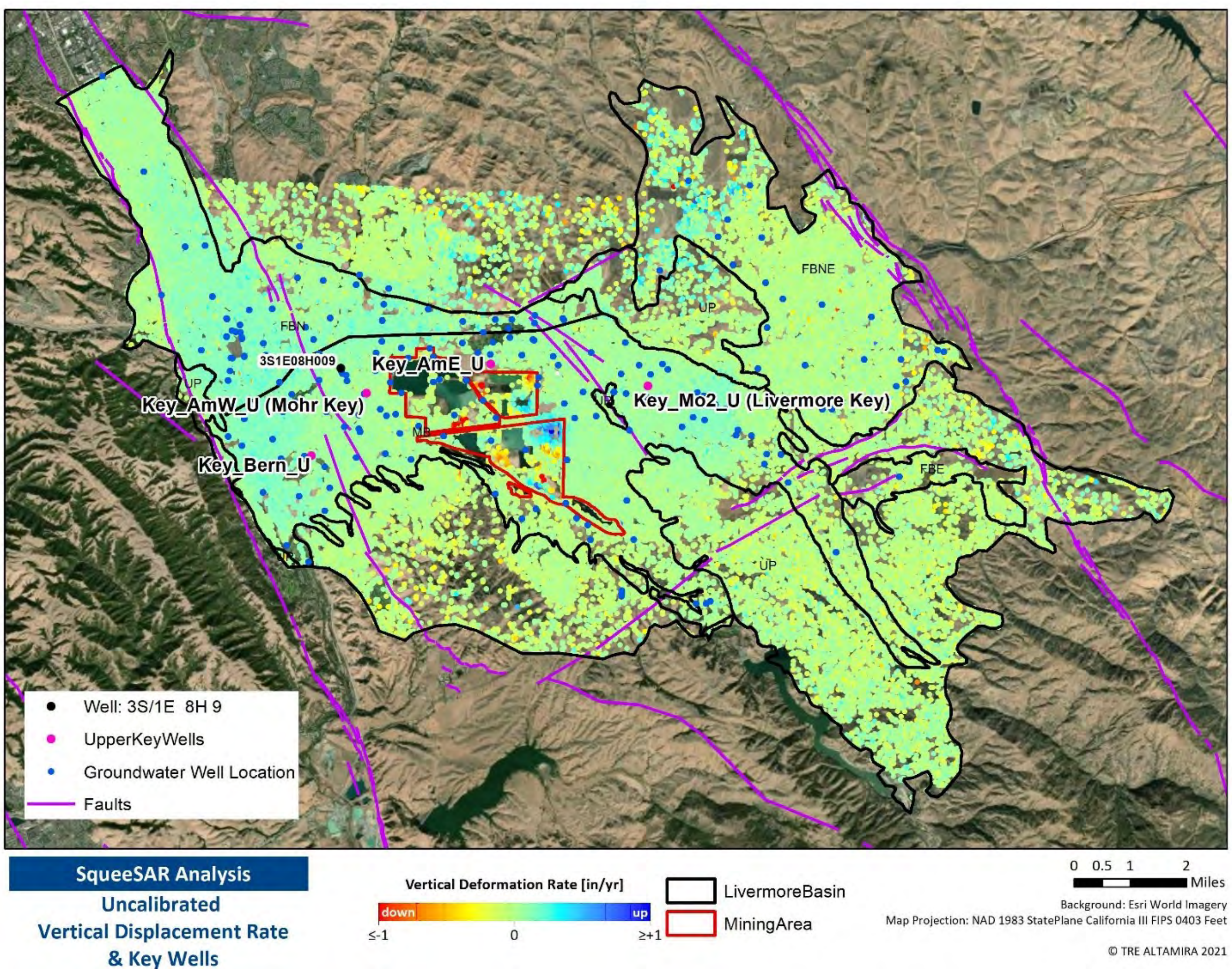
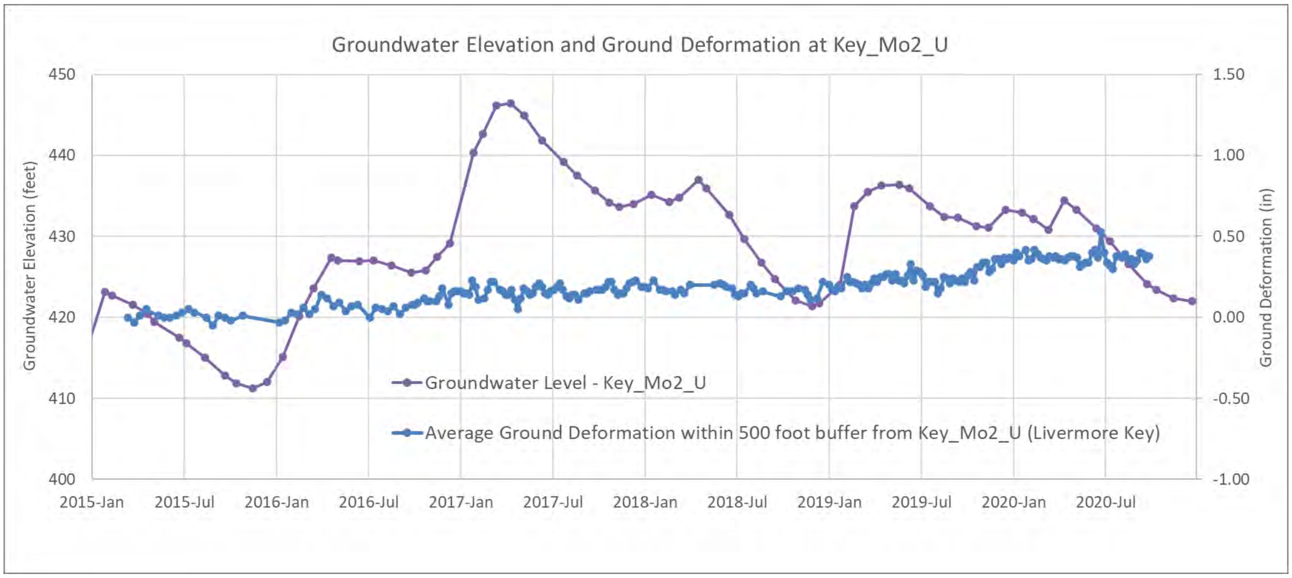


Figure 12: Key well locations, ground displacement and faults.



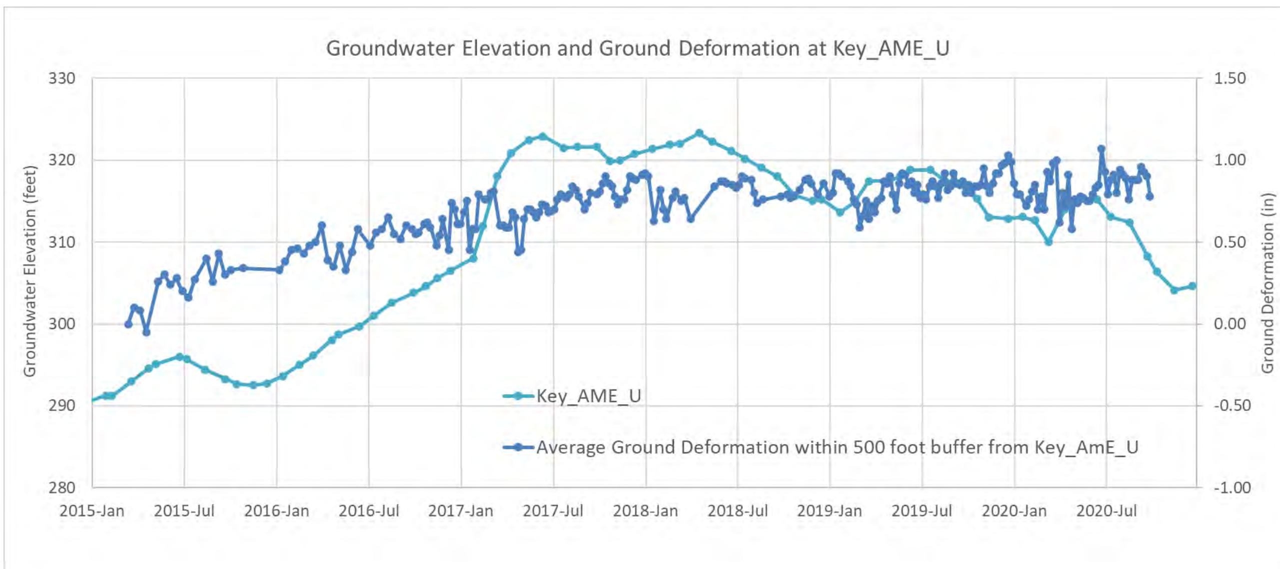


Figure 13: Groundwater elevation vs. ground displacement at Key_Mo2_U (top) and Key_AME_U (bottom).

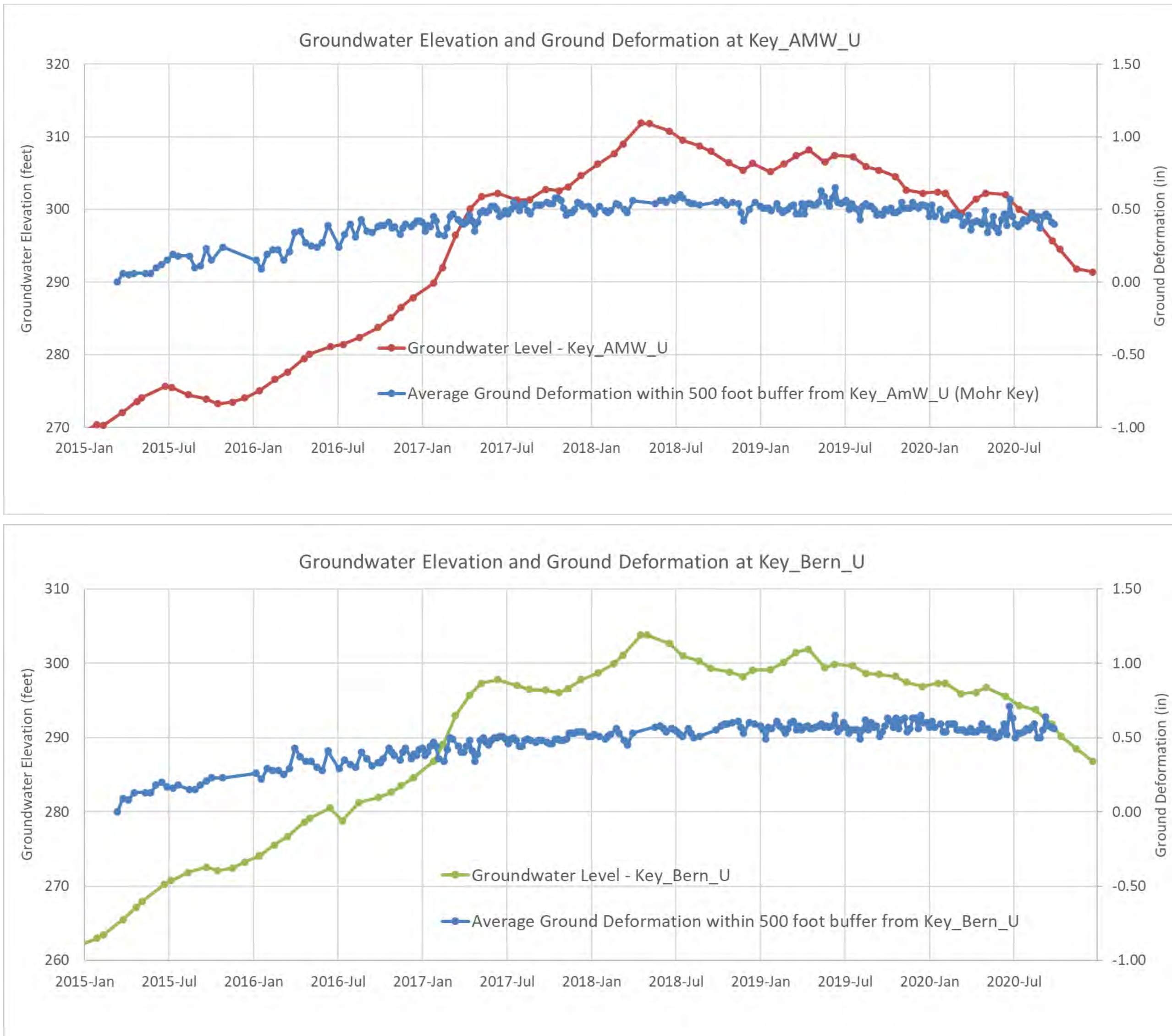


Figure 14: Groundwater elevation vs. ground displacement at Key_AMW_U (top) and Key_Bern_U (bottom).

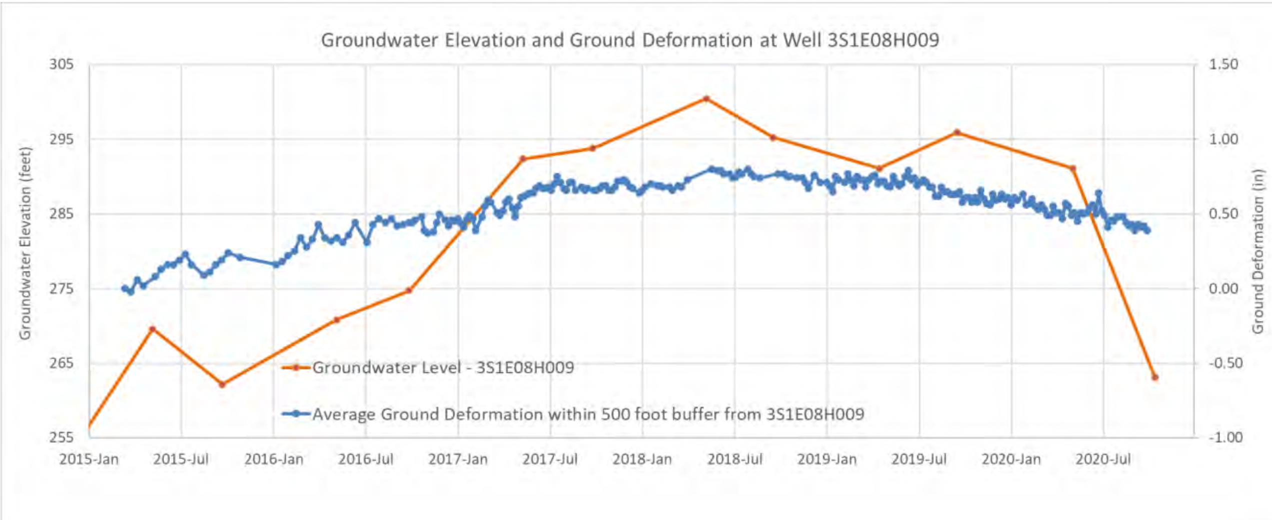


Figure 15: Groundwater elevation vs. ground displacement at well 3S1E08H009.

Table 3: Measurement points within 500-foot buffer to the wells.

Key Wells	Measurement point CODE
Key_Mo2_U	A3UQ07K, A3U4KLT, A3VBFTD, A3VWVF5, A3WIB0X, A3TJ502, A3UQ07M, A3VBFTE, A3VWVF6, A3WIB0Y, A3TJ503, A3U4KLV, A3VBFTF, A3VWVF7, A3WIB0Z, A3UQ07O, A3VBFTG, A3WIB10, A3U4KLX
Key_AME_U	A40OC6W, A43NI7S, A42GN0B, A4322M3
Key_AMW_U	A3RQU27, A3QJYUO, A3RQU28, A3SC9O0, A3SXP9T, A3PYJ8Y, A3RQU2A, A3SC9O2, A3SXP9U, A3QJYUR, A3R5EGJ, A3SXP9V, A3QJYUS, A3RQU2C
Key_Bern_U	A36B89C, A354D1T, A35PSNL, A36B89D, A36WNV5, A34IXG2, A35PSNM, A354D1V, A35PSNN, A36B89F, A36WNV7, A37I3GZ, A34IXG4, A35PSNO, A36WNV8, A35PSNP, A36B89H, A36WNV9
3S1E08H009	A402WIO, A3YALPD, A3YW1B5, A40OC4H, A3ZHGWY, A40OC4I, A419RQA, A3YW1B7, A3ZHGWZ, A3YALPG, A419RQC, A3YW1B9, A3ZHGX1, A402WIT, A40OC4L

5. Summary and Recommendations

TRE Altamira used its SqueeSAR® algorithm to process Sentinel images coupled with a GNSS calibration procedure to carry out a 2-D analysis of ground displacement over Livermore spanning 13 March 2015 to 30 September 2020. The current analysis provides an annual update for the period September 2019 to September 2020.

Up to -0.25 inches observed over the Main Basin over Livermore in 2020. The precision of the InSAR results is maintained within a quarter of an inch (±0.15 inches).

Appendix 1: Delivered Files

List of Deliverables

Table 4 list the deliverables including the present report, the InSAR data files and an updated version of the TRE toolbar, a software tool for assisting with the loading, viewing and interrogation of the data in ESRI ArcGIS 10.x software (For set-up procedure and functionalities, see the attached manual *TREToolbarSetup_5.0.pdf*).

Table 4: List of deliverables.

Description	File name
SqueeSAR Data	**LOS Calibrated & Uncalibrated:** Ascending: LIVERMORE_SNT_T35_A_SEP2020_NAD83_IMPERIAL_CA3030A1S.shp Descending: LIVERMORE_SNT_T42_D_SEP2020_NAD83_IMPERIAL_CA3030A2S.shp **2-D Calibrated & Uncalibrated:** Vertical: LIVERMORE_SNT_VERT_SEP2020_NAD83_IMPERIAL_CA3030A3V.shp East-West: LIVERMORE_SNT_EAST_SEP2020_NAD83_IMPERIAL_CA3030A4E.shp
MXD project file containing all the data (ESRI ArcGIS version 10.0 and 10.8)	Livermore_InSAR_Analysis_2014-2020.mxd
Technical Report	Livermore_Annnual_SqueeSAR_Analysis_2020_Report.pdf
TRE Toolbar v5.8.5 (ESRI® ArcGIS 10.x)	TREToolbar_5.0 TREToolbarSetup_5.0.pdf

Database Structure

The SqueeSAR vector data are delivered in a shapefile format and projected to NAD_1983_StatePlane_California_III_FIPS_0403_Feet (EPSG:2227) coordinates. The shapefile of each elaboration contains details about the measurement points identified, including displacement rate, elevation, cumulative displacement and quality index. The information associated within the database files (dbf) are described in Table 5.

Table 5: Description of the fields contained in the database of the vector data. *Field is only present in LOS data sets.

Field	Description
CODE	Measurement Point (MP) identification code.
HEIGHT*	Topographic Elevation referred to WGS84 ellipsoid of the measurement point [ft].
H_STDEV*	Height standard deviation of the measurement point [ft].
VEL	MP displacement rate [in/yr]. • **Ascending LOS:** Positive values correspond to motion toward the satellite (i.e. uplift and/or westward movement); negative values correspond to motion away from the satellite (i.e. downward and/or eastward movement). • **Descending LOS:** Positive values correspond to motion toward the satellite (i.e. uplift and/or eastward movement); negative values correspond to motion away from the satellite (i.e. downward and/or westward movement). • **Vertical (VEL_V):** Positive values indicate uplift; negative values indicate downward movement. • **E-W Horizontal (VEL_E):** Positive values indicate eastward movement; negative values westward movement.
V_STDEV	Displacement rate standard deviation [in/yr].
ACC*	Acceleration rate [in/yr^2].
A_STDEV*	Standard deviation of the acceleration value [in/yr^2].
SEASPM_AMP*	Average seasonal amplitude [in]
S_AMP_STD*	Average seasonal amplitude standard deviation [in]
SEASON_PHS*	Average seasonal phase [day]
S_PHS_STD*	SEASON_PHS standard deviation [day]
COHERENCE*	Quality measure between 0 and 1.

STD_DEF*	Displacement time series error bar [in]
EFF_AREA*	This parameter represents the effective extension of the area [ft^2] covered by Distributed Scatterers (DS). For permanent scatterers (PS), its value is set to 0.
Dyyyymmdd	Series of columns that contain the displacement values of successive acquisitions relative to the first acquisition available [in].

TREmaps

TREmaps® is our proprietary online GIS platform to view and interrogate the InSAR datasets. TREmaps has been completely revamped to include features and functionality previously available only within the TRE ArcGIS toolbar. Little or no training is required and no specialized GIS software is necessary. With internet access, the platform allows data to be overlaid on an optical image and to perform various operations on the data.

Functionalities include:

- Time-Series tool to view the history of displacement for each measurement point
- Average Time-Series tool to view the average history of displacement for a group of selected points.
- Cross-section tool to view the evolution of the ground surface over time
- Data download and data export (of subsets of data) to common formats (SHP, KML, GeoDB, CSV)
- Dynamic filtering tool to filter a subset of the results by a specified time period
- Client data integration.

TREmaps is hosted by Microsoft Azure, with all the advantages of data security and the cloud-based environment, with minimal downtime and robust internet connectivity. TREmaps runs directly on most Internet browsers and is accessed through a secure client login.

To log in, please go to:

https://tremaps5.tre-altamira.com/treaviewer

For assistance on any of the functions, please click the Help icon on the viewer or go to:

https://site.tre-altamira.com/tremaps-getting-started/

Appendix 2: Additional Radar Data Details

InSAR-based approaches measure surface displacement on a one-dimensional plane, along the satellite line-of-sight (LOS). The LOS angle varies depending on the satellite and on the acquisition parameters while another important angle, between the orbit direction and the geographic North, is nearly constant.

An ascending orbit denotes a satellite travelling from south to north and imaging to the east, while a descending orbit indicates a satellite travelling from north to south and imaging to the west. Table 6 lists the values of the angles for this study, while Figure 16 and Figure 17 show the geometry of the image acquisitions over the site for the ascending and descending orbits, respectively. The symbol Θ (theta) represents the angle the LOS forms with the vertical and δ (delta) the angle formed with the geographic north.

Table 6: Satellite viewing angles for the study.

Satellite	Wavelength	Orbit	Beam Mode/ Track	Symbol	Angle
Sentinel	C-Band 2.19 in	Ascending	35	θ	41.92°
				δ	10.48°
		Descending	42	θ	42.34°
				δ	8.94°

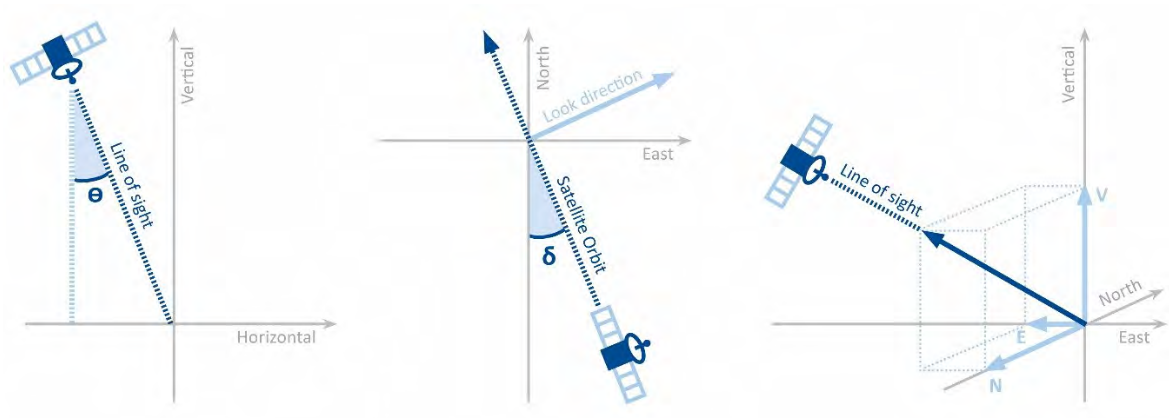


Figure 16: Geometry of the image acquisitions along the ascending orbit.

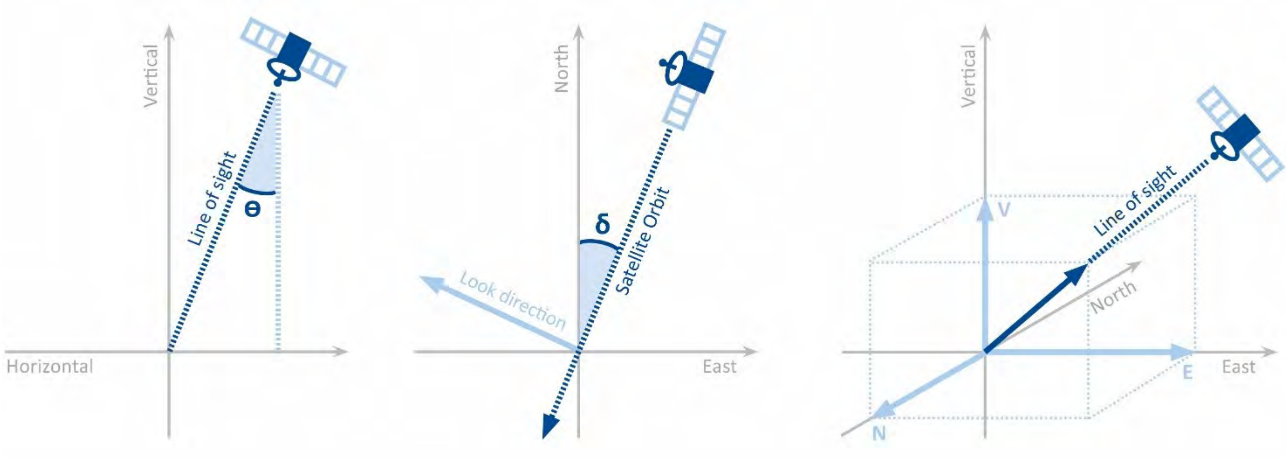


Figure 17: Geometry of the image acquisitions along the descending orbit.

Appendix 3: Calibration Methodology

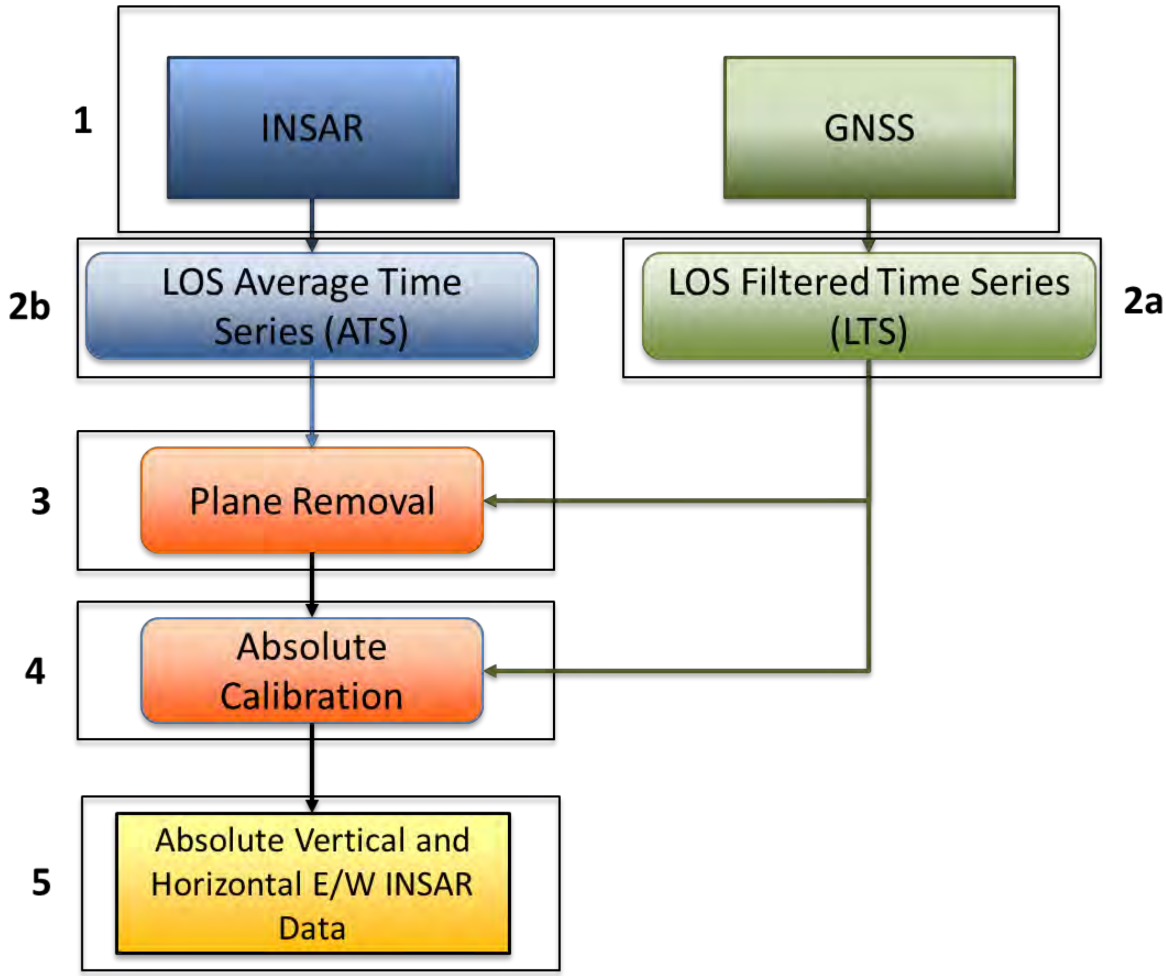
The **calibration methodology** applied to Livermore consists of the following steps (Figure 18):

1. Data collection: InSAR LOS measurements and GNSS measurements are collected independently.
2. Time series filtering:
   a) To reduce the noise of GNSS measurements, the daily time series are filtered using a 30-day moving average (15 days prior and 15 days following any given date). The filtered GNSS 3-D measurements are then projected to the satellite 1-D LOS to create a GNSS LOS time series (LTS). This step allows a direct comparison of the two independent measurements (measurement direction correspondence).

   b) All InSAR measurement points (MP) within a 100 meter radius of each GNSS are selected and used to calculate an average time series (ATS) for the period of overlap with the GNSS time series (one ATS for each GNSS). This step allows the comparison of data collected at a same location over a corresponding period of time (spatial and temporal correspondence).
3. Plane removal: to remove possible linear errors related to potential satellite orbital inaccuracies, a difference in average velocity (linear trend) is calculated for each ATS and corresponding LTS. The differences calculated for each ATS and LTS pair are then used to estimate and remove a first order surface (plane) from the InSAR data. The time series of each InSAR MP are now corrected from any possible linear trend related to orbital inaccuracies.
4. Absolute calibration: to tie the two measurement techniques together and convert the relative InSAR measurements to the absolute reference of the GNSS network, it is necessary to calibrate the InSAR time series. The procedure involves the generation of a time series of residuals by comparing the ATS to the corresponding LTS for each GNSS location. All the time series of residuals are then averaged to define a common time series of residuals (cRTS). This cRTS represents the movement of the local InSAR reference points with respect to the absolute GNSS reference frame. The cRTS is then removed from every InSAR MP time series.

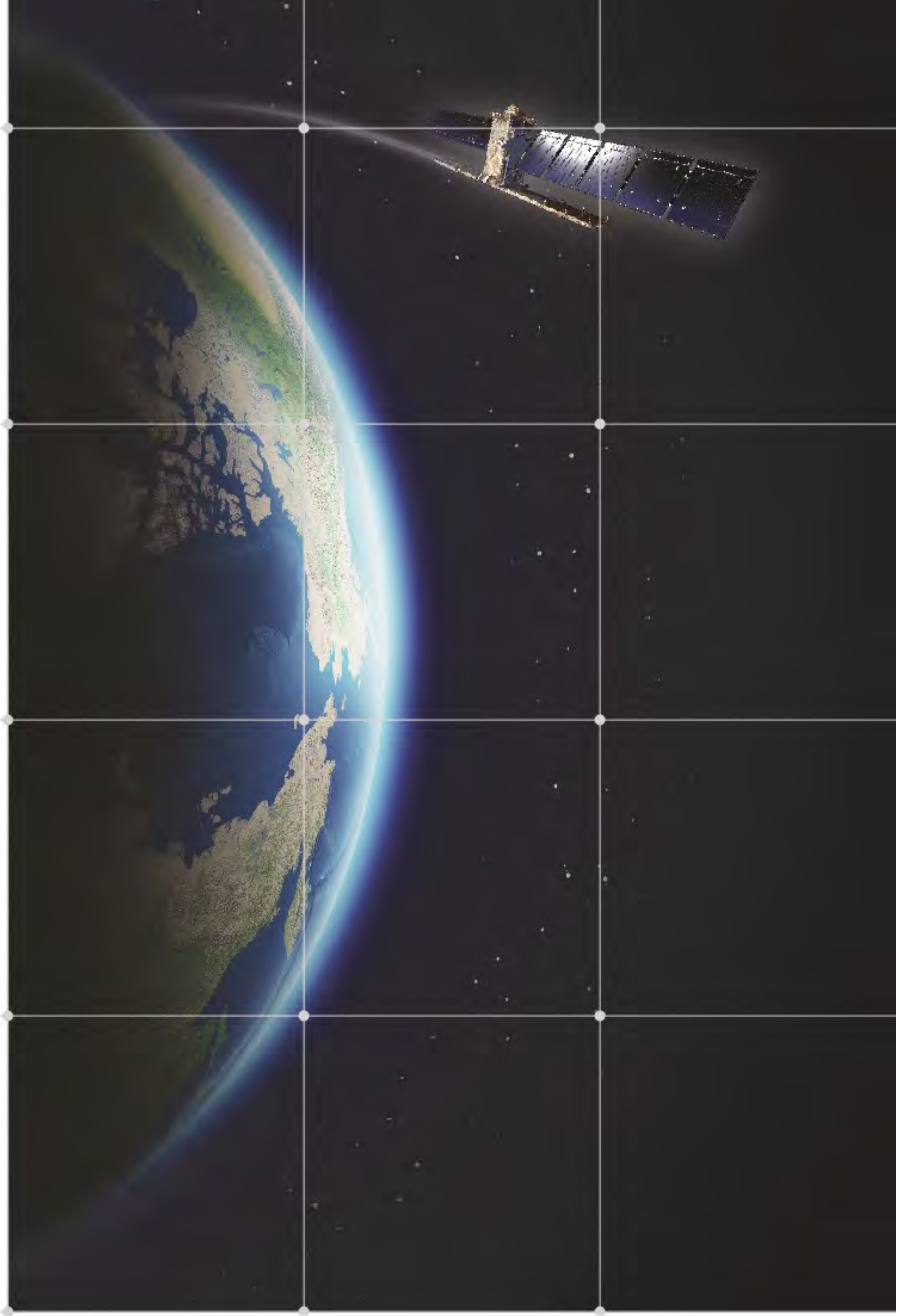
5. Absolute Vertical InSAR: The output of the absolute calibration is a LOS InSAR data set fixed to the same absolute reference system of the GNSS network. The calibration is performed separately for each orbit (ascending and descending) and the absolute LOS InSAR results will then be combined to produce the vertical and horizonal east/west displacement.

-



-

Figure 18: Diagram of the calibration methodology applied over the site.



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APPENDIX K

ZONE 7 2020 URBAN WATER MANAGEMENT PLAN

2020 Urban Water Management Plan

June 2021

ZONE 7 WATER AGENCY

Delivering Quality, Reliability and Safety

2020 Urban Water Management Plan

Prepared for

Zone 7 Water Agency

Project No. 411-60-20-18

Project Manager: Rhodora Biagtan, PE	June 2021 Date
QA/QC Review: Jim Connell, PE	June 2021 Date

WEST YOST
Water. Engineered.

FINAL REPORT | JUNE 2021

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LIST OF ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
ABAG	Association of Bay Area Governments
Act	Urban Water Management Planning Act
ACWA	Association of California Water Agencies
ACWD	Alameda County Water District
AF	Acre-Feet
AFY	Acre-Feet Annually
AIP	Agreement in Principle
AMP	Asset Management Plan
BARDP	Bay Area Regional Desalination Project
BARR	Bay Area Regional Reliability
BART	Bay Area Rapid Transit
BAWAC	Bay Area Water Agencies Coalition

BAWSCA	Bay Area Water Supply and Conservation Agency
Cal Water	California Water Service-Livermore District
CalWEP	California Water Efficiency Partnership
CASGEM	California Statewide Groundwater Elevation Monitoring
CCTV	Closed-Circuit Television
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	Cubic Feet Per Second
CII	Commercial, Industrial, and Institutional
CIMIS	California Irrigation Management Information System
CIP	Capital Improvement Program
COA	Coordinated Operations Agreement
COLs	Chain of Lakes
Cr(VI)	Hexavalent Chromium
CUWA	California Urban Water Agencies
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
CWC	California Water Code
cm	Centimeter
DCP	Delta Conveyance Project
DCR	Delivery Capability Report
DEIR	Draft Environmental Impact Report
DERWA	DSRSD-EBMUD Recycled Water Authority
District	Alameda County Flood Control and Water Conservation District
DMMs	Demand Management Measures
DOC	Dissolved Organic Carbon
DRA	Drought Risk Assessment
DSRSD	Dublin San Ramon Services District
DVWTP	Del Valle Water Treatment Plant
DWR	Department of Water Resources
DWR Guidebook	2020 Urban Water Management Plans Guidebook for Urban Water Suppliers
DYTP	Dry Year Transfer Program
EBMUD	East Bay Municipal Utility District
EDSP	Eastern Dublin Specific Plan
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ET_o	Evapotranspiration
FEMA	Federal Emergency Management Agency

GHG	Greenhouse Gas
GIS	Geographic Information Systems
GMP	Groundwater Management Plan
gpcd	Gallons Per Capita Per Day
GPQ	Groundwater Pumping Quota
GSA	Groundwater Sustainability Agency
HET	High-Efficiency Toilet
HEW	High-Efficiency Clothes Washers
HMP	Hazard Mitigation Plan
INSP	Isabel Neighborhood Specific Plan
InSAR	Interferometric Synthetic Aperture Radar
kWh	Kilowatt-hours
LAVWMA	Livermore-Amador Valley Water Management Agency
LHMP	Local Hazard Mitigation Plan
LVE	Los Vaqueros Reservoir Expansion
M&I	Municipal and Industrial
MCL	Maximum Contaminant Level
MG	Million Gallon
MGD	Million Gallons Per Day
MGDP	Mocho Groundwater Demineralization Plant
MIB	2-methylisoborneol
MMWD	Marin Municipal Water District
msl	Mean Sea Level
MTC	Metropolitan Transportation Commission
MWQI	Municipal Water Quality Investigations
NMP	Nutrient Management Plan
NOP	Notice of Preparation
PFAS	Polyfluoroalkyl Substances
PPWTP	Patterson Pass Water Treatment Plant
QWEL	Qualified Water Efficient Landscaper
RHNA	Regional Housing Needs Allocation
RUWMP	Regional Urban Water Management Plan
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SB X7-7	Water Conservation Act of 2009
SBA	South Bay Aqueduct
SCADA	Supervisory Control and Data Acquisition
SFPUC	San Francisco Public Utilities Commission
SGMA	Sustainable Groundwater Management Act

SMP	Salt Management Plan
SNMP	Salt and Nutrient Management Plan
SRVRWP	San Ramon Valley Recycled Water Program
SWP	State Water Project
T&O	Taste-and-Odor
TAF	Thousand Acre-Feet
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOD	Transit-Oriented Development
TRE	TRE Altamira
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
VW	Valley Water (formerly known as the Santa Clara Valley Water District)
WaterFix	California WaterFix Project
WBIC	Weather-Based Irrigation Controller
WEL	Water-Efficient Lawn
WMT Amendment	Water Management Tools Amendment
WRP	Water Reclamation Plant
WSCP	Water Shortage Contingency Plan
WSE	Water Supply Evaluation
WSIP	Water Storage Investment Program
WUE	Water Use Efficiency
Zone 7	Zone 7 Water Agency
Zone 7 Board	Zone 7 Board of Directors

EXECUTIVE SUMMARY

An Urban Water Management Plan (UWMP) helps water suppliers assess the availability and reliability of their water supplies and current and projected water use to help ensure reliable water service under different conditions. This water supply planning is especially critical for California currently, as climate change alters rainfall and snowfall (impacting water supply availability) and development occurs statewide (increasing the need for reliable water supplies). The Urban Water Management Planning Act (Act) requires larger water suppliers that provide water to urban users (whether directly or indirectly) to develop UWMPs every five years. UWMPs evaluate conditions for the next 20 years, so these regular updates ensure continued, long-term planning.

Zone 7 Water Agency (Zone 7) is a water wholesaler, meaning it sells water to other agencies who then sell it to individual water users (e.g., residents and businesses). These other agencies are known as water retailers. Zone 7's retailers consist of the California Water Service (Cal Water), the City of Pleasanton (Pleasanton), the City of Livermore (Livermore), and the Dublin San Ramon Services District (DSRSD). Because Zone 7's water supplies are provided to more than 3,000 users (through its retailers), it is required to prepare a UWMP.

This Executive Summary serves as a Lay Description of Zone 7's UWMP, as required by California Water Code §10630.5.

CALIFORNIA WATER CODE REQUIREMENTS

The California Water Code documents specific requirements for California water suppliers. The Act is included in the California Water Code and specifies the required elements of a UWMP, including discussing Zone 7's water system and facilities, calculating how much water its customers use (i.e., water demand) and how much water Zone 7 can supply, and detailing how Zone 7 would respond during a drought or other water supply shortage. Also, a UWMP must describe what specific coordination steps were taken to prepare, review, and adopt the plan.

The Act has been revised over the years. The Water Conservation Act of 2009 (also known as Senate Bill [SB] X7-7) required retail water agencies to establish water use targets for 2015 and 2020 that would result in statewide water savings of 20 percent by 2020. In 2020, retail water agencies are required to report on their compliance with SB X7-7.

The 2012 to 2016 statewide drought led to further revisions to the Act to improve water supply planning for long-term reliability and resilience to drought and climate change. These revisions were formalized in the 2018 Water Conservation Legislation and include:

- Five Consecutive Dry-Year Water Reliability Assessment: Analyze water supply reliability for five consecutive dry years over the planning period of this UWMP (see Chapter 7).
- Drought Risk Assessment: Assess water supply reliability from 2021 to 2025 assuming that the next five years are dry years (see Chapter 7).
- Seismic Risk: Identify the seismic risk to the agency's water facilities and have a plan to address identified risks; the region's Local Hazard Mitigation Plan may address this requirement (see Chapter 8).
- Energy Use Information: If data is available, include reporting on the amount of electricity used to obtain, treat, and distribute water (see Chapter 6).

- Water Shortage Contingency Plan (WSCP): Update the agency's plan to include an annual process for assessing potential gaps between planned water supply and demands; conform with the State's standard water shortage levels (including a shortage level greater than 50 percent) for consistent messaging and reporting; and provide water shortage responses that are locally appropriate (see Chapter 8 and Appendix G).
- Lay Description: Provide a lay description of the findings of the UWMP; this Executive Summary serves as the "Lay Description" for this 2020 UWMP.

Major components and other findings of Zone 7's 2020 UWMP are summarized below.

ZONE 7 WATER SYSTEM

Zone 7's water facilities produce, treat, store, and deliver treated or drinking water to its customers, which include its four retailers (Cal Water, DSRSD, Livermore, and Pleasanton) and a small number of other users. While this 2020 UWMP focuses on Municipal and Industrial customers that receive treated (potable) water, Zone 7 also serves untreated water supply, largely to agricultural users in the eastern part of Alameda County.

Zone 7 produces water by pumping it from wells (groundwater), collecting it from the local watershed (local surface water), and importing water from outside the area (imported water). All water must be treated before it can be safely consumed. In addition to treatment systems for groundwater wells, Zone 7 operates two surface water treatment plants to produce safe drinking water. Zone 7 also owns and operates an extensive network of pipelines and pumping facilities to deliver that drinking water to its retailers.

WATER USE BY ZONE 7 CUSTOMERS

Zone 7's water service area includes Livermore, Pleasanton, the City of Dublin, and the Dougherty Valley portion of the City of San Ramon via an out-of-service-area agreement with DSRSD. Zone 7 does not have land use authority and therefore does not make decisions on community growth; this role rests with the local jurisdictions. Many of these areas anticipate significant growth in the next 20 years, which would increase their demand for water. Thorough and accurate accounting of current and future water demands is critical for Zone 7's planning efforts. To continue delivering safe and reliable drinking water, Zone 7 must know how much water its customers currently use and how much they expect to use in the future.

Zone 7 coordinated closely with each of the four retailers to estimate water demands through the year 2045. This process involved reviewing development and planning documents for each city within Zone 7's service area. For all of Zone 7's customers (retailers and smaller customers), water demand is expected to increase approximately 24 percent (from 2020 levels) by 2045. Most of that growth is expected in the next ten years.

ZONE 7 WATER SUPPLIES

Imported water from the State Water Project (water originating in Lake Oroville and delivered to Zone 7 through reservoirs, rivers, aqueducts and pipelines that make up the State Water Project) makes up approximately 80 percent of Zone 7's water supply, with the remainder coming from groundwater (which also originated as imported water) and local surface water (water originating as rainfall within the local watershed). The future reliability of imported water is a concern. Drought, sea level rise, and natural disasters threaten the Sacramento-San Joaquin Delta (Delta), a critical component of the delivery system bringing water to Zone 7. As a result, Zone 7 is participating in and evaluating various projects that would provide alternate water supplies and/or storage or protect the existing delivery system against threats. These projects include installing a new diversion and conveyance system for Delta supplies (Delta Conveyance Project), desalinating brackish water (water with high salt content) (Bay Area Regional Desalination Project), reusing highly treated wastewater (potable reuse), participating in the construction of a new reservoir to capture surplus water from the Sacramento River (Sites Reservoir), and expanding an existing reservoir near Zone 7 for additional storage and adding a new connection to the South Bay Aqueduct (Los Vaqueros Reservoir Expansion).

Zone 7's future water supplies are expected to keep pace with water demands through temporary water transfers and long-term projects. In 2045, water supplies are expected to be approximately 49 percent higher than in 2020. Note, estimates of new supply are preliminary and subject to change as projects progress and are better defined, and as Zone 7 selects the projects to ultimately implement.

Zone 7 reviewed the amount of electricity used to obtain, treat, and distribute water. In Table 6-13 of this plan, the energy intensity of Zone 7's water service is calculated for a typical year's energy use (2019). The total energy intensity for Zone 7's water service is 342 kilowatt-hours per acre-foot (kWh/AF). Understanding the energy intensity allows Zone 7 to assess various water supply management and system operation strategies.

CONSERVATION TARGET COMPLIANCE

As a wholesale water agency, Zone 7 is not required meet 20 percent reduction targets by 2020 in accordance with SB X7-7. However, it has fully supported the achievement of SB X7-7 water use reduction targets by its retailers. Each of Zone 7's retailers has achieved and exceeded the goals of their water use reduction targets. Conservation continues to play a key role in achieving long-term water supply reliability for the Tri-Valley.

ZONE 7 WATER SERVICE RELIABILITY

The California Water Code asks agencies to evaluate their water service reliability by examining the impact of drought on their water supplies and comparing those reduced supplies during drought to the retailer's expected water demands. Specifically, agencies should calculate their water supplies during a single dry year and five consecutive dry years using historical records. For example, Zone 7 can estimate its imported water supply during a single dry year by looking at the imported water supply reduction during the driest year on record. If that previous dry year reduction was 50 percent, then Zone 7 can conservatively assume a similar 50 percent reduction in imported water supplies in a future dry year.

With continued strategic planning and implementation of key projects, Zone 7 is well-positioned to withstand the effects of a single dry year and a five-year drought. Water supplies exceed water demands during dry conditions, and this remains true for five-year droughts beginning in 2025, 2030, 2035, 2040, and 2045. Zone 7's drought risk was also specifically assessed between 2021 and 2025, assuming that the next five years are dry years. As shown in Table ES-1, Zone 7 expects to meet demands under these conditions, with any extra supplies largely going to storage for use during the following year(s) after accounting for system losses.

Table ES-1. Projected Supplies and Demands for Drought Risk Assessment: 2021-2025

SUPPLY SOURCE Calendar Year	Available Supply, AFY				
	2021	**2022**	**2023**	**2024**	**2025**
Equivalent Hydrologic Year	*Actual*	*1988*	*1989*	*1990*	*1991*
State Water Project Table A	4,000	8,900	48,400	10,500	20,200
State Water Project Carryover from Previous Year	8,900	10,300	9,600	12,800	9,900
Water Transfers	10,000	6,000	5,000	6,000	8,000
Arroyo Valle (Local Water)	700	700	6,900	6,900	2,700
Main Basin (Local Groundwater)	13,200	13,200	11,000	10,000	11,000
Semitropic Water Storage District (Groundwater Bank)	9,100	9,100	0	9,100	9,100
Cawelo Water District (Groundwater Bank)	10,000	10,000	0	5,000	1,900
Total Supplies	**55,900**	**58,200**	**80,900**	**60,300**	**62,800**
Total Demands	**45,200**	**47,600**	**48,500**	**49,400**	**50,300**
Difference/Surplus	**10,700**	**10,600**	**32,400**	**10,900**	**12,500**

As shown above, the water reliability assessment for a five-consecutive-dry-year period reveals that Zone 7's supplies are adequate to meet projected demands on average.

Still, there is a potential that operational constraints—especially during a Delta outage when there may be no or minimal water moving through the South Bay Aqueduct from the Delta—could result in shortages, particularly in the near-term before major water supply projects are implemented around 2030. Untreated water customers would be most vulnerable because of their reliance on Delta water. As described in the WSCP, in these cases, Zone 7 could call for voluntary or mandatory conservation and make operational adjustments to minimize such shortages. Furthermore, during dry periods, water reserves will be drawn down and need to be replenished in the following years.

WATER SHORTAGE CONTINGENCY PLAN

A WSCP describes an agency's plan for preparing for and responding to water shortages. Zone 7 updated its WSCP (see Appendix G) to include its process for assessing potential gaps between planned water supply and demands for the current year and the next potentially dry year. In coordination with its retailers, Zone 7 aligned its service area's water shortage levels with the State's shortage levels for consistent messaging and planned for locally appropriate water shortage responses. For example, a State 2 shortage (defined as an up to 20 percent shortage) has the same definition for Zone 7 as it does for the State. When Zone 7 anticipates or identifies that water supplies may not be adequate to meet the normal water supply needs of its customers, the Zone 7 Board may determine that a water shortage exists and consider a resolution (sample in WSCP, Appendix C) to declare a water shortage emergency and associated stage. The shortage stage provides direction on shortage response actions (WSCP, Section 4). Note that Zone 7 will also consider any statewide actions or declarations in any local declarations of a shortage stage.

UWMPs are required to include a seismic risk assessment and mitigation plan to assess and mitigate a water system's seismic vulnerabilities. In 2018, Zone 7 participated in the development of a regional local hazard mitigation plan, which found that earthquakes on the Hayward and Calaveras faults would be most significant. Seven days after an earthquake on the Hayward Fault, a utility facility has an approximately 52 percent chance of being fully functional. This percentage increases to approximately 84 percent for an earthquake on the Calaveras Fault and above 92 percent for earthquakes on the Greenville, Mt. Diablo, and San Andreas faults.

The WSCP may be used for foreseeable and unforeseeable events and is adopted concurrently with this UWMP by separate resolution to allow for updates as conditions change.

UWMP PREPARATION, REVIEW, AND ADOPTION

Zone 7 developed this 2020 UWMP in coordination with its retailers and the public. While preparing its UWMP, Zone 7 notified other stakeholders (e.g., Alameda County, Contra Costa County, Dublin, San Ramon) of its preparation, its availability for review, and the public hearing prior to adoption. Zone 7 encouraged community participation in the development of the 2020 UWMP using newspaper advertisements and web-based communication. These public notices included the time and place of the public hearing, as well as the location where the plan would be available for public inspection. Zone 7 also conducted public meetings before the public hearing, including a meeting with the Water Resources Committee on February 23, 2021 and a Zone 7 Board workshop on April 1, 2021.

The public hearing provided an opportunity for Zone 7's water users and the general public to become familiar with the 2020 UWMP and ask questions about Zone 7's water supply; its continuing plans for providing a reliable, safe, high-quality water supply; and its plans to address potential water shortages. Following the public hearing, the Zone 7 Board of Directors adopted the 2020 UWMP on May 19, 2021. A copy of the adopted Plan was submitted to the Department of Water Resources and is available on Zone 7's website (www.zone7water.com).

CHAPTER 1
Introduction

This chapter provides an introduction and overview of the Zone 7 Water Agency (Zone 7) 2020 Urban Water Management Plan (UWMP), including the importance and extent of Zone 7's water management planning efforts, changes since the preparation of Zone 7's 2015 UWMP, demonstration of consistency with the Delta Plan for participants in covered actions, and the organization of Zone 7's 2020 UWMP. This 2020 UWMP has been prepared jointly by Zone 7 staff and West Yost.

1.1 INTRODUCTION

The Urban Water Management Planning Act (Act) was originally established by Assembly Bill (AB) 797 on September 21, 1983. Passage of the Act was recognition by state legislators that water is a limited resource and a declaration that efficient water use and conservation would be actively pursued throughout the state. The primary objective of the Act is to direct "urban water suppliers" to develop a UWMP that provides a framework for long-term water supply planning and documents how urban water suppliers are carrying out their long-term resource planning responsibilities to ensure adequate water supplies are available to meet existing and future water demands. A copy of the current version of the Act, as incorporated in Sections 10610 through 10657 of the California Water Code, is provided in Appendix A of this plan.

1.2 IMPORTANCE AND EXTENT OF ZONE 7'S WATER MANAGEMENT PLANNING EFFORTS

The purpose of the UWMP is to document and communicate Zone 7's plans for developing and delivering municipal and industrial (M&I) water supplies (also referred to as potable water or treated water in this plan) to Zone 7's water service area and maintaining a reliable water supply system.

Every five years, Zone 7 updates its UWMP, documenting the latest results of Zone 7's water supply planning efforts. In particular, the 2019 Water Supply Evaluation Update[1] (2019 WSE Update) served as the foundation for the 2020 UWMP. An evaluation of Zone 7's water supply conditions, needs, and options was completed as part of the 2019 WSE Update. The Annual Report for the Sustainable Groundwater Management Program (2019 Water Year), Zone 7's Capital Improvement Program (CIP), and the 2020 Tri-Valley Municipal and Industrial Water Demand Study[2] (Regional Demand Study) also provided critical information. The 2020 UWMP, along with the reference documents listed above, are accessible through Zone 7's website at www.zone7water.com.

1.3 CHANGES FROM 2015 UWMP

The Act has been modified over the years in response to the State's water shortages, droughts, and other factors. A significant amendment was made in 2009, after the 2007 to 2009 drought, and as a result of the Governor's call for a statewide 20 percent reduction in urban water use by the year 2020. This was the Water Conservation Act of 2009, also known as Senate Bill Seven of the Senate's Seventh Extraordinary Session of 2009 (SB X7-7). The Water Conservation Act of 2009 required agencies to

[1] Zone 7 Water Agency, 2019. Water Supply Evaluation Update.

[2] Woodard & Curran, 2021. 2020 Tri-Valley Municipal and Industrial Water Demand Study. Available at www.zone7water.com after completion.

establish water use targets for 2015 and 2020 that would result in statewide water savings of 20 percent by 2020. The 2012 to 2016 statewide drought has led to further amendments to the California Water Code to improve water supply planning for long-term reliability and resilience to drought and climate change.

Summarized below are the major additions and changes to the California Water Code since Zone 7's 2015 UWMP was prepared.

- **Five Consecutive Dry-Year Water Reliability Assessment** [CWC §10635(a)]. The Legislature modified the dry-year water reliability planning from a "multi-year" time period to a "drought lasting five consecutive water years" designation. This statutory change requires the urban water supplier to analyze the reliability of its water supplies to meet its water use over an extended drought period. This requirement is addressed in the water use assessment presented in Chapter 4; the water supply analysis presented in Chapter 6; and the water reliability determinations in Chapter 7 of this plan.
- **Drought Risk Assessment** [CWC §10635(b)]. The California Legislature created a new UWMP requirement for drought planning because of the significant duration of recent California droughts and the predictions about hydrological variability attributable to climate change. The Drought Risk Assessment (DRA) requires the urban water supplier to assess water supply reliability over a five-year period from 2021 to 2025 that examines water supplies, water uses, and the resulting water supply reliability under a reasonable prediction for five consecutive dry years. The DRA is discussed in Chapter 7 based on the water use information in Chapter 4; the water supply analysis is presented in Chapter 6; and the water reliability determinations are discussed in Chapter 7 of this plan.
- **Seismic Risk** [CWC §10632.5]. The Water Code now requires urban water suppliers to specifically address seismic risk to various water system facilities and to have a mitigation plan. Water supply infrastructure planning is correlated with the regional hazard mitigation plan associated with the urban water supplier. Zone 7's seismic risk is discussed in Chapter 8 of this plan.
- **Energy Use Information** [CWC §10631.2]. The Water Code now requires Suppliers to include readily obtainable information on estimated amounts of energy for their water supply extraction, treatment, distribution, storage, conveyance, and other water uses. Zone 7's energy use for its urban water deliveries are provided in Chapter 6.
- **Water Loss Reporting for Five Years** [CWC §10608.34]. The Water Code added the requirement that water retailers include the past five years of water loss audit reports as part of this UWMP. Although not required of wholesalers, Zone 7 voluntarily reported on its water losses in Chapter 4.
- **Water Shortage Contingency Plan** [CWC §10632]. In 2018, the Legislature modified the UWMP laws to require a Water Shortage Contingency Plan (WSCP) with specific elements. The WSCP is a document that provides the urban water supplier with an action plan for a drought or catastrophic water supply shortage. Although the new requirements are more prescriptive than previous versions, many of these elements have long been included in WSCPs, other sections of UWMPs, or as part of the urban water supplier's standard procedures and response actions. Many of these actions were implemented by the urban water suppliers during the last drought to successfully meet changing local water supply challenges. The WSCP is used by the California Department of Water Resources (DWR), the State Water Board, and the Legislature in addressing extreme drought conditions or

statewide calamities that impact water supply availability. Zone 7's WSCP is presented in Chapter 8 of this plan.

- **Groundwater Supplies Coordination** [CWC §10631(b)(4)]. In 2014, the Legislature enacted the Sustainable Groundwater Management Act to address groundwater conditions throughout California. Water Code now requires 2020 UWMPs to be consistent with Groundwater Sustainability Plans in areas where those plans have been completed by Groundwater Sustainability Agencies. This requirement is addressed in Chapter 6 of this plan.
- **Lay Description** [CWC §10630.5]. The Legislature included a new statutory requirement for the urban water supplier to include a lay description of the fundamental determinations of the UWMP, especially regarding water service reliability, challenges ahead, and strategies for managing reliability risks. This section of the UWMP could be viewed as a go-to synopsis for new staff, new governing members, customers, and the media, and it can ensure a consistent representation of the supplier's detailed analysis. This requirement is addressed in the Executive Summary of this plan.
- **Water Loss Management** [CWC §10608.34(a)(1)]. The Legislature included a requirement for urban water suppliers to report on their plan to meet the water loss performance standards in their 2020 UWMPs. This requirement is addressed in the Demand Management Measures presented in Chapter 9 of this plan.

1.4 DEMONSTRATION OF CONSISTENCY WITH THE DELTA PLAN FOR PARTICIPANTS IN COVERED ACTIONS

Urban water suppliers that anticipate participating in or receiving water from a proposed project (covered action), such as a multi-year water transfer, conveyance facility, or new diversion that involves transferring water through, exporting water from, or using water in the Sacramento-San Joaquin Delta (Delta) should provide information in their 2015 and 2020 UWMPs that demonstrates consistency with Delta Plan Policy WR P1, Reduce Reliance on the Delta Through Improved Regional Water Self-Reliance (California Code Reg., tit. 23, § 5003). To demonstrate reduced reliance on the Delta and improve regional self-reliance, urban water suppliers are to:

1. Complete an Urban Water Management Plan;
2. Identify, evaluate, and commence implementation of programs and projects included in the UWMP that are locally cost effective and technically feasible in reducing reliance on the Delta; and
3. Include expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance in their UWMPs, commencing in their 2015 UWMPs and continuing in their subsequent UWMPs. Programs and projects identified above should reduce the amount or percentage of water used from the Delta watershed. For the purposes of reporting, water efficiency is considered a new source of water supply.

Zone 7 is an urban water wholesaler, as described in Section 2.1 of this plan. As a contractor of the State Water Project (SWP), Zone 7 and its retailers—California Water Service-Livermore District (Cal Water), the City of Livermore (Livermore), the City of Pleasanton (Pleasanton), and Dublin San Ramon Services District (DSRSD)—anticipate participating in a covered action and are therefore required to demonstrate reduced Delta reliance. Appendix B of this UWMP demonstrates Zone 7's consistency with Delta Plan Policy WR P1.

Zone 7 completed and adopted its 2015 UWMP in March 2016. This 2020 UWMP was completed and adopted by Zone 7 in May 2021. Chapter 6 (Water Supply Characterization) of Zone 7's 2015 and 2020 UWMPs identifies and evaluates existing and future projects whose implementation improves regional self-reliance. Chapter 9 (Demand Management Measures) of Zone 7's 2015 and 2020 UWMPs describes demand management measures that Zone 7 has implemented as part of its Water Conservation Program.

1.5 PLAN ORGANIZATION

This 2020 UWMP contains the appropriate sections and tables required per CWC Division 6, Part 2.6 (Urban Water Management Planning Act), included in Appendix A of this 2020 UWMP, and has been prepared based on guidance provided by DWR in their "2020 Urban Water Management Plans Guidebook for Urban Water Suppliers" (DWR Guidebook).

This 2020 UWMP is organized into the following chapters:

- Chapter 1: Introduction
- Chapter 2: Plan Preparation
- Chapter 3: System Description
- Chapter 4: Water Use Characterization
- Chapter 5: SBX7-7 Baseline, Targets, and 2020 Compliance
- Chapter 6: Water Supply Characterization
- Chapter 7: Water Service Reliability and Drought Risk Assessment
- Chapter 8: Water Shortage Contingency Plan
- Chapter 9: Demand Management Measures
- Chapter 10: Plan Adoption, Submittal, and Implementation

This 2020 UWMP also contains the following appendices of supplemental information and data related to Zone 7's 2020 UWMP:

- Appendix A: Legislative Requirements
- Appendix B: Demonstration of Reduced Delta Reliance
- Appendix C: DWR 2020 Urban Water Management Plan Tables
- Appendix D: DWR 2020 Urban Water Management Plan Checklist
- Appendix E: Agency and Public Notices
- Appendix F: Zone 7 Water Agency Water Supply Reliability Policy (Resolution 13-4230)
- Appendix G: Water Shortage Contingency Plan
- Appendix H: UWMP and WSCP Adoption Resolutions

Furthermore, this 2020 UWMP contains all the tables recommended in the DWR Guidebook, both embedded into the UWMP chapters where appropriate and included separately in Appendix C.

DWR's Urban Water Management Plan Checklist, as provided in the DWR Guidebook, has been completed by West Yost to demonstrate the plan's compliance with applicable requirements. A copy of the completed checklist is included in Appendix D.

CHAPTER 2
Plan Preparation

This chapter describes the preparation of Zone 7's 2020 UWMP and WSCP, including the basis for the preparation of the plan, individual or regional planning, units of measure, and plan coordination and outreach. Zone 7's reporting is based on the calendar year.

2.1 BASIS FOR PREPARING A PLAN

The Act requires every "urban water supplier" to prepare and adopt a UWMP, to periodically review its UWMP at least once every five years and make any amendments or changes which are indicated by the review. An "urban water supplier" is defined as a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually (AFY).

Zone 7 manages Water System CA0110010 and is primarily a wholesaler. While Zone 7 directly serves 13 retail municipal connections, including commercial and institutional water users, the total population served through direct connections is less than 3,000, and the five-year (2016-2020) average retail water demand is approximately 800 AFY. As a result, Zone 7 is considered primarily an "urban wholesale water supplier" for the purposes of the 2020 UWMP and only needs to address wholesaler requirements. This 2020 UWMP updates the 2015 UWMP and Zone 7's WSCP. Zone 7's last UWMP, the 2015 UWMP, was adopted by the Zone 7 Board of Directors (Zone 7 Board) on March 16, 2016.

Note that the California Environmental Quality Act (CEQA) does not apply to the preparation and adoption of a UWMP as stated in CWC 10652, and therefore did not require the public process associated with CEQA.

2.2 REGIONAL PLANNING

As described in Section 2.3, Zone 7 has prepared this 2020 UWMP on an individual reporting basis, not part of a regional planning process. However, Zone 7 regularly coordinates with its water retailer customers—DSRSD, Pleasanton, Livermore, and Cal Water—to ensure that a safe and reliable water supply is delivered to its existing customers and that plans for serving future customers are implemented as efficiently as possible. Zone 7 routinely coordinates with its retailers on water supply and water conservation matters, including preparation of Zone 7's 2019 WSE Update, 2020 UWMP, and WSCP update. Zone 7 also assisted the water retailer agencies in the preparation of their individual UWMPs.

2.3 INDIVIDUAL OR REGIONAL PLANNING AND COMPLIANCE

This 2020 UWMP has been prepared on an individual reporting basis covering only Zone 7's service area, as noted in Table 2-1. Zone 7 does not participate in a regional alliance, and it has not prepared a Regional Urban Water Management Plan (RUWMP). As described in Section 2.5, Zone 7 has notified and coordinated planning and compliance with appropriate regional agencies and constituents, including its retailers.

Table 2-1. Plan Identification (DWR Table 2-2)

Select Only One	Type of Plan		Name of RUWMP or Regional Alliance *if applicable* (select from drop down list)
☑	**Individual UWMP**		
	☐	Water Supplier is also a member of a RUWMP	
	☐	Water Supplier is also a member of a Regional Alliance	
☐	**Regional Urban Water Management Plan (RUWMP)**		

2.4 FISCAL OR CALENDAR YEAR AND UNITS OF MEASURE

Zone 7 is a water wholesaler.

Zone 7's 2020 UWMP has been prepared on a calendar year basis, with the calendar year starting on January 1 and ending on December 31 of each year. Water use and planning data for the entire calendar year of 2020 have been included.

The water volumes in this 2020 UWMP are reported in units of acre-feet (AF).

Zone 7's reporting methods for this 2020 UWMP are summarized in Table 2-2.

Table 2-2. Agency Identification (DWR Table 2-3)

Type of Supplier (select one or both)	
☑	Supplier is a wholesaler
☐	Supplier is a retailer
Fiscal or Calendar Year (select one)	
☑	UWMP Tables are in calendar years
☐	UWMP Tables are in fiscal years
Units of measure used in UWMP * (select from drop down)	
Unit	AF
**** Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*	

2.5 COORDINATION AND OUTREACH

This section discusses Zone 7's inter-agency coordination and coordination with the general public. The Act requires Zone 7 to coordinate the preparation of its UWMP and updates to its WSCP both internally with all Zone 7 departments and externally with other appropriate agencies, including other water suppliers that share a common source, water management agencies, and relevant public agencies. These agencies, as well as the public, participated in the coordination and preparation of this 2020 UWMP as summarized below.

2.5.1 Wholesale and Retail Coordination

Zone 7 provides wholesale water service to four customers: Cal Water, Livermore, Pleasanton, and DSRSD. In accordance with CWC Section 10631, Zone 7 provided supply information to the agencies receiving wholesale water supplies (i.e., retailers) shown in Table 2-3. As part of the Regional Demand Study, Zone 7 developed population and water demand projections in coordination with its retailers.

Table 2-3. Water Supplier Information Exchange (DWR Table 2-4 Wholesale)

☐	Supplier has informed more than 10 other water suppliers of water supplies available in accordance with Water Code Section 10631. Completion of the table below is optional. If not completed, include a list of the water suppliers that were informed.
	Provide page number for location of the list.
☑	Supplier has informed 10 or fewer other water suppliers of water supplies available in accordance with Water Code Section 10631. **Complete the table below.**
Water Supplier Name	
California Water Service Company	
City of Livermore	
City of Pleasanton	
Dublin San Ramon Services District	

2.5.2 Coordination with Other Agencies and the Community

As a contractor of the SWP, Zone 7 is heavily engaged with DWR, which owns, operates, and maintains the SWP. Through membership in the State Water Contractors, Zone 7 also regularly interacts with other water agencies receiving water from the SWP and serving a total of over 25 million people across the State. The State and Federal Contractors Water Agency is a Joint Powers Authority that brings together SWP contractors like Zone 7 and Central Valley Project (CVP) contractors to work towards assuring sufficient and reliable export water supplies from the SWP and CVP.

Through membership and active participation in the California Urban Water Agencies (CUWA), Zone 7 regularly confers with other urban water agencies across California on statewide water issues such as drought management, water supply reliability challenges, and water quality management. Zone 7 is also an active member of the Association of California Water Agencies (ACWA), the largest statewide coalition of public water agencies in the country representing water suppliers responsible for 90 percent of the water delivered to cities, farms, and businesses in California.

At the regional level, Zone 7 is actively engaged in the Bay Area Water Agencies Coalition (BAWAC), which is comprised of water agencies in Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties. BAWAC is committed to advancing water conservation in the region as part of the Bay Area Integrated Regional Water Management Plan. Zone 7 is also a member of the Bay Area Regional Reliability Partnership, which brings together nine Bay Area water agencies aiming to improve regional water supply reliability by working cooperatively on a mutually beneficial and regionally focused basis.

Zone 7 also actively encourages local community participation in water management activities and specific water-related projects. Zone 7's public participation program includes both active and passive means of obtaining input from the community, such as mailings, public meetings, and web-based communication. Zone 7's website describes on-going projects and posts announcements of planned rate increases to fund these water projects. Water supply planning documents are posted on Zone 7's website, along with monthly water inventories to inform the public of water supply conditions over the year.

As part of the 2020 UWMP and WSCP update, Zone 7 conducted public meetings including a Water Resources Committee meeting on February 23, 2021, a Zone 7 Board workshop on April 1, 2021, and a public hearing on May 19, 2021. A public comment period was conducted before the hearing from May 3 to May 19, 2021. Public noticing, pursuant to Section 6066 of the Government Code, was conducted prior to commencement of a public comment period. Public hearing notices are included in Appendix E of this plan. During the public comment period, the Draft 2020 UWMP, which includes an updated WSCP, was made available on Zone 7's website and at its administrative office.

As noted above, Zone 7 coordinated the preparation of this 2020 UWMP and WSCP with its retailers. In addition, Zone 7 sent a notice of preparation to the following agencies:

- California Water Service
- City of Livermore
- City of Pleasanton
- Dublin San Ramon Services District (DSRSD)
- Department of Water Resources
- Alameda County
- Contra Costa County
- City of Dublin
- City of San Ramon
- Contra Costa Water District (CCWD)
- East Bay Municipal Utility District (EBMUD)
- Livermore-Amador Valley Water Management Agency (LAVWMA)
- DSRSD-EBMUD Recycled Water Authority (DERWA)

The public hearing provided an opportunity for all Zone 7 water users and the general public to become familiar with the UWMP and ask questions about Zone 7's water supply and its plans for continuing to provide a reliable, safe, high-quality water supply.

2.5.3 Notice to Cities and Counties

CWC Section 10621 (b) requires agencies to notify the cities and counties to which they serve water at least 60 days in advance of the public hearing that the plan is being updated and reviewed. On November 24, 2020, a notice of preparation was sent to the cities and counties and other stakeholders, to inform them of the UWMP and WSCP update process and schedule, and to solicit input for the 2020 UWMP and updated WSCP. A second notice was issued on March 10, 2021 that included a notice of the amendment of the 2015 UWMP to incorporate demonstration of consistency with Delta Plan Policy WR P1. A copy of these notifications are included in Appendix E. The notifications to cities and counties, the public hearing notifications, and the public hearing and adoption are discussed in Chapter 10.

CHAPTER 3
System Description

This chapter describes Zone 7's history as a water agency, as well as its water system facilities and service area. In addition, this chapter discusses the climate, population, demographics, and land use within Zone 7's service area.

3.1 GENERAL DESCRIPTION

Of the ten active zones of the Alameda County Flood Control and Water Conservation District (District), Zone 7 is the only one that provides water services in addition to flood protection. Zone 7 manages water resources and provides wholesale treated potable water supply to water retailers in the Livermore-Amador Valley, serves treated water directly to a small number of direct retail customers, and serves untreated water to agriculture. This section provides an overview of Zone 7 and its water system.

3.1.1 Zone 7 History

The District was created in 1949 by the California State Legislature through passage of the Alameda County Flood Control and Water Conservation District Act to control flood and storm waters and to conserve water for beneficial uses. The District is also vested with the power to store water in surface or underground reservoirs within or outside of the District for the common benefit of the District; conserve and reclaim water for present and future use within the District; appropriate and acquire water and water rights; and import water into the District.

In 1957, residents of Livermore-Amador Valley voted to create a separate Zone 7 Water Agency in response to groundwater overdraft, poor drainage and flood hazards, and uncertainty over future water supplies. Zone 7 is governed by a locally elected, seven-member Board of Directors (Zone 7 Board). Each director is elected at-large by residents within Zone 7's service area to a four-year term. The Zone 7 Board sets policy and provides direction to Zone 7 management and staff.

Zone 7's key water resource management responsibilities include:

- Serving as the contractor with DWR for the State Water Project
- Managing the local water right on Arroyo Valle
- Procuring other water supplies as necessary to meet demands
- Providing wholesale treated water supply
- Providing untreated water for agriculture
- Sustainably managing the Livermore Valley Groundwater Basin
- Operating and maintaining water treatment and transmission systems
- Managing regional stormwater for public safety and protection of property

Under Zone 7's Groundwater Management Program, Zone 7 administers oversight of the local groundwater basin—the Livermore Valley Groundwater Basin—and prevents groundwater overdraft. Furthermore, the Sustainable Groundwater Management Act of 2014 (SGMA) designates Zone 7 as the exclusive local agency to become the Groundwater Sustainability Agency (GSA) for the groundwater basins within its statutory boundaries. In January 2017, Zone 7 formally accepted its role of GSA for the Livermore Valley Groundwater Basin.

3.1.2 Zone 7 Retailers

Zone 7 is the water wholesaler for the Livermore-Amador Valley, also commonly referred to as the Tri-Valley, serving Livermore, Pleasanton, the City of Dublin (Dublin), and part of the City of San Ramon (San Ramon). Dougherty Valley in San Ramon, which is located in Contra Costa County, is served via an out-of-service-area agreement with DSRSD. Zone 7 supplies treated water to four retail water supply agencies (retailers) in the Tri-Valley: Cal Water, DSRSD, Livermore, and Pleasanton.

These retailers deliver water for M&I purposes within their individual service areas. Zone 7 works closely with its retailers on Tri-Valley water issues.

Throughout this UWMP, the terms "potable," "treated," and "M&I" are used interchangeably to describe Zone 7's water supply to its urban water retailers.

3.1.3 Zone 7 Water System Facilities

As shown on Figure 3-1, Zone 7 has a robust water supply system consisting of an aqueduct, surface water treatment plants, wells, a groundwater demineralization plant, and a storage and transmission system.

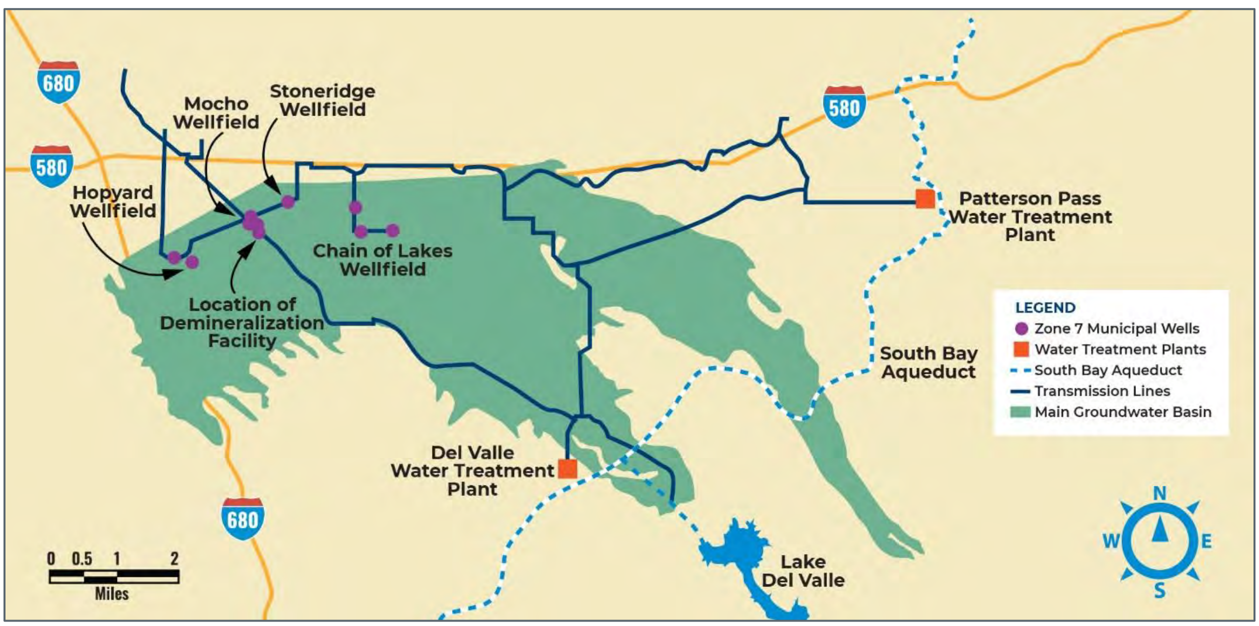

Figure 3-1. Zone 7 Facilities

3.1.3.1 South Bay Aqueduct

Zone 7 imports raw surface water from the SWP through the South Bay Aqueduct (SBA) for direct irrigation use by agricultural users; for treatment and transmission to retailers and direct retail customers; and for groundwater recharge. The SBA, which is owned, operated, and maintained by DWR as part of the SWP system, starts from Bethany Reservoir near the City of Tracy in the northeastern corner of Zone 7's service area and leaves the service area southwest of San Antonio Reservoir, ultimately terminating in the City of San Jose. The SBA serves the Alameda County Water District (ACWD) and Valley Water (VW, formerly known as the Santa Clara Valley Water District), in addition to Zone 7 (collectively, SBA contractors). The SBA delivers SWP water pumped from the Delta and water released from Lake Del Valle, which is part of the SWP system. Other water supplies procured by Zone 7 (e.g., via water transfer agreements) are also delivered through the Delta and SBA system. The SBA also conveys Delta water to Lake Del Valle for storage and later use by SBA contractors.

3.1.3.2 Surface Water Treatment Plants

Zone 7 operates two water treatment plants: the Del Valle Water Treatment Plant (DVWTP) and the Patterson Pass Water Treatment Plant (PPWTP).

Built in the 1970s, the DVWTP is located along the SBA, just south of Lake Del Valle, and has an average capacity of 36 million gallons per day (MGD), although it is permitted to operate up to 40.9 MGD. The DVWTP can receive water either directly from the SBA or from Lake Del Valle. As shown on Figure 3-2, the treatment processes include newly installed ozone disinfection, along with coagulation, flocculation, clarification, multi-media biofiltration, and chlorine for backup/supplemental disinfection. In addition, chloramine is added to maintain a disinfectant residual in the transmission system.

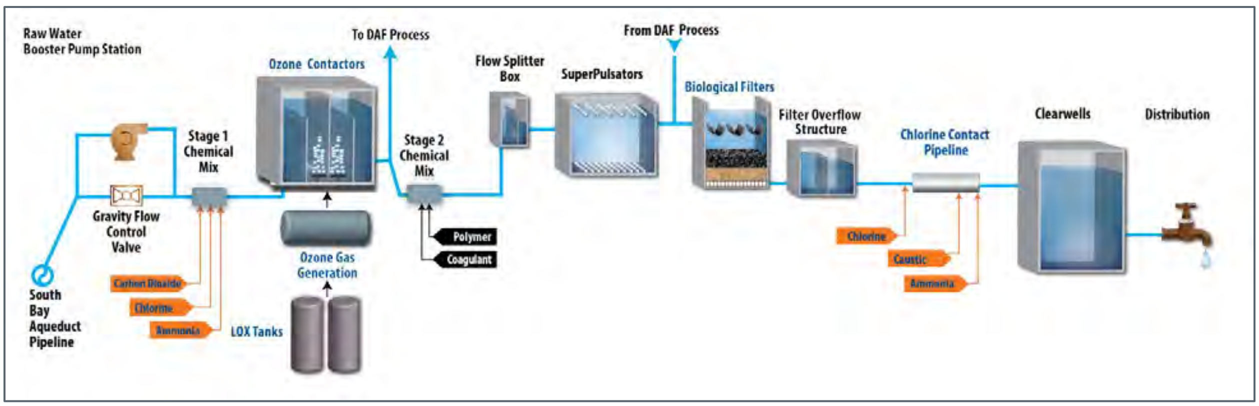

Figure 3-2. DVWTP Treatment Processes

Constructed in the early 1960s, the PPWTP is also strategically located along the SBA, just south of Interstate 580 (I-580), and has a production capacity of 12 MGD. A pilot parallel ultrafiltration plant at the same site is no longer in use. Zone 7 is currently upgrading the PPWTP, including increasing production capacity to 24 MGD, adding new ozonation facilities, and installing a new 5 million gallon (MG) treated water storage tank. These improvements, along with replacement and upgrade of aging plant components, are expected to be completed by spring 2022. Because the PPWTP is upstream of Lake Del Valle, it is not able to physically receive water from this water supply source. There is a 30-MG raw water reservoir onsite, operated by DWR. Once upgrades are complete, treatment processes will include ozonation, coagulation, flocculation, clarification, biological filtration, and chlorine for backup/supplemental disinfection. Similar to the DVWTP, chloramine is used to maintain a disinfectant residual in the transmission system.

3.1.3.3 Wells

Zone 7 owns and operates ten municipal supply wells located in four wellfields. The Hopyard, Mocho, Stoneridge, and Chain of Lakes wellfields are situated in the west side of the service area. Their rated capacities are summarized in Table 3-1 below. The total combined pumping capacity of all wells is approximately 39.0 MGD. Of the total pumping capacity, 10.8 MGD is intended primarily for use in emergency and drought conditions. Therefore, total groundwater pumping capacity under normal operating conditions is approximately 28.2 MGD. Zone 7 uses the wells to supplement the DVWTP and

PPWTP during daily peaks in demands, during the dry season to meet higher average monthly demands, and during emergencies or outage(s) of the DVWTP and/or PPWTP.

Table 3-1. Zone 7 Groundwater Well Capacities

Wellfield	Facility	Rated Capacity	
		gpm	MGD
Hopyard	Hopyard 6	3,817	5.5
	Hopyard 9	1,110	1.6
	Hopyard Subtotal	**4,927**	**7.1**
Mocho 1 and 2	Mocho 1[a]	0	0
	Mocho 2	2,221	3.2
	Mocho 1 and 2 Subtotal	**2,221**	**3.2**
Mocho 3 and 4[b]	Mocho 3	4,164	6.0
	Mocho 4	3,678	5.3
	Mocho 3 and 4 Subtotal	**7,842**	**11.3**
Stoneridge	--	4,580	6.6
Chain of Lakes	Chain of Lakes 1	2,498	3.6
	Chain of Lakes 2	3,470	5.0
	Chain of Lakes 5	1,527	2.2
	Chain of Lakes Subtotal	**7,495**	**10.8**
	Total	**27,066**	**39.0**

(a) Mocho 1 will be on standby for the foreseeable future.
(b) When the demineralization facility is operating, water production is lower due to brine concentrate losses.

3.1.3.4 Mocho Groundwater Demineralization Plant

A reverse osmosis membrane-based demineralization facility (Mocho Groundwater Demineralization Plant or MGDP) was installed in 2009 at the Mocho 3 and 4 wellfield to improve delivered water quality (lower Total Dissolved Solids [TDS] and hardness) and mitigate salt build-up in the groundwater basin via export of brine from the MGDP. This facility can produce up to 6.1 MGD of demineralized water. Under normal operation, 20 percent of the influent to the MGDP is lost through brine disposal.

3.1.3.5 Storage and Transmission System

Zone 7’s treated water transmission system is shown on Figure 3-1. It has four treated water storage reservoirs within the system: Dougherty Reservoir (joint use with DSRSD), DVWTP Clearwells 1 and 2, and PPWTP Clearwell. These four facilities provide a total storage volume of 13.5 MG. The new clearwell under construction at the PPWTP will add 5 MG of storage to the system.

Zone 7’s transmission system consists of approximately 40 miles of pipeline ranging from 12 to 52 inches in diameter. Elevations across the transmission system range from 520 to 680 feet above mean sea level (msl) on the eastern side of the service area, to approximately 330 feet above msl on the western side of the service area.

3.2 SERVICE AREA BOUNDARY

Zone 7's water service area is shown on Figure 3-3. It is located about 40 miles southeast of San Francisco and encompasses approximately 425 square miles of the eastern portion of Alameda County, including the Livermore-Amador Valley, Sunol Valley, and portions of the Diablo Range. Zone 7 also serves a portion of Contra Costa County (Dougherty Valley in San Ramon) through an out-of-service-area agreement with DSRSD.

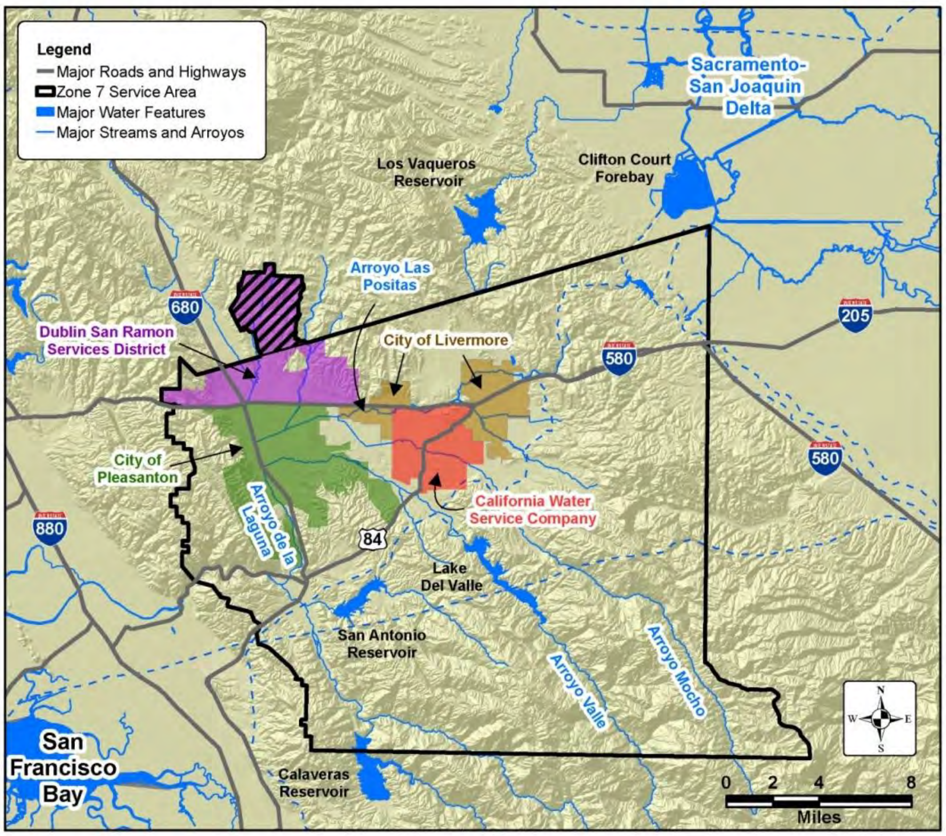

Figure 3-3. Zone 7 Service Area Boundary Map

3.3 SERVICE AREA CLIMATE

Climate in Zone 7's service area is characteristically Mediterranean, with hot, dry summers and cool, moist winters. This section discusses historical climate in Zone 7's water service area (using Pleasanton as an example) and the potential effects of climate change.

3.3.1 Historical Climate

The historical climate characteristics affecting water management in the Zone 7's water service area, including average evapotranspiration (ET_o), rainfall, and temperature, are shown in Table 3-2. The average annual precipitation is approximately 17.2 inches, while the total evapotranspiration is approximately 51.5 inches. Average monthly temperatures vary from 47 to 70 degrees Fahrenheit throughout the year.

Note that the Livermore portion of the service area tends to have warmer temperatures, with average high temperatures nearly reaching 90 degrees Fahrenheit during the summer.

Table 3-2. Monthly Average Climate Data Summary

Month	Standard Monthly Average ET_o[a], inches	Average Total Rainfall[b], inches	Average Temperature[b], degrees Fahrenheit
January	1.51	2.83	47.4
February	2.17	2.70	50.6
March	3.63	2.95	53.8
April	4.94	1.47	56.9
May	6.16	0.57	61.1
June	7.10	0.23	67.0
July	7.53	0.09	70.2
August	6.61	0.09	69.3
September	4.98	0.12	67.2
October	3.50	1.09	61.0
November	1.93	1.66	52.6
December	1.41	3.36	47.1
Total	**51.5**	**17.2**	**--**

(a) Source: California Irrigation Management Information System (CIMIS) data for Station #191: Pleasanton (downloaded November 11, 2020).
(b) Source: CIMIS data for Station #191: Pleasanton (data from October 2004 through October 2020).

3.3.2 Potential Effects of Climate Change

California Water Code now requires water suppliers to account for the impacts of climate change on water supplies and supply reliability. A discussion of the effects of climate change on water demands, supplies, and reliability can be found in Chapters 4, 6, and 7 of this UWMP. This section summarizes those discussions.

In general, climate change is expected to increase water demand for irrigation and the year-to-year variability of demands. This is the result of increased temperatures (which increases evapotranspiration) and more variability in precipitation (which impacts supply availability and reliability). Also, natural disasters such as wildfires, droughts, and floods are expected to increase in both frequency and intensity.

Responding to climate change generally takes two forms: mitigation and adaptation. Mitigation means reducing the contribution to the causes of climate change (e.g., greenhouse gas emissions). Adaptation is the process of responding to the effects of climate change by modifying systems and behaviors to function in a warmer and more variable climate.

In the water sector, climate change mitigation is generally achieved by reducing energy use, increasing energy efficiency, and/or replacing fossil fuel-based energy sources with renewable energy sources. Zone 7 has a solar facility at the DVWTP and continues to explore ways to increase the renewable energy portion of its energy portfolio. Zone 7 obtains energy from various sources that are already about 90 percent carbon-free and 70 percent renewable.

Because water requires energy to move, treat, use, and discharge, water conservation results in energy conservation. Adaptation initiatives include alternative water supply/storage options that Zone 7 is considering (further discussed in Chapter 6). These options bolster Zone 7's ability to adapt to climate change through additional storage, providing a buffer against more variable hydrology (Sites Reservoir and Los Vaqueros Reservoir Expansion), and potable reuse and desalination, which are not as vulnerable to hydrologic variations. Sites Reservoir performs well under the greater rainfall expected under climate change. SWP infrastructure improvements are also key adaptation tools: the Delta Conveyance Project will address higher sea levels and greater salinity in the Delta and the greater vulnerability of the Delta levees.

3.4 SERVICE AREA POPULATION AND DEMOGRAPHICS

3.4.1 Service Area Population

The current population within Zone 7's service area is estimated at 266,000. Current and projected populations within Zone 7's service area are presented in Table 3-3 and are based on Zone 7's Regional Demand Study. By 2045, the population in Zone 7's service area is projected to grow by approximately 20 percent to 323,000.

Table 3-3. Population – Current and Projected (DWR Table 3-1 Wholesale)

Population Served	2020	2025	2030	2035	2040	2045*(opt)*
	266,000	284,000	299,000	312,000	323,000	323,000
NOTES: Current and projected populations are based on the Regional Demand Study and are rounded to the nearest thousand people.						

3.4.2 Other Social, Economic, and Demographic Factors

The California Water Code now requires UWMPs to include service area socioeconomic information as part of the system description. However, differences in household water use across sociodemographic groups in Zone 7's service area have not been studied, nor does Zone 7 differentiate water management by sociodemographic factors. To comply with the new regulation, the following social, economic, and demographic information from the U.S. Census Bureau[3] is provided. Information is for Livermore-Pleasanton Census County Division during the five-year period from 2014 to 2018.

- The average number of people per household was 2.9
- The median household income was $135,132
- The owner-occupied housing unit rate was 70 percent, with a median home value of $815,700
- The median gross rent was $2,214 per month

[3] United States Census Bureau. American Community Survey, 2014-2018 ACS 5-Year Data Profile for Livermore-Pleasanton Census County Division

- The median age was 39.6 years
- Of persons 25 years or older, 94.4 percent had earned at least a high school diploma or equivalent, and 54.6 percent had earned a bachelor's degree or higher
- By race/ethnicity, 51.9 percent of people were White, 2.3 percent were Black, 0.2 percent were American Indian or Alaska Native, 27 percent were Asian, 0.4 percent were Hawaiian Native or Pacific Islander, 4.2 percent were two or more races, and 14 percent were Hispanic or Latino
- 26.1 percent of residents were foreign born

3.5 LAND USES WITHIN SERVICE AREA

This section describes the current and projected land uses for each municipality within Zone 7's service area. Land use information is based on each city's adopted General Plan and specific plans, and the Regional Demand Study, which used the latest information on planned development that was provided by the retailers and City planners to develop demand projections. The final subsection reviews long-range land use planning for the Tri-Valley region overall.

3.5.1 City of Livermore

Existing land use within Livermore is predominantly single-family residential. Multi-family residential parcels are found primarily on major streets along with retail services. Office and retail parcels comprise Livermore's downtown, while industrial uses are concentrated on the eastern side of Livermore near I-580. The remainder of Livermore's existing land uses consist of public, institutional, parks/recreation/open space, agricultural, airport, and undeveloped land.

The Isabel Neighborhood Specific Plan (INSP) is a significant component of Livermore's projected land use. Currently under review, the INSP guides development for approximately 1,138 acres surrounding the previously proposed Isabel Bay Area Rapid Transit (BART) station in Livermore's western water service area. Land uses within the INSP include business park; service, neighborhood, and large office commercial; educational/institutional; open space; and various residential designations ranging in density from attached dwellings and low-rise garden apartments to multi-story condominiums.

3.5.2 City of Dublin

Land use planning for Dublin consists of three areas: the Primary Planning Area, the Eastern Extended Planning Area, and the Western Extended Planning Area. Most of the Primary Planning Area has been developed, with primary land uses including single-family residential, business park/industrial, open space, and parks. One exception within the Primary Planning Area is Downtown Dublin, which is being redeveloped to focus on higher density, mixed-use projects following the opening of the West Dublin BART station.

Development opportunities are also limited in the Western Extended Planning Area, where approximately 85 percent of the Western Extended Planning Area's 3,132 acres lies outside Dublin's Urban Limit Line. The Urban Limit Line protects natural resources in Dublin's western hills, and Dublin will not extend services or facilities (e.g., utilities or roads) beyond the Urban Limit Line. Most of the Western Extended Planning Area acreage within the Urban Limit Line has been designated open space, with the remainder reserved for low density residential development.

A significant portion of future development within Dublin will occur within the Eastern Extended Planning Area. This is formalized in the Eastern Dublin Specific Plan (EDSP), which provides a framework for growth and development of approximately 3,300 acres east of the Camp Parks Reserve Forces Training Area. While residential designations within the EDSP area range from rural residential/agriculture to high density multi-family, approximately 55 percent of new dwelling units will be single-family residential. Non-residential land uses within the EDSP area include retail, service, office, governmental, research and development, and light industrial.

3.5.3 City of San Ramon

The following land use discussion focuses on the portions of San Ramon that DSRSD serves. This includes the southern and Dougherty Valley areas of San Ramon, to which DSRSD provides wastewater and potable/recycled water services, respectively. Note that Zone 7 only serves as a wholesale treated water provider to the Dougherty Valley portion.

San Ramon is divided into nine planning subareas, four of which overlap DSRSD's wastewater and potable water service areas: Westside, Southern San Ramon, Dougherty Hills, and Dougherty Valley. The Westside subarea is mostly unincorporated open hillsides, though an area along San Ramon Valley Boulevard is designated primarily for residential development and a neighborhood shopping center. In contrast, the Southern San Ramon and Dougherty Hills subareas are suburban communities with primarily residential land uses. Development of Dougherty Valley is detailed in the Dougherty Valley Specific Plan, which envisioned residential neighborhood clusters served by their own public facilities, a mixed-use activity center (Village Center), and a backdrop of broad open space. The development of the Dougherty Valley area is substantially complete.

3.5.4 City of Pleasanton

Existing land use within Pleasanton generally consists of distinct residential neighborhoods typically separated from non-residential land uses to reduce the potential incompatibility of non-residential and residential uses. Pleasanton was predominantly a residential community until 1980, when industrial, commercial, and office development increased. This non-residential development includes the Stoneridge Mall, seven major business parks, five major hotels, and a variety of service centers. Abundant open space surrounds the developed areas of Pleasanton.

Pleasanton's current General Plan[4] encourages mixed land uses and transit-oriented development (TOD), particularly near the BART stations, for future growth. Mixed use development combines office, commercial, hotel, institutional, and residential land uses on a single site or adjacent, interrelated sites. TOD provides walkable, mixed use communities designed around transit stations. Mixed use developments (including TODs) would provide the opportunity for people to use alternative modes of transportation to automobiles since residential and non-residential land uses would be combined or integrated on a single or nearby site.

To identify future growth in Pleasanton's service area, Zone 7's Regional Demand Study obtained a list of known proposed development projects from Pleasanton's Community Development Department. These proposed projects include mixed use, single-family residential, and multi-family residential developments.

[4] City of Pleasanton, 2005. Pleasanton General Plan 2005-2025.

3.5.5 Long-Range Land Use Planning

This section discusses long-range land use planning that may affect water management. Long-range planning includes years beyond the planning horizon of this UWMP but should be noted for consideration in future UWMP updates.

The Association of Bay Area Governments (ABAG) and Metropolitan Transportation Commission (MTC) is preparing Plan Bay Area 2050, which provides long-range plans to guide the growth of the nine-county region. Plan Bay Area 2050 is expected to be completed in 2021 and integrates strategies for transportation, housing, the environment, and the economy. ABAG published the *Draft RHNA Methodology Release* in December 2020 to support Plan Bay Area 2050; this methodology has been used to develop "illustrative" RHNA allocations for each city and county in the region. Allocations will be finalized in 2021 through the remaining steps of the RHNA process. The proposed housing unit allocations for the cities in Zone 7's service area are 3,719 for Dublin, 4,449 for Livermore, 5,965 for Pleasanton, and 5,111 for San Ramon.[5]

ABAG is expected to approve a Final Methodology and issue Draft Allocations in spring 2021. Issuing the Draft Allocations will be followed by an appeal period, with ABAG issuing Final Allocations by the end of 2021. Each of the cities in Zone 7's service area will need to update the Housing Element of their respective general plans. Although the region's RHNA allocation may not affect Zone 7's projected long-term water demand projections, it may accelerate the rate at which demand increases in the near term. Zone 7 will incorporate those updates in a future UWMP.

[5] Association of Bay Area Governments, December 2020. Release of ABAG Draft RHNA Methodology and Final Subregional Shares, Appendix 3.

CHAPTER 4
Water Use Characterization

This chapter describes and quantifies Zone 7's past, current, and projected potable water demands. Water demand projections are based on the projected growth within the Zone 7's service area. Zone 7's Regional Demand Study was completed concurrently with the preparation of this UWMP and was used to inform this chapter.

4.1 NON-POTABLE VERSUS POTABLE WATER USE

Potable water is water that is safe to drink and typically has had various levels of treatment and disinfection. Non-potable water is not safe to drink and includes both recycled water and raw water. Zone 7 provides wholesale potable water to its retailers for M&I purposes within their service areas. Six direct retail customers, including commercial and institutional water users, are also served by Zone 7; they represent a small percentage of Zone 7's overall water demand.

In addition to treated water, Zone 7 supplies raw or untreated water for agricultural purposes to approximately 3,500 acres, primarily consisting of vineyards in the southern portion of Livermore Valley. Zone 7 does not produce nor distribute recycled water directly, however three retailers—DSRSD, Livermore, and Pleasanton—provide recycled water (mainly for landscape irrigation) within their respective service areas.

4.2 WATER USE BY SECTOR

Zone 7's service area includes a diverse, vibrant, and rapidly growing community that supports a population of approximately 266,000 people and a myriad of vital and dynamic commercial, agricultural, and industrial enterprises. The eastern reaches of Zone 7's service area include oil wells and acres of energy-generating windmills, while other areas include large employers such as Kaiser Permanente, Safeway, Oracle, Providian Financial, SAP, and Lawrence Livermore National Laboratory. The area also supports several award-winning wineries. Industrial water use is not a major component of water use in the area, but industrial users do exist, such as The Clorox Company (chemical company), Roche Molecular Systems (medical diagnostic products), and A-1 Enterprise (waste hauler).

For any given year, surplus water is used in the following ways: recharge of the local groundwater basin, storage in groundwater banks in Kern County (Semitropic Water Storage District and Cawelo Water District), storage in the SWP system as "carryover" in San Luis Reservoir, and storage of local water in Lake Del Valle.

4.2.1 Past and Current Water Use

Zone 7's actual historical and current (i.e., 2020 calendar year) potable water demands are reported in Table 4-1 and Table 4-2, respectively.

Table 4-1. Historical Water Demands

Water Use Sector	Water Demands[a], AFY		
	2004	2009	2015
Retailer Demand	42,371	38,083	24,300
Untreated Water Demand	3,530	4,920	5,600
Direct Retail Demand	775	233	300
Losses	523	1,900	800
Total	**47,199**	**45,136**	**31,000**

(a) As reported in Zone 7's 2005, 2010, and 2015 UWMPs. Zone 7's 2005 and 2010 UWMPs used 2004 and 2009, respectively, as the "current" year.

Table 4-2. Demands for Potable and Non-Potable Water – Actual (DWR Table 4-1 Wholesale)

Use Type	2020 Actual		
Drop down list May select each use multiple times These are the only use types that will be recognized by the WUE data online submittal tool	Additional Description (as needed)	Level of Treatment When Delivered Drop down list	Volume*
Sales to other agencies	Retailer Demand	Drinking Water	38,020
Agricultural irrigation	Untreated Water Demand	Raw Water	5,810
Retail demand for use by suppliers that are primarily wholesalers with a small volume of retail sales	Direct Retail Demand	Drinking Water	730
Losses		Drinking Water	180
		TOTAL	44,740

**** Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF.

4.2.2 Projected Water Use

This section presents water demand projections for Zone 7's service area on a 25-year planning horizon and, for the DRA, a characteristic five-year basis.

Zone 7 works closely with its retailers to develop the demand projection under "Sales to other agencies," which represents most of Zone 7's demand. The projected water demands provided are based on the Regional Demand Study, which Zone 7 prepared in coordination with its retailers. Zone 7 also develops projections for its direct retail customers, untreated water (agricultural) customers, and losses (i.e., unaccounted-for water) in its water supply system.

The primary goal of the Regional Demand Study was to develop a regional, land-use based water demand forecasting model that can be used for planning efforts, including this UWMP. Historically, the retailers have conducted independent demand forecasting, with Zone 7 using those forecasts to develop a regional forecast (after some adjustment). The Regional Demand Study developed a consistent method for estimating demands across the Tri-Valley region, while still considering the unique characteristics of each of Zone 7's retailers, including demographic data, historical water use, demand hardening patterns, and future projections for land use and population.

The Regional Demand Study forecasts demands by parcel, allowing Zone 7 and the retailers to analyze how current and near future developments may trigger changes in demand forecasts, as well as how changes in land use or unique demand management approaches may change the outcomes. General Plans, Specific Plans, and other current information on planned development (provided by the retailers and city planners) were incorporated as much as possible in the Regional Demand Study. The focus of the Regional Demand Study was developing an estimate of the demand at buildout, which is expected to occur around 2040. Demands for 2045 were assumed to be the same as in 2040. Note that the Regional Demand Study evaluated multiple scenarios; the Baseline Scenario was considered the most appropriate buildout demand scenario to use for planning purposes.

The Regional Demand Study provided a demand curve from present to buildout by interpolating data between 2019 and buildout. For this plan, Zone 7 is using a demand forecast that holds 2021 demands at 2020 levels, reflecting expected conservation in 2021 as a result of dry conditions, and incorporates the retailers' delivery requests for the years 2022 to 2025. Retailers submit their five-year delivery requests to Zone 7 annually, and these requests are the basis of Zone 7's contractual obligations. Demands for 2026 to 2039 are then linearly interpolated between the 2025 delivery request and the estimated Baseline Scenario demand at buildout developed in the Regional Demand Study. This method results in higher demands in the near term and is considered a more conservative approach for the period before buildout. Figure 4-1 compares the Regional Demand Study results with the demand forecast used in the 2020 UWMP.

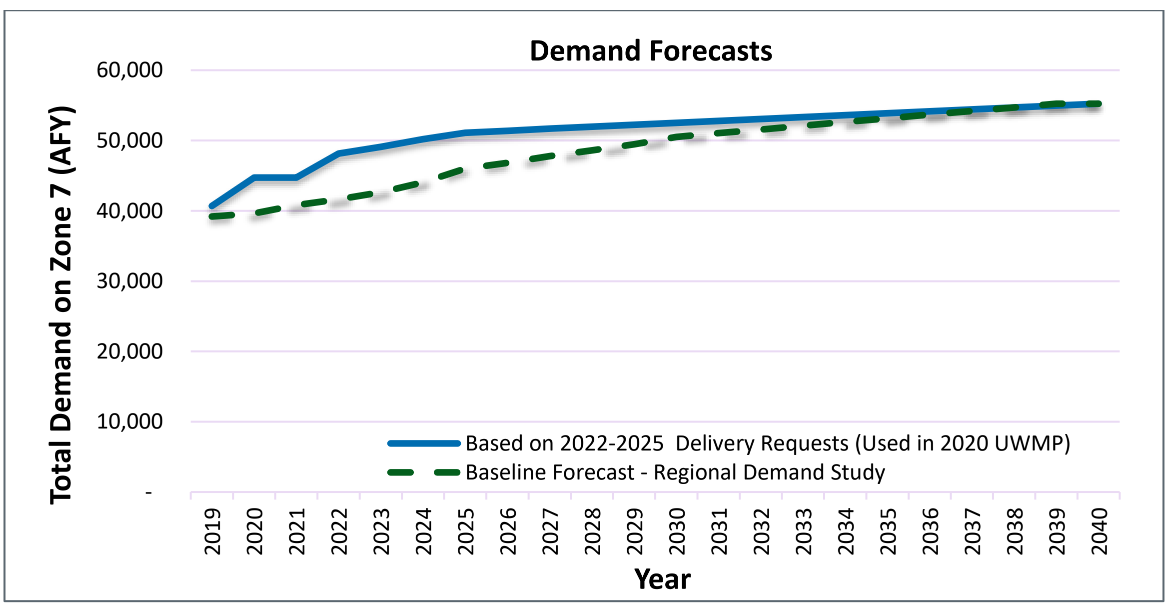

Figure 4-1. Comparison of Demand Forecasts

Uncertainty is inherent with any type of projection; the rate of increase of demands and the ultimate demands will be affected by economic and local development conditions, regulations (e.g., land use ordinances), technology (e.g., water efficiency of future appliances), consumer behavior, climate conditions, and other factors. The 2020 UWMP demand projections are lower than the 2015 UWMP projections due to continuing water conservation post-drought and the expectation that long-term conservation is necessary to meet regulations. Zone 7 will continue to re-evaluate demand trends annually.

4.2.2.1 25-Year Planning Horizon

Table 4-3 reports Zone 7's total projected potable and raw water demands through the year 2045. As noted above, retailer demand projections were developed using general plans and other land use information for each city in Zone 7's service area and adjusted to account for climate change, recycled water use, and expected conservation. Retailer demand projections also reflect the retailers' delivery requests from 2022 to 2025.

Table 4-4 summarizes Zone 7's actual and projected water use. Because Zone 7 does not provide recycled water supply for recycled water use, data is not provided for recycled water demand. Note that the demands shown in Table 4-3 include customer demands from Zone 7, as well as treatment and transmission system losses. Surplus water that goes into storage in the Kern County groundwater banks or additional water stored in the groundwater basin or SWP system in any given year is not reflected in Table 4-3.

Table 4-3. Use for Potable and Raw Water – Projected (DWR Table 4-2 Wholesale)

Use Type	Additional Description (as needed)	Projected Water Use * Report To the Extent that Records are Available				
Drop down list May select each use multiple times These are the only Use Types that will be recognized by the WUEdata online submittal tool.		2025	2030	2035	2040	2045 (opt)
Sales to other agencies	Retailer Demand	43,000	43,200	43,400	43,700	43,700
Agricultural irrigation	Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Retail demand for use by suppliers that are primarily wholesalers with a small volume of retail sales	Direct Retail Demand	800	800	800	800	800
Losses		1,000	1,000	1,300	2,500	2,500
TOTAL		50,300	52,800	53,800	55,300	55,300
***Units of measure (AF, CCF, MG)** *must remain consistent throughout the UWMP as reported in Table 2-3.*						
NOTES: Volumes are in AF.						

Table 4-4. Total Water Use (Potable and Non-Potable) (DWR Table 4-3 Wholesale)

	2020	2025	2030	2035	2040	2045 (opt)
Potable and Raw Water From Tables 4-1W and 4-2W	44,740	50,300	52,800	53,800	55,300	55,300
Recycled Water Demand* From Table 6-4W	0	0	0	0	0	0
TOTAL WATER DEMAND	44,740	50,300	52,800	53,800	55,300	55,300
**Recycled water demand fields will be blank until Table 6-4 is complete.*						
NOTES: Volumes are in AF. Zone 7 does not produce nor distribute recycled water directly. However, several retailers do provide recycled water in Zone 7's service area. Table references refer to DWR table numbers.						

4.2.2.2 Characteristic Five-Year Water Use

Water Code Section 10635(b) requires urban suppliers to include a five-year DRA in their UWMP. A key component of the DRA is estimating demands for the next five years (2021-2025) without drought conditions (i.e., unconstrained demand). Chapter 7 details the DRA, but the five-year demand projections are summarized in Table 4-5 by water use sector. The retailer demand forecast (i.e., sales other agencies) holds 2021 demands at 2020 levels, reflecting expected conservation in 2021 as a result of dry conditions, and incorporates the retailers' delivery requests for the years 2022 to 2025.

Table 4-5. Projected Water Demands for Drought Risk Assessment

Water Use Sector	Water Demands, AFY				
	2021	2022	2023	2024	2025
Sales to other agencies[(a)]	38,000	40,300	41,200	42,100	43,000
Agricultural irrigation	5,500	5,500	5,500	5,500	5,500
Retail demand for use by suppliers that are primarily wholesalers with a small volume of retail sales	700	800	800	800	800
Losses	1,000	1,000	1,000	1,000	1,000
Total[(b)]	**45,200**	**47,600**	**48,500**	**49,400**	**50,300**

(a) Retailer demand projections assume 2020 demand levels for the year 2021 and are based on retailer delivery requests for 2022-2025.
(b) Differences due to rounding.

4.3 DISTRIBUTION SYSTEM WATER LOSSES

As a wholesaler, Zone 7 is not required to perform water loss audits and reporting. However, Zone 7 monitors water loss and conducts audits for reliability planning and water demand projections.

The volume of water loss in Zone 7's transmission system for the previous five calendar years (2016-2020) is provided in Table 4-6. Note that the water loss for 2020 is unusually low, which may be related to the metering at the Del Valle Water Treatment Plant. Zone 7 continues to investigate metering accuracy to support improved management of water losses in the system.

Table 4-6. 12-Month Water Loss Audit Reporting (DWR Table 4-4 Wholesale)

Reporting Period Start Date (mm/yyyy)	Volume of Water Loss [1,2]
01/2016	1,321
01/2017	2,022
01/2018	1,740
01/2019	632
01/2020	180
[1] *Taken from the field "Water Losses" (a combination of apparent losses and real losses) from the AWWA worksheet.* [2] ***Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*	
NOTES: Volumes are in AF.	

The State is currently developing standards for retailer water distribution system water loss. At this time, the standards have not yet been adopted.

4.4 CLIMATE CHANGE CONSIDERATIONS

Climate change may impact Zone 7's future water demand and use patterns. Warmer temperatures are expected to increase irrigation demand and lengthen the growing season. In addition, climate change may increase the frequency and intensity of wildfires, which would increase the fire industry's water demands. Increased water efficiency and conservation, along with expanded use of recycled water by Zone 7's retailers, could mitigate the effects of climate change on water demands.

The Regional Demand Study accounts for climate change by increasing outdoor water demands by 5 percent by 2040. This demand multiplier starts at 0 percent in 2020, increases linearly to 5 percent in 2040, and remains at 5 percent through 2045. As the actual impact of climate change on water use becomes clearer, this value can easily be updated in the model that informs the Regional Demand Study.

A general discussion regarding the potential impacts of climate change on Zone 7's water supplies is provided in Chapter 6.

CHAPTER 5
SB X7-7 Baseline, Targets, and 2020 Compliance

Since Zone 7 is a water wholesaler and serves only a small number of urban water users directly, it is not required to meet any water conservation targets associated with the Water Conservation Act of 2009. However, Zone 7 fully supports its water retailers in achieving their water conservation targets. This chapter details the extent of that support.

5.1 BACKGROUND

In November 2009, SB X7-7 was signed into law as part of a comprehensive water legislation package. The Water Conservation Act addressed both urban and agricultural water conservation. The legislation set a goal of achieving a 20 percent statewide reduction in urban per capita water use by December 31, 2020 (i.e., “20 by 2020”). To meet the urban water use target requirement, each retail supplier was required to determine its baseline water use, as well as its target water use for the year 2020.

Wholesale water suppliers like Zone 7 are not required to establish and meet baselines and targets for daily per capita water use, nor are wholesalers required to complete the SB X7-7 Compliance Forms; however, wholesale agencies are required to provide an assessment of present and proposed programs and policies that will help retail water suppliers achieve their SB X7-7 water use reduction targets. Chapter 9 of this plan details Zone 7’s programs and policies for water conservation and demand management.

5.2 ZONE 7 SUPPORT TO RETAILERS

Zone 7 fully supported the achievement of SB X7-7 water use reduction targets by its retailers. Zone 7 provides regional coordination of conservation programs, which include community workshops and other events, school education programs, and rebate and giveaway programs.

Zone 7’s Conservation Coordinator actively engages in various conservation-oriented regional and state organizations, including the CUWA and the California Water Efficiency Partnership (CalWEP). The Coordinator tracks conservation-related state legislation and local ordinances and integrates them into the Zone 7 conservation program development process to ensure timely compliance and achievement of conservation goals.

Zone 7 also fully supports the current and expanded use of recycled water in the Tri-Valley—resulting in lower consumption of potable water supplies—by updating the Salt Management Plan to address nutrient management and by supporting retailer grant applications for recycled water infrastructure funding. Additionally, Zone 7 has been working closely with its retailers in exploring potential options for expanding recycled water use beyond irrigation applications (i.e., potable reuse), as discussed in Chapter 6 (Section 6.2.9.1.3).

CHAPTER 6
Water Supply Characterization

This chapter describes the Zone 7's water supply portfolio, including purchased or imported water, groundwater, and other surface water supply. This section includes a description of each water source, limitations on each water source, storage, and water exchange opportunities. Zone 7's projects to increase water supply reliability are also discussed in this chapter.

6.1 WATER SUPPLY ANALYSIS OVERVIEW

Zone 7's water supplies are used to meet treated water demands from M&I customers (i.e., water retailers and direct retail customers) and untreated water demands from agricultural customers. Zone 7's existing incoming water supplies—or sources of new water in any given year—are all surface water supplies, delivered to the Tri-Valley via the SBA. These sources of incoming supplies are primarily comprised of SWP water (specifically Table A) and local water from Arroyo Valle captured in Lake Del Valle, as described in Section 6.2. Other potential sources of incoming supplies include surplus SWP water (i.e., Article 21 water), the Yuba Accord (a type of water transfer), and other water transfers.

In years of abundant supply, Zone 7 places water in storage both locally and outside its service area to prepare for future dry years, emergencies, and planned facility outages. Zone 7 typically reserves about 10,000 AF of SWP Table A water to carry over for use in the following year, with water stored in the SWP's San Luis Reservoir. Incoming supplies are also stored in the Livermore Valley Groundwater Basin through artificial recharge when excess surface water is available from the SWP. Finally, surplus water can be transferred to non-local storage in groundwater banks in Kern County (i.e., Semitropic Water Storage District and Cawelo Water District). Unused Arroyo Valle runoff is stored in Lake Del Valle for use during the following year. If needed during dry years, emergencies, or planned facility outages, stored water is released to meet demands.

On average, imported surface water directly provides 80 percent of the water that Zone 7 supplies, locally captured watershed runoff makes up on average 10 percent, and previously-imported supplies stored in the local groundwater basin make up the remaining 10 percent. Groundwater is not considered a separate source of water supply because Zone 7 only extracts groundwater that is recharged from surface water supplies as described in Section 6.2.2. Using the groundwater basin as a local storage reservoir is critical for long-term reliability in the Tri-Valley, as it does not rely on external conveyance facilities. Given the highly variable hydrology in California—and corresponding variable water supplies—the use of storage facilities, both local and outside of the Tri-Valley, is key to Zone 7's strategy for maintaining water supply system reliability.

Zone 7 is currently evaluating a number of local, regional, and statewide projects for improved water supply reliability and to meet additional water demands through buildout in the Tri-Valley as described in Section 6.2.9. A "portfolio" of these projects could provide additional water and/or storage to Zone 7's water supply system.

In addition to water provided by Zone 7, water supplies for the Tri-Valley are supplemented by additional groundwater pumping and recycled water. Two of the retailers, Cal Water and Pleasanton, pump groundwater under their Groundwater Pumping Quotas (3,069 AFY and 3,500 AFY, respectively), which supplement the potable water supply provided by Zone 7 in their respective service areas. DSRSD and Livermore produce recycled water to meet non-potable or irrigation water demands in the Tri-Valley.

In this chapter, the management of each supply in correlation with other supplies is discussed, along with the measures that Zone 7 has taken to acquire and develop additional sources of water and additional storage.

Anticipated availability of Zone 7's water supplies under a normal water year is provided in this chapter. The availability of Zone 7's water supplies under a single dry year and a drought lasting five years, as well as more frequent and severe periods of drought are described in detail in Chapter 7 of this UWMP, along with the basis of those estimates.

6.2 WATER SUPPLY CHARACTERIZATION

As described above, Zone 7's water supply has two major components: 1) incoming water supplies available through contracts and water rights each year, and 2) accumulated water supplies in storage derived from previous years. Incoming water supplies typically consist of annually allocated imported surface water supply and local surface water runoff. Accumulated or "banked" water supplies are available in local and non-local storage locations.

Three of Zone 7's retailers—DSRSD, Livermore, and Pleasanton—also produce and/or supply recycled water to their service areas; more details about recycled water are available in Section 6.2.6.1. Two retailers, Pleasanton and Cal Water, pump groundwater directly in addition to the water supply provided by Zone 7. DSRSD has a contract with Zone 7 wherein Zone 7 will pump groundwater on DSRSD's behalf.

To optimize use of its local resources, Zone 7 practices conjunctive use of the Livermore Valley Groundwater Basin, which is detailed in Section 6.2.2. Zone 7 also stores local runoff from the Arroyo Valle watershed in the local reservoir (Lake Del Valle), which is owned and operated by the DWR.

Two long-term water storage ("banking") agreements with agencies south of Zone 7's service area in Kern County (Semitropic Water Storage District and Cawelo Water District) provide additional flexibility in managing annual fluctuations in supplies. These agreements are described in Section 6.2.5.

To mitigate the risk associated with significant reliance on imported water supply, Zone 7 continues to develop local sources of water and to diversify its water supply portfolio. In April 2019, Zone 7 completed its 2019 WSE Update, a follow-up to its 2016 Water Supply Evaluation Update that documents Zone 7's current water supplies based on new information and experience gained since the 2012-2016 statewide drought. The 2019 WSE Update also evaluates various future water supply portfolios, which are discussed in Section 6.2.9.

In this section, Zone 7's water supplies and their management in relation with each other are described in detail. Zone 7's efforts to meet future water demands are also discussed.

6.2.1 Purchased or Imported Water

Purchased or imported water consists of SWP water and water transfers through the Yuba Accord and other agreements.

6.2.1.1 State Water Project (SWP)

Imported water from the SWP, which is owned and operated by DWR, is by far Zone 7's largest water source, providing over 80 percent of the treated water supplied to its customers on an annual average basis.

SWP water originates within the Feather River watershed, is captured in and released from Lake Oroville, and flows through the Delta before it is conveyed by the SBA to Zone 7 and two other water agencies (VW and ACWD). Much of the SWP water continues to southern California via the California Aqueduct. Lake Del Valle is part of the SWP's SBA system and is used for storage of SWP water, as well as local runoff.

At Zone 7, SWP water is directly used to meet treated water demands from M&I customers—primarily wholesale to water retailers and some direct retail customers—and untreated water demands from agricultural customers. It is also used to recharge the local groundwater basin, as discussed in Section 6.2.2, and to fill non-local groundwater storage in Kern County.

The following sections describe Zone 7's contract with DWR for SWP water and the types of water Zone 7 receives under this contract.

6.2.1.1.1 Contract with DWR

DWR provides water supply from the SWP to 29 SWP contractors, including Zone 7, in exchange for contractor payment of all costs associated with providing that supply. DWR and each of the contractors entered into substantially uniform long-term water supply SWP contracts in the 1960s with 75-year terms. The first set of contracts originally terminated in 2035, and most of the remaining contracts terminated within three years after that. Zone 7's original contract was executed in 1961 and was set to expire in 2036. Over the last few years, there have been a number of key amendments to the SWP contracts, as described below:

- ***Contract Extension***

  The majority of the capital costs associated with the development and maintenance of the SWP is financed using revenue bonds. These bonds have historically been sold with 30-year terms. It has become more challenging in recent years to affordably finance capital expenditures for the SWP because bonds used to finance these expenditures are limited to terms that only extend to the year 2035, significantly less than 30 years from 2021. To ensure continued affordability of debt service to SWP contractors, it was necessary to extend the termination date of the contracts to allow DWR to continue to sell bonds with 30-year terms ("Water Supply Contract Extension Project").

  Public negotiations to extend the SWP contracts took place between DWR and the SWP contractors during 2013 and 2014. An Agreement in Principle (AIP) was reached and was the subject of analysis under the requirements of the California Environmental Quality Act (CEQA) (Notice of Preparation dated September 12, 2104). On December 11, 2018, the DWR Director approved the Water Supply Contract Extension Project. On January 18, 2019, DWR and Zone 7 agreed to extend the SWP water supply contract to at least December 31, 2085 ("Extension Amendment"). In accordance with CEQA, DWR also filed its Notice of Determination for the project with the Governor's Office of Planning and Research. In addition, DWR filed an action in Sacramento County Superior Court to validate the Contract Extension Amendments. The Extension Amendment is currently the subject of the validation action and two CEQA lawsuits. As of late March 2021, DWR and 22 SWP contractors have executed the Extension Amendment.

- ***Water Management Tools***

  In a December 2017 Notice to Contractors, DWR indicated its desire to supplement and clarify the water management tools in the SWP contracts through this public process. Seeking greater flexibility to manage the system in order to address changes in hydrology and further constraints placed on DWR's SWP operations, DWR and SWP contractors conducted public negotiations in 2017 to improve water management tools under a new amendment to the SWP contracts ("WMT Amendment"). The goal of the negotiations was to develop concepts to supplement and clarify the existing SWP contracts' water transfer and exchange provisions to provide improved water management amongst the SWP contractors.

  In June 2018, the SWP contractors and DWR completed an AIP, which included specific principles to accomplish this goal. These principles included adding contract language to include a process for transparency for transfers and exchanges. The principles also include amending existing contract provisions to provide new flexibility for single and multi-year non-permanent water transfers, allowing SWP contractors to set terms of compensation for transfers and exchanges, and providing for the limited transfer of non-Table A SWP water.

  In October 2018, a Draft Environmental Impact Report (DEIR) was circulated for the WMT Amendment. The AIP at that time included cost allocation for the California WaterFix project (WaterFix), a project aimed at improving conveyance of SWP water through the Delta. In early 2019, the Governor decided not to move forward with WaterFix, and DWR rescinded its approvals for WaterFix. After this shift, the SWP contractors and DWR held a public negotiation session and agreed to remove the WaterFix cost allocation sections from the AIP, while maintaining the water management provisions. The AIP for water management provisions was finalized on May 20, 2019. In February 2020, DWR amended and recirculated the Partially Recirculated DEIR for the State Water Project Supply Contract Amendments for Water Management and, in August 2020, DWR certified the Final EIR. The EIR is being challenged in court; however, the WMT Amendment became effective on February 28, 2021 for the SWP contractors that approved the amendment, including Zone 7. The enhanced ability to transfer and exchange SWP water will be available during litigation unless there is a final court order prohibiting its implementation.

- ***Delta Conveyance Project***

  The third set of amendments to the SWP contracts would allocate Delta Conveyance Project costs and benefits among the SWP contractors. The Delta Conveyance Project is the current DWR project designed to address the need for alternative conveyance in the Delta to reliably deliver SWP supplies. It replaces the WaterFix project and is described in more detail in Section 6.2.9.1.2. Public negotiations between DWR and the SWP contractors for the Delta Conveyance Project began in 2019 and were completed in April 2020. These negotiations led to an AIP for an Amendment to the State Water Contract regarding the Delta Conveyance Project. The AIP's goal was to equitably allocate costs and benefits of a Delta Conveyance Project and to preserve SWP operational flexibility. A decision by each participating SWP contractor for approving a contract amendment with DWR would not occur until after the environmental review for the Delta Conveyance Project is completed. That decision would likely occur in 2023, at the earliest.

6.2.1.1.2 SWP Supplies

The following sections describe the types of water available to Zone 7 from the SWP.

6.2.1.1.2.1 Table A Allocation

Each SWP contractor is limited to a maximum annual contract amount as specified in Article 6(c) and Table A of the SWP Contract; this amount is therefore commonly referred to as "Table A." As noted above, Zone 7 first entered into the SWP Contract in November 1961; as the SWP was expanded and as Zone 7 demands increased over the years, Zone 7's Table A amount was increased, reaching the amount of 46,000 AFY in 1997. Since then, Zone 7 has increased its supply from the SWP through a series of five permanent transfers. In December 1999, Zone 7 secured Table A SWP allocations from Lost Hills Water District of 15,000 AFY and Berrenda Mesa Water District of 7,000 AFY. In December 2000, 10,000 AFY of SWP allocation from Belridge Water Storage District was acquired. An additional 2,219 AFY was obtained from the same source in October 2003. Finally, 400 AFY of water was acquired from the Tulare Lake Basin Water Storage District in 2003. Together, these transfers have raised Zone 7's current Table A allocation to 80,619 AFY.

In practice, the actual amount of SWP water available to Zone 7 under the Table A allocation process (presented as % Table A) varies from year to year due to hydrologic conditions, water demands of other contractors, existing SWP stored water, SWP facility capacity, and environmental/regulatory requirements. The Table A allocation is typically less than 100% of the Table A amount. SWP reliability is defined based on the long-term average Table A allocation. DWR prepares a biennial report to assist SWP contractors and local planners in assessing the availability of supplies from the SWP. DWR issued its most recent update, the Final 2019 State Water Project Delivery Capability Report (2019 DCR)[6], in August 2020. In this update, DWR provides SWP supply estimates for SWP contractors to use in planning efforts, including the 2020 UWMP. The 2019 DCR includes DWR's estimates of SWP water supply availability under both existing (2020) and future conditions (2040).

DWR's estimates of SWP deliveries are based on a computer model that simulates monthly operations of the SWP and Central Valley Project systems. Key inputs to the model include system facilities, hydrologic inflows to the system, regulatory and operational constraints on system operations, and contractor demands for SWP water. In conducting its model studies, DWR must make assumptions regarding each of these key inputs.

In the 2019 DCR model for existing (2020) conditions, DWR assumed: existing facilities, hydrologic inflows to the model based on 82 years of historical inflows (1922 through 2003), current regulatory and operational constraints, and contractor demands at maximum Table A amounts. Note that the regulatory and operational constraints include the 2018 Coordinated Operations Agreement (COA) Amendment, 2019 Biological Opinions, and 2020 Incidental Take Permit. The 2018 COA Amendment lays out the terms under which the CVP operates with the SWP. The 2019 Biological Opinions for the Long-Term Operation of the CVP and SWP reflect the federal government's (U.S. Fish and Wildlife Service) opinion as to whether or not the operation of the CVP and SWP is likely to jeopardize the continued existence of threatened and endangered species or result in the destruction or adverse modification of critical habitat. Finally, the 2020 Incidental Take Permit is a requirement for the SWP's California Endangered Species Act (CESA) compliance with regards to state-protected longfin smelt and state- and federally-protected delta smelt, winter-run Chinook, and spring-run Chinook.

[6] Department of Water Resources, 2020. *State Water Project Delivery Capability Report 2019*.

To evaluate SWP supply availability under future conditions, the 2019 DCR included a model study representing hydrologic and sea level rise conditions at 2040. The future condition study used all of the same model assumptions as the study under existing conditions but reflected changes expected to occur from climate change, specifically, projected temperature and precipitation changes centered around 2035 (2020 to 2049) and a 45 centimeter (cm) sea level rise.

For Zone 7's Table A supply, the 2019 DCR's existing condition was assumed to represent 2020 (59% Table A reliability, 47,600 AFY)[7], and the future condition (54% Table A reliability, 43,500 AFY)[7] was applied to 2040; the years in between were interpolated between these two bookends[8]. Note that the effect of the proposed Delta Conveyance Project on SWP water supply yield is still being analyzed and has not been included.

As a SWP contractor, Zone 7 has the option to store unused Table A water from one year to the next in the SWP's San Luis Reservoir, when there is storage capacity available. This "carryover" water is also called Article 12e or 56c water, in reference to the relevant contract terms. Article 12e water must be taken by March 31 of the following year, but Article 56c water may remain as carryover as long as San Luis Reservoir storage is available. The analysis in this UWMP assumes Zone 7 carries over 10,000 AF of water each year on average.

6.2.1.1.2.2 Article 21 Water (Interruptible or Surplus Water)

Under Article 21 of Zone 7's SWP contract, Zone 7 also has access to excess water supply from the SWP that is available only if: 1) it does not interfere with SWP operations or Table A allocations, 2) excess water is available in the Delta, and 3) it will not be stored in the SWP system. As described in the 2019 DCR, Article 21 water deliveries are highly variable. This water becomes available during short time windows in the wet season when there is excess water in the system (due to storms) that DWR cannot store in San Luis Reservoir. When Article 21 water becomes available, SWP contractors can request delivery, and the available water is distributed generally in proportion to the Table A contract amounts of those contractors requesting delivery. Delivery of Article 21 water requires accessible storage during very wet conditions and/or the ability to use the water directly without impacting Table A deliveries to Zone 7. Historically, these conditions have been difficult to meet for Zone 7 and have resulted in infrequent and low yields. ***Therefore, Zone 7 is not assuming any water supply yield from Article 21 at this time.*** As Zone 7 develops the Chain of Lakes project, which will increase Zone 7's local storage and ability to capture Article 21 water as described in Section 6.2.9.3.1, Zone 7 will re-evaluate the potential increase in Article 21 yield.

6.2.1.1.2.3 Article 56d Water (Turnback Pool Water)

Article 56d is a contract provision that allows SWP contractors with unused Table A water to sell that water to other SWP contractors via a "turnback pool" administered by DWR on an annual basis. Historically, only a few SWP contractors have been able to make turnback pool water available for purchase, particularly in normal or dry years.

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[7] Data for Existing and Future conditions were derived from Table 8 of the AltSWPReporting_Existing_DCR2019.xlsm and AltSWPReporting_Future_DCR2019.xlsm files, respectively, provided by DWR as addenda to the 2019 DCR.

[8] For comparison, the 2015 UWMP assumed 62% Table A reliability (50,000 AFY). The 2019 WSE Update assumed 49% Table A reliability (39,500 AF). Table A allocations over the last ten years have ranged between 5% and 85%, with an average of 48%.

With the enhanced ability to directly transfer or exchange SWP water from one SWP contractor to another under the Water Management Tools contract amendment described earlier, it is expected that there will not be much water available under Article 56d in the future. ***Zone 7 is therefore assuming no supplies are available from this source under normal conditions.***

6.2.1.1.3 Yuba Accord

In 2008, Zone 7 entered into a contract with DWR to purchase additional water under the Lower Yuba River Accord (Yuba Accord). The original contract expires in 2025, and several amendments have been made to the original agreement over the years, including a new pricing agreement executed in 2020.

There are four different types (“Components”) of Yuba Accord water made available as a water purchase or transfer; Zone 7 has the option to purchase Components 1, 2, and 3 water during drought conditions, and Component 4 water when the Yuba County Water Agency has determined that it has water supply available to sell.

Water is primarily available during dry years under the Yuba Accord, and the amount is highly variable: 400 AF in 2014, approximately 300 AF in 2015, and 3,000 AF in 2020. ***For planning purposes, Zone 7 currently does not assume any water supply yield specifically from the Yuba Accord, although ‘water transfers’ (see Section 6.2.8) could potentially include any supplies from the Yuba Accord.***

6.2.2 Groundwater

Zone 7 has managed local surface water and groundwater resources for beneficial uses in the Livermore Valley Groundwater Basin for more than 50 years. Consistent with its management responsibilities, duties, and powers, Zone 7 is designated in the 2014 SGMA as the exclusive Groundwater Sustainability Agency (GSA) within its jurisdictional boundaries.

6.2.2.1 Basin Description

Zone 7 overlies the Livermore Valley Groundwater Basin; the Main Basin is the portion of the Basin that contains high-yielding aquifers and generally the best-quality groundwater. Figure 6-1 provides a map of the Basin, identifying the Main Basin and sub-basins. More detailed descriptions of the Basin and Main Basin are available in Zone 7’s Groundwater Management Plan (GMP)[9]. The associated Annual Report for the 2019 Water Year[10] is also available online.

As defined in DWR Bulletin 118 Update 2003 (California’s Groundwater), the Basin (DWR Basin 2-10) extends from the Pleasanton Ridge east to the Altamont Hills and from the Livermore Uplands north to the Tassajara Uplands. The Basin is not adjudicated, and DWR has identified it as medium priority; Basin 2-10 is not identified as either in overdraft or expected to be in overdraft. Surface drainage features include Arroyo Valle, Arroyo Mocho, and Arroyo Las Positas as principal streams, with Alamo Creek, South San Ramon Creek and Tassajara Creek as minor streams. All streams converge on the west side of the basin to form Arroyo de la Laguna, which flows south and joins Alameda Creek in Sunol Valley and ultimately drains to the San Francisco Bay. Some geologic structures restrict the lateral movement of

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[9] Jones & Stokes, 2005. Groundwater Management Plan for Livermore-Amador Valley Groundwater Basin.

[10] Zone 7 Water Agency, 2020. Annual Report for the Groundwater Management Program 2019 Water Year.

groundwater, but the general groundwater gradient is from east to west, towards Arroyo de la Laguna, and from north to south along South San Ramon Creek and Arroyo de la Laguna.

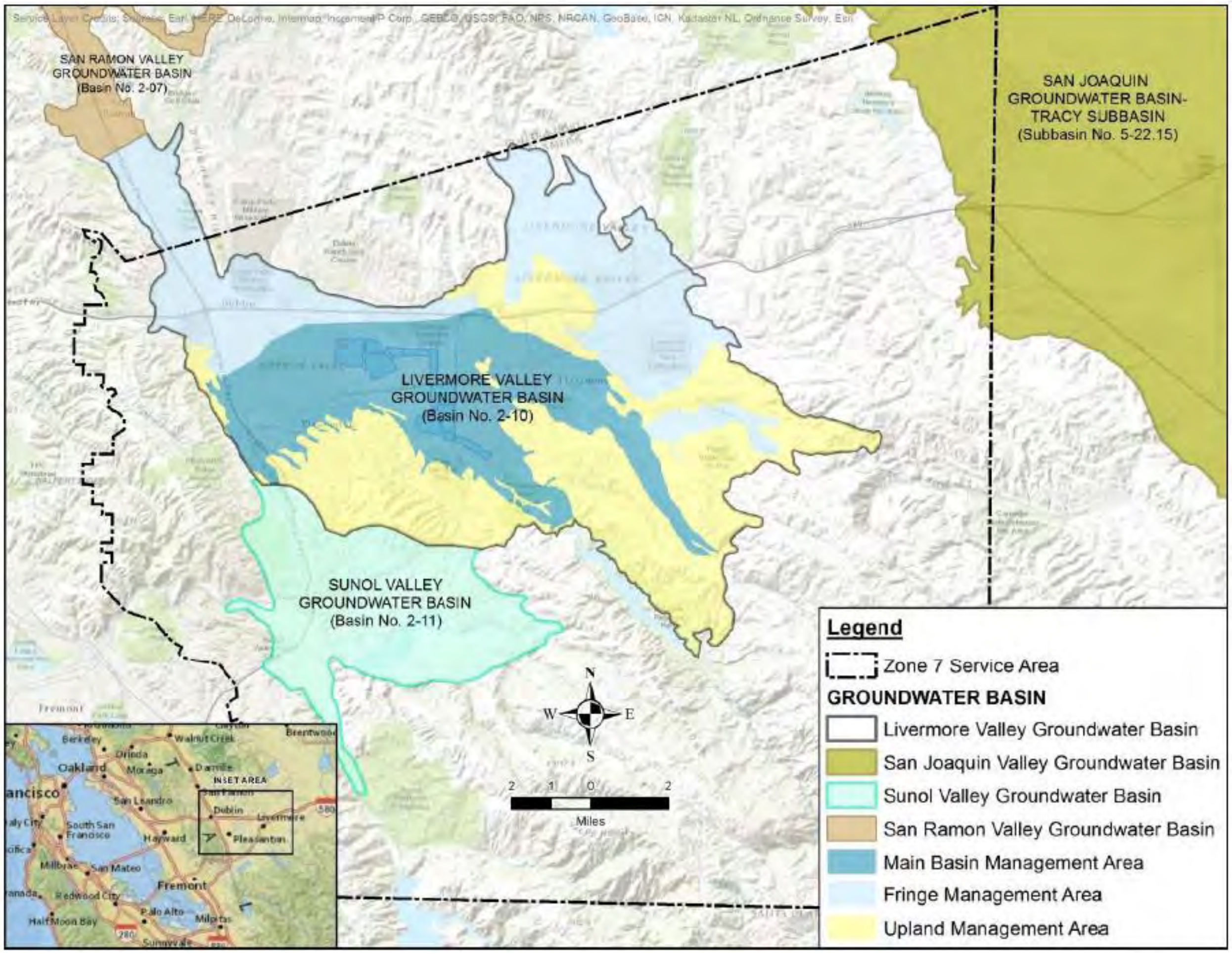


Figure 6-1. Livermore Valley Groundwater Basin

The entire floor of the Livermore Valley and portions of the upland areas on all sides of the valley overlie groundwater-bearing materials. The materials are mostly continental deposits from alluvial fans, outwash plains, and lakes. They include valley-fill materials, the Livermore Formation, and the Tassajara Formation. Under most conditions, the valley-fill and Livermore Formation yield adequate to large quantities of groundwater to all types of wells, with the larger supply wells being in the Main Basin. The Main Basin is composed of the Castle, Bernal, Amador, and Mocho II sub-basins, with an estimated total storage capacity of 254,000 AF.

6.2.2.2 Groundwater Management

The 2005 GMP[9] documented all of Zone 7's then-current groundwater management policies and programs and was developed to satisfy the requirements set forth in the California Groundwater Management Planning Act (Water Code Sections 10750, *et seq*.). More recently, a Salt and Nutrient Management Plan has been incorporated into the GMP. Zone 7 prepares annual reports that summarize the results of the groundwater monitoring, evaluation, and management efforts by water year; the most recent version of the annual report is for the 2019 water year (October 1, 2018 through September 30, 2019). In addition to the annual reports completed over the years, Zone 7 completed the Alternative Groundwater Sustainability Plan for the Livermore Valley Groundwater Basin (Alternative GSP) in 2016 as required under SGMA.

For Zone 7's operations, the Main Basin is considered a storage facility and not a long-term water supply, because Zone 7 does not have access to naturally recharged water ("sustainable yield"). Zone 7 only pumps groundwater that has been artificially recharged with surface water supplies. As part of this conjunctive use program, Zone 7's policy is to maintain groundwater levels above historic lows in the Main Basin to minimize the risk of inducing land subsidence. Currently, this is accomplished by releasing SWP water to the arroyos for percolation and replenishment of the aquifers and by managing pumping activities.

Zone 7 established historic lows based on the lowest measured groundwater elevations in various wells in the Main Basin. The difference between water surface elevations when the Main Basin is full and water surface elevations when the Main Basin is at historic lows defines Zone 7's operational storage. Of the estimated total storage capacity of 254,000 AF, operational storage is about 126,000 AF based on Zone 7's experience operating the Main Basin, with the remaining 128,000 AF considered emergency reserve storage.

6.2.2.2.1 Groundwater Level Monitoring and Storage Estimates

Zone 7 routinely monitors groundwater levels within the Main Basin. Some of the data collected is submitted to DWR under the California Statewide Groundwater Elevation Monitoring (CASGEM) program. All the data is reflected in the annual reporting on the Groundwater Management Program.

Two independent methods are used to estimate groundwater storage: 1) Hydrologic Inventory, and 2) Nodal Groundwater Elevation. The Hydrologic Inventory method computes storage change each quarter from basin supply and demand data; this method can also be used to forecast future water storage conditions. The Nodal Groundwater Elevation method computes storage from hundreds of water level measurements. Zone 7 continues to refine the calculation methods; the average of the two results is generally used as the estimate of total groundwater storage volume.

Figure 6-2 depicts Main Basin storage levels calculated using the average of these two methods in thousand acre-feet (TAF). Note the declines in storage due to drought, particularly between 1987 and 1992 and more recently between 2012 and 2015. Stored groundwater at the end of the 2020 water year was approximately 240,000 AF, with 112,000 AF of groundwater available as operational storage.

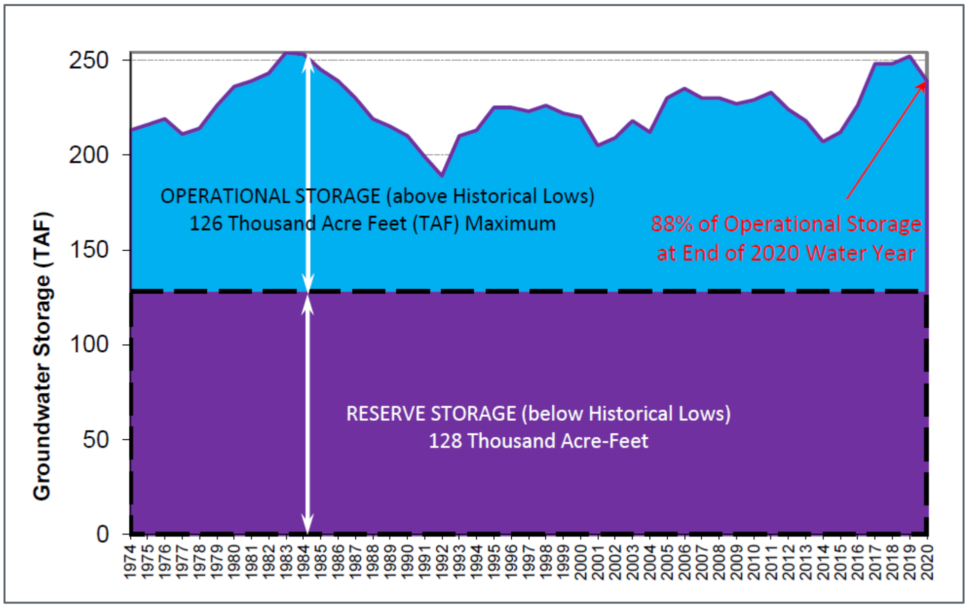


Figure 6-2. Main Basin Groundwater Storage

6.2.2.2.2 Current Sustainable Yield and Groundwater Allocation

Long-term natural sustainable yield is contractually defined as the average amount of groundwater annually replenished by natural recharge in the Main Basin—through percolation of rainfall, natural stream flow, and irrigation waters, and inflow of subsurface waters—and which can therefore be pumped without lowering the long-term average groundwater volume in storage. In contrast, "artificial recharge" is the aquifer replenishment that occurs from artificially induced or enhanced stream flow. With artificial recharge, more groundwater can be sustainably extracted from the Main Basin each year. Zone 7 only uses groundwater that has been artificially recharged by Zone 7.

The natural sustainable yield of the Main Basin has been determined to be about 13,400 AFY, which is about 11 percent of the operational storage. This long-term natural sustainable yield is based on over a century of hydrologic records and projections of future recharge conditions. Table 6-1 summarizes how this sustainable yield is allocated among non-Zone 7 groundwater users.

Each retailer has an established "Groundwater Pumping Quota" (GPQ), formerly referred to as the "Independent Quota" in the original Municipal and Industrial water supply contract between Zone 7 and each retailer. Pleasanton and Cal Water pump their own GPQ, while Zone 7 pumps DSRSD's GPQ. Livermore has not had any groundwater pumping capability for many years and has therefore not been using their GPQ. Averages are maintained by allowance of "carryover"—limited to 20 percent of the GPQ—when less than the GPQ is used in a given year. A retailer must pay a "recharge fee" for all groundwater pumped exceeding their GPQ and any carryover. This practice helps avoid a repeat of historical over-drafting of the basin by the larger municipal users. The fee covers the cost of importing and recharging additional water into the Main Basin. The balance of the natural sustainable yield is pumped for other municipal, agricultural, and gravel mining uses.

Table 6-1. Natural Sustainable Yield Demand Components	
Demand Component of the Sustainable Yield	Sustainable Average, AFY
Pleasanton	3,500
Cal Water	3,069
DSRSD	645
Retailer Subtotal[(a)]	**7,214**
Other groundwater pumping[(b)]	1,186
Agricultural pumping	400
Mining area losses[(c)]	4,600
Total	**13,400**

(a) Based on calendar year. Livermore has a GPQ of 31 AF, but it has not been used for many years.
(b) For drinking water supply.
(c) Includes mining area evaporation, discharges that are diverted to arroyos and flow out of the Main Basin area, and losses incurred during gravel production and export.

Zone 7's groundwater extraction for its treated water system does not use the natural sustainable yield from the Main Basin; instead, Zone 7 pumps only water that has been recharged as part of its artificial recharge program using its available surface water supplies. During high demand periods, groundwater is used to supplement surface water supply delivered via the SBA. Groundwater is also used when the SBA is out of service due to maintenance and improvements or when Zone 7's surface water treatment plants are operating under reduced capacity due to construction, repairs, etc. Finally, Zone 7 taps into its stored groundwater under emergency or drought conditions, when there may be insufficient surface water supply available. Zone 7 also pumps groundwater out of the Main Basin during normal water years to help reduce the salt loading in the Main Basin in accordance with the Salt Management Plan.

The MGDP has been in operation since 2009 to achieve additional salt removal. During emergency or drought conditions, MGDP operations may be reduced to maximize available water supply and avoid water loss due to brine disposal from the MGDP, as discussed in Section 3.1.3.4.

Table 6-2 presents Zone 7's groundwater pumping over the last five years. On average, Zone 7 plans to recharge about 9,200 AFY in the future, which means Zone 7 can pump an equivalent 9,200 AFY from the Main Basin on average as indicated in Table 6-3.

Table 6-2. Groundwater Volume Pumped (DWR Table 6-1 Wholesale)

☐	Supplier does not pump groundwater. The supplier will not complete the table below.					
☑	All or part of the groundwater described below is desalinated.					
Groundwater Type	Location or Basin Name	2016*	2017*	2018*	2019*	2020*
Add additional rows as needed						
Alluvial Basin	Livermore Valley Groundwater Basin	1,871	4,859	5,691	10,433	12,400
	TOTAL	1,871	4,859	5,691	10,433	12,400
**** Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*						
NOTES: Volumes are in AF. Zone 7 pumps only water that has been recharged as part of its artificial recharge program using its surface water supplies. Actual groundwater used as supply is lower than the total groundwater volume pumped shown in the table because of demineralization losses at the MGDP.						

Table 6-3. Actual and Projected Artificial Recharge and Groundwater Extraction during Normal Water Years[a]

Volume, AF	Actual	Projected (Normal Years)				
	2020	2025	2030	2035	2040	2045
Artificial Recharge	1,400	9,200	9,200	9,200	9,200	9,200
Groundwater Extraction	12,400[b]	9,200	9,200	9,200	9,200	9,200
Net Change	**-11,000**	**0**	**0**	**0**	**0**	**0**

(a) Zone 7 does not use the Main Basin's natural sustainable yield, so it only pumps what it artificially recharges.
(b) Actual groundwater extracted in 2020 includes 600 AF of demineralization losses at the MGDP.

6.2.2.2.3 Artificial Recharge and Groundwater Extraction by Zone 7

Before the construction of the SWP in the early 1960s, groundwater was the sole water source for the Livermore-Amador Valley. This resource has gone through several periods of extended withdrawal and subsequent recovery. The Main Basin was over drafted in the 1960s when approximately 110,000 AF of groundwater was extracted. The Main Basin was allowed to recover from 1962 to 1983. It was during this era that Zone 7 first conducted a program of groundwater replenishment by recharging imported surface water via its streams or arroyos (“in-stream recharge” or “artificial recharge”) for storage in the Main Basin, supplying treated surface water to customers to augment groundwater supplies, and regulating municipal pumping by other users.

Figure 6-3 shows Zone 7’s total annual artificial recharge amounts, pumping amounts, and cumulative net impacts to operational storage from the 1974 water year to the 2020 water year. Zone 7's operational policy is to maintain the balance between the combination of natural and artificial recharge and withdrawal or pumping to maintain groundwater levels above the emergency reserve storage. Zone 7 has generally been able to pump as much groundwater as it has needed to over the last five years; however, during the recent drought, decreases in groundwater elevation did noticeably affect the production of certain wells. Zone 7 is continuing to study the groundwater basin and developing new tools (such as an improved groundwater model) to better understand the levels of groundwater extraction possible under various conditions and contributing factors such as groundwater connectivity, spatial distribution of groundwater in the Main Basin, and others.

Since 1974, Zone 7 has artificially recharged over 67,000 AF more water than it has pumped, helping to offset demands and keep the Main Basin’s groundwater levels above the historical lows. Between 1974 and 2007 Zone 7 had artificially recharged approximately 70,000 AF more than it had pumped during that same time; however, since 2007, Zone 7 has artificially recharged about 3,000 AF less than it has pumped, primarily due to construction work on the SBA, recent drought conditions, and lower-than-average SWP allocations over that same time period. Overall net groundwater storage remains significantly above historical lows, as shown on Figure 6-2.

Zone 7 plans to augment its current groundwater in-stream recharge capacity with off-stream recharge using the future Chain of Lakes, which is described further in Section 6.2.9.

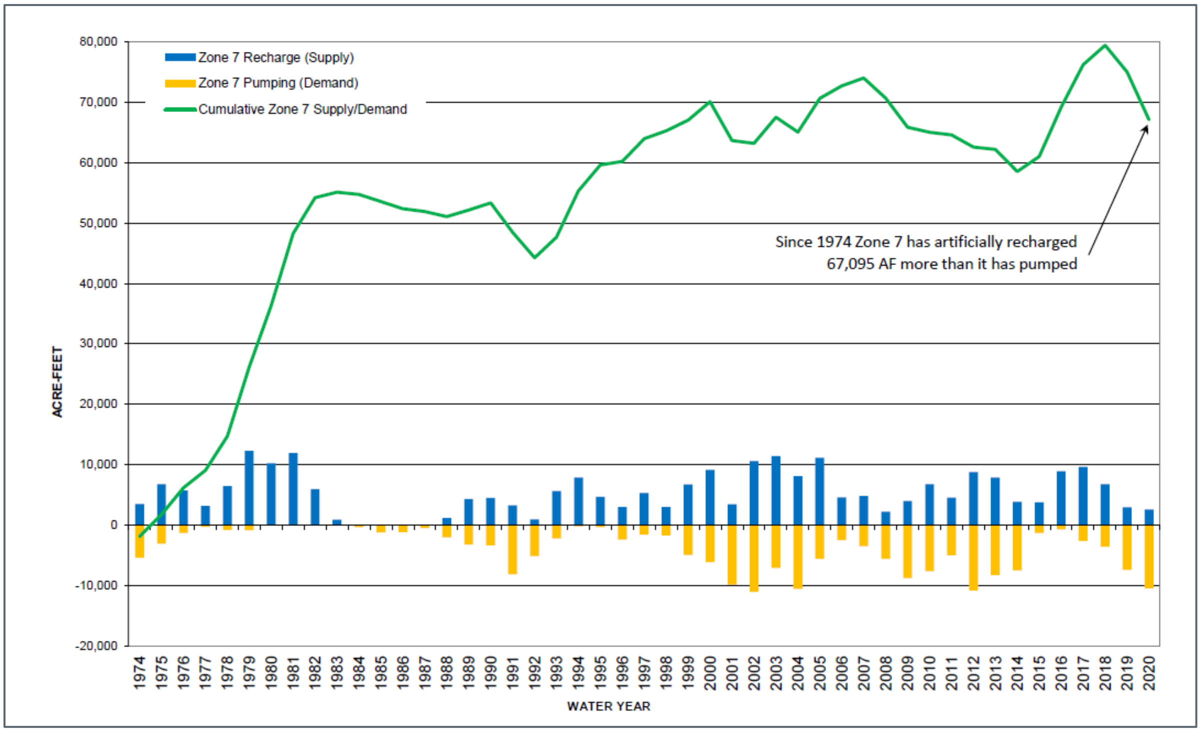


Figure 6-3. Artificial Recharge, Pumping, and Net Cumulative Impacts to Operational Storage

6.2.2.2.4 Groundwater Quality Monitoring and Protection

In general, the Main Basin contains good-quality groundwater that meets all state and federal drinking water standards; groundwater is chloraminated to match the disinfectant residual in the transmission system. Zone 7 has several groundwater wells with naturally-occurring hexavalent chromium (Cr(VI)) concentrations near the Maximum Contaminant Level (MCL) and polyfluoroalkyl substances (PFAS) above the notification limit. In response, Zone 7 is actively managing flows from the affected wells. For example, Cr(VI) levels at the Stoneridge well is being managed through system blending and/or blending with other wells. Also, the PFAS levels in the Mocho 2 well currently require blending with the other wells in that wellfield and/or being sent through the MGDP. These conditions are being monitored and may change in the future.

Over the last few decades, there has been a slow degradation of groundwater quality as evidenced by rising TDS and hardness levels. To address this problem, Zone 7 developed a Salt Management Plan[11] (SMP), which was approved by the Regional Water Quality Control Board (RWQCB) in 2004, satisfying a condition of the Master Water Recycling Permit. The SMP was incorporated into Zone 7's GMP in 2005. Salinity levels are being addressed primarily through groundwater pumping and demineralization[12]. Zone 7 completed construction of the 6.1-MGD MGDP in 2009 in the Mocho wellfield. The facility simultaneously allows for the removal and export of concentrated minerals or salts from the Main Basin and the delivery of treated water with reduced TDS and hardness levels to Zone 7's customers. Table 6-4 lists the average TDS and hardness for each year from 2016 through 2020.

[11] Zone 7 Water Agency, 2004. Salt Management Plan.

[12] The brine concentrate resulting from the treatment system is exported to the San Francisco Bay via a regional wastewater export pipeline.

Table 6-4. Groundwater Quality: TDS and Hardness (2016-2020)		
Year	Total Dissolved Solids (TDS), mg/L	Hardness, mg/L
2016	685	416
2017	673	395
2018	673	409
2019	687	417
2020	683	433

Zone 7 implements a wastewater and recycled water monitoring program as part of the GMP. In the 2020 water year, about 14 percent (1,036 AF) of the recycled water produced in the Tri-Valley area was applied to landscapes over the Main Basin; the remainder was applied on areas outside of the Main Basin, primarily on areas overlying the Dublin and Camp fringe basins and the Tassajara uplands. There is also a small amount of untreated wastewater (681 AF in the 2020 water year) that is discharged to the Main Basin as leachate from wastewater treatment ponds located in southern Livermore, from onsite domestic wastewater systems (septic systems), and from leaking wastewater and recycled water pipelines that run throughout the Basin.

Nitrates and salinity have historically been the primary water quality constituents-of-concern in wastewater and recycled water, but nitrates have become less of a concern since 1995, when the Livermore Water Reclamation Plant—which, along with DSRSD's Regional Wastewater Treatment Facility, is one of the two wastewater treatment facilities in the area feeding into recycled water facilities—reduced nitrates in its effluent. Salinity is addressed by the SMP, as discussed above. In 2015, Zone 7 completed a Nutrient Management Plan (NMP)[13], which provides an assessment of the existing and future groundwater nutrient concentrations relative to the current and planned expansion of recycled water projects and future development in the Livermore Valley. The NMP also presents planned actions for addressing positive nutrient loads and high groundwater nitrate concentrations in localized Areas of Concern where the use of septic systems is the predominant method for sewage disposal. The NMP was prepared as a supplement to the SMP; together, they are a Salt and Nutrient Management Plan (SNMP), which has been incorporated into the GMP and Alternative GSP.

Under the Toxic Sites Surveillance Program, Zone 7 documents and tracks polluted sites across the groundwater basin that pose a potential threat to drinking water and interfaces with lead agencies to ensure that the Main Basin is protected. Information is gathered from state, county, and local agencies, as well as from Zone 7's well permitting program and the State Water Resources Control Board's GeoTracker website and compiled in a geographic information systems (GIS) database. In general, there are two types of spills potentially threatening the Livermore Valley Groundwater Basin: petroleum-based fuel products and industrial chemical contaminants. In the 2020 water year, Zone 7 tracked the progress of 56 active sites where contamination has been detected in groundwater or is threatening groundwater. More details on the affected sites and their remediation can be found in the annual report.[14]

[13] Zone 7 Water Agency, 2015. Nutrient Management Plan – Livermore Valley Groundwater Basin.

[14] Zone 7 Water Agency, 2020. Annual Report for the Sustainable Groundwater Management Program 2019 Water Year.

6.2.2.2.5 Land Surface Elevation Monitoring Program

Previously, Zone 7's Land Surface Elevation Monitoring Program involved contracting with a licensed land surveyor to measure land surface elevations within the Main Basin boundary twice per year. The program included a network of approximately 40 elevation benchmarks encompassing Zone 7's production wellfields and spanning the Bernal and Amador Subareas within the Main Basin.

In the 2016 water year, Zone 7 contracted with TRE Altamira (TRE) to evaluate Interferometric Synthetic Aperture Radar (InSAR) as an alternative to land surveying for subsidence monitoring. TRE analyzed InSAR data from three different satellites over a 24-year period (from 1992 to 2016) which included approximately 120 satellite images with between 415 and 1,202 measuring points per square mile. Each measuring point contains a deformation time series, including cumulative displacement, average deformation rate, acceleration, and seasonal amplitude. The study results correlated well with topographic surface measurements taken by land surveys within the same time period. An added benefit of the InSAR dataset was that it included a larger area (i.e., the entire Main Basin) than the land surveying.

Starting in the 2019 water year, Zone 7 retired the land surveying program and transitioned to InSAR for monitoring land subsidence. In general, observed land surface elevation changes between September 2018 to September 2019 near Zone 7's municipal wells were within the range Zone 7 considers to be "elastic deformation" (i.e., rebound to their original location when groundwater levels return to previous levels).

6.2.3 Surface Water – Arroyo Valle

Zone 7, along with ACWD, has a water right (Permit 11319 [Application 17002]) to divert flows from Arroyo Valle. Runoff from the Arroyo Valle watershed above Lake Del Valle is stored in the lake, which is managed by DWR as part of the SWP. Lake Del Valle also stores imported surface water deliveries from the SWP and serves both a flood control function, as well as a recreational one. In late fall, DWR typically lowers lake levels in anticipation of runoff from winter storm events. Water supply in Lake Del Valle is made available to Zone 7 via the SBA through operating agreements with DWR. Inflows to Lake Del Valle, after accounting for permit conditions, are equally divided between ACWD and Zone 7 under their respective permits.

Zone 7's latest modeling forecasts future average yields from Arroyo Valle to Zone 7 at approximately 5,500 AFY, using historical hydrology adjusted for climate change impacts. Previous planning documents, including the 2015 UWMP, assumed an average yield of 7,300 AFY, and the ten-year calendar year average (2011-2020) has been 3,500 AFY. Construction of the Chain of Lakes Arroyo Valle diversion structure and pipeline (discussed in Section 6.2.9) will allow Zone 7 to capture more of the storm releases from Lake Del Valle and will likely increase the yield from this water supply in the future. The conservative average yield estimate of 5,500 AFY is consistent with the 2019 WSE Update; it will be re-evaluated as more climate change downscaled information is developed and as the Chain of Lakes projects progress.

6.2.4 Stormwater and Local Storage

Zone 7 has two existing local storage options: Lake Del Valle and the Main Basin. Lake Del Valle stores both runoff from the Arroyo Valle watershed and imported surface water deliveries from the SWP. Zone 7 can store up to about 7,500 AF of its share of Arroyo Valle runoff in the lake; runoff collected in any given year is required to be delivered to Zone 7 by the end of the following year. The Main Basin is used conjunctively and is artificially recharged with SWP water. Zone 7 relies on the operational storage capacity of 126,000 AF in the Main Basin.

6.2.5 Non-Local Storage

In addition to local storage, Zone 7 also participates in the two non-local (also called “out-of-basin”) groundwater banking programs described below; both banks are located in Kern County. Note that while these banking programs provide a water source during drought years, they represent water previously stored from Zone 7’s surface water supplies during wet years. Therefore, they do not have a net contribution to Zone 7’s water supply over the long-term and in fact result in some operational losses as described below. While the out-of-basin groundwater banks significantly enhance system reliability, this banked water supply requires Banks Pumping Plant in the Delta and the SBA to be operational; low SWP Table A allocations (and generally low levels of water movement in the SWP system) can limit the delivery of these banked supplies via exchange. Figure 6-4 shows the historical operation of the Kern County banks—note the successful use of the groundwater banks to augment water supplies during the recent drought, and the recovery in the following years.

Point of Delivery Agreements with DWR and Kern County Water Agency, a SWP contractor, allow Zone 7 to store SWP water in and recover water from Semitropic Water Storage District (Semitropic) and Cawelo Water District (Cawelo). Semitropic and Cawelo are member units of Kern County Water Agency, which manages water deliveries to these agencies. Zone 7 has been storing water in the water banks operated by Semitropic since 1998 and by Cawelo since 2006. In November 2020, the Zone 7 Board authorized the execution of amendments to existing Point of Delivery Agreements that would extend water delivery terms for storage in Semitropic and Cawelo through 2030 and recovery of banked water through 2035.

6.2.5.1 Semitropic Water Storage District

Zone 7 originally acquired a storage capacity of 65,000 AF in the Semitropic groundwater banking program in 1998. Subsequently, Zone 7 agreed to participate in Semitropic’s Stored Water Recovery Unit, which increased pumpback capacity and allowed Zone 7 to contractually store an additional 13,000 AF. Zone 7 currently has a total of 78,000 AF of groundwater banking storage capacity available to augment water supplies during drought and emergency conditions and as needed. Zone 7 can store up to 5,883 AFY in the Semitropic groundwater bank. Note that a 10 percent loss is associated with water stored in Semitropic.

Under the contract terms, Zone 7 can request up to 9,100 AF of pumpback and up to 8,645 AF of exchange water. Pumpback is water that is pumped out of the Semitropic aquifer and into the SWP system. Exchange water is water that is transferred between Zone 7 and Semitropic by adjusting the amounts of Table A water delivered to Zone 7 and Semitropic; the availability of this type of water depends on the SWP allocation. During the recent drought, Zone 7 was able to recover 9,900 AF in 2014 and about 12,800 AF in 2015. Zone 7 has largely been storing water in Semitropic over the past few years but did recover 324 AF in 2016 and 1,000 AF in 2020.

6.2.5.2 Cawelo Water District

Similar to the arrangements with Semitropic, Zone 7 has 120,000 AF of groundwater banking storage capacity available with Cawelo, as executed in a 2006 agreement. Zone 7 can store up to 5,000 AFY in the bank. Zone 7 can request up to 10,000 AFY of pumpback (or SWP exchange water) from Cawelo. During the recent drought, Zone 7 was able to recover 10,000 AF, delivered evenly over 2014 and 2015. Most of this water was used directly, while the rest was stored in San Luis Reservoir for use the following year. Zone 7 only accumulates 50 percent of the water sent to storage in Cawelo; the other 50 percent goes towards water loss and compensation to Cawelo.

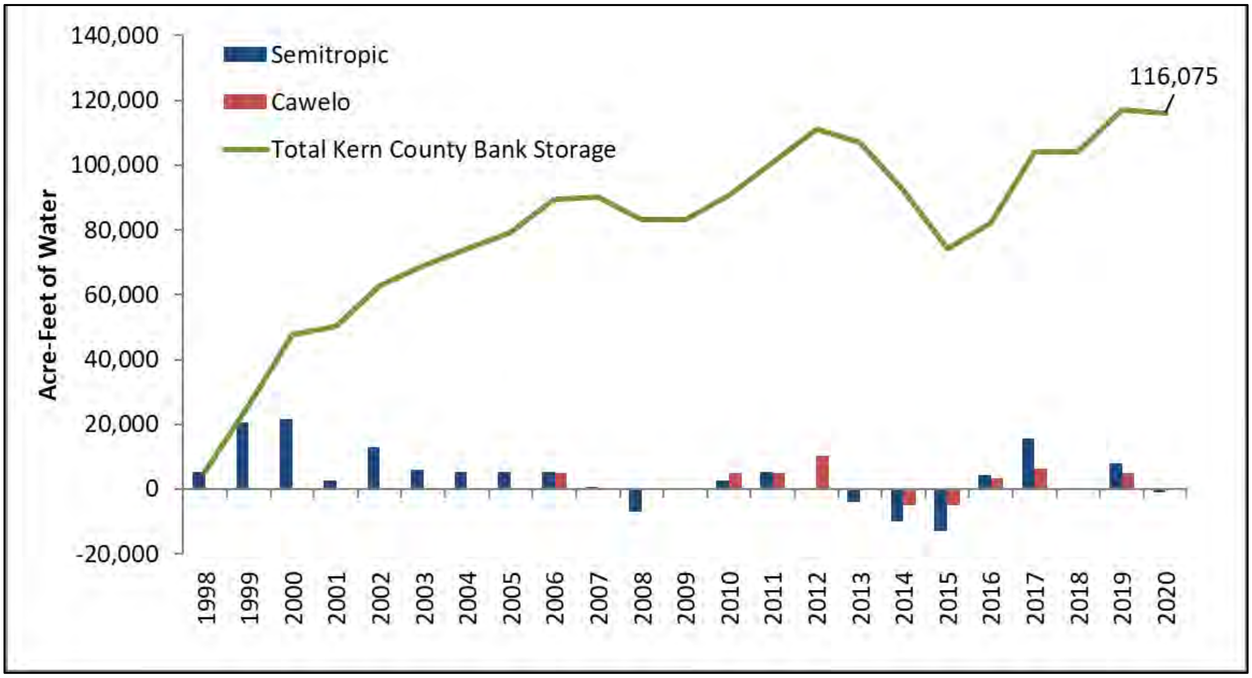


Figure 6-4. Kern County Groundwater Banks Operations

6.2.6 Wastewater and Recycled Water

Zone 7 does not currently handle wastewater nor recycled water; however, three local agencies—all water supply retailers—are involved in wastewater and recycled water activities as listed in Table 6-5. Further details regarding recycled water use in Zone 7's service area can be found in the 2020 UWMPs of Livermore, Pleasanton, and DSRSD. In the Zone 7 service area, recycled water is currently only used for non-potable applications, primarily landscape irrigation.

Table 6-5. Local Agencies Involved in Wastewater and Recycled Water

Local Agency	Collects Wastewater	Treats and Discharges Wastewater	Produces Recycled Water	Distributes Recycled Water
Livermore	✓	✓	✓	✓
Pleasanton	✓			✓
DSRSD	✓	✓	✓	✓

6.2.6.1 Recycled Water Coordination

As the groundwater basin management agency, Zone 7 is cognizant of the potential salt loading impacts arising out of recycled water use. Zone 7 has taken a proactive approach to mitigate such impacts, particularly within the Main Basin.

Recognizing that recycled water is an important part of a complete water resource management program for the Livermore-Amador Valley, Zone 7 is incorporating its use in future water supply planning. In joint efforts with the retailers, Zone 7 supports the search for safe, economically feasible, and publicly acceptable methods to increase local water resources, including the use of recycled water.

To encourage and optimize future recycled water use, Zone 7 will continue to work with the retailers to develop recycled water use projects for non-potable uses (e.g., irrigation) in the Livermore-Amador Valley and to identify potential opportunities for storage—which would facilitate expanded recycled water use—during non-irrigation months. This coordination includes supporting retailer applications for State and federal grants for construction of additional recycled water infrastructure. The feasibility of developing potable reuse will also continue to be evaluated as detailed in Section 6.2.9.1.3.

Plans for water recycling within the Zone 7 service area are coordinated amongst Zone 7, the retailers, the wastewater/recycled water agencies (DSRSD, Livermore, and Pleasanton), the regulatory agencies such as the Division of Drinking Water and the RWQCB, and planning agencies such as the City of Livermore Community Development Department. Zone 7 reviews recycled water plans both from a water supply management perspective and from a groundwater protection perspective. Given Zone 7's integral role in water supply and groundwater management in the Livermore-Amador Valley, Zone 7 is a co-permittee under the Master Water Recycling Permit issued by the RWQCB in December 1993 (Order No. 93-159).

Provision D.1.c.ii of the Master Water Recycling Permit requires the development of a SMP to assess and manage cumulative salt loading impacts on the Livermore Valley Groundwater Basin (Basin). Approved in October 2004 by the RWQCB, the SMP identified demineralization with export of the brine stream as the best means of mitigating salt loading in the Basin. DSRSD and Pleasanton are now operating under State Water Board General Order WQ 2016-0068-DDW, while Livermore still operates under Master Permit Order 96-011. The SWRCB's 2009 Recycled Water Policy required the development of a Nutrient Management Plan, which Zone 7 completed in 2015; a combined SNMP has been incorporated into the GMP originally developed in September 2005. All of these documents were developed in close consultation with the retailers and other stakeholders.

Recharging with low TDS water is a cornerstone of the SMP. Zone 7 is also currently operating a demineralization facility (MGDP) to help manage the salt loading in the Main Basin. The MGDP has the added benefit of providing softer water to Zone 7's potable water customers in the western portion of Zone 7's service area, where there is a regional concentration of groundwater production facilities with relatively high levels of TDS. Expansion of recycled water use over the groundwater basin will require additional measures to mitigate the associated additional salt loading.

6.2.6.2 Wastewater Collection, Treatment, and Disposal

DSRSD and Livermore treat all the wastewater collected within the city limits of Pleasanton, Dublin, and Livermore, and portions of San Ramon. Wastewater transport out of the area is handled through the LAVWMA, a joint-powers authority (JPA) composed of DSRSD, Livermore, and Pleasanton. Since 1979, LAVWMA has owned the conveyance facilities that transport treated wastewater from the treatment plants west over the Dublin grade, and eventually to the East Bay Dischargers Authority, which dechlorinates the effluent and discharges it through a deepwater pipeline into San Francisco Bay.

Since Zone 7 does not handle wastewater or recycled water, Table 6-6 is intentionally blank.

Table 6-6. Wastewater Treatment and Discharge Within Service Area in 2020 (DWR Table 6-3 Wholesale)

☑	Wholesale Supplier neither distributes nor provides supplemental treatment to recycled water. The Supplier will not complete the table below.											
								2020 volumes [1]				
Wastewater Treatment Plant Name	Discharge Location Name or Identifier	Discharge Location Description	Wastewater Discharge ID Number *(optional)* [2]	Method of Disposal *Drop down list*	Does This Plant Treat Wastewater Generated Outside the Service Area? *Drop down list*	Treatment Level *Drop down list*	Wastewater Treated	Discharged Treated Wastewater	Recycled Within Service Area	Recycled Outside of Service Area	Instream Flow Permit Requirement
						Total	0	0	0	0	0

[1] **Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.
[2] If the **Wastewater Discharge ID Number** is not available to the UWMP preparer, access the SWRCB CIWQS regulated facility website at https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=RegulatedFacility

6.2.6.3 Recycled Water System Description

In Livermore, recycled water was first used in the early 1960's to irrigate grain fields surrounding the Livermore Municipal Airport. When the Las Positas Golf Course opened in 1966, the course was also irrigated with secondary treated recycled water. After the treatment plant upgrade in 1974, Livermore started outdoor irrigation with tertiary treated recycled water. In 2002, ultraviolet disinfection was added to the treatment process in lieu of chlorine. Today, Livermore provides disinfected tertiary treated recycled water to the northwestern portion of the City. The distribution system consists of two aboveground reservoirs with a holding capacity of 1.88 MG each. There are approximately 20 miles of distribution pipeline ranging in size from 4 to 18 inches in diameter, with 168 metered connections. There are also 100 recycled water fire hydrants available for contractors to use during construction and for firefighting and system maintenance. Currently, recycled water is provided for several uses including landscape and agricultural irrigation, fire protection, construction, street sweeping and toilet and urinal flushing. In 2020, the Livermore Water Reclamation Plant (WRP) distributed approximately 2,270 AF of recycled water, with 2,180 AF used within the Livermore Municipal Service Area.

In 1995, DSRSD and EBMUD, a major water and wastewater retailer serving a portion of San Ramon, formed a JPA called the "DSRSD-EBMUD Recycled Water Authority" (DERWA). This entity operates the San Ramon Valley Recycled Water Program (SRVRWP), which supplies recycled water to portions of DSRSD's and EBMUD's service areas. Through DERWA's SRVRWP, DSRSD began supplying tertiary-treated water (sand filtration or microfiltration followed by UV disinfection) in 2006 for landscape irrigation. In 2015, Pleasanton entered into an agreement with DERWA for purchase of recycled water for its service area. In 2020, DERWA supplied approximately 4,270 AF of recycled water combined to DSRSD's and Pleasanton's service area. By 2040, it is estimated that DERWA will serve approximately 3,040 AF to DSRSD and 1,800 AF to Pleasanton, for a total of 4,840 AF of recycled water. Within Zone 7's service area, existing uses for recycled water include landscape irrigation, fire protection, commercial/industrial use, golf course irrigation, and construction.

6.2.6.4 Potential, Current, and Projected Recycled Water Uses

Zone 7 does not handle recycled water, so Table 6-7 and Table 6-8 are intentionally blank. Further details regarding recycled water use in Zone 7's service area can be found in the 2020 UWMPs of Livermore, Pleasanton, and DSRSD.

Table 6-7. Current and Projected Retailers Provided Recycled Water Within Service Area (DWR Table 6-4 Wholesale)

☑	Recycled water is not directly treated or distributed by the Supplier. The Supplier will not complete the table below.						
Name of Receiving Supplier or Direct Use by Wholesaler	Level of Treatment *Drop down list*	2020*	2025*	2030*	2035*	2040*	2045* *(opt)*
	Total	0	0	0	0	0	0
*** Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.							

Table 6-8. 2015 UWMP Recycled Water Use Projection Compared to 2020 Actual (DWR Table 6-5 Wholesale)

☑	Recycled water was not used or distributed by the supplier in 2015, nor projected for use or distribution in 2020. The wholesale supplier will not complete the table below.	
Name of Receiving Supplier or Direct Use by Wholesaler	2015 Projection for 2020*	2020 Actual Use*
Total	0	0
***Units of measure (AF, CCF, MG)** *must remain consistent throughout the UWMP as reported in Table 2-3.*		

6.2.7 Desalinated Water

Opportunity for a desalinated water project is available to Zone 7 through the Bay Area Regional Desalination Project (BARDP), a joint effort with CCWD, EBMUD, San Francisco Public Utilities Commission (SFPUC), Zone 7, and VW. The BARDP involves constructing a regional brackish water treatment plant in eastern Contra Costa County. Previous studies assumed that Zone 7 could receive up to a 5,600-AFY share from the BARDP; the estimated Zone 7 water yield from this project will be refined further and will depend on project yield and demands from the final participants. The project is still in the planning phase and there is no formally approved project at this time. If a project is approved, it could be in service by 2030. The project is detailed in Section 6.2.9.1.1.

As noted in Section 6.2.2, Zone 7 desalinates a portion of its groundwater.

6.2.8 Water Exchanges and Transfers

Zone 7 periodically supplements existing supplies with short-term transfers when needed and intends to more regularly acquire water transfers over the coming decade until major supply reliability project(s) come online starting around 2030. The proposed water transfers include water from the Yuba Accord and the Dry Year Transfer Program (DYTP) administered by the SWP contractors but could also include transfer agreements between Zone 7 and other SWP contractors and potentially Zone 7 and other water purveyors. The DYTP coordinates and negotiates water sales between interested SWP contractors and sellers in the Feather River watershed. A transfer agreement with another SWP contractor using the SWP system—which Zone 7 is already invested in—is likely the most expedient and cost-effective transfer option. Transfer water would be conveyed to Zone 7 through the Delta and the SBA; the transfer amount could vary from year-to-year depending on hydrology but could average between 5,000 to 10,000 AFY. For the 2020 UWMP, ***Zone 7 is assuming 5,000 AFY in water transfers through 2030***.

Zone 7 will continue to pursue and evaluate transfer opportunities in the Bay Area and statewide. Through the Bay Area Regional Reliability Partnership, Zone 7 is participating in a reclamation grant-funded project to develop a "Regional Water Market Program," which will identify transfer types and opportunities and develop a road map to facilitate transfers and exchanges in the Bay Area. The Delta Conveyance Project, discussed in Section 6.2.9.1.2, may also create opportunities for long-term water transfers between SWP contractors across the state.

6.2.9 Future Water Projects

Zone 7 anticipates future supply deficits as SWP reliability continues to decline and Zone 7's service area population grows. As a result, Zone 7 is pursuing several water supply reliability projects to obtain additional water storage and water supplies, address the need for alternative conveyance in the Delta, and improve access to groundwater and local emergency supplies. The 2019 WSE Update evaluated potential future water projects and their impacts on the reliability of Zone 7's water supply system. Zone 7 expects that a portfolio (likely a subset) of these projects will be needed to address future supply deficits; these projects are described below.

6.2.9.1 Supply Projects

6.2.9.1.1 Bay Area Regional Desalination Project (BARDP)

Brackish water desalination for Zone 7 would be accomplished through the BARDP. The project is shown on Figure 6-5 and would involve constructing a regional brackish water treatment plant in eastern Contra Costa County producing 10-20 MGD. Water would be diverted using CCWD's Mallard Slough Pump Station. Using an existing water right license and permit, both held by CCWD, and/or a new water right, Zone 7 could potentially receive up to 5,600 AFY. Zone 7 could take delivery of this new water supply through a reliability intertie with EBMUD or through the Delta/SBA by exchanging water with CCWD. Furthermore, this project could potentially provide a new water supply component for the Los Vaqueros Reservoir Expansion (LVE) project and make use of LVE's additional storage and new conveyance facilities.

There has been recent renewed interest in desalination as part of the Bay Area Regional Reliability Partnership, and there may be new developments in the near-term. The water yield of the project is being re-evaluated, and the participating agencies may change. As noted in Section 6.2.7, BARDP is still in the planning phase, and there is no formally approved project at this time. If a project is approved over the next few years, it could be in service by 2030.

For the 2020 UWMP, 5,000 AFY was assumed as the total potential yield from BARDP and/or potable reuse (described in Section 6.2.9.1.3) with either or both systems operational by 2030. As noted above, BARDP water could potentially be conveyed through a new intertie supplying the west side of Zone 7's transmission system. This mode of delivery provides an alternative conveyance not subject to Delta outages.

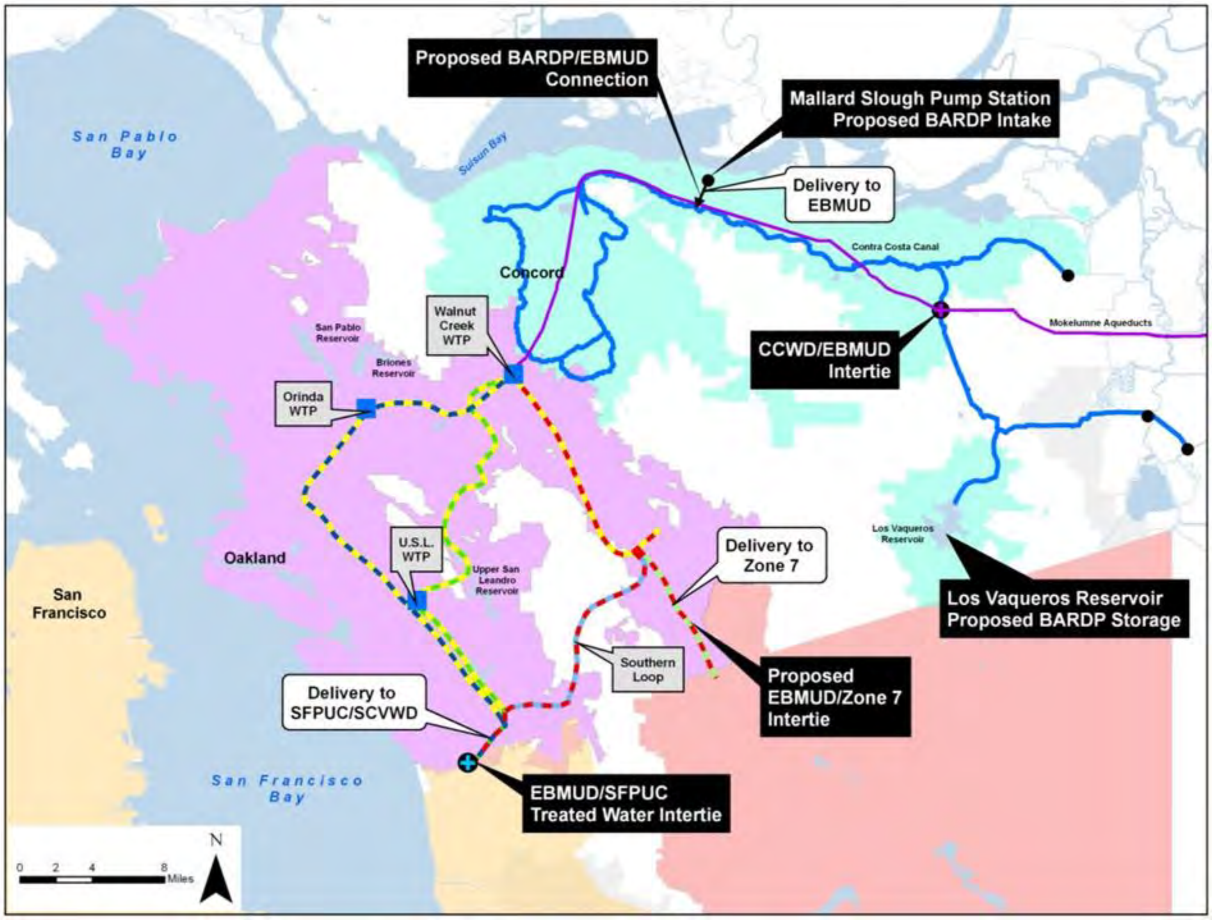


Figure 6-5. Bay Area Regional Desalination Project: Diversion and Conveyance Facilities

6.2.9.1.2 Delta Conveyance Project

Accounting for imported and local surface water, the retailers' GPQs, and recycled water, the Tri-Valley area receives approximately 70 percent of its incoming water supplies through the Delta as delivered by DWR. For Zone 7, the Delta conveys about 90 percent of its existing incoming supplies under normal conditions. SWP water, carryover water, water banked in Kern County and transfer water all come through the Delta.

This key conveyance component of the SWP is increasingly threatened by ecosystem considerations, seismic risk, and climate change/sea level rise, reducing the reliability of the SWP system. DWR's proposed Delta Conveyance Project (DCP) would install a new tunnel to convey freshwater from north of the Delta to a point south of the Delta. The DCP will likely increase SWP reliability and improve water quality, but an alternate conveyance system for the majority of Zone 7's water is the significant benefit as follows:

- A major Northern California earthquake could take out levees in the Delta. Experts suggest that fresh water supply through the Delta could be lost for months, if not a year or two. The DCP would provide an alternative conveyance of freshwater from north of the Delta (near Sacramento) to a point south of the Delta (near Byron) while levee repairs and other work are being completed.

- The South Delta is currently about 3 feet above sea level, while the North Delta is about 15 feet above sea level. Climate change projections call for sea level rise of 5 to 10 feet. This could render the South Delta unusable for portions of the year due to saltwater intrusion. The DCP would provide an alternative conveyance of freshwater from north of the Delta to a point south of the Delta when the Delta is too saline.

In July 2017, DWR approved the California WaterFix Project, which was a dual conveyance project that involved two new diversion points and two tunnels moving water from the Sacramento River north of the Delta under the Delta to SWP and Central Valley Project water pumping facilities in the South Delta. In the State of the State address in January 2019, Governor Newsom announced that he did not support WaterFix as configured but that he did support a single-tunnel conveyance project.

In January 2020, DWR released a Notice of Preparation (NOP) of an Environmental Impact Report (EIR) pursuant to CEQA for the DCP. Note that the DCP is part of Governor Newsom's portfolio approach to water management. While the proposed project in the DCP is a single tunnel up to 6,000 cubic feet per second (cfs), DWR is considering alternatives including capacities ranging from 3,000 to 7,500 cfs. Anticipated benefits include: 1) water supply reliability and SWP resiliency (climate change adaptation/stormwater capture, sea-level rise adaptation, seismic resilience), 2) South Delta flow pattern improvements for fisheries, 3) water transfer capacity and carriage water savings, and 4) water quality improvements for SWP deliveries. Potential DCP facilities are shown on Figure 6-6.

As described in Section 6.2.1.1.2.1, Zone 7 has a long-term contract with DWR for a Table A amount of 80,619 AFY from the SWP, but SWP reliability has decreased significantly over the years. Estimates of SWP reliability (i.e., projected long-term average of Table A allocations) have been adjusted over the years as they account for changing regulatory and operational conditions, among other factors. The 2019 DCR estimates SWP reliability to decrease from an average Table A allocation of 59 percent in 2020 to 54 percent Table A in 2040. The potential increase in SWP reliability from the DCP has not been incorporated in the 2019 DCR and will be evaluated once the project and its operational and permitting terms are better defined.

As described above, the DCP will protect the reliability of SWP supplies from the effects of climate change and seismic events, among other risks. DWR's current schedule for the DCP environmental planning and permitting extends through the end of 2024. The DCP will potentially be operational in 2040 following extensive planning, permitting, and construction. ***Since the DCP is not anticipated to be in service until the end of the 2020 UWMP planning period, its impacts on supply have not been incorporated in DWR's 2019 DCR and have not been included in this plan.*** With permitting efforts over the next few years, quantitative information on the reliability associated with the DCP will be included in the 2025 UWMP.

Through mid-2024, DWR will be completing environmental planning efforts on the DCP. In November 2020, the Zone 7 Board approved continued participation in the DCP at a 2.2 percent participation level based on Zone 7's Table A amount of 80,619 AF. The Board also approved Zone 7 funding of these efforts up to $2,800,000 for calendar years 2021 and 2022. A separate future request for Zone 7 Board action would address participation and funding beyond 2022.

Continued participation by Zone 7 in the planning efforts will allow Zone 7 to elect to participate in the DCP implementation in the future based on information developed in the planning process, allow access by Zone 7 to information related to benefits and costs, and provide Zone 7 influence throughout the process. The work over the next two to four years will inform the Zone 7 Board's decision-making as the DCP continues to advance.

As a contractor of the SWP, Zone 7 is working very closely with DWR and other water agencies, environmental groups, regulatory agencies, and natural resource agencies to address the declining reliability of the SWP through the DCP and other efforts. More details on the challenges faced by the Delta and the SWP can be found in Chapter 7 (Section 7.1.1.1).

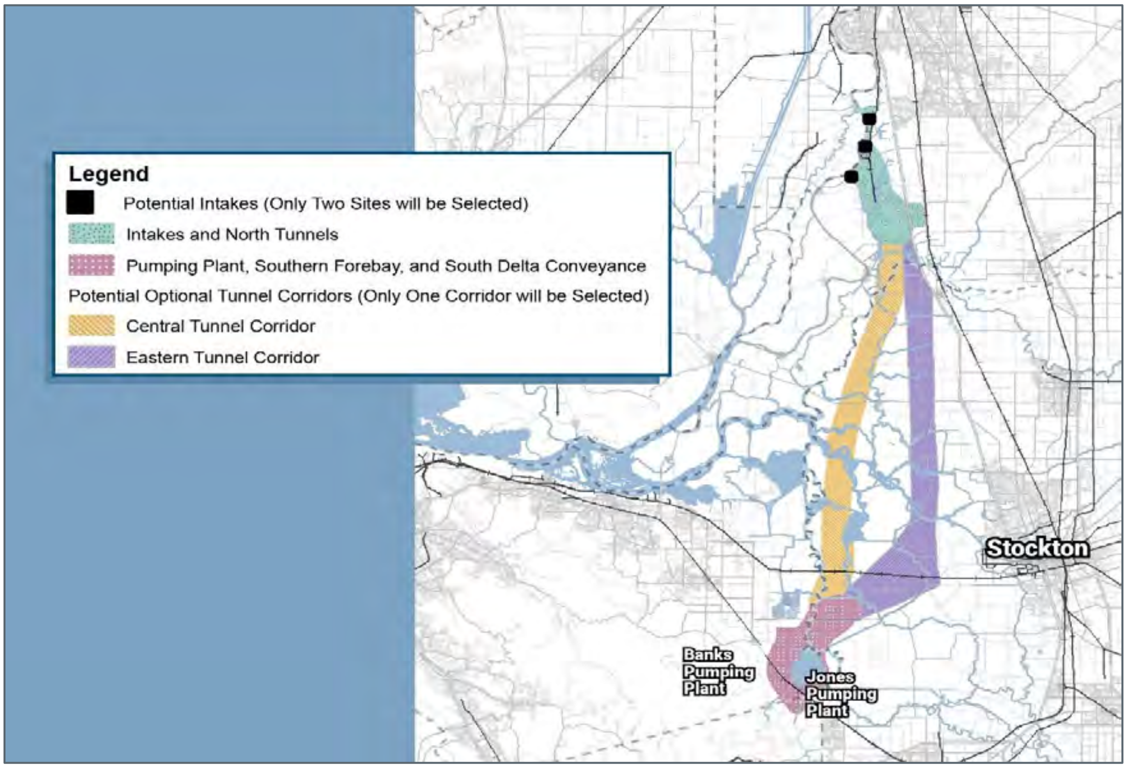


Figure 6-6. Delta Conveyance Project: Potential Facilities

6.2.9.1.3 Potable Reuse

Potable reuse is the use of purified water derived from wastewater effluent to supplement potable water supplies. While recycled water, the use of treated wastewater for non-potable uses such as irrigation, has been available for many years in the Tri-Valley, potable reuse would be a new use of local wastewater resources collected by DSRSD and Livermore. Its main benefits include local production and control, drought resistance, and use of an existing water resource.

In 2018, the Tri-Valley Water Agencies completed the Joint Tri-Valley Potable Reuse Technical Feasibility Study[15] (Potable Reuse Study) with these goals: 1) to evaluate the feasibility of a wide range of potable reuse options for the Tri-Valley based on technical, financial, and regulatory considerations, and 2) assuming that potable reuse is found to be technically feasible, to recommend next steps for the agencies. The Potable Reuse Study also refined cost estimates for potable reuse.

The Potable Reuse Study investigated three potential end uses for purified water in detail: 1) groundwater augmentation or recharge via injection wells, 2) groundwater recharge via Chain of Lakes surficial recharge, and 3) raw water augmentation to Zone 7's Del Valle Water Treatment Plant. Looking at annual

[15] Tri-Valley Agencies and Carollo Engineers, *Joint Tri-Valley Potable Reuse Technical Feasibility Study*, May 2018.

yields ranging from 5,500 to 10,000 AFY, the Potable Reuse Study concluded that potable reuse is technically feasible for the Tri-Valley, with benefits to reliability and water quality. The lower yield would use only Livermore wastewater supply with year-round operations, while the higher yield would be achieved with seasonal availability of DSRSD wastewater supply. Water availability would increase over time as development occurs in the Tri-Valley and more wastewater is generated and collected. In other words, the maximum yield is expected to only be available after a certain point in the future; only a fraction of the maximum yield is available before buildout.

In the 2019 WSE Update, raw water augmentation was modeled with the option for a two-phased project that initially produces a lower yield but increases to the maximum yield in 2035 (following a growth in available wastewater). Reflecting a more conservative estimate of future wastewater availability, the 2019 WSE Update used a reduced yield of 4,000 AFY starting in 2027 and 7,000 AFY after 2035. Conservation regulations have set low indoor water use targets for California, which are expected to reduce future wastewater flows. The estimates in the Potable Reuse Study had not incorporated the recently set statewide indoor water use targets. Future analyses will adjust estimates as necessary based on actual indoor water use trends and updated projections of wastewater availability for potable reuse.

Zone 7, along with the retailers, are completing a number of technical studies over the next few years that will support continued evaluation of potable reuse options and their costs and benefits. ***For planning purposes, the 2020 UWMP assumes 5,000 AFY of future supply from BARDP (discussed in Section 6.2.9.1.1) and/or potable reuse, with either or both systems online by 2030.***

6.2.9.1.4 Sites Reservoir

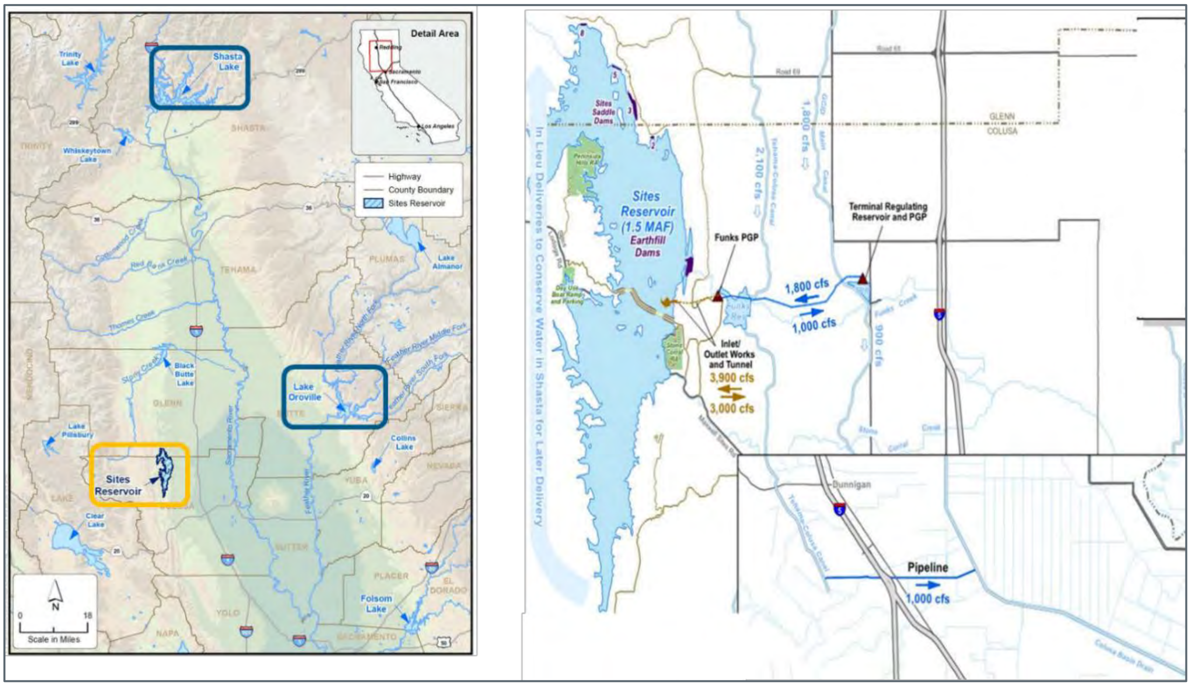
Sites Reservoir is a proposed new 1,500,000 AF off-stream storage reservoir in northern California near Maxwell. Sacramento River flows will be diverted during excess flow periods and stored in the off-stream reservoir and released for use in the drier periods. Shown on Figure 6-7, Sites Reservoir aims to supplement and optimize use of the State’s existing storage and conveyance systems such as the CVP’s Shasta Reservoir and the SWP’s Oroville Reservoir, which collects much of the water for the SWP system.

The participants in the Sites Reservoir project include 31 entities, including Zone 7 and several other SWP contractors. Sites Reservoir is currently undergoing environmental planning and permitting and is expected to provide approximately 240 TAF per year[16] of additional deliveries on average to participating agencies under existing conditions. Operations modeling will continue to be refined over the next few years to reflect a range of permit and operational conditions, which will define the ultimate yield. For example, it is uncertain at this time whether the delivery of Sites Reservoir releases using SWP facilities in the Delta could result in a “carriage loss,” which would reduce the net yield to Zone 7 and other SWP contractors. Full operation of the Sites Reservoir is estimated to start by 2029 following environmental planning, permitting, and construction.

Sites Reservoir is expected to provide water supply, environmental, flood, and recreational benefits. Consequently, Sites Reservoir was conditionally awarded $816 million from the California Water Commission for ecosystem, recreation, and flood control benefits under Proposition 1. The US Bureau of Reclamation (Reclamation) may also invest in Sites Reservoir under the Water Infrastructure Improvements for the Nation Act and recently transmitted a final Federal Feasibility Report to Congress for the project.

[16] Sites Project Management Team, 2020. Sites Project Value Planning Alternatives Appraisal Report.

The Sites Project Authority (Authority) was formed on August 26, 2010 as a JPA to pursue the development and construction of Sites Reservoir. The Authority is governed by a 12-member Board of Directors representing Sacramento Valley leadership in government and water management. Water agencies across California—including Zone 7—that are investing in the project are members of the Sites Reservoir Project Committee, which oversees the planning efforts and provides recommendations to the Authority.



Source: Sites Project Authority

Figure 6-7. Sites Reservoir Project: Location and Facilities

Sites Reservoir could provide both water supply and storage for Zone 7. In December 2016, the Zone 7 Board authorized participation in Phase 1 at a cost of $850,000. In December 2019, the Zone 7 Board authorized participation in Phase 2 (2019 Sites Reservoir Project Agreement) at a cost of $600,000. The Zone 7 Board then approved continued participation in Phase 2 through December 2021 at an amount not-to-exceed $1,000,000 in July 2020. Key work under these two phases include planning, design, financial analysis, and environmental review and permitting.

In the 2019 WSE Update, Zone 7 considered 5,000 to 10,000 AFY of average yield from Sites Reservoir, in combination with other water supply options. The availability of this supply was varied based on hydrology, with more water delivered to Zone 7 during dry years. At Zone 7's request, water would be released from Sites Reservoir annually to the Sacramento River, then conveyed by the SWP system through the Delta and to the SBA. Based on model results, Sites Reservoir's key benefit is the availability of water during dry years when the shortage risk is greatest. Sites Reservoir is a good complement to the DCP, which could potentially increase SWP yield during wet years. Because Sites Reservoir provides both storage and new supply, it adds flexibility to Zone 7's water supply system; for example, the timing of deliveries from Sites Reservoir could be modified to maximize yields from other water supplies and/or to accommodate delivery timing restrictions of other supplies. For Zone 7, water could be released from Sites Reservoir annually to the Sacramento River, generally during dry and critical years, then conveyed by the SWP system through the Delta and to the SBA.

Recently, the Zone 7 Board re-affirmed continued participation in Sites Reservoir at a 10,000 AFY share. ***This plan therefore assumes an average water supply of 10,000 AFY to Zone 7 from Sites Reservoir.***

6.2.9.2 Storage Project – Los Vaqueros Reservoir Expansion (LVE)

Constructed in 1997, Los Vaqueros Reservoir is an off-stream reservoir owned by CCWD and located in southeastern Contra Costa County (see Figure 6-8). It currently has a capacity of 160,000 AF following its expansion (Phase 1) from 100,000 AF in 2012. CCWD is planning to further expand the reservoir to 275,000 AF (Phase 2) and construct the Transfer-Bethany Pipeline, which would connect the reservoir to the SBA and the California Aqueduct. The LVE's key objectives are to: 1) develop water supplies for environmental water management, and 2) increase water supply reliability for Bay Area water agencies. In addition, the LVE would improve water quality for municipal and industrial customers in the San Francisco Bay Area while providing improved habitat and recreation and flood control benefits.

Recognizing LVE's potential benefits as emergency conveyance and storage, the Zone 7 Board approved participation in the Los Vaqueros Reservoir Expansion Project Planning in September 2016, with a $100,000 cash contribution. In January 2019, the Zone 7 Board approved continued participation in the project's planning activities through execution of the Multi-Party Agreement in an amount not-to-exceed $355,000. In August 2020, the Zone 7 Board approved continued participation in the LVE Multi-Party Agreement through December 2021 at a cost up to $1.014 million.

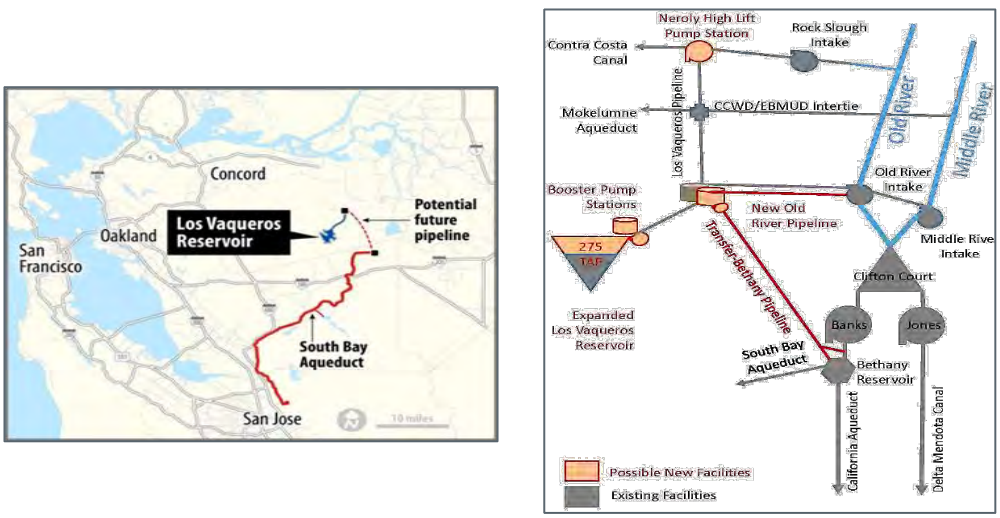


Figure 6-8. Los Vaqueros Reservoir: Location and Facilities (Source: CCWD)

Under the LVE, water would be diverted from the Delta at CCWD's Rock Slough, Old River, and Middle River Intakes, and at the Freeport Intake on the Sacramento River. This water could then be delivered to agencies within CCWD's service area, the Bay Area, the Delta, neighboring regions, and the south-of-Delta wildlife refuges. Under existing and new water right and permit conditions, CCWD would be able to divert different types of water, including: Delta surplus water under CCWD's Los Vaqueros water right, Central Valley Project water, SWP water, Mokelumne River water, and other water acquired by project partners through transfer agreements. Existing and new facilities would be used to store and convey water under the LVE (Figure 6-8).

Water could be stored in Los Vaqueros Reservoir for later use or delivered directly to partners. Potential LVE participants envision different operational schemes for the reservoir and associated facilities, and these various scenarios are continuing to be evaluated through modeling by CCWD staff. While some new water supply may be available from LVE, Zone 7 is primarily evaluating the project as storage due to the uncertainty of the availability of such supplies given increasing Delta restrictions. The 2019 WSE Update assumed emergency storage in Los Vaqueros Reservoir at 10,000 AF.

In 2017, CCWD and Reclamation completed the Draft Supplement to the Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the LVE. The project was successfully selected for funding under the State's Water Storage Investment Program (WSIP) in July 2018 of up to $459 million based on its environmental and other public benefits. Reclamation also contributes to LVE costs, which are estimated to total $1.1 billion. Reclamation and CCWD published final environmental documents for the LVE in February 2020. A JPA is planned to be formed in spring 2021 to oversee project planning, design, and operation. Work is proceeding on the project's design, engineering, environmental and other permitting, financial analysis, and operations planning. The Transfer-Bethany Pipeline is scheduled for completion by around 2025 and the expanded reservoir by around 2030.

6.2.9.3 Infrastructure Projects

6.2.9.3.1 Chain of Lakes (COLs) Diversion Structures and Pipeline

The future Chain of Lakes (COLs), shown on Figure 6-9, is a series of former or active gravel quarry pits located in the heart of the Livermore-Amador Valley. The COLs will ultimately consist of ten lakes named Lakes A through I and Cope Lake, connected through a series of conduits. Zone 7 currently owns Lake I and Cope Lake and expects Lakes A and H to be transferred to Zone 7 within the next few years, once reclamation is completed. The remaining lakes (B through G) will be transitioned to Zone 7 over the next decades, likely through 2060. The COLs will ultimately cover approximately 1,500 acres and have about 150,000 AF of total storage volume; 31,000 AF is estimated to be available for operational storage.

Zone 7 envisions using the COLs as a large facility for water management and related purposes, including surface storage of local runoff, SWP water, other potential future sources of surface water, stormwater, and, possibly recycled water. This surface water storage capability allows Zone 7 to facilitate increased recharge of the Main Basin and perfect its water right on the Arroyo Valle, thereby increasing future yields from this local supply. Lake I is currently planned to be the key recharge lake. More details on the potential future use of the COLs can be found in the 2020 Update of the Preliminary Lake Use Evaluation for the Chain of Lakes[17].

Zone 7 is also planning the Chain of Lakes Pipeline, a multi-use pipeline that will connect the northern COLs area with Lake A and the SBA/DVWTP. The concept of the pipeline is to convey excess surface water supply—including imported water and local water from the Arroyo Valle—to the COLs for storage and groundwater recharge. The pipeline will also supply raw water from the COLs to the DVWTP for use under emergency and drought situations. A pipeline alignment study is underway and scheduled for completion in 2021. Design of this pipeline will consider future facilities and potential uses of the lakes.

[17] Zone 7 Water Agency, 2020. Addendum 1 – 2020 Update Preliminary Lake Use Evaluation for the Chain of Lakes.

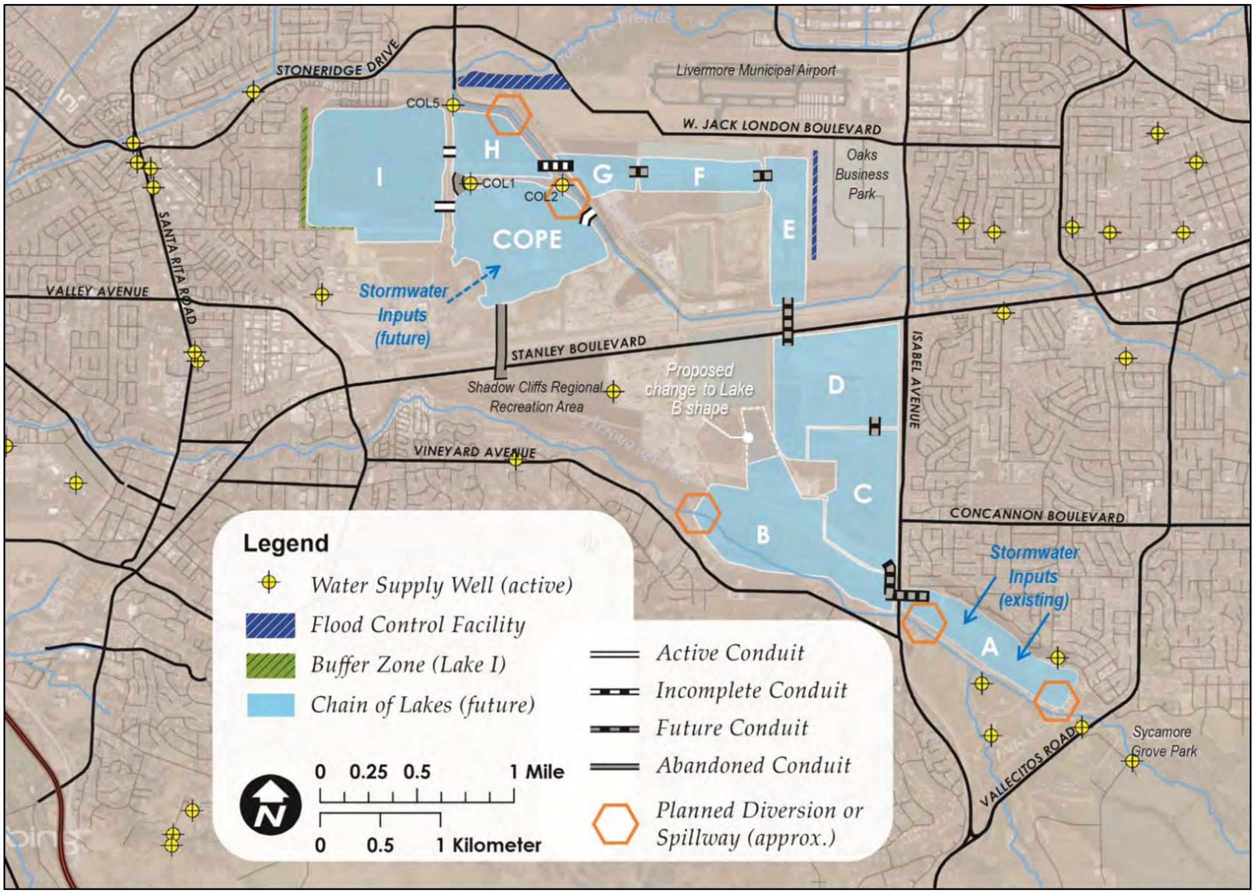


Figure 6-9. Chain of Lakes: Existing and Planned Facilities

6.2.9.3.2 New Wells

Additional municipal water supply wells could maximize access to existing local storage in the Main Basin during droughts and facility outages. These wells would be constructed in the Chain of Lakes (two wells, 8.6 MGD), Busch Valley wellfield (one well, 2.9 MGD), and the Bernal wellfield (3.6 MGD), resulting in about 15 MGD of additional capacity. New wells are planned to be in-service incrementally over the next ten to fifteen years.

6.2.9.3.3 Reliability Intertie with EBMUD

Zone 7 is planning to construct a 30-inch diameter treated water pipeline connection with EBMUD on the west side of Zone 7's transmission system. This reliability would provide an additional or alternative means of delivering water to Zone 7 during Delta and/or SBA outages and is planned to be in service by around 2030.

6.2.9.4 Summary of Future Water Projects

Table 6-9 summarizes Zone 7's potential future water supply projects, including planned implementation schedule, use conditions, and expected increase in supply. Other projects detailed above either do not increase incoming supply (groundwater wells and EBMUD intertie) or are too preliminary to quantify additional supply at this time (DCP, COLs, and LVE).

Table 6-9. Expected Future Water Supply Projects or Programs (DWR Table 6-7 Wholesale)

☑	Some or all of the supplier's future water supply projects or programs are not compatible with this table and are described in a narrative format.					
6-21 through 6-30	Provide page location of narrative in the UWMP					
Name of Future Projects or Programs	Joint Project with other suppliers?		Description *(if needed)*	Planned Implementation Year	Planned for Use in Year Type *Drop Down list*	Expected Increase in Water Supply to Supplier*
	Drop Down Menu	*If Yes, Supplier Name*				
Bay Area Regional Desalination Project	*Yes*	Contra Costa Water District, SFPUC, Santa Clara Valley Water District	Brackish water desalination in eastern Contra Costa County	2030	All Year Types	5,600
Delta Conveyance Project	*Yes*	Department of Water Resources and other SWP contractors	Construction of new intakes and tunnel as part of the State Water Project	2040	All Year Types	TBD
Los Vaqueros Reservoir Expansion	*Yes*	Contra Costa Water District, and a number of Bay Area M&I water agencies plus Grassland Water District and San Luis & Delta-Mendota Water Authority.	Expansion of Los Vaqueros Reservoir and construction of the Transfer-Bethany Pipeline, which would connect the reservoir to the South Bay Aqueduct and California Aqueduct	2025 (Pipeline) and 2030 (Reservoir Expansion)	Dry Years	TBD
Potable Reuse	*Yes*	Livermore, DSRSD, Pleasanton, Cal Water	Use of purified water derived from wastewater effluent to supplement potable water supplies	2030	All Year Types	4,000-7,000
Sites Reservoir	*Yes*	Sites Project Authority and Sites Reservoir Project Committee members	Construction of a new 1.5 million AF off-stream reservoir in Colusa County	2030	All Year Types	10,000
SWP Transfers	*Yes*	Other SWP contractor/s	Temporary water transfer agreement/s until major projects are implemented	2021	All Year Types	varies
***Units of measure (AF, CCF, MG)** *must remain consistent throughout the UWMP as reported in Table 2-3.*						
NOTES: Volumes are in AF. These projects are in the conceptual or planning stages. Zone 7 is participating in the planning efforts of these potential future water supply and/or storage projects to evaluate their benefits, including water supply yield. Implementation of these projects has not been approved by the Zone 7 Board but it is expected that a subset of these projects will be needed to meet future water demands and increase the reliability of Zone 7's system. The partners listed above are potential partners; final participation will be determined when the project has been approved by the respective agencies' governing boards. The 'expected increase in water supply...' are estimates at this time and may need to be adjusted when a final project has been approved. The 'planned implementation year' may also vary depending on project progress.						

6.2.10 Summary of Existing and Planned Sources of Water

Each year, Zone 7 provides a status report of water in storage and available water for use during the upcoming five years. An example of the data presented in this Annual Review of Sustainable Water Supply is contained in Table 6-10 and Table 6-11, which show Zone 7's existing water storage volumes and actual supply sources for 2020.

Table 6-10. Zone 7's 2020 Water Storage and Operational Storage Capacity

Storage Option		Water in Storage through December 2020, AF	Operational Storage Capacity, AF
Local	Lake Del Valle	0	7,500
	Main Basin	115,000	126,000
Non-Local Groundwater Banks	Semitropic	86,230	78,000
	Cawelo	29,900	120,000
Other Non-Local	SWP - Carryover	0	Varies
	Total	**231,130**	**At least 331,500**

Table 6-11. 2020 Water Supplies Actual (DWR Table 6-8 Wholesale)

Water Supply	Additional Detail on Water Supply	2020		
Drop down list May use each category multiple times.These are the only water supply categories that will be recognized by the WUEdata online submittal tool		Actual Volume*	Water Quality Drop Down List	Total Right or Safe Yield* (optional)
Add additional rows as needed				
Purchased or Imported Water	SWP Table A	16,124	Other Non-Potable Water	
Purchased or Imported Water	Yuba Accord	2,100	Other Non-Potable Water	
Purchased or Imported Water	Water Transfer	5,000	Other Non-Potable Water	
Supply from Storage	SWP Carryover	10,800	Other Non-Potable Water	
Groundwater (not desalinated)	Main Basin	12,000	Other Non-Potable Water	
Surface water (not desalinated)	Arroyo Valle	8,700	Other Non-Potable Water	
Supply from Storage	Non-Local Storage	1,000	Other Non-Potable Water	
	Total	55,724		0

****Units of measure (AF, CCF, MG)* *must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF. These amounts reflect net yield for Yuba Accord and groundwater (i.e., they do not include carriage loss from Yuba Accord [900 AF] and brine disposal from groundwater production [400 AF]). Arroyo Valle supply includes carryover from 2019 (8,100 AF) and 2020 yield (600 AF).

Table 6-12 summarizes Zone 7's average projected water supplies available during a normal hydrologic water year. Under dry, drought, or emergency conditions, the percentage distribution of sources used by Zone 7 to meet demands may shift; in particular, Zone 7 is likely to tap into water stored in the various storage facilities listed in Table 6-10. Note, however, that even under normal water supply conditions, water from storage—particularly SWP carryover and local groundwater—is a key component of Zone 7's operations.

As shown in Table 6-12, it was assumed that the BARDP and/or potable reuse would provide approximately 5,000 AFY. Both desalination and potable reuse are considered drought-resistant water supplies. Sites Reservoir would provide 10,000 AFY of new supply. At this time, no additional yield has been included for the DCP; this will be revisited when the project is better defined. In the interim, water transfers would provide 5,000 AFY on average, until major water supply projects come online around 2030. Table 6-12 also shows that Zone 7's total projected normal year water supplies range from 76,700 AF in 2025 to 90,700 AF in 2030 and down to 83,200 AF at buildout around 2040.

Table 6-12. Water Supplies Projected (DWR Table 6-9 Wholesale)

Water Supply	Additional Detail on Water Supply	**Projected Water Supply*** Report To the Extent Practicable				
		2025	**2030**	**2035**	**2040**	**2045** (opt)
Drop down list May use each category multiple times. These are the only water supply categories that will be recognized by the WUEdata online submittal		Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume
Purchased or Imported Water	SWP Table A[a]	47,000	46,000	45,000	43,500	43,500
Purchased or Imported Water	Yuba Accord (available mainly in dry years)	0	0	0	0	0
Supply from Storage	SWP Carryover[b]	10,000	10,000	10,000	10,000	10,000
Surface water (not desalinated)	Arroyo Valle[c]	5,500	5,500	5,500	5,500	5,500
Groundwater (not desalinated)	Main Basin	9,200	9,200	9,200	9,200	9,200
Supply from Storage	Semitropic (used mainly in dry years)	0	0	0	0	0
Supply from Storage	Cawelo (used mainly in dry years)	0	0	0	0	0
Other	SWP/Other Transfer[d]	5,000	5,000			
Other	BARDP or Potable Reuse[e]		5,000	5,000	5,000	5,000
Purchased or Imported Water	Sites Reservoir[f]		10,000	10,000	10,000	10,000
	Total	76,700	90,700	84,700	83,200	83,200

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF.
a. Based on the 2019 Delivery Capability Report. "Existing" assumed for 2020, the "Future" applied to 2040; years in between were interpolated. The effect of the Delta Conveyance Project on water supply yield is still being analyzed and has not been included here.
b. Zone 7 regularly carries over SWP water from year to year, targeting approximately 10,000 AFY.
c. Arroyo Valle: From 2019 Water Supply Evaluation, observed ten-year (2008 to 2017) average was 6,200 AFY, reduced to 5,500 AFY to reflect climate change impacts. This will be refined as more information on the role of the Chain of Lakes on capturing Arroyo Valle water is developed over the coming years.
d. Zone 7 is pursuing water transfer agreements for the period through 2030.
e. These projects are under consideration as potential components of Zone 7's future water supply portfolio.
f. Zone 7 is currently participating in the planning phase of Sites Reservoir at a level of 10,000 AFY of average yield.

6.2.11 Climate Change Impacts

Since the SWP is the main source of Zone 7's water supplies, climate change impacts to the SWP will significantly impact Zone 7. As shown in Table 6-12, supplies derived from the SWP, including Table A deliveries, groundwater (i.e., stored SWP water), and SWP carryover, represent about 90 percent of Zone 7's 2025 supplies. This percentage remains high, with SWP-derived supplies comprising approximately 75 percent of Zone 7's total supplies in 2045. The scenarios in the 2019 SWP Delivery Capability Report that were used for this UWMP account for climate change impacts based on 2035 emissions level and 45 cm sea level rise; therefore, these impacts have been incorporated into Zone 7's water supply planning efforts.

Zone 7 has also evaluated the impacts of climate change to local water supplies (Arroyo Valle) for the 2019 WSE Update, which incorporates a more conservative risk-based analysis; as downscaling of climate change data is refined further, local climate change impacts will continue to be incorporated in future UWMPs.

6.3 ENERGY INTENSITY

In accordance with CWC §10631.2(a), the energy intensity to provide water service to Zone 7's customers over a one-year period is presented in this section to the extent that the information is available. The amount of energy to divert, pump, treat, and distribute the Zone 7's water supply within the system it owns and operates is included. The amount of energy that Zone 7's water retailers require to transport and deliver treated water to their customers are excluded from this plan.

Water energy intensity is the total amount of energy, calculated on a whole-system basis, used to deliver water to Zone 7's customers for use. Energy intensity is the total amount of energy in kilowatt-hours (kWh) expended on a per AF basis to take water from Zone 7's source to its point of delivery. Understanding the whole-system energy intensity would allow Zone 7 to make the following water supply management and system operation strategies:

- Identifying energy saving opportunities as energy consumption is often a large portion of the cost of delivering water;
- Calculating energy savings and greenhouse gas (GHG) emissions reductions associated with water conservation programs;
- Identifying potential opportunities for receiving energy efficiency funding for water conservation programs;
- Informing climate change mitigation strategies; and
- Benchmarking energy use at each water acquisition and delivery step and comparing energy use among similar agencies.

In Table 6-13, the energy intensity of Zone 7's water service is calculated for 2019, as it provides a typical year's energy use. Energy data from 2020 was not used because the COVID-19 pandemic may have altered water use in Zone 7's service area as shelter-in-place and restrictions on businesses went into effect. The total energy intensity for Zone 7's water service is 342 kWh/AF, accounting for facilities under Zone 7's operational control. This represents average energy use and reflects the use of surface water and groundwater in 2019. The breakdown of energy use by Zone 7 was as follows: water treatment plants

(21.3 percent); wells, including treatment (72.4 percent); transmission system (3.2 percent); and offices (3.1 percent).

Groundwater production has a higher intensity than surface water treatment, about 700 kWh/AF versus 100 kWh/AF, because of the energy required to pump water from deep in the groundwater basin. Removal of salts from groundwater using the MGDP also takes a significant amount of energy. While significant energy is used to treat surface water, delivery from the water treatment plants is typically done by gravity (i.e., limited pumping required) because the plants are at a higher elevation than the service area.

Table 6-13. Recommended Energy Intensity – Total Utility Approach: Facilities Under Zone 7's Operational Control (DWR Table O-1B)

		Urban Water Supplier Operational Control		
Enter Start Date for Reporting Period	1/1/2019			
End Date	12/31/2019			
☐ Is upstream embedded in the values reported?		Sum of All Water Management Processes	Non-Consequential Hydropower	
Water Volume Units Used	*AF*	Total Utility	Hydropower	Net Utility
Volume of Water Entering Process (volume unit)		*36,185*	*0*	*36,185*
Energy Consumed (kWh)		*12,377,060*	*0*	*12,377,060*
Energy Intensity (kWh/volume)		*342.0*	*0.0*	*342.0*

Quantity of Self-Generated Renewable Energy

600,000 kWh

Data Quality *(Estimate, Metered Data, Combination of Estimates and Metered Data)*

Metered Data

Data Quality Narrative:

Water production and energy consumption data are based on metered data collected and provided by Zone 7.

Narrative:

Zone 7's water management processes that consume energy include raw water treatment; groundwater pumping, recharge, and treatment; and treated water pumping.

Note, however, that importing surface water into the Tri-Valley and into the treatment plants (and to the arroyos for recharging the groundwater basin, which Zone 7 eventually pumps as groundwater supply) does require a significant amount of energy. This conveyance of water supply is under DWR's operational control. About 1,165 kWh/AF[18] is consumed to convey water from the Delta into the SBA system and to facilities under Zone 7's operational control. Adding the energy intensity of the conveyance of water to

[18] DWR Bulletin 132-18, Table 7 of Appendix B.

Zone 7's system, the total energy intensity for Zone 7's water supply (i.e., from water sources to Zone 7's transmission system) becomes approximately 1,500 kWh/AF (1,165 + 342).

As discussed in Section 6.2.6, Zone 7 does not provide wastewater collection, treatment, or disposal services in its service area. Nor does it handle recycled water. Thus, Zone 7 has not included energy intensity data for those services.

As discussed in Section 3.3.2, Zone 7 has a solar facility at the DVWTP (which provided about 4 percent of Zone 7's energy supply) and continues to explore ways to increase the renewable energy portion of its energy portfolio. Zone 7 obtains energy from various sources which are already about 90 percent carbon-free and 70 percent renewable.

Sixty percent of the SWP system's energy needs are served by hydropower, a greenhouse gas emission-free energy source. By 2030, DWR, which operates the SWP, will cut its greenhouse gas emissions by 60 percent or more below 1990 levels.

CHAPTER 7
Water Service Reliability and Drought Risk Assessment

This chapter describes Zone 7's water service reliability under various hydrologic conditions, including a severe drought for the next five years. Responses to actual water shortage conditions are addressed in Chapter 8.

To analyze its water service reliability, Zone 7 developed a model that uses probability curves for key water system variables (e.g., rainfall or local runoff). The dynamic model also allows for a year-by-year analysis of water system operations in response to hydrologic conditions (e.g., drought). Originally developed about ten years ago, the Zone 7 Water Supply Risk Model is a powerful tool for water supply decision-making and planning. The model simulates water system behavior and calculates reliability forecasts on an annual time scale using a Monte Carlo technique that generates a range of future water supply conditions, random Delta outage scenarios, and uncertain climate impacts. This allows the model to simulate thousands of possible future scenarios and draw conclusions from the collective results, such as the probability of meeting a target level of reliability in a given year. Data from the 2019 DCR were incorporated into the model to represent latest information on the reliability of the SWP, the source of most of Zone 7's supply. The 2019 DCR includes potential climate change impacts on the SWP system, and the model also reflects potential climate change impacts on Zone 7's local surface water supply. Updated information about water supply projects were incorporated where available.

On October 17, 2012, the Zone 7 Board of Directors approved a revised Water Supply Reliability Policy (Resolution No. 13-4230, included as Appendix F), which adopts the following level-of-service goals to guide the management of Zone 7's treated water supplies and its CIP:

- **Goal 1**: Zone 7 will meet its treated water customers' water supply needs, in accordance with Zone 7's most current Contracts for M&I Water Supply, including existing and projected demands as specified in Zone 7's most recent UWMP, during normal, average, and drought conditions, as follows:
  - At least 85 percent of M&I water demands 99 percent of the time
  - 100 percent of M&I water demands 90 percent of the time
- **Goal 2**: Provide sufficient treated water production capacity and infrastructure to meet at least 80 percent of the maximum month M&I contractual demands should any one of Zone 7's major supply, production, or transmission facilities experience an extended unplanned outage of at least one week.

The water service reliability analysis presented here is based on future water supply options developed to meet the above Zone 7 policy over the long-term.

7.1 WATER SERVICE RELIABILITY ASSESSMENT

This section presents the constraints on Zone 7's existing and planned water sources and describes the historical basis for projecting available supplies in various hydrologic conditions (i.e., normal year, single dry year, and five consecutive dry years). Zone 7's water service reliability is then presented in five-year increments through 2045 based on earlier analysis of water use (discussed in Chapter 4) and supply (Chapter 6). Finally, this section discusses Zone 7's water management tools and options to promote regional supply reliability and minimize the need to import water from other regions.

7.1.1 Constraints on Water Sources

This section discusses the constraints on water supply sources that affect their reliability, and Zone 7's strategies for managing the risks associated with each supply.

7.1.1.1 Imported Water: State Water Project

Constraints on the SWP water supplies, including Delta conveyance, water quality, and SBA conveyance are discussed below.

7.1.1.1.1 Delta Conveyance

Zone 7's long-term contract with DWR for SWP water provides Zone 7 access to Table A water (and Article 56c water or carryover), Article 21 water, Article 56d water, and Yuba Accord water. As an SWP contractor, Zone 7 is also able to use SWP facilities for conveying water transfers or exchanges of SWP water (from another contractor) or from another water agency outside of the SWP system. SWP water moves through the Delta before it is conveyed by the California Aqueduct and the SBA to Zone 7's water facilities.

The instability of the aging levees in the Delta (including their vulnerability to seismic events and climate change), regulatory uncertainty, water quality issues including saltwater intrusion, and the declining health of the Delta ecosystem all challenge the long-term reliability of the SWP and, more generally, the water conveyance capability of the Delta. These issues directly challenge the Tri-Valley's long-term water supply reliability since a majority of Zone 7's water supply is and will continue to be tied to the Delta and SWP system.

In 2018, DWR published their Delta Flood Emergency Management Plan, which provides strategies for responding to Delta levee failures. This plan includes a strategy to establish an emergency freshwater pathway from the central Delta along Middle River and Victoria Canal to the export pumps in the south Delta. The plan also includes the pre-positioning of emergency construction materials at existing and new stockpile and warehouse sites in the Delta. The plan has found that using pre-positioned stockpiles of rock, sheet pile and other materials, multiple earthquake-generated levee breaches and levee slumping along the freshwater pathway can be repaired in less than six months.

The DWR Delta Levees Subventions and Special Projects Programs have prioritized, funded, and implemented levee improvements along the emergency freshwater pathway and other water supply corridors in the central and south Delta. These efforts are complementary to the Delta Flood Emergency Management Plan, which, along with pre-positioned emergency flood fighting materials, ensures reasonable seismic performance of levees and timely pathway restoration after a severe earthquake.

Furthermore, Zone 7 and other SWP contractors are currently working with DWR and other key stakeholders to address the many complex issues undermining the Delta through the proposed DCP. The proposed new diversion structure in the northern Delta provides alternative intakes in case the Delta is affected by an earthquake, levee failure, or some other catastrophic event that impacts water quality and prevents pumping from the Delta. The DCP would also provide alternative intakes that could be used to minimize harm to endangered and threatened species in the Delta. DWR is working closely with regulatory and natural resource agencies to address regulatory uncertainty and protect the Delta ecosystem under an adaptive management framework based on the best available science. With these benefits, the DCP is expected to significantly alleviate constraints on SWP operation and provide more water supply reliability.

Zone 7 is also participating in the LVE project, which includes construction of the Transfer-Bethany Pipeline. This pipeline would provide an alternative means of conveying water supply to Zone 7 when the Delta is inaccessible. More details can be found in Chapter 6 of this plan.

7.1.1.1.2 Water Quality

Until the DCP is constructed and operational, there continue to be water quality concerns associated with transport through the Delta. In 1982, DWR formed the Interagency Delta Health Aspects Monitoring Program to monitor water quality in the Delta and protect human health. The program was renamed the Municipal Water Quality Investigations Program (MWQI Program) in 1990. From a municipal water supply perspective, water quality issues in the Delta are associated with salinity from seawater intrusion, wastewater effluent discharges, agricultural drainages from the islands, and recreational activities. Water quality issues of specific concern to Zone 7 are:

- **Algal byproducts:** Parameters of concern include compounds that cause taste-and-odor (T&O) and algal toxins. T&O is primarily a problem in the warmer months, when algal blooms may be present. It can affect supplies from the Delta and from Lake Del Valle (which stores SWP water). Algae produce geosmin and 2-methylisoborneol (MIB), which are key T&O-causing compounds in surface water supply. Algal toxins derived from blue-green algae can also be a concern. Zone 7's new ozonation facilities (recently installed at the DVWTP and scheduled for completion at the PPWTP in 2022) effectively treat algal byproducts. Without ozonation, high levels of algal byproducts in both Delta and Lake Del Valle supplies may necessitate temporarily switching to groundwater supplies; blending of sources is also an option depending on the source of algal byproducts and severity.
- **Total and dissolved organic carbon (TOC/DOC):** Zone 7 treats organic carbon with coagulant and disinfectant chemicals, and therefore higher levels of organic carbon increase costs. In addition, TOC/DOC help form disinfectant byproducts (DBPs), which are regulated compounds in drinking water. Historically, Zone 7's water treatment plants (WTPs) have managed high TOC/DOC by increasing coagulant dosages. However, this operational change results in greater sludge production and limits plant production. The use of ozone reduces coagulant and chlorine demands, thus reducing typical chlorination DBPs; however, formation of ozonation DBPs such as bromate will need to be controlled.
- **Turbidity:** like TOC/DOC, turbidity affects the amount of chemicals used in treatment and Zone 7's ability to meet drinking water standards. It also can reduce the production capacities of Zone 7's WTPs, requiring increased groundwater production under high demands. Coagulant dosages can be adjusted to address high turbidity (which can happen after big storms), but if filters require more frequent backwashing, then production may be decreased.
- **Salinity or TDS:** salinity has significant impacts on SWP operations and the availability of water. To meet the salinity objectives in the Delta, water exports from the Delta may be restricted, reducing the amount of water supply available during certain times of the year. Salinity intrusion can be a problem during dry years, when there is insufficient freshwater to repel salinity. Sea level rise due to climate change is also expected to increase salinity in Delta. Finally, levee breaks—due to earthquakes and other factors—would result in significant saltwater intrusion from the Bay as water floods affected islands in the Delta that are below sea level.

- **Algal blooms:** in addition to T&O and the threat of algal toxins, algal blooms can significantly degrade filter performance through clogging. Filter clogging reduces plant production capacities and could require supplemental groundwater use.

As noted above, Zone 7 has state-of-the-art ozonation facilities at the DVWTP, and ozonation facilities will be operational at the PPWTP in 2022. Ozonation improves treatment of T&O, TOC/DOC, turbidity, and algal blooms and significantly increasing the surface water system's reliability.

In 2008, the SBA contractors (ACWD, VW, and Zone 7) developed the SBA Watershed Protection Program to protect water quality once the water from the Delta reaches the SBA. The primary objectives of the SBA Watershed Protection Program include developing a Watershed Management Program for the SBA system, including Lake Del Valle and Bethany Reservoir, and protecting local drinking water and water resources from identified contaminant sources (e.g., septic tanks) for urban, agricultural, recreational, and environmental uses.

7.1.1.1.3 SBA Conveyance

One of the main limitations of Zone 7's water system is the lack of interties. All of Zone 7's imported water supplies are conveyed through the Delta and the SBA; Arroyo Valle water is also conveyed through the SBA. Zone 7 has been working closely with DWR, VW, and ACWD to improve the reliability of the SBA. Between 2003 and 2012, DWR made improvements to the SBA within Zone 7's service area to increase capacity and improve reliability. The work included a new pump station (180 cubic feet per second (cfs)) and inline reservoir (500 AF), and increased the canal carrying capacity to 380 cfs. As part of this project, Zone 7 installed an emergency slide gate to maintain service in the event of a pipeline rupture downstream. Zone 7 will continue coordinating with DWR and South Bay Contractors to improve the reliability of the entire SBA system.

In addition, Zone 7 is pursuing the following projects to diversify its conveyance options:

- **Reliability Intertie**: Zone 7 is also planning for the construction of a reliability intertie with another major water agency that would provide an alternative means of conveying water to Zone 7's service area when the Delta and/or the SBA undergo an outage. For example, an intertie with EBMUD could convey treated water supply to the western portion of Zone 7's service area.
- **Chain of Lakes Pipeline**: This pipeline would allow for access to water stored in the Chain of Lakes as an alternative local water supply; water would be accessible to the DVWTP via one of the SBA turnouts.

7.1.1.2 Groundwater

Chapter 6 details the issues affecting Zone 7's use of the Main Basin, specifically water quality management and prevention of overdraft.

Zone 7 is actively implementing its SNMP. Salinity levels are being addressed primarily through groundwater pumping and demineralization using the MGDP in the Mocho wellfield. The facility simultaneously allows for the export of concentrated minerals or salts from the Main Basin while improving the water quality of treated water.

Zone 7 has several groundwater wells with naturally-occurring Cr(VI) concentrations near the MCL and PFAS above the notification limit. In response, Zone 7 is actively managing flows from the affected wells. Conditions are regularly monitored, and management actions may change in the future. A PFAS treatment facility is under consideration for construction based on pending regulations.

Zone 7 continues to study the groundwater basin and develop new tools (e.g., an improved groundwater model) to better understand the levels of groundwater extraction possible under various conditions while maintaining levels above the historical levels that have been reached in certain portions of the Main Basin ("historic lows"). Zone 7 also plans to augment its ability to recharge the Main Basin (e.g., through the COLs) to increase local storage and allow for more pumping when necessary. Recharging the Main Basin will improve both water supply reliability and salt management. Zone 7 plans to build an additional demineralization facility to continue to decrease the salt content of the Main Basin.

Finally, Zone 7 plans to build additional wells to allow for improved management of groundwater levels and to increase groundwater production capacity during droughts and surface water-related outages. A new booster pump station will improve Zone 7's ability to convey groundwater throughout Zone 7's service area and increase production capacity.

7.1.1.3 Arroyo Valle and Lake Del Valle

ACWD and Zone 7 both have water rights to divert water from the Arroyo Valle. This water is captured and stored in Lake Del Valle, which is owned and operated by DWR. Because Lake Del Valle is used for water supply storage, flood control, and recreation, withdrawing water from the lake needs to be coordinated with the lake's other uses. Typically, DWR lowers the lake elevation after Labor Day for flood control purposes, allowing Zone 7 and ACWD to put runoff from the Arroyo Valle to beneficial use. In the summer months, lake elevations are raised for recreational purposes. Historically, access to Zone 7's stored water in Lake Del Valle has not been problematic, unless there is an outage on the Del Valle Branch pipeline. Zone 7 closely coordinates use of Arroyo Valle water with both ACWD and DWR.

Water collected from the local watershed is protected under the SBA Watershed Protection Program Plan. In general, the water quality of Arroyo Valle runoff is good and does not affect the reliability of this water supply; however, as noted above, T&O can also affect supplies from Lake Del Valle. Zone 7 treats T&O using ozonation, although a switch to groundwater supplies is sometimes necessary under excessive levels of T&O compounds. Algal blooms in the lake can also reduce production capacities, though new ozonation facilities at the DVWTP have significantly reduced the impact.

7.1.1.4 Local Storage

Constraints for Zone 7's existing local storage options, the Main Basin and Lake Del Valle, are discussed in Sections 7.1.1.2 and 7.1.1.3, respectively. The future COLs will provide significant local storage, but uncertainty surrounds its complete transfer to Zone 7. Favorable economic conditions could extend gravel mining operations, and even after mining ceases, reclamation must occur. These steps could delay a full COLs transition to about 2060. Zone 7 continues to work closely with the mining companies and quarry operators so planning efforts can be coordinated. With the Chain of Lakes Pipeline, Zone 7 can enhance its use of the available lakes in the interim period.

7.1.1.5 Non-Local Storage

Access to banked water in Semitropic and Cawelo—both located downstream of Zone 7—requires exchange(s) with other SWP contractors located south of Kern County (e.g., Metropolitan Water District). There must be sufficient water flowing through the Delta and California Aqueduct system to facilitate these exchanges, which could be challenging during a drought. Furthermore, the banked water must be conveyed through the Delta, rendering this supply susceptible to the Delta disruptions described in Section 7.1.1.1.

During the recent drought, access to banked water became uncertain because of the historically low Table A allocation (leading to minimal amounts of water moving through the SWP) and the potential cessation of pumping in the Delta to control salinity intrusion. DWR was able to manage salinity so that Delta pumping could continue, and, with coordination among stakeholders including Zone 7, DWR prioritized the delivery of banked water to Zone 7 and other SBA contractors. Ultimately, even during the serious drought conditions in 2014 and the minimal 5 percent SWP allocation, Zone 7 was able to successfully recover almost 15,000 AF, or approximately 78 percent of the maximum recovery requested by Zone 7. In 2015, Zone 7 recovered approximately 18,000 AF from non-local storage.

Zone 7 will continue to coordinate closely with DWR, other SWP contractors, Semitropic, and Cawelo to ensure the future reliability of the banked water supplies.

Some of Semitropic's wells are affected by arsenic. This is currently being managed through treatment before the affected groundwater water is pumped into the California Aqueduct. Arsenic criteria have been established for this "pump-in" by the DWR Facilitation Group to mitigate any impacts to the downstream SWP contractors. Semitropic and the banking partners have developed a coordination process for discussing arsenic treatment. While the presence of arsenic in the Semitropic groundwater bank is likely to increase the cost of this water storage option, it is not likely to affect its overall reliability.

7.1.2 Year Type Characterization

The quantity available from each of Zone 7's water supply sources varies from year-to-year depending on hydrologic conditions. Consequently, Zone 7 reviewed historical data and developed a projected yield for each water supply source under three conditions: (1) normal water year, (2) single dry year, and (3) five-consecutive-year drought. Each condition is defined as follows:

- **Normal Water Year**: The year in the historical sequence most closely representing average runoff or allocation levels and patterns.
- **Single Dry Year**: The year in the historical sequence with the lowest annual runoff or allocation.
- **Five-Consecutive-Year Drought**: Zone 7 considers a six-year "design drought" as part of its water supply analyses (e.g., 2019 WSE Update). Selection of the design drought corresponds with the driest six-year sequence on record, 1987-1992. This same sequence was utilized in the UWMP to maintain consistency with Zone 7's water supply planning efforts and is more conservative than the minimum required five-year drought scenario.

For each of Zone 7's sources, this section presents the available supply under the hydrologic conditions described above. Data presented below were derived from historical conditions, adjustments to account for climate change impacts and other projected trends, DWR's 2019 DCR (using modeling estimates that separated Table A allocations from carryover deliveries), and Zone 7's Water Supply Risk Model results.

7.1.2.1 State Water Project

The quantity of water available from the SWP, including Table A, Article 21 and Article 56d, Yuba Accord, and carryover water are discussed below.

7.1.2.1.1 Table A Water

The current reliability of SWP supplies is derived from the 2019 DCR, which is described in more detail in Chapter 6. DWR's estimates of SWP deliveries are based on a computer model that simulates operations of the SWP and CVP systems. Note that DWR's model currently only includes hydrology from 1922-2003; future updates will extend this range into later years. The 2019 DCR uses the following assumptions to model current (2020) conditions: existing facilities, hydrologic inflows to the model based on 82 years of historical inflows (1922 through 2003), current regulatory and operational constraints, and contractor demands at maximum Table A amounts. To evaluate SWP supply availability under future conditions, the 2019 DCR included a model study representing hydrologic and sea level rise conditions at 2040.

For Zone 7, the 2019 DCR's existing condition was assumed to represent 2020 (59 percent Table A reliability, 47,600 AFY[19]) , and the future condition (54 percent Table A reliability, 43,500 AFY[19]) was applied to 2040; the years in between were interpolated between these two bookends. Note that while the proposed DCP is designed to increase the SWP's reliability, the quantitative effect on SWP water supply yield is still being analyzed and has not been included at this time to allow for a more conservative analysis.

Figure 7-1 illustrates projected SWP allocations from 1922 to 2003[20] using the results from the 2019 DCR for existing and future conditions. As shown on Figure 7-1, 1965 (52 percent) closely represents the average allocation (54 percent) under future conditions, while 1987 to 1992 closely represents the driest six-year period included in DWR's model. This dry period includes SWP allocations ranging from 10 percent to 67 percent under future (2040) conditions.

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[19] This is the average reliability (Table A allocation) based on DWR's modeling in the 2019 DCR.

[20] DWR plans to extend the modeling period past 2003 in future versions of their model, which will be reflected in future Delivery Capability Reports.

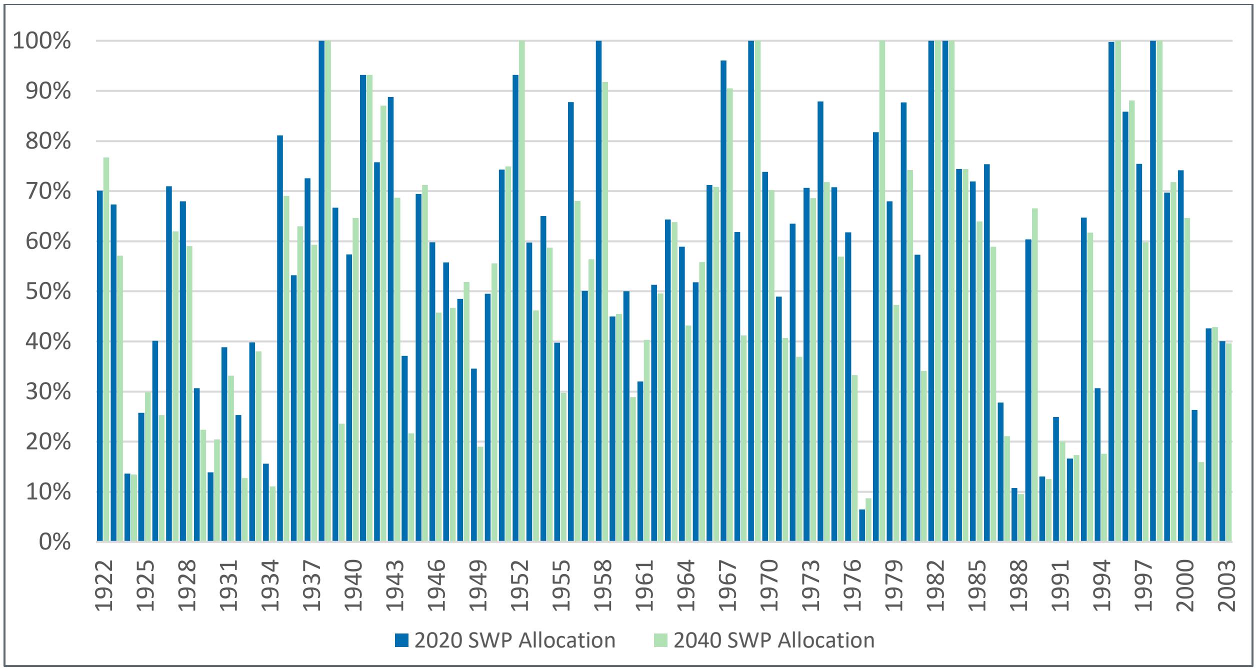

Figure 7-1. Existing and Future SWP Table A Allocations from the 2019 Delivery Capability Report

Figure 7-1 also indicates that the lowest allocation over the modeling period used by DWR occurs in 1977 at 9 percent Table A allocation (2040 conditions); however, the 2014 actual allocation was lower at 5 percent. The extremely dry sequence from the beginning of January 2013 through the end of 2014 was one of the driest two-year periods in the historical record. The extraordinarily dry conditions in 2013 and 2014 resulted in the historically lowest 5 percent Table A allocation that was only available starting in the fall of 2014. This UWMP uses a conservative assumption that a 5 percent allocation of SWP Table A amounts represents the worst-case single dry year scenario. Note that a 5 percent allocation of SWP Table A amounts corresponds to 9 percent of normal year SWP Table A amounts.

Table 7-1 summarizes the basis of water year and available supply for Zone 7 from the SWP.

Table 7-1. Basis of Water Year and Available Supply: SWP Table A Water (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	43,500	100%
Single-Dry Year	2014	4,000	9%
Consecutive Dry Years 1st Year	1987	16,900	39%
Consecutive Dry Years 2nd Year	1988	8,100	19%
Consecutive Dry Years 3rd Year	1989	54,000	124%
Consecutive Dry Years 4th Year	1990	10,500	24%
Consecutive Dry Years 5th Year	1991	16,100	37%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for the State Water Project Table A. Volumes are in AF. The Average, Single Dry Year, and Multiple Dry Years are based on 2040 Future SWP Reliability Allocations.			

7.1.2.1.2 Article 21 Water and Article 56d Water

As a contractor of the SWP, Zone 7 also has access to Article 21 water (interruptible or surplus water) and Article 56d water (turnback pool water). Neither Article 21 nor Article 56d water were included in this UWMP for planning-level purposes. Zone 7's access to Article 21 water may increase in the future once the Chain of Lakes Pipeline is in service; this access will be reflected in a future UWMP as appropriate. Water that could have been part of the Article 56d turnback pool will now be available through water transfers, which are a component of Zone 7's supply, as described below.

7.1.2.1.3 Yuba Accord

Water is primarily available during dry years under the Yuba Accord, but the amount is relatively small: 400 AF in 2014, approximately 300 AF in 2015, and 3,000 AF in 2020. For planning purposes, Zone 7 currently does not assume any water supply yield specifically from the Yuba Accord, although Zone 7 will continue to pursue this supply when available. Water from the Yuba Accord could contribute to Zone 7's supply as a water transfer.

7.1.2.1.4 Carryover

As a SWP contractor, Zone 7 can carry water from one year to the next in San Luis Reservoir – also called Article 56(c) water. The amount of carryover depends on DWR's allocation for that year. For example, if allocations are equal to or less than 50 percent of Zone 7's Table A amount, then carryover is limited to 25 percent of Zone 7's total Table A amount, or approximately 20,200 AFY (25 percent of 80,619 AF). However, if allocations are at least 75 percent of Zone 7's Table A amount, then carryover increases to 50 percent of Zone 7's total Table A amount, or approximately 40,300 AFY (50 percent of 80,619 AF).

If the San Luis Reservoir level gets too high, a portion of Zone 7's carryover can be lost; this condition is more likely when the reservoir is relatively full and hydrologic conditions are above normal. Zone 7 manages carryover to avoid or minimize losses. As part of its operating agreement with DWR, Zone 7 can also carry inflow from Arroyo Valle in Lake Del Valle from one year to the next.

Typically, any carryover into a normal water year would be used in that year; however, a similar amount of current year supply would also be carried over for use in the following year. Zone 7 typically targets carryover of about 10,000 AF of water from one year into the next. In the past, Zone 7 had significant carryover water available (greater than 15,000 AF), and much of this supply was used during the 2012-2016 drought. Available carryover supplies were derived from the Water Supply Risk Model analysis using averages over the period 2025-2040. The estimate of available supplies reflects Monte Carlo simulations of Zone 7's use of supplies and resulting storage levels.

Table 7-2 summarizes the average available carryover under each water year type; base years were chosen to match those for the SWP Table A supply. Modeled average carryover over 2025-2040 was estimated at about 12,700 AF, while carryover is reduced significantly during multiple dry years, averaging about 2,000 AF during the latter four years of drought. Zone 7 would likely pursue additional water transfers during such periods to increase these carryover levels. As indicated in Chapter 6, Zone 7 normally plans for about 10,000 AF of carryover.

Table 7-2. Basis of Water Year and Available Supply: Carryover Water (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	10,000	100%
Single-Dry Year	2014	15,500	155%
Consecutive Dry Years 1st Year	1987	15,500	155%
Consecutive Dry Years 2nd Year	1988	2,800	28%
Consecutive Dry Years 3rd Year	1989	1,800	18%
Consecutive Dry Years 4th Year	1990	1,800	18%
Consecutive Dry Years 5th Year	1991	1,800	18%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for Carryover. Volumes are in AF. Average is based on Zone 7's normal operational target. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.			

7.1.2.2 Water Transfers

A transfer agreement with another SWP contractor using the SWP system—which Zone 7 is already invested in—is likely the most expedient and cost-effective transfer option. The transfer amount could vary from year-to-year depending on hydrology but could average between 5,000 and 10,000 AFY. For the 2020 UWMP, Zone 7 is assuming a constant 5,000 AFY in water transfers through 2030.

Table 7-3 summarizes the basis of water year and available supply from SWP transfers. Base years were chosen to match those of the SWP, although as noted above, 5,000 AF was assumed for all year types.

Table 7-3. Basis of Water Year and Available Supply: SWP/Other Transfers (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	5,000	100%
Single-Dry Year	2014	5,000	100%
Consecutive Dry Years 1st Year	1987	5,000	100%
Consecutive Dry Years 2nd Year	1988	5,000	100%
Consecutive Dry Years 3rd Year	1989	5,000	100%
Consecutive Dry Years 4th Year	1990	5,000	100%
Consecutive Dry Years 5th Year	1991	5,000	100%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for Water Transfers. Volumes are in AF. Amounts are likely to vary from year-to-year but variability has not been quantified at this time.			

7.1.2.3 Local Surface Water: Arroyo Valle

Figure 7-2 shows estimated and measured historical inflows from Arroyo Valle into Lake Del Valle. Note that inflows are used for environmental releases and for water supply to Zone 7 and ACWD. Some inflows may end up as flood releases when there is insufficient capacity in the lake and insufficient ability for Zone 7 and ACWD to store/use the water.

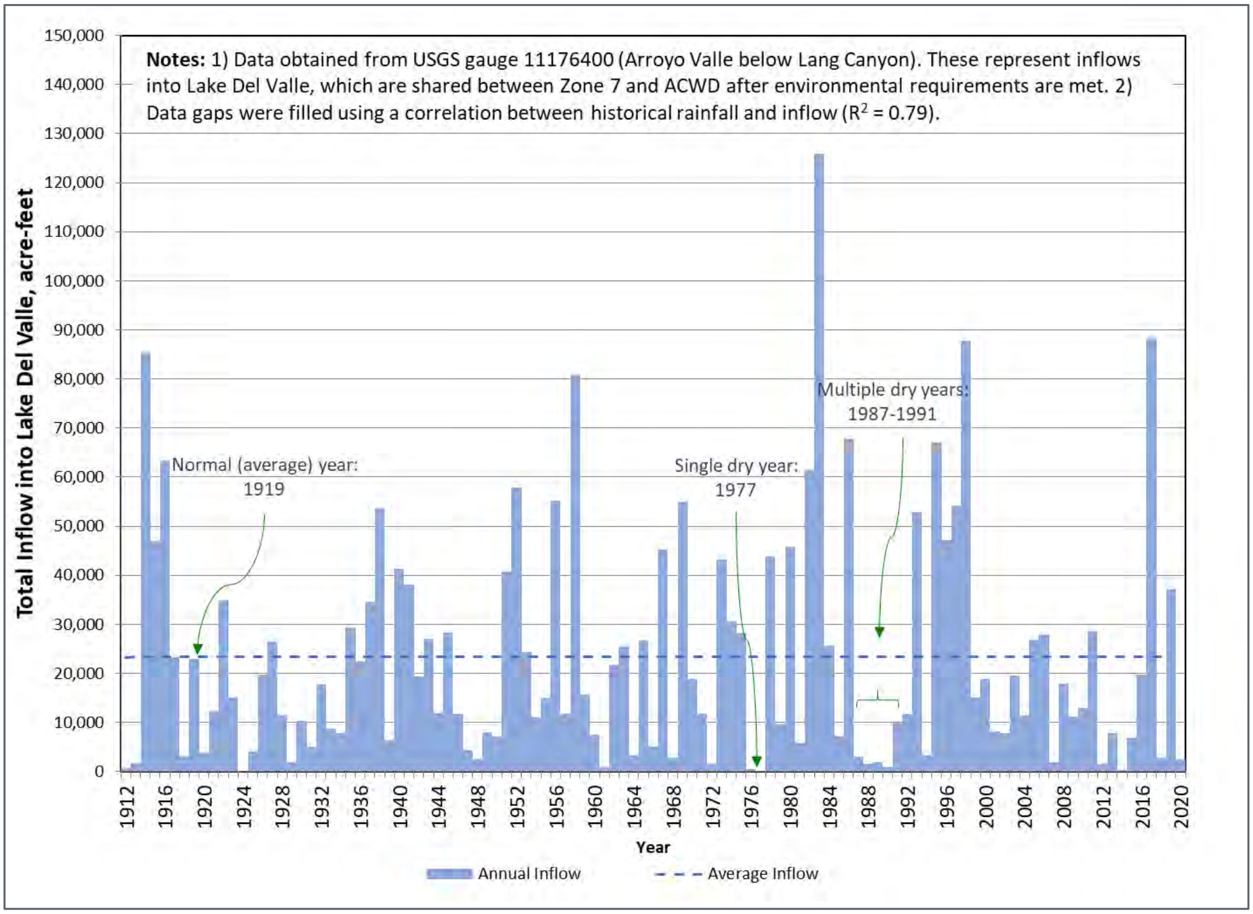

Figure 7-2. Estimated and Measured Inflows from Arroyo Valle into Lake Del Valle

Zone 7's latest modeling forecasts future average yields from Arroyo Valle to Zone 7 at approximately 5,500 AFY, using historical hydrology adjusted for climate change impacts. The ten-year calendar year average (2011-2020) has been 3,500 AFY; local climate change effects on the watershed are expected to reduce the yield over time. Conversely, construction of the Chain of Lakes Arroyo Valle diversion structure and pipeline (discussed in Section 6.2.9) will allow Zone 7 to capture more of the storm releases from Lake Del Valle, and likely increase the yield from this water supply in the future. The conservative average yield estimate of 5,500 AFY is consistent with the 2019 WSE Update; it will be re-evaluated as more climate change downscaled information is developed and as the COLs projects progress and additional yield could be better quantified.

Based on water supply yields to Zone 7, the year closest to the average supply is 1919, while the lowest 5-year average is from 1987 to 1991. The analysis in this UWMP assumes that inflow is available during a single dry year and uses a base year of 1977. Table 7-4 summarizes the basis of water year and available supply for Zone 7 from local runoff under the Arroyo Valle water right permit.

Table 7-4. Basis of Water Year and Available Supply: Arroyo Valle (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1919	5,500	100%
Single-Dry Year	1977	0	0%
Consecutive Dry Years 1st Year	1987	1,700	31%
Consecutive Dry Years 2nd Year	1988	1,500	27%
Consecutive Dry Years 3rd Year	1989	1,500	27%
Consecutive Dry Years 4th Year	1990	1,500	27%
Consecutive Dry Years 5th Year	1991	1,500	27%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Arroyo Valle and includes carryover from the previous year. Volumes are in AF. Based on SWP Table A base years. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.

7.1.2.4 Local Storage

As mentioned previously, Zone 7's existing local storage options include Lake Del Valle and the Main Basin. With future completion of the COLs Pipeline around 2025, Zone 7 could begin to use the COLs for storage of imported or local surface water, which will also enhance groundwater recharge in the Main Basin. Furthermore, the pipeline will allow for access to stored water in the COLs. The stored water in the lakes is a combination of surface water and groundwater. In Zone 7's Water Supply Risk Model, the water supply accounting for the COLs is closely tied to groundwater storage levels. The amounts shown in Table 7-5 indicate the amount of water supply that could be conveyed to the DVWTP during droughts and emergencies. It would not be used during normal years.

Table 7-5. Basis of Water Year and Available Supply: Chain of Lakes (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	10,100	100%
Single-Dry Year	2014	8,300	82%
Consecutive Dry Years 1st Year	1987	8,800	87%
Consecutive Dry Years 2nd Year	1988	7,900	78%
Consecutive Dry Years 3rd Year	1989	6,900	68%
Consecutive Dry Years 4th Year	1990	6,000	59%
Consecutive Dry Years 5th Year	1991	5,200	51%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for stored water in the Chain of Lakes that could be conveyed to the Del Valle Water Treatment Plant. Volumes are in AF.			

The use of Lake Del Valle is tied to SWP reliability, discussed under Section 7.1.2.1, and to the availability of local water from the Arroyo Valle, discussed under Section 7.1.2.3. The following focuses on the reliability of the groundwater supply from the Main Basin.

Based on a review of current well capacities and groundwater modeling, Zone 7 estimates that it can pump approximately 28,000 AF over a one-year period, assuming the Main Basin is approximately greater than or equal to 80 percent full. This annual limit is projected to increase to as high as 34,400 AF once all the Well Master Plan[21] wells are in service. For conservative planning-level purposes in this UWMP, Zone 7 staff included limits on the total volume of groundwater pumped during multiple dry years to ensure that water surface elevations remain above historic lows during a multiple-dry year event. The pumping

[21] CH2M Hill, 2003. Well Master Plan.

is limited by the groundwater basin level, ensuring less pumping as the basin level decreases. A historical low within the model prohibits groundwater levels from dipping below this value.

Table 7-6 summarizes the available supply under each water year type. Base years were chosen to match those of the SWP, as this reflects the need for supplemental local groundwater supply. Note that the averages of 2025-2040 long-term projection runs from the Water Supply Risk Model were used and these values are groundwater pumping capacity, or groundwater availability, and not volumes of groundwater pumped. Zone 7 normally targets about 9,200 AFY of groundwater pumping.

Table 7-6. Basis of Water Year and Available Supply: Main Basin (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	29,200	100%
Single-Dry Year	2014	27,600	95%
Consecutive Dry Years 1st Year	1987	27,600	95%
Consecutive Dry Years 2nd Year	1988	25,100	86%
Consecutive Dry Years 3rd Year	1989	20,600	71%
Consecutive Dry Years 4th Year	1990	15,100	52%
Consecutive Dry Years 5th Year	1991	9,700	33%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for groundwater from the Main Basin. Volumes are in AF. Data shown are from averages of a long-term modeling run from the Water Supply Risk Model. Values show groundwater pumping capacity, or availability, not volumes pumped. Zone 7 targets average groundwater pumping at 9,200 AFY.			

7.1.2.5 Non-Local Storage

The water supply reliability of the Semitropic Water District and Cawelo Water District non-local supplies is discussed below.

7.1.2.5.1 Semitropic Water District

Zone 7 has 78,000 AF of groundwater banking storage capacity available through Semitropic to augment water supplies during drought conditions. During non-drought periods, Zone 7 can store up to 5,883 AFY into the Semitropic groundwater bank. During droughts, Zone 7 can request up to 9,100 AFY of pumpback and up to 8,645 AFY of exchange water, though the availability of exchange water depends on projected SWP deliveries.

Table 7-7 summarizes the projected Semitropic stored water that would likely be available under normal, single-dry, and five consecutive dry years. The values are based on averages of 2025-2040 long-term projection runs from the Water Supply Risk Model, and reflect storage levels, conveyance/delivery capacity, and potential Delta outages built into the Water Supply Risk Model that could affect access to this supply. Note that Zone 7 generally does not rely on water stored in Semitropic during normal water years, so while water may be available, it would generally not be used. Base years were chosen to match those of the SWP.

Table 7-7. Basis of Water Year and Available Supply: Semitropic (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1965	13,000	100%
Single-Dry Year	2014	6,500	50%
Consecutive Dry Years 1st Year	1987	10,000	77%
Consecutive Dry Years 2nd Year	1988	10,000	77%
Consecutive Dry Years 3rd Year	1989	10,000	77%
Consecutive Dry Years 4th Year	1990	10,100	78%
Consecutive Dry Years 5th Year	1991	10,100	78%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Semitropic Water Storage District's banking program. Volumes are in AF. Average year value is the average from 2025-2040 of a long-term model run from the Water Supply Risk Model. Other data are from averages of a long-term modeling run from the Water Supply Risk Model. Note that Zone 7 typically does not recover water from Semitropic during normal years.

7.1.2.5.2 Cawelo Water District

Zone 7 has 120,000 AF of groundwater banking storage capacity available with Cawelo to augment water supplies during drought conditions. During non-drought periods, Zone 7 can bank 5,000 AFY[22]. During droughts, Zone 7 can request up to 10,000 AFY of pumpback.

Table 7-8 summarizes the projected Cawelo stored water supply that would be available under normal, single-dry, and five consecutive dry years. Base years were chosen to match those of the SWP. The values are based on averages of 2025-2040 long-term projection runs from the Water Supply Risk Model, and reflect storage levels, conveyance/delivery capacity, and potential Delta outages built into the Water Supply Risk Model that could affect access to this supply. Note that Zone 7 generally does not rely on water stored in Cawelo during normal water years, so while water may be available, it would generally not be used. Base years were chosen to match those of the SWP.

Table 7-8. Basis of Water Year and Available Supply: Cawelo (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	9,700	100%
Single-Dry Year	2014	7,100	73%
Consecutive Dry Years 1st Year	1987	9,700	100%
Consecutive Dry Years 2nd Year	1988	9,700	100%
Consecutive Dry Years 3rd Year	1989	9,700	100%
Consecutive Dry Years 4th Year	1990	9,700	100%
Consecutive Dry Years 5th Year	1991	9,700	100%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for the Cawelo Water District's banking program. Volumes are in AF. Average year value is the average from 2025-2040 of a long-term model run from the Water Supply Risk Model. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.			

[22] Zone 7 only gets storage credit for 50 percent of the water provided to Cawelo. Per the existing contract, Zone 7 can only send 10,000 AF in any given year to Cawelo; therefore, the maximum contractual credit is 5,000 AF (50 percent of 10,000 AF).

7.1.2.6 Sites Reservoir

Sites Reservoir is assumed to increase Zone 7's water supplies by an average of 10,000 AFY beginning in 2030. Delivery would vary based on hydrology and Zone 7's needs, and available storage. Deliveries would be coordinated with SWP deliveries.

Table 7-9 summarizes the water supply assumptions for Sites Reservoir used in this plan, with water supplies assumed to be available by 2030. Base years were chosen to match those of the SWP.

Table 7-9. Basis of Water Year and Available Supply: Sites Reservoir Project (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	10,000	100%
Single-Dry Year	2014	15,300	153%
Consecutive Dry Years 1st Year	1987	16,800	168%
Consecutive Dry Years 2nd Year	1988	17,700	177%
Consecutive Dry Years 3rd Year	1989	16,300	163%
Consecutive Dry Years 4th Year	1990	15,900	159%
Consecutive Dry Years 5th Year	1991	15,800	158%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.			
****Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Multiple versions of this table are being used; this table is for the Sites Reservoir Project. Volumes are in AF. Dry year values are based on 2040 conditions from the Water Supply Risk Model.			

7.1.2.7 Other New Water Supplies: BARDP and/or Potable Reuse

As discussed in Section 6.2.9.1, Zone 7 is pursuing desalination and potable reuse to potentially increase future supplies. This plan assumes the total potential yield from BARDP and/or potable reuse is 5,000 AFY, with either or both systems operational by 2030.

These projects remain in early planning stages. Consequently, projected supplies are preliminary and subject to change. Zone 7 will monitor each project's progress and update supply projections as appropriate. Table 7-10 summarizes the water supply assumptions used in this UWMP, with water supplies assumed to be available by 2030. Base years were chosen to match those of the SWP. Because these supplies are generally drought-resistant, they have been assumed to provide a constant 5,000 AFY under all conditions.

Table 7-10. Basis of Water Year and Available Supply: Other Potential New Water Supplies – Bay Area Regional Desalination Project and/or Potable Reuse (DWR Table 7-1 Wholesale)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	5,000	100%
Single-Dry Year	2014	5,000	100%
Consecutive Dry Years 1st Year	1987	5,000	100%
Consecutive Dry Years 2nd Year	1988	5,000	100%
Consecutive Dry Years 3rd Year	1989	5,000	100%
Consecutive Dry Years 4th Year	1990	5,000	100%
Consecutive Dry Years 5th Year	1991	5,000	100%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for Bay Area Regional Desalination Project and/or potable reuse. Volumes are in AF. Because these supplies are generally drought-resistant, they have been assumed to provide a constant 5,000 AFY under all conditions.

7.1.3 Water Service Reliability

This section presents comparisons of projected water supplies and demands from 2025 through 2045 under the following hydrologic conditions: normal year, single dry year, and five consecutive dry years. Zone 7's projected demands are presented in Chapter 4, while supply sources are described in Chapter 6.

The estimated average amounts of water available during various hydrologic conditions are summarized in Table 7-11. The yields presented reflect the expected range of water supply available based on historical use records, hydrologic records, and existing supplies and storage options, or expected increases in yield or capacity due to new facilities and supplies.

Table 7-11. Summary of Estimated Available Water Supply

Water Source	Yield, AFY		
	Normal Year	Single Dry Year	Five Consecutive Dry Years
SWP – Table A[(a)]	43,500	4,000	8,100-54,000
SWP – Carryover[(b)]	10,000	15,500	1,800-15,500
Water Transfers[(c)]	5,000	5,000	5,000
Arroyo Valle	5,500	0	1,500-1,700
Sites Reservoir[(d)]	10,000	15,300	15,800-17,700
BARDP and/or Potable Reuse[(e)]	5,000	5,000	5,000
From Storage			
Main Basin[(f)]	29,200	27,600	9,700-27,600
Semitropic[(g)]	13,000	6,500	10,000-10,100
Cawelo[(g)]	9,700	7,100	9,700
Chain of Lakes[(h)]	10,100	8,300	5,200-8,800

(a) Based on 2040 future SWP reliability Table A allocations.
(b) Zone 7's operational target is typically 10,000 AF for normal years.
(c) Zone 7 is pursuing water transfer agreements for the period through 2030. Amounts may vary from year-to-year, but variability has not been quantified.
(d) Supplies from Sites Reservoir are assumed to be available by 2030.
(e) Supplies from these sources are assumed to be available by 2030.
(f) These are estimated available supplies, not necessarily what would be pumped. Zone 7's typical operational target is around 9,200 AF for normal years.
(g) Semitropic and Cawelo supplies are typically not used during normal years.
(h) The Chain of Lakes Pipeline, which provides access to water stored in the Chain of Lakes, is assumed to be completed around 2025. Water stored in the Chain of Lakes is assumed to be available by 2030 and would not be used during normal years.

7.1.3.1 Water Service Reliability – Normal Year

Table 7-12 shows that under normal hydrologic conditions, Zone 7's supplies are adequate to meet projected demands. Surplus supplies are stored as carryover, used to recharge the Main Basin, and stored in the Kern County groundwater banks. Note that the supplies shown below are representative of expected normal conditions or normal operational targets.

Table 7-12. Normal Year Supply and Demand Comparison (DWR Table 7-2 Wholesale)

	2025	2030	2035	2040	2045 *(Opt)*
Supplies					
SWP Table A	47,000	46,000	45,000	43,500	43,500
Yuba Accord	0	0	0	0	0
Turnback Pool	0	0	0	0	0
SWP Carryover	10,000	10,000	10,000	10,000	10,000
Arroyo Valle	5,500	5,500	5,500	5,500	5,500
Main Basin	9,200	9,200	9,200	9,200	9,200
Semitropic	0	0	0	0	0
Cawelo	0	0	0	0	0
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir Project	0	10,000	10,000	10,000	10,000
Transfers	5,000	5,000	0	0	0
Chain of Lakes	0	0	0	0	0
Supply totals *(autofill from Table 6-9)*	76,700	90,700	84,700	83,200	83,200
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Demand totals *(autofill from Table 4-3)*	50,300	52,800	53,800	55,300	55,300
Difference	26,400	37,900	30,900	27,900	27,900
NOTES: Volumes are in AF. Table references refer to DWR table numbers. Surplus supplies are stored as carryover, used to recharge the Main Basin, and stored in the Kern County groundwater banks.					

7.1.3.2 Water Service Reliability – Single Dry Year

Table 7-13 shows that in a single dry year, Zone 7's supplies are adequate to meet projected demands on average. The values in Table 7-13 reflect average output from Zone 7's water supply risk model, which was initialized given 2020 conditions and configured to simulate a single-dry year beginning in each year required in the drought risk assessment (e.g., 2025, 2030, etc.). The model simulates 10,000 trials to reflect varying hydrologic conditions. Given this model configuration, reported availability may differ slightly from values in the tables in Section 7.1.2.

The single dry year is based on 2014 critically dry conditions—worst case for State Water Project. This scenario assumes the worst local conditions with no local water available. Note that conservation is not included in the demands; any extra supply as a result of conservation will remain in storage or go towards storage.

There is a potential for operational constraints, especially during a Delta outage when there may be no or minimal water moving through the SBA from the Delta, could result in shortages, particularly in the near-term before major water supply projects are implemented. Untreated water customers would be most vulnerable because of their reliance on Delta water. As described in the WSCP, in these cases, Zone 7 could call for voluntary or mandatory conservation and also make operational adjustments to minimize such shortages.

7.1.3.3 Water Service Reliability – Five Consecutive Dry Years

Table 7-14 through Table 7-18 show that in five consecutive dry years, Zone 7's supplies are adequate to meet projected demands on average.

The values in Table 7-14 through Table 7-18 reflect average output from Zone 7's water supply risk model, which was initialized given 2020 conditions and configured to simulate a five-consecutive-dry years scenario beginning in each year required in the reliability assessment (e.g., 2025, 2030, etc.). The model simulates 10,000 trials to reflect varying hydrologic conditions. The five-consecutive-dry year scenario reflects hydrologic years 1987-1991, which are randomly shuffled throughout the 10,000 trials (e.g., hydrologic year 1988 may not follow 1987 within the five-consecutive-years sequence). Given this model configuration, reported availability may differ slightly from long-term average values identified in the tables in Section 7.1.2. As noted previously, Zone 7 generally uses a six-year drought (1987-1992) for water supply planning purposes. While not required for the UWMP, Table 7-20 shows conditions during the sixth year of drought.

As noted previously, operational constraints, especially during a Delta outage when there may be no or minimal water moving through the SBA from the Delta, could result in shortages. Untreated water customers would be most vulnerable because of their reliance on Delta water. As described in the WSCP, in these cases, Zone 7 could call for voluntary or mandatory conservation and also make operational adjustments to minimize such shortages. The possibility and amount of such shortages decrease as major water supply projects are implemented starting around 2030.

Table 7-13. Single Dry Year Supply and Demand Comparison (DWR Table 7-3 Wholesale)

	2025	2030	2035	2040	2045 (Opt)
Supplies					
SWP Table A	4,400	4,400	4,400	4,400	4,400
Yuba Accord	0	0	0	0	0
Turnback Pool	0	0	0	0	0
SWP Carryover	15,500	12,000	13,800	12,600	12,700
Arroyo Valle	0	0	0	0	0
Main Basin	27,600	29,900	31,800	32,200	32,500
Semitropic	6,500	6,600	6,600	6,500	6,500
Cawelo	7,100	7,100	7,100	7,100	7,000
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir Project	0	14,200	15,700	15,300	15,100
Transfers	4,500	4,600	0	0	0
Chain of Lakes	0	8,300	9,800	9,400	9,100
Supply totals*	65,600	92,100	94,200	92,500	92,300
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Demand totals*	50,300	52,800	53,800	55,300	55,300
Difference	15,300	39,300	40,400	37,200	37,000
***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*					
NOTES: Volumes are in AF.					

Table 7-14. First Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - First Year	2025	2030	2035	2040	2045
Supplies					
SWP Table A	19,900	19,500	19,500	19,500	19,400
SWP Carryover	15,500	12,000	13,800	12,600	12,700
Arroyo Valle	1,700	1,700	1,700	1,700	1,700
Main Basin	27,600	29,900	31,800	32,200	32,500
Semitropic	10,000	9,900	10,000	10,000	9,900
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	15,300	17,000	16,800	16,600
Water Transfers	4,800	4,800	0	0	0
Chain of Lakes		8,800	10,000	9,600	9,300
Total Supplies	**89,200**	**116,600**	**118,500**	**117,100**	**116,800**
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Total Demands	**50,300**	**52,800**	**53,800**	**55,300**	**55,300**
Difference	38,900	63,800	64,700	61,800	61,500
NOTES: Volumes are in AF.					

Table 7-15. Second Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - Second Year	2026	2031	2036	2041	2046
Supplies					
SWP Table A	20,200	19,800	19,800	19,600	19,600
SWP Carryover	2,800	4,400	3,500	3,100	3,100
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	25,100	29,400	31,400	31,600	31,900
Semitropic	10,000	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	18,100	18,300	17,700	17,800
Water Transfers	4,900	0	0	0	0
Chain of Lakes	600	7,900	8,800	8,400	8,200
Total Supplies	**74,800**	**105,800**	**108,000**	**106,600**	**106,800**
Demands					
Retailer Demand	43,000	43,200	43,500	43,700	43,700
Untreated Water Demand	6,900	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,060	1,600	2,500	2,500
Total Demands	**51,700**	**53,360**	**54,200**	**55,300**	**55,300**
Difference	23,100	52,440	53,800	51,300	51,500
NOTES: Volumes are in AF.					

Table 7-16. Third Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - Third Year	2027	2032	2037	2042	2047
Supplies					
SWP Table A	20,200	19,800	19,700	19,700	19,600
SWP Carryover	1,800	2,700	2,500	2,300	2,300
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	20,600	28,300	30,300	30,300	30,700
Semitropic	10,000	10,000	9,900	10,000	9,900
Cawelo	9,700	9,800	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	16,600	16,400	16,300	16,300
Water Transfers	4,900	0	0	0	0
Chain of Lakes	400	6,900	7,700	7,500	7,300
Total Supplies	**69,100**	**100,600**	**102,700**	**102,300**	**102,300**
Demands					
Retailer Demand	43,100	43,300	43,500	43,700	43,700
Untreated Water Demand	7,100	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,120	1,800	2,500	2,500
Total Demands	**52,000**	**53,520**	**54,400**	**55,300**	**55,300**
Difference	17,100	47,080	48,300	47,000	47,000
NOTES: Volumes are in AF.					

Table 7-17. Fourth Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - Fourth Year	2028	2033	2038	2043	2048
Supplies					
SWP Table A	20,200	19,500	19,800	19,700	19,800
SWP Carryover	1,800	2,100	2,000	1,900	1,900
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	15,100	26,900	28,800	28,600	28,900
Semitropic	10,100	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	16,000	16,000	15,900	15,900
Water Transfers	4,900	0	0	0	0
Chain of Lakes	300	6,000	6,700	6,600	6,500
Total Supplies	**63,600**	**96,700**	**99,500**	**98,900**	**99,200**
Demands					
Retailer Demand	43,100	43,300	43,600	43,700	43,700
Untreated Water Demand	7,350	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,180	2,000	2,500	2,500
Total Demands	**52,250**	**53,580**	**54,700**	**55,300**	**55,300**
Difference	11,350	43,120	44,800	43,600	43,900
NOTES: Volumes are in AF.					

Table 7-18. Fifth Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - Fifth Year	2029	2034	2039	2044	2049
Supplies					
SWP Table A	20,200	19,800	19,700	19,600	19,600
SWP Carryover	1,800	1,900	1,900	1,900	1,900
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	9,700	25,200	27,000	26,500	26,900
Semitropic	10,100	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	15,800	15,800	15,800	15,700
Water Transfers	4,900	0	0	0	0
Chain of Lakes	300	5,200	5,900	5,900	5,800
Total Supplies	**58,200**	**94,100**	**96,500**	**95,900**	**96,100**
Demands					
Retailer Demand	43,100	43,400	43,600	43,700	43,700
Untreated Water Demand	7,600	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,240	2,300	2,500	2,500
Total Demands	**52,500**	**53,740**	**55,000**	**55,300**	**55,300**
Difference	5,700	40,360	41,500	40,600	40,800
NOTES: Volumes are in AF.					

Table 7-19. Sixth Dry Year Supply and Demand Comparison (DWR Table 7-4 Wholesale)

Projections - Sixth Year	2030	2035	2040	2045	2050
Supplies					
SWP Table A	19,900	19,500	19,500	19,300	19,300
SWP Carryover	1,800	1,900	1,800	1,800	1,800
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	7,100	23,400	24,900	24,100	24,400
Semitropic	10,000	10,000	10,000	9,900	9,900
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	5,000	5,000	5,000	5,000	5,000
Sites Reservoir	15,300	15,700	15,800	15,800	15,800
Water Transfers	4,900	0	0	0	0
Chain of Lakes	900	4,500	5,100	5,300	5,200
Total Supplies	**76,100**	**91,200**	**93,300**	**92,400**	**92,600**
Demands					
Retailer Demand	43,200	43,400	43,700	43,700	43,700
Untreated Water Demand	7,800	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,300	2,500	2,500	2,500
Total Demands	**52,800**	**53,800**	**55,300**	**55,300**	**55,300**
Difference	23,300	37,400	38,000	37,100	37,300
NOTES: Volumes are in AF.					

7.1.4 Water Management Tools and Options

Zone 7 promotes regional supply reliability and reduced reliance on water imports by:

- Evaluating and pursuing new water supply options, including potable reuse and brackish water desalination;
- Supporting the expansion of recycled water use for irrigation;
- Working closely with its retailers to implement an active conservation program; and
- Optimizing and expanding local storage.

In addition, Zone 7 is a member of the Bay Area Regional Reliability (BARR) partnership, which brings together eight Bay Area water agencies to improve regional water supply reliability. In addition to Zone 7, these agencies include: ACWD, SFPUC, the Bay Area Water Supply and Conservation Agency (BAWSCA), CCWD, EBMUD, Marin Municipal Water District (MMWD), and VW. The BARR partners have agreed to work cooperatively to address water supply reliability concerns and drought preparedness on a mutually beneficial and regionally focused basis. Near- and long-term joint water supply reliability projects may be evaluated through BARR, such as use of the capacity of existing facilities, changes to infrastructure (including new interties, recycled water, water conservation, expanded treatment, regional desalination, and water transfers and exchanges), and other projects or institutional arrangements that encourage a regional approach to achieving water supply reliability in the Bay Area.

As part of its existing CIP, Zone 7 is planning to construct a reliability intertie with another major water agency (e.g., EBMUD or SFPUC) to help mitigate some of the risk during a major water supply interruption from the Delta and to create opportunities for transfers/exchanges. This intertie could allow Zone 7 to acquire emergency water supplies to help meet minimum health and safety water supply needs during a major Delta outage, assuming the partnering agency has available supply and the transmission capacity available during the emergency period. A conceptual 24- to 30-inch diameter intertie with EBMUD could connect to the west side of Zone 7's transmission system and convey up to 10 to 15 MGD of supply. Additional wells would also increase access to local groundwater and improve its management, while a new booster pump station would improve conveyance of groundwater across the Tri-Valley. The new Chain of Lakes Pipeline would allow for access to water stored locally in the Chain of Lakes.

7.2 DROUGHT RISK ASSESSMENT

In accordance with CWC Section 10612, urban water suppliers must conduct a DRA, which evaluates the risk of a severe drought occurring for the next five consecutive years (2021-2025). Supply conditions for the DRA shown here are based on the multi-year drought scenario, with adjustments to consider plausible changes in climate, regulations, and other locally applicable criteria.

This section reviews the data and methods used to define the DRA water shortage condition and evaluates each water source's reliability under the proposed drought condition. Finally, total water supplies during the five-year drought are compared to projected demands, accounting for any applicable supply augmentation or demand reduction measures available to Zone 7.

7.2.1 Data, Methods, and Basis for Water Shortage Condition

The water shortage condition for the DRA is the same as the five-consecutive-dry years drought described in Section 7.1.2. Since the DRA can be updated outside of the UWMP five-year plan cycle, the narrative description of the data and basis for the water shortage condition is repeated in this section.

The DRA assumes 5, 11, 60, 13, and 25 percent Table A allocations for 2021-2025, respectively. The last four years reflect the last four years of the multiple-dry year scenario previously discussed, based on 2020 values from the 2019 DCR. Data for 2021 reflect current projected available supplies. Projections are based on existing facilities and the expected availability of supplies from various sources given the constraints previously described. Surplus water is stored for use during subsequent years; a portion is also lost to evaporation, unavailable as carriage loss under water transfers, and lost to brine disposal.

7.2.2 DRA Water Source Reliability

Table 7-20 summarizes Zone 7's available supplies and projected demands for each year of the DRA.

Table 7-20. Projected Supplies and Demands for Drought Risk Assessment

SUPPLY SOURCE	Available Supply, AFY				
Calendar Year	2021	2022	2023	2024	2025
Equivalent Hydrologic Year	*Actual*	*1988*	*1989*	*1990*	*1991*
SWP Table A[(a)]	4,000	8,900	48,400	10,500	20,200
SWP Carryover	8,900	10,300	9,600	12,800	9,900
Water Transfers[(b)]	10,000	6,000	5,000	6,000	8,000
Arroyo Valle[(c)]	700	700	6,900	6,900	2,700
Main Basin (Local Groundwater)	13,200	13,200	11,000	10,000	11,000
Semitropic Water Storage District	9,100	9,100	0	9,100	9,100
Cawelo Water District	10,000	10,000	0	5,000	1,900
Total Supplies	**55,900**	**58,200**	**80,900**	**60,300**	**62,800**
Total Demands[(d)]	**45,200**	**47,600**	**48,500**	**49,400**	**50,300**
Surplus[(e)]	**10,700**	**10,600**	**32,400**	**10,900**	**12,500**

(a) Assumes 5, 11, 60, 13, and 25 percent Table A allocations from 2021 through 2025, respectively. 2021 reflects current projected available supplies, while 2022-2025 reflect the last four years of a multiple-dry year scenario.
(b) Includes Yuba Accord and other transfers.
(c) Includes carryover and current year's yield.
(d) Refer to Table 4-5 of this plan. Demands include treated and untreated customer demands and transmission system losses; conservation not included. Based on delivery requests for 2022-2025.
(e) Surplus largely goes toward storage for use the following year. A portion is also lost to evaporation, unavailable as carriage loss under water transfers, and lost to brine disposal; these losses can consume up to 900 AF of surplus water in this 5-year outlook.

7.2.3 Total Water Supply and Use Comparison

As shown in Table 7-21, during a five-year drought beginning in 2021, Zone 7's supplies are projected to be adequate to meet projected demands through 2025, even without water conservation. However, this would draw down Zone 7's stored supplies by about 112,000 AF by the end of 2025, from 240,000 AF to 128,000 AF.

Table 7-21. Five-Year Drought Risk Assessment Tables to Address Water Code Section 10635(b) (DWR Table 7-5)

2021	Total
Total Water Use	45,200
Total Supplies	55,900
Surplus/Shortfall w/o WSCP Action	10,700
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,700
Resulting % Use Reduction from WSCP action	0%
2022	**Total**
Total Water Use	47,600
Total Supplies	58,200
Surplus/Shortfall w/o WSCP Action	10,600
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,600
Resulting % Use Reduction from WSCP action	0%
2023	**Total**
Total Water Use	48,500
Total Supplies	80,900
Surplus/Shortfall w/o WSCP Action	32,400
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	32,400
Resulting % Use Reduction from WSCP action	0%
2024	**Total**
Total Water Use	49,400
Total Supplies	60,300
Surplus/Shortfall w/o WSCP Action	10,900
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,900
Resulting % Use Reduction from WSCP action	0%
2025	**Total**
Total Water Use	50,300
Total Supplies	62,800
Surplus/Shortfall w/o WSCP Action	12,500
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	12,500
Resulting % Use Reduction from WSCP action	0%

CHAPTER 8
Water Shortage Contingency Plan

This chapter summarizes Zone 7's WSCP, seismic risk to Zone 7's facilities, and WSCP adoption procedures. To allow for WSCP updates to be made outside of the UWMP preparation process, Zone 7's WSCP is included in this plan as Appendix G.

8.1 WATER SHORTAGE CONTINGENCY PLANNING BACKGROUND

Water shortages occur whenever the available water supply cannot meet the normally expected customer water use. These shortages can be due to several reasons, including population growth, climate change, drought, and catastrophic events. Drought, regulatory actions, and natural and manmade disasters may occur at any time. A WSCP presents how an urban water supplier plans to respond to a water shortage condition and helps prevent catastrophic service disruptions.

The 2018 Water Conservation Legislation set new requirements for water shortage contingency planning; Zone 7's WSCP has been updated to be consistent with these requirements.

In accordance with CWC §10632.3, the State defers to the implementation of the locally adopted WSCP to the extent practicable.

8.2 ZONE 7 WATER SHORTAGE CONTINGENCY PLAN

Zone 7's WSCP describes its strategic plan for preparing and responding to water shortages. The WSCP includes water shortage stages and associated shortage response actions, as well as Zone 7's legal authorities and communication protocols. Since Zone 7 is a water wholesaler, most compliance and enforcement efforts and monitoring/reporting is left to Zone 7's retailers.

Zone 7's WSCP is included in this plan as Appendix G to allow for updates outside of the UWMP preparation process. Zone 7 intends for its WSCP to be dynamic, so that it may assess response action effectiveness and adapt to foreseeable and unforeseeable events. When an update to the WSCP is proposed, the revised WSCP will undergo the process described in Section 8.4.

8.3 SEISMIC RISK ASSESSMENT AND MITIGATION PLAN

CWC §10632.5(a) requires that UWMPs include a seismic risk assessment and mitigation plan to assess and mitigate a water system's seismic vulnerabilities. Local Hazard Mitigation Plans (LHMPs) may be incorporated in this UWMP to meet this requirement if they address seismic risk. Zone 7 participated in the development of a regional hazard mitigation plan, which was prepared collaboratively for the main cities within its service area—Dublin, Livermore, and Pleasanton. The 2018 Tri-Valley Local Hazard Mitigation Plan Update (2018 LHMP) addressed seismic risk and is incorporated into this UWMP by reference. The 2018 LHMP was finalized in September 2018 and submitted to the Federal Emergency Management Agency (FEMA), which found it in conformance with Title 44 Code of Federal Regulations Part 201.6 Local Mitigation Plans. The 2018 LHMP is available on each of the collaborating city's websites:

- Dublin (dublin.ca.gov) – under the "Government" menu, click on the "Disaster Preparedness" department. Links to the 2018 LHMP is provided under "Additional Resources."

- Livermore: (www.cityoflivermore.net) – under the "City Government" menu, hover over "LPFD Home" and then "About Our Department." Click on "Disaster Preparedness," and then click on "City Preparation" under the navigation menu.
- Pleasanton (www.cityofpleasantonca.gov) – under the "Government" menu, click on the "Community Development" department. On the "Community Development" page, click the "Planning Division" link. Under the navigation menu, hover over "Plans & Programs" and click on "Tri-Valley Hazard Mitigation Plan."

Further, Zone 7 developed its own hazard mitigation plan (Zone 7 HMP) that addresses earthquake hazards. FEMA found the Zone 7 HMP in conformance with Title 44 Code of Federal Regulations Part 201.6 Local Mitigation Plans. To maintain security of the Zone 7 water system, the Zone 7 HMP is maintained as a confidential document. Zone 7 is in the process of implementing mitigation strategies, which are similar to those documented in the 2018 LHMP, as described below.

Earthquakes are common, relatively well-tracked, and studied in California. While California experiences hundreds of earthquakes each year, most are below 3.0 on the Richter Scale (i.e., magnitude 3.0) and cause minimal damage. The United States Geological Survey (USGS) roughly defines strong earthquakes (which can cause moderate damage to structures) as measuring greater than 5.0 on the Richter Scale, while major earthquakes measure more than 7.0 on the Richter Scale. In California, strong earthquakes occur every two to three years, and major earthquakes occur once a decade.

The Calaveras, Greenville, Hayward, and Mt. Diablo faults are in the vicinity of the Tri-Valley region. A 2016 report[23] by the USGS estimated the probabilities for magnitude-6.7 (or larger) earthquakes on major fault lines in the San Francisco Bay Area by the year 2043. The Hayward Fault has a 33 percent chance of one or more earthquakes of magnitude-6.7 or larger by 2043, while the Calaveras Fault has a 26 percent chance of one or more such earthquakes in that timeframe. The Greenville and Mt. Diablo faults each have a 16 percent chance of one or more earthquakes of magnitude-6.7 or larger by 2043.

The 2018 LHMP evaluated the impact of earthquakes on critical facilities and infrastructure using a Hazus analysis. Results for utilities infrastructure (including water system facilities) are presented in terms of level of damage and time to return to functionality. There are five damage levels (no damage, slight damage, moderate damage, extensive damage, and complete damage) and six time increments (1, 3, 7, 14, 30, and 90 days). Results are categorized by earthquake location; there are separate scenarios for earthquakes on each of the Calaveras, Greenville, Hayward, Mt. Diablo, and San Andreas faults.

According to the 2018 LHMP, earthquakes on the Hayward and Calaveras faults would be most significant. Over 80 percent of (120 total) utility facilities in the Tri-Valley region would experience at least moderate damage for an earthquake on the Hayward Fault, while approximately 44 percent would be at least moderately damaged by a Calaveras Fault earthquake. For earthquakes on the other faults analyzed (Greenville, Mt. Diablo, San Andreas), this number is below 15 percent. Seven days after an earthquake on the Hayward Fault, a utility facility has an approximately 52 percent chance of being fully functional. This percentage increases to approximately 84 percent for an earthquake on the Calaveras Fault and above 92 percent for earthquakes on the Greenville, Mt. Diablo, and San Andreas faults.

[23] U.S. Geological Survey (USGS), 2016. *Earthquake Outlook for the San Francisco Bay Region 2014-2043.*

Table 18-3 of the 2018 LHMP summarizes alternatives for mitigating the earthquake hazard on personal, corporate, and government scales. Mitigation options potentially applicable to Zone 7 include the following:

- Locate critical facilities outside hazard area where possible
- Harden infrastructure
- Provide redundancy for critical functions
- Include retrofitting and replacement of critical system elements in capital improvement plan
- Warehouse critical infrastructure components such as pipe materials
- Develop and adopt a continuity of operations plan

8.4 WATER SHORTAGE CONTINGENCY PLAN ADOPTION, SUBMITTAL, AND AVAILABILITY

The WSCP (Appendix G) is adopted concurrently with Zone 7's 2020 UWMP, by separate resolution. Prior to adoption, a duly noticed public hearing was conducted. A copy of the WSCP will be submitted to DWR within 30 days of adoption.

No later than 30 days after adoption, copies of the WSCP will be available at Zone 7's offices. A copy will also be provided to Alameda County, Contra Costa County, and Zone 7's retailers. An electronic copy of the WSCP will also be available for public review and download on Zone 7's website.

Zone 7's WSCP is an adaptive management plan and is subject to refinements as needed to ensure that Zone 7's shortage response actions and mitigation strategies are effective and produce the desired results. When a revised WSCP is proposed, the revised WSCP will undergo the process described in this section for adoption by the Zone 7 Board and distribution to Alameda County, Contra Costa County, Zone 7's customers, and the general public.

CHAPTER 9
Demand Management Measures

Zone 7 implements demand management measures (DMMs) to sustainably manage its water resources, reduce Delta reliance, and maintain the reliability of its water supply. This chapter describes Zone 7's Water Conservation Program, the status of its DMMs, and projected future implementation of water conservation measures.

9.1 DEMAND MANAGEMENT MEASURES FOR WHOLESALE SUPPLIERS

As discussed in Chapter 6, Zone 7 provides treated water supply to its retailers on a wholesale basis. As a wholesale agency, Zone 7 actively implements the following DMMs:

- Metering;
- Public education and outreach;
- Water Conservation Program coordination and staffing support;
- Wholesale Supplier Assistance Programs; and
- Asset management.

For each DMM above, the current program is described, followed by a description of how the DMM was implemented over the previous five years and plans for continued implementation.

As a wholesaler, Zone 7 provides regional coordination of conservation programs in the Tri-Valley area. For detailed descriptions of the individual conservation programs implemented by the retailers, see the 2020 UWMPs for Livermore, Pleasanton, Cal Water, and DSRSD.

Zone 7 is committed to supporting California's long-term conservation framework by: 1) reducing indoor water use to continue to make progress towards the 50 gallons per capita per day (GPCD) target required by state legislation, and 2) maintaining or reducing the outdoor water use component of water demand in the Tri-Valley. To meet these goals, Zone 7's conservation program has largely focused on public outreach and education and rebate programs, as described below. Proper metering also supports conservation efforts.

9.1.1 Metering

Zone 7's wholesale water deliveries are fully metered, and calibration is verified on an annual basis. All facilities except for three wholesale meters (Cal Water Turnout #7, Cal Water Turnout #8, and Livermore Turnout #8) are fully equipped with Supervisory Control and Data Acquisition (SCADA) and security alarms and are maintained by Zone 7 mechanical, electrical, and instrumentation staff. Maintenance is performed per contract with the receiving wholesale customer.

Zone 7 has metered its water deliveries over the past five years and plans to continue this effort into the future.

9.1.2 Public Education and Outreach

A description of Zone 7's public education and outreach programs, the implementation over the past five years, and plans for continued implementation is provided below.

9.1.2.1 DMM Description

Zone 7 promotes water conservation both independently and in coordination with its retailers. Zone 7 collaborates on water conservation programs, including public education and outreach, with its retailers through the Tri-Valley Water Conservation Task Force, which is discussed in further detail in Section 9.1.3.

Zone 7's outreach is conducted mainly through events/workshops and its website, which contains the following information:

- Links to educational resources on water conservation;
- Calendar of upcoming workshops and events;
- Rebate programs, including informational brochures and application forms;
- Landscaping and gardening tips; and
- Profiles of Tri-Valley residents saving water.

More recently, Zone 7 has also started using social media platforms such as Facebook. Zone 7's public education and outreach programs focusing on water conservation and water awareness include the annual and periodic activities listed in Table 9-1.

Table 9-1. Zone 7 Public Education and Outreach Programs	
Program	Summary
Bay Qualified Water Efficient Landscaper (QWEL)	QWEL is a WaterSense professional certification program that provides water conservation professionals and the landscape workforce with a thorough understanding of sustainable landscaping and efficient irrigation principles and practices. QWEL was administered by Zone 7 in-house with a contracted instructor from 2012-2017; a new regional program was launched in 2020. The California Water Efficiency Partnership (CalWEP) is currently hosting a regional QWEL training program—sponsored by ten Bay Area water providers, including Zone 7—which are taught using the newly updated QWEL curriculum in both English and Spanish.
Home & Garden Shows, Alameda County Fair	Zone 7 staff attend these public events to host a booth and/or participate in discussions on water quality, conservation, drought tolerant gardens, etc.
Living Arroyos	Living Arroyos is a unique community engagement opportunity that renews and enhances urban stream and riparian (streamside) habitats and reconnects people and the arroyos in their community. Working with volunteers, Living Arroyos educates the public about the value of the watershed and how best to protect it through waterwise and native landscaping and other means.
Media Campaigns	Zone 7 hosts annual campaigns, such as: • Fix a Leak Week - coordinating with EPA's annual Fix a Leak Week in March. • May Water Awareness Month - including support for the East Bay's Bringing Back the Natives Garden Tour. Zone 7 also launches specific campaigns, as needed, to boost awareness of rebate programs, water supply conditions, adjustment of watering, etc.
Public Workshops	Various workshops are hosted by Zone 7 and the retailers with focus on water awareness and waterwise gardening: • Zone 7 Open House with speakers and hands-on activities • East Bay California Native Plants Workshop • Water-Wise Gardening Workshop • Lawn Conversion "Parties" Historically, Zone 7 has primarily hosted in-person workshops. Zone 7 and the retailers are now planning more virtual workshops (webinars) as a response to the pandemic and the positive public response, with greater levels of participation due to accessibility.
Schools Program	The Zone 7 Schools Program has grown steadily over the years and expanded its outreach to provide standards-based water-science education for students in kindergarten through high school. The program currently reaches nearly 20,000 students annually.
Student Science Fair Water Projects	Zone 7 participates in middle and high school science & engineering fairs, with three winners in the water sciences category recognized by the Zone 7 Board and given awards.
Tri-Valley Water-Wise Gardening Website	The website was especially designed to showcase sustainable, climate-appropriate, and drought tolerant shrubs, trees and grass that thrive in the Tri-Valley area.
Zone 7 Newsletter	Zone 7 issues regular newsletters to customers including messaging on water conservation, flood preparedness, water rates, public meetings, and more.

9.1.2.2 Implementation Over the Past Five Years

Zone 7 had an active public outreach and education program over the past five years. Highlights of this DMM's accomplishments include:

- **Bay QWEL:** Through 2017, Zone 7 had trained a total of 154 graduates who have passed the QWEL EPA certification test. The regional Bay QWEL program began classes across the Bay Area in 2020, including students from Zone 7's service area.
- **Home & Garden Shows, Alameda County Fair:** Zone 7 participated in these events annually to promote water efficiency to thousands of Bay Area residents.
- **Living Arroyos Urban Watershed Partnership:** Zone 7 organized volunteer events focused on stream clean-up and enhancement with 250-500+ volunteers each year.
- **Media Campaigns:** in 2020, the Strategic Communications Plan was updated to reflect Zone 7's updated Five-Year Strategic Plan and to align with digital media trends. This included refreshed branding and more consistent messaging. In 2020, the "Wonderous World of Water" water quality campaign was launched to educate residents about the quality of their water and the water treatment infrastructure that treats and distributes the Tri-Valley's water. The "Flood Ready Freddy" flood preparedness campaign was also launched that fall to educate residents about the dangers of flooding and promote emergency preparedness. Staff is currently working on a new conservation campaign to expand messaging on water conservation. Zone 7 is also currently undertaking a complete website redesign scheduled to launch in the spring of 2021.
- **Public Workshops:** Zone 7 hosted or co-sponsored three to four workshops each year (only one in 2020 due to pandemic) on various topics, including stream management, water supply, and PPWTP upgrades. Each workshop had 30-70+ participants.
- **Schools Program:** Zone 7 provides Tri-Valley teachers free classroom programs covering water conservation, drinking water quality, and other topics. The Schools Program typically reaches 14,000-20,000 kindergarten through twelfth grade students each year.
- **Student Science Fair Water Projects:** every year, hundreds of Tri-Valley students participate in science fairs, and the Zone 7 Board recognizes three students for researching and developing exceptional water-related projects. These students receive awards from the Zone 7 Board and present their projects at a Zone 7 Board meeting.

- **Tri-Valley Water-Wise Gardening Website:** Zone 7 maintains this website, which provides information on how to design, install, and maintain a water-wise garden. Approximately 20,000 people visited the web site in 2020.

- **Zone 7 E-Newsletters:** Zone 7 distributes its E-Newsletter directly to 778 residents in the Tri-Valley. The E-Newsletter is sent at least monthly and contains updates on Zone 7 Board actions, water conservation tips, and special events. E-Newsletters are also shared monthly on Zone 7's Facebook page and website.

As noted above, Zone 7 has been enhancing outreach through increased use of social media over the last two years. In 2020, public in-person events were not conducted due to the pandemic; however, a webinar was hosted on Gardening with Natives.

9.1.2.3 Plans for Continued Implementation

Implementation of this DMM is ongoing and expected to help Zone 7 continue to achieve its water efficiency objectives by educating water users about the importance of water use efficiency and avoiding water waste. Based on the positive response and participation rate in the 2020 webinar, Zone 7 intends to sponsor and host more webinars as part of its outreach in coordination with the retailers and other organizations. Staff is currently drafting a new conservation campaign. The campaign will include media buys, a social media campaign, and videos to provide residents with actionable tips for saving water in and around the home.

9.1.3 Water Conservation Program Coordination and Staffing Support

A description of Zone 7's water conservation program coordination and staffing support, the implementation over the past five years, and plans for continued implementation is provided below.

9.1.3.1 DMM Description

The Tri-Valley Water Task Force (Task Force) was formed in 2005 and generally consists of Zone 7 and retailer conservation staff, as well as public outreach staff. The Task Force meets about six to eight times a year, as needed, to discuss and coordinate on current and future conservation programs, legislative activities related to conservation and water use efficiency, and public outreach and training activities. With Zone 7's Conservation Coordinator active in state-wide and regional organizations and committees, the Task Force also serves as a main venue for information/knowledge exchange among the agencies. During the recent drought, the Task Force led the coordination of drought response activities, with more active participation from management.

Zone 7 has designated staff to actively develop, promote, enforce, and maintain water conservation programs. Zone 7 has a full-time Water Conservation Coordinator position, supported by administrative staff as needed on rebate processing and customer inquiries. A full-time Communications Specialist currently leads public outreach and education activities, including administration of the Schools Program and media campaigns.

Key duties of the Water Conservation Coordinator include:

- Tracking of water conservation regulations and industry developments
- Rebate program development and management, including communication with customers and retailers
- Support/promotion for Bay QWEL sessions for water efficient landscaper trainings

- Grant coordination and program management
- Coordination with the retailers' water conservation representatives through the Tri-Valley Water Conservation Task Force
- Participation in California Water Efficiency Partnership
- Development/coordination of the conservation component of public outreach and education workshops, along with the Communications Specialist

9.1.3.2 Implementation over the Past Five Years

Zone 7 has continued to coordinate conservation program activities with the retailers through the Tri-Valley Water Conservation Task Force. At the federal, state, and regional levels, Zone 7 coordinates the program through the EPA's WaterSense program, Alliance for Water Efficiency, California Water Efficiency Partnership, Integrated Regional Water Management Program, and DWR committees/workgroups etc.

Over the past five years, Zone 7 has largely maintained its Water Conservation Program team. However, the Water Conservation Coordinator has been temporarily vacant since late March 2020 due to retirement. The duties of the Water Conservation Coordinator have been jointly fulfilled by a Water Resources Technician, Integrated Planning Manager, and Communications Specialist in the interim.

Over the past five years, Zone 7 has spent approximately $220,000 to $435,000 per year on conservation program-related efforts.

9.1.3.3 Plans for Continued Implementation

Implementation of this DMM is a vital element of Zone 7's Water Conservation Program and will therefore continue. While the positions or duties may shift, Zone 7 will continue robust coordination with the retailers and other organizations on conservation.

9.1.4 Wholesale Supplier Assistance Programs

Zone 7 offers several rebate programs in cooperation with three of its water retailers (Livermore, Pleasanton, and DSRSD). In recent years, Cal Water has administered its own statewide rebate conservation program. Zone 7 provides funding for the rebates and assists with the retailers' rebate administration, including follow-up with applicants. Zone 7 coordinates with its retailers to offer rebate programs to promote water efficiency. After making water efficient improvements, customers can apply for a rebate to have some of the associated costs reimbursed.

Along with three of its retailers (DSRSD, Livermore, and Pleasanton), Zone 7 currently jointly offers three rebate programs to encourage indoor and outdoor water savings: Water-Efficient Lawn Conversion, Weather-Based Irrigation Controllers, and High-Efficiency Clothes Washers. Cal Water oversees their own statewide conservation program. These programs can reduce the cost for customers to increase water efficiency, thereby reducing water demand. Each program is discussed below.

9.1.4.1 Water-Efficient Lawn Conversion

Customers who replace grass lawns with low-water-use, drought-tolerant, or Mediterranean plants can receive a rebate for up to 50 percent of the project cost, up to a maximum of $750 for single-family residences and $4,500 for multi-family residences or non-residential properties. Project plans are developed in coordination with retailers or Zone 7 and must be approved prior to removing the lawn to be converted.

9.1.4.2 Weather-Based Irrigation Controllers (WBIC)

Weather-based irrigation controllers automatically adjust watering based on precipitation, reducing unnecessary water use (e.g., immediately following rain). Installing weather-based irrigation controllers qualifies customers for a rebate of up to 50 percent of associated costs, up to a maximum of $75 for single-family residences, $100 for multi-family residences, or $3,000 for non-residential properties.

9.1.4.3 High-Efficiency Clothes Washers (HEW)

High-efficiency clothes washing machines use about 50 percent less water than conventional, top-loading models (20 to 30 gallons of water per load compared to 40 to 45 gallons per load). After switching to a high-efficiency clothes washer, the estimated savings for a typical household is about 5,100 gallons per year. Zone 7 and its retailers offer a rebate of up to $75 for the purchase and installation of a qualifying "ENERGY STAR Most Efficient" labeled high-efficiency clothes washer.

9.1.4.4 Implementation over the Past Five Years

The High-Efficiency Toilet (HET) rebate program ended in 2017, with HETs increasing in market saturation. There was a pause in the HEW program in December 2018, but that program was reinstated and is currently active. The WEL program remains active, as well as the WBIC program.

Over the past five years, Zone 7 coordinated with its retailers to provide $329,500 in rebates for the above listed programs with 330 HET, 1,734 HEW, 623 WBIC, and 93 WEL applications.

9.1.4.5 Plans for Continued Implementation

Zone 7 periodically updates its rebate conservation program based on market saturation conditions, funding availability, demand patterns, grant funding opportunities, regulations, and other factors. Zone 7 will be reviewing its conservation program strategy—including rebates—over the next few years based on updated demand information and upcoming regulatory requirements.

A new rebate program, "Garden by Number" is planned and will be launched as soon as pandemic conditions improve. Under this program, customers can select from one to five garden pallet designs and plant by number, streamlining transition to a drought-tolerant garden without the expense of a landscape architect/other contractor.

9.1.5 Asset Management

As water infrastructure assets age, renewal and replacement become critical. Zone 7 utilizes an asset management process that systematically prioritizes rehabilitation and replacement and ensures long-term infrastructure sustainability. To maintain a reliable and high-quality water supply, Zone 7's asset management strategy focuses on core framework areas such as long-range planning, life-cycle costing, proactive operations and maintenance, long-term funding strategies, and capital replacement plans.

Zone 7's Asset Management Plan (AMP) formally summarizes its asset management process and strategy by forecasting near-term renewal needs and long-term funding requirements through fiscal year 2057/2058. The AMP is updated regularly, with the most recent update in 2017[24].

In 2021, Zone 7 is in the process of completing a pipeline inspection program study to update the AMP pipeline condition evaluation process. The pipeline inspection program study reviewed Zone 7's water transmission pipeline network, pipeline failure risk factors (e.g., documented repairs, potential for corrosion, pipeline depth, geologic conditions), criticality in delivering water, and Zone 7's current inspection program. These factors were used to recommend updates to the inspection program including inspection methods (e.g., manned entry, closed-circuit television [CCTV], acoustical measurements, and electromagnetic measurements), inspection schedule, and costs for the inspections for future infrastructure improvements. The outcome of the study will be to determine the funding and frequency needed to properly inspect each Zone 7 pipeline. Each pipeline will be assessed for the proper inspection method, improvements needed for proper inspection, recurrence interval for inspection, and costs for the improvements and implementation of the inspection method.

9.2 WATER USE OBJECTIVES (FUTURE REQUIREMENTS)

In 2018, the State Legislature enacted two policy bills, (SB 606 (Hertzberg) and AB 1668 (Friedman)), to establish long-term water conservation and drought planning to adapt to climate change and the associated longer and more intense droughts in California. These two policy bills build on SB X7-7 and sets authorities and requirements for urban water use efficiency. The legislation sets standards for indoor residential use and requires the State Water Board, in coordination with DWR, to adopt efficiency standards for outdoor residential use; water losses; and commercial, industrial, and institutional (CII) outdoor landscape areas with dedicated irrigation meters. At the time of preparation of this UWMP, DWR and the State Water Board are in the process of developing efficiency standards. These standards will require urban water retailers to develop agency-wide water use objectives, provide annual reports, and update their UWMPs.

The State Legislature established indoor residential water use standards as 55 GPCD until January 2025, 52.5 GPCD from 2025 to 2029, and 50 GPCD in January 2030, or a greater standard recommended by DWR and the State Water Board. By June 30, 2022, the State Water Board is anticipated to adopt an outdoor residential use standard, a standard for CII outdoor landscape area with dedicated irrigation meters, and performance measures for CII water uses. At that time, the State Water Board will adopt guidelines and methodologies for calculating the water use objectives. In accordance with CWC §10609.20(c), the water use objective for urban water retailers will be based on the estimated efficient indoor and outdoor residential water use, efficient outdoor irrigation of CII landscaped areas, estimated water losses, and estimated water use for variances approved by the State Water Board aggregated across the population in its water service area.

By November 1, 2023, and November 1 of every year thereafter, Zone 7's water retailers are anticipated to calculate their urban water use objective and actual water use and provide an annual report to the State. By January 1, 2024, Zone 7's water retailers are anticipated to prepare their UWMP supplemental

[24] HDR, 2017. Asset Management Plan Long-Term Funding Forecast Update.

incorporating DMMs and other water efficiency standards that they plan to implement to achieve their water use objective by January 1, 2027.

Zone 7 will continue coordinating with its retailers and support their efforts in achieving their water use objectives through its Water Conservation Program.

9.3 CALIFORNIA WATER EFFICIENCY PARTNERSHIP

Zone 7 is a participating member of the CalWEP, which was established in 2018 to combine expertise on California water issues, challenges, and opportunities and advance water efficiency both on the agency-wide and statewide level. CalWEP evolved from the California Urban Water Conservation Council (CUWCC), which administered an agreement between DWR, water utilities, environmental organizations, and other interested groups to implement best water management practices for reducing consumption of California’s water resources. Zone 7 was a participating member of CUWCC.

CalWEP also provides opportunities for networking and partnerships to improve water efficiency and conservation. Members are voluntarily organized into two main committees. The Research and Evaluation Committee collaboratively identifies and pursues research projects to benefit CalWEP members. The Program Committee shares needs, successes, and challenges, and identifies actionable steps for addressing water conservation program needs.

CHAPTER 10
Plan Adoption, Submittal, and Implementation

This chapter provides information regarding the notification, public hearing, adoption, and submittal of Zone 7's 2020 UWMP and updated WSCP. It also includes discussion on plan implementation and the process of amending the UWMP and the WSCP.

10.1 INCLUSION OF ALL 2020 DATA

Because 2020 is the final compliance year for SB X7-7, the 2020 UWMPs must contain data through the end of 2020. If a water supplier bases its accounting on a fiscal year (July through June) the data must be through the end of the 2020 fiscal year (June 2020). If the water supplier bases its accounting on a calendar year, the data must be through the end of the 2020 calendar year (December 2020).

As indicated in Section 2.4 of this plan, Zone 7 uses a calendar year for water supply and demand accounting; therefore, this 2020 UWMP includes data through December 2020.

10.2 NOTICE OF PUBLIC HEARING

In accordance with the Act, Zone 7 must provide an opportunity for the public to provide input on this 2020 UWMP and the WSCP. Zone 7 must consider all public input prior to its adoption. There are two audiences to be notified for the public hearing: cities and counties, and the public.

10.2.1 Notices to Cities and Counties

Zone 7 provided greater than a 60-day notice regarding the preparation of its 2020 UWMP and WSCP to cities and counties in its service area as discussed in Section 2.5 of this plan. In addition, Zone 7 provided notices to the following agencies:

- California Water Service
- Dublin San Ramon Services District
- Department of Water Resources
- Contra Costa Water District
- East Bay Municipal Utility District
- Livermore-Amador Valley Water Management Agency
- DSRSD-EBMUD Recycled Water Authority

Zone 7 coordinated the preparation of its UWMP and WSCP update internally and with its retailers. Included as Appendix E, the notice of preparation was sent to the cities and counties in Zone 7's service area and the above listed agencies. Upon substantial completion of this 2020 UWMP, Zone 7 provided the agencies listed above, including internally within Zone 7, notice of public hearing (Appendix E).

Notifications to cities and counties, in accordance with the Act, are summarized in Table 10-1.

Table 10-1. Notification to Cities and Counties (DWR Table 10-1 Wholesale)

☐	Supplier has notified more than 10 cities or counties in accordance with Water Code Sections 10621 (b) and 10642. **Completion of the table below is not required. Provide a separate list of the cities and counties that were**	
	Provide the page or location of this list in the UWMP.	
☑	Supplier has notified 10 or fewer cities or counties. **Complete the table below.**	
City Name	60 Day Notice	Notice of Public Hearing
Add additional rows as needed		
Dublin	Yes	Yes
Livermore	Yes	Yes
Pleasanton	Yes	Yes
San Ramon	Yes	Yes
County Name *Drop Down List*	60 Day Notice	Notice of Public Hearing
Add additional rows as needed		
Alameda County	Yes	Yes
Contra Costa County	Yes	Yes

10.2.2 Notice to the Public

Zone 7 issued a Notice of Public Hearing to the public and provided a public review period following the notice, and prior to adoption, to allow ample time for public comments to be prepared and received.

A Notice of Public Hearing was issued in accordance with Government Code Section 6066 and was published twice in a local newspaper (East Bay Times) to notify all customers and local governments of the public hearing. In addition, the notice was posted on Zone 7's website. A copy of the published Notice of Public Hearing is included in Appendix E.

10.3 PUBLIC HEARING AND ADOPTION

Zone 7 encouraged community participation in the development of this 2020 UWMP, including its WSCP, using public notices and web-based communication. The notice included the time and place of the public hearing, as well as the location where the plan is available for public inspection.

The public hearing provided an opportunity for Zone 7 water users and the general public to become familiar with the 2020 UWMP and ask questions about Zone 7's water supply, its continuing plans for providing a reliable, safe, high-quality water supply, and its plans to mitigate various potential water shortage conditions. Copies of the draft UWMP, including the WSCP, were made available for public inspection at Zone 7's administrative office and on the Zone 7 website.

10.3.1 Public Hearing

A public hearing was held on May 19, 2021, during which the Zone 7 Board received and considered input from the public before adopting the 2020 UWMP and updated WSCP.

10.3.2 Adoption

Subsequent to the public hearing, this 2020 UWMP was adopted by the Zone 7 Board on May 19, 2021. Zone 7 adopted the updated WSCP separately so that it may be updated as necessary. Copies of the adopted resolutions are included in Appendix H.

10.4 PLAN SUBMITTAL

This 2020 UWMP will be submitted to DWR within 30 days of adoption and by July 1, 2021. The adopted 2020 UWMP will be submitted electronically to DWR using the Water Use Efficiency (WUE) data submittal tool. A CD or hardcopy of the adopted 2020 UWMP will also be submitted to the California State Library.

No later than 30 days after adoption, a copy of the adopted 2020 UWMP, including the WSCP, will be provided to the cities and counties within which Zone 7 provides water.

10.5 PUBLIC AVAILABILITY

No later than 30 days after submittal to DWR, copies of this plan, including the adopted WSCP, will be available at Zone 7's administrative office in Livermore, California for public review during normal business hours. An electronic copy of this 2020 UWMP will also be available for review and download on Zone 7's website.

10.6 AMENDING AN ADOPTED UWMP OR WATER SHORTAGE CONTINGENCY PLAN

Zone 7 may amend its 2020 UWMP and WSCP jointly or separately. If Zone 7 amends one or both documents, Zone 7 will follow the notification, public hearing, adoption, and submittal process described in Sections 10.2 through 10.4 above. In addition to submitting amendments to DWR through the WUE data portal, within 30 days after adoption, Zone 7 will submit copies of amendments or changes to the plans to the California State Library and the cities or counties within which Zone 7 provides water.

Appendix A

Legislative Requirements

WATER CODE - WAT

DIVISION 6. CONSERVATION, DEVELOPMENT, AND UTILIZATION OF STATE WATER RESOURCES [10000 - 12999]
(Heading of Division 6 amended by Stats. 1957, Ch. 1932.)

PART 2.55. SUSTAINABLE WATER USE AND DEMAND REDUCTION [10608 - 10609.42] *(Part 2.55 added by Stats.2009, 7th Ex. Sess., Ch. 4, Sec. 1.)*

CHAPTER 1. General Declarations and Policy [10608 - 10608.8] *(Chapter 1 added by Stats. 2009, 7th Ex. Sess., Ch. 4, Sec. 1.)*

10608.

The Legislature finds and declares all of the following:

(a) Water is a public resource that the California Constitution protects against waste and unreasonable use.

(b) Growing population, climate change, and the need to protect and grow California's economy while protecting and restoring our fish and wildlife habitats make it essential that the state manage its water resources as efficiently as possible.

(c) Diverse regional water supply portfolios will increase water supply reliability and reduce dependence on the Delta.

(d) Reduced water use through conservation provides significant energy and environmental benefits, and can help protect water quality, improve stream flows, and reduce greenhouse gas emissions.

(e) The success of state and local water conservation programs to increase efficiency of water use is best determined on the basis of measurable outcomes related to water use or efficiency.

(f) Improvements in technology and management practices offer the potential for increasing water efficiency in California over time, providing an essential water management tool to meet the need for water for urban, agricultural, and environmental uses.

(g) The Governor has called for a 20 percent per capita reduction in urban water use statewide by 2020.

(h) The factors used to formulate water use efficiency targets can vary significantly from location to location based on factors including weather, patterns of urban and suburban development, and past efforts to enhance water use efficiency.

(i) Per capita water use is a valid measure of a water provider's efforts to reduce urban water use within its service area. However, per capita water use is less useful for measuring relative water use efficiency between different water providers. Differences in weather, historical patterns of urban and suburban development, and density of housing in a particular location need to be considered when assessing per capita water use as a measure of efficiency.

(*Added* by Stats. 2009, 7th Ex. Sess., Ch. 4, Sec. 1. (SB 7 7x) Effective February 3, 2010.)

10608.4

It is the intent of the Legislature, by the enactment of this part, to do all of the following:

(a) Require all water suppliers to increase the efficiency of use of this essential resource.

(b) Establish a framework to meet the state targets for urban water conservation identified in this part and called for by the Governor.

(c) Measure increased efficiency of urban water use on a per capita basis.

(d) Establish a method or methods for urban retail water suppliers to determine targets for achieving increased water use efficiency by the year 2020, in accordance with the Governor's goal of a 20-percent reduction.

(e) Establish consistent water use efficiency planning and implementation standards for urban water suppliers and agricultural water suppliers.

(f) Promote urban water conservation standards that are consistent with the California Urban Water Conservation Council's adopted best management practices and the requirements for demand management in Section 10631.

(g) Establish standards that recognize and provide credit to water suppliers that made substantial capital investments in urban water conservation since the drought of the early 1990s.

(h) Recognize and account for the investment of urban retail water suppliers in providing recycled water for beneficial uses.

(i) Require implementation of specified efficient water management practices for agricultural water suppliers.

(j) Support the economic productivity of California's agricultural, commercial, and industrial sectors.

(k) Advance regional water resources management.

(Added by Stats. 2009, 7th Ex. Sess., Ch. 4, Sec. 1. (SB 7 7x) Effective February 3, 2010.)

10608.8

(a) (1) Water use efficiency measures adopted and implemented pursuant to this part or Part 2.8 (commencing with Section 10800) are water conservation measures subject to the protections provided under Section 1011.

(2) Because an urban agency is not required to meet its urban water use target until 2020 pursuant to subdivision (a) of Section 10608.24, an urban retail water supplier's failure to meet those targets shall not establish a violation of law for purposes of any state administrative or judicial proceeding prior to January 1, 2021. Nothing in this paragraph limits the use of data reported to the department or the board in litigation or an administrative proceeding. This paragraph shall become inoperative on January 1, 2021.

(3) To the extent feasible, the department and the board shall provide for the use of water conservation reports required under this part to meet the requirements of Section 1011 for water conservation reporting.

(b) This part does not limit or otherwise affect the application of Chapter 3.5 (commencing with Section 11340), Chapter 4 (commencing with Section 11370), Chapter 4.5 (commencing with Section 11400), and Chapter 5 (commencing with Section 11500) of Part 1 of Division 3 of Title 2 of the Government Code.

(c) This part does not require a reduction in the total water used in the agricultural or urban sectors, because other factors, including, but not limited to, changes in agricultural economics or population growth may have greater effects on water use. This part does not limit the economic productivity of California's agricultural, commercial, or industrial sectors.

(d) The requirements of this part do not apply to an agricultural water supplier that is a party to the Quantification Settlement Agreement, as defined in subdivision (a) of Section 1 of Chapter 617 of the Statutes of 2002, during the period within which the Quantification Settlement Agreement remains in effect. After the expiration of the Quantification Settlement Agreement, to the extent conservation water projects implemented as part of the Quantification Settlement Agreement remain in effect, the conserved water created as part of those projects shall be credited against the obligations of the agricultural water supplier pursuant to this part.

(Added by Stats. 2009, 7th Ex. Sess., Ch. 4, Sec. 1. (SB 7 7x) Effective February 3, 2010.)

WATER CODE - WAT

DIVISION 6. CONSERVATION, DEVELOPMENT, AND UTILIZATION OF STATE WATER RESOURCES [10000 - 12999] *(Heading of Division 6 amended by Stats. 1957, Ch. 1932.)*

PART 2.55. SUSTAINABLE WATER USE AND DEMAND REDUCTION [10608 - 10609.42] *(Part 2.55 added by Stats. 2009, 7th Ex. Sess., Ch. 4, Sec. 1.)*

CHAPTER 9. Urban Water Use Objectives and Water Use Reporting [10609 - 10609.38] *(Chapter 9 added by Stats. 2018, Ch. 15, Sec. 7.)*

10609. (a) The Legislature finds and declares that this chapter establishes a method to estimate the aggregate amount of water that would have been delivered the previous year by an urban retail water supplier if all that water had been used efficiently. This estimated aggregate water use is the urban retail water supplier's urban water use objective. The method is based on water use efficiency standards and local service area characteristics for that year. By comparing the amount of water actually used in the previous year with the urban water use objective, local urban water suppliers will be in a better position to help eliminate unnecessary use of water; that is, water used in excess of that needed to accomplish the intended beneficial use.

(b) The Legislature further finds and declares all of the following:

(1) This chapter establishes standards and practices for the following water uses:

(A) Indoor residential use.

(B) Outdoor residential use.

(C) CII water use.

(D) Water losses.

(E) Other unique local uses and situations that can have a material effect on an urban water supplier's total water use.

(2) This chapter further does all of the following:

(A) Establishes a method to calculate each urban water use objective.

(B) Considers recycled water quality in establishing efficient irrigation standards.

(C) Requires the department to provide or otherwise identify data regarding the unique local conditions to support the calculation of an urban water use objective.

(D) Provides for the use of alternative sources of data if alternative sources are shown to be as accurate as, or more accurate than, the data provided by the department.

(E) Requires annual reporting of the previous year's water use with the urban water use objective.

(F) Provides a bonus incentive for the amount of potable recycled water used the previous year when comparing the previous year's water use with the urban water use objective, of up to 10 percent of the urban water use objective.

(3) This chapter requires the department and the board to solicit broad public participation from stakeholders and other interested persons in the development of the standards and the adoption of regulations pursuant to this chapter.

(4) This chapter preserves the Legislature's authority over long-term water use efficiency target setting and ensures appropriate legislative oversight of the implementation of this chapter by doing all of the following:

(A) Requiring the Legislative Analyst to conduct a review of the implementation of this chapter, including compliance with the adopted standards and regulations, accuracy of the data, use of alternate data, and other issues the Legislative Analyst deems appropriate.

(B) Stating legislative intent that the director of the department and the chairperson of the board appear before the appropriate Senate and Assembly policy committees to report on progress in implementing this chapter.

(C) Providing one-time-only authority to the department and board to adopt water use efficiency standards, except as explicitly provided in this chapter. Authorization to update the standards shall require separate legislation.

(c) It is the intent of the Legislature that the following principles apply to the development and implementation of long-term standards and urban water use objectives:

(1) Local urban retail water suppliers should have primary responsibility for meeting standards-based water use targets, and they shall retain the flexibility to develop their water supply portfolios, design and implement water conservation strategies, educate their customers, and enforce their rules.

(2) Long-term standards and urban water use objectives should advance the state's goals to mitigate and adapt to climate change.

(3) Long-term standards and urban water use objectives should acknowledge the shade, air quality, and heat-island reduction benefits provided to communities by trees through the support of water-efficient irrigation practices that keep trees healthy.

(4) The state should identify opportunities for streamlined reporting, eliminate redundant data submissions, and incentivize open access to data collected by urban and agricultural water suppliers.

(Amended by Stats. 2019, Ch. 497, Sec. 287. (AB 991) Effective January 1, 2020.)

10609.2. (a) The board, in coordination with the department, shall adopt long-term standards for the efficient use of water pursuant to this chapter on or before June 30, 2022.

(b) Standards shall be adopted for all of the following:

(1) Outdoor residential water use.

(2) Outdoor irrigation of landscape areas with dedicated irrigation meters in connection with CII water use.

(3) A volume for water loss.

(c) When adopting the standards under this section, the board shall consider the policies of this chapter and the proposed efficiency standards' effects on local wastewater management, developed and natural parklands, and urban tree health. The standards and potential effects shall be identified by May 30, 2022. The board shall allow for public comment on potential effects identified by the board under this subdivision.

(d) The long-term standards shall be set at a level designed so that the water use objectives, together with other demands excluded from the long-term standards such as CII indoor water use and CII outdoor water use not connected to a dedicated landscape meter, would exceed the statewide conservation targets required pursuant to Chapter 3 (commencing with Section 10608.16).

(e) The board, in coordination with the department, shall adopt by regulation variances recommended by the department pursuant to Section 10609.14 and guidelines and methodologies pertaining to the calculation of an urban retail water supplier's urban water use objective recommended by the department pursuant to Section 10609.16.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.4. (a) (1) Until January 1, 2025, the standard for indoor residential water use shall be 55 gallons per capita daily.

(2) Beginning January 1, 2025, and until January 1, 2030, the standard for indoor residential water use shall be the greater of 52.5 gallons per capita daily or a standard recommended pursuant to subdivision (b).

(3) Beginning January 1, 2030, the standard for indoor residential water use shall be the greater of 50 gallons per capita daily or a standard recommended pursuant to subdivision (b).

(b) (1) The department, in coordination with the board, shall conduct necessary studies and investigations and may jointly recommend to the Legislature a standard for indoor residential water use that more appropriately reflects best practices for indoor residential water use than the standard described in subdivision (a). A report on the results of the studies and investigations shall be made to the chairpersons of the relevant policy committees of each house of the Legislature by January 1, 2021, and shall include information necessary to support the recommended standard, if there is one. The studies and investigations shall also include an analysis of the benefits and impacts of how the changing standard for indoor residential water use will impact water and wastewater management, including potable water usage, wastewater, recycling and reuse systems, infrastructure, operations, and supplies.

(2) The studies, investigations, and report described in paragraph (1) shall include collaboration with, and input from, a broad group of stakeholders, including, but not limited to, environmental groups, experts in indoor plumbing, and water, wastewater, and recycled water agencies.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.6. (a) (1) The department, in coordination with the board, shall conduct necessary studies and investigations and recommend, no later than October 1, 2021, standards for outdoor residential use for adoption by the board in accordance with this chapter.

(2) (A) The standards shall incorporate the principles of the model water efficient landscape ordinance adopted by the department pursuant to the Water Conservation in Landscaping Act (Article 10.8 (commencing with Section 65591) of Chapter 3 of Division 1 of Title 7 of the Government Code).

(B) The standards shall apply to irrigable lands.

(C) The standards shall include provisions for swimming pools, spas, and other water features. Ornamental water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, shall be analyzed separately from swimming pools and spas.

(b) The department shall, by January 1, 2021, provide each urban retail water supplier with data regarding the area of residential irrigable lands in a manner that can reasonably be applied to the standards adopted pursuant to this section.

(c) The department shall not recommend standards pursuant to this section until it has conducted pilot projects or studies, or some combination of the two, to ensure that the data provided to local agencies are reasonably accurate for the data's intended uses, taking into consideration California's diverse landscapes and community characteristics.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.8. (a) The department, in coordination with the board, shall conduct necessary studies and investigations and recommend, no later than October 1, 2021, standards for outdoor irrigation of landscape areas with dedicated irrigation meters or other means of calculating outdoor irrigation use in connection with CII water use for adoption by the board in accordance with this chapter.

(b) The standards shall incorporate the principles of the model water efficient landscape ordinance adopted by the department pursuant to the Water Conservation in Landscaping Act (Article 10.8 (commencing with Section 65591) of Chapter 3 of Division 1 of Title 7 of the Government Code).

(c) The standards shall include an exclusion for water for commercial agricultural use meeting the definition of subdivision (b) of Section 51201 of the Government Code.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.9. For purposes of Sections 10609.6 and 10609.8, "principles of the model water efficient landscape ordinance" means those provisions of the model water efficient landscape ordinance applicable to the establishment or determination of the amount of water necessary to efficiently irrigate both new and existing landscapes. These provisions include, but are not limited to, all of the following:

(a) Evapotranspiration adjustment factors, as applicable.

(b) Landscape area.

(c) Maximum applied water allowance.

(d) Reference evapotranspiration.

(e) Special landscape areas, including provisions governing evapotranspiration adjustment factors for different types of water used for irrigating the landscape.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.10. (a) The department, in coordination with the board, shall conduct necessary studies and investigations and recommend, no later than October 1, 2021, performance measures for CII water use for adoption by the board in accordance with this chapter.

(b) Prior to recommending performance measures for CII water use, the department shall solicit broad public participation from stakeholders and other interested persons relating to all of the following:

(1) Recommendations for a CII water use classification system for California that address significant uses of water.

(2) Recommendations for setting minimum size thresholds for converting mixed CII meters to dedicated irrigation meters, and evaluation of, and recommendations for, technologies that could be used in lieu of requiring dedicated irrigation meters.

(3) Recommendations for CII water use best management practices, which may include, but are not limited to, water audits and water management plans for those CII customers that exceed a recommended size, volume of water use, or other threshold.

(c) Recommendations of appropriate performance measures for CII water use shall be consistent with the October 21, 2013, report to the Legislature by the Commercial, Industrial, and Institutional Task Force entitled "Water Use Best Management Practices," including the technical and financial feasibility recommendations provided in that report, and shall support the economic productivity of California's commercial, industrial, and institutional sectors.

(d) (1) The board, in coordination with the department, shall adopt performance measures for CII water use on or before June 30, 2022.

(2) Each urban retail water supplier shall implement the performance measures adopted by the board pursuant to paragraph (1).

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.12. The standards for water loss for urban retail water suppliers shall be the standards adopted by the board pursuant to subdivision (i) of Section 10608.34.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.14. (a) The department, in coordination with the board, shall conduct necessary studies and investigations and, no later than October 1, 2021, recommend for adoption by the board in accordance with this chapter appropriate variances for unique uses that can have a material effect on an urban retail water supplier's urban water use objective.

(b) Appropriate variances may include, but are not limited to, allowances for the following:

(1) Significant use of evaporative coolers.

(2) Significant populations of horses and other livestock.

(3) Significant fluctuations in seasonal populations.

(4) Significant landscaped areas irrigated with recycled water having high levels of total dissolved solids.

(5) Significant use of water for soil compaction and dust control.

(6) Significant use of water to supplement ponds and lakes to sustain wildlife.

(7) Significant use of water to irrigate vegetation for fire protection.

(8) Significant use of water for commercial or noncommercial agricultural use.

(c) The department, in recommending variances for adoption by the board, shall also recommend a threshold of significance for each recommended variance.

(d) Before including any specific variance in calculating an urban retail water supplier's water use objective, the urban retail water supplier shall request and receive approval by the board for the inclusion of that variance.

(e) The board shall post on its Internet Web site all of the following:

(1) A list of all urban retail water suppliers with approved variances.

(2) The specific variance or variances approved for each urban retail water supplier.

(3) The data supporting approval of each variance.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.15. To help streamline water data reporting, the department and the board shall do all of the following:

(a) Identify urban water reporting requirements shared by both agencies, and post on each agency's Internet Web site how the data is used for planning, regulatory, or other purposes.

(b) Analyze opportunities for more efficient publication of urban water reporting requirements within each agency, and analyze how each agency can integrate various data sets in a publicly accessible location, identify priority actions, and implement priority actions identified in the analysis.

(c) Make appropriate data pertaining to the urban water reporting requirements that are collected by either agency available to the public according to the principles and requirements of the Open and Transparent Water Data Act (Part 4.9 (commencing with Section 12400)).

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.16. The department, in coordination with the board, shall conduct necessary studies and investigations and recommend, no later than October 1, 2021, guidelines and methodologies for the board to adopt that identify how an urban retail water supplier calculates its urban water use objective. The guidelines and methodologies shall address, as necessary, all of the following:

(a) Determining the irrigable lands within the urban retail water supplier's service area.

(b) Updating and revising methodologies described pursuant to subparagraph (A) of paragraph (1) of subdivision (h) of Section 10608.20, as appropriate, including methodologies for calculating the population in an urban retail water supplier's service area.

(c) Using landscape area data provided by the department or alternative data.

(d) Incorporating precipitation data and climate data into estimates of a urban retail water supplier's outdoor irrigation budget for its urban water use objective.

(e) Estimating changes in outdoor landscape area and population, and calculating the urban water use objective, for years when updated landscape imagery is not available from the department.

(f) Determining acceptable levels of accuracy for the supporting data, the urban water use objective, and compliance with the urban water use objective.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.18. The department and the board shall solicit broad public participation from stakeholders and other interested persons in the development of the standards and the adoption of regulations pursuant to this chapter. The board shall hold at least one public meeting before taking any action on any standard or variance recommended by the department.

(Added by Stats. 2018, Ch. 15, Sec. 7. (AB 1668) Effective January 1, 2019.)

10609.20. (a) Each urban retail water supplier shall calculate its urban water use objective no later than January 1, 2024, and by January 1 every year thereafter.

(b) The calculation shall be based on the urban retail water supplier's water use conditions for the previous calendar or fiscal year.

(c) Each urban water supplier's urban water use objective shall be composed of the sum of the following:

(1) Aggregate estimated efficient indoor residential water use.

(2) Aggregate estimated efficient outdoor residential water use.

(3) Aggregate estimated efficient outdoor irrigation of landscape areas with dedicated irrigation meters or equivalent technology in connection with CII water use.

(4) Aggregate estimated efficient water losses.

(5) Aggregate estimated water use in accordance with variances, as appropriate.

(d) (1) An urban retail water supplier that delivers water from a groundwater basin, reservoir, or other source that is augmented by potable reuse water may adjust its urban water use objective by a bonus incentive calculated pursuant to this subdivision.

(2) The water use objective bonus incentive shall be the volume of its potable reuse delivered to residential water users and to landscape areas with dedicated irrigation meters in connection with CII water use, on an acre-foot basis.

(3) The bonus incentive pursuant to paragraph (1) shall be limited in accordance with one of the following:

(A) The bonus incentive shall not exceed 15 percent of the urban water supplier's water use objective for any potable reuse water produced at an existing facility.

(B) The bonus incentive shall not exceed 10 percent of the urban water supplier’s water use objective for any potable reuse water produced at any facility that is not an existing facility.

(4) For purposes of this subdivision, “existing facility” means a facility that meets all of the following:

(A) The facility has a certified environmental impact report, mitigated negative declaration, or negative declaration on or before January 1, 2019.

(B) The facility begins producing and delivering potable reuse water on or before January 1, 2022.

(C) The facility uses microfiltration and reverse osmosis technologies to produce the potable reuse water.

(e) (1) The calculation of the urban water use objective shall be made using landscape area and other data provided by the department and pursuant to the standards, guidelines, and methodologies adopted by the board. The department shall provide data to the urban water supplier at a level of detail sufficient to allow the urban water supplier to verify its accuracy at the parcel level.

(2) Notwithstanding paragraph (1), an urban retail water supplier may use alternative data in calculating the urban water use objective if the supplier demonstrates to the department that the alternative data are equivalent, or superior, in quality and accuracy to the data provided by the department. The department may provide technical assistance to an urban retail water supplier in evaluating whether the alternative data are appropriate for use in calculating the supplier’s urban water use objective.

(Amended by Stats. 2019, Ch. 239, Sec. 2. (AB 1414) Effective January 1, 2020.)

10609.21. (a) For purposes of Section 10609.20, and notwithstanding paragraph (4) of subdivision (d) of Section 10609.20, “existing facility” also includes the North City Project, phase one of the Pure Water San Diego Program, for which an environmental impact report was certified on April 10, 2018.

(b) This section shall become operative on January 1, 2019.

(Added by Stats. 2018, Ch. 453, Sec. 4. (SB 875) Effective September 17, 2018. Section operative January 1, 2019, by its own provisions.)

10609.22. (a) An urban retail water supplier shall calculate its actual urban water use no later than January 1, 2024, and by January 1 every year thereafter.

(b) The calculation shall be based on the urban retail water supplier’s water use for the previous calendar or fiscal year.

(c) Each urban water supplier’s urban water use shall be composed of the sum of the following:

(1) Aggregate residential water use.

(2) Aggregate outdoor irrigation of landscape areas with dedicated irrigation meters in connection with CII water use.

(3) Aggregate water losses.

(Amended by Stats. 2019, Ch. 239, Sec. 3. (AB 1414) Effective January 1, 2020.)

10609.24. (a) An urban retail water supplier shall submit a report to the department no later than January 1, 2024, and by January 1 every year thereafter. The report shall include all of the following:

(1) The urban water use objective calculated pursuant to Section 10609.20 along with relevant supporting data.

(2) The actual urban water use calculated pursuant to Section 10609.22 along with relevant supporting data.

(3) Documentation of the implementation of the performance measures for CII water use.

(4) A description of the progress made towards meeting the urban water use objective.

(5) The validated water loss audit report conducted pursuant to Section 10608.34.

(b) The department shall post the reports and information on its internet website.

(c) The board may issue an information order or conservation order to, or impose civil liability on, an entity or individual for failure to submit a report required by this section.

(Amended by Stats. 2019, Ch. 239, Sec. 4. (AB 1414) Effective January 1, 2020.)

10609.25. As part of the first report submitted to the department by an urban retail water supplier no later than January 1, 2024, pursuant to subdivision (a) of Section 10609.24, each urban retail water supplier shall provide a narrative that describes the water demand management measures that the supplier plans to implement to achieve its urban water use objective by January 1, 2027.

(Added by Stats. 2019, Ch. 239, Sec. 5. (AB 1414) Effective January 1, 2020.)

10609.26. (a) (1) On and after January 1, 2024, the board may issue informational orders pertaining to water production, water use, and water conservation to an urban retail water supplier that does not meet its urban water use objective required by this chapter. Informational orders are intended to obtain information on supplier activities, water production, and conservation efforts in order to identify technical assistance needs and assist urban water suppliers in meeting their urban water use objectives.

(2) In determining whether to issue an informational order, the board shall consider the degree to which the urban retail water supplier is not meeting its urban water use objective, information provided in the report required by Section 10609.24, and actions the urban retail water supplier has implemented or will implement in order to help meet the urban water use objective.

(3) The board shall share information received pursuant to this subdivision with the department.

(4) An urban water supplier may request technical assistance from the department. The technical assistance may, to the extent available, include guidance documents, tools, and data.

(b) On and after January 1, 2025, the board may issue a written notice to an urban retail water supplier that does not meet its urban water use objective required by this chapter. The written notice may warn the urban retail water supplier that it is not meeting its urban water use objective described in Section 10609.20 and is not making adequate progress in meeting the urban water use objective, and may request that the urban retail water supplier address areas of concern in its next annual report required by Section 10609.24. In deciding whether to issue a written notice, the board may consider whether the urban retail water supplier has received an informational order, the degree to which the urban retail water supplier is not meeting its urban water use objective, information provided in the report required by Section 10609.24, and actions the urban retail water supplier has implemented or will implement in order to help meet its urban water use objective.

(c) (1) On and after January 1, 2026, the board may issue a conservation order to an urban retail water supplier that does not meet its urban water use objective. A conservation order may consist of, but is not limited to, referral to the department for technical assistance, requirements for education and outreach, requirements for local enforcement, and other efforts to assist urban retail water suppliers in meeting their urban water use objective.

(2) In issuing a conservation order, the board shall identify specific deficiencies in an urban retail water supplier's progress towards meeting its urban water use objective, and identify specific actions to address the deficiencies.

(3) The board may request that the department provide an urban retail water supplier with technical assistance to support the urban retail water supplier's actions to remedy the deficiencies.

(d) A conservation order issued in accordance with this chapter may include requiring actions intended to increase water-use efficiency, but shall not curtail or otherwise limit the exercise of a water right, nor shall it require the imposition of civil liability pursuant to Section 377.

(Amended by Stats. 2019, Ch. 239, Sec. 6. (AB 1414) Effective January 1, 2020.)

10609.27. Notwithstanding Section 10609.26, the board shall not issue an information order, written notice, or conservation order pursuant to Section 10609.26 if both of the following conditions are met:

(a) The board determines that the urban retail water supplier is not meeting its urban water use objective solely because the volume of water loss exceeds the urban retail water supplier's standard for water loss.

(b) Pursuant to Section 10608.34, the board is taking enforcement action against the urban retail water supplier for not meeting the performance standards for the volume of water losses.

(Added by Stats. 2019, Ch. 203, Sec. 1. (SB 134) Effective January 1, 2020.)

10609.28. The board may issue a regulation or informational order requiring a wholesale water supplier, an urban retail water supplier, or a distributor of a public water supply, as that term is used in Section 350, to provide a monthly report relating to water production, water use, or water conservation.

(Added by Stats. 2018, Ch. 14, Sec. 12. (SB 606) Effective January 1, 2019.)

10609.30. On or before January 10, 2024, the Legislative Analyst shall provide to the appropriate policy committees of both houses of the Legislature and the public a report evaluating the implementation of the water use efficiency standards and water use reporting pursuant to this chapter. The board and the department shall provide the Legislative Analyst with the available data to complete this report.

(a) The report shall describe all of the following:

(1) The rate at which urban retail water users are complying with the standards, and factors that might facilitate or impede their compliance.

(2) The accuracy of the data and estimates being used to calculate urban water use objectives.

(3) Indications of the economic impacts, if any, of the implementation of this chapter on urban water suppliers and urban water users, including CII water users.

(4) The frequency of use of the bonus incentive, the volume of water associated with the bonus incentive, value to urban water suppliers of the bonus incentive, and any implications of the use of the bonus incentive on water use efficiency.

(5) The early indications of how implementing this chapter might impact the efficiency of statewide urban water use.

(6) Recommendations, if any, for improving statewide urban water use efficiency and the standards and practices described in this chapter.

(7) Any other issues the Legislative Analyst deems appropriate.

(Added by Stats. 2018, Ch. 14, Sec. 13. (SB 606) Effective January 1, 2019.)

10609.32. It is the intent of the Legislature that the chairperson of the board and the director of the department appear before the appropriate policy committees of both houses of the Legislature on or around January 1, 2026, and report on the implementation of the water use efficiency standards and water use reporting pursuant to this chapter. It is the intent of the Legislature that the topics to be covered include all of the following:

(a) The rate at which urban retail water suppliers are complying with the standards, and factors that might facilitate or impede their compliance.

(b) What enforcement actions have been taken, if any.

(c) The accuracy of the data and estimates being used to calculate urban water use objectives.

(d) Indications of the economic impacts, if any, of the implementation of this chapter on urban water suppliers and urban water users, including CII water users.

(e) The frequency of use of the bonus incentive, the volume of water associated with the bonus incentive, value to urban water suppliers of the bonus incentive, and any implications of the use of the bonus incentive on water use efficiency.

(f) An assessment of how implementing this chapter is affecting the efficiency of statewide urban water use.

(Added by Stats. 2018, Ch. 14, Sec. 14. (SB 606) Effective January 1, 2019.)

10609.34. Notwithstanding Section 15300.2 of Title 14 of the California Code of Regulations, an action of the board taken under this chapter shall be deemed to be a Class 8 action, within the meaning of Section 15308 of Title 14 of the California Code of Regulations, provided that the action does not involve relaxation of existing water conservation or water use standards.

(Added by Stats. 2018, Ch. 14, Sec. 15. (SB 606) Effective January 1, 2019.)

10609.36. (a) Nothing in this chapter shall be construed to determine or alter water rights. Sections 1010 and 1011 apply to water conserved through implementation of this chapter.

(b) Nothing in this chapter shall be construed to authorize the board to update or revise water use efficiency standards authorized by this chapter except as explicitly provided in this chapter. Authorization to update the standards beyond that explicitly provided in this chapter shall require separate legislation.

(c) Nothing in this chapter shall be construed to limit or otherwise affect the use of recycled water as seawater barriers for groundwater salinity management.

(Added by Stats. 2018, Ch. 14, Sec. 16. (SB 606) Effective January 1, 2019.)

10609.38. The board may waive the requirements of this chapter for a period of up to five years for any urban retail water supplier whose water deliveries are significantly affected by changes in water use as a result of damage from a disaster such as an earthquake or fire. In establishing the period of a waiver, the board shall take into consideration the breadth of the damage and the time necessary for the damaged areas to recover from the disaster.

(Added by Stats. 2018, Ch. 14, Sec. 17. (SB 606) Effective January 1, 2019.)

DIVISION 6. CONSERVATION, DEVELOPMENT, AND UTILIZATION OF STATE WATER RESOURCES [10000 - 12999]
(Heading of Division 6 amended by Stats. 1957, Ch. 1932.)

PART 2.6. URBAN WATER MANAGEMENT PLANNING [10610 - 10657] *(Part 2.6 added by Stats. 1983, Ch. 1009, Sec..)*

CHAPTER 1. General Declaration and Policy [10610 - 10610.4] ***(Chapter 1 added by Stats. 1983, Ch. 1009, Alec. 1.)***

10610 This part shall be known and may be cited as the "Urban Water Management Planning Act."

(Added by Stats. 1983, Ch. 1009, Sec. 1.)

10610.2. (a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate, and increasing long-term water conservation among Californians, improving water use efficiency within the state's communities and agricultural production, and strengthening local and regional drought planning are critical to California's resilience to drought and climate change.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years now and into the foreseeable future, and every urban water supplier should collaborate closely with local land-use authorities to ensure water demand forecasts are consistent with current land-use planning.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact on water management strategies and supply reliability.

(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

(Amended by Stats. 201B, Ch. 14, Sec. 18. (SB 606) Effective January 1, 201 9.)

10610.4 The Legislature finds and declares that it is the policy of the state as follows:

(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.

CHAPTER 2. Definitions [10611 - 1 0618] ***(Chapter 2 added by Stats. 1983, Ch. 1009, iec. 1.)***

10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

(Added by Stats. 1983, Ch. 1009, Sec. 1.)

10611.3 "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

Added by renumbering Section 10612 by Stats. 2018, Ch. 14, Sec. 20. (SB 606) Effective January 1, 2019.)

10611.5 "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

(Amended by Stats. 1995, Ch. 854, Sec. 3. Effective January 1, 1996.)

10612 "Drought risk assessment" means a method that examines water shortage risks based on the driest five- year historic sequence for the agency's water supply, as described in subdivision (b) of Section 10635.

(Added by Stats. 2018, Ch. 14, Sec. 21. (SB 606) Effective January 1, 201 9.)

10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

(Added by :3tats. 1983, Ch. 1009, Exec. 1.)

10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

(Added by Stats. 1983, Ch. 1009, Sec. 1.)

10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

(Amended by Stats. 1995, *Ch. 854, Sec. 4. Effective January 1, 1996.)*

10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

(Added by Stats. 1983, Ch. 1009, Sec. 1.)

10616.5 "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

(Added by Stats. 1995, Ch. 854, Sec. 5. Effective January 1, 1996)

10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

(Amended by Stats. 1996, *Ch. 1023, Sec. 428. Effective January 29, 1996.)*

10617.5. "Water shortage contingency plan" means a document that incorporates the provisions detailed in subdivision (a) of Section 10632 and is subsequently adopted by an urban water supplier pursuant to this article.

(Added by Stats. 2018, Ch. 14, Sec. 22. (SB 606) Effective January 1, 2019)

10618 "Water supply and demand assessment" means a method that looks at current year and one or more dry year supplies and demands for determining water shortage risks, as described in Section 10632.1.

(Added by Stats. 2018, Ch. 14, Sec. 23 (SB 606). Effective January 1, 2019)

CHAPTER 3. Urban Water Management Plans [10620 - 10645] *(Chapter 3 added by* Stabs. *1983, Ch. 1009, Sec. 1.)*

ARTICLE 1. General Provisions [10620 - 1 0621] *(Article 1 added by Stats. 1 983, Ch. 1009, Sec. 1.)*

10620. (a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.

(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.

(d) (l) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation, efficient water use, and improved local drought resilience.

(2) Notwithstanding paragraph (1), each urban water supplier shall develop its own water shortage contingency plan, but an urban water supplier may incorporate, collaborate, and otherwise share information with other urban water suppliers or other governing entities participating in an areawide, regional, watershed, or basinwide urban water management plan, an agricultural management plan, or groundwater sustainability plan development.

(3) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.

(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

(Amended by Stats. 2018, Ch. 14, Sec. 24. (SB 606) Effective January 1, 2019.)

10621 (a) Each urban water supplier shall update its plan at least once every five years on or before July 1, in years ending in six and one, incorporating updated and new information from the five years preceding each update.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days before the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

(c) An urban water supplier regulated by the Public Utilities Commission shall include its most recent plan and water shortage contingency plan as part of the supplier's general rate case filings.

(d) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640)

(e) Each urban water supplier shall update and submit its 2015 plan to the department by July1, 2016

(f) Each urban water supplier shall update and submit its 2020 plan to the department by July 1,2021

(Amended by Stats. 2019, Ch. 239, Sec. 7. (AB 1414) Effective January 1, 2020.)

CHAPTER 3. Urban Water Management Plans [10620 - 10645] ***(Chapter 3 added by Stats. 1983, Ch. 1009, Sec. 1.)***

ARTICLE 2. Contents of Plans [10630 - 1 0634] ***(Article 2 added by Stats. 1 983, Ch. 1009, Sec. 1.)***

10630 It is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied, while accounting for impacts from climate change.

(Amended by Stats. 2018, Ch. 14, Sec. 26. (SB 606) Effective January 1, 201 9.)

10630.5 Each plan shall include a simple lay description of how much water the agency has on a reliable basis, how much it needs for the foreseeable future, what the agency's strategy is for meeting its water needs, the challenges facing the agency, and any other information necessary to provide a general understanding of the agency's plan.

(Added by Stats. 2018, Ch. 14, Sec. 27. (SB 606) Effective January 1, 2019.)

10631 A plan shall be adopted in accordance with this chapter that shall do all of the following:

(a) Describe the service area of the supplier, including current and projected population, climate, and other social, economic, and demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available. The description shall include the current and projected land uses within the existing or anticipated service area affecting the supplier's water management planning. Urban water suppliers shall coordinate with local or regional land use authorities to determine the most appropriate land use information, including, where appropriate, land use information obtained from local or regional land use authorities, as developed pursuant to Article 5 (commencing with Section 65300) of Chapter 3 of Division 1 of Title 7 of the Government Code.

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a), providing supporting and related information, including all of the following:

(1) A detailed discussion of anticipated supply availability under a normal water year, single dry year, and droughts lasting at least five years, as well as more frequent and severe periods of drought, as described in the drought risk assessment. For each source of water supply, consider any information pertinent to the reliability analysis conducted pursuant to Section 10635, including changes in supply due to climate change.

(2) When multiple sources of water supply are identified, a description of the management of each supply in correlation with the other identified supplies.

(3) For any planned sources of water supply, a description of the measures that are being undertaken to acquire and develop those water supplies.

(4) If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information:

The current version of any groundwater sustainability plan or alternative adopted pursuant to Part 2.74 (commencing with Section 10720), any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management for basins underlying the urban water supplier's service area.

(A) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For basins that a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. For a basin that has not been adjudicated, information as to whether the department has identified the basin as a high- or medium-priority basin in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to coordinate with groundwater sustainability agencies or groundwater management agencies listed in subdivision (c) of Section 10723 to maintain or achieve sustainable groundwater conditions in accordance with a groundwater sustainability plan or alternative adopted pursuant to Part 2.74 (commencing with Section 10720).

(B) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(C) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(d) (l) For an urban retail water supplier, quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, based upon information developed pursuant to subdivision (a), identifying the uses among water use sectors, including, but not necessarily limited to, all of the following:

(A) Single-family residential.

(B) Multifamily.

(C) Commercial.

(D) Industrial.

(E) Institutional and governmental.

(F) Landscape.

(G) Sales to other agencies.

(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.

(I) Agricultural.

(J) Distribution system water loss.

(2) The water use projections shall be in the same five-year increments described in subdivision (a).

(3) (A) The distribution system water loss shall be quantified for each of the five years preceding the plan update, in accordance with rules adopted pursuant to Section 10608.34.

(B) The distribution system water loss quantification shall be reported in accordance with a worksheet approved or developed by the department through a public process. The water loss quantification worksheet shall be based on the water system balance methodology developed by the American Water Works Association.

(C) In the plan due July 1, 2021, and in each update thereafter, data shall be included to show whether the urban retail water supplier met the distribution loss standards enacted by the board pursuant to Section 10608.34.

(4) (A) Water use projections, where available, shall display and account for the water savings estimated to result from adopted codes, standards, ordinances, or transportation and land use

plans identified by the urban water supplier, as applicable to the service area.

(B) To the extent that an urban water supplier reports the information described in subparagraph (A), an urban water supplier shall do both of the following:

(i) Provide citations of the various codes, standards, ordinances, or transportation and land use plans utilized in making the projections.

(ii) Indicate the extent that the water use projections consider savings from codes, standards, ordinances, or transportation and land use plans. Water use projections that do not account for these water savings shall be noted of that fact.

(e) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) (A) For an urban retail water supplier, as defined in Section 10608.12, a narrative description that addresses the nature and extent of each water demand management measure implemented over the past five years. The narrative shall describe the water demand management measures that the supplier plans to implement to achieve its water use targets pursuant to Section 10608.20.

(B) For the supplement required of urban retail water suppliers by paragraph (2) of subdivision (f) of Section 10621, a narrative that describes the water demand management measures that the supplier plans to implement to achieve its urban water use objective by January 1, 2027, pursuant to Chapter 9 (commencing with Section 10609) of Part 2.55.

(C) The narrative pursuant to this paragraph shall include descriptions of the following water demand management measures:

(i) Water waste prevention ordinances.

(ii) Metering.

(iii) Conservation pricing.

(iv) Public education and outreach.

(v) Programs to assess and manage distribution system real loss.

(vi) Water conservation program coordination and staffing support.

(vii) Other demand management measures that have a significant impact on water use as measured in gallons per capita per day, including innovative measures, if implemented.

(2) For an urban wholesale water supplier, as defined in Section 10608.12, a narrative description of the items in clauses (ii), (iv), (vi), and (vii) of subparagraph (C) of paragraph (1), and a narrative description of its distribution system asset management and wholesale supplier assistance programs.

(f) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use, as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in normal and single-dry water years and for a period of drought lasting five consecutive water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(g) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

(h) An urban water supplier that relies upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (f). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (f).

(Amended by Stats. 2018, Ch. 14, Sec. 28. (SB 606) Effective January 1, 2019.)

10631 1 (a) The water use projections required by Section 10631 shall include projected water use for single- family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier.

(b) It is the intent of the Legislature that the identification of projected water use for single-family and multifamily residential housing for lower income households will assist a supplier in complying with the requirement under Section 65589.7 of the Government Code to grant a priority for the provision of service to housing units affordable to lower income households.

(Added by Stats. 2005, Ch. 727, Sec. 2. Effective January 1, 2006.)

10631.2. (a) In addition to the requirements of Section 10631, an urban water management plan shall include any of the following information that the urban water supplier can readily obtain:

(1) An estimate of the amount of energy used to extract or divert water supplies.

(2) An estimate of the amount of energy used to convey water supplies to the water treatment plants or distribution systems.

(3) An estimate of the amount of energy used to treat water supplies.

(4) An estimate of the amount of energy used to distribute water supplies through its distribution systems.

(5) An estimate of the amount of energy used for treated water supplies in comparison to the amount used for nontreated water supplies.

(6) An estimate of the amount of energy used to place water into or withdraw from storage.

(7) Any other energy-related information the urban water supplier deems appropriate.

(b) The department shall include in its guidance for the preparation of urban water management plans a methodology for the voluntary calculation or estimation of the energy intensity of urban water systems. The department may consider studies and calculations conducted by the Public Utilities Commission in developing the methodology.

(c) The Legislature finds and declares that energy use is only one factor in water supply planning and shall not be considered independently of other factors.

(Amended by Stats. 2018, Ch. 14, Sec. 29. (SB 606a Effective January 1, 2019.)

10632 (a) Every urban water supplier shall prepare and adopt a water shortage contingency plan as part of its urban water management plan that consists of each of the following elements:

(1) The analysis of water supply reliability conducted pursuant to Section 10635.

(2) The procedures used in conducting an annual water supply and demand assessment

that include, at a minimum, both of the following:

(A) The written decision making process that an urban water supplier will use each year to determine its water supply reliability.

(B) The key data inputs and assessment methodology used to evaluate the urban water supplier's water supply reliability for the current year and one dry year, including all of the following:

(i) Current year unconstrained demand, considering weather, growth, and other influencing factors, such as policies to manage current supplies to meet demand objectives in future years, as applicable.

(ii) Current year available supply, considering hydrological and regulatory conditions in the current year and one dry year. The annual supply and demand assessment may consider more than one dry year solely at the discretion of the urban water supplier.

(iii) Existing infrastructure capabilities and plausible constraints.

(iv) A defined set of locally applicable evaluation criteria that are consistently relied upon for each annual water supply and demand assessment.

(v) A description and quantification of each source of water supply.

(3) (A) Six standard water shortage levels corresponding to progressive ranges of up to 10, 20, 30, 40, and 50 percent shortages and greater than 50 percent shortage. Urban water suppliers shall define these shortage levels based on the suppliers' water supply conditions, including percentage reductions in water supply, changes in groundwater levels, changes in surface elevation or level of subsidence, or other changes in hydrological or other local conditions indicative of the water supply available for use. Shortage levels shall also apply to catastrophic interruption of water supplies, including, but not limited to, a regional power outage, an earthquake, and other potential emergency events.

(B) An urban water supplier with an existing water shortage contingency plan that uses different water shortage levels may comply with the requirement in subparagraph (A) by developing and including a cross-reference relating its existing categories to the six standard water shortage levels.

(4) Shortage response actions that align with the defined shortage levels and include, at a minimum, all of the following:

(A) Locally appropriate supply augmentation actions. Locally appropriate demand reduction actions to adequately respond to shortages.

(B) Locally appropriate operational changes.

(C) Additional, mandatory prohibitions against specific water use practices that are in addition to state-mandated prohibitions and appropriate to the local conditions.

(D) For each action, an estimate of the extent to which the gap between supplies and demand will be reduced by implementation of the action.

(5) Communication protocols and procedures to inform customers, the public, interested parties, and local, regional, and state governments, regarding, at a minimum, all of the following:

(A) Any current or predicted shortages as determined by the annual water supply and demand assessment described pursuant to Section 10632.1.

(B) Any shortage response actions triggered or anticipated to be triggered by the annual water supply and demand assessment described pursuant to Section 10632.1.

(C) Any other relevant communications.

(6) For an urban retail water supplier, customer compliance, enforcement, appeal, and exemption

procedures for triggered shortage response actions as determined pursuant to Section 10632.2.

(7) (A) A description of the legal authorities that empower the urban water supplier to implement and enforce its shortage response actions specified in paragraph (4) that may include, but are not limited to, statutory authorities, ordinances, resolutions, and contract provisions.

(B) A statement that an urban water supplier shall declare a water shortage emergency in accordance with Chapter 3 (commencing with Section 350) of Division 1.

(C) A statement that an urban water supplier shall coordinate with any city or county within which it provides water supply services for the possible proclamation of a local emergency, as defined in Section 8558 of the Government Code.

(8) A description of the financial consequences of, and responses for, drought conditions, including, but not limited to, all of the following:

(A) A description of potential revenue reductions and expense increases associated with activated shortage response actions described in paragraph (4).

(B) A description of mitigation actions needed to address revenue reductions and expense increases associated with activated shortage response actions described in paragraph (4).

(C) A description of the cost of compliance with Chapter 3.3 (commencing with Section 365) of Division 1.

(9) For an urban retail water supplier, monitoring and reporting requirements and procedures that ensure appropriate data is collected, tracked, and analyzed for purposes of monitoring customer compliance and to meet state reporting requirements.

(10) Reevaluation and improvement procedures for systematically monitoring and evaluating the functionality of the water shortage contingency plan in order to ensure shortage risk tolerance is adequate and appropriate water shortage mitigation strategies are implemented as needed.

(b) For purposes of developing the water shortage contingency plan pursuant to subdivision (a), an urban water supplier shall analyze and define water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, separately from swimming pools and spas, as defined in subdivision (a) of Section 115921 of the Health and Safety Code.

(c) The urban water supplier shall make available the water shortage contingency plan prepared pursuant to this article to its customers and any city or county within which it provides water supplies no later than 30 days after adoption of the water shortage contingency plan.

(Repealed and added by Stats. 2018, Ch. 14, Sec. 32. (SB 606) Effective January 1, 2019.)

10632.1 An urban water supplier shall conduct an annual water supply and demand assessment pursuant to subdivision (a) of Section 10632 and, on or before June 1 of each year, submit an annual water shortage assessment report to the department with information for anticipated shortage, triggered shortage response actions, compliance and enforcement actions, and communication actions consistent with the supplier's water shortage contingency plan. An urban water supplier that relies on imported water from the State Water Project or the Bureau of Reclamation shall submit its annual water supply and demand assessment within 14 days of receiving its final allocations, or by June 1 of each year, whichever is later.

(Added by Stats. 2018, Ch. 14, Sec. 33. (SB 606) Effective January 1, 2019.)

10632.2. An urban water supplier shall follow, where feasible and appropriate, the prescribed procedures and implement determined shortage response actions in its water shortage contingency plan, as identified in subdivision

(a) of Section 10632, or reasonable alternative actions, provided that descriptions of the alternative actions are submitted with the annual water shortage assessment report pursuant to Section

10632.1. Nothing in this section prohibits an urban water supplier from taking actions not specified in its water shortage contingency plan, if needed, without having to formally amend its urban water management plan or water shortage contingency plan.

(Added by Stats. 2018, Ch. 14, Sec. 34. (SB 606) Effective January 1, 2019.)

10632.3 It is the intent of the Legislature that, upon proclamation by the Governor of a state of emergency under the California Emergency Services Act (Chapter 7 (commencing with Section 8550) of Division 1 of Title 2 of the Government Code) based on drought conditions, the board defer to implementation of locally adopted water shortage contingency plans to the extent practicable.

(Added by Stats. 2018, Ch. 14, Sec. 35. (SB 606) Effective January 1, 2019.)

10632.5 (a) In addition to the requirements of paragraph (3) of subdivision (a) of Section 10632, beginning January 1, 2020, the plan shall include a seismic risk assessment and mitigation plan to assess the vulnerability of each of the various facilities of a water system and mitigate those vulnerabilities.

(b) An urban water supplier shall update the seismic risk assessment and mitigation plan when updating its urban water management plan as required by Section 10621.

(c) An urban water supplier may comply with this section by submitting, pursuant to Section 10644, a copy of the most recent adopted local hazard mitigation plan or multihazard mitigation plan under the federal Disaster Mitigation Act of 2000 (Public Law 106-390) if the local hazard mitigation plan or multihazard mitigation plan addresses seismic risk.

(Added by Stats. 2015, Ch. 681, Sec. 1. (SB 664a *Effective January 1, 2OJ* 6.g

10633 The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area, and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.

(c) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(d) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(e) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(f) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

(g) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

(Amended by Stats. 2009, Ch. 534, Sec. 2. (AB 1465) Effective January 1, 2010.)

10634 The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.

(Added by Stats. 2001, Ch. 644, Sec. 3. Effective January 1, 2002.)

CHAPTER 3. Urban Water Management Plans [10620 - 10645] ***(Chapter 3 added by*** **Stabs.** ***1983, Ch. 1009, Sec. 1.)***

ARTICLE 2.5. Water Service Reliability [10635- 10635.] ***(Article 2.5 added by Stats. 1995, Ch. 854, Sec. 11.)***

10635. (a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the long-term total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and a drought lasting five consecutive water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

(b) Every urban water supplier shall include, as part of its urban water management plan, a drought risk assessment for its water service to its customers as part of information considered in developing the demand management measures and water supply projects and programs to be included in the urban water management plan. The urban water supplier may conduct an interim update or updates to this drought risk assessment within the five-year cycle of its urban water management plan update. The drought risk assessment shall include each of the following:

(1) A description of the data, methodology, and basis for one or more supply shortage conditions that are necessary to conduct a drought risk assessment for a drought period that lasts five consecutive water years, starting from the year following when the assessment is conducted.

(2) A determination of the reliability of each source of supply under a variety of water shortage conditions. This may include a determination that a particular source of water supply is fully reliable under most, if not all, conditions.

(3) A comparison of the total water supply sources available to the water supplier with the total projected water use for the drought period.

(4) Considerations of the historical drought hydrology, plausible changes on projected supplies and demands under climate change conditions, anticipated regulatory changes, and other locally applicable criteria.

(c) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

(d) Nothing in this article is intended to create a right or entitlement to water service or any specific level of water service.

(e) Nothing in this article is intended to change existing law concerning an urban water supplier’s obligation to provide water service to its existing customers or to any potential future customers

(Amended by Stats. 2018, Ch. 14, Sec. 36. (SB 606) Effective January 1, 2019.)

CHAPTER 3. Urban Water Management Plans [10620 - 10645] ***(Chapter 3 added by*** **Stabs.** ***1983, Ch. 1009, Sec. 1.)***

ARTICLE 3. Adoption and Implementation of Plans [1 0640 - 10645] ***Article 3 added by Stats. 1983, Ch. 1009, Sec. 1.)***

10640. (a) Every urban water supplier required to prepare a plan pursuant to this part shall prepare its plan pursuant to Article 2 (commencing with Section 10630). The supplier shall likewise periodically review the plan as required by Section 10621, and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

(b) Every urban water supplier required to prepare a water shortage contingency plan shall prepare a water shortage contingency plan pursuant to Section 10632. The supplier shall likewise periodically review the water shortage contingency plan as required by paragraph (10) of subdivision (a) of Section 10632 and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

(Amended by Stats. 2018, Ch. 14, Sec. 37. (SB 606a *Effective January 1, 2OJ* 9.g

10641 An urban water supplier required to prepare a plan or a water shortage contingency plan may consult with, and obtain comments from, any public agency or state agency or any person who has special expertise with respect to water demand management methods and techniques.

(Amended by Stats. 2018, Ch. 14, Sec. 38. (SB 606a *Effective January 1, 20J* 9.g

10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of both the plan and the water shortage contingency plan. Prior to adopting either, the urban water supplier shall make both the plan and the water shortage contingency plan available for public inspection and shall hold a public hearing or hearings thereon. Prior to any of these hearings, notice of the time and place of the hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of a hearing to any city or county within which the supplier provides water supplies. Notices by a local public agency pursuant to this section shall be provided pursuant to Chapter 17.5 (commencing with Section 7290) of Division 7 of Title 1 of the Government Code. A privately owned water supplier shall provide an equivalent notice within its service area. After the hearing or hearings, the plan or water shortage contingency plan shall be adopted as prepared or as modified after the hearing or hearings.

(Amended by Stats. 2018, Ch. 14, Sec. 39. (SB 606$ *Effective January 1, 70J* 9.g

10643 An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.

(Added by Stats. 1983, Ch. 1009, Sec. 1.)

10644 (a) (1) An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption.Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption.

(2) The plan, or amendments to the plan, submitted to the department pursuant to paragraph (1)

shall be submitted electronically and shall include any standardized forms, tables, or displays specified by the department.

(b) If an urban water supplier revises its water shortage contingency plan, the supplier shall submit to the department a copy of its water shortage contingency plan prepared pursuant to subdivision (a) of Section 10632 no later than 30 days after adoption, in accordance with protocols for submission and using electronic reporting tools developed by the department.

(c) (1) (A) Notwithstanding Section 10231.5 of the Government Code, the department shall prepare and submit to the Legislature, on or before July 1, in the years ending in seven and two, a report summarizing the status of the plans and water shortage contingency plans adopted pursuant to this part. The report prepared by the department shall identify the exemplary elements of the individual plans and water shortage contingency plans. The department shall provide a copy of the report to each urban water supplier that has submitted its plan and water shortage contingency plan to the department. The department shall also prepare reports and provide data for any legislative hearings designed to consider the effectiveness of plans and water shortage contingency plans submitted pursuant to this part.

(B) The department shall prepare and submit to the board, on or before September 30 of each year, a report summarizing the submitted water supply and demand assessment results along with appropriate reported water shortage conditions and the regional and statewide analysis of water supply conditions developed by the department. As part of the report, the department shall provide a summary and, as appropriate, urban water supplier specific information regarding various shortage response actions implemented as a result of annual supplier-specific water supply and demand assessments performed pursuant to Section 10632.1.

(C) The department shall submit the report to the Legislature for the 2015 plans by July 1, 2017, and the report to the Legislature for the 2020 plans and water shortage contingency plans by July 1, 2022.

(2) A report to be submitted pursuant to subparagraph (A) of paragraph (1) shall be submitted in compliance with Section 9795 of the Government Code.

(d) The department shall make available to the public the standard the department will use to identify exemplary water demand management measures.

(Amended by Stats. 2018, Ch. 14, Sec. 40. (SB 606) Effective January 1, 2019.)

10645. (a) Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

(b) Not later than 30 days after filing a copy of its water shortage contingency plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

(Amended by Stats. 2018, Ch. 14, Sec. 41. (SB 606) Effective January 1, 201 9.)

CHAPTER 4. Miscellaneous Provisions [1 0650 - 10657] ***(Chapter 4 added by :itats. 1 983, Ch. 1009, iec. 1.)***

10650 Any actions or proceedings, other than actions by the board, to attack, review, set aside, void, or annul the acts or decisions of an urban water supplier on the grounds of noncompliance with this part shall be commenced as follows:

(a) An action or proceeding alleging failure to adopt a plan or a water shortage contingency plan shall be commenced within 18 months after that adoption is required by this part.

(b) Any action or proceeding alleging that a plan or water shortage contingency plan, or action taken pursuant to either, does not comply with this part shall be commenced within 90 days after filing of the plan or water shortage contingency plan or an amendment to either pursuant to Section 10644 or the taking of that action.

(Amended by Stats. 2018, Ch. 14, Sec. 42. (SB 606) Effective January 1, 2019.)

10651 In any action or proceeding to attack, review, set aside, void, or annul a plan or a water shortage contingency plan, or an action taken pursuant to either by an urban water supplier on the grounds of noncompliance with this part, the inquiry shall extend only to whether there was a prejudicial abuse of discretion. Abuse of discretion is established if the supplier has not proceeded in a manner required by law or if the action by the water supplier is not supported by substantial evidence.

(Amended by Stats. 2018, Ch. 14, Sec. 43. (SB 606) *Effective January 1, 2019*

10652 The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) does not apply to the preparation and adoption of plans pursuant to this part or to the implementation of actions taken pursuant to Section 10632. Nothing in this part shall be interpreted as exempting from the California Environmental Quality Act any project that would significantly affect water supplies for fish and wildlife, or any project for implementation of the plan, other than projects implementing Section 10632, or any project for expanded or additional water supplies.

(Amended by Stats. 1995, Ch. 854, Sec. 6. *Effective January 1, 1996.)*

10653 The adoption of a plan shall satisfy any requirements of state law, regulation, or order, including those of the board and the Public Utilities Commission, for the preparation of water management plans, water shortage contingency plans, or conservation plans; provided, that if the board or the Public Utilities Commission requires additional information concerning water conservation, drought response measures, or financial conditions to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan that complies with analogous federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part.

(Amended by Stats. 2018, Ch. 14, Sec. 45. (SB 606) *Effective January 1, 2019)*

10654 An urban water supplier may recover in its rates the costs incurred in preparing its urban water management plan, its drought risk assessment, its water supply and demand assessment, and its water shortage contingency plan and implementing the reasonable water conservation measures included in either of the plans.

(Amended by Stats. 2018, Ch. 14, Sec. 44. (SB 606) *Effective January 1, 2019)*

10655 If any provision of this part or the application thereof to any person or circumstances is held invalid, that invalidity shall not affect other provisions or applications of this part which can be given effect without the invalid provision or application thereof, and to this end the provisions of this part are severable.

(Amended by Stats. 1983, Ch. 1009, Sec. 1)

10656 An urban water supplier is not eligible for a water grant or loan awarded or administered by the state unless the urban water supplier complies with this part.

(Amended by Stats. 2018, Ch. 14, Sec. 46. (SB 606) *Effective January 1, 2019)*

10657 The department may adopt regulations regarding the definitions of water, water use, and reporting periods, and may adopt any other regulations deemed necessary or desirable to implement this part. In developing regulations pursuant to this section, the department shall solicit broad public participation from stakeholders and other interested persons.

(Amended by Stats. 2018, Ch. 14, Sec. 47. (SB 606) *Effective January 1, 2019)*

Appendix B

Demonstration of Reduced Delta Reliance

FINAL | JUNE 2021

Zone 7 Water Agency
Reduced Reliance on the Delta

JOINTLY PREPARED BY

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LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

AFY	Acre-Feet Per Year
BARDP	Bay Area Regional Desalination Project
Delta	Sacramento-San Joaquin Delta
DWR	Department of Water Resources
Guidebook	Urban Water Management Plan Guidebook 2020
M&I	Municipal and Industrial
Plan	Urban Water Management Plan
SWP	State Water Project
UWMP	Urban Water Management Plan
WR P1	Delta Plan Policy WR P1
Zone 7	Zone 7 Water Agency

Zone 7 Water Agency
Reduced Reliance on the Delta

The purpose of this document is to demonstrate compliance with the Sacramento-San Joaquin Delta Reform Act of 2009. The Sacramento-San Joaquin Delta Reform Act of 2009 is described below, followed by an analysis of Zone 7 Water Agency's (Zone 7) reduced reliance in accordance with State protocols and expected outcomes for reduced reliance on the Delta.

1.0 SACRAMENTO-SAN JOAQUIN DELTA REFORM ACT OF 2009

Under the Sacramento-San Joaquin Delta Reform Act of 2009, state and local public agencies proposing a "covered action" in the Sacramento-San Joaquin Delta (Delta) must submit a written certification of consistency to the Delta Stewardship Council as to whether the covered action is consistent with applicable Delta Plan policies. Covered actions include a multi-year water transfer, conveyance facility, or new diversion that involves transferring water through, exporting water from, or using water in the Delta. Anyone may appeal a certification of consistency, and if the Delta Stewardship Council grants the appeal, the covered action may not be implemented until the agency proposing the covered action submits a revised certification of consistency, and either no appeal is filed, or the Delta Stewardship Council denies the subsequent appeal.

An urban water supplier that anticipates participating in or receiving water from a proposed covered action is required to provide information in their 2015 and 2020 Urban Water Management Plans (UWMPs) that can then be used in the covered action process to demonstrate consistency with Delta Plan Policy WR P1, Reduce Reliance on the Delta Through Improved Regional Water Self-Reliance (WR P1).

WR P1 details what is needed for a covered action to demonstrate consistency with reduced reliance on the Delta and improved regional self-reliance. WR P1 subsection (a) states that:

> *(a) Water shall not be exported from, transferred through, or used in the Delta if all of the following apply:*
>
> *(1) One or more water suppliers that would receive water as a result of the export, transfer, or use have failed to adequately contribute to reduced reliance on the Delta and improved regional self-reliance consistent with all of the requirements listed in paragraph (1) of subsection (c);*
>
> *(2) That failure has significantly caused the need for the export, transfer, or use; and*
>
> *(3) The export, transfer, or use would have a significant adverse environmental impact in the Delta.*

WR P1 subsection (c)(1) further defines what adequately contributing to reduced reliance on the Delta means in terms of (a)(1) above.

> *(c)(1) Water suppliers that have done all the following are contributing to reduced reliance on the Delta and improved regional self-reliance and are therefore consistent with this policy:*
>
> *(A) Completed a current Urban or Agricultural Water Management Plan (Plan) which has been reviewed by the California Department of Water Resources for compliance with the applicable requirements of Water Code Division 6, Parts 2.55, 2.6, and 2.8;*
>
> *(B) Identified, evaluated, and commenced implementation, consistent with the implementation schedule set forth in the Plan, of all programs and projects included in the Plan that are locally cost effective and technically feasible which reduce reliance on the Delta; and*

(C) Included in the Plan, commencing in 2015, the expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance. The expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance shall be reported in the Plan as the reduction in the amount of water used, or in the percentage of water used, from the Delta watershed. For the purposes of reporting, water efficiency is considered a new source of water supply, consistent with Water Code section 1011(a).

The analysis and documentation provided below include all of the elements described in WR P1(c)(1) that need to be included in a water supplier's UWMP to support a certification of consistency for a future covered action. Including this document as an appendix in the 2015 and 2020 Urban Water Management Plans fulfills the requirements of WR P1 subsection (c)(1) Paragraph A.

2.0 REDUCED RELIANCE ANALYSIS

The data used in this analysis represent the regional efforts of the Zone 7 to serve its customers in the Tri-Valley, including municipal and industrial (M&I) retailers (California Water Service, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton), M&I direct retail customers, and untreated water customers. The analysis was coordinated with Zone 7's retailers as part of the UWMP coordination process as described in the 2020 UWMP. In accordance with UMWP requirements, Zone 7's retailers report their demand and supply data for their respective service areas in their respective UWMPs. This appendix reports demands on Zone 7 and supplies served by Zone 7. The retailers report their other sources of supplies used to supplement Zone 7 supplies in their UWMPs as applicable (e.g., recycled water, groundwater pumped by the retailer). Zone 7 provided the info presented here to the retailers so they can appropriately represent the nature of their wholesale supplies from Zone 7, and those supplies' contributions to reduced Delta reliance.

The methodology used to determine Zone 7's reduced Delta reliance and improved regional self-reliance is consistent with the approach detailed in Appendix C of Department of Water Resources' (DWR) Urban Water Management Plan Guidebook 2020 (Guidebook Appendix C) issued in April 2021, including the use of narrative justifications for the accounting of supplies and the documentation of specific data sources. General assumptions include:

- All data were obtained from the current 2020 UWMP or previously adopted UWMPs and represent average or normal water year conditions.
- All analyses were conducted at the wholesale level, focusing on demands on Zone 7 and Zone 7's sources of supplies served to the Tri-Valley.
- As described in Chapter 6 of the 2020 UWMP, Zone 7 is currently pursuing a number of water supply and storage alternatives to bolster water system reliability while reducing reliance on the Delta. The future projects described in Chapter 6 and the demand management measures described in Chapter 9 fulfill the requirements of WR P1 subsection (c)(1) Paragraph B. For the purposes of the 2020 UWMP, a representative future water supply portfolio was selected; that portfolio is reflected in this analysis.

Tables 1 through 4 present the analysis of Zone 7's reduced Delta reliance using DWR's spreadsheet tool and fulfill the requirements of WR P1 subsection (c)(1) Paragraph C. Descriptions of the various inputs of the analysis are provided below:

- **Baseline (2010) and 2015-2045 Conditions** – The analysis uses a normal water year representation of 2010 as the baseline, which is consistent with the approach described in DWR's Guidebook. Data for the 2010 baseline were taken from the 2010 UWMP (Table 9-11). To evaluate conditions relative to the baseline, actual conditions for 2015 (Table 4-1 of 2015 UWMP) and 2020 (Table 4-1 of 2020 UWMP) are presented. Normal year projections for 2025 through 2045 from the 2020 UWMP are then subsequently used. In its 2020 UWMP, Zone 7 does not include operational storage—groundwater recharge and State Water Project (SWP) carryover—in its current or projected demands. To maintain consistency with baseline and 2015 conditions, operational storage has been added to actual (2020) and projected (2025-2045) demands presented in Zone 7's 2020 UWMP.
- **Service Area Water Demands with Water Use Efficiency Accounted For** – These values reflect Zone 7's actual and projected water use, including water placed in storage as applicable.
- **Non-Potable Water Demands** – This item includes untreated water demands, raw water losses, and water placed in storage.
- **Water Supplies Contributing to Regional Self-Reliance**
  - ***Water Use Efficiency*** – This amount is calculated by DWR's spreadsheet tool based on Zone 7's baseline demand, actual demands, and expected future demands. The value shown is the reduction in per capita water demand from the baseline (2010) multiplied by the projected population for each. Because the Tri-Valley has successfully reduced potable water demands over time, conserved water is contributing significantly to Zone 7's regional self-reliance.
  - ***Conjunctive Use Projects*** – Zone 7's use of operational storage in the Main Basin is included here. The Main Basin is recharged with SWP water and local Arroyo Valle water. This water is locally available for use during normal operations, drought, and emergencies.
  - ***Local and Regional Water Supply and Storage Projects*** – This includes actual use and future projected use of local Arroyo Valle water.
  - ***Other Programs and Projects that Contribute to Regional Self-Reliance*** –As discussed in Chapter 6 of the 2020 UWMP, Zone 7 has included Sites Reservoir (10,000 acre-feet per year (AFY) of average yield) and 5,000 AFY from a combination of potable reuse and desalinated brackish water from the Bay Area Regional Desalination Project (BARDP) as a representative portfolio of future supplies. As stated in a letter from the Delta Stewardship Council to the Sites Project Authority on May 2, 2018, "Sites Reservoir would be located upstream from the Delta, outside the legal Delta boundary" and "does not meet the definition of a covered action"; consequently, Sites Reservoir has been categorized as a water supply contributing to regional self-reliance. Potable reuse, which would use locally generated wastewater, also contributes to regional self-reliance; the amount was assumed to be 2,500 AF from 2030 onwards for the purposes of this analysis.

- Water Supplies from the Delta Watershed
  - ***CVP/SWP Contract Supplies*** – Zone 7 derives a large portion of its supplies from the SWP system, as reflected in the analysis.
  - ***Transfers and Exchanges of Supplies from the Delta Watershed*** – Water transfers and exchanges that Zone 7 receives via the Delta and South Bay Aqueduct have been included here. This includes water from the Yuba Accord, Byron-Bethany Irrigation District, and future water transfers expected to be part of Zone 7's water supply portfolio through 2030.
  - ***Other Water Supplies from the Delta Watershed*** – SWP carryover water and actual recovered water from the Kern County groundwater banks delivered through the Delta have been included here. Note that future projections do not include water from the banks because that supply is not part of normal year operations. In addition, water from the BARDP (assumed at 2,500 AFY for the purposes of this analysis) has been included from 2030 onwards, since brackish water would be derived from the Delta.

Table 1. Optional Calculation of Water Use Efficiency (DWR Table C-1)

Service Area Water Use Efficiency Demands (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Service Area Water Demands with Water Use Efficiency Accounted For	66,200	47,900	55,040	69,500	72,000	73,000	74,500	74,500
Non-Potable Water Demands	20,000	22,500	16,110	24,700	27,000	27,500	27,500	27,500
Potable Service Area Demands with Water Use Efficiency Accounted For	46,200	25,400	38,930	44,800	45,000	45,500	47,000	47,000

Total Service Area Population	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045
Service Area Population	216,000	238,600	265,811	283,964	299,121	311,887	322,742	322,742

Water Use Efficiency Since Baseline (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Per Capita Water Use (GPCD)	191	95	131	141	134	130	130	130
Change in Per Capita Water Use from Baseline (GPCD)		(96)	(60)	(50)	(57)	(61)	(61)	(61)
Estimated Water Use Efficiency Since Baseline		25,634	17,924	15,937	18,979	21,209	22,031	22,031

Table 2. Calculation of Service Area Water Demands Without Water Use Efficiency (DWR Table C-2)

Total Service Area Water Demands (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Service Area Water Demands with Water Use Efficiency Accounted For	66,200	47,900	55,040	69,500	72,000	73,000	74,500	74,500
Reported Water Use Efficiency or Estimated Water Use Efficiency Since Baseline		25,634	17,924	15,937	18,979	21,209	22,031	22,031
Service Area Water Demands without Water Use Efficiency Accounted For	66,200	73,534	72,964	85,437	90,979	94,209	96,531	96,531

Table 3. Calculation of Supplies Contributing to Regional Self-Reliance (DWR Table C-3)

Water Supplies Contributing to Regional Self-Reliance (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Water Use Efficiency		25,634	17,924	15,937	18,979	21,209	22,031	22,031
Water Recycling								
Stormwater Capture and Use								
Advanced Water Technologies								
Conjunctive Use Projects	9,200	2,000	12,000	9,200	9,200	9,200	9,200	9,200
Local and Regional Water Supply and Storage Projects	7,100	2,860	8,700	5,500	5,500	5,500	5,500	5,500
Other Programs and Projects that Contribute to Regional Self-Reliance					12,500	12,500	12,500	12,500
Water Supplies Contributing to Regional Self-Reliance	16,300	30,494	38,624	30,637	46,179	48,409	49,231	49,231

Service Area Water Demands without Water Use Efficiency (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Service Area Water Demands without Water Use Efficiency Accounted For	66,200	73,534	72,964	85,437	90,979	94,209	96,531	96,531

Change in Regional Self Reliance (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Water Supplies Contributing to Regional Self-Reliance	16,300	30,494	38,624	30,637	46,179	48,409	49,231	49,231
Change in Water Supplies Contributing to Regional Self-Reliance		14,194	22,324	14,337	29,879	32,109	32,931	32,931

Percent Change in Regional Self Reliance (As Percent of Demand w/out WUE)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Percent of Water Supplies Contributing to Regional Self-Reliance	24.6%	41.5%	52.9%	35.9%	50.8%	51.4%	51.0%	51.0%
Change in Percent of Water Supplies Contributing to Regional Self-Reliance		16.8%	28.3%	11.2%	26.1%	26.8%	26.4%	26.4%

Table 4. Calculation of Reliance on Water Supplies from the Delta Watershed (DWR Table C-4)

Water Supplies from the Delta Watershed (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
CVP/SWP Contract Supplies	51,400	16,100	16,100	47,000	46,000	45,000	43,500	43,500
Delta/Delta Tributary Diversions								
Transfers and Exchanges of Supplies from the Delta Watershed	4,645	380	7,100	5,000	5,000			
Other Water Supplies from the Delta Watershed		26,560	11,800	10,000	12,500	12,500	12,500	12,500
Total Water Supplies from the Delta Watershed	56,045	43,040	35,000	62,000	63,500	57,500	56,000	56,000

Service Area Water Demands without Water Use Efficiency (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Service Area Water Demands without Water Use Efficiency Accounted For	66,200	73,534	72,964	85,437	90,979	94,209	96,531	96,531

Change in Supplies from the Delta Watershed (Acre-Feet)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Water Supplies from the Delta Watershed	56,045	43,040	35,000	62,000	63,500	57,500	56,000	56,000
Change in Water Supplies from the Delta Watershed		(13,005)	(21,045)	5,955	7,455	1,455	(45)	(45)

Percent Change in Supplies from the Delta Watershed (As a Percent of Demand w/out WUE)	Baseline (2010)	2015	2020	2025	2030	2035	2040	2045 (Optional)
Percent of Water Supplies from the Delta Watershed	85%	59%	48%	73%	70%	61%	58%	58%
Change in Percent of Water Supplies from the Delta Watershed		-26%	-37%	-12%	-15%	-24%	-27%	-27%

3.0 EXPECTED OUTCOMES FOR REDUCED RELIANCE ON THE DELTA

As stated in WR P1(c)(1)(C), the policy requires that, commencing in 2015, UWMPs include expected outcomes for measurable reduction in Delta reliance and improved regional self-reliance. WR P1 further states that those outcomes shall be reported in the UWMP as the reduction in the amount of water used, or in the percentage of water used, from the Delta.

The following provides a summary of the near-term (2025) and long-term (2045) expected outcomes for Zone 7's Delta reliance and regional self-reliance based on the assumptions described in the previous section and DWR's analysis tool. The results show that Zone 7 is measurably reducing reliance on the Delta and improving regional self-reliance, based on the percentage of Zone 7's water supplies from the Delta Watershed.

Expected Outcomes for Regional Self-Reliance

- Near-term (2025) – Normal water year regional self-reliance is expected to increase by approximately 14,300 AFY from the 2010 baseline (see Table 3). Conserved water is the source of this increase.
- Long-term (2045) – Normal water year regional self-reliance is expected to increase by approximately 32,900 AFY from the 2010 baseline (see Table 3). Conserved water is a major contributor to this increase, supplemented by Sites Reservoir and potable reuse.

Expected Outcomes for Percent of Water Supplies from the Delta Watershed

- Near-term (2025) – Normal water year reliance on supplies from the Delta watershed is expected to decrease by 12 percent relative to the 2010 baseline (see Table 4).
- Long-term (2045) – Normal water year reliance on supplies from the Delta watershed is expected to decrease by 27 percent relative to the 2010 baseline (see Table 4).

4.0 NEW APPENDIX TO 2015 UWMP

The information contained in this Appendix is also included as a new Appendix G to Zone 7's 2015 UWMP, consistent with WR P1 subsection (c)(1)(C) (Cal. Code Regs. tit. 23, § 5003). As described in Chapter 10 of the 2015 and 2020 UWMPs, Zone 7 followed the required public notification, public review and hearing, and adoption processes required by the Urban Water Management Planning Act.

Zone 7's 2020 UWMP (including this Appendix), Water Shortage Contingency Plan, and Appendix G to the 2015 UWMP were adopted by the Zone 7 Board of Directors on May 19, 2021 (see Resolution Nos. 21-42 and 21-43 in Appendix H of the 2020 UWMP).

Appendix C

DWR 2020 Urban Water Management Plan Tables

Submittal Table 2-2: Plan Identification			
Select Only One	Type of Plan		Name of RUWMP or Regional Alliance *if applicable* (select from drop down list)
☑	Individual UWMP		
	☐	Water Supplier is also a member of a RUWMP	
	☐	Water Supplier is also a member of a Regional Alliance	
☐	Regional Urban Water Management Plan (RUWMP)		
NOTES:			

Submittal Table 2-3: Supplier Identification	
Type of Supplier (select one or both)	
☑	Supplier is a wholesaler
☐	Supplier is a retailer
Fiscal or Calendar Year (select one)	
☑	UWMP Tables are in calendar years
☐	UWMP Tables are in fiscal years
Units of measure used in UWMP * (select from drop down)	
Unit	AF
**** Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*	
NOTES:	

Submittal Table 2-4 Wholesale: Water Supplier Information Exchange (select one)	
☐	Supplier has informed more than 10 other water suppliers of water supplies available in accordance with Water Code Section 10631. Completion of the table below is optional. If not completed, include a list of the water suppliers that were informed.
	Provide page number for location of the list.
☑	Supplier has informed 10 or fewer other water suppliers of water supplies available in accordance with Water Code Section 10631. **Complete the table below.**
Water Supplier Name	
California Water Service Company	
City of Livermore	
City of Pleasanton	
Dublin San Ramon Services District	
NOTES:	

Submittal Table 3-1 Wholesale: Population - Current and Projected						
Population Served	2020	2025	2030	2035	2040	2045*(opt)*
	266,000	284,000	299,000	312,000	323,000	323,000
NOTES: Current and projected populations are based on the Regional Demand Study and are rounded to the nearest thousand people.						

Submittal Table 4-1 Wholesale: Demands for Potable and Non-Potable Water - Actual			
Use Type	2020 Actual		
Drop down list May select each use multiple times These are the only use types that will be recognized by the WUE data online submittal tool	Additional Description (as needed)	Level of Treatment When Delivered Drop down list	Volume*
Sales to other agencies	Retailer Demand	Drinking Water	38,020
Agricultural irrigation	Untreated Water Demand	Raw Water	5,810
Retail demand for use by suppliers that are primarily wholesalers with a small volume of retail sales	Direct Retail Demand	Drinking Water	730
Losses		Drinking Water	180
		TOTAL	44,740
**** Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*			
NOTES: Volumes are in AF.			

Submittal Table 4-2 Wholesale: Use for Potable and Raw Water - Projected						
Use Type	Additional Description (as needed)	**Projected Water Use *** Report To the Extent that Records are Available				
Drop down list May select each use multiple times These are the only Use Types that will be recognized by the WUEdata online submittal tool.		2025	2030	2035	2040	2045 (opt)
Sales to other agencies	Retailer Demand	43,000	43,200	43,400	43,700	43,700
Agricultural irrigation	Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Retail demand for use by suppliers that are primarily wholesalers with a small volume of retail sales	Direct Retail Demand	800	800	800	800	800
Losses		1,000	1,000	1,300	2,500	2,500
	TOTAL	50,300	52,800	53,800	55,300	55,300
**** Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*						
NOTES: Volumes are in AF.						

Submittal Table 4-3 Wholesale: Total Water Use (Potable and Non-Potable)						
	2020	2025	2030	2035	2040	2045 (opt)
Potable and Raw Water From Tables 4-1W and 4-2W	44,740	50,300	52,800	53,800	55,300	55,300
Recycled Water Demand* From Table 6-4W	0	0	0	0	0	0
TOTAL WATER DEMAND	44,740	50,300	52,800	53,800	55,300	55,300

**Recycled water demand fields will be blank until Table 6-4 is complete.*

NOTES: Volumes are in AF. Zone 7 does not produce nor distribute recycled water directly. However, several retailers do provide recycled water in Zone 7's service area. Table references refer to DWR table numbers.

OPTIONAL Table 4-4 Wholesale: Last Five Years of Water Loss Audit Reporting	
Reporting Period Start Date (mm/yyyy)	Volume of Water Loss [1,2]
01/2016	1,321
01/2017	2,022
01/2018	1,740
01/2019	632
01/2020	180

[1] *Taken from the field "Water Losses" (a combination of apparent losses and real losses) from the AWWA worksheet.*

[2] ***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF.

Submittal Table 6-1 Wholesale: Groundwater Volume Pumped

☐	Supplier does not pump groundwater. The supplier will not complete the table below.					
☑	All or part of the groundwater described below is desalinated.					
Groundwater Type	Location or Basin Name	2016*	2017*	2018*	2019*	2020*
Alluvial Basin	Livermore Valley Groundwater Basin	1,871	4,859	5,691	10,433	12,400
	TOTAL	1,871	4,859	5,691	10,433	12,400

*** Units of measure (AF, CCF, MG)** *must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF. Zone 7 pumps only water that has been recharged as part of its artificial recharge program using its surface water supplies. Actual groundwater used as supply is lower than the total groundwater volume pumped shown in the table because of demineralization losses at the MGDP.

Submittal Table 6-3 Wholesale: Wastewater Treatment and Discharge Within Service Area in 2020

☑ Wholesale Supplier neither distributes nor provides supplemental treatment to recycled water.
The Supplier will not complete the table below.

Wastewater Treatment Plant Name	Discharge Location Name or Identifier	Discharge Location Description	Wastewater Discharge ID Number *(optional)* [2]	Method of Disposal *Drop down list*	Does This Plant Treat Wastewater Generated Outside the Service Area? *Drop down list*	Treatment Level *Drop down list*	2020 volumes [1]				
							Wastewater Treated	Discharged Treated Wastewater	Recycled Within Service Area	Recycled Outside of Service Area	Instream Flow Permit Requirement
						Total	0	0	0	0	0

[1] **Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.
[2] If the **Wastewater Discharge ID Number** is not available to the UWMP preparer, access the SWRCB CIWQS regulated facility website at https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=RegulatedFacility

NOTES:

Submittal Table 6-4 Wholesale: Current and Projected Retailers Provided Recycled Water Within Service Area							
☑	Recycled water is not directly treated or distributed by the Supplier. The Supplier will not complete the table below.						
Name of Receiving Supplier or Direct Use by Wholesaler	Level of Treatment *Drop down list*	2020*	2025*	2030*	2035*	2040*	2045* *(opt)*
	Total	0	0	0	0	0	0
*** Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.							
NOTES:							

Submittal Table 6-5 Wholesale: 2015 UWMP Recycled Water Use Projection Compared to 2020 Actual		
☑	Recycled water was not used or distributed by the supplier in 2015, nor projected for use or distribution in 2020. The wholesale supplier will not complete the table below.	
Name of Receiving Supplier or Direct Use by Wholesaler	2015 Projection for 2020*	2020 Actual Use*
Total	0	0
****Units of measure (AF, CCF, MG)*** *must remain consistent throughout the UWMP as reported in Table 2-3.*		
NOTES:		

Submittal Table 6-7 Wholesale: Expected Future Water Supply Projects or Programs						
☐	No expected future water supply projects or programs that provide a quantifiable increase to the agency's water supply. Supplier will not complete the table below.					
☑	Some or all of the supplier's future water supply projects or programs are not compatible with this table and are described in a narrative format.					
6-21 through 6-30	Provide page location of narrative in the UWMP					
Name of Future Projects or Programs	Joint Project with other suppliers?		Description *(if needed)*	Planned Implementation Year	Planned for Use in Year Type	Expected Increase in Water Supply to Supplier*
	Drop Down Menu	*If Yes, Supplier Name*			*Drop Down list*	
Bay Area Regional Desalination Project	*Yes*	Contra Costa Water District, SFPUC, Santa Clara Valley Water District	Brackish water desalination in eastern Contra Costa County	2030	All Year Types	5,600
Delta Conveyance Project	*Yes*	Department of Water Resources and other SWP contractors	Construction of new intakes and tunnel as part of the State Water Project	2040	All Year Types	TBD
Los Vaqueros Reservoir Expansion	*Yes*	Contra Costa Water District, and a number of Bay Area M&I water agencies plus Grassland Water District and San Luis & Delta-Mendota Water Authority.	Expansion of Los Vaqueros Reservoir and construction of the Transfer-Bethany Pipeline, which would connect the reservoir to the South Bay Aqueduct and California Aqueduct	2025 (Pipeline) and 2030 (Reservoir Expansion)	Dry Years	TBD
Potable Reuse	*Yes*	Livermore, DSRSD, Pleasanton, Cal Water	Use of purified water derived from wastewater effluent to supplement potable water supplies	2030	All Year Types	4,000-7,000
Sites Reservoir	*Yes*	Sites Project Authority and Sites Reservoir Project Committee members	Construction of a new 1.5 million AF off-stream reservoir in Colusa County	2030	All Year Types	10,000
SWP Transfers	*Yes*	Other SWP contractor/s	Temporary water transfer agreement/s until major projects are implemented	2021	All Year Types	varies

***Units of measure (AF, CCF, MG)** *must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF. These projects are in the conceptual or planning stages. Zone 7 is participating in the planning efforts of these potential future water supply and/or storage projects to evaluate their benefits, including water supply yield. Implementation of these projects has not been approved by the Zone 7 Board but it is expected that <u>a subset of these projects</u> will be needed to meet future water demands and increase the reliability of Zone 7's system. The partners listed above are <u>potential</u> partners; final participation will be determined when the project has been approved by the respective agencies' governing boards. The 'expected increase in water supply...' are <u>estimates at this time</u> and may need to be adjusted when a final project has been approved. The 'planned implementation year' may also vary depending on project progress.

Submittal Table 6-8 Wholesale: Water Supplies — Actual					
Water Supply	Additional Detail on Water Supply	2020			
Drop down list May use each category multiple times.These are the only water supply categories that will be recognized by the WUEdata online submittal tool		Actual Volume*	Water Quality Drop Down List	Total Right or Safe Yield* (optional)
Purchased or Imported Water	SWP Table A	16,124	Other Non-Potable Water	
Purchased or Imported Water	Yuba Accord	2,100	Other Non-Potable Water	
Purchased or Imported Water	Water Transfer	5,000	Other Non-Potable Water	
Supply from Storage	SWP Carryover	10,800	Other Non-Potable Water	
Groundwater (not desalinated)	Main Basin	12,000	Other Non-Potable Water	
Surface water (not desalinated)	Arroyo Valle	8,700	Other Non-Potable Water	
Supply from Storage	Non-Local Storage	1,000	Other Non-Potable Water	
	Total	55,724		0

Units of measure (AF, CCF, MG) *must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF. These amounts reflect net yield for Yuba Accord and groundwater (i.e., they do not include carriage loss from Yuba Accord [900 AF] and brine disposal from groundwater production [400 AF]). Arroyo Valle supply includes carryover from 2019 (8,100 AF) and 2020 yield (600 AF).

Submittal Table 6-9 Wholesale: Water Supplies — Projected						
Water Supply	Additional Detail on Water Supply	Projected Water Supply* Report To the Extent Practicable				
		2025	2030	2035	2040	2045 (opt)
Drop down list May use each category multiple times. These are the only water supply categories that will be recognized by the WUEdata online submittal		Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume	Reasonably Available Volume
Purchased or Imported Water	SWP Table A[a]	47,000	46,000	45,000	43,500	43,500
Purchased or Imported Water	Yuba Accord (available mainly in dry years)	0	0	0	0	0
Supply from Storage	SWP Carryover[b]	10,000	10,000	10,000	10,000	10,000
Surface water (not desalinated)	Arroyo Valle[c]	5,500	5,500	5,500	5,500	5,500
Groundwater (not desalinated)	Main Basin	9,200	9,200	9,200	9,200	9,200
Supply from Storage	Semitropic (used mainly in dry years)	0	0	0	0	0
Supply from Storage	Cawelo (used mainly in dry years)	0	0	0	0	0
Other	SWP/Other Transfer[d]	5,000	5,000			
Other	BARDP or Potable Reuse[e]		5,000	5,000	5,000	5,000
Purchased or Imported Water	Sites Reservoir[f]		10,000	10,000	10,000	10,000
	Total	76,700	90,700	84,700	83,200	83,200

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Volumes are in AF.

a. Based on the 2019 Delivery Capability Report. "Existing" assumed for 2020, the "Future" applied to 2040; years in between were interpolated. The effect of the Delta Conveyance Project on water supply yield is still being analyzed and has not been included here.

b. Zone 7 regularly carries over SWP water from year to year, targeting approximately 10,000 AFY.

c. Arroyo Valle: From 2019 Water Supply Evaluation, observed ten-year (2008 to 2017) average was 6,200 AFY, reduced to 5,500 AFY to reflect climate change impacts. This will be refined as more information on the role of the Chain of Lakes on capturing Arroyo Valle water is developed over the coming years.

d. Zone 7 is pursuing water transfer agreements for the period through 2030.

e. These projects are under consideration as potential components of Zone 7's future water supply portfolio.

f. Zone 7 is currently participating in the planning phase of Sites Reservoir at a level of 10,000 AFY of average yield.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	**Base Year** If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	**Available Supplies if Year Type Repeats**	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	43,500	100%
Single-Dry Year	2014	4,000	9%
Consecutive Dry Years 1st Year	1987	16,900	39%
Consecutive Dry Years 2nd Year	1988	8,100	19%
Consecutive Dry Years 3rd Year	1989	54,000	124%
Consecutive Dry Years 4th Year	1990	10,500	24%
Consecutive Dry Years 5th Year	1991	16,100	37%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the State Water Project Table A. Volumes are in AF. The Average, Single Dry Year, and Multiple Dry Years are based on 2040 Future SWP Reliability Allocations.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	**Base Year** If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	**Available Supplies if Year Type Repeats**	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	10,000	100%
Single-Dry Year	2014	15,500	155%
Consecutive Dry Years 1st Year	1987	15,500	155%
Consecutive Dry Years 2nd Year	1988	2,800	28%
Consecutive Dry Years 3rd Year	1989	1,800	18%
Consecutive Dry Years 4th Year	1990	1,800	18%
Consecutive Dry Years 5th Year	1991	1,800	18%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for Carryover. Volumes are in AF. Average is based on Zone 7's normal operational target. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	**Base Year** If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	**Available Supplies if Year Type Repeats**	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1919	5,500	100%
Single-Dry Year	1977	0	0%
Consecutive Dry Years 1st Year	1987	1,700	31%
Consecutive Dry Years 2nd Year	1988	1,500	27%
Consecutive Dry Years 3rd Year	1989	1,500	27%
Consecutive Dry Years 4th Year	1990	1,500	27%
Consecutive Dry Years 5th Year	1991	1,500	27%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Arroyo Valle and includes carryover from the previous year. Volumes are in AF. Based on SWP Table A base years. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1965	29,200	100%
Single-Dry Year	2014	27,600	95%
Consecutive Dry Years 1st Year	1987	27,600	95%
Consecutive Dry Years 2nd Year	1988	25,100	86%
Consecutive Dry Years 3rd Year	1989	20,600	71%
Consecutive Dry Years 4th Year	1990	15,100	52%
Consecutive Dry Years 5th Year	1991	9,700	33%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for groundwater from the Main Basin. Volumes are in AF. Data shown are from averages of a long-term modeling run from the Water Supply Risk Model. Values show groundwater pumping capacity, or availability, not volumes pumped. Zone 7 targets average groundwater pumping at 9,200 AFY.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)

Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	13,000	100%
Single-Dry Year	2014	6,500	50%
Consecutive Dry Years 1st Year	1987	10,000	77%
Consecutive Dry Years 2nd Year	1988	10,000	77%
Consecutive Dry Years 3rd Year	1989	10,000	77%
Consecutive Dry Years 4th Year	1990	10,100	78%
Consecutive Dry Years 5th Year	1991	10,100	78%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Semitropic Water Storage District's banking program. Volumes are in AF. Average year value is the average from 2025-2040 of a long-term model run from the Water Supply Risk Model. Other data are from averages of a long-term modeling run from the Water Supply Risk Model. Note that Zone 7 typically does not recover water from Semitropic during normal years.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	**Base Year** If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	**Available Supplies if Year Type Repeats** ☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________ ☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	**% of Average Supply**
Average Year	1965	9,700	100%
Single-Dry Year	2014	7,100	73%
Consecutive Dry Years 1st Year	1987	9,700	100%
Consecutive Dry Years 2nd Year	1988	9,700	100%
Consecutive Dry Years 3rd Year	1989	9,700	100%
Consecutive Dry Years 4th Year	1990	9,700	100%
Consecutive Dry Years 5th Year	1991	9,700	100%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Cawelo Water District's banking program. Volumes are in AF. Average year value is the average from 2025-2040 of a long-term model run from the Water Supply Risk Model. Other data are from averages of a long-term modeling run from the Water Supply Risk Model.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1965	5,000	100%
Single-Dry Year	2014	5,000	100%
Consecutive Dry Years 1st Year	1987	5,000	100%
Consecutive Dry Years 2nd Year	1988	5,000	100%
Consecutive Dry Years 3rd Year	1989	5,000	100%
Consecutive Dry Years 4th Year	1990	5,000	100%
Consecutive Dry Years 5th Year	1991	5,000	100%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for Bay Area Regional Desalination Project and/or potable reuse. Volumes are in AF. Because these supplies are generally drought-resistant, they have been assumed to provide a constant 5,000 AFY under all conditions.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1965	10,000	100%
Single-Dry Year	2014	15,300	153%
Consecutive Dry Years 1st Year	1987	16,800	168%
Consecutive Dry Years 2nd Year	1988	17,700	177%
Consecutive Dry Years 3rd Year	1989	16,300	163%
Consecutive Dry Years 4th Year	1990	15,900	159%
Consecutive Dry Years 5th Year	1991	15,800	158%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for the Sites Reservoir Project. Volumes are in AF. Dry year values are based on 2040 conditions from the Water Supply Risk Model.

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)				
Year Type	**Base Year** If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats		
		☐	Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ___________________________	
		☑	Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *		**% of Average Supply**
Average Year	1965	5,000		100%
Single-Dry Year	2014	5,000		100%
Consecutive Dry Years 1st Year	1987	5,000		100%
Consecutive Dry Years 2nd Year	1988	5,000		100%
Consecutive Dry Years 3rd Year	1989	5,000		100%
Consecutive Dry Years 4th Year	1990	5,000		100%
Consecutive Dry Years 5th Year	1991	5,000		100%
Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.				
***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*				
NOTES: Multiple versions of this table are being used; this table is for Water Transfers. Volumes are in AF. Amounts are likely to vary from year-to-year but variability has not been quantified at this time.				

Submittal Table 7-1 Wholesale: Basis of Water Year Data (Reliability Assessment)			
Year Type	Base Year If not using a calendar year, type in the last year of the fiscal, water year, or range of years, for example, water year 1999-2000, use 2000	Available Supplies if Year Type Repeats	
		☐ Quantification of available supplies is not compatible with this table and is provided elsewhere in the UWMP. Location ______________________	
		☑ Quantification of available supplies is provided in this table as either volume only, percent only, or both.	
		Volume Available *	% of Average Supply
Average Year	1965	10,100	100%
Single-Dry Year	2014	8,300	82%
Consecutive Dry Years 1st Year	1987	8,800	87%
Consecutive Dry Years 2nd Year	1988	7,900	78%
Consecutive Dry Years 3rd Year	1989	6,900	68%
Consecutive Dry Years 4th Year	1990	6,000	59%
Consecutive Dry Years 5th Year	1991	5,200	51%

Supplier may use multiple versions of Table 7-1 if different water sources have different base years and the supplier chooses to report the base years for each water source separately. If a supplier uses multiple versions of Table 7-1, in the "Note" section of each table, state that multiple versions of Table 7-1 are being used and identify the particular water source that is being reported in each table. Suppliers may create an additional worksheet for the additional tables.

***Units of measure (AF, CCF, MG)** must remain consistent throughout the UWMP as reported in Table 2-3.*

NOTES: Multiple versions of this table are being used; this table is for stored water in the Chain of Lakes that could be conveyed to the Del Valle Water Treatment Plant. Volumes are in AF.

Submittal Table 7-2 Wholesale: Normal Year Supply and Demand Comparison					
	2025	2030	2035	2040	2045 *(Opt)*
Supplies					
SWP Table A	47,000	46,000	45,000	43,500	43,500
Yuba Accord	0	0	0	0	0
Turnback Pool	0	0	0	0	0
SWP Carryover	10,000	10,000	10,000	10,000	10,000
Arroyo Valle	5,500	5,500	5,500	5,500	5,500
Main Basin	9,200	9,200	9,200	9,200	9,200
Semitropic	0	0	0	0	0
Cawelo	0	0	0	0	0
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir Project	0	10,000	10,000	10,000	10,000
Transfers	5,000	5,000	0	0	0
Chain of Lakes	0	0	0	0	0
Supply totals *(autofill from Table 6-9)*	76,700	90,700	84,700	83,200	83,200
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Demand totals *(autofill from Table 4-3)*	50,300	52,800	53,800	55,300	55,300
Difference	26,400	37,900	30,900	27,900	27,900
NOTES: Volumes are in AF. Table references refer to DWR table numbers. Surplus supplies are stored as carryover, used to recharge the Main Basin, and stored in the Kern County groundwater banks.					

Submittal Table 7-3 Wholesale: Single Dry Year Supply and Demand Comparison					
	2025	2030	2035	2040	2045 (Opt)
Supplies					
SWP Table A	4,400	4,400	4,400	4,400	4,400
Yuba Accord	0	0	0	0	0
Turnback Pool	0	0	0	0	0
SWP Carryover	15,500	12,000	13,800	12,600	12,700
Arroyo Valle	0	0	0	0	0
Main Basin	27,600	29,900	31,800	32,200	32,500
Semitropic	6,500	6,600	6,600	6,500	6,500
Cawelo	7,100	7,100	7,100	7,100	7,000
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir Project	0	14,200	15,700	15,300	15,100
Transfers	4,500	4,600	0	0	0
Chain of Lakes	0	8,300	9,800	9,400	9,100
Supply totals*	65,600	92,100	94,200	92,500	92,300
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Demand totals*	50,300	52,800	53,800	55,300	55,300
Difference	15,300	39,300	40,400	37,200	37,000
Units of measure (AF, CCF, MG) *must remain consistent throughout the UWMP as reported in Table 2-3.*					
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison

Projections - First Year	2025	2030	2035	2040	2045
Supplies					
SWP Table A	19,900	19,500	19,500	19,500	19,400
SWP Carryover	15,500	12,000	13,800	12,600	12,700
Arroyo Valle	1,700	1,700	1,700	1,700	1,700
Main Basin	27,600	29,900	31,800	32,200	32,500
Semitropic	10,000	9,900	10,000	10,000	9,900
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	15,300	17,000	16,800	16,600
Water Transfers	4,800	4,800	0	0	0
Chain of Lakes	0	8,800	10,000	9,600	9,300
Total Supplies	**89,200**	**116,600**	**118,500**	**117,100**	**116,800**
Demands					
Retailer Demand	43,000	43,200	43,400	43,700	43,700
Untreated Water Demand	5,500	7,800	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,000	1,300	2,500	2,500
Total Demands	**50,300**	**52,800**	**53,800**	**55,300**	**55,300**
Difference	38,900	63,800	64,700	61,800	61,500
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison					
Projections - Second Year	2026	2031	2036	2041	2046
Supplies					
SWP Table A	20,200	19,800	19,800	19,600	19,600
SWP Carryover	2,800	4,400	3,500	3,100	3,100
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	25,100	29,400	31,400	31,600	31,900
Semitropic	10,000	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	18,100	18,300	17,700	17,800
Water Transfers	4,900	0	0	0	0
Chain of Lakes	600	7,900	8,800	8,400	8,200
Total Supplies	**74,800**	**105,800**	**108,000**	**106,600**	**106,800**
Demands					
Retailer Demand	43,000	43,200	43,500	43,700	43,700
Untreated Water Demand	6,900	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,060	1,600	2,500	2,500
Total Demands	**51,700**	**53,360**	**54,200**	**55,300**	**55,300**
Difference	23,100	52,440	53,800	51,300	51,500
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison					
Projections - Third Year	2027	2032	2037	2042	2047
Supplies					
SWP Table A	20,200	19,800	19,700	19,700	19,600
SWP Carryover	1,800	2,700	2,500	2,300	2,300
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	20,600	28,300	30,300	30,300	30,700
Semitropic	10,000	10,000	9,900	10,000	9,900
Cawelo	9,700	9,800	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	16,600	16,400	16,300	16,300
Water Transfers	4,900	0	0	0	0
Chain of Lakes	400	6,900	7,700	7,500	7,300
Total Supplies	**69,100**	**100,600**	**102,700**	**102,300**	**102,300**
Demands					
Retailer Demand	43,100	43,300	43,500	43,700	43,700
Untreated Water Demand	7,100	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,120	1,800	2,500	2,500
Total Demands	**52,000**	**53,520**	**54,400**	**55,300**	**55,300**
Difference	17,100	47,080	48,300	47,000	47,000
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison

Projections - Fourth Year	2028	2033	2038	2043	2048
Supplies					
SWP Table A	20,200	19,500	19,800	19,700	19,800
SWP Carryover	1,800	2,100	2,000	1,900	1,900
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	15,100	26,900	28,800	28,600	28,900
Semitropic	10,100	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	16,000	16,000	15,900	15,900
Water Transfers	4,900	0	0	0	0
Chain of Lakes	300	6,000	6,700	6,600	6,500
Total Supplies	**63,600**	**96,700**	**99,500**	**98,900**	**99,200**
Demands					
Retailer Demand	43,100	43,300	43,600	43,700	43,700
Untreated Water Demand	7,350	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,180	2,000	2,500	2,500
Total Demands	**52,250**	**53,580**	**54,700**	**55,300**	**55,300**
Difference	11,350	43,120	44,800	43,600	43,900
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison					
Projections - Fifth Year	2029	2034	2039	2044	2049
Supplies					
SWP Table A	20,200	19,800	19,700	19,600	19,600
SWP Carryover	1,800	1,900	1,900	1,900	1,900
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	9,700	25,200	27,000	26,500	26,900
Semitropic	10,100	10,000	10,000	10,000	10,000
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	0	5,000	5,000	5,000	5,000
Sites Reservoir	0	15,800	15,800	15,800	15,700
Water Transfers	4,900	0	0	0	0
Chain of Lakes	300	5,200	5,900	5,900	5,800
Total Supplies	**58,200**	**94,100**	**96,500**	**95,900**	**96,100**
Demands					
Retailer Demand	43,100	43,400	43,600	43,700	43,700
Untreated Water Demand	7,600	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,240	2,300	2,500	2,500
Total Demands	**52,500**	**53,740**	**55,000**	**55,300**	**55,300**
Difference	5,700	40,360	41,500	40,600	40,800
NOTES: Volumes are in AF.					

Submittal Table 7-4 Wholesale: Multiple Dry Years Supply and Demand Comparison					
Projections - Sixth Year	2030	2035	2040	2045	2050
Supplies					
SWP Table A	19,900	19,500	19,500	19,300	19,300
SWP Carryover	1,800	1,900	1,800	1,800	1,800
Arroyo Valle	1,500	1,500	1,500	1,500	1,500
Main Basin	7,100	23,400	24,900	24,100	24,400
Semitropic	10,000	10,000	10,000	9,900	9,900
Cawelo	9,700	9,700	9,700	9,700	9,700
BARDP/Potable Reuse	5,000	5,000	5,000	5,000	5,000
Sites Reservoir	15,300	15,700	15,800	15,800	15,800
Water Transfers	4,900	0	0	0	0
Chain of Lakes	900	4,500	5,100	5,300	5,200
Total Supplies	**76,100**	**91,200**	**93,300**	**92,400**	**92,600**
Demands					
Retailer Demand	43,200	43,400	43,700	43,700	43,700
Untreated Water Demand	7,800	8,300	8,300	8,300	8,300
Direct Retail Demand	800	800	800	800	800
Losses	1,000	1,300	2,500	2,500	2,500
Total Demands	**52,800**	**53,800**	**55,300**	**55,300**	**55,300**
Difference	23,300	37,400	38,000	37,100	37,300
NOTES: Volumes are in AF.					

Submittal Table 7-5: Five-Year Drought Risk Assessment Tables to address Water Code Section 10635(b)	
2021	**Total**
Total Water Use	45,200
Total Supplies	55,900
Surplus/Shortfall w/o WSCP Action	10,700
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,700
Resulting % Use Reduction from WSCP action	0%
2022	**Total**
Total Water Use	47,600
Total Supplies	58,200
Surplus/Shortfall w/o WSCP Action	10,600
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,600
Resulting % Use Reduction from WSCP action	0%
2023	**Total**
Total Water Use	48,500
Total Supplies	80,900
Surplus/Shortfall w/o WSCP Action	32,400
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	32,400
Resulting % Use Reduction from WSCP action	0%
2024	**Total**
Total Water Use	49,400
Total Supplies	60,300
Surplus/Shortfall w/o WSCP Action	10,900
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	10,900
Resulting % Use Reduction from WSCP action	0%
2025	**Total**
Total Water Use	50,300
Total Supplies	62,800
Surplus/Shortfall w/o WSCP Action	12,500
Planned WSCP Actions (use reduction and supply augmentation)	
WSCP - supply augmentation benefit	
WSCP - use reduction savings benefit	
Revised Surplus/(shortfall)	12,500
Resulting % Use Reduction from WSCP action	0%

Submittal Table 8-1 Water Shortage Contingency Plan Levels		
Shortage Level	**Percent Shortage Range**	**Shortage Response Actions** (*Narrative description)*
1	Up to 10%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
2	Up to 20%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
3	Up to 30%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
4	Up to 40%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
5	Up to 50%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
6	>50%	Implement actions per DWR Table 8-2 and DWR Table 8-3.
NOTES:		

Submittal Table 8-2: Demand Reduction Actions				
Shortage Level	Demand Reduction Actions ***Drop down list*** *These are the only categories that will be accepted by the WUEdata online submittal tool. Select those that apply.*	How much is this going to reduce the shortage gap? *Include units used (volume type or percentage)*	Additional Explanation or Reference *(optional)*	Penalty, Charge, or Other Enforcement? ***For Retail Suppliers Only*** *Drop Down List*
1	Expand Public Information Campaign	(see Note)	Public outreach to support voluntary conservation.	No
	Other	Up to the full shortage gap	Ask retailers for voluntary demand reduction, as needed.	No
2	Expand Public Information Campaign	(see Note)	Expand public outreach to support conservation.	No
	Other	Up to the full shortage gap	Ask retailers for voluntary or mandatory demand reduction, as needed. Only the latter will be enforced.	Yes
3*	Expand Public Information Campaign	(see Note)	Intensify public outreach to support conservation.	No
	Other	Up to the full shortage gap	Ask retailers for mandatory demand reduction.	Yes
NOTES: Expand public information campaign boosts water conservation overall, so no shortage gap reduction estimate provided. Actions introduced in a lower stage will also be used in higher stages, unless otherwise noted. *At Stage 3 and higher, Zone 7 will likely require its retailers to reduce demands up to the applicable shortage percentage.				

Submittal Table 8-3: Supply Augmentation and Other Actions			
Shortage Level	Supply Augmentation Methods and Other Actions by Water Supplier **_Drop down list_** _These are the only categories that will be accepted by the WUEdata online submittal tool_	How much is this going to reduce the shortage gap? _Include units used (volume type or percentage)_	Additional Explanation or Reference _(optional)_
1	Other actions (describe)	Up to the full shortage gap.	Optimize use of groundwater and surface water supplies and adjust use of locally vs. remotely stored water.
	Other actions (describe)	N/A	Improve monitoring, analysis, and tracking of customer water usage rates.
	Other actions (describe)	N/A	In anticipation of decreased revenue, reduce discretionary spending
2	Transfers	Up to the full shortage gap.	Pursue opportunities for additional water transfers to lower the shortage gap, beyond what is already in the Annual Sustainability Report.
	Exchanges	Up to the full shortage gap.	Pursue opportunities for (additional) water exchanges to lower the shortage gap.
	Implement or Modify Drought Rate Structure or Surcharge	N/A	Consider implementation of water shortage surcharge correlated with stage (requires Board approval).
	Other actions (describe)	N/A	Evaluate timing of maintenance activities that could negatively impact ability to manage water supplies/shortages, or could result in loss of water supply.
	Other actions (describe)	up to 100 AF	Consider greater incentives under rebate program and focus on high-consumption customers.
3	Other actions (describe)	unknown - depends on project/s identified	Review CIP program and accelerate projects facilitating immediate improvement in water supply management if feasible/necessary.
	Stored emergency supply	To be determined based on operational conditions.	Consider/plan for/implement pumpback into South Bay Aqueduct if no supplies are available from Delta pumping.
NOTES: Actions introduced in a lower stage will also be used in higher stages, unless otherwise noted.			

Submittal Table 10-1 Wholesale: Notification to Cities and Counties (select one)		
☐	Supplier has notified more than 10 cities or counties in accordance with Water Code Sections 10621 (b) and 10642. **Completion of the table below is not required. Provide a separate list of the cities and counties that were**	
	Provide the page or location of this list in the UWMP.	
☑	Supplier has notified 10 or fewer cities or counties. **Complete the table below.**	
City Name	60 Day Notice	Notice of Public Hearing
Dublin	Yes	Yes
Livermore	Yes	Yes
Pleasanton	Yes	Yes
San Ramon	Yes	Yes
County Name *Drop Down List*	60 Day Notice	Notice of Public Hearing
Alameda County	Yes	Yes
Contra Costa County	Yes	Yes
NOTES:		

Table O-1B: Recommended Energy Reporting - Total Utility Approach

		Urban Water Supplier Operational Control		
Enter Start Date for Reporting Period	1/1/2019			
End Date	12/31/2019			
☐ Is upstream embedded in the values reported?		Sum of All Water Management Processes	Non-Consequential Hydropower	
Water Volume Units Used	*AF*	Total Utility	Hydropower	Net Utility
Volume of Water Entering Process (volume unit)		*36,185*	*0*	*36,185*
Energy Consumed (kWh)		*12,377,060*	*0*	*12,377,060*
Energy Intensity (kWh/volume)		*342.0*	*0.0*	*342.0*

Quantity of Self-Generated Renewable Energy

600,000 kWh

Data Quality *(Estimate, Metered Data, Combination of Estimates and Metered Data)*

Metered Data

Data Quality Narrative:

Water production and energy consumption data are based on metered data collected and provided by Zone 7.

Narrative:

Zone 7's water management processes that consume energy include raw water treatment; groundwater pumping, recharge, and treatment; and treated water pumping.

Appendix D

DWR 2020 Urban Water Management Plan Checklist

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Chapter 1	10615	A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities.	Introduction and Overview	Executive Summary
X	X	Chapter 1	10630.5	Each plan shall include a simple description of the supplier's plan including water availability, future requirements, a strategy for meeting needs, and other pertinent information. Additionally, a supplier may also choose to include a simple description at the beginning of each chapter.	Summary	Executive Summary
X	X	Section 2.2	10620(b)	Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.	Plan Preparation	Section 2.1
X	X	Section 2.6	10620(d)(2)	Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	Plan Preparation	Section 2.5
X	X	Section 2.6.2	10642	Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan and contingency plan.	Plan Preparation	Section 2.5.2
X		Sections 2.6 and 6.1	10631(h)	Retail suppliers will include documentation that they have provided their wholesale supplier(s) - if any - with water use projections from that source.	System Supplies	Not Applicable (N/A)
	X	Section 2.6	10631(h)	Wholesale suppliers will include documentation that they have provided their urban water suppliers with identification and quantification of the existing and planned sources of water available from the wholesale to the urban supplier during various water year types.	System Supplies	Section 2.5.1
X	X	Section 3.1	10631(a)	Describe the water supplier service area.	System Description	Section 3.2
X	X	Section 3.3	10631(a)	Describe the climate of the service area of the supplier.	System Description	Section 3.3
X	X	Section 3.4	10631(a)	Provide population projections for 2025, 2030, 2035, 2040 and optionally 2045.	System Description	Section 3.4.1
X	X	Section 3.4.2	10631(a)	Describe other social, economic, and demographic factors affecting the supplier's water management planning.	System Description	Section 3.4.2
X	X	Sections 3.4 and 5.4	10631(a)	Indicate the current population of the service area.	System Description and Baselines and Targets	Section 3.4.1
X	X	Section 3.5	10631(a)	Describe the land uses within the service area.	System Description	Section 3.5

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 4.2	10631(d)(1)	Quantify past, current, and projected water use, identifying the uses among water use sectors.	System Water Use	Section 4.2
X	optional	Section 4.2.4	10631(d)(3)(C)	Retail suppliers shall provide data to show the distribution loss standards were met.	System Water Use	Section 4.3
X	X	Section 4.2.6	10631(d)(4)(A)	In projected water use, include estimates of water savings from adopted codes, plans, and other policies or laws.	System Water Use	Section 4.2.2.1
X	X	Section 4.2.6	10631(d)(4)(B)	Provide citations of codes, standards, ordinances, or plans used to make water use projections.	System Water Use	Section 4.2.2.1
X	optional	Section 4.3.2.4	10631(d)(3)(A)	Report the distribution system water loss for each of the 5 years preceding the plan update.	System Water Use	Section 4.3
X	optional	Section 4.4	10631.1(a)	Include projected water use needed for lower income housing projected in the service area of the supplier.	System Water Use	N/A
X	X	Section 4.5	10635(b)	Demands under climate change considerations must be included as part of the drought risk assessment.	System Water Use	Section 4.4
X		Chapter 5	10608.20(e)	Retail suppliers shall provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	Baselines and Targets	N/A
X		Chapter 5	10608.24(a)	Retail suppliers shall meet their water use target by December 31, 2020.	Baselines and Targets	N/A
	X	Section 5.1	10608.36	Wholesale suppliers shall include an assessment of present and proposed future measures, programs, and policies to help their retail water suppliers achieve targeted water use reductions.	Baselines and Targets	Section 5.2
X		Section 5.2	10608.24(d)(2)	If the retail supplier adjusts its compliance GPCD using weather normalization, economic adjustment, or extraordinary events, it shall provide the basis for, and data supporting the adjustment.	Baselines and Targets	N/A
X		Section 5.5	10608.22	Retail suppliers' per capita daily water use reduction shall be no less than 5 percent of base daily per capita water use of the 5-year baseline. This does not apply if the suppliers base GPCD is at or below 100.	Baselines and Targets	N/A
X		Section 5.5 and Appendix E	10608.4	Retail suppliers shall report on their compliance in meeting their water use targets. The data shall be reported using a standardized form in the SBX7-7 2020 Compliance Form.	Baselines and Targets	N/A
X	X	Sections 6.1 and 6.2	10631(b)(1)	Provide a discussion of anticipated supply availability under a normal, single dry year, and a drought lasting five years, as well as more frequent and severe periods of drought.	System Supplies	Chapters 6 and 7

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 6.1	10631(b)(1)	Provide a discussion of anticipated supply availability under a normal, single dry year, and a drought lasting five years, as well as more frequent and severe periods of drought, *including changes in supply due to climate change.*	System Supplies	Chapters 6 and 7
X	X	Section 6.1	10631(b)(2)	When multiple sources of water supply are identified, describe the management of each supply in relationship to other identified supplies.	System Supplies	Section 6.2
X	X	Section 6.1.1	10631(b)(3)	Describe measures taken to acquire and develop planned sources of water.	System Supplies	Section 6.2.9
X	X	Section 6.2.8	10631(b)	Identify and quantify the existing and planned sources of water available for 2020, 2025, 2030,2035, 2040 and optionally 2045.	System Supplies	Section 6.2.10
X	X	Section 6.2	10631(b)	Indicate whether groundwater is an existing or planned source of water available to the supplier.	System Supplies	Section 6.2.2
X	X	Section 6.2.2	10631(b)(4)(A)	Indicate whether a groundwater sustainability plan or groundwater management plan has been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	System Supplies	Sections 6.2.2.1 and 6.2.2.2; link to plan provided in footnote 4 on page 6-7
X	X	Section 6.2.2	10631(b)(4)(B)	Describe the groundwater basin.	System Supplies	Section 6.2.2.1
X	X	Section 6.2.2	10631(b)(4)(B)	Indicate if the basin has been adjudicated and include a copy of the court order or decree and a description of the amount of water the supplier has the legal right to pump.	System Supplies	Section 6.2.2.1
X	X	Section 6.2.2.1	10631(b)(4)(B)	For unadjudicated basins, indicate whether or not the department has identified the basin as a high or medium priority. Describe efforts by the supplier to coordinate with sustainability or groundwater agencies to achieve sustainable groundwater conditions.	System Supplies	Section 6.2.2.1
X	X	Section 6.2.2.4	10631(b)(4)(C)	Provide a detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years	System Supplies	Sections 6.2.2.2.1 and 6.2.2.2.2
X	X	Section 6.2.2	10631(b)(4)(D)	Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped.	System Supplies	Section 6.2.2.2.2
X	X	Section 6.2.7	10631(c)	Describe the opportunities for exchanges or transfers of water on a short-term or long- term basis.	System Supplies	Section 6.2.8
X	X	Section 6.2.5	10633(b)	Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	System Supplies (Recycled Water)	Section 6.2.6.2
X	X	Section 6.2.5	10633(c)	Describe the recycled water currently being used in the supplier's service area.	System Supplies (Recycled Water)	Section 6.2.6.4

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 6.2.5	10633(d)	Describe and quantify the potential uses of recycled water and provide a determination of the technical and economic feasibility of those uses.	System Supplies (Recycled Water)	Sections 6.2.6.1, 6.2.6.3, and 6.2.6.4
X	X	Section 6.2.5	10633(e)	Describe the projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected.	System Supplies (Recycled Water)	Section 6.2.6.4
X	X	Section 6.2.5	10633(f)	Describe the actions which may be taken to encourage the use of recycled water and the projected results of these actions in terms of acre-feet of recycled water used per year.	System Supplies (Recycled Water)	Section 6.2.6.1 and Section 6.2.9.1.3
X	X	Section 6.2.5	10633(g)	Provide a plan for optimizing the use of recycled water in the supplier's service area.	System Supplies (Recycled Water)	Section 6.2.6.1
X	X	Section 6.2.6	10631(g)	Describe desalinated water project opportunities for long-term supply.	System Supplies	Section 6.2.7
X	X	Section 6.2.5	10633(a)	Describe the wastewater collection and treatment systems in the supplier’s service area with quantified amount of collection and treatment and the disposal methods.	System Supplies (Recycled Water)	Section 6.2.6.2
X	X	Sections 6.2.8 and 6.3.7	10631(f)	Describe the expected future water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and for a period of drought lasting 5 consecutive water years.	System Supplies	Section 6.2.9
X	X	Section 6.4 and Appendix O	10631.2(a)	The UWMP must include energy information, as stated in the code, that a supplier can readily obtain.	System Suppliers, Energy Intensity	Section 6.3
X	X	Section 7.2	10634	Provide information on the quality of existing sources of water available to the supplier and the manner in which water quality affects water management strategies and supply reliability	Water Supply Reliability Assessment	Sections 7.1.1.1.2, 7.1.1.2, and 7.1.1.3
X	X	Section 7.2.4	10620(f)	Describe water management tools and options to maximize resources and minimize the need to import water from other regions.	Water Supply Reliability Assessment	Section 7.1.4
X	X	Section 7.3	10635(a)	Service Reliability Assessment: Assess the water supply reliability during normal, dry, and a drought lasting five consecutive water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next20 years.	Water Supply Reliability Assessment	Section 7.1.3
X	X	Section 7.3	10635(b)	Provide a drought risk assessment as part of information considered in developing the demand management measures and water supply projects.	Water Supply Reliability Assessment	Section 7.2

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 7.3	10635(b)(1)	Include a description of the data, methodology, and basis for one or more supply shortage conditions that are necessary to conduct a drought risk assessment for a drought period that lasts 5consecutive years.	Water Supply Reliability Assessment	Section 7.2.1
X	X	Section 7.3	10635(b)(2)	Include a determination of the reliability of each source of supply under a variety of water shortage conditions.	Water Supply Reliability Assessment	Section 7.2.2
X	X	Section 7.3	10635(b)(3)	Include a comparison of the total water supply sources available to the water supplier with the total projected water use for the drought period.	Water Supply Reliability Assessment	Section 7.2.3
X	X	Section 7.3	10635(b)(4)	Include considerations of the historical drought hydrology, plausible changes on projected supplies and demands under climate change conditions, anticipated regulatory changes, and other locally applicable criteria.	Water Supply Reliability Assessment	Section 7.2.1 & Section 7.2.2
X	X	Chapter 8	10632(a)	Provide a water shortage contingency plan (WSCP) with specified elements below.	Water Shortage Contingency Planning	Section 8.2 and Appendix G
X	X	Chapter 8	10632(a)(1)	Provide the analysis of water supply reliability (from Chapter 7 of Guidebook) in the WSCP	Water Shortage Contingency Planning	Appendix G (Section 1.0)
X	X	Section 8.10	10632(a)(10)	Describe reevaluation and improvement procedures for monitoring and evaluation the water shortage contingency plan to ensure risk tolerance is adequate and appropriate water shortage mitigation strategies are implemented.	Water Shortage Contingency Planning	Appendix G (Section 2.0)
X	X	Section 8.2	10632(a)(2)(A)	Provide the written decision- making process and other methods that the supplier will use each year to determine its water reliability.	Water Shortage Contingency Planning	Appendix G (Section 2.1)
X	X	Section 8.2	10632(a)(2)(B)	Provide data and methodology to evaluate the supplier's water reliability for the current year and one dry year pursuant to factors in the code.	Water Shortage Contingency Planning	Appendix G (Sections 2.2 and 2.3)
X	X	Section 8.3	10632(a)(3)(A)	Define six standard water shortage levels of 10, 20, 30, 40, 50 percent shortage and greater than 50 percent shortage. These levels shall be based on supply conditions, including percent reductions in supply, changes in groundwater levels, changes in surface elevation, or other conditions. The shortage levels shall also apply to a catastrophic interruption of supply.	Water Shortage Contingency Planning	Appendix G (Section 3.0)
X	X	Section 8.3	10632(a)(3)(B)	Suppliers with an existing water shortage contingency plan that uses different water shortage levels must cross reference their categories with the six standard categories.	Water Shortage Contingency Planning	Appendix G (Section 3.0)
X	X	Section 8.4	10632(a)(4)(A)	Suppliers with water shortage contingency plans that align with the defined shortage levels must specify locally appropriate supply augmentation actions.	Water Shortage Contingency Planning	Appendix G (Section 4.3)

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 8.4	10632(a)(4)(B)	Specify locally appropriate demand reduction actions to adequately respond to shortages.	Water Shortage Contingency Planning	Appendix G (Section 4.1)
X	X	Section 8.4	10632(a)(4)(C)	Specify locally appropriate operational changes.	Water Shortage Contingency Planning	Appendix G (Section 4.4)
X	X	Section 8.4	10632(a)(4)(D)	Specify additional mandatory prohibitions against specific water use practices that are in addition to state-mandated prohibitions are appropriate to local conditions.	Water Shortage Contingency Planning	Appendix G (Section 4.2)
X	X	Section 8.4	10632(a)(4)(E)	Estimate the extent to which the gap between supplies and demand will be reduced by implementation of the action.	Water Shortage Contingency Planning	Appendix G (Sections 4.1 and 4.3)
X	X	Section 8.4.6	10632.5	The plan shall include a seismic risk assessment and mitigation plan.	Water Shortage Contingency Plan	Section 8.3
X	X	Section 8.5	10632(a)(5)(A)	Suppliers must describe that they will inform customers, the public and others regarding any current or predicted water shortages.	Water Shortage Contingency Planning	Appendix G (Section 5.0)
X	X	Sections 8.5 and 8.6	10632(a)(5)(B) 10632(a)(5)(C)	Suppliers must describe that they will inform customers, the public and others regarding any shortage response actions triggered or anticipated to be triggered and other relevant communications.	Water Shortage Contingency Planning	Appendix G (Section 5.0)
X		Section 8.6	10632(a)(6)	Retail supplier must describe how it will ensure compliance with and enforce provisions of the WSCP.	Water Shortage Contingency Planning	N/A
X	X	Section 8.7	10632(a)(7)(A)	Describe the legal authority that empowers the supplier to enforce shortage response actions.	Water Shortage Contingency Planning	Appendix G (Section 7.0)
X	X	Section 8.7	10632(a)(7)(B)	Provide a statement that the supplier will declare a water shortage emergency Water Code Chapter 3.	Water Shortage Contingency Planning	Appendix G (Section 7.0)
X	X	Section 8.7	10632(a)(7)(C)	Provide a statement that the supplier will coordinate with any city or county within which it provides water for the possible proclamation of a local emergency.	Water Shortage Contingency Planning	Appendix G (Section 2.1 and Section 7.0)
X	X	Section 8.8	10632(a)(8)(A)	Describe the potential revenue reductions and expense increases associated with activated shortage response actions.	Water Shortage Contingency Planning	Appendix G (Section 8.0)
X	X	Section 8.8	10632(a)(8)(B)	Provide a description of mitigation actions needed to address revenue reductions and expense increases associated with activated shortage response actions.	Water Shortage Contingency Planning	Appendix G (Section 8.0)
X		Section 8.8	10632(a)(8)(C)	Retail suppliers must describe the cost of compliance with Water Code Chapter 3.3: Excessive Residential Water Use During Drought	Water Shortage Contingency Planning	N/A

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X		Section 8.9	10632(a)(9)	Retail suppliers must describe the monitoring and reporting requirements and procedures that ensure appropriate data is collected, tracked, and analyzed for purposes of monitoring customer compliance.	Water Shortage Contingency Planning	Appendix G (Section 9.0)
X		Section 8.11	10632(b)	Analyze and define water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, separately from swimming pools and spas.	Water Shortage Contingency Planning	Appendix G (Section 11.0)
X	X	Sections 8.12 and 10.4	10635(c)	Provide supporting documentation that Water Shortage Contingency Plan has been, or will be, provided to any city or county within which it provides water, no later than 30 days after the submission of the plan to DWR.	Plan Adoption, Submittal, and Implementation	Section 8.4 and Appendix G (Section 12.0)
X	X	Section 8.14	10632(c)	Make available the Water Shortage Contingency Plan to customers and any city or county where it provides water within 30 after adopted the plan.	Water Shortage Contingency Planning	Section 8.4 and Appendix G (Section 12.0)
	X	Sections 9.1 and 9.3	10631(e)(2)	Wholesale suppliers shall describe specific demand management measures listed in code, their distribution system asset management program, and supplier assistance program.	Demand Management Measures	Chapter 9
X		Sections 9.2 and 9.3	10631(e)(1)	Retail suppliers shall provide a description of the nature and extent of each demand management measure implemented over the past five years. The description will address specific measures listed in code.	Demand Management Measures	N/A
X		Chapter 10	10608.26(a)	Retail suppliers shall conduct a public hearing to discuss adoption, implementation, and economic impact of water use targets (recommended to discuss compliance).	Plan Adoption, Submittal, and Implementation	Section 10.3
X	X	Section 10.2.1	10621(b)	Notify, at least 60 days prior to the public hearing, any city or county within which the supplier provides water that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. Reported in Table 10-1.	Plan Adoption, Submittal, and Implementation	Section 10.2.1
X	X	Section 10.4	10621(f)	Each urban water supplier shall update and submit its 2020 plan to the department by July 1, 2021.	Plan Adoption, Submittal, and Implementation	Section 10.4
X	X	Sections 10.2.2, 10.3, and 10.5	10642	Provide supporting documentation that the urban water supplier made the plan and contingency plan available for public inspection, published notice of the public hearing, and held a public hearing about the plan and contingency plan.	Plan Adoption, Submittal, and Implementation	Section 10.2.2 and Appendix E
X	X	Section 10.2.2	10642	The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water.	Plan Adoption, Submittal, and Implementation	Section 10.3
X	X	Section 10.3.2	10642	Provide supporting documentation that the plan and contingency plan has been adopted as prepared or modified.	Plan Adoption, Submittal, and Implementation	Section 10.3.2 and Appendix H
X	X	Section 10.4	10644(a)	Provide supporting documentation that the urban water supplier has submitted this UWMP to the California State Library.	Plan Adoption, Submittal, and Implementation	Section 10.4

Retail	Wholesale	2020 Guidebook Location	Water Code Section	Summary as Applies to UWMP	Subject	2020 UWMP Location (For Agency Review Use)
X	X	Section 10.4	10644(a)(1)	Provide supporting documentation that the urban water supplier has submitted this UWMP to any city or county within which the supplier provides water no later than 30 days after adoption.	Plan Adoption, Submittal, and Implementation	Section 10.4
X	X	Sections 10.4.1 and 10.4.2	10644(a)(2)	The plan, or amendments to the plan, submitted to the department shall be submitted electronically.	Plan Adoption, Submittal, and Implementation	Section 10.4
X	X	Section 10.5	10645(a)	Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the supplier has or will make the plan available for public review during normal business hours.	Plan Adoption, Submittal, and Implementation	Section 10.5
X	X	Section 10.5	10645(b)	Provide supporting documentation that, not later than 30 days after filing a copy of its water shortage contingency plan with the department, the supplier has or will make the plan available for public review during normal business hours.	Plan Adoption, Submittal, and Implementation	Section 10.5
X	X	Section 10.6	10621(c)	If supplier is regulated by the Public Utilities Commission, include its plan and contingency plan as part of its general rate case filings.	Plan Adoption, Submittal, and Implementation	N/A
X	X	Section 10.7.2	10644(b)	If revised, submit a copy of the water shortage contingency plan to DWR within 30 days of adoption.	Plan Adoption, Submittal, and Implementation	Section 10.6

Appendix E

Agency and Public Notices

Rhodora Biagtan

From:	Rank, Elke <erank@zone7water.com>
Sent:	Tuesday, November 24, 2020 4:21 PM
To:	drepp@cityofpleasantonca.gov; NFialho@cityofpleasantonca.gov; rdicandia@cityofpleasantonca.gov; dbruzzone@cityofpleasantonca.gov; citymanager@cityoflivermore.net; hfling@cityoflivermore.net; yzhang@cityoflivermore.net; mcintyre@dsrsd.com; jlee@dsrsd.com; Irene Suroso; Judy Zavadil; fvallejo; mstorms@calwater.com; J Freeman; weir@lavwma.com; info@lavwma.com; linda.smith@dublin.ca.gov; public.works@dublin.ca.gov; albert.lopez@acgov.org; danielw@acpwa.org; susan.muranishi@acgov.org; jgorton@sanramon.ca.gov; rbartlett@sanramon.ca.gov; spedowfski@sanramon.ca.gov; ryan.hernandez@dcd.cccounty.us; Jami.Napier@cob.cccounty.us; David.Twa@cao.cccounty.us; jrossi.derwa@gmail.com; clifford.chan@ebmud.com
Cc:	Flores, Amparo; Mahoney, Carol; Bradley, Alexandra; Rhodora Biagtan
Subject:	Notice for 2020 UWMP and WSCP

[This message has originated from outside of West Yost]

NOTICE OF REVIEW & POTENTIAL AMENDMENTS
2020 Urban Water Management Plan and Water Shortage Contingency Plan
November 24, 2020

Zone 7 Water Agency (Zone 7) is a water wholesaler serving over 260,000 people in Pleasanton, Livermore and Dublin in Alameda County, and the Dougherty Valley area of San Ramon in Contra Costa County. Zone 7 sells treated water to four retailers: City of Pleasanton, City of Livermore, Dublin San Ramon Services District and California Water Service Company.

Zone 7 is currently in the process of updating its Urban Water Management Plan (UWMP) and Water Shortage Contingency Plan (WSCP), which are required to be submitted to the California Department of Water Resources by July 1, 2021. The UWMP is a planning document and a source document which reports, describes and evaluates water deliveries and uses, water supply sources and conservation efforts. The WSCP provides a plan for response to various water supply shortage conditions.

Zone 7 coordinates with water management agencies, relevant public agencies and other water suppliers (including the four retailers) on the preparation of the UWMP and WSCP updates. Zone 7 will be reviewing the UWMP and WSCP and will make amendments and updates, as appropriate.

Additional notices regarding the status of the 2020 UWMP and WSCP, including schedules for public review and Zone 7 Board approval, will be distributed and posted on Zone 7's web site at www.zone7water.com.

Questions or comments regarding preparation of the UWMP and WSCP may be directed to Elke Rank, erank@zone7water.com.

Elke Rank | Associate Water Resources Planner
Zone 7 Water Agency
100 North Canyons Parkway Livermore, CA 94551
Direct: 925.454.5005 | Main: 925.454.5000 | E-mail: erank@zone7water.com

Zone 7 is hiring Engineers!

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, ZONE 7
100 NORTH CANYONS PARKWAY, LIVERMORE, CA 94551 • PHONE (925) 454-5000 • FAX (925) 454-5723

NOTICE OF REVIEW & POTENTIAL AMENDMENTS
2020 Urban Water Management Plan, Water Shortage Contingency Plan, and Consistency with Delta Plan Policy WR P1
March 10, 2021

Zone 7 Water Agency (Zone 7) is a water wholesaler serving over 260,000 people in Pleasanton, Livermore and Dublin in Alameda County, and the Dougherty Valley area of San Ramon in Contra Costa County. Zone 7 sells treated water to four retailers: City of Pleasanton, City of Livermore, Dublin San Ramon Services District and California Water Service Company.

Zone 7 is currently in the process of updating its Urban Water Management Plan (UWMP) and Water Shortage Contingency Plan (WSCP), which are required to be submitted to the California Department of Water Resources by July 1, 2021. The UWMP is a planning document and a source document which reports, describes and evaluates water deliveries and uses, water supply sources and conservation efforts. The WSCP provides a plan for response to various water supply shortage conditions.

Furthermore, Zone 7 is adding a new appendix to our previously adopted 2015 UWMP to incorporate demonstration of consistency with Delta Plan Policy WR P1, Reduce Reliance on the Delta Through Improved Regional Water Self-Reliance (Cal. Code Regs. tit. 23, § 5003).

Zone 7 coordinates with water management agencies, relevant public agencies and other water suppliers (including the four retailers) on the preparation of the UWMP and WSCP updates. Zone 7 will be reviewing the UWMP and WSCP and will make amendments and updates, as appropriate.

A Board workshop will be conducted on April 1, 2021 at 6 pm to discuss the Draft 2020 UWMP and WSCP, and the addition to the 2015 UWMP. Additional notices regarding the status of the 2020 UWMP and WSCP, including schedules for public meetings, public review and Zone 7 Board public hearing and adoption, will be distributed and posted on Zone 7's web site at www.zone7water.com.

Questions or comments regarding preparation of the UWMP and WSCP may be directed to Elke Rank, erank@zone7water.com.

Rhodora Biagtan

From:	Rank, Elke <erank@zone7water.com>
Sent:	Monday, May 3, 2021 3:19 PM
To:	drepp@cityofpleasantonca.gov; NFialho@cityofpleasantonca.gov; rdicandia@cityofpleasantonca.gov; dbruzzone@cityofpleasantonca.gov; citymanager@cityoflivermore.net; hfling@cityoflivermore.net; yzhang@cityoflivermore.net; mcintyre@dsrsd.com; jlee@dsrsd.com; Irene Suroso; Judy Zavadil; fvallejo; mstorms@calwater.com; J Freeman; weir@lavwma.com; info@lavwma.com; linda.smith@dublin.ca.gov; public.works@dublin.ca.gov; albert.lopez@acgov.org; danielw@acpwa.org; susan.muranishi@acgov.org; jgorton@sanramon.ca.gov; rbartlett@sanramon.ca.gov; spedowfski@sanramon.ca.gov; ryan.hernandez@dcd.cccounty.us; Jami.Napier@cob.cccounty.us; David.Twa@cao.cccounty.us; jrossi.derwa@gmail.com; clifford.chan@ebmud.com; Laurie Sucgang; bosdis1@acgov.org; bosdist4@acgov.org
Cc:	Flores, Amparo; Mahoney, Carol; Bradley, Alexandra; Rhodora Biagtan
Subject:	Notice for 2020 UWMP, WSCP, and Consistency with Delta Plan Policy WR P1
Attachments:	UWMP Public Notice 5-3-2021.pdf

Follow Up Flag:	Follow up
Flag Status:	Flagged

[This message has originated from outside of West Yost]

Please see the attached notice for Zone 7's 2020 UWMP, WSCP, and Consistency with Delta Plan Policy WR P1.

Key dates:

- Zone 7's Board of Directors will hold a public hearing at their regularly scheduled meeting on Wednesday, May 19, 2021, at 7 p.m. to take public comment on the Public Draft 2020 UWMP and WSCP, and the addition to the 2015 UWMP.
- We encourage written comments to be submitted by Monday, May 17, 2021 to allow the Board of Directors opportunity to review before the hearing.

Best,
Elke

Elke Rank | Associate Water Resources Planner
Zone 7 Water Agency
100 North Canyons Parkway Livermore, CA 94551
Direct: 925.454.5005 | Main: 925.454.5000 | E-mail: erank@zone7water.com

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, ZONE 7
100 NORTH CANYONS PARKWAY, LIVERMORE, CA 94551 • PHONE (925) 454-5000 • FAX (925) 454-5723

NOTICE OF AVAILABILITY & NOTICE OF PUBLIC HEARING
2020 Urban Water Management Plan, Water Shortage Contingency Plan, and Consistency with Delta Plan Policy WR P1
May 3, 2021

Zone 7 Water Agency (Zone 7) is a water wholesaler serving over 260,000 people in Pleasanton, Livermore and Dublin in Alameda County, and the Dougherty Valley area of San Ramon in Contra Costa County. Zone 7 sells treated water to four retailers: City of Pleasanton, City of Livermore, Dublin San Ramon Services District and California Water Service Company.

Zone 7 has updated its Urban Water Management Plan (UWMP) and Water Shortage Contingency Plan (WSCP), which are required to be submitted to the California Department of Water Resources by July 1, 2021. The 2020 UWMP is a planning document, which reports, describes and evaluates water deliveries and uses, water supply sources and conservation efforts. The WSCP provides a plan for response to various water supply shortage conditions. Furthermore, Zone 7 is adding a new appendix to the 2020 UWMP and to our previously adopted 2015 UWMP to incorporate demonstration of consistency with Delta Plan Policy WR P1, Reduce Reliance on the Delta Through Improved Regional Water Self-Reliance (Cal. Code Regs. tit. 23, § 5003).

Materials: These materials are posted for review on Zone 7's website, www.zone7water.com. A limited number of paper copies are available, on a first come-first served basis, at Zone 7's main office in Livermore; contact Elke Rank to make arrangements for pick-up (24-hour notice is required).

Public Hearing: Zone 7's Board of Directors will hold a public hearing at their regularly scheduled meeting on Wednesday, May 19, 2021, at 7 p.m. to take public comment on the Public Draft 2020 UWMP and WSCP, and the addition to the 2015 UWMP. The Board is expected to consider adoption of these items at this meeting, which will be held virtually. Meeting details will be posted on Zone 7's website at least 72 hours prior to the meeting.

Public Comments: We welcome public comments, either written or spoken. We encourage written comments to be submitted by Monday, May 17, 2021 to allow the Board of Directors opportunity to review before the hearing. All comments must be received by Zone 7 by the close of the public hearing on Wednesday, May 19, 2021.

Questions or comments regarding preparation of the UWMP and WSCP may be directed to Elke Rank, erank@zone7water.com.

NOTICE OF AVAILABILITY &
NOTICE OF PUBLIC HEARING
2020 Urban Water Management Plan,
Water Shortage Contingency Plan, and
Consistency with Delta Plan Policy WR P1
May 3, 2021

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Questions or comments regarding preparation of the UWMP and WSCP may be directed to Elke Rank, erank@zone7water.com.

PT/VT 6572876; May 3, 10, 2021

Appendix F

Zone 7 Water Agency Water Supply Reliability Policy (Resolution 13-4230)

ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO 13-4230

INTRODUCED BY DIRECTOR QUIGLEY
SECONDED BY DIRECTOR STEVENS

Water Supply Reliability Policy

WHEREAS, the Zone 7 Board of Directors desires to maintain a highly reliable Municipal and Industrial (M&I) water supply system so that existing and future M&I water demands can be met during varying hydrologic conditions; and

WHEREAS, the Board has an obligation to communicate to its M&I customers and municipalities within its service area the ability of Zone 7's water supply system to meet projected water demands; and

WHEREAS, the Board on August 18, 2004 adopted Resolution No. 04-2662 setting forth its Reliability Policy for Municipal & Industrial Water Supplies; and

WHEREAS, the Board desires to revise the Reliability Policy to reflect recent data, analysis, and studies.

NOW, THEREFORE, BE IT RESOLVED that the Board hereby rescinds Resolution No. 04-2662 adopting the August 18, 2004 Reliability Policy for Municipal & Industrial Water Supplies; and

BE IT FURTHER RESOLVED that the Board hereby adopts the following level of service goals to guide the management of Zone 7's M&I water supplies as well as its Capital Improvement Program (CIP):

Goal 1.Zone 7 will meet its treated water customers' water supply needs, in accordance with Zone 7's most current Contracts for M&I Water Supply, including existing and projected demands as specified in Zone 7's most recent Urban Water Management Plan (UWMP), during normal, average, and drought conditions, as follows:

- At least 85% of M&I water demands 99% of the time
- 100% of M&I water demands 90% of the time

Goal 2:Provide sufficient treated water production capacity and infrastructure to meet at least 80% of the maximum month M&I contractual demands should any one of Zone 7's major supply, production, or transmission facilities experience an extended unplanned outage of at least one week.

BE IT FURTHER RESOLVED that to ensure that this Board policy is carried out effectively, the Zone 7 General Manager will provide a water supply status report to the Board every five years with the Zone 7 Urban Water Management Plan that specifies how these goals will be, or are being, achieved.

If the General Manager finds that the goals cannot be met during the first five years of the Urban Water Management Plan, then the Board will hold a public hearing within two months of the General Manager's finding to consider remedial actions that will bring Zone 7 into substantial compliance with the stated level of service goals. Remedial actions may include, but are not limited to, voluntary conservation or mandatory rationing to reduce water demands, acquisition of additional water supplies, and/or a moratorium on new water connections. After reviewing staff analyses and information gathered at the public hearing, the Board shall, as expeditiously as is feasible, take any additional actions that are necessary to meet the level of service goals during the following five-year period; and

BE IT FURTHER RESOLVED that the Zone 7 General Manager shall prepare an Annual Review of the Sustainable Water Supply Report which includes the following information:

(1) An estimate of the current annual average water demand for M&I water as well as a five-year projection based on the same information used to prepare the UWMP and CIP;
(2) A Summary of available water supplies to Zone 7 at the beginning of the calendar year;
(3) A comparison of current water demand with the available water supplies; and
(4) A discussion of water conservation requirements and other long-term supply programs needed to meet Zone 7 M&I water demands for single-dry and multiple-dry year conditions, as specified in the Zone 7's UWMP.

A summary of this review will be provided to M&I customers.

<u>Definitions</u>

Level of Service for Annual Water Supply Needs—the level of service is the percent of existing or projected water demand that Zone 7's water supply system can meet during two key conditions: (1) during various hydrologic conditions and (2) during unplanned outages of major facilities.
Capital Improvement Program (CIP)—the CIP is Zone7's formal program for developing surface and ground water supplies, along with associated infrastructure, including import water conveyance facilities, surface water treatment plants, groundwater wells, and M&I water transmission system to meet projected water demands.

Normal conditions—conditions that most closely represent median runoff or allocation from all normally contracted or available water supplies from the historic record.

Average conditions—conditions that most closely represent the average runoff or allocation from all normally contracted or legally available water supplies from the historic record.

Drought conditions—conditions that most closely represent reduced runoff or allocation level from the historic record from all normally contracted or legally available water supplies, including both single-dry and multiple-dry year conditions.

Single-dry year condition—a condition that most closely represents the lowest yield over a one-year period from the historic record from all normally contracted or legally available supplies.

Multiple-dry year condition—a condition that most closely represents three or more consecutive dry years from the historic record that represent the lowest yields from all normally contracted or legally available supplies.

Available water supplies—consist solely of (1) water supplies that Zone 7 has contracted for (e.g., listed under Schedule A of the State Water Contract, dry-year water options, special contracts with other water districts, etc.) and (2) water actually stored in surface and subsurface reservoirs.

Maximum Month—the largest monthly average water use.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GRECI, MACHAEVICH, PALMER, QUIGLEY, RAMIREZ HOLMES STEVENS

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on October 17, 2012.

By____________________

President, Board of Directors

Appendix G

Water Shortage Contingency Plan

FINAL | JUNE 2021

Zone 7 Water Agency
Water Shortage Contingency Plan

JOINTLY PREPARED BY

Table of Contents

LIST OF TABLES

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LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
AWSDA	Annual Water Supply and Demand Assessment
Cal Water	California Water Service-Livermore District
ccf	Hundred cubic feet
CIP	Capital Improvement Program
CWC	California Water Code
Delta	Sacramento-San Joaquin Delta
DSRSD	Dublin San Ramon Services District
DWR	Department of Water Resources
EOC	Emergency Operations Center
ERP	Emergency Response Plan
Legislature	California State Legislature
Livermore	City of Livermore
M&I	Municipal and Industrial
PIO	Public Information Officer
Pleasanton	City of Pleasanton
SB	Senate Bill
SBA	South Bay Aqueduct
UWMP	Urban Water Management Plan
WARN	Water/Wastewater Agency Response Network
WSCP	Water Shortage Contingency Plan
Zone 7	Zone 7 Water Agency
Zone 7 Board	Zone 7 Board of Directors

Zone 7 Water Agency
Water Shortage Contingency Plan

Water shortages occur whenever the available water supply cannot meet the normally expected customer water use. This can be due to several reasons, such as climate change, drought, and catastrophic events. Drought, regulatory action constraints, and natural and manmade disasters may occur at any time. In 2018, the California State Legislature (Legislature) enacted two policy bills, (Senate Bill (SB) 606 (Hertzberg) and Assembly Bill (AB) 1668 (Friedman)) (2018 Water Conservation Legislation), to establish a new foundation for drought planning to adapt to climate change and the resulting longer and more intense droughts in California. The 2018 Water Conservation Legislation set new requirements for water shortage contingency planning.

Zone 7 Water Agency's (Zone 7) goal is to maintain a highly reliable Municipal and Industrial (M&I) water supply system to meet existing and future demands under various water supply conditions. Zone 7's Water Supply Reliability Policy (Resolution 13-4230), adopted on October 17, 2012 and included as Appendix A to this WSCP, guides the management of its water supplies to meet this goal.

This Water Shortage Contingency Plan (WSCP) reflects Zone 7's Water Supply Reliability Policy and describes its strategic plan in preparation for and responses to water shortages, including water shortage stages and associated shortage response actions. This WSCP provides a guide for Zone 7 to proactively prevent catastrophic service disruptions and has been updated to be consistent with the 2018 Water Conservation Legislation requirements. As part of this WSCP, Zone 7's legal authorities, communication protocols, compliance and enforcement, and monitoring and reporting are described.

Zone 7 intends for this WSCP to be dynamic so that it may assess response action effectiveness and adapt to emergencies and catastrophic events. Refinement procedures to this WSCP are provided to allow Zone 7 to modify this WSCP outside of the Urban Water Management Plan (UWMP) process.

1.0 WATER SUPPLY RELIABILITY ANALYSIS

Chapters 6 and 7 of Zone 7's 2020 UWMP present Zone 7's water supply sources and reliability, respectively. Findings show Zone 7 can reliably meet its projected demands through 2045 in normal and dry hydrologic conditions, including single dry years and five consecutive dry years.

Statewide water supply conditions, changes in groundwater levels, and actions by other agencies may impact Zone 7's available water supply. For Zone 7, a water shortage condition occurs when the available supply of potable water cannot meet its retailers' normal water demands for human consumption, sanitation, fire protection, and other beneficial uses. Zone 7's retailers include the California Water Service-Livermore District (Cal Water), the City of Livermore (Livermore), the City of Pleasanton (Pleasanton), and the Dublin San Ramon Services District (DSRSD).

The analysis associated with this WSCP was developed in the context of Zone 7's water supply sources and system reliability. In some cases, Zone 7 may be able to foresee its water shortage condition, but the water shortage may also be caused by an unforeseen emergency event. In general, Zone 7's water supply conditions may be affected by the following:

- SWP supply allocations and storage levels
- Sacramento-San Joaquin Delta (Delta) water quality

- Occurrence of threatened/endangered species near Banks Pumping Plant in the Delta
- Delta vulnerability to seismic events, changing environmental and regulatory requirements, and climate change
- Local hydrology affecting availability of Arroyo Valle water supply
- Contaminants in the Main Basin
- Outages of Delta (e.g., Banks Pumping Plant) and South Bay Aqueduct (SBA) facilities
- Outages of treated water production facilities

2.0 ANNUAL WATER SUPPLY AND DEMAND ASSESSMENT PROCEDURES

Beginning July 1, 2022, California Water Code (CWC) §10632.1 requires water suppliers to submit an Annual Water Supply and Demand Assessment (AWSDA). Water suppliers will also be required to submit an Annual Water Shortage Assessment Report beginning July 1, 2022. Zone 7 plans to satisfy both requirements via its "Annual Review of the Sustainable Water Supply" (Annual Sustainability Report), which Zone 7 has been producing since it adopted an updated Water Supply Reliability Policy on October 17, 2012. The Annual Sustainability Report is submitted to the Zone 7 Board of Directors (Zone 7 Board) annually in April; the 2020 report is included in this WSCP as Appendix B. In addition to the Annual Sustainability Report, Zone 7 also prepares and updates its Water Supply Operations Plan over the course of the year. The Water Supply Operations Plan is a more detailed plan focused on the current year, but it also informs the longer-term outlook of the Annual Sustainability Report.

Zone 7's Annual Sustainability Report covers near-term planning of water supplies over the upcoming five years and includes the following:

- An estimate of the current annual demand for treated and untreated water, as well as a five-year projection (including water losses and water conservation) based on projections from Zone 7's retailers, observed trends, and other updated information. The Annual Sustainability Report is more focused on "Delivery Requests" submitted by the retailers, while Zone 7's Water Supply Operations Plan is generally based on forecasted demands based on observed trends updated over the year.
- A description and quantification of available water supplies to Zone 7 at the beginning of the calendar year and projected water supplies over the next five years.
- A comparison of current and projected water demand with the available water supplies to determine if a water shortage condition is anticipated.
- A review of water supply programs (to maintain long-term service reliability) and existing infrastructure and capabilities.
- A discussion of water conservation requirements and other long-term supply programs needed to meet Zone 7 treated and untreated water demands for single-dry and multiple-dry year conditions, as specified in Zone 7's UWMP.

Zone 7 will modify the contents of its Annual Sustainability Report as needed to meet the requirements of the AWSDA and the Annual Water Shortage Assessment Report. For the purposes of this WSCP, the Annual Sustainability Report is assumed to meet these requirements for the AWSDA and the Annual Water Shortage Assessment Report.

This section provides the decision-making process, key data inputs, and methodology necessary for Zone 7 to produce its Annual Sustainability Report. This process includes steps Zone 7 may take to declare a water shortage emergency and associated water shortage stage (see Section 3.0) and implement water shortage response actions (see Section 4.0).

2.1 Decision-Making Process

Zone 7 will use the decision-making process described below to consistently produce its Annual Sustainability Report but may adjust and improve this process as needed.

Zone 7 staff will prepare the Annual Sustainability Report and submit it to the California Department of Water Resources (DWR) by July 1 of each year under the new requirement effective on July 1, 2022. Key data inputs described in Section 2.2 will be gathered and the assessment will be conducted in accordance with Section 2.3.

The findings from the Annual Sustainability Report are presented to the Zone 7 Board in April of each year. If available supply will not meet expected demands, recommendations on determining a water shortage condition and associated actions will be included for Board consideration. Based on the findings of the Annual Sustainability Report, the Zone 7 Board is responsible for determining if a water shortage condition exists and whether to adopt a resolution declaring a water shortage emergency and an associated water shortage stage and authorizing water shortage actions (a sample resolution is provided in this WSCP as Appendix C). Recommended actions may include declaration of a water shortage emergency, declaration of a water shortage stage, and implementation of shortage response actions. Such actions will be coordinated interdepartmentally, with the Tri-Valley's water service providers, and with Alameda and Contra Costa counties for the possible proclamation of a local emergency.

To produce the Annual Sustainability Report, Zone 7 will follow the approximate schedule of activities and decision-making shown on Table 1 and Table 2, respectively. Due to variations in climate and hydrologic conditions and other factors from year-to-year, the dates shown in the tables are approximate and may be adjusted as needed. The intent of the schedule is to allow Zone 7 to implement shortage response actions to effectively address anticipated water shortage conditions in a timely manner while complying with the State's reporting requirements. Preparation of the Water Supply Operations Plan and Annual Sustainability Report is currently assigned to the Integrated Planning Section as the lead, with close coordination with other Zone 7 sections (i.e., Operations, Engineering, Groundwater, Water Quality, Finance). Executive Management approves the Annual Sustainability Report and Water Supply Operations Plans before presentation to the Water Resources Committee and Zone 7 Board.

Table 1. Schedule of Annual Sustainability Report and Water Supply Operations Plan Activities	
Schedule	Activities
Mid-December (prior year) to mid-January	Prepare Preliminary Water Supply Operations Plan and present to the Water Resources Committee of the Zone 7 Board. This gives a preview of water supply conditions and initiates planning for any potential actions.
January to mid-March (may continue over the year)	Monitor water supply, demand, and hydrologic condition trends and coordinate with DWR. Coordinate with groundwater banks to plan for any banked water recovery, if needed. Arrange for water transfer, if needed.
Mid-March to mid-April	Using the most current information, prepare the summaries of water supply sources for current year, a following dry year, and subsequent average three years for a five-year outlook. Describe sources and quantities considering factors affecting supply as described in Section 2.2.
Mid-March to mid-April	Document water demands for the current year and subsequent four years assuming the hydrologic conditions described above. Demands will generally be based on retailers' delivery requests. Describe demand types and quantities considering factors affecting demand as described in Section 2.2.
Mid-March to mid-April	Using the methodology described in Section 2.3, calculate Zone 7's water supply reliability over the five-year period. Determine if a water shortage condition is expected and recommend associated actions. Prepare the Annual Sustainability Report.
April Zone 7 Board Meeting	Present the findings and recommendations from the Annual Sustainability Report for Zone 7 Board consideration.
Late April-May	Update the Water Supply Operations Plan based on the latest information.
June	Present the Water Supply Operations Plan to the Water Resources Committee.
Before July 1	Submit the Annual Sustainability Report to DWR.
July-December	Update the Water Supply Operations Plan, as needed.

Table 2. Schedule of Decision-Making Activities		
Start Date	Activities	Approval
January to mid-March	Initiate any requests for banked water recovery and arrange for water transfers, as needed.	Executive Management
Mid-March to mid-April	If a water shortage emergency condition exists, prepare recommendations on water shortage condition determination and actions based on Annual Sustainability Report findings. Determine financial consequences of a water shortage emergency. Prepare resolution/s[(a)] approving determinations and actions.	Executive Management
April Zone 7 Board Meeting (currently third Wednesday)	Receive presentation of Annual Sustainability Report, including determinations and recommendations. Adopt resolution/s approving determinations and actions, as appropriate.	Zone 7 Board
January-April	Finalize water transfer requests and any new agreements, if needed. New agreements will require Zone 7 Board approval.	Zone 7 Board
(a) Sample resolutions are provided in Appendix C.		

2.2 Key Data Inputs

The State requires that the Annual Sustainability Report evaluate supplies and demands for, at a minimum, the current year and one subsequent dry year. Zone 7 provides a five-year outlook, assuming the last three years are of average conditions. The following key data inputs will be used to evaluate Zone 7's water supply reliability.

In reviewing planned water supplies, the Annual Sustainability Report will consider, as appropriate and applicable:

1. Hydrologic conditions
2. SWP supply availability
3. Local water availability
4. Storage conditions
5. Regulatory conditions
6. Contractual constraints
7. Surface water and groundwater quality conditions
8. Groundwater well production limitations
9. Infrastructure capacity constraints or changes
10. Capital improvement project implementation

Planned water supply sources and quantities will be described and shall be reasonably consistent with the supply projections in Chapter 6 of Zone 7's most recent UWMP. If supply sources and projections differ significantly between the Annual Sustainability Report and the UWMP, Zone 7 will explain the differences as needed.

In reviewing planned unconstrained water demands (i.e., without conservation) for the five-year outlook, the Annual Sustainability Report will consider, as appropriate and applicable:

1. Retailers' Delivery Requests
2. Local weather conditions
3. Demand trends
4. Water year type
5. Population changes (e.g., due to development projects)
6. Anticipated new demands (e.g., changes to land use)
7. Pending policy changes that may impact demands
8. Infrastructure capacities and constraints (Zone 7 and retailers)
9. Retailer groundwater pumping

Planned water demand types and quantities will be described and shall be reasonably consistent with the demand projections in Chapter 4 of Zone 7's most recent UWMP. If demands differ significantly between the Annual Sustainability Report and the UWMP, Zone 7 will explain the differences as needed.

2.3 Assessment Methodology

In preparing the Annual Sustainability Report, Zone 7 will use the following assessment methodology and criteria to evaluate the agency's water supply reliability for the current year and following dry year (followed by three years of average conditions). Zone 7 assesses the data listed in Section 2.2 to develop its supply and demand forecasts, which are then compared to determine Zone 7's water supply reliability. Zone 7's water supply will be deemed reliable if it can meet planned water demands. If water supply cannot meet planned water demands in the current year or the following dry year, the extent of the water shortage condition will be determined, and Zone 7 will prepare recommended response actions in accordance with this WSCP. Findings from the Annual Sustainability Report will be presented to the Zone 7 Board, along with the recommendations for action.

3.0 SIX STANDARD WATER SHORTAGE STAGES

To provide a consistent regional and statewide approach to conveying the relative severity of water supply shortage conditions, the 2018 Water Conservation Legislation mandates that water suppliers plan for six standard water shortage levels that correspond to progressive reductions of up to 10, 20, 30, 40, 50 percent, and greater than 50 percent from normal conditions. Each shortage condition should correspond to additional actions water suppliers would implement to meet the severity of the impending shortages.

For each of the State's standard shortage levels (also called "stages"), Table 3 summarizes the water shortage range (i.e., percent shortage from normal supplies) and a brief narrative description of the corresponding water shortage condition. These water shortage stages apply to both foreseeable and unforeseeable water supply shortage conditions. Zone 7's 2015 UWMP included four stages that addressed up to 35 percent water demand reduction in the first three stages and more than 35 percent water demand reduction in Stage 4. Table 3 presents Zone 7's reorganized stages, which align with the State's standard stages.

As described in Section 2.0, Zone 7 will prepare the Annual Sustainability Report to determine its water supply condition for at least the current year and the following one dry year. Preparing the Annual Sustainability Report helps Zone 7 ascertain and communicate the need to declare a water shortage emergency and water shortage stage due to anticipated conditions. In other cases, Zone 7 may need to declare a water shortage emergency due to unforeseen water supply interruptions. When Zone 7 anticipates or identifies that water supplies may not be adequate to meet the normal water supply needs of its customers, the Zone 7 Board may determine that a water shortage exists and consider a resolution (sample in Appendix C) to declare a water shortage emergency and associated stage. The shortage stage provides direction on shortage response actions. Note that Zone 7 will also consider any statewide actions or declarations in any local declarations of a shortage stage.

Table 3. Water Shortage Contingency Plan Levels (DWR Table 8-1)			
Shortage Level	Percent Shortage Range	Water Shortage Condition	Shortage Response Actions
1	Up to 10%	• Agency has adequate supply and seeks to preserve water resources for the future; or • Assessment shows that water supply is not able to meet normal demands by up to 10%; or • Definable event has reduced water supply by up to 10%.	Implement actions per Table 4 and Table 5
2	Up to 20%	• Assessment leads to a reasonable conclusion that water supplies may not adequately meet normal demands in the current or upcoming years; or • Assessment shows that water supply is not able to meet normal demands by up to 20%; or • Definable event has reduced water supply by up to 20%.	Implement actions per Table 4 and Table 5
3	Up to 30%	• Previous water conservation target has not been met; or • Assessment shows that water supply is not able to meet normal demands by up to 30%; or • Definable event has reduced water supply by up to 30%.	Implement actions per Table 4 and Table 5
4	Up to 40%	• Previous water conservation target has not been met; or • Assessment shows that water supply is not able to meet normal demands by up to 40%; or • Definable event has reduced water supply by up to 40%.	Implement actions per Table 4 and Table 5
5	Up to 50%	• Previous water conservation target has not been met; or • Assessment shows that water supply is not able to meet normal demands by up to 50%; or • Definable event has reduced water supply by up to 50%.	Implement actions per Table 4 and Table 5
6	>50%	• Previous water conservation target has not been met; or • Assessment shows that water supply is not able to meet normal demands by more than 50%; or • Definable event has reduced water supply by more than 50%.	Implement actions per Table 4 and Table 5
Notes: Assessment is based on findings from the Annual Sustainability Report. Zone 7 will also consider any statewide actions or declarations in any local declarations of a shortage stage.			

4.0 SHORTAGE RESPONSE ACTIONS AND EFFECTIVENESS

CWC §10632 (a)(4) requires shortage response actions that align with the defined shortage levels. Zone 7's shortage response actions consist of a combination of demand reduction (in coordination with its retailers), supply augmentation, and operational changes. Zone 7's suite of response actions depends on the event that precipitates a water shortage stage, the time of the year the event occurs, the water supply sources available, and the condition of its water system infrastructure. In general, Zone 7 plans to use a balanced and dynamic approach, adapting its response actions to close the gap between water supplies and water demand and meet the water use goals associated with the declared water shortage stage.

Zone 7's water system is fully metered, from production to retailer turnouts. Records of water deliveries to each retailer are prepared daily and can be used to track the effectiveness of Zone 7's response actions. Water production and water use can be compared to the previous year, previous month, or previous week. Water use can also be compared by retailer. This continuous monitoring allows Zone 7 to evaluate its demand reduction efforts in real-time and adjust its shortage response actions accordingly.

As noted above, Zone 7's overall shortage response will be dynamic to close the gap between water supply and demands to meet the goal of the declared stage. For example, Zone 7 may intensify its public outreach or work with its retailers to enforce water use prohibitions more vigorously if water demand reduction goals are not met.

The shortage response actions discussed below may be considered as tools that allow Zone 7 to respond to water shortage conditions. Because Zone 7 may continuously monitor and adjust its response actions to reasonably equate demands with available supply, the extent to which implementation of each action reduces the gap between water supplies and water demand is difficult to quantify and thus only estimated. Certain response actions, such as public outreach and enforcement, support the effectiveness of other response actions and do not have a quantifiable effect on their own.

4.1 Demand Reduction

Since Zone 7 operates as a wholesale water agency, it cannot set or enforce consumption limits at the customer (e.g., household) level. As a result, this WSCP does not include per capita allotment, penalties, or customer incentives for conservation for any customer sector. Zone 7's retailers will provide their demand reduction response actions in their respective UWMPs. However, Zone 7 may request that retailers reduce demands when supplies are insufficient. Up to Stage 2, Zone 7's demand reduction requests to its retailers may be voluntary or mandatory, depending on conditions. At Stage 3 and higher, Zone 7 will likely require its retailers to reduce demands up to the applicable shortage percentage.

Zone 7's other demand reduction actions include public outreach and financial actions through Zone 7 Board resolutions. Public outreach to support voluntary conservation begins with Stage 1 and expands and intensifies with increasing shortage stages. At any shortage stage, the Zone 7 Board will pass a resolution to officially declare a water shortage emergency and stage, and potentially a separate resolution for implementation of a water shortage surcharge (see sample resolutions in Appendix C).

Table 4 summarizes Zone 7's demand reduction actions, which are organized by the triggering water shortage level (i.e., stage), and each action includes an estimate of how much its implementation will reduce the shortage gap. For each demand reduction action, Table 4 also indicates if Zone 7 uses compliance actions such as penalties, charges, or other enforcement. Demand reduction actions are only listed in Table 4 in the stage when they are first implemented. Zone 7 will continue to use these actions in higher stages unless otherwise noted.

Table 4. Demand Reduction Actions (DWR Table 8-2)

Shortage Level	Demand Reduction Actions **_Drop down list_** *These are the only categories that will be accepted by the WUEdata online submittal tool. Select those that apply.*	How much is this going to reduce the shortage gap? *Include units used (volume type or percentage)*	Additional Explanation or Reference *(optional)*	Penalty, Charge, or Other Enforcement? ***For Retail Suppliers Only*** *Drop Down List*
1	Expand Public Information Campaign	(see Note)	Public outreach to support voluntary conservation.	No
	Other	Up to the full shortage gap	Ask retailers for voluntary demand reduction, as needed.	No
2	Expand Public Information Campaign	(see Note)	Expand public outreach to support conservation.	No
	Other	Up to the full shortage gap	Ask retailers for voluntary or mandatory demand reduction, as needed. Only the latter will be enforced.	Yes
3*	Expand Public Information Campaign	(see Note)	Intensify public outreach to support conservation.	No
	Other	Up to the full shortage gap	Ask retailers for mandatory demand reduction.	Yes
NOTES: Expanding public information campaign boosts water conservation overall, so no shortage gap reduction estimate provided. Actions introduced in a lower stage will also be used in higher stages, unless otherwise noted. *At Stage 3 and higher, Zone 7 will likely require its retailers to reduce demands up to the applicable shortage percentage.				

Zone 7 will monitor water production, demands, and changing conditions to determine the intensity of its public outreach, the extent of its enforcement actions, and the need to adjust its water shortage stage declaration as discussed in Section 9.0.

4.2 Additional Mandatory Restrictions

As a wholesaler, Zone 7 does not have direct authority to institute water use prohibitions. Zone 7 will support mandatory restrictions imposed by its retailers on their customers and coordinate with its retailers to provide consistent public outreach messaging.

4.3 Supply Augmentation and Other Actions

Chapter 6 of Zone 7's 2020 UWMP describes Zone 7's normal water supply portfolio, as well as dry-year and emergency supplies. Zone 7's non-local groundwater storage in the Kern County groundwater banks is largely intended to provide water supply during drought years or during definable water shortage events. Water transfer amounts would also be adjusted to meet supply deficits. These supply augmentation options are already included in the Annual Sustainability Report as needed to close the gap between supplies and demands, so they are not counted again as a potential shortage response.

Table 5 lists the supply augmentation methods and other actions (including operational changes described in Section 4.4) Zone 7 can utilize during each shortage level. These actions are only listed in Table 5 in the stage when they are first implemented. Zone 7 will continue to use these actions in higher stages unless otherwise noted.

Table 5. Supply Augmentation and Other Actions (DWR Table 8-3)

Shortage Level	Supply Augmentation Methods and Other Actions by Water Supplier *Drop down list* *These are the only categories that will be accepted by the WUEdata online submittal tool*	How much is this going to reduce the shortage gap? *Include units used (volume type or percentage)*	Additional Explanation or Reference *(optional)*
1	Other actions (describe)	Up to the full shortage gap.	Optimize use of groundwater and surface water supplies and adjust use of locally vs. remotely stored water.
	Other actions (describe)	N/A	Improve monitoring, analysis, and tracking of customer water usage rates.
	Other actions (describe)	N/A	In anticipation of decreased revenue, reduce discretionary spending
2	Transfers	Up to the full shortage gap.	Pursue opportunities for additional water transfers to lower the shortage gap, beyond what is already in the Annual Sustainability Report.
	Exchanges	Up to the full shortage gap.	Pursue opportunities for (additional) water exchanges to lower the shortage gap.
	Implement or Modify Drought Rate Structure or Surcharge	N/A	Consider implementation of water shortage surcharge correlated with stage (requires Board approval).
	Other actions (describe)	N/A	Evaluate timing of maintenance activities that could negatively impact ability to manage water supplies/shortages, or could result in loss of water supply.
	Other actions (describe)	up to 100 AF	Consider greater incentives under rebate program and focus on high-consumption customers.
3	Other actions (describe)	unknown - depends on project/s identified	Review CIP program and accelerate projects facilitating immediate improvement in water supply management if feasible/necessary.
	Stored emergency supply	To be determined based on operational	Consider/plan for/implement pumpback into South Bay Aqueduct if no supplies are available from Delta pumping.
NOTES: Actions introduced in a lower stage will also be used in higher stages, unless otherwise noted.			

4.4 Operational Changes

Beginning with Stage 2, Zone 7 will adjust operations to minimize supply losses. This includes improved monitoring, analysis, and tracking of customer water usage and optimizing use of Zone 7's water supplies to emphasize shortage management. In addition, Zone 7 will evaluate the timing of maintenance activities that could negatively impact the ability to manage water supplies or shortages or could result in a loss of water supply.

At Stage 3 and beyond, Zone 7 will implement more significant operational changes, including reviewing its Capital Improvement Program (CIP) to accelerate projects that would immediately improve water supply management.

4.5 Emergency Response Plan

As stated in Section 3.0, Zone 7's water shortage stages outlined in Table 3 apply to both foreseeable and unforeseeable water supply shortage conditions. The latter includes catastrophic water shortage conditions, which are addressed in Zone 7's Emergency Response Plan (ERP). The ERP outlines preparation, response, and recovery procedures associated with unforeseeable incidents such as water supply contamination, earthquake, infrastructure failure, and other events.

Zone 7 has an Emergency Operations Center (EOC) and EOC Staff made up of personnel representing different skills and disciplines within Zone 7. The EOC Staff would respond in the event of a natural or man-made emergency.

If imported water deliveries from the Delta are interrupted, Zone 7 plans to meet its water demands with existing facilities using groundwater and Zone 7's share of water stored in Lake Del Valle. Retailers with groundwater pumping capacity—Pleasanton and Cal Water—may be asked to increase their groundwater pumping, if possible. Deliveries to Zone 7's retailers would be reduced as necessary if supplies are insufficient. In coordination with the retailers, Zone 7 would declare a water shortage emergency. The retailers' WSCPs and the associated voluntary and mandatory water consumption reductions would go into effect. Under this scenario, most of the Zone 7's untreated water customers reliant on the imported water from the Delta would receive no water.

Zone 7 has emergency generators (both portable and dedicated) at strategic locations in preparation for any regional power outage. These generators would allow both the Del Valle Water Treatment Plant and the Patterson Pass Water Treatment Plant to continue operating even under a power outage. Assuming no interruptions in surface water supply, Zone 7 would be able to provide service to all treated water contractors. If warranted by demand, Zone 7 would also operate groundwater wells, which have either a dedicated generator in place (Mocho 1) or have the necessary hook-ups to receive power from a portable generator. If the power failure were to occur during high demand season (i.e., summer months), Zone 7 may be unable to meet hourly peak demands throughout the transmission system. Zone 7 would work closely with the retailers to manage demands to minimize impacts.

Water storage, treatment, and pumping facilities have been constructed to meet earthquake safety standards and are inspected regularly. Zone 7 also participates in the Water/Wastewater Agency Response Network (WARN), a statewide public utility mutual assistance organization.

5.0 COMMUNICATION PROTOCOLS

In the event of a water shortage, Zone 7 must inform its customers, the general public and interested parties, and local, regional, and state entities. Communication protocols for foreseeable and unforeseeable events are provided in this section. In any event, timely and effective communication must occur for appropriate response to the event. Key Zone 7 staff are provided cell phones, emergency radios, and agency email accounts to communicate internally and externally.

5.1 Communication for Foreseeable Events

A water shortage may be foreseeable when Zone 7 conducts its Annual Sustainability Report as described in Section 2.0. For foreseeable water shortages, Zone 7 will follow the communication protocols and procedures detailed below. Zone 7 may trigger any of these protocols at any water shortage stage.

1. As Zone 7 prepares its Preliminary Water Supply Operations Plan, starting in mid-December, Zone 7 will communicate with DWR, the Kern County groundwater banks, and potential or existing water transfer partners to discuss Zone 7's water supply conditions, as needed.
2. Public outreach on conservation will begin as soon as late winter/early spring if hydrologic conditions are below normal. Messaging will be developed based on specific conditions and will be coordinated with the retailers.
3. Zone 7 will present the findings from the Annual Sustainability Report at the April Zone 7 Board meeting, including recommendations for a water shortage emergency and shortage response actions, as applicable.
4. If a water shortage emergency is anticipated, Zone 7 will coordinate interdepartmentally, with the region's water service providers and the cities they serve, and with Alameda and Contra Costa counties for the possible proclamation of a local emergency.
5. Zone 7 will communicate conditions to the general public using some or all of the following options, as needed at the various shortage levels: public meetings, press releases, digital newsletters, postings on Zone 7's website, social media posts and digital advertising (e.g., Google, newspaper ads, boosted Facebook posts), YouTube, NextDoor, newspaper ads, and public service radio announcements. Staff also keeps interest lists for specific interest groups and community members for targeted messaging.

5.2 Communication for Unforeseeable Events

A water shortage may occur during unforeseeable events such as earthquakes, fires, infrastructure failures, civil unrest, and other catastrophic events. Zone 7's ERP provides specific communication protocols and procedures to convey water shortage contingency planning actions during these events. Zone 7 may trigger any of these communication protocols at any water shortage stage, depending on the event.

In general, communications and notifications should proceed along the chain of command. Notification decisions will be made under the direction of the Incident Commander, while internal and external communications will be managed by the Public Information Officer (PIO). All Zone 7 staff are provided their communication responsibilities. The ERP provides a list of relevant contacts to notify at the local, regional, and state level.

The PIO is the official spokesperson for Zone 7 and is responsible for interfacing with the public, media, other agencies, and stakeholders. The PIO maintains a list of contacts to disseminate information to the public, typically via radio, television, newspapers, or social media. Zone 7 may also elect to make telephone calls to certain types of facilities (e.g., day care centers, homeless centers, hospitals) as appropriate.

To maintain the security of Zone 7's water system, the ERP is maintained as a confidential document and may not be incorporated in this UWMP.

6.0 COMPLIANCE AND ENFORCEMENT

When supplies are insufficient, Zone 7 can ask its retailers to reduce demands, but the specific compliance and enforcement mechanisms are at the discretion of the retailers. Zone 7 is committed to working with and supporting its retailers in implementing water shortage response actions.

7.0 LEGAL AUTHORITIES

Zone 7 has the legal authority to create, manage, and activate emergency plans and carry out the responsibilities of those plans under the California Emergency Services Act, which authorizes all political subdivisions of the state (i.e., special districts, cities, and counties) to conduct emergency operations. Zone 7 Board Resolution 95-1777 describes the process for declaration of an agency emergency by the General Manager, with subsequent ratification by the Zone 7 Board no later than ten days after such declaration.

When a water shortage is determined, Zone 7 will coordinate interdepartmentally, with the region's water service providers, and with Alameda and Contra Costa counties for the possible proclamation of a local emergency in accordance with California Government Code, California Emergency Services Act (Article 2, Section 8558).

In a duly noticed meeting, the Zone 7 Board will determine whether a water shortage emergency condition exists and, if so, the degree of the emergency and what regulations and restrictions should be enforced in response to the shortage. Zone 7 shall declare a water shortage emergency in accordance with CWC Chapter 3 Division 1.

> *Water Code Section Division 1, Section 350*
> *…The governing body of a distributor of a public water supply…shall declare a water shortage emergency condition to prevail within the area served by such distributor whenever it finds and determines that the ordinary demands and requirements of water consumers cannot be satisfied without depleting the water supply of the distributor to the extent that there would be insufficient water for human consumption, sanitation, and fire protection.*

The water shortage emergency declaration triggers communication protocols described in Section 5.0 and compliance and enforcement actions described in Section 6.0.

8.0 FINANCIAL CONSEQUENCES OF WSCP

Zone 7 anticipates revenue losses and increased expenses during the potential water shortages described in this WSCP. Revenue losses result from decreased water sales due to conservation and/or lower amounts of water supply available to sell. Increased expenses can include supplemental water supply purchases, infrastructure improvements to increase treated water production or bolster system reliability, and higher water transfer costs.

Water conservation directly affects Zone 7's revenue stability, as Zone 7 currently recovers 60 percent of its revenue through volumetric or consumption-based rates, even though the majority of Zone 7's costs are fixed. Zone 7 prepares for these events through prudent financial planning, including water rate studies, and the establishment of reserves to offset revenue losses, smooth rates, and fund capital improvement projects. A water shortage surcharge may also be enacted by the Zone 7 Board to address revenue impacts from conservation.

8.1 Use of Financial Reserves

On May 15, 2019, the Zone 7 Board adopted the revised Reserve Policy per Resolution No. 19-37. The revised Reserve Policy condensed four reserves within the Water Enterprise Fund to three. This revision eliminated the Drought Contingency and Rate Stabilization Reserves and established the Reserve for Economic Uncertainties. The Reserve for Economic Uncertainties is designed to protect Zone 7 from the effects of fluctuations in water usage and the cost of imported water (to which Zone 7 is vulnerable) and other unforeseen events, such as a natural disaster, water shortage emergency, or other unanticipated adverse situations.

The Reserve for Economic Uncertainties is currently funded at the target level with a balance of $4.9 million. To mitigate potential revenue loss from demand reduction, Zone 7 may utilize funds in the Reserve for Economic Uncertainties in an amount up to the minimum reserve requirement to offset revenue loss. This reserve will be replenished over time with direction from the Zone 7 Board.

The 2012 to 2016 statewide drought provides an example of the financial impacts of water shortages on Zone 7 and the associated use of financial reserves. During the drought, Zone 7's retailers were required to meet mandatory conservation as stated in the Governor's Executive Order B-29-15 issued on April 1, 2015. Zone 7's retailers were very successful in implementing conservation and achieved approximately 40 percent conservation in 2015. As a result of voluntary and mandatory conservation efforts, Zone 7 reduced reserves by a total $25M within the Water Enterprise Fund over a three-year period starting in Fiscal Year 2013-2014 and ending in Fiscal Year 2015-2016.

8.2 Drought Rate Structures and Surcharges

If a declared water shortage emergency and associated stage generates a reduction in water usage and corresponding sales, use of reserves alone may not be sufficient for Zone 7 to maintain its fiscal health. Therefore, upon approval by the Zone 7 Board, Zone 7 may also implement a water shortage surcharge. The Zone 7 Board will determine when such a surcharge is necessary. To align with the State's standard water shortage level, Zone 7 plans to revise its water shortage surcharge as presented in Table 6.

Table 6. Water Shortage Surcharges

Water Shortage Stage	Demand Reduction Target	Water Shortage Surcharge per Hundred Cubic Feet (ccf)
1	≤ 10%	Not Applicable
2	11-20%	$0.26
3	21-30%	$0.59
4	31-40%	$1.04
5	41-50%	$1.67
6	> 50%	$2.60

A water shortage surcharge adopted by the Zone 7 Board becomes effective on the first day of the month following thirty days after adoption. The adopted water shortage surcharge will sunset after six months, unless extended or modified by action of the Zone 7 Board.

8.3 Other Measures

Zone 7 reviews its capital budget annually and re-prioritizes projects as needed given current and forecasted resources, needs, and funding availability. In some cases, projects may be accelerated or deferred. For example, in 2014, Zone 7 accelerated the construction of a new well and a pipeline to better meet water demands during the drought, and potential following dry years. Currently, Zone 7 is planning for a new booster pump station to increase Zone 7's water system reliability during times of drought and emergencies, increasing groundwater production and providing more flexibility to move available water in the system to where it is needed. The estimated project cost is $5.9M, paid by water rates; it will be completed in July 2023.

Zone 7 will continue to evaluate its capital budget and pursue grant opportunities where possible to meet demands and overcome future impacts to revenue and expenditures.

9.0 MONITORING AND REPORTING

In their UWMPs, Zone 7's retailers will detail their monitoring and reporting requirements and procedures that ensure appropriate data is collected, tracked, and analyzed to evaluate customer compliance with conservation goals. As mentioned above, Zone 7's water system is fully metered, including production at its water treatment facilities and groundwater wells. Zone 7 can also track deliveries to its retailers through their respective turnouts.

Zone 7 will work collaboratively with its retailers to monitor water use and support their reporting.

10.0 WSCP REFINEMENT PROCEDURES

This WSCP is an adaptive management plan. It is subject to refinements as needed to ensure that Zone 7's shortage response actions and mitigation strategies are effective and produce the desired results. Based on monitoring described in Section 6.0 and the need for compliance and enforcement actions described in Section 6.0, Zone 7 may adjust its response actions and modify its WSCP. Zone 7 will also seek input from staff, its retailers, and the public regarding the effectiveness of its WSCP and ideas for improvements.

When a revised WSCP is proposed, the revised WSCP will undergo the process described in Section 12.0 for adoption by the Zone 7 Board and distribution to Alameda County, Contra Costa County, Zone 7's retailers, and the general public.

11.0 SPECIAL WATER FEATURE DISTINCTION

Zone 7 is a water wholesaler and does not directly supply treated water to customers with water features; that is done by Zone 7's retailers. As described in their respective UWMPs, each retailer distinguishes water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, separately from swimming pools and spas.

12.0 PLAN ADOPTION, SUBMITTAL, AND AVAILABILITY

This WSCP is adopted concurrently with Zone 7's 2020 UWMP, by separate resolution. Prior to adoption, a duly noticed public hearing was conducted. A copy of this WSCP will be submitted to DWR within 30 days of adoption.

No later than 30 days after adoption, copies of this WSCP will be available at Zone 7's offices. A copy will also be provided to Alameda County, Contra Costa County, and Zone 7's retailers. An electronic copy of this WSCP will also be available for public review and download on Zone 7's website.

Appendix A

Zone 7 Board Resolution No. 13-4230

ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO 13-4230

INTRODUCED BY DIRECTOR QUIGLEY
SECONDED BY DIRECTOR STEVENS

Water Supply Reliability Policy

WHEREAS, the Zone 7 Board of Directors desires to maintain a highly reliable Municipal and Industrial (M&I) water supply system so that existing and future M&I water demands can be met during varying hydrologic conditions; and

WHEREAS, the Board has an obligation to communicate to its M&I customers and municipalities within its service area the ability of Zone 7's water supply system to meet projected water demands; and

WHEREAS, the Board on August 18, 2004 adopted Resolution No. 04-2662 setting forth its Reliability Policy for Municipal & Industrial Water Supplies; and

WHEREAS, the Board desires to revise the Reliability Policy to reflect recent data, analysis, and studies.

NOW, THEREFORE, BE IT RESOLVED that the Board hereby rescinds Resolution No. 04-2662 adopting the August 18, 2004 Reliability Policy for Municipal & Industrial Water Supplies; and

BE IT FURTHER RESOLVED that the Board hereby adopts the following level of service goals to guide the management of Zone 7's M&I water supplies as well as its Capital Improvement Program (CIP):

Goal 1.Zone 7 will meet its treated water customers' water supply needs, in accordance with Zone 7's most current Contracts for M&I Water Supply, including existing and projected demands as specified in Zone 7's most recent Urban Water Management Plan (UWMP), during normal, average, and drought conditions, as follows:

- At least 85% of M&I water demands 99% of the time
- 100% of M&I water demands 90% of the time

Goal 2:Provide sufficient treated water production capacity and infrastructure to meet at least 80% of the maximum month M&I contractual demands should any one of Zone 7's major supply, production, or transmission facilities experience an extended unplanned outage of at least one week.

BE IT FURTHER RESOLVED that to ensure that this Board policy is carried out effectively, the Zone 7 General Manager will provide a water supply status report to the Board every five years with the Zone 7 Urban Water Management Plan that specifies how these goals will be, or are being, achieved.

If the General Manager finds that the goals cannot be met during the first five years of the Urban Water Management Plan, then the Board will hold a public hearing within two months of the General Manager's finding to consider remedial actions that will bring Zone 7 into substantial compliance with the stated level of service goals. Remedial actions may include, but are not limited to, voluntary conservation or mandatory rationing to reduce water demands, acquisition of additional water supplies, and/or a moratorium on new water connections. After reviewing staff analyses and information gathered at the public hearing, the Board shall, as expeditiously as is feasible, take any additional actions that are necessary to meet the level of service goals during the following five-year period; and

BE IT FURTHER RESOLVED that the Zone 7 General Manager shall prepare an Annual Review of the Sustainable Water Supply Report which includes the following information:

(1) An estimate of the current annual average water demand for M&I water as well as a five-year projection based on the same information used to prepare the UWMP and CIP;
(2) A Summary of available water supplies to Zone 7 at the beginning of the calendar year;
(3) A comparison of current water demand with the available water supplies; and
(4) A discussion of water conservation requirements and other long-term supply programs needed to meet Zone 7 M&I water demands for single-dry and multiple-dry year conditions, as specified in the Zone 7's UWMP.

A summary of this review will be provided to M&I customers.

<u>Definitions</u>

Level of Service for Annual Water Supply Needs—the level of service is the percent of existing or projected water demand that Zone 7's water supply system can meet during two key conditions: (1) during various hydrologic conditions and (2) during unplanned outages of major facilities.
Capital Improvement Program (CIP)—the CIP is Zone7's formal program for developing surface and ground water supplies, along with associated infrastructure, including import water conveyance facilities, surface water treatment plants, groundwater wells, and M&I water transmission system to meet projected water demands.

Normal conditions—conditions that most closely represent median runoff or allocation from all normally contracted or available water supplies from the historic record.

Average conditions—conditions that most closely represent the average runoff or allocation from all normally contracted or legally available water supplies from the historic record.

Drought conditions—conditions that most closely represent reduced runoff or allocation level from the historic record from all normally contracted or legally available water supplies, including both single-dry and multiple-dry year conditions.

Single-dry year condition—a condition that most closely represents the lowest yield over a one-year period from the historic record from all normally contracted or legally available supplies.

Multiple-dry year condition—a condition that most closely represents three or more consecutive dry years from the historic record that represent the lowest yields from all normally contracted or legally available supplies.

Available water supplies—consist solely of (1) water supplies that Zone 7 has contracted for (e.g., listed under Schedule A of the State Water Contract, dry-year water options, special contracts with other water districts, etc.) and (2) water actually stored in surface and subsurface reservoirs.

Maximum Month—the largest monthly average water use.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GRECI, MACHAEVICH, PALMER, QUIGLEY, RAMIREZ HOLMES STEVENS

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on October 17, 2012.

By______________________________
President, Board of Directors

Appendix B

2020 Annual Sustainability Report

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, ZONE 7
100 NORTH CANYONS PARKWAY, LIVERMORE, CA 94551 • PHONE (925) 454-5000 • FAX (925) 454-5727

ORIGINATING SECTION: Integrated Planning
CONTACT: Sal Segura/Amparo Flores

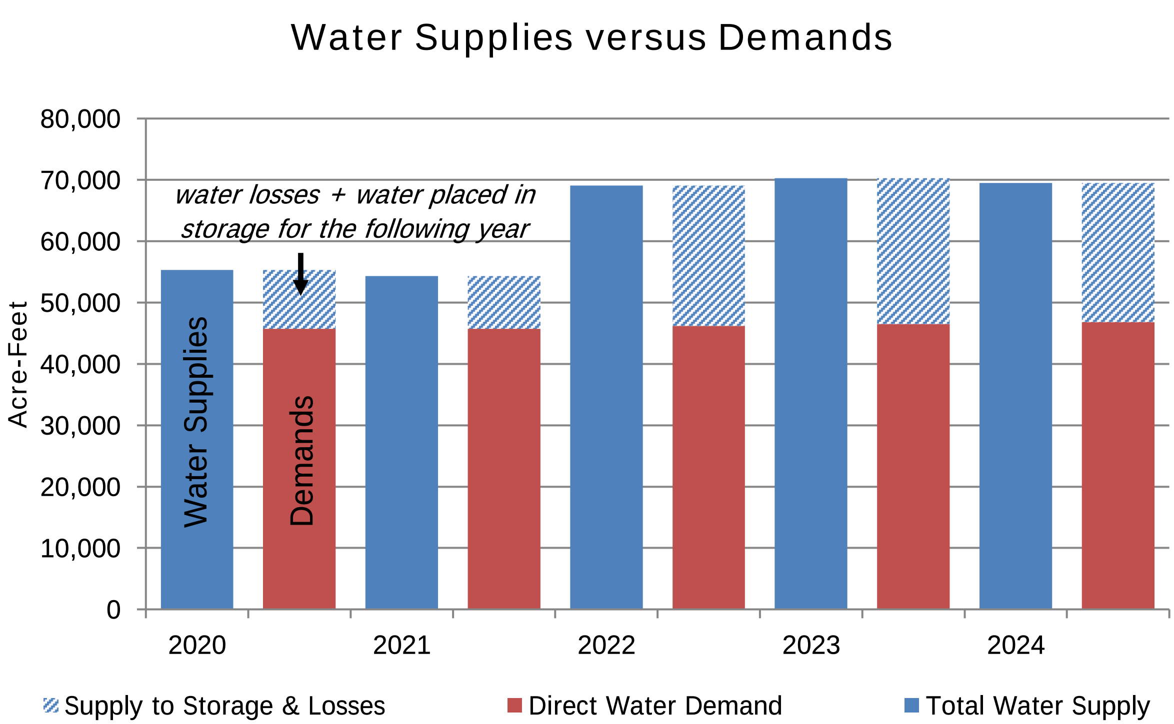
AGENDA DATE: April 15, 2020

SUBJECT: 2020 Annual Sustainability Report

SUMMARY:

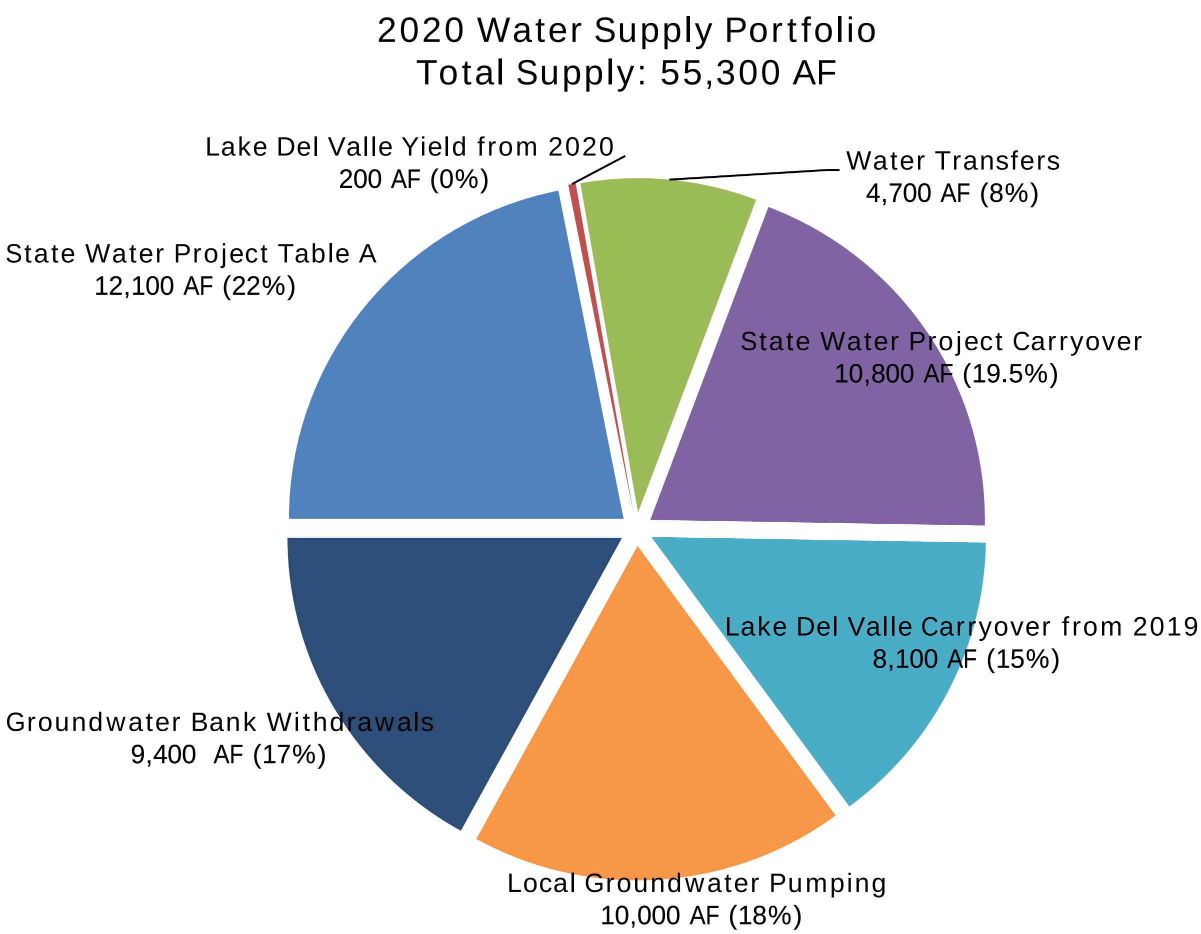
- Central to Zone 7 Water Agency's mission is the commitment to provide a reliable supply of high-quality water to the Tri-Valley.
- Zone 7's Water Supply Reliability Policy requires an annual review of sustainable water supplies. A key purpose of this report is to demonstrate Zone 7's ability to meet delivery requests over the next five years.
- As shown in Figure 1 below, a comparison of projected water supply and demand indicates that, based on supply availability, Zone 7 can deliver 100% of requested water deliveries in 2020 and 2021, even given low incoming supplies from the State Water Project (SWP) and Lake Del Valle (LDV), and even if conditions turn critically dry in 2021. Zone 7 also expects to meet demands over 2022-2024, assuming average conditions return over that time period.

Figure 1: Water Supplies versus Demands



- The SWP and LDV will provide a portion of 2020's water supply, but local and Northern Sierra dry conditions, and resulting low water allocation from the SWP, will require more use of groundwater and surface water already in storage. Stored water is also used in normal water operations to meet peak demands, accommodate the surface water treatment plant shutdowns, and to shift supply locations for improved system reliability. Zone 7 also expects to supplement water supplies with withdrawals from non-local groundwater banks, and water transfers (e.g., Yuba Accord and other transfers). Figure 2 shows the expected relative contributions of different water supplies in 2020.

Figure 2: Expected 2020 Water Supply Portfolio



- In June 2020, staff plan to provide an updated Operations Plan to the Water Resources Committee; this plan will reflect the latest actual supply and demand conditions and Zone 7's most feasible operational scenario for 2020.
- Zone 7 staff will continue to monitor both state and local conditions and will adjust operations and projections accordingly.
- Staff recommends that the Board maintain the ten percent voluntary conservation target for the Tri-Valley, consistent with the 2016 Board Resolution 16-142, considering the current dry conditions and the State's long-term conservation goals.

FUNDING:

Funding for water supply expenditures in 2020 are included in the approved budget. Future expenditures will be included in future budgets for Board approval.

RECOMMENDED ACTION:

Information only.

ATTACHMENT:

Annual Sustainability Report 2020

ANNUAL SUSTAINABILITY REPORT 2020

BACKGROUND

On October 17, 2012, Zone 7 Water Agency (Zone 7) adopted the Water Supply Reliability Policy (Resolution 13-4230, see Attachment A), which requires an annual review of sustainable water supplies (Annual Review). This memorandum presents the Annual Review and covers the following topics:

- Key hydrologic and water supply conditions
- Projected water demands for the next five years
- Projected water supplies for the next five years
- Comparison of supplies and demands for the next five years
- Programs necessary to continue meeting water demands going forward

SUMMARY OF FINDINGS

For calendar year 2020, Zone 7's planned incoming supplies consist of the following:

- 12,100 acre-feet (AF) based on a 15% State Water Project (SWP) allocation,
- 200 AF captured in Lake Del Valle (LDV) in 2020, and
- approximately 4,700 AF of water transfers through Yuba Accord and other water transfer options.

Given the dry conditions and low incoming supplies, Zone 7 is also planning to draw from storage as follows:

- 10,800 AF of SWP carryover from 2019 at the beginning of January 2020,
- 8,100 AF of net local runoff captured in LDV in 2019,
- 9,400 AF from Semitropic Water Storage District in Kern County, and
- 10,000 AF from the local groundwater basin.

Planned incoming water supplies, combined with withdrawal from various stored supplies, result in a total of 55,300 AF that will be used to meet customer demands of 45,700 AF. A portion of the remaining water will be unavailable as operational losses (evaporation and brine loss). As part of the water management strategy, the rest of the supplies will be redeposited into various storage locations for use in 2021. A comparison of projected water supply and demand indicates that Zone 7 can deliver 100% of requested water deliveries in 2020 and 2021, even if conditions turn critically dry in 2021. Zone 7 also expects to meet demands over 2022-2024, assuming average hydrologic conditions over that time period.

As described in the 2019 Water Supply Evaluation Update, Zone 7 has been participating in several potential future water supply and storage options to bolster long-term water supply reliability. A number of planned capital projects (new wells, the Chain of Lakes Pipeline, Chain of Lakes diversion structures, and reliability intertie) and the completed Chain of Lakes will bolster the reliability of Zone 7's water supply system over the coming years. These projects will also optimize the long-term yield from the Arroyo Valle, a key source of incoming supplies, and the use of the groundwater basin for storage.

Zone 7 will continue to monitor local and statewide hydrologic conditions, adjust operations as necessary to optimize use of available resources, remain prepared for another single or multi-year drought, and continue to coordinate regularly with the local water supply retailers, untreated water customers, and the Department of Water Resources (DWR) – the agency responsible for operating the SWP.

To guide Zone 7's efforts in pursuing short- and long-term water transfers, a 'Water Transfers 101 Workshop' is planned be conducted with the Water Resources Committee on April 20, 2020; transfer options and opportunities will be presented for consideration.

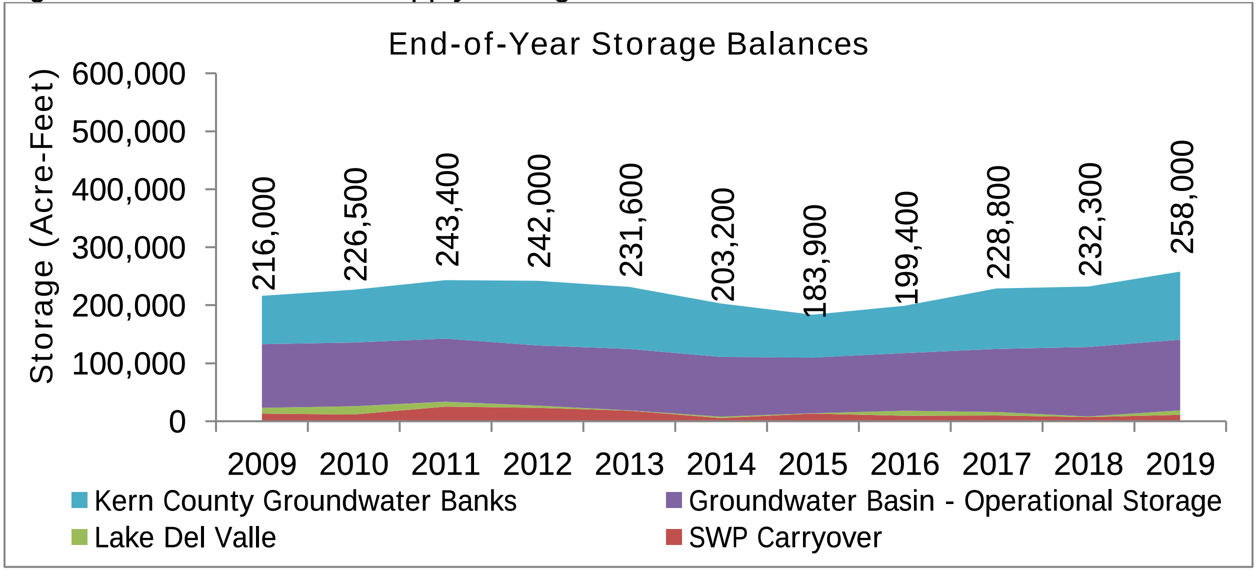
In light of the current dry conditions and the State's long-term conservation goals, Staff recommends that the Board maintain a ten percent (10%) voluntary conservation target for the Tri-Valley, consistent with the 2016 Board Resolution 16-142.

KEY HYDROLOGIC AND WATER SUPPLY CONDITIONS

Initial Storage Conditions (January 1, 2020)

Zone 7 started 2020 with a SWP carryover of 10,800 AF, LDV carryover of 8,100 AF, local groundwater operational storage of 122,000 AF (98% of capacity), and 117,100 AF of water stored in the Kern County groundwater banks (Semitropic Water Storage District [Semitropic] and Cawelo Water District [Cawelo]). At the beginning of 2020, Zone 7's storage portfolio had about 258,000 AF, as shown on Figure 3 below, showing continuing recovery from the recent drought. This does not include 128,000 AF of emergency storage in the local groundwater basin.

Figure 3: Historical Water Supply Storage Conditions



Reservoir Conditions

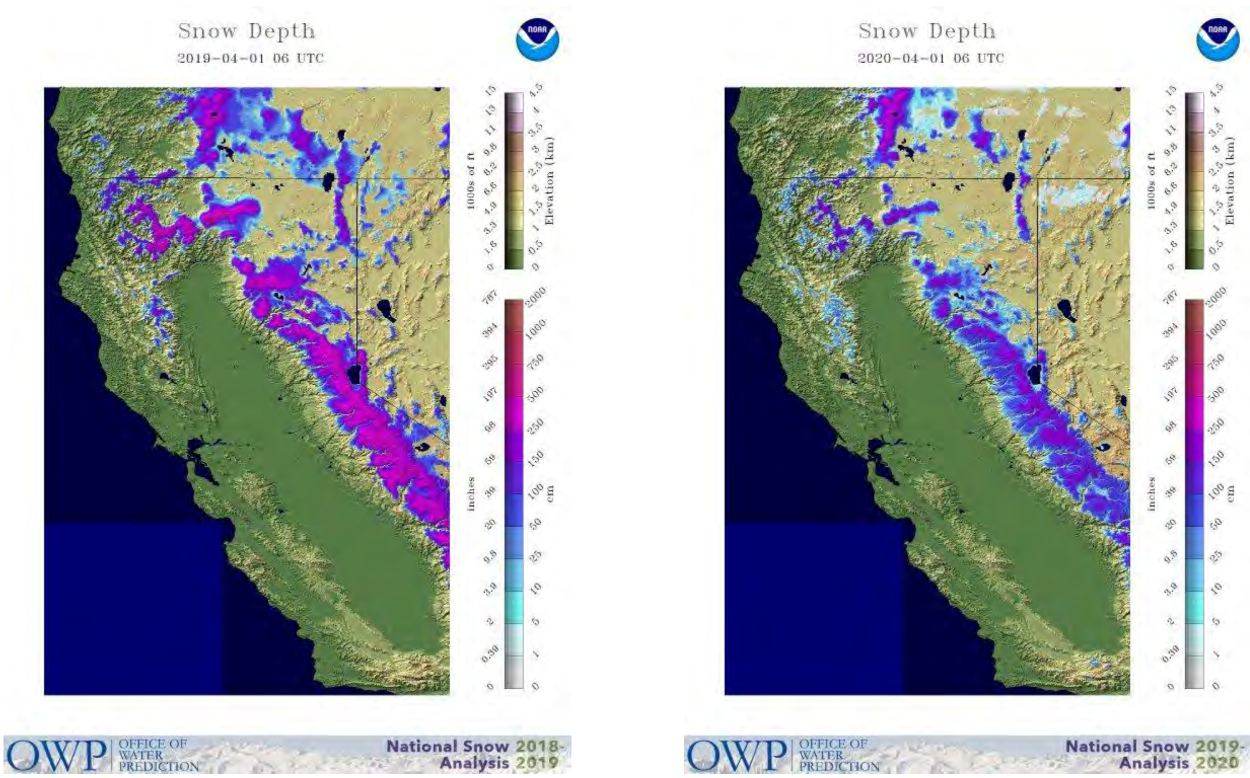
Storage in Oroville Reservoir, as of March 31, was at 2.29 million acre-feet (MAF) or 65% of capacity. Oroville Reservoir collects runoff from the Feather River watershed in northern California, the main source of supply for the SWP. San Luis Reservoir, the main reservoir for the SWP south of the Delta, was at 1.51 MAF or 74% of capacity. Zone 7's Table A carryover is stored in San Luis Reservoir; the reservoir is not expected to spill this year, which means Zone 7's full Table A carryover amount will be available for use.

Sierra Snowpack and Precipitation (April 1, 2020)

The statewide Sierra snowpack on April 1, 2020, was estimated at about 53% of average (see Attachment B), compared to 161% at the same time last year. April 1 is normally when the snowpack level peaks before the spring melt begins. The snowpack level in northern California, the main source of supply for the SWP during the spring and summer, is currently 57% of the April 1 average. Figure 4 presents a comparison of snow depths in the Sierras in April 2019 versus those anticipated for April 2020. The snowpack in 2020 is significantly shallower and more sparse than in 2019. In 2020, the predominant snow depth was 100 cm (~3 ft) versus the depth in 2019 of 500 cm (~17 ft).

Northern Sierra precipitation, which is a strong constituent in SWP allocation, was 24.2 inches as of March 31, 2020, or 56% of average (Attachment B).

Figure 4: Statewide Snowpack in the Sierra Nevada: 2019 versus 2020

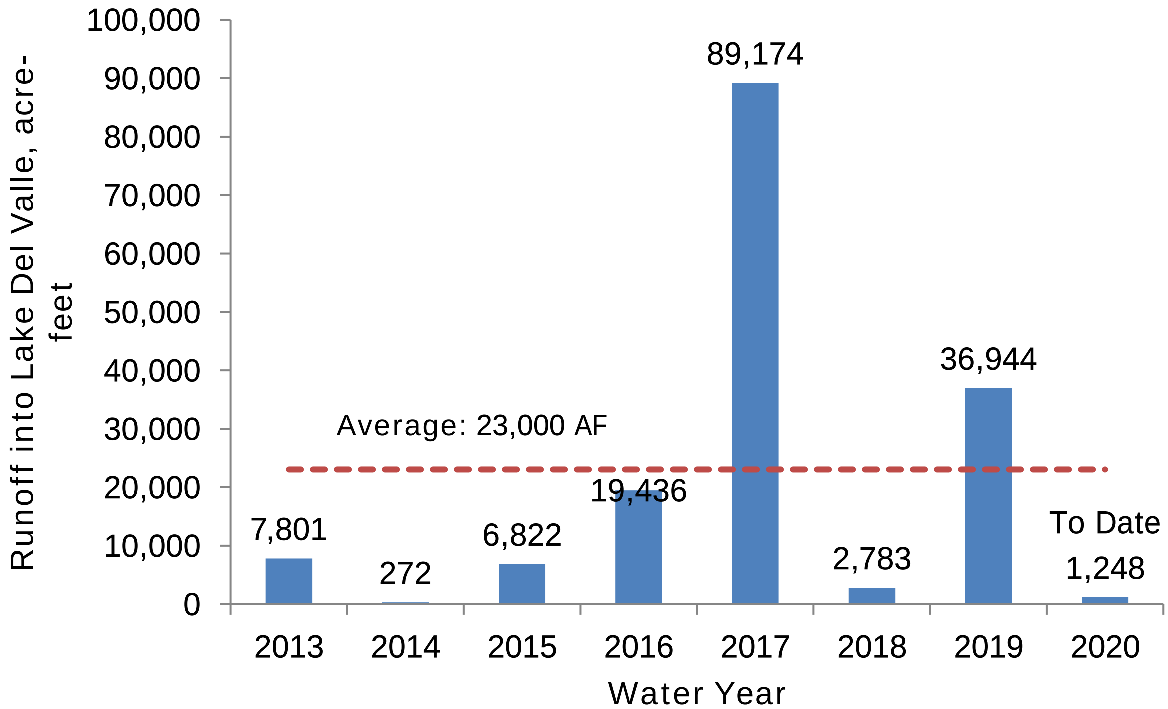


(Source: National Weather Service Remote Sensing Center, www.nohrsc.noaa.gov/nsa)

Local Runoff and Precipitation In 2020

The Tri-Valley area has experienced significantly less runoff this year compared to the same time last year. Figure 5 shows that as of April 1, 2020, runoff into Lake Del Valle is 5% of average (1,248 AF compared to 23,000 AF). Locally captured water is split with Alameda County Water District and stored in the lake for future use in accordance with Zone 7's water rights permit. Based on DWR's calculations, Zone 7 has approximately 8,300 AF of local water in Lake Del Valle as of April 1, 2020, including the 8,100 AF carried over from 2019. Local precipitation is at 46% of average year-to-date at Livermore Rainfall Station 15E for April 1, 2020 (Attachment B, note that due to station reporting delays, data from the most recent rainfall events in March were not available at the time of writing).

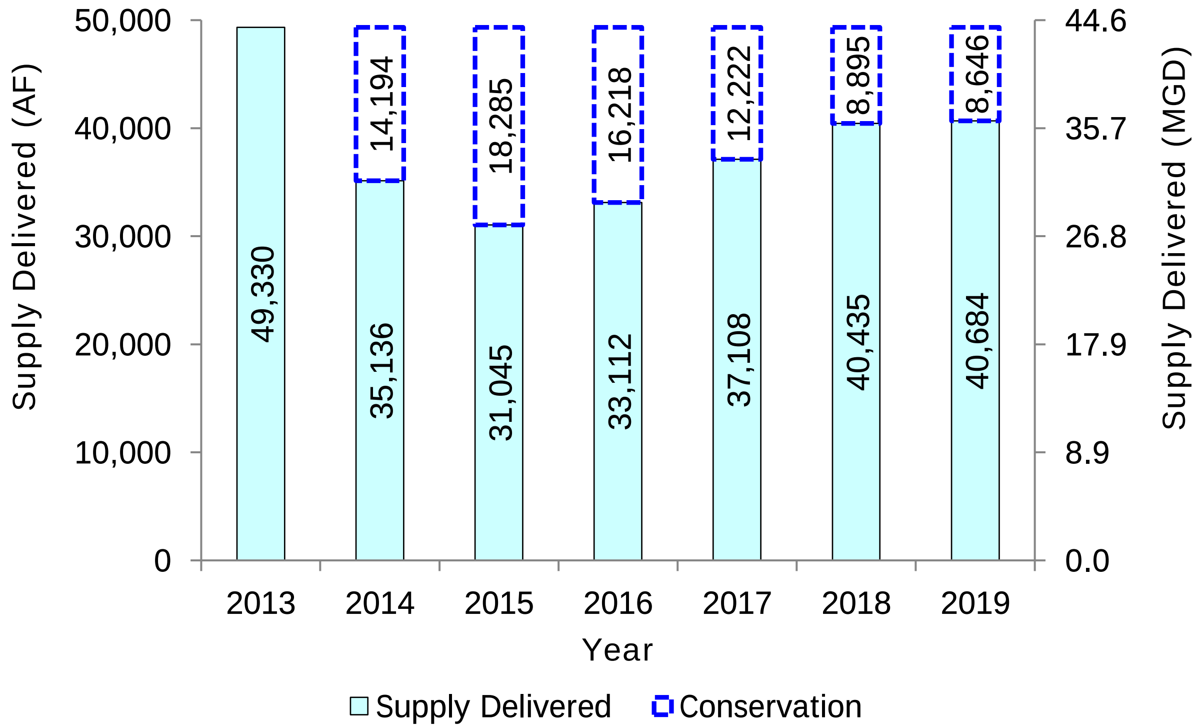
Figure 5: Runoff into Lake Del Valle (USGS Stream Gauge Arroyo Valle Below Lang Canyon)



Conservation in the Tri-Valley

The Tri-Valley's response to the recent drought reduced the required water supply delivery from Zone 7 relative to 2013 water demand by 29% in 2014, 37% in 2015, 33% in 2016, 25% in 2017, 18% in 2018 and 18% in 2019; this represents a cumulative water supply savings of 78,500 AF over the past six years. Figure 6 compares each calendar year to 2013. The Zone 7 Board lifted the local drought emergency in June 2017, but set a voluntary 10% conservation target to support ongoing statewide water conservation efforts, and the Tri-Valley community has continued exceeding the conservation target through 2019. Water supply conservation supports Zone 7's ability to meet retailer delivery requests in current and subsequent years.

Figure 6: Conservation in the Tri-Valley



2020 SWP Table A Allocation: 15% as of April 1, 2020

Zone 7 has a contract with DWR for up to 80,619 AF of SWP water in any given year; the percent of this amount Zone 7 will actually receive is called the "Table A" allocation. The 2020 SWP Table A allocation is 15% as of April 1, 2020, reflecting dry hydrologic conditions in the North Sierra. This is equivalent to 12,100 AF for Zone 7. The Table A allocation is expected to be finalized in May.

ANNUAL SUSTAINABILITY REPORT ASSUMPTIONS

To illustrate Zone 7's ability to meet delivery requests made by the retailers and the untreated water customers, the analysis in this memorandum conservatively assumes critically dry conditions (equivalent to 1977 conditions) in 2021, followed by average conditions in 2022 through 2024. As described in the 2019 Water Supply Evaluation

Update[1], projected average conditions equate to an assumed 49% SWP allocation or 39,500 AF, down from 60% or 48,400 AF used in previous years; this assumption also aligns with the average of actual conditions over the last ten years. Local water supply is expected to yield an average 6,200 AF per year, also based on actual recent conditions; this has been reduced from the 7,300 AF per year assumed in 2018. Each year, Zone 7 strives to carry over to the following year 10,000 AF in SWP facilities except in critically dry years (Table A or SWP Carryover). Any water captured locally in Lake Del Valle is also carried over into the following year. Reserving water for future years is good water management given the uncertainty and variability of hydrologic conditions from year to year.

PROJECTED WATER DEMANDS: NEXT FIVE YEARS

Each year, Zone 7 receives Municipal and Industrial (M&I) treated water delivery requests from the retailers for the next five years (Table 1 and Figure 7), which are used in the Annual Review. Zone 7 estimates demands for untreated water from agricultural customers' past usage. As shown in Table 1, the projected total water demand for direct use (treated and untreated water) in 2020 is about 12% higher than the actual 2019 water demand (45,700 vs 40,700 AF). Zone 7's retailers are predicting about 96% recovery to 2013 pre-drought treated water demand by 2024 (43,200 AF vs. 41,300, see Figure 7). Figure 8 shows untreated water demand projections used in the analysis.

As shown in Table 1, in addition to direct use, demands also include losses and water planned to be placed in storage for future use.

[1] Zone 7 Water Agency, 2019 Water Supply Evaluation Update. Available at: https://www.dropbox.com/s/fzhdf6olhcvnmyc/2019%20WSE%20Update.pdf?dl=0

Table 1: Actual and Projected Five-Year Demands (Direct Use), Water Planned for Storage, and Losses

DEMANDS/PLANNED FOR STORAGE/LOSS Acre-Feet	ACTUAL 2019	PROJECTIONS 2020	2021	2022	2023	2024
Hydrologic Year Equivalent	*2002*	*2015*	*1977*	*Average*	*Average*	*Average*
Table A Allocation	*75%*	*15%*	*10%*	*49%*	*49%*	*49%*
Direct Water Demand						
Treated Water Delivery Requests	36,200	40,200	40,200	40,700	41,000	41,300
Agricultural/Untreated Water Projection	4,500	5,500	5,500	5,500	5,500	5,500
Deposits into Storage						
Groundwater Recharge	3,600	200	0	6,700	8,300	8,400
Lake Del Valle Carryover	8,100	200	0	6,200	6,200	6,200
State Water Project Carryover	10,800	8,400	8,000	9,000	8,200	7,000
Semitropic Storage	8,900	0	0	0	0	0
Cawelo Storage	10,000	0	0	0	0	0
Losses						
Demineralization Concentrate-Brine	450	400	100	400	400	400
Lake Del Valle Evaporation Losses	600	400	500	600	700	700
Total	83,150	55,300	54,300	69,100	70,300	69,500

Notes:

(a) Projected demands were rounded to the nearest 100 acre-feet.

(b) Treated Water Delivery Request = M&I = Municipal and Industrial. Demands include retailer delivery requests, direct retail, Zone 7's unaccounted-for water (operational losses) and the groundwater pumping quota (GPQ) for Dublin San Ramon Services District.

(c) Retailer demand projections were provided as delivery requests by California Water Service Company, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton. Zone 7 estimates demands for direct retail customers.

(d) Zone 7's untreated water demand is used primarily for agricultural and golf course irrigation; projections are based on recent past usage.

Figure 7: Historical and Projected Five-Year Treated Water Demands

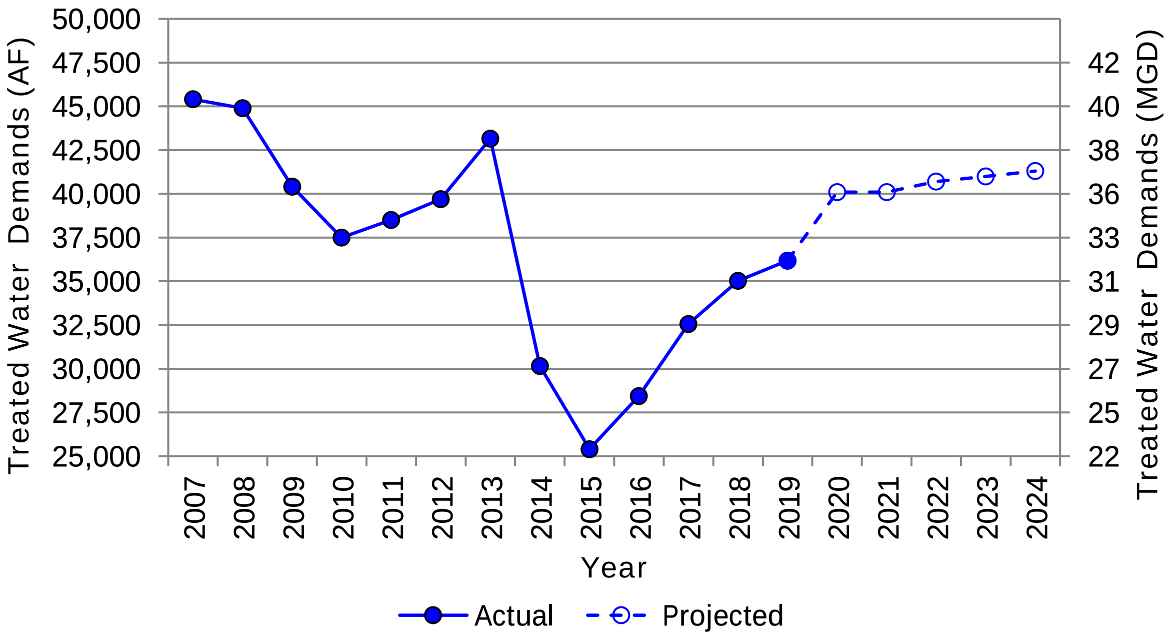
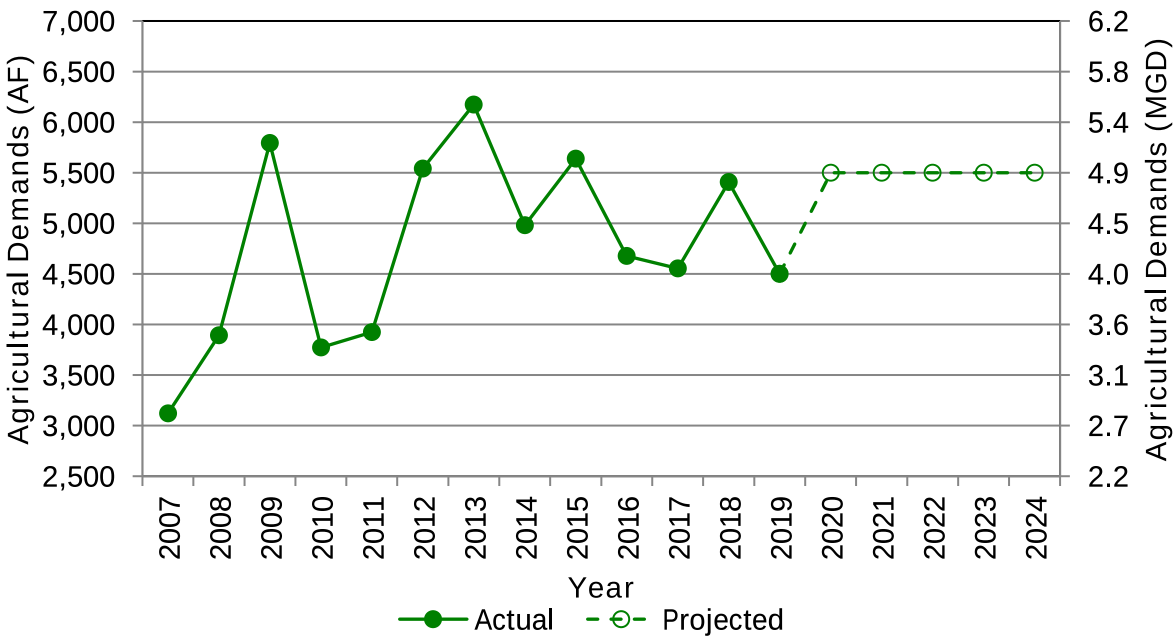


Figure 8: Historical and Projected Agricultural/Untreated Water Demands



Note that the State of California has been rolling out regulations designed to achieve the goals of the Long-Term Conservation Framework, which was developed in response to Governor Jerry Brown's 2016 Executive Order (B-37-16). For example, indoor residential water use is required to decrease to an average 55 gallons per capita per day (gpcd) by 2023; by 2030, the requirement will decrease to 50 gpcd. Future demands will therefore reflect a combination of water conservation (i.e., reduced per capita water consumption) and population growth in the Tri-Valley. Zone 7 will continue to coordinate closely with the retailers to verify demands and track the effects of conservation. A regional demand study is also underway to improve long-term demand estimates.

PROJECTED WATER SUPPLIES: NEXT FIVE YEARS

Incoming Supplies

Each year Zone 7 receives water from its contract with DWR for imported SWP water[2] and its local water right permit on Arroyo Valle. For 2020, Zone 7 is also planning to acquire about 5,000 AF of water transfers to supplement these supplies. Approximately 700 AF is expected to be available from Yuba Accord. For the remaining 4,000 AF, Zone 7 will pursue other water transfers such as a water transfer agreement with another SWP contractor. To preserve water in storage for dry or critically dry years, purchase of transfer water in 2021 and 2022 is also recommended to partially refill water withdrawn from storage.

Table 2 presents the expected yields in 2020 and estimates for 2021 assuming 1977 critically dry hydrologic conditions, followed by average allocation years from 2022 through 2024. Each year in the table below is paired with a comparable historical hydrologic year in anticipation of receiving a similar yield (e.g., Table A allocation). Figure 9 shows the incoming supplies for 2020 totaling 17,000 AF.

Water from Storage

Zone 7 currently stores surplus water in various storage facilities, including the local groundwater basin, LDV and Kern County groundwater banks (Semitropic and Cawelo) to help meet water demands as needed during dry years. Water is withdrawn from storage when needed to supplement that year's incoming supply to meet demands. Water may also be shifted from one type of storage to another as part of water management; in 2020, for example, water is withdrawn from storage then a portion is subsequently redeposited into storage in other locations as required by operational needs. Figure 10 shows that Zone 7 plans to access 38,300 AF of its storage supplies in 2020. Table 2 shows Zone 7 is planning to recover banked water from Kern County in 2021 and 2022 based on assumed hydrologic conditions.

[2] This includes Table A or SWP carryover from 2019, which is discussed in the next section.

Table 2: Projected Supply Sources: Incoming Supplies and Water from Storage

SUPPLY SOURCES Acre-Feet	ACTUAL 2019	PROJECTIONS 2020	2021	2022	2023	2024
Hydrologic Year Equivalent	*2002*	*2015*	*1977*	*Average*	*Average*	*Average*
Table A Allocation	*75%*	*15%*	*10%*	*49%*	*49%*	*49%*
New Incoming Supplies						
State Water Project Table A	60,500	12,100	8,100	39,500	39,500	39,500
Lake Del Valle Yield	8,100	200	0	6,200	6,200	6,200
Yuba Transfer	0	700	1,000	1,000	1,000	1,000
Other Water Transfer	0	4,000	5,000	2,000	0	0
Withdrawals from Storage						
State Water Project Carryover	2,600	10,800	8,400	8,000	9,000	8,200
Lake Del Valle Carryover	1,000	8,100	200	0	6,200	6,200
Groundwater Production	9,900	10,000	14,500	8,400	8,400	8,400
Kern County Groundwater Bank: Semitropic	0	9,400	9,100	4,000	0	0
Kern County Groundwater Bank: Cawelo	0	0	8,000	0	0	0
Total	82,100	55,300	54,300	69,100	70,300	69,500

Notes:

(a) See Zone 7's 2015 Urban Water Management Plan for more details about Zone 7 supplies: http://www.zone7water.com/images/pdf_docs/water_supply/uwmp_2015.pdf.

(b) 2020 yield is based on 15% (current 2020 allocation) of 12,100 AF. Long-term average yield is 49% of Zone 7's Table A amount (80,619 AF) per DWR's Final 2016 Delivery Capability Report and recent conditions. A critically dry year has a 10% SWP Allocation.

(c) Zone 7 is planning to obtain water transfers in 2020, and if 2021 is critically dry, transfers are recommended in 2021 and 2022. To obtain a net yield of 700 AF of Yuba Transfer in 2020, Zone 7 has to purchase about 1,000 AF to cover conveyance losses in the Delta.

(d) Zone 7 stored 8,100 AF in LDV in 2019 and has captured an additional 200 AF in 2020. Additional capture is expected by the end of December 2020; however, to be conservative, only 200 AF is assumed for 2020. An average annual yield of 6,200 is assumed in line with recent conditions over the last ten years.

Figure 9: Incoming Water Supplies in 2020

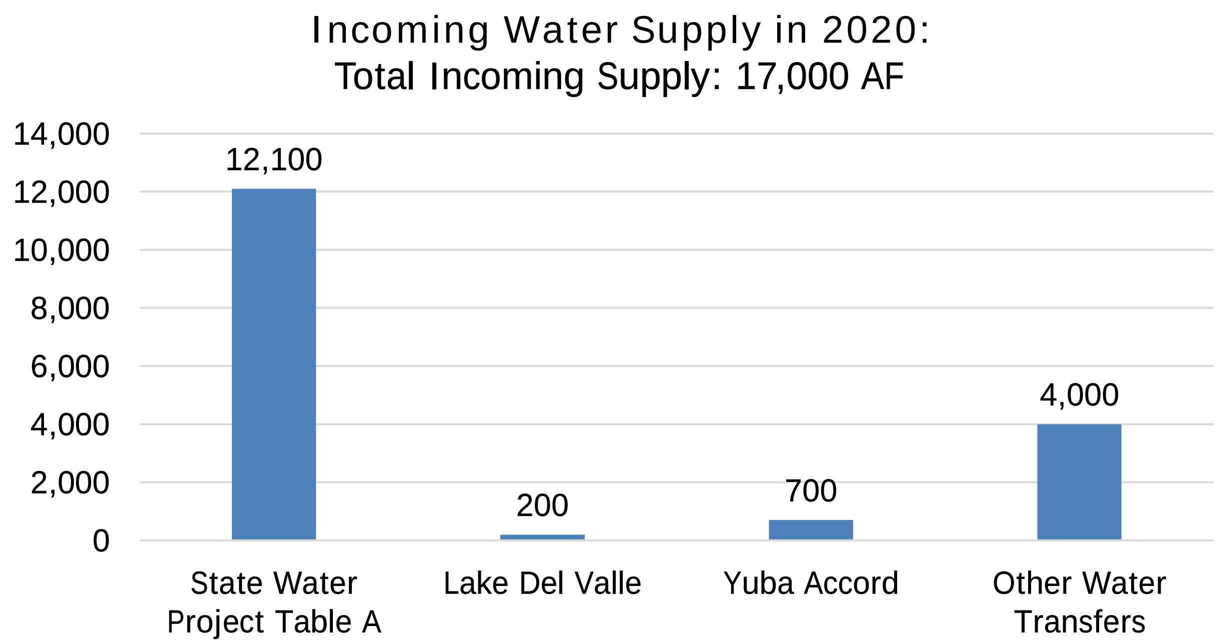


Figure 10: Water Supply Withdrawals from Storage in 2020

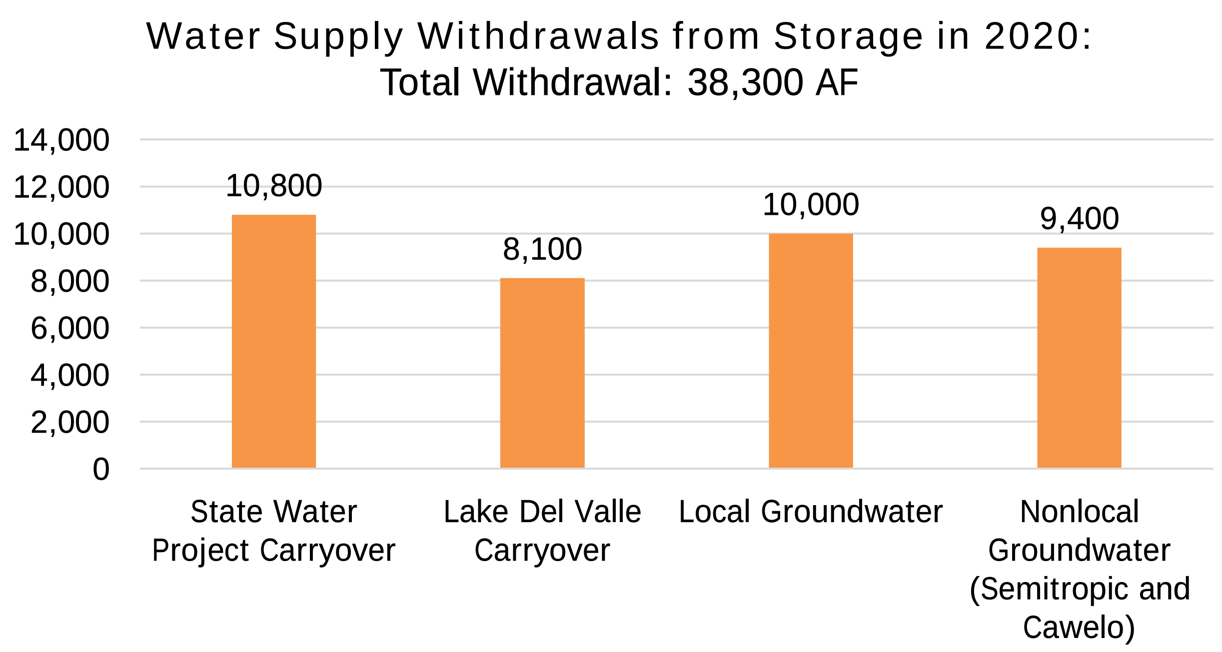
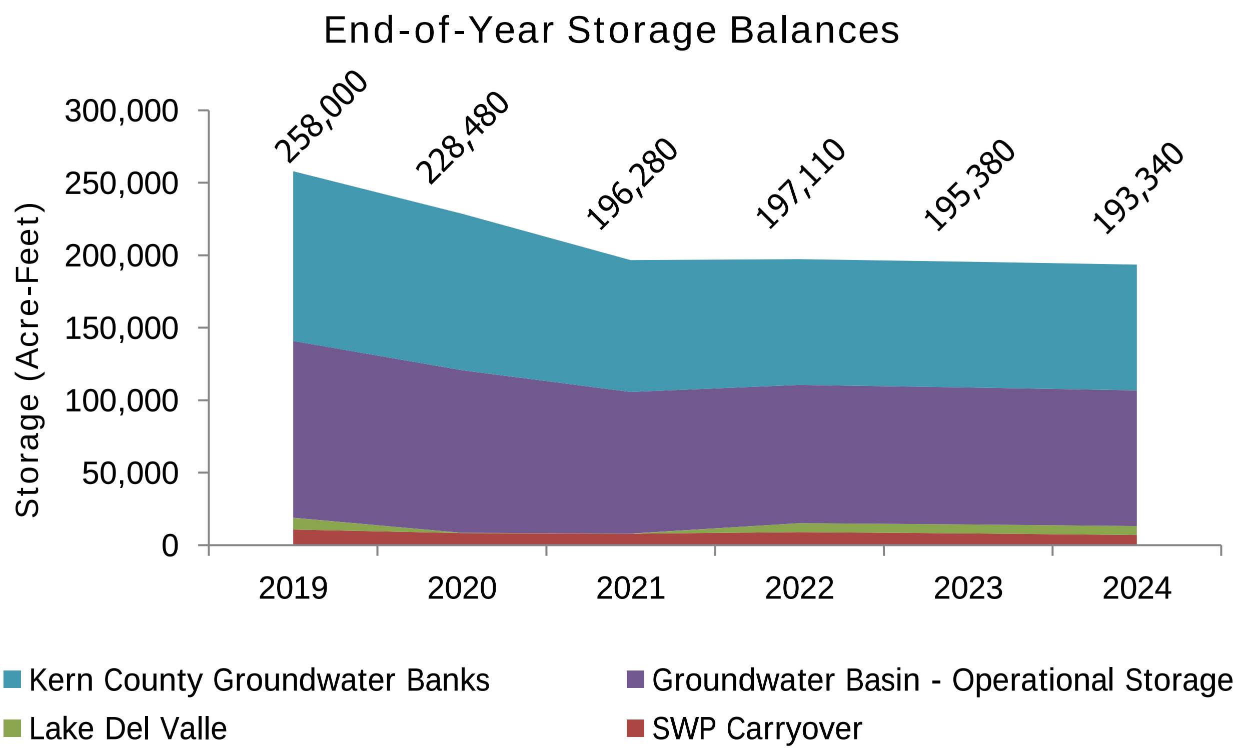


Table 3 and Figure 11 summarize the total water in storage available as of the end of 2019, and projected storage levels over 2020 through 2024. Storage projections show a decrease of about 64,700 AF over the next five years from the end of 2019 through the end of 2024 based on assumed hydrologic conditions and demands. This trend is a preliminary estimate based on projected deposits and withdrawals from the various storage categories. For example, while it accounts for 10% groundwater loss from local storage activities, it does not account for the natural influx to storage that occurs in the local groundwater basin due to rainfall runoff. The declining storage trend could be mitigated through the additional purchase of transfer water. Staff will monitor conditions to determine the appropriate amounts of transfer water in future years.

Table 3: End-of-Year Storage Balances (Actual and Projected)

	ACTUAL	PROJECTIONS				
End of Year Storage Balance (Acre-Feet)	2019	2020	2021	2022	2023	2024
SWP Carryover	10,800	8,400	8,000	9,000	8,200	7,000
Lake Del Valle	8,100	200	0	6,200	6,200	6,200
Groundwater Basin - Operational Storage	122,000	112,180	97,680	95,310	94,380	93,540
Kern County Groundwater Banks	117,100	107,700	90,600	86,600	86,600	86,600
Semitropic	87,200	77,800	68,700	64,700	64,700	64,700
Cawelo	29,900	29,900	21,900	21,900	21,900	21,900
TOTAL STORAGE	258,000	228,480	196,280	197,110	195,380	193,340

Figure 11: End-of-Year Storage Balances (Actual and Projected)



COMPARISON OF SUPPLY AND DEMAND: NEXT FIVE YEARS

As shown in Table 4, Zone 7 can deliver water to supply 100% of delivery requests for 2020 through 2024 based on current projected demands and assumed hydrology for 2020 through 2024. Additional conservation would allow more water not used to meet direct demands to be placed into storage, while higher demands (than currently projected) could be met by using additional storage supplies.

Table 4: Comparison of Supplies and Demands: Next Five Years

SUPPLIES VS DEMANDS	ACTUAL	PROJECTIONS				
Acre-Feet	2019	2020	2021	2022	2023	2024
Hydrologic Year Equivalent	*2002*	*2015*	*1977*	*Average*	*Average*	*Average*
Table A Allocation	*75%*	*15%*	*10%*	*49%*	*49%*	*49%*
Incoming Supply[(a)]	68,600	17,000	14,100	48,700	46,700	46,700
Water Supply from Storage[(b)]	13,500	38,300	40,200	20,400	23,600	22,800
Total Water Supply	82,100	55,300	54,300	69,100	70,300	69,500
Direct Water Demand[(c)]	40,700	45,700	45,700	46,200	46,500	46,800
Deposits into Storage and Losses[(d)]	41,400	9,600	8,600	22,900	23,800	22,700
% of Demand Delivered	100%	100%	100%	100%	100%	100%

Notes:

(a) From Table 2: SWP (Table A), LDV Yield, and transfers.

(b) From Table 2: SWP Carryover, LDV Carryover, GW Production, and Semitropic/Cawelo.

(c) From Table 1: Treated and Agricultural/Untreated Demands (direct use).

(d) From Table 1: Storage water placed in LDV and SWP as carryover, groundwater recharge, and water stored in Semitropic/Cawelo. A portion of this goes towards operational losses.

PROGRAMS NECESSARY TO MEET WATER DEMANDS GOING FORWARD

The Annual Review indicates that Zone 7 has enough water supplies to meet projected water demands over the next five years based on current delivery requests and assumed hydrology. To achieve long-term water supply reliability through buildout while accounting for hydrologic and other uncertainties (e.g., major system outages), Zone 7 has been evaluating several potential future water supply and storage options. Most recently, the 2019 Water Supply Evaluation Update included the following water supply and storage alternatives:

- Bay Area Regional Desalination Project
- Delta Conveyance (formerly California WaterFix)
- Los Vaqueros Reservoir Expansion
- Potable Reuse
- Short and Long-Term Water Transfers
- Sites Reservoir

Zone 7 also continues to evaluate and optimize the long-term local water yield from the Arroyo Valle currently captured in LDV. A number of planned capital projects (new wells, the Chain of Lakes Pipeline, Chain of Lakes diversion structures, and reliability intertie) will help bolster the reliability of Zone 7's water supply system. The turnover of the lakes in the Chain of Lakes for Zone 7 use also continues to be a key component of Zone 7's long-term reliability.

Zone 7 staff will also continue to monitor local and statewide conditions, adjust operations as necessary to optimize use of available resources, remain prepared for another single or multi-year drought, and continue to coordinate regularly with its local water supply retailers, untreated water customers, and with DWR. To guide Zone 7's efforts in pursuing short- and long-term water transfers, a 'Water Transfers 101 Workshop' will be conducted with the Water Resources Committee in late April/May 2020; transfer options and opportunities will be presented for consideration. In June 2020, staff will provide an updated Operations Plan to the Water Resources Committee; this plan will reflect the latest actual supply and demand conditions and Zone 7's most feasible operational scenario for 2020.

Staff recommends that the Board maintain the ten percent (10%) voluntary conservation target for the Tri-Valley, consistent with the 2016 Board Resolution 16-142, in light of the current dry conditions and the State's long-term conservation goals. This acknowledges and supports the Tri-Valley's continuing conservation efforts—which was nearly 20% in 2019—since the drought ended. Zone 7 will continue to implement rebate and public outreach programs in partnership with the retailers. As previously noted, Zone 7 is undertaking a regional demand study, which will help refine the demand projections as the region looks towards compliance with the State's Long-Term Conservation Framework.

ATTACHMENTS:

A. Water Supply Reliability Policy
B. Latest Hydrologic Conditions

Attachment A
Water Supply Reliability Policy

ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO 13-4230

INTRODUCED BY DIRECTOR QUIGLEY
SECONDED BY DIRECTOR STEVENS

Water Supply Reliability Policy

WHEREAS, the Zone 7 Board of Directors desires to maintain a highly reliable Municipal and Industrial (M&I) water supply system so that existing and future M&I water demands can be met during varying hydrologic conditions; and

WHEREAS, the Board has an obligation to communicate to its M&I customers and municipalities within its service area the ability of Zone 7's water supply system to meet projected water demands; and

WHEREAS, the Board on August 18, 2004 adopted Resolution No. 04-2662 setting forth its Reliability Policy for Municipal & Industrial Water Supplies; and

WHEREAS, the Board desires to revise the Reliability Policy to reflect recent data, analysis, and studies.

NOW, THEREFORE, BE IT RESOLVED that the Board hereby rescinds Resolution No. 04-2662 adopting the August 18, 2004 Reliability Policy for Municipal & Industrial Water Supplies; and

BE IT FURTHER RESOLVED that the Board hereby adopts the following level of service goals to guide the management of Zone 7's M&I water supplies as well as its Capital Improvement Program (CIP):

Goal 1.Zone 7 will meet its treated water customers' water supply needs, in accordance with Zone 7's most current Contracts for M&I Water Supply, including existing and projected demands as specified in Zone 7's most recent Urban Water Management Plan (UWMP), during normal, average, and drought conditions, as follows:

- At least 85% of M&I water demands 99% of the time
- 100% of M&I water demands 90% of the time

Goal 2:Provide sufficient treated water production capacity and infrastructure to meet at least 80% of the maximum month M&I contractual demands should any one of Zone 7's major supply, production, or transmission facilities experience an extended unplanned outage of at least one week.

BE IT FURTHER RESOLVED that to ensure that this Board policy is carried out effectively, the Zone 7 General Manager will provide a water supply status report to the Board every five years with the Zone 7 Urban Water Management Plan that specifies how these goals will be, or are being, achieved.

If the General Manager finds that the goals cannot be met during the first five years of the Urban Water Management Plan, then the Board will hold a public hearing within two months of the General Manager's finding to consider remedial actions that will bring Zone 7 into substantial compliance with the stated level of service goals. Remedial actions may include, but are not limited to, voluntary conservation or mandatory rationing to reduce water demands, acquisition of additional water supplies, and/or a moratorium on new water connections. After reviewing staff analyses and information gathered at the public hearing, the Board shall, as expeditiously as is feasible, take any additional actions that are necessary to meet the level of service goals during the following five-year period; and

BE IT FURTHER RESOLVED that the Zone 7 General Manager shall prepare an Annual Review of the Sustainable Water Supply Report which includes the following information:

(1) An estimate of the current annual average water demand for M&I water as well as a five-year projection based on the same information used to prepare the UWMP and CIP;

(2) A Summary of available water supplies to Zone 7 at the beginning of the calendar year;

(3) A comparison of current water demand with the available water supplies; and

(4) A discussion of water conservation requirements and other long-term supply programs needed to meet Zone 7 M&I water demands for single-dry and multiple-dry year conditions, as specified in the Zone 7's UWMP.

A summary of this review will be provided to M&I customers.

<u>Definitions</u>

Level of Service for Annual Water Supply Needs—the level of service is the percent of existing or projected water demand that Zone 7's water supply system can meet during two key conditions: (1) during various hydrologic conditions and (2) during unplanned outages of major facilities.
Capital Improvement Program (CIP)—the CIP is Zone7's formal program for developing surface and ground water supplies, along with associated infrastructure, including import water conveyance facilities, surface water treatment plants, groundwater wells, and M&I water transmission system to meet projected water demands.

Normal conditions—conditions that most closely represent median runoff or allocation from all normally contracted or available water supplies from the historic record.

Average conditions—conditions that most closely represent the average runoff or allocation from all normally contracted or legally available water supplies from the historic record.

Drought conditions—conditions that most closely represent reduced runoff or allocation level from the historic record from all normally contracted or legally available water supplies, including both single-dry and multiple-dry year conditions.

Single-dry year condition—a condition that most closely represents the lowest yield over a one-year period from the historic record from all normally contracted or legally available supplies.

Multiple-dry year condition—a condition that most closely represents three or more consecutive dry years from the historic record that represent the lowest yields from all normally contracted or legally available supplies.

Available water supplies—consist solely of (1) water supplies that Zone 7 has contracted for (e.g., listed under Schedule A of the State Water Contract, dry-year water options, special contracts with other water districts, etc.) and (2) water actually stored in surface and subsurface reservoirs.

Maximum Month—the largest monthly average water use.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GRECI, MACHAEVICH, PALMER, QUIGLEY, RAMIREZ HOLMES STEVENS

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on October 17, 2012.

By________________________

President, Board of Directors

Attachment B
Hydrologic Conditions

Figure 12: California Snow Water Content as of April 1, 2020

NORTH	
Data as of April 1, 2020	
Number of Stations Reporting	30
Average snow water equivalent (Inches)	16.5
Percent of April 1 Average (%)	57
Percent of normal for this date (%)	57

CENTRAL	
Data as of April 1, 2020	
Number of Stations Reporting	41
Average snow water equivalent (Inches)	16.7
Percent of April 1 Average (%)	56
Percent of normal for this date (%)	56

SOUTH	
Data as of April 1, 2020	
Number of Stations Reporting	28
Average snow water equivalent (Inches)	11.5
Percent of April 1 Average (%)	45
Percent of normal for this date (%)	45

STATE	
Data as of April 1, 2020	
Number of Stations Reporting	99
Average snow water equivalent (Inches)	15.2
Percent of April 1 Average (%)	53
Percent of normal for this date (%)	53

Figure 13: Northern Sierra Precipitation as of March 31, 2020

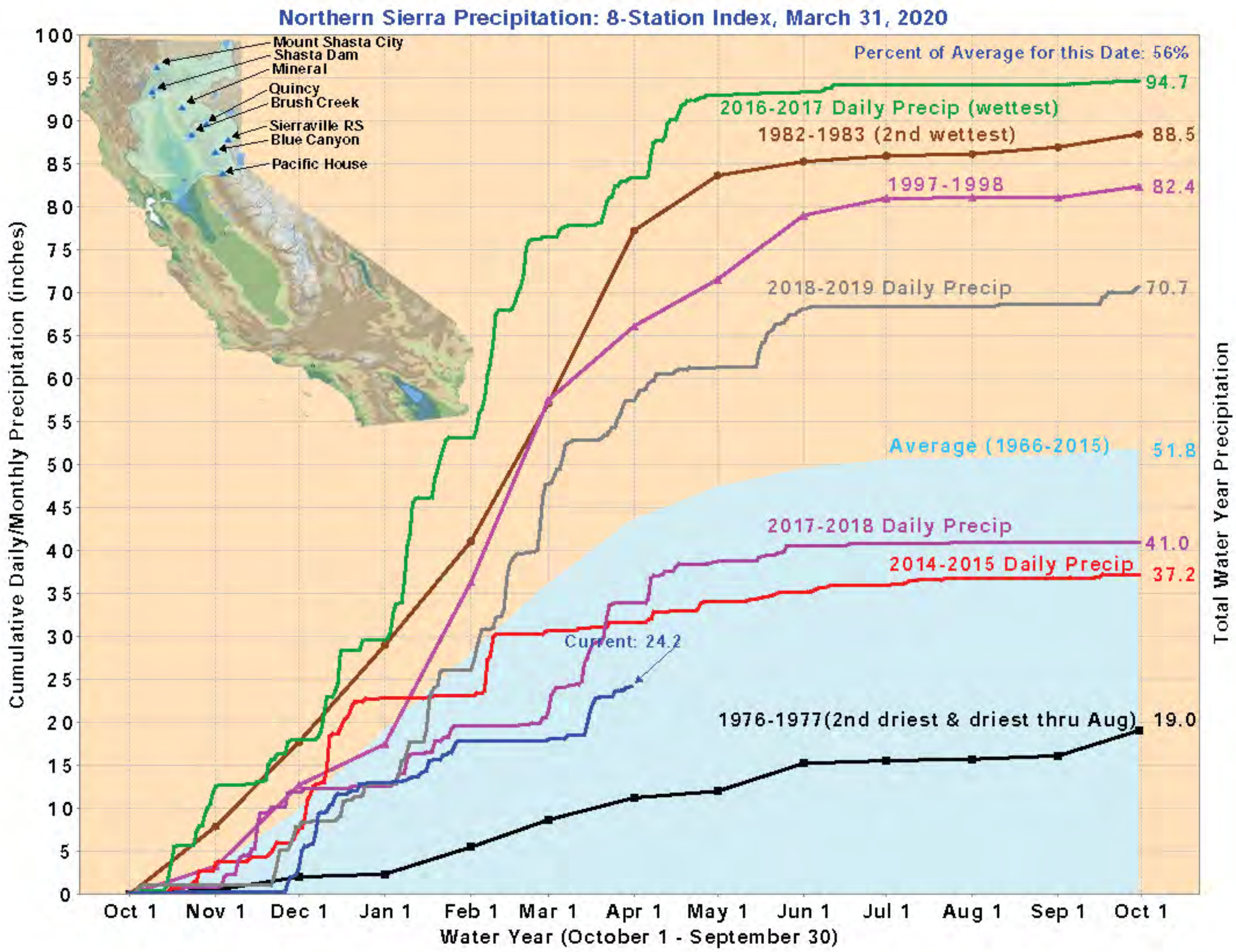


Figure 14: California Reservoir Conditions as of March 31, 2020

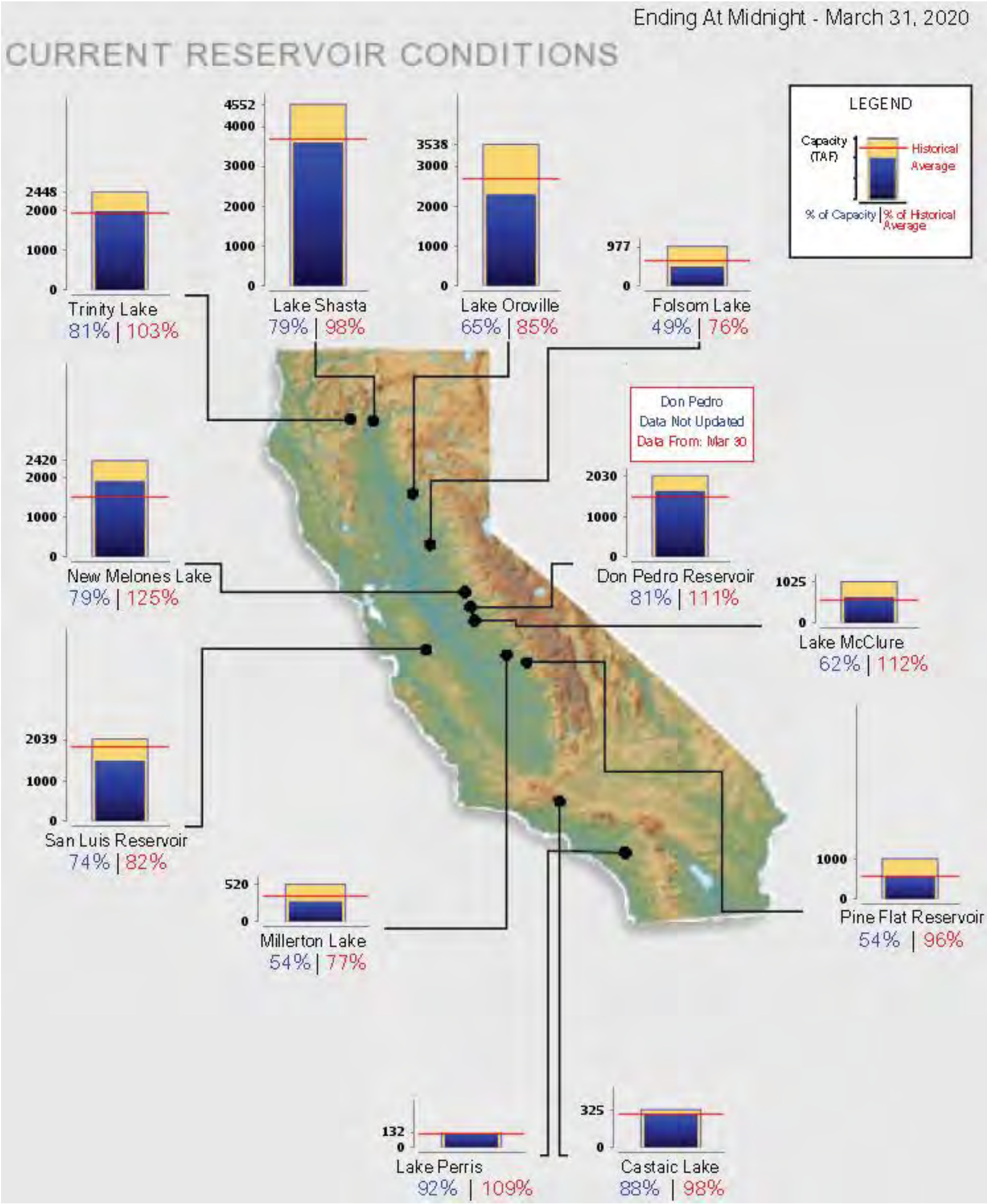
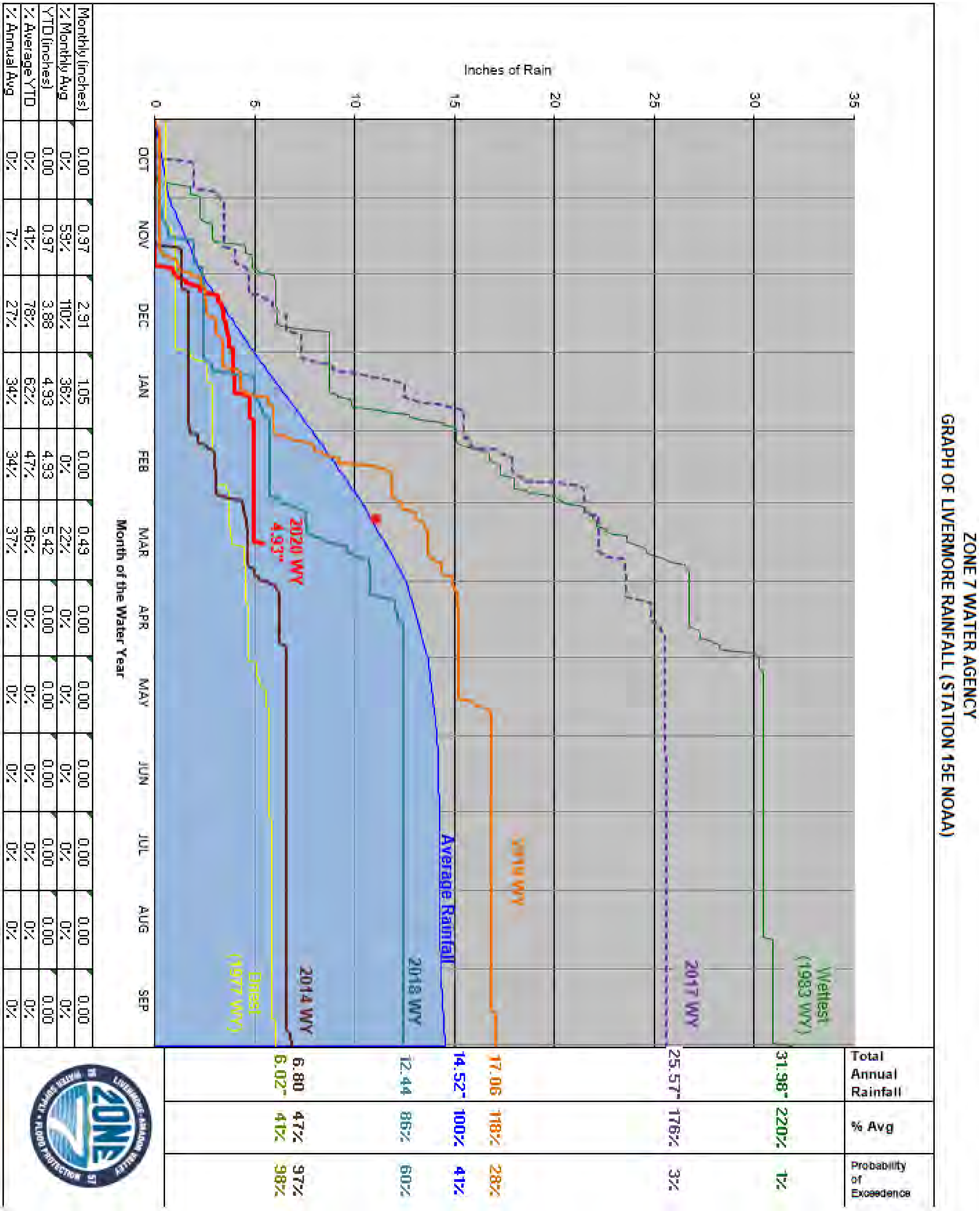


Figure 15 Local Rainfall (Livermore Station 15E NOAA) as of April 1, 2020



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Monthly (inches)	0.00	0.97	2.91	1.05	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
% Monthly Avg	0%	59%	110%	36%	0%	22%	0%	0%	0%	0%	0%	0%
YTD (inches)	0.00	0.97	3.88	4.93	4.93	5.42	0.00	0.00	0.00	0.00	0.00	0.00
% Average YTD	0%	41%	78%	62%	47%	46%	0%	0%	0%	0%	0%	0%
% Annual Avg	0%	7%	27%	34%	34%	37%	0%	0%	0%	0%	0%	0%

Note: due to station reporting delays, data from most recent March rainfall events were unavailable at the time of writing.

ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
BOARD OF DIRECTORS

RESOLUTION NO

INTRODUCED BY
SECONDED BY

Declaration of a Water Shortage Emergency

WHEREAS, the California Urban Water Management Planning Act ("Act") requires urban water suppliers to adopt an Urban Water Management Plan every five years; and

WHEREAS, Zone 7 adopted its 2020 Urban Water Management Plan in accordance with the provisions of the Act on May/June XX, 2021; and

WHEREAS, a required component of the Urban Water Management Plan is a Water Shortage Contingency Plan, which establishes criteria and guidelines for operations, water conservation, and response actions during a water shortage; and

WHEREAS, on April X, 202X the Zone 7 Board was presented with the Annual Review of Sustainable Water Supply ("Annual Sustainability Report"); and

WHEREAS, the Annual Sustainability Report determined that Zone 7 can only deliver XX% of expected water demands in 202X due to [cite conditions: e.g., critically dry conditions]. ***And/Or***

WHEREAS, on X/XX/20XX, the Governor of the State of California declared a drought state of emergency [asking/requiring] residents to reduce water use by XX%. ***And/Or***

WHEREAS, on X/XX/20XX, the Department of Water Resources announced a X% allocation from the State Water Project. ***And/Or***

WHEREAS, the Board has determined that water shortage emergency conditions exist within the Zone 7 service area due to [cite event: e.g., supply disruption from the Delta due to an earthquake]; and

WHEREAS, the Water Shortage Contingency Plan in the 2020 Urban Water Management Plan adopted by the Board on May/June XX, 2021 identifies stages of water shortage levels and actions associated with each stage.

WHEREAS, current conditions warrant declaration of a Stage Y water shortage with XX% [voluntary/mandatory] reduction in water use.

NOW, THEREFORE BE IT RESOLVED, the Board hereby declares a Stage Y water shortage level;

BE IT FURTHER RESOLVED that the Board directs staff to implement the following actions from the Water Shortage Contingency Plan as soon as feasible:

- [Action 1]
- [Action 2]
- Etc.

ADOPTED BY THE FOLLOWING VOTE:

AYES:

NOES:

ABSENT:

ABSTAIN:

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on ______________.

By: ________________________________
President, Board of Directors

Appendix C

Zone 7 Board Sample Resolutions

ZONE 7
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO.

INTRODUCED BY
SECONDED BY

Implementation of Water Shortage Surcharge

WHEREAS, the Zone 7 Board has declared a Stage Y water shortage which requires a XX% [voluntary/mandatory] reduction in water use;

WHEREAS, the Water Shortage Contingency Plan in the 2020 Urban Water Management Plan adopted by the Board on XX/XX/2021 identifies stages of water shortage levels and planned and potential response actions associated with each stage;

WHEREAS, response actions include use of reserves, deferral/acceleration of capital projects, grants and other cost cutting measures; and

WHEREAS, the Water Shortage Contingency Plan identifies both water shortage surcharges and use of reserves to ensure full revenue recovery for each water shortage stage.

NOW, THEREFORE BE IT RESOLVED, that Stage Y water shortage surcharge in accordance with the table below shall take effect on the first day of the month following thirty days after the adoption of this resolution.

Stage	**Demand Reduction Targets**	**Water Shortage Surcharges [per Hundred cubic feet (ccf)]**
1	< 10%	N/A
2	10-20%	$0.26
3	20-30%	$0.59
4	30-40%	$1.04
5	40-50%	$1.67
6	>50%	$2.60

BE IT FURTHER RESOLVED, that the Stage Y water shortage surcharge will sunset after six months unless extended or modified by action of the Board.

ADOPTED BY THE FOLLOWING VOTE:

AYES:

NOES:

ABSENT:

ABSTAIN:

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on _______________.

By: _________________________________
President, Board of Directors

Appendix H

UWMP and WSCP Adoption Resolutions

ZONE 7

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO. 21-42

INTRODUCED BY DIRECTOR PALMER
SECONDED BY DIRECTOR RAMIREZ HOLMES

Adoption of the 2020 Urban Water Management Plan
and Addendum to the 2015 Urban Water Management Plan

WHEREAS, the Urban Water Management Planning Act (Water Code Division 6, Part 2.6, Sections 10610 through 10657), requires all urban water suppliers serving more than 3,000 customers either directly or indirectly, or more than 3,000 acre-feet of water annually, to prepare and submit an Urban Water Management Plan (UWMP), or plan update, once every five years; and

WHEREAS, said plan is for the purpose of evaluating and developing water management policies to achieve conservation and efficient use of urban water supplies; and

WHEREAS, the Urban Water Management Planning Act was updated between 2015 and 2020 to incorporate 2018 Water Conservation Legislation (AB 1668 (Friedman) and SB 606 (Hertzberg)); and

WHEREAS, Zone 7 Water Agency is required to prepare an addendum to its 2015 UWMP to demonstrate consistency with Delta Plan Policy WR P1, Reduce Reliance on the Delta Through Improved Regional Water Self-Reliance (Cal. Code Regs. tit. 23, § 5003) (Draft 2015 UWMP Addendum), to support a certification of consistency for a future covered action; and

WHEREAS, Zone 7 Water Agency is the wholesale water management agency for the Livermore-Amador Valley, including the Cities of Dublin, Livermore, and Pleasanton in Alameda County, and a portion of San Ramon in Contra Costa County; and

WHEREAS, Zone 7 Water Agency issued notices of preparation at least 60 days in advance of the public hearing to the cities and counties that it serves; and coordinated with the Livermore-Amador Valley water suppliers, including Cal Water-Livermore District, the Cities of Livermore and Pleasanton, and Dublin San Ramon Services District, and other agencies and the community, on the preparation of the Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and Draft 2015 UWMP Addendum; and

WHEREAS, Zone 7 Water Agency has circulated for public review for a minimum of 14 days the Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and Draft 2015 UWMP Addendum; and

WHEREAS, a public hearing regarding the Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and Draft 2015 UWMP Addendum was properly noticed and held to receive comments.

NOW, THEREFORE, BE IT RESOLVED that the General Manager is authorized to make non-substantive changes to and finalize the Draft 2020 UWMP and Draft 2015 UWMP Addendum to produce the 2020 UWMP and 2015 UWMP Addendum; and

BE IT FURTHER RESOLVED that the 2020 UWMP be approved and adopted for the Zone 7 Water Agency; and

BE IT FURTHER RESOLVED that the 2015 UWMP Addendum is adopted as an addendum to the 2015 UWMP to incorporate demonstration of consistency with Delta Plan Policy WR P1; and

BE IT FURTHER RESOLVED that Zone 7 reaffirms its commitment to maintain the long-term reliability of its water supply; and

BE IT FURTHER RESOLVED that the 2020 UWMP and 2015 UWMP Addendum be filed with the California Department of Water Resources.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GAMBS, GREEN, PALMER, RAMIREZ HOLMES, SANWONG, SMITH MCDONALD

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on May 19, 2021.

DocuSigned by:

By: Olivia Sanwong

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President, Board of Directors

ZONE 7

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

BOARD OF DIRECTORS

RESOLUTION NO. 21-43

INTRODUCED BY DIRECTOR PALMER
SECONDED BY DIRECTOR RAMIREZ HOLMES

Adoption of 2020 Water Shortage Contingency Plan

WHEREAS, the Urban Water Management Planning Act (Water Code Division 6, Part 2.6, Sections 10610 through 10657), requires all urban water suppliers serving more than 3,000 customers either directly or indirectly, or more than 3,000 acre-feet of water annually, to prepare and submit an Urban Water Management Plan (UWMP), or plan update, once every five years; and

WHEREAS, said plan is for the purpose of evaluating and developing water management policies to achieve conservation and efficient use of urban water supplies; and

WHEREAS, the Urban Water Management Planning Act was updated between 2015 and 2020 to incorporate 2018 Water Conservation Legislation (AB 1668 (Friedman) and SB 606 (Hertzberg)); and

WHEREAS, Zone 7 Water Agency is required to update its Water Shortage Contingency Plan for consistency with the updated Urban Water Management Planning Act; and

WHEREAS, Zone 7 Water Agency is the wholesale water management agency for the Livermore-Amador Valley, including the Cities of Dublin, Livermore, and Pleasanton in Alameda County, and a portion of San Ramon in Contra Costa County; and

WHEREAS, Zone 7 Water Agency issued notices of preparation at least 60 days in advance of the public hearing to the cities and counties that it serves; and coordinated with the Livermore-Amador Valley water suppliers, including Cal Water-Livermore District, the Cities of Livermore and Pleasanton, and Dublin San Ramon Services District, and other agencies and the community, on the preparation of its Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and its Draft 2015 UWMP Addendum; and

WHEREAS, Zone 7 Water Agency has circulated for public review for a minimum of 14 days the Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and Draft 2015 UWMP Addendum; and

WHEREAS, a public hearing regarding the Draft 2020 UWMP, Draft Water Shortage Contingency Plan, and Draft 2015 UWMP Addendum was properly noticed and held to receive comments.

NOW, THEREFORE, BE IT RESOLVED that the General Manager is authorized to make non-substantive changes to and finalize the Draft Water Shortage Contingency to produce the 2020 Water Shortage Contingency Plan; and

BE IT FURTHER RESOLVED that the 2020 Water Shortage Contingency Plan be approved and adopted for the Zone 7 Water Agency; and

BE IT FURTHER RESOLVED that Zone 7 reaffirms its commitment to maintain the long-term reliability of its water supply; and

BE IT FURTHER RESOLVED that the 2020 Water Shortage Contingency Plan be filed with the California Department of Water Resources.

ADOPTED BY THE FOLLOWING VOTE:

AYES: DIRECTORS FIGUERS, GAMBS, GREEN, PALMER, RAMIREZ HOLMES, SANWONG, SMITH MCDONALD

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

I certify that the foregoing is a correct copy of a Resolution adopted by the Board of Directors of Zone 7 of the Alameda County Flood Control and Water Conservation District on May 19, 2021.

DocuSigned by:
Olivia Sanwong
8A3F19465A6B4C0...

By: ______________________
President, Board of Directors

Concord

1001 Galaxy Way, Suite 310
Concord CA 95420
925-949-5800

Davis

2020 Research Park Drive, Suite 100
Davis CA 95618
530-756-5905

Eugene

1650 W 11th Avenue, Suite 1-A
Eugene OR 97402
541-431-1280

Lake Forest

23692 Birtcher Drive
Lake Forest CA 92630
949-420-3030

Lake Oswego

5 Centerpointe Drive, Suite 130
Lake Oswego OR 97035
503-451-4500

Oceanside

804 Pier View Way, Suite 100
Oceanside CA 92054
760-795-0365

Olympia

825 Legion Way SE, Suite A6
Olympia WA 98501
360-350-4523

Phoenix

4505 E Chandler Boulevard, Suite 230
Phoenix AZ 85048
602-337-6110

Pleasanton

6800 Koll Center Parkway, Suite 150
Pleasanton CA 94566
925-426-2580

Sacramento

8950 Cal Center Drive, Bldg. 1, Suite 363
Sacramento CA 95826
916-306-2250

San Diego

11939 Rancho Bernardo Road, Suite 100
San Diego CA 92128
858-505-0075

Santa Rosa

2235 Mercury Way, Suite 105
Santa Rosa CA 95407
707-543-8506

WEST YOST
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APPENDIX L

SUPPORTING SALT AND NUTRIENT LOADING TABLES

TABLE
MAIN BASIN SALT LOADING CALCULATIONS
2020 WATER YEAR

INFLOW COMPONENTS	SURFACE WATER			RECHARGED WATER			SALT LOAD
	Volume Applied (AF)	TDS Conc (mg/L)	% Recharged	Volume Recharged (AF)	TDS Conc (mg/L)	Salt Load (Tons)	(Tons per TAF of Rch)
NATURAL STREAM RECHARGE	**5,872**	**554**	**44%**	**2,596**	**554**	**1,953**	**750**
Arroyo Valle	**1,284**	**265**	**62%**	**794**	**265**	**286**	**360**
Flood releases recharge	0	203	0%	0	203	0	0
Natural inflow (above AVNL)	317	293	87%	275	293	109	400
Natural inflow (below AVNL)	967	250	54%	519	250	176	340
Arroyo Mocho	1,224	573	88%	**1,072**	**573**	**834**	**780**
Arroyo Las Positas	3,363	840	22%	**730**	**840**	**833**	**1,140**
ARROYO VALLE PRIOR RIGHTS	**2,397**	**200**	**38%**	**916**	**200**	**249**	**270**
ARTIFICIAL STREAM RECHARGE	**4,361**	**202**	**56%**	**2,461**	**202**	**675**	**270**
Arroyo Valle	3,945	200	52%	**2,045**	**200**	**556**	**270**
Arroyo Mocho	416	210	100%	**416**	**210**	**119**	**290**
Arroyo Las Positas	0	210	0%	**0**	**210**	**0**	**0**
INJECTION WELL RECHARGE	**-**	**-**	**-**	**0**	**0**	**0**	**0**
RAINFALL RECHARGE	**15,868**	**0**	**18%**	**2,869**	**0**	**0**	**0**
LAKE RECHARGE	-	-	-	*7,529*	*389*	*3,979*	*530*
LEAKAGE	**-**	**-**	**-**	**1,209**	**500**	**821**	**680**
APPLIED WATER RECHARGE	**13,234**	**366**	**19%**	**2,465**	**1,968**	**6,588**	**2,670**
Urban - Municipal	10,545	355	20%	2,109	1,774	5,084	2,410
Urban - Recycled Water	646	662	20%	129	3,311	581	4,500
Agricultural - Municipal (SBA)	1,377	264	6%	80	4,568	494	6,210
Agricultural - Groundwater	79	633	18%	14	3,498	67	4,720
Golf Courses - Groundwater	252	341	26%	66	1,301	116	1,760
Golf Courses - Recycled Water	335	540	20%	67	2,702	246	3,670
SUBSURFACE BASIN INFLOW				**1,000**	**1,620**	**2,201**	**2,200**
TOTAL INFLOW				**13,516**	**680**	**12,486**	**920**

OUTFLOW COMPONENTS		WATER EXTRACTED			SALT REMOVED
		Volume Removed (AF)	TDS Conc (mg/L)	Salt Removed (Tons)	(Tons/TAF of Export)
MUNICIPAL PUMPAGE		**16,349**	**558**	**12,388**	**760**
Zone 7 Wells - Hop, Stone, COL		**6,299**	**519**	**4,441**	**710**
HOP 6		806	632	692	860
HOP 9		7	545	5	710
COL 1		1,055	486	696	660
COL 2		1,791	408	992	550
COL 5		415	486	274	660
STONERIDGE_1		2,195	597	1,782	810
Zone 7 Wells - Mocho		**5,448**	**661**	**4,890**	**900**
MOCHO 1		0	609	0	0
MOCHO 2		1,757	599	1,428	810
MOCHO 3		2,755	645	2,412	880
MOCHO 4		911	849	1,050	1,150
Demin Salts Exported from Valley	*(subset of Zone 7 - Mocho)*	*344*	*2,633*	*1,231*	*3,580*
Other		**4,603**	**489**	**3,057**	**660**
AGRICULTURAL PUMPAGE (all salt is reapplied)		**112**	**633**	**97**	**860**
MINING USE		**4,840**	**55**	**363**	**80**
Stream Export		0	382	0	0
	Discharge to Cope	*7,906*	*389*	*4,178*	*530*
Evaporation		4,140	0	0	0
Processing Losses		700	382	363	520
GROUNDWATER BASIN OVERFLOW		**146**	**570**	**113**	**770**
TOTAL OUTFLOW		**21,447**	**445**	**12,961**	**600**

NET IN 2020 WY		**-7,931**	**44**	**-475**	

TDS Concentrations are flow-weighted averages based on monthly and/or quarterly data, when available.

WRE:\PROJECTS\2020 Grant 5Yr Update AltGSP\T10-Report\FiguresTables\Fig08-20-GraphsSaltLoading74to20.xlsxAnnual
12/10/2021

TABLE 1.
UPDATED NITROGEN LOADING ESTIMATES - DETAILED
MAIN BASIN

Loading Source	Loading Mechanism	Updated Method	Total Applied Nitrogen Loading Rates				Leachable Nitrogen Loading Rates				Quantities			Total Nitrogen Mass Loading (lbs/yr)
			Representative Value	Units	Source(s)	Notes	% Leachable N	Leachable Nitrogen Loading Rate	Units	Notes	Quantity	Units	Source(s)	
Hydrologic (Wet) Loading	**Rainfall Recharge**	Concentrations * recharge/inflow volumes	0.11	mg/L	Zone 7 water quality monitoring data		100%	0.11	mg/L	Based on aqueous NO3 concentrations, 100% of which are leachable	4,300	AF	From natural sustainable yield	**1,321**
	Stream Recharge (natural)		0.18	mg/L			100%	0.18	mg/L		6,600	AF	From natural sustainable yield	**3,203**
	Stream Recharge (artificial)		0.34	mg/L			100%	0.34	mg/L		5,300	AF	From sustainable yield	**4,897**
	Groundwater Inflow		2.90	mg/L			100%	2.90	mg/L		1,000	AF	From natural sustainable yield	**7,888**
Applied Water	**Pipe Leakage**	Supply source concentrations * irrigation / leakage volumes	6.82	mg/L	Zone 7 water quality monitoring data	Reflects weighted average NO3 concentrations of irrigation water based on 2020 Zone 7 delivery records and calculated private groundwater demands.	100%	6.82	mg/L	Based on aqueous NO3 concentrations, 100% of which are leachable	1,000	AF	From sustainable yield	**18,554**
	Agricultural Irrigation		0.90	mg/L			100%	0.90	mg/L		300	AF	From natural sustainable yield	**736**
	Urban Irrigation		0.84	mg/L			100%	0.84	mg/L		1,300	AF	From natural sustainable yield	**2,987**
Fertilization	**Vineyards**	N loading rates per acre * acreages by land use category	21.40	lbs/acre	Ransom et al. 2018	Based on Scenario 1 values from Ransom et al. 2018	23%	4.86	lbs/acre	EKI calculation yields a 67% plant uptake and 10% volatilization rate. RMC 2012 assumes a leaching fraction of 10% on vineyards	1,516	acres	Zone 7 2020 Land Use GIS data	**7,366**
	Other Agriculture		18.38	lbs/acre		Weighted average value based of other (non-vineyard) agricultural crops estimated from DWR land use viewer (2016)	18%	3.24	lbs/acre	EKI calculation yields a 72% plant uptake rate and 10% volatilization rate; Leaching factors can cary from 10% to 30% depending on type of agricultural land use	150	acres		**486**
	Golf Courses		154.00	lbs/acre	GCSAA 2009	Average N fertiilzation rates based on a study of >2,500 golf courses across the United States.	13%	20.02	lbs/acre	13% is likely the upper bound under moderate irrigation and fertilization conditions (Bock and Easton 2019)	356	acres		**7,118**
	Urban Landscaping (low/medium density)		23.10	lbs/acre	Ransom et al. 2018	Based on "peri-urban" N loading rates from Ransom et al., 2018. Includes urban park, low density residential areas	25%	5.79	lbs/acre	EKI calculation yields 65% plant uptake and 10% volatilization. RMC 2012 assumes a leaching fraction of up to 25% on urban areas	8,402	acres		**48,648**
	Urban Landscaping (high density)		12.40	lbs/acre		Based on "urban" N loading rates from Ransom et al., 2018. Includes urban commercial and industrial, public, and high density residential areas	17%	2.16	lbs/acre	EKI calculation yields 73% plant uptake and 10% volatilization, RMC 2012 assumes a leaching fraction of up to 25% on urban areas	2,269	acres		**4,902**
Rural/Residential	**Fertilization**	N loading rates per acre * # acres	23.10	lbs/acre	Ransom et al. 2018	Based on "peri-urban" N loading rates from Ransom et al., 2018.	25%	5.79	lbs/acre	EKI calculation yields 65% plant uptake and 10% volatilization. RMC 2002 assumes a leaching fraction of up to 50% on rural areas.	126	acres	Assume certain area (0.5 acres) of each rural property are fertilized.	**730**
	OWTS (< 7 acre properties)	N loading rates per property * # properties	34.00	lbs/ property	NMP 2015 & GIS data from ACDEH	Assumes N loading of 34.8 lbs/yr for 1 RRE. 1 RRE for every property < 7 acres. Used ACDEH layer to calculate avg # bldgs on props > 7 acres, then 1RRE * number properties * avg num blgs	100%	34.00	lbs/property	Assumes 100% of septic losses are leachable	217	properties	From ACDEH layer	**7,378**
	OWTS (> 7 acre properties)	N loading rates per acre * # of acres	62.17	number of bldgs x 1RRE/building			100%	62.17	lbs/property		35	properties	From ACDEH layer	**2,176**
	Livestock (Manure)		21.50	lbs / acre	RMC 2002	Based on assumptions of rural livestock ownership from RMC 2002 study of the Buena Vista area.	100%	21.50	lbs/acre	All manure assumed to be left on the ground	20	acres	Assume certain percent (10%) of each rural property has livestock.	**422**
Industrial	**Horse Boarding**	N loading rates per acre * # acres	51.10	lbs / acre	USGS/US DOI Report 2006-5012	Range based on a horse density estimate of 0.33 - 1 horse/acre. Representative value assumes 0.5 horse/acre	100%	51.10	lbs/acre	All manure assumed to be left on the ground	257	acres		**13,113**
	Wineries (small)	N loading rates by winery size * # of wineries	54.00	lbs / winery	RMC 2002	Using same N loading rates as was provided in Zone 7 2015 SNMP; any future refinements will require a more detailed analysis of local winery operations and waste	100%	54.00	lbs/winery	All winery wastes assumed to be disposed in on-site surface detention ponds	14	wineries		**756**
	Wineries (medium)		200.00	lbs / winery			100%	200.00	lbs/winery		3	wineries		**600**
	Wineries (large)		355.00	lbs / winery			100%	355.00	lbs/winery		2	wineries		**710**
Roads	**Dry deposition from vehicles**	N loading rates per acre * # of acres	10.00	lbs /acre	Santa Clara SNMP 2014, Weiss et al. 1999, Alameda County Transportation Commission	Representative value provided from Santa Clara SNMP 2014. We applied a +/- 50% uncertainty for the upper and lower range	5%	0.50	lbs/acre	Assumes 80% plant uptake and 15% volatilization	1,610	acres	EKI visually estimated lengths of freeway segments from I-236, I-680, and I-580 in Zone 7 and applied a 100-meter impacted width to calculate total impacted acreages.	**805**
													TOTAL Nitrogen Mass Loading (lbs/yr):	**134,795**

Abbreviations

AFY = acre-feet per year
GCSSA = Golf Course Superintendents Association of America
GIS = Geographic Information System
I-238 = Interstate - 238
I-580 = Interstate - 580
I-680 = Interstate - 680
IDC = Integrated Water Flow Model Demand Calculator
lbs = pounds
SNMP = Salt and Nutrient Management Plan
US DOI = United Sstates Department of Interoir
USGS = United States Geological Survey
UWMPs = Urban Water Management Plans
WY = Water Year

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