EAST CONTRA COSTA SUBBASIN
Groundwater Sustainability Plan

East Contra Costa Subbasin Groundwater Sustainability Plan

Prepared for ECC GSA Working Group

Luhdorff & Scalmanini Consulting Engineers

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ECC Working Group

City of Antioch GSA, Byron-Bethany Irrigation District GSA, City of Brentwood GSA, Contra Costa Water District, County of Contra Costa GSA, Diablo Water District GSA, Discovery Bay Community Services District GSA, and East Contra Costa County Irrigation District GSA comprise the ECC Subbasin Working Group.

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LIST OF ACRONYMS & ABBREVIATIONS

AB	Assembly Bill
AC	Advisory Councils
ACS	US Census American Community Survey
AF	Acre Feet
AFY	Acre feet per year
AMI	Automatic Meter Infrastructure
AMR	Automated Meter Reading
AMSL	above mean sea level
AN	Above Normal
ASR	Aquifer Storage & Recovery
AWMP	Agricultural Water Management Plan
BAC	Bacon Island at Old River
B&C	Brown & Caldwell
BBID	Byron Bethany Irrigation District
BBM	Basin Boundary Modification
bgs	Below Ground Surface
BIMID	Bethel Island Municipal Improvement District
bm	bench mark
BMP	Best Management Practices
BN	Below Normal
BPs	Best Water Use Practices
C	Critical
CA	California
Caltrans	State Department of Transportation
CASGEM	California Statewide Groundwater Elevation
CCC	Contra Costa County
CCCDCD	Contra Costa County Department of Conservation and Development
CCCEHD	Contra Costa County Environmental Health Division
CCCGP	Contra Costa County General Plan
CCHSHMP	Contra Costa Health Services Hazardous Materials Programs
CCR	California Code of Regulations
CCWD	Contra Costa Water District
CEC	Constituent of Emerging Concern
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
Cfs	Cubic Feet per Second

CGMA	Cooperative Monitoring/Adaptive Groundwater Management Agreement
CGPS	Continuous Global Positioning System
CIMIS	California Irrigation Management Information System
COA	Cooperated Use Agreement
CoAGP	City of Antioch General Plan
COB or Brentwood	City of Brentwood
CoBGP	City of Brentwood General Plan
CoOGP	City of Oakley General Plan
COBWTP	City of Brentwood Water Treatment Plant
CPTs	Cone Penetrating Testing
CSD	Community Services District
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB or Regional Board	Central Valley Regional Water Quality Control Board
CWC	California Water Code
D	Dry
DA	Disadvantaged Area
DAC	Disadvantaged Community
DBCSD	Discovery Bay Community Service District
days/yr	days per year
DD	Delta Diablo
DDW	California Division of Drinking Water
DFW	Department of Fish and Wildlife
DMS	Data Management System
DNPG	De Novo Water District
DO	dissolved oxygen
DOD	Department of Defense
DPC	Delta Protection Commission
DQO	Data Quality Objectives
ds/m	decimeters per meter
DTW	Depth to water
DWD	Diablo Water District
DWR	Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
DZ	Deep Zone
EBMUD	East Bay Municipal Utilities District

EC	Electrical Conductivity
ECC or Subbasin	East Contra Costa Subbasin
ECCID	East Contra Costa Irrigation District
ECCSims	East Contra Costa Groundwater Surface Water Simulation Model
ECCWMA	East Contra Costa Water Management Association
EDA	Economically Distressed Area
EIR	Environmental Impact Report (under CEQA)
EIS	Environmental Impact Study (under NEPA)
EISIP	Expanded irrigation System Improvement Program
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
eWRIMS	Electric Water Rights Information Management System
ET (or ETo)	evapotranspiration
EWM	Water Data Library
EWMP	Efficient Water Management Practices
FMMP	California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program
FONSI	Finding of no significant impact
ft	feet or foot
ft/day	feet per day
ft/yr	feet per year
ft bgs	feet below ground surface
ft msl	feet above mean sea level
FSS	Facilitation Support Services
FTE	Fulltime equivalent
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	Groundwater Dependent Ecosystem
GDEi	Groundwater Dependent Ecosystem indicators
GIS	geographic information systems
GMP	Groundwater Management Plan
gpd/ft	gallons per day per foot
gpm	gallons per minute
GPS	Global Positioning System
GQMP	Groundwater Quality Management Plant
GQTM	Groundwater Quality Trend Monitoring Plan
GSP or Plan	Groundwater Sustainability Plan
GSA	Groundwater Sustainability Agency

GSFLOW	Groundwater and Surface-water Flow Model
GSI	GSI Water Solutions, Inc.
GW	Groundwater
GWE	Groundwater Elevation
GWMP	Groundwater Management Program
HCM	Hydrogeologic Conceptual Model
ILRP	Irrigated Lands Regulatory Program
IMs	Interim Milestones
InSAR	Interferometric Synthetic-Aperture Radar
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
ISD	Ironhouse Sanitary District
IWFM	Integrated Water Flow Model
JPA	Joint Powers Authority
KDSA	Kenneth D. Schmidt & Associates
LID	Low Impact Development
LAO	Legislative Analyst’s Office
LSA	LSA Associates
LSCE	Luhdorff & Scalmanini Consulting Engineers
LU	Land Use
LUST	Leaky Underground Storage Tank
MAF	Million Acre-Feet
MCL	Maximum Containment Level
MGD	Million gallons per day
µg/L	microgram per liter
mg/L	milligrams per liter
MHI	Median Household Income
MMP	Monitoring and Mitigation Program
MNM	Monitoring Network Module
MO	Measurable Objectives
MOA	Memorandum of Agreement
Model	Groundwater Model
MODFLOW	Modular Finite-difference Flow Model
MOU	Memorandum of Understanding
MRMP	Mitigation Monitoring and Reporting Program
msl	Mean seal level
MT	Minimum Thresholds

MTBE	methyl tertiary-butyl ether
MW	monitoring well
MWD	Municipal Water District of South California
MWR	Master Water Report
my	million years
mya	million years ago
mybp	million years before present
N	Nitrogen
NA	Not Applicable
NAHC	Native American Heritage Commission
NAIP	National Agricultural Imagery Program
NASL	Naval Air Station Lemoore
NDVI	Normalized Derived Vegetation Index
NAVD88	North American Vertical Datum of 1988
NCCAG	Natural Communities Commonly Associated with Groundwater
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NHP	Natural Hydrography Database
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	Natural Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWIC	Sonoma Northwest Information Center
NWIS	National Water Information System
°C	degrees Celsius
°F	degrees Fahrenheit
O&M	operations and maintenance
ORP	Oxidation Reduction
OS	Open Space
OSWCR	DWR Online System for Well Completion Reports
PBO	Plate Boundary Observatory
pH	potential of hydrogen
PLSS	Public Land Survey System
PMAs	Projects and Management Actions
ppm	parts per million
ppt	parts per trillion
PUC	Public Utilities Commission

PWIS	CA Water Boards Public Water Information System
PWS	Public Water System
QA/QC	Quality assurance/quality control
RBWTP	Randall Bold Water Treatment Plant
RC	Resource conservation
RD	Reclamation District
RMP	Representative Monitoring Point
RMS	Representative Monitoring Sites
RP	Reference Point
RPE	Reference Point Elevation
RW	recycled water
RWQCB	Regional Water Quality Control Board
RWSA	Raw Water Service Area
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SDAC	Severely Disadvantaged Communities
SRF	State Water Resources Board Revolving Fund
SGMA	Sustainable Groundwater Management Act
SJR	San Joaquin River
SMC	Sustainable Management Criteria
SMCL	Secondary Maximum Containment Level
SNL	State Notification Level
SNMP	Salt and Nutrient Management Plan
SOI	Sphere of Influence
SPI	Standardized Precipitation Index
SRF	State Water Resources Control Board Revolving Fund
SSURGO	Soil Survey Geographic Database
SWP	State Water Project
SWQCB	State Water Quality Control Board
SWRCB	California State Water Resources Control Board
SZ	Shallow Zone
TDS	Total Dissolved Solids
TMDLs	Total Maximum Daily Load
TNC	The Nature Conservancy
TODB	Town of Discovery Bay Community Services District
UAVSAR	Uninhabited Aerial Vehicle Synthetic Aperture Radar

ULL	Urban Limit Line
Umhos/cm	micromhos per centimeter
UNAVCO	University NAVSTAR Consortium
UPRR	Union Pacific Railroad
USACE	United States Army Corps of Engineers
USFWS	US Fish and Wildlife Services
USGS	United States Geologic Survey
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
UST	Underground Storage Tanks
UWMP	Urban Water Management Plan
Valley	San Joaquin Valley
VOC	volatile organic chemical
W	Wet
WCR	Well Completion Report
WDL	Water Data Library
WRAC	Water Resources Advisory Committee
WTP	Water Treatment Plant
WWTF	Wastewater Treatment Facilities
WWTP	Wastewater Treatment Plant
WY	Water Year

ES 1. EXECUTIVE SUMMARY (CCR §354.4(A))

In 2014, a legislative package, referred to as the Sustainable Groundwater Management Act (SGMA), created a fundamental change in the governance of California's groundwater. SGMA required the formation of groundwater sustainability agencies (GSAs) for over 140 groundwater basins, including the East Contra Costa (ECC) Subbasin. Signed into law by Governor Jerry Brown, and effective January 1, 2015, SGMA set forth a long-term, statewide framework to protect groundwater resources.

Under the new law, seven GSAs, each charged with the development and implementation of a groundwater sustainability plan (GSP), were formed within the ECC Subbasin (Subbasin). The purpose of a GSP is to sustainably manage groundwater and avoid undesirable results within and beyond the 50-year planning and implementation horizon. The GSAs along with partners, worked collaboratively to prepare a single GSP for the Subbasin in accordance with the codified principle that sustainable groundwater management is best achieved locally[1]. The Subbasin boundary and GSA areas are shown in **Figure ES-1**.

ES 2. CONSIDERATION OF ALL BENEFICIAL USES AND USERS (WC §10723.2)

Beneficial uses and users of water are established in the state constitution and codified in the state Code of Regulations. The State Water Board, which is charged with protection of all water resources, designates or establishes beneficial uses throughout the state. In the ECC Subbasin, which lies within the San Joaquin River Basin, groundwater is considered suitable for municipal and domestic water supply, agricultural supply, and industrial uses.

The sustainability goal for this GSP establishes the protection of all beneficial uses and users of groundwater in the ECC Subbasin. The GSAs are comprised of two cities (Antioch and Brentwood), two special districts serving agricultural water supply (Byron Bethany Irrigation District and East Contra Costa Irrigation District), a special district and community services district providing municipal supply (Diablo Water District and Town of Discovery Bay), and Contra Costa County, which represents unincorporated areas not covered by other districts or cities. Along with Contra Costa Water District, which provides water to various municipal users in the region, these agencies represent and are responsible to the needs and values of all water users present in the Subbasin including urban and rural residents, farmers, various commercial industries, and environmental users all of which rely on groundwater to one degree or another. The GSAs have endeavored to reach out and engage these constituencies to ensure that this GSP reflects all concerns over water supply whether quality, quantity, or both. From residents that rely on a small capacity well providing drinking water in their homes, to small farmers that rely wholly on groundwater for their businesses and livelihoods, and to small water systems serving disadvantaged communities, this GSP recognizes that declining water levels and degradation of water quality as potentially having particularly harmful effects on health and welfare. It also values the unique Delta environment and long history of agricultural activity for which sustainable management is vital to the character and economic diversity of the region.

The GSAs have adopted sustainable management principles that include engagement of all interested parties and stakeholders; protection of potentially underrepresented communities; recognition and prioritization of environmental justice and groundwater dependent ecosystems; and continuation of cooperative water resources management to ensure that all activities needed to maintain sustainability are identified, funded, and implemented.

[1] California Water Code, Division 1, Section 113.

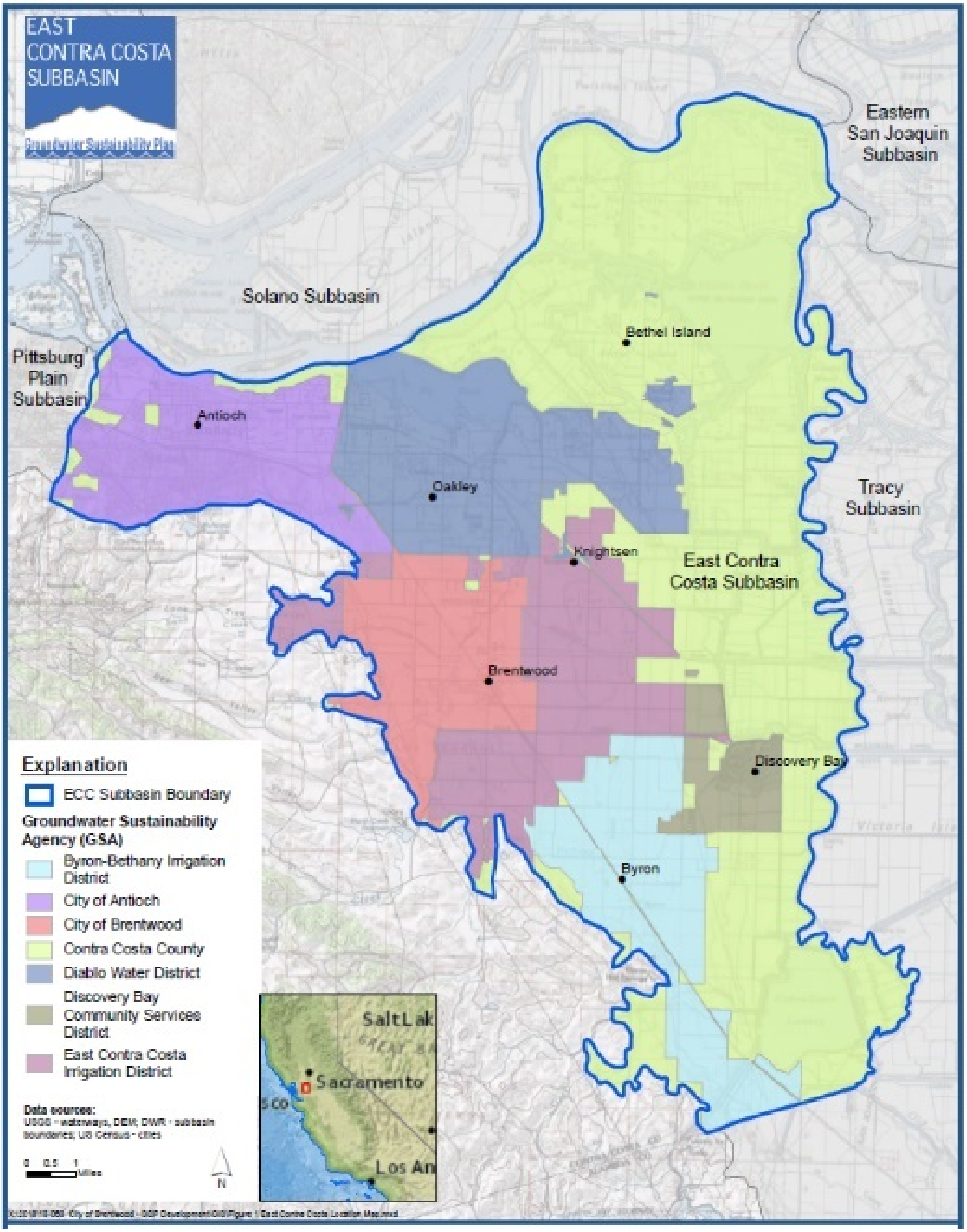

Figure ES-1 East Contra Costa Subbasin Groundwater Sustainability Agencies

ES 3. KEY FACTORS FOR THE ECC SUBBASIN GSP

Through preparation of this GSP, key factors governed the approach and planning to meet the requirements of new SGMA regulations to ensure sustainability of groundwater resources in the plan area (see **Figure ES-1**). Some of these factors are listed below.

ECC Subbasin Priority Ranking

Many groundwater basins and subbasins in the state have experienced significant adverse effects attributed to overpumping; that is, pumping that exceeds groundwater replenishment. Such basins were assigned Critically Overdrafted and High priority rankings. The ECC Subbasin shows no signs of over pumping and was assigned a Medium priority ranking and is required to submit a GSP in January 2022. Although the ECC Subbasin has not been overdrafted, its ranking was based on the importance that groundwater serves as a source of supply for varied uses including domestic, agricultural, and environmental. Domestic users include individual residences, small water systems, and municipalities. In addition, there are many disadvantaged communities[2] that rely on groundwater as a sole source of supply. East Contra Costa also has a long history of agriculture dating back over 100 years.

Sustainable Conditions in the ECC Subbasin

Groundwater conditions in the ECC Subbasin are favorable and reflect stability over the past 30 years or more. Using various analogies, the Subbasin can be described as generally full through various water-year types, including drought, and is in good "health." The favorable conditions are in part due to surface water availability that represents the largest source of supply for municipal and agricultural uses in the Subbasin.

Outlook for Future Sustainability

Using the best available data and a robust water budget model, the ECC Subbasin is projected to be sustainable under various future scenarios including those that incorporate climate change and sea level rise.

Local Management of the ECC Subbasin

On March 28, 2019, the state approved a subdivision of the Tracy Subbasin that separated the East Contra Costa portion (now called the ECC Subbasin) from the San Joaquin County portion (retained the Tracy Subbasin name), thereby providing more local control of groundwater resources. In addition, seven GSAs were formed by local public agencies to ensure that their diverse constituents are represented in this GSP. If needed, each GSA has authorities to enact policies to protect groundwater resources based on conditions within their respective jurisdictions. This provides stakeholders with more focused engagement through a local GSA.

[2] Disadvantaged communities refer to the areas which most suffer from a combination of economic, health, and environmental burdens. The state identifies these areas by collecting and analyzing information from communities all over the state.
https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/disadvantaged-communities

Non-Applicability to De Minimis Extractors

SGMA is intended to address existing and potential adverse effects typically attributed to the largest groundwater uses and users. Policies and programs aimed at achieving and maintaining sustainability may include pumping restrictions, fees, and reporting requirements. Such actions, which would be enacted locally by GSAs, *do not* apply to de minimis extractors. Under SGMA, a de minimis extractor is defined as a person who extracts two acre-feet or less per year of groundwater for domestic use. Thus, typical residential well owners are shielded from practically all potential management actions described in this GSP. Further, the GSP sustainability goal (**Section 7**) is intended to protect such users from adverse effects of sustainable management undertaken by the GSAs.

Impacts to Individual Wells

The GSP is concerned with protecting groundwater resources for future generations and maintaining sustainability as required under SGMA legislation. The GSP identifies baseline groundwater levels and water quality that protect all classes of beneficial users. The GSP *does not* mitigate conditions that were present prior to January 1, 2015 (Water Code 10727.2(b)(4)) such operational problems related to well features (e.g., depth, perforation interval, pump setting).

Water Quality

Groundwater contains numerous naturally occurring minerals that vary throughout the ECC Subbasin. While groundwater quality is generally favorable with respect to primary drinking water quality constituents, some areas have elevated total dissolved minerals, hardness, and some secondary constituents which may affect domestic and agricultural uses. The GSP is intended to avoid degradation of water quality as a result of implementing sustainable management policies, projects or actions; for example, projects that affect pumping patterns resulting in movement and mixing of groundwater sources would be evaluated to ensure that no adverse effects occur to any users. The GSP does not mitigate groundwater quality in the Subbasin that is naturally occurring during the historical baseline.

Impacts of Drought

Temporary imbalances between extraction and replenishment due to drought are not considered an undesirable result as long as groundwater conditions recover in subsequent normal to wet years. Thus, a drop in groundwater levels may occur in very dry years, which may produce a short-term impact on wells.

ES 4. GSP CONTENTS

The GSP provides information demonstrating that the past and present actions of the ECC GSAs have created a sustainably managed groundwater basin. The GSP outlines planned management oversight and activities that will result in continued sustainability of the groundwater resources in east Contra Costa.

This Executive Summary and the companion GSP are organized as follows:

- Executive Summary
- Section 1 Introduction
- Section 2 Plan Area
- Section 3 Basin Setting
- Section 4 Historical, Current, and Projected Water Supply

- Section 5 Water Budget
- Section 6 Monitoring Network and Data Management System
- Section 7 Sustainable Management Criteria
- Section 8 Project and Management Actions
- Section 9 Plan Implementation
- Section 10 Notice and Communication

An overview of each section of the ECC Subbasin GSP is presented below.

Section 1 Introduction

The ECC Subbasin, also referred to as San Joaquin Valley-East Contra Costa Subbasin (5-022.19), is a Medium priority groundwater basin based on the Groundwater Basin Prioritization by the State Department of Water Resources (DWR). Under SGMA, Medium priority subbasins must submit an adopted GSP by January 31, 2022. Management of the ECC Subbasin through the GSP will be based on achieving and maintaining groundwater sustainability over a 50-year planning and implementation horizon.

SGMA authorizes a "local public agency that has water supply, water management, or land use responsibilities within a groundwater subbasin or basin to elect to become a GSA and to develop, adopt, and implement a GSP (Water Code § 10721(n).)" The following agencies formed GSAs and coordinated preparation of this GSP. **Figure ES-1** shows the service area for each GSA.

- Byron Bethany Irrigation District (BBID) GSA
- City of Antioch GSA
- City of Brentwood GSA
- Contra Costa County (CCC) GSA
- Diablo Water District (DWD) GSA
- Discovery Bay Community Services District (DBCSD[3]) GSA
- East Contra Costa Irrigation District (ECCID) GSA

Contra Costa Water District (CCWD), while not a GSA, is a partner in the development of this jointly prepared GSP. CCWD provides surface water to various entities within its service area. Because surface water plays a part in future water resources management for the Subbasin, CCWD is an equal partner in the development of the ECC Subbasin GSP.

On May 9, 2017, the seven GSAs and CCWD entered into a Memorandum of Understanding (MOU). Under this MOU the agencies share costs and management of the development and implementation of the GSP.

[3] Also referred to as Town of Discovery Bay (TODB).

Section 2 Plan Area

The ECC Subbasin covers a 168-square mile area (107,596 acres) in the eastern portion of Contra Costa County (**Figure ES-1**). The Subbasin includes the communities of Antioch, Bethel Island, Byron, Brentwood, the Town of Discovery Bay (TODB), Knightsen, and Oakley and two agricultural districts (Byron Bethany Irrigation District and East Contra Costa Irrigation District). The Subbasin is located on the southwestern part of the Sacramento-San Joaquin Delta, which is the largest estuary on the West Coast and provides critical habitat to fish and wildlife species. The 2015 land use in the Subbasin is mainly agricultural (41 percent), followed by urban (about 23 percent), then by water and native vegetation (both about 14 percent). As quantified in Section 4, the Subbasin has three main water supply sources: surface water, groundwater, and recycled water. Surface water provides, on average, about 80 percent of the aggregate demand for all use sectors in the Subbasin. This percentage is projected to remain stable at 80 to 85 percent through at least 2050 (see **Section 4**, **Table 4-5**).

Section 3 Basin Setting

The ECC Subbasin setting is described through a hydrogeologic conceptual model depicting the physical features of the aquifer system and groundwater conditions.

Hydrogeologic Conceptual Model

- ECC Subbasin is bounded on the north, east, and south by the Contra Costa County line, which is contiguous with the San Joaquin River (north) and Old River (east). In the west, the Subbasin is bounded by marine sediments of the Coast Range.
- Topography and geological formations gently slope to the northwest. The upper 400 feet of sediments are comprised of alluvial deposits with discontinuous clay layers interspersed with more permeable coarse-grained units.
- The ECC Subbasin aquifer system is divided into the upper unconfined Shallow Zone (to about 150 feet below ground surface) and a lower semi-confined to confined Deep Zone (the Corcoran Clay is not present in the Subbasin). Most water wells are constructed within the upper 400 feet of the aquifer system.
- Groundwater conditions throughout the Subbasin are monitored through water level measurements and water quality testing. Water level data indicate that groundwater storage is largely stable and fluctuate with water-year type (wet, normal, dry).

Sustainability Indicators

DWR is charged with determining the adequacy of GSPs in meeting SGMA’s requirements. Generally, to achieve sustainability, the amount of groundwater extracted must be less than or equal to the amount of groundwater replenishment. Temporary imbalances between extraction and replenishment due to drought are not considered an undesirable result as long as groundwater conditions recover in subsequent normal to wet years. In addition, the GSP regulations[4] list six sustainability indicators that must be addressed in GSPs.

[4] California Water Code § 354.26

California Department of Water Resources, 2016

Following are the ECC findings for each of the sustainability indicators.

- **Groundwater Elevations**- Groundwater levels in the ECC Subbasin are stable indicating that the Subbasin has been managed within its sustainable yield[5]. This is partially due to surface water availability for agricultural and urban uses.
- **Change in Groundwater Storage** - As determined through the water budget analysis in **Section 5**, the cumulative change in groundwater storage was unchanged between 1997 and 2018 despite three drought periods (2001-2002, 2007-2009, 2012-2016).
- **Seawater Intrusion** - The ECC Subbasin is situated in the San Francisco Bay/Sacramento-San Joaquin Delta. This GSP recognizes the potential for interactions between saline baywater and shallow groundwater. While the baywater is fresh, adverse intrusion may occur if saline water infiltrates the Delta and intrudes into shallow groundwater. This potential mechanism may be triggered or exacerbated by sea level rise and/or shifts in groundwater flow directions and gradients caused by future pumping patterns. There is no direct connection between ocean seawater and groundwater in the Subbasin.
- **Groundwater Quality** - Groundwater quality is generally favorable with respect to primary drinking water quality constituents. Naturally elevated mineral content may pose localized restrictions for domestic (e.g., hardness) and agricultural (crop sensitivity) uses. Key monitoring constituents are total dissolved solids, chloride, hardness, nitrate, and boron. With the exception of nitrate, these constituents are naturally occurring in the ECC Subbasin.
- **Land Subsidence** - There is no historical evidence of inelastic land subsidence due to groundwater withdrawal in the ECC Subbasin.
- **Depletions of Interconnected Surface Water** – This indicator is of concern where shallow groundwater and surface water are hydraulically connected. Marsh Creek, the San Joaquin River, and Old River are considered interconnected surface water bodies in the ECC Subbasin. Impacts to these features due to groundwater pumping will be managed through this GSP through monitoring of shallow wells and stream gage stations.

[5] "Sustainable yield" means 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. Cited from: Section 10733.2, Water Code

Section 4 Historical, Current, and Projected Water Supply

This section describes the ECC Subbasin land uses, population, and metered historical, current and projected water supplies. Water supply amounts were provided by the GSAs and CCWD. When historical or projected water supply were not provided, land uses and population data were used to estimate these data. This information is integrated into the Subbasin surface water/groundwater model (GSP **Section 5**).

Section 5 Water Budget

In accordance with technical guidance documents provided by DWR, water budget scenarios were evaluated using a groundwater flow model that quantified historical, current, and projected groundwater budget conditions. The development of the ECC Groundwater-Surface Water Simulation Model (ECCSim) was a refinement of two other validated and widely used modeling platforms, IWFM and C2VSim-FG Beta2[6]. These were selected as the modeling platform due to the versatility in simulating crop-water demands in the predominantly agricultural setting of the Subbasin, groundwater surface-water interaction, the existing hydrologic inputs existing in the model for the time period through the end of water year 2015, and the ability to customize the existing C2VSim-FG Beta2 model to be more representative of local conditions in the area of the ECC Subbasin. Use of publicly available modeling platforms is a guiding principle under DWR Best Management Practices[7] and facilitates independent assessment of modeling results.

Based on the modeling results, the ECC Subbasin is historically, currently, and projected to be sustainable. **Figure ES-2** shows a breakdown in water budget components for the model base period of 1997 to 2018. The modeling results indicate that the cumulative change in groundwater storage fluctuated while cumulative storage was essentially unchanged at the end of the base period despite three state-wide drought periods (2001-2002, 2007-2009, 2012-2016). Over the base period, total pumping in the Subbasin ranged from 32,500 to 58,250 AFY and averaged 46,455 AFY.

[6] The development of the East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim) involved starting with and evaluating the U.S. Geological Survey's Central Valley Hydrologic Model (CVHM) and the beta version (released 5/1/2018) of DWR's fine-grid version of the California Central Valley Groundwater-Surface Water Flow Model (C2VSim-FG Beta2). C2VSim-FG Beta2 utilizes the most current version of the Integrated Water Flow Model (IWFM) code available at the time of the ECCSim development.

[7] 23 CCR §352.4(f)

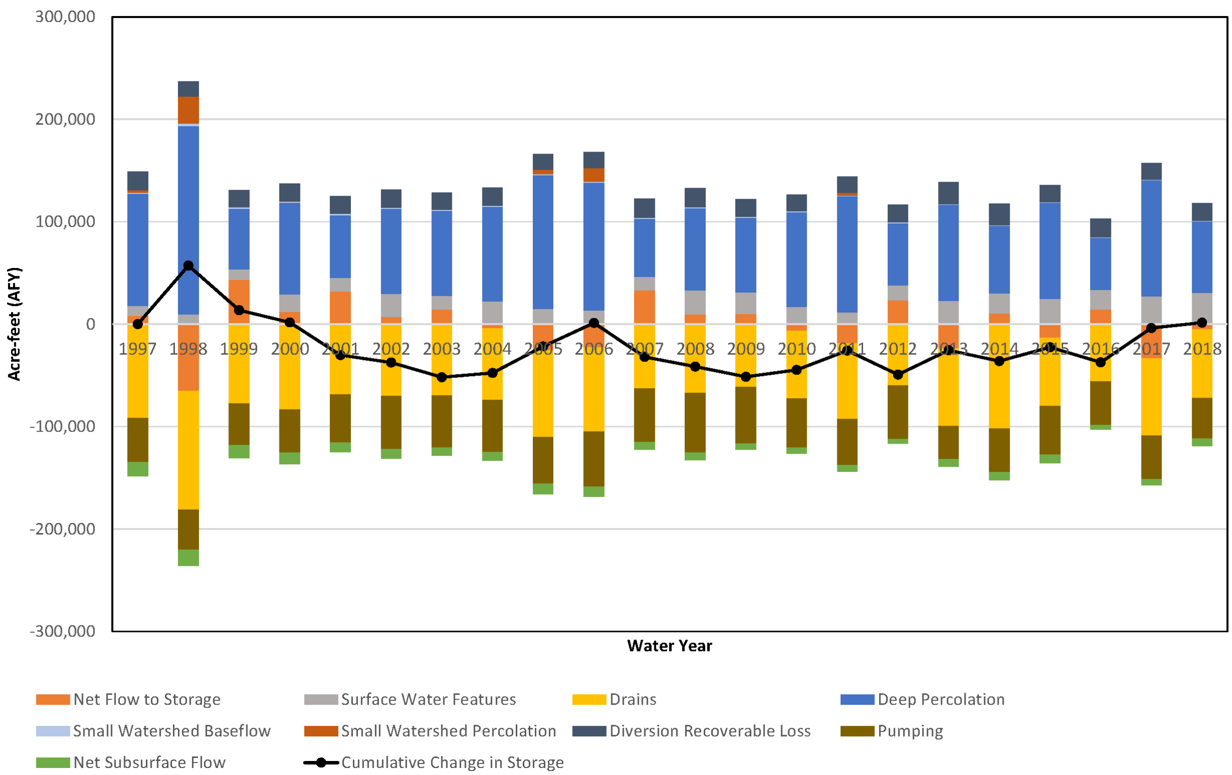

Figure ES-2 Groundwater Budget for East Contra Costa Subbasin Historical Calibration Period (1997-2018)

Various future scenarios were evaluated using the ECC Subbasin groundwater flow model including sustainable yield. The projected sustainable yield is the amount of pumping that can occur while avoiding undesirable results for the six sustainability indicators. The sustainable yield for the ECC Subbasin is estimated at approximately 72,000 AFY, or about 55 percent greater pumping than the historical average. At higher levels of pumping, the modeling indicates the potential to increase streamflow depletion and inter-basin flow beyond historical baselines. Like the base period scenario, a chronic decline in groundwater storage was not a factor in the sustainable yield threshold. The margin between the average pumping rate in the Subbasin over the base period (46,455 AFY) and the stated sustainable rate of 72,000 AFY provides an ability to meet short-term surface water supply shortages in critically dry years through increased groundwater pumping. This is a hallmark of effective conjunctive use of surface water and groundwater resources.

The projected water budget was also evaluated under climate change and sea level rise. Based on the model results, the ECC Subbasin is projected to be sustainable over the 50-year implementation and planning horizon required under SGMA.

Through adaptive management, the groundwater flow detailed in **Section 5** will be updated and refined to reflect actual future conditions and serve in the adaptive management of the ECC Subbasin using the best available information.

Section 6 Monitoring Networks and Data Management System

Monitoring networks are developed to quantify current and future groundwater conditions in the ECC Subbasin, as well as within individual GSA jurisdictions. Monitoring networks were developed for each of the six SGMA sustainability indicators. Some sustainability indicators needed to be expanded to fill data gaps and improve the ability to demonstrate sustainability and refine the hydrogeologic conceptual model. The networks include:

- **Groundwater Level Monitoring Network**- Groundwater level data from a network of monitoring wells reflect groundwater occurrence, flow direction, hydraulic gradients between principal aquifers, and interaction between groundwater and surface water features. Dedicated monitoring wells are located within the jurisdiction of the seven GSAs. The ECC Subbasin has 55 basin-wide wells and 12 of these comprise a network of representative monitoring sites (RMS) as defined under new regulations governing GSPs.
- **Groundwater Storage** – Groundwater levels serve as a proxy for the groundwater storage sustainability indicator monitoring network.
- **Seawater Intrusion** – Intrusion of saline baywater, if it occurs, is evaluated based on chloride concentrations from monitoring wells adjacent to the San Joaquin River.
- **Groundwater Quality** –Groundwater quality monitoring will be conducted at an existing network of 22 basin-wide water supply wells, 11 of these are part of a representative monitoring network.
- **Land Subsidence** – A land subsidence monitoring network is comprised of four Plate Boundary Observatory (PBO) stations in and adjacent to the ECC Subbasin and data collected by DWR using InSAR[8] satellite data.
- **Interconnected Surface Water** – Interconnected surface water will be monitored through existing stream gages (19) and Shallow Zone groundwater level monitoring wells (15). New shallow wells were installed as part of this GSP to address a data gap.

A Data Management System (DMS) was developed to store and analyze data collected as part of this GSP. With submittal and implementation of the ECC Subbasin GSP, there will be a publicly accessible weblink to view reports, maps, graphs, and current data under the Subbasin monitoring plan.

Section 7 Sustainable Management Criteria

Sustainable management criteria include establishing a sustainability goal for the Subbasin, defining undesirable results, and quantifying minimum thresholds and measurable objectives.

The sustainability goal for the ECC Subbasin GSP is to manage the groundwater Subbasin to:

- Protect and maintain safe and reliable sources of groundwater for all beneficial uses and users.
- Ensure current and future groundwater demands account for changing groundwater conditions due to climate change.

[8] InSAR is Interferometric Synthetic Aperture Radar.

- Establish and protect sustainable yield for the Subbasin by achieving measurable objectives set forth in this GSP in accordance with implementation and planning periods[9].
- Avoid undesirable results defined in the GSP in accordance with SGMA.

Sustainable management criteria (SMC) also define the conditions that constitute sustainable groundwater management. Note that undesirable results have not occurred historically in the ECC Subbasin and are not projected to occur in the future. The sustainable management criteria will commit the GSAs to meeting the sustainability goal for the Subbasin.

Table ES-1 summarizes the SMC for the six SGMA sustainability indicators and includes the minimum thresholds and measurable objectives required under GSP regulations:

Table ES-1 Sustainable Management Criteria Summary

Sustainability Indicator	Measurable Objective (MO)	Minimum Threshold (MT)	Undesirable Result
Chronic Lowering of Groundwater Levels	Average spring elevation of groundwater at the Representative Monitoring Site (RMS) and its vicinity	The lowest historical water levels observed in a well plus an additional 10 feet lower	The MT in any well is exceeded over three consecutive years, indicating a trend, and do not recover in normal to wet years
Reduction in Groundwater Storage	Use as a proxy, the MO for chronic lowering of groundwater levels	Use as a proxy, the MT for chronic lowering of groundwater levels	Use as a proxy, the undesirable result for chronic lowering of groundwater levels
Seawater intrusion	The MO at each RMS is the average chloride concentrations from 2013 to 2017.	Chloride concentration for any Shallow Zone or Deep Zone well is set at 250 mg/L secondary maximum contaminant level	A bayside monitoring well has a chloride concentration above 250 mg/L over three consecutive years and is determined to be induced by GSAs' actions.
Degraded Groundwater Quality	The MO for each RMS is the average concentrations (2013 to 2017) for each constituent of concern	The three-year running average exceedance of an MCL for a key monitoring constituent.	Any RMS that exceeds any state drinking water standard during GSP implementation because of GSAs' actions
Land Subsidence	The MO is set at UNAVCO station P256 at the average seasonal elastic movement (0.6 inch vertical).	An MT of 1-inch land surface elevation outside the historical elastic range over a three-year period as	Associated impacts due to groundwater pumping: impacts to infrastructure such as damage to roads and structures, reduced

[9] As defined under SGMA, the GSP implementation period is 20 years. The planning and implementation horizon is a 50-year time period over which the GSAs determine that plans and measures will be implemented to ensure that the basin or subbasin is operated within its sustainable yield.

Sustainability Indicator	Measurable Objective (MO)	Minimum Threshold (MT)	Undesirable Result
		shown by monitoring data at the UNAVCO site P256.	capacity of water conveyances, and increased vulnerability to flooding.
Depletion of interconnected surface water	The MO is set at the average annual groundwater pumping during the Base Period 1997 to 2018, or 54,000 AFY.	Based on the groundwater flow model results, a conservative interim MT is set at a value for sustained basin-wide pumping above the historic baseline average which induces exceedances in estimated streamflow depletion as compared to baseline conditions. [10]	Depletions that result in reductions in flow or stage of major rivers and streams that are hydrologically connected to groundwater in the Subbasin and which cause significant and unreasonable impacts on beneficial uses and users of surface water and the environment

Section 8 Projects and Management Actions

Projects and management actions (PMAs) were developed to achieve the ECC Subbasin sustainability goal by 2042 and avoid undesirable results during and beyond the GSP planning and implementation horizon. Because the ECC Subbasin is currently and projected to be sustainable (i.e., no onset of undesirable results), PMAs are not expected to be essential for sustainability. However, future conditions are uncertain and PMAs will be employed through the principle of adaptive management on an as-needed basis.

Seven projects are included in the GSP representing a variety of project types to increase water supply availability and reliability including infrastructure to provide in-lieu recharge, improve water quality, and increase use of recycled wastewater. Projects are divided into three status categories: completed, under construction, and planned. The three completed projects are operating and provide in-lieu groundwater benefits of over 5,500 AFY. The two projects under construction will be operating by 2042 and are projected to provide over 8,000 AFY.

Management actions consisting of water well policies (e.g., metering and reporting, spacing, and construction features) and demand management would be implemented locally by individual GSAs on an as-needed basis. Except for a measure designed to protect water quality, such as seal depths, such management actions are not applicable to de minimis users.

[10] The interim MT for interconnected surface water will be replaced with monitored shallow groundwater levels and calculations of the rate or volume of depletion when the data gap for shallow monitoring is filled as described in **Section 6**.

Section 9 Plan Implementation

Estimated Cost to Implement the GSP

The estimated total cost to the ECC GSP Working Group[11] over the first five years of GSP implementation is between $2.6 and 3.1 million. Costs are based on best available estimates. These costs include public outreach, monitoring and well maintenance, data management, and GSP reporting (e.g., annual and 5-year updates). Individual member agencies will continue to fund individual projects and/or management actions and monitoring activities. The budget will be adjusted over time as the GSP implementation costs are better understood through sustainable management activities and guidance from DWR on the submitted GSP and subsequent reporting.

Implementation of the projects will be borne by the project proponents.

Funding Sources and Mechanisms

GSA implementation costs will be paid for through contributions from the member GSAs and CCWD under a cost-sharing arrangement to be developed following GSP adoption. Grant funding will be pursued when available.

Schedule for Implementation

Figure ES-3 provides a projected schedule for ECC GSP implementation including outreach and communication, monitoring, and GSP reporting activities.

[11] ECC GSP Working Group consists of the seven GSAs and Contra Costa Water District.

Figure ES-3 GSP Implementation Schedule

Task Name	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Plan Implementation																					
GSP Submittal to DWR	x																				
Joint Implementation Agreement			x																		
Outreach and Communication																					
Monitoring and DMS																					
GSP Reporting																					
Annual Reports	x	x	x	x	x		x	x	x	x		x	x	x	x		x	x	x	x	
5-year GSP Evaluation Reports						x					x					x					x

x Indicates a submittal.
Indicates ongoing event.

Section 10 Notice and Communication

Development of the ECC GSP was a collaborative effort among the ECC GSP Working Group (seven GSAs and CCWD), technical consultants, community members, and stakeholders. The Working Group conducted over 40 meetings, from 2018 to 2021. Documents posted to a publicly accessible website, Working Group meeting notes, surveys, newspaper notices, and direct email outreach were used to keep the public informed of the GSP development and provide opportunities for public input.

The Working Group members also provided regular updates through individual agency public meetings and websites. Information was also provided through social media by those agencies with a presence on such platforms. Three public workshops, held between July 2020 and September 2021, were used to inform and engage beneficial users of groundwater in the ECC Subbasin and discuss each section of the GSP. Stakeholder comments were incorporated into the final GSP.

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1. INTRODUCTION

1.1. Background

1.1.1. Purpose of the Groundwater Sustainability Plan

The Sustainable Groundwater Management Act (SGMA), effective January 1, 2015, established a framework of priorities and requirements to facilitate sustainable groundwater management throughout California. The intent of the SGMA mandate is for groundwater to be managed by local public agencies (Groundwater Sustainability Agencies [GSAs]) to ensure a groundwater basin is operated within its sustainable yield through the development and implementation of a Groundwater Sustainability Plan (GSP or Plan).

1.1.2. Sustainability Goal

Each GSP must include a sustainability goal for the basin to manage groundwater in a manner that avoids undesirable results within 20 years of the statutory deadline (i.e., by or before January 31, 2042).

"Undesirable result means one or more of the following effects caused by groundwater conditions occurring throughout the basin" (Water Code §10721.x):

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.*

As required by SGMA regulations, the ECC GSAs developed a sustainability goal for the Subbasin that is described in detail in **Section 7**.

Definitions for terms used in SGMA from the California Water Code 10721 and the California Code of Regulations Title 23 351 are included in **Appendix 1a**.

1.1.3. Description of the East Contra Costa Subbasin

The original boundary of the Tracy Groundwater Subbasin included the jurisdiction of multiple cities and the counties of Contra Costa and San Joaquin. To streamline the development of the required GSP, the GSAs in Contra Costa and San Joaquin Counties, on September 6, 2018 applied to the State to divide the Tracy Subbasin along the border of Contra Costa and San Joaquin Counties. Dividing a groundwater basin is known as a Basin Boundary Modification or BBM. This allows the GSAs in each County to develop their own GSP under the Act. On February 11, 2019, the Department of Water Resources approved dividing the

Tracy Subbasin into two subbasins (e.g., East Contra Costa Subbasin and the new Tracy Subbasin) thereby creating a separate groundwater basin entirely within Contra Costa County.

The East Contra Costa Subbasin (ECC Subbasin), also referred to as San Joaquin Valley-East Contra Costa (5-022.19), is a medium priority groundwater basin based on the Groundwater Basin Prioritization by the State Department of Water Resources (DWR) (**Figure 1-1**). Under SGMA, medium priority subbasins must submit an adopted GSP by January 31, 2022. The ECC Subbasin's boundaries are generally defined by the San Joaquin River on the north, Old River on the East, the Contra Costa County boundary on the south, and the non-water bearing geologic units on the west. As mentioned above, the ECC Subbasin is contained entirely within Contra Costa County and underlies all or portions of the Cities of Antioch, Oakley, Brentwood, the Town of Discovery Bay and the communities of Bethel Island, Byron and Knightsen.

1.2. Agency Information

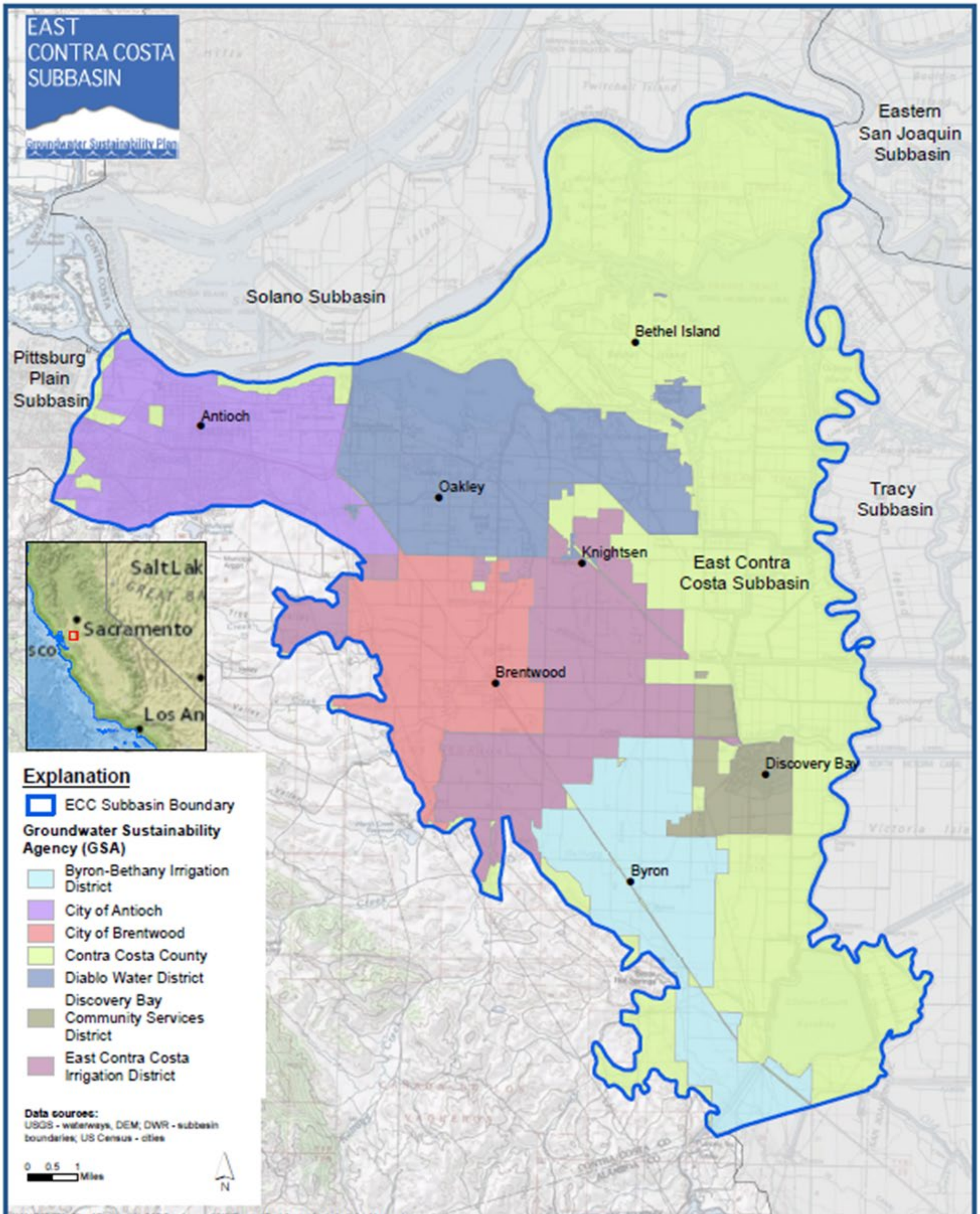
1.2.1. GSAs in East Contra Costa Subbasin

In the East Contra Costa Subbasin, eight agencies are working together in developing the GSP. The agencies include:

- Byron Bethany Irrigation District (BBID)
- City of Antioch
- City of Brentwood
- Contra Costa County (CCC)
- Contra Costa Water District (CCWD)
- Diablo Water District (DWD)
- Discovery Bay Community Services District (DBCSD or TODB)
- East Contra Costa Irrigation District (ECCID)

SGMA authorizes a "local public agency that has water supply, water management, or land use responsibilities within a groundwater subbasin or basin to elect to become a GSA and to develop, adopt, and implement a GSP (Water Code § 10721(n).)" All agencies listed above became GSAs with the exception of CCWD. CCWD is a water district that provides surface water to entities within their service area. Surface water may play a part in future management of a groundwater basin and so CCWD is an equal partner in the development of the ECC GSP. On May 9, 2017, the eight agencies entered a Memorandum of Understanding (MOU). Under this MOU the agencies share costs and management of the development and implementation of the GSP. In addition, the MOU was updated with the subbasin name change as a result of the BBM in March 2020 when the eight agencies signed an updated MOU to develop a GSP (**Appendix 1b**).

Prior to the basin boundary modification, the Tracy Subbasin was successful in obtaining one million dollars in Proposition 1 Round 2 grant funds for GSP development. After the BBM, the ECC and Tracy Subbasins split the grant funding to prepare a GSP for each of the two subbasins. On October 24, 2019, San Joaquin County and the City of Brentwood signed an agreement for the management of the grant funds. In addition, the ECC Subbasin received Proposition 68 Round 3 funding.



East Contra Costa Subbasin, GSAs, and Adjacent Subbasins

Figure 1-1

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

1.2.2. Agency Names and Mailing Addresses

As per California Water Code §10723.8, the following contact information is provided for each GSA.

City of Brentwood GSA (**Plan Manager**)
Attention: Water Operations Manager Public Works Operations
James Wolfe
2201 Elkins Way
Brentwood CA, 94513-7344
jwolfe@brentwoodca.gov
925.516.6025

Byron Bethany Irrigation District
Attention: Assistant General Manager
7995 Bruns Road
Byron, CA 94514-1625

City of Antioch GSA
Attention: Project Manager
200 H Street
Antioch, CA 94509

Contra Costa County GSA
Attention: Manager, Contra Costa County Water Agency
30 Muir Road
Martinez, CA 94553

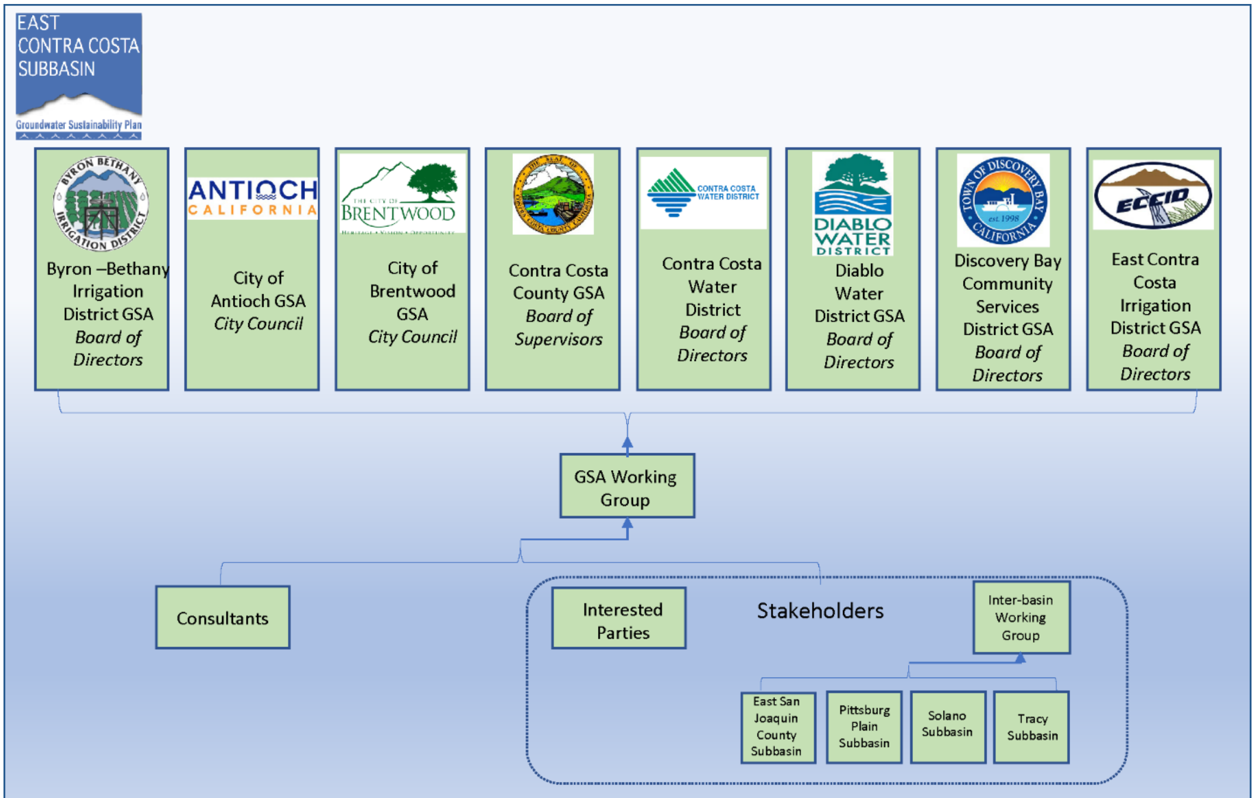
Diablo Water District GSA
Attention: General Manager
P.O. Box 127
87 Carol Lane
Oakley, CA 94561

Discovery Bay Community Services District GSA
Attention: General Manager
1800 Willow Lake Road
Discovery Bay, CA 94505-9376

East Contra Costa Irrigation District GSA
Attention: General Manager
1711 Sellers Avenue
Brentwood, CA 94513

1.2.3. Agencies' Organization, Management Structure, and Legal Authority of the GSAs and CCWD

The seven (7) GSAs that cover the ECC Subbasin and participate in the development and administration of the GSP each have their own organization and management structure and legal authority as described below. Prior to becoming a GSA, each entity submitted notifications to DWR as outlined in Water Code §10723.8. GSA boundaries are shown in **Figure 1-1,** and the ECC Subbasin management structure is shown in **Figure 1-2**. The GSA Working Group is made up of GSA representatives plus a representative from CCWD that meet monthly to coordinate GSP development. The organization and management structure for the seven GSAs and CCWD (an equal partner and financial contributor) are described below.



Management Structure, ECC Subbasin
East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California
Figure 1-2

1.2.3.1. City of Brentwood GSA (Plan Manager)

The City of Brentwood GSA operates within its current city organization and management structure as a General Law City. Government Code section 36501 authorizes general law cities be governed by a city council of five members (Mayor, Vice Mayor, and three Council Members). Bentwood's GSA activities are staffed through the City's Public Works Department and one member attends the monthly GSA Working Group meeting that coordinates GSP activities. The person with management authority for implementation of the Plan is the City Manager or designee.

1.2.3.2. Byron-Bethany Irrigation District GSA

Byron-Bethany Irrigation District GSA operates within its current organization and management structure under its seven-member Board of Directors and its legal authority as a multi-county special district, operating under Division 11 of the California Water Code. It was originally created to deliver raw, agricultural water to area farmers. The District elected to serve as the GSA for the portion of BBID that is situated within the boundaries of the ECC Subbasin. A portion of BBID is also within the adjacent Tracy Subbasin. The General Manager sits on the GSA Working Group that coordinates ECC Subbasin GSP activities. The person with management authority for implementation of the Plan is the District's General Manager.

1.2.3.3. City of Antioch GSA

The City of Antioch GSA operates within its current organization and management structure as a General Law City under its current City Council that consists of five members. Its legal authority is described in the City ordinances, and it abides by state codes. The GSA activities are staffed through the City's Capital Improvements Division. The Project Manager of the Capital Improvements Division sits on the GSA Working Group that coordinates ECC Subbasin GSP activities. The person with management authority for implementation of the Plan is the City Manager or designee.

1.2.3.4. Contra Costa County GSA

The Contra Costa County GSA operates within its current organization and management structure by a five-member Board of Supervisors as well as its legal authority set forth in the Sustainable Groundwater Management Act, California Water Code section 10720, et seq. The GSA activities are staffed through the Contra Costa County Water Agency and one member sits on the monthly GSA Working Group meeting that coordinates GSP activities. The person with management authority for implementation of the Plan is the director of the Department of Conservation and Development.

1.2.3.5. Contra Costa Water District

Contra Costa Water District is not a GSA but is an equal partner and financial contributor to the development of the ECC GSP through the District's execution of the ECC MOU.

1.2.3.6. Diablo Water District GSA

The Diablo Water District GSA operates within its current organization and management structure by a five-member Board of Directors as well as its legal authority as a special district. The General Manager and staff operate the District following policies set by the Board. The General Manager and Manager of Water Operations sit on the GSA Working Group that coordinates ECC Subbasin GSP activities. The person with management authority for implementation of the Plan is the General Manager.

1.2.3.7. Discovery Bay Community Services District GSA

The Town of Discovery Bay GSA operates within its current organization and management structure as a California Independent Community Services District and is governed by a five-member Board of Directors, as well as legal authority as a special district. The District's General Manager is tasked to carry out the policy decisions of the Board and oversee day-to-day operations. The General Manager sits on the GSA Working Group that coordinates ECC Subbasin GSP activities. The person with management authority for implementation of the Plan is the General Manager.

1.2.3.8. East Contra Costa Irrigation District GSA

The East Contra Costa Irrigation District GSA operates within its current organization and management structure under a five-member Board of Directors representing five Divisions within the District as well as legal authority as a special district. The General Manager sits on the GSA Working Group that coordinates ECC Subbasin GSP activities. The person with management authority for implementation of the Plan is the General Manager.

1.2.4. Governance Structure

Figure 1-1 shows the extent of the GSP area (the entire ECC Subbasin) and each of the seven GSA jurisdictional boundaries. The following powers and authorities are granted to GSAs to implement the GSP in accordance with the requirements of California Water Code § 10725 *et seq:*

- Adopt standards for measuring and reporting water use
- Adopt rules, regulations, policies and procedures to govern the adoption and implementation of the GSP, as authorized by SGMA including funding of the GSA, and the collection of fees or charges as may be applicable
- Develop and implement conservation best management practices
- Develop and implement metering, monitoring and reporting related to groundwater pumping
- Hire consultants as determined necessary or appropriate by the GSA
- Prepare a budget

1.2.4.1. Memorandum of Understanding for GSP Development

As mentioned above, the seven GSAs and CCWD entered into a MOU on May 9, 2017. The purpose of the MOU was to collaborate to develop a single GSP for the ECC Subbasin and for each GSA to consider adopting and implementing the GSP within its GSA management area. The term of the MOU is until January 31, 2022 when the GSP is due to DWR. An updated MOU was required as a result of the BBM resulting in the new subbasin name. An updated MOU was signed on March 2020 (**Appendix 1b**).

1.2.4.2. Description of Initial Notification

The first step in preparing a GSP is notifying DWR of the intent to develop a GSP. In February 2018, the City of Brentwood submitted an Initial Notification to prepare a GSP for the Tracy Subbasin. Although the new ECC Subbasin was formed on February 2019, the ECC GSP development efforts continued from February 12, 2018 (when the Tracy Subbasin Initial Notification was submitted). The initial Notification to DWR is posted on the DWR website: https://sgma.water.ca.gov/portal/gsp/init/all.

1.3. Report Organization and Elements Guide

This Report will be organized into the following sections:

Section 1: Introduction

Section 2: Plan Area

Section 3: Basin Setting

Section 4: Historical, Current, and Projected Water Supplies

Section 5: Water Budget

Section 6: Monitoring Network and Data management System

Section 7: Sustainable Management Criteria

Section 8: Projects and Management Actions

Section 9: Plan Implementation

Section 10: Notice and Communication

DWR has provided the Elements Guide[1] that lists information required to be included in a GSP by the Sustainable Groundwater Management Act and the Groundwater Sustainability Plan Emergency Regulations. It is a cross reference to where this information can be found in the GSP (e.g., page number, figure number, and/or table number).

[1] Source: https://sgma.water.ca.gov/portal/resources: Printable Elements Guide Excel Template

1.4. References

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2 PLAN AREA

2.1 Description of Plan Area

2.1.1 Summary of Jurisdictional Areas and Other Features (§354.8 a and b)

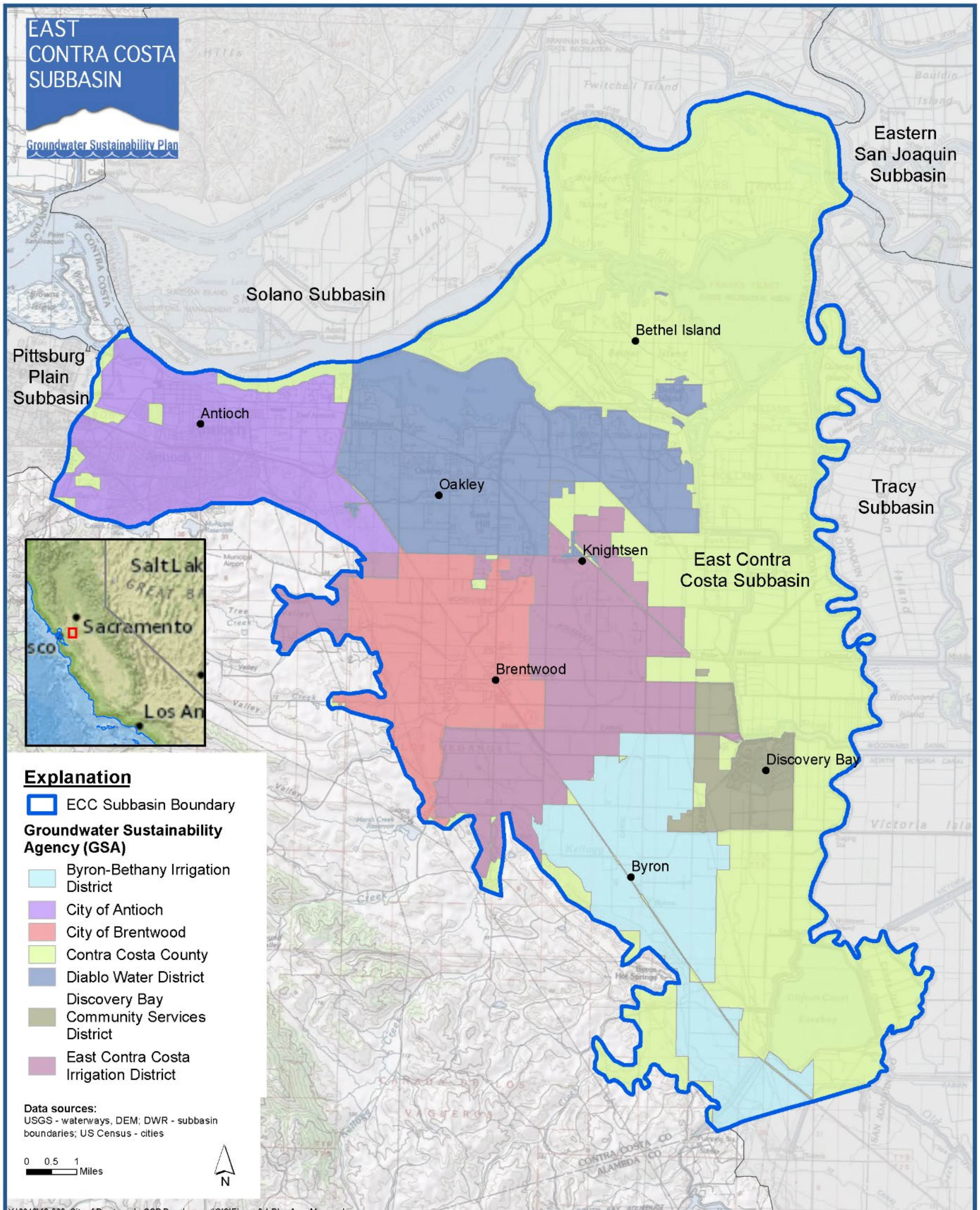
The ECC Subbasin (Subbasin) covers a 168 square mile area (107,596 acres) in the eastern portion of Contra Costa County, spans 18 miles from north to south and ranges from four to 13 miles from east to west, and includes seven communities: Antioch, Bethel Island, Byron, Brentwood, the Town of Discovery Bay (TODB), Knightsen, and Oakley. Three (Antioch, Brentwood and Oakley) are incorporated cities, Discovery Bay is a California Community Services District, Bethel Island is a Special Act District created by the California State legislature (1960) and named the Bethel Island Municipal Improvement District, the remaining two (Byron, and Knightsen) are census designated places. The Subbasin lies within the northwestern portion of the larger San Joaquin Valley Groundwater Basin. The Subbasin is bound by the Coast Range to the west and other groundwater subbasins to the northwest (Pittsburg Plain, DWR Subbasin 2-004), north (Solano Subbasin, DWR Subbasin 5-021.66), northeast (Eastern San Joaquin Basin, DWR Subbasin 5-022.01), and to the south and east (Tracy Subbasin, DWR Subbasin 5-022.15) (**Figure 2-1**). All adjacent subbasins are required to submit a GSP with the exception of Pittsburg Plain Subbasin (due to a "Very Low" basin prioritization that does not require a GSP to be completed).

2.1.1.1 Adjudicated Areas and Areas Covered by an Alternative GSP

This GSP covers the entire ECC Subbasin and is managed by seven exclusive GSAs (**Figure 2-1**). There are no known adjudicated areas within the ECC Subbasin or any areas covered by an Alternative GSP.

2.1.1.2 Cities and County Jurisdictions

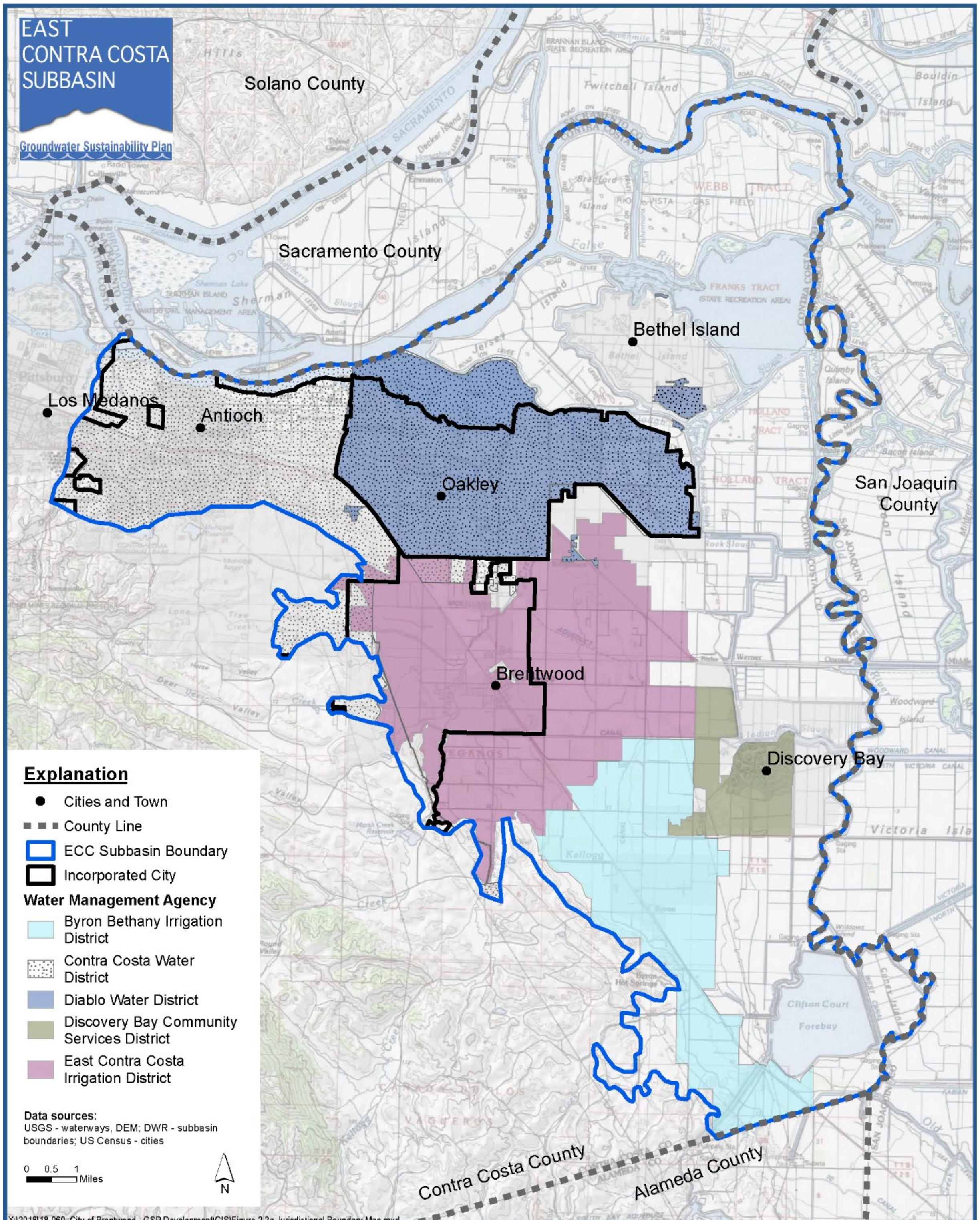
Figure 2-2a shows city and county boundaries, and agencies with water management responsibilities. Apart from GSAs in the Subbasin, no other agencies have direct authority over groundwater, though Contra Costa County permits and regulates wells and septic systems throughout the Subbasin, including the cities, pursuant to Contra Costa County Ordinance code. Contra Costa Water District (CCWD) is a public water entity in Contra Costa County (County) but with no direct authority over groundwater within the Subbasin. Each City regulates land use within their city and the County regulates land use in the unincorporated areas of the Subbasin.



East Contra Costa Subbasin, and Adjacent Subbasins

Figure 2-1

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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Jurisidictional Boundaries, Cities, Counties and Agencies with Water Management Responsibilities

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-2a

2.1.1.3 Water Agency Jurisdictions and the East County Regional Water Management Association

The water agencies in East Contra Costa County are listed below with a description of their authorities and responsibilities. Each of the GSAs in the Subbasin belong to the East County Regional Water Management Association, in some capacity. Because of this association there is a long history of collaboration in water management decisions in the region. **Table 2-1** outlines the thirteen agencies joined together to form the Regional Water Management Group and their primary function (IRWMP, 2015). Seven of those members are GSAs, and they are described in more detail below.

Table 2-1. Regional Water Management Group Members and Primary Function[1]

Member Agency	Water Supply/ Quality	Wastewater	Recycled	Stormwater/ Flood Management	Watershed/ Habitat
City of Antioch	X	X	X	X	X
City of Brentwood	X	X	X	X	X
Byron-Bethany Irrigation District	X	X[2]			
Contra Costa County Flood Control				X	X
Contra Costa County		X		X	X
Contra Costa Resource Conservation District	X				X
Contra Costa Water District	X				X
Delta Diablo		X	X		
Diablo Water District	X				
Discovery Bay Community Services District	X	X		X	
East Contra Costa County Habitat Conservancy	X				X
East Contra Costa Irrigation District	X				
Ironhouse Sanitary District		X	X		

[1] Source: 2015 IRWM Plan Update

[2] BBID provides management services and operations and maintenance support to the Byron Sanitary District, which provides wastewater and sewer services to Byron residents.

City of Antioch

The City of Antioch is a public water purveyor that provides water to a population of approximately 108,000 (in 2015) within the service area (WYA, 2016); however, the City's total service area extends outside the Subbasin. Surface water is the City's only source of water supply and includes (for 2015, WYA, 2016): 1. surface water purchased from CCWD (12,000-acre feet per year [AFY]) 2. surface water diverted from the San Joaquin River through the City's intake (1,200 AFY), 3. Recycled water from Delta Diablo (50 AFY). Surface water is stored in a municipal reservoir and treated at the Antioch Water Treatment Plant. Recycled water is used to irrigate four parks and its municipal golf course. The City does not use groundwater for water supply, nor does it expect to use groundwater by the year 2040 (WYA, 2016).

City of Brentwood

The City of Brentwood is a public water purveyor that provides water to a population of over 56,000 within the service area (B&C, 2016). The City's service area within the Subbasin is a subset of its total service area. The City's annual supply includes: 1. surface water purchased from CCWD (4,720 AFY pumped to the Randall Bold Water Treatment Plant (RBWTP) from the Rock Slough intake via the Contra Costa Canal), 2. groundwater from seven active wells with a capacity of 7,000 AFY), 3. surface water from ECCID (entitlement of 14,800 AFY pumped from Rock Slough through the Contra Costa Canal for treatment at the City of Brentwood Water Treatment Plant [COBWTP]) (B&C, 2016). In drought years, the City relies upon groundwater more than in normal years.

Byron-Bethany Irrigation District (BBID)

BBID provides agricultural water to southeastern CCC. It is a public agency governed by an elected board of directors and was established for the purpose of providing water to the lands within Alameda County, Contra Costa and San Joaquin Counties. In 2012, BBID served 5,663 acres within CCC and delivered 18,484 AF of water (IRWIM, 2015). In 2014, CCWD began coordination with BBID to install an intertie between Byron Division Canal 45 and the CCWD Old River pipeline. This will facilitate water transfers with CCWD and/or storage of BBID water in the Los Vaqueros Reservoir for later use in the northern portions of the Byron Division. By July 2015, a portion of the project had been implemented. In 2015, 214 AF of groundwater from growers' wells was used to supplement surface water during the drought. Though some private pumping occurs, landowners predominantly rely on surface water allocation in the Byron and Bethany Divisions (AWMP, 2015).

Contra Costa Water District (CCWD)

The CCWD was formed in 1936 to provide water for irrigation and industry. It is currently one of California's largest urban water districts that provides untreated and treated water to municipal, residential, commercial, industrial, landscape irrigation, and agricultural customers. It draws its water from the Delta primarily under a contract with the federal Central Valley Project (CVP). CCWD manages the Los Vaqueros Reservoir. The Contra Costa Canal is the backbone of CCWD conveyance system that was originally owned by the U.S. Bureau of Reclamation (USBR). CCWD is currently taking ownership of the Canal (expected by 2022) and will continue to operate and maintain the facility. Water is supplied to the canal from Rock Slough as well as from Old and Middle Rivers via pipelines. One of CCWD's two water treatment plants is located in the Subbasin (e.g., RBWTP in Oakley [jointly with DWD]). CCWD supplies water to the Cities of Antioch and Brentwood and Diablo Water District.

Diablo Water District (DWD)

DWD was established in 1953 to provide water to customers in downtown Oakley and now serves the City of Oakley, the Town of Knightsen, and some of Bethel Island. It serves a population of about 42,000 people in a 21 square mile area (e.g., Oakley, Cypress Corridor, Hotchkiss Tract, and Summer Lakes, Bethel Island, and Knightsen). The majority (about 80% per CDM Smith, 2016) of water delivered is surface water supplied by CCWD and treated in RBWTP[1] (owned jointly with CCWD). Two municipal wells supplement DWD's surface water source providing about 2,000 AFY (CDM Smith, 2016).

East Contra Costa Irrigation District (ECCID)

ECCID is an independent special district established in 1926 to provide agricultural irrigation water to properties within ECCID (IRWM, 2019). ECCID boundaries include the City of Brentwood, and portions of the Cities of Oakley and Antioch and the unincorporated community of Knightsen. ECCID has a 1912 appropriative right to divert water from Indian Slough on Old River and also operates nine groundwater wells (IRWM, 2019*).* In 2012, ECCID pumped about 330 AF of groundwater.

Town of Discovery Bay Community Services District (TODB)

The TODB was formed in 1998 to provide over 15,000 residents with water, treatment, distribution, and storage. All the water supply is from six groundwater supply wells (IRWM, 2019) pumping about 3,000 AFY.

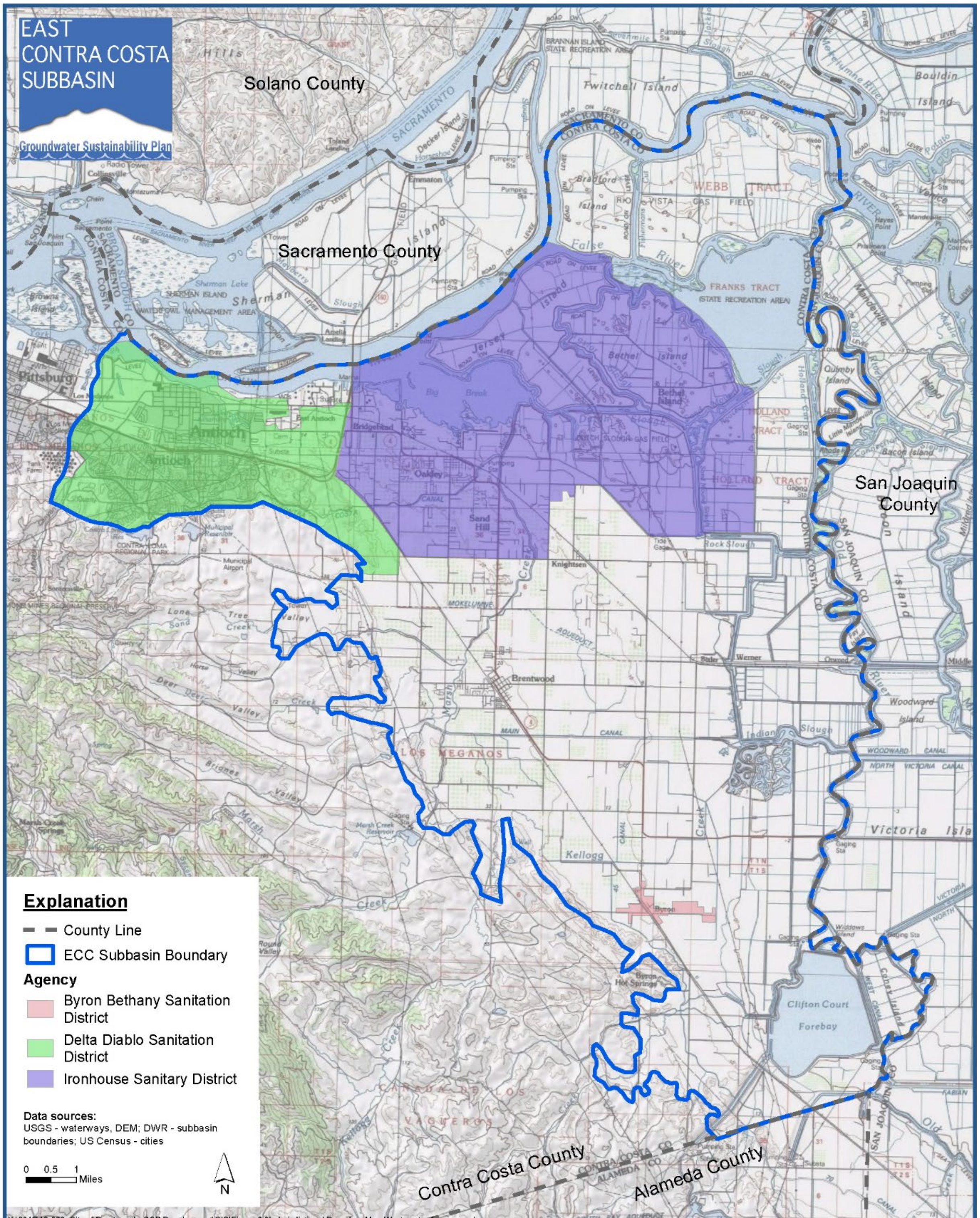
Other Agencies

Ironhouse Sanitary District (ISD) maintains sanitary services for nearly 30,000 customers in the Oakley and Bethel Island area (**Figure 2-2b**). Water is treated at its facility in Oakley California and recycled water is spread on its 3,600-acre Jersey Island fields, which are used for grazing of cattle. In addition, the fields are used for wildlife and habitat for waterfowl. ISD processes 4,800 AFY of recycled water and half is spread on ISD fields near the Oakley facility on Jersey Island to water hay fields and the other half is released into the San Joaquin River (SJR).

Delta Diablo (DD) District provides wastewater treatment and recycled water production for the City of Antioch, Bay Point and Pittsburg, however, only the City of Antioch is in the Subbasin. It treats 15,000 AFY of water (2016) and releases the treated water into New York Slough. It provides about 9,000 AFY of recycled water (treated domestic wastewater used more than once) used for cooling two power generating plants and irrigation of two golf courses and 12 city parks in the DD service area (**Figure 2-2b**).

Bethel Island Municipal Improvement District (BIMID) is responsible for maintaining levees and drainage on Bethel Island but also has the authority to create and maintain parks and playgrounds https://bimid.com/about-bimid/).

[1] Randall Bold Water Treatment Plant



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Jurisdictional Boundaries,Wastewater Agencies

Figure 2-2b

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Byron Sanitary District[2] encompasses the unincorporated community of Byron and serves a population of 800. It is an independent special district with a five-member board of directors, and a General Manager. The wastewater treatment and disposal facility is located on 30 acres of land with 8 acres of evaporation ponds and 10 acres irrigated with treated effluent.

Small Water Systems

Small water systems and mutual water companies supply drinking water to communities between 2 and 199 service connections; or serve 25 or more people at least 60 days per year (days/yr). Three areas in the Subbasin (Bethel Island [twelve systems], Oakley [six systems], and Byron [four systems]) have small community water systems (15 to 199 service connections) that rely on groundwater as the only water supply source (IRWM, 2019, pg 2-31). Small community water systems are regulated by Contra Costa Environmental Health[3].

2.1.1.4 Federal, State, Tribal, and Special District Jurisdictions

Other entities have authority and responsibilities within the Subbasin that need to be considered when developing a GSP. **Figure 2-3** shows Federal-owned and state-owned lands and the agency with jurisdiction over the land. Dutch Slough (managed by DWR) is 1,187 acres of land that is being transformed into tidal marsh to provide habitat for salmon and other native fish and wildlife. In addition, the map includes lands owned and managed by East Bay Regional Park District (a special district) that preserves natural and cultural resources in Alameda and Contra Costa Counties.

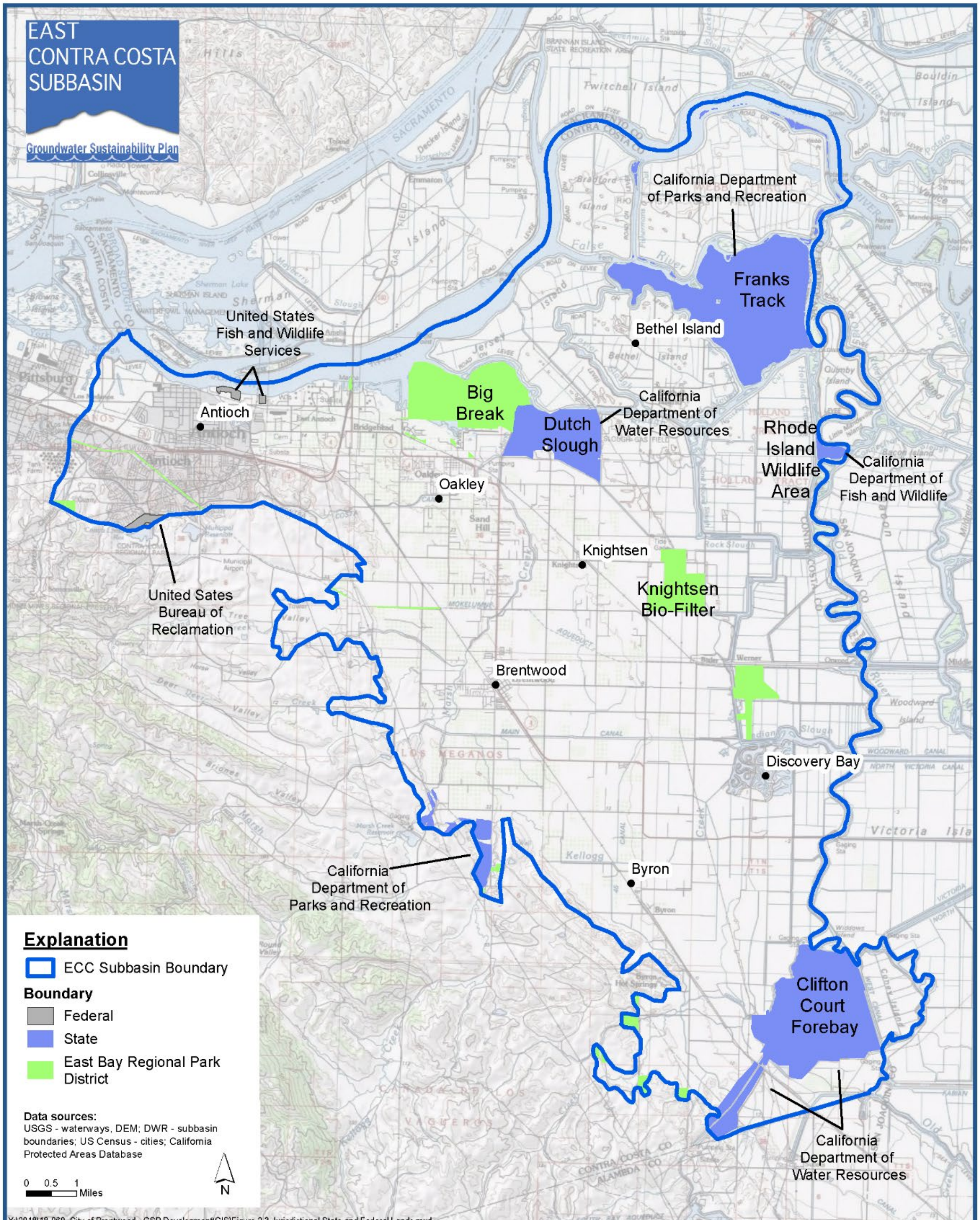
There are no known federally designated tribal lands or tribes in the Subbasin. The Sonoma Northwest Information Center (NWIC) (Sonoma State) searched for sacred lands, and none were found in the area. The Native American Heritage Commission (NAHC) record search returned no information for the Subbasin. NAHC further recommended contacting individual tribal leaders and provided a list of seven people for the GSAs to contact. On April 18, 2019, a separate email was sent to each person recommended by NAHC requesting information on whether there was knowledge of sacred lands in the vicinity of the Subbasin, followed by a phone call. To date, we received no responses identifying federally designated tribal lands in the East Contra Costa Subbasin.

2.1.1.5 Major Water Related Infrastructure

Major water-related infrastructure in the Subbasin **Figure 2-4** is relied upon by multiple cities, water agencies and private water users. These facilities deliver supplies to GSA members and to the State Water Project (SWP) including the California Aqueduct and the Delta Mendota Canal.

[2] Source: https://contracostasda.specialdistrict.org/byron-sanitary-district-3715f00

[3] In addition to small community water systems listed above there are also Local Small Water Systems (2-4 connections), State Small Water Systems (5-14 connections), as well as non-community public water systems all regulated by Contra Costa Environment Health.



X:\2018\18-060 City of Brentwood - GSP Development\GIS\Figure 2.3 Jurisdictional State and Federal Lands.mxd

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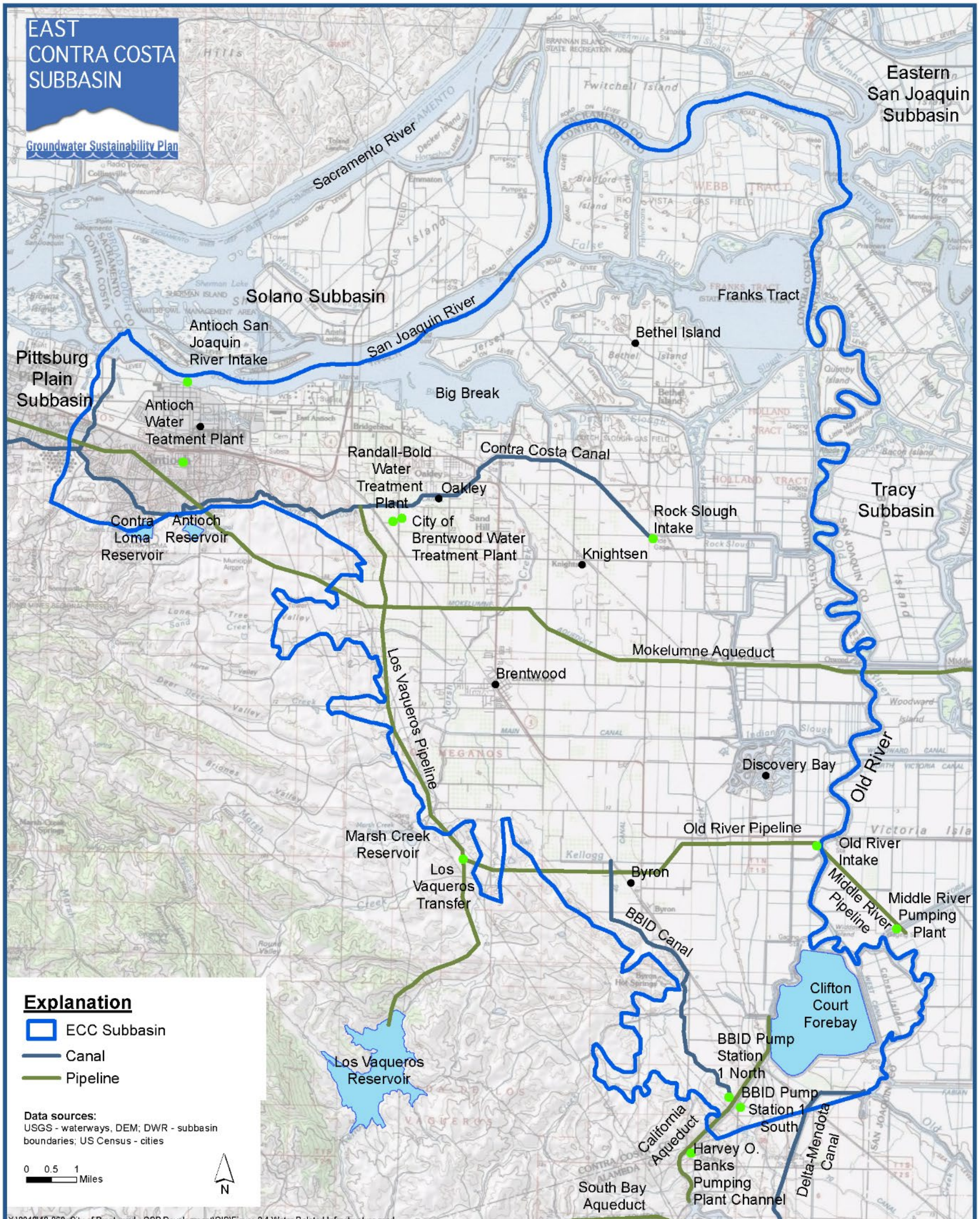
Jurisdictional Boundaries, State, Federal Lands, and Special Districts

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-3



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Water Related Infrastructure

Figure 2-4

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Contra Costa Water District Facilities

The Contra Costa Water District facilities in the ECC Subbasin are shown on **Figure 2-4.** CCWD jointly owns RBWTP with DWD which has been operated by CCWD since the plant came online in 1992. Raw water is conveyed to the RBWTP from the Rock Slough intake via the Contra Costa Canal (operated by CCWD) as well as from the Old River and Middle River intakes via pipelines. Water can be stored in the Los Vaqueros Reservoir from the Old River and Middle River intakes during periods of low salinity (winter and spring) in the Delta. It is then later used (late summer and early fall) to blend with raw water from the Rock Slough intake when high salinity conditions are experienced in the Delta. Surface water supplies for the City of Brentwood originate from Rock Slough. The supply is transported through the Contra Costa Canal for treatment at the City of Brentwood Water Treatment Plant (COBWTP). CCWD supplies water to the City of Antioch from diversions at the Middle River (Victoria Canal), Rock Slough, and Old River. The Los Vaqueros Reservoir Phase 2 Expansion project would increase capacity from 160,000 to 275,000-acre feet and is scheduled for completion by 2027. This expansion will improve water supply reliability while protecting Delta fisheries.

Byron-Bethany Irrigation District Facilities

BBID service area is both within the ECC Subbasin (Byron Division) and in the Tracy Subbasin (Bethany Division, raw water service area (RWSA) 1 and 2, and CVP Service Area). The water supply distribution system for the Byron, Bethany Divisions and RWSA1 includes pump stations on the intake channel at the Harvey O. Banks Pumping Plant (**Figure 2-4**). BBID Pump 1 diverts the District's pre-1914 water supply north to the Byron Division and south to the Bethany Division and RWSA 1.

State Water Project (SWP)

Clifton Court Forebay is part of the SWP and serves as the starting point of the California Aqueduct, which delivers water to Southern California. In addition, it provides water via the Delta-Mendota Canal to the San Joaquin Valley. The Harvey O. Banks Pumping Plant at Clifton Court Forebay lifts the water from the Delta into the California Aqueduct (**Figure 2-4**). Eleven pumps at the Banks Pumping Plant (2.5 miles southwest of Clifton Court Forebay) pull water from Old River. This water has been diverted from the Sacramento River near Walnut Grove (via Delta Cross Channel and Snodgrass Slough) to the Mokelumne River into the SJR and then south up Old River.

2.1.1.6 Sacramento-San Joaquin River Delta (the Delta)

The Sacramento-San Joaquin Delta is the center of California's water supply, providing fresh water to the majority of the state's population and to millings of acres of farmland. It is the largest estuary on the West Coast and provides critical habitat to fish and wildlife species. The East Contra Costa Groundwater Subbasin is located on the southwestern part of the Delta. The Delta is a 1,300 square mile area where the Sacramento, San Joaquin, and Mokelumne Rivers come together that was once a tule marsh. In the mid to late 1800s and early 1900s, settlers installed a levee system that formed many of the islands. When the islands were dewatered for agricultural development, land subsidence resulted from oxidation of organic soils, some Delta Islands in the Subbasin have lowered more than 15 feet in response to peat oxidation (not related to groundwater extraction). Problems facing the delta are compounding because subsiding delta islands and rising sea levels would increase pressure on the levees and rising sea level would and push salt water further into the delta.

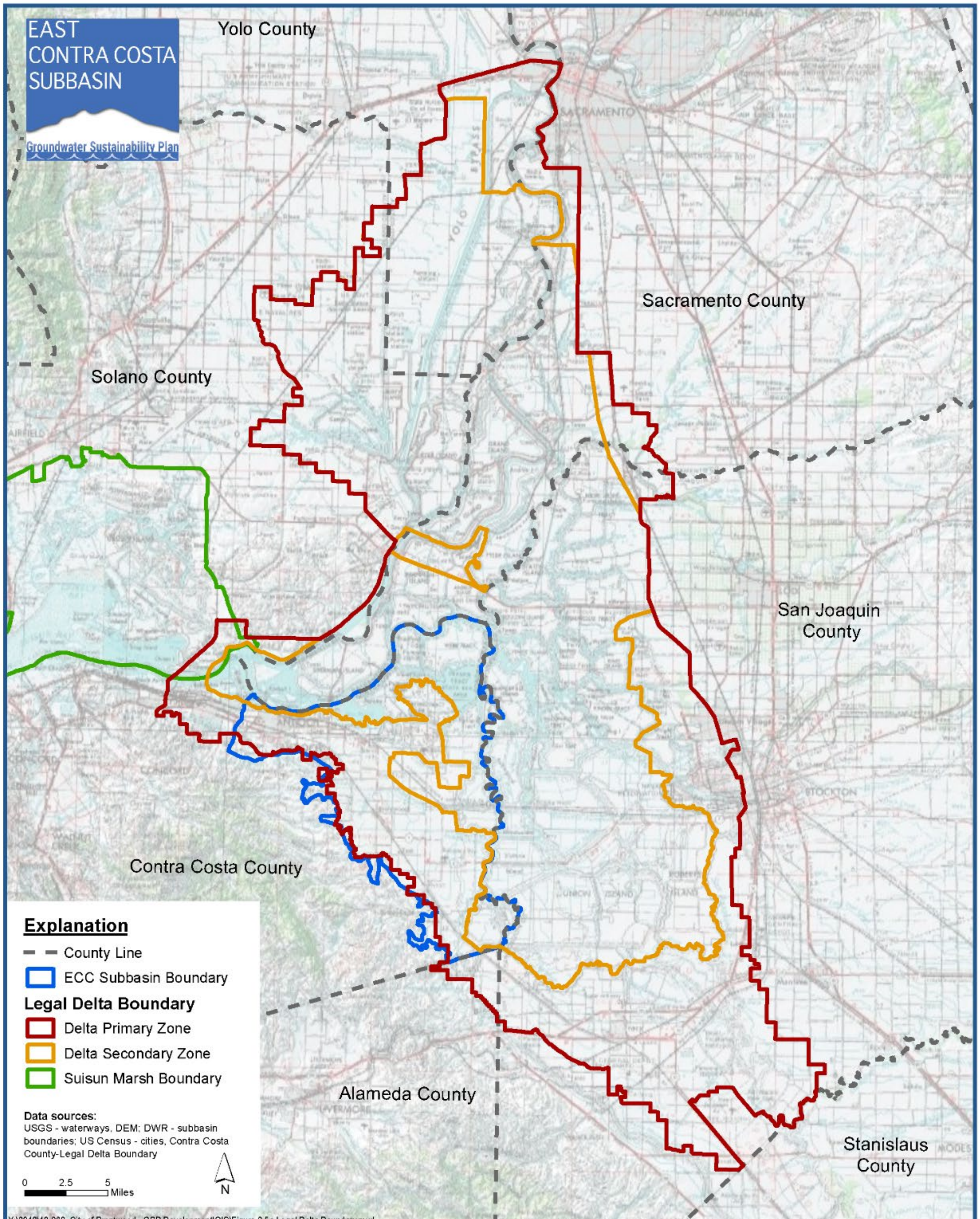
The Delta is composed of three zones. The Primary Zone is the center of the Delta (**Figure 2-5a, b**), the largest zone (490,050 acres) and is primarily rural farmland but includes a few small towns[4]. The Secondary Zone includes 247,320 acres of farmland and cities and suburbs. The third area (Suisun Marsh) is northwest of the Primary Zone and not discussed in this section. Two state agencies have land use jurisdiction in the Delta: Delta Stewardship Council described in the Delta Plan, 2013, and the Delta Protection Commission (DPC). The Council and the DPC have concurrent jurisdiction in the Delta's Primary Zone to ensure that local land use planning is consistent with their own laws and plans.

About two-thirds of the islands and tracts in the Sacramento-San Joaquin Delta are below sea level and are surrounded by levees that protect the land from floods and high tides. There are more than 1,100 miles of levees in the delta contracted to protect farmland. The predominant land use of the islands in the ECC Subbasin is agriculture with a small population of farm workers. Agencies with responsibilities for levee maintenance and drainage systems in the Subbasin include: BIMID, RD 2024 (Orwood and Palm Tracts), RD 2025 (Holland Tract), RD 2026 (Webb Tract), RD 2059 (Bradford Island), RD 2065 (Veale Tract), RD 2090 (Quimby Island), RD 2121 (Bixler Tract), RD 2137 (Dutch Slough Restoration Project site), RD 799 (Hotchkiss Tract, planned residential development and ecological restoration project), RD 800 (Byron Tract and Discovery Bay), RD 830 (Jersey Island owned by ISD and recycled water used to grow hay).

2.1.2 Density of Wells

The density of different well types provides a general distribution of agricultural, industrial and domestic well users and identify communities dependent on groundwater; another tool to understand groundwater use in the Subbasin. Well data and well construction information were obtained from DWR's well completion report database, ECC pumping records, and from DWR's Well Completion Report Map Application (DWR, 2019). DWR Well Completions Report Map Application is an interactive mapping tool that displays submitted well completions reports. DWR categorizes wells in the mapping application as either domestic, production and public supply, and this database was used to create **Figures 2-6a**, **b**, and **c**. **Figure 2-6a** illustrates the well density of domestic wells by each Public Land Survey System (PLSS) township-range and section (typically a 1-mile by 1-mile square grid). This map indicates that the highest density of domestic wells occurs along an east-west swath between Knightsen and Brentwood, as well as near Byron. The domestic wells are considered de minimis extractors, pumping less than two AF annually and would collectively pump less than 2,000 AFY. **Figure 2-6b** illustrates the well density of production wells per square mile and shows the highest density of these types of wells to be located in the vicinity of Oakley, Knightsen, and Brentwood, with others located in the Town of Discovery Bay and Byron. DWR defines "production wells" as "those wells that are designated as irrigation, municipal, public, or industrial on Well Completion Reports". **Figure 2-6c** illustrates the well density of public supply wells, with the highest density of public supply wells occurring in the Town of Discovery Bay. The DWR database allows the wells to be filtered for planned use and wells with the designation of Irrigation-Agriculture are illustrated on **Figure 2-6d** with the highest density of these wells om the Knightsen/Oakley area.

[4] The Delta Plan, Ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value.



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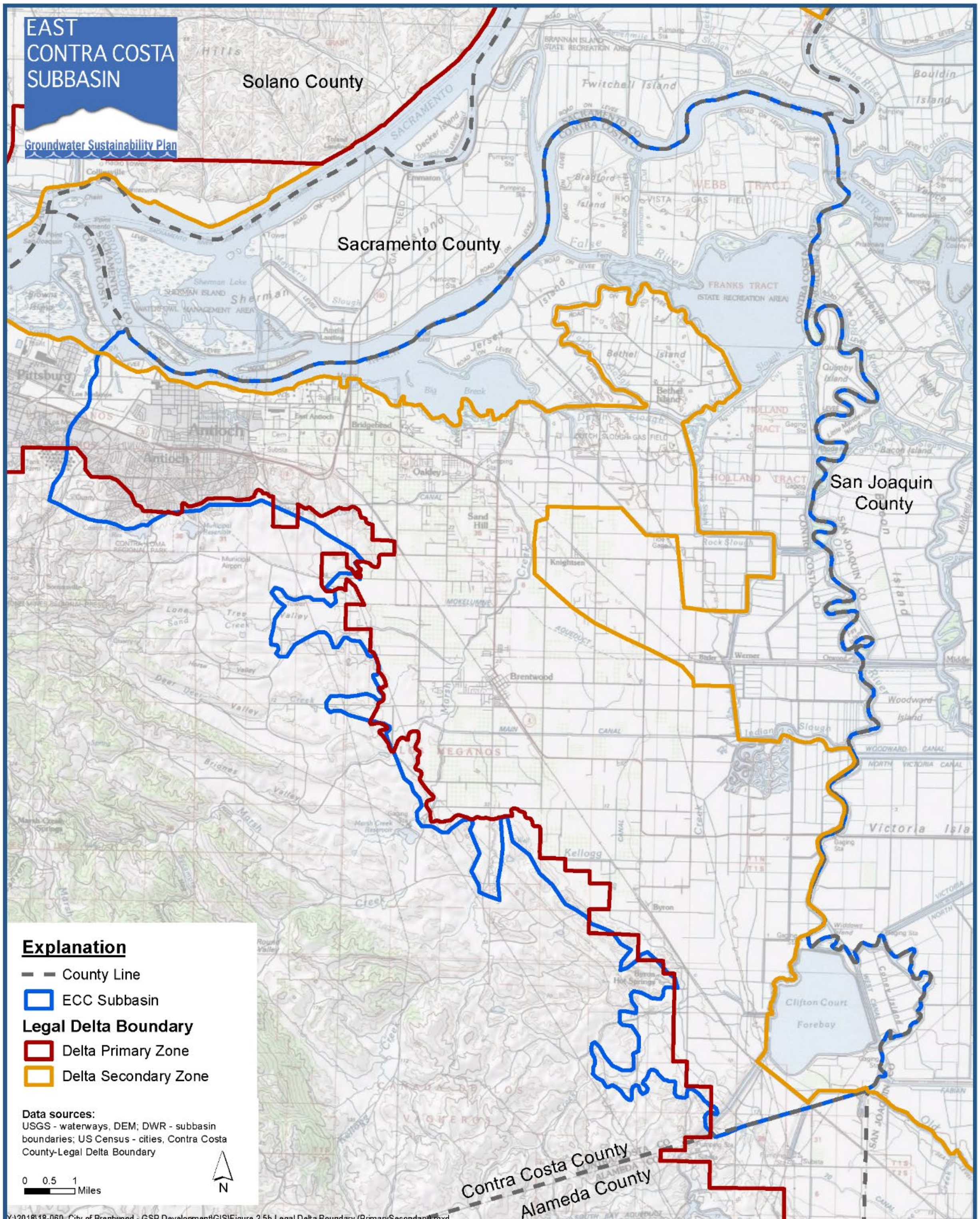
Legal Delta Boundary

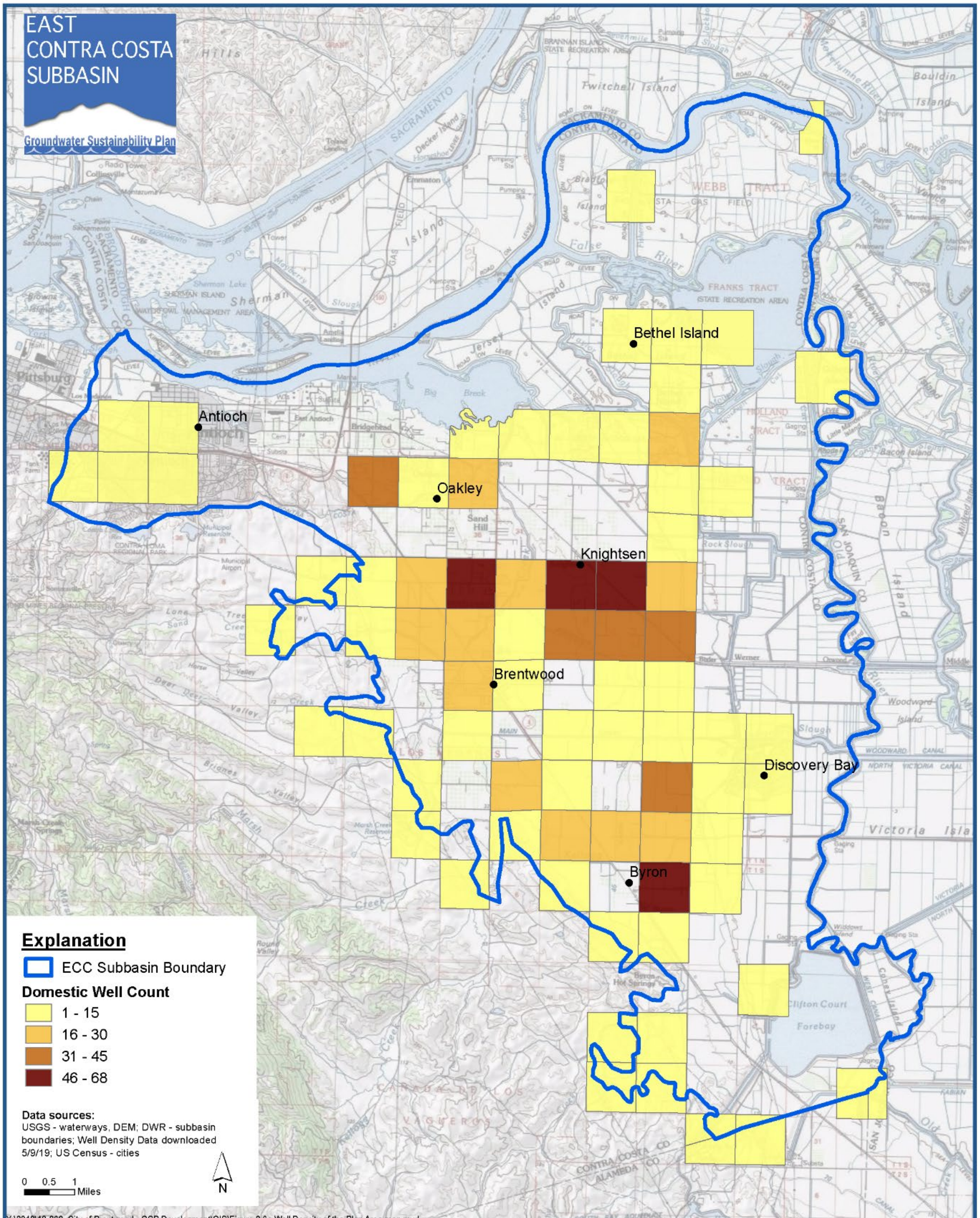
East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-5a



Legal Delta Boundary- Primary and Secondary Zones **Figure 2-5b**

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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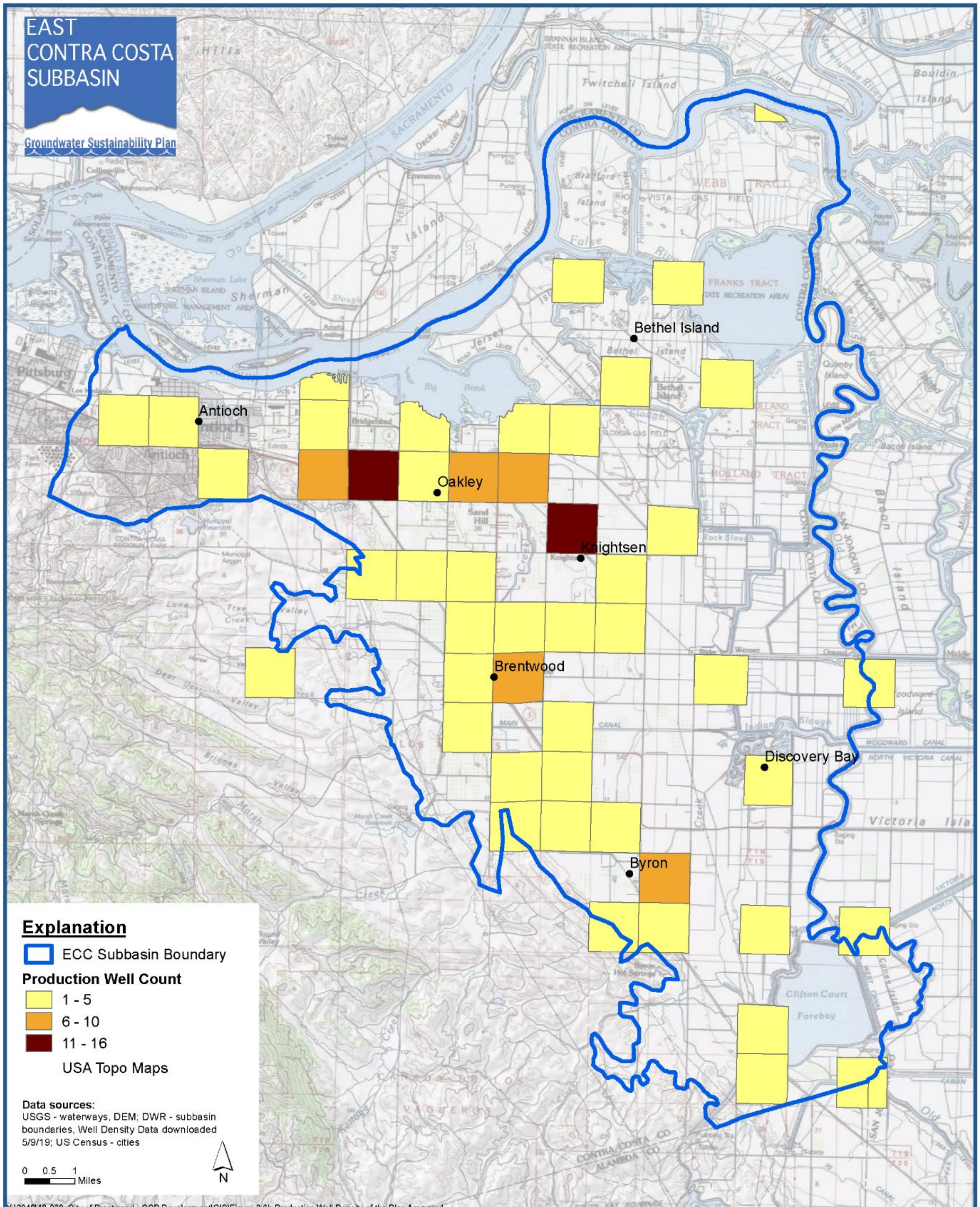
Domestic Well Density per Square Mile

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-6a



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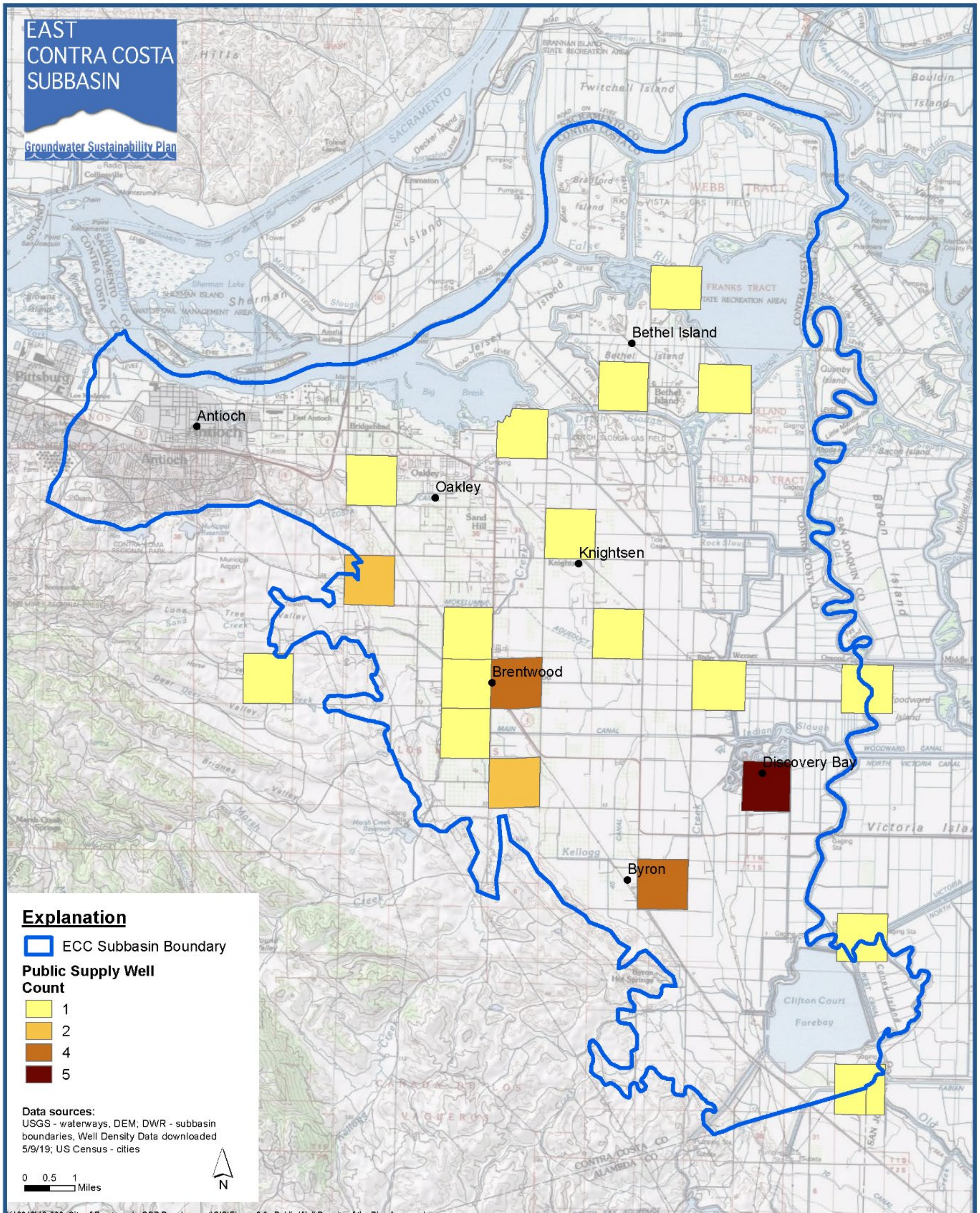
Production Well Density per Square Mile

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-6b



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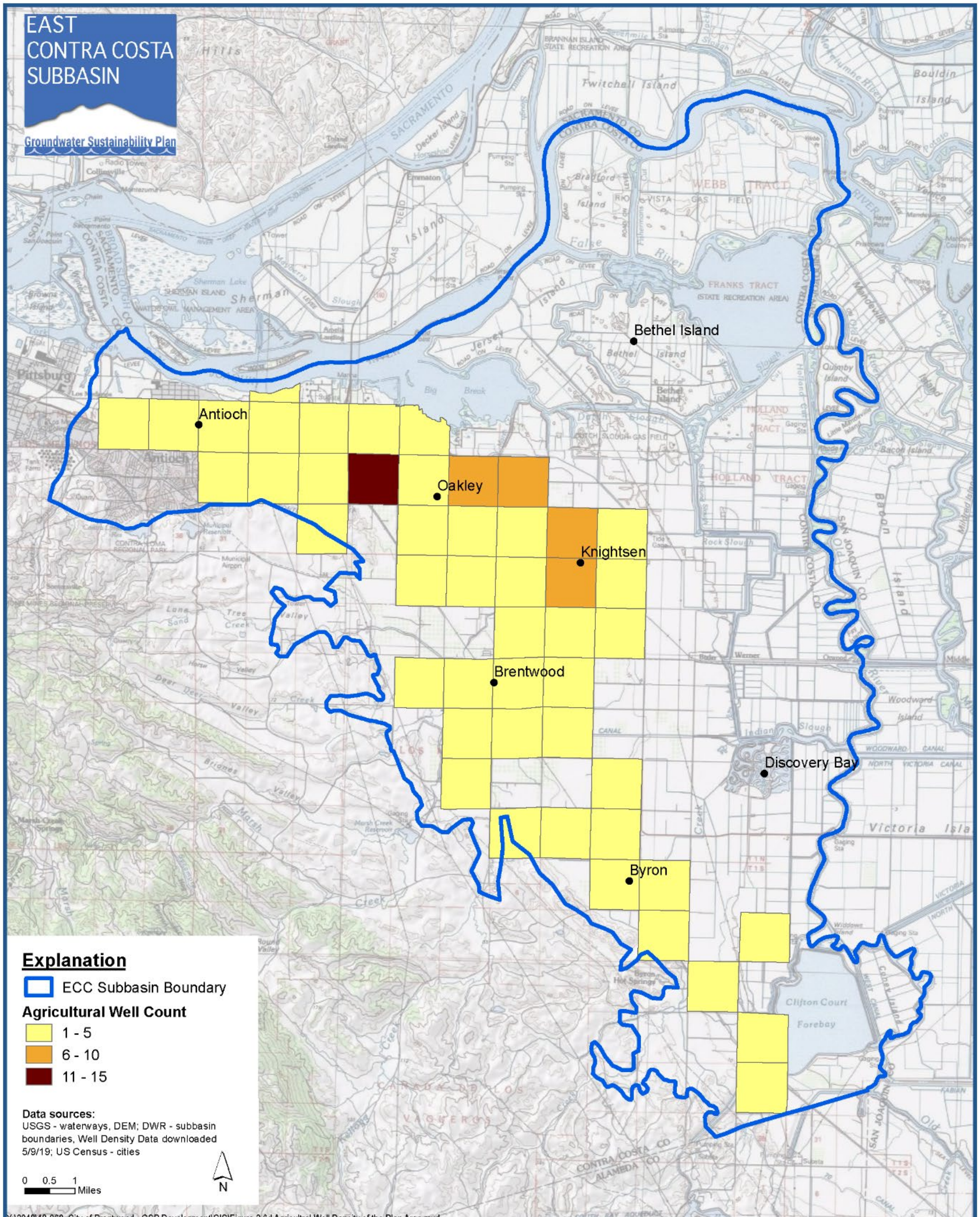
Public Supply Well Density per Square Mile

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-6c



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Agricultural Well Density per Square Mile

Figure 2-6d

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

The DWR well completion database contains over 5,000 wells historically drilled in the Subbasin. The DWR mapping application estimates the number of wells in ECC at approximately 1,180 wells. The difference between the two sources is thought to be due to wells that are inactive or destroyed. **Table 2-2** summarizes well types by use for the wells in the DWR Well Completion Report Map Application. Based on DWR's map application, the estimated well density ranges from approximately 1 to 68 wells per square mile, but as stated above, there are uncertainties associated with the DWR well coverage that may double count wells and/or include missing and incorrect values.

Table 2-2. Types of Wells[1]

Type of Well	Total Wells
Domestic	975
Production	156
Public Supply	51
Agricultural	136
TOTAL	**1,182**

[1]DWR SGMA Data Viewer – Well Reports Statistics in ECC Subbasin; downloaded on May 9, 2019

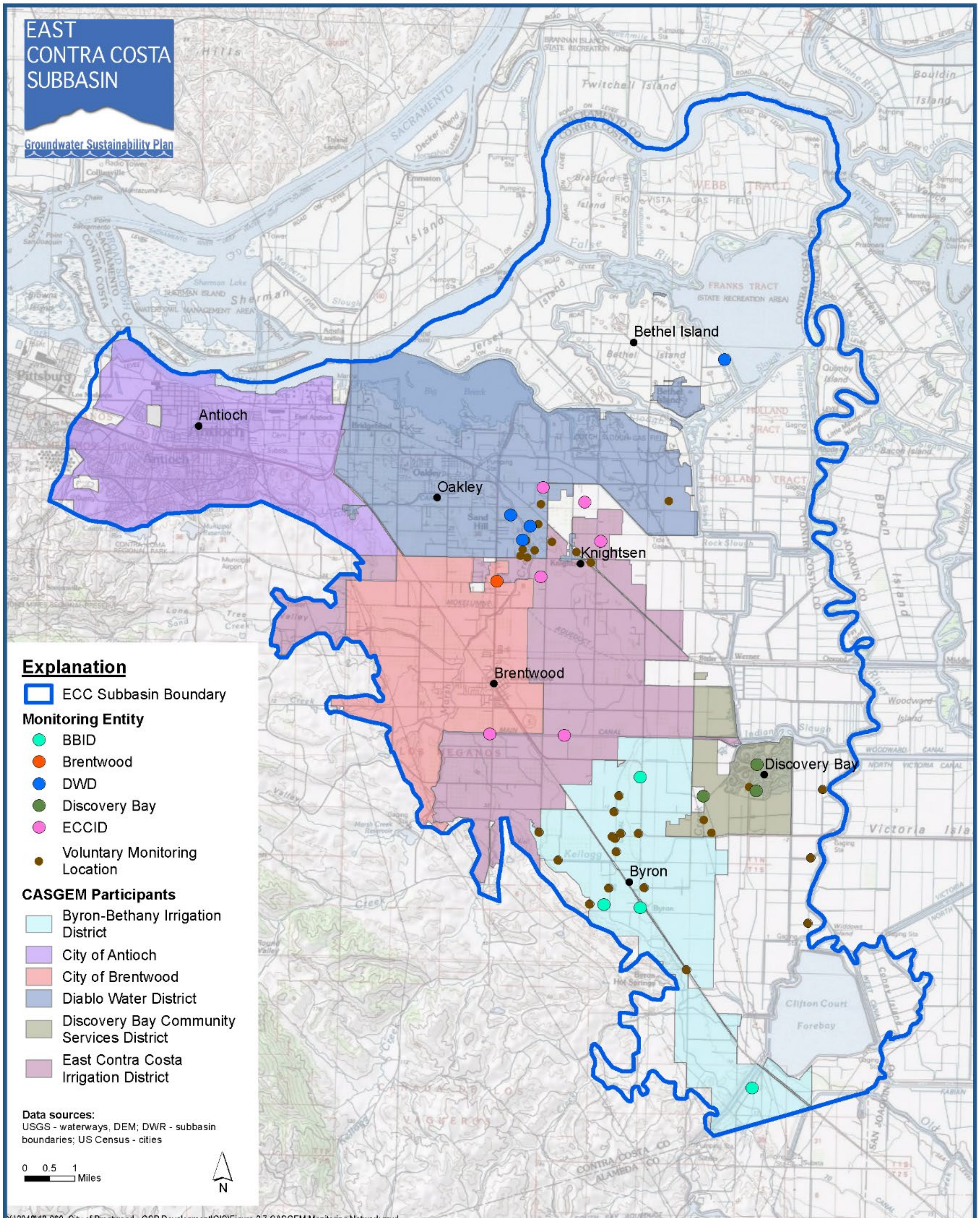
2.2 Water Resources Monitoring and Management Programs[5] (10727G) (§354.8c, d, and e)

2.2.1 CASGEM and Historical Groundwater Level Monitoring

The East Contra Costa County California Statewide Groundwater Elevation Monitoring (CASGEM) Network tracks seasonal and long-term groundwater level trends. The ECC CASGEM Network began in 2011 and is managed by DWD; it was updated in 2014 and updated again in 2018. **Figure 2-7** displays the CASGEM network of 27 wells by monitoring entity. In addition, BBID, DWD, ECCID, and TODB voluntarily share groundwater depth data for over an additional 20 wells. Once the GSP is implemented it will replace the CASGEM Monitoring Plan. The GSP monitoring well groundwater levels will be entered into the SGMA Monitoring Network Module (MNM) instead of CASGEM. However, voluntary or non-SGMA wells data will still upload the CASGEM Operating System.

Historically, groundwater levels have been monitored by various agencies since the 1950s. Numerous reports were prepared to evaluate these data and groundwater conditions in the basin and include: An Initial investigation of Ground Water Resources (LSCE, 1999) that serves as a baseline for future groundwater conditions reports, DWD Groundwater Management Plan (GMP) (LSCE, 2007), and Groundwater Quality Monitoring Plan (GQMP) (LSCE, 2018).

[5] It is not clear at this time how these programs will change with the development and implementation of the GSPs.



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ECC CASGEM Monitoring Network

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-7

2.2.2 Department of Water Resources (DWR) and EWM

DWR takes annual measurements (spring and fall) in three wells in the ECC Subbasin that are included in the Subbasin CASGEM well network. In addition, DWR manages the EWM (it used to be called the Water Data Library and then CASGEM). The EWM includes historical groundwater level measurements since the early 1900s and periodic water quality data.

2.2.3 Groundwater Ambient Monitoring and Assessment Program (GAMA)

As part of the GAMA program, the State Water Resources Control Board (SWRCB) collects data from water agencies and private well owners and makes it available to the public. The data aide interpretation of groundwater quality and monitoring efforts.

2.2.4 GeoTracker

The SWRCB provides data for sites that have impacted water quality including groundwater. These records contain not only general mineral and contaminated constituent concentrations but also groundwater levels.

2.2.5 California Division of Drinking Water (DDW)

Formerly the Department of Health Services, DDW is a division of the SWRCB that regulates public drinking water systems. They asses the quality of the drinking water and identify specific water quality problems. Public water system (PWS) wells are to meet Title 22 water quality requirements and DDW provides these PWS data to the public.

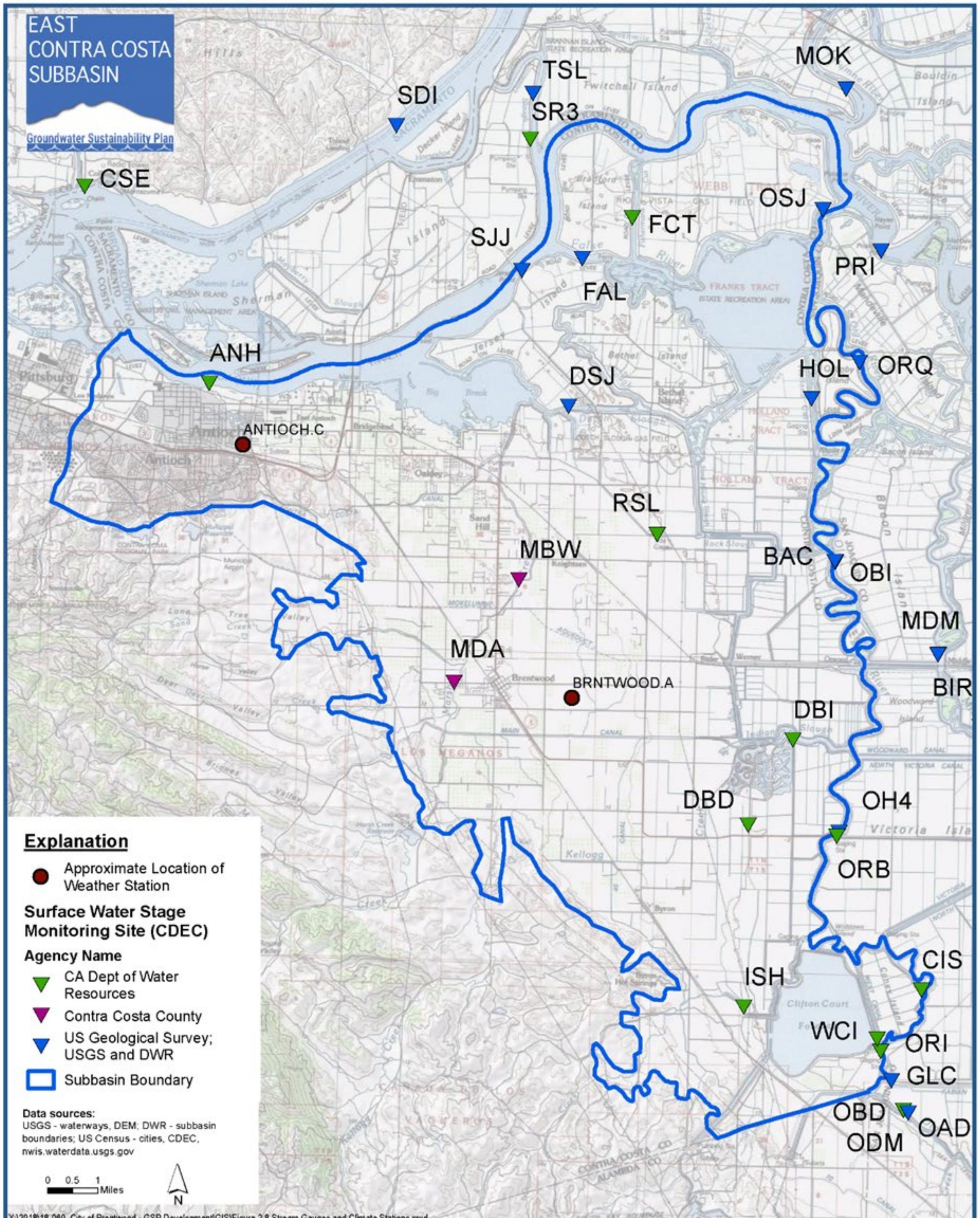
2.2.6 U.S. Geological Survey (USGS)

USGS monitors wells for water levels and water quality generally for special projects (i.e., not on a regular monitoring schedule). The USGS makes the data available for public on the National Water Information System (NWIS) website. The USGS maintains a series of stream gauges in the vicinity of the Subbasin. Fifteen of the USGS stream gauges have historical data and are currently active in the Subbasin (**Figure 2-8**).

2.2.7 Subsidence Monitoring

Subsidence monitoring in the Subbasin consists of a Continuous Global Positioning System (CGPS) station managed by the Plate Boundary Observatory/UNAVCO. These stations were generally constructed to monitor motions caused by plate tectonics, but they are also used for other applications (e.g., assessing subsidence). UNAVCO GPS (P256) is located in the ECC Subbasin with measurements starting in 2005.

Additional subsidence monitoring in adjacent subbasins includes DWR Surveying/spirit leveling (Solano and Yolo Subbasin), USGS Interferometric Synthetic-Aperture Radar (InSAR) (Delta-Mendota Subbasin), and an extensometer in the Yolo Subbasin.



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Stream Gauges and Climate Stations

Figure 2-8

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

2.2.8 Climate Monitoring

The locations for two climate stations (Antioch and Brentwood) are shown on **Figure 2-8.** Climate is discussed in more detail in Chapter 5 of the GSP.

2.2.9 Incorporating Existing Monitoring Programs into the GSP

The existing monitoring programs listed above will provide the basis for the GSP monitoring program. Specifically, the CASGEM Network will provide the foundation of groundwater level data, as described in more detail in Chapter 3.3 of this document that describes the GSP Monitoring Program. In addition, the GSP monitoring program will incorporate production well water quality data as well as monitoring data from existing stream gauges.

2.2.10 Limits to Operational Flexibility

The existing monitoring programs are not anticipated to limit the operational flexibility of this GSP. The current groundwater monitoring programs will form the basis of the future GSP monitoring program. This includes some CASGEM wells for water levels, proposed dedicated groundwater monitoring wells (water level and quality), DDW monitoring for water quality and existing subsidence monitoring stations as appropriate. No existing groundwater management or monitoring programs are expected to limit the operational flexibility of the groundwater Subbasin.

2.2.11 Conjunctive Use

The majority of water used in the ECC Subbasin is surface water (e.g., the City of Antioch purchases surface water only from CCWD and has a water right to river diversion water). Conjunctive use programs (coordinated use of surface water and groundwater) in the ECC Subbasin are currently implemented and planned by individual agencies.

CCWD receives its water from the Sacramento-San Joaquin Delta and in recent years it has used Los Vaqueros Reservoir to help improve water quality and as an emergency supply resource (LSCE, 2007).

The City of Brentwood primarily receive surface water deliveries and pump groundwater on an as needed basis.

TODB operates solely on groundwater and has multiple pumping wells in the town’s boundary.

DWD uses 80% surface water (CVP provides water and DWD also purchases surface water) and has the capacity to pump groundwater to meet up to 20% of the demand in its service area.

Both ECCID and BBID are able to operate fully on surface water in nearly all water years. ECCID has groundwater wells in its area to help meet water demands as needed. In 2000, the two agencies entered an agreement with CCWD that allows them to sell water to CCWD during drought years and allows CCWD to purchase a smaller amount in non-drought years (LSCE, 2007).

2.3 Land Use Elements or Topic Categories of Relevant General Plans (§354.8a and f)

Land use is a key factor in determining water demand. Changing land use conditions and irrigation practices are also factors that affect water demand from year to year.

2.3.1 Current and Historical Land Use

General land use conditions based on DWR survey data for CCC are illustrated in **Figures 2-9** through **2-11** and summarized in **Table 2-3** and **Figure 2-12**. The 2015 land use in the Subbasin is mainly agricultural (41%), followed by urban (about 23%), then by water and native vegetation (both about 14%) (source: DWR Crop Mapping Delta 2015 geospatial dataset[6]). The crop types with the highest land use coverage in the Subbasin are pasture (14%) and field crops (12%). Outside of the Subbasin, the existing land use is mainly field crops, truck crops and pasture **(Figure 2-9**) in the delta area.

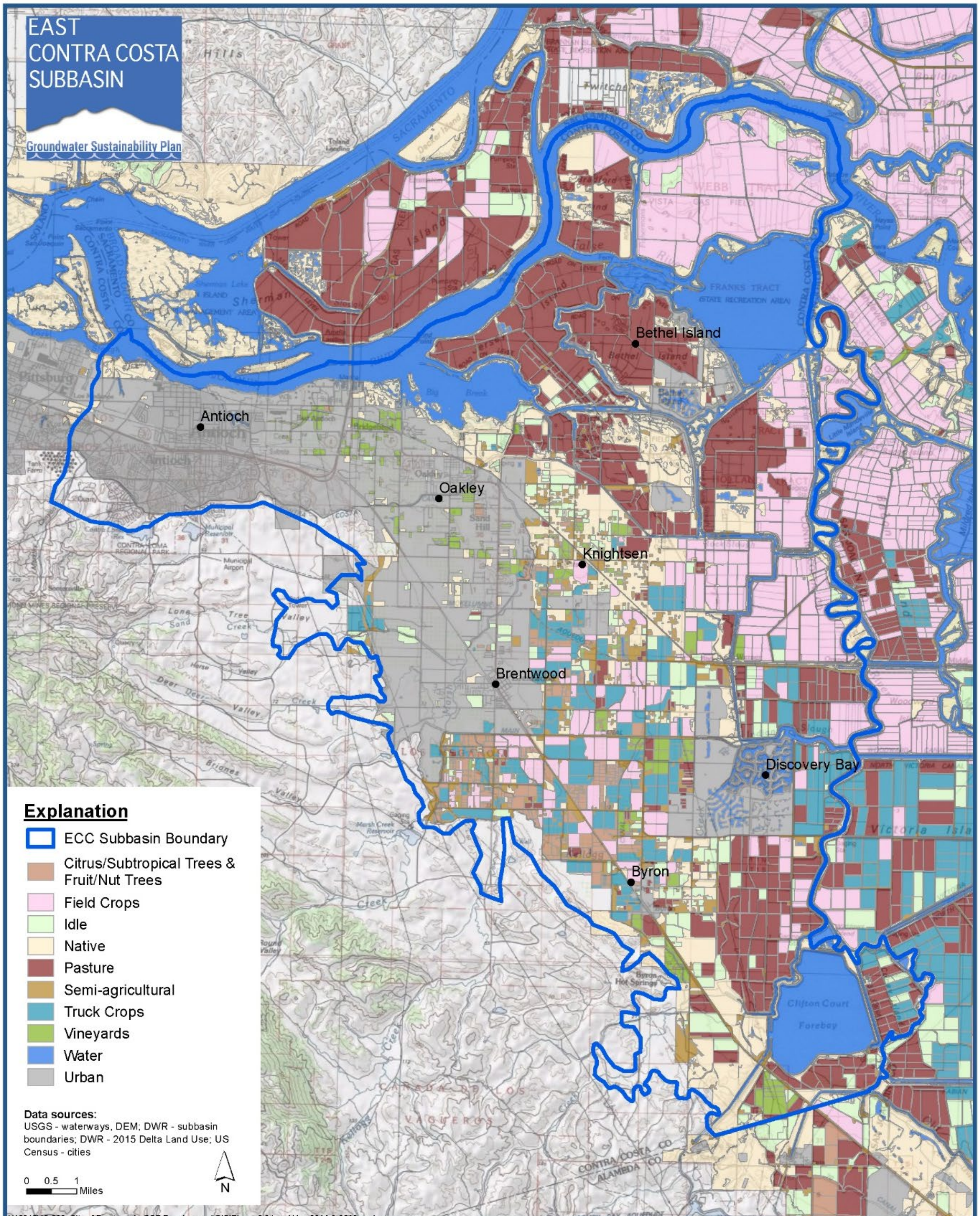
Table 2-3. Land Use Summary

Land Use Designation	1976		1995		2015	
	acres	%	acres	%	acres	%
Field Crops Total[1]	23,153	22%	18,195	17%	13,467	13%
Idle	916	1%	5,754	5%	3,527	3%
Native[2]	25,040	23%	23,400	22%	15,581	15%
Fruit/Nut Trees & Citrus/Subtropical Trees	12,057	11%	6,398	6%	1,947	2%
Pasture	12,979	12%	11,087	10%	14,809	15%
Semi-agricultural[3]	797	1%	868	1%	6,276	6%
Truck Crops	7,747	7%	6,800	6%	5,428	5%
Urban[4]	9,726	9%	19,231	18%	23,523	23%
Vineyards	848	1%	876	1%	1,980	2%
Water	14,368	13%	14,868	14%	14,926	15%
Total[5]	**107,632**	**100%**	**107,477**	**100%**	**101,462**	**100%**

Source and Abbreviations:
California Open Data Portal, https://data.ca.gov/dataset/crop-mapping-delta-2015, accessed June 2019. Also used 2014 data for areas not covered by 2015 mapping.
California Department of Water Resources, https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys, accessed June 2019

1- Includes land designated as Grain and Hay in 1976.
2- Includes land designated as Native, Native Riparian, Native Vegetation.
3-Includes incidental to agricultural, farmsteads, feed lots, dairies, lawns, cemeteries.
4- Includes land designated as Recreation in 1976.
5-Total area differs due to different survey areas monitored. Total about 107,000 acres (168 square miles).
6-1995 and 2015 Surveys have land that was not surveyed and was given "Not Designated" description.

[6] California Open Data Portal, https://data.ca.gov/dataset/crop-mapping-delta-2015, accessed June, 2019.



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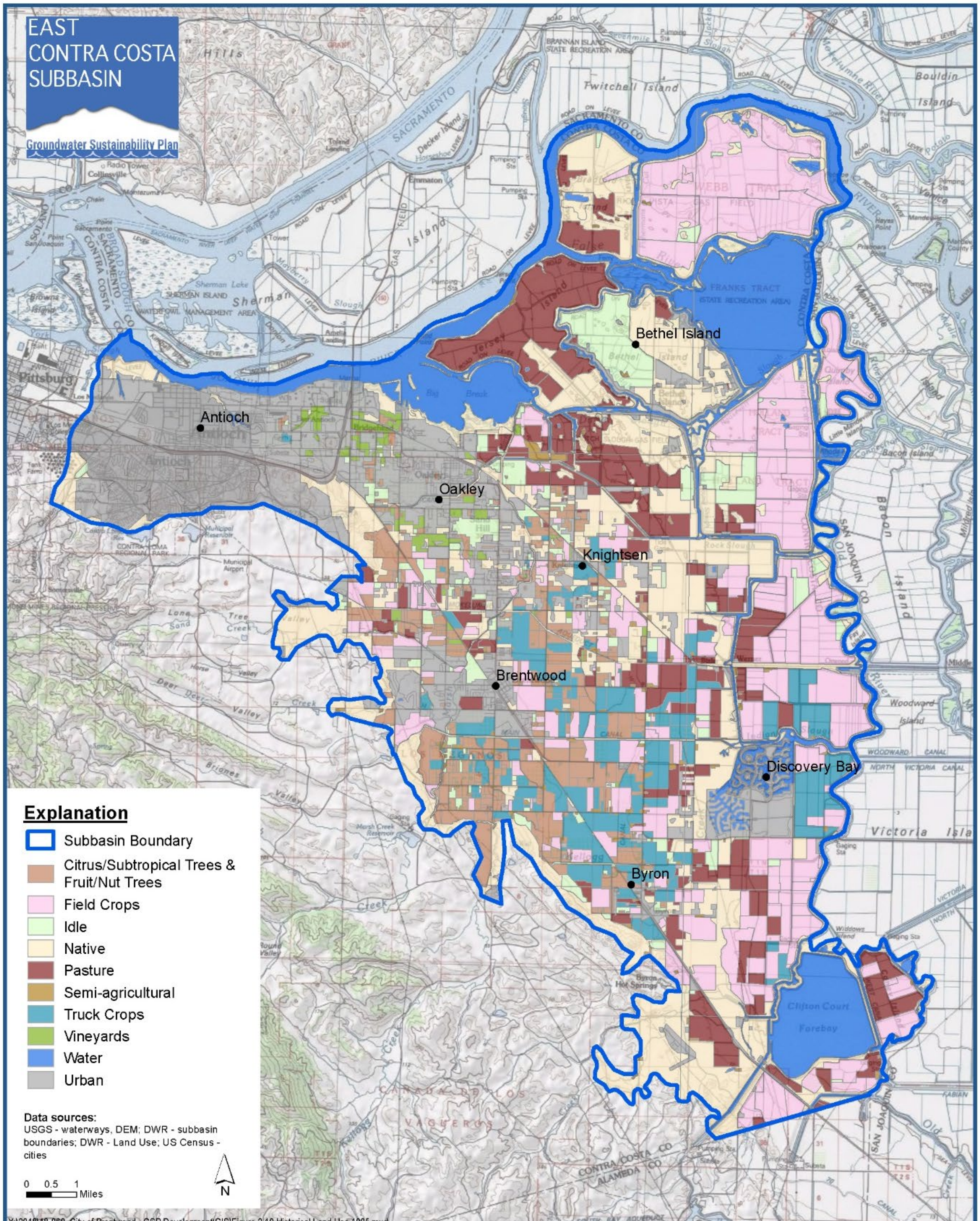
Land Use- 2014 & 2015

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-9



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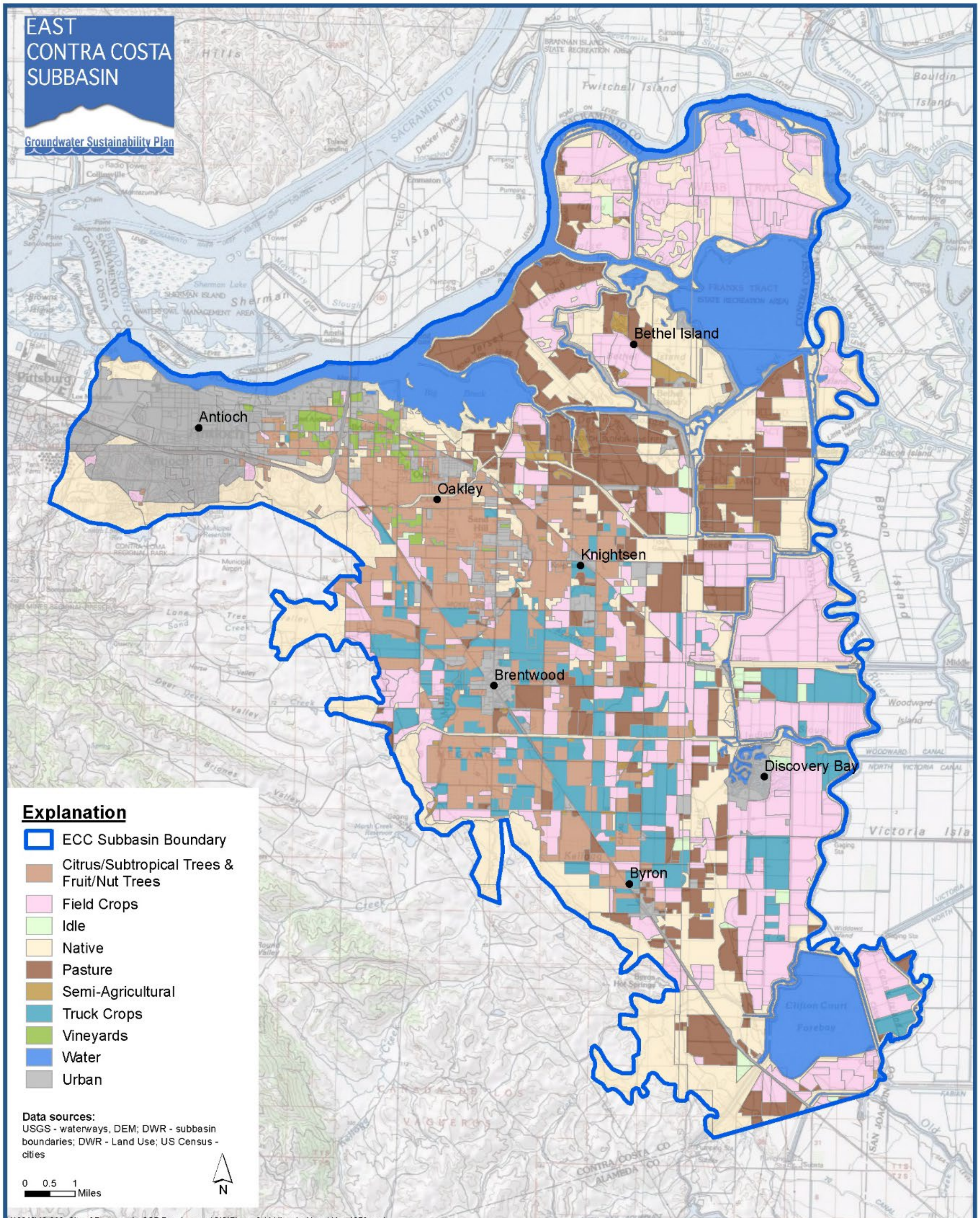
Historical Land Use-1995

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-10



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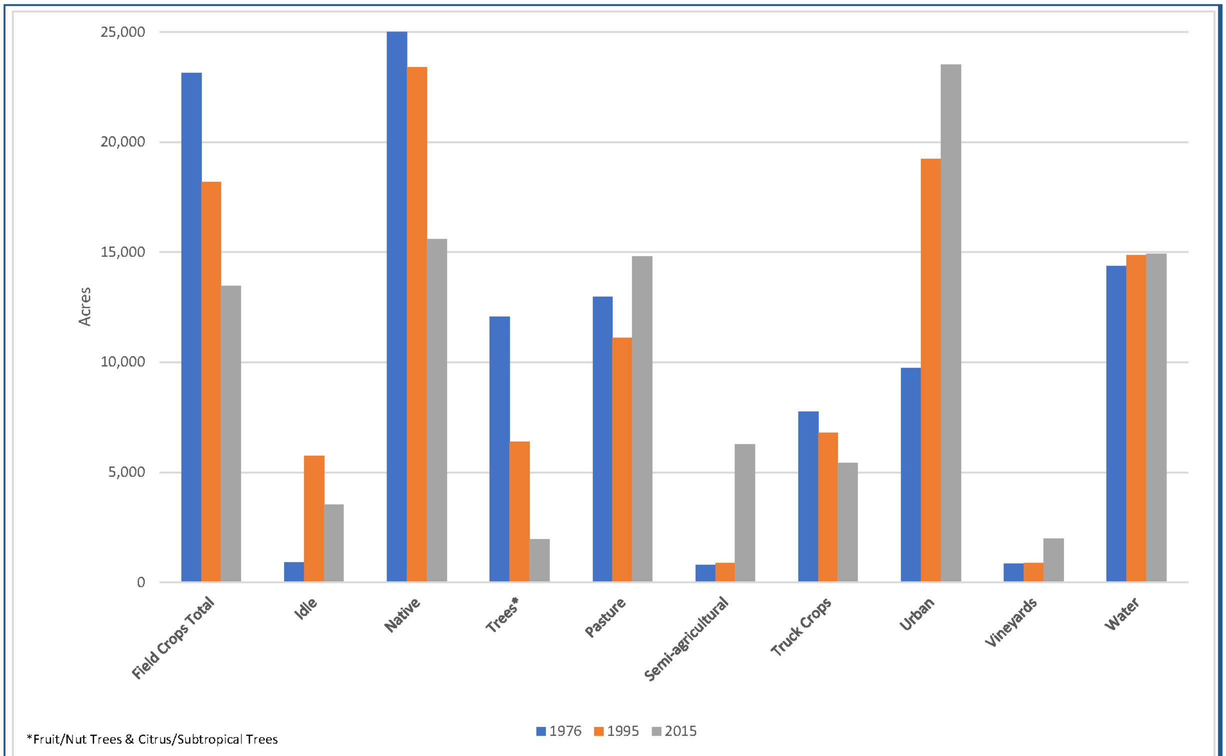
Historical Land Use-1976

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-11



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Land Use Summary

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-12

Figures 2-10 and **2-11** illustrate historical land use for the years 1995 and 1976, respectively. **Table 2-3** and **Figure 2-12** summarize land use trends over a 40-year span (1976 to 2015) that shows increasing urban lands and decreasing agricultural (field crops and fruit trees) and native lands. Chapter 4.1 provides additional detail on current and historical land uses.

2.3.2 Disadvantaged Area: DAC, SDAC and EDA

Nearly 35% of the ECC Subbasin is considered a Disadvantaged Area and (**Table 2-4** and **Figure 2-13a**), which accounts for almost 20% of the population of the Subbasin (**Table 2-5** and **Figure 2-13b)**. The term "Disadvantaged Area" includes the severely disadvantaged communities (SDAC), disadvantaged communities (DAC), and economically distressed areas (EDA), (collectively referred to as Disadvantaged Area [DA]).

There are 15,253 people in 5,610 acres of land in the ECC Subbasin that are categorized as a DAC, an additional 17,689 people in 5,095 acres are designated as SDACs, making approximately 18% of the 178,618 population and 10% of the 107,600 acres of the ECC Subbasin covered by DACs and SDACs. DACs are areas identified as having a median household income (MHI) of less than 80% of the California statewide annual MHI, and SDACs have an MHI of less than 60% of the statewide MHI. The DAC/SDAC acreage is based on the Median Household Income ($63,783) for 2012-2016 US Census American Community Survey (ACS) and in accordance with data from DWR's DAC Mapping Tools. The areas within the Subbasin identified as DACs and SDACs are displayed on **Figure 2-13**. A summary of DAC area by Census geography type (e.g., Census Block Groups, Census Place, and Census Tracts) is included in **Table 2-4**.

There are 2,645 people in 26,389 acres of land in the ECC Subbasin that are categorized as an EDA. The areas within the Subbasin identified as EDAs are displayed on **Figure 2-13a**, and **2-13b**. A summary of EDA areas by Census geography type (i.e., by Tracts and Blocks) is included in **Table 2-4 (by area)** and **Table 2-5 (by population)**. The EDAs by Tract and Block fulfill three criterion: EDA Criterion 1 and 2 municipality with MHI of less than 85% of the Statewide MHI and a population of less than 20,000; and EDA Criterion 3 has a low population density (less than or equal to 100 persons/square mile). The total percentage of people in the Subbasin comprising EDAs is about 2% and 24.5% percent of land are considered EDAs.

Table 2-4. Summary of Disadvantaged Areas by Area

Area Description	Acres[1]	Percent of Subbasin	Cumulative Acres[1]	Cumulative Percent of Subbasin
East Contra Costa Subbasin	**107,596**	**100%**	**107,596**	**100%**
Disadvantaged Communities[2]				
Census Block Groups				
SDAC	1,512	1.41%	1,512	1.41%
DAC	3,218	2.99%	4,730	4.40%
Census Place				
SDAC	3,583	3.33%	8,313	7.73%
Census Tracts				
DAC	2,392	2.22%	10,705	9.95%
Total Census Block Group and Tract DACs & SDACs			**10,705**	**9.95%**
Economically Distressed Areas[3]				
Census Tract and Block				
Total EDA	26,389	24.53%	26,389	24.53%
Total DACs, SDACs, and EDAs for All Census Geographies			**37,095**	**34.5%**

[1] Areas calculated using geographic projection NAD 1983 California Teale Albers.

[2] DAC = Disadvantaged Community: $38,270 < median household income [MHI] < $51,026.
SDAC = Severely Disadvantaged Community: MHI < $38,270 (60% of statewide MHI).

[3] EDA=Economically Distressed Area: a municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 20,000 persons or less, with an annual median household income that is less than 85% of the Statewide median household income, and with one or more of the following conditions as determined by the department: (1) financial hardship, (2) unemployment rate at least 2% higher than the Statewide average, or (3) low population density. (Water Code §79702(k)).

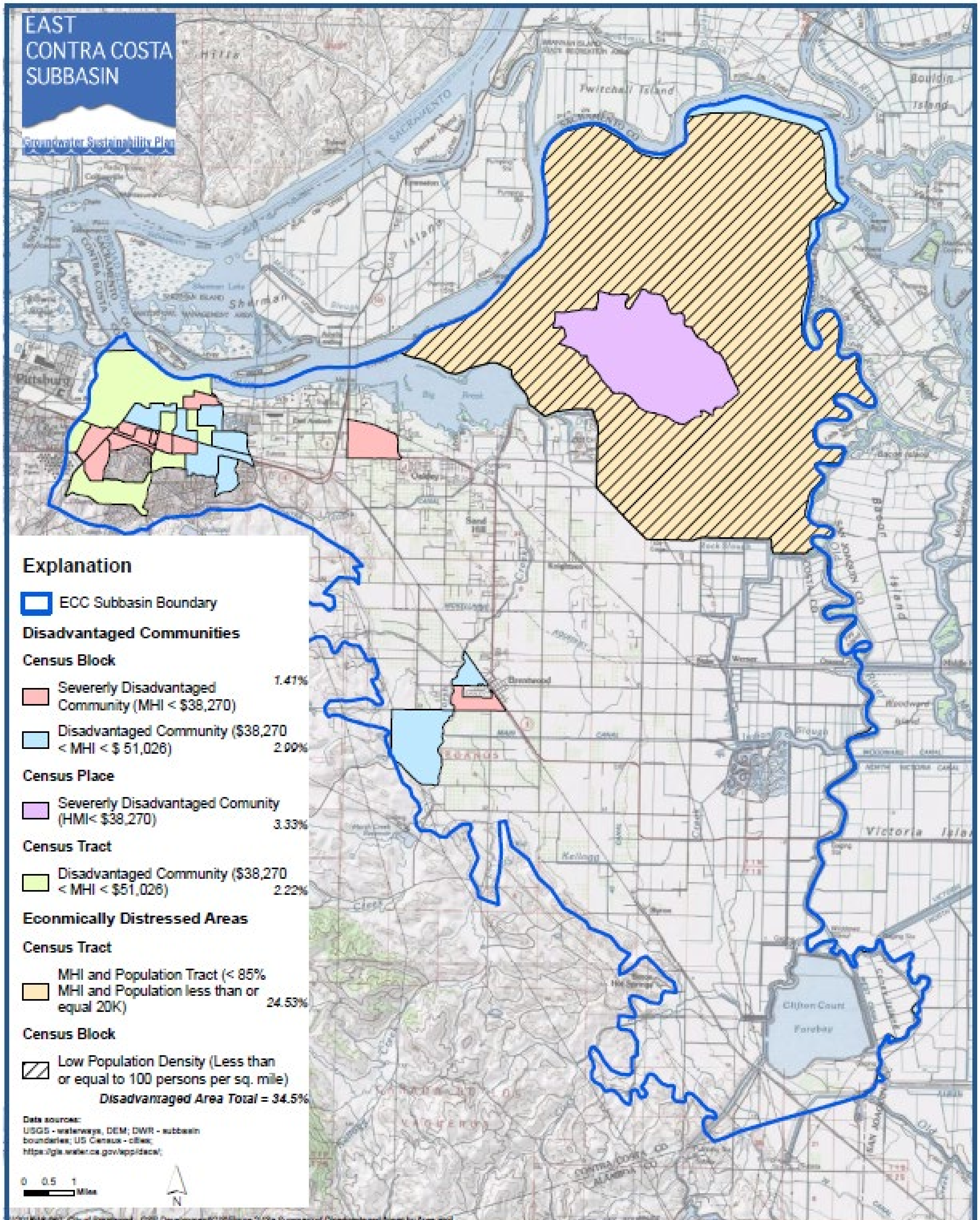
Table 2-5. Summary of Disadvantaged Areas by Population

Area Description	Population[1]	Percent of Subbasin	Cumulative Population[1]	Cumulative Percent of Subbasin
East Contra Costa Subbasin	**178,618**	**100%**	**178,618**	**100%**
Disadvantaged Communities[2]				
Census Block Groups				
SDAC	15,490	8.67%	15,490	8.67%
DAC	13,684	7.66%	29,174	16.33%
Census Place				
SDAC	2,199	1.23%	41,373	17.56%
Census Tracts				
DAC	1,569	0.88%	32,942	18.44%
Total Census Block Group and Tract DACs & SDACs			**32,942**	**18.44%**
Economically Distressed Areas[3]				
Census Tract and Block				
Total EDA	**2,645**	**1.48%**	**2,645**	**1.48%**
Total DACs, SDACs, and EDAs for All Census Geographies			**35,587**	**19.9%**

[1] Population calculated using Census Tract data.

[2] DAC = Disadvantaged Community: \$38,270 < median household income [MHI] < \$51,026.
SDAC = Severely Disadvantaged Community: MHI < \$38,270 (60% of statewide MHI).

[3] EDA=Economically Distressed Area: a municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 20,000 persons or less, with an annual median household income that is less than 85% of the Statewide median household income, and with one or more of the following conditions as determined by the department: (1) financial hardship, (2) unemployment rate at least 2% higher than the Statewide average, or (3) low population density. (Water Code §79702(k)).



Summary of Disadvantaged Areas by Area

Figure 2-13a

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Contra Costa County, California

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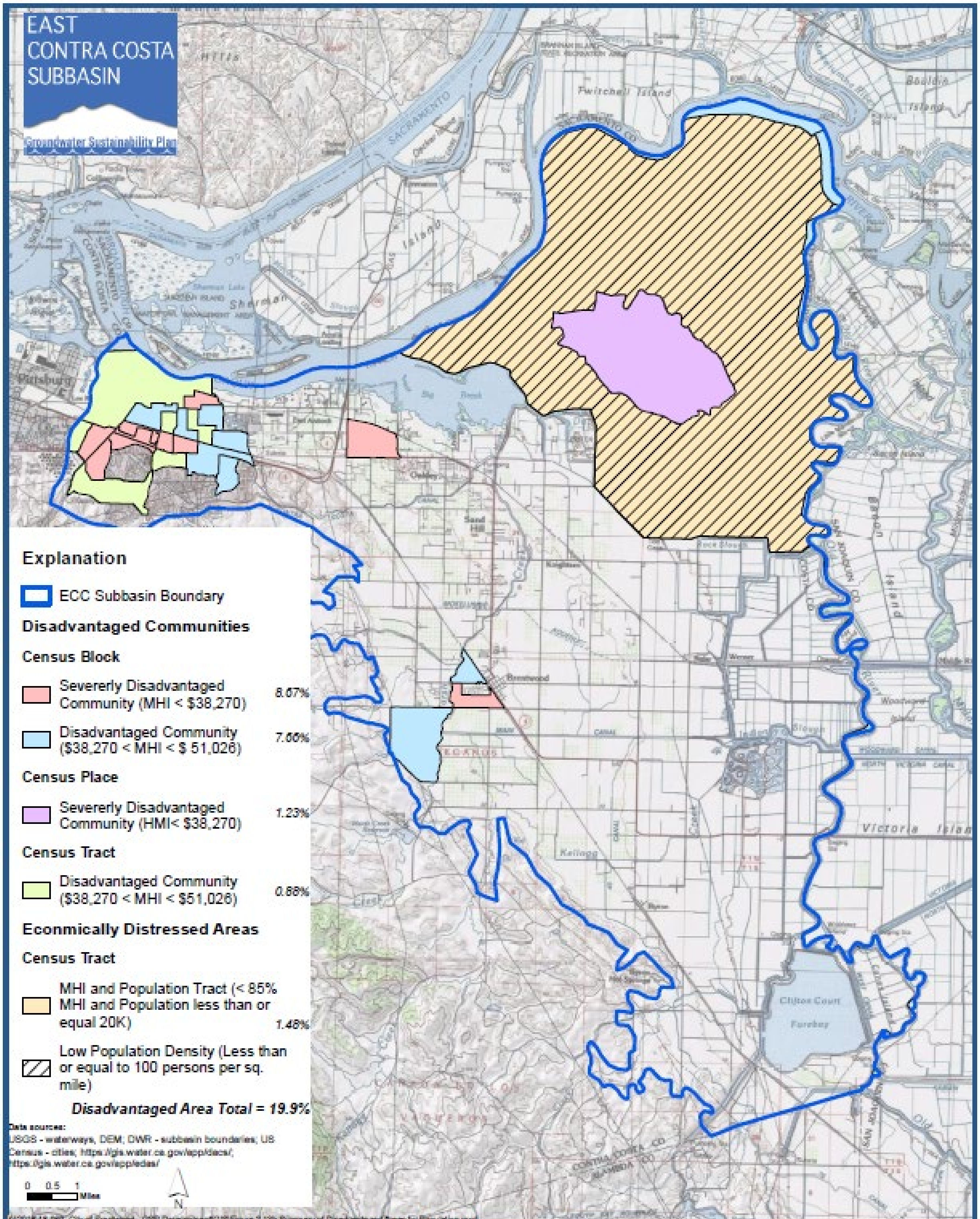

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Summary of Disadvantaged Areas by Population

Figure 2-13b

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

2.3.3 Water Use Sector and Water Source Type

SGMA regulations define "water use sector" as "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[7]." **Figure 2-14** shows the distribution of the water use sectors in the Subbasin. Agriculture is the predominant water use sector followed by urban (Cities of Antioch, Oakley, Brentwood, and Discovery Bay) and native vegetation.

The Subbasin has three water source types: surface water (primary source about 80,000 AFY); groundwater (secondary source about 8,000 AFY); and recycled water (about 2,700 AFY) (IRWMP, 2019, based on 2010 Urban Water Management Plans). Land use by water source in the ECC Subbasin is shown in **Figure 2-15.** Conjunctive use of surface water and groundwater is practiced throughout much of the Subbasin. Urban centers water sources vary The City of Antioch uses surface water exclusively, while the Cities of Brentwood and Oakley (water provided by DWD) use a combination of surface water and groundwater, and the Town of Discovery Bay uses only groundwater. ECCID and BBID hold water rights to divert surface water from Old River and meet remaining demand with groundwater. The unincorporated portions of the Subbasin generally have surface water as the water source however, these amounts are not quantified. The exceptions to this are domestic users and small community water systems which rely on groundwater. The Ironhouse Sanitary District uses recycled water to irrigate crops for animal feed on Jersey Island (2,700 AF in 2010).

2.3.4 General Plans

Four entities in the ECC Subbasin have land use authority[8] (**Figure 2-16**), which is an important factor in water management. Below is a description of the plans and how they may affect implementing the GSP. The Town of Discovery Bay does not have land use authority; however, the Town can advise the County on decisions affecting land use. The following section describes policies in the Plans related to water resources management in the ECC Subbasin. General Plans in the ECC Subbasin include:

- Contra Costa County General Plan (CCCDCD,2005)
- City of Antioch General Plan (LSA, 2003)
- City of Brentwood General Plan (DNPG, 2014)
- City of Oakley General Plan (CoO, 2016)

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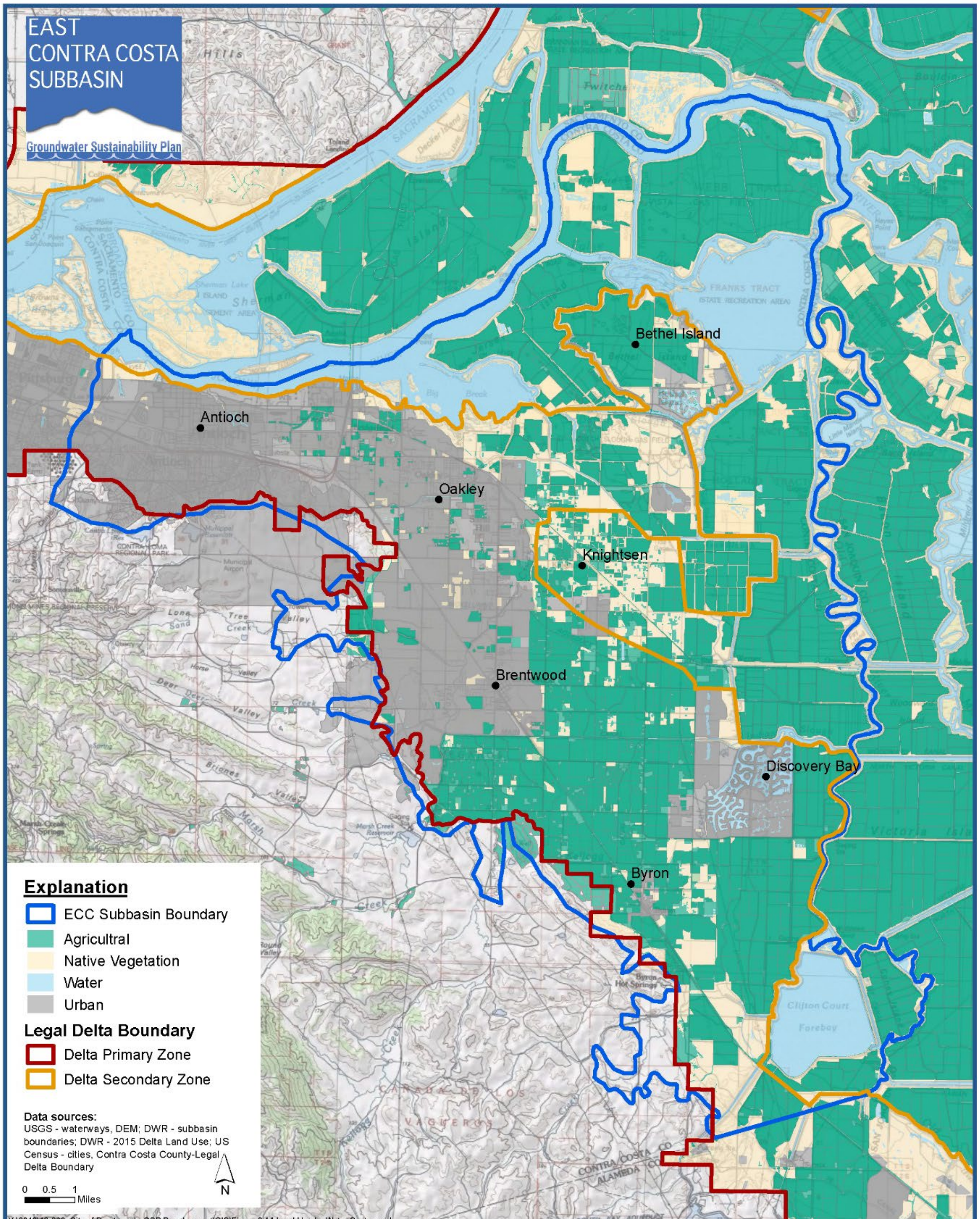
[7] California Code of Regulations, Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans, Article 2. Definitions

[8] CC County -Title 8, Zoning
https://library.municode.com/ca/contra_costa_county/codes/ordinance_code?nodeId=TIT8ZO
City of Brentwood – Title 17, Zoning
http://qcode.us/codes//brentwood/?view=desktop&topic=17-viii-17_467-17_467_002
City of Antioch – Title 9, Planning and Zoning
https://codelibrary.amlegal.com/codes/antioch/latest/overview
City of Oakley – Title 9 Land Use Regulation
https://www.codepublishing.com/CA/Oakley/



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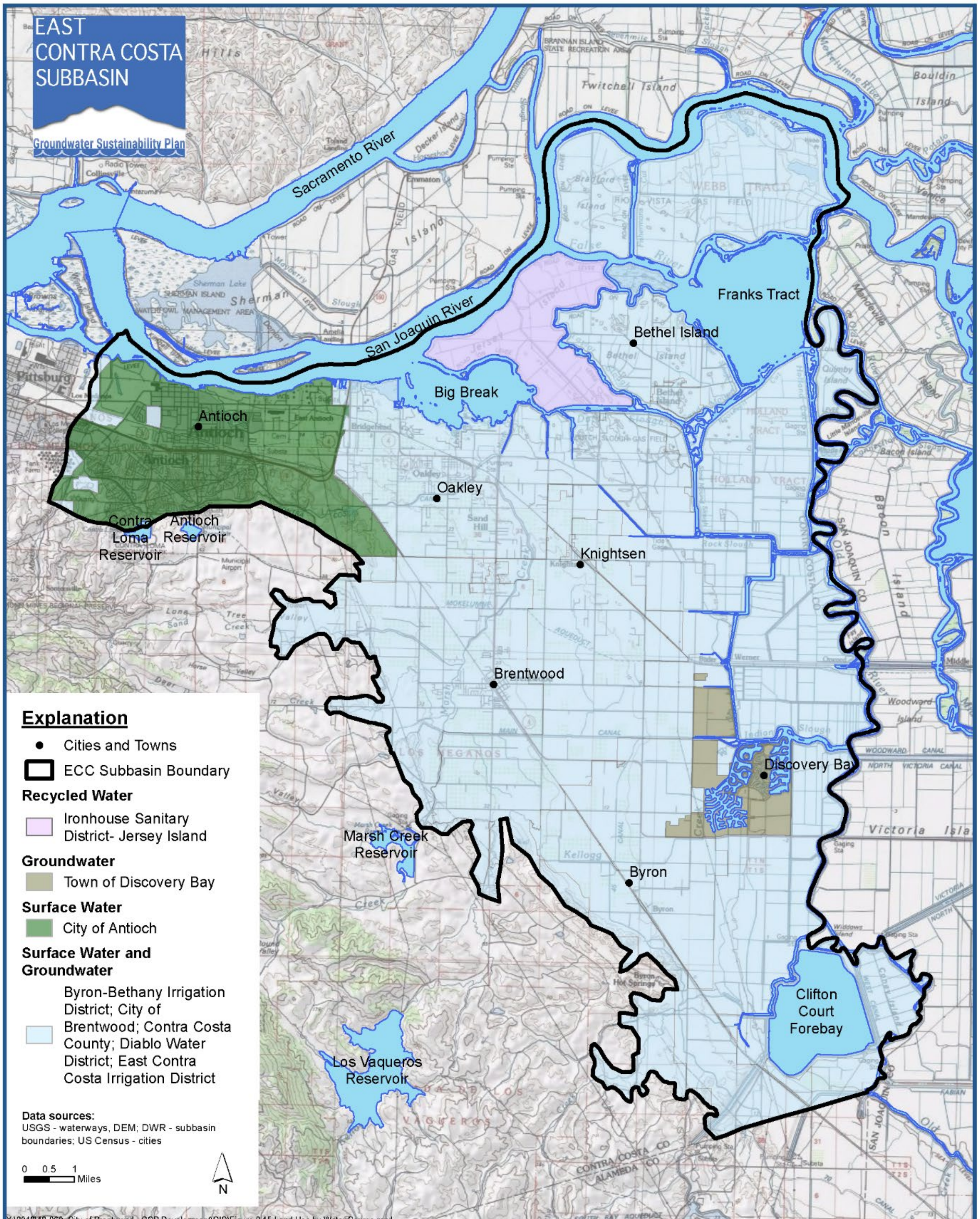
Land Use by Water Sector

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-14



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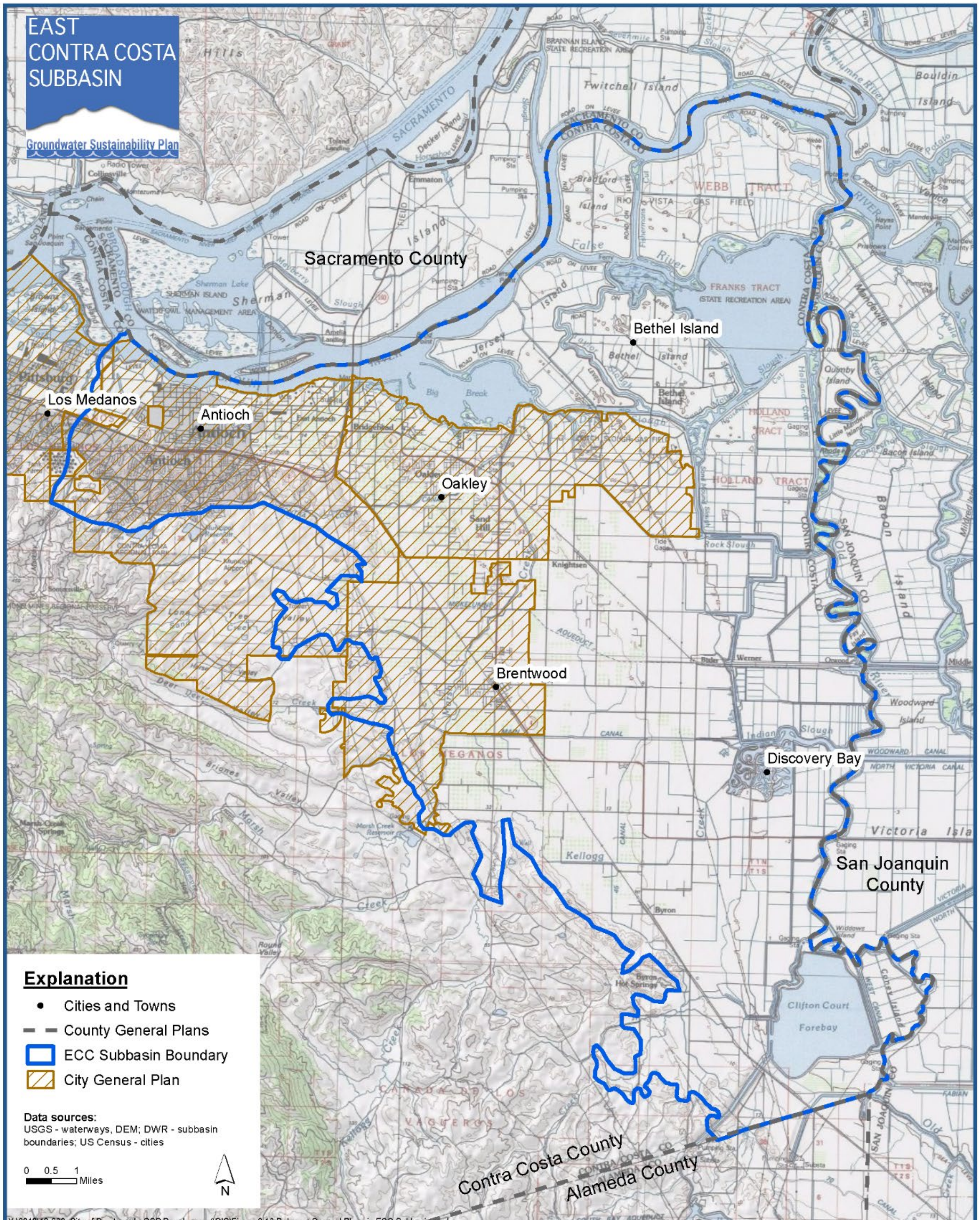
Land Use by Water Source (2010)

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-15



Relevant General Plans in ECC Subbasin

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 2-16

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2.3.4.1 Contra Costa General Plan

The planned land use for the Subbasin is outlined in the Contra Costa County General Plan (CCCGP). The CCCGP was developed for 2005 to 2020 (CCC, 2005). Currently the county is working on a comprehensive update to the General Plan; a draft is anticipated to be ready for review in 2021. The county is mandated by California Government Code (§65350-65362) to prepare a General Plan to help and guide future development in the county as related to land use, development, and conservation. It describes that much of the county's future growth (2000 to 2010) was planned along the Pittsburg-Antioch corridor.

In regard to conservation the CCCGP developed five overall policies:

- 8-1. Resource utilization and development shall be planned within a framework of maintaining a healthy and attractive environment.
- 8-2. Areas that are highly suited to prime agricultural production shall be protected and preserved for agriculture and standards for protecting the viability of agricultural land shall be established.
- 8-3. Watersheds, natural waterways, and areas important for the maintenance of natural vegetation and wildlife populations shall be preserved and enhanced.
- 8-4. Areas designated for open space/agricultural uses shall not be considered as a reserve for urban uses and the 65 percent standard for non-urban uses must not be violated.
- 8-5. In order to reduce adverse impacts on agricultural and environmental values, and to reduce urban costs to taxpayers, scattered urban development in outlying areas shall be precluded outside the urban limit line.

2.3.4.2 City of Antioch General Plan

The City of Antioch prefers that development not outpace infrastructure. The City foresees that a lot of development will occur in the area and requires developers to pay for infrastructure improvements so current infrastructure will not be overly stressed. The City also wants the infrastructure to be outlined prior to completing development to avoid want temporary work arounds. The City anticipates more growth, and its goal is to continue water conservation efforts. The City presents several options to meet water demands besides conservation. These include (LSA, 2003):

- Confirm new developments can be supported with a reliable water source
- New development landscaping must be drought tolerant
- Work to make recycled water a viable option
- Protect potential groundwater recharge areas
- Fight policies that would reduce river rights (i.e., increase salinity)

2.3.4.3 City of Brentwood General Plan

The City of Brentwood General Plan was updated in 2014 (DNPG) and provides the framework to guide growth and conserve open space. The City's goal with regard to water requirements is to provide safe and reliable water to its citizens. The General Plan outlines three ways it plans to achieve this goal. The City plans to continually assess water saving strategies and water demands. The City also plans to discuss the possibility of receiving additional water from East Bay Municipal Utility District (EBMUD), CCWD, and ECCID. In 2006, voters approved an Urban Limit Line (ULL); the line would limit the development of urban infrastructure. Current land use maps show small areas are planned for future development (DNPG, 2014).

2.3.4.4 City of Oakley General Plan

The City of Oakley also has a ULL and a desire to "preserve quality of life for residents". The City's goal to meet current and future water requirements is to require new development to detail how water supplies will be met, request that water agencies meet quality standards, and protect water sources from pollution by working with regulatory agencies. The City also will urge water agencies to have written plans in case of drought (CoO, 2016).

2.3.4.5 Land Use Plans and the GSP Water Supply Assumptions

In general, land use and water supply assumptions included in the General Plans in the ECC Subbasin are consistent with current and future land use and water demand projections used in the GSP. The county and cities' policies include water conservation and sustainable management of groundwater resources. GSP implementation is expected to be consistent with future water use and land use as projected in the General Plans, urban water management plans, and agricultural water management plans. These documents were used to project future land use and resulting water demand for the future water budgets used in the GSP.

2.3.5 Water Management Plans

Many water management plans cover the Subbasin. These are described below.:

2.3.5.1 Urban Water Management Plan

Urban Water Management Plans (UWMP) are required by the Urban Water Management Plan Act for any water supplier distributing more than 3,000 AFY or that has more than 3,000 connections. A UWMP must be prepared and submitted to DWR every 5 years. Each UWMP should asses the reliability of water for the next 20 years, how demands are met including shortages, conservation efforts with the goal being a 20% reduction in water use per person, and finally a goal for recycled water use in the agency's sphere of influence. The following UWMPs have been developed in the Subbasin:

- City of Antioch Urban Water Management Plan (WYA, 2015)
- City of Brentwood Urban Water Management Plan (B&C, 2016)
- Diablo Water District 2015 Urban Water Management Plan (CDM, 2015)
- Town of Discovery Bay Community Services District 2015 Urban Water Management Plan (LSCE, 2017)
- Contra Costa Water District Urban Water Management Plan (CCWD, 2015)

2.3.5.2 Agricultural Water Management Plan

Agricultural Water Management Plans (AWMP) are required by the Water Conservation Act of 2009 (SB X7-7) for any water supplier distributing more than 25,000 AFY (excluding recycled water deliveries) to prepare a plan and submit it to DWR. The Act requires that each agency/region develop a water budget for a water year identifying inflow and outflow components, ways to improve water efficiency, quantify water use, and outline a plan for droughts. In addition, the AWMP must include the status of Efficient Water Management Practices (EWMP). EWMP must be followed for delivery point measurements and volumetric pricing; the remaining EWMPs are to be implemented if they are technically feasible or funding is available. The following AWMP was developed in the Subbasin:

- Byron Bethany Irrigation District Agricultural Water Management Plan (CH2M, 2017)

2.3.5.3 Integrated Regional Water Management Plan

In an effort to address California's water supply and management practices, DWR created policies that encourage Integrated Regional Water Management Plans (IRWMP) and grant funding to implement the program. The goal of the IRWMP is to evaluate all aspects of water management. In 2015, CCC updated their IRWMP (ECCWMA, 2015). Their plan has 25 objectives that are used by the ECCWMA members to address their water management issues:

- Protect/improve source water quality
- Maintain/improve regional treated drinking water quality
- Maintain/improve regional recycled water quality
- Increase understanding of groundwater quality and potential threats to groundwater quality
- Meet current and future water quality requirements for discharges to the Delta
- Limit quantity and improve quality of stormwater discharges to the Delta
- Manage local stormwater
- Improve regional flood risk management
- Enhance understanding of how groundwater fits into the water portfolio and investigate groundwater as a regional source (e.g., conjunctive use)
- Protect, restore and enhance habitat in the Delta and connected waterways
- Protect, restore and enhance the watersheds that feed and contribute to the Delta ecosystem
- Minimize impacts to the Delta ecosystem and other environmental resources
- Reduce greenhouse gas emissions
- Protect Delta ecosystem against habitat disruption due to emergencies, such as levee failure
- Increase shoreline access for subsistence fishing and recreation
- Increase regional cost efficiencies in treatment and delivery of water, wastewater, and recycled water
- Develop projects with regional benefits that are implementable and competitive for grant funding
- Use financial resources strategically to maximize return on investment on grant applications for project development/implementation
- Develop a funding pool to self-fund regional efforts such as grant applications, outreach, website development, and other planning activities
- Increase public awareness of project importance to pass ballot measures or obtain matching funds through other means that require public support
- Ensure projects with existing matching funds are prioritized to maximize regional funding opportunities
- Identify and engage DACs
- Collaborate with and involve DACs in the IRWM process
- Promote equitable distribution of proposed projects across the region
- Increase awareness of water resource management issues and projects with the general public

2.3.5.4 Additional Water Plans in Subbasin

The City of Brentwood developed and updated a Water Master Plan in 2003 and 2017 (Ennis, 2017). The plan has two main goals: 1) identify limitations of the current water system and whether current infrastructure could be modified to resolve any deficiencies, and 2) identify what infrastructure will need to be modified to serve new development.

In 2012, the TODB developed a Water Master Plan (LSCE, 2012). The plan has two main objectives 1) evaluate system efficiency, and 2) outline any capital improvement projects that would enable TODB to meet the current and future water demands of the service area.

CCWD prepares a Water Management Plan to be submitted to the USBR as part of their contract for CVP water. CCWD prepares a Water Management Plan (Plan) every five years (the last one was submitted in 2017) and also periodically prepares a Future Water Supply Study. The intent of the Plan is for CCWD to demonstrate federal water "is put to reusable and beneficial use." CCWD demonstrates this to USBR by outlining water conservation efforts, providing information on water-related infrastructure, and description of the district which includes district demographics, topography, climate, natural and cultural resources, district rules and regulations, and billing and pricing.

As a result of Assembly Bill (AB) 3030, the California Water Code (CWC), Section 10750, DWD board of directors agreed to prepare a groundwater management plan. DWD's goal was "to provide a management framework for maintaining a high quality, reliable, and sustainable supply of groundwater within the District's sphere of influence." In 2007, DWD implemented the Diablo Water District Groundwater Management Plan for AB 3030 (LSCE, 2007).

2.4 County Well Construction, Destruction and Permitting

2.4.1 Wellhead Protection and Well Permitting

Wellhead protection is governed by county, state and federal regulations within the Subbasin.

Well permitting in the Subbasin is overseen by the CCC Health Services, Environmental Health Division. The Environmental Health Division requires a Well Permit Application to be completed prior to any ground surface breaking that includes well construction, reconstruction, or destruction, including water wells, dewatering wells, monitoring wells, cathodic protection wells, geothermal wells, piezometers, inclinometers, soil vapor probes, Cone Penetrating Testing (CPTs), soil borings, and geotechnical borings. Environmental Health Division reviews the well permit and either approves, denies, or requests modification. CCC also has well regulations to meet water supply demands for new housing construction (CCC, 1981).

2.4.1.1 Well Installations

A county official reviews permits for new well construction, and the application will be approved, dismissed, or more information will be requested. The well must be installed by a licensed C-57 Driller that maintains current registration with the county. Well installation requirements follow the standards outlined in the California Well Standards, Bulletin 74-81 and 74-90. The bulletin discusses the proper well locations (i.e. distance from property line, septic tanks, streams, livestock) for water supply wells, proper approaches for sealing the annulus (materials, methods, conditions and placement), casing material, and the material/construction of the completion monument (flush or stick up, with respect to the ground surface). A county official is required to inspect the grout mixture prior to well completion, and it is the responsibility of the driller to schedule the inspection. A pump test might be required if the county determines the need for one in the area.

2.4.1.2 Well Abandonment

As per Section 21 of Bulletin 74-81:

A well is considered 'abandoned' or permanently inactive if it has not been used for one year, unless the owner demonstrates intention to use the well again. In accordance with Section 24400 of the California Health and Safety Code, the well owner shall properly maintain an inactive well as evidence of intention for future use in such a way that the following requirements are met:

(1) The well shall not allow impairment of the quality of water within the well and groundwater encountered by the well.
(2) The top of the well or well casing shall be provided with a cover that is secured by a lock or by other means to prevent its removal without the use of equipment or tools, prevent unauthorized access, prevent a safety hazard to humans and animals, and prevent illegal disposal of wastes in the well. The cover shall be watertight where the top of the well casing or other surface openings to the well are below ground level, such as in a vault or below known levels of flooding. The cover shall be watertight if the well is inactive for more than five consecutive years. A pump motor, angle drive, or other surface feature of a well, when in compliance with the above provisions, shall suffice as a cover.
(3) The well shall be marked so as to be easily visible and located and labeled so as to be easily identified as a well.
(4) The area surrounding the well shall be kept clear of brush, debris, and waste materials."

2.4.1.3 Well Destruction

A permit must be submitted to the agency for approval of well destruction. The county states its requirements are as follows:

(1) Remove any obstructions from the well.
(2) Perforate or remove the well casing to the bottom of the well.
(3) Excavate around the casing to a depth of 6 ft.
(4) Place approved sealing material in the well extending from the bottom to the surface. Environmental Health staff will inspect this stage of the work. The well contractor is responsible for contacting Contra Costa Environmental Health to schedule inspection appointments. The greater the advance notice, the more likely a mutually convenient inspection appointment can be arranged.

2.5 Additional Plan Elements (WCS 10727.4)

Table 2-6 lists the additional Plan Elements listed in Water Code Section 10727.4 that should be included in a GSP, where appropriate, and the location in the GSP where these are addressed.

Table 2-6. Additional Plan Elements

Section Number	Code Description	Section in GSP with More Detail
10727.4 (a)	Control of saline water intrusion.	3.3.4
10727.4 (b)	Wellhead protection areas and recharge areas.	2.4.1 and 3
10727.4 (c)	Migration of contaminated groundwater.	3.3.6
10727.4 (d)	A well abandonment and well destruction program.	2.4
10727.4 (e)	Replenishment of groundwater extractions.	3
10727.4 (f)	Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage.	2.2
10727.4 (g)	Well construction policies.	2.4
10727.4 (h)	Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects.	3 and 4
10727.4 (i)	Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use.	4 and 8
10727.4 (j)	Efforts to develop relationships with state and federal regulatory agencies.	8
10727.4 (k)	Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.	8
10727.4 (l)	Impacts on groundwater dependent ecosystems.	3.3.9

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APPENDICES

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3. BASIN SETTING

3.1 Overview

This Basin Setting section of the East Contra Costa (ECC) Groundwater Sustainability Plan (GSP) describes the Hydrogeologic Conceptual Model (HCM) (Section 3.2) and historical and current Groundwater Conditions (Section 3.3). The sections were developed using best available science and serve as the basis upon which ECC GSAs will select management criteria to maintain sustainable groundwater conditions in the ECC Subbasin. Groundwater Sustainability Agencies (GSAs) "have the responsibility for adopting a Plan that defines the basin setting and establishes criteria that will maintain or achieve sustainable groundwater management" as detailed by DWR in the GSP regulations (Title 23 California Code of Regulations [CCR] Section 350.4e). The two main topics covered in this section include:

- **Hydrogeologic Conceptual Model (HCM):** Section 3.2 describes the physical components of the Subbasin including the regional geology, structural properties, boundaries of the Subbasin, principal aquifer descriptions with cross sections, topographic and soil characteristics, recharge areas, and significant surface water bodies.
- **Groundwater Conditions:** Section 3.3 provides current and historical groundwater conditions including discussions of groundwater level maps and time-series graphs, groundwater storage, seawater intrusion, groundwater quality, land subsidence, interconnected surface water systems, and groundwater dependent ecosystems.

3.2 Hydrogeologic Conceptual Model

The HCM describes the geologic and hydrologic framework that governs how water moves through the ECC Subbasin. This description provides the basis to develop water budgets, monitoring networks, and ultimately a surface water/groundwater mathematical model (**Section 5** of this GSP). This section includes information about the regional geologic and structural setting, lateral and vertical basin boundaries, and principal aquifers. This section is based on technical studies and maps that characterize the physical components and interaction of the surface water and groundwater systems, pursuant to Section 354.14 Hydrogeologic Conceptual Model. Information was compiled for this section from two main references: *Investigation of Ground-Water Resources in the East Contra Costa Area* (LSCE, 1999) and *An Evaluation of Geological Conditions, East Contra Costa County* (LSCE, 2016). Both reports are included in this document as **Appendices 3a and 3b**.

3.2.1 Regional Geological and Structural Setting

The San Joaquin Valley formed between two mountain ranges (Coast Ranges and the Sierras). The ECC Subbasin lies on the western side of the northern San Joaquin Valley portion of the Great Valley province of California. The western boundary of the Subbasin is a no flow boundary with respect to groundwater and is delineated by exposed bedrock of highly deformed Tertiary age and older marine sediments of the Coast Range Diablo Mountains. Most of the Subbasin is filled with freshwater-bearing alluvium, eroded continental sediments from the Coast Ranges, that are Quaternary in age. Surficial geology from multiple sources is provided in **Figure 3-1a** and a detailed legend is in **Figure 3-1b and c**.

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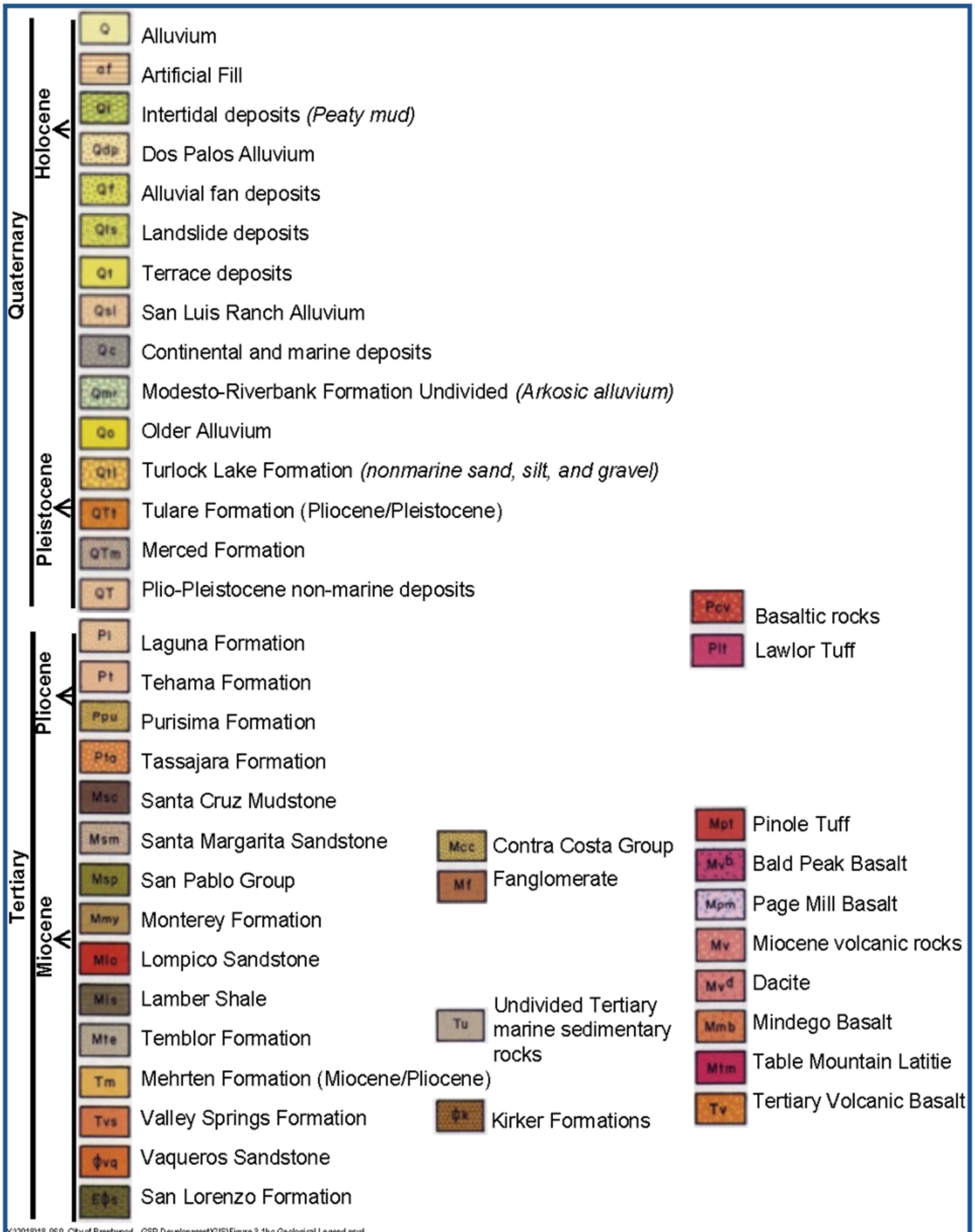
Surficial Geology and Faults

Figure 3-1a

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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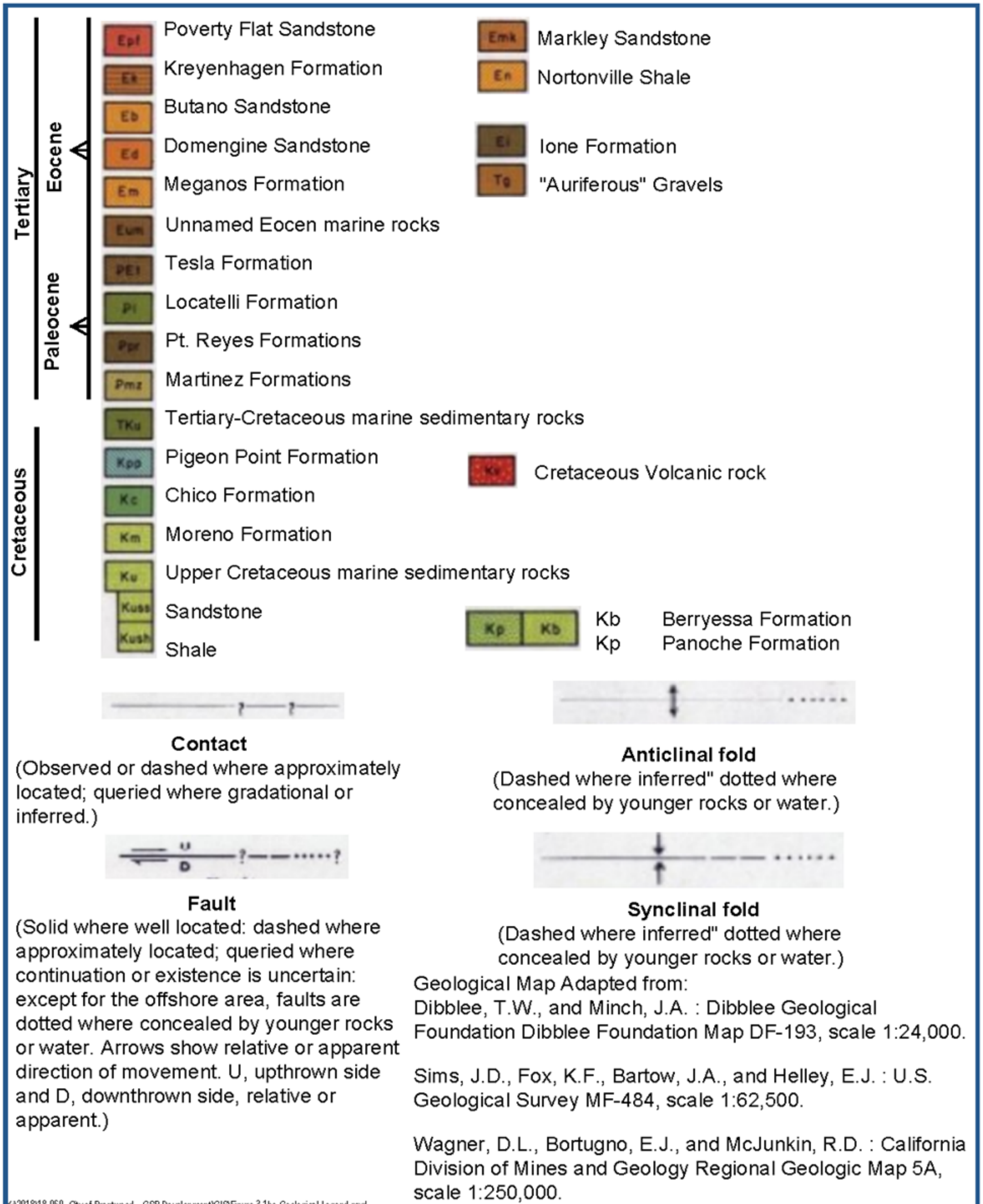
Surficial Geology Legend

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-1b



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Surficial Geology Legend

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-1c

3.2.1.1 Topographic Information

The topography of the Subbasin is generally flat with land surface elevations that slope gently downward to the east. Topographic elevations vary from about 200 feet above mean sea level (msl) in the west to less than 10 feet from msl in the delta area over a distance of about 10 miles (**Figure 3-2**). There are portions of the Subbasin (e.g., Delta islands) in the northeast and southeast that are below sea level.

3.2.1.2 Depositional Model

Regional geologic studies (Bartow, 1991; and Bertoldi and others, 1991) reported that Miocene marine deposition occurred in the area as shown by the Tertiary marine rocks exposed in the Coast Ranges. During the following Pliocene epoch, the San Joaquin Valley drained south to the ocean via the Salinas Valley. The Sacramento Valley drained westward through the Delta area, and the Coast Range locally had not yet been uplifted. Deposition may have been confined to distal fluvial plains sourced from the Sierra Nevada area, such that little sand was carried into the area. Similar aged fine-grained deposits are seen in southern Sacramento County, near Vacaville, and around Rio Vista reaching thicknesses of 2,000 to 2,500 feet.

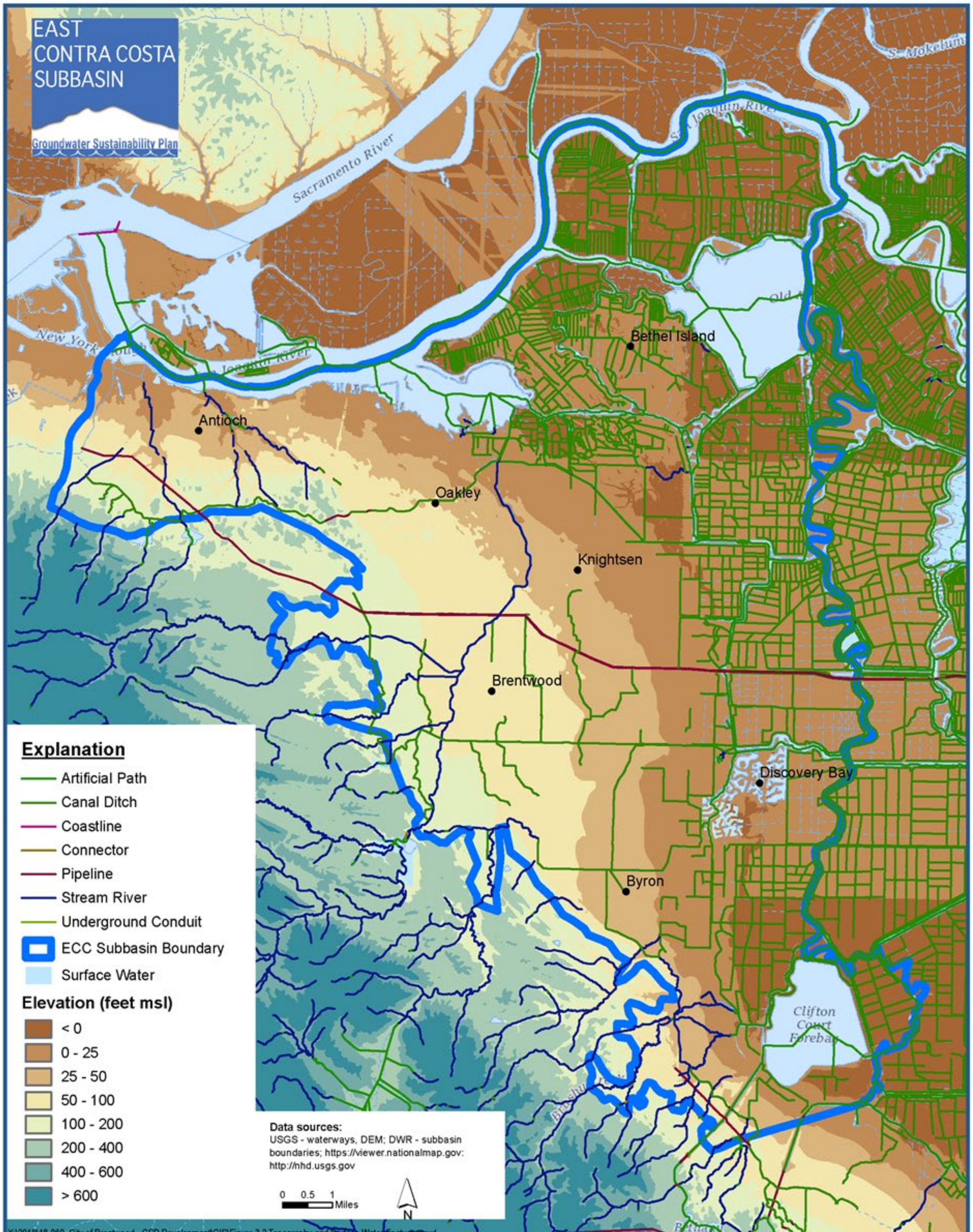
In the Quaternary (mid-Pleistocene) period, the San Joaquin Valley south of Tracy was occupied by a large freshwater lake known as Corcoran Lake. Associated with the lake was deposition of the Corcoran Clay, also termed E-Clay unit. Neither the lake nor the Corcoran Clay unit extended as far north as the ECC Subbasin distinguishing the Subbasin from other parts of the San Joaquin Valley Groundwater Basin to the south and east. At about 600,000 years ago, northern San Joaquin River drainage and local Coast Range uplift began. It is suspected that this activity marked the beginning of the alluvium deposition where coarse-grained deposits were formed and carried into the area by the San Joaquin River and from erosion of the uplifting Coast Ranges.

3.2.1.3 Surficial Geology and Geological Formations

Bedrock formations observed in outcrops along the western boundary of the ECC Subbasin consist of strongly deformed marine sedimentary rocks that range in age from over 63 million years (my) to 5my. The Tertiary marine rocks of sandstones, shales and mudstones dip east beneath the San Joaquin Valley with increasing depths. Because of their marine origin, well consolidated nature, and saline water, the Mesozoic and Tertiary marine rocks are not a source of fresh groundwater in the Subbasin (LSCE, 1999; 2016). Additional information about these units can be found in **Appendix 3a**.

Overlying the Tertiary marine rocks are a sequence of Tertiary-Quaternary non-marine sedimentary deposits (Pliocene to Pleistocene). These older sediments have limited areas of exposure along the edge of the Coast Range. These deposits are not well understood in the study area, but they are believed to consist of fine-grained clays, silts, and mudstones with a few sand beds. They dip moderately to the east and northeast under the San Joaquin Valley. Limited information from a few deep water well boreholes indicate they occur from 400 feet to depths of over 1,500 feet below the San Joaquin River. The lower portion of these deposits may be equivalent to the Mehrten Formation on the east side of the San Joaquin Valley. The upper portion of these older non-marine sediments may be equivalent to the Tulare Formation to the south of the Subbasin and the Tehama Formation to the north. Water quality appears to become brackish with depth (LSCE, 1999 and 2016).

Overlying the Tertiary/Quaternary non-marine sediments are the primary groundwater-bearing units in the ECC Subbasin.



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Topography and Surface Water Features

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-2

These Quaternary alluvium deposits are unconsolidated beds of gravel, sand, silts, and clays becoming weakly consolidated with increasing age and burial depth. The alluvium thickens eastward to over 300 feet beneath Brentwood and about 400 feet below Old River. As discussed in Section 3.2.4, the units around Brentwood are believed to have been deposited by streams forming alluvial fans of silts and clays off the uplifted Diablo Mountains. Units around Discovery Bay are believed to be stream channel deposits of coarser sands and gravels. Separation of the alluvium into distinct units is difficult using well drillers' reports. The sand and gravel can be correlated locally, but the fine-grained sand and clays are so massive, a greater spatial correlation is not possible (LSCE, 1999). Sand and gravel beds and their distribution are discussed further in this chapter.

About 600,000 years before present, Corcoran Lake formed in nearly the entire San Joaquin Valley northward to the Stockton-Tracy area. A blue lake clay was deposited across the San Joaquin Valley and is known as the Corcoran Clay or E-clay. However, as cited above, this clay unit has not been identified north of the Stockton-Tracy area into the Delta area of Contra Costa County or in the Sacramento Valley (LSCE, 2016).

3.2.2 Faults and Structural Features

Three inactive faults (Midland, Sherman, and Antioch) trend in a north-south direction across the Subbasin (**Figure 3-1,** dashed lines). They are not known to inhibit groundwater flow or to impact water conveyance infrastructure. The Vernalis Fault is located southeast of Clifton Court Forebay (off of the geology map, **Figure 3-1**). Uplift or deformation along this fault may have caused a ridge that may influence groundwater flow as discussed below. No surface expression has been noted of this fault (LSCE, 2016).

3.2.3 Basin Boundaries

The lateral extent of the ECC Subbasin is defined primarily by jurisdictional and surface water boundaries (**Figure 3-3**). ECC Subbasin is bounded on the north, east, and south by the Contra Costa County line, which is contiguous with the San Joaquin River (north) and Old River (east). In the west, a non-jurisdictional Subbasin boundary corresponds to the non-water bearing geologic units which form a bedrock barrier to groundwater flow. **Figure 3-3** is a diagrammatic illustration of the western ECC Subbasin boundary in relation to the bedrock outcrop of older consolidated marine sediments (green, blue, and tan colors).

The base of the ECC Subbasin is defined by the vertical extent of available and extractable freshwater. The base of freshwater has been mapped previously in the general area by Page (1973) and Berkstressser (1973), and in a detailed map of the ECC Subbasin constructed by LSCE (2016). The base of freshwater map prepared by LSCE (**Figure 3-4**) updates the delineation of freshwater resources through additional oil and gas well electric logs in Montezuma Hills, Rio Vista, and the northwestern hills of Mount Diablo (Davis et al., 2018). The base of freshwater aquifers was determined from electric log responses in thick sand beds that had high resistivity values, and the character of the spontaneous-potential (S-P). This approach distinguished zones of poor water quality within sand beds, though it did not quantify salinity. Nevertheless, the geophysical characteristics of sand beds from electric logs provide a sound estimate of the vertical extent of freshwater in the Subbasin. Deeper sandy units with low resistivity values and indeterminable S-P characteristics were considered to be non-viable as aquifers. The examination by LSCE (2016) showed the deepest base of freshwater is to the northeast and east near the Subbasin boundary (-1,000 to -1,200 feet from msl) and rising to the west to elevations of 200 feet msl. In the Clifton Court Forebay area a subsurface ridge-like feature, possibly caused by the Vernalis Fault, extends eastward from the valley edge and may influence groundwater flow around the ridge or impede any northwest flow from the south at depths below -400 feet elevation.

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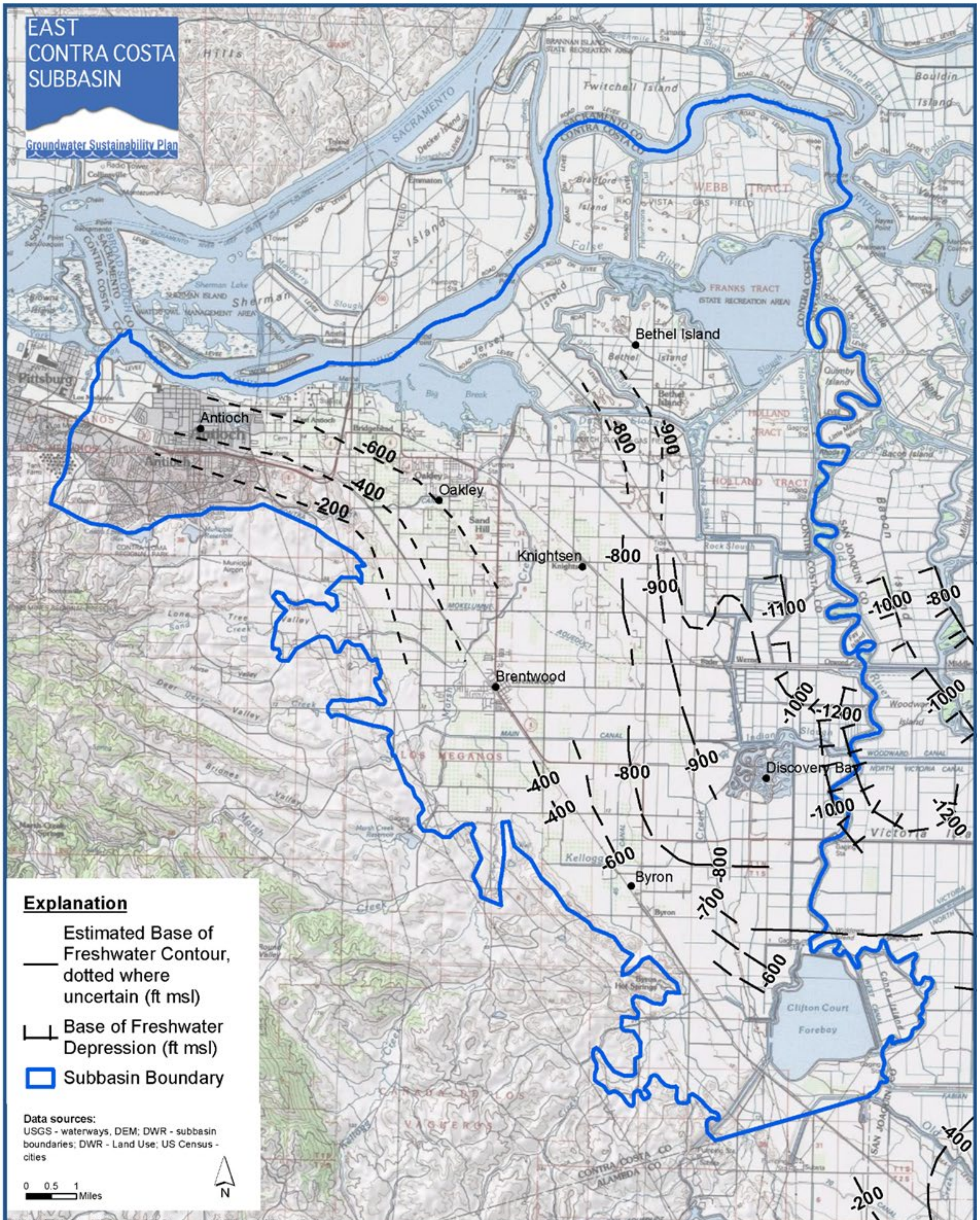
Basin Boundary- Jurisdictional and Natural

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-3



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Base of Freshwater

Figure 3-4

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

3.2.4 Geologic Cross Sections and Depositional Facies Model

In 1999, LSCE performed a detailed hydrogeologic study of eastern Contra Costa County groundwater. The focus of the study was the uppermost 500 feet where most water wells are completed in the region. This study included construction of cross sections from drillers' logs and oil and gas logs to assess sand bed characteristics and their extent. Five cross sections were constructed in an east-west direction perpendicular to the Coast Range and three were drawn in a north-south direction (**Figure 3-5**). Two cross sections (4-4' and C-C', **Figures 3-6a and 3-6b**) are included in this report and all eight cross sections are included in **Appendix 3a**. These sections illustrate the ground surface, lithology associated with each well log, and the base of fresh water (LSCE, 2016).

The geologic cross-sections show the interbedded and variable nature of fine- and coarse-grained sediments both laterally and vertically and throughout the study area. They illustrate in detail the primary water-bearing units for water supply purposes. Coarse-grained units were identified primarily in the upper 400 feet where the majority of public supply wells are perforated however, it was noted that the units are difficult to correlate laterally. Well information was lacking for depths below 400 feet below ground surface (bgs) but consistent with the discussion in the previous section, it was expected that the units are fine grained and become brackish at depth.

From the vertical and lateral variability in sediments reflected in cross sections, general patterns in the occurrence and character of sand and gravel aquifers could be identified. These variations were explained by different depositional environments (e.g., stream and delta) as detailed below. In addition, these depositional environments were used to inform groundwater model calibration and for other quantitative purposes.

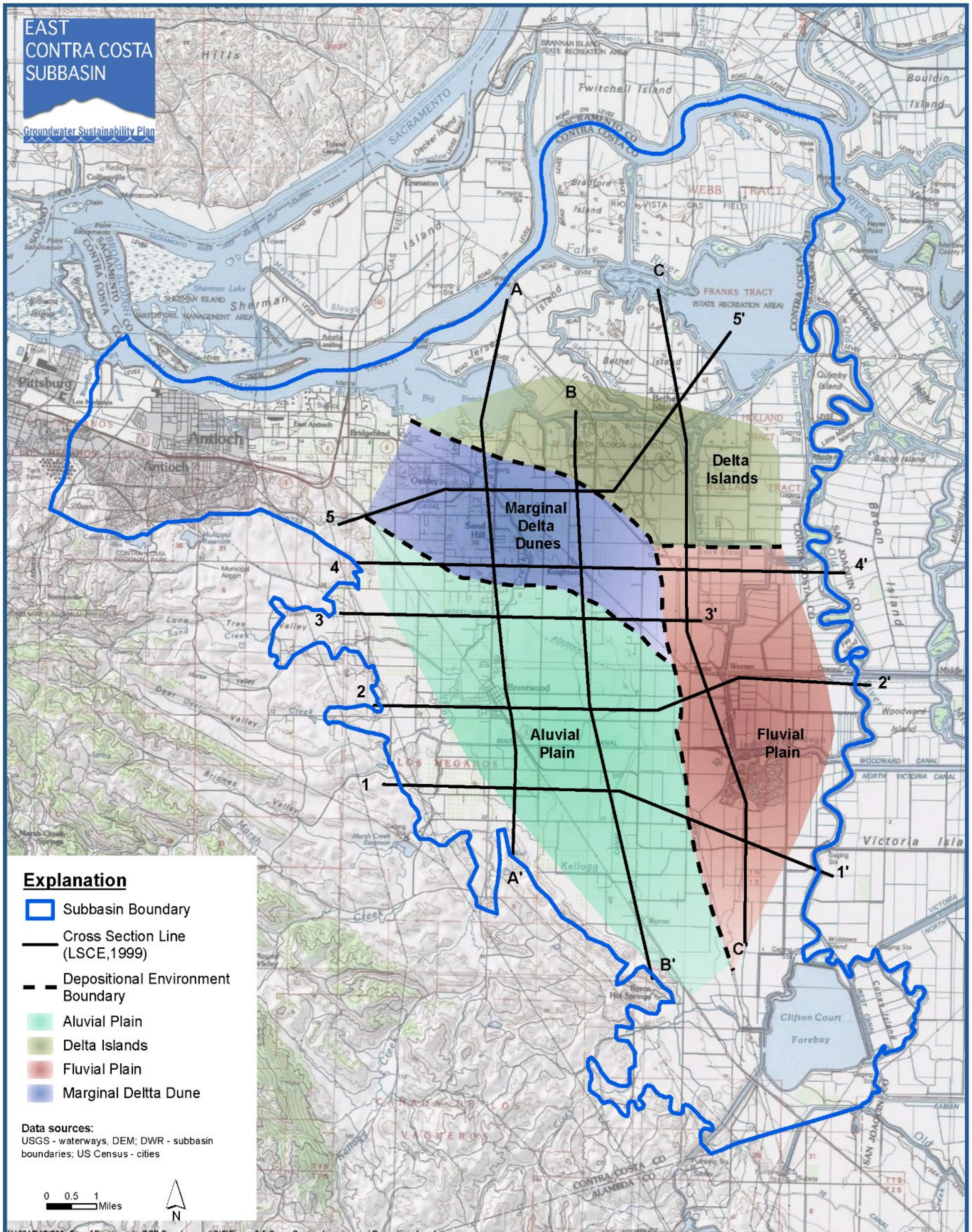
From the work described above, a facies model for four depositional regions in the Subbasin was developed as part of the Subbasin HCM (**Figure 3-5**). The depositional regions are detailed below:

Fluvial Plain

This is representative of the eastern portions of the Subbasin including Discovery Bay. It is defined by a zone of well-defined, thick-bedded sands and gravels with sand thickness of generally 30 feet or more per 100 feet. The depositional environment was probably similar to that which occurs in the present-day area with northward flowing river channels, distributaries, and sloughs across floodplains of overbank areas. Deposits extend to depths of about 350 feet, below which occur largely fine-grained silts and clays with poor to brackish water quality (TODB et al., 2017).

Delta Islands

This is representative of the northeastern portion of Subbasin (Diablo Water District GSA and encompasses Bethel Island and vicinity). Sand and gravel beds may correlate to the Fluvial Plain, but net sand thicknesses increase northward from about 30 to 60 feet per 100 feet below Bethel Island. Sand beds exist to depths of about 300 to 350 feet bgs. There is evidence of shallow saline or brackish water that may be present in shallow sand beds below the Delta Islands. The depositional environment is interpreted as multiple stream channels meandering between islands. Channels would be active with through-flowing waters, then abandoned as new channels developed. Possibly slower stream flow and tidal fluctuations allowed thicker, fine-grained sand deposits to form.



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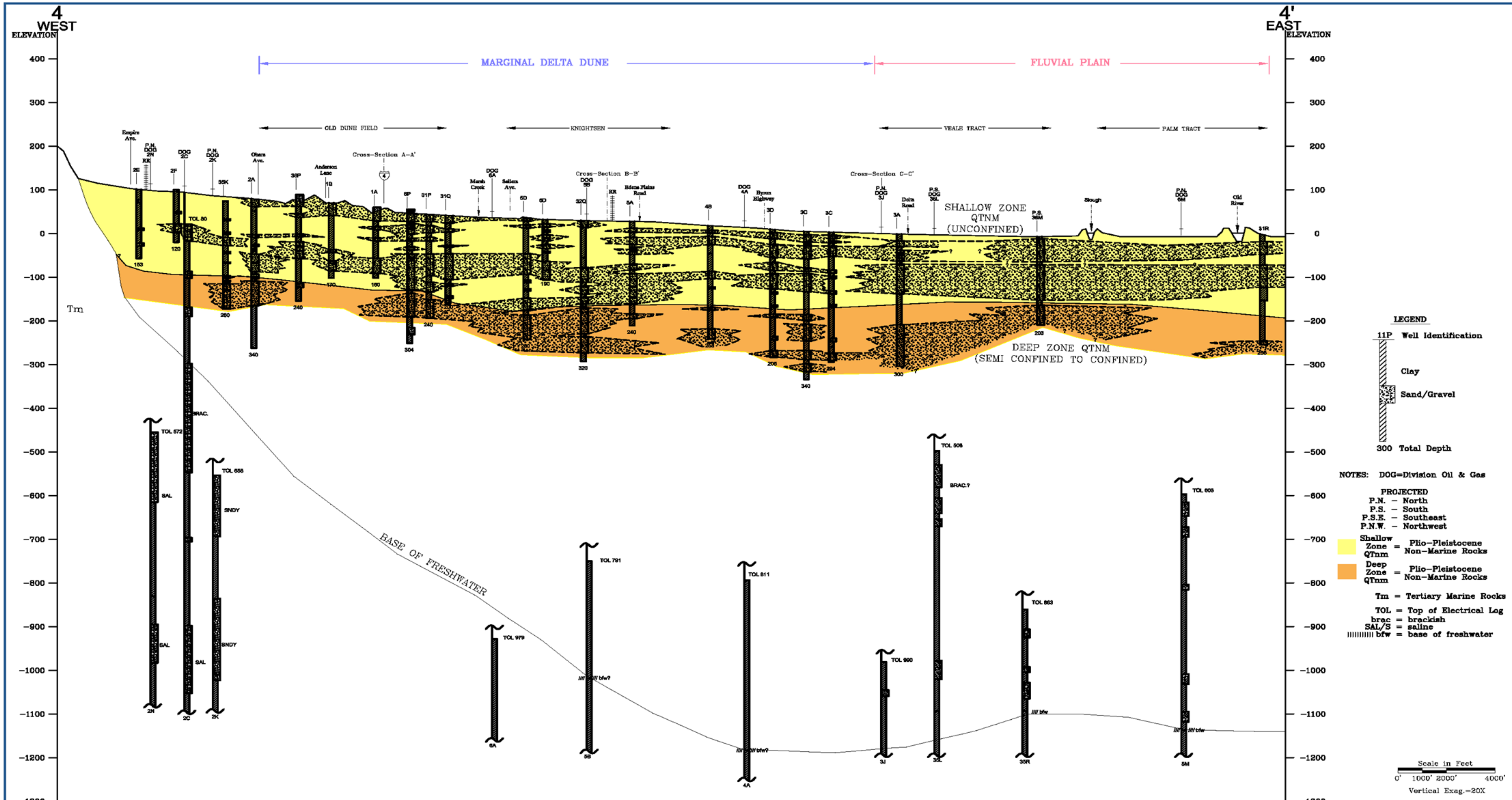
Cross Section Location and Depositional Environment

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-5



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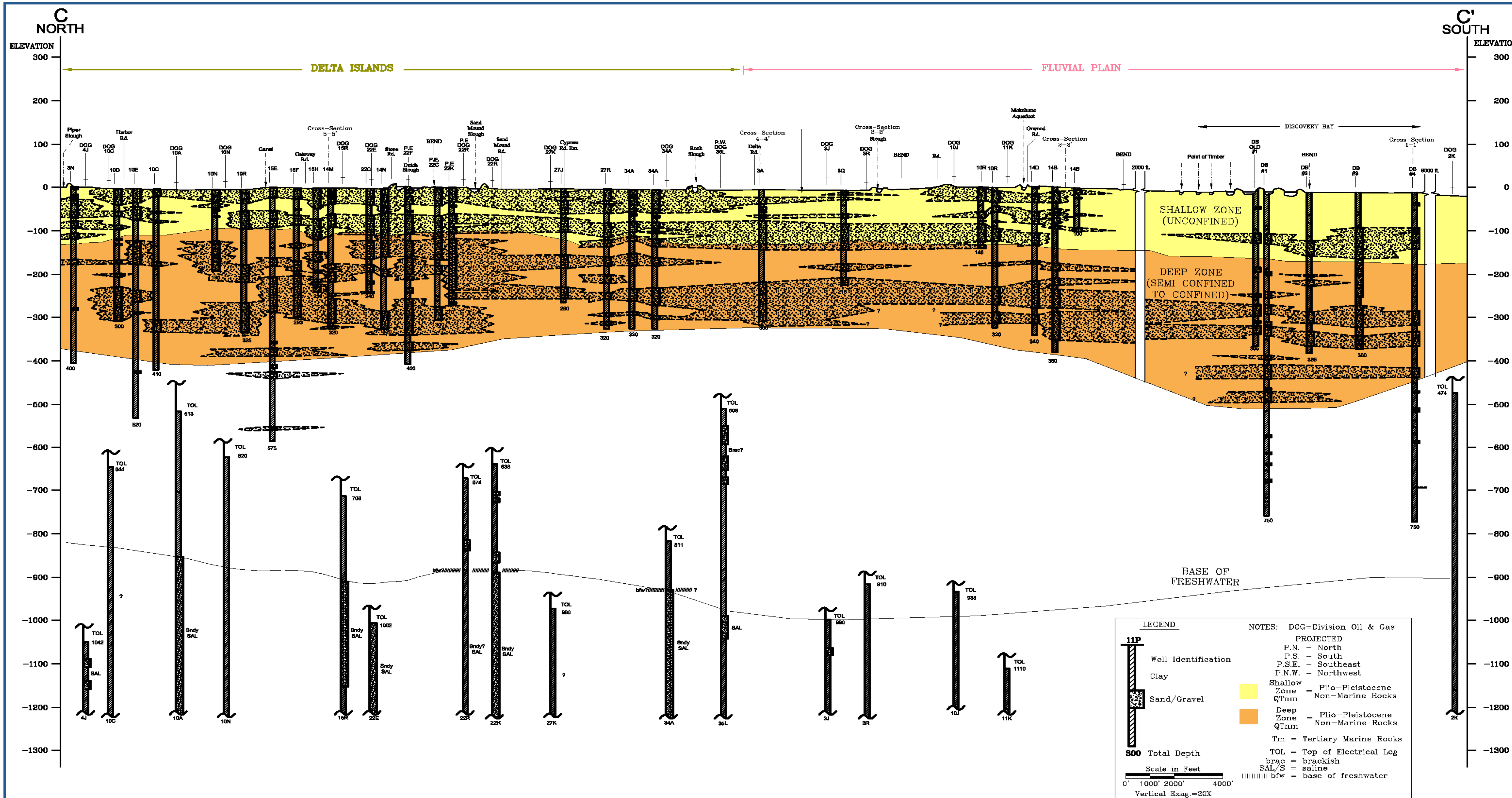
Geologic Cross Section 4-4'

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-6a



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Luhdorff & Scalmanini Consulting Engineers

Geologic Cross Section C-C'

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-6b

Marginal Delta Dunes

This is representative of the Oakley area and defined by numerous thin to thick sand beds that are on the order of 30 to 60 feet thick per 100 feet. The depositional environment is a mixture of delta fluvial distributary channels and possibly aeolian dune fields. A surface deposit of rolling gentle hills of relic sand dunes occurs between Oakley and northern Brentwood. These sand dunes are believed to have been generated by strong winds blowing sand off the delta margins. Some deeper sand beds across the Marginal Delta Dunes area may be older dune fields.

Alluvial Plain

This is representative of greater Brentwood south of the Marginal Delta Dune and City of Oakley, and west of the Fluvial Plain and defined by thin sand and gravel beds with a lower sand thickness (less than 20 feet per 100 feet). The depositional environment is small streams draining eastward from the Coast Range foothills to the west. Flood flows of these streams spread out from the hills depositing fine-grained materials, possibly as mudflows with high sediment content. Stream flows deposited thicker sand and gravel beds that tended to stack upon each other causing the thicker bands of sand beds. The thicker stream deposited sand and gravel bands extend eastward until the sands either thin out or have not been reached by wells. In the north, the stream deposits appear to reach into the Marginal Delta Dunes area, blending into the sand units that are present there.

Antioch and Byron Areas

Due to lack of well control, these two areas could not be examined in detail. The Antioch area is poorly defined, but it appears to be a thin alluvial plain with thin sand beds overlying Plio-Pleistocene non-marine deposits. The Byron area appears to have only a few thin sand beds in a small alluvial plan area that is marginal to the Fluvial Plain region where fine-grained deposits dominate.

3.2.5 Principal Aquifers and Aquitards

Two primary aquifer zones are identified in the East Contra Costa Subbasin: an unconfined to semi- confined Shallow Zone and a semi-confined to confined Deep Zone, with clay layers separating the two. These aquifers are composed of alluvial deposits as illustrated on the representative cross sections (**Figures 3-6a** and **3-6b)**. The Shallow Zone extends from ground surface to a less permeable material (i.e., clay and silt) generally to a depth of less than 150 feet bgs. The Deep Zone directly underlies the shallow zone, is the primary production zone for public supply wells (generally 200-400 feet in depth, LSCE, 2011), and extends to the base of fresh water (a maximum of 1,200 feet from mean sea level).

As indicated previously, the Corcoran Clay does not extend into the ECC Subbasin nor does a similar feature occur that separates major aquifer units. However, in the Alluvial Plain (around the City of Brentwood) there appears to be local confinement by multiple clay layers which separates shallow and deep zones (LSCE, 1999). This separation is seen through distinctive water levels (see **Section 3.3.1**). The Fluvial Plain (around Discovery Bay, **Figure 3-6a**) and Marginal Delta Dune (around Oakley) both have a confined Deep Zone with an extensive layer of clay separating a shallow zone from the deep zone that serves as the primary production aquifer. The Delta Islands area does not have clay layers separating a deep confined zone from shallower aquifer materials nor water levels that reflect it. The primary use of the Shallow Zone is by domestic wells and small community water systems which may have poorer water quality due to Bay-Delta influences. The primary use of the Deep Zone is for municipal supply (City of Brentwood, Discovery Bay and DWD) and agricultural irrigation supply (ECCID and BBID).

Groundwater System Conceptualization

The ECC Subbasin aquifer system is subdivided into two zones: an upper unconfined Shallow Zone that sits above discontinuous to locally continuous clay layers and, a lower semi-confined to confined Deep Zone. As illustrated in the geologic cross-sections described above, the upper 400 feet of sediments is comprised of alluvial deposits with discontinuous clay layers interspersed with more permeable coarse-grained units. Most water wells are constructed within the upper 400 feet where coarse grained units are identified. Water well information is lacking for depths below 400 feet bgs to the base of fresh water but the units are likely fine grained and become brackish at and below that depth based on the current HCM.

3.2.6 Soil Characteristics

There are many soil types found throughout the Subbasin (**Figure 3-7a**). The soil data were gathered from the Natural Resource Conservation Service (NRCS) as part of the Soil Survey Geographic Database (SSURGO). The data are compiled from various maps, which are updated on a yearly basis. The predominate soil types in the Subbasin are the Brentwood, Capay, Delhi, Marcuse, and Rindge series. The Brentwood series is reported to be a well-drained silty clay loam found in valleys and valley floors near Brentwood. The Capay series is noted to be a moderately well-drained clay and is found throughout the Subbasin often near the Brentwood series. The Delhi series is noted to be a somewhat excessively drained sand found primarily in Oakley and Antioch and is derived from eolian deposits. The Marcuse series is noted to be a poorly drained clay and silty clay with a small amount of sand and is found throughout the center of the Subbasin. The Rindge is noted to be a very poorly drained silty clay loam to muck, and is found along the Delta Islands (i.e., Bethel Island) and near the Old River boundary.

3.2.6.1 Soil Properties

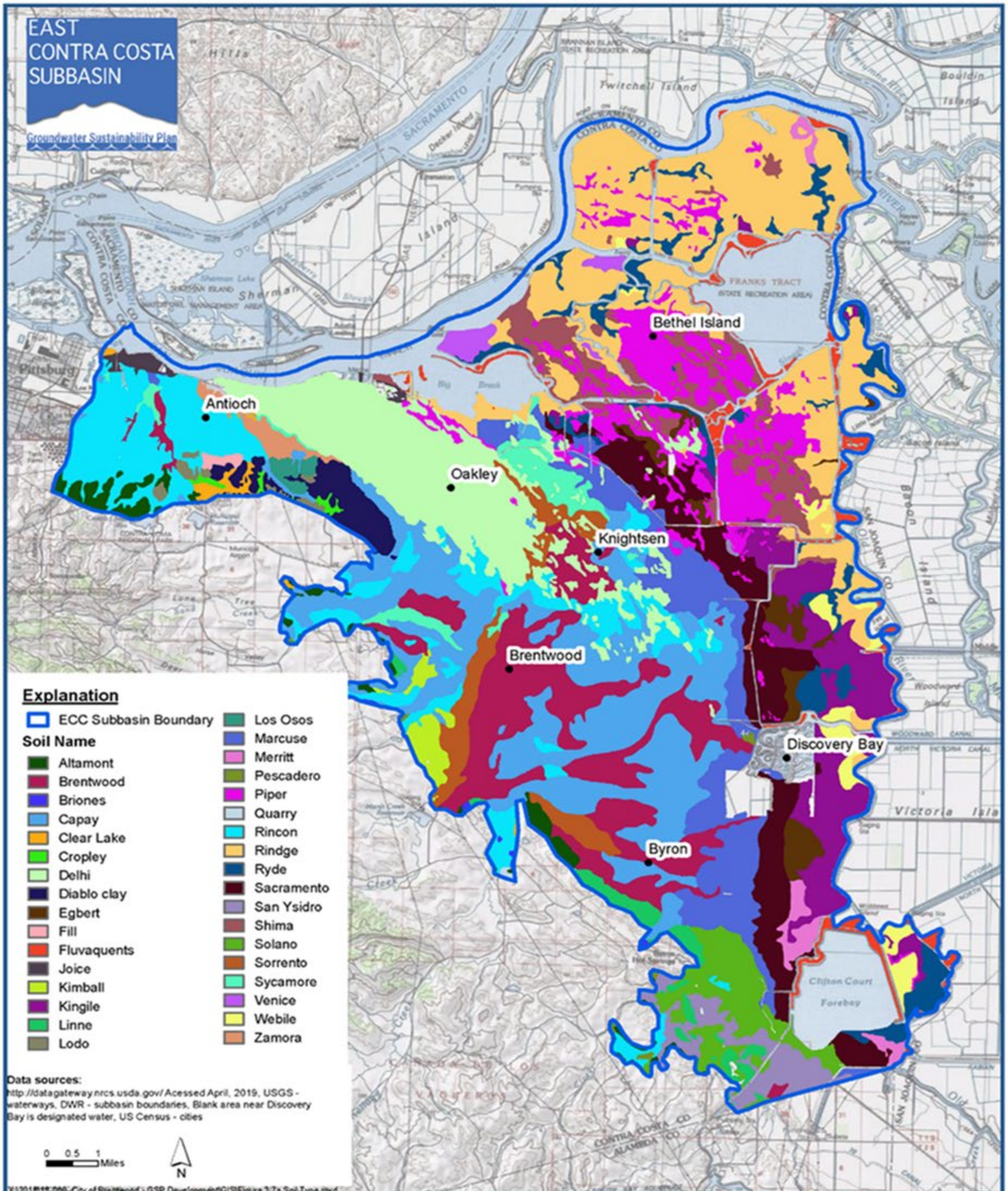
Soil properties are important to the HCM to the extent that they provide a pathway for groundwater infiltration through the soil and have high or low runoff potential. This information is used to calculate surface water recharge and to estimate deep percolation for surface water/ groundwater models. **Figure 3-7b** illustrates the soil texture of the surficial soils found in the Subbasin as outlined by NRCS. The dominant soil textures are clay, clay loam, sand, and muck. Clays and clay loams are found throughout the Subbasin. Sand is concentrated near Antioch and Oakley in the northwestern part of the Subbasin. Muck is found in the eastern portion of the Subbasin along the Old River and the Delta Islands. Muck is defined by the NRCS as “the most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic material”.

Figure 3-7c presents the average hydraulic conductivity[1] for soils in the Subbasin. The hydraulic conductivity of soils ranges from less than 1 ft per day to more than 15 ft per day (ft/day). The highest conductivity areas are those with soil textures of muck, sand, or loamy sand. The areas around Oakley and on the northeastern and eastern border of the Subbasin have the highest hydraulic conductivity possibly due to the occurrence of dune sands.

Figure 3-7d shows the soil salinity for the Subbasin. Soil salinity is measured by electric conductivity (EC) and is measured by the amount of soluble salts in the soil. Almost the entire Subbasin has electric conductivity values of less than 2 deSiemens per meter (dS/m) which is low. Higher EC is noted in the center of the Subbasin, following a similar pattern as the distribution of the Marcuse soil, which was noted to be poorly

[1] Capacity for soil to transmit water with units of Length/Time. Units used in this report are feet/day.

drained clay. There is also a small area near Antioch that has ECs greater than 15 dS/m, in an area with a muck texture.



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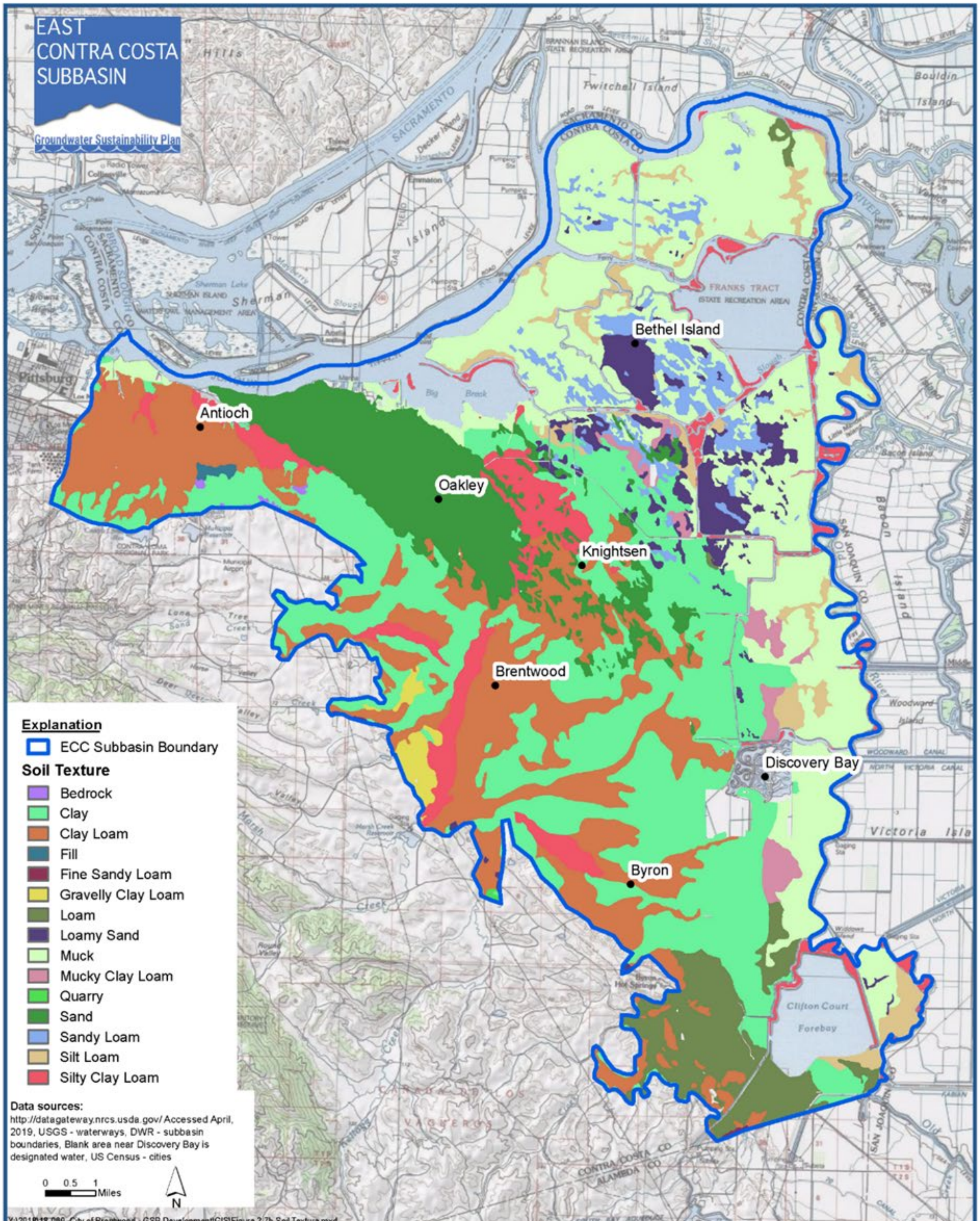
Soil - Type

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-7a



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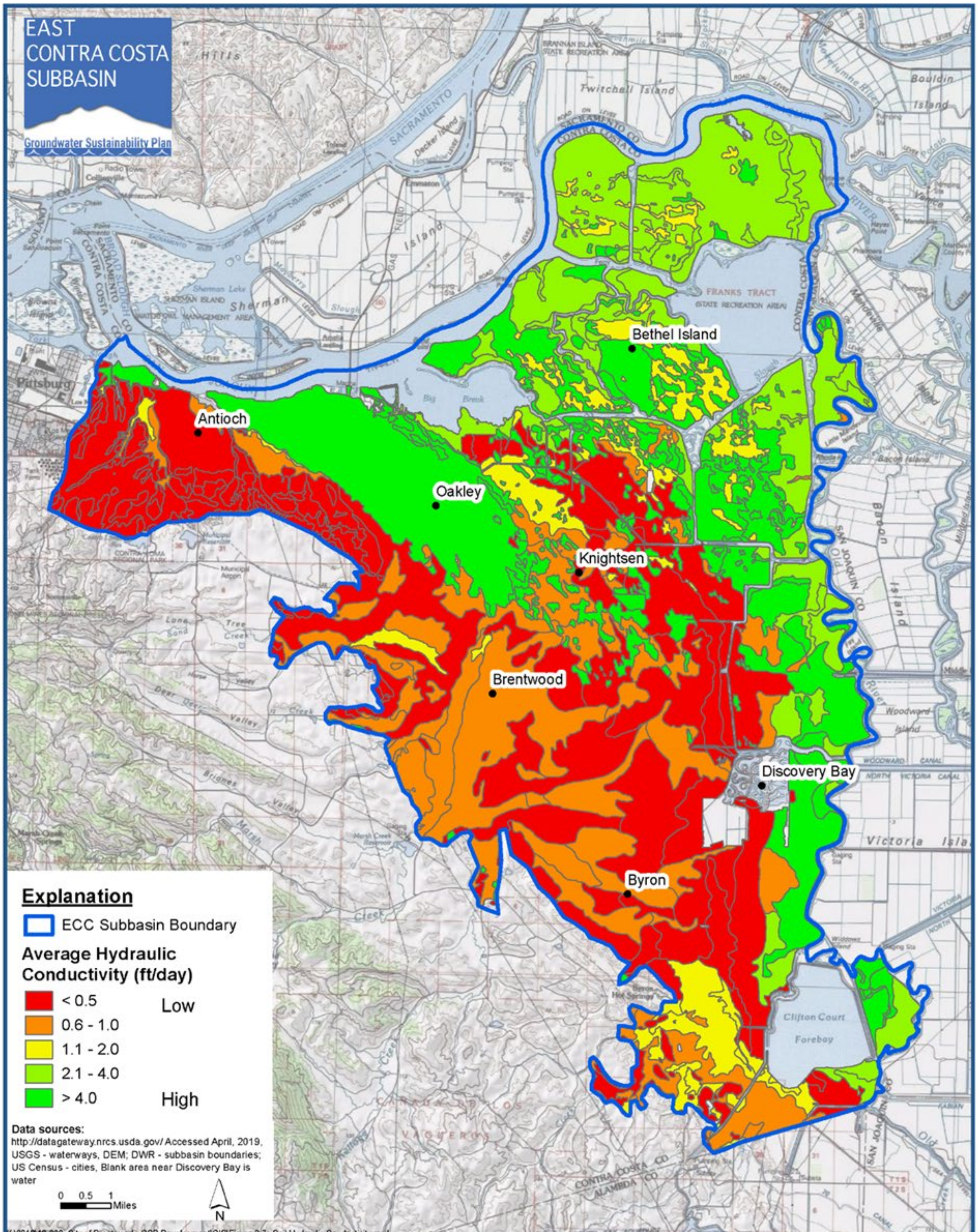
Soil - Texture

Figure 3-7b

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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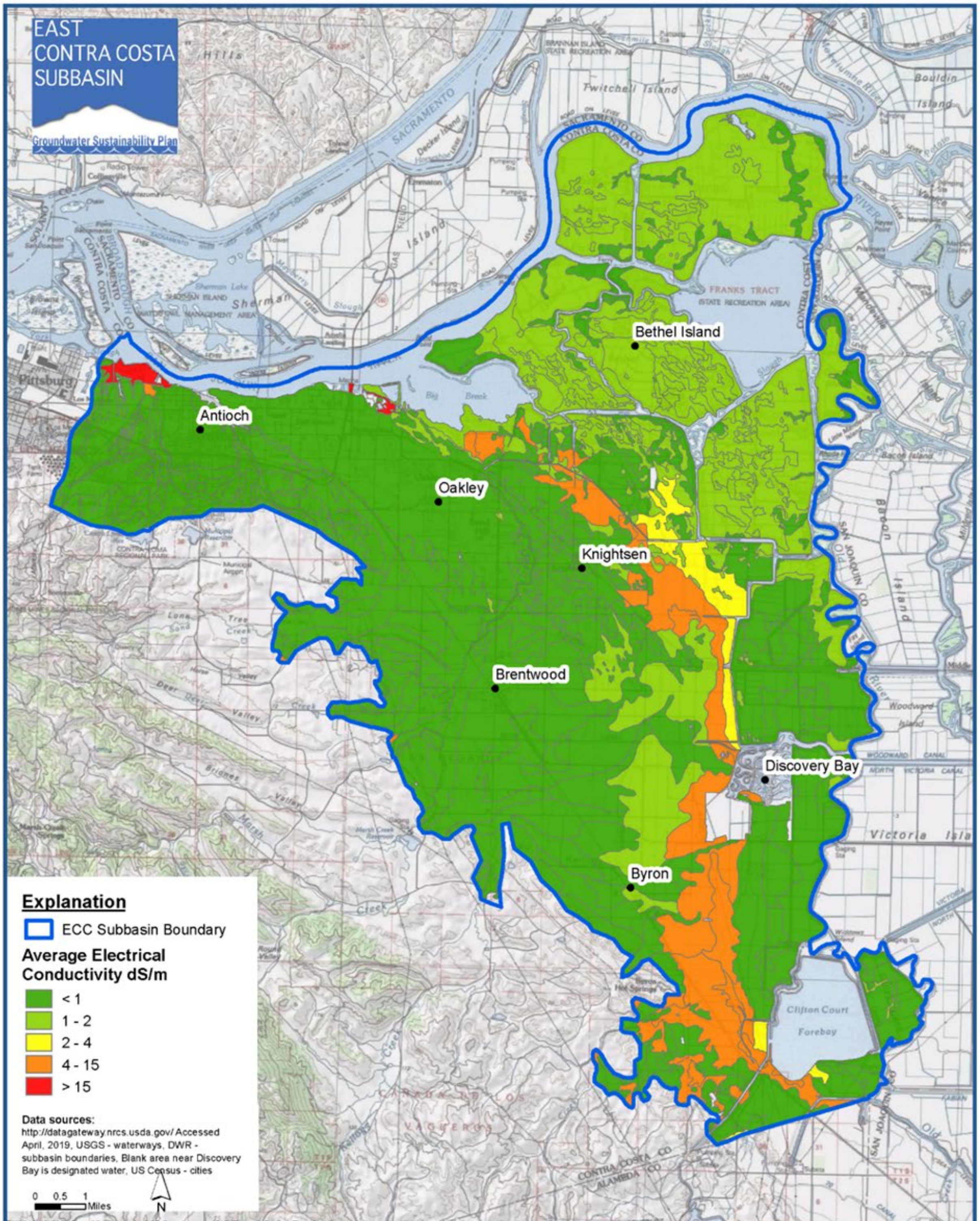
Soil - Hydraulic Conductivity

Figure 3-7c

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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Soil - Electrical Conductivity

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-7d

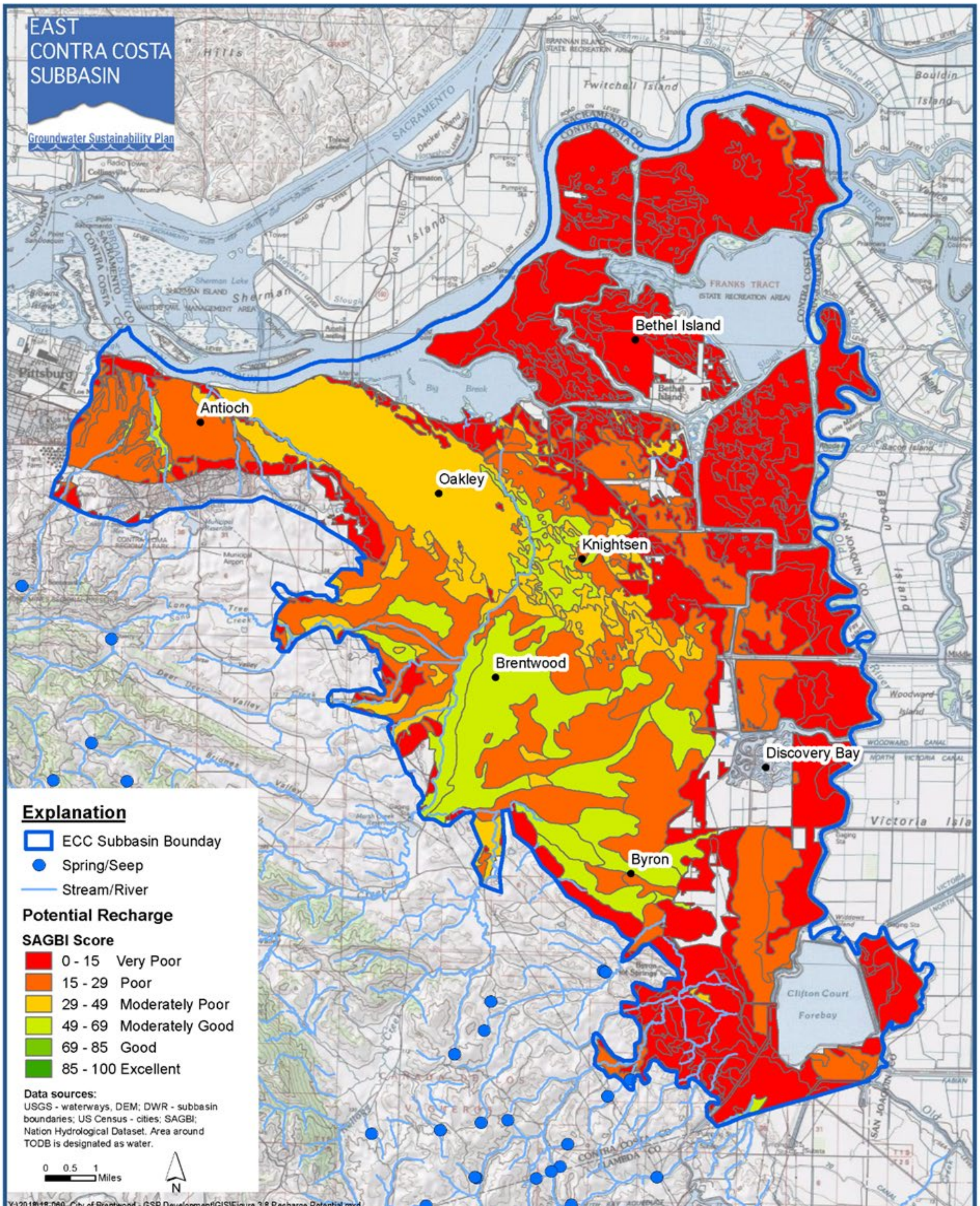
3.2.7 Groundwater Recharge and Discharge Areas

Groundwater recharge can occur from infiltration of precipitation and applied water (e.g., irrigation), surface water infiltration, subsurface inflows from outside the Subbasin, and unintentional recharge (e.g., leaky pipes). This section identifies the areas that may provide greater potential for future managed surficial recharge under the GSP implementation. Surface areas with favorable recharge potential (**Figure 3-8**) were evaluated using soil mapping data and the Soil Agricultural Groundwater Banking Index (SAGBI). The SAGBI provides a characterization of potential for groundwater recharge on agricultural land. The SAGBI score is based on five elements: deep percolation, root zone residence time, topography, chemical limitations, and soil surface conditions. **Figure 3-8** illustrates the main areas of percolation; however, these are not the same areas as those with high hydraulic conductivity (**Figure 3-7c**) and high infiltration potential (**Figure 3-7d**). The areas with highest recharge potential are along Marsh Creek near Brentwood and Kellogg Creek in the Byron area (moderately good), and the dune sands in the Oakley area (moderately poor). However, as discussed below, water levels indicate very little space, if any, available in the aquifer for additional recharge.

Due to the different depositional environments that occur in the Subbasin, there are a variety of natural recharge sources. The Alluvial Plain area is recharged from the Coast Range Foothills and groundwater moves through the Alluvial Plain and the Marginal Delta Dunes' area. The Fluvial Plain area likely has a different recharge source from the south as a function of its fluvial setting (LSCE, 1999). Recharge for the Delta Islands may be a combination of different sources, including fluvial influence from the Delta.

Groundwater discharge from the Subbasin can occur from discharge to surface water and springs, subsurface outflow from the Subbasin, and groundwater extraction by wells. Groundwater discharge from the Subbasin is from groundwater pumping (agricultural, municipal, domestic, and industrial uses). Maps of general locations of wells are provided in **Figures 2-6a** to **2-6d**. These maps indicate that the majority of domestic wells are located in the western portion of the Subbasin, public supply wells are mostly concentrated in urban centers of Discovery Bay, Brentwood, and Oakley, and agricultural wells are located on the western side of the Subbasin. Maps of the average depths (in feet) of domestic, agricultural, and public supply wells by section are provided in **Figures 3-9a** to **3-9c**. Domestic well depths are generally less than 200 feet bgs (**Figure 3-9d**). Agricultural well depths vary across the Subbasin with ranges from 60 to 800 feet bgs. Public supply wells are most commonly in the 200 to 400-foot bgs range.

The USGS's National Hydrography Dataset (NHD) maps one spring in the Subbasin located along the southwestern boundary. There are multiple springs that could be sources of recharge, in addition to streams, located in the foothills west of the Subbasin boundary (**Figure 3-8**).



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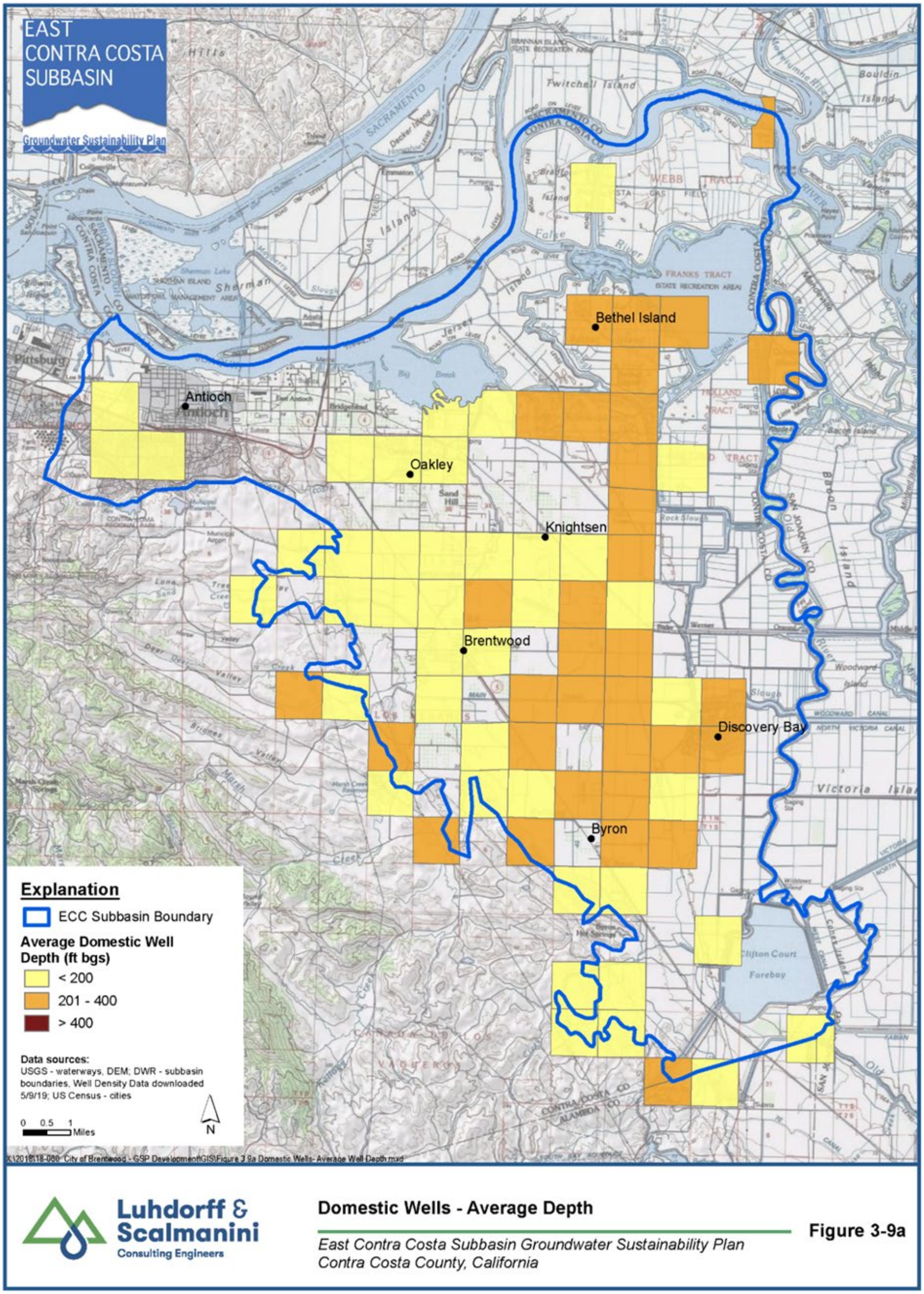
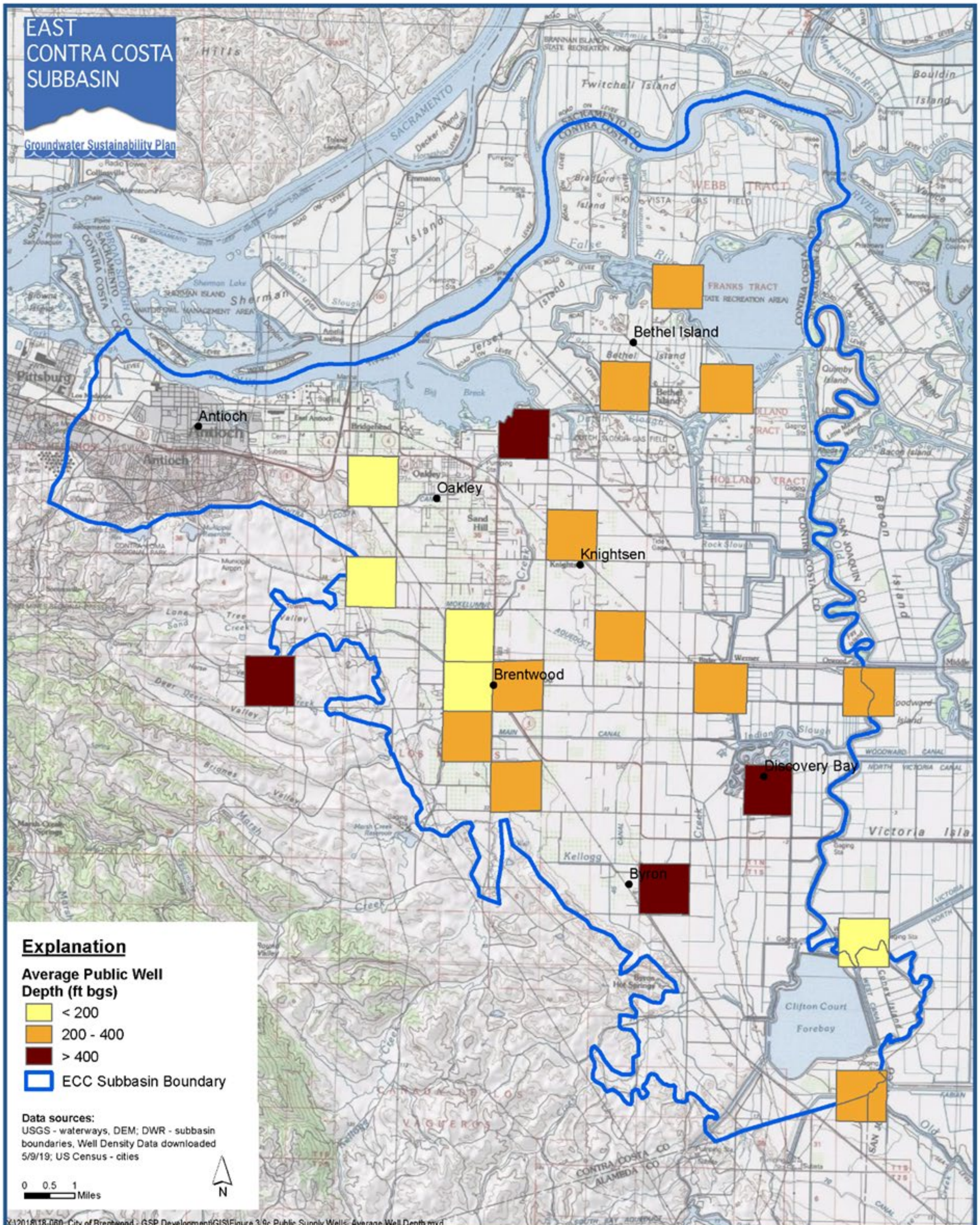
Soil - Potential Recharge

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-8


EAST CONTRA COSTA SUBBASIN
Groundwater Sustainability Plan
Bethel Island
Antioch
Oakley
Knightsen
Brentwood
Discovery Bay
Byron
Explanation
ECC Subbasin Boundary
Average Domestic Well Depth (ft bgs)
< 200
201 - 400
> 400
Data sources:
USGS - waterways, DEM; DWR - subbasin boundaries, Well Density Data downloaded 5/9/19; US Census - cities
0 0.5 1 Miles
N
Luhdorff & Scalmanini Consulting Engineers
Domestic Wells - Average Depth
East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California
Figure 3-9a



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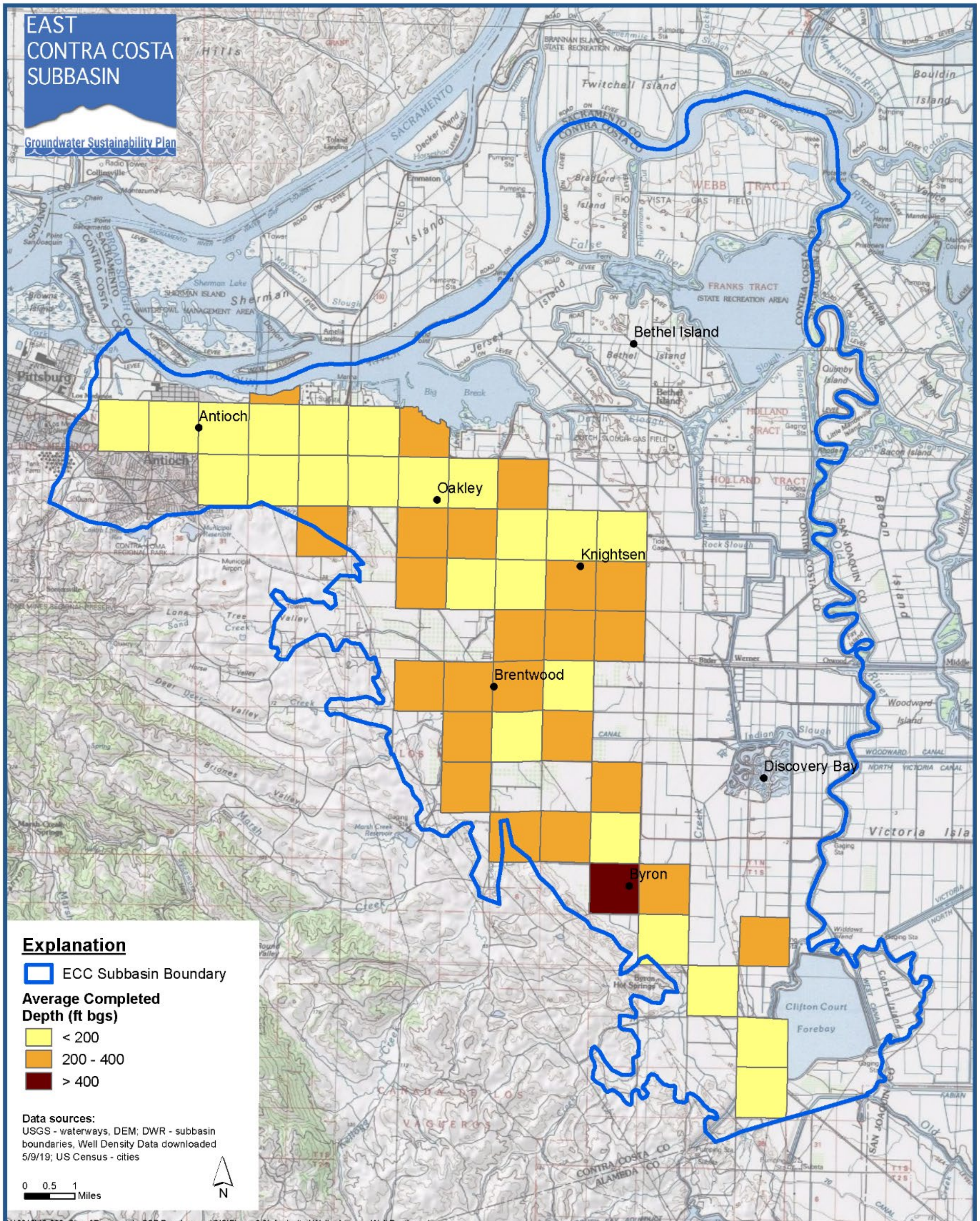
Public Supply Wells - Average Depth

Figure 3-9b

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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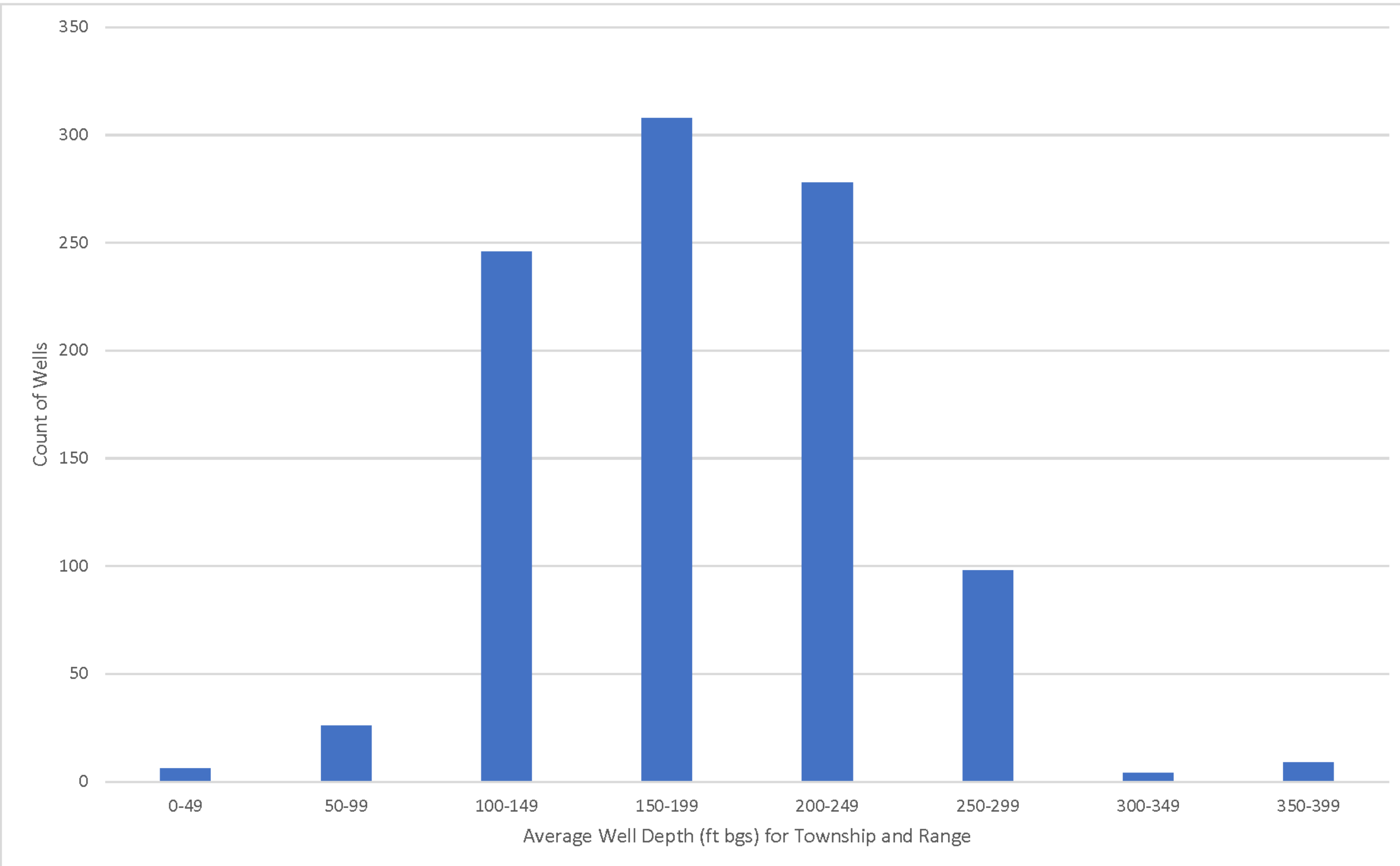
Agricultural Wells - Average Depth

Figure 3-9c

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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Domestic Well Depths

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-9d

3.2.8 Imported Supplies

Contra Costa Water District draws water from the Delta primarily under a contract with the federal Central Valley Project (CVP). Surface water is diverted at two intake locations within the Subbasin: Rock Slough and Old River (**Figure 2-4**). Two entities in the Subbasin purchase water from CCWD: City of Antioch and Diablo Water District. In addition, CCWD diverts and conveys ECCID surface water for the City of Brentwood.

3.2.9 Surface Water Bodies

There are a number of surface water bodies that are significant to the management of the Subbasin (**Figure 3-10**). The Clifton Court Forebay, Franks Tract, and Big Break are large surface water bodies in the Subbasin. Two rivers are the primary natural surface water features in the ECC Subbasin. The San Joaquin River flows from east to west along the northern edge of the Subbasin and Old River flows from north to south on the eastern edge of the Subbasin. Numerous streams from the Coast Range enter the Subbasin from the west and discharge into the Delta (ECC IRWM, 2019). Marsh Creek drains parts of Mt. Diablo and has flows impounded (stored/captured) by the Marsh Creek Reservoir. Flow and water quality information is available for 2012 to 2013[2] in connection to the Dutch Slough Project. Similar to groundwater quality, March Creek water quality analyses showed TDS and chloride that exceeded the recommended secondary MCL (500 mg/L and 250 mg/l, respectively). Kellogg Creek drains the watershed south of Marsh Creek and includes the CCWD operated Los Vaqueros Reservoir. Brushy Creek is south of Kellogg Creek and drains into Old River and Clifton Court Forebay.

3.2.10 Hydrogeologic Conceptual Model Data Gaps and Uncertainty

This section identifies the data gaps and levels of uncertainty of the information for the physical setting and characteristics of the basin and current conditions.

Lithologic, water quality, and water level measurement controls exist for purposes of developing the hydrogeologic conceptual model mostly in the urban areas of Brentwood, Discovery Bay and Oakley. There are large areas in the north near Antioch and Bethel Island and in the south, west of Clifton Court Forebay, that have low well density as a result of a more rural setting. Many wells used for municipal purposes were also primarily screened to less than 500 feet bgs, which leads to uncertainty in the nature of the deeper subsurface materials. Many lithological descriptions come from drillers' logs which are limited in quality as a function of driller's experience and attention to detail. Geophysical logs provide the most consistent and quantitative information, but well control is highly variable as a function of current and historic groundwater use patterns. Expanded monitoring by aquifer for groundwater quality and level measurements and additional lithologic descriptions outside the urban areas would benefit development of the hydrogeologic conceptual model.

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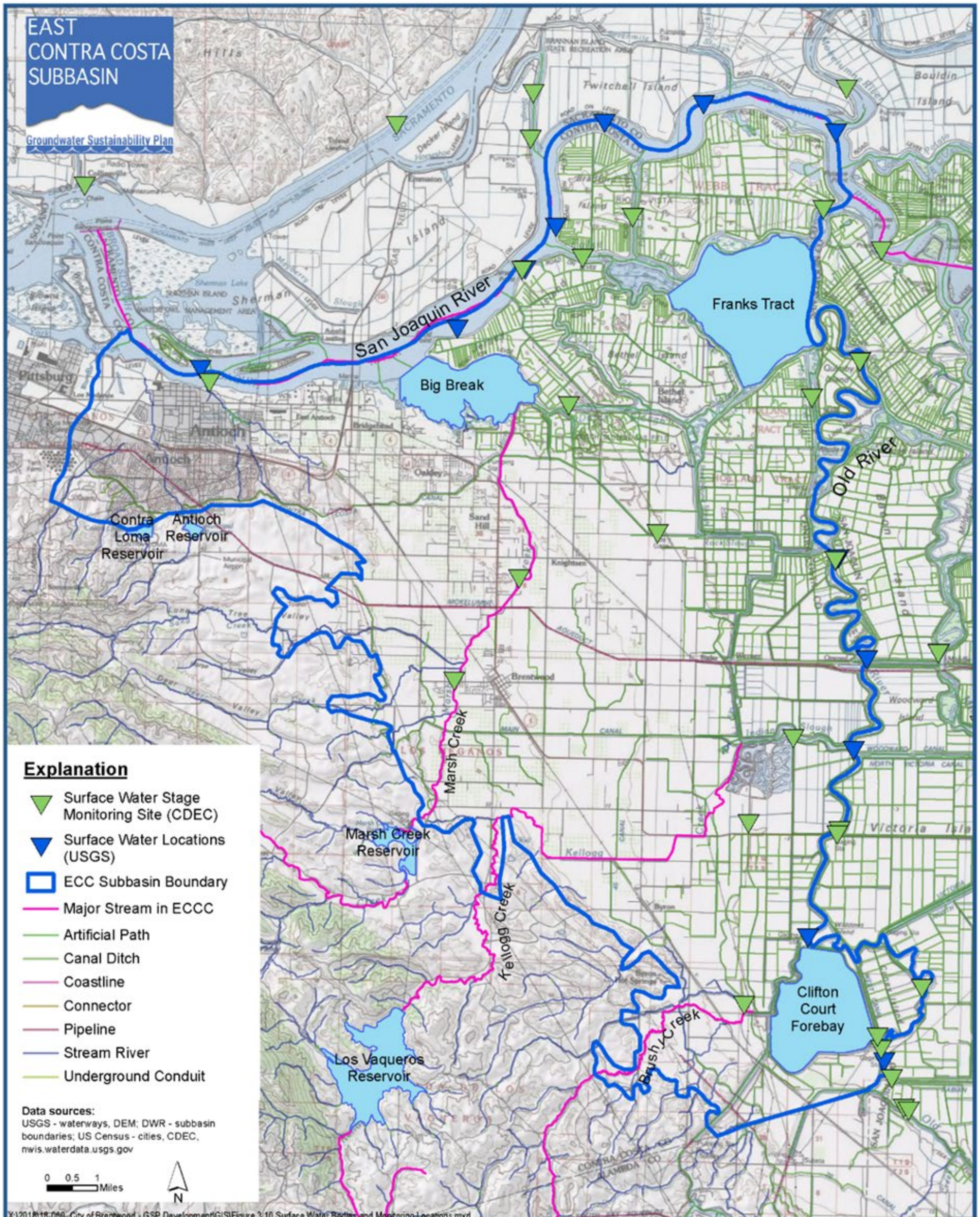
[2] Hydrofocus Inc. 2014. Dutch Slough Restoration Area Surface Water Quality Monitoring Report, September 2012 to August 2013. April 11, 2014. 228 pages.



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Surface Water Bodies and Monitoring Locations

Figure 3-10

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

3.3 Groundwater Conditions

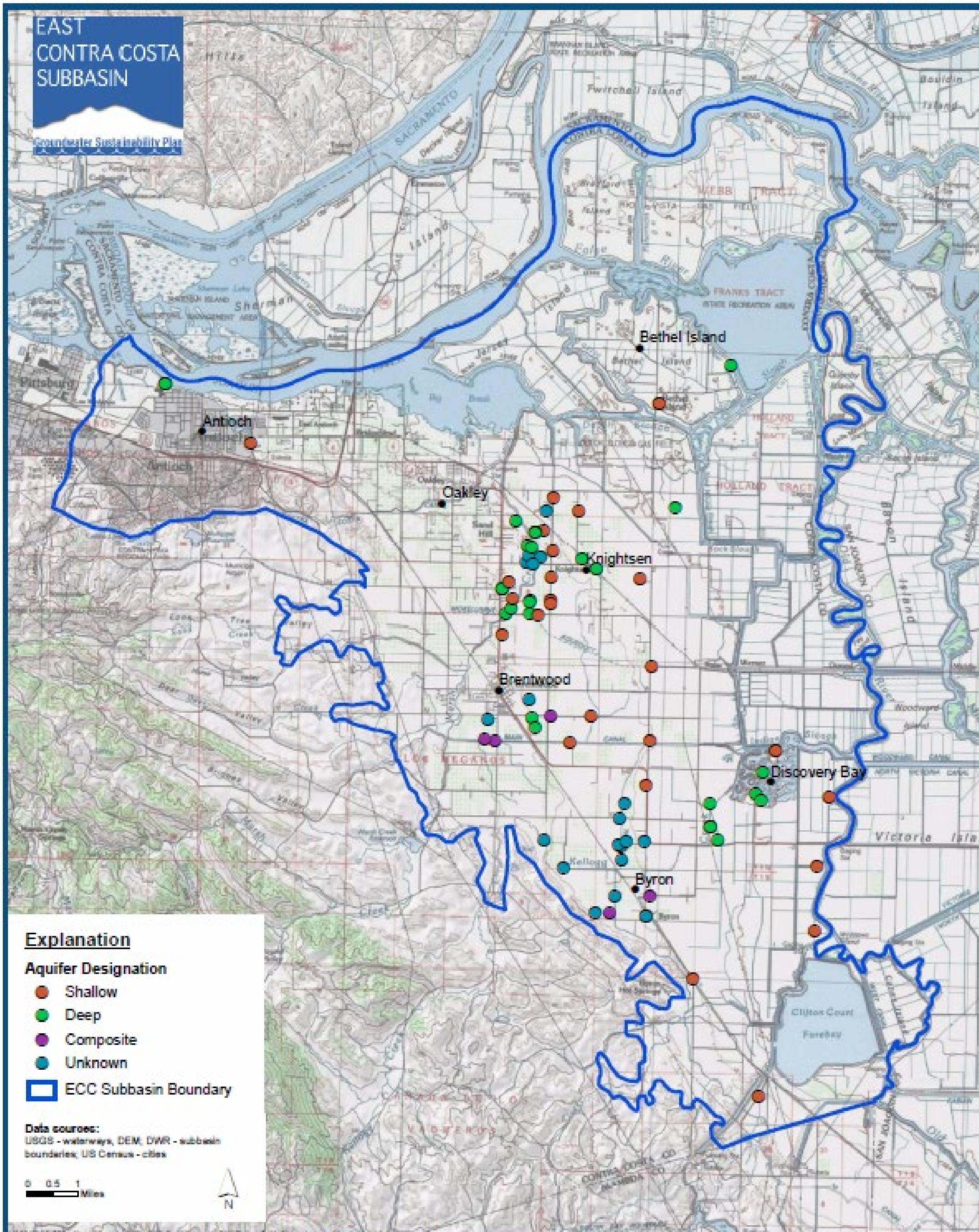
This Groundwater Conditions section describes historical groundwater conditions in the ECC Subbasin through present day. Groundwater levels and storage, seawater intrusion, groundwater and surface water quality, land subsidence, interconnected surface water, and groundwater dependent ecosystems are presented in this section.

3.3.1 Groundwater Levels

Groundwater levels provide useful data for understanding groundwater conditions and trends over time. Groundwater levels are affected by natural recharge and discharge which are in turn governed by variations in climate conditions. Groundwater pumping and water usage such as in agriculture also affect groundwater levels. Groundwater movement, as governed by regional and local gradients and aquifer properties are also reflected in groundwater levels. All factors play a role in changes in groundwater storage over time which is a primary consideration in the HCM.

Groundwater level records were compiled from the various entities in the Subbasin in addition to data from Geotracker, USGS, and DWR. A small subset of wells has a long period of record for water level monitoring, but most data are relatively recent, within the last 15 years. The wells with the longest period of record have over 50 years of data and are primarily concentrated in the ECCID area (**Figure 2-1**). All data were reviewed and compiled in a Data Management System (DMS). Data of similar type was converted to the same units and, if applicable, the method used to gather data was noted (e.g., surveyed reference point elevations versus estimated elevations). A well was assigned an aquifer zone designation (Shallow Zone, Deep Zone, Composite, or Unknown) based on the well screen interval and/or total well depth. This well construction information is presented in **Appendix 3c** for over 1,100 wells in the ECC Subbasin. The contact between the Shallow Zone and Deep Zone ranges in depth from 100 and 150 ft bgs throughout the Subbasin but is generally about 120 ft bgs. Wells with screen intervals in both zones were given the designation Composite. Wells with missing well construction information were designated Unknown. **Figure 3-11** illustrates the groundwater level monitoring well locations in the Subbasin and their assigned aquifer designations (Shallow Zone, Deep Zone, Composite, or Unknown) based on well construction. Selected groundwater level hydrographs are presented for Shallow Zone wells in **Figure 3-12a**, for Deep and Composite Zone wells in **Figure 3-12b,** and all hydrographs are presented in **Appendix 3d**. Overall, water levels are stable for the periods of record.

Figure 3-12a is a panel map with hydrographs from wells completed in the unconfined Shallow Zone. Shallow groundwater level information is concentrated in the Oakley, Brentwood, and Discovery Bay areas. These data indicate that basin-wide Shallow Zone water levels have remained fairly stable with no evidence of long-term declines. A minor shift in water level is seen in one well, 5 Binn in the southern portion of the Subbasin, that has dropped five feet over a 22-year period. This is not considered a significant factor to either groundwater quantity or quality in the Subbasin.



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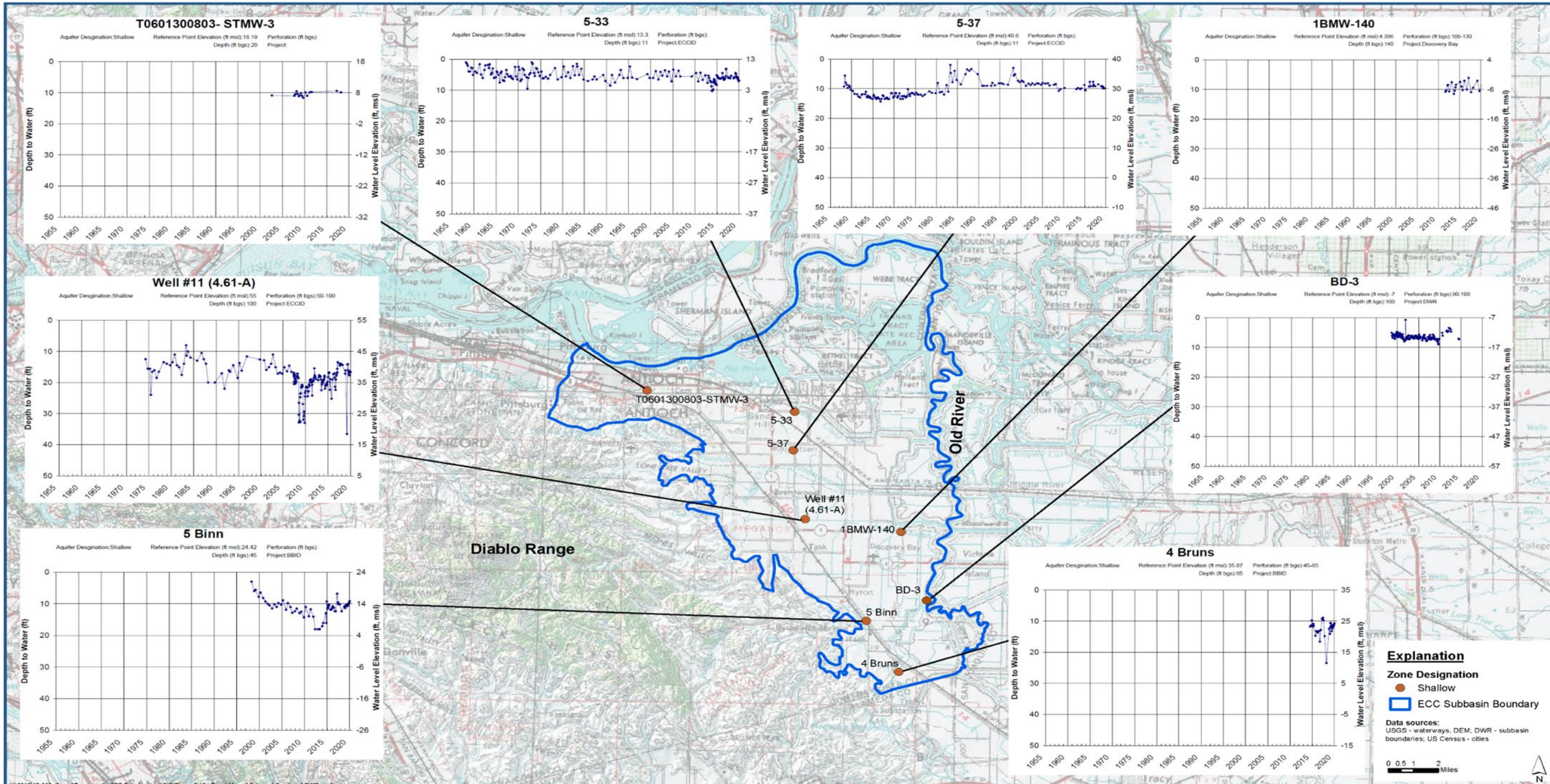
Groundwater Level Monitoring Locations

Figure 3-11

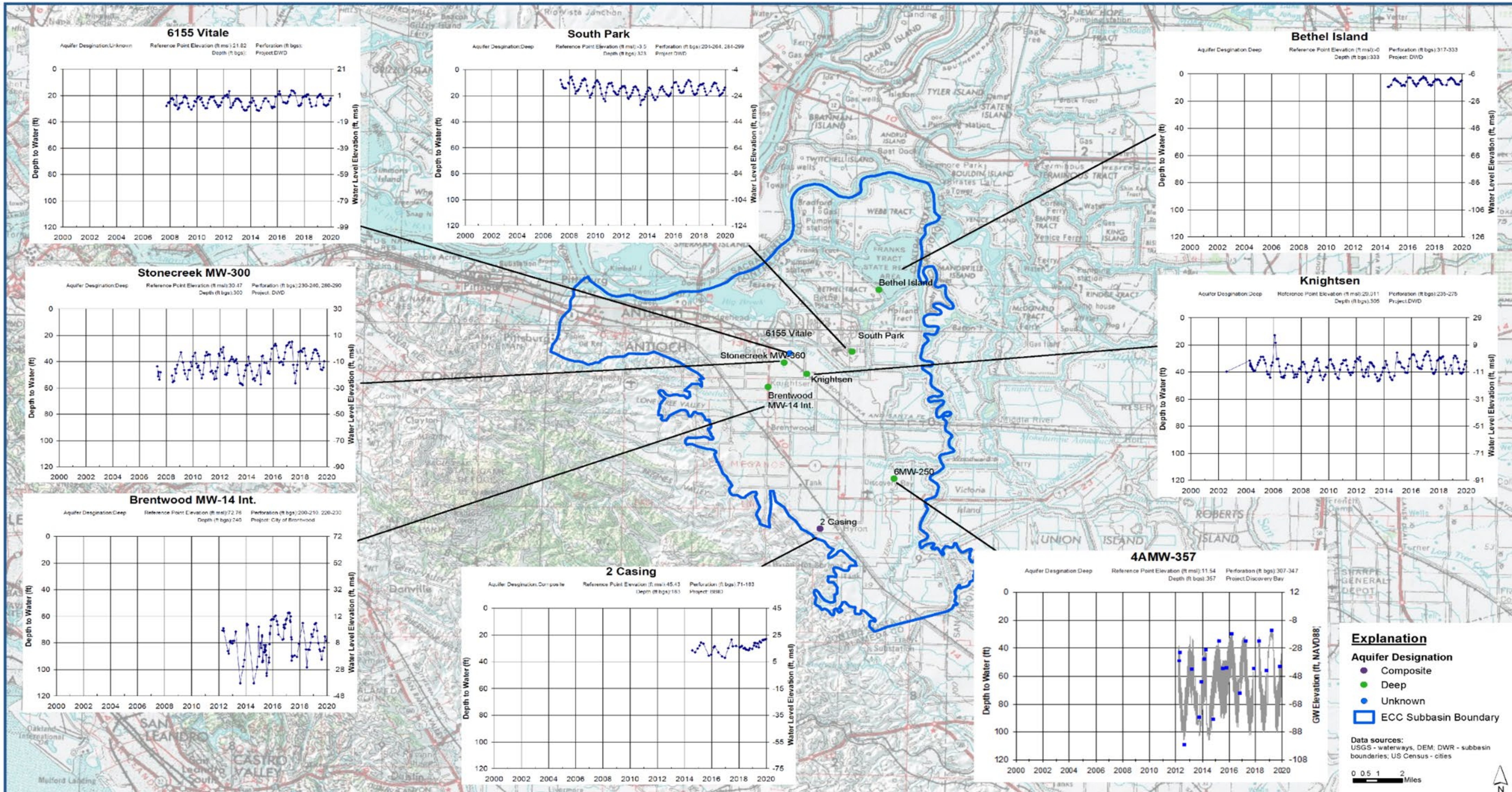
East Contra Costa Subbasin Groundwater Sustainability Plan
Contro Coasta County, California



Selected Graphs of Groundwater Elevations - Shallow Zone

Figure 3-12a

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California



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Selected Graphs of Groundwater Elevations - Deep and Composite Zone

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

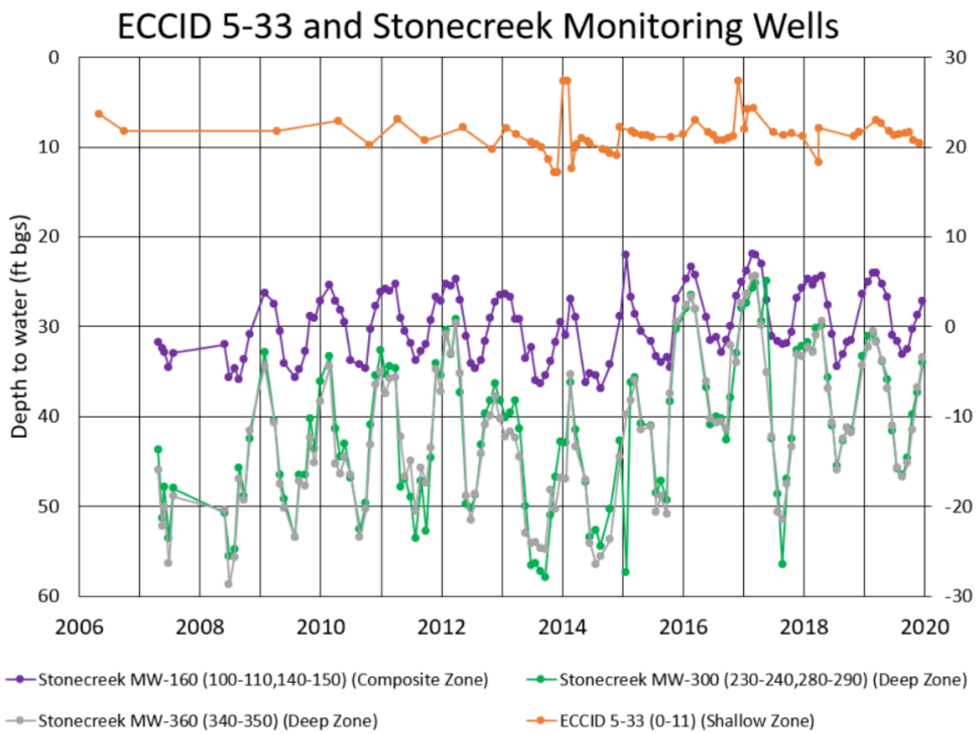
Figure 3-12b

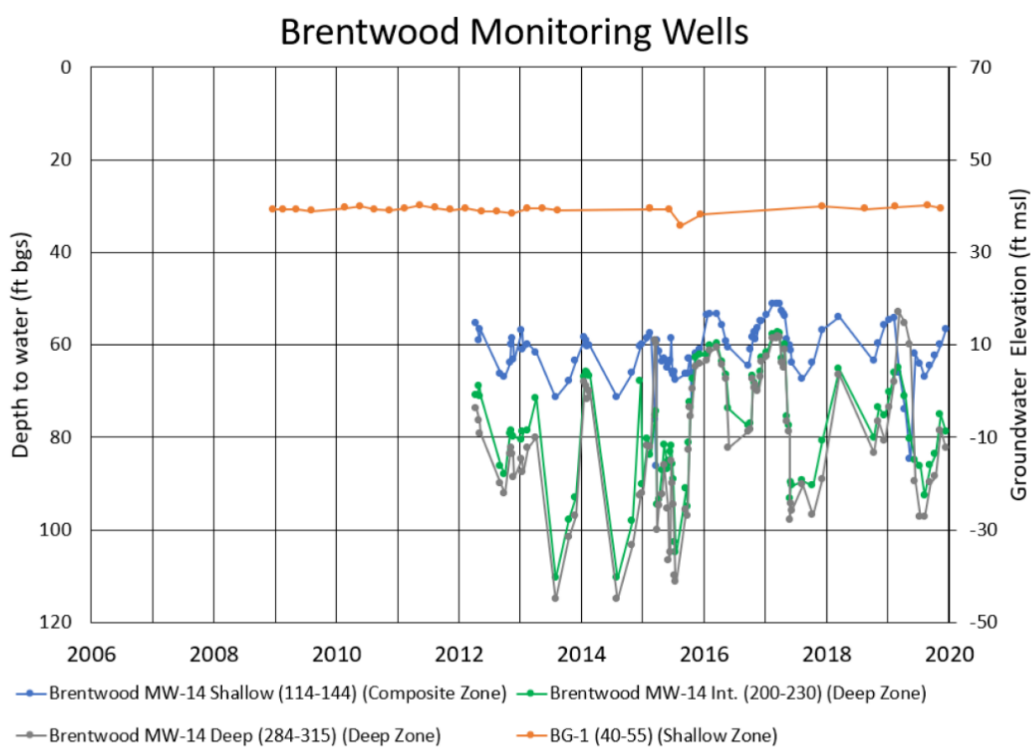
Shallow Zone seasonal variations in groundwater levels on a regional basis are very minor (one to three feet). In the Oakley and Brentwood areas, a few Shallow Zone wells with deeper completions (100 to 150 ft bgs) show more variable seasonal trends (10 to 15 feet annual fluctuation in water levels) that suggest a slight increase in confinement (semi-confined) with depth. Shallow monitoring wells in the Discovery Bay area and eastward along Old River (BD-1, 2, 3) do not have pronounced seasonal water level changes (less than five feet annually) that may be attributed to influence by and proximity to the Delta. Shallow wells located in the western portion of the Subbasin (e.g., Well #11 [4.61-A], **Appendix 3d**) have more pronounced seasonal water level changes (about 10 feet annually) that is likely influenced by boundary effects due to proximity to the edge of the groundwater basin (e.g., the Diablo Range). The Delta Islands have a unique shallow groundwater situation unlike the rest of the Subbasin. Depth to water in subsided Delta islands (described in more detail below) is controlled by drainage ditches that convey irrigation water and seepage water from adjacent channels that is then pumped back into Delta channels. Deverel et al. (2016) reports that, due to this drainage system, groundwater levels are generally maintained at about 2-1/2 to 4 feet bgs in the Delta islands area.

Figure 3-12b shows select hydrographs of the confined Deep and Composite Zone wells in the Subbasin. Regional large capacity supply wells target the Deep Zone and are generally over 200 feet in depth (LSCE, 2011). The hydrographs show generally stable conditions with seasonal water level fluctuation from 10 to 30 feet bgs with maximum decline during the summer months. This is followed by a full recovery of water levels during wet months (November to March). Some variation in annual peak water levels according to climatic trends is noted in the period between 2007 and 2010 and 2012 to 2015 when water levels appear to be affected by the state-wide droughts (**Appendix 3d**). There is no evidence of pumping-induced groundwater level declines.

Vertical groundwater gradients can be monitored with nested monitoring wells. When plotted together, the water levels show the variation of groundwater levels in an unconfined, semi-confined and confined aquifer system (**Figures 3-13a and b**). The ECC Subbasin has three locations with nested monitoring wells: Stonecreek Monitoring Wells, Brentwood MW-14 Monitoring Wells, and Discovery Bay (**Figure 3-13c**). The Stonecreek Monitoring Well cluster has three monitoring wells screened between 100 and 350 ft bgs with a local shallow well (ECCID 5-33) that has a well depth of 11 ft bgs. Brentwood MW 14 has three wells screened between 114 and 315 ft bgs and a shallower well (BG-1) screened between 40-55 ft bgs. Discovery Bay MW4A has two wells screened between 122 and 347 ft bgs. All three nested wells show similar trends. In Stonecreek and Brentwood wells, the two deeper screened wells exhibit similar groundwater levels with seasonal variations of up to 30 ft. The shallower wells have higher groundwater levels with less seasonal variation (less than five feet for the ECCID 5-33 well). The Discovery Bay Deep Zone monitoring well (4AMW-357) has up to 60 feet seasonal variation and the Shallow Zone monitoring well (4AMW-152) has less than 5 feet of seasonal variation.

These hydrographs demonstrate that groundwater levels in ECC Subbasin wells are stable and that groundwater conditions in the Subbasin are consistent with sustainable use. The water levels, by virtue of their consistent seasonal recoveries, also indicate that the Subbasin on the whole is full, with no room for additional groundwater recharge.





X:\2018\18-060 City of Brentwood - GSP Development\GIS\Figure 3.14a Vertical Groundwater Gradients.mxd

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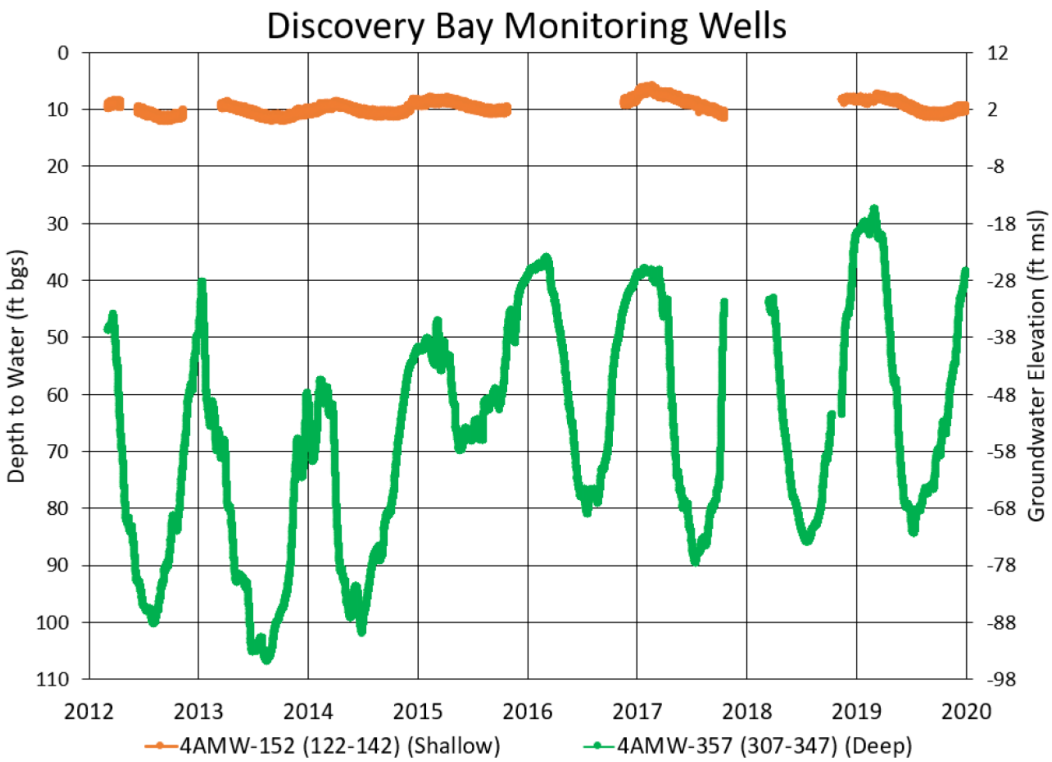
Vertical Groundwater Gradients

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-13a



X:\2018\18-060 City of Brentwood - GSP Development\GIS\Figure 3.14b Vertical Groundwater Gradients.mxd

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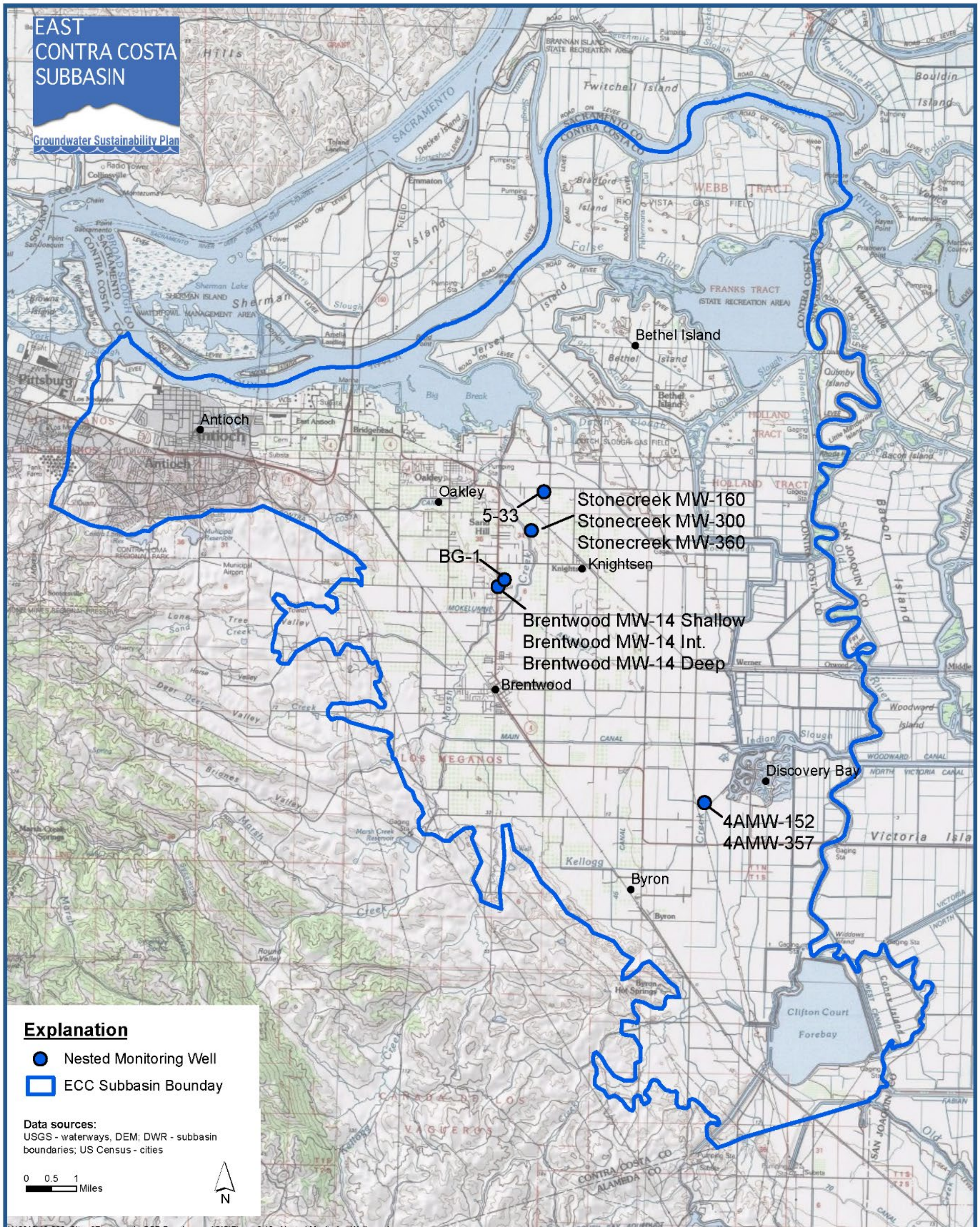
Vertical Groundwater Gradients

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-13b



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Nested Monitoring Well Locations

Figure 3-13c

East Contra Costa Subbasin Groundwater Sustainability Plan
Contro Coasta County, California

3.3.2 Groundwater Elevation Contours

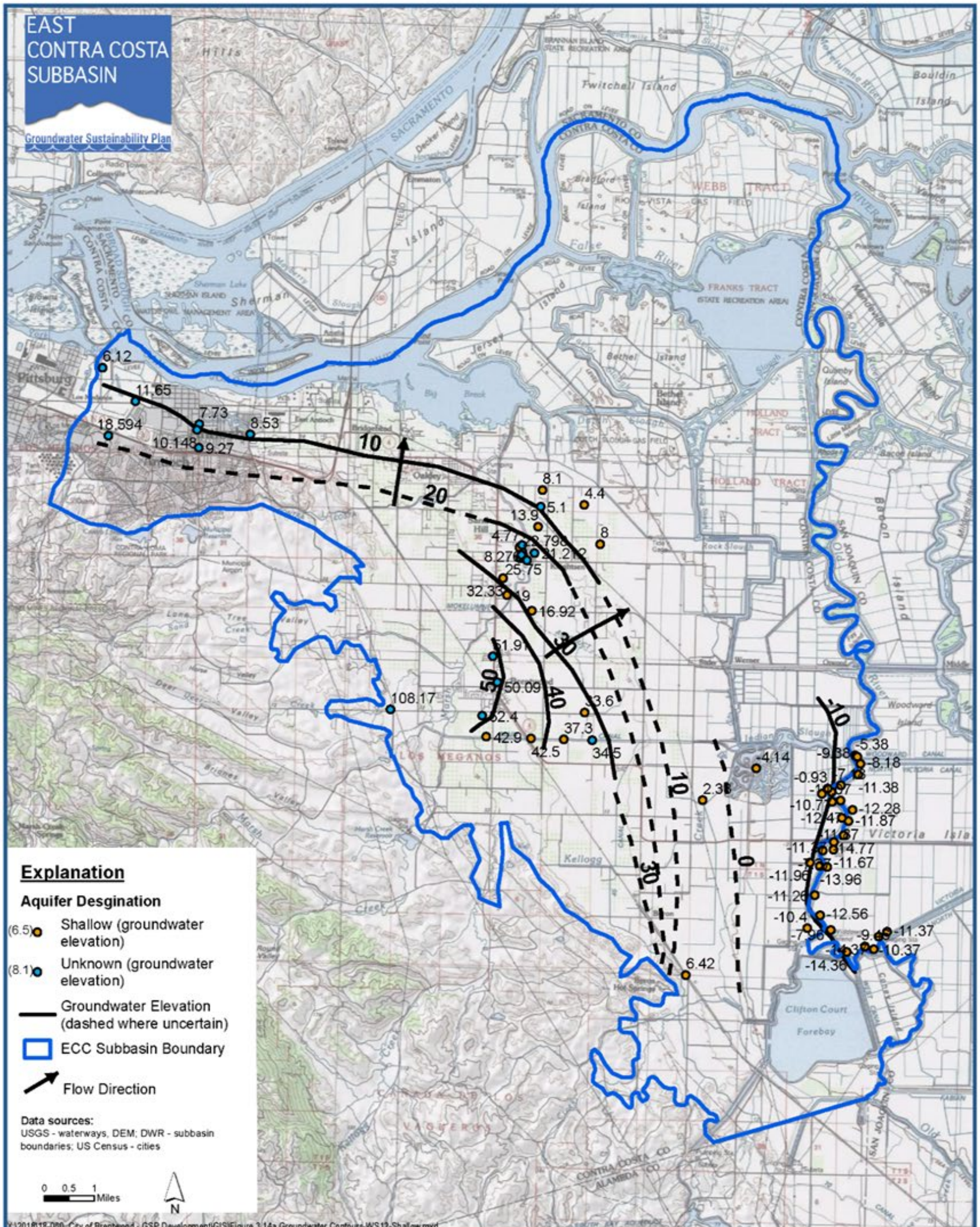
Maps of groundwater elevation from 1958 to present indicate groundwater flow direction is from the Diablo foothills towards the Delta, generally from the southwest to the northeast in the central East Contra Costa Subbasin. Groundwater elevation contour maps developed by LSCE (1999) are available for selected years between 1958 to 1996 (**Appendix 3e**). These maps were developed with water level measurements for wells mostly constructed in the Shallow Zone and are representative of the unconfined aquifer. To evaluate recent groundwater level conditions in the Subbasin, groundwater elevation contour maps were prepared for Spring 2012 and 2018 for both the Shallow and Deep Zones (**Figures 3-14a** to **Figure 3-14d)**.

Shallow Zone

The spring 1958 through spring 2018 groundwater contours for the Shallow Zone exhibit a similar pattern of flow, generally from the southwest to the northeast. In 1958, groundwater elevations ranged from about 55 feet msl in Brentwood to about 5 feet msl near the Delta north of Oakley; however, data is only available in the vicinity of Brentwood and Oakley. In spring 1991 additional data were available for the area south of Brentwood on the basin boundary where the groundwater elevation was as high as 75 ft msl to -15 ft msl around Discovery Bay. In spring 2012 (**Figure 3-14a**), the highest groundwater elevations were south of Brentwood at about 45 ft msl to a low of about -10 ft msl along Old River. In spring 2018 (**Figure 3-14b**) the Shallow Zone high groundwater elevations were again located south of Brentwood at about 40 ft msl to a low of about -5 ft in Discovery Bay. The general groundwater flow directions remained the same (to the northeast) and elevations north of Oakley were still around 5 ft msl.

Deep Zone

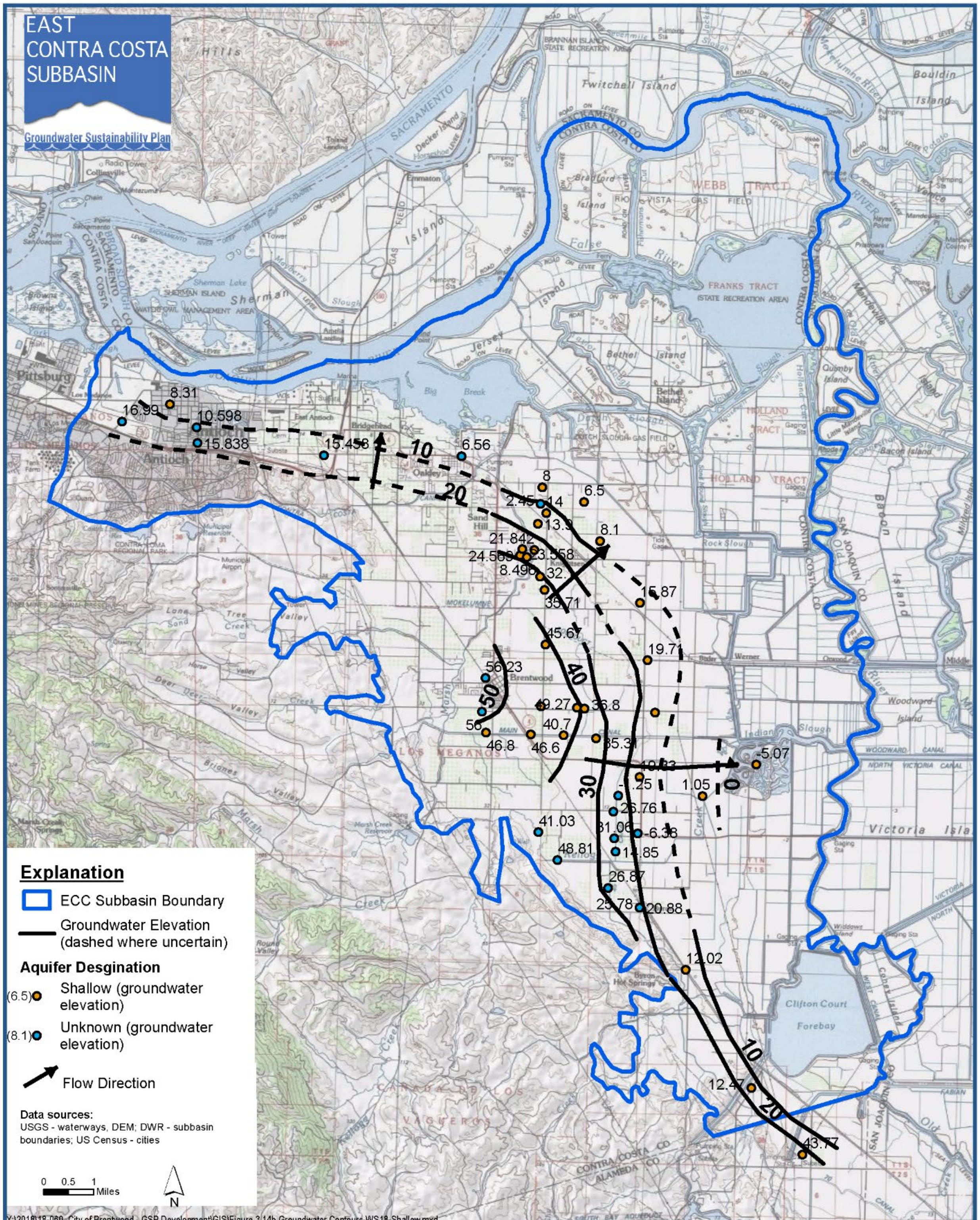
Contouring groundwater elevations in the Deep Zone is difficult due to the lack of well control exclusively in the Deep Zone. In contouring groundwater levels in the Deep Zone, water levels were used from wells with known construction in the Deep Zone and composite wells (constructed in both the Deep and Shallow Zones). The composite wells are identified by a different colored symbol on the contour maps and allow contours to tentatively be extended outward. Deep Zone groundwater level data is not available until 2007 around Oakley and 2012 around Brentwood and Discovery Bay. Given the limited data points and spatial representation, two Deep Zone groundwater contour maps were constructed: spring 2012 and spring 2018 (**Figures 3-14c and d**). In spring 2012, the highest Deep Zone groundwater elevations were about 50 ft msl south of Brentwood to a low of less than -20 feet msl around Discovery Bay. The spring 2018 Deep Zone contour map illustrates similar groundwater elevations to spring 2012 with high levels of 52 ft msl south of Brentwood, less than -20 ft msl in Discovery Bay, and about 2 ft msl north of Oakley. The Deep Zone groundwater flow direction is to the northeast which is similar to the Shallow Zone flow direction. Due to the limited spatial coverage of Deep Zone wells, evaluating groundwater flow and gradients within the Subbasin are challenging.



Groundwater Contours Spring 2012 - Shallow Zone

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-14a



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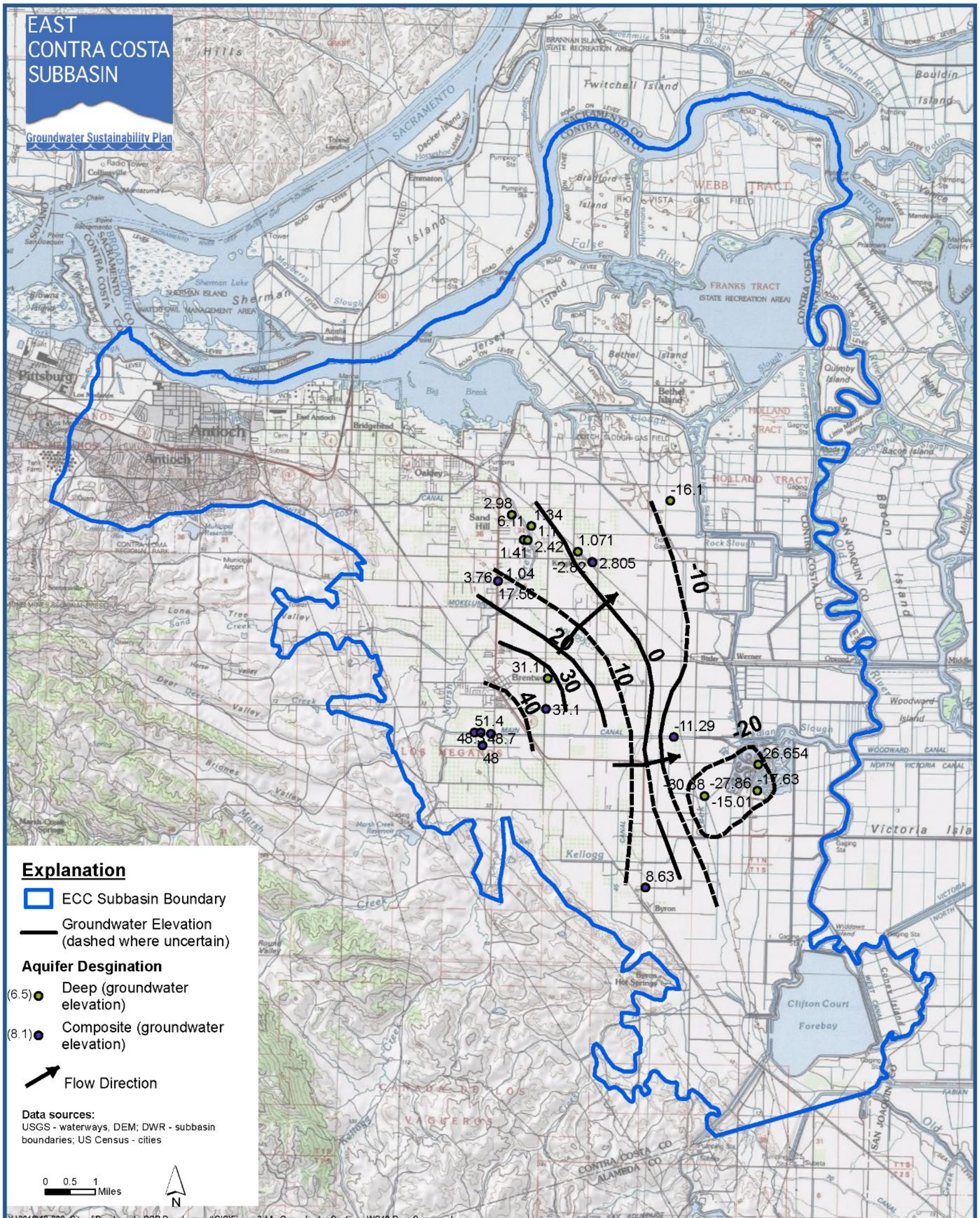
Groundwater Contours Spring 2018 - Shallow Zone

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-14b



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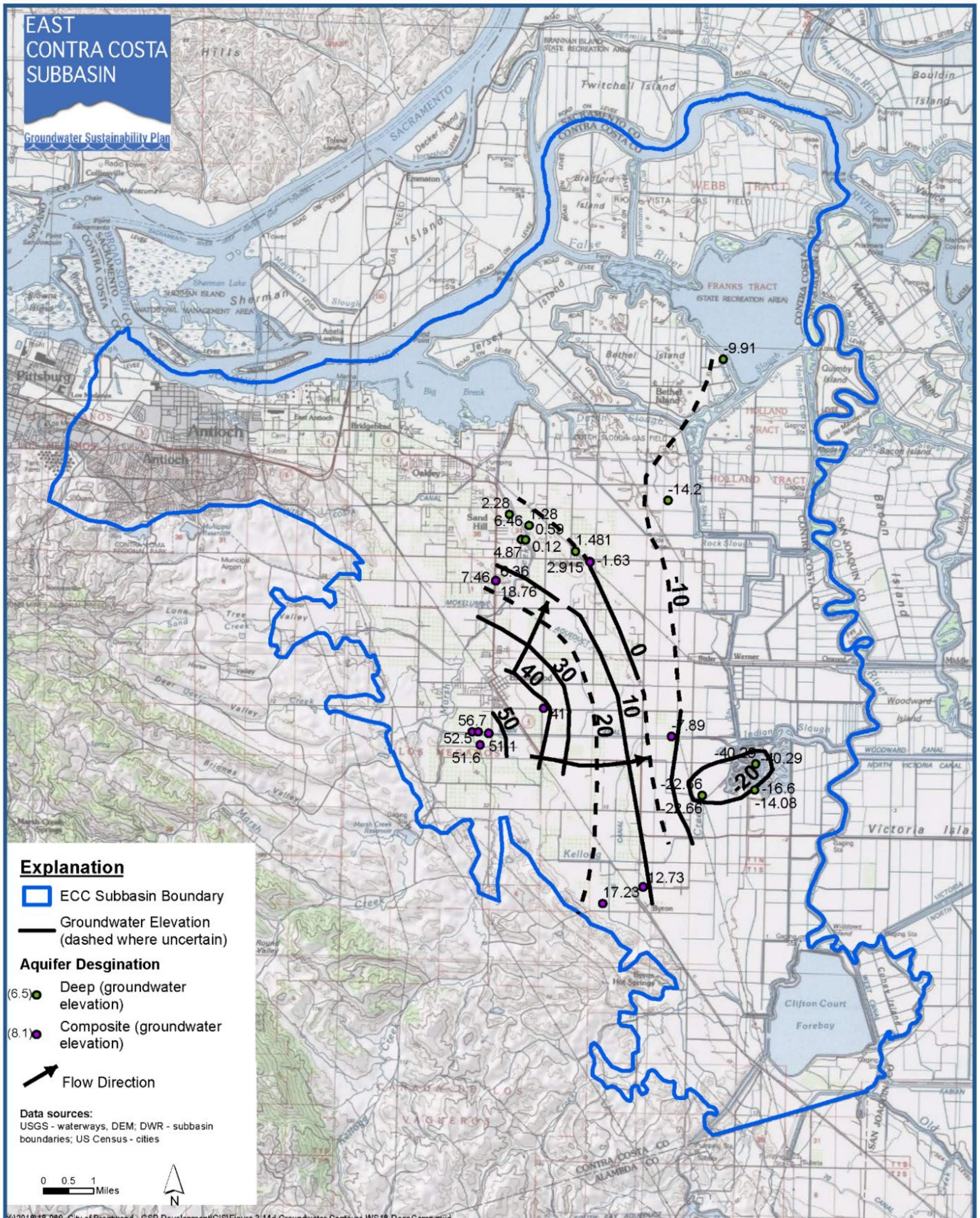
Groundwater Contours Spring 2012 - Deep Zone and Composite Wells

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-14c



Luhdorff & Scalmanini Consulting Engineers

Groundwater Contours Spring 2018 - Deep Zone and Composite Wells

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-14d

3.3.3 Storage

The total groundwater storage volume within the East Contra Costa Subbasin above the base of freshwater is estimated to be between 4.5 million AF (MAF) and 9.0 MAF based on the specific yield range of 5 to 10 percent and using spring 2018 groundwater level contours. DWR Bulletin 118 (2016 update), did not estimate total groundwater storage in the ECC Subbasin but did provide specific yield value ranges of 7 to 10 percent for the San Joaquin Subbasin and Delta for water bearing deposits. **Table 3-1** summarizes calculations of total groundwater storage in the Subbasin using the 7 and 10 percent specific yield values and a lower value of 5 percent as a sensitivity for lower computed storage. An additional analysis is included in **Table 3-1** ("To Base of Major Production Zone") that estimates groundwater storage for the saturated thickness in the Subbasin from the regional water table (spring 2018) to the base of the major production zone (about 300 feet bgs). The total groundwater storage volume for this subsurface unit is estimated to be between 1.5 MAF and 3.0 MAF. There has not been a change in groundwater storage over time because groundwater levels between 1993 to 2019 have been stable. Sustainable yield[3] refers to conditions under which extraction has not adversely impacted a variety of parameters including groundwater levels, storage, quality, etc. Historical conditions as reflected in the hydrographs and contour maps, where data is available, indicate that groundwater extraction has not impacted groundwater levels and storage and that the Subbasin is operating within its sustainable yield.

Table 3-1. Estimates of Total Groundwater Storage (2018)

Area	ECC Subbasin Volume (acre-feet)	Specific Yield (percent)	Total Groundwater Storage (acre-feet)	Notes on Specific Yield Basis
To Base of Major Production Zone	30,254,373	5%	1,513,000	
		7%	2,118,000	Range of 7 to 10% for water bearing deposits DWR Bull. 118 (2003) Tracy Subbasin
		10%	3,025,000	
To Base of Freshwater	89,839,409	5%	4,493,000	
		7%	6,290,000	Range of 7 to 10% for water bearing deposits DWR Bull. 118 (2003) Tracy Subbasin
		10%	8,986,000	

3.3.4 Seawater Intrusion

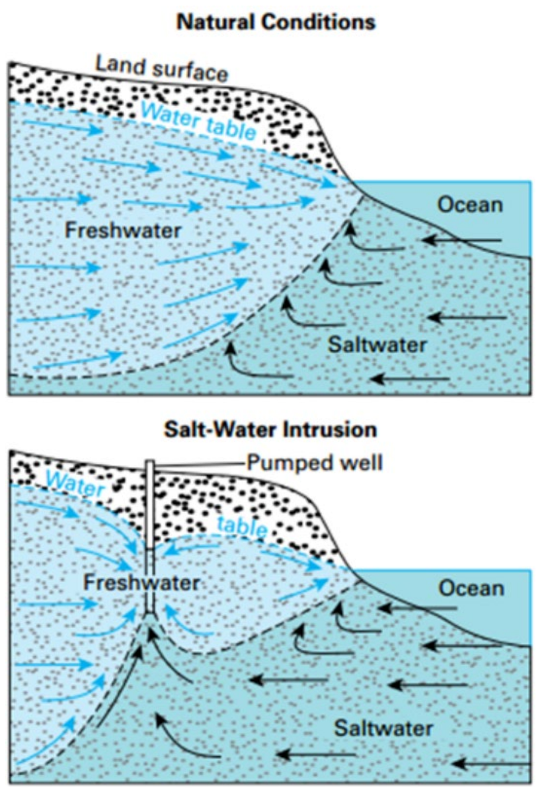
The East Contra Costa Subbasin has no coastline, is not bordered by the ocean, and direct seawater intrusion is not present. The Sacramento-San Joaquin River Delta has historically had brackish tidal water drawn in from the San Francisco Bay; however, levees installed around Delta islands to facilitate agriculture, and development of the Central Valley and State Water Projects, have altered the movement

[3] "In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results." DWR, 2017.

of tidal water through the Delta to maximize freshwater flow. A surface water salinity interface of two parts per thousand near Chipps Island west of the ECC Subbasin, is the State Water Resources Control Board adopted[4] water quality objective to regulate Delta outflow. Though salinity in groundwater may occur naturally in parts of the Subbasin, it is not due to direct seawater intrusion into aquifers.

The mechanism for seawater intrusion is illustrated in **Figure 3-15.** When a direct connection exists such as along the coast, seawater may be drawn into aquifers when the gradient for freshwater outflow is reduced or reversed due to over-pumping. This causes the saltwater/freshwater aquifer interface to move inland. As mentioned above, this is not present in the ECC Subbasin.

Figure 3-15 The Process of Saltwater Intrusion from an Aquifer



Source: https://www.usgs.gov/media/images/process-saltwater-intrusion

In the Bay-Delta setting of the ECC Subbasin, there is no saltwater interface in the subsurface and the aquifers are freshwater. A potential source of saline water intrusion might be migration of baywater into the Shallow Zone aquifers. While fresh baywater outflow through the Delta is managed, increases in baywater salinity could potentially occur due to sea-level rise. This occurrence may potentially impact sustainability if intruded shallow groundwater migrated vertically downward into the Deep Zone aquifers used for water supply. This mechanism is illustrated by two cross-sections (A-A' and C-C') from the 1999 LSCE report (**Figure 3-16a, b, c**). **Figures 3-16b** and **3-16c** show the potential for interactions through hydraulic pathways between stream and delta channels and shallow aquifers. **Figure 3-16b** shows

[4] https://www.baydeltalive.com/maps/11634

substantial clay layers that impede vertical migration to the Deep Zone. Connection to the Deep Zone may be of concern for some areas where domestic and agricultural pumping occurs. One possible area is depicted on Section C-C' (**Figure 3-16c**) where there are fewer hydraulic clay barriers present. **Figure 3-16d** presents the average chloride concentrations measured in the Shallow Zone and Deep Zone wells over the last ten years. Chloride concentrations are below 500 mg/L and are generally around the 250 mg/L Recommended MCL with a few isolated exceptions.

Seawater Intrusion (or baywater in the ECC Subbasin) will be evaluated with chloride concentration maps that include the new dedicated Shallow Zone monitoring wells (see **Section 6.2.4** for monitoring well list and well map). These wells will act as sentinels for intrusion-related degradation of water quality. There is currently no chloride concentration contour since the monitoring wells have not been installed. A chloride concentration map will be produced for the initial annual report and then for each 5-year update unless more frequent reporting is warranted through analysis of test results. Based on initial sampling and an assessment of basin-wide Shallow Zone water quality characteristics, a baseline for intrusion will be determined. A threshold is set at 250 mg/L, which is the Recommended Limit Secondary Maximum Contaminant Level (SMCL) for chloride as defined by the EPA and below which are the majority of chloride concentration is in the Subbasin.

Figure 3-16a Partial Cross Section Location

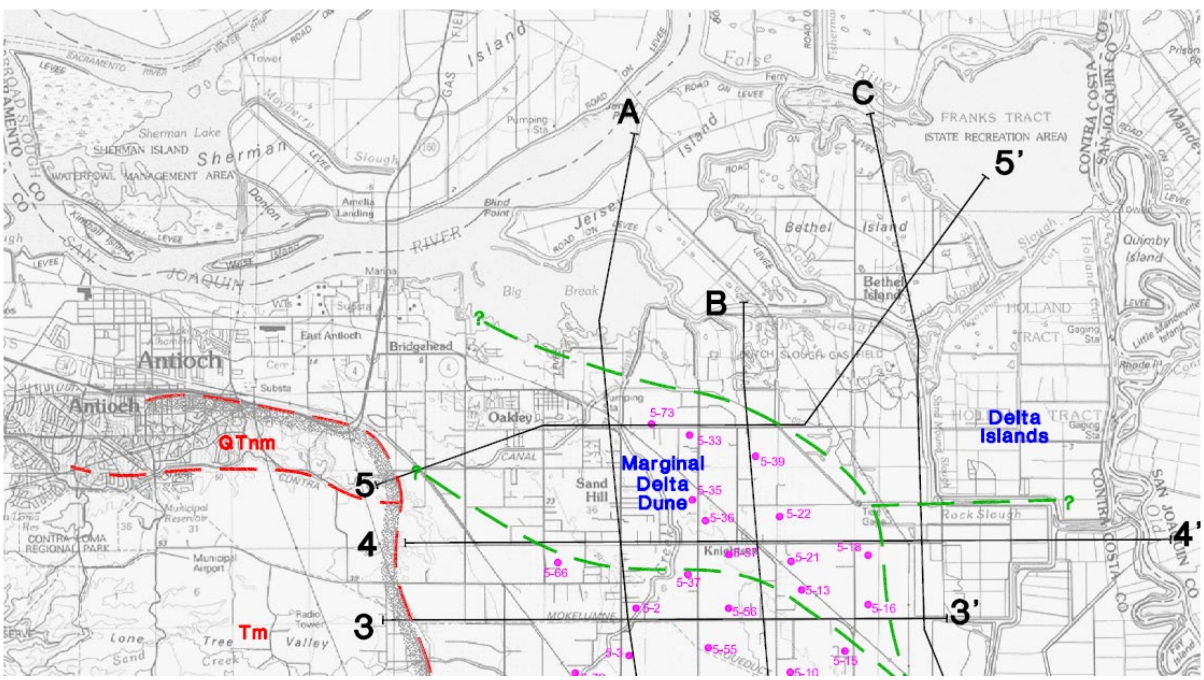


Figure 3-16b Partial of Cross Section A-A'-Clay Barriers Prevent Vertical Baywater Migration

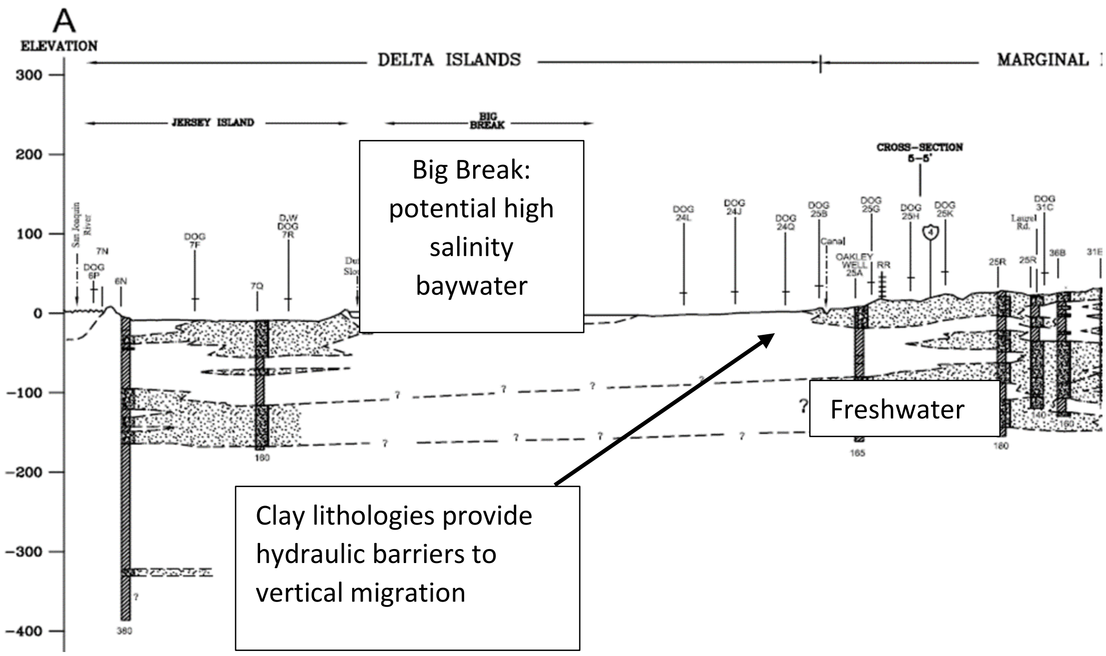
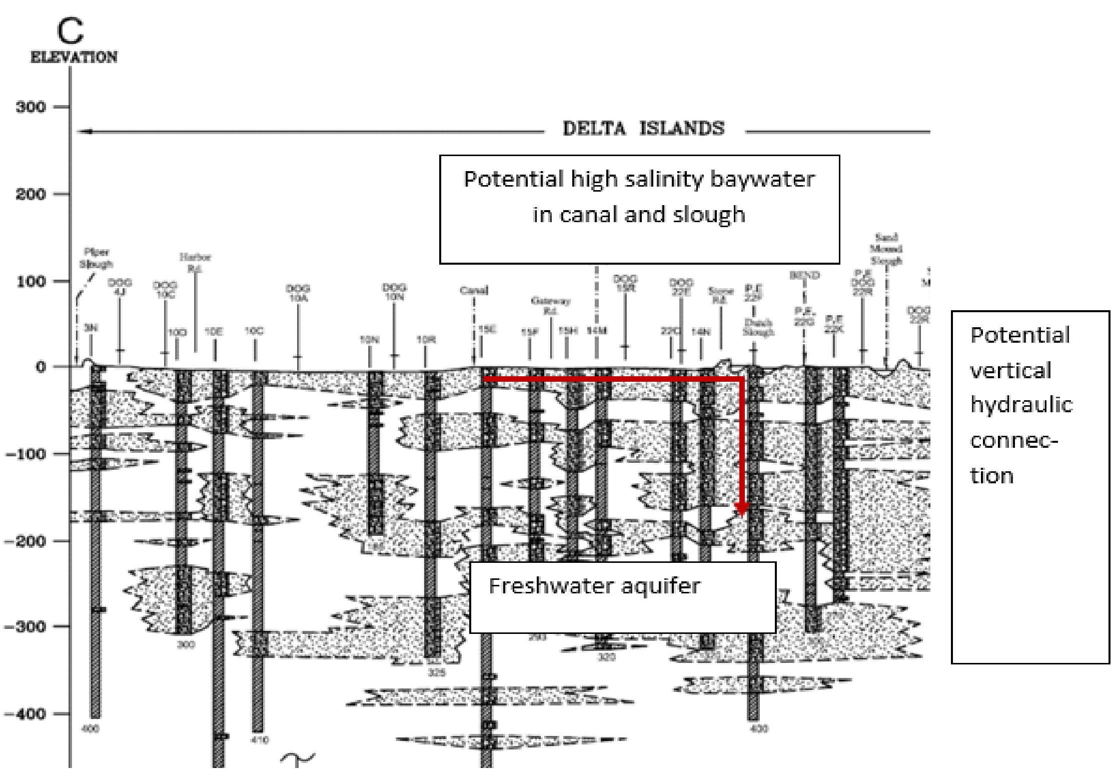
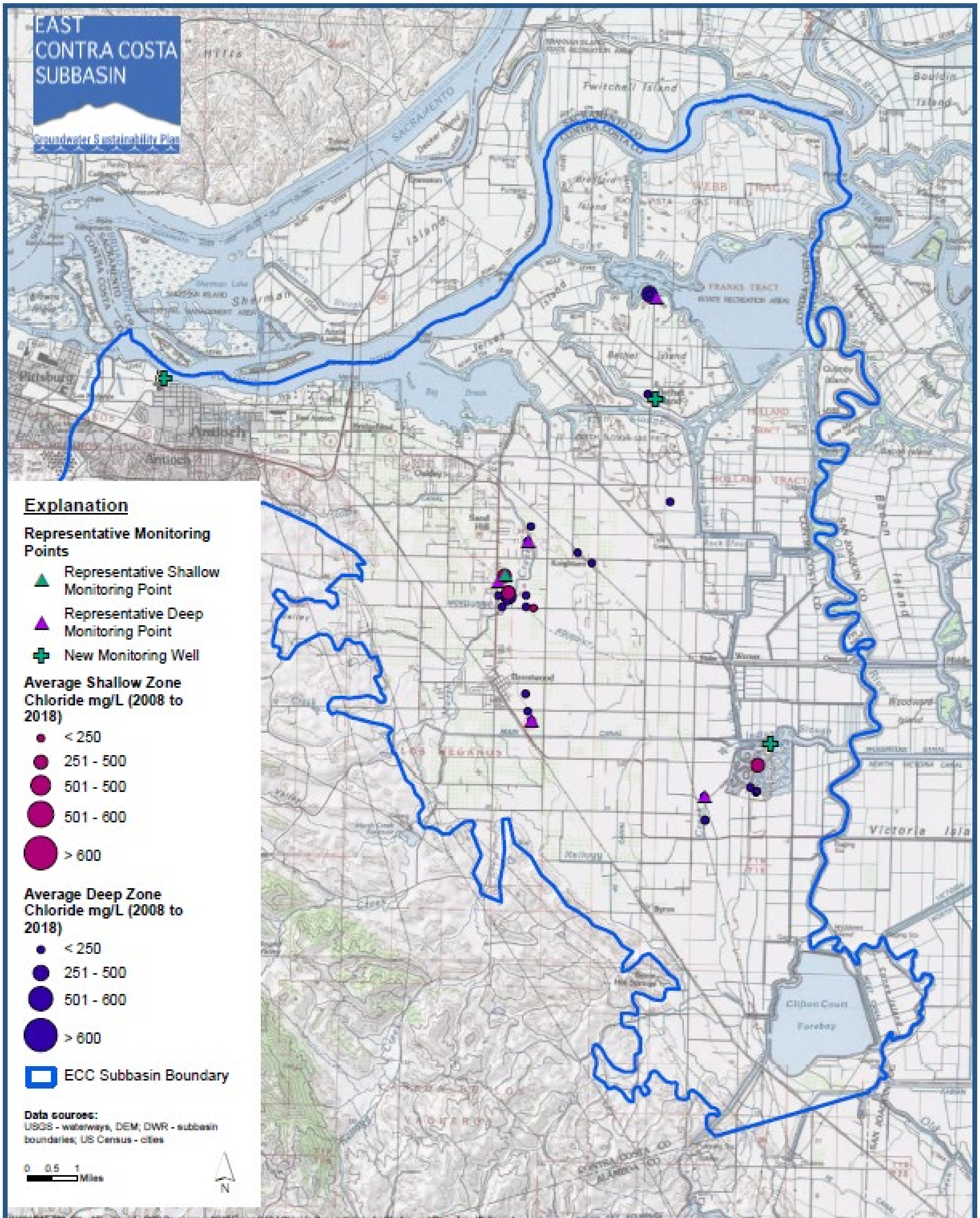


Figure 3-16c Partial Cross Section C-C': Potential for High Salinity Baywater Migration





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Chloride Concentrations for Shallow and Deep Zone Wells

East Contra Costa Subbasin Groundwater Sustainability Plan
Contro Coasta County, California

Figure 3-16d

3.3.5 Groundwater Quality

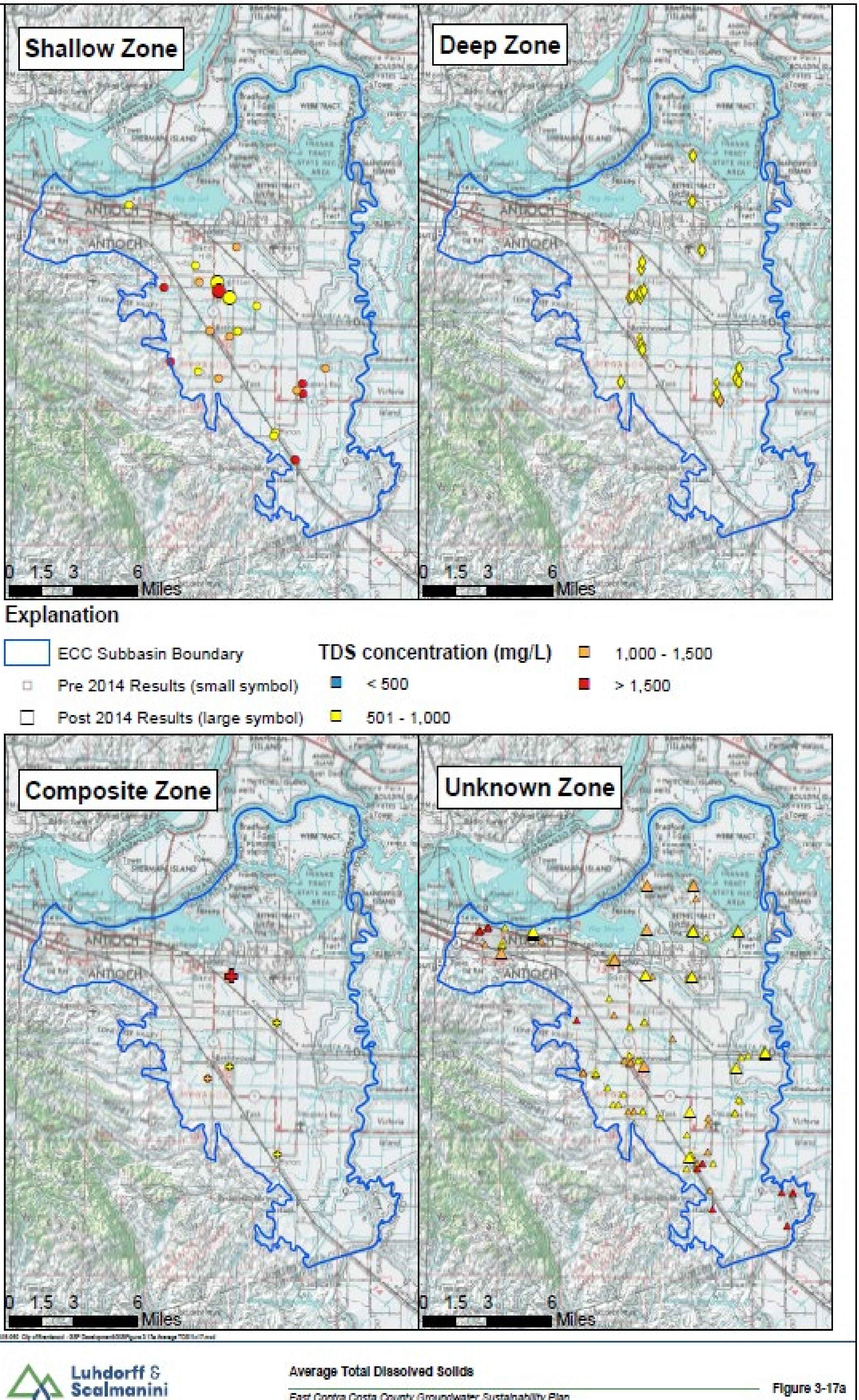
Groundwater quality in the Subbasin is characterized for this section through a variety of tables, maps and graphs. The entire water quality data set is provided in **Appendix 3f**. Key groundwater quality constituents discussed below include total dissolved solids (TDS), nitrate, chloride, arsenic, boron, and mercury. These constituents were selected because they have the potential to influence sustainability (as opposed to localized, or site-specific contamination). A concern for domestic water supply, including individual domestic wells and large public water systems serving municipalities, is groundwater hardness. This concern is included as a sustainability issue in **Section 7 Sustainable Management Criteria**. Monitoring and reporting on trends in hardness of well water are also discussed in **Section 6 Monitoring Network and Data Management System**.

Maps of average and maximum concentration for the selected constituents are displayed in **Figures 3-17a** and **b** through **3-20a** and **b.** Recent data (after 2014) are lacking for some constituents so concentrations for wells with results prior to 2014 are included on the map with a smaller symbol. Time series graphs for these same constituents are presented in **Appendix 3g** and can be used to evaluate trends over time (e.g., TDS or chloride increasing or decreasing over time). In general, groundwater quality meets most water quality objectives and serves a variety of domestic and agricultural uses throughout the Subbasin. However, minor restrictions (discussed in more detail below) are caused by naturally occurring salinity levels that are elevated basin wide and nitrate levels that are slightly elevated in the shallow zone (less than 150 ft bgs).

Water quality concentrations in wells are compared for some constituents (nitrate as nitrate, arsenic, and mercury) to the California State Water Quality Control Board (SWQCB) drinking water standards called maximum contaminant levels (MCLs). Not all constituents (e.g., TDS and chloride) have an MCL and are compared to the secondary MCLs (SMCLs) that address esthetics such as taste and odor.

Total Dissolved Solids

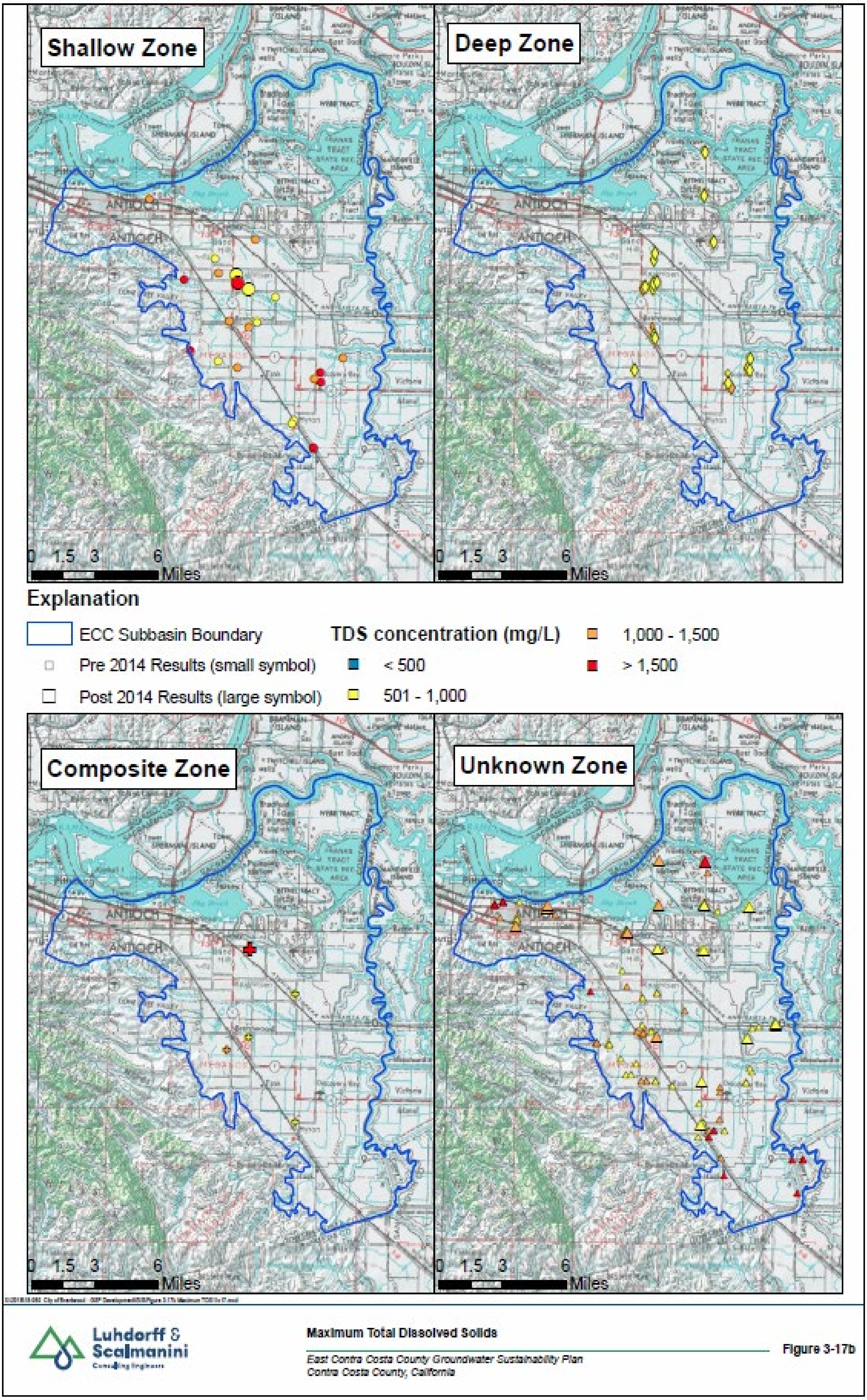
TDS is a general measure of salinity and overall water quality. Salinity of groundwater may increase as influenced by land use or may be naturally sourced where subsurface geologic materials are derived from marine sediments. **Figures 3-17a** and **b** illustrate the average and maximum TDS concentrations for Shallow, Deep, and Composite Zones and for wells where the zone is unknown. TDS varies widely across the Subbasin, although it is characteristically high, ranging between 500 and 1,500 mg/L, in all areas. The Secondary maximum contaminant level (SMCL) for TDS is 500 mg/L (Recommended), 1,000 mg/l (Upper Limit), and 1,500 (Short-Term Limit). The SMCL is established for aesthetic reasons such as taste and odor and is not based on public health concerns. In the Shallow Zone, only three wells in Brentwood have recent results (since 2014) with TDS concentrations ranging between 500 and over 1,500 mg/L and older data indicate similar values. The lack of data for Shallow Zone wells is noted as a data gap. A lower portion of the Shallow Zone (between 80 and 140 ft bgs) in the vicinity of Discovery Bay contains brackish to saline water with EC levels between 2,000 and 6,500 uS/cm (Wells 1B, 4A, and 7, spring 2013). To prevent cross contamination of aquifer units, production wells are constructed with a deep cement seal below 140 ft bgs. The Deep Zone has many wells with TDS concentrations between 500 and 1,000 mg/L. The Deep Zone Discovery Bay wells have TDS concentrations generally below 600 mg/L and three City of Brentwood wells (wells 6, 7, and 8) increased from 600 mg/L and have stabilized with TDS concentrations around 1,000 mg/L (the upper secondary MCL) (**Appendix 3g**). The areas around Antioch and Byron have elevated TDS concentrations compared to the rest of the Subbasin, with some average results over 2,000 mg/L.



Average Total Dissolved Solids

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

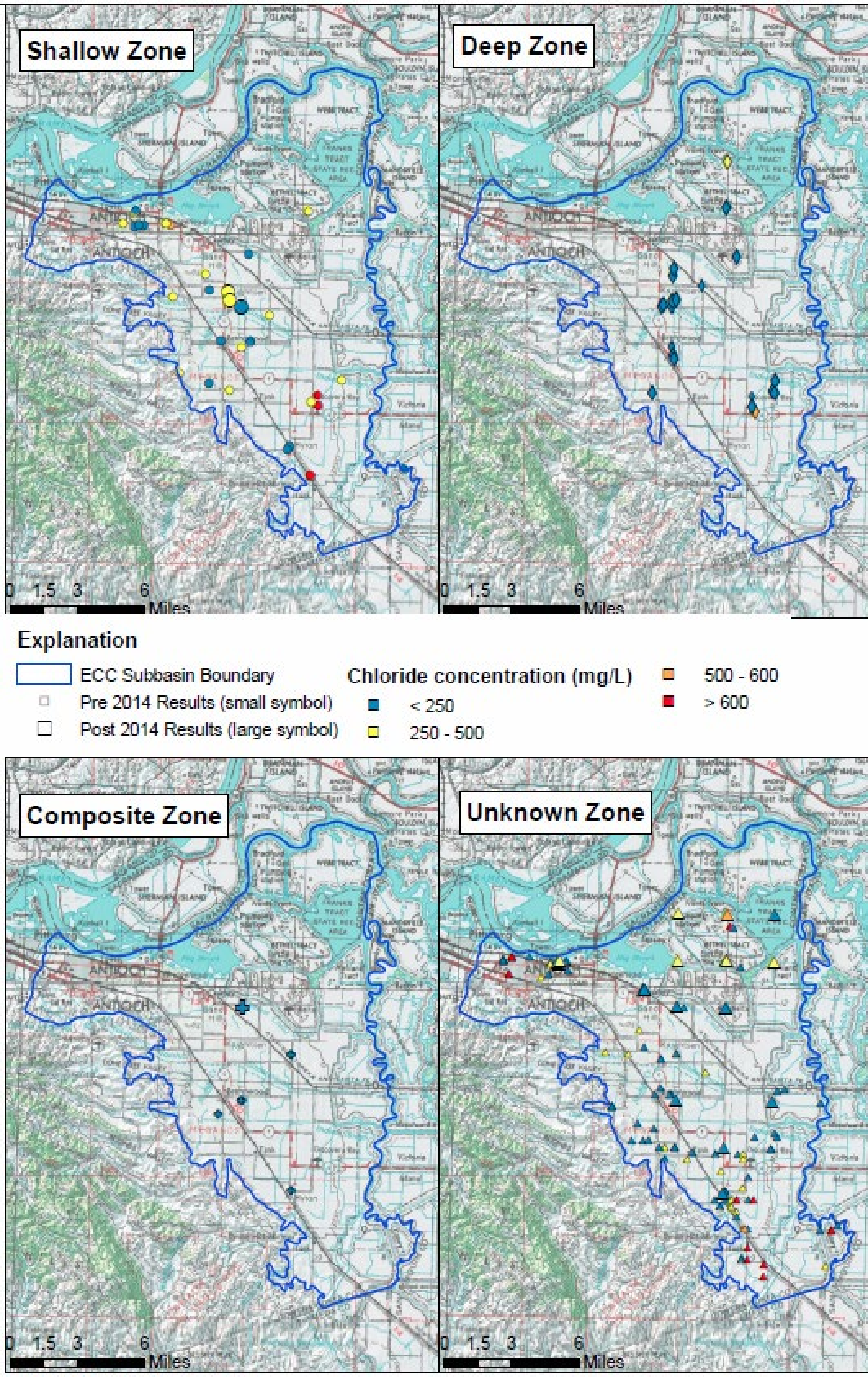
Figure 3-17a



Maximum Total Dissolved Solids

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

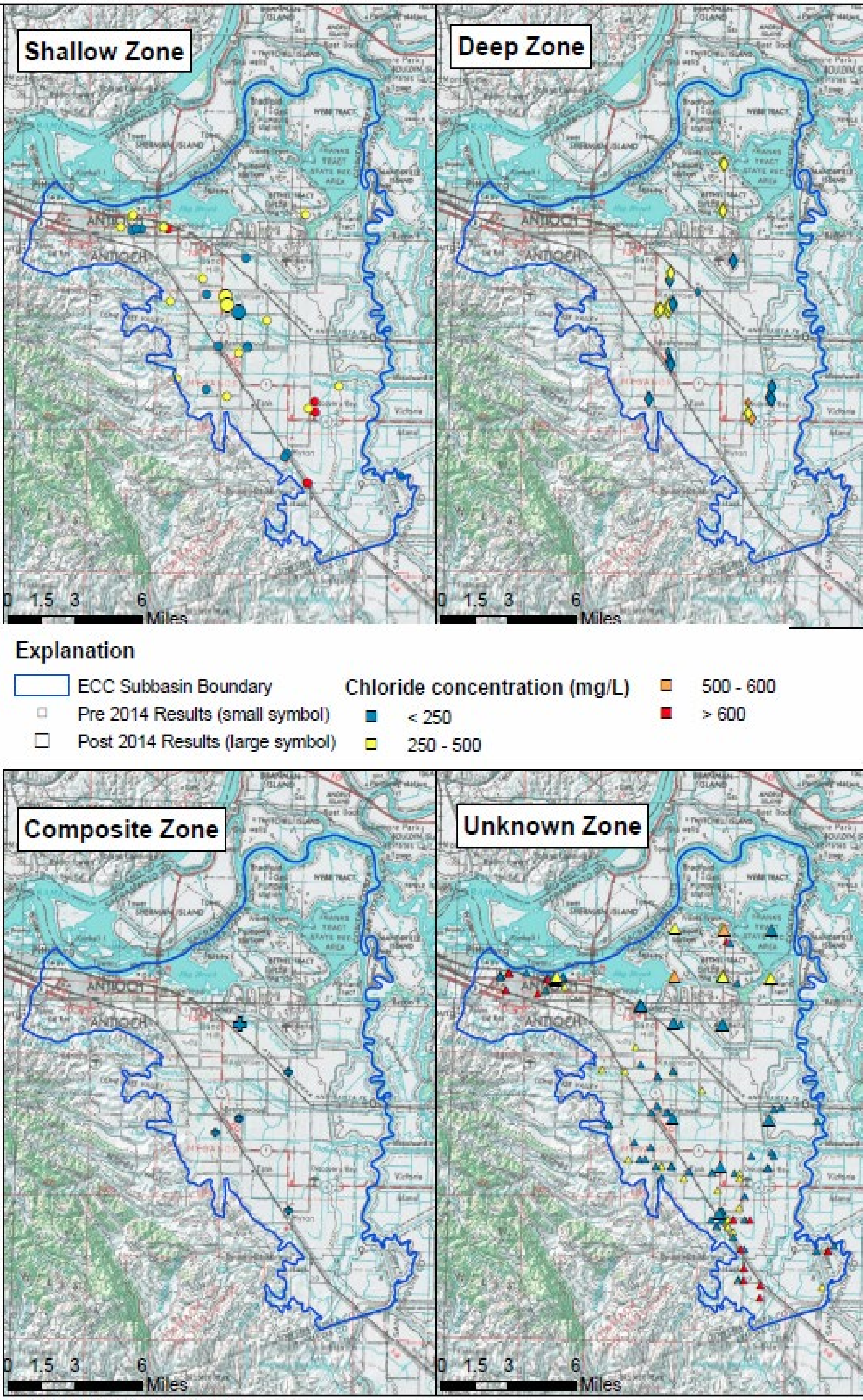
Figure 3-17b



Average Chloride

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-18a



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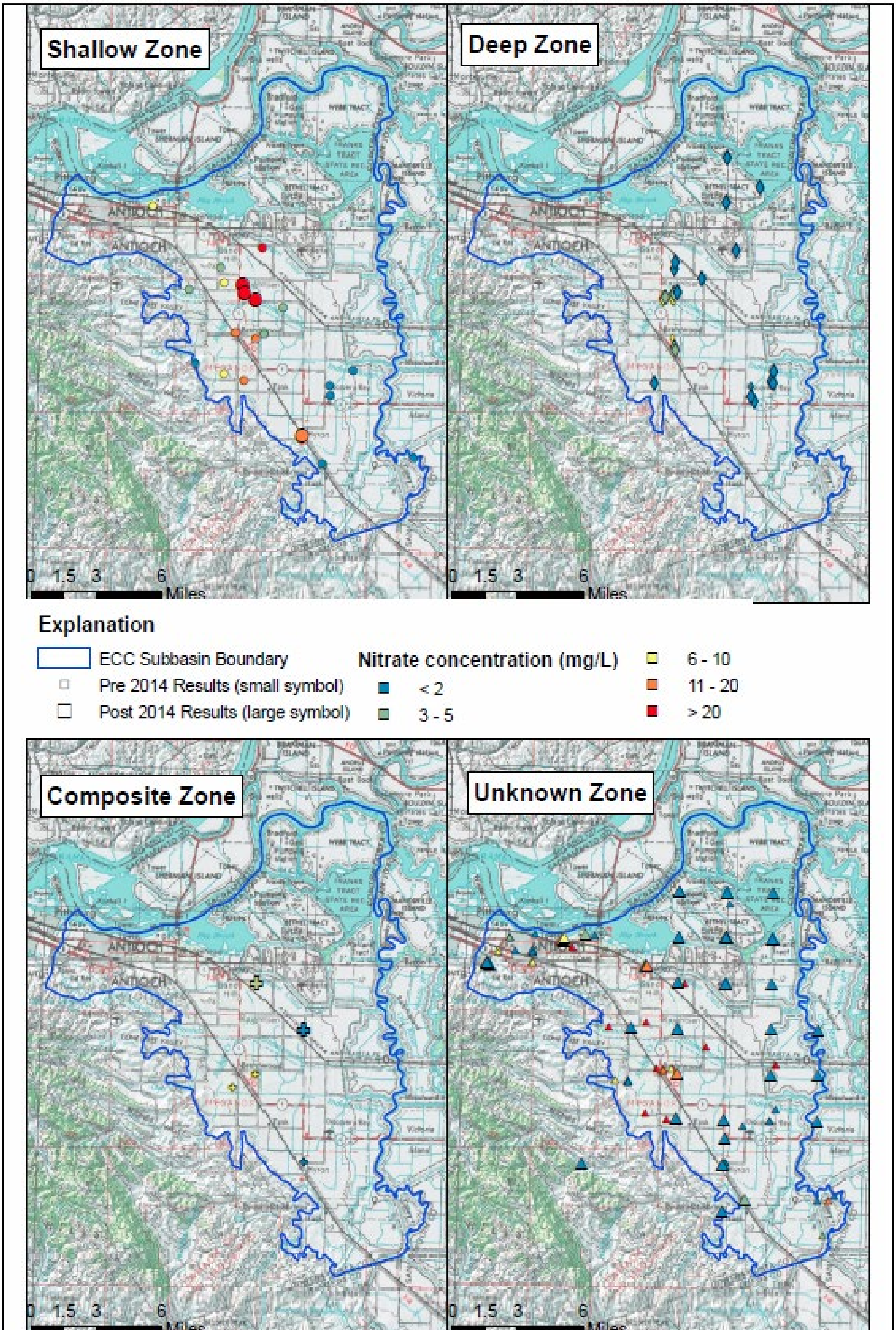
Maximum Chloride

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

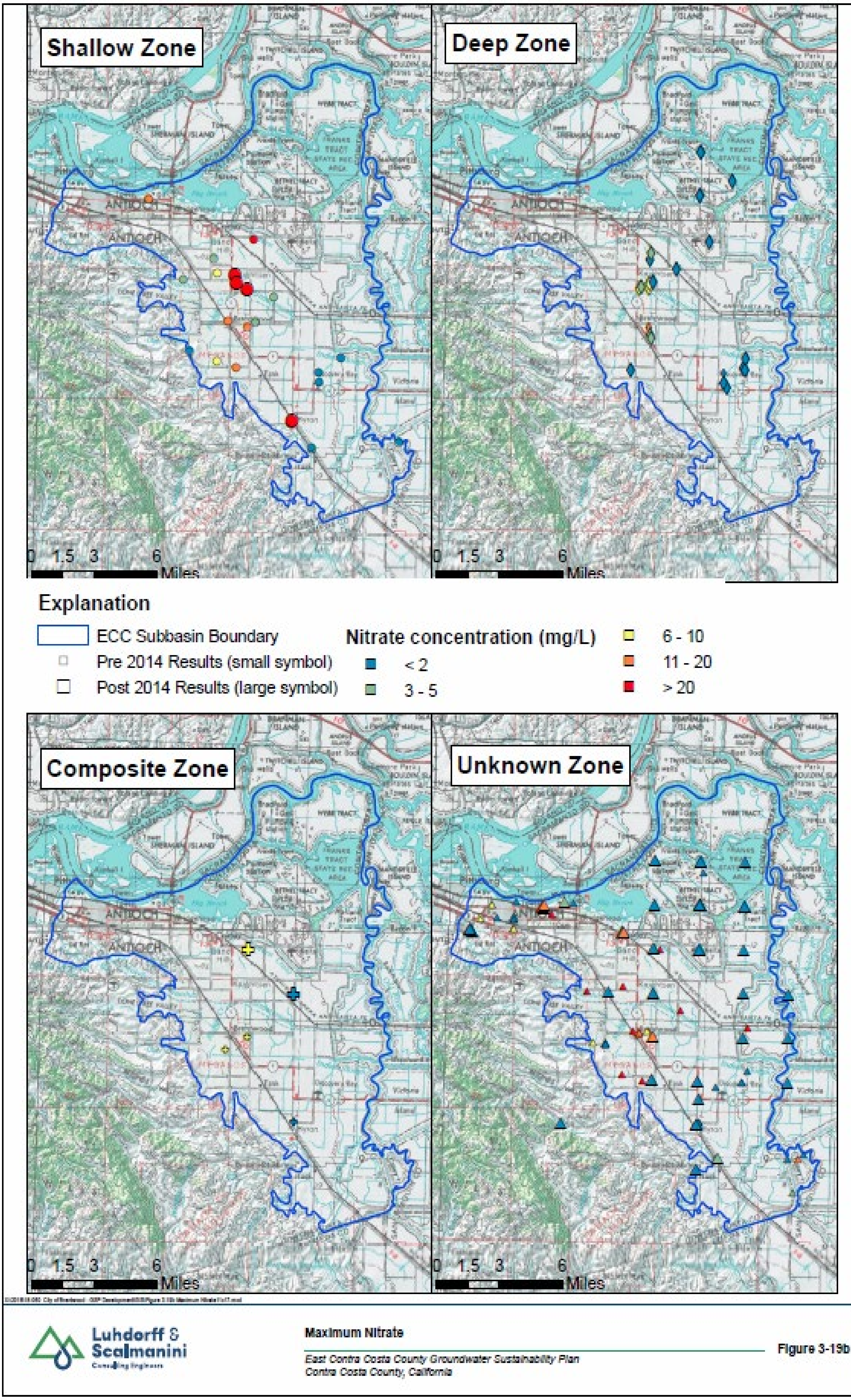
Figure 3-18b



Average Nitrate

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

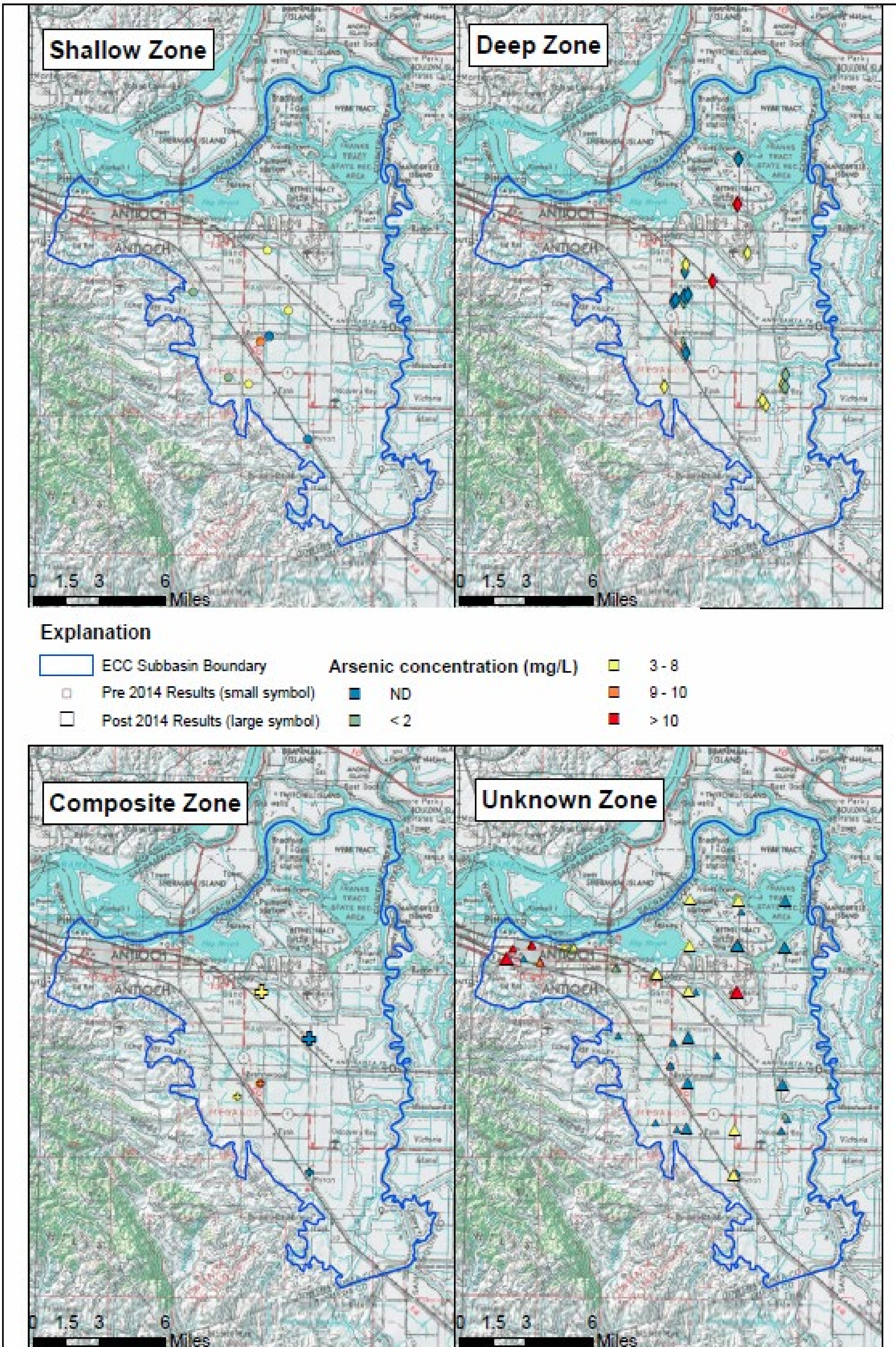
Figure 3-19a



Maximum Nitrate

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-19b



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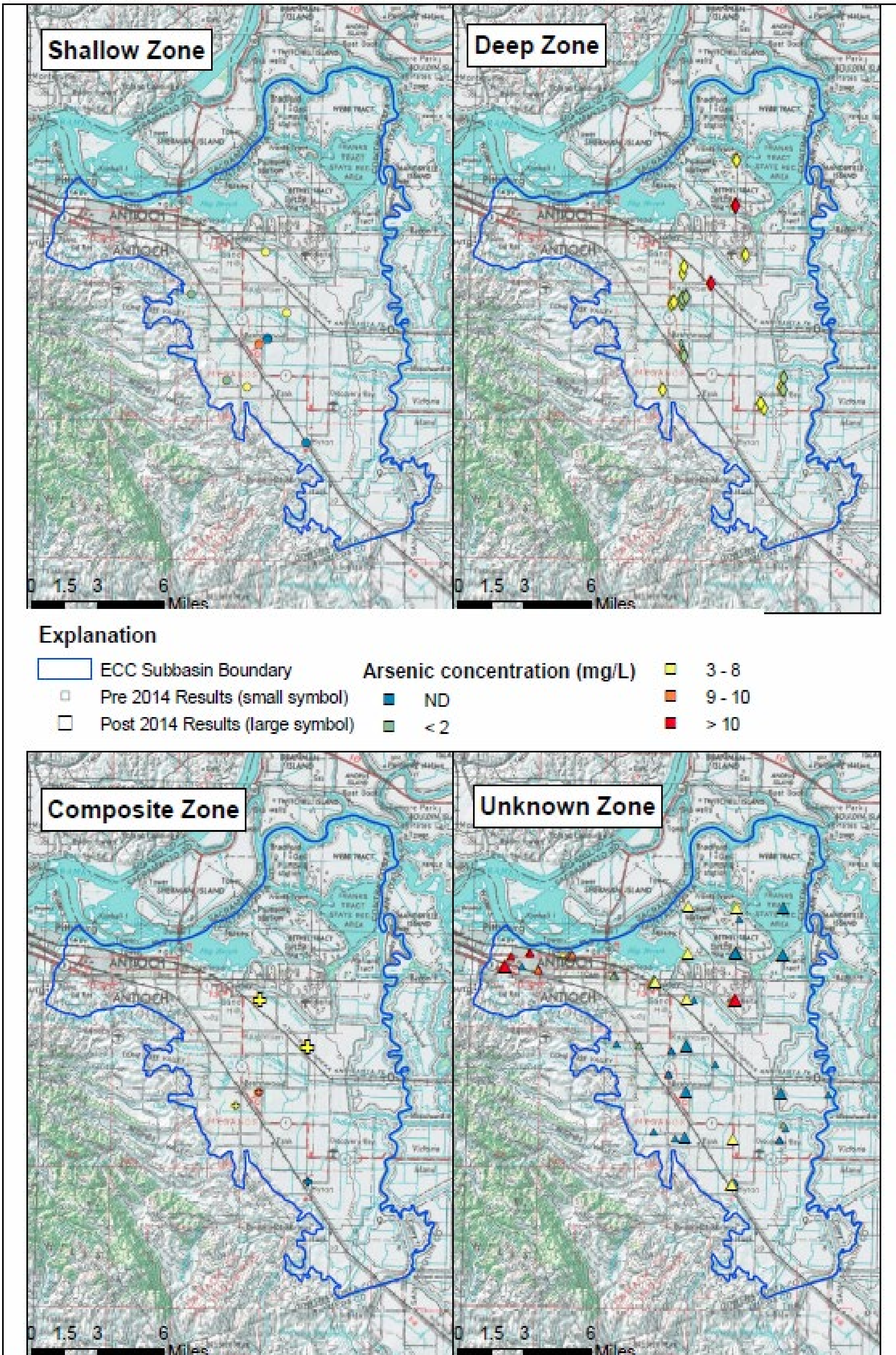
Average Arsenic

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-20a



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Maximum Arsenic

East Contra Costa County Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-20b

In summary, TDS concentrations in groundwater in the Subbasin exceed or are near the recommended SMCL (500 mg/L) in most wells (**Table 3-2**) suggesting that water concentrations are naturally higher for TDS (LSCE 1999).

Table 3-2. Water Quality Concentrations for Key Constituents

Constituent (Units)	Date Range	Number of Wells					No. of Measurements	Concentration			
		DDW	DWR	Geo-tracker	USGS	Total		Range	Median	Average	St Dev
TDS (mg/L)	1957-2019	87	46	73	22	228	802	86 - 20,400	885	1,098	1,431
Chloride (mg/L)	1957-2019	97	67	80	36	280	1562	11 - 4,900	168	231	310
NO3-N (mg/L)	1957-2019	135	23	125	30	313	2360	ND - 1,400	0.5	4.7	30.5
Arsenic (ug/L)	1957-2019	88	12	81	9	190	959	ND - 750	3	8	29

Chloride

Chloride is also a common way to indicate salinity. **Figures 3-18a** and **b** illustrate the average and maximum chloride results for the Shallow, Deep, and Composite Zones and the wells where the zone is unknown. Where zones are known, chloride concentrations generally decrease with depth to under 200 mg/L. Shallow Zone wells have higher chloride concentrations in the vicinity of Brentwood (230 to 280 mg/L) and Discovery Bay (360 to 2,000 mg/L) than the Deep Zone wells. Deep Zone wells (Wells 6, 7, and 8) in Brentwood have increased from less than 100 mg/L to over 200 mg/L) and Discovery Bay wells are stable and generally <100 mg/L. All results in the two zones (Shallow and Deep) are generally under 500 mg/. The areas around Antioch and Byron have elevated chloride concentrations compared to the rest of the Subbasin, with average results up to over 1,800 mg/L. The SMCL for chloride is 250 mg/L (Recommended), 500 mg/L (Upper Limit), and 600 mg/L (Short-Term).

In summary, chloride concentrations in groundwater in the Subbasin exceed or are near the recommended SMCL for chloride (250 mg/l) in most wells (**Table 3-2**) suggesting that water concentrations are naturally higher for chloride (LSCE 1999).

Nitrate

Nitrate is both naturally occurring and can be a result of human activity (e.g., fertilizers, septic systems, and animal waste). The MCL for nitrate as nitrogen (N) is 10 mg/L for drinking water. **Figures 3-19a** and **b** illustrate the average and maximum nitrate concentrations as N for the Shallow, Deep, and Composite Zones and for wells with an unknown aquifer zone. Wells with average nitrate as N concentrations that exceed the MCL are Shallow Zone wells in the Brentwood area (24 to 121 mg/L) and Unknown Zone wells scattered in the central western portion of the Subbasin. A few City of Brentwood composite production wells have been taken out of service due to high nitrate concentrations. In previous work, the higher Shallow Zone concentrations have been attributed to agricultural influences in the area and lack of confining clay units between soil horizons and shallow aquifer materials. Continued monitoring of

Brentwood Deep Zone wells (currently all below 10 mg/L) will monitor whether nitrate is migrating from the Shallow Zone. Deep Zone production wells in the Discovery Bay and Oakley area have nitrate concentrations less than 2 mg/L. Wells in the Delta Island area in the northern and eastern portion of the Subbasin generally have very low nitrate as N concentrations.

In summary, nitrate is observed in some Shallow Zone areas of the Subbasin (i.e., Brentwood), with concentrations exceeding the MCL (10 mg/L) that may be linked to historical agricultural influences in the area.

Arsenic

Arsenic is a naturally occurring constituent and is commonly found in groundwater throughout California. An MCL was established at 10 ug/L in California in 2008. **Figures 3-20a** and **b** illustrate the average and maximum arsenic concentrations for the Shallow, Deep, and Composite Zones and the wells where the zone is unknown. For wells in the Shallow and Deep Zones, all have average and maximum arsenic concentrations at or below 10 µg/L with four exceptions: Knightsen, two public water systems on Sandmound Blvd., and Bethel Island. Near Discovery Bay, there have been detections of 10 µg/L; but, on average, the Discovery Bay area has concentrations less than 8 µg/L. For Unknown Zones, most of the wells are less than 8 µg/L. An exception is in the Antioch area which has higher concentrations of arsenic with average results over 100 µg/L.

In summary, arsenic concentrations are less than the MCL (10 ug/L) basin wide.

Boron

Boron is a naturally occurring constituent in groundwater and particularly in Contra Costa County[5]. The most common sources of boron in drinking water are from leaching of rocks and soils, wastewater, and fertilizers/pesticides. Boron concentrations in the Subbasin range from 500 ug/L to over 4,000 ug/L with the majority over 1,000 (**Appendix 3f**). MCLs for boron have not been established but there is an agricultural goal (700 ug/L) where some crops may become sensitive, a state notification level (SNL)l[6] (1,000 ug/L), and a US EPA Health Advisory for non-cancer health effect (5,000 ug/L). Boron concentrations in groundwater in the Subbasin exceed the agricultural and SNL (1,000 ug/L) in most wells but are less than the EPA Health Advisory (5,000 ug/L) suggesting that water concentrations are naturally higher.

Mercury

Marsh Creek runs from Mt. Diablo through Brentwood and out to the San Joaquin River and drains water from the Mt. Diablo Mercury Mine operated from 1849 to 1971. There is potential for rainwater to leach mercury from mine tailings and to flow into the Marsh Creek watershed. However, there is no evidence that mercury has contaminated groundwater in the Subbasin and no wells in the ECC Subbasin tested for mercury have exceeded the MCL (2 ug/L).

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[5] The SWQCB Division of Water Quality GAMA Program "Groundwater Information Sheet for Boron (B), revised November 2017. Contra Costa County was identified on one of the top three counties in the state for boron detection from a study of public water supply wells from 2007 to 2017.
[6] Notification levels are non-regulatory health-based advisory levels establish by the SWRCB for chemicals with not established MCL.

Appendix 3f is a table of all groundwater quality (general minerals and trace elements) in the Subbasin, by zone. Most of the wells in the Subbasin are missing construction information so water quality for the Shallow and Deep Zones is limited.

In summary, groundwater in the Subbasin generally exceeds or is near the recommended SMCL for TDS (500 mg/L) and chloride (250 mg/l) (**Table 3-2**). The observed concentrations may reflect a naturally higher baseline for these constituents (LSCE 1999). Nitrate is observed in some Shallow Zone areas (i.e., Brentwood) in the Subbasin, with concentrations generally exceeding the MCL (10 mg/L) that may be linked to past agricultural influences in the area. Arsenic concentrations are generally less than the MCL (10 ug/L) basin wide. Boron concentrations are high in most wells and are attributed to a naturally elevated baseline. Groundwater serves a variety of domestic and agricultural uses throughout the Subbasin with limited restrictions due to natural (salinity and boron) and anthropogenic (nitrate) causes. The availability of surface water gives the opportunity to mitigate these issues when necessary. Depending on local groundwater quality, the stringent municipal standards for drinking water are met by a mix of water sources: City of Antioch uses surface water only, DWD and Brentwood blend groundwater with surface water, and TODB uses groundwater only. The ECC Subbasin's groundwater quality is generally stable which indicates that groundwater extraction is not degrading water quality and the Subbasin is being operated within its sustainable yield.

3.3.6 Groundwater Contamination Risk

There are numerous potential anthropogenic sources of groundwater contamination in the ECC Subbasin. Almost any human related activity involving hazardous substances and waste has the potential to contaminate groundwater. Some activities may lead to groundwater contamination by first contacting soil and then seeping to groundwater. In the ECC Subbasin, the depth to groundwater may occur within a few feet of the ground surface thus increasing the risk that soil contamination may reach a shallow aquifer. Other sources may involve more direct contact between groundwater and hazardous substances such as associated with hydrocarbon transmission lines or leaky storage tanks at retail gasoline stations. Historical and current industrial activity in the east Contra Costa region is also a source of past and potential future groundwater contamination. In Oakley, shallow groundwater and soil contamination occurred at a former Dupont plant that manufactured a gasoline agent, refrigeration cooling compounds, and additives for household products and food. That site operated from 1956 to 1998 and, in 2015, remedial obligations were transferred to Chemours, a subsidiary of Dupont. Chemours worked with the Department of Toxic Substances Control (DTSC) to remediate the site and ultimately returning most of it to a new commercial use now underway[7].

Another potential source of groundwater contamination is the historical and current oil and gas activity in the area. Although areas of current and future activity may be more restrictive in areas of urban growth, it is expected that continued development and redevelopment of oil and gas fields may occur in rural and unincorporated areas of the subbasin. In the ECC Subbasin, oil and gas wells would penetrate the Shallow and Deep Zone freshwater aquifers that are a source of supply for domestic, agricultural, industrial, and environmental uses. Pathways for contamination via these wells would be present and may be of concern

[7] https://eastcountytoday.net/oakley-officially-breaks-ground-on-new-logistics-center-could-create-2800-jobs/

to GSAs seeking to protect water quality and maintain long-term sustainability of groundwater resources in the subbasin.

The following sections provide an overview of these anthropogenic sources of potential concern to groundwater quality. Although, SGMA does not transfer oversight of regulation of hazardous substances to GSAs, the agencies may seek to mitigate risks by informing the applicable regulatory agency of the intersection between contamination sources and mechanisms by which degradation may occur in the unique hydrogeologic setting of the ECC Subbasin. **Section 8** discusses a potential policy for GSA engagement with agencies responsible for mitigating and remediating hazardous waste that may reach groundwater.

3.3.6.1 Groundwater Contamination Sites

Figures 3-21a and 3-21b illustrate the open and closed groundwater contamination sites in the ECC Subbasin. Contaminated sites can pose a hazard to human health through the contamination of aquifers if the area is using groundwater. Contamination site data were taken from Geotracker[8] and are divided into cleanup program sites, leaky underground storage tank (LUST) sites, and land disposal sites. **Appendix 3h** lists the 35 open sites and 105 closed sites including the potential contaminants of concern for each site. The majority of sites are in Antioch and Brentwood and the most common contaminant is hydrocarbon.

3.3.6.2 Oil and Gas Wells

Oil and gas wells are regulated and permitted through the state Department of Conservation, Geologic Energy Management Division (CalGEM). In east Contra Costa County, there are as many as eleven oil and gas fields either wholly or partially within the ECC Subbasin which target oil and/or gas sands at several thousand feet below ground surface. Produced water in these sands is saline based on interpretation of electric geophysical logs performed in open boreholes prior to well installation.

As with all oil and gas wells in the subbasin, CalGEM regulations require a separate surface casing to be installed below the base of freshwater[9]. In Brentwood, for example, surface casings extend to 1,750 feet. This depth is consistent with the basin conceptualization presented in this GSP. Even though the interpreted base of freshwater is as deep as 1,750 feet, most groundwater production in the ECC Subbasin is shallower than 500 feet.

The legacy of oil and gas activity in the ECC Subbasin is the presence of up to several hundred abandoned and plugged wells. The abandonment programs are regulated through CalGEM requiring cement plugs at various depths to ensure that fluids in the oil zone (oil, gas and connate water) do not migrate upward into freshwater aquifers. **Appendix 3i** contains figures showing oil and gas fields and wells located in the ECC Subbasin as obtained from CalGEM's online well finder tool[10]. Production records are also available online through CalGEM[11].

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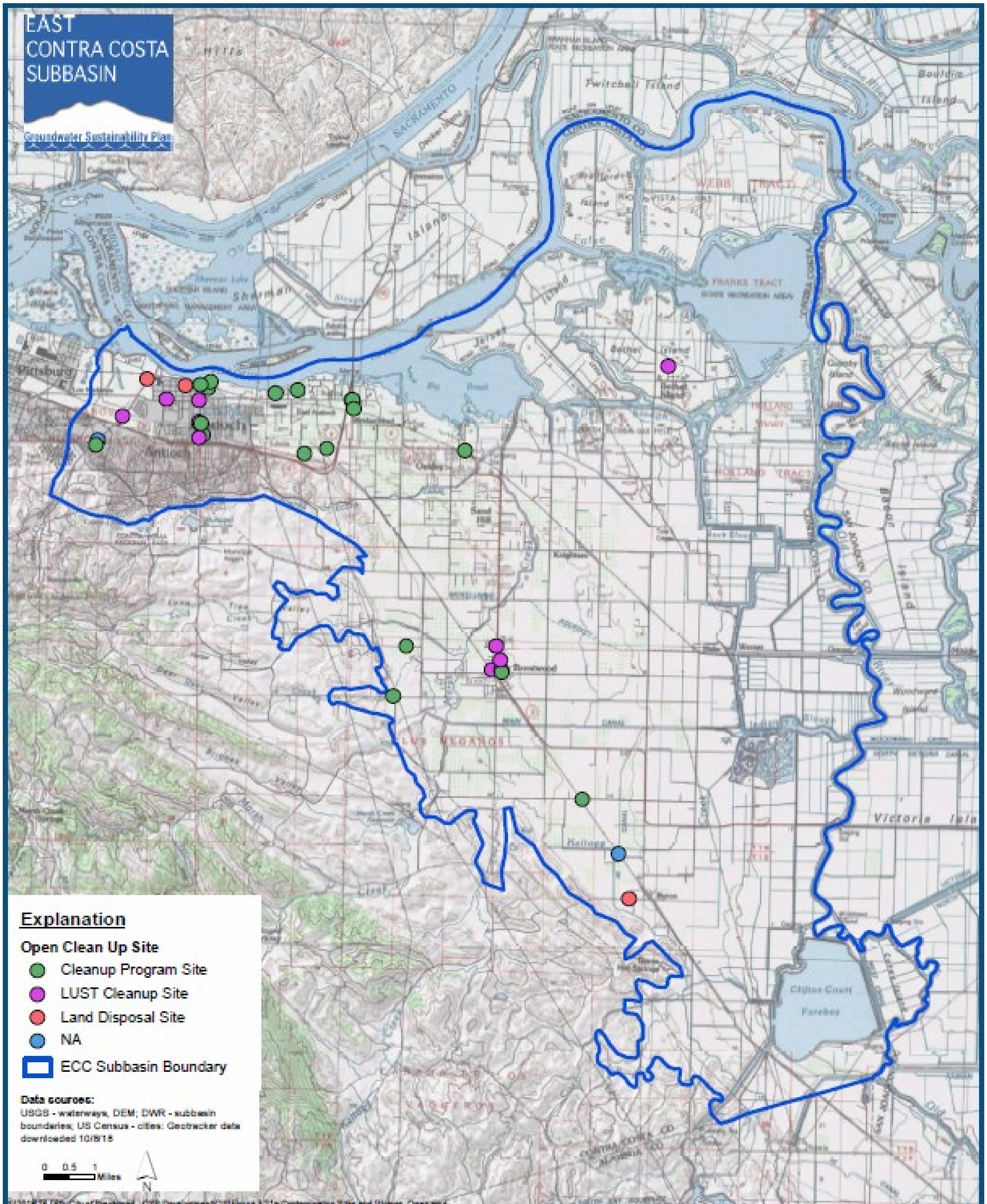
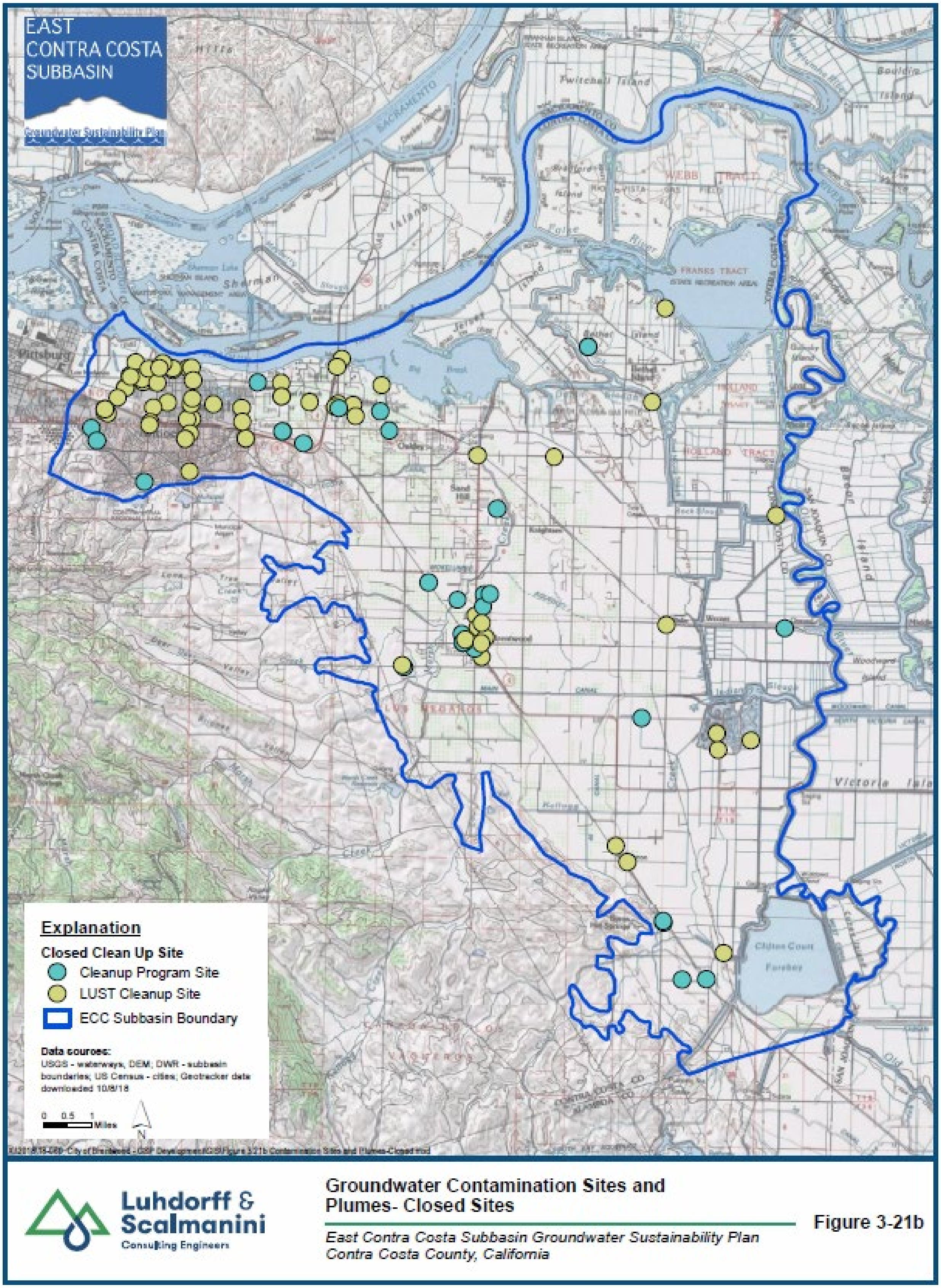
[8] Geotracker is the state Water Board's online resource to track data from waste discharges to land and includes unauthorized releases of hazardous substances from underground tanks: https://geotracker.waterboards.ca.gov/.
[9] https://www.conservation.ca.gov/calgem/Pages/Oil,-Gas,-and-Geothermal-Rulemaking-and-Laws.aspx
[10] https://www.conservation.ca.gov/calgem/Pages/WellFinder.aspx
[11] https://filerequest.conservation.ca.gov/?q=production_injection_data



Groundwater Contamination Sites and Plumes: Open Sites

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-21a



Groundwater Contamination Sites and Plumes- Closed Sites

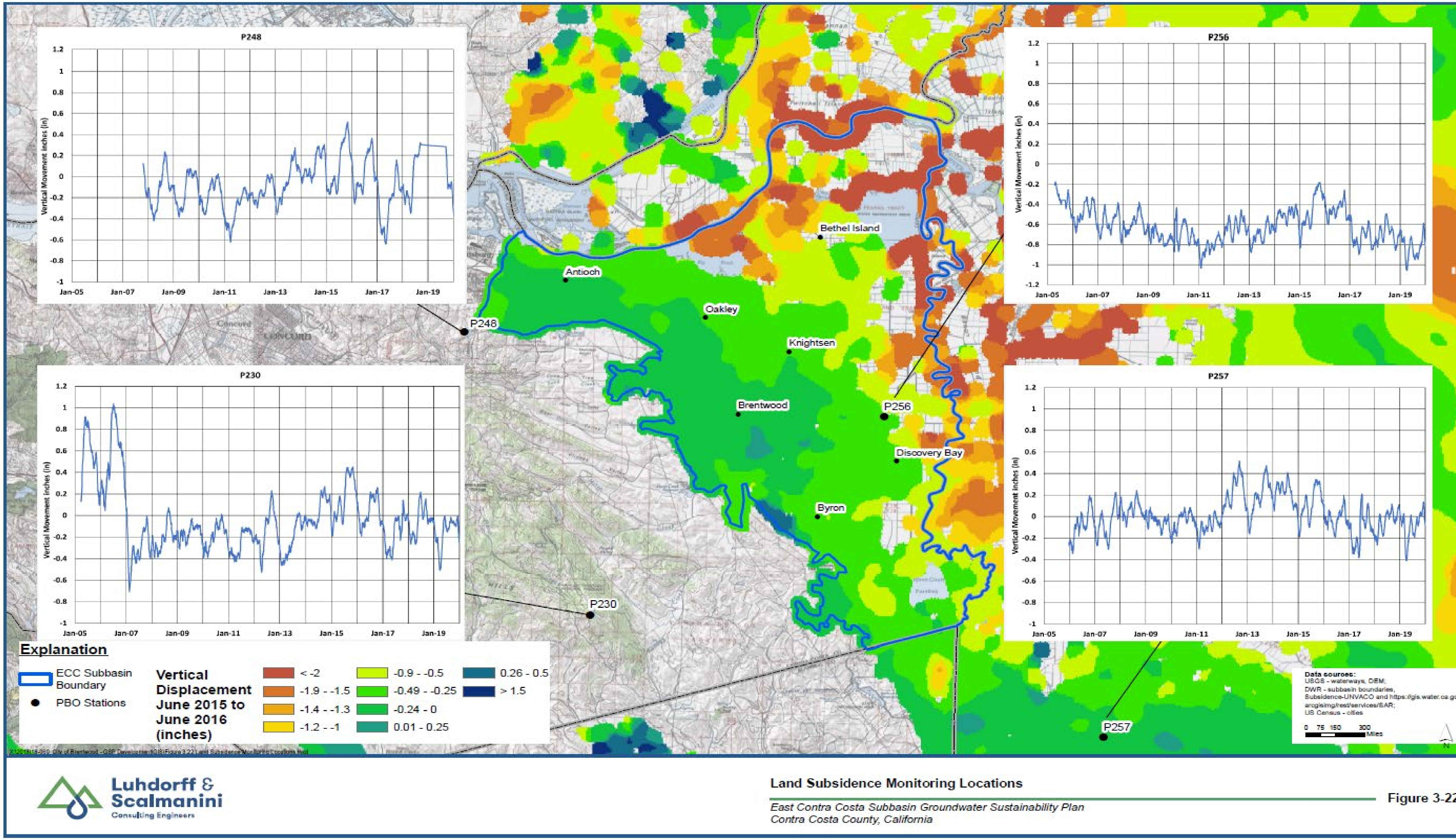
Figure 3-21b

3.3.7 Land Subsidence

There are no historical records of impacts from subsidence due to groundwater withdrawal in the ECC Subbasin. Land subsidence in the Subbasin is continuously monitored by the Plate Boundary Observatory (PBO) monitoring network managed by University NAVSTAR Consortium (UNVACO). The PBO's main task is to "quantify three-dimensional deformation and its temporal variability across the active boundary zone between the Pacific and North American plates." The PBO stations can be used to monitor for land subsidence using vertical land surface measurements. PBO stations are used to measure centimeter to millimeter-scale movement on the Earth's surface. Four stations located in or near the Subbasin (**Figure 3-22**) all show minor displacements. PBO stations take measurement once per day, to mitigate erroneous data a 30-day rolling average was applied to the data. PBO Station 256 (P256), located inside the Subbasin, has shown a vertical displacement from 2005 to 2019 of -0.01096 inches per year. PBO Station 230 (P230) west in the Diablo Mountains also has a slight downward displacement of -0.01461 inches per year. Two stations near Antioch and Tracy (P248 and P257) have a slight upward displacement of the land surface. **Table 3-3** below provides the estimated rate of land surface change. Trends do not indicate inelastic downward displacement in the land surface.

Table 3-3. Land Surface Displacement Rates at PBO Sites

Monitoring Location	Location Relative to Subbasin	Period of Record	Rate of Land Surface Displacement (inches per year)	Rate of Land Surface Displacement (feet per year)
Inside East Contra Costa Subbasin				
P256	East of Center of Subbasin	2005-2019	-0.0093	-0.00077
Outside East Contra Costa Subbasin				
P230	Southwest of Subbasin	2005-2019	-0.01487	-0.00124
P248	Northwest of Subbasin	2007-2019	.01092	0.00091
P257	Southeast of Subbasin	2006-2019	.001461	0.00122



Land Subsidence Monitoring Locations

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-22

DWR has also published Interferometric Synthetic Aperture Radar (InSAR) results in partnership with the European Space Agency's Sentinel-1A satellite with the data processed by TRE ALTAMIRA[12]. These data present measurements of vertical ground surface displacement between two different dates. InSAR mapping of land surface elevation is particularly useful for complementing high spatial and temporal resolution data at CGPS station locations with observations of land subsidence over a large area for highlighting locations where change is occurring. Throughout most of the Subbasin there has been minimal vertical changes between June 2015 and June 2019 (**Figure 3-22**), vertical measurement accuracy is reported to be about 18 millimeters (0.7in) (DWR 2021). Vertical displacement during this time period was mostly stable, no change to slightly downward with most values ranging from -0.5in to 0.25in in the western portion of the Subbasin. The Delta area (northern and eastern portion of the Subbasin) shows higher vertical displacement that is due to a mechanism that is described below (hydrocompaction). The InSAR data in the vicinity of P256 has a similar vertical displacement (about 0.4in) as observed at P256 during the June 2015 to June 2019 time period.

In the late 1800s to the early 1900s levees were built along stream channels in the delta and the rich land was converted to agriculture (discussed in more detail in **Section 2.1**). However, this caused ongoing land subsidence associated with drainage for agriculture, called hydrocompaction, on islands in the Delta including parts of the ECC Subbasin specifically.

Hydrocompaction is due to dewatering of peat soil that dries out and compresses[13] as a result of land reclamation. This caused many central Delta islands to drop 10 to nearly 25 feet below sea level (USGS, 1999, **Figure 3-23a).** The Delta soils are composed of 1) coarser sediments concentrated near the natural waterways of the Delta and 2) peat from decaying marsh vegetation concentrated near the centers of the islands (up to 60 feet thick in the western Delta). **Figure 3-23b** illustrates the late 1880's freshwater tidal marsh land surface profile (upper diagram) and the current configuration of many islands (lower diagram) that is saucer-shaped due to compacted peat soils in the interior and mineral sediments at their edge. Currently, groundwater levels are maintained on the islands by a network of drains at three to six feet bgs with drainage water pumped back into the stream channels (**Figure 3-23b**). Though this GSP is only required to discuss subsidence due to groundwater withdrawal, understanding of how these Delta islands are constructed improves understanding of interactions between surface water and groundwater in the Delta area.

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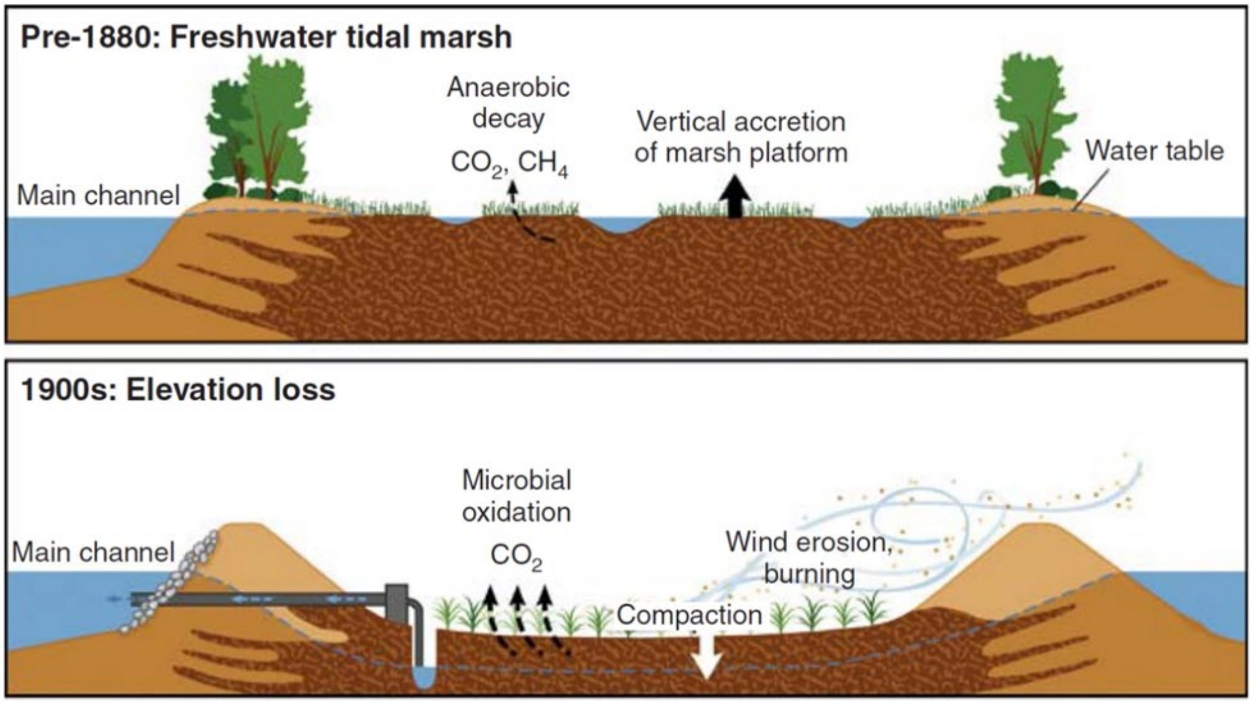
[12] https://gis.water.ca.gov/arcgisimg/rest/services/SAR
[13] Source: Water Education Foundation, 2020. Can Carbon Credits Save Sacramento-San Joaquin Delta Islands and Protect California's Vital Water Hub? Gary Pitzer, February 27, 2020.

Figure 3-23a. Subsidence on Delta Islands

(California Department of Water Resources)

(source: https://www.usgs.gov/centers/ca-water-ls/science/subsidence-sacramento-san-joaquin-delta?qt-science_center_objects=0#qt-science_center_objects)

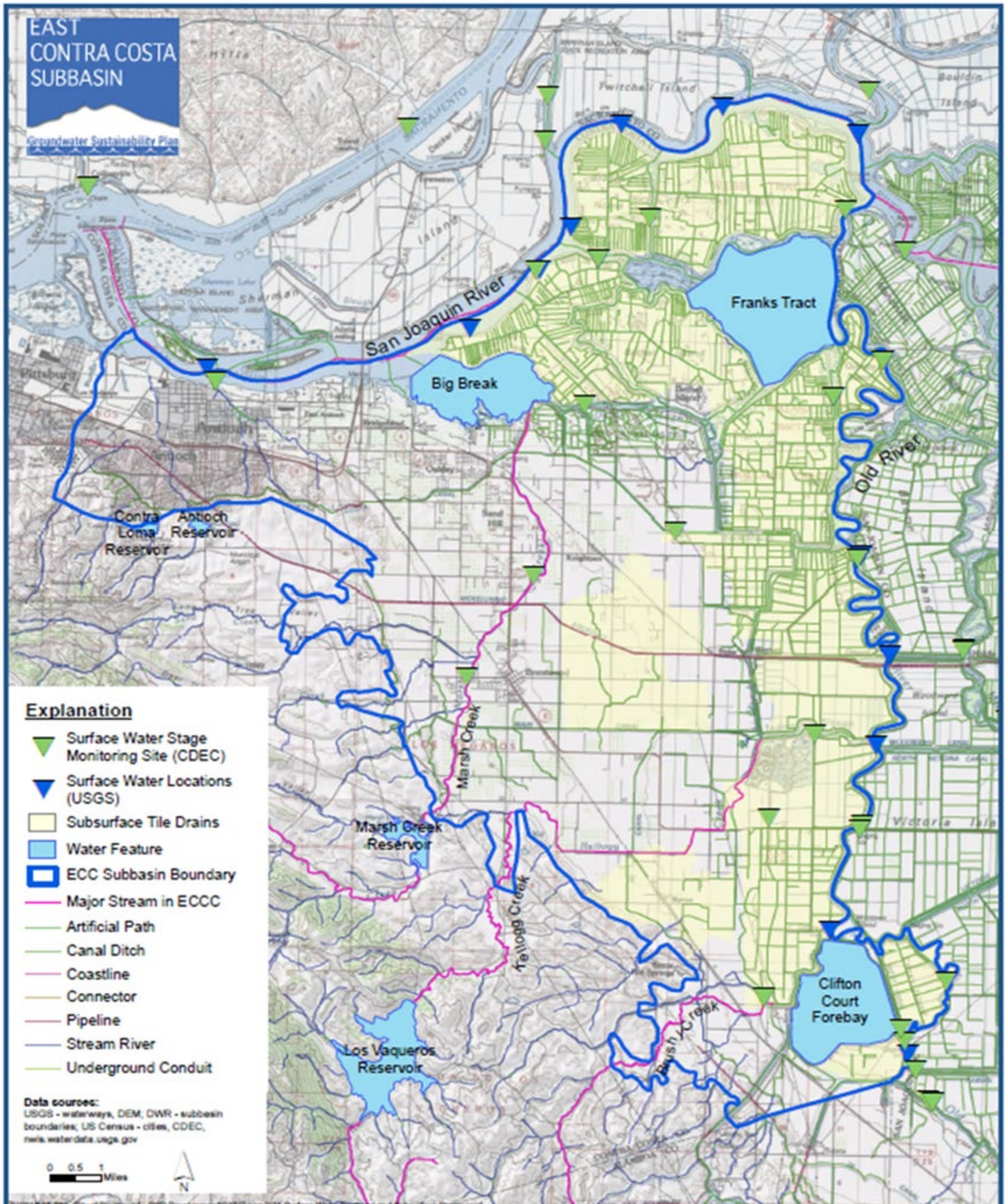
Figure 3-23b. Cross-section of Subsidence and Drains on Delta Island. Source: Mount and Twiss (2005)



3.3.8 Interconnected Surface Water Systems

Interconnected surface water systems are the locations where groundwater and surface water are hydrologically connected. It is important to know where these systems are located in order to minimize impacts of groundwater pumping on the surface water bodies and biological communities that rely on the interconnected water system. The ECC Subbasin is bounded by the San Joaquin River to the north and Old River to the east with an extensive network of canals installed (**Figure 3-10**). Delta islands located in the northern and eastern portion of the Subbasin, as described above, are protected by levees and require excess water that collects in subsurface drains to be discharged to the Delta. **Figure 3-24** identifies the surface water features in the Subbasin and vicinity and illustrates coverage of subsurface tile drains installed at between 5 and 8[14] feet bgs to provide drainage of water to the river. Given this unusual configuration, Old River and the San Joaquin River are considered interconnected rivers and currently or historically, surface water depletions have not occurred along these rivers. In the western portion of the Subbasin a few creeks are present that are considered a natural source of recharge to the Subbasin (**Figure 3-24**) and have the potential to be considered interconnected systems. Marsh Creek, the most prominent, is earthen lined and channelized, and is adjacent to both the City of Brentwood and DWD pumping wells. The Marsh Creek dam passively drains all flows that enter it until the level subsides to the primary spillway level. It may be vulnerable to impacts from the loss of interconnected surface water due to groundwater pumping and groundwater level declines. Currently there is an incomplete understanding of the ECC Subbasin surface water/groundwater connection, but this is expected to be remedied through installation of multiple completion monitoring wells and future monitoring efforts related to this GSP.

[14] As communicated by individual water districts.



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Surface Water Features and Subsurface Drains

Figure 3-24

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

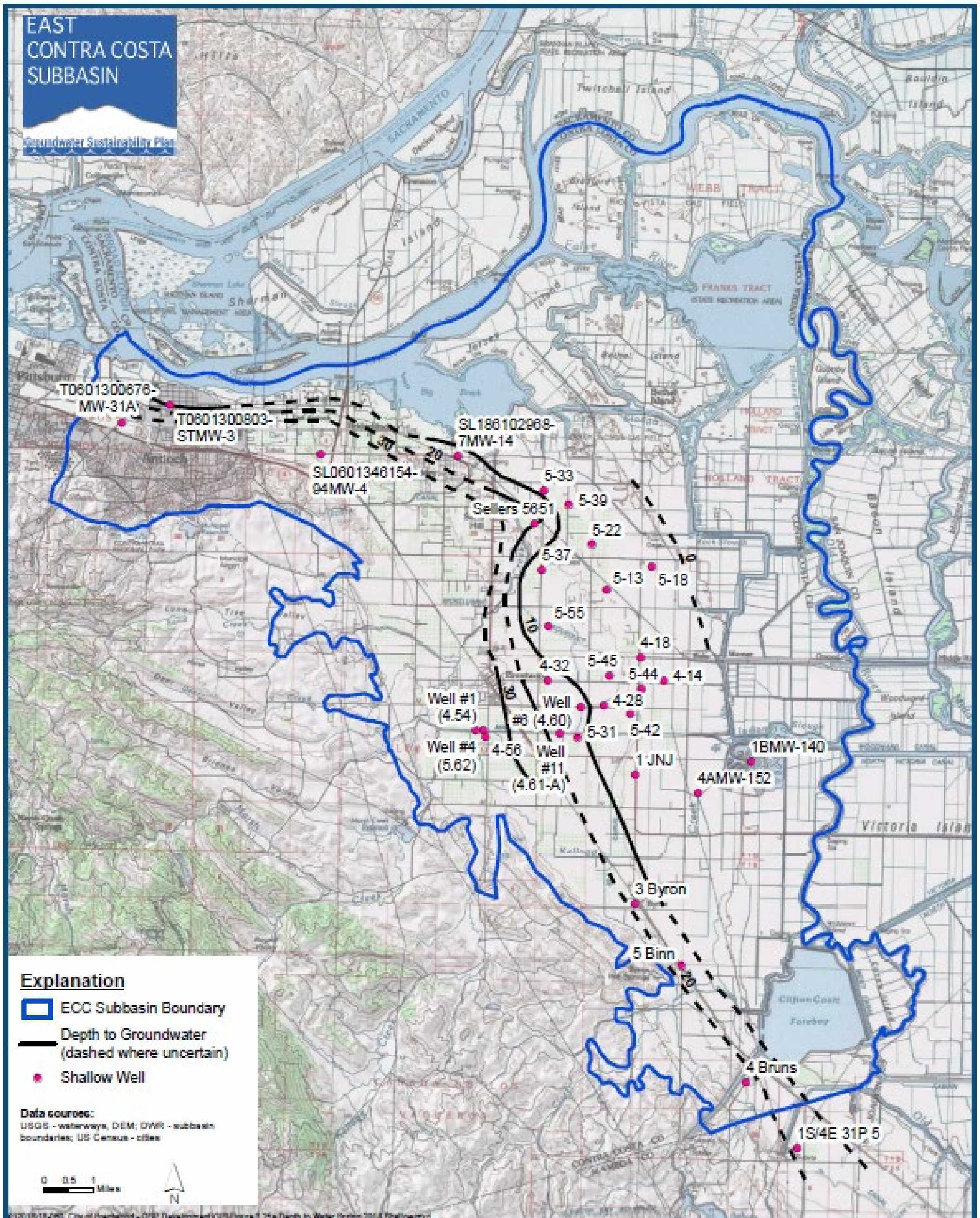
Figure 3-25a is a map illustrating the spring 2018 depth to shallow groundwater in the ECC Subbasin. There is not complete coverage of the Subbasin, but it does present the 30 ft depth to water contour that may represent the point when a stream is no longer considered interconnected to groundwater. Review of the depth to water figure indicates that the majority of the Subbasin may have interconnected surface water and groundwater. Specifically, the San Joaquin River, Old River, and portions of western creeks are likely connected to the groundwater system and there is then potential for regional groundwater pumping to impact groundwater dependent ecosystems (GDEs). **Figure 3-25b** shows the natural and artificial channels in the Subbasin with the most conservative estimates of potential for interconnectivity using 2018 shallow DTW created from subtracting the digital elevation model from groundwater elevation contours. Most of the natural channels in the Subbasin are located in the west of the Subbasin. Marsh Creek however starts to become likely connected with groundwater in Brentwood. Many artificial channels in the eastern part of the Subbasin may exhibit interconnectedness with groundwater as they are commonly located in areas where DTW is less than 10 feet.

3.3.9 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) "refers to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" outlined in the GSP Emergency Regulations. Each plan is required to identify groundwater dependent ecosystems within the basin, utilizing data available from DWR or the best available information. GSAs are only responsible for impacts to GDEs resulting from changing groundwater conditions resulting from pumping or groundwater management in the Subbasin (TNC, 2019). For example, if groundwater conditions stay the same but GDEs lose access to water due to surface water diversions/depletions, this is not the GSA's responsibility.

GDEs are similarly defined as "the plants, animals, and natural communities that rely on groundwater to sustain all or a portion of their water needs" by The Nature Conservancy (TNC) in the Guidance for preparing Groundwater Sustainability Plans (Rohde et al, 2018). GDEs are an important aspect of the diverse California landscape and are found in nearly all subbasins. The GDEs are diminishing rapidly and largely due to human interference and unsustainable groundwater extraction (Rohde et al, 2018). Water Code Section 10723.2 requires the GSP to identify GDEs and determine how groundwater does or does not affect them. The following section describes the process for identifying the GDEs within the ECC Subbasin and mapping their location.

The Natural Communities Commonly Associated with Groundwater (NCCAG) Dataset was used as a starting point to identify GDEs within the Subbasin. This dataset is compiled from 48 publicly available agencies datasets and was then reviewed by a working group comprised of DWR, TNC, and the California Fish and Wildlife **(Figures 3-26a** and **b)**. The Subbasin GDEs exhibited in **Figures 3-26a** and **b** were compared by the county with local information, and it was concluded that these are the best available data. Further analysis of GDEs in ECC was conducted by identifying areas where depth to groundwater is greater than 30 feet, the general vegetation maximum rooting depth. The assumption was that those areas could be eliminated however, groundwater level monitoring is lacking in some of the western areas of the Subbasin so no changes to Wetland or Vegetation NCCAG Datasets were made. Current land use was also analyzed to determine if the parcel was still a GDE. Using DWR's 2016 Land use data set it was found that 67 acres of vegetation and 18 acres of wetland were no longer classified as native materials and the corresponding GDEs were removed. A total of 13,970 potential GDE acres (11,985 wetlands and 4,304 vegetation with some areas of overlap in the ECC Subbasin) were identified by the NCCAG database and retained for this GSP. Most of these areas are located in the Delta with a few occurring along western creeks. **Table 3-4** includes all species in the ECC Subbasin as identified by TNC. TNC has identified 22 vegetation species and additional category of Not Applicable. The majority of species represent a small percentage of the total GDEs; the largest designation is Not Applicable. **Figure 3-27** identifies critical habitat for species in the ECC Subbasin: Steelhead (threatened), Delta smelt (threatened), and vernal pool fairy shrimp (threatened).



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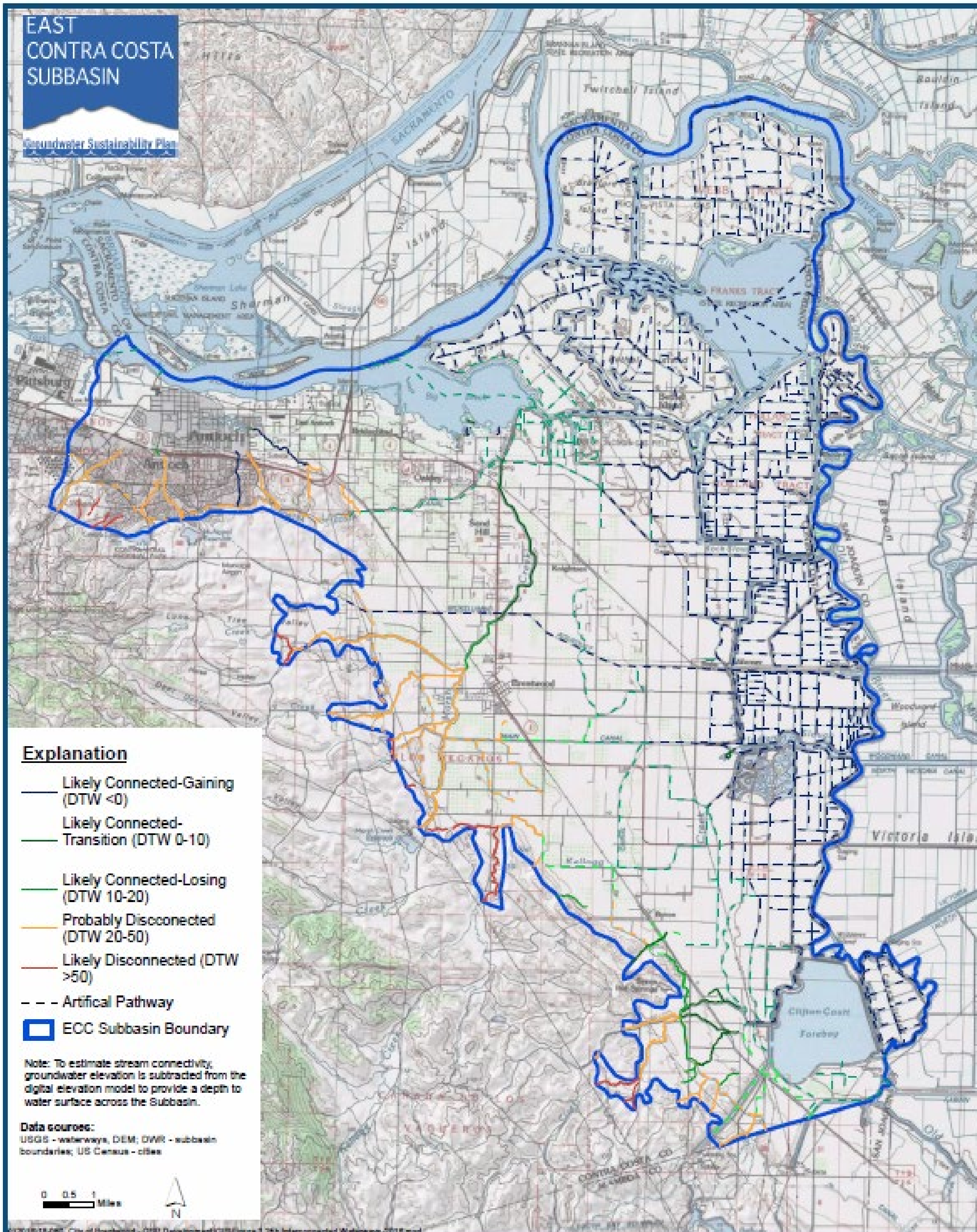
Depth to Shallow Groundwater- Spring 2018

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-25a



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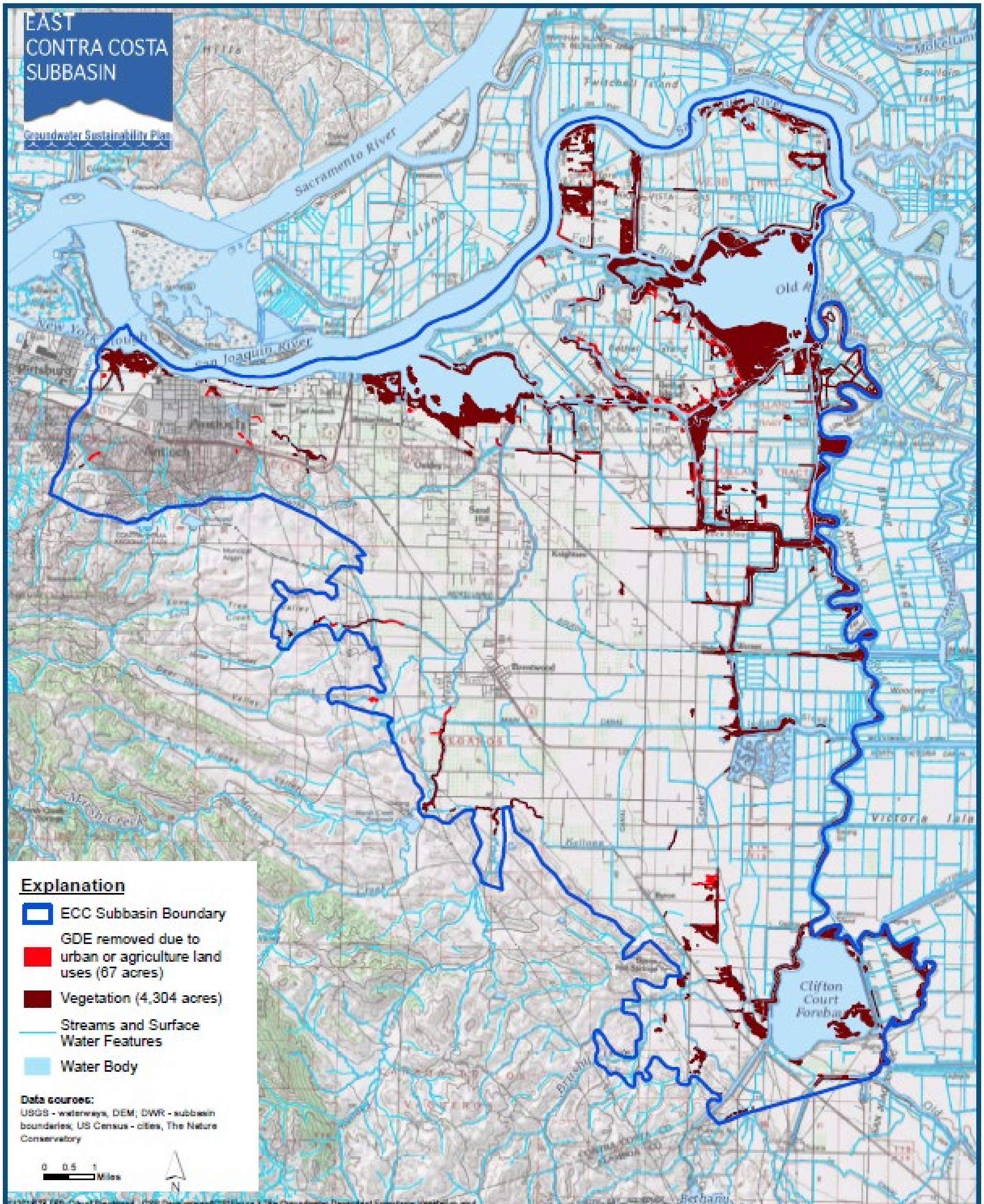
Interconected Surface Water-Minumum Depth to Water Spring 2018

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-25b



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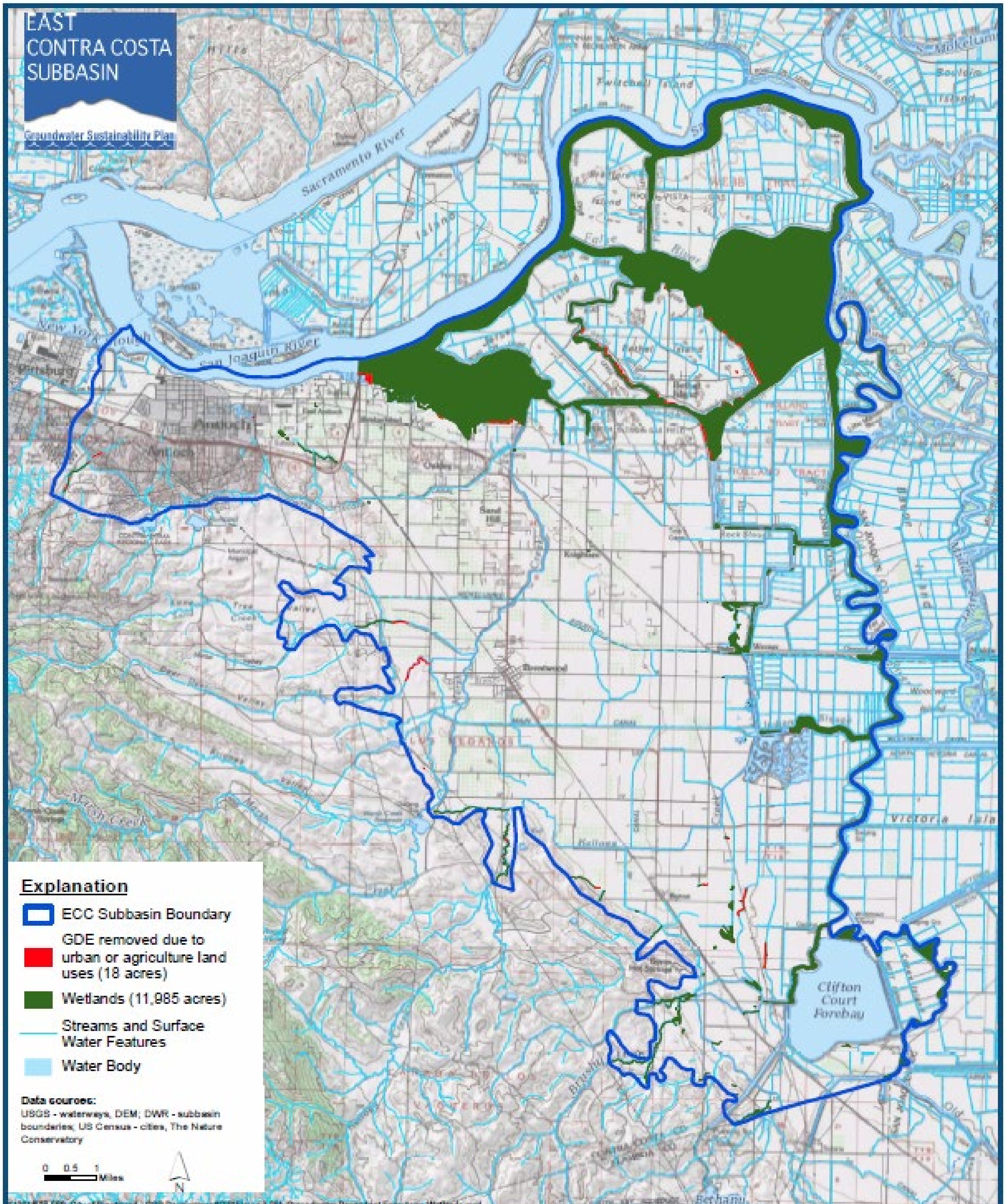
Groundwater Dependent Ecosytems-Vegetation

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-26a



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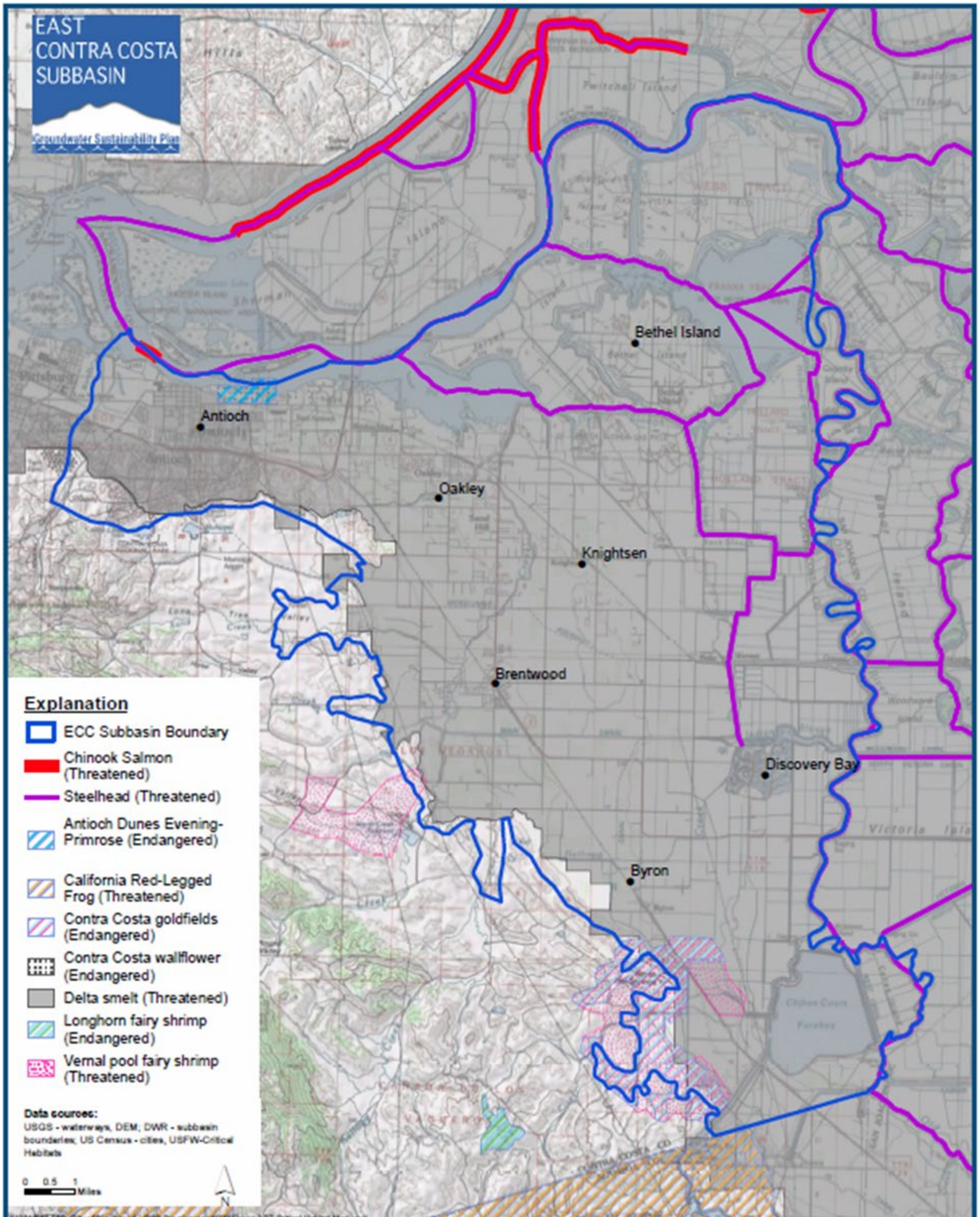
Groundwater Dependent Ecosytems- Wetlands

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-26b



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Critical Habitat Map

East Contra Costa Subbasin Groundwater Sustainability Plan
Contro Coasta County, California

Figure 3-27

Table 3-4 Vegetation Species in Subbasin

Dominate Species	Percentage of Total Vegetation	Dominant Species	Percentage of Total Vegetation
Arctic Rush	< 1%	Iodine Bush	4%
Arroyo Willow	9%	Narrowleaf Cattail	< 1%
Broadleaf Cattail	1%	Narrowleaf Willow	2%
Broadleaf Pepper-grass	4%	Northern California Black Walnut	< 1%
California Bulrush	7%	Not applicable	37%
California Rose	< 1%	Red Willow	0%
Common Reed	1%	Shrubby Seepweed	1%
Fremont Cottonwood	1%	Three-square Bulrush	< 1%
Giant Reed	< 1%	Tree-of-Heaven	< 1%
Goodding's Willow	10%	Valley Oak	< 1%
Hardstem Bulrush	16%	White Alder	< 1%
Himalayan blackberry	5%	--	--

The Subbasin has multiple GDE areas, mostly in the Delta in the north along the San Joaquin River and the east along the Old River in addition to various canals located in the east. However, these areas have minimum groundwater pumping from mostly domestic wells (**Figure 2-3a**). TODB is wholly reliant on groundwater and has GDEs noted around the town; a shallow zone groundwater monitoring well has been identified as a Data Gap and will be installed as part of this GSP. Brentwood also uses groundwater but no GDEs are noted in the area; however, three shallow zone monitoring wells are part of the monitoring network. Bethel Island has a groundwater production well that is located near GDEs for both wetlands and vegetation, and this also has been identified as a Shallow Zone monitoring well Data Gap. The southern portion of the Subbasin has small areas of GDEs but with no municipal groundwater production; however, this area is also identified as a Shallow Zone monitoring well Data Gap for this GSP.

New projects that include construction of wetlands are in the planning and/or constructions phase and will be added to the GDE maps when completed. They include Dutch Slough Tidal Restoration Project[15] located at the intersection of Marsh Creek and the Delta (managed marsh and tidal), Three Creeks Parkway Project[16] located in Brentwood, and Franks Track State Park[17]. Municipal Water District of Southern California (MWD) owns all or parts of two islands[18] in the Delta area of the ECC Subbasin:

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[15] Information can be access here: https://water.ca.gov/Programs/Integrated-Regional-Water-Management/Delta-Ecosystem-Enhancement-Program/Dutch-Slough-Tidal-Restoration-Project. Construction to restore 1,200 acres launched in 2018, planting occurred in 2020 and a levee breach is planned for 2021.
[16] Information can be accessed here: https://www.contracosta.ca.gov/5814/Three-Creeks-Parkway-Project
[17] Information can be accessed on Franks Tract Futures here: https://franks-tract-futures-ucdavis.hub.arcgis.com/
[18] Holland and Webb Tracts are owned by Municipal Water District (MWD) that are part of the proposed water storage project call Delta Wetlands Project. Information can be accessed here:

Webb Tract (100% MWD owned) and Holland Tract (75% MWD owned). Originally Webb Tract was slated to be a Reservoir Island to store available water in winter and discharged in summer or fall and 845 acres of Holland Tract was to be wetlands and a dedicated Habitat Island. However, as of September 2020 the islands are projected to continue as farms for at least the next 5 years with no major land use change and MWD is reportedly not pursuing the island storage project[19]. Future updates to the GSP will include refinement of GDE locations in the Subbasin as land use changes.

3.3.9.1 Evaluation of GDE Health

The GDE Pulse dataset, developed by TNC, was also reviewed and evaluated for the Subbasin (Klausmeyer et al., 2019) in relation to GDEs. The GDE Pulse dataset utilizes remote sensing data from Landsat satellites to monitor the health of GDEs by observing how moisture and greenness change over time (Klausmeyer et al., 2019). The most common way to assess the health of the GDEs using remote sensing data is through the Normalized Derived Vegetation Index (NDVI). NDVI is calculated as follows:

$$NDVI = \frac{Near\ Infrared - Visible\ Red\ Light}{Near\ Infared + Visible\ Red\ Light}$$

Calculated NDVI values less than zero indicate unhealthy or dead vegetation, values between zero and 0.1 are most likely barren, values of 0.2 to 0.3 are considered moderate vegetation, and values above 0.6 are very dense and green vegetation (Weier and Herring, 2000). TNC merged the NCCAG and remote sensing datasets together and removed background noises such as clouds and calculated the NDVI yearly average values. According to Klausmeyer et al. (2019), yearly average NDVI values between July 9 to September 7 represent readings during the typically dry months when GDEs would be dependent on groundwater. The yearly average was calculated by finding the medoid, which is "a multi-dimensional feature space median" (Klausmeyer et al., 2019). **Figure 3-28a through Figure 3-28e** illustrates the NDVI changes in the Subbasin for 1997, 2004, 2010, 2015, and 2018. The five years selected show the likely GDEs identified in the Subbasin under a variety of water year conditions ranging from wet (1997, during and after several wet years), dry (2004, during and after several dry years), more moderate (2010, above normal after a dry year; 2018, below normal after a very wet year), and critically dry (2015, during and after two critical years).

For evaluating the GDE health in the Subbasin over the last 20 years, NDVI values greater than 0.2 were interpreted to be healthy, based on guidance from Weier and Herring (2000), and values less than 0.2 were interpreted to be unhealthy. The NDVI changes throughout the Subbasin have occurred through many different water year types. NDVI data changed the most in Clifton Court Forebay and the Delta region of the Subbasin. Throughout time the GDE health has changed in several areas of the Subbasin particularly in Franks Tract, but in general GDE health poorer historically compared to recent years. In the earlier periods, larger areas had values of less than 0.2 while, in the more recent surveys (2015 and 2018), the overall health of the vegetation is greater than 0.2. NDVI data along Franks Tract and Clifton Court Forebay appear to be consistently below 0.2; however, in some instances, the values rise 0.2, but other factors could be contributing to this phenomenon. The values of less than 0.2 can be due to the NCCAG

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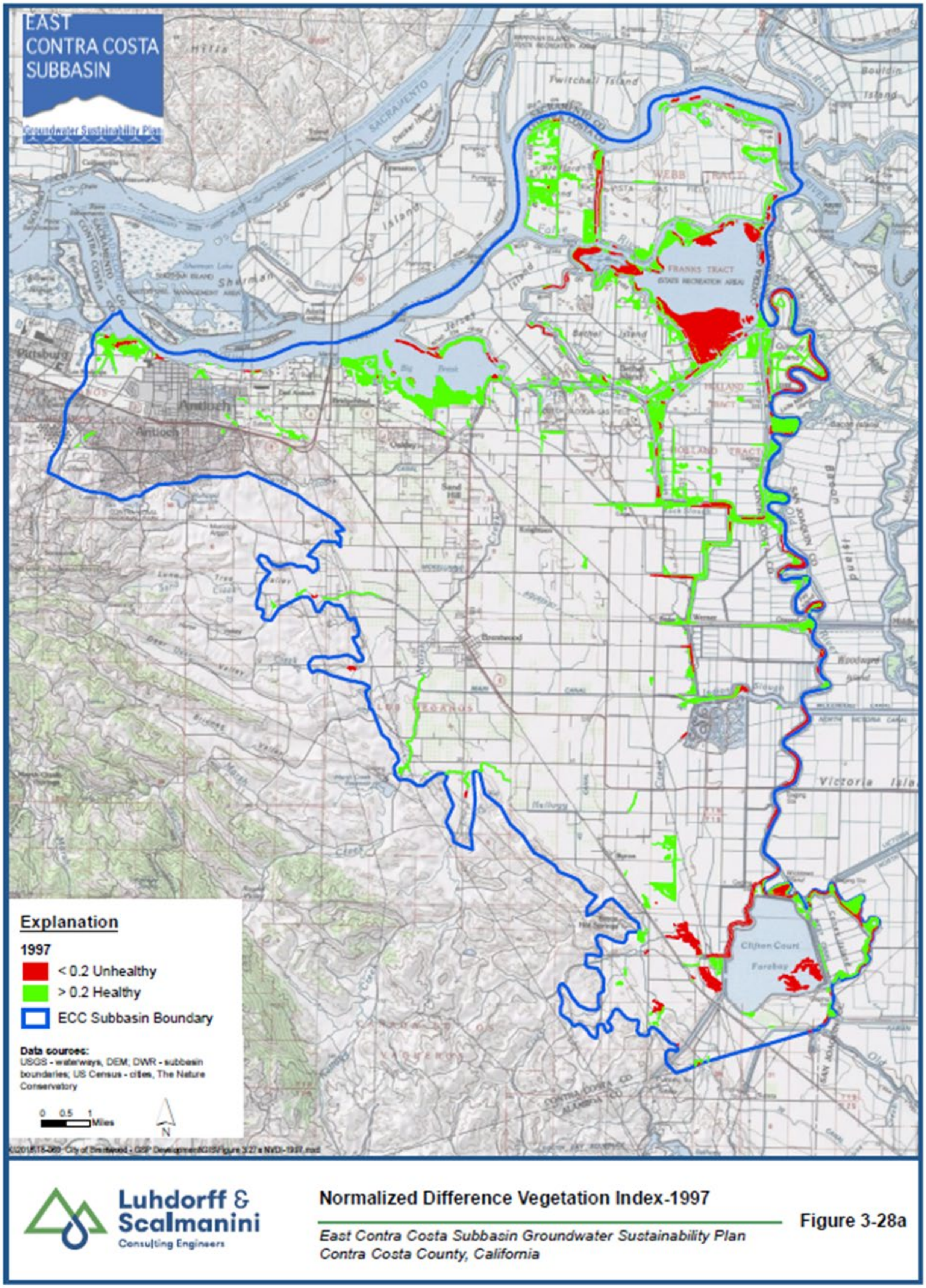
https://www.spk.usace.army.mil/Portals/12/documents/regulatory/eis/190109804-eis/190109804-SDEIS/AppendixJ.pdf

[19] Delta Protection Commission meeting, September 17, 2020, report by Stephen Arakawa, MWD, on Delta Islands.

vegetation dataset, which is based on more current conditions and historically vegetation may not have always been present in these areas.

The evaluation of NDVI data suggest that the overall GDE health within the Subbasin has experienced changes but generally remained stable between 1997 and 2018. The greatest periods of stress to GDE communities appears to have occurred during the earliest and later part of the 1997-2018 period, in 1997 and 2018. This could be explained by changes geography in the area, what was historically water channels could presently have vegetation or be considered a wetland. Very few areas of stressed GDE health are evident in 2015, when the groundwater conditions in the Subbasin were at historically low levels because of drought conditions, compared to the moderate 2018 conditions. **Figure 3-28f and Figure 3-28g** shows the NDVI changes throughout the available record (1985-2018) for likely GDE areas along Big Break and Marsh Creek. The NDVI data for communities along Big Break shows a gradual increase in GDE health with the average plotting above 0.2 for the entire record, only a small portion of GDEs plotted below 0.2 in the early part of the record. In Marsh Creek there are limited GDEs identified, and the health has been stable throughout time. These data suggest that overall health of the GDE communities along Big Break and Marsh Creek are healthy with majority of NDVI values above 0.2 and a long-term upward trend (Big Break) and stable healthy conditions (Marsh Creek), suggestive of general improving or stable health conditions between 1985 and 2018.


EAST CONTRA COSTA SUBBASIN
Groundwater Sustainability Plan
Explanation
1997
< 0.2 Unhealthy
> 0.2 Healthy
ECC Subbasin Boundary
Data sources:
USGS - waterways, DEM; DWR - subbasin boundaries; US Census - cities, The Nature Conservatory
0 0.5 1 Miles
N
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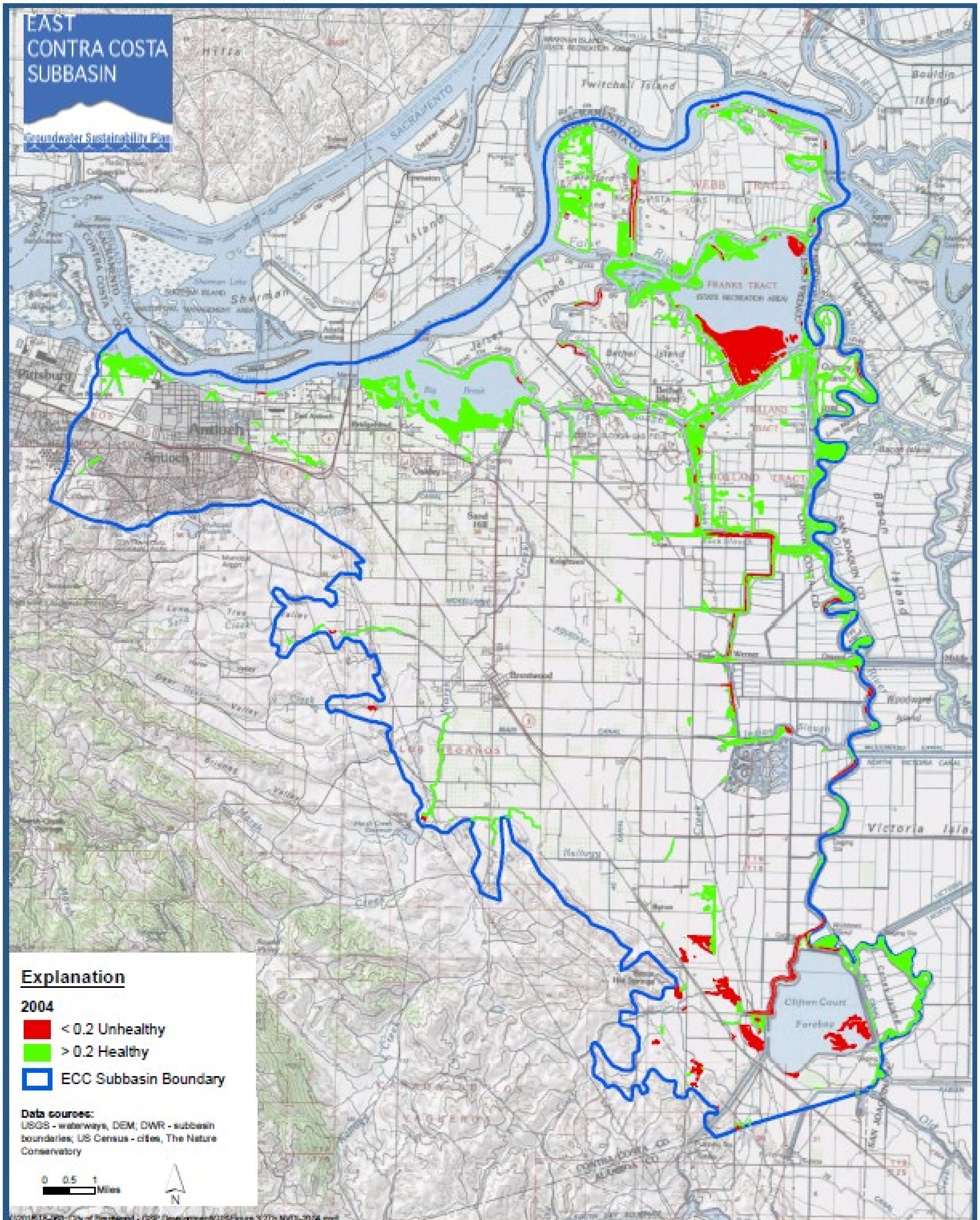
Normalized Difference Vegetation Index-1997
East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

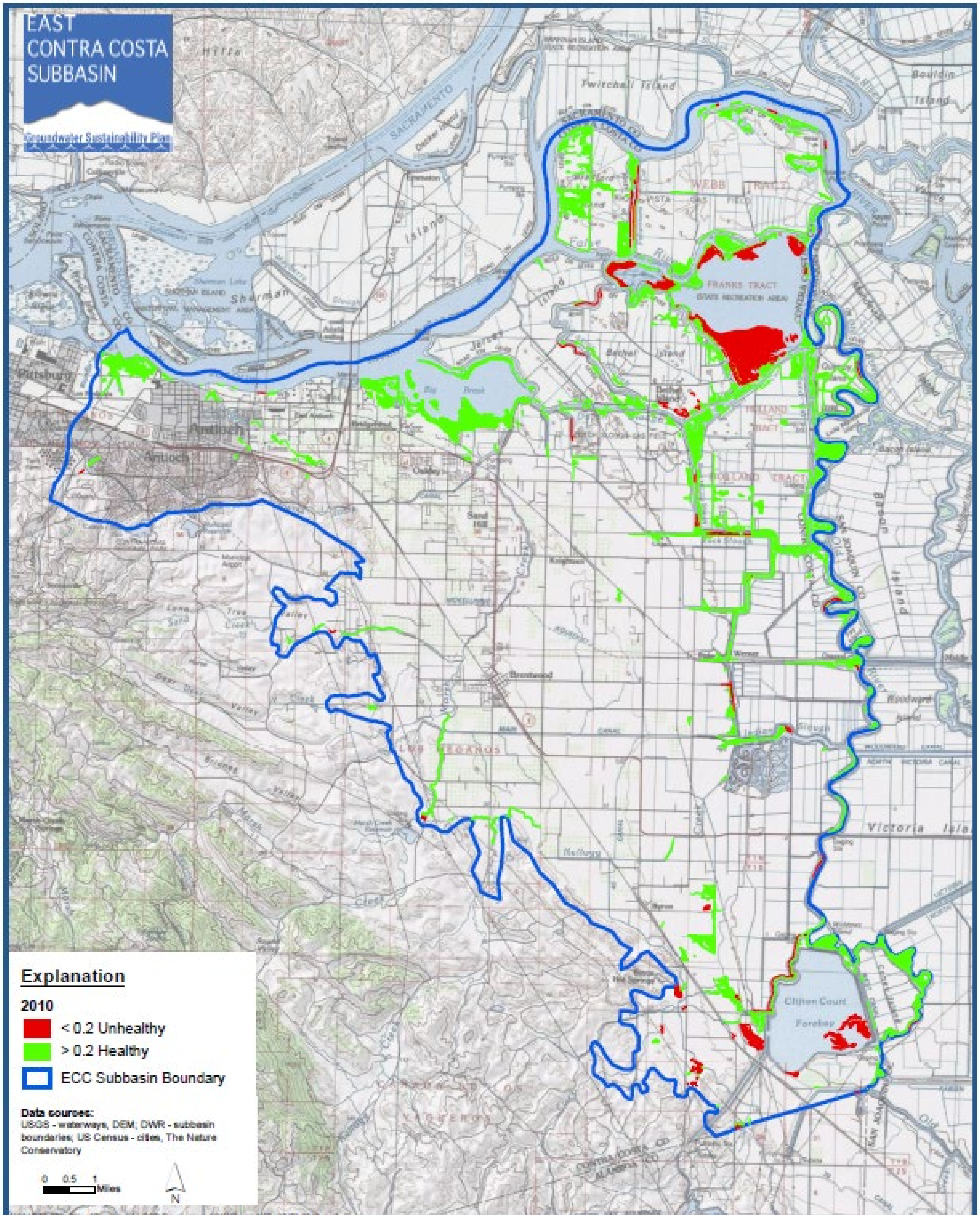
Figure 3-28a



Normalized Difference Vegetation Index- 2004

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28b



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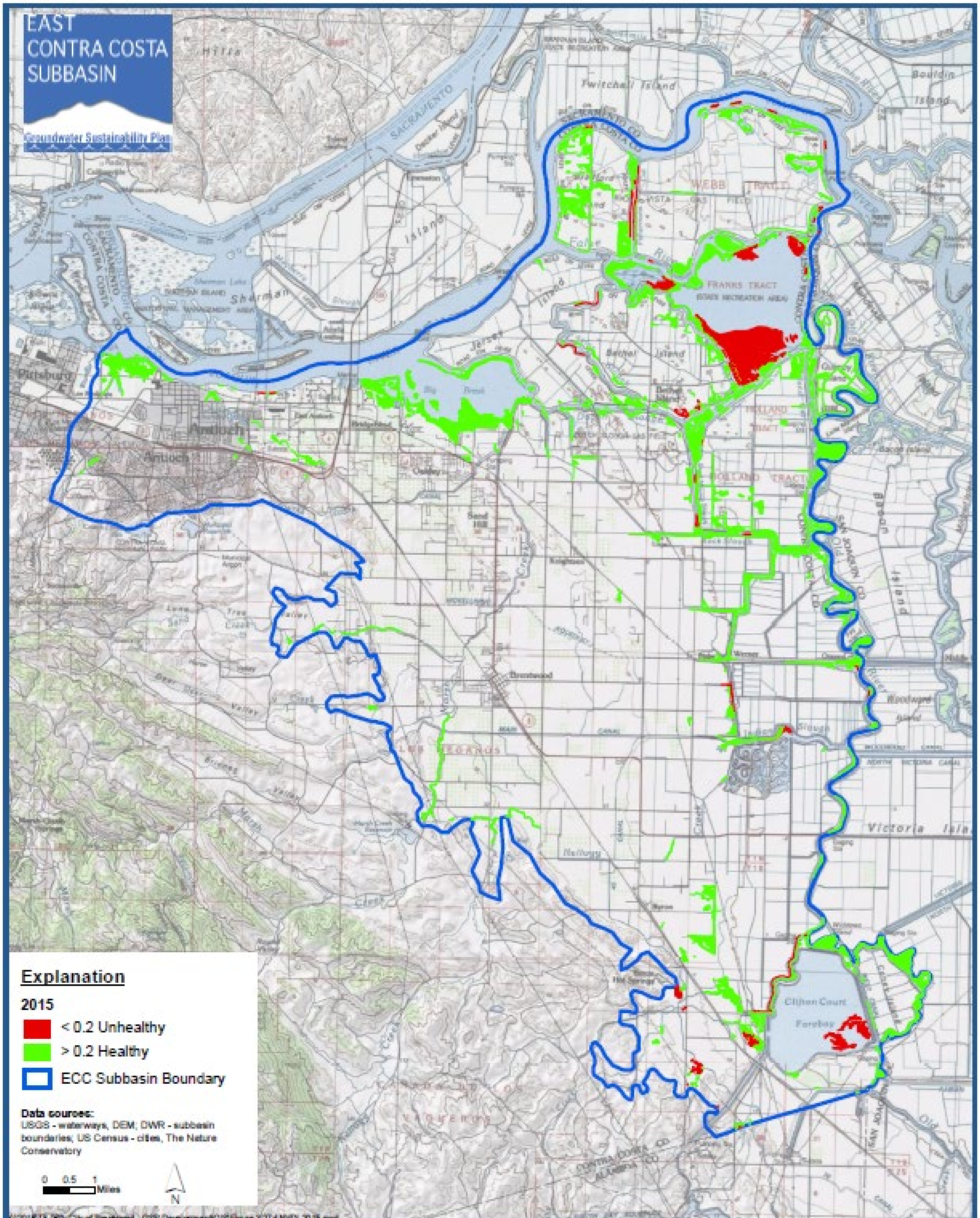
Normalized Difference Vegetation Index- 2010

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28c



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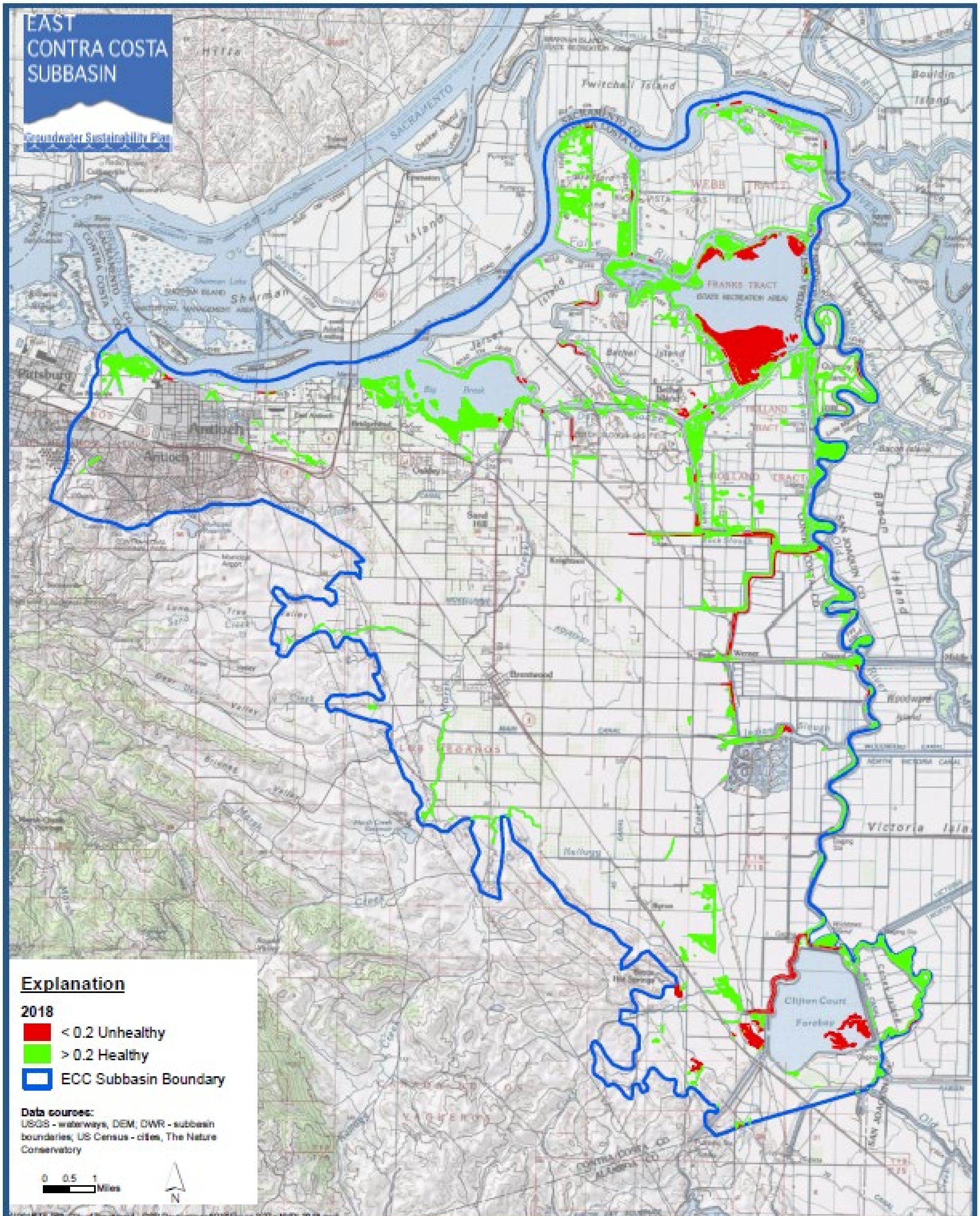
Normalized Difference Vegetation Index- 2015

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28d



Normalized Difference Vegetation Index- 2018

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28e

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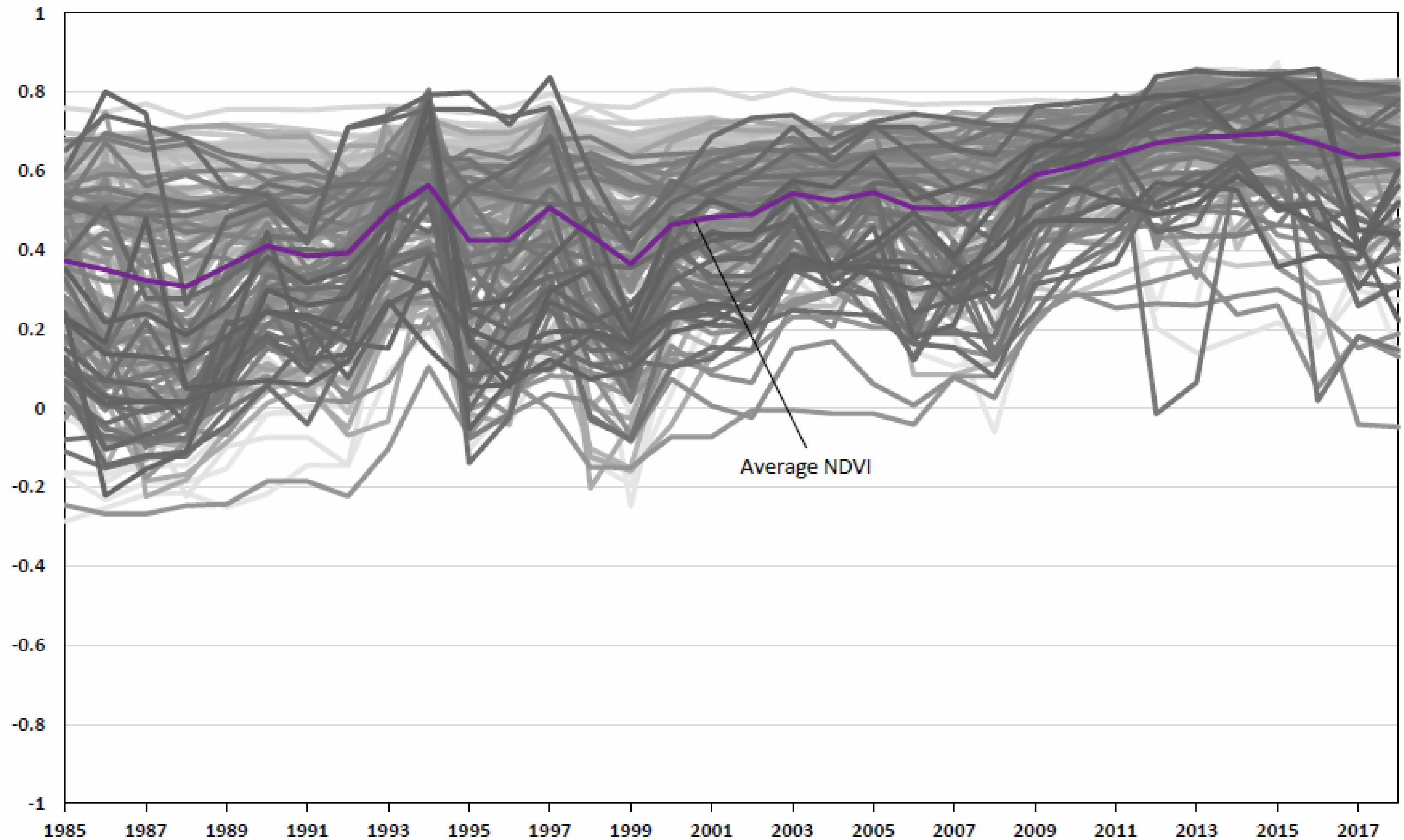

Data Source: *https://gde.codefornature.org*

\\server-01\Clerical\2018\18-060 City of Brentwood - GSP Development\REPORT\Figures\Figure 3-27f Big Break NVDI.xlsx

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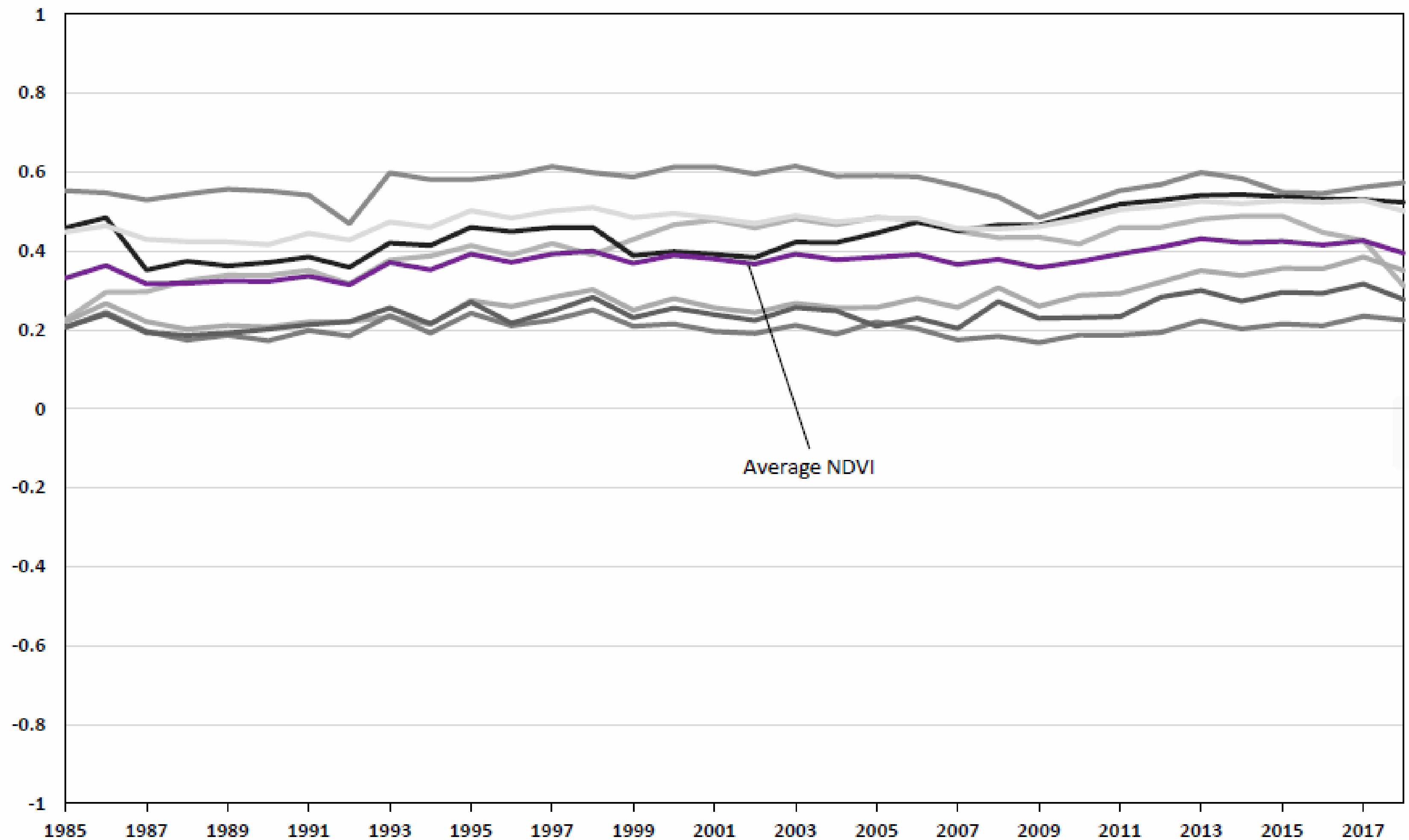
Normalized Difference Vegetation Index- Big Break

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28f



Data Source: *https://gde.codefornature.org*

\\server-01\Clerical\2018\18-060 City of Brentwood - GSP Development\REPORT\Figures\Figure 3-27f Marsh Creek NVDI.xlsx

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Normalized Difference Vegetation Index- Marsh Creek

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 3-28g

3.4 Summary

Basin Setting

- ECC Subbasin is bounded on the north, east, and south by the Contra Costa County line, which is contiguous with the San Joaquin River (north) and Old River (east). In the west, the Subbasin is bounded by marine sediments of the Coast Range.
- Topography and geological formations gently slope to the northwest. The upper 400 feet of Subbasin sediments is comprised of alluvial deposits with discontinuous clay layers interspersed with more permeable coarse-grained units.
- The ECC Subbasin aquifer system is divided into the upper unconfined Shallow Zone (to about 150 ft bgs) and a lower semi-confined to confined Deep Zone (the Corcoran Clay is not present in the Subbasin). Most water wells are constructed within the upper 400 feet.

Groundwater Conditions

- Groundwater levels in the ECC Subbasin are stable which indicates that the Subbasin is being operated within its sustainable yield. This is due to surface water being the major supply source for agricultural and urban uses. Groundwater flow direction is generally from the southwest to the northeast toward the Delta.
- Groundwater quality is generally good with no restrictions for agricultural or urban uses in the Subbasin. Constituents of concern are TDS, chloride, nitrate as N, and boron which all have natural sources with the exception of nitrate. TDS concentrations in both the Shallow Zone and Deep Zone are generally stable and average 1,100 mg/L, around the SMCL of 1,000 mg/L. Chloride is another indicator of salinity and averages around 230 mg/L which is near the SMCL of 250 mg/L. Nitrate levels are primarily below the MCL of 10 mg/L, with slightly elevated concentrations in the Shallow Zone around Brentwood due to past land uses. Boron does not have a drinking water standard, but the agricultural goal is 700 ug/L where some crops may become sensitive to it. Boron concentrations in ECC wells are generally over 1,000 ug/L.
- Groundwater Storage: the total volume of groundwater in storage in the Subbasin was estimated to be between 4.5 MAF and 9 MAF when measuring to the base of fresh water (to over 1,000 ft bgs) and between 1.5 MAF to 3 MAF when measuring the current production zone (to average of 300 ft bgs). There has not been a change in groundwater storage overtime because groundwater levels between 1993 to 2019 have been stable.
- Land Subsidence: there are no historical records of inelastic subsidence due to groundwater withdrawal in the ECC Subbasin.
- Seawater Intrusion: the East Contra Costa Subbasin is located in the Bay-Delta with the potential for interactions between saline baywater and shallow groundwater. While the baywater is fresh, intrusion may be of concern if saline water infiltrates the Delta and intrudes into shallow groundwater. This potential mechanism may be triggered or exacerbated by sea level rise. There are no direct connections between ocean seawater and groundwater in the Subbasin.

- Interconnected Surface Water: are locations where groundwater and surface water are hydrologically connected. The San Joaquin River and Old River are considered interconnected rivers in this Subbasin. Impacts on these surface water bodies due to groundwater pumping will be managed under this GSP to minimize stream depletion.
- Groundwater Dependent Ecosystems: potential GDEs are identified and GDE health is stable or improving.

3.5 References

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4. HISTORICAL, CURRENT AND PROJECTED WATER SUPPLY

This section describes the East Contra Costa (ECC) Subbasin land uses, population, and metered historical, current and projected water supplies. Water supply amounts were provided by the Groundwater Sustainability Agencies (GSA) and Contra Costa Water District (CCWD). When historical or projected water supply were not provided, land uses and population data was used to estimate these data. This information is integrated into the Subbasin surface water/groundwater model (GSP **Section 5**).

4.1 Land Uses

Department of Water Resources Land Use Surveys

Since the 1950s, DWR has periodically conducted detailed and high-quality land use surveys. The project began as an effort to understand water and land use as well as to understand current and projected water demands. DWR land use surveys conducted in Contra Costa County provide historical land use details of the Subbasin for the years 1976 and 1995 (**Figures 2-11 and 2-10**, respectively). The most current land use conditions for the Subbasin are derived from a Delta crop map for 2015 (**Figure 2-9)** integrated with a 2014 statewide map to fill in areas not covered by the former. The resultant map does not cover the entire Subbasin leaving small areas along the western boundary as not designated, approximately 6,200 acres, which is about 6 percent of the area of the Subbasin. These lands were assigned a land use based on the 1995 land survey and cross-checked with Google earth. The total area of the Subbasin is 107, 596[1] acres.

A breakdown of land use categories reported in historical and current surveys is given in **Table 2-3**. In 1976, native vegetation and field crops were the major land use categories (about 25,000 and 23,000 acres, respectively), which collectively accounted for about 45 percent of the area within the Subbasin. Surface water and pasture (about 14,000 and 13,000 acres, respectively) covered about 25 percent of the land area. After field crops, deciduous trees and truck crops (e.g., melons and tomatoes) were the major cultivated crops (about 12,000 and 8,000 acres, respectively) accounting for about 18 percent of the area. Approximately 9 percent of the area in the Subbasin (about 9,700 acres) was designated as urban areas. The remaining land cover was comprised of semi-agricultural lands, idle lands, and vineyards.

Between 1976 and 1995, acreage of urban lands (**Figure 2-12**) increased to about 19,000 acres (about 18 percent of the Subbasin area). Area of the idle lands increased from about 900 acres in 1976 to 5,800 acres in 1995 (from about 1 percent to 5 percent of the Subbasin area). During this period, both deciduous trees and field crops acreages decreased by about 5,700 and 5,000 acres, respectively. Decrease of pasture, native vegetation and truck crops were about 1,900, 1,600 and 950 acres, respectively. Acreages of the other land use categories remained nearly unchanged during this period.

In 2015, the total area of urban lands was about 23,500 acres (22 percent of the Subbasin area), making it the largest single land use category within the Subbasin. Native vegetation coverage was about 15,500 acres (14 percent of the Subbasin area), which was a decrease of about 9,500 acres from 1995. A part of this decrease, approximately 4,000 acres may be attributed to the lands that were designated as native vegetation in previous surveys but categorized as "Not Designated" in the 2015 survey. Pasture and surface water bodies each covered about 14 percent of the Subbasin area (each about 15,000 acres). The

[1] The California Department of Water Resources ECC subbasin boundary shape file was used to calculate the area in GIS based on the map projection.

total area of all crop lands was about 23,000 acres (21 percent of the Subbasin area) in 2015. Field crops, which accounted for about 13,500 acres (13 percent of the Subbasin area) was the major crop category, and it showed a decrease of about 4,700 acres from 1995. Areas of truck crops, deciduous trees and vineyards totaled about 9,400 acres (about 9 percent of the Subbasin area). Semi-agricultural lands, which include farmsteads, feed lots (livestock and poultry), and dairies, increased from about 900 acres in 1995 to 6,300 acres in 2015 (6 percent of the Subbasin area). These figures indicate a transition from a predominantly agricultural area of field crops and other deciduous crops to a roughly even split between urban and agriculture. Within the Subbasin, a large area of native vegetation has been preserved over the time period evaluated (15,000 acres in 2015).

The current Contra Costa County General Plan (CCC, 2005) extends until 2020. The county is presently working to develop its 2040 General Plan that will outline the planned land use for the unincorporated areas of the subbasin. The 2040 General Plan is expected to be available in late 2020.

Farmland Mapping and Monitoring Program – Land Use Information

California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program (FMMP) has reported on the ECCC Subbasin land use. Land use data for the Subbasin has been recorded since 1984 on a biannual basis. The FMMP has designated the following eight types of land use:

1. Prime Farmland- Irrigated land with the best combination of physical and chemical features able to sustain long term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date.
2. Farmland of Statewide Importance- Irrigated land similar to Prime Farmland that has a good combination of physical and chemical characteristics for the production of agricultural crops. This land has minor shortcomings, such as greater slopes or less ability to store soil moisture than Prime Farmland. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date.
3. Unique Farmland- Lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated but may include non-irrigated orchards or vineyards as found in some climatic zones in California. Land must have been cropped at some time during the four years prior to the mapping date.
4. Farmland of Local Importance- These lands (the Antioch area and the Delta) are typically used for livestock grazing. They are capable of producing dryland grain on a two-year summer fallow or longer rotation with volunteer hay and pasture. The farmlands in this category are included in the U.S. Natural Resources Conservation Service's Land Capability Classes I, II, III, and IV, and lack some irrigation water.
5. Grazing Land- Land on which the existing vegetation is suited to the grazing of livestock. This category is used only in California and was developed in cooperation with the California Cattlemen's Association, University of California Cooperative Extension, and other groups interested in the extent of grazing activities.
6. Urban and Built-Up Land- Urban and Built-Up land is occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. Common examples

include residential, industrial, commercial, institutional facilities, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, and water control structures.

7. Other land- Land which does not meet the criteria of any other category. Typical uses include low density rural development, heavily forested land, mined land, or government land with restrictions on use.
8. Water- Water areas with an extent of at least 40 acres.

All eight types of land use are present in the ECC Subbasin. The majority of land use has consistently been a type of farmland. Prime farmland has been the highest percentage of land use in the Subbasin since 1984 (**Figure 4-1**). Prime farmland had steady decline from 1984 to 2008 and from 2009 to 2016 the acreage was stable. Since 1984 there has been an increase in urban and farmland of local importance. The data produced by FMMP is not as detailed compared to DWR land use data. FMMP collects its data from aerial images, public review, computer mapping, and field inspections. The data provides the ECC Subbasin an approximation of changes in land use over time that supports DWR land use data findings of increasing urban land and decreasing farmland.

Irrigation Methods

DWR has irrigation data for the 1976 and 1995 land use surveys. The 1995 land use surveys also detail the irrigation method used. About 52 percent of lands in the ECC Subbasin were designated as irrigated in the 1976 survey. That percentage has decreased to about 45 percent in 1995, mainly due to increased urbanization. In the 1995 survey, DWR categorize irrigated lands into four groups based on irrigation methods employed in those lands:

Gravity - Surface Irrigations (most common method in the Subbasin area)

Micro - Low volume irrigation such as drip and micro spray

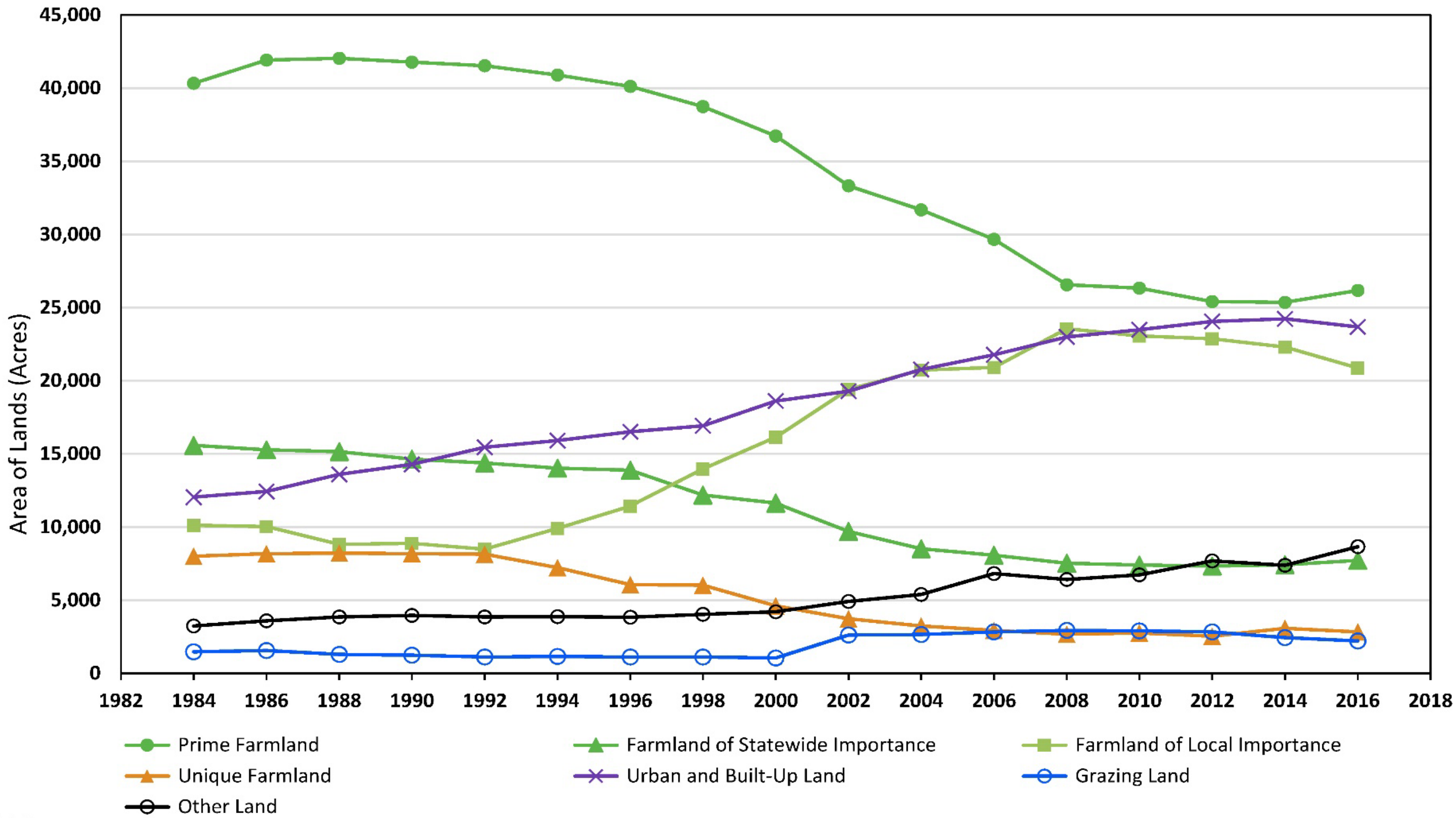
Sprinkler- Permanent, solid set, and movable sprinkler systems

- Irrigation method unknown

The crop map data sets of 2014 and 2015 provided by DWR do not include irrigation details. However, recent information on irrigation methods are available from local agencies that provide irrigation water. Byron Bethany Irrigation District (BBID) reports that in 2014[2] approximately 50 percent (3,100 acres) of irrigated lands in its service area uses drip and micro-spray methods (BBID, 2017 AWMP). Flood irrigation and sprinklers are used in about 39 percent and 11 percent of irrigated lands, respectively.

Drip and micro-spray methods are the primary irrigation methods in the ECCID service area (personal communication, Aaron Trott, August 2020).

[2] Since 2016, and in response to drought conditions, the percent of irrigated lands using drip and micro-spray methods has increased to nearly 90 percent, mostly a switch from prior flood irrigation methods.



Data Source:
California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program

\\server-01\Clerical\2018\18-060 City of Brentwood - GSP Development\REPORT\Figures\Figure 4-1 Land Use Summary.xlsx

Luhdorff & Scalmanini
Consulting Engineers

Change in Land Use 1984 - 2016

East Contra Costa Subbasin Groundwater Sustainability Plan
Contra Costa County, California

Figure 4-1

4.2 Population Trends

The East Contra Costa County region has exhibited increasing population growth over time (ECCC IRWMP, 2019). The Cities of Antioch, Brentwood, Oakley and the unincorporated communities of Town of Discovery Bay, Bethel Island, Byron, and Knightsen located within the ECC Subbasin have exhibited an increasing trend of population at variable rates. Parts of Antioch and Brentwood are located outside the ECC Subbasin. Therefore, in the following discussion, population of those two cities are proportioned based on the area located within the Subbasin (74 percent of the City of Antioch and 90 percent of the City of Brentwood). The comparatively smaller populations in rural areas in the Subbasin (i.e., outside the boundaries of cities, towns, and service areas of public water supply entities) are uncertain and are not included in the estimates presented in this discussion.

Historical, current, and projected populations of the cities and unincorporated communities are given in **Table 4-1** and shown in graphical form in **Figure 4-2**. Populations for 1950 through 2010 are based on the US decennial census data. Estimated population of 2015 through 2040 are based on the projections presented in 2015 Urban Water Management Plans (UWMP) of City of Antioch, City of Brentwood, and the Diablo Water District, as well as the Town of Discovery Bay 2020 Draft UWMP (population of 2020-2045) and the City of Antioch 2020 Water System Master Plan Update Technical Memorandum (Brown and Caldwell, 2020), and the DWD 2020 Facilities Plan (CDM Smith, 2020). Projections for 2045 and 2050 were obtained by applying the countywide population growth rate provided in CA Department of Finance Population Projections as detailed below.

According to the US census data, the total population within the ECC Subbasin in 2010 was about 176,000. Population in the Cities of Antioch, Brentwood and Oakley were about 75,500, 46,300 and 35,400, respectively. In unincorporated communities, the Town of Discovery Bay (TODB) had the highest population (about 13,400) and the other three communities had a combined population of about 5,000. Historical data show that the population of the Cities of Antioch, Brentwood and Oakley increased at a rapid rate (112 percent, 426 percent, and 800 percent, respectively, or 198 percent in their combined areas, from 1980 to 2000 (**Figure 4-2**). The growth rate has decreased since then but remained higher than the overall growth rate of Contra Costa County (49 percent in the three cities in the ECC Subbasin versus 22 percent in the County). The eastern region of the County in which the Subbasin is situated "is expected to be the fastest growing area of the County in the foreseeable future" (ECCC IRWMP, 2019). As the Cities reach the build-out population limits in 2040, growth is expected to continue but at a slower rate. This post-2040 slower growth rate was the basis to apply the countywide growth rate to estimate the 2045 and 2050 population given in **Table 4-1**. The total population in the Subbasin is expected to increase to about 264,000 in 2040 and 279,000 in 2050, which correspond to increases of 50 percent and 59 percent compared to 2010 population **(Table 4-1**). For these same time periods, the countywide population has an expected growth rate of 27 percent (2040) and 32 percent (2050) relative to 2010 population (Department of Finance Population Projections, 2019).

Table 4-1 Historical, Current and Projected Population

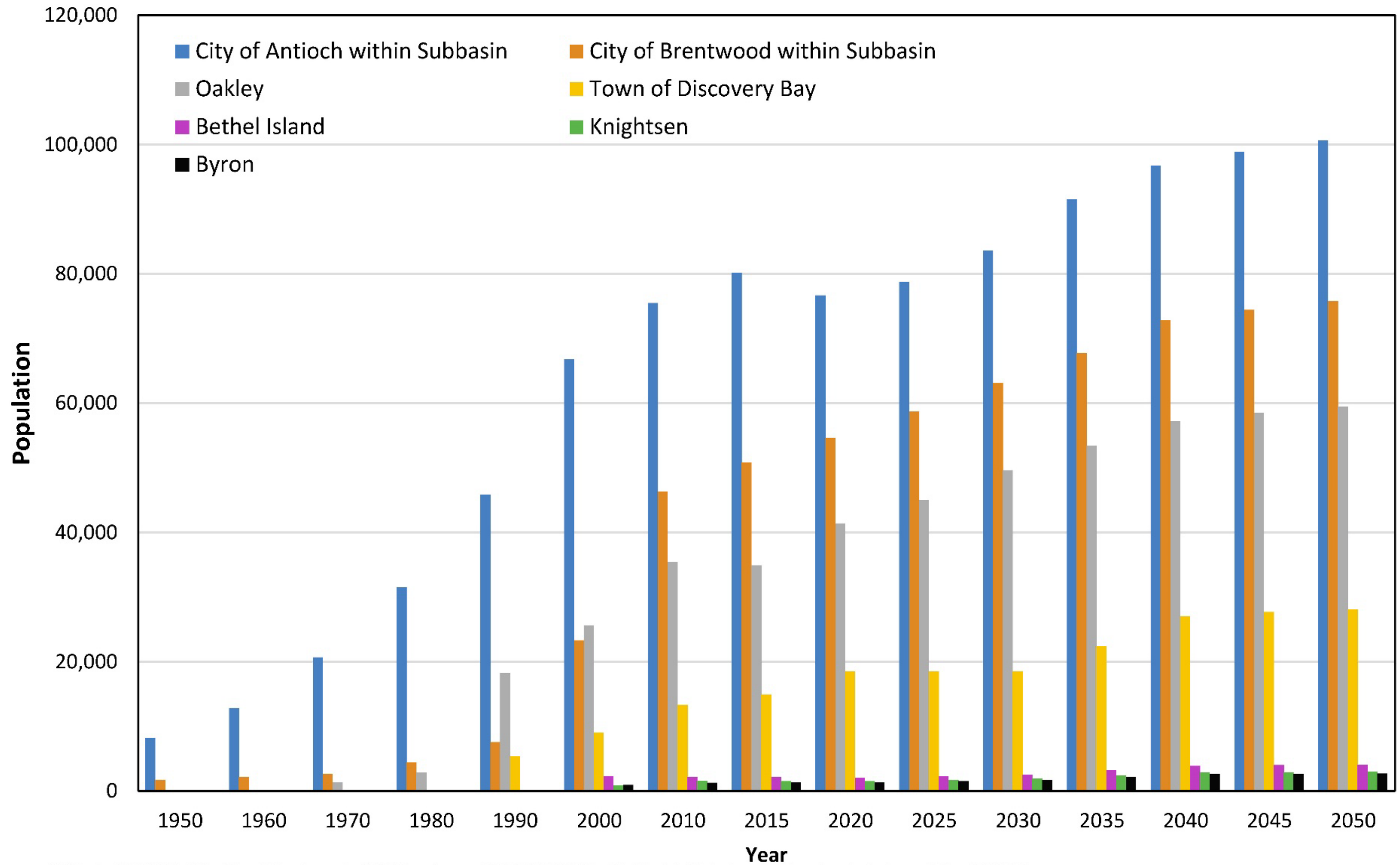
Year	Population within ECC Subbasin[1]									Entire City Population	
	City of Antioch within Subbasin[2]	City of Brentwood within Subbasin[3]	Oakley	Town of Discovery Bay	Bethel Island	Knight-sen	Byron	Subbasin Total	% increase since 2010	City of Antioch	City of Brent-wood
1950	8,200	1,729						9,929	–	11,051	1,729
1960	12,800	2,186						14,986	–	17,305	2,186
1970	20,700	2,649	1,306					24,655	–	28,060	2,649
1980	31,500	4,434	2,844					38,778	–	42,683	4,434
1990	45,900	7,563	18,225	5,351				77,039	–	62,195	7,563
2000	66,800	23,302	25,619	8,981	2,312	861	916	128,791	–	90,532	23,302
2010	75,500	46,300	35,432	13,352	2,137	1,568	1,277	175,566	0%	102,372	51,481
2015	79,900	50,800	34,900	14,895	2,200	1,500	1,300	185,500	6%	108,298	56,493
2020	76,400	54,600	41,400	15,575	2,000	1,500	1,400	192,900	10%	103,595	60,702
2025	78,600	58,700	45,000	18,600	2,300	1,700	1,500	206,400	18%	106,480	65,225
2030	83,300	63,100	49,600	21,600	2,500	1,900	1,700	223,700	27%	112,960	70,084
2035	91,300	67,800	53,400	24,500	3,200	2,400	2,200	244,800	39%	123,755	75,306
2040	96,500	72,800	57,200	28,300	3,900	2,900	2,600	264,200	50%	130,725	80,917
2045	98,600	74,400	58,500	32,600	4,000	2,900	2,600	273,600	56%	133,600	82,700
2050	100,300	75,800	59,500	33,200	4,100	3,000	2,700	278,600	59%	136,000	84,200

1. Populations of rural areas in the Subbasin are uncertain and not included in this table.
2. Area-weighted adjustments were applied for all years to estimate City of Antioch population within the Subbasin (about 74% of the City's area in the Subbasin).
3. Area-weighted adjustments were applied for 2010 and later years to estimate the City of Brentwood population within the Subbasin (expansion of the City outside the Subbasin was about 10% in and after 2010.

Data Sources

-US Census Bureau (1950 through 2010 population data)

-2015 through 2040 population estimates: 2015 Urban Water Management Plans (City of Antioch, City of Brentwood, Diablo Water District); City of Antioch 2020 Water System Master Plan Update Technical Memorandum; Diablo Water District 2020 Facilities Plan; Town of Discovery Bay Community Services District 2020 Draft UWMP (population of 2020-2045).
-Bethel Island, Knightsen and Byron 2010 and 2015 populations--https://worldpopulationreview.com
-Populations of 2045 and 2050 were estimated applying the countywide growth rates (provided by CA Department of Finance) to 2040 polulations.



\\server-01\Clerical\2018\18-060 City of Brentwood - GSP Development\REPORT\Tables\Table 4-1 Historic current and projected population 2020-08-20_Updated.xlsx

Luhdorff & Scalmanini
Consulting Engineers

Historical, Current and Projected Population

East Contra Costa Subbasin Groundwater Sustainability Plan

Figure 4-2

4.3 Water Demands, Supplies and Utilization

The purpose of defining water demand (outflows) and supplies (inflows) is that they contribute to the understanding of the ECC Subbasin water budget. This section describes the groundwater and surface water components of the water budget that are measured (e.g., groundwater pumping and surface water deliveries). Other water budget components will be developed in the groundwater/surface water model described in **Section 5**. A water budget accounts for the total groundwater and surface water entering and leaving a subbasin and are necessary to develop a sustainable water budget for the ECC Subbasin.

4.3.1 Historic and Current Water Supplies

Annual water usage and sources of water supply from 1985 to 2019 by seven entities in the Subbasin are provided in **Tables 4-2 and Table 4-3. Table 4-2** lists annual metered groundwater extracted by water use sector (urban, industrial, and agricultural). Groundwater production by domestic well users (de minimis user) and small community systems are not metered but are estimated and described below. Groundwater use by private agricultural wells and native vegetation are estimated in **Section 4**. **Table 4-3** lists annual metered surface water use for the seven entities by sector and individual surface water diverters with water rights permits. **Table 4-4** lists the total water use by source and water use sector from 1985 to 2019. Projected available supplies and water demand (2020 through 2050) for the seven entities are provided in **Table 4-5**. Below is a description of the seven retail and wholesale water suppliers that operate within the Subbasin, their water rights, and sources of water. Surface water diverted out of Old River for uses outside the ECC Subbasin (e.g., California Aqueduct and the Delta Mendota Canal) does not play a role in supplying water to fulfill the demand of the Subbasin and is therefore not included in the water budget.

Byron Bethany Irrigation District

The BBID service area extends beyond the ECC Subbasin boundaries, into the adjacent Tracy and Delta Mendota Subbasins. Byron and a portion of the Bethany Divisions of BBID are located within the ECC Subbasin. For purposes of this GSP, only the reported Byron Division supply will be used and the small portion of the Bethany Division that falls in the ECC Subbasin will not be estimated. The Byron and Bethany Divisions are served by the District's pre-1914 water rights of 50,000 AFY[3]. Water is obtained from the intake channel at the Harvey O. Banks Pumping Plant located between the Byron and Bethany Divisions and delivered to customers through distribution canals. During normal conditions, water is delivered for agricultural uses from March to November. During drought periods (e.g., 2013-2015) the water delivery period was extended depending on supply and demand conditions.

From 1997 to 2019, the pre-1914 surface water supply to the Byron Division ranged from about 7,000 AF (2017) to 28,000 AF (2009) and averaged about 14,500 AFY (**Table 4-3**). In 2015, during the drought, available surface water was not sufficient to meet water demands of the service area. Byron Division received two additional sources of water: about 2,000 AF purchased (transfer) water and, for the first time in its operational history, BBID obtained about 510 AF of groundwater (3 percent of total supplies) from private well owners in the Byron District. BBID does not maintain records on groundwater use for irrigation by private well owners in the District.

[3] Ch2M, 2017: "The District asserts claims under this pre-1914 water right for reasonable and beneficial use of 60,000 AF. In exchange for operational certainty, the District has agreed to limit their annual diversion from the Delta to 50,000 AF through their Agreement with DWR"

Table 4-2 Groundwater Extractions by Water Use Sector, Historical and Current ECC Subbasin (acre-feet), 23CCR $354.18(b)(3)

Year	Urban and Industrial (metered)			Agricultural (metered)		Total Metered	Unmetered Groundwater			Total Un-metered
	City of Brent-wood[a]	DWD	TODB	ECCID	BBID[b]		Dom-estic Wells[c]	Small PWS[d]	Native Vege-tation	
1994	2,100	270	1,811		0	4,181				
1995	2,312	270	1,912		0	4,494				
1996	2,524	269	2,019		0	4,813				
1997	2,735	287	2,256		0	5,277				
1998	3,109	252	2,157		0	5,518				
1999	4,011	178	2,403		0	6,592				
2000	3,619	70	2,480		0	6,169				
2001	3,840		2,510		0	6,350				
2002	4,852		2,612		0	7,464				
2003	5,196		2,826		0	8,023				
2004	5,302		3,176		0	8,478				
2005	5,350		3,695		0	9,045				
2006	5,788	198	3,637		0	9,622				
2007	4,085	942	4,057	977	0	10,061				
2008	4,016	927	4,075	3,127	0	12,145				
2009	3,791	791	3,934	4,176	0	12,692				
2010	3,536	1,032	4,009	793	0	9,370				
2011	2,709	1,326	3,600	751	0	8,385				
2012	3,076	650	3,738	327	0	7,790				
2013	5,053	787	3,947	415	0	10,202				
2014	4,503	965	3,446	1,028	0	9,942				
2015	2,541	736	2,613	2,132	515	8,537	600	500		1,100
2016	1,328	524	2,765	514	23	5,154	600	500		1,100
2017	2,081	819	2,842	456	0	6,197	600	500		1,100
2018	1,685	900	2,724	600	11	5,920	600	500		1,100
2019	1,992	905	2,970	694	0	6,561	600	500		1,100

Notes: Red text indicate estimated values. Blank space indicates no information.

a. Groundwater volumes were not adjusted because all groundwater is pumped from areas within the ECC Subbasin.

b. Bethany and Mountain House Divisions of BBID are located outside the ECC Subbasin and are not included in this estimate

c. It was estimated that 620 domestic wells are active in the subbasin and that the average domestic well pumps about 1 AFY. The Total Domestic well uses is about 600 AFY. This is identified as a data gap and will be refined over the next five years.

d. Small public water systems groundwater pumping was estimated from reported pumpage from 11 water systems and the estimated population served. This is identified as a data gap and will be refined in future reports.

Table 4-3 Historical and Current Metered Surface Water Supplies by Water Use Sector ECC Subbasin (AF)

Entity	Urban and Industrial						Agricultural					Total Metered Surface Water
	City of Antioch[a]		Brentwood[b]			DWD[d]	BBID[e]		ECCID	CCWD	Individual Diverters with Water Rights Permits[f]	
Water Supply Type	Purchased from CCWD (CVP)	River Water Rights	Purchased from ECCID (via CCWD RBWTP[c])	Purchased from ECCID (COBWTP[c])	Purchased from ECCID for Irrigation	Purchased from CCWD RBWTP (CVP)	Pre-1914 Surface Water Rights	Purchased (transfer)	Surface Water Rights (pre-1914)	Agricultural water (Antioch area)		
1994	9,548	4,233				4,430	15,000	0	33,513	87		66,811
1995	6,619	4,396				4,639	15,000	0	32,315	64		63,033
1996	8,122	4,559				4,790	15,000	0	32,420	35		64,926
1997	9,049	9,516	241			4,790	16,225	0	36,031	103		75,954
1998	3,020	9,307	359			3,565	12,656	0	27,294	62		56,264
1999	7,523	6,091	850			3,925	15,981	0	31,785	62		66,218
2000	9,098	4,668	1,794			4,132	15,664	0	30,382	80		65,818
2001	11,462	3,361	2,574			4,593	16,173	0	26,605	61		64,828
2002	10,278	5,205	2,636			4,915	14,858	0	24,197	10		62,099
2003	8,915	6,451	2,714			5,055	13,615	0	24,119	5		60,874
2004	11,868	4,077	3,742			5,374	15,094	0	25,861	11		66,026
2005	9,428	5,895	4,535			5,470	13,615	0	21,968	3		60,914
2006	8,896	5,975	4,720			5,257	13,074	0	21,132	4		59,059
2007	12,462	3,548	7,320		1,525	5,492	16,137	0	27,900	4		74,387
2008	10,898	3,638	4,827	2,475	1,554	5,453	26,373	0	23,994	14	89,861	169,087
2009	9,507	3,794	1,551	5,727	1,377	4,895	27,734	0	21,813	3	142,655	219,057
2010	6,971	5,619	1,556	4,706	1,098	4,676	12,489	0	20,883	3	177,649	235,650
2011	5,015	8,110	2,288	4,631	1,154	4,365	12,038	0	20,576	4	179,091	237,271
2012	9,099	3,786	704	6,768	1,197	5,359	13,537	0	22,252	6	176,444	239,152
2013	8,371	3,482	1,629	4,898	1,102	5,327	14,681	0	21,743	6	195,874	257,112
2014	11,100	1,263	2,567	3,252	829	4,526	15,859	0	21,201	20	140,380	200,997
2015	8,908	926	1,948	3,052	739	3,730	11,259	2,224	18,922	4	122,719	174,430
2016	7,077	3,262	1,572	4,794	594	4,005	8,776	0	18,057	2	155,526	203,664
2017	6,046	4,909	2,112	4,901	488	4,334	7,200	0	16,090	4	145,912	191,995
2018	8,509	2,833	960	6,734	696	4,657	9,531	0	16,933	5	114,184	165,043
2019	6,112	4,860	1,620	5,862	781	4,566	8,318	0	18,529	2	137,186	187,835

Notes: Red text indicates estimated values. Blue text indicates uncertain values. Blank space indicates no information.

a. City of Antioch: Area-weighted adjustments (about 74%) were applied to all supplies from 1994 when google earth images show development in areas outside the subbasin. Amounts purchased from CCWD are based on data provided by CCWD.

b. City of Brentwood: Area-weighted adjustments (95% from 2005 to 2009 and 90% from 2010) were applied to surface water and recycled water supplies. Google Earth images were used to identify development in areas outside the subbasin. Groundwater volumes were not adjusted because all groundwater is pumped from areas within the ECC Subbasin.

c. The annual surface water supply reported in this table from RBWTP and COBWTP are reported by the City of Brentwood. These amounts are generally 20% to 0% less than the amount reported for the same period by CCWD, possibly due to water losses.

d. The annual supply listed was reported by DWD with the exception of 2001-2003 and 2005 when CCWD annual supply was used because DWD data were incomplete. The annual supply of 1995, 1996 and 1999 reported by DWD are 7% to 12% higher than annual supply reported by CCWD. In other years, CCWD reports annual supply amounts that vary from DWD amounts by up to 5%.

e. BBID: includes Byron Division only, the Bethany and Mountain House Divisions of BBID are located outside the ECC Subbasin and are not included in this estimate.

f. Individual Diverters: The uncertainty of diversion data has been acknowledged by the Water Boards and will be improved in the future.

Table 4-4 Total Water Use by Source and Water Use Sector ECC Subbasin (AF)

	Urban and Industrial[a]			PWS and Rural Domestic	Agricultural[b]		Managed Wetlands, Managed Recharge, Native Vegetation		Total
Water Supply Type	Ground-water	Surface Water	Recycled Water	Ground-water	Ground-water	Surface Water	Ground-water	Surface Water	
1994	4,181	18,211	0			48,600			70,991
1995	4,494	15,654	0			47,379			67,528
1996	4,813	17,471	0			47,455			69,738
1997	5,277	23,596	0			52,359			81,232
1998	5,518	16,251	0			40,012			61,782
1999	6,592	18,389	0			47,828			72,809
2000	6,169	19,692	0			46,126			71,987
2001	6,350	21,990	0			42,839			71,179
2002	7,464	23,034	0			39,065			69,563
2003	8,023	23,134	0			37,739			68,896
2004	8,478	25,061	0			40,965			74,504
2005	9,045	25,328	115			35,586			70,074
2006	9,622	24,848	78			34,210			68,759
2007	9,084	30,347	23		977	44,041			84,472
2008	9,018	28,845	73		3,127	140,242			181,305
2009	8,516	26,851	67		4,176	192,206			231,815
2010	8,577	24,626	50		793	211,024			245,070
2011	7,634	25,563	66		751	211,709			245,722
2012	7,463	26,913	99		327	212,239			247,041
2013	9,787	24,809	195		415	232,303			267,510
2014	8,915	23,537	374		1,028	177,460			211,313
2015	5,891	19,303	371	1,100	2,647	155,128			184,439
2016	4,617	21,304	466	1,100	537	182,361			210,384
2017	5,741	22,790	501	1,100	456	169,205			199,793
2018	5,309	24,389	495	1,100	611	140,654			172,558
2019	5,867	23,801	401	1,100	694	164,035			195,897

Note: Blank space indicates no information. Red indicates Estimated or uncertain. Black text indicates metered values. Blue text indicates some uncertain metered values adjusted (see table 4-3).

a. Area-weighted adjustments were applied to the Cities of Antioch (from 1994) and Brentwood (from 2005) supplies to account for parts of the cities in the Subbasin. Google Earth images were used to identify development in areas outside the subbasin. City of Brentwood adjustments applied to surface water and recycled water supplies only, all groundwater supplies are assumed to be used inside the ECC Subbasin.

b. Includes BBID Byron Division only , the Bethany and Mountain House Divisions of BBID are located outside the ECC Subbasin and are not included in this estimate.

Table 4-5 Projected Water Demand and Supply (including Antioch and Brentwood areas outside the Subasin)

Entity	Water Demand/Supply Type	Projected Water Demand (AFY)							Projected Available Supply (AFY)						
		2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050
Bethany-Byron Irrigation District Total Water[1]		9,242	10,000	10,000	10,000	10,000	10,000	10,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
	Demand within ECC Subbasin (Byron Division)	9,242	10,000	10,000	10,000	10,000	10,000	10,000							
	Surface Water (Pre-1914 Rights)								25,000	25,000	25,000	25,000	25,000	25,000	25,000
City of Antioch Total Water		12,100	12,400	12,600	12,800	13,100	13,400	13,600	59,000	59,000	59,000	59,000	59,000	59,000	59,000
(including areas outside the subbasin)	Surface Water (purchased from CCWD, CVP)[2]	11,100	10,900	11,100	11,300	11,600	11,900	12,100	40,000	40,000	40,000	40,000	40,000	40,000	40,000
	Surface Water (City of Antioch River Rights)[3]								18,000	18,000	18,000	18,000	18,000	18,000	18,000
	Recycled Water	1,000	1,500	1,500	1,500	1,500	1,500	1,500	1,000	1,500	1,500	1,500	1,500	1,500	1,500
City of Brentwood Total Water		13,800	15,100	16,300	17,700	19,200	19,600	20,000	28,200	30,800	30,800	30,800	30,800	30,800	30,800
(including areas outside the subbasin)	Groundwater	*3,300*	*3,550*	*3,800*	*4,100*	*4,400*	*4,500*	*4,600*	5,600	5,600	5,600	5,600	5,600	5,600	5,600
	Surface Water (ECCID entitlement[4], RBWTP purchased from CCWD)								6,700	6,700	6,700	6,700	6,700	6,700	6,700
	Surface Water (ECCID entitlement[4], COBWTP)	*9,900*	*10,650*	*11,400*	*12,300*	*13,200*	*13,500*	*13,800*	7,300	7,300	7,300	7,300	7,300	7,300	7,300
	Surface Water (ECCID entitlement[4], non-potable raw water for irrigation)								800	800	800	800	800	800	800
	Total demand potable and raw water	13,200	14,200	15,200	16,400	17,600	18,000	18,400							
	Recycled Water	600	900	1,100	1,300	1,600	1,600	1,600	7,800	10,400	10,400	10,400	10,400	10,400	10,400
Contra Costa Water District	Surface Water- irrigation to Antioch Area[5]	<60	<60	<60	<60	<60	<60	<60							
Diablo Water District Total Water		5,900	7,900	10,000	12,000	14,000	14,400	14,600	16,800	16,800	20,400	20,400	20,400	20,400	20,400
	Surface Water (purchased from CCWD, CVP)	4,700	6,300	8,000	9,600	11,200	11,500	11,700	14,000	14,000	16,800	16,800	16,800	16,800	16,800
	Groundwater[6]	1,200	1,600	2,000	2,400	2,800	2,900	2,900	2,800	2,800	3,600	3,600	3,600	3,600	3,600
East Contra Costa Irrigation District Total Water		20,038	20,038	20,038	20,038	20,038	20,038	20,038	35,200	35,200	35,200	35,200	35,200	35,200	35,200
	Surface Water (Pre-2014 Rights)[7]								35,200	35,200	35,200	35,200	35,200	35,200	35,200
Town of Discovery Bay (Discovery Bay Community Services District)	Groundwater	3,200	4,400	5,000	5,600	6,600	7,600	7,900	7,700	7,700	7,700	7,700	7,700	7,700	7,700
	Total	68,280	73,838	77,938	82,138	86,938	89,038	90,138	171,900	175,000	178,600	178,600	178,600	178,600	178,600
	SW Total (AF)	54,980	57,888	60,538	63,238	66,038	66,938	67,638	147,000	147,000	149,800	149,800	149,800	149,800	149,800
	GW Total (AF)	7,700	9,550	10,800	12,100	13,800	15,000	15,400	16,100	16,100	16,900	16,900	16,900	16,900	16,900
	Recycled (AF)	1,600	2,400	2,600	2,800	3,100	3,100	3,100	8,800	11,900	11,900	11,900	11,900	11,900	11,900
	SW Total %	81%	78%	78%	77%	76%	75%	75%	86%	84%	84%	84%	84%	84%	84%
	GW Total%	11%	13%	14%	15%	16%	17%	17%	9%	9%	9%	9%	9%	9%	9%
	Recycled%	2%	3%	3%	3%	4%	3%	3%	5%	7%	7%	7%	7%	7%	7%

Footnotes

1. BBID pre-1914 water right is 50,000 AFY for both Byron and Bethany Districts. 25,000 AFY is used here as available supply for Byron District.
2. City of Antioch: Calculated based on the peak supply of 36.0 MGD (40,000 AFY)
3. City of Antioch available supply from river water rights is limited at 7,500 AFY by the water conveyance infrastructure capacity
4. ECCID and Brentwood have an agreement that ECCID will provide up to 14,800 AFY of raw water. Total demand "potable and raw water" amounts provided in COB UWMP (2016). Separation of Groundwater and surface water based on 25% estimated groundwater use from historical record. It is not know if this is viable.
5. Demand will be between 0 and 60 based on recent supply data and expected land developments
6. When groundwater supply fully implemented it could comprise up to 20% of DWD's total supply (page 4-1 CDM Smith, 2020).
7. ECCID total pre-2014 surface water rights are 50,000 AFY however, 14,800 AFY are shown under the City of Brentwood and not shown here.

Notes on projected demand/supply:

a. Projected demands and supplies of 2020 through 2040 were taken from 2015 or 2020 UWMPs of entities
b. 2045 and 2050 water demands were estimated using the projected population and per capita water demand (PCWD) of each entity
c. 2045 and 2050 water demands of DWD are based on the estimated total population of Oakley, Bethel Island and Knightsen

Data Sources

1 - City of Antioch 2020 UWMP
2 - Town of Discovery Bay 2015 UWMP
3 - City of Brentwood 2020 UWMP
4 - Diablo Water District 2015 UWMP and 2020 Water Master Plan

City of Antioch

The City of Antioch (Antioch) relies entirely on surface water for water supply. Antioch purchases raw water from CCWD and pumps water from the Sacramento-San Joaquin Delta when the chloride concentration is not over 250 milligrams per liter (mg/L). The current agreement between Antioch and CCWD is for a peak supply of 40,000 AFY (WYA, 2015). Antioch's water right to obtain water from the Delta for beneficial use does not specify a limitation, but the withdrawal rate is currently constrained to about 18,000 AFY by pumping and conveyance systems. Raw water from both sources can be directly pumped to Antioch's Water Treatment Plant (WTP) or into a municipal reservoir (Antioch Reservoir, **Figure 2-4**[1]) for storage. The municipal reservoir has a capacity of 736 AF and is used to maintain a reliable supply to the WTP when the ability to pump from the Delta is limited due to water quality. The maximum capacity of the WTP is over 40,000 AFY.

From 1997 to 2019, surface water supplies for the entire City of Antioch ranged from a low of around 14,000 AFY (2015 to 2017) to a high of 19,000 AFY to 21,000 AFY (2001 to 2008). However, 26 percent of the City's jurisdiction falls outside the ECC Subbasin. To account for this, the total Antioch supply is adjusted in **Table 4-3** to remove the estimated 26 percent delivered to the portion of the city that falls outside the Subbasin. The adjusted surface water supply for the Subbasin ranges from around 10,000 AFY to 11,500 AFY (2015 to 2019) and 14,000 AFY to 16,000 AFY (2001 to 2008). The reduction in demand in recent years (2015 to 2019) is due to changes in customer water use patterns since the recent drought. As a result, projected demands are expected to decrease due to conservation and continuation of the drought-influenced water use patterns through 2040. Antioch's projected total water demand (**Table 4-4**) is expected to increase to about 13,500 AFY in 2050 with 12,000 AFY derived from surface water and 1,500 AFY from recycled water. Since 2011, the City has purchased recycled water from Delta Diablo for landscape irrigation, which currently accounts for about 0.25 percent of the City's total water usage.

The City of Brentwood

The City of Brentwood (COB or Brentwood) uses three sources of water to meet demand: surface water, groundwater, and recycled water. In 1999, Brentwood entered into an agreement with ECCID to obtain up to 14,800 AFY of raw surface water that is pumped from the Delta. The majority of water is transported from the Rock Slough intake through the Contra Costa Canal to the City of Brentwood Water Treatment Plant (COBWTP). The COBWTP was constructed in 2008 jointly by the City and CCWD. The current capacity of the COBWTP is 18,500 AFY[4] (16.5 million gallons per day [MGD]), but it can be increased to 36,000 AFY to meet future water demand. In addition, raw surface water used for landscape irrigation is purchased from ECCID and transported through their Main Canal. A portion of the ECCID entitlement is treated at the Randall-Bold Water Treatment Plant (RBWTP) under an agreement with CCWD[5]. In a 1999 agreement with a 2000 amendment, COB has a permanent capacity of around 3,200 AFY (6 MGD) at the RBWTP[6]. Historically, surface water purchased by COB from both ECCID and CCWD has increased from a low in 1994 to 1999 (less than 1,000 AFY) to the higher range in 2007 to 2019 (6,300 AFY to 9,600 AFY). Future surface water supply (to 2050) is expected to not exceed the current allocation of 14,800 AFY.

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[4] Personal communication, Eric Brennan, City of Brentwood November 13, 2020.
[5] Even though this water is provided under an agreement with CCWD it is included as part of the total 14,800 AFY agreement with ECCID; it is not CVP water.
[6] Personal communication, Jill Mosley, CCWD, November 13, 2020.

As of 2015, the City has seven active groundwater production wells within its service area. Capacity of the active wells in 2015 was over 7,000 AFY (COB 2015 UWMP). From 1998 to 2019, COB pumped between 1,300 AFY (2016) to 5,800 AFY (2006). On an annual basis, contribution of groundwater has decreased in relation to the total city demand over the last 25 years. COB groundwater supply percentage was the highest from 1994 to 1999 with 80 percent to 90 percent (2,000 AFY to 4,000 AFY). From 2000 to 2006, 50 percent to 70 percent (3,600 AFY to 5,800) of COB water supply was from groundwater. In the last 13 years groundwater supply decreased to 15 percent and 25 percent (1,300 AFY to 3,000 AFY) in normal years and from 30 percent to about 40 percent (4,000 AFY to 5,000 AFY) in drought years (2007 to 2009 and 2013 and 2014) as a result of the greater use of surface water sources. Future City pumpage is expected to not exceed 5,600 AFY through 2050 (**Table 4-4**).

Recycled water provided by the City's wastewater treatment plant has been used for landscape irrigation and industrial purposes. Recycled water has accounted for less than 1 percent to 5 percent of the total water supply of the City since 2005 when recycled water became available. Projected buildout recycled water demand for 2040 was estimated at 1,500 AFY (COB 2015).

Contra Costa Water District

CCWD is a regional water supplier to entities within and outside the Subbasin. It has a contract with the United States Bureau of Reclamation (USBR) for 195,000 AF per year through February 2045 (CDM Smith, 2016). The Sacramento-San Joaquin Delta (Delta) is the primary source of water and CCWD receives this water from the Central Valley Project (CVP). CCWD also obtains water through Delta surplus water right, Mallard Slough water rights and transfers from ECCID, as well as uses recycled water and a minor amount of local groundwater (CCWD, 2016).

CCWD serves both as a retail and wholesale water supplier to the northern, eastern, and central parts of Contra Costa County but only CCWD surface water supplies for the ECC Subbasin will be discussed here. In the ECC Subbasin area, CCWD is a wholesale supplier of treated and raw water to the City of Antioch and Diablo Water District (DWD). CCWD also diverts and conveys ECCID surface water for the City of Brentwood. CCWD water supplied to these three entities is listed in **Table 4-3** under the entity name. Water supplied to these entities is pumped from Rock Slough, Old River, and Victoria Canal (Middle River) intakes located in the Sacramento-San Joaquin Delta (Delta) and, is treated at the RBWTP and COBWTP. The RBWTP is jointly owned by CCWD and DWD and operated by CCWD and primarily serves the Subbasin. Water pumped from Old River and Victoria Canal intakes can be stored in the Los Vaqueros Reservoir, which has a 160,000 AF capacity, and released when supplies from the Delta are limited due to poor water quality. In addition, CCWD supplies agricultural water (**Table 4-3**) to the Antioch area inside the ECC Subbasin. These agricultural water supplies within the Subbasin (Antioch area) have ranged from 60-100 AFY (1994-2001) to 2-5 AFY (2015-2019). Future agricultural demands may decrease further depending on the conversion of agricultural lands to urban.

Diablo Water District

DWD supplies water to the City of Oakley, the Town of Knightsen, and some areas of Bethel Island. DWD uses two sources of water to meet demand (CDM Smith, 2020), the primary source is surface water with additional supply from groundwater (10-20 percent, 2007 to 2019). Surface water is purchased from CCWD, supplied from the Contra Costa Canal and the Los Vaqueros Project, and treated at the RBWTP. DWD's current capacity of the RBWTP is 8,400 AFY but this can be increased to 16,800 AFY per agreement with

CCWD. DWD purchases CVP water from CCWD which has a contract with the US Bureau of Reclamation (USBR) for 195,000 AFY through February 2045. From 1994 to 2019 total water supply ranged from around 3,000 AFY (2001) to about 6,400 AFY (2007 and 2008). DWD's surface water supply has ranged from 3,100 AFY (2001) to 5,500 AFY (2007) (**Table 4-3**) and groundwater supply has ranged from a low of 0 AFY (2001-2005) to a high of 1,300 AFY (2011) (**Table 4-2**). From 2012 to 2019, groundwater supply has averaged about 800 AFY. Future demand is dependent on rate of DWD's growth and consumer conservation but is expected to be about 14,000 AFY in 2040 with 80 percent met by surface water and 20 percent met by groundwater (**Table 4-4**). DWD is proposing the installation of two new groundwater production wells in the vicinity of the Glen Park well (south-central portion of the District) in the next 10 to 20 years.

Groundwater is currently pumped from two wells in Oakley, then conveyed to the Blending Facility, where it is treated and blended with treated surface water prior to distribution to customers. The Blending Facility is operated so that the distributed water does not exceed 280 mg/L total dissolved solids (TDS). During water shortages this may be relaxed by DWD to 500 mg/L (TDS). Groundwater is supplied year-round because it can be provided at a lower cost than surface water.

DWD does not use recycled water for any beneficial use. Ironhouse Sanitary District (ISD) owns and operates the wastewater treatment system in DWD's service area and also includes Bethel Island, Jersey Island, and part of Holland Tract. In 2011, ISD completed construction of the Waste Recycling Facility producing tertiary-treated recycled water. The operating capacity is currently 4,800 AFY with an expansion capacity up to 7,600 AFY. The recycled water is currently applied on agricultural land owned by ISD (on Jersey Island), provided at fill stations, or discharged to the San Joaquin River.

Other groundwater pumping in the DWD service area is described in the Oakley General Plan (City of Oakley, 2016 amended) that states that over 30 small water companies or service districts serving less than 5,000 people are located in the eastern portion of the District's sphere of influence (SOI). Also, within the District's SOI are residences with individual domestic wells, generally shallower than 200 feet, that are considered di minimis users for SGMA purposes. However, these wells will be considered as beneficial users and potentially impacted by other groundwater pumping as discussed further below. The Oakley General Plan has a policy (4.8.8) that encourages rural residences currently served by well water to connect to municipal water service when it becomes available. DWD assumes that the small water systems would be replaced by a system meeting DWD standards when DWD treated water service becomes available in these areas (CDM Smith, 2020).

East Contra Costa Irrigation District

The East Contra Costa Irrigation District (ECCID) is an independent special district established in 1926. The primary purpose of ECCID is to provide agricultural irrigation water to properties within the District boundaries. In addition, it provides raw water for treatment facilities in urban areas. ECCID's approximately 40 square mile service area includes the City of Brentwood, parts of the Cities of Antioch and Oakley, the unincorporated community of Knightsen, and unincorporated areas located south and east of Brentwood. Water is supplied primarily from surface water diverted from Indian Slough off Old River but is also supplemented with groundwater. ECCID holds pre-1914 water rights for up to 50,000 AFY, that is not subject to delivery reduction during water shortages including regulatory-restricted and drought years.

Surface water provided for agricultural irrigation ranged from about 30,000 AFY to 34,000 AFY) between 1994 to 2000 to about 17,000 AFY in 2017 and 2018 (**Table 4-3**). The decrease reflects the conversion of agricultural lands to urban lands within ECCID's service area.

ECCID also operates nine groundwater wells (ECWMA, 2019) that generally pump between 300 to 800 AFY in normal years and increases to between 1000 to 4,000 AFY in drought years (2008, 2009, 2014, and 2015). As mentioned above, CCWD has an agreement with ECCID to provide groundwater to CCWD when there is a shortage of CVP water as represented in ECCID's drought year pumping.

ECCID provides surface water to Brentwood and CCWD through agreements described below. These annual surface water diversions for Brentwood and CCWD are tabulated under the Brentwood heading in **Table 4-3**.

- In 1999, Brentwood and ECCID entered into an agreement under which ECCID would provide up to 14,800 AFY of raw water each year. The water is available on Indian Slough, Rock Slough, or the intake on Old River to the Vaqueros Project. The City treats and distributes water to customers located within the City or ECCID boundaries.
- In 2000, CCWD and ECCID entered into an agreement in which ECCID provides up to 8,200 AFY surplus irrigation water to CCWD to serve municipal and industrial needs within the overlapping areas of the two agencies. Furthermore, ECCID may provide up to 4,000 AFY of groundwater to CCWD by exchange for the use within the CCWD service area when there is a shortage of CVP water.

In the future, ECCID anticipates some reduction in agricultural lands, however, these lands have been fallowed for many years so water demand by the agricultural core area is not expected to change and would remain at about 20,000 AFY. In the next 15 years, ECCID expects a 15 percent increase in urban non-potable landscape water deliveries for Brentwood that is fed through the ECCID main canal.

The Town of Discovery Bay

TODB Community Services District operates the public water supply system of the Town. The TODB relies exclusively on groundwater. Raw water pumped from six groundwater wells are treated at two water treatment plants (Willow Lake WTP and Newport WTP) located in the area. The combined capacity of wells is approximately 16,000 AFY, while the combined capacity of the two water treatment plants is approximately 12,000 AFY. Groundwater pumped between 1994 varied from about 1,800 AFY in 1994 to over 4,000 AFY in the drought years of 2007 to 2009 (**Table 4-2**). The District operates two wastewater treatment facilities, but recycled water is not used for any beneficial purpose because it is not cost effective and all water demands can be sustainably met with groundwater. Projected demand is expected to reach about 6,200 AFY by 2040 that will be met entirely by groundwater (**Table 4-4**).

Small Water Systems and De Minimis Users

Additional groundwater is pumped in the Subbasin by small public water systems (PWS) and rural domestic (de minimis) wells that are not metered. In order to estimate groundwater pumped by the PWS, a variety of information was collected. In 2018, Contra Costa County Environmental Health reported 62 small public water systems (those with <200 connections) in the ECC Subbasin. This list was refined with duplicates removed leaving 51 PWS currently in the ECC Subbasin. These consisted of a variety of facilities including marinas, schools, churches, a golf course, restaurants, and mutual water companies.

However, the County does not estimate total groundwater demand by these users. The California State Water Resources Control Board (Water Board) collects self-reported annual inventory information of public water systems. As per the most recent data available from the Water Board[7] (reporting year 2016, data set updated in October 2019), 26 small water systems owned by local governments or private parties exist within the ECC Subbasin. These water systems are designed to serve a population of more than 4,500. Reported data from 11 water systems show that about 83 AFY of water, entirely obtained from groundwater wells, has been distributed to a population of about 2,300 in 2016. Supply details of the other 15 water systems are not available. To account for these groundwater users, an estimate was assigned of about 500 AFY total water for the PWS. PWS locations and groundwater demand have been identified as a data gap and will be refined over the next five years.

DWR's well completion report database[8] lists about 975 domestic wells (de minimis user) in the ECC Subbasin (**Figure 2-6a**). This list was refined to remove any well installed over 30 years ago (assuming that a domestic well life span is 30 years) leaving about 620 domestic wells. It was assumed that the average domestic well pumps about 1[9] AFY; domestic wells in the ECC subbasin produce about 600 AFY. The number of domestic wells, their locations, and average water use has been identified as a data gap and will be refined over the next five years.

Individual Surface Water Diversions

Individual surface water diversions are made by those with water rights permits and are reported by the State Water Resources Control Board (SWRCB). **Table 4-3** lists the annual amount reported[10] as diverted by individual water rights holders in the ECC Subbasin and ranges in the last 10 year from between 114,000 AFY (2018) to 196,000 AFY (2013). California Water Code § 5101 requires individual surface water diversions made by those with water rights permits to report water diversion to the state on an annual basis. At present, there are 272 currently active "Application Numbers", each of which uniquely identifies a surface water diversion point and its owner, in the ECC Subbasin. However, the Electronic Water Rights Information Management System (eWRIMS) of the SWRCB does not contain diversion records of any of those Application Numbers until 2008. Diversion data of about 15% of Application Numbers are available for 2009, but that percentage is 68% for 2010, 79% for 2015 and 95% for 2019. **Appendix 4a** lists the diversions by tract and subarea. The State Water Board acknowledges that the data is uncertain, possibly due to a mix of units (gallons vs acre-feet) and/or double reporting[11] and they are working to improve the reporting. For purposes of calculating total water use in the ECC Subbasin, these amounts are used and will be refined in the future.

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[7] https://data.ca.gov/dataset/drinking-water-public-water-system-annually-reported-water-production-and-delivery-information. Downloaded July 14, 2020.

[8] Downloaded May 2019.

[9] Estimate for domestic well pumpage: 100 gallons/day/person x 4 persons/household*365 days/year=about .5 AFY plus extra for irrigation= total for one domestic well annual pumpage 1 AFY.

[10] Monthly self-reported surface water diversions for the years 2008-2019 downloaded from:
https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/reportingDiversionDownloadPublicSetup.do.
GIS files of Points of Diversion downloaded from:
https://waterrightsmaps.waterboards.ca.gov/viewer/index.html?viewer=eWRIMS.eWRIMS_gvh#

[11] Michael George, Delta Watermaster, Delta Protection Commission meeting, September 17, 2020.

Summary

In the previous 10 years (2010 to 2019), the ECC Subbasin total metered and estimated water use (**Table 4-4**) has ranged from, 173,000 AFY (2018) to, 214,000 AFY (2013). Sources of water supplies during this same time frame included: surface water ranging from 165,000 AFY to 259,000 AFY (95 percent to 97 percent of total supply); groundwater supplies range from about 6,000 AFY to 11,000 AFY (3 percent to 5 percent of total supply); and recycled water supplies ranged from 50 AFY to 500 AFY (less than 1 percent of total supply).

4.3.2 Projected Water Demands and Supplies

Table 4-5 provides the projected water demand from 2020 to 2050 in five-year intervals within the service area of each supplier. Note that projections are for major water users and do not include unmetered di minimis users, PWS, or individual surface water diverters. Estimated demands and supplies for the 2020-2040 period were obtained from the following sources: 2015 or draft 2020 Urban Water Management Plans of the water suppliers, Technical Memorandum of City of Antioch 2020 Existing and Projected Water Use, Diablo Water District 2020 Facilities Plan, and personal communication (ECCID and BBID). Water demands for 2045 and 2050 were estimated using the projected population for those years and 2040 per capita water demands given in UWMPs and other reports. Available supplies for the 2045 and 2050 were assumed to be equal to the supplies estimated for 2040 in UWMPs.

As mentioned above, population in the ECC Subbasin will be increasing and water demand in service areas of water suppliers are expected to stay the same or increase with the new development in the area. In comparison to reported water supplies in 2019, water demand in 2050 is projected to decrease by 7 percent in Antioch because of water conservation practices. Irrigation water demand of ECCID and BBID service area is expected to remain nearly unchanged during the projected period. Projected water demands for all other entities are expected to increase with population growth and other developments in the area. Within the same period, the increase of water demand will be about 70 percent in Brentwood, 170 percent in both the DWD and TODB service areas. The demand for water is expected to increase: for surface water from the 2019 amount[12] (50,000 AF) to the 2050 amount[13] (68,000 AF), for groundwater[14] from the 2019 pumped amount (10,000 AF) to the projected amount in 2050 (15,000 AF), and recycled water from the current 2019 amount (400 AF) to the projected 2050 amount (3,000 AF). In 2050, groundwater is expected to supply 17 percent (15,000 AFY) of the ECC Subbasin demand which is an increase of 5,000 AFY from 2019.

[12] All 2019 amounts are from Table 4-3 for the ECC Subbasin only,

[13] 2050 amounts are from Table 4-4 and are for the entire ECC Subbasin.

[14] Note that groundwater totals from 2019 and projected 2050 include an estimated groundwater use for domestic wells and public water systems totally 4,000 AFY.

4.3.3 Water Availability and Reliability

Historically, 80 to 87 percent of annual water demand in the Subbasin was met with surface water (2000 – 2019 period). Availability of water from the Delta, the primary source of surface water, largely depends on water quality and water rights.

It has been reported that the water quality of the Delta has been degrading regardless of the measures taken to improve it (CCWD, 2015 UWMP). CCWD, one of the main water suppliers in the Subbasin, identified several contributing factors to deteriorating water quality in its 2015 UWMP.

Changes in local and regional precipitation patterns can affect the timing and quantity of freshwater flow into the Delta. Lack of local precipitation and reduced flow from the upstream contribute to increased salinity levels in the Delta.

Excessive pumping of Delta water and sea level rise can increase the salinity of the Delta water.

- Increased flows of wastewater, storm water and agricultural drainage to the Delta also degrade the water quality of Delta.

Water quality of the Delta is generally evaluated using its chloride concentration. The secondary maximum contaminant level of chloride in drinking water is 250 mg/L. Historically, chloride concentration at Delta water intakes has fluctuated between 20 and 250 mg/L (DWD, 2015 UWMP), but periods where daily mean chloride concentration increased over 1,000 mg/L have been reported (CCWD, 2010). The Los Vaqueros reservoir (160,000 AF capacity) is used to store higher quality Delta water to blend with high salinity water pumped from the Delta during late summer and fall months as well as dry periods. Furthermore, the reservoir can provide emergency supply; a minimum of 70,000 AF in wet years and 44,000 AF in dry years (CCWD, 2015 UWMP).

Another critical factor that affects availability of CCWD CVP water from the Delta is regulatory actions imposed due to biological opinions associated with environmental protection. As per some biological opinions, quantity and timing of CVP and State Water Project water supplies used for urban or irrigation purposes may be limited when environmental supplies are prioritized. As a policy, CCWD plans to meet the entire demand in normal years and meet 85 percent of demand during drought periods. The unmet supply of 15 percent is to be managed with short-term demand management measures.

The City of Antioch, which entirely relies on surface water to meet its water demands, is expected to meet 100 percent of the projected water demands in normal years (COA, 2015 UWMP). During drought conditions, at least 85 percent of the 2040 projected demand will be met during the third year of a drought period. The deficiency of supplies will be managed with short-term water purchases and short-term water conservation programs during droughts.

Raw and treated water supplies that Brentwood receives may be affected by the limitations of availability of surface water. At present, groundwater quality of the City's active supply wells meets potable water quality requirements. Groundwater is pumped from the Tulare Formation from wells perforated from 200 to 500 ft deep. Relatively high total dissolved solids (TDS), nitrate and chloride concentrations have been reported in shallow groundwater, but water quality improves with the increasing depth. If necessary, in the future, groundwater will be mixed with surface water to preserve quality. Available supplies exceed the 2040 projected water demand even in the third year of a drought period (COB, 2015 UWMP).

DWD is capable of meeting 100 percent of 2040 projected water demand in normal years and until the first year of a drought period only with water received from CCWD RBWTP (CDM Smith, 2016). Surface water supplies from CCWD are expected to fulfil up to 94 percent and 85 percent of the 2040 projected demand in the second and third years of a drought period, respectively. The remaining demand will be met with groundwater supplies from the District's wells. DWD plans to increase the groundwater supply up to about 20 percent of the total supplies by 2030 (CDM Smith, 2020) and it is expected to remain at 20 percent through 2040. However, if sufficient amounts of groundwater are not available during drought periods, DWD will request additional water from CCWD, explore other local sources, and/or implement water conservation programs as needed.

TODB, which uses groundwater to meet its entire water demand, has been conducting a groundwater monitoring program since 1980s. The perforated interval of supply wells ranges from 250 to 350 ft bgs. Groundwater water level data indicate that groundwater pumping has been sustainable, even during the 2013 to 2015 drought period (TODB, 2015 UWMP). Groundwater quality from its supply wells meet all state of California primary drinking water standards. Manganese concentration exceeds the maximum limit specified in the secondary standards (0.005 mg/L); therefore, water is treated to remove excess manganese before distribution. Groundwater supplies can meet 100 percent of 2040 projected water demand during the third year of a drought period.

Both irrigation districts (BBID and ECCID) have pre-1914 rights which is projected to meet the Districts' water demands in 2050. To prepare for reliable water during droughts, BBID has executed an agreement with CCWD for an intertie between the Byron Division Canal 45 and the Old River Pipeline to allow storage of BBID water in the Los Vaqueros Reservoir for later use in the Byron Division and to facilitate water transfers with CCWD (Ch2M, 2017).

Available supplies for the BBID, Antioch, Brentwood, CCWD, DWD, ECCID, and TODB meet or exceed the projected water demand of 2050 in normal years.

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APPENDICES

Appendix 5a Model Documentation

5. WATER BUDGET (§ 354.18)

The water budget developed for the East Contra Costa Subbasin provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the Subbasin, including historical, current and projected water budget conditions, and the change in the volume of water stored. The water budgets for various future scenarios were quantified in accordance with DWR Best Management Practices guidelines for water budgets and modeling (DWR, 2016).

5.1 East Contra Costa Subbasin Hydrologic Base Period[1]

In accordance with GSP regulations and BMP guidelines, a base period was selected in order to reduce bias that might result from the selection of an overly wet or dry period, while accounting for changes in other conditions including land use and water demands. The historical base period must include a minimum of 10 years of surface water supply information, with 30 years recommended. The current base period must also include a representative recent one-year period; and the projected base period must include a minimum of 50 years of historical precipitation, evapotranspiration, and streamflow data.

The historical, current, and projected water budget base periods were selected on a water year(WY) basis considering the following criteria:

1. Cumulative departure from average annual precipitation curves[2];
2. San Joaquin Valley water year type[3];
3. Inclusion of both wet and dry periods;
4. Antecedent dry conditions[4];
5. Adequate data availability; and
6. Inclusion of current hydrologic, cultural, and water management conditions in the Subbasin.

For the ECC Subbasin, a 22-year historical water budget base period of water years 1997-2018 was selected. The cumulative departure from mean annual precipitation curve provided an efficient way to analyze historic and current water conditions in the Subbasin. The cumulative departure curve is presented in **Figure 5-1 Cumulative Departure from Mean Annual Precipitation** and illustrates that the

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[1] A base period is representative of long-term conditions in the basin that reflects natural variations in precipitation and is not biased by being overly wet.

[2] Cumulative departure curves are used to show patterns of precipitation or streamflow to characterize long-term hydrology including drier and wetter periods relative to the mean annual precipitation. Negative, or downward, slopes indicate dry patterns while positive or upward slopes indicate wetter periods relative to the mean. Flatter portions of the cumulative departure curve indicate stable, or average, conditions during that period.

[3] Water year types are used for the development of historical and current water budgets as available from the Department of Water Resources. The dataset applicable to the ECC Subbasin is based on the San Joaquin Valley Index from which precipitation is derived for various conditions (i.e., wet, above normal, below normal, dry, critical); DWR (2021).

[4] Selecting a base period with antecedent (or prior) dry conditions minimizes the effects of the unsaturated zone on basin-wide groundwater budgets. The volume of water in the unsaturated zone is difficult to determine on the scale of a groundwater basin, so it is best to select a base period that has relatively dry conditions antecedent to the beginning of the study or base period.

selected base period (1997 to 2018) includes both wet and dry periods, along with dry conditions prior to the beginning of the start of the base period and represents current land use and water practices.

The selected base period also has the best collection of groundwater and surface water data. Groundwater pumping records from entities within the Subbasin are typically not available prior to the 1990s, and the quality and quantity of specific groundwater data improves closer to the present. Surface water data is also available during the selected base period through public databases, and greatly improves in quality and quantity to the present, particularly for surface water deliveries.

5.2 Summary of Water Year 2015 Hydrologic Conditions

For the current water budget, the water year 2015 is used. This year is appropriate because it represents current land use in years with available data at the initiation of SGMA data collection and analysis work. Hydrologic conditions in water year 2015 including precipitation[5], evapotranspiration[6], groundwater levels[7], and surface water flows[8] can also be used to represent current conditions.

5.3 Projected 50-Year Hydrology (§354.18(c)(3))

The projected 50-year hydrology was developed using average historical precipitation, evapotranspiration, and streamflow information from the selected model base period as the baseline condition for estimating future hydrology. A numerical groundwater flow model was used to simulate projected future scenarios including under expected changes in urban growth[9] (land use), and anticipated climate change[10] and sea level rise[11] (hydrology). Model selection is described in **Section 5.1.5** and is referred to as the East Contra Costa Groundwater-Surface Water Simulation Model, or ECCSim. Model simulation scenarios are run from WY 2019 through 2068 (50 years) beginning on October 1, 2018, and ending September 30, 2068, at a monthly time step.

The projected water demand uses the most recent land use at the beginning of the scenario and follows urban growth patterns from IRWMP, UWMP, or Contra Costa LAFCO documents. For future scenarios, evapotranspiration, precipitation, and streamflow are varied using DWR's SGMA Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development document (DWR, 2018). DWR provides adjustments for different climate change scenarios. DWR summarizes the various model outputs and respective timelines, which indicates that the most recent fifty-year period of common simulation periods is 1954-2003. Therefore, the historic simulation period selected to apply climatic adjustments over a 50-year period for ECC is 1954-2003. The adjustment factors for precipitation and reference evapotranspiration were gridded over the entire state and provided by DWR. Sea level rise is also considered and incorporated into the future scenarios using DWR's guidance documentation that provides median predicted values for the years 2030 and 2070 that translate to about 0.5 to 1.4 feet of

[5] Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail.

[6] Evapotranspiration is the sum of evaporation from the land surface plus transpiration from plants.

[7] Groundwater level is the depth or elevation above or below sea level at which the surface of groundwater stands.

[8] Surface water flow is the continuous movement of water in runoff or open channels

[9] Urban growth is the rate at which the population of an urban area increases.

[10] Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional, and global climates.

[11] Sea level rise is an increase in the level of the world's oceans due to the effects of global warming.

sea-level rise, respectively[12]. The combination of land use, climate change, and sea level rise is also simulated for the projected 50-year hydrology simulations.

The water demand uncertainty associated with projected changes in local land use planning, population growth, and climate is addressed by evaluating the groundwater budget components using all of the various future model scenarios.

Projected surface water supply uses the most recent water supply information as the baseline condition for estimating future surface water supply. The surface water supply availability and reliability are a function of the historical surface water supply, which has been generally stable over the model Base Period where records of diversions are available. While some users in the Subbasin rely wholly on groundwater as a source of supply (e.g., individual domestic well owners and small domestic water systems[13]), large-scale users (e.g., municipal water systems and agriculture) are projected to use groundwater to supplement surface water when insufficient amounts are available.

5.4 Water Budget Framework

The water budget framework for the ECC Subbasin accounts for the total annual volumes of groundwater and surface water entering and leaving the subbasin. These volumes are described as inflows and outflows as described below.

5.4.1 Surface Water Inflows and Outflows

There are many surface water bodies that comprise the surface water system in the ECC basin, including Marsh Creek, Clifton Court Forebay, Franks Tract, Old River, San Joaquin River, Big Break, and other Delta features. Surface water inflows and outflows are summarized below:

- Surface water inflows into the Subbasin as streamflow occur via Marsh Creek, San Joaquin River, and Old River;
- Surface water inflows to the Subbasin from outside through conveyance facilities via a series of sloughs and canals off of Old River and San Joaquin River;
- Surface water outflows from the Subbasin as runoff and groundwater discharge to surface water bodies including the Delta.

5.4.2 Groundwater Inflows and Outflows

Groundwater flows are summarized below for the Subbasin:

- Groundwater inflows to the Subbasin from groundwater recharge and subsurface inflows along Subbasin boundaries;
- Groundwater outflows from the Subbasin via subsurface lateral flow; and

[12] Department of Water Resources, Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development, July 2018.

[13] In Contra Costa County, a small water system is defined as a Public Water System (CA Health and Safety Code §11625) serving domestic purposes for two to one-hundred ninety-nine connections (County Ordinance Code §414-4.221).

- Groundwater outflows due to evapotranspiration, subsurface drains, and groundwater pumping.

5.4.3 Summary of Water Budget Components

All water budget components and sources of data used with the ECCSim model are summarized in **Table 5-1**, including a) general components included in every water use sector water budget and b) specific components unique to individual water use sectors.

Table 5-1. Water Budget Components

Component	Category	Data Type	Calculation Or Estimation Method
Precipitation	Inflow	Meteorological Data	C2VSim and Antioch/Brentwood precipitation stations
Subsurface Lateral Flow	Inflow/Outflow	Groundwater Data	ECCSim
Surface Water Deliveries	Inflow	Surface Water Data	Reported by historical water rights and statements of diversion (eWRIMS); estimated based on records when unavailable.
Evapotranspiration (ET) of Applied Water	Outflow	Meteorological Data, Crop Water Use	Estimated by the Integrated Water Flow Model Demand Calculator (IDC) component of the ECCSim model
Evapotranspiration (ET) of Precipitation	Outflow	Meteorological Data, Crop Water Use	Estimated by the Integrated Water Flow Model Demand Calculator (IDC) component of the ECCSim model
Runoff	Outflow	Surface Data	Estimated by the Integrated Water Flow Model Demand Calculator (IDC) component of the ECCSim model
Groundwater Pumping	Outflow	Groundwater Data	Pumping records for municipalities and closure term for domestic/irrigation pumping (pumping records provided by Brentwood, ECCID, Town of Discovery Bay, and Diablo Water District (Oakley).
Drains	Outflow	Groundwater Data	Drain elevations and extent based on historic maps and data requests to GSAs
Change in Storage	Inflow/Outflow	Groundwater Data	Estimated using analytical methods and numerical modeling (ECCSim) techniques.

5.5 Groundwater/Surface Water Flow Model

5.5.1 Evaluation of Existing Integrated Hydrologic Models

The development of the East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim) involved starting with and evaluating the U.S. Geological Survey's Central Valley Hydrologic Model (CVHM) and the beta version (released 5/1/2018) of DWR's fine-grid version of the California Central Valley Groundwater-Surface Water Flow Model (C2VSim-FG Beta2). Both publicly available models were evaluated for suitability in the preparation of the ECC Subbasin GSP. The CVHM model was published in 2009, but the simulation period ends in September 2003. C2VSim-FG Beta2 simulated to September 2015. Neither of these models were current at the time of ECCSim development, and they lacked important simulated surface water features specific to the ECC area due to their application for more regional analyses. Additionally, neither existing model had sufficient calibration points in the ECC Subbasin.

Since the C2VSim model's simulation period more closely matched the end of the model Base Period (i.e., water years 1997-2018), and that the aquifer parameters in the ECC domain were more similar, the C2VSim-fine grid beta version was selected for use as a basis for the ECC Subbasin model. This led to extracting a local model domain and conducting local refinements to the model structure (e.g., nodes, elements) and modifying or replacing inputs as needed to accurately simulate local conditions in the Subbasin within the model domain.

C2VSim-FG Beta2 utilizes the most current version of the Integrated Water Flow Model (IWFM) code available at the time of the ECCSim development. IWFM and C2VSim-FG Beta2 were selected as the modeling platform, in part, due to:

1. the versatility in simulating crop-water demands in the predominantly agricultural setting of the subbasins,
2. groundwater surface-water interaction,
3. the existing hydrologic inputs existing in the model for the time period through the end of water year 2015, and
4. the ability to customize the existing C2VSim-FG Beta2 model to be more representative of local conditions in the area of the ECC Subbasin.
5. ECCSim was refined from C2VSim-FG Beta2 and calibrated to a diverse set of available historical data using industry standard techniques.

5.5.2 Selection and Refinements to Model Platform

The modeling code and platform utilized for ECCSim are described below. As required by GSP regulations, the selected model code is in the public domain (see link below or request data from groundwaterinfo@dcd.cccounty.us). The decision to select the model codes for the ECCSim was based on providing the Subbasin with a modeling tool that can be used for GSP development and future planning with sufficient representation of local conditions, while utilizing to the extent possible, other available modeling tools, including regional models.

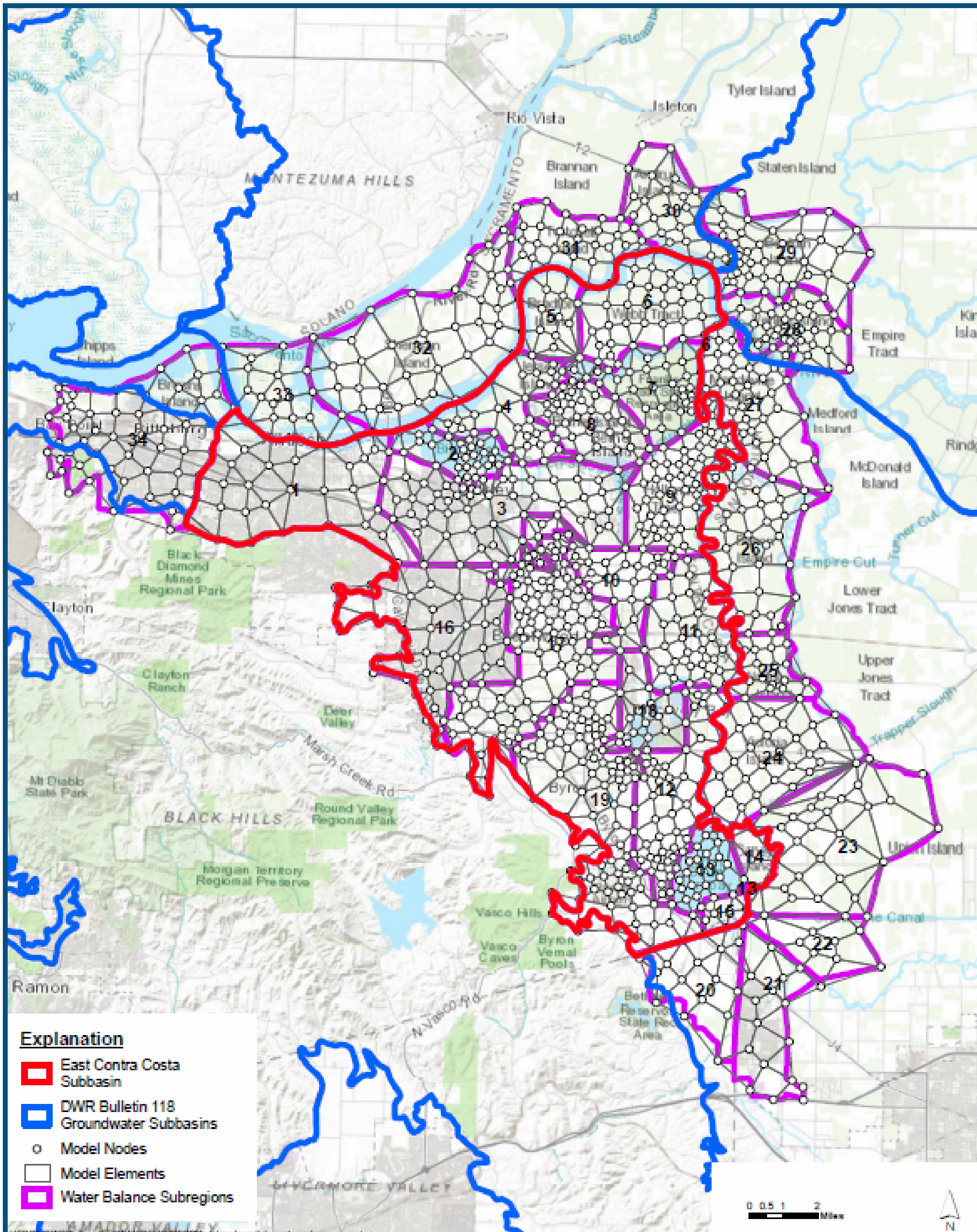
Several refinements were performed to the C2VSim-FG Beta2 model during development of ECCSim. These refinements produce a clearer, more comprehensive water budget model for future planning analyses and include the following:

- Model grid (node and element) refinements (**Figure 5-1a**)
  - The ECCSim grid contains 1,097 nodes and 1,209 elements that align with GSA boundaries, surface water features, and delta island geometry.
- Model subregion refinements (**Figure 5-1b** and **Table 5-2**)
  - The ECCSim model domain groups elements into subregions to assist in the summarization of model results and development of water budgets.
  - The ECCSim has 34 subregions; 19 of which are in the ECC Subbasin.
- Surface water bodies (**Figure 5-1c**)
  - CVHM and C2VSim-FG Beta2 only simulated the San Joaquin River and the Delta; ECCSim simulates Marsh Creek, Old River, Middle River, San Joaquin River, Big Break, Franks Tract, and Clifton Court Forebay.
- Model layers
  - The C2VSim-FG Beta2 model layering was adapted for ECCSim purposes to better represent the hydrogeological conceptual model (HCM) of the aquifer system through model layering.
  - The ECCSim model includes four aquifer layers (Shallow Aquifer in layers 1 and 2; Deep Aquifer in layers 3 and 4).
- Land use refinements
  - Due to changes in the model element and node configurations, the land use was updated and refined relative to C2VSim-FG Beta2 using land use surveys from 1995, 2014, and 2016 (DWR). The major land use types include irrigated agriculture crops, riparian and native vegetation, and urban.
- Aquifer parameter refinements
  - Due to differences in model layering and the more extensive calibration associated with ECCSim, aquifer parameters were refined by incorporating information about depositional environments for subsurface materials such as Alluvial Plain, Delta Islands, Fluvial Plain, and Marginal Delta Dune which are part of the basin setting (see **Section 3**).
- Model boundary conditions
  - General head boundaries were developed along the northern, eastern, and southern borders based on interpreted groundwater elevations from C2VSimFG Beta2 and calculated horizontal conductivity, distance between boundary nodes, aquifer layer thickness, and the distance from the model boundary.
- Groundwater pumping
  - Pumping within ECCSim is simulated using a combination of individual wells with assigned pumping and elemental pumping[14].

[14] The IWFM modeling platform allows for prescribed groundwater pumping from individual wells as time-series extraction data. Alternatively, for wells of known construction, water use type, and location, IWFM can estimate the amount of monthly pumping necessary to fulfill the water demands within each water balance subregion. These wells are assigned an extraction amount by the model itself, to the particular model element they are located within, and are therefore considered to be “elemental pumping”.

- Wells serving municipalities for which GSAs provided monthly pumping records were simulated directly.
- Elemental pumping is calculated internally by the Integrated Water Flow Model Demand Calculator component of the ECCSim model to meet both agricultural and domestic/urban demands after available surface water deliveries have been accounted for.
- The distribution of pumping by layer was modified based on well construction information in DWR's database of Well Completion Reports for wells within the model domain.

- Tile drains
  - Tile drains were incorporated in ECCSim based on historic drain maps and direct information from GSAs.
  - Information from GSAs indicate that tile drains occur at 5 to 8 feet below land surface.
- Surface water deliveries
  - Surface water deliveries for ECCSim were assigned as diversions from specified stream nodes with an assigned delivery destination (water balance subregion), and amounts were based on data received from individual GSAs as well as the State Water Resources Control Board Electronic Water Rights Information Management System (eWRIMS) database.



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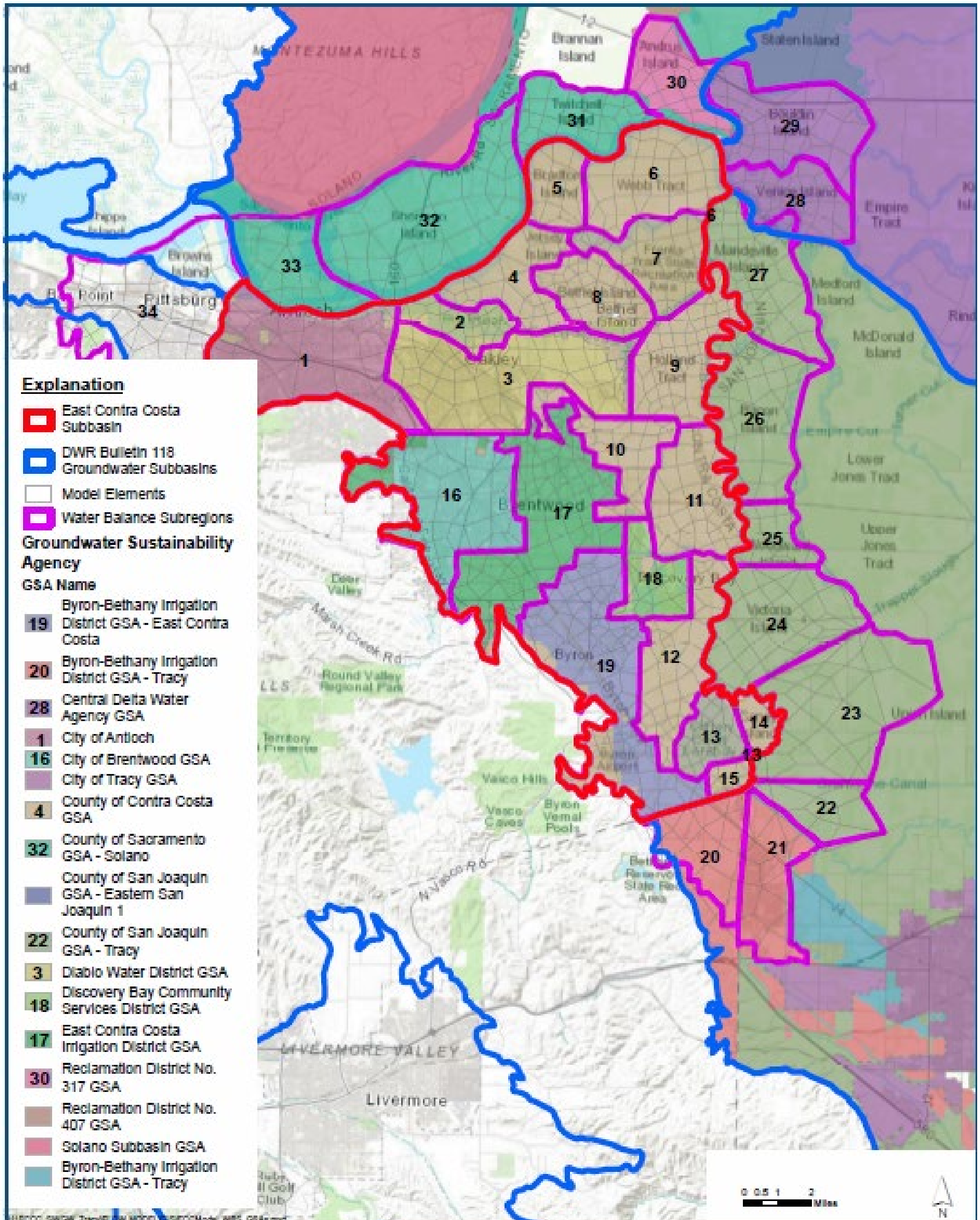
Model Grid and Node Refinement

East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim)

Figure 5-1a



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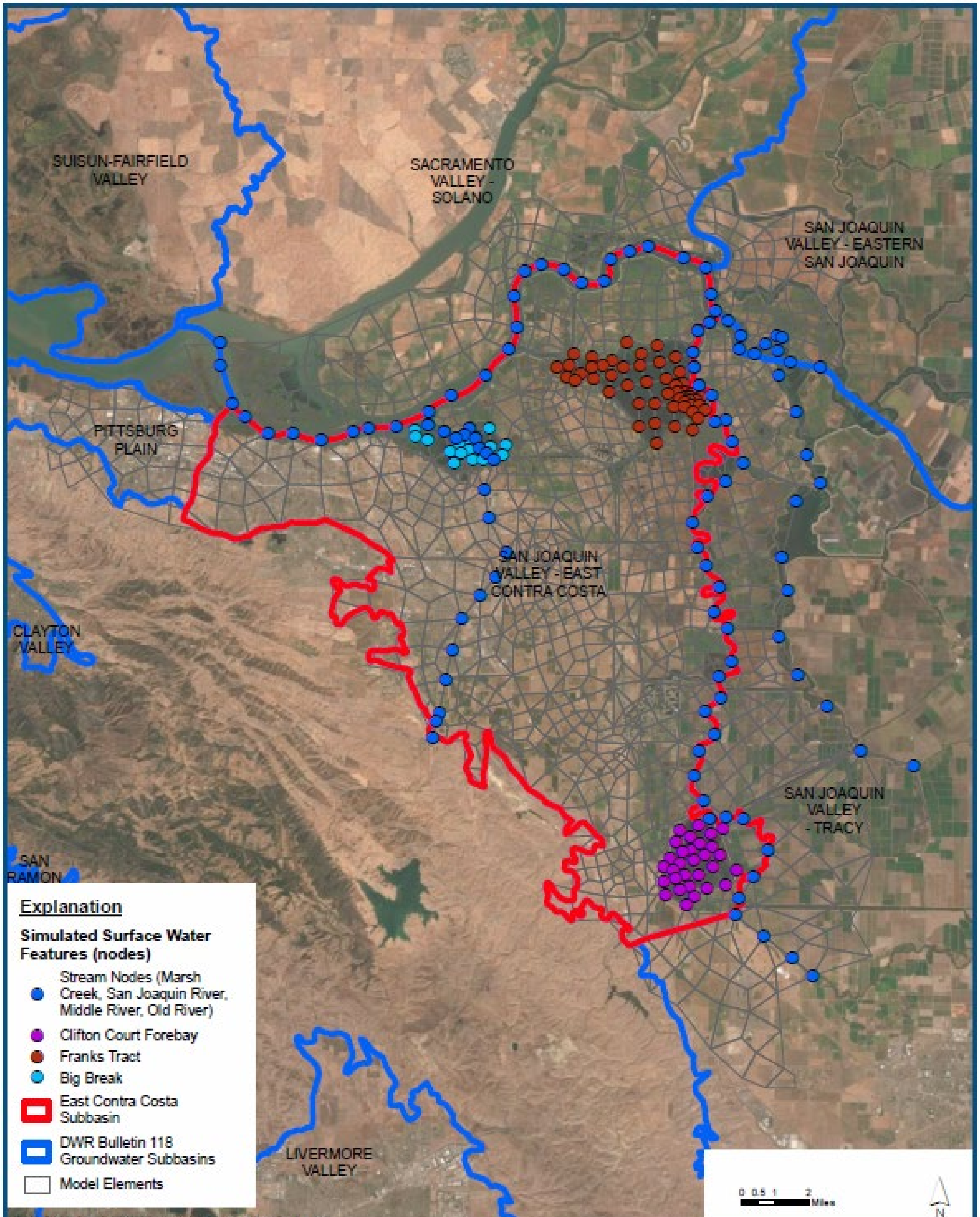
Model Grid and Node Refinement

East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim)

Figure 5-1b



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Model Nodes for Simulated Surface Water Features

East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim)

Figure 5-1c

Table 5-2 Water Balance Subregions

Subregion	Subbasin/Basin	GSA	Area
1	East Contra Costa	City of Antioch GSA	Antioch
2	East Contra Costa	Diablo Water District GSA	Big Break
3			Oakley
4	East Contra Costa	County of Contra Costa GSA	Jersey Island
5			Bradford Island
6			Webb Tract
7			Franks Tract
8			Bethel Island
9			Holland Tract
10			Knightsen
11			Orwood
12			South Discovery Bay
13			Clifton Court Forebay
14			Coney Island
15			South Clifton Court Forebay
16	East Contra Costa	City of Brentwood GSA	Brentwood
17	East Contra Costa	East Contra Costa Irrigation District GSA	ECCID
18	East Contra Costa	Discovery Bay Community Services District GSA	Town of Discovery Bay
19	East Contra Costa	Byron-Bethany Irrigation District GSA – East Contra Costa	BBID North (Byron Division)
20	Tracy	Byron-Bethany Irrigation District GSA - Tracy	BBID South (Bethany Division)
21			BBID Mountain House Division
22	Tracy	County of San Joaquin GSA – Tracy	Hammer Island
23			Union Island
24			Victoria Island
25			Woodward Island
26			Bacon Island
27			Mandeville Island
28	Eastern San Joaquin	Central Delta Water Agency GSA	Venice Island
29			Bouldin Island
30	Solano	Reclamation District No. 317 GSA	Andrus Island
31	Solano	County of Sacramento GSA - Solano	Twitchell Island
32			Sherman Island
33			Kimball Island
34	Pittsburg Plain	Not Applicable	Pittsburg

5.5.3 Projected (Future) Model Scenario(s)

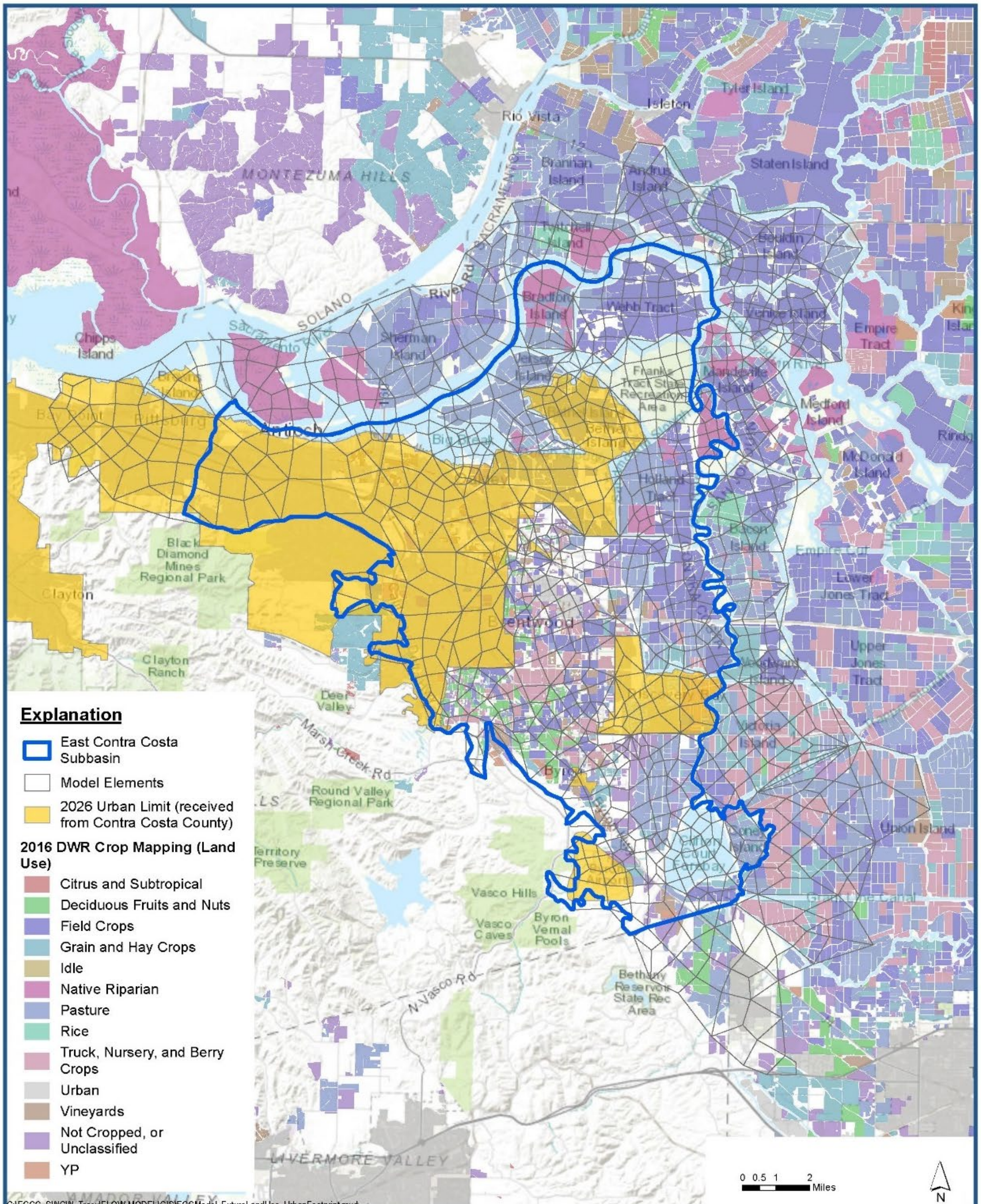
The projected future model scenarios involve simulating conditions in the ECC Subbasin from water year 2019 through water year 2068. Various future projected model scenarios were developed for this GSP document:

1) Future Land Use Change – this model scenario incorporates anticipated urban growth by 2026, as provided by Contra Costa County, with repeated hydrology;
2) Future Climate Change – this model scenario utilizes the land use change (urban growth) as well as the 2070 Central Tendency climate change adjustment factors to hydrologic conditions including evapotranspiration (ET), precipitation, surface water levels, and diversions;
3) Future Sea Level Rise – this model scenario utilizes the land use change (urban growth) in addition to incremental sea level rise on the northern surface water bodies in the ECCSim model domain, while using repeated hydrology;
4) Future Climate Change Plus Sea Level Rise – this model scenario incorporates land use change (urban growth), as well as both climate change and sea level rise adjustments to the hydrology;
5) Sustainable Yield – this model scenario incorporates land use change (urban growth) but was developed to increase groundwater pumping to determine an estimated sustainable yield of the ECC Subbasin.

The future land use scenario results in a larger urban footprint **(Figure 5-2)** based on planning information from the County[15]. Hydrology including evapotranspiration, precipitation, and surface water levels were adapted from values from previous years using the pattern of water year type associated with the historic 50-year time period (1954 to 2003). Development of the future climate change hydrology conditions inputs are based on DWR's Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development document (DWR, 2018). DWR provides climate change adjustment values for climate data, streamflow data, and sea-level rise information. These adjustments are applied to historical hydrology to achieve a future hydrologic period of 50 years that are representative of hydrology potentially occurring in the future. The 2070 central tendency climate change scenario was selected for this future climate scenario analysis.

Regarding sea level rise, DWR's Guidance Document mentions that sea-level rise estimates by the National Research Council (NRC) provide two values of expected sea-level rise as median predicted values for the years 2030 and 2070. These two values are 15 and 45 centimeters, respectively, or about 0.5 to 1.4 feet of sea-level rise. Values were assigned on an annual basis through linear interpolation of these projections.

[15] Contra Costa County provided a GIS shapefile representing the 2030 urban footprint via email (pers. comm. Ryan Hernandez, February 18, 2021).



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Future Urban Footprint (2026) & Land Use (2016)

East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim)

Figure 5–2

5.6 Subbasin Water Budget Results (§354.18(a) to (d))

This section includes a description of the 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.

5.6.1 Inflows and Outflows Entering and Leaving the Basin

The various water budget components of inflows and outflows including surface water entering and leaving the basin occurs through various locations along the border of the ECC Subbasin. Using the integrated groundwater and surface water model, ECCSim, it is possible to quantify the amount of water entering and exiting the basin via various water budget components. Groundwater inflows include subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems (e.g., streams, rivers, canals, and conveyance systems). Groundwater outflows include evapotranspiration, groundwater extraction (pumping), groundwater discharge to surface water sources, and subsurface groundwater outflow.

Water budget components can be grouped or categorized into detailed water budget accounting centers to represent different mechanisms within the Subbasin:

1. land and water use activities (such as supply and demand for urban and agricultural land uses),
2. root zone activities (such as agricultural applied water, precipitation, evapotranspiration, and percolation), as well as
3. groundwater activities (such as surface water/groundwater interaction, tile drain flows, groundwater pumping, recharge via deep percolation, small watershed contributions, and subsurface lateral flow).

Water budget components for these three accounting centers are qualitatively described in **Table 5-3** below. Each water budget component listed in in the table is calculated on a monthly basis using ECCSim and summarized annually for each water year. The quantitative values are presented in both graphical and tabular form for the model Base Period (water years 1997 to 2018) depending on the detailed water budget accounting center.

Table 5-3. Water Budget Accounting Components Simulated Using ECCSim

Simulated Water Budget Accounting Center	Detailed Component	Category	Description
Land and Water Use (Agricultural and urban land use sectors)	Surface Water Deliveries	Inflow	Deliveries from conveyance systems to customers; includes diversions and surface water rights. This water component is separated for urban and agricultural water uses.
	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands. This water component is separated for urban and agricultural water uses.
	Urban Demand	Outflow	Water demand associated with urban land use.
	Agricultural Demand	Outflow	Water demand associated with agricultural land use.
Root Zone (Agricultural, urban, and native/riparian vegetation land use sectors)	Agricultural Applied Water	Inflow	Applied water to satisfy agricultural water demand (may come from surface water deliveries and/or groundwater extraction).
	Agricultural Effective Precipitation	Inflow	Precipitation on agricultural land that helps meet agricultural demand.
	Agricultural Evapotranspiration	Outflow	Evapotranspiration associated with the variety of crops within the Subbasin.
	Agricultural Percolation	Outflow	Applied water and precipitation on agricultural land that is in excess of the evapotranspiration requirement and passes through the root zone to reach the groundwater water table.
	Urban Applied Water	Inflow	Water applied to landscaping within urban land use features (can come from surface water deliveries and/or groundwater pumping).
	Urban Effective Precipitation	Inflow	Water from precipitation that helps support outdoor urban land use demands such as landscaping.
	Urban Evapotranspiration	Outflow	Evapotranspiration associated with outdoor urban water demand.
	Urban Percolation	Outflow	Applied water and precipitation on urban land that is in excess of the evapotranspiration requirement and passes through the root zone to reach the groundwater water table.

Simulated Water Budget Accounting Center	Detailed Component	Category	Description
	Native/Riparian Vegetation Effective Precipitation	Inflow	Water from precipitation that supports native and riparian vegetation.
	Native/Riparian Vegetation Evapotranspiration	Outflow	Evapotranspiration associated with native and riparian vegetation within the Subbasin.
	Native/Riparian Vegetation Percolation	Outflow	Precipitation on native/riparian vegetation that is in excess of the evapotranspiration requirement and passes through the root zone to reach the groundwater water table.
Groundwater (all land use sectors including urban, agricultural, and native/riparian vegetation)	Groundwater flow to/from Surface Water Features	Inflow or Outflow	This is the surface water/groundwater interaction component that represents stream leakage (in the case of losing stream conditions) or groundwater contributions to surface water (during gaining stream conditions). Streams include Marsh Creek, Old River, and the San Joaquin River. For the ECC Subbasin, this component also includes surface water interaction with groundwater associated with delta island surface water features, such as Big Break and Franks Tract, but also Clifton Court Forebay to the south.
	Drains	Outflow	Tile drains historically and currently used to lower the water table in certain areas within the Subbasin.
	Diversion Recoverable Loss	Inflow	This water budget component represents leakage of surface water through conveyances within the Subbasin.
	Small Watershed Contributions	Inflow	Small watersheds along the western boundary of the Subbasin contribute some water to the groundwater system.
	Recharge via Deep Percolation	Inflow	Water that travels vertically through the root zone to reach the water table and enter the groundwater system.
	Groundwater Extraction (Pumping)	Outflow	Pumping of groundwater to satisfy urban and agricultural water demands.
	Subsurface Inflow and Outflow	Inflow or Outflow	Subsurface lateral flow into or out of the Subbasin.
	Groundwater Storage	Inflow minus Outflow = Change in Storage	This component is used to determine the change in aquifer storage over time and can help determine if a basin is in balance, is full, or is in overdraft.

The first simulated water budget accounting center, for land and water use, utilizes well pumping information developed for the GSP by the GSAs within the ECC Subbasin. Elemental groundwater pumping (where pumping rates are not directly input) is invoked when surface water deliveries (specified for urban, agricultural, or both land uses) are insufficient to meet water demands. Elemental groundwater pumping is based on well completion report (WCR) records for which well depths and well types are known or estimated. Surface water deliveries previously developed for the GSP as reported by GSAs within ECC Subbasin were supplemented by individual water rights adapted from eWRIMS. **Table 5-4** below shows the simulated land and water use for the Subbasin, as well as the average land and water use amounts associated with the model Base Period (water years 1997-2018). ECCSim simulates the majority of agricultural and urban demand being satisfied by surface water deliveries. The simulation indicates that during some years there are small amounts of surplus water supplies (agricultural or urban demand shortage term is negative), and other years there are small amounts of water demand shortage.

The simulated root zone budget details the movement of different water sources within agricultural, urban, and native/riparian vegetation land use sectors, the land surface, and the underlying groundwater aquifer system. Using the ECCSim monthly timestep simulated outputs, these components are summarized for water years during the model Base Period (water years 1997-2018). The annual values of simulated applied water, effective precipitation, evapotranspiration, and percolation that occur in the root zone are provided in **Table 5-5** for agricultural, urban, and native/riparian vegetation land uses.

Table 5-4. Simulated Land and Water Use Budget Components for Base Period, WY 1997-2018 (Units in Acre-Feet per Year, AFY)

Water Year	Ag. Supply Requirement	Ag. Pumping	Ag. Deliveries	Ag. Demand Shortage	Urban Supply Requirement	Urban Pumping	Urban Deliveries	Urban Water Demand Shortage
1997	173,948	35,436	138,553	-41	24,246	7,470	17,102	-325
1998	139,759	29,767	110,091	-99	25,303	8,980	15,356	967
1999	164,080	32,735	130,615	730	26,360	8,176	17,085	1,100
2000	166,727	34,359	132,094	275	27,393	7,612	18,403	1,377
2001	173,716	39,147	132,851	1,719	28,425	7,713	19,969	743
2002	174,548	42,841	131,694	13	29,458	8,794	20,389	274
2003	167,222	41,496	125,794	-68	30,490	9,349	20,583	558
2004	174,627	41,093	133,654	-120	31,523	9,798	21,708	17
2005	150,977	35,293	115,679	5	32,555	10,123	21,844	588
2006	162,067	42,915	119,338	-187	33,588	10,830	21,565	1,193
2007	182,393	42,027	139,957	410	34,620	10,213	24,181	226
2008	186,743	47,873	138,754	116	35,303	10,378	23,183	1,743
2009	174,105	45,618	129,367	-880	32,658	10,024	23,112	-477
2010	155,735	37,990	117,843	-98	33,084	10,080	22,931	73
2011	147,850	35,498	112,640	-289	33,509	9,467	23,847	195
2012	174,046	43,108	128,765	2,173	33,935	9,088	24,383	465
2013	191,902	21,655	169,710	537	33,982	10,849	21,663	1,470
2014	194,431	31,298	163,386	-253	34,407	11,017	22,070	1,320
2015	166,604	39,747	127,011	-155	25,924	7,893	17,768	264
2016	172,588	35,734	136,356	498	26,607	6,439	20,495	-327
2017	156,725	35,233	121,314	178	26,724	7,174	19,836	-285
2018	159,944	32,947	127,004	-7	26,724	6,733	20,170	-178
Average	168,670	37,446	131,021	203	30,310	9,009	20,802	499

Table 5-5. Simulated Root Zone Budget Components for Base Period, WY 1997-2018
(Units in Acre-Feet per Year, AFY)

Water Year	Agricultural Land Use Area (Acres)	Ag. Precip. (+)	Ag. Applied Water (+)	Ag. Et (-)	Ag. Perc. (-)	Urban Land Use Area (Acres)	Urban Precip (+)	Urban Applied Water (+)	Urban Et (-)	Urban Perc. (-)	Native & Riparian Veg. Land Use Area (Acres)	Native & Riparian Veg. Precip (+)	Native & Riparian Veg. Et (-)	Native & Riparian Veg. Perc. (-)
1997	50,035	67,815	173,990	179,806	61,747	19,396	25,436	24,571	16,831	33,165	39,719	52,569	36,907	15,679
1998	50,035	113,418	139,858	170,867	82,546	19,396	44,125	24,336	21,809	46,600	39,719	88,097	59,334	28,389
1999	50,035	51,736	163,350	173,000	41,955	19,396	19,096	25,260	18,297	26,083	39,719	39,688	34,648	5,331
2000	50,035	67,803	166,453	179,642	54,775	19,396	25,724	26,016	19,556	32,171	39,719	52,511	41,042	11,453
2001	50,035	50,060	171,997	182,790	39,257	19,396	18,350	27,682	19,440	26,596	39,719	39,294	35,012	4,296
2002	50,035	53,812	174,535	181,778	46,484	19,396	20,229	29,184	19,049	30,375	39,719	42,216	34,929	7,464
2003	50,035	60,586	167,289	179,842	48,083	19,396	22,172	29,932	20,183	31,909	39,719	47,479	38,591	8,699
2004	50,035	53,734	174,747	181,061	47,444	19,396	20,049	31,506	18,722	32,802	39,719	41,940	33,746	8,079
2005	50,035	89,122	150,972	177,575	62,718	19,396	35,331	31,967	24,160	43,133	39,719	69,438	54,484	15,051
2006	50,035	82,988	162,253	183,310	61,892	19,396	32,715	32,395	23,020	42,103	39,719	64,515	50,055	14,569
2007	50,035	34,448	181,984	180,444	36,028	19,396	12,766	34,394	19,289	27,840	39,719	26,252	23,110	3,194
2008	50,035	42,795	186,627	183,910	45,315	19,396	15,828	33,560	18,248	31,192	39,719	33,414	26,749	6,813
2009	50,035	51,320	174,985	185,103	41,132	19,396	21,119	33,135	21,764	32,480	39,719	40,184	34,840	5,031
2010	50,035	66,927	155,833	175,730	47,212	19,396	27,654	33,011	23,930	36,728	39,719	52,014	45,226	6,928
2011	50,035	81,377	148,138	173,735	55,812	19,396	31,783	33,314	24,446	40,655	39,719	63,282	51,093	12,048
2012	50,035	41,388	171,873	178,126	35,115	19,396	16,672	33,470	21,315	28,821	39,719	31,933	28,907	3,199
2013	41,730	39,117	191,365	181,222	48,381	21,454	19,479	32,512	22,012	35,438	45,965	42,132	33,445	6,708
2014	41,730	29,643	194,684	183,458	40,737	21,454	15,859	33,087	20,758	28,235	45,965	32,179	29,069	3,252
2015	41,329	42,671	166,759	163,801	46,733	22,585	24,714	25,660	18,676	32,463	45,236	46,561	35,228	11,194
2016	41,329	20,731	172,090	161,966	30,947	22,585	11,211	26,934	16,102	22,038	45,236	21,969	19,246	2,789
2017	41,329	63,558	156,547	168,560	51,785	22,585	33,834	27,009	21,803	39,012	45,236	68,607	53,525	14,773
2018	41,329	41,399	159,951	165,665	35,596	22,585	21,522	26,903	20,655	27,783	45,236	44,783	39,796	5,051
Average	47,697	56,657	168,467	176,881	48,259	20,163	23,439	29,811	20,458	33,074	41,290	47,321	38,135	9,090

The simulated groundwater budget embodies the movement of water within the groundwater aquifer. Using the ECCSim monthly timestep simulated outputs, these components are summarized for water years during the model Base Period (water years 1997-2018). Simulated values of groundwater leaving the subsurface via drains, the movement, or exchange, of water between surface water features, contributions from small watersheds in the western portion of the Subbasin, contributions from unlined conveyances (diversion recoverable loss), groundwater leaving the aquifer via groundwater extraction (pumping), and subsurface lateral flow are presented in **Table 5-6**. These groundwater budget terms provide the inflows and outflows from which the change in storage can be calculated (inflow minus outflow = change in storage). The annual changes in groundwater storage and the cumulative change in groundwater storage are also presented in **Table 5-6**.

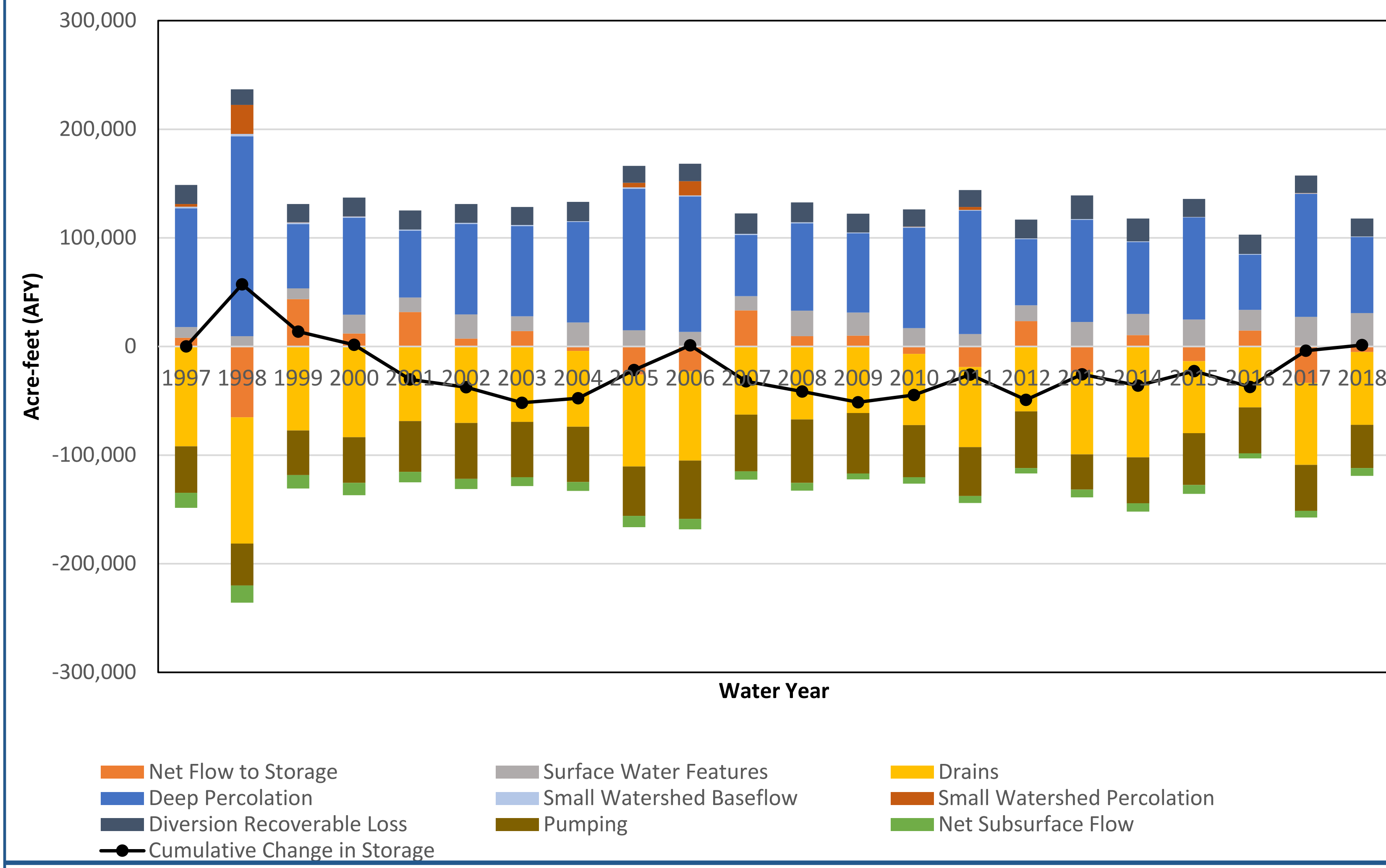
5.6.2 ECC Subbasin Water Balance

Generally, water leaves the groundwater system within ECC Subbasin through drains, groundwater extraction (pumping), and through subsurface lateral flow (leaving the subbasin). Water enters the groundwater body via surface water features, deep percolation (recharge), small watershed contributions, and diversion recoverable loss. The change in storage term along with the cumulative change in storage term indicate that the ECC Subbasin is in balance. If the subbasin was depleting groundwater storage, or in overdraft, the change in storage and the cumulative change in storage would be negative and growing more negative over time. The simulation results indicate that this is not the case in the ECC Subbasin. The simulated groundwater budget timeseries components are plotted along with the cumulative change in storage in order to illustrate the proportions of the various components and to see that the basin is operating within its sustainable yield during the model Base Period (water year 1997-2018) (**Figure 5-3**).

The following sections discuss groundwater inflows and outflows in the ECC Subbasin and the resultant changes in storage.

Table 5-6. Simulated Groundwater Budget Components for Base Period, WY 1997-2018 (Units in Acre-Feet per Year, AFY)

WATER YEAR	DRAINS	SURFACE WATER FEATURES	DEEP PERCOLATION	SMALL WATERSHED BASEFLOW	SMALL WATERSHED PERCOLATION	DIVERSION RECOVERABLE LOSS	PUMPING	NET SUBSURFACE FLOW	NET STORAGE CHANGE	CUMULATIVE CHANGE IN STORAGE
1997	-91,890	9,843	109,296	1,417	2,499	17,688	-42,906	-13,738	-8,095	0
1998	-116,071	9,481	184,027	2,320	26,702	14,255	-38,747	-15,817	65,310	57,214
1999	-77,389	10,075	58,923	1,617	110	16,784	-40,910	-12,461	-43,556	13,659
2000	-83,593	17,343	89,128	1,340	85	17,102	-41,971	-11,243	-12,012	1,647
2001	-68,650	13,188	61,586	1,160	0	17,366	-46,860	-9,614	-31,853	-30,206
2002	-70,279	22,222	83,420	1,034	0	17,282	-51,636	-9,302	-7,272	-37,478
2003	-69,411	13,556	83,001	949	0	16,634	-50,844	-8,204	-14,293	-51,771
2004	-69,792	22,056	92,525	853	0	17,655	-50,891	-8,218	4,180	-47,591
2005	-84,609	14,873	130,479	1,102	4,232	15,628	-45,417	-10,363	25,834	-21,757
2006	-82,001	13,348	124,671	1,172	13,094	16,012	-53,745	-9,590	22,896	1,139
2007	-62,782	13,268	56,414	965	0	18,652	-52,240	-7,426	-33,147	-32,008
2008	-67,260	23,472	80,468	860	0	18,402	-58,251	-7,163	-9,469	-41,477
2009	-61,145	21,351	72,929	764	0	17,327	-55,642	-5,523	-9,933	-51,410
2010	-65,629	16,888	92,632	730	71	15,997	-48,070	-5,897	6,732	-44,679
2011	-73,746	11,409	113,521	850	2,717	15,510	-44,965	-6,426	18,871	-25,807
2012	-59,777	14,511	60,715	768	0	17,403	-52,196	-4,888	-23,432	-49,239
2013	-75,616	22,718	93,805	695	0	21,747	-32,504	-7,131	23,716	-25,523
2014	-101,955	19,546	66,114	612	0	21,075	-42,315	-7,768	-10,493	-36,016
2015	-66,415	24,787	93,960	572	0	16,452	-47,640	-8,290	13,411	-22,605
2016	-56,081	19,034	50,799	498	0	17,824	-42,173	-4,664	-14,713	-37,319
2017	-75,304	27,194	113,293	682	212	16,040	-42,407	-6,123	33,549	-3,769
2018	-66,938	30,852	69,813	518	0	16,724	-39,680	-7,161	5,216	1,447
Average	-74,833	17,773	90,069	976	2,260	17,253	-46,455	-8,500	66	-21,980



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Groundwater Budget for East Contra Costa Subbasin Historical Calibration Period (1997-2018)

East Contra Costa Groundwater-Surface Water Simulation Model (ECCSim) Report

Figure 5-3

5.6.3 Quantification of Groundwater Inflow

The simulated groundwater budget described and quantified above indicate that the groundwater inflow components of the water budget include contributions from surface water features, deep percolation (recharge), small watershed contributions, and diversion recoverable loss (conveyance systems). These groundwater inflows are presented in tabular form in **Table 5-7** and graphically in **Figure 5-4**. The largest groundwater inflow component is groundwater recharge through deep percolation. Deep percolation includes water reaching past the root zone to the water table from precipitation and excess applied water. Surface water features and diversion recoverable losses account for most of the remaining groundwater inflows, with a very small proportion contributed by the small watersheds to the west of the Subbasin.

Table 5-7. Simulated Groundwater Inflow Components for Base Period, WY 1997-2018 (Units are in Acre-Feet per Year, AFY)

Water Year	Surface Water Features	Deep Percolation	Small Watershed Baseflow	Small Watershed Percolation	Diversion Recoverable Loss
1997	9,843	109,296	1,417	2,499	17,688
1998	9,481	184,027	2,320	26,702	14,255
1999	10,075	58,923	1,617	110	16,784
2000	17,343	89,128	1,340	85	17,102
2001	13,188	61,586	1,160	0	17,366
2002	22,222	83,420	1,034	0	17,282
2003	13,556	83,001	949	0	16,634
2004	22,056	92,525	853	0	17,655
2005	14,873	130,479	1,102	4,232	15,628
2006	13,348	124,671	1,172	13,094	16,012
2007	13,268	56,414	965	0	18,652
2008	23,472	80,468	860	0	18,402
2009	21,351	72,929	764	0	17,327
2010	16,888	92,632	730	71	15,997
2011	11,409	113,521	850	2,717	15,510
2012	14,511	60,715	768	0	17,403
2013	22,718	93,805	695	0	21,747
2014	19,546	66,114	612	0	21,075
2015	24,787	93,960	572	0	16,452
2016	19,034	50,799	498	0	17,824
2017	27,194	113,293	682	212	16,040
2018	30,852	69,813	518	0	16,724
Average	17,773	90,069	976	2,260	17,253