# TRACY SUBBASIN
# Groundwater Sustainability Plan

PREPARED FOR:

Banta-Carbona Irrigation District GSA
Byron-Bethany Irrigation District GSA
City of Lathrop GSA
City of Tracy GSA
County of San Joaquin GSA
Stewart Tract GSA

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# Tracy Subbasin Groundwater Sustainability Plan

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Tracy Subbasin GSAs

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# Abbreviations and Acronyms

| | |
|---|---|
| AB | Assembly Bill |
| Act | Delta Protection Act |
| AF | acre-feet |
| AFY | acre-feet per year |
| ASR | Aquifer Storage and Recovery |
| AWMP | Agricultural Water Management Plan |
| Basin Plan | Water Quality Control Plan for the Sacramento and San Joaquin River Basins |
| BBID | Byron-Bethany Irrigation District |
| BCID | Banta-Carbona Irrigation District |
| bgs | below ground surface |
| BMP | Best Management Practice |
| C2VSim-CG | C2VSim Coarse Grid model, formerly called “CVGSM” |
| C2VSim-FG | C2VSim Fine Grid Version 1.0 |
| Cal Water | California Water Service Company |
| CASGEM | California Statewide Groundwater Elevation Monitoring |
| CDFW | California Department of Fish and Wildlife |
| CDWA | Central Delta Water Agency |
| cfs | cubic feet per second |
| COCs | Constituents of Concern |
| County | San Joaquin County |
| CGPS | continuous global positioning system |
| CSA | county services area |
| CVGSM | California Central Valley Groundwater Surface Water Model, renamed the C2VSim Coarse Grid (C2VSim-CG) model |
| CVP | Central Valley Project |
| CVRWQCB | Central Valley Regional Water Quality Control Board |
| DAC | Disadvantaged Communities |
| DBCP | dibromochloropropane |
| DDW | California Department of Water Resources Division of Drinking Water |
| Delta | San Joaquin Delta |
| DMC | Delta-Mendota Canal |
| DMS | data management system |
| DPC | Delta Protection Commission |
| DWR | California Department of Water Resources |
| EDB | ethylene dibromide |
| EPA | United States Environmental Protection Agency |
| ET | evapotranspiration |
| GAMA | USGS Groundwater Ambient Monitoring and Assessment |
| GDEs | groundwater dependent ecosystems |
| gpd/ft | gallons per day per foot |
| gpm | gallons per minute |

| | |
|---|---|
| GPS | Global Positioning System |
| GSA | Groundwater Sustainability Agency |
| GSP | Groundwater Sustainability Plan |
| HCM | Hydrologic Conceptual Model |
| ID | identification |
| ILRP | Irrigated Lands Regulatory Program |
| InSAR | interferometric synthetic aperture radar |
| IRWMP | Integrated Regional Water Management Program |
| MAF | million acre-feet |
| MCL | Maximum Contaminant Level |
| mg/L | milligrams per liter |
| MHI | Median Household Income |
| MOA | Memorandum of Agreement |
| msl | mean sea level |
| NASA JPL | National Aeronautics and Space Administration Jet Propulsion Laboratory |
| NCCAG | Natural Communities Commonly Associated with Groundwater |
| NJDD | New Jerusalem Drainage District |
| NOAA | National Oceanic and Atmospheric Administration |
| NWIS | National Water Information System |
| PCE | perchloroethylene |
| PFAS | perfluorooctanoic acids |
| Plan | Groundwater Sustainability Plan |
| PWS | public water supply |
| RD | Reclamation District |
| Reclamation | U.S. Bureau of Reclamation |
| RP | reference point |
| RWQCB | Regional Water Quality Control Board |
| SAGBI | Soil Agricultural Groundwater Banking Index |
| SB | Senate Bill |
| SB X7-7 | Water Conservation Act of 2009 |
| SCSWSP | South County Surface Water Supply Project |
| SCWSP | South County Water Supply Program |
| SDAC | Severely Disadvantaged Community |
| SDWA | South Delta Water Agency |
| SGMA | Sustainable Groundwater Management Act |
| SJCFCWCD | San Joaquin County Flood Control and Water Conservation District |
| SJRI | San Joaquin River Index |
| SLDMWA | San Luis Delta Mendota Water Authority |
| SMC | Sustainable Management Criteria |
| SSJID | South San Joaquin Irrigation District |
| State Water Board | California State Water Resources Control Board |
| Subbasin | Tracy Subbasin |
| SWP | State Water Project |
| TCE | trichloroethylene |
| TDS | Total Dissolved Solids |

| | |
|---|---|
| TNC | The Nature Conservancy |
| UNAVCO | University NAVSTAR Consortium |
| U.S. | United States |
| USACE | U.S. Army Corps of Engineers |
| USGS | United States Geologic Survey |
| UWMP | Urban Water Management Plan |
| W-SJ | Westside-San Joaquin |
| Water Code | State of California Water Code |
| WCR | well completion report |
| WSID-PID MA | West Side Irrigation District-Patterson Irrigation District Management Areas |

# Executive Summary

## Introduction – Chapter 1

In 2014, the Sustainable Groundwater Management Act (SGMA) was signed by the governor, setting the framework for local agencies to sustainably manage California's groundwater basins. SGMA requires groundwater basins/subbasins designated by the California Department of Water Resources (DWR) as medium or high priority to follow four basic steps:

Step 1 – Form Groundwater Sustainability Agency(s) (GSA)

Step 2 – Develop and adopt a Groundwater Sustainability Plan (GSP or Plan)

Step 3 – Implement the Plan to achieve a sustainability goal and avoid undesirable results within 20 years

Step 4 – Report the implementation activities to DWR to document whether the sustainability goal and the avoidance of undesirable results has been achieved

Ultimately, six GSAs were formed to manage groundwater in the Tracy Subbasin (Subbasin), completing Step 1. Figure ES-1 shows the location of the Subbasin and the GSAs. This GSP and adoption by each GSA will complete Step 2. This GSP will be updated every 5 years as additional information becomes available. Steps 3 and 4 will be implemented over the next 20 years.

SGMA identified six sustainability indicators that, when there are no significant and undesirable results present, indicate a sustainable basin. The six sustainability indicators are:

- chronic lowering of groundwater levels
- reduction of storage
- land subsidence
- seawater intrusion
- degradation of water quality
- surface water depletion

For each sustainability indicator, the GSP must identify the significant and undesirable results (as locally defined), minimum thresholds, and measurable objectives that will be used to guide and define sustainable conditions and the overall groundwater management goals.

The Tracy Subbasin was designated by DWR as a "medium priority" subbasin and is therefore required to comply with SGMA. The Tracy Subbasin is bounded by three adjacent subbasins that were also designated as "medium" and "high priority" and are required to comply with SGMA. Two of these adjacent subbasins, the Eastern San Joaquin and Delta-Mendota subbasins, were designated as "high priority" and "critically over-drafted," submitted their GSPs to DWR in 2020. These two subbasins are currently implementing their plans. The East Contra Costa subbasin is a medium priority subbasin and is currently developing its GSP. Figure ES-1 shows the location of the Tracy Subbasin along with the adjacent subbasin names and locations.

### Agency Information – Chapter 2

Six agencies (Banta-Carbona Irrigation District, Byron-Bethany Irrigation District, City of Lathrop, City of Tracy, San Joaquin County, and the Stewart Tract) comprise the six GSAs responsible for sustainability managing groundwater in the Subbasin. Figure ES-1 shows the areas managed by each GSA. SGMA requires the GSAs are to consider the interests of all beneficial users and uses in the Subbasin. Beneficial users and uses in the Subbasin include water for agricultural users, domestic well owners, public water systems, environmental users, surface water, federal government facilities, disadvantaged communities, and small community water systems. The GSAs have entered into a Memorandum of Agreement (MOA) to manage groundwater conditions with each GSA having jurisdiction within their respective areas.

The GSAs have elected San Joaquin County (County) to be the lead agency, to have primary point of contact with DWR. In this lead role, the County organized and lead the GSP development and, looking forward, can also contract for services and grants to implement this GSP. Fiscal budgets have been developed and the County will manage these funds. The MOA allows for the GSAs to elect an alternative lead agency.

A thorough budget was developed for implementation of this GSP, which includes annual operating budgets and costs for projects and management actions. The costs were divided into two categories: 1) local costs to be borne by each GSA, and 2) shared costs, those that benefit all GSAs. The average cost for the first 5 years of implementing the GSP is about $234,000 per year.

The GSAs discussed and agreed upon a cost sharing distribution. Some of the shared costs will be funded by the County through an existing Water Investigation Zone No. 2 funds, funds obtained from a Proposition 218 (Zone 2) that has been used for decades to fund water resources programs in the County. The remaining balance of the unfunded shared costs was distributed by GSA.

### Plan Area – Chapter 3

The Tracy Subbasin boundaries follow the Old River on the northwest, the Coastal Range on the southwest and south, and the San Joaquin River on the east. The southeast boundary of the Subbasin, along the San Joaquin-Stanislaus county line, follows irregular water district boundaries. The Subbasin is almost entirely with San Joaquin County but includes a small triangular portion of Alameda County. About one-half of the Subbasin is a mix of Delta islands (mostly agriculture) and waterways while the other half is comprised of urban and agricultural communities (Non-Delta areas). Figure ES-2 shows the Delta and Non-Delta areas as designated by this GSP.

Surface water is available to most areas of the basin and is supplemented with groundwater. Groundwater levels within the Subbasin have been relatively stable and recover after periods of pumping with only a few areas indicating declining groundwater levels. About 2,400 wells (about 1,950 domestic and 450 agricultural, industrial and municipal wells) are present in the Subbasin and provide about 12,000 acre-feet annually for drinking water and irrigation, but this only constitutes about 3 percent of the total water supplies for the Subbasin. The remaining 97 percent of water used is surface water. Domestic wells, because of the small amount that they pump (less than 2 acre-feet per year), are considered to be de-minimis users. The agricultural, industrial, and municipal wells are considered high-capacity wells and their pumping can create significant changes in the groundwater levels.

### Hydrogeologic Setting – Chapter 4

The Subbasin has two principal aquifers (Upper and Lower) which are separated by a low permeability Clay (the Corcoran Clay) that extends beyond the Subbasin into the San Joaquin Valley. The depth of the Corcoran Clay varies through the Subbasin but generally is about 200 feet below ground surface (bgs). The extent of the Corcoran Clay is not fully defined in the Subbasin.

The Upper aquifer provides water to domestic wells, groundwater dependent ecosystems and public and small community water systems. The Upper aquifer receives recharge from precipitation, deep percolation of applied water for agriculture and rivers. The Upper aquifer also discharges groundwater to the rivers.

The Lower aquifer is used by public water systems and agriculture. The aquifer is recharged from other subbasins south of the Subbasin. The Corcoran Clay is absent near the foothills where precipitation can also recharge the aquifers. Because the Corcoran Clay may be absent beneath the Delta islands and possible in the western portions of the Subbasin, groundwater from the Upper aquifer may also recharge the Lower aquifer.

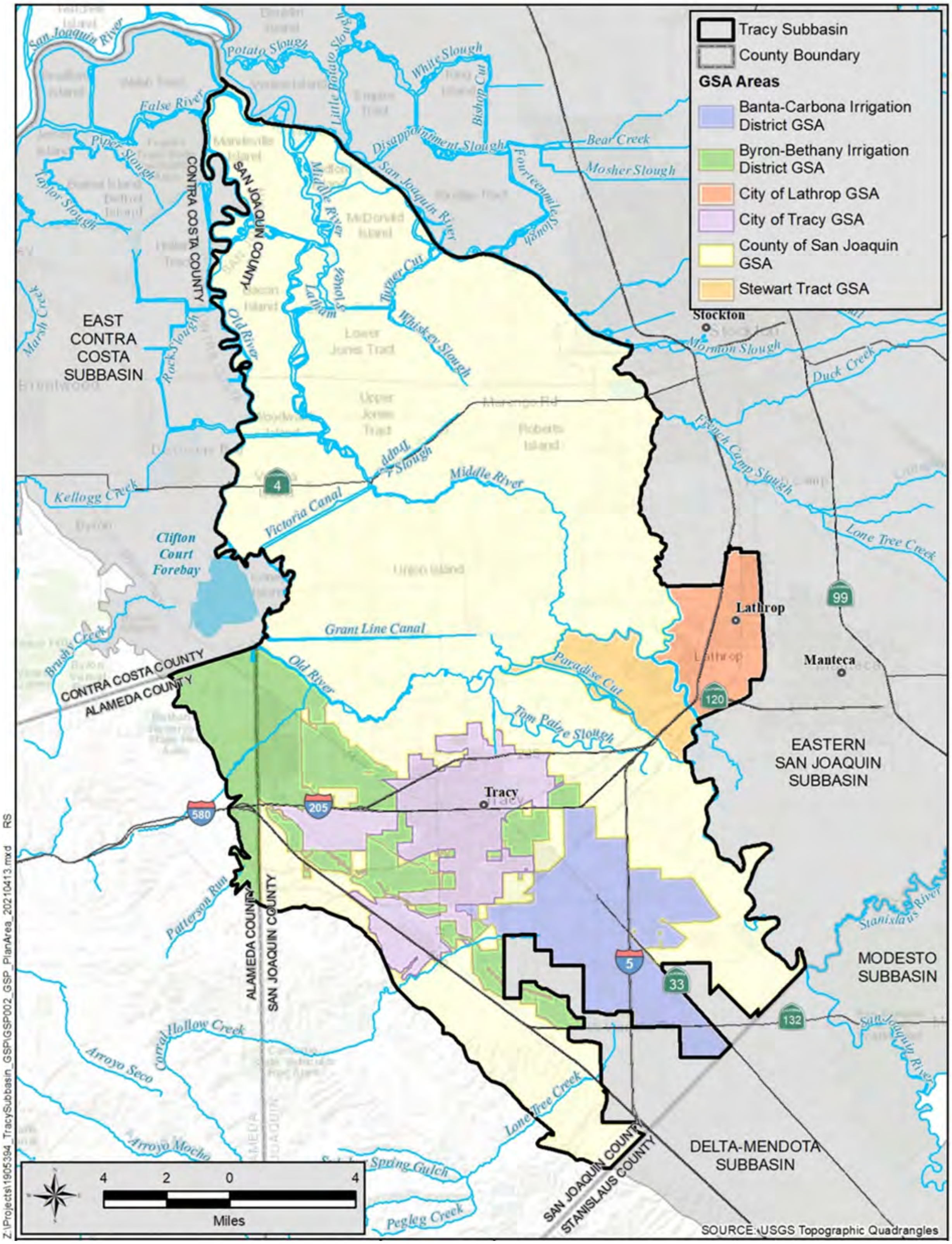


**Figure ES-1. Tracy Subbasin GSAs**

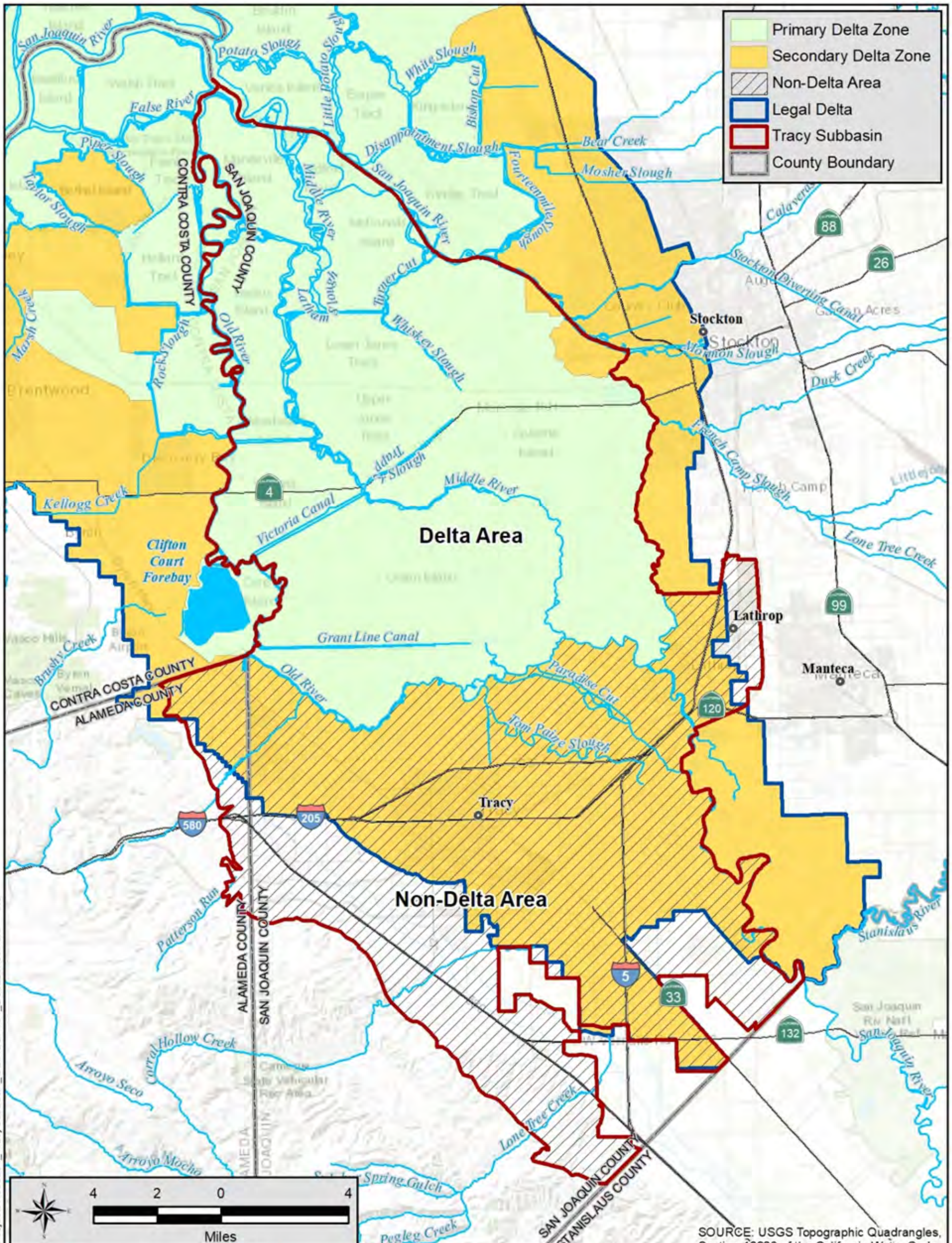


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**Figure ES-2. Delta and Non-Delta Management Areas**

## Groundwater Conditions – Chapter 5

The depth to groundwater in the Upper aquifer varies from a few feet bgs in the Delta islands and near the rivers to as much as 80 feet bgs near the foothills. The depth to groundwater in the Lower aquifer is deeper, ranging from 20 feet bgs to as much as 270 feet bgs near the foothills. Groundwater levels in the Lower aquifer are above the Corcoran Clay; therefore, the potential for subsidence is low.

The groundwater flow direction in the Upper aquifer, in the Non-Delta areas, is generally from the foothills toward the rivers. Groundwater elevations in the Upper aquifer are higher than in the Lower aquifer so there is generally a downward flow of groundwater.

Groundwater in the Lower aquifer also has this same general flow direction but there is also flow from the south, from the Delta-Mendota subbasin. Groundwater from the Lower aquifer discharges into the Eastern San Joaquin Subbasin and into the East Contra Costa Subbasin.

Groundwater levels in most of the Subbasin are stable or rising, however, there are five wells based on long-term records (1998-2020), two in the southern portion of the Non-Delta Management area and three in the western portion of the Non-Delta Management area where groundwater levels are declining. The two southern area wells appear to be constructed in both the Upper and Lower aquifers and new monitoring wells are planned to replace them and to ascertain which aquifer is having declining levels. One of the wells in the western portion of the Subbasin has unknown construction details and two new monitoring wells are planned in this area to resolve which aquifer has groundwater levels declining. The other two wells with declining water levels are near the Old River and monitor the Upper aquifer and have declined by about 4 feet; in a predominately agricultural area with most of the area provided surface water by BBID.

The concentration and depth of the naturally occurring elements varies widely over the Subbasin at any given location. All water supplied by public water systems meets drinking water standards either naturally or is treated prior to being provided to the public. Groundwater quality in the Subbasin has locally exceeded the maximum contaminant levels (MCLs) for drinking water for specific elements, some exceedances are scattered, and some are clustered. Poor groundwater quality has been noted in the following general areas:

- Salinity, as represented by total dissolved solids (TDS), is high in both the Upper and Lower aquifers with a few areas with good quality water
- Elevated concentrations of sulfate are present near the foothills in both the Upper and Lower aquifers potentially from recharge water originating from the Coast Ranges
- Elevated concentrations of arsenic are only in the Upper aquifer and within the Delta area and not in the Lower aquifer
- Boron is present in the Upper aquifer. Most elevated concentrations are present in the Non-Delta areas and in the northern portions of the Delta area

- Elevated concentrations of arsenic are only in the Upper aquifer and within the Delta area and not in the Lower aquifer
- Elevated concentrations of iron and manganese are found randomly in the Subbasin in both aquifers. Elevated concentrations of manganese appear to be more prevalent in the Upper aquifer in the Delta area

Approximately 25 percent of domestic wells may have water quality risks for one or more constituents with an MCL. According to the State Water Resources Control Board, four constituents (arsenic, 1,2,3 TCP, nitrate, and gross alpha [radioactive elements]) account for 80 percent of elevated water quality risk. Of those wells with water quality analysis, up to 20 percent of those wells (domestic and municipal) have exceeded the MCL for these constituents other than for gross alpha which has only occasionally exceeded the MCL.

In addition to these constituents, localized areas of manmade contamination, including trihalomethanes, volatile organic compounds (solvents), and gasoline are present in the groundwater. In the City of Lathrop, uranium, and perfluorooctanoic acids (PFASs) are present in the groundwater above their MCLs. Locally, groundwater has been contaminated at the former Occidental Chemical Corporation site, Sharpe Army Depot, and the Army Tracy Depot. All of these sites are undergoing remediation of groundwater contamination and these cleanup efforts are being overseen by the state.

In order to resolve groundwater levels and supplement the monitoring network for surface water depletion and groundwater dependent ecosystems, six additional monitoring wells are needed to fill data gaps. Well construction information for public water supply systems are also needed to refine the representative water quality monitoring well network.

### Management Area – Chapter 6

The Delta islands are a unique area in the state of California, where groundwater has to be drained or pumped away to maintain groundwater levels below ground surface. Most of the Delta islands ground surfaces are below sea level. The water is pumped back from the islands into the adjacent waterways. There is always a direct and constant connection between surface water and groundwater in the Delta Management area, requiring management of groundwater levels (dewatering) within the islands. There are hundreds of diversions that divert surface water from the adjacent waterways for agricultural purpose, and therefore groundwater pumping in these areas is minimum. The Delta islands area (Primary Management Zone, *refer to* Figure ES-2) have an enforceable long-term sustainable management plan to ensure coordinated action at the federal, state, and local levels (Delta Stewardship Council, *see* **Chapter 3.9.4 – Delta Protection Commission & Delta Stewardship Council**).

In contrast, the Non-Delta Management area of the Subbasin is where most agricultural, domestic and municipal wells are present and where groundwater is used.

The Delta Management area will not require active groundwater by the GSAs to maintain sustainability while the Non-Delta Management area may require active management to be sustainable.

## Water Budgets – Chapter 7

Three water budgets were created for historic (1974-2015), current (2015-2019) and projected (50 years into the future, with climate change) conditions for the entire Subbasin were derived using a state developed groundwater model for the entire Central Valley (C2VSim-FG_v1.0). Water budgets for just the Non-Delta Management area shows the historic water budget to be in slight surplus but the projected water budget with climate change shows a slight deficient. The deficit, about 800 acre-feet per year (AFY), is occurring in the Upper aquifer, while the lower aquifer is showing a slight surplus of about 100 AFY. This is without implementing any projects or management actions.

The water budgets for the Non-Delta Management area with projected water demands and climate change show that in comparison to historic conditions depletion of surface water is projected to increase but is likely to change with updates to the model. Net outflow decreases by 4,000 AFY which may affect neighboring subbasins.

As with all groundwater models there are uncertainties and room for improvement. Opportunities to improve the model, for the required 5-year GSP update, are provided to improve the model's predictive ability, which may change the apparent increased surface water depletion and subsurface outflow projections. These model refinements are necessary for the Central Valley-wide model to better reflect the local conditions of the Tracy Subbasin.

## Monitoring Networks – Chapter 8

Groundwater levels and water quality are currently being monitored by local agencies, and the County, state and federal entities. Representative monitoring wells were selected from this larger network that are spatially distributed, actively being monitored, and that have construction details to prove which aquifer they are monitoring. A total of 26 representative monitoring wells for groundwater levels (to monitor for chronic lowering of groundwater levels, reduction of storage, and surface water depletion) were selected and split with about 75 percent in the Upper aquifer and 25 percent in the Lower aquifer. The groundwater quality monitoring network consists of six public water supply wells. The water quality network is planned to be expanded to provide additional information about the Upper aquifer where most domestic wells obtain water. Representative monitoring wells were not selected to monitor for subsidence but instead will use satellite-based-radar measurements (InSAR, interferometric synthetic aperture radar, a state-funded program) to detect land elevation changes.

## Sustainable Management Criteria – Chapter 9

The sustainability goal for the Non-Delta Management portions of the Subbasin is:

> *To provide reliable and sustainable groundwater resources for existing and future needs of all beneficial users in the Subbasin that does not degrade or decrease over-time and will continue to be sustained through continued local adaptive management of the resources.*

Significant and undesirable results (locally defined), minimum thresholds, and measurable objectives were developed for five of the six sustainability indicators: chronic lowering of groundwater levels, reduction of storage, land subsidence, degradation of water quality, and surface water depletion. Seawater intrusion has not occurred in the past and is unlikely to occur in the future and therefore sustainability criteria were not established for this sustainability indicator.

Undesirable results were defined for chronic lowering of groundwater levels and change in storage and surface water to be protective of most sensitive beneficial users. The most sensitive users to groundwater level changes were found to be domestic wells and environmental users. Because agricultural and municipal groundwater users typically have deeper wells, their interests would also be protected. Maintaining groundwater levels near their historic levels protects the area from subsidence.

Minimum thresholds (the maximum allowable groundwater level depth/elevation or poorest water quality) and measurable objectives (desired level or concentration) were then selected to avoid adverse effects to these sensitive users.

Ground levels minimum thresholds were established at similar levels to historic levels but were modified based on future groundwater modeling results and accounting for climate change, except for surface water depletion, where the minimum thresholds were established within one foot of historic levels. Because groundwater quality is marginal to poor in most of the Subbasin, minimum thresholds were established to not allow concentrations to increase above their current concentrations by more than 10 percent. Where good quality water is present, the MCL was used as the minimum threshold. Measurable objectives were also established along with interim milestones.

### Projects and Management Actions – Chapter 10

The water budget (**Chapter 7**) showed that the Non-Delta Management Area may be about 800 AFY in deficit in the Upper aquifer while being a positive 100 AFY in the Lower aquifer. The GSAs have one project that can resolve the deficit, reducing groundwater pumping by 1,000 AFY. They also have two supplemental projects, one project that benefits the Upper aquifer by reducing pumping by up to 3,000 AFY and a second project that can increase recharge to the Lower aquifer by up to 3,000 AFY. However, the water budget also shows there may be two sustainability indicators, increased surface water depletion and a reduction of subsurface inflow and outflow, which may indicate the Subbasin is not sustainable in the long term, but due to uncertainties in the groundwater modeling and resulting water budgets does not currently allow for accurate confirmation of these results. Improvements to the groundwater model have been identified to resolve these uncertainties before the 5-year update to the GSP and additional projects may be required but until the water budgets reach a higher level of certainty, the GSAs are only committing to these two projects.

Both projects are to be funded by grants and the local GSAs who have the fiscal capacity to provide matching funding.

Future refinements of the groundwater model may show different effects and as necessary, the GSAs have supplemental projects that have been identified and could be implemented. Combination of groundwater modeling results from adjacent subbasin has yet to be performed and could affect the water budget for the Subbasin.

## Outreach Efforts – Chapter 11

This GSP was developed with input from the public. The GSAs reached out to the public by developing a website and a list interested parties. The GSAs sought input from the stakeholders by notifying them of the status *via* newsletters (both English and Spanish) and direct mailer post cards. The GSAs developed information materials and held at over 40 public meetings (both at board and city councils and monthly technical committee meeting), workshops, and contact by trusted messengers to connect with hard-to-reach stakeholder groups.

The public had opportunities to comment directly on this GSP during individual releases of draft chapters followed by another opportunity to comment on the Public Draft GSP. If a comment was specific to an individual section of the GSP, the GSP text was revised. General comments that raised substantial technical or policy issues may have resulted changes to multiple GSP sections. Comments that were general in nature or that did raise substantial issues were noted, but no changes were made.

# 1. Introduction

In 2014, the Sustainable Groundwater Management Act (SGMA) was signed by the governor, setting the framework for attaining sustainably managed groundwater in California. SGMA's requirements apply to groundwater basins/subbasins designated by the California Department of Water Resources (DWR) as medium- or high-priority and consist of four basic steps: 1) creation of a Groundwater Sustainability Agency(s) (GSA); 2) development of a Groundwater Sustainability Plan (GSP or Plan); 3) implementation of the Plan and management to quantifiable objectives; and 4) reporting of the implementation activities to the DWR to document whether the basin is being sustainably managed.

The Tracy Subbasin (Subbasin) was designated by DWR as a 'medium priority' subbasin and is therefore required to comply with SGMA. Surrounding subbasins were also designated as medium and high priority and are required to comply with SGMA. **Figure 1-1** shows the location of the Subbasin and adjacent subbasins.

The Tracy Subbasin (No. 5-022.15) is bounded on the northwest by the Old River south to the tri-county confluence point; south of the Clifton Forebay where it then follows the Contra Costa-Alameda County line to the foothills of the Coastal Range mountains. The northeast boundary follows the San Joaquin River south to the San Joaquin County Line with a slight jog to include the City of Lathrop on the west side of the river. The southern border of the Subbasin generally follows the San Joaquin-Stanislaus County line, with some irregular areas belonging to the Delta-Mendota Subbasin to the south. The western border follows the Coastal Range foothills from the San Joaquin-Stanislaus County line; north to the Contra Costa-Alameda County line. The Subbasin is a mix of Delta islands (mostly agriculture) and waterways along with urban and agricultural communities on the southern edge. Surface water is available to most areas and supplemented with groundwater supplies in the southern portion of the Subbasin. Groundwater levels within the Subbasin have been relatively stable and recover after periods of pumping. About 2,400 wells are present in the Subbasin and provide about 12,000 acre-feet annually for drinking water and irrigation, but this only constitutes about 3 percent of the total water supplies for the Subbasin (DWR 2019a).

Initially seven public GSAs were voluntarily and cooperatively formed to continue to manage groundwater in the Subbasin, completing Step 1 of SGMA. During the preparation of this GSP, one of the GSAs service areas was acquired by another GSA reducing the number of GSAs in the Subbasin to six.

This GSP serves to complete Step 2 of the SGMA process – to identify the current basin conditions and develop a plan to sustainability manage the Subbasin for the next 50 years. This Plan was developed cooperatively by the GSAs, with input from stakeholders and in coordination with the adjacent subbasins, This GSP:

- Describes the geography, geologic features, and historic and current groundwater conditions in the Subbasin.
- Provides a historic water budget and forecasts future groundwater use for a 50-year period to assess whether groundwater conditions remain sustainable, even with urban growth and climate change.
- Describes locally defined sustainability goals and undesirable results for the six groundwater sustainability indicators identified by SGMA.
- Establishes management criteria, the operating range in which groundwater levels will be maintained, in the form of minimum thresholds and measurable objectives.
- Identifies projects and management actions intended to maintain groundwater within the sustainable operating range for the next 50 years. Costs for implementation of these projects and management actions were developed to assess fiscal impacts and to establish a strategy of how to fund and implement projects.
- Establishes an annual reporting mechanism to assess the management performance and sets forth procedures for 5-year updates of this GSP to adaptively maintain sustainability in the Subbasin.

Per SGMA statute, neither the GSAs nor this GSP, "…determines or alters surface water rights or groundwater rights under common law or any provision of law that determines or grants surface water rights" [California Water Code Section 10720.5(b)].

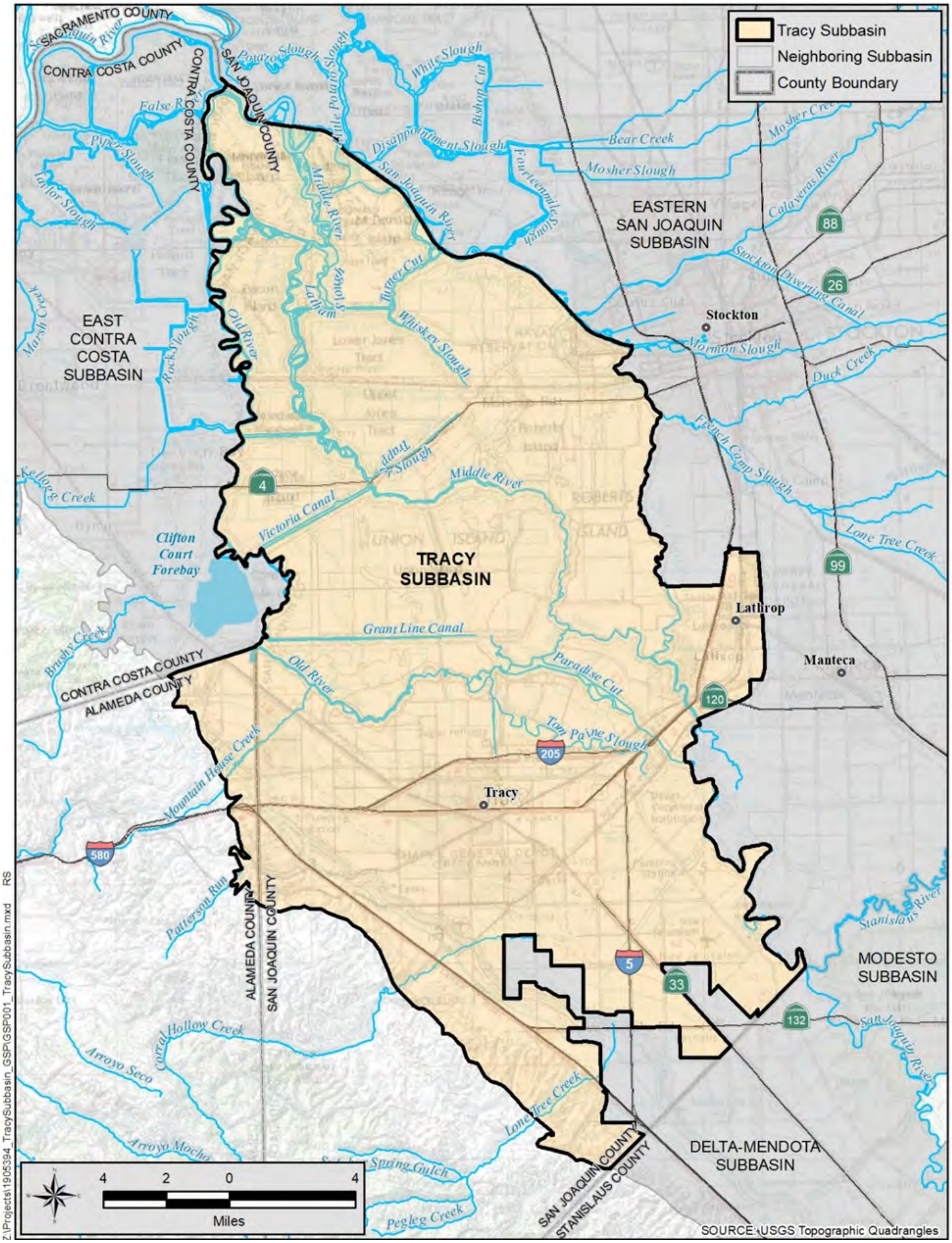


**Figure 1-1. Tracy Subbasin**

# 2. Agency Information

This section provides a description of GSAs in the Subbasin and their authority to implement the GSP, along with contact information for the elected basin coordinator (Agency), and legal authority to implement the GSP. A cost estimate for implementing the GSP is provided along with a general description of how the Agency plans to meet those costs.

## 2.1 GSA Organization and Management Structure

Six agencies filed with DWR to become GSAs to cover the entire Subbasin. DWR designated them as exclusive in 2016 and 2017. In 2018, the Subbasin boundaries were modified which resulted in the formation of the East Contra Costa Subbasin and inclusion of the City of Lathrop areas into the Tracy Subbasin. The six GSAs in the Subbasin are:

- Banta-Carbona Irrigation District
- Byron-Bethany Irrigation District
- City of Lathrop
- City of Tracy
- County of San Joaquin
- Stewart Tract

**Figure 2-1** shows the areas covered by each GSA. All of the agencies have the legal authority to implement this GSP. None of the agencies have adopted any new bylaws, ordinances, or new authorities to manage or limit groundwater use since the adoption of SGMA in 2014. A brief description of each GSA is provided below.

### 2.1.1 *Banta-Carbona Irrigation District*

The Banta-Carbona Irrigation District (BCID) is an agricultural water purveyor in the Subbasin serving approximately 18,000 acres of agricultural land. BCID delivers surface water for agricultural uses in the Subbasin. BCID water supplies consist of a pre-1914 water right, two licenses, and a CVP DMC supplemental water contract. The pre-1914 water right and two licenses entitle the BCID to divert up to 204 cfs from the San Joaquin River in the south Delta. The CVP DMC contract provides up to 20,000 AFY from the DMC as hydrologic conditions permit. There are a few production wells located in the BCID that tend to be used only under drought conditions as the water contains boron and some salts. Also, some areas of the district are subject to shallow groundwater levels, which is controlled by a series of drains. Individual growers supplement their surface water supplies with groundwater, especially in drier years, when less surface water is available. BCID is looking to improve local groundwater level and groundwater quality conditions to enhance their long-term groundwater supply reliability, provide greater operational flexibility, and provide for greater drought resiliency.

### 2.1.2 *Byron-Bethany Irrigation District*

Byron-Bethany Irrigation District (BBID) provides surface water to irrigate approximately 8,000 acres of farmland within the Subbasin. BBID was formed in 1919 and was reorganized in 2004 to annex the territory of the Plain View Water District. The district encompasses about 29,000 acres within Alameda, Contra Costa, and San Joaquin counties and covers the six service areas listed below.

1. Byron Agricultural Service Area
2. Bethany Agricultural Service Area
3. Raw Water Service Area 1, serving the community of Mountain House
4. Raw Water Service Area 2, serving Tracy Hills, a development being constructed within the City of Tracy
5. Central Valley Project (CVP) Service Area, formerly the boundary of Plainview Water District
6. West Side Service Area, formerly The West Side Irrigation District

BBID's water supply is based upon a pre-1914 water right established by BBID, which does not apply to the former Plainview Water District area. The BBID asserts a claim under this pre-1914 water right in exchange for operational certainty, the BBID has agreed to limit the annual diversion to 50,000 AFY through an agreement with DWR. BBID delivers surface water for agricultural and some urban uses in the Subbasin. Because of its location, BBID uses very little groundwater. Individual growers periodically supplement their surface water supplies with groundwater, especially in drier years, when less surface water is available. BBID also has a CVP contract for 20,600 acre-feet for agriculture and municipal and industrial.

In 2020, BBID acquired The West Side Irrigation District (initially a GSA) and expanded BBID service area by about 6,800 acres with a significant portion located within the City of Tracy sphere of influence. The total irrigated acreage is about 5,700 acres. BBID also acquired 1916 water right to Old River of 82.5 cubic feet per second (cfs) between March 1 and Oct 31 and contracts for 2,500 acre-feet of agricultural water through 2030 from the CVP Delta-Mendota Canal (DMC).

### 2.1.3 *City of Lathrop*

The City of Lathrop is located just west of the City of Manteca and south of the City of Stockton. In 2019, the population of Lathrop was about 25,000. The City of Lathrop's water system serves approximately 7,300 metered service connections within 14,400-acre (22-square-mile) area of the Subbasin. Water sources include groundwater pumped by five wells and treated surface water purchased from SSJID through the SCWSP. The City receives surface water supplies from SSJID to help reduce its use of groundwater. Average water demand is about 9,000 acre-feet per year (AFY). The future (build-out) water demand for the City is estimated to be 20,000 AFY.

In 2012, the City of Lathrop constructed a centralized water treatment facility to remove arsenic from the groundwater. In prior years, high salinity was the primary water quality issue in the groundwater. Today, perfluorooctanoic acids (PFAS) has impacted the City of Lathrop's wells, emerging as a contaminant of concern. Also, uranium has been detected in a well (Well 21), manganese and nitrates are of concern. TDS concentration at the City of Lathrop's wells may require treatment within the next 10 years, which may be accomplished by blending with SCWSP water and/or treatment by reverse osmosis. The City does not foresee any immediate water reliability issues.

### 2.1.4 *City of Tracy*

The City of Tracy and surrounding urban areas encompass approximately 15,000 acres in the Subbasin. Tracy is in western San Joaquin County about 15 miles southwest of Stockton and overlies the southern part of the Subbasin. The City supplies, treats, and delivers potable water to its residents. Tracy has historically used groundwater to meet its municipal and industrial water needs. Currently, the City relies on a combination of surface water and groundwater to meet the water demands within its service area. The groundwater supply has elevated total dissolved solids (TDS) levels and requires blending with surface water. The City receives surface water supplies from the South San Joaquin Irrigation District (SSJID) through the South County Water Supply Program (SCWSP) to help reduce its use of groundwater.

Average water demand, as calculated from 2000 to 2004, is 16,400 acre-feet. The future (build-out) water demand for the City is estimated to be 35,700 acre-feet. The City has agreements with the agencies listed in **Table 2-1** for supplemental water supply.

**Table 2-1. City of Tracy Water Supply Agreements**

| Agreement Agency | Purpose | Volume of Water (AF/Y) |
|---|---|---|
| U.S. Bureau of Reclamation (Reclamation) | M&I Reliability | 10,000 |
| Reclamation | Agricultural Reliability | 10,000 |
| SSJID | M&I | 11,120 |

The City of Tracy operates an Aquifer Storage and Recovery project (one well) where high-quality water is injected into the confined aquifer and stored. The water is later pumped out and delivered to its customers.

### 2.1.5 *County of San Joaquin*

The county of San Joaquin (County) covers all of the Subbasin except for a small triangle of land within Alameda County. The San Joaquin County Public Works Division has been extensively involved in the formation and organizing of GSAs in the Subbasin. The County GSA area covers all areas not covered by other GSAs in the Subbasin. In general, the County GSA area is mostly the Delta portion of the Subbasin (lands within the Central and South Delta Water Agency) and areas along the San Joaquin River to the south. The County GSA also includes the Naglee Burk Irrigation District just south of the Delta and some highland areas south of Highway 580.

### 2.1.6 *Stewart Tract*

In 2017, Island Reclamation District 2062 (RD 2062) notified DWR of its decision to become a GSA under the name Stewart Tract GSA. RD 2062 was formed in 1922 as an independent public agency. RD 2062 is located within the City of Lathrop on Stewart Tract, bounded by the San Joaquin River, Paradise Cut, and Old River, and covers 14,000 acres. A portion of the Stewart Tract area is outside the boundaries of, and not served by, RD 2062, but is within RD 2107. The RD 2062 is authorized to acquire, build, and operate reclamation work as defined by the California Water Code. This includes flood control, drainage, and non-potable water supply infrastructure, as well as drains, canals, sluices, bulkheads, water gates, levees, embankments, pumping plants, dams, diversion works, and irrigation works. It also includes bridges and road systems to ensure access to the reclamation works. RD 2062 currently owns and operates approximately 17 miles of State Plan of Flood Control, project and non-project levees, several lakes, and several different pumping systems. The RD 2062 has both riparian and appropriative water rights and provides surface water from the San Joaquin River and Paradise Cut to their agricultural customers. The Stewart Tract GSA also contains Mossdale Reclamation District 2107, which entered into an agreement with RD 2062 in June 2017 to be included in the Stewart Tract GSA and allow RD 2062 to be the managing agency of the GSA. The boundaries of both RD 2062 and RD 2107 together include the entire Stewart Tract area, although only a portion of RD 2107 is located within the City of Lathrop. RD 2062 does not provide potable water. All potable water for development within the Stewart Tract is provide by the City of Lathrop. The River Islands Development project is located within the City of Lathrop, and is supplied potable water, sewer and recycled water from the City.

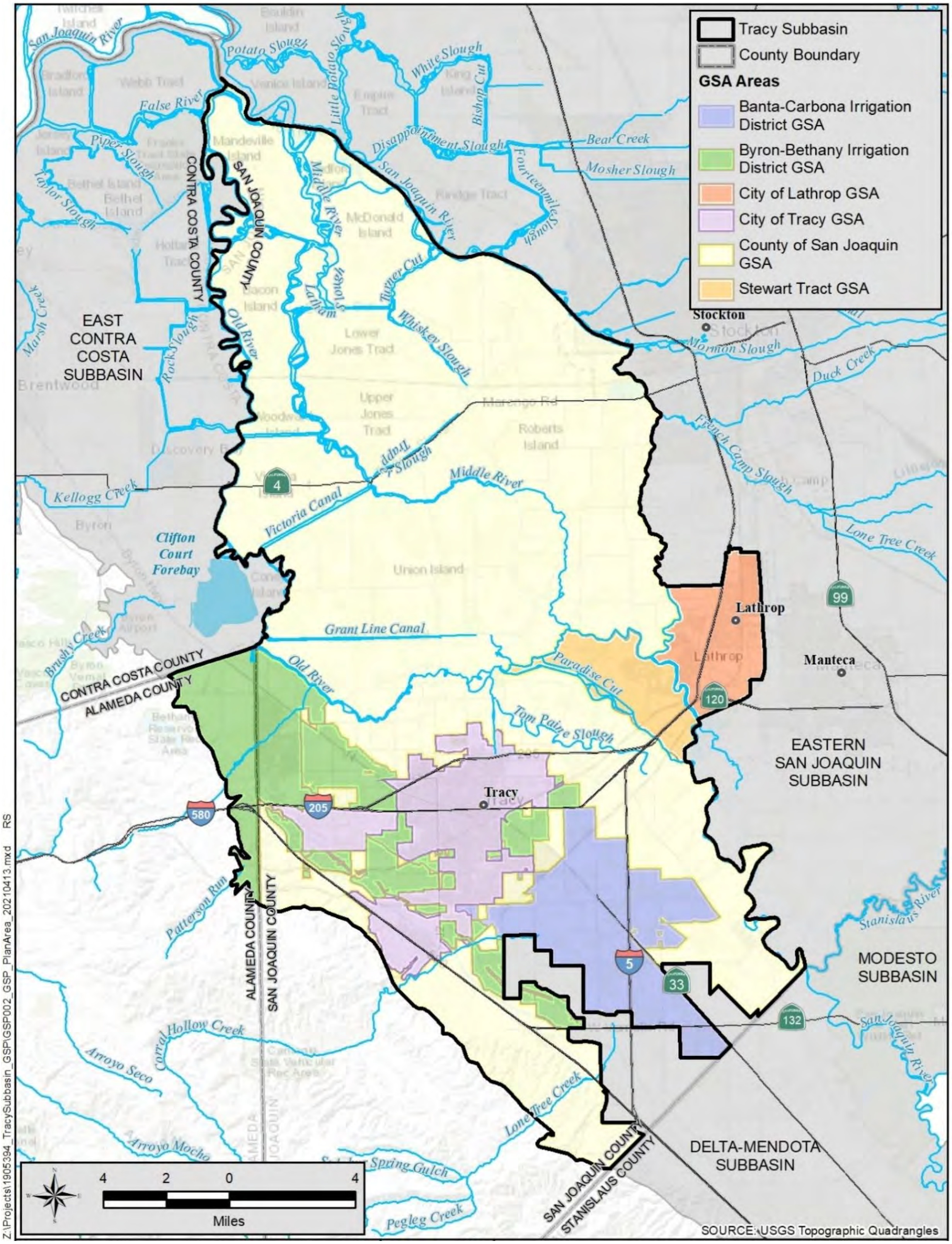

**Figure 2-1. GSP Plan Area and GSAs**

## 2.2 Plan Manager Contact Information

The County was elected by the six GSAs to be the plan manager and lead agency for the preparation of the Subbasin GSP and implementation. A copy of the Memorandum of Agreement (MOA) is contained in **Appendix A**. The contact information is provided below.

| | |
|---|---|
| Agency's Name: | San Joaquin County Public Works Department |
| Agency's Address: | 1810 East Hazelton Avenue, Stockton, CA 95205 |
| Agency's Website: | https://www.sjgov.org |
| Contact person: | Matt Zidar |
| Phone Number: | (209) 953-7460 |
| Email: | mzidar@sjgov.org |

## 2.3 Implementation Authority

Any local public agency that has water supply, water management, or land use responsibilities in a basin can decide to become a GSA under SGMA. All six of the Tracy Subbasin GSAs meet at least one of these criteria and has legal authority to jointly prepare, adopt, and implement a GSP. Each GSAs has the legal authorities granted to a GSA under the California Water Code (Water Code) to sustainability manage groundwater in their area.

All six GSAs have entered into a MOA for the implementation of this GSP, which will include management of the Subbasin along with projects and management actions. The agencies have designated San Joaquin County as the lead agency with the option that this leadership can be changed. **Appendix A** provides a copy of the signed agreement.

## 2.4 GSP Implementation Costs

A thorough budget was developed for implementation of this GSP and includes costs for meeting regulatory requirements, program management and administrative fees, professional services, and projects and management actions. It includes costs for groundwater level and quality monitoring, annual reporting, 5-year GSP updates, public outreach and data gap resolution. A detailed budget for the first 5-years of GSP implementation is provided in **Appendix B, Table B-1**. The costs were divided into two categories: 1) local costs to be borne by each GSA, and 2) shared costs, those that benefit all GSAs.

Annual budgets were developed and classified as a local or shared cost. Annual shared costs for the first 5 years range from $147,000 to $326,000. To reduce the variability of annual costs, an average annual operating shared budget was developed and is about $234,000 per year. Some portion of the annual revenue fees may be spent or accumulated but at the end of the 5-year period the no funds are expected to remain. The budget will be updated in the 5-year GSP update and funding schedule re-established.

The GSAs are discussing shared costs funding distribution to generate revenue to fund GSP implementation. Some of the shared costs will be funded by an existing Water Investigation Zone No. 2

funds, funds obtained from a Proposition 218 that has been used to fund water resources programs in the County. The remaining balance of the unfunded shared costs were distributed by GSA. his cost sharing approach is documented in the MOA.

The GSAs decided that funds to implementation of projects to continue the sustainability of the Subbasin, detailed in **Chapter 10 – Projects and Management Actions**, would be a local GSA cost and not a shared cost. Therefore, **Table B-1** does not include these costs. Grant funding is planned to be sought after to fund portions of these projects.

# 3. Description of Plan Area

## 3.1 GSP Plan Area

The Subbasin encompasses an area of about 238,429 acres (370 square miles) in San Joaquin and Alameda counties, primarily between the eastern extent of the Coast Ranges on the south and the San Joaquin River on the east. The Subbasin is bounded on the north and the east by the San Joaquin River, on the south by the San Joaquin-Stanislaus counties border, and on the west by the aerial extent of sedimentary deposits bounded by the Coastal Ranges. The San Joaquin, Old, and Middle rivers are the principal rivers within or bordering the Subbasin. **Figure 3-1** shows the plan area of the Subbasin and surrounding groundwater basins as defined by DWR. The topography changes across the Subbasin are small. Ground surface elevations are the highest, approximately 200 feet above mean sea level (msl), on the southwestern side of the Subbasin, and gradually decline to the north and east.

Water uses in the Subbasin include agricultural, municipal, industrial, domestic, and native vegetation and aquatic species. Some water is also being used for managed habitats, mostly for migrating birds. Some water purveyors rely exclusively on either groundwater or surface water, but most rely on a combination of surface water and groundwater.

The Subbasin is about half Delta islands and waterways, generally north of the Old River and Tom Payne Slough, and the surrounding uplands areas (those lands at or above 5-foot elevation) to the south where agriculture dominates the area. **Figure 3-1** shows outline of the legal Delta Boundary (Section 12220 Water Code) and also the division between the lowlands and upland areas. The Subbasin also includes the cities of Lathrop and Tracy, the community of Mountain House, and the industrial area west of the City of Tracy. Most of the undeveloped land in the Subbasin is south of Highway 580, to the southern edge of the Subbasin. Most of the groundwater pumping occurs in the area south of Old River and east of the San Joaquin River (Lathrop). North of the Old River, surface water from the Sacramento-San Joaquin Delta, is used to meet most of the water demand.

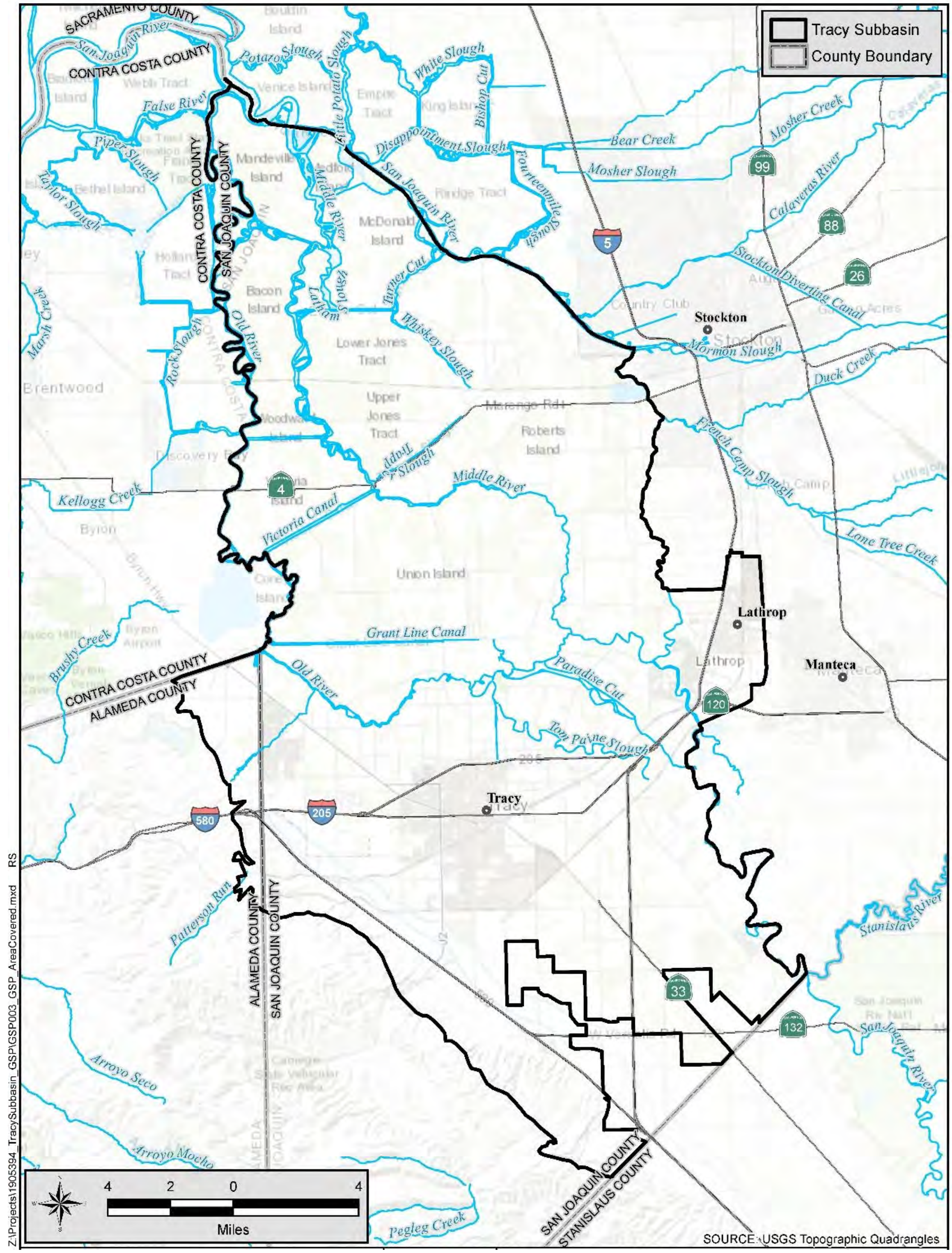


**Figure 3-1. Area Covered by GSP**

## 3.2 Adjudicated Areas

The Subbasin is not adjudicated, nor are the surrounding subbasins.

## 3.3 Jurisdictional Areas

Within the Subbasin, there are areas with federal, state, and county land-use jurisdictional responsibilities. Land use authorities belong to the counties of San Joaquin and Alameda and the cities of Lathrop and Tracy. Water districts or agencies provide potable water, and irrigation districts and some reclamation districts provide surface water for agriculture. Within many of the irrigation districts and cities are reclamation districts that are responsible for managing and maintaining the levees, freshwater channels, sloughs, canals, pumps, and other flood protection structures in the area. Drainage Districts (*refer to* **Section 3.3.11** for details) also maintain drainage pipelines to control shallow groundwater. The following sections describe the jurisdictional areas and agencies within the Subbasin. **Figure 3-2** through **Figure 3-4** show these jurisdictional areas.

All the GSAs, cities, water agencies, and reclamation districts have open communication with state and federal agencies to comply with reporting and permitting. Federal and state agencies have been included in the Subbasin communication and engagement plan and are on the interested parties list of notifications.

### 3.3.1 *Federal*

Several federal agencies have jurisdiction over lands and waterways in the Subbasin. The United States Army Corps of Engineers (USACE) has jurisdictional authorities on all navigable waterways in the Subbasin.

Reclamation owns the CVP canals. The San Luis Delta Mendota Water Authority operates the canal under agreement with Reclamation. The Delta-Mendota Canal crosses the entire length of the Subbasin south of Highway 580.

The federal government owns the Tracy and Sharpe Defense Distribution depots (USACE). The Sharpe Depot is expected to be decommissioned in the next 6 to 12 months as the Depot is closed and has been reported as Army excess property for property disposal through the General Services Administration. The City of Lathrop will then provide services to properties within former Sharpe Army Depot boundaries. The federal government also used to own land for a former naval base in Rough and Ready Island, opposite Stockton. The Stockton Port Authority currently owns the land but still has a federal designation. Federal ownership of lands is also indicated for some lands, but the ownership is uncertain. For example, two properties are reported as federal jurisdiction, but the records show the owners to be Contra Costa Water District and the City of San Francisco. Lands with unclear ownership are shown in **Figure 3-2**.

**Figure 3-2** shows the federal lands in the Subbasin where SGMA does not apply. Federal government officials have been invited to assist in the development of this GSP.

### 3.3.2 *State of California*

The California State Department of Transportation has authority for lands occupied by freeways and highways and maintenance yards. Major roads crossing the Subbasin are Interstates 5, 205, and 580, Highway 4, and multiple bridges. The California State Department of Parks and Recreation has authority over the recreational areas along the San Joaquin River.

The state also has authority over some small specific conservation land and preserves. DWR has jurisdictional authority for maintaining levees associated with the State Plan of Flood Control. **Figure** 3-2 shows the state-owned lands in the Subbasin. State government officials have been invited to assist in the development of this GSP.

The California Aqueduct, a State Water Project (SWP) facility, is owned and operated by DWR. The Clifton Court Forebay, located just west of the Subbasin, takes water from the Delta and places it into the Aqueduct, which traverses the entire length of the Subbasin. Additional SWP facilities in the Subbasin include the Banks Pumping Plant and South Bay Aqueduct.

Deuel Vocational Institution is a state of California correctional facility is located west of Interstate 5 and south of the City of Lathrop. The facility uses four groundwater wells for water supply and has a sewage treatment plant that discharges the treated water to the Deuel Drain, which is tributary to the San Joaquin River. The state is planning to deactivate the institution by September 2021.

### 3.3.3 *California Native American Tribes*

There are no tribal lands within the Subbasin.

### 3.3.4 *County*

Most of the Subbasin is within San Joaquin County, plus a small triangular portion is in Alameda County. **Figure** 3-2 shows the county boundaries. Each of the counties has General Plans and land use authorities. Each plan has policies for protection and reasonable use of groundwater and protection of water quality.

The San Joaquin County General Plan describes the official county “blueprint” for the location of future land use, type of development encouraged, and decisions regarding resource conservation. Stakeholder input informed the development of the County’s vision and guiding principles, which represent the County’s core values and establish benchmarks for the General Plan’s goals and policies. The General Plan encourages the preservation of the County’s groundwater resources and states that future urban and agricultural growth should occur within the sustainable capacity of these resources.

### 3.3.5 *City*

There are three incorporated cities within the Subbasin, including the cities of Tracy, Lathrop, and a small portion of Stockton. Each of the cities has land use management and planning authority granted through the state of California, which is derivative of the city or county general police power. This power allows cities and counties to establish land use and zoning laws that govern development. Each of the land use agencies has existing policies in place that allow for future development to maintain a sustainable and reliable water supply through conjunctive use of surface water primarily and groundwater during drought, emergency, or stressed times. Each policy allows for protection and reasonable use of groundwater and protection of water quality.

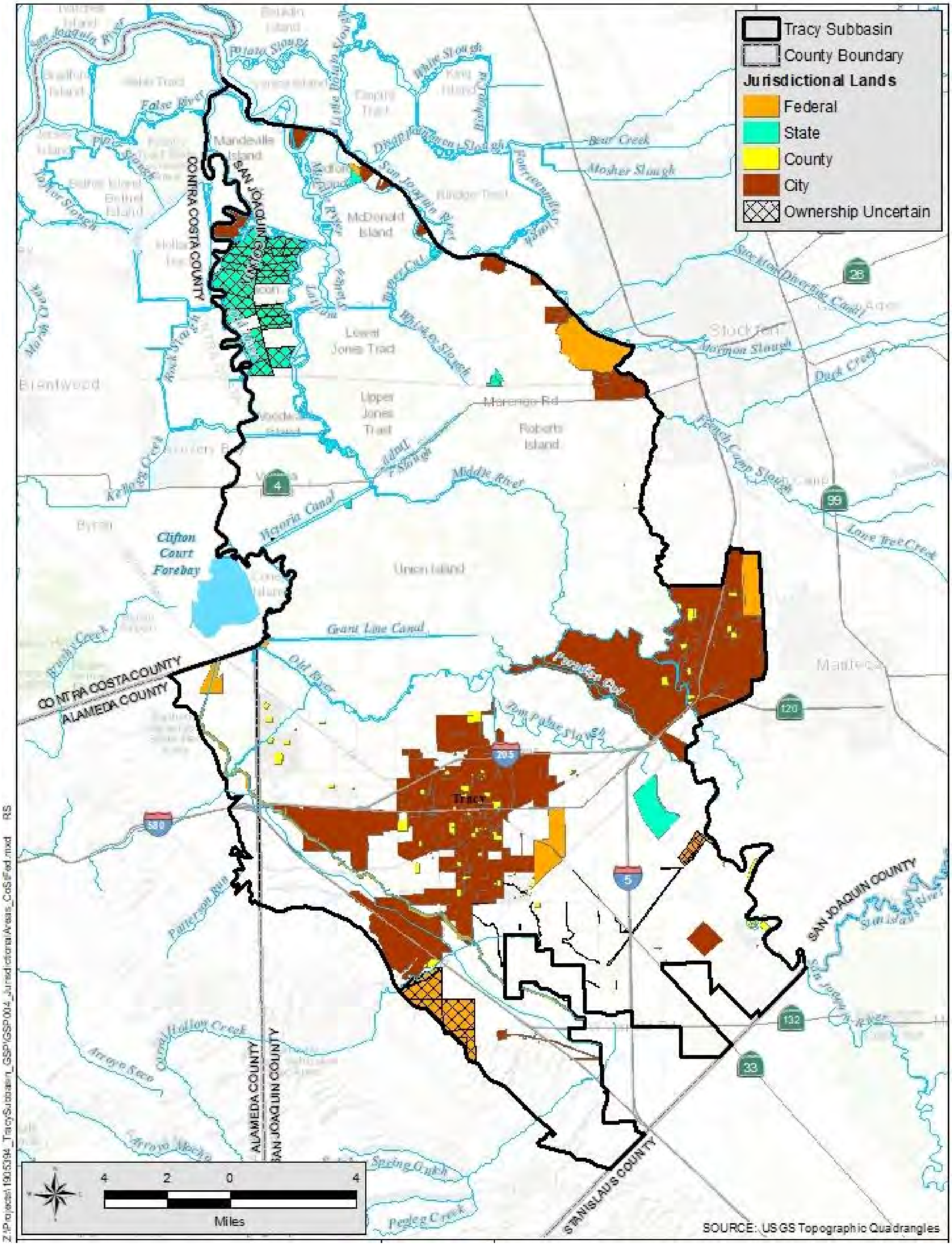


**Figure 3-2. City, County, State, and Federal Jurisdictional Areas and Lands**

### 3.3.6 *Water Agencies*

The Central and South Delta Water agencies are located within the Subbasin and represent surface water rights holders. **Figure 3-3** shows the location of water agencies, districts, and companies. Some are public water agencies, while others are private water companies.

The general purpose of the Central Delta Water Agency (CDWA) is for making and administering agreements for the provision of a dependable surface water supply to those within their boundaries. They advise and assist landowners and local districts in reclamation and flood control matters. The CDWA area encompasses a total of 52,000 acres in the northern half of the Subbasin. The primary land use in this area is agriculture with crops such as vineyards, fruit and nut trees, row crops, and field crops. CDWA protects water supply within its service area (which extends outside of the Subbasin), assists landowners and reclamation districts with water issues, and represents landowners in flood control matters. CDWA does not own any facilities, and surface water from the Delta is the area's only utilized source of water, along with limited private groundwater pumping.

The South Delta Water Agency (SDWA) is a municipal corporation that represents the interests of surface water rights holders in the Southern Sacramento-San Joaquin Delta. SDWA was initially formed to address local water supply and water quality concerns in the south Delta area. The SDWA encompasses a total of approximately 150,000 acres within its boundaries with most of the land, about 132,000 acres, in the Subbasin. SDWA does not own any facilities or water rights. Instead, SDWA protects property owners who have individual water rights. Surface water is the primary source of water used within the agency boundaries, given that most of the groundwater is highly saline.

### 3.3.7 *Community Water Systems*

Four community water system agencies are located within the Subbasin and provide potable water to residents (DWR 2019a) (*see* **Figure 3-3** for locations). Community water agencies include:

- City of Tracy
- City of Lathrop
- Mountain House Community Services District
- California Water Service Company (Cal Water)

Municipal water supplies are both surface and groundwater. The cities of Lathrop and Tracy receive water from the South San Joaquin Irrigation District' South County Water Supply Project. There are some multi-jurisdictional areas where potable water may be served by community water systems but raw water for irrigation on agricultural lands are provided by irrigation district or reclamation districts.

Cal Water provides water to a small area of the City of Stockton that extends west of the San Joaquin River in the Subbasin. The potable water is from treated surface water wholesaled by Stockton East Water District and groundwater wells within the East San Joaquin Subbasin. The area served is within the Stockton East Water District service area and is also within RD 0403.

The Deuel Vocational Institution and the Sharpe Defense Distribution Depot are also classified as community water system. Both rely on groundwater as their source of supply.

Disadvantaged Communities (DAC) communities in the cities of Lathrop and Tracy areas are provided water through the municipal water supply systems. Stockton East Water District also provides wholesale treated surface water which is retailed to Stockton area customers by the California Water Service Company including a small DAC area within the Delta area.

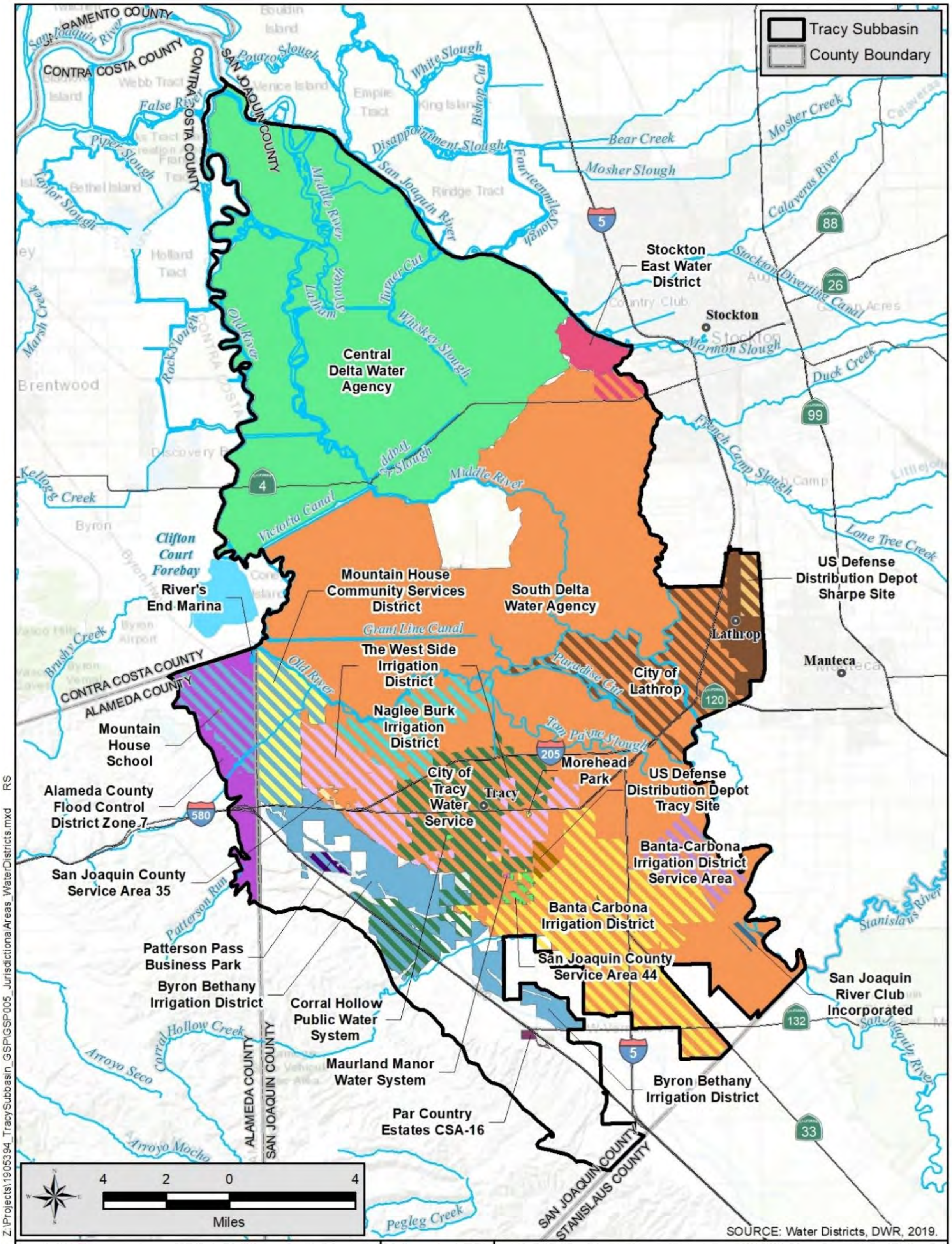


**Figure 3-3. Water Districts Jurisdictional Areas**

### 3.3.8 *Small Community Water Systems*

Community water services districts (non-community non-transient water systems) provide water to small communities and are under the jurisdiction of San Joaquin County (*refer to* **Figure 3-3**). They rely solely on groundwater supplies and include:

- Par County Estates County Service Area (CSA-16)
- CSA 50 (Patterson Industrial Park)
- Corral Hollow Public Water System
- San Joaquin CSA 35
- Morehead Park
- Maurland Manor Water System
- San Joaquin CSA 44

The San Joaquin River Club is also a small community water system but is not under County jurisdiction.

The Tracy Defense Distribution Depot system is classified as a non-community non-transient water system and uses three groundwater wells as their source of supply.

### 3.3.9 *Agricultural Water Providers*

There are several agricultural water purveyors in the Subbasin (*refer to* **Figure 3-3**). Surface water is supplied to agriculture by:

- Banta-Carbona Irrigation District
- Byron-Bethany Irrigation District
- Naglee-Burk Irrigation District
- Island Reclamation District 2062

The irrigation districts typically supply a significant portion of the water supplies for crops within their service areas. Crop irrigation demands not satisfied by surface water deliveries is provided by privately-owned wells. BBID provides raw surface water to the City of Tracy, Mountain House Community Services District and to CSA 50.

### 3.3.10 *Reclamation Districts*

RDs are a form of special-purpose districts in the United States that are responsible for reclaiming and/or maintaining land for agricultural, residential, commercial, or industrial use that is threatened by permanent or temporary flooding. Twenty-seven RD’s cover almost the entire Delta region of the Subbasin including a few RDs south of the Delta along the San Joaquin River. **Figure 3-4** shows the locations of RDs in the Subbasin.

In the Delta islands networks of ditches collect and transport levee seepage and irrigation and precipitation deep percolation to pumps that discharge to adjacent channels. Because the islands are underlain by peat, and as the peat oxidizes and disappears, the drainage ditches are deepened to maintain sufficient unsaturated soils for crop production.

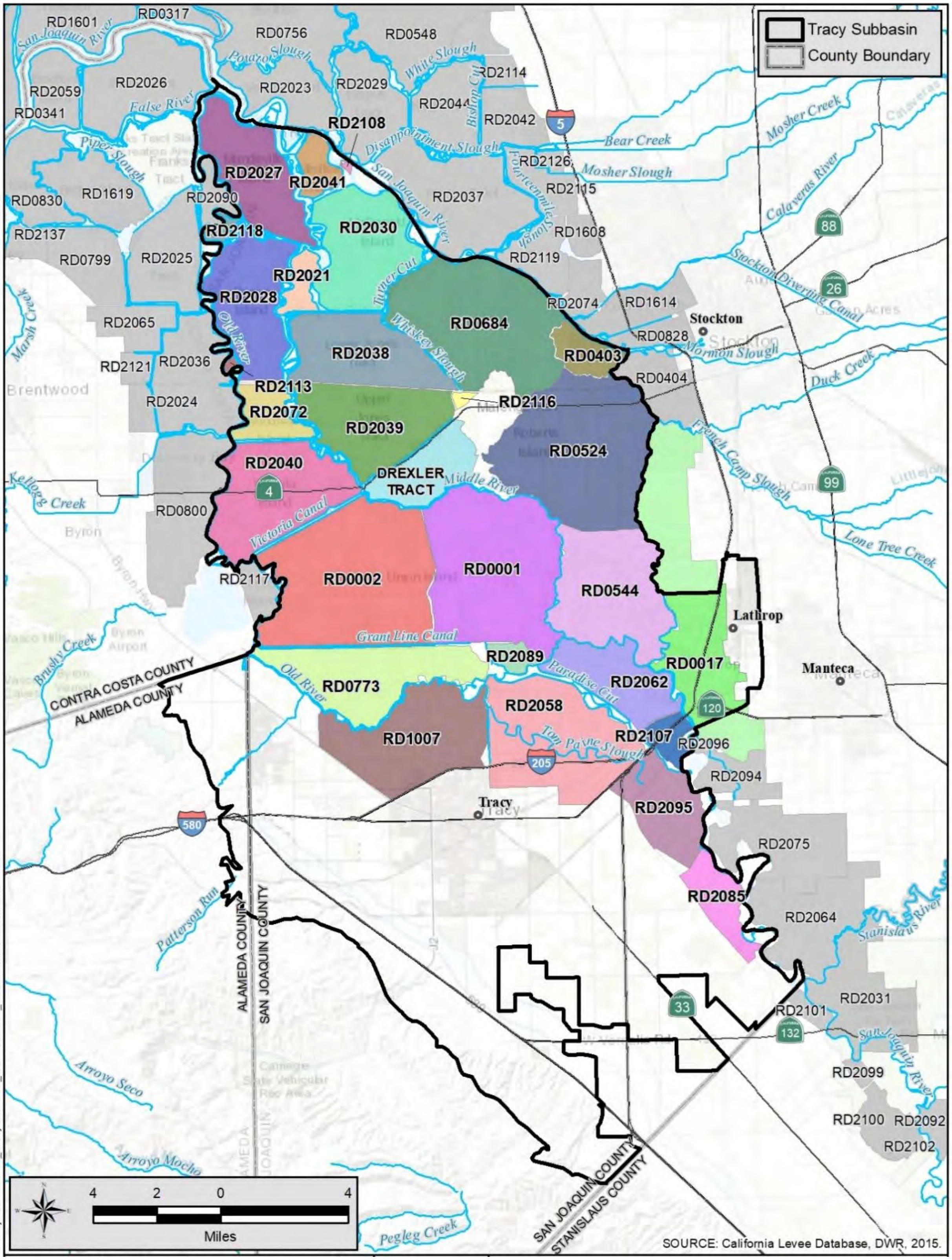


**Figure 3-4. Reclamation Districts Jurisdictional Areas**

### 3.3.11 *Drainage Districts*

Within RD 2085 is the New Jerusalem Drainage District (NJDD) collection system, which collects shallow groundwater and discharges the water to the San Joaquin River. The NJDD service area includes portions of the BCID service area as well as areas outside of the BCID service area, as shown in **Figure 3-5**. The areas outside the BCID service area extend to the southeast into the Vernalis Gas Field (a collection of wells that extract natural gas from the underlying marine sediments). NJDD's drainage collection facilities are located underground and collect shallow groundwater through collector pipes that farmers tie into their underground tile systems. **Figure 3-5** shows the location of the drainage collection system. BCID owns and operates five shallow wells to maintain groundwater levels below the root zone. All wells pump to the NJDD drains.

All of the RDs in the Delta islands have drainage canals that pump water over the levees and into the nearby channels. Drainage canals are also present in the non-Delta portions of RD 1007 and 2058, south of the Tom Paine Slough, and from non-RD lands south of RD 0773. The drainage system extends beneath the northern parts of the City of Tracy. Tile drains are also present in these areas, but their locations are poorly documented.

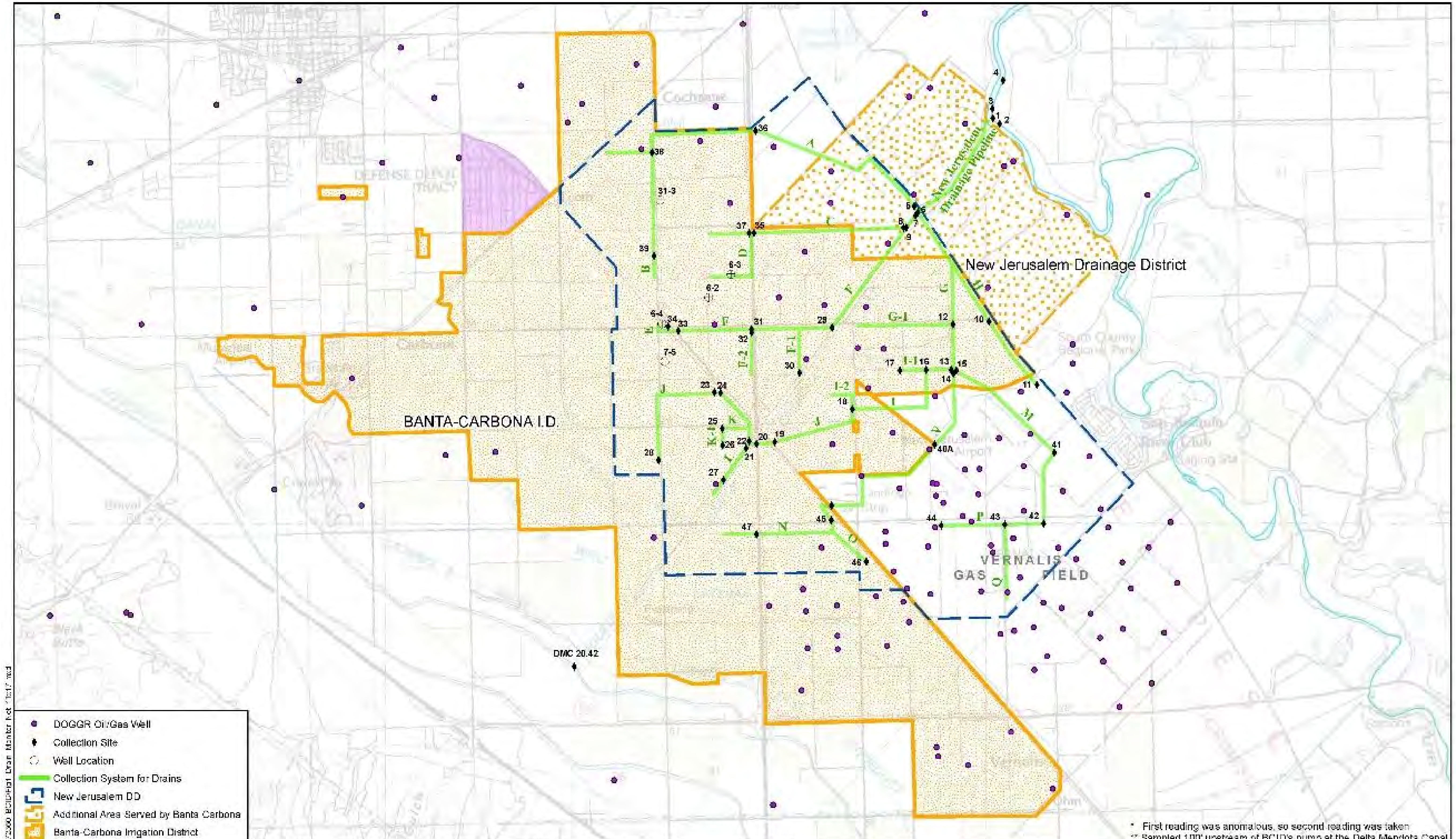


**Figure 3-5. New Jerusalem Drainage Network**

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## 3.4 Land Use

Historically, the Subbasin was dominated by perennial native grasslands, broad riparian zones, and freshwater marsh wetlands. During the 1800s, settlers drained wetland and riparian areas and converted the land for agriculture. Grasslands were similarly eliminated from the region as a result of concentrated grazing and agricultural conversion. Today, irrigated agriculture and urban land uses are the primarily developed land use within the Subbasin.

In 2014, the Subbasin was roughly about 7 percent urban, 60 percent farmland, and less than 1 percent managed habitats (riparian vegetation) (Land IQ 2017). About 32 percent of the land was not classified. The unclassified areas may include land being converted from agriculture to urban, such as the Stewart Tract development southwest of the City of Lathrop and undeveloped lands around the fringe of the basin and waterways in the Delta. **Figure 3-6** shows the 2014 land use in the Subbasin, based on satellite and airborne remote sensing data. The total acres by each significant land use category and crop types are summarized in **Table 3-1**. Riparian vegetation also occurs along the fringes of the rivers, canals, sloughs, and tributaries. The Land IQ data did not quantify or map these fringe areas in their survey and are not shown on **Figure 3-6**.

Future land use calculations were developed using estimates of expected land-use changes within the current sphere of influence for the cities and communities. **Figure 3-7** shows the locations of approved urban development areas in the Subbasin as identified from the Alameda and San Joaquin counties, General Plans. For projected agricultural land use conditions, the current crop mix was assumed to remain unchanged from current conditions other than for the conversion of agricultural land to urban. About 17,400 acres of land is expected to be urbanized, reducing agricultural land by about 10,000 acres of agricultural due to a high percentage of the proposed land being within the unclassified area (undeveloped land).

The counties have each prepared conservation and habitat plans to assess current preserves and easements and provide goals and plans for the next 50 years to continue to increase these areas (San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2000). Currently, the Subbasin has about 3,000 acres of habitat conservation preserves and easements (*see* **Figure 3-8** for locations).

Some grain crop land in the Subbasin maybe being managed for habitat, by flooding fields in the late fall to create habitat for migrating waterfowl. The areas where these activities are occurring are uncertain and are not shown on **Figure 3-8**.

**Table 3-1. Land Use Summary**

| Land Use | Acres | Percent |
|---|---|---|
| **Urban** | **17,140** | **7.19%** |
| Urban | 17,140 | 7.19% |
| **Agriculture** | **143,117** | **60.02%** |
| Citrus and Subtropical | 477 | 0.20% |
| Deciduous Fruits and Nuts | 13,604 | 5.71% |
| Field Crops | 30,374 | 12.74% |
| Grain and Hay Crops | 9,488 | 3.98% |
| Idle | 9,688 | 4.06% |
| Pasture | 45,246 | 18.98% |
| Rice | 75 | 0.03% |
| Truck Nursery and Berry Crops | 31,065 | 13.03% |
| Vineyard | 2,886 | 1.21% |
| Young Perennial | 213 | 0.09% |
| **Managed Wetlands** | **2,104** | **0.88%** |
| Riparian Vegetation | 2,104 | 0.88% |
| **Water Ways and Bodies** | **0** | **0.00%** |
| No Data | 0 | 0.00% |
| **Not Classified** | **76,068** | **31.90%** |
| No Data | 76,068 | 31.90% |
| **Total** | **238,429** | **100%** |

Source: Land IQ 2017

## 3.5 Disadvantaged Communities

DACs and Severely Disadvantaged Communities (SDACs) are present in the Subbasin (DWR 2018). **Figure 3-9** show their locations. Most are located within rural areas of the Delta as well as some along the San Joaquin River in the non-Delta areas. Some are located within the cities of Lathrop and Tracy where municipal water service is available.

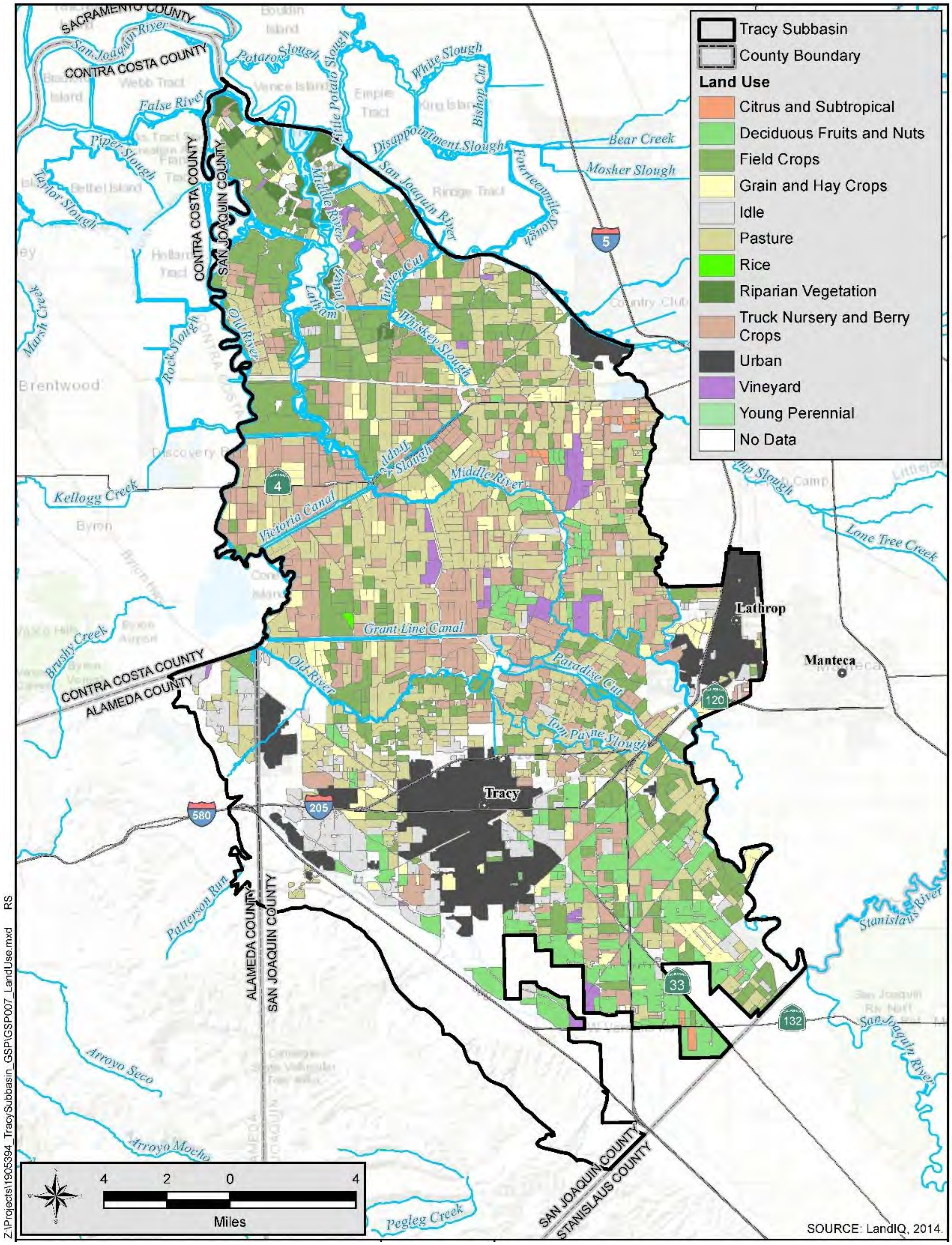

Figure 3-6. Existing Land Use 2014

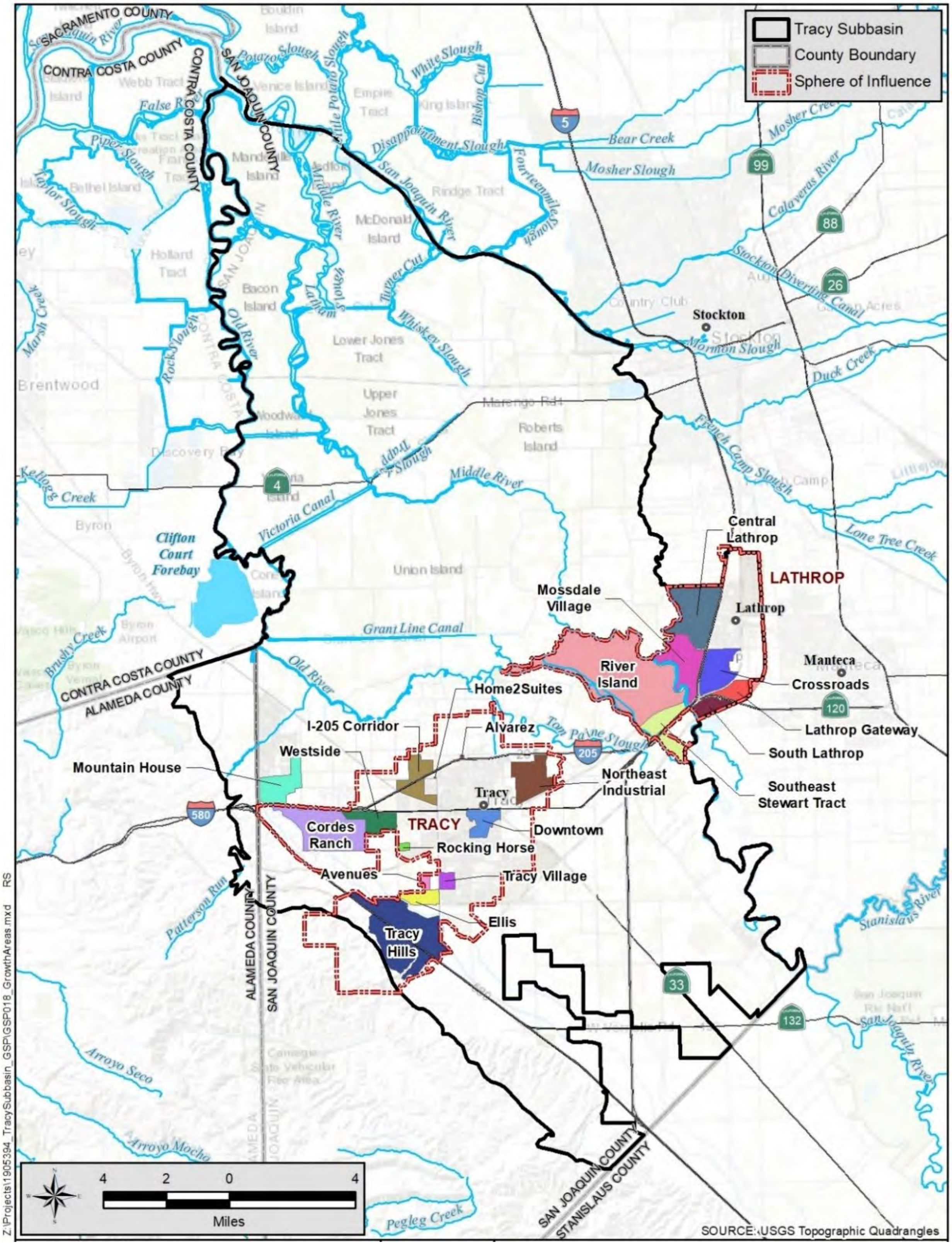


**Figure 3-7. Growth Areas**

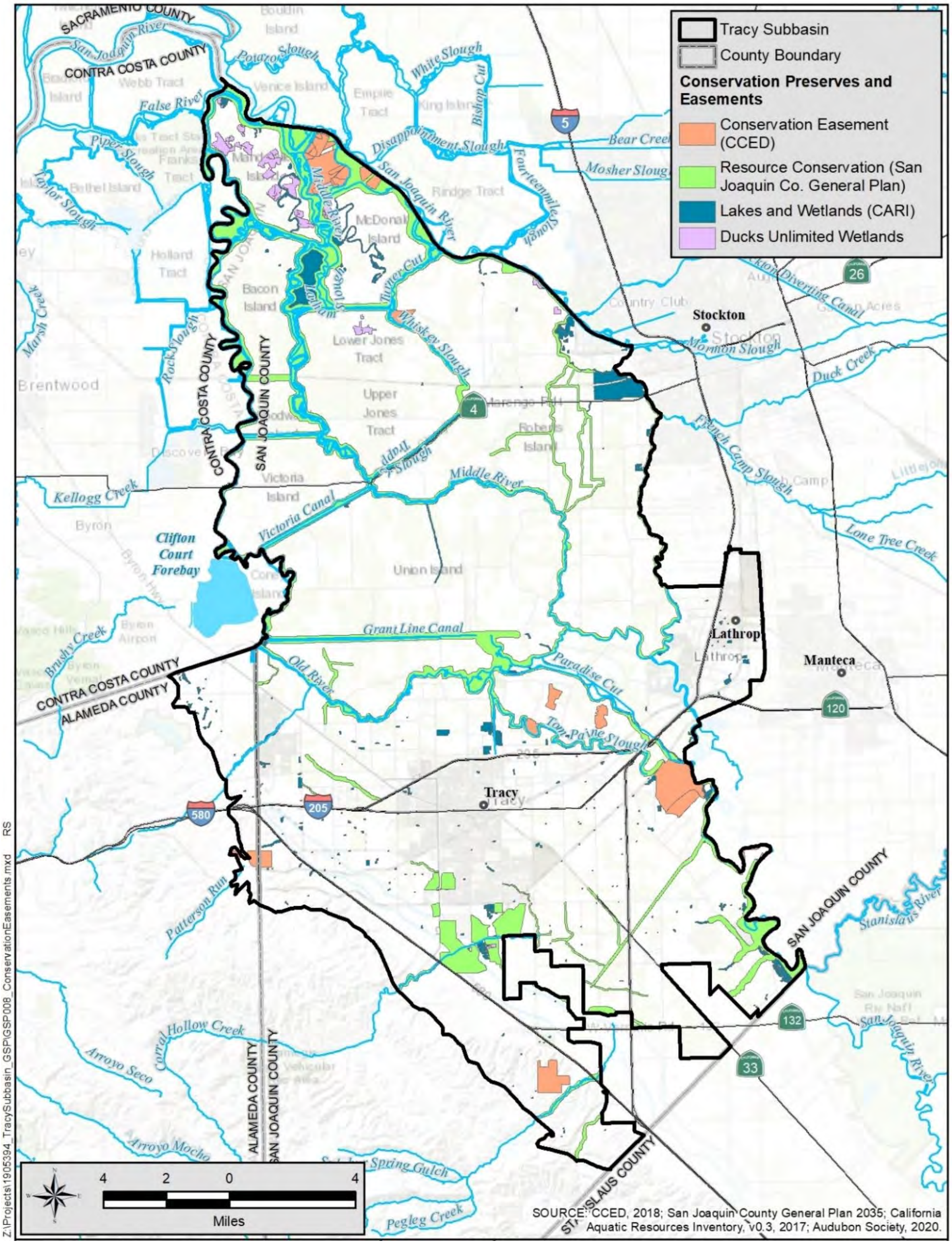


**Figure 3-8. Habitat Conservation Preserves and Easements**

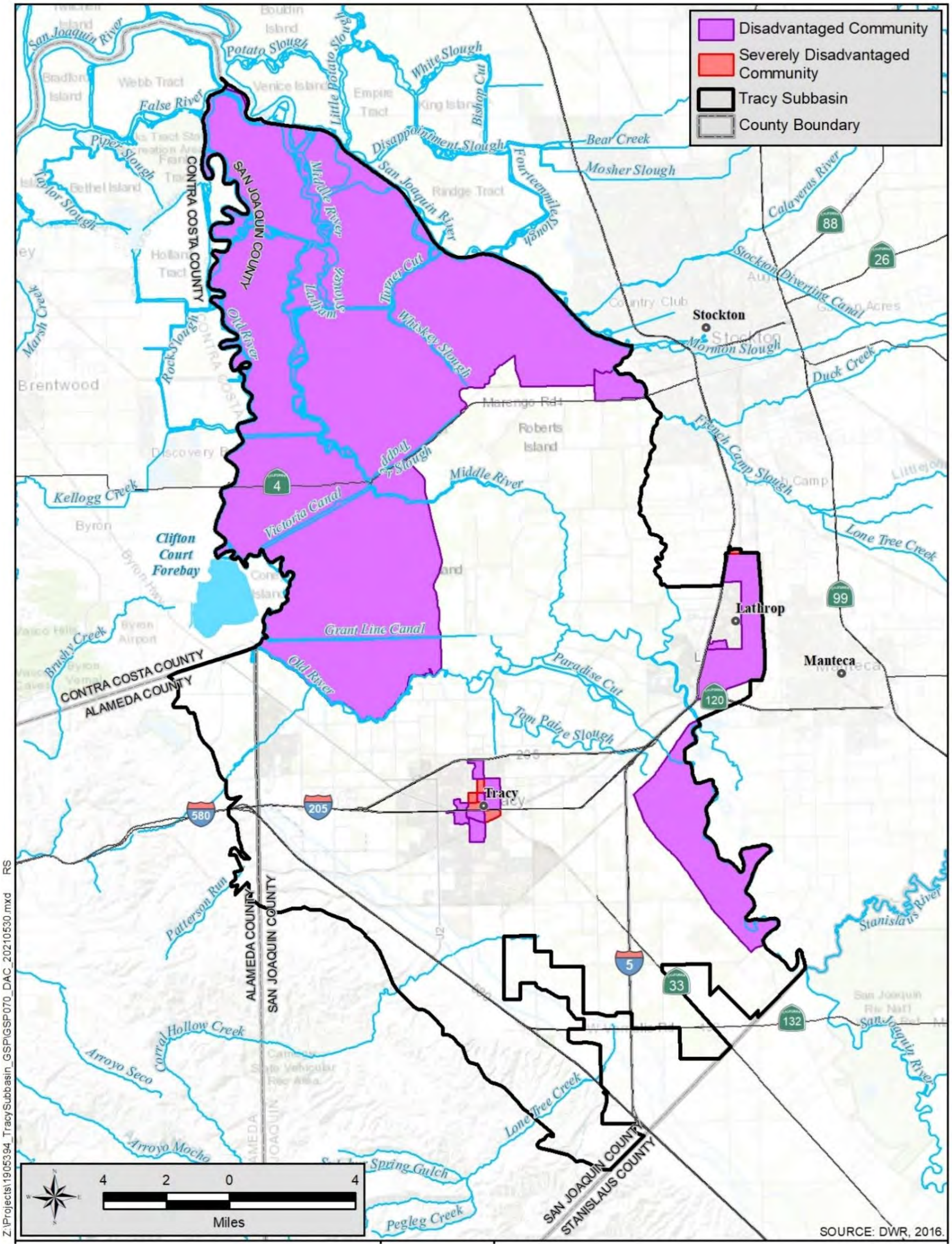


**Figure 3-9. Disadvantaged and Severely Disadvantaged Communities**

## 3.6 Water Use Sectors

Water for urban, agriculture, industrial, and native habitat use is a mixture of surface water only, groundwater only, and a combination of groundwater and surface water.

**Figure 3-10.** Agricultural and Municipal Water Source and Water Use

**,** shows the water supply types for agricultural and urban areas in the Subbasin. Most of the agricultural and urban areas have groundwater and surface water sources and, therefore, can conjunctively use these resources to manage groundwater in those areas. Rural area residents typically have domestic wells and rely upon groundwater (De minimis extractor). Domestic well use of groundwater is not shown on **Figure 3-10.** Agricultural and Municipal Water Source and Water Use

but the general distribution across the Subbasin is shown on **Figure 3-13**.

### 3.6.1 *Municipal and Industrial*

State and federal governments own properties (Deuel Vocational Institution, Sharpe and Tracy defense depots) within the Subbasin and use water for municipal and industrial purposes. These facilities use groundwater as their source of supply.

### 3.6.2 *Urban and Rural*

Portions of the non-Delta land areas, south of the Old River, contain urban developments including the cities of Lathrop and Tracy, and the community of Mountain House. These urban areas are served by three community water systems, as shown on **Figure 3-10.** Agricultural and Municipal Water Source and Water Use

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The cities rely on a combination of surface water and groundwater to meet the water demands within their service area. Mountain House relies solely on surface water supplied through agreements with BBID. **Figure 3-10.** Agricultural and Municipal Water Source and Water Use

**,** shows the water sources in these urban areas.

There are multiple small community and transient water districts in the area that rely solely on groundwater. Rural property owners also rely solely on private wells and groundwater as their source of water throughout the Subbasin. Because of their wide distribution and limited groundwater use their uses of groundwater are not shown on **Figure 3-10.** Agricultural and Municipal Water Source and Water Use

.

### 3.6.3 *Agriculture*

Agriculture in the Subbasin uses surface water and groundwater. In the Delta area of the Subbasin, north of the Old River, agriculture predominately uses surface water. In non-Delta areas, essentially south of the Old River, BBID, and BCID supply surface water, which is augmented by private groundwater supply wells. Groundwater wells only supply about 2 percent of the total agricultural water demand with the remaining demand is met by surface water. Generally, areas above the DMC and California Aqueduct rely on groundwater in the unclassified areas of the Subbasin. A few areas rely solely on groundwater for agricultural purposes. **Figure 3-10.** Agricultural and Municipal Water Source and Water Use

**,** shows the availability of water sources for these agricultural areas.

### 3.6.4 *Native Vegetation and Aquatic Species*

About 500 plant and animal species inhabit the Delta. Rivers, sloughs, and canals in the Subbasin support more than 22 species of native and nonnative fish in the Delta. Subbasin currently contains a range of vegetation and habitat types, including riparian woodlands, seasonal wetlands, farmed wetlands, and non-native grasslands. **Figure 3-11.** NCCAG Vegetation and Wetlands and Managed Wetlands

shows these native vegetation and wetlands areas (NCCAG 2018.)

### 3.6.5 *Managed Habitat*

Some agriculture lands are also used for habitat. Surface water is used to create “managed” habitat areas for waterfowl on some of Delta islands such as Lower Jones Tract and Mandeville Island. After harvest, the fields are flooded to create habitat and allow migrating waterfowl to forage for corn, wheat, and barley that was not harvested.

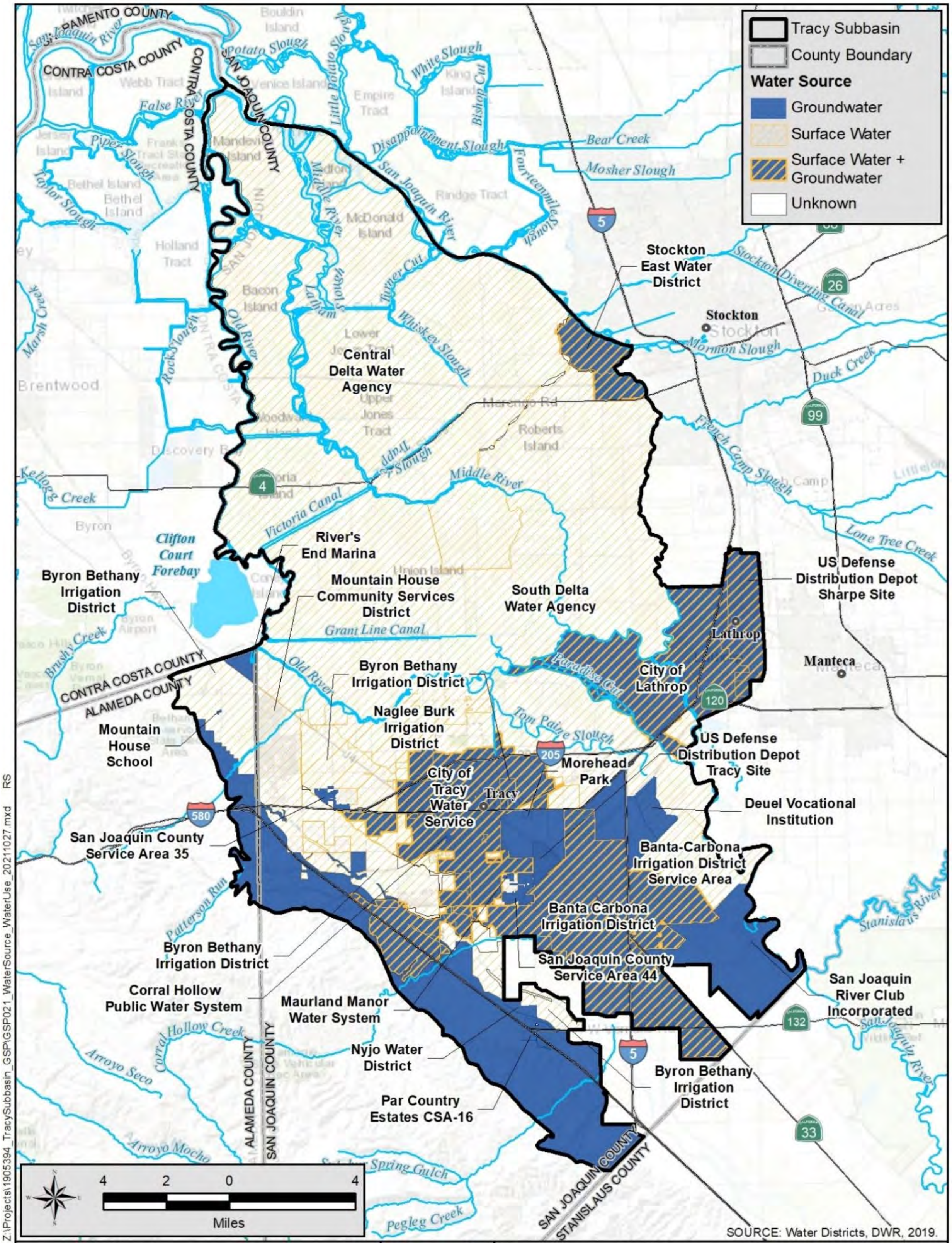


**Figure 3-10. Agricultural and Municipal Water Source and Water Use**

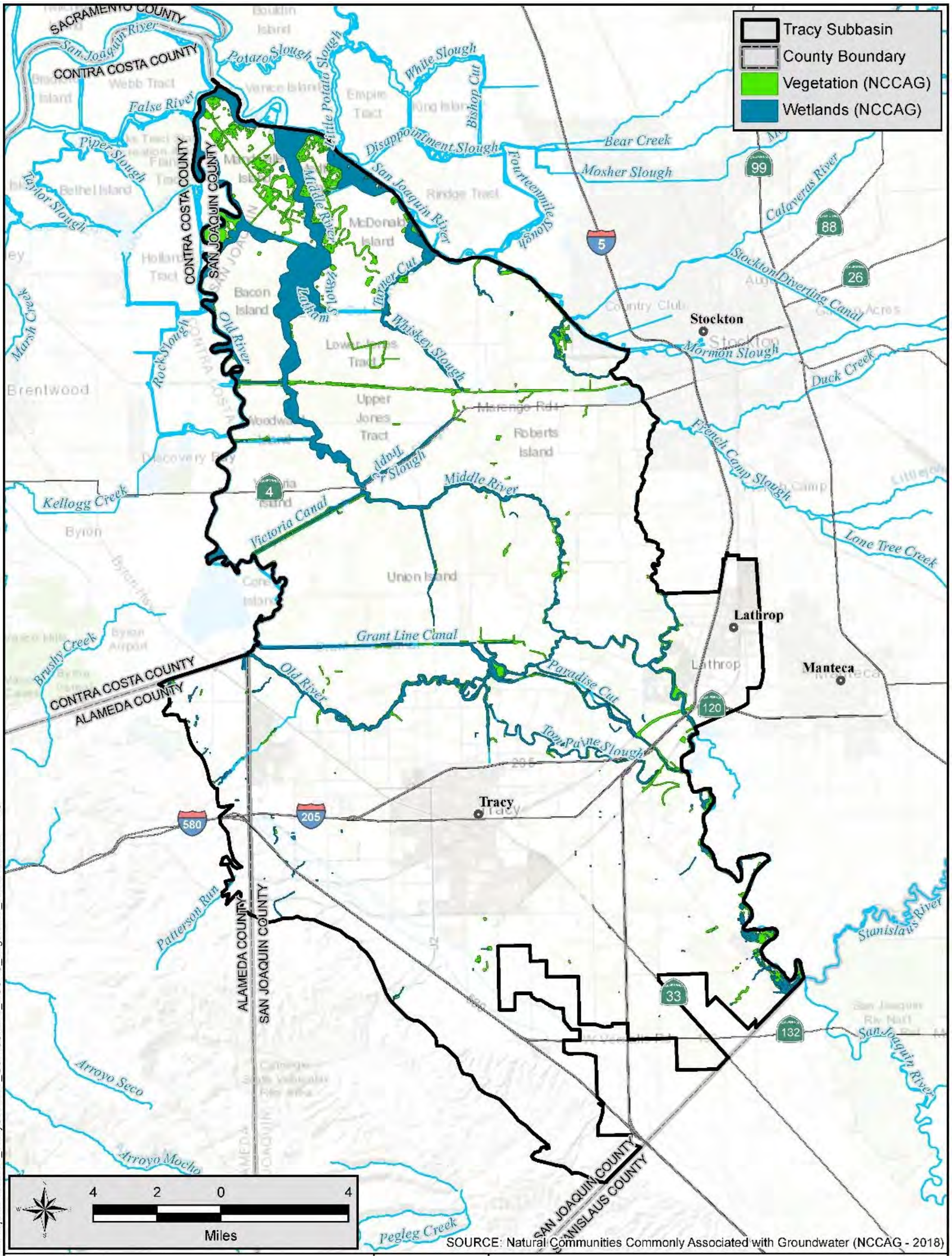


**Figure 3-11. NCCAG Vegetation and Wetlands and Managed Wetlands**

### 3.6.6 *Environmental Cleanup*

There are three large groundwater remediation sites with cleanup in progress in the Subbasin. Groundwater is extracted, treated, and then either placed into percolation basins or injected into the aquifers.

- **Tracy Defense Distribution Depot.** The federal government is in the process of remediating groundwater contamination beneath the 448-acre Tracy Defense Depot site. In 1990, Tracy Defense Depot installed remediation measures to control off-site migration of trichloroethylene (TCE) and perchloroethylene (PCE) to 5 parts per billion. This remedial system will operate up to 30 years to meet remediation goals. Since 1999, the Tracy Defense Depot treats about 90 AFY of groundwater. The treated water at times have been spread onto adjacent lands or injected back into the aquifers but is currently being placed into infiltration galleries, but in all cases returning the water to the aquifers. The pumping is expected to continue through 2026.
- **Sharpe Defense Distribution Depot.** The federal government is in the process of remediating groundwater contamination beneath portions of the 724-acre Sharpe Depot site. Groundwater is contaminated with volatile organic compounds, primarily TCE and PCE. Recent testing of the groundwater has also found the presence of perfluorooctanesulfonic and perfluorooctanoic acids, commonly known as PFOS and PFAS. In 2019, the remediation effort pumped about 900 AFY and it is expected to continue through at least 2040. Treated groundwater is placed into basins and allowed to percolate back into the aquifers.
- **Occidental.** The former Occidental Chemical manufacturing plant, now occupied by Simplot, is about 185 acres and is a Superfund site. Occidental Chemical is responsible for remediation of the contamination. Groundwater has been impacted by Sulfolane, dibromochloropropane (DBCP) and ethylene dibromide (EDB) along with the high concentration of ammonia, sulfate, and total dissolved solids (as high as 25,000 milligrams per liter [mg/L]). Groundwater remediation consists of pumping contaminated groundwater and treatment and then injecting the treated water into the aquifers below the Corcoran Clay. About 450 to 500 AFY of groundwater was extracted in 2018-2019 and treated before being injected back into the ground.

## 3.7 Water Source Types

In general, water agencies in the Subbasin as a whole, meet agricultural water demands almost entirely (97%) with surface water (about 403,500 AF) with minor amounts (12,797 AF) of groundwater (DWR BP 2019). The groundwater use is split about evenly between urban (5,501 AF) and agricultural (6,296 AF) use.

### 3.7.1 *Groundwater*

There are about 2,400 "production" wells in the subbasin, of which about 450 are production wells (agricultural and municipal), and about 1,950 domestic wells (DWR 2019b), although these estimates vary (DWR 2019a). DWR classifies wells as "production" wells if the well casing is greater than or equal to 4 inches in diameter, and the total depth is greater than or equal to 22 feet. Most of the production wells in the Subbasin are domestic wells, which may be classified as de-minimis extractors who pump less than 2 AFY. **Table 3-2** summarizes the number of wells by type.

The cities of Lathrop and Tracy rely, to some extent, on groundwater as well as agricultural (private well owners) in the non-Delta portions of the Subbasin. Where water services are not available, rural homeowners use domestic wells. The Deuel Vocational Institute and Sharpe and Tracy Defense depots also rely upon wells for their water supply. The Tracy Depot uses about 100 AFY.

There are seven active mining operations in the Subbasin. These quarries produce sand, gravel, and other aggregate. Three of the seven quarries are located at the intersection of Interstates 580 and 5, south of State Route 132. These quarries operate above historic groundwater levels in the area, so groundwater use is incidental to quarry operations and not due to dewatering operations. The remaining quarries are located near and around the Tracy Municipal Airport. The quarries use groundwater as their source of water supply. Additionally, the Brown Sand mining operation is located south of Interstate 5, between State Route 120 and Interstate 205. The pits expose the groundwater surface and mining is done via dredge lines under water.

**Table 3-2. Well Type Summary**

| Well Type | Count |
|---|---|
| Production – Domestic | 1,958 |
| Production – Agriculture | 373 |
| Production – Municipal | 74 |
| **Production Well Total** | **2,405** |

### 3.7.2 *Surface Water*

Surface water in the Subbasin is obtained from the Sacramento and San Joaquin rivers and the Delta, either directly or indirectly. Agriculture in the Delta-portion of the Subbasin obtains its surface water supplies directly from the rivers and the Delta, while the non-Delta portions of the Subbasin obtain the water either directly or indirectly from the CVP facilities and the Old River.

Water is imported into the Subbasin for municipal water from the Stanislaus River, by SSJID through the South County Surface Water Supply Project (SCSWSP). The SCSWSP supplies Stanislaus River water to the cities of Manteca, Escalon, Lathrop, and Tracy using SSJID pre-1914 water right to water from the Stanislaus River.

In the non-Delta regions of the Subbasin, BBID, BCID, and Naglee-Burk Irrigation District, hold pre- and post-1914 water rights contracts and other agreements to obtain water from the San Joaquin River, Old River and CVP. BBID has an agreement to provide Tracy with surface water, based on post-1914 water rights. BBID has a wholesale agreement with CSA 50, which is located just to the west of the City of Tracy and Mountain House Community Services District.

### 3.7.3 *Recycled Water*

The cities of Lathrop and Tracy have wastewater treatment plants and are actively pursuing recycled water supplies. **Figure 3-12** shows the location of the treatment plants. The cities are planning on recycled water use to offset potable water demands for future developments as well as for current uses such as parks, business park landscaping, and industry.

The City of Lathrop currently treats wastewater at its Consolidated Treatment Facility plant and supplies tertiary-treated water to several agricultural lands located within the City limits. The City has approximately 30 miles of recycled water pipes (purple pipes) installed and is ready to begin serving street landscape areas, parks, and playing fields.

The City of Tracy owns and operates the Tracy Wastewater Treatment Plant and discharges tertiary-treated wastewater to Old River. The City of Tracy has planned and constructed recycled water pipeline infrastructure, including recycled water transmission pipelines and pump stations, to provide recycled water to parks, professionally managed landscape areas, and other non-potable uses. The pipeline will eventually be extended to connect to the Central Valley Project Delta Mendota Canal. The recycled water pipeline and pump stations have been constructed but a permit has not yet to be obtained to use and distribute the recycled water. New developments in the City are required to include recycled water distribution systems in accordance with the City's Recycled and Non-Potable Water Ordinance.

Mountain House Community Services District currently owns and operates a wastewater treatment plant and discharges tertiary-treated wastewater to Old River. The District has no recycled water use and does not have any projects for any future recycled water use.

Both depots (Sharpe Defense Distribution and Tracy Defense) have wastewater treatment plants. The Sharpe Depot currently places its treated wastewater into percolation basins where the water returns to the aquifers. After the Depot is decommissioned, the City of Lathrop will convey the wastewater to the City of Manteca to provide treatment, outside of the Subbasin. At the Tracy Depot, about 20 AFY of treated wastewater is placed into percolation basins where it percolates back to the aquifers.

The Deuel Vocational Institution has a sewage treatment plant that discharges their treated water to the Deuel Drain, which is tributary to the San Joaquin River. The state is planning to deactivate Deuel Vocational Institution by September 2021.

### 3.7.4 *Water Reuse*

Excess applied surface water from agricultural fields and from urban areas in and around the cities either percolates into the soils or flows into drains where it is recaptured by the irrigation districts, drainage districts, or reclamation districts in the Subbasin. Shallow groundwater may also discharge to these drains, but only in areas where the groundwater surface is near the ground surface.

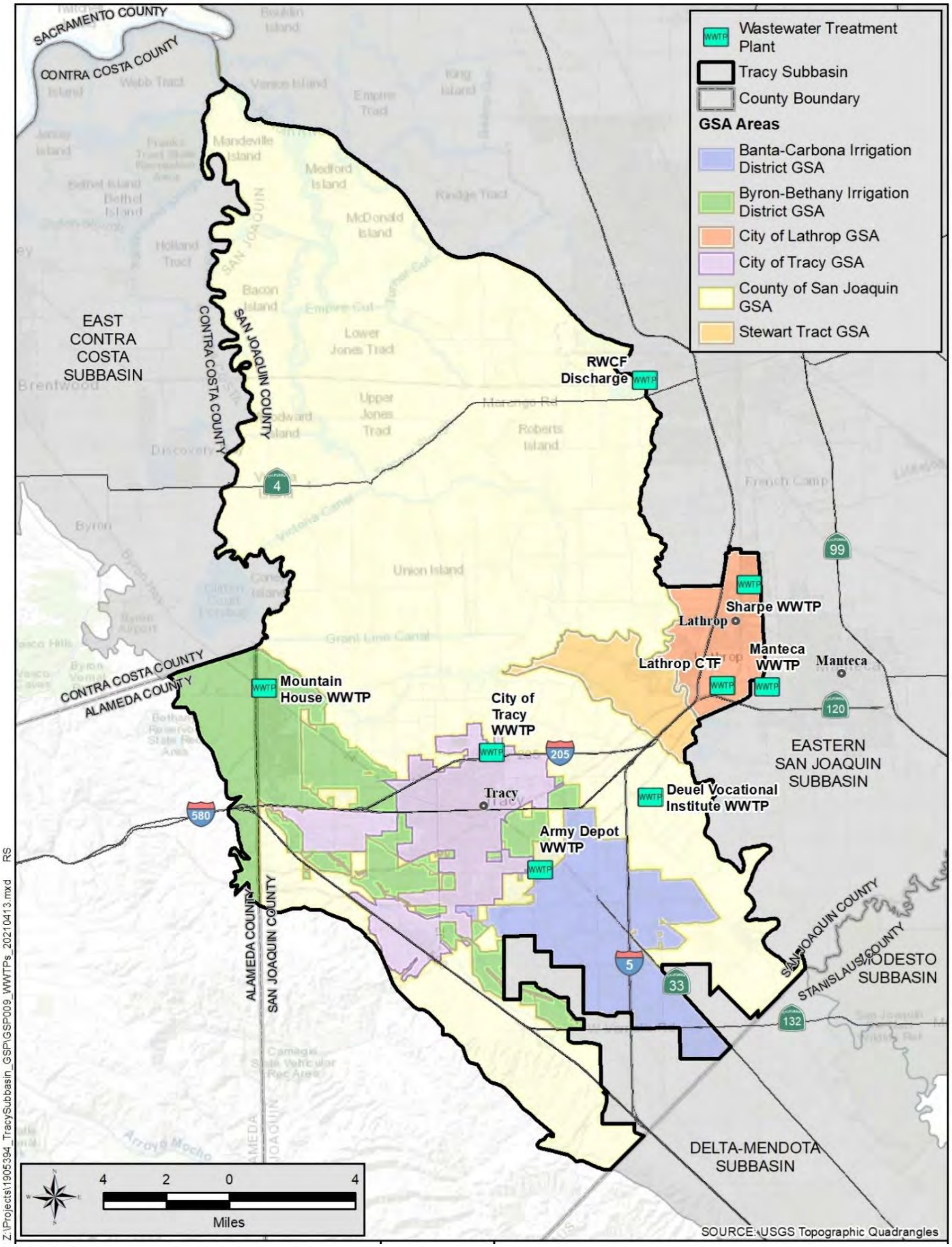


**Figure 3-12. Wastewater Treatment Plants**

## 3.8 Density of Wells

Groundwater in the Subbasin is used for municipal, industrial, irrigation, domestic, stock watering, frost protection, and other purposes (*refer to* **Table 3-2** which provides a summary of the number of wells by general types in the Subbasin). It should be noted that the number of wells is based on well logs filed and contained within DWR's Water Well Drillers Reports and may not reflect the actual number of active wells; many of the wells contained in DWR files may have been destroyed.

**Figure 3-13** through **Figure 3-18** show the distribution of domestic, production, and municipal wells per square mile and the minimum depths of the wells (DWR 2019b). There are considerably more wells in the non-Delta areas, south of the Old River, than in the Delta area of the Subbasin. The depths of wells are generally deeper in the non-Delta portion of the Subbasin as compared to the Delta portion of the Subbasin. In general, the domestic wells are constructed to shallower depths than the production wells. It is unknown if this is an artifact of very old wells, pre-1950, being included in the database when groundwater levels were much shallower and may have since been destroyed due to lower groundwater levels. Overall, the municipal wells are constructed deeper than either the domestic or production wells.

Outlines of DACs and SDACs are also shown on the domestic and municipal well density. **Figures 3-12 and 3-16** show that within the Delta area, the communities are not dense residential areas and likely use domestic wells. There are many sections where disadvantage communities are designated but no domestic or municipal wells are present. A few DAC and SDAC communities are present within the cities of Lathrop and Tracy where municipal water supplies are available. In the southern portion of the Subbasin, adjacent to the San Joaquin River, there are a couple of large areas designated as DAC and SDACs. These areas have a relatively high density of domestic wells, (*see* **Figure 3-12**), which likely provide water to people in these areas.

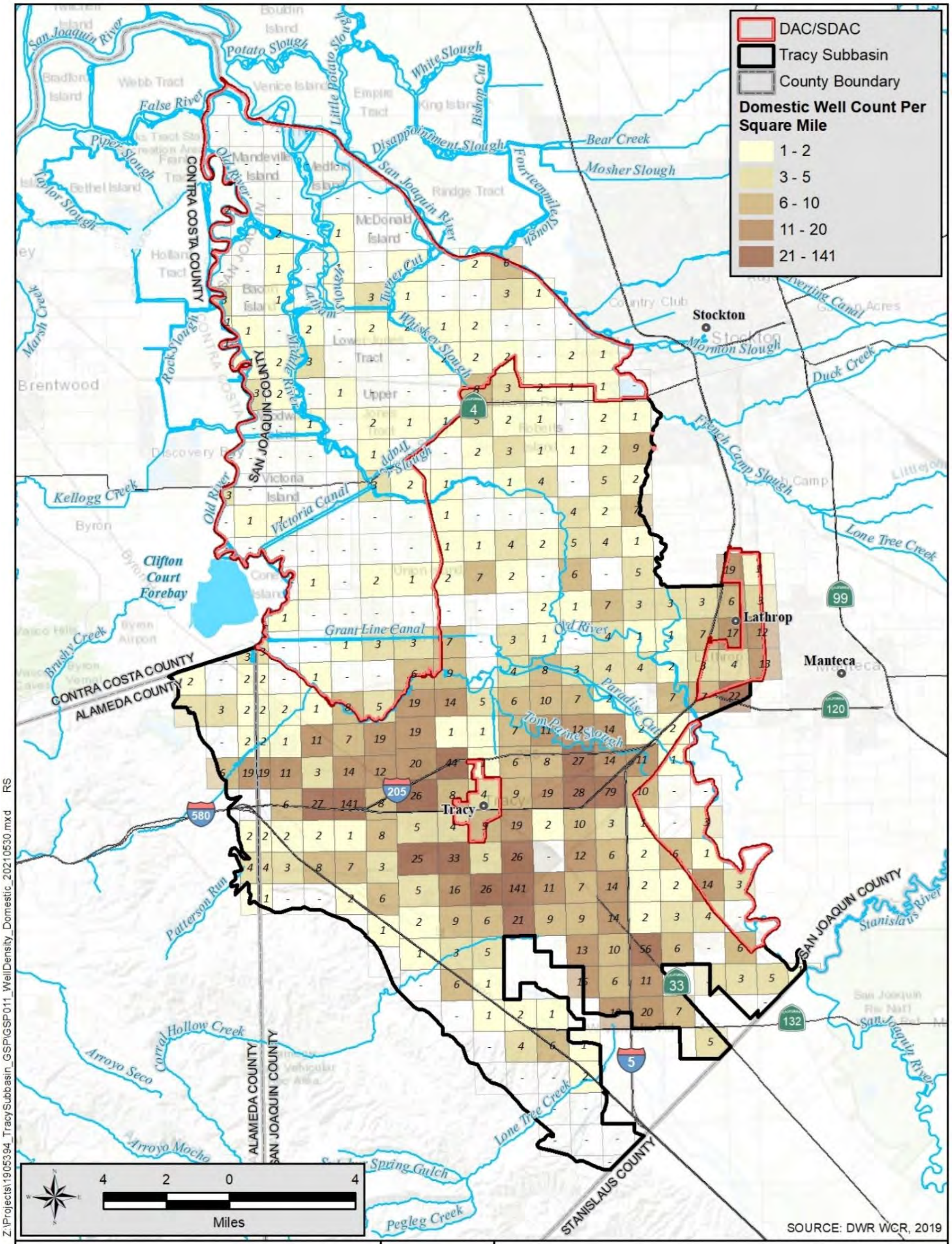


**Figure 3-13. Density of Domestic Wells Per Square Mile**

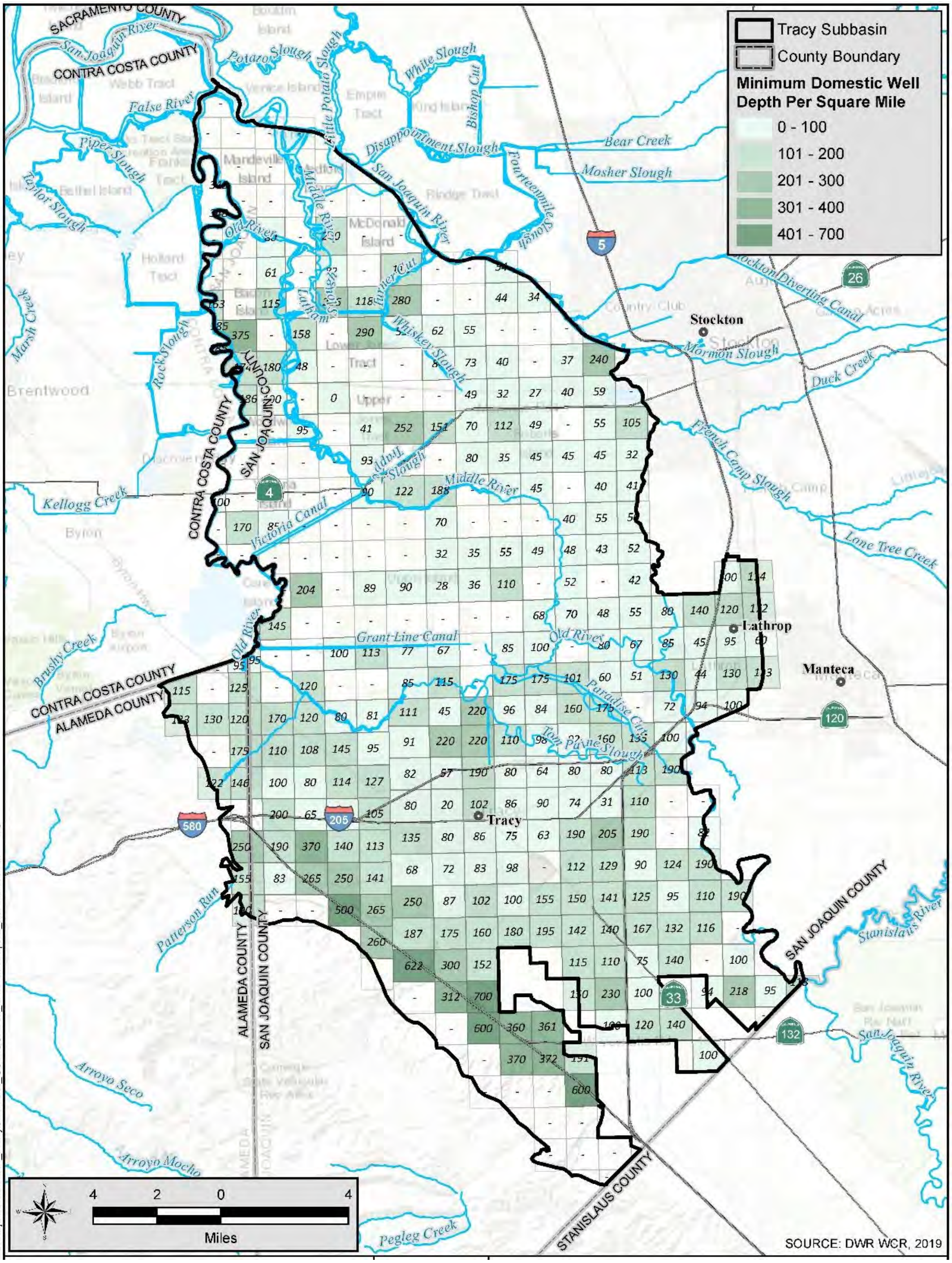


**Figure 3-14. Minimum Depths of Domestic Wells Per Square Mile**

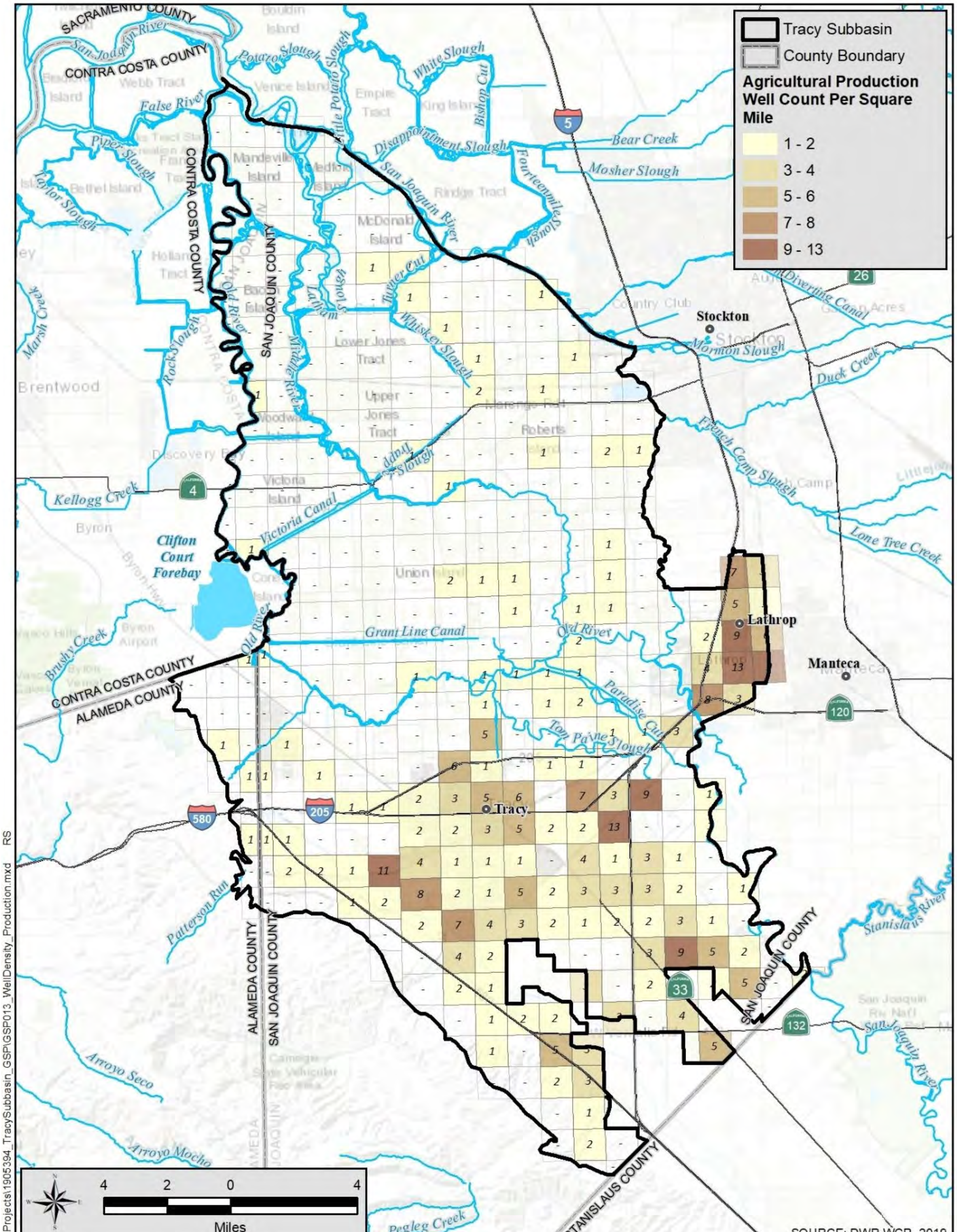


Figure 3-15. Density of Production Wells Per Square Mile

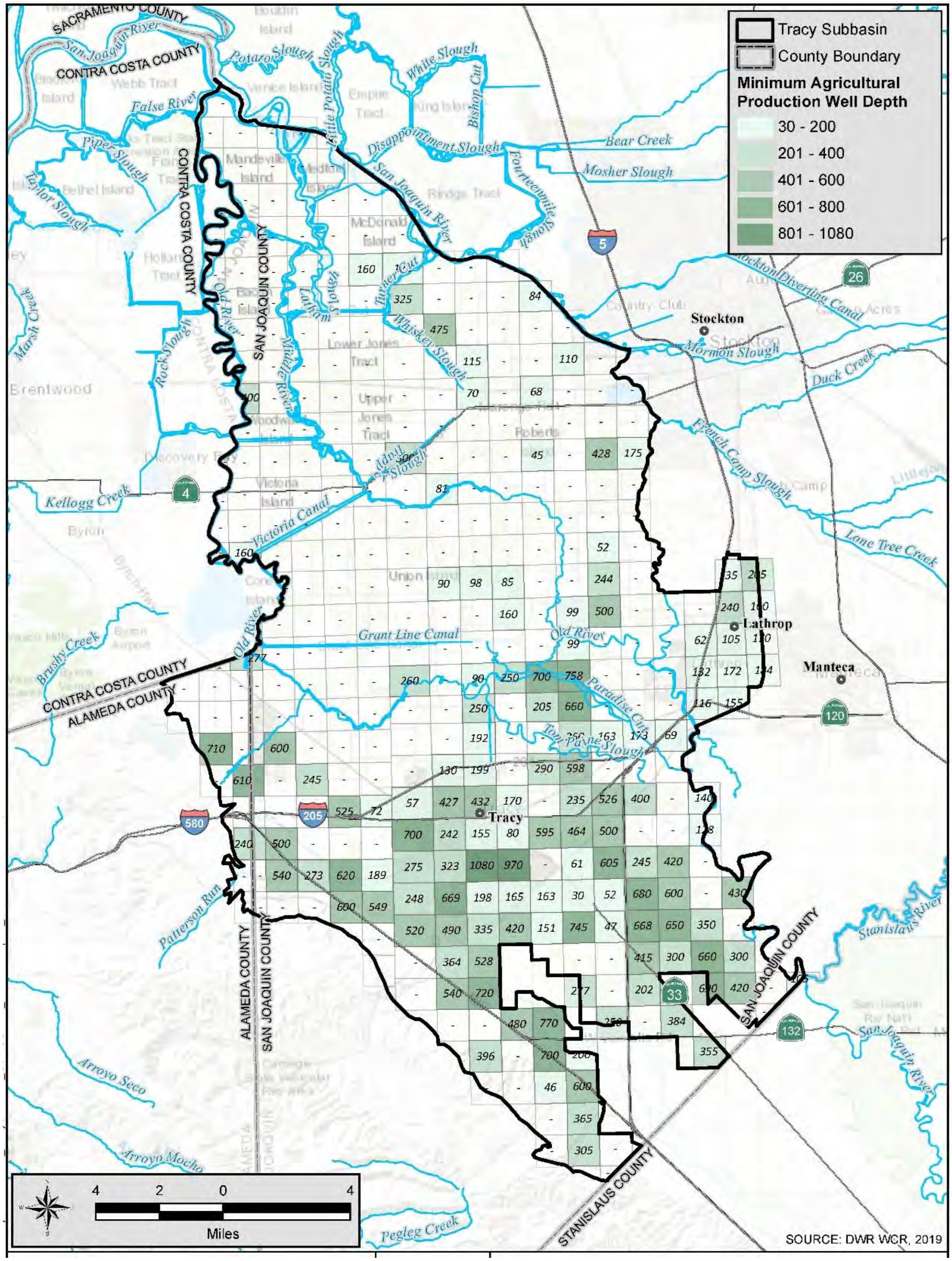


**Figure 3-16. Minimum Depths of Production Wells Per Square Mile**

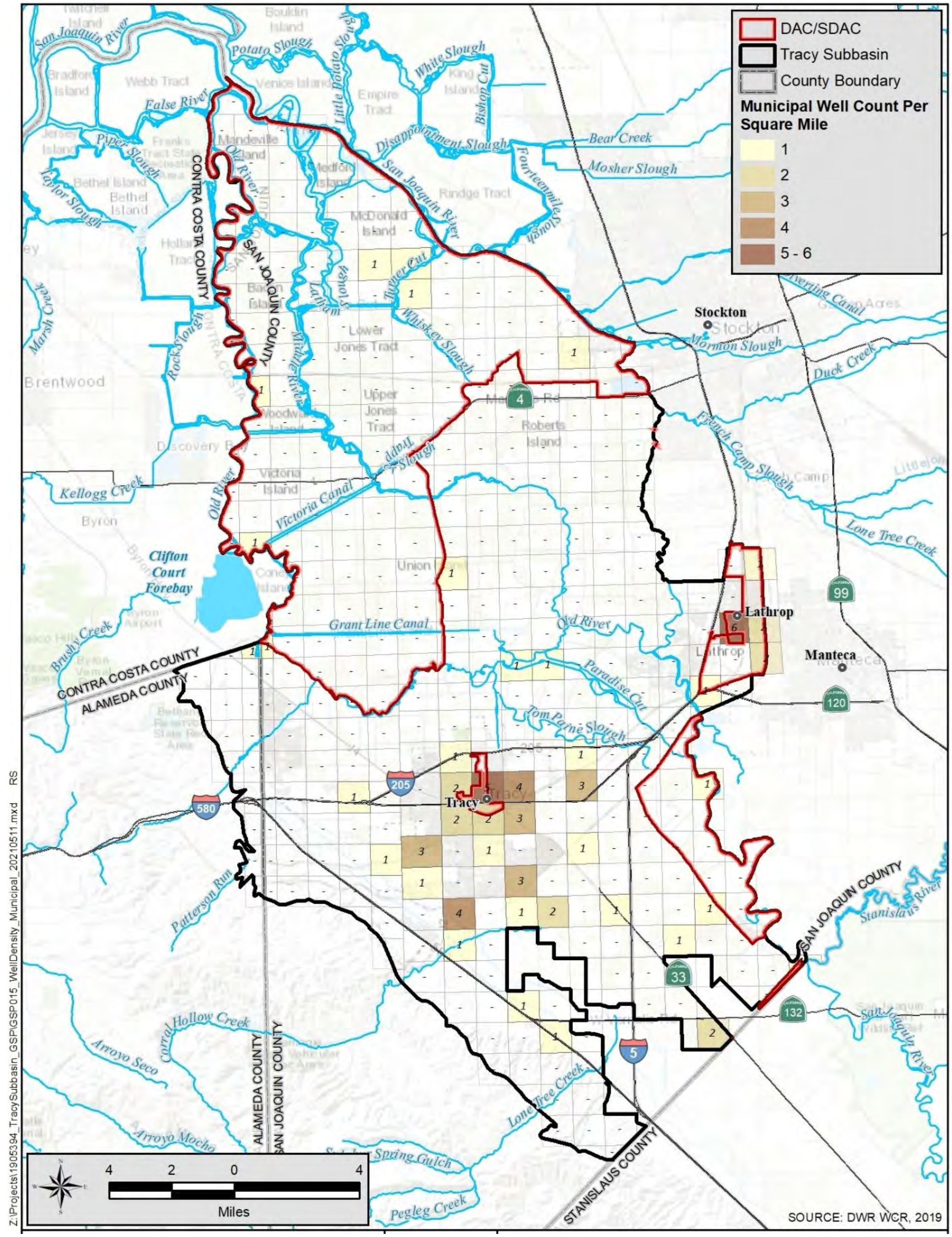


Figure 3-17. Density of Municipal Wells Per Square Mile

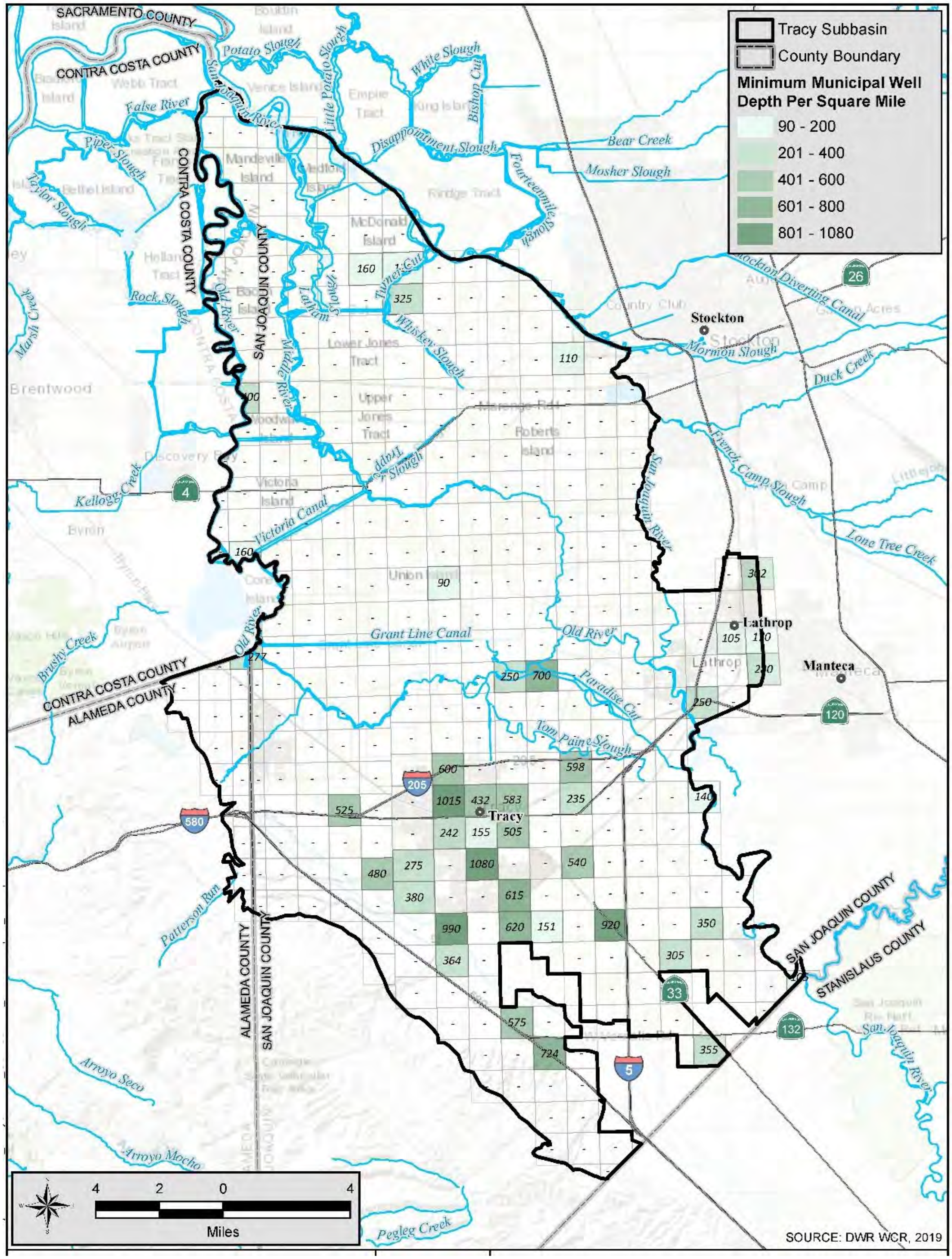


**Figure 3-18. Minimum Depths of Municipal Wells Per Square Mile**

## 3.9 Existing Water Resources Management Plans

In 1992, the California State Legislature adopted Assembly Bill (AB) 3030, and in 2002 the Legislature enacted Senate Bill (SB) 1938. SB 1938 provides that the adoption of a groundwater management plan will be a prerequisite to obtaining funding assistance for groundwater projects from funds administered by DWR. These two pieces of legislation were incorporated into the State Water Code, Section 10753, to encourage local public agencies/water purveyors to voluntarily adopt formal plans to manage groundwater resources within their jurisdictions. The 2007 Tracy Regional Groundwater Management Plan covers the entire Subbasin. This existing Groundwater Management Plan will be replaced with this GSP. The following subsections provide a summary of other existing groundwater management plans that the GSAs plan to incorporate and use in the development of this GSP to manage groundwater resources in the Subbasin.

### 3.9.1 *Westside-San Joaquin County Integrated Regional Water Management Plan*

The Westside-San Joaquin (W-SJ) Integrated Regional Water Management Plan (IRWMP) covers a large planning area and includes much of the Subbasin and the Delta Mendota Subbasin to the south. The IRWMP covers the areas within BBID, BCID, and the City of Tracy, but does not include the Delta portion or fringe areas in the Subbasin. The City of Lathrop belongs to the Eastern San Joaquin Integrated Regional Water Management Plan.

The 2019 W-SJ IRWMP emphasizes multiagency collaboration, stakeholder involvement, regional approaches to water management, water management involvement in land use decisions, and project monitoring to evaluate results of current practices. The W-SJ IRWMP identifies projects that help achieve regional objectives while working to address water-related challenges in the region.

The San Luis Delta Mendota Water Authority (SLDMWA), acting as the Regional Water Management Group for the region, has coordinated the evolution of planning documents and regional objectives since 2001. Plan development and updates have been iterative and driven by stakeholder participation resulting in an overarching goal of providing a more reliable water supply, protecting agricultural, municipal, and environmental water uses, and meeting community needs (including DACs), by improving water supply sustainability, water quality, and drainage.

The IRWMP also includes specific projects and implementation programs and agreements between different affected agencies to identify projects to put conjunctive use in place.

### 3.9.2 *Urban Water Management Plans*

The Urban Water Management Planning Act was developed in response to the state's water shortages, droughts, and other factors. Every urban water supplier that provides over 3,000 acre-feet of water annually or serves more than 3,000 urban connections is required to submit an Urban Water Management Plan (UWMP). UWMP requirements include updating water shortage contingency plans, extended drought risk assessments, and energy intensity reporting. UWMP plans include a report on the progress that urban water suppliers are making in meeting their water use targets, current and projected water demands, current and projected water sources, water management actions to improve supply reliability, and an evaluation of the sufficiency of supplies to meet the forecasted demands under both normal and drought conditions. Entities within the Subbasin with UWMP plans include:

- City of Tracy
- City of Lathrop
- Mountain House Community Services District

UWMP plans from 2015 were used to develop this GSP. Updated UWMP plans were adopted in 2021, but due to their recent release date, the information from these plans could not be incorporated into this GSP. The 5-year GSP update will include information from these plans.

Each of the cities have developed and are implementing water conservation measures to promote efficient water management practices as required by the Water Conservation Act of 2009 and documented in each of their UWMP plans. The agencies have developed Water Shortage Continency Plans that comply with the 2015 California State Water Resources Control Board (State Water Board) mandated water conservation standards set during the recent drought.

### 3.9.3 *Agricultural Water Management Plans*

The Water Conservation Act of 2009 (SB X7-7) requires agricultural water suppliers serving more than 25,000 irrigated acres (excluding recycled water deliveries) to adopt an Agricultural Water Management Plan (AWMP) and submit to DWR. These plans must include reports on the implementation status of specific Efficient Water Management Practices required under SB X7-7. Required components of an AWMP include:

- Annual water budget
- Identification of water management objectives to improve system efficiency
- Quantification of water use efficiency with all water uses being accounted for include crop water use, agronomic use, environmental use, and recoverable surface flows
- A Drought Plan, for periods of limited water supplies, that describes actions for drought preparedness

Districts which have adopted AWMPs are:

- BBID
- BCID

The BBID and BCID AWMPs comply with SB X7-7 of 2009.

### 3.9.4 *Delta Protection Commission & Delta Stewardship Council*

The Delta Protection Commission (DPC) is an organization established by the Delta Protection Act of 1992, to develop a long-term resource management plan for the Delta Primary Zone. The primary goal of the DPC is to, "…protect, maintain and, where possible, enhance and restore the overall quality of the delta environment" The regional plan is to protect agricultural land within the Primary Zone from the intrusion of nonagricultural uses.

The Delta Stewardship Council is a California State Agency formed as a result of the Delta Reform Act in November 2009. The Council is made up of seven members who provide a broad, statewide perspective and diverse expertise spanning agriculture, science, the environment, public service, and beyond. The membership is made up of four governor appointees, one Senate and one Assembly appointee, with the final member being the Chair of the DPC.

The Council was created to advance the state's coequal goals for the Delta – a more reliable statewide water supply and a healthy and protected ecosystem, both achieved in a manner that protects and enhances the unique characteristics of the Delta as an evolving place. To do this, the Delta Reform Act required that the Council develop an enforceable long-term sustainable management plan for the Delta to ensure coordinated action at the federal, state, and local levels. The Delta Plan, adopted in 2013, includes both regulatory policies and non-binding recommendations (Delta Stewardship Council 2013).

### 3.9.5 *Salt/Nutrient Management Plan*

In February 2009, the State Water Board adopted Resolution No. 2009-011, which established a statewide Recycled Water Policy. Central to this Policy was the requirement that local water and wastewater entities, together with local salt- and nutrient-contributing stakeholders, develop a Salt and Nutrient Management Plan for each groundwater basin and subbasin in California. The plans include management strategies, plans for stormwater and recycled water use, a monitoring program, and an antidegradation analysis.

In response, the San Joaquin County & Delta Water Quality Coalition was established to help irrigated agriculture meet the requirements of the California Regional Water Quality Control Board's (RWQCB) Irrigated Lands Regulatory Program (ILRP) in San Joaquin County (including all of the Subbasin), Calaveras County, and Contra Costa County. The Coalition is operated and governed by the San Joaquin County Resource Conservation District. The Central Valley Regional Water Quality Control Board (CVRWQCB) approved a new General Order for the San Joaquin County and Delta Watershed area on March 12, 2014.

The Coalition developed a Groundwater Quality Assessment Report and a comprehensive Groundwater Quality Management Plan. The Groundwater Quality Management Plan presents a baseline picture of groundwater quality, establishes a framework under which salt and nutrient issues can be managed, and streamlines the permitting process of new recycled water projects while meeting water quality objectives and protecting beneficial uses.

### 3.9.6 *Water Quality Control Plan*

In 2018, the CVRWQCB prepared a Water Quality Control Plan for the Sacramento and the San Joaquin River Basins (Basin Plan) along with subsequent amendments (CVRWQCB, 2018). The objective of the Basin Plan is to show how the quality of the surface water and groundwater in the San Joaquin and Sacramento regions should be managed to provide the highest water quality reasonably possible. Water uses and water benefits vary depending upon the location in the basins. Water quality is an important factor in determining use and benefit. For example, drinking water must be of higher quality than the water used to irrigate pastures. Both are legitimate uses, but the quality requirements for irrigation are different from those for domestic use. The Basin Plan recognizes such variations.

The Basin Plan lists beneficial users, describes the water quality which must be maintained to allow those uses, and contains an implementation plan, State Water Board and CVRWQCB plans and policies to protect water quality, and statewide surveillance and monitoring as well as regional surveillance and monitoring programs. Present and potential beneficial uses for inland waters in the basins are listed below:

- Surface water and groundwater as municipal (water for community, military, or individual water supplies)
- Agricultural
- Groundwater recharge
- Recreational water contact and non-contact
- Sport fishing
- Warm freshwater habitat
- Wildlife habitat
- Rare, threatened, or endangered species
- Spawning, reproduction, and/or early development of fish

Water Quality Objectives for both groundwater (drinking water and irrigation) and surface water are provided in the Basin Plan.

## 3.10 Existing Water Resources Monitoring Programs

Existing management and monitoring plans in the Subbasin are described below. Some of the programs will be incorporated into the GSP monitoring network or were used to develop this GSP.

### 3.10.1 *Groundwater Level Monitoring Programs and Networks*

Historical groundwater level data measurements were made by DWR, local water districts, and the United States Geological Survey (USGS). Information from these monitoring programs have been incorporated into this GSP.

Groundwater level monitoring is being performed by designated monitoring entities in the Subbasin as part of the California Statewide Groundwater Elevation Monitoring (CASGEM) program. This network of groundwater level monitoring wells provides data that is the foundation for many groundwater management decisions. San Joaquin County is the designated reporting agency in the Subbasin. DWR continues to monitor groundwater levels in the Subbasin. The CASGEM groundwater level monitoring network is shown on **Figure 3-19**.

The San Joaquin County Flood Control and Water Conservation District (SJCFCWCD) publishes semi-annual groundwater reports covering groundwater conditions in San Joaquin County. These reports include tables, hydrographs, and maps on groundwater levels. Groundwater level results from each semi-annual report are compared with values from the previous period. Groundwater level data collected by the district include CASGEM and additional data. The data are maintained by the SJCFCWCD.

**Appendix C** provides the groundwater level monitoring well construction details. Some, not all, of the wells are dedicated nested monitoring wells (small diameter wells that are screened opposite individual aquifers).

There are three large remediation programs with extensive monitoring networks in the Subbasin (refer to **Chapter 3.6.6 – Environmental Cleanup**). Selected wells from these sites have been incorporated into the Subbasin monitoring network. In addition to these monitoring wells, the City of Lathrop has a monitoring well network associated with the distribution of recycled water onto agricultural lands. Some of these wells have also been incorporated into the monitoring network.

USGS monitors thousands of wells across the United States including10 wells within the Subbasin which have been incorporated into the monitoring network. The extensive water data, which includes manual measurements of depth to groundwater in wells throughout California, are stored in the National Water Information System (NWIS) online database. The database stores historical observations of active and discontinued sites in addition to current conditions with measurements transmitted hourly. Groundwater level measurements at these wells are taken approximately once per quarter.

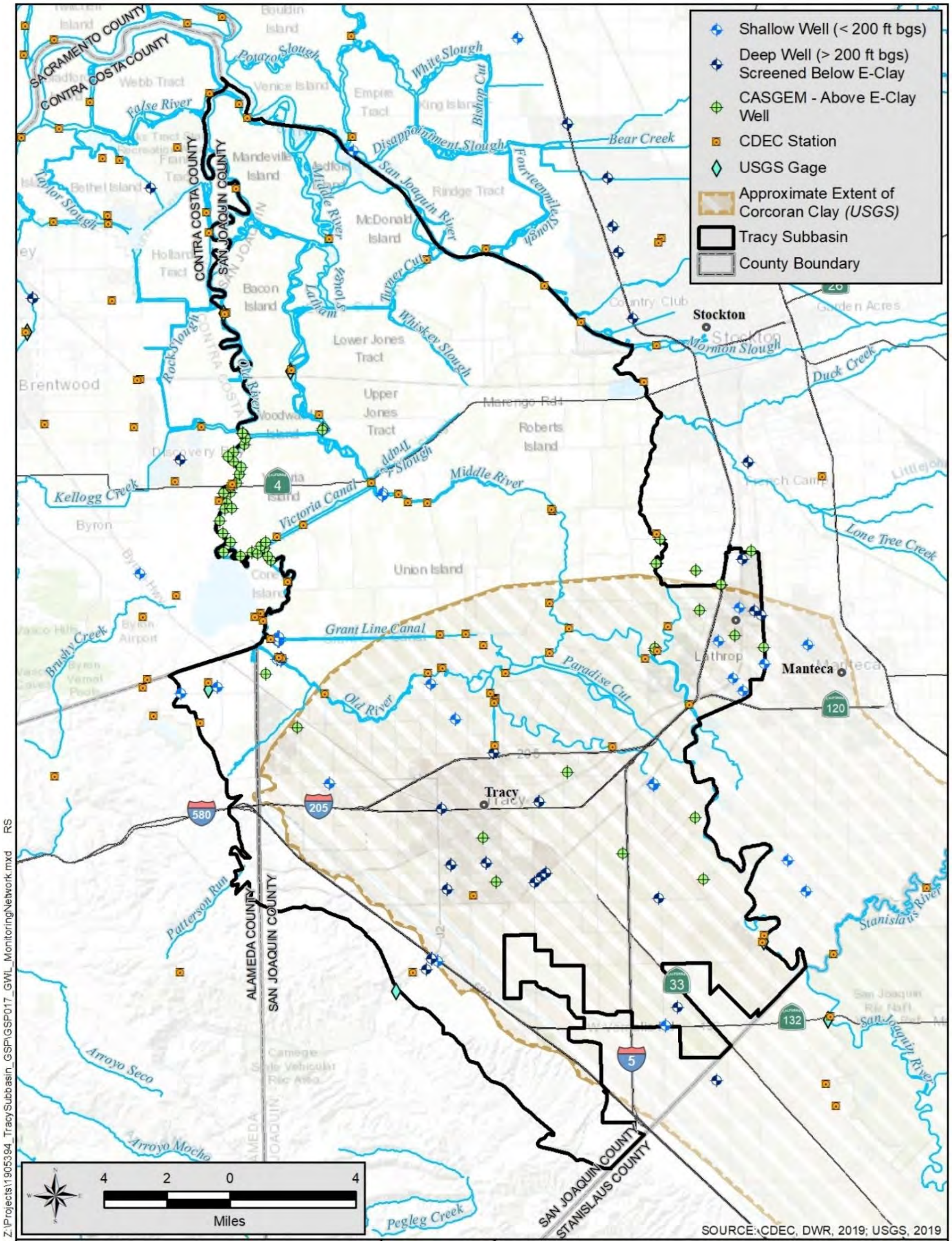


**Figure 3-19. Groundwater Level Monitoring Network**

## 3.10.2 *Groundwater Quality Monitoring Programs and Network*

Groundwater quality is monitored under several different programs and by different agencies, including:

- **Municipal and community water purveyors**. Municipal and community water purveyors (serving 15 or more connections) must collect water quality samples on a routine basis for compliance monitoring and reporting to State Water Board's Division of Drinking Water (DDW).
- **USGS Groundwater Ambient Monitoring and Assessment (GAMA)**. The USGS collects water quality data on a routine basis under the GAMA program. The previously discussed USGS NWIS contains groundwater quality data in addition to groundwater level measurements. Groundwater quality results in NWIS relate to GAMA records, but there is no direct link between the two databases. Some NWIS sites have a state identification (ID) listed, which is a common identifier used for wells. This indicates these wells can be connected to other databases using the state ID information. However, differences in the format of the state ID between NWIS and other databases create challenges in cross-referencing between databases. In this GSP, NWIS water quality measurements are utilized for basin characterization but are acquired from other programs.
- **Irrigated Lands Regulatory Program**. As part of the ILRP, the San Joaquin County & Delta Water Quality Coalition members monitor drinking water wells on enrolled parcels for nitrates. This requirement began January 1, 2019, based on the February 7, 2018, revision of ILRP Waste Discharge Requirements for the Eastern San Joaquin River Watershed by the State Water Board. The ILRP program is in the process of developing a comprehensive monitoring network for future use to address the ILRP data objectives. The San Joaquin County & Delta Water Quality Coalition members also monitor domestic wells for nitrate in high vulnerability areas.

**Figure 3-20** shows the location of these water quality monitoring wells, just those that are municipal water supply wells with known construction details that could be assigned to a single aquifer. Information collected by these programs have been incorporated into this GSP. Due to most of these wells being community water supply wells, their construction details are not provided.

In addition to these monitoring programs, there are multiple sites that are monitoring groundwater quality as part of investigation or compliance monitoring programs through the CVRWQCB.

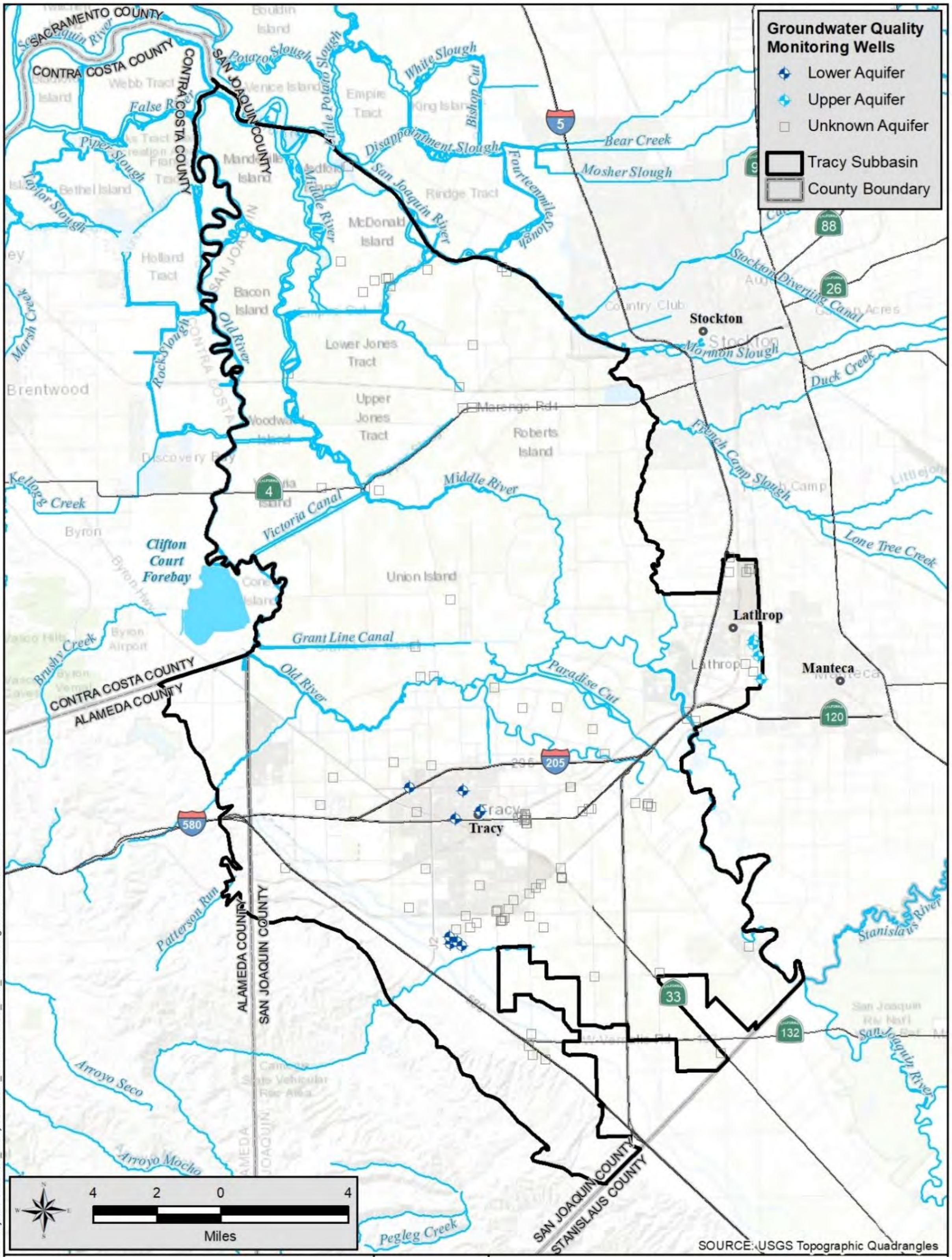


**Figure 3-20. Groundwater Quality Monitoring Network**

### 3.10.3 *Surface Water Monitoring Networks*

DWR and USGS maintain surface water gages along the rivers, creeks, and sloughs in the Subbasin. Dependent upon the station, DWR or the USGS may measure just the level of water (stage) or the discharge. **Figure 3-21** shows the location of these gages. This GSP uses the data collected by these agencies from some of these gages.

### 3.10.4 *Precipitation Monitoring Network*

Precipitation is measured at two stations located in the Subbasin (*see* **Figure 3-21**). This GSP uses the data collected by various agencies that maintain and report the data.

The Tracy Carbona rain station (TCR, Index Number 04-899-05) has the Subbasin's longest and most continuous record of precipitation, from 1935 through present. It is located in the southern portion of the Subbasin (*see* **Figure 3-21**) and is considered representative of the entire Subbasin. The average precipitation, for this 69-year period is 10.83 inches. Using the state climatologist definition of a recent representative period of years, water year 1988-89 through 2008-09, is 10.95 inches at this location. **Figure 3-22** shows the annual precipitation for water years (October 1 – September 31 of any given year).

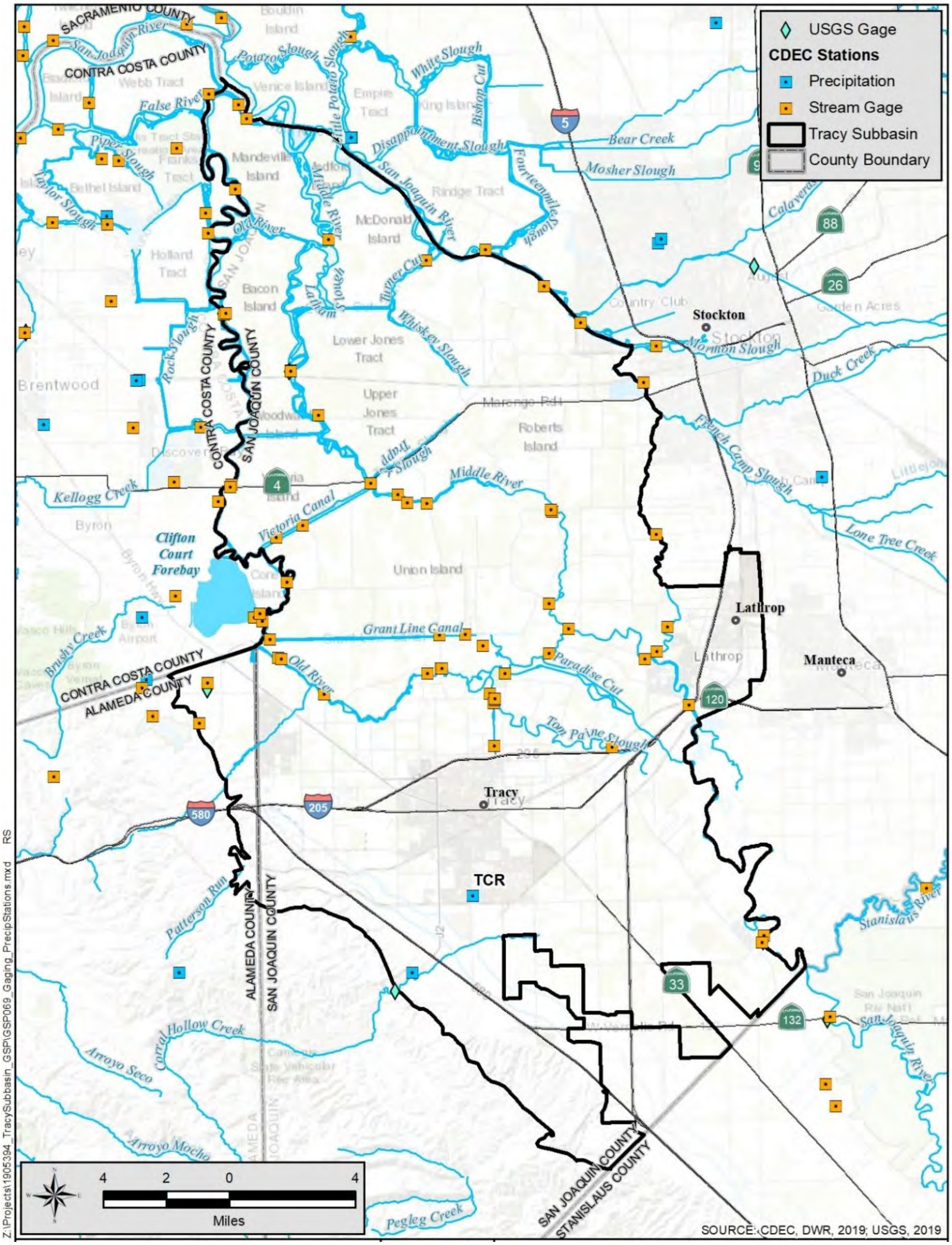


**Figure 3-21. River Gages and Precipitation Stations**

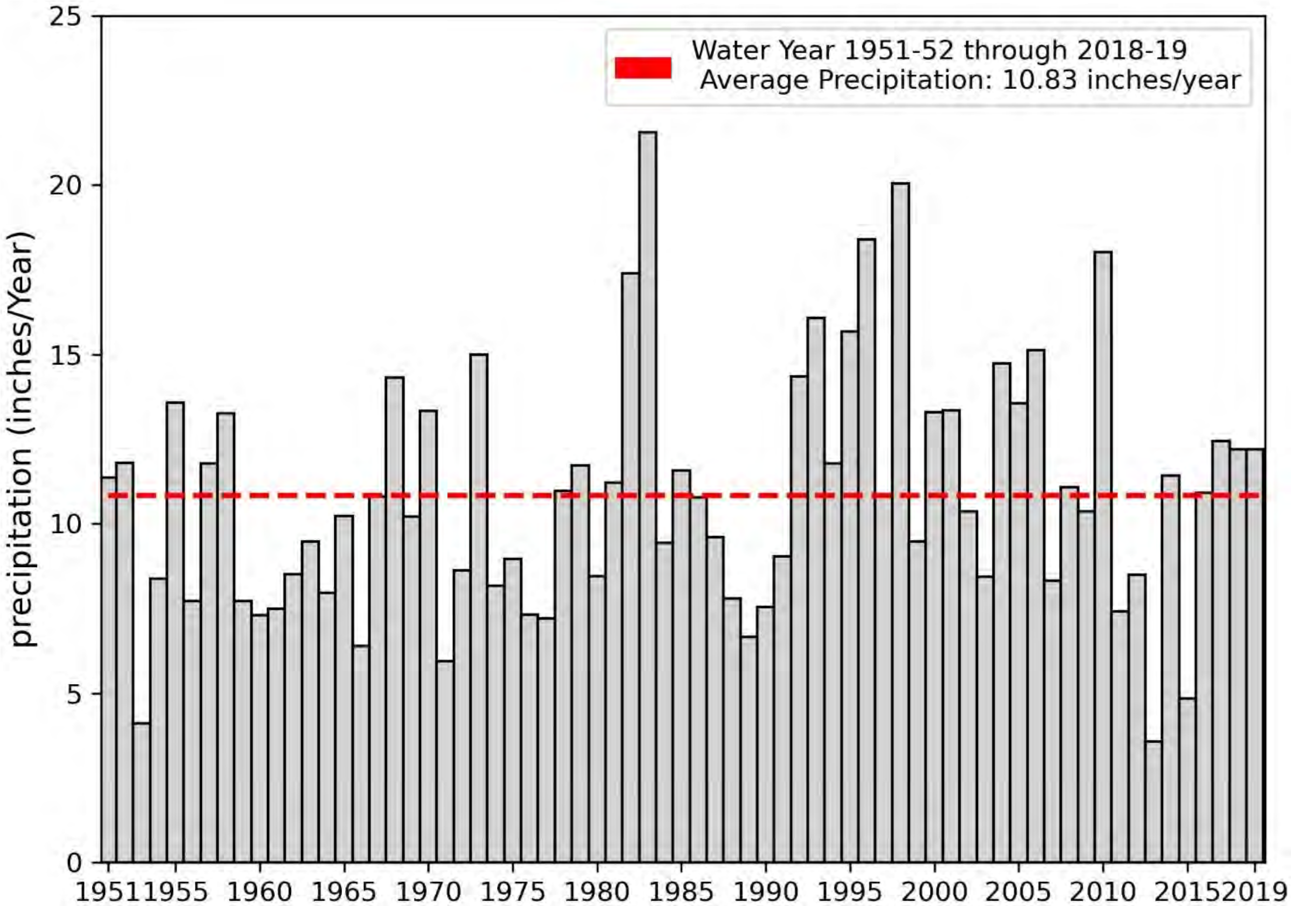


**Figure 3-22. Water Year Precipitation**

### 3.10.5 *Subsidence Monitoring Network*

Local and regional subsidence monitoring is being performed in the Subbasin. The City of Tracy has six benchmarks that have been repeatedly surveyed up to 2005. The San Luis Delta-Medota Water Authority also has a series of benchmarks along the DMC. The location of these benchmarks is shown on **Figure 3-23**. Subsidence monitoring is also performed using continuous global positioning system (CGPS) stations.

University NAVSTAR Consortium's (UNAVCO) Plate Boundary Observatory Program (formerly University Navigation Satellite Timing and Ranging or NAVSTAR Consortium), reporting since 2004, consists of a network of about 1,100 CGPS and meteorology stations in the western United States to measure deformation resulting from the constant motion of the Pacific and North American tectonic plates. Stations located within the Subbasin contain data from at least 2006 to current and include station P257 in the western portion of the City of Tracy. The location of this station is shown on **Figure 3-23**. Other stations are also available near the Subbasin in the East Contra Costa County (P256), and in the East San Joaquin (P273) and Delta Mendota (P255) subbasins.

Subsidence analyses have also been conducted using satellite-based methods over limited time periods, as described below.

- **United States Geological Survey** – The USGS report Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-2010 (Sneed et al. 2013) presents land subsidence data in the southwestern portion of the Subbasin from 2007 to 2010.
- **Other** – DWR has made two InSAR datasets available for SGMA application: TRE Altamira, Inc.'s InSAR point and raster data and National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA JPL) raster data (Farr, et. al. 2016). Vertical displacement approximations in both datasets are collected by the European Space Agency's Sentinel-1A satellite. The two different datasets represent two different processing results, one by TRE Altamira and one by NASA JPL. The TRE Altamira data have coverage between January 2015 to present. Both annual and total raster datasets from TRE Altamira are available and represent interpolations of the vertical displacement point features. The NASA JPL processed dataset spans Spring of 2015 to Fall of 2020 (DWR 2020).

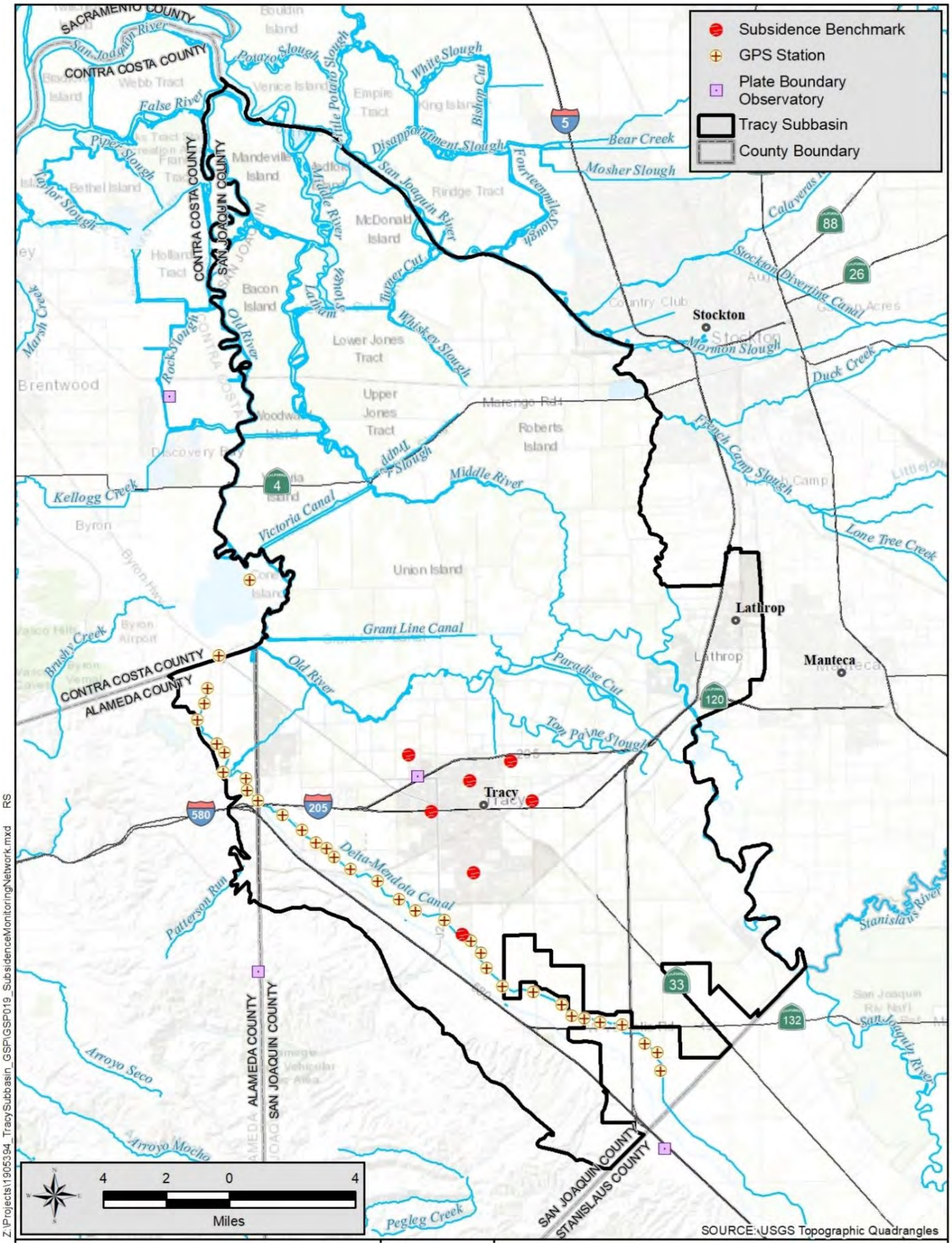


**Figure 3-23. Subsidence Monitoring Network**

## 3.11 Limits to Operational Flexibility

Overall, the Subbasin has senior water rights to surface water and along with generally moderate to poor-quality water; therefore, groundwater pumping is relatively small, only about 3 percent of the total supply. The limits to operational flexibility (based on the existing water resources management plans and monitoring programs to implement this GSP) are, as follows:

- The City of Tracy currently has a General Order Permit for using Aquifer Storage and Recovery (ASR) wells to recharge groundwater. The permit limits the water source for injection purposes to water from the San Joaquin Irrigation District, from the Stanislaus River. The City of Tracy also has water rights from the Delta-Mendota canal and an existing treatment plant. This limits the potential expansion of their ASR program. RWQCB appears willing to create a new permit to allow use of Delta-Mendota canal water.
- SGMA required DWR to develop and provide tools for GSAs to use in the development of GSPs. The C2VSim Fine Grid Version 1.0 groundwater model was provided but many subbasins developed different groundwater models and not reflected in the state's groundwater model making an evaluation of adjacent subbasin GSP implementation effects on adjacent subbasin impossible. An update of the state's model is needed to incorporate all the different models.
- The ILRP reports are indicating that groundwater levels are being collected when access is available. However, the groundwater level measurements are currently not being recorded on a website to provide use by this GSP.
- The current land use planning does not provide the ability to manage groundwater resources. The ability of agricultural users to convert from row crops to orchards and increase and harden water supply demand, without the GSAs having the ability to know if this increased use is being provided with surface water or groundwater and whether that increase pumping will exceed the sustainable yield of the Subbasin, until after the orchards are planted.
- Well permitting agencies do not have any requirements, considerations or special provisions for construction of wells near rivers or groundwater dependent ecosystem areas.

## 3.12 Conjunctive Use Programs

Conjunctive use is the planned, coordinated use of groundwater and surface water to optimize available water supplies. Surface water is used when it is available; groundwater is used when surface water supplies are reduced or not available. The aquifer is utilized as a storage reservoir that can be recharged from precipitation, subsurface inflow, applied surface water, or injection wells. This stored water is then available when needed.

Although not a formal program, irrigation districts and mutual water companies in the Subbasin also provide conjunctive use by increasing their deliveries of surface water during times of surplus, thereby reducing the amount of groundwater pumped by private well owners. The City of Tracy operates an aquifer storage and recovery program, currently using only one well out of nine.

## 3.13 Land Use Plans

A land use management and planning authority allows cities and counties to establish land use and zoning laws that govern development. Agencies with land use authority in the Subbasin are the cities of Lathrop and Tracy and the counties of San Joaquin and Alameda. The City of Tracy is considered a charter City, which provides additional constitutional freedoms to govern municipal affairs, even if a conflict with state law exists. General Plans and UWMP plans have been developed by the cities of Lathrop and Tracy and by San Joaquin County. Their planning horizons (to 2040) include the anticipated planned growth in the region. The Sharpe Depot is expected to be decommissioned in the next 6 to 12 months after which the City of Lathrop will provide services to properties within former Sharpe Army Depot boundaries.

Water purveyors also have a voice in land use planning, but not necessarily an authority. Because the purveyors provide water supply, any new development is required to demonstrate that adequate water supply will be made available to serve the project and, therefore, may affect land use. Proof of adequate water supplies is required as defined under California Water Code Section 10910 et seq and Government Code section 66473.7, which are intended to assist water suppliers, cities, and counties with integrating water and land use planning.

Current water demands for the cities and communities in Subbasin are shown in **Table 3-3** for comparison to projected future water supplies. Water supplies for new developments will be a mixture of surface water, groundwater, and recycled water. Surface water and recycled water use is planned to increase based on UWMPs. Groundwater use is also planned to increase by about 8,500 AF above current levels but then stabilize. **Table 3-3** summarizes the projected groundwater supplies for the next 20 years.

**Table 3-3. Projected Water Supplies**

| Agency | Acre-Feet 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | Buildout |
|---|---|---|---|---|---|---|---|
| **City of Tracy** | | | | | | | |
| Surface Water | 13,522 | 18,455 | 19,260 | 20,065 | 20,871 | 21,677 | 28,325 |
| Groundwater | 519 | 767 | 837 | 907 | 977 | 1,046 | 1,423 |
| Recycled Water | 0 | 963 | 1,926 | 2,889 | 3,851 | 4,814 | 7,696 |
| **City of Lathrop** | | | | | | | |
| Surface Water | 241 | 6,760 | 6,811 | 6,863 | 6,887 | 10,671 | 10,671 |
| Groundwater | 3,204 | 6,253 | 7,060 | 7,060 | 7,060 | 7,060 | 7,060 |
| Recycled Water | 429 | 1,159 | 1,067 | 1,067 | 1,067 | 1,067 | 2,350 |
| **Mountain House** | | | | | | | |
| Surface Water | 2,394 | 5,120 | 6,394 | 7,666 | 8,938 | 10,172 | 10,172 |
| Groundwater | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Recycled Water | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Unincorporated County** | | | | | | | |
| Surface Water | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Groundwater | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Recycled Water | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Projected Growth on Surface Water** | **16,157** | **30,335** | **32,465** | **34,594** | **36,696** | **42,520** | **49,168** |
| **Total Projected Growth on Groundwater** | **3,723** | **7,020** | **7,897** | **7,967** | **8,037** | **8,106** | **8,483** |
| **Total Projected Growth on Recycled Water** | **429** | **2,122** | **2,993** | **3,956** | **4,918** | **5,881** | **10,046** |

**Note:** Projected normal year supplies from the City of Lathrop's Water Master Plan (Table 5-8 in the Plan) only reflect the supplies from the City of Lathrop's sources and do not include those from industrial, domestic, and agricultural groundwater users.

# 3.14 GSP Implementation Effects on Land Use

The General Plans in the Subbasin provide guidelines to facilitate anticipated growth within the sustainable capacity of existing resources. Successful land use planning promotes sustainable water supply and use within the region. Due to the complementary nature of the General Plans and the GSP, the goals and policies in the General Plans support the ability of the GSAs to achieve sustainability.

Implementation of this GSP, including changes in groundwater management, may influence the type of land use and location of future development. The result will depend on the level of changes set forth by this GSP such as enacted programs, plans, and policies. While General Plan implementation may result in land use changes and changes in water consumption, minimal change in water demand is expected from GSP implementation. The potential for future management actions, which could impact water supplies and development, is discussed in **Chapter 10 – Projects and Management Actions**.

Most of the land within the Subbasin is currently developed to some use (*refer to* Section 3.4), and conversion from agricultural uses to urban uses is not anticipated to increase overall water demand significantly. However, conversion from agriculture to urban use may have an effect on water source and depending on the location in the Subbasin, may shift supply from groundwater to surface water.

## 3.15 GSP Implementation Effects on Water Supply

The water budgets for the Subbasin show that it is currently within balance and that projected conditions with climate change results in only a slight imbalance of about 800 AFY (refer to **Chapter 7 – Water Budgets**). One project is planned that can bring the water budget into balance and within its sustainable yield. Therefore, with these conditions this GSP does not intend to curtain groundwater use. Two supplemental projects are also under consideration in case physical measurements require additional management actions.

### 3.15.1 *Urban Water Supply*

The reliability of urban supplies is expected to improve with implementation of this GSP. The City of Tracy is planning to increase recharge to the aquifers by using Aquifer Storage and Recovery wells (*see* **Chapter 10 – Projects and Management Actions**) with the ultimate goal of matching pumping and recharge. With this approach the City may essentially reduce its current net groundwater pumping effects of 18,000 AFY to zero. The City's initial project is to reduce pumping by 3,000 AFY.

### 3.15.2 *Agricultural Water Supply*

Agricultural uses mostly surface water to grow crops. The irrigation districts have very senior water rights, pre-1914, and therefore their supplies are very reliable. Because this is expected to continue, groundwater pumping for agricultural purposes is not anticipated to increase. Therefore, implementation of this GSP is should not affect agricultural water supply.

### 3.15.3 *Domestic Water Supply*

Groundwater levels are expected to remain near their current levels and therefore no domestic wells are projected to go dry.

### 3.15.4 *Environmental Water Supplies*

As stated above, groundwater levels are expected to remain near their current levels and therefore groundwater supply to potential groundwater dependent ecosystems is not expected to be lowered or reduced during implementation of this GSP.

Surface water depletion may increase in the Non-Delta Management Area based on current water budget projections, but the groundwater model needs further improvements before this projection can be relied upon. These depletions can be offset with discharges of treated recycled water, which originated as imported surface water, to the waterways and the decrease of pumping due to expansion of BCIDs service area to provide surface water to replace groundwater pumping.

## 3.16 Water Well Permitting

DWR has responsibility for developing standards for wells for the protection of water quality under California Water Code Section 231. Counties, cities, and water agencies, where appropriate, were required to adopt a well ordinance that meets or exceeds DWR well standards. Both San Joaquin and Alameda counties have well-permitting authority in the Subbasin.

### 3.16.1 *San Joaquin County*

San Joaquin County oversees a well permitting program for construction of any new, replacement, back-up, and de minimis wells. The purpose of this program is to prevent groundwater contamination and safety hazards by regulation of the location, construction, repair, and destruction of water supply, monitoring, and geophysical wells and borings. Pursuant to Water Code §13808, all new wells that do not meet the exemption criteria must submit additional information prior to the issuance of a permit by the San Joaquin County Environmental Health Department. The permit program is enforced by Ordinance Code of San Joaquin County §9-1115. Applicants must provide information about groundwater elevation estimates, land elevation estimates, extraction volume estimates, depth of Corcoran Clay, and other basic well characteristics.

The San Joaquin County Well Standards contains requirements for well location (minimum distances from potential sources of contamination and pollution), construction or repair, well disinfection, sampling, construction and abandonment of geophysical or seismological test holes or wells, and monitoring wells. Special requirements for well construction in San Joaquin County include determination of water quality during construction, depth limitations, perforation specification, and sealing-off strata listed in Bulletin 74-81 (DWR 1990), which was approved by DWR. To prohibit intermingling of poor-quality aquifers above and below the Corcoran Clay layer, wells constructed and perforated below the Corcoran Clay layer shall have sealing requirements determined on a site specific basis and approved by the Director.

County Zoning Code (Division 11: Infrastructure Standards and Requirements, Chapter 9-1115) states that a well permit may be approved by the Director of Environmental Health Division only if the following conditions are met:

- The proposed well shall not be offensive, dangerous, or injurious to health, or create a nuisance
- The proposed water complies in all respects to the standards of the Environmental Health Division for the construction of wells
- Upon completion of the well, the applicant or the Well Contractor shall file a copy of a Well Drillers Report with the Environmental Health Division, where these report forms will be furnished by the Director of Environmental Health Division or the State Water Board.

Policy IS-4.15 of the County General Plan states that prior to issuing building permits for new development that will rely on groundwater, the County shall require confirmation for existing wells and test wells for new wells to ensure that water quality and quantity are adequate to meet the needs of existing, proposed, and planned future development.

There are minimum setbacks requirements for construction of supply wells near the rivers, creeks, streams and canals of 50 feet but these may not be sufficient to maintain or reduce surface water depletion or protection of groundwater dependent ecosystems. All aquifers containing saline water shall be properly sealed off to prevent intermingling.

### 3.16.2 *Alameda County*

Alameda County oversees a well permitting program for construction of any new, replacement, back-up, and de minimis wells. The purpose of this program is to prevent groundwater contamination and safety hazards by regulation of the location, construction, repair, and destruction of water supply, monitoring, and geophysical wells and borings. The conditions to permit and construct a new or replacement wells is contained in Alameda County, Code of Ordinances, Title 6- Health and Safety, Chapter 6.88 – Water Wells.

The administering agency may designate special requirement areas where special well construction techniques and/or well seal(s) are required to prevent spreading of contaminants or mixing of water between water-bearing zones. These areas are typically areas where one or more underlying aquifers of differing water quality are separated from each other by a zone of low permeability. The administering agency, in consultation with applicable agencies, shall identify the boundaries of these areas of special concern. Where an applicant proposes well construction, reconstruction, or destruction work in such an area, the administering agency may require the applicant to provide a report prepared by a registered Professional Geologist or registered Professional Civil Engineer (California Business and Professions Code Sections 7850 and 6762, respectively) that identifies the affected water bearing and non-water bearing strata, as well as the zone(s) of contamination or poor quality water, and recommends construction techniques and seal location(s) designed to prevent the spread of the contamination or poor quality water by the well or during well construction. All aquifers containing saline water shall be properly sealed off to prevent intermingling.

There are no setbacks or special investigation requirements for construction of supply wells near the rivers or tributaries to maintain or reduce surface water depletion or protection of groundwater dependent ecosystems.

### 3.16.3 *Aquifer Storage and Recovery Wells*

The State Water Board permits use of Aquifer Storage and Recovery wells under a statewide General Order. The order requires technical studies prior to approval of the well for injecting water into the aquifers. The well also must be registered with the United States Environmental Protection Agency (EPA).

## 3.17 Land Use Plans Outside of the Subbasin

This GSP has not evaluated land use implementation plans outside the Subbasin.

# 4. Hydrogeologic Conceptual Model

## 4.1 Basin Boundaries

The Tracy Subbasin (Subbasin No. 5-22.15) lies in the northwestern portion of the San Joaquin Valley Groundwater Basin west of the San Joaquin River, except for the City of Lathrop area which lies east of the river. Aquifers beneath the Subbasin extend into the adjacent Eastern San Joaquin, Delta-Mendota, and the East Contra Costa subbasins. The Tracy Subbasin, along its southwestern border, is bounded by non-water bearing rocks of the Coast Ranges. **Figure 4-1** shows the Tracy Subbasin and the surrounding subbasins.

The bottom of the Subbasin is the base of fresh water which is generally positioned at the top of the marine sediments that contain saline water. The base of freshwater is the boundary between water of TDS of about 2,000 mg/L and higher. In the Tracy Subbasin, the mapped base of freshwater ranges from about -400 to -2,000 feet elevation beneath the Subbasin (Page 1968, Berkstresser 1973). **Figure 4-2** shows the irregular base of freshwater as defined by two different authors with a slight gap in coverage between the two studies.

## 4.2 Topography

The Tracy Subbasin generally slopes downward from the south to the north. The topography of the Subbasin is shown in **Figure 4-3**. The Subbasin is drained by the San Joaquin River and Old River and westside tributaries; Corral Hollow, Mountain House, Lone Tree and Patterson Run creeks which drain water from the Coast Ranges. The San Joaquin River flows northward into and through the Sacramento and San Joaquin deltas and discharges into the San Francisco Bay.

Ground surface elevations are the highest, approximately 200 feet above msl, on the southwestern side of the Subbasin and gradually decline to sea level to the north and east. Portions of the Delta islands north of the river are below sea level.

## 4.3 Surface Water Bodies

Major water bodies within the Subbasin consist of the San Joaquin, Old, and Middle rivers along with various sloughs, canals, and cuts as the waters converge and flow within the Delta. **Figure 4-3** shows the location of these surface water bodies. The San Joaquin River makes up almost the entire eastern boundary of the Subbasin except for the City of Lathrop, which was recently introduced into the Subbasin through a basin boundary modification. The Old River diverges from the San Joaquin River near the City of Lathrop and meanders west until turning north and eventually rejoining the San Joaquin River. It feeds water into the SWP Clifton Court Forebay, which is located just west of the Subbasin. The Middle River also diverges from the San Joaquin River near the City of Lathrop and meanders northwest through the Delta before connecting with the Old River.

Two major pump stations lift water out of the Old River from the Clifton Court Forebay into two large canals: the California Aqueduct and the Delta-Mendota Canal. Although these canals are not a natural part of the Subbasin surface water system, these large canals traverse the southwestern portion of the Subbasin, transporting water from the Delta to portions of BBID and to BCID that lie within the Subbasin, and to other agricultural and urban water suppliers in the San Joaquin Valley and southern California.

In addition to the major natural waterways that surround the majority of the Subbasin, there are networks of agricultural irrigation canals that convey surface water to agricultural lands.

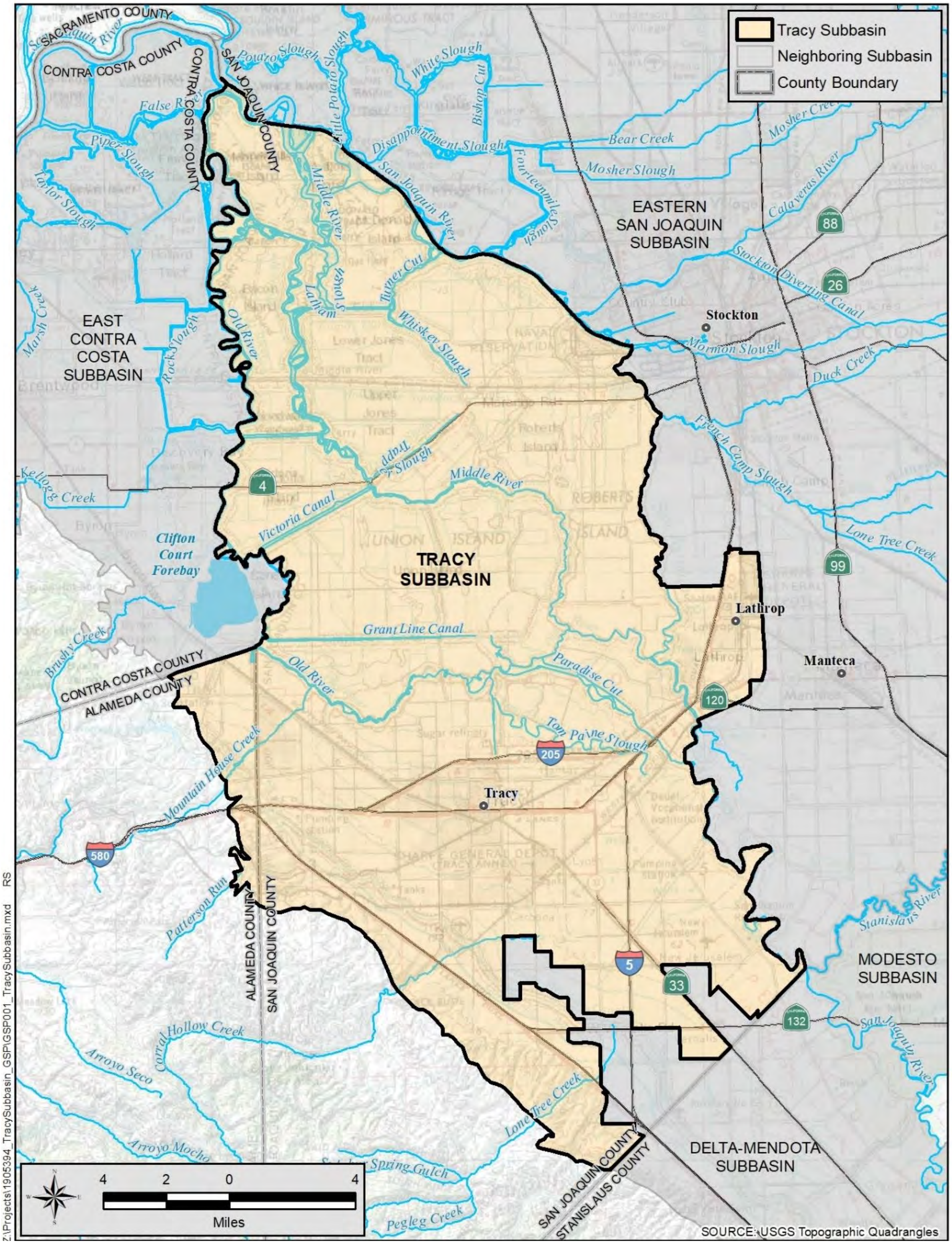


**Figure 4-1. Tracy Subbasin**

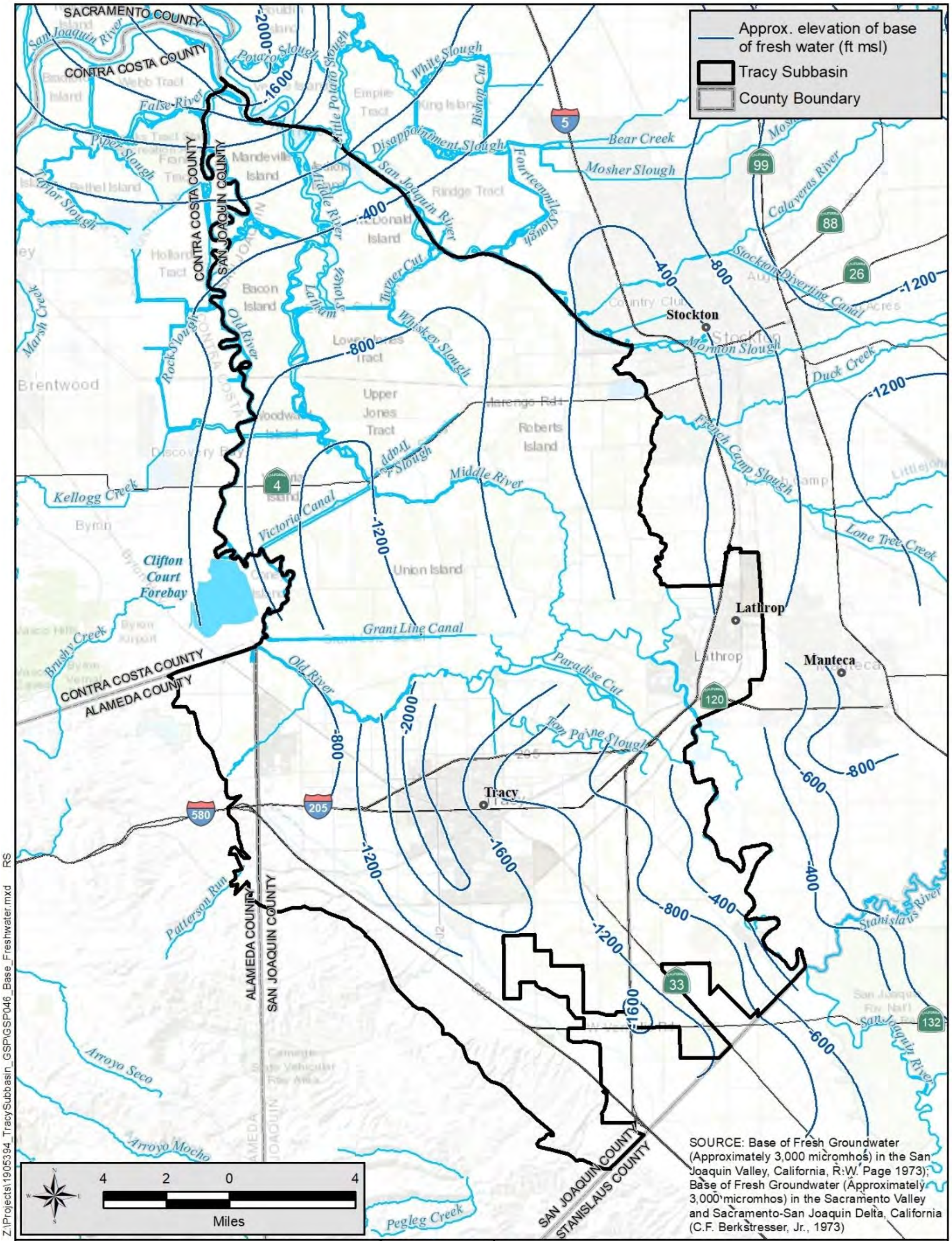


**Figure 4-2. Base of Freshwater**

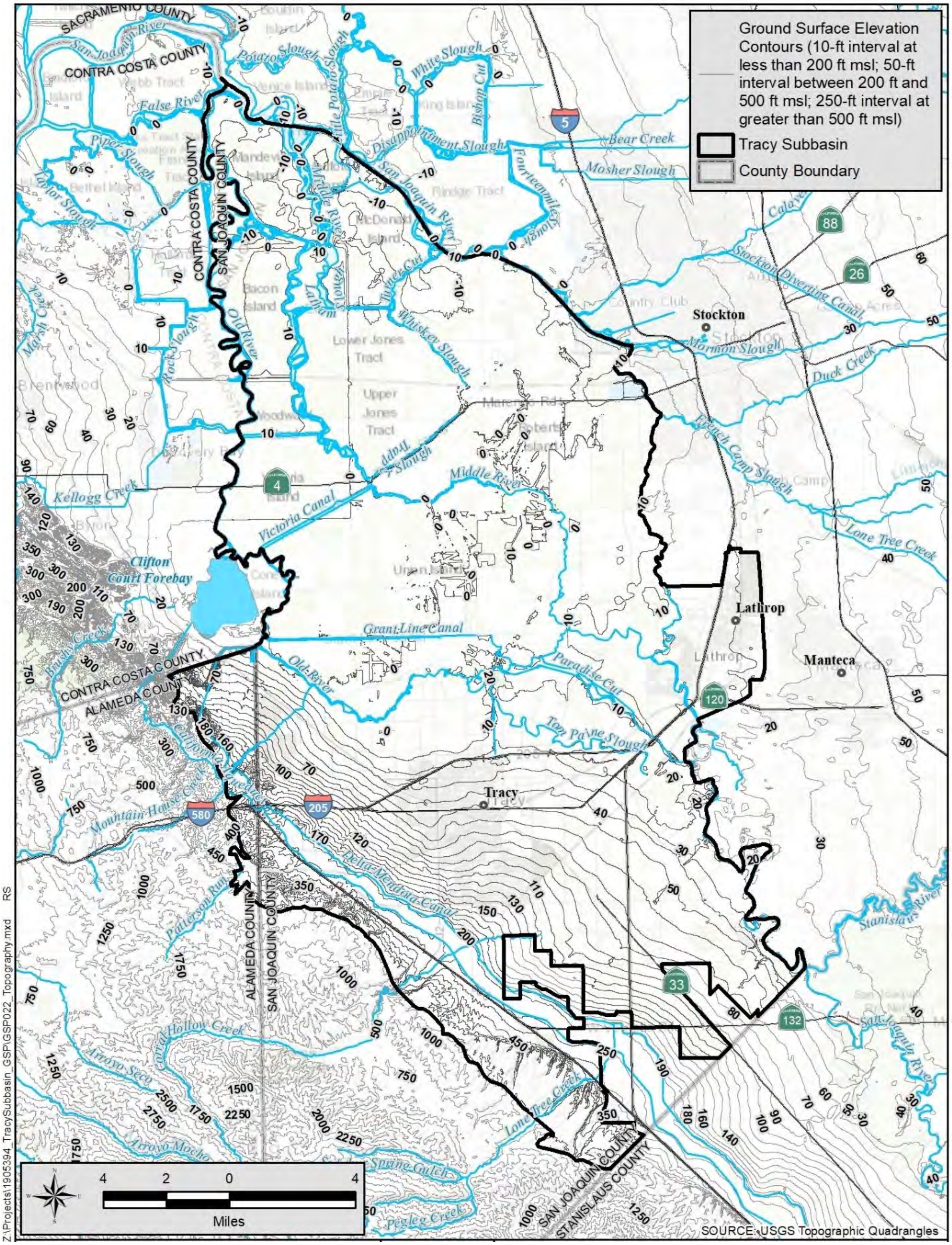


**Figure 4-3 Topography**

## 4.4 Soils

The Subbasin is underlain by alluvial soils whose age generally corresponds with the relative age of the alluvial geologic units. The oldest soils lie along the southwestern margin of the subbasin where alluvial fans from the Coast Range ranges are exposed above the valley, with progressively younger soils toward the north and east near the rivers and Delta.

Surface recharge potential in the Subbasin is a function of soil type. The surface recharge potential of the soil was interpreted based on the hydrologic soil group as mapped and categorized by the U.S. Department of the Agriculture's Natural Resources Conservation Service (SSURGO 2019). Hydrologic soil groups are classified according to their ability to infiltrate water and affect runoff. The soils are grouped according to the amount of water infiltration when the soils are thoroughly wet and receive additional precipitation. The four primary hydrologic soil groups are:

Group A: Soils having a high infiltration rate (low runoff potential) when thoroughly wet

Group B: Soils having a moderate infiltration rate when thoroughly wet

Group C: Soils having a slow infiltration rate when thoroughly wet

Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet

**Figure 4-4** shows the hydrologic soil groups in the Subbasin. The area associated with soils with highest infiltration rate (Group A) is along Corral Hollow, within the City of Lathrop and extending to the west along the southern portions of the Old and Middle Rivers. The rest of the Subbasin has Group C or D type soils with low to very low infiltration rates.

The Soil Agricultural Groundwater Banking Index (SAGBI), developed by researchers at UC Davis (O'Greene, et al. 2015), is a suitability index for groundwater recharge on agricultural land and takes into account the effects of agricultural modifications (deep ripping) to the native soils. The SAGBI is based on five major factors that are critical to successful agricultural groundwater banking: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. **Figure 4-5** shows the SAGBI index classified soil distribution in the Subbasin.

Most of the Delta area of the Subbasin is covered with "Poor" rated soils due to the low possibility of deep percolation and root zone residence time. This Poor rating is due to the fine silts and clays brought in by the rivers. While these less permeable soil types often inhibit flow to the subsurface, these soils classifications are generalizations of soil types and localized windows of connection to the underlying aquifers can exist, particularly when streams are incised through the soil profile. Most of these coarse-grained, well-drained soil windows occur along the southern extent of the Old and Middle rivers and east into the City of Lathrop area. These windows are rated as "Excellent".

The non-Delta area of the Subbasin has more favorable areas for groundwater recharge. The area consists of both Moderately Poor to Very Poor and some pockets of Moderate Good to Excellent ranked soils. There are pockets of Excellent rated soils are along some of the tributary channels from the Coast Ranges.

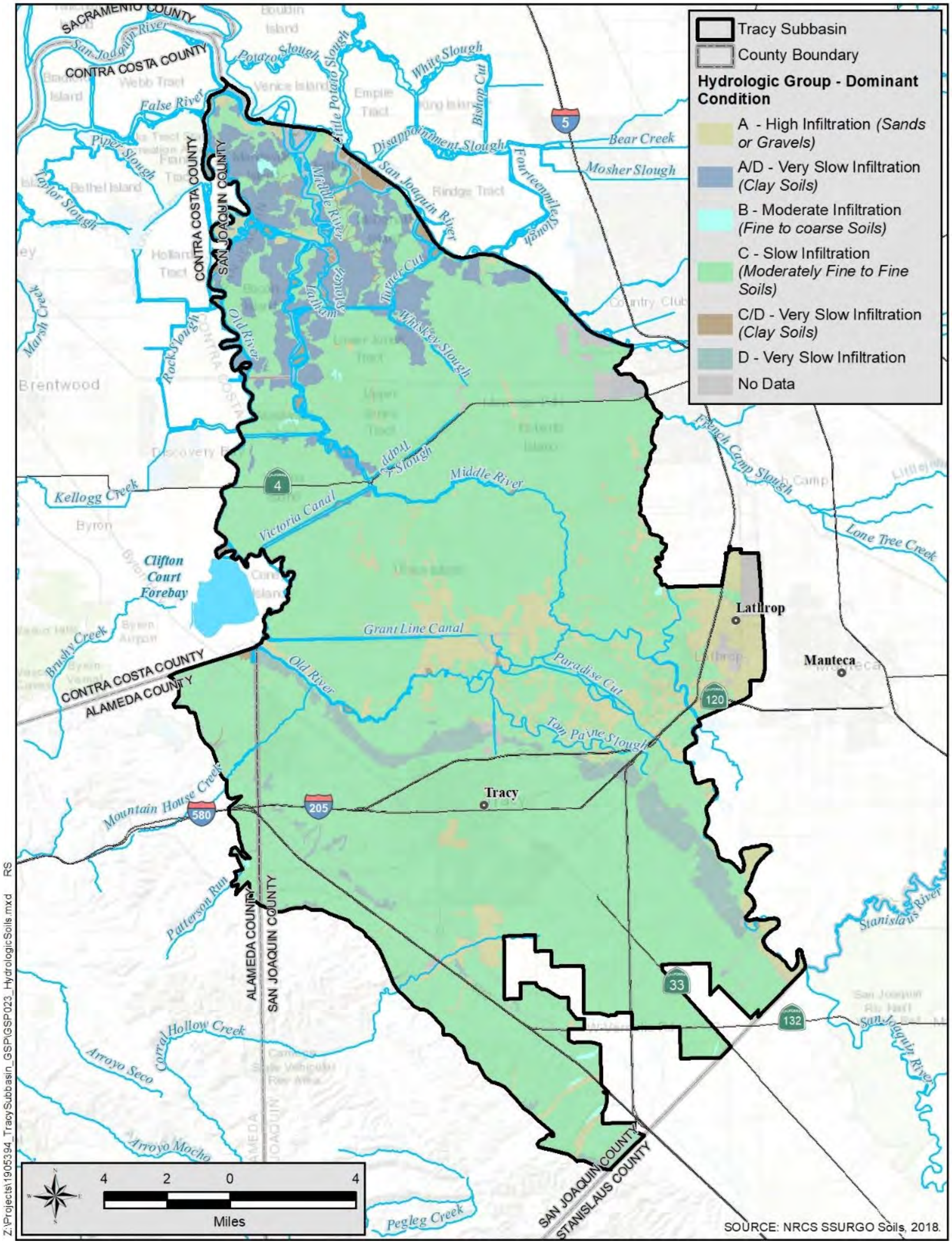


**Figure 4-4 SSURGO Hydrologic Soils Classification**

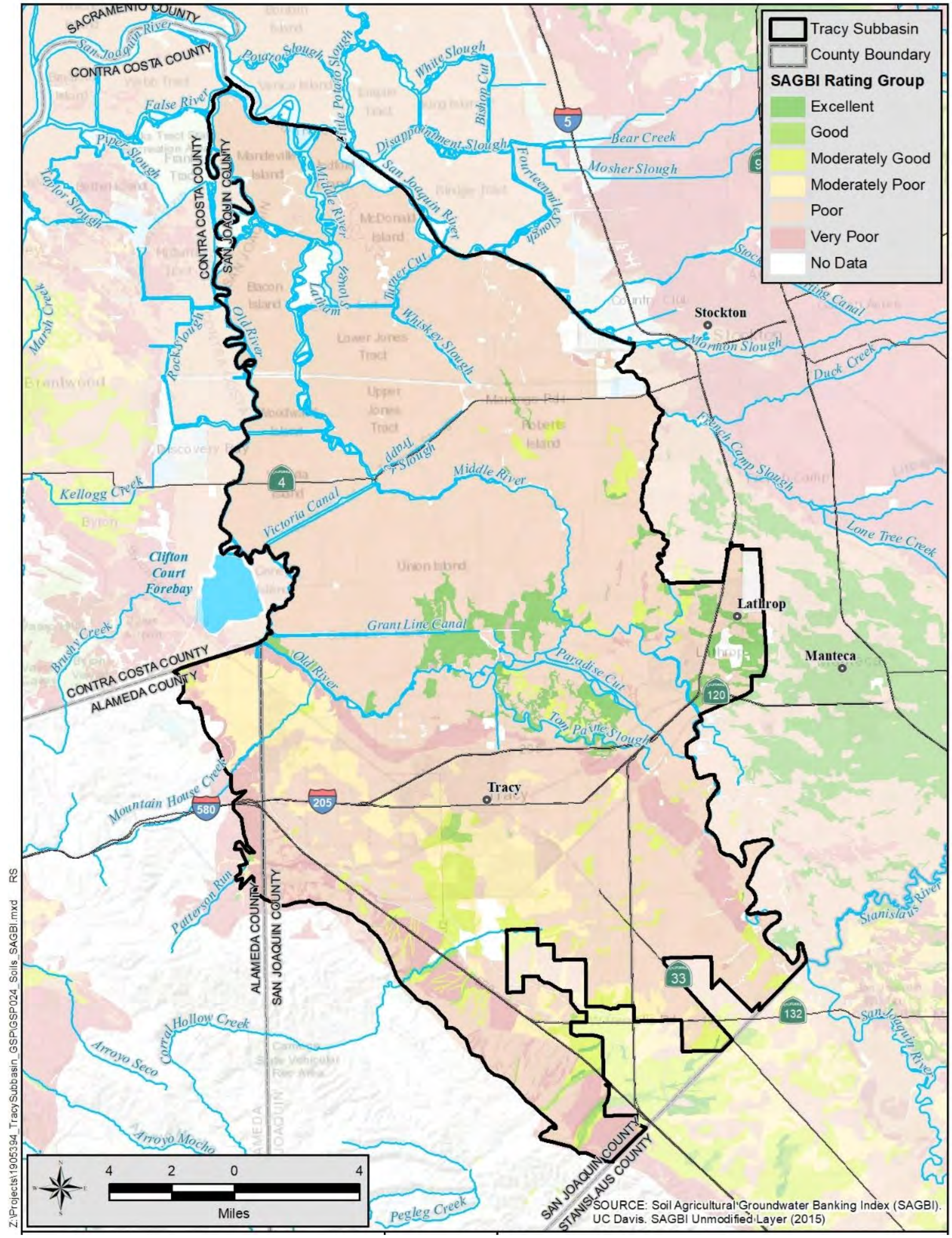


**Figure 4-5 SAGBI Soils**

## 4.5 Regional Geology

The San Joaquin Valley is a large structural depression bounded on the east by the Sierra Nevada, whose rocks extend beneath the valley. The Sierra Nevada consists of metamorphic rocks intruded by igneous rocks. The San Joaquin Valley is bounded on the west by the Coast Ranges which contain old sedimentary formations, metamorphic and igneous rocks.

The younger river and creek lain deposits comprise the major portion of the San Joaquin Valley's fresh-water aquifer system. The sediments in the valley depict a regional change in the environments, from one dominated initially by marine sedimentary processes to continental sedimentary processes. The San Joaquin Valley, including the Tracy Subbasin, are filled with marine sedimentary rocks that still contain ancient seawater and traps of natural gases. Some of these marine sediments are exposed in the Coast Ranges. As the valley began filling with continentally derived sediments there were periods of intense erosion that resulted in sand and gravel deposits. Large freshwater lakes also formed in the valley which accumulated fine-grained sediments (silts and clays). Some lakes extended throughout the central and western portions of the valley while others were smaller and more localized. One of the more regional lake beds extends into the Subbasin. These lakebed deposits have since been covered by hundreds of feet of sediments, some of which eroded and removed the lakebed deposits.

## 4.6 Freshwater-Bearing Formations

Freshwater-bearing sediments in the Subbasin, from youngest to oldest, include Alluvium, Flood Basin and Intertidal deposits, Alluvial Fan Deposits, Older Alluvium, Modesto Formation, Los Banos Alluvium, Tulare Formation, and Fanglomerates. These formations, except for the Tulare Formation, are shown on **Figure 4-6**. The Tulare Formation is not exposed at ground surface but is buried by the other sediments. The cumulative thickness of these deposits increases from a few hundred feet near the Coast Range foothills on the south to about 2,000 feet just north of Tracy. Information regarding the water-bearing units and groundwater conditions were taken from several sources (Hotchkiss and Balding 1971, Bertoldi et al. 1991, Davis G.H. et al. 1959) and sorted to agree with more recent geologic map compilation (Wagner et al. 1991).

### 4.6.1 *Alluvium*

The Alluvium (Q), due to its limited extent, is not shown on **Figure 4-6**. It includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They are present along Corral Hollow Creek and consist of unconsolidated silt, sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and yield significant quantities of water to wells. The thickness of the younger alluvium in the Tracy Subbasin is less than 100 feet (DWR 2006).

### 4.6.2 *Flood Basin and Intertidal Deposits*

The Flood Basin Deposits (Dos Palos Alluvium [Qdp]) and Intertidal Deposits (Qi) are located in the Delta portions of the Subbasin. They consist of peaty mud, clay, silt, sand and organic materials. Stream-channel deposits of coarse sand and gravel are also included in this unit. The flood basin deposits have low permeability and generally yield low quantities of water to wells due to their fine-grained nature. Flood basin deposits generally contain poor quality groundwater with occasional zones of fresh water. The maximum thickness of the unit is about 1,400 feet (DWR 2006).

### 4.6.3 *Alluvial Fan Deposits*

Along the southern margin of the Subbasin, in the Non-Delta uplands areas of the Subbasin are fan deposits (Qf) from the Coast Ranges. These deposits consist of loosely to moderately compacted sand, silt, and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages. The fan deposits likely interfinger with the Flood Basin Deposits. The thickness of these fans is about 150 feet (DWR 2006).

### 4.6.4 *Modesto Formation*

The Modesto Formation (Qm) is located along the east side of the San Joaquin River and is slightly older that the Alluvial Fan Deposits. The formation consists of granitic sands over stratified silts and sands. Near the southern margin of the Subbasin, there are small occurrences of Los Banos Alluvium (Qlb) and Older Alluvium (Qo) that are of similar age as the Modesto Formation.

### 4.6.5 *Tulare Formation*

The Tulare Formation is Pleistocene in age and consists of semi consolidated, poorly sorted, discontinuous deposits of clay, silt, sand and gravel. The Tulare Formation is not exposed at ground surface in the Subbasin. The Tulare Formation sand and gravel deposits are moderately permeable, and most of the larger agricultural, municipal, and industrial operations extract from this formation. Wells completed in this zone can produce up to 3,000 gallons per minute (gpm). The thickness of the Tulare Formation is about 1,400 feet. Specific yield values for water-bearing deposits in the San Joaquin Valley and Delta area range from about 7 to 10 percent.

The lower portion of the Tulare Formation is typically coarser than the upper portion of the formation. The sediments consist of sand and gravel beds that are interbedded with clays and silt.

Within the Tulare Formation is the Corcoran Clay, one of the largest lakebed deposits in the San Joaquin Valley. The clay is about 60 to 100 feet thick in the Subbasin**. Figure 4-7** shows the extent and structure of the Corcoran Clay based on geologic profiles and geophysical logs as well as USGS datasets in the Subbasin. The clay is present beneath most of the non-Delta areas and extends into the southern portions of the Delta areas. Near the southern edge of the Subbasin the Corcoran Clay appears to be absent due to the presence of older fanglomerates (Mf). The fanglomerate gravels are a potential conduit to convey water below the Corcoran Clay. The extent of the Corcoran Clay is not fully characterized to the west and north (Page 1986) due to the lack of deep wells. However, geologic sections have shown the clay likely continues to the west, into the East Contra Costa Subbasin (GEI 2007).

### 4.6.6 *Fanglomerate*

Older fan deposits (Mf) are also present in the non-Delta portions of the Subbasin, along portions of the southern fringe of the Subbasin adjacent to the Coast Ranges. The Mf are Miocene age and predate the

Tulare Formation indicating the Corcoran Clay may not extend to the edge of the Subbasin and could be a conduit to recharge aquifers below the clay.

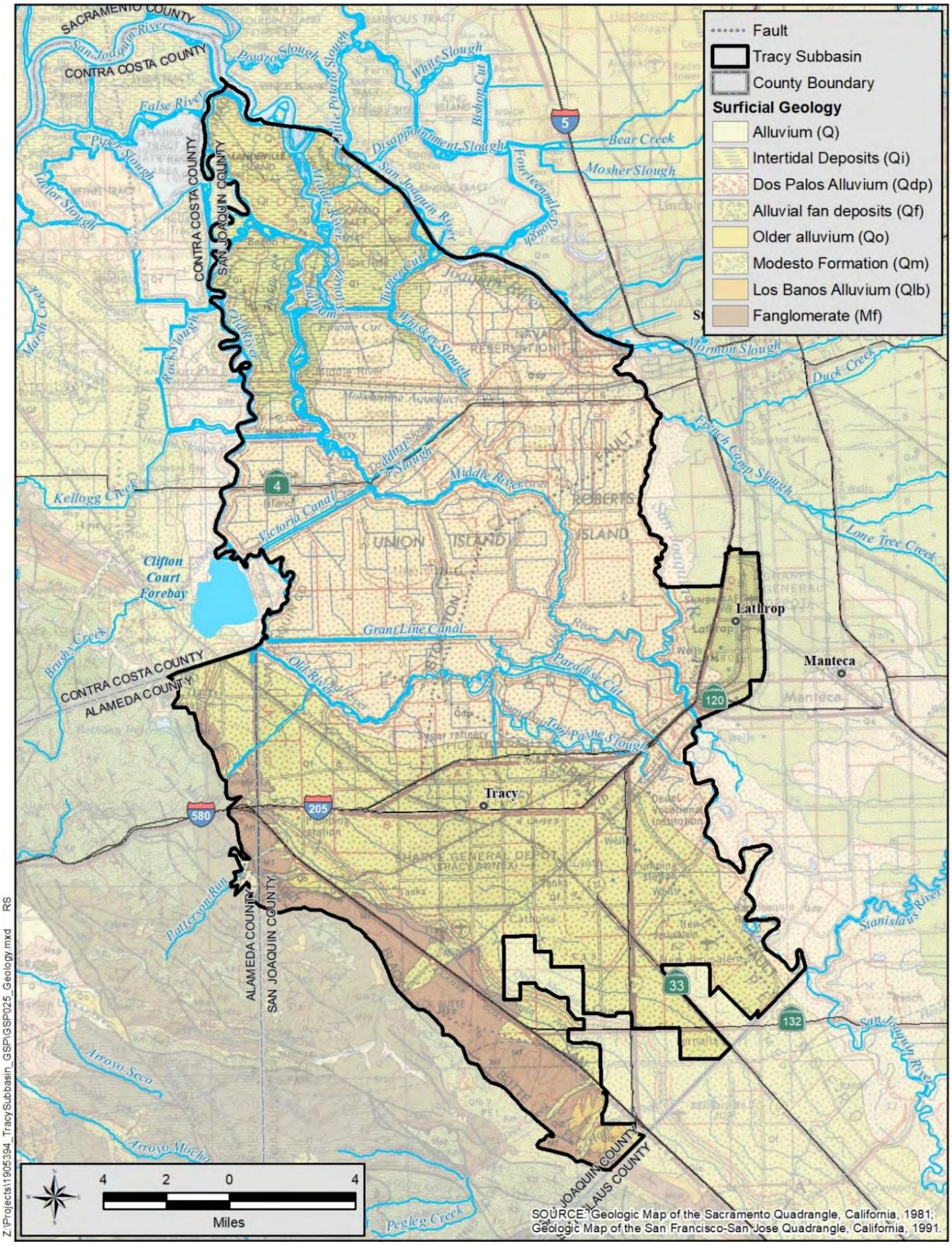


**Figure 4-6 Surface Geology**

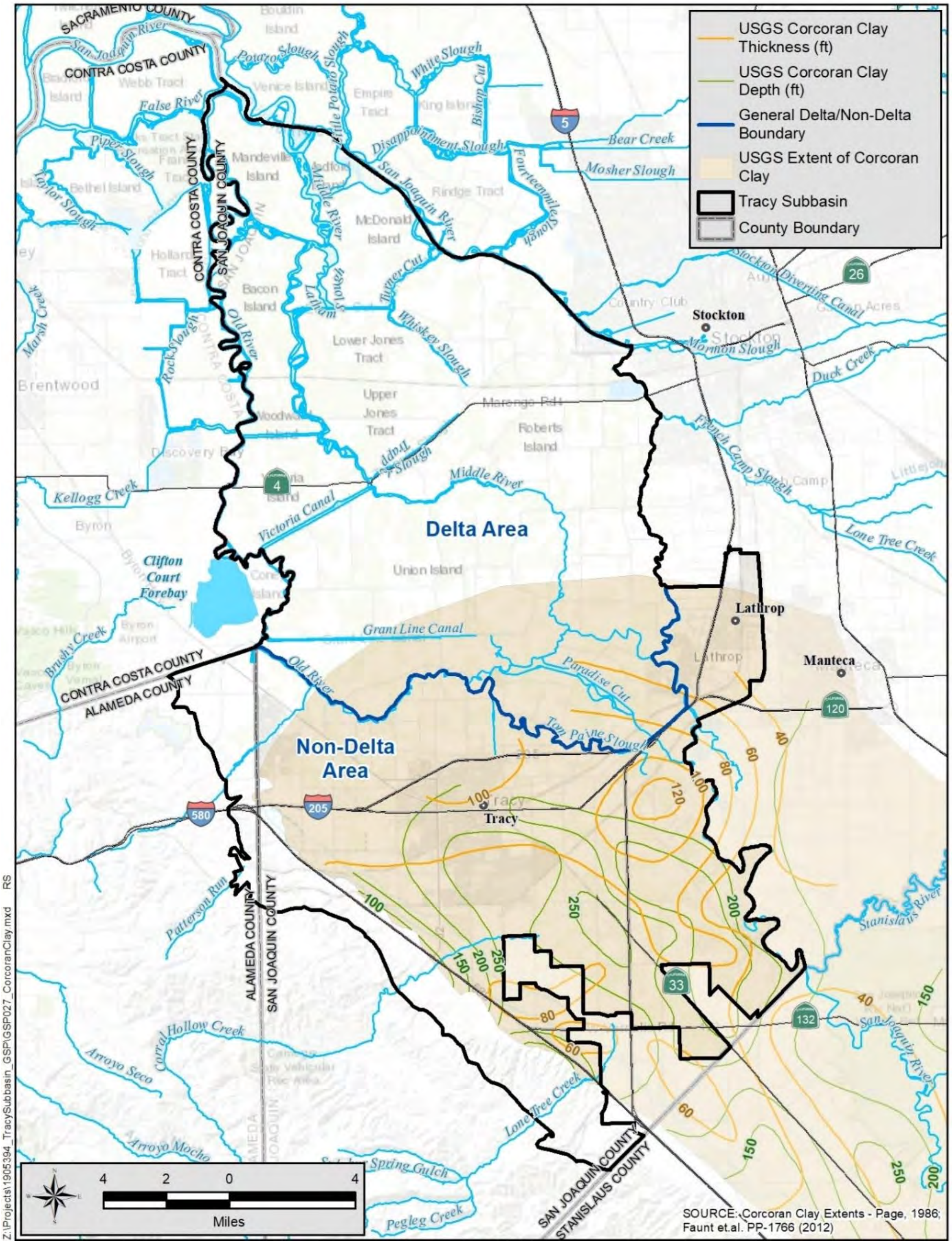


**Figure 4-7 Corcoran Clay Extent**

## 4.7 Non-Water or Non-Freshwater Bearing Formations

All of the freshwater bearing formations and sediments mentioned above are underlain by various marine formations and/or igneous and metamorphic rocks, potentially similar to those exposed in the Coast Ranges. The uppermost beds of the San Joaquin Formation underlie the freshwater bearing sediments (Hotchkiss and Balding 1971). It is predominantly marine in origin and contains ancient sea water. Multiple other older marine formations underlie the San Joaquin Formation and contain natural gases. **Figure 4-8** show the locations of natural gas wells within the Subbasin.

The old, consolidated sediment, metamorphic and igneous rocks, exposed in the Coast Ranges are typically considered to be non-water bearing, as the water is only contained in joint and fractures and is of limited quantity.

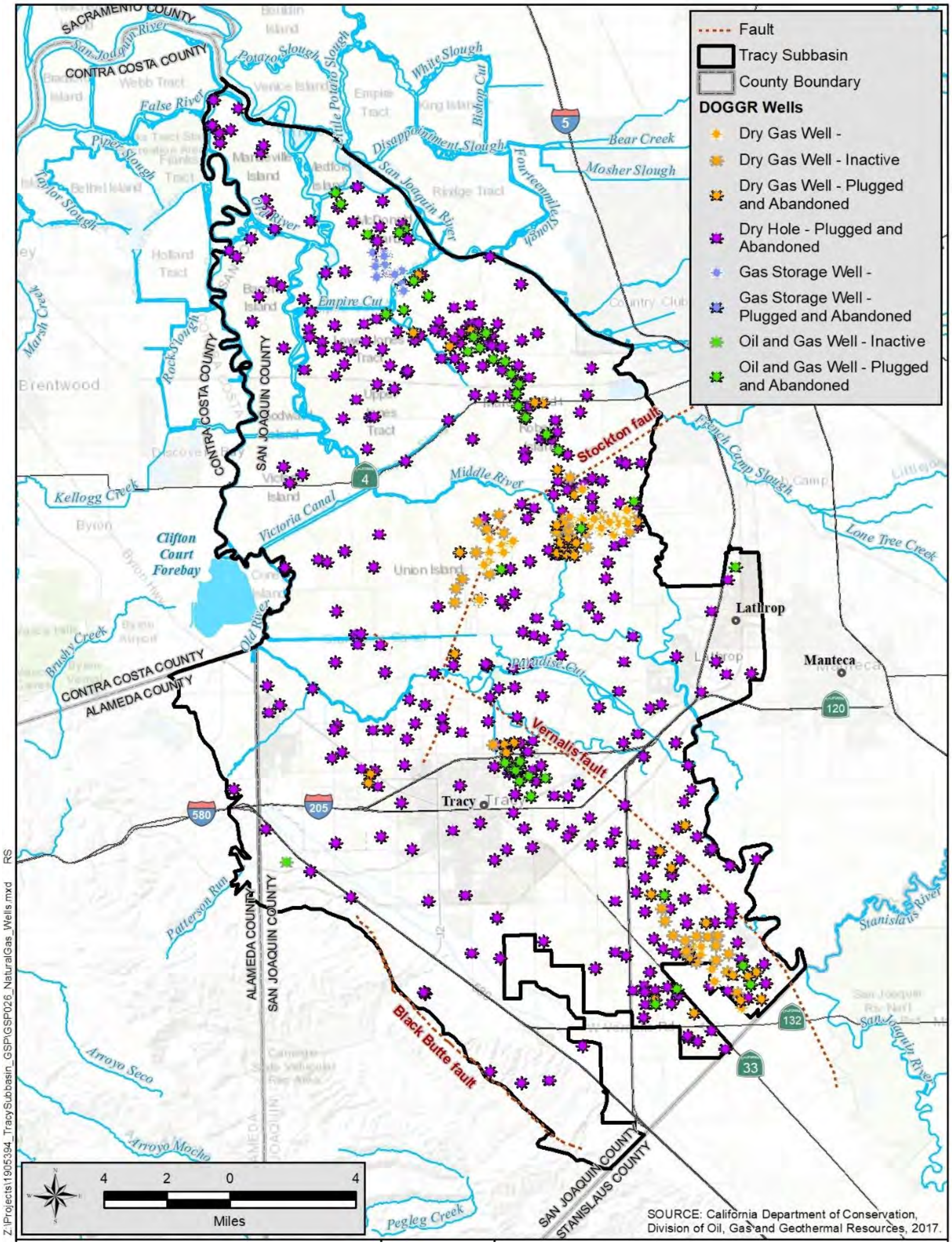


**Figure 4-8. Natural Gas Wells**

## 4.8 Geologic Structure

The Tracy Subbasin has a few geologic structures that may restrict flow in the aquifers or possibly affect water quality.

Impermeable/semi-permeable clay layers are present throughout the Tracy Subbasin, but the only regionally significant layer is the Corcoran Clay, which is present throughout the southern portion of the Subbasin. The clay deposits have a low permeability, hydraulically separating aquifers above and below the clay. The extent of the clay is uncertain in the northern portions of the Subbasin. Near the foothills the clay layers interfingers with coarse grained Mf from the Coast Ranges. The clay extends into portions of the Eastern San Joaquin and Delta Mendota subbasins. The aquifers beneath the clay are confined and generally under pressure.

Faults may affect groundwater flow by bringing geologic materials with different hydraulic properties into contact across the fault plane or by fracturing the sediments, which could either increase or decrease permeability, depending on the degree of fracturing. Faults might, therefore, act as a boundary or barrier affecting the lateral flow of groundwater between adjacent areas and could act as a conduit allowing vertical upward flow within the fault zone. Although there are faults in the Subbasin, none are known to act as barriers to groundwater flow in the freshwater bearing formations. Springs are not present uphill or near the exposures of the Black Butte Fault supporting the non-barrier classification.

The Stockton and Vernalis faults may indirectly affect groundwater quality. Neither fault has a surface trace and their positions have only been determined from natural gas well logs, where the faults have created offset of the marine sediments (Bartow 1985). These faults may act as a conduit allowing vertical upward flow of water from the underlying marine sediments into the freshwater bearing aquifers.

## 4.9 Regional Geologic Sections

Geologic sections (cross-sections or sections) have been developed for the Subbasin as shown on **Figure 4-9**, all crossing the entire length of the Subbasin to show the relationship of the geologic units. The longest and most detailed sections were prepared for the Tracy Subbasin Groundwater Management Plan (GEI 2007) and were used for this GSP with modifications to reflect additional information obtained since 2007. Lithologic information from well logs available in the area was normalized and digitized to generally conform with the Unified Soil Classification System. Lithology and well screens from dedicated groundwater monitoring wells constructed since the sections were created were also added to the geologic sections. The profiles are presented to illustrate the subsurface relationships and distribution of the formations and coarse-grained sediments that constitute the principal aquifers. **Figures 4-10** through **4-14** illustrate the subsurface and show sediment types, the base of freshwater, and the general contact between the Tulare Formation sediments and younger formations. The profiles also show the presence and extent of the Corcoran Clay. The sections were created from water well drillers reports, which are attached in **Appendix D**.

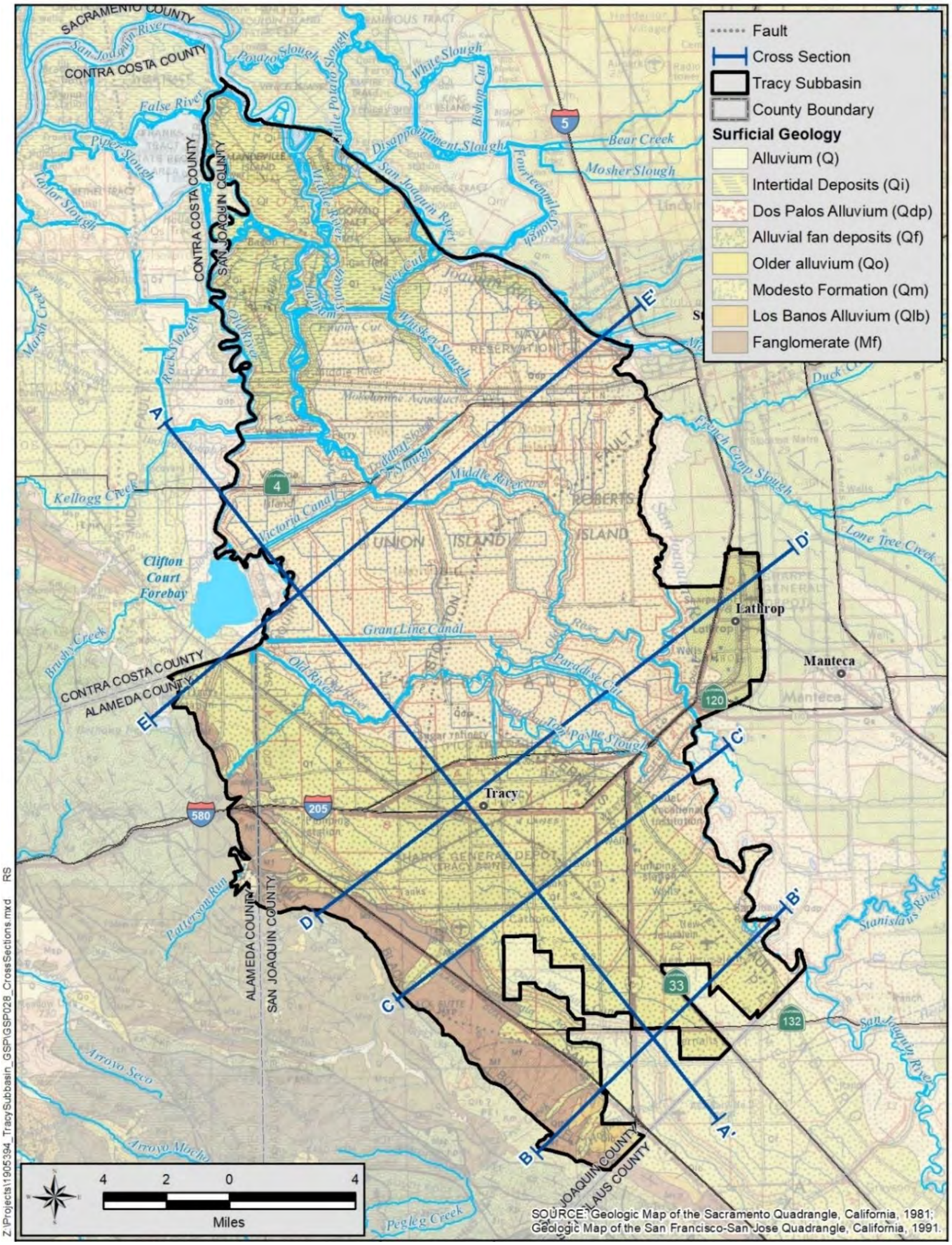


**Figure 4-9. Geologic Section Locations**

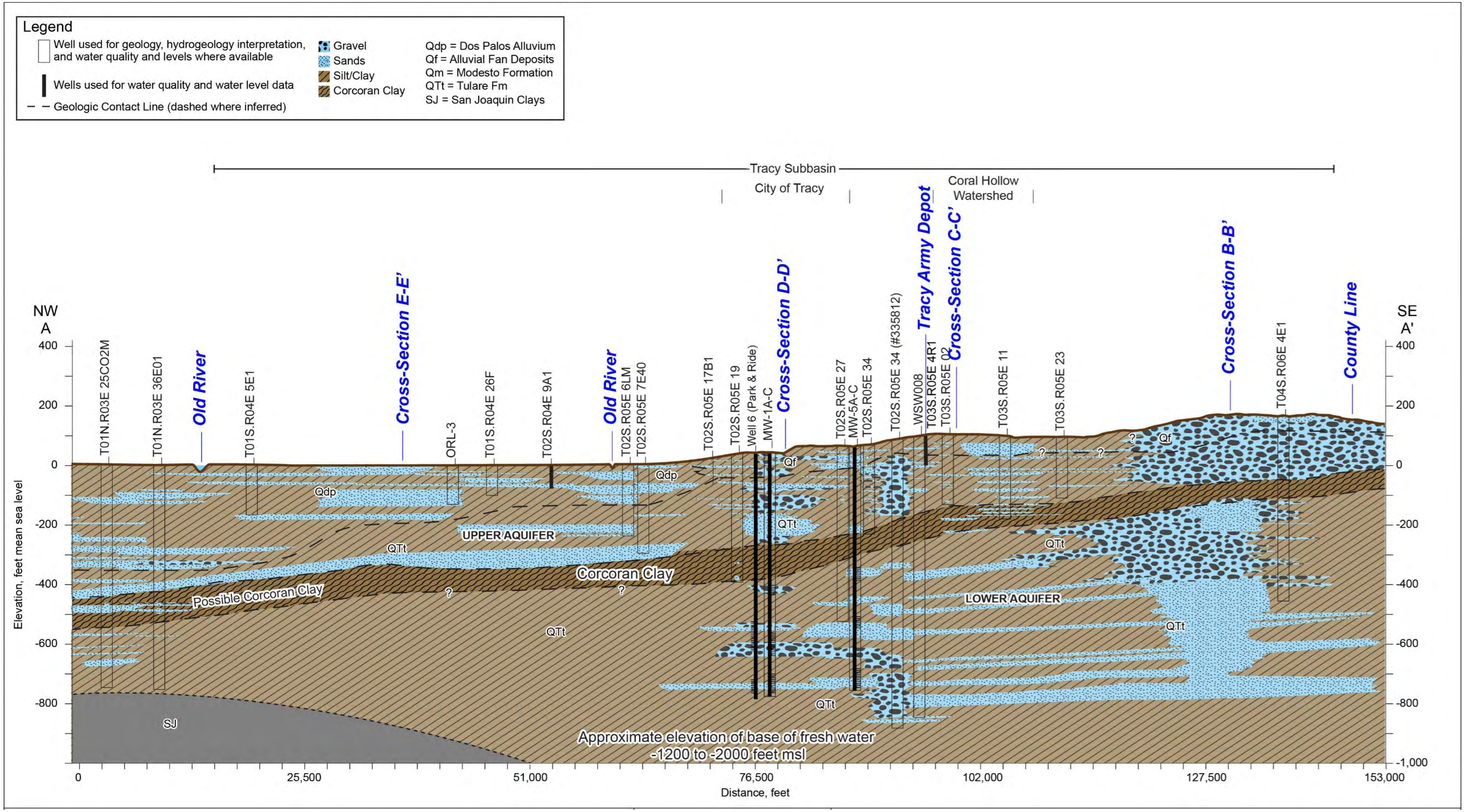


**Figure 4-10. Geologic Section A-A'**

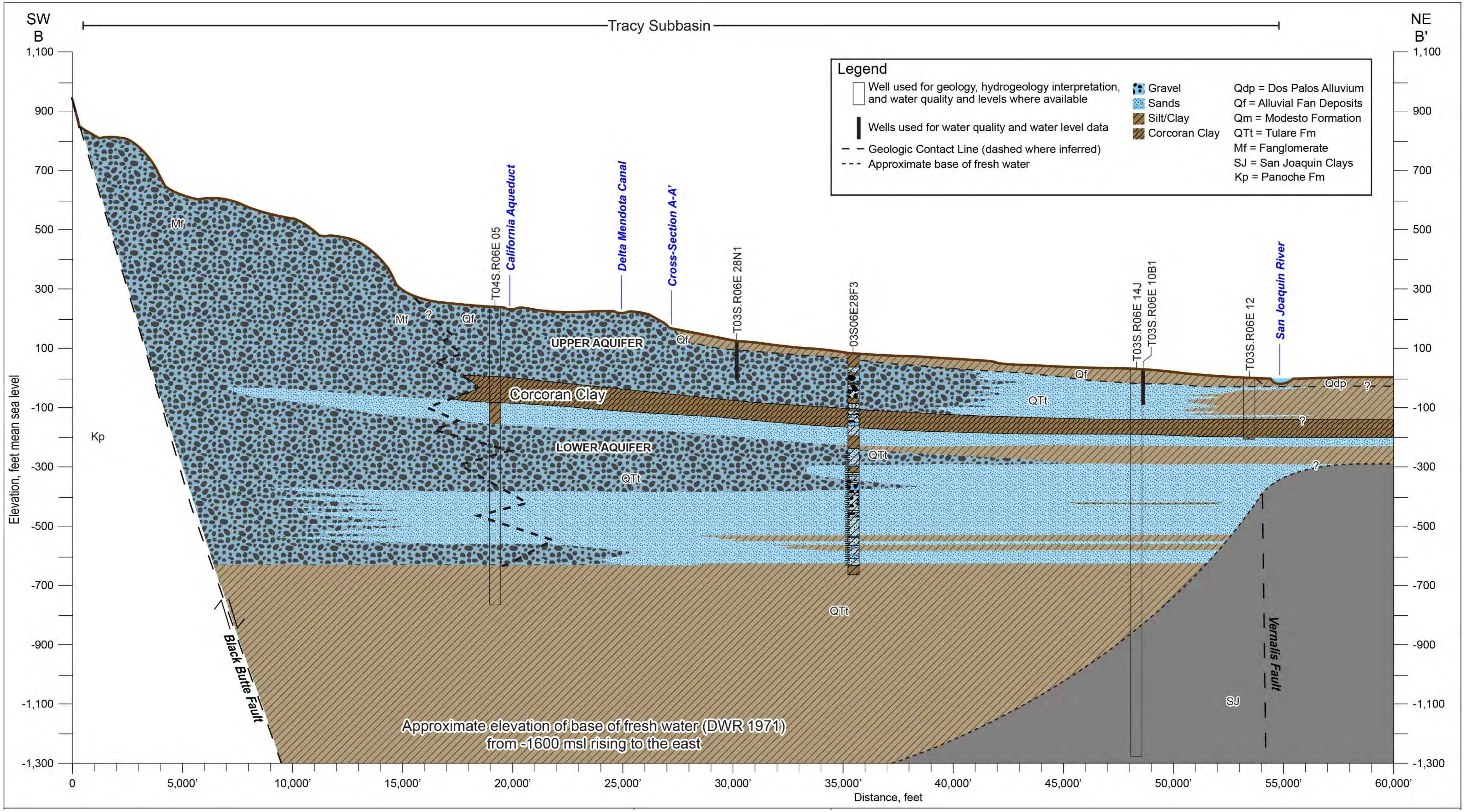

**Figure 4-11. Geologic Section B-B'**

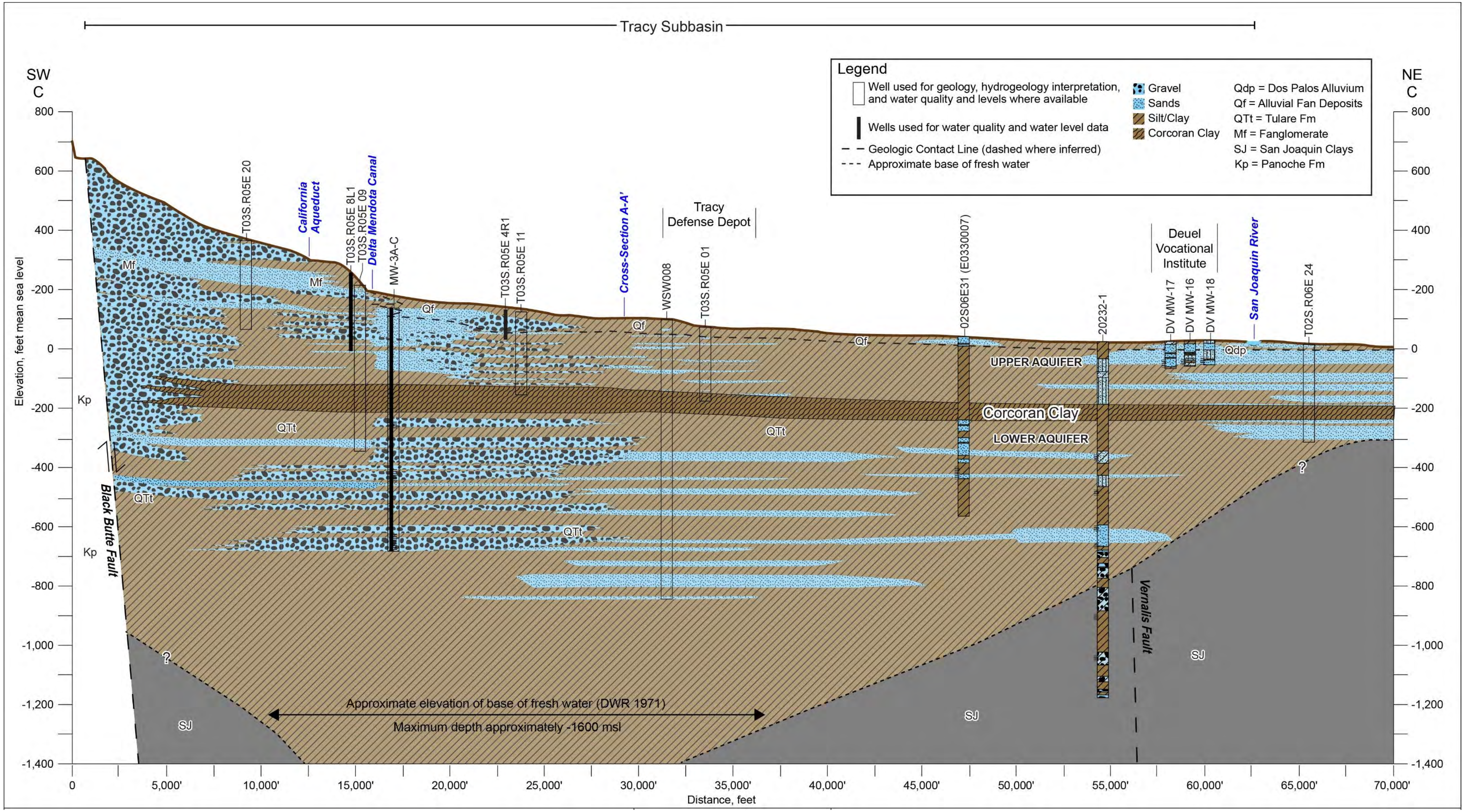


**Figure 4-12. Geologic Section C-C'**

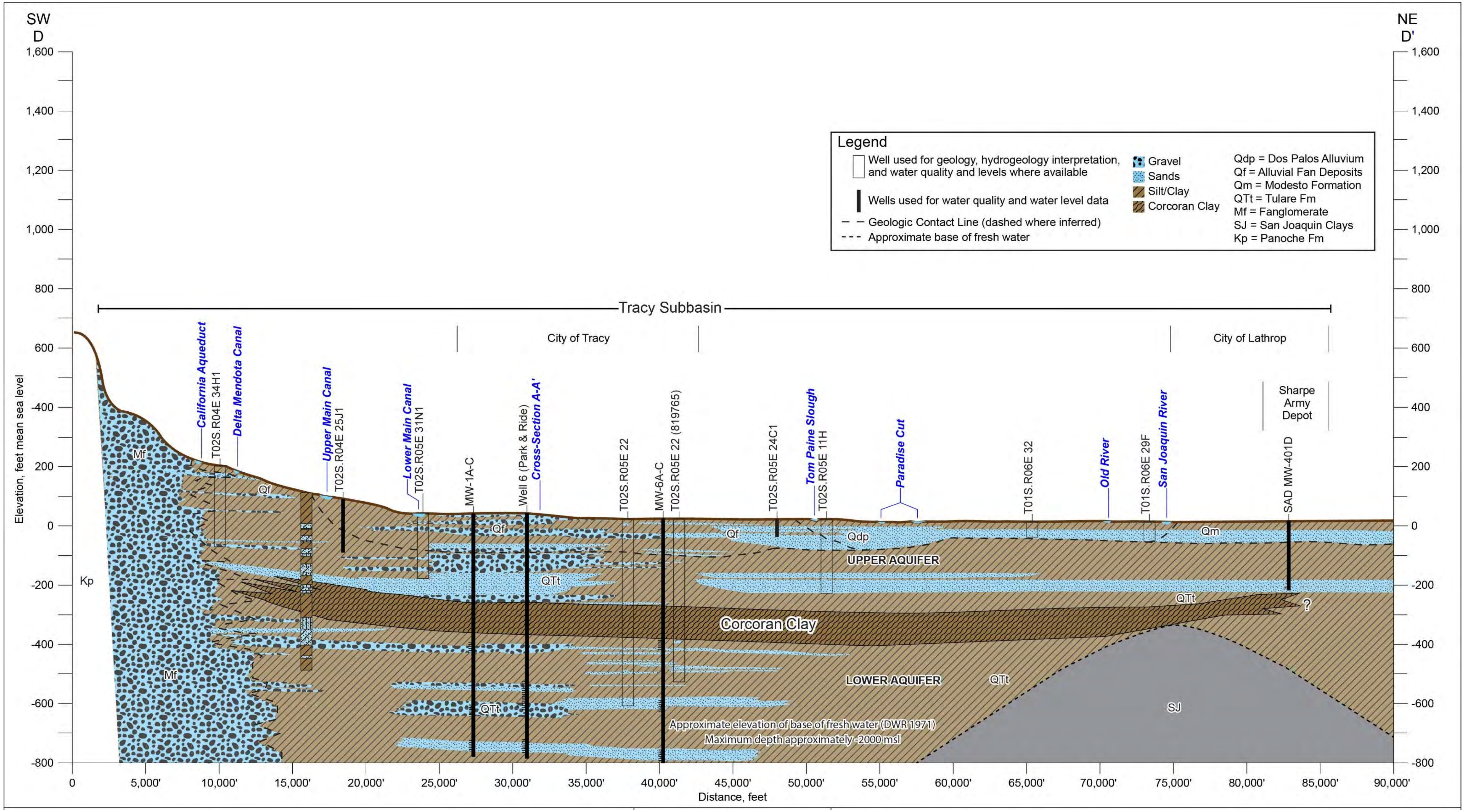


**Figure 4-13. Geologic Section D-D'**

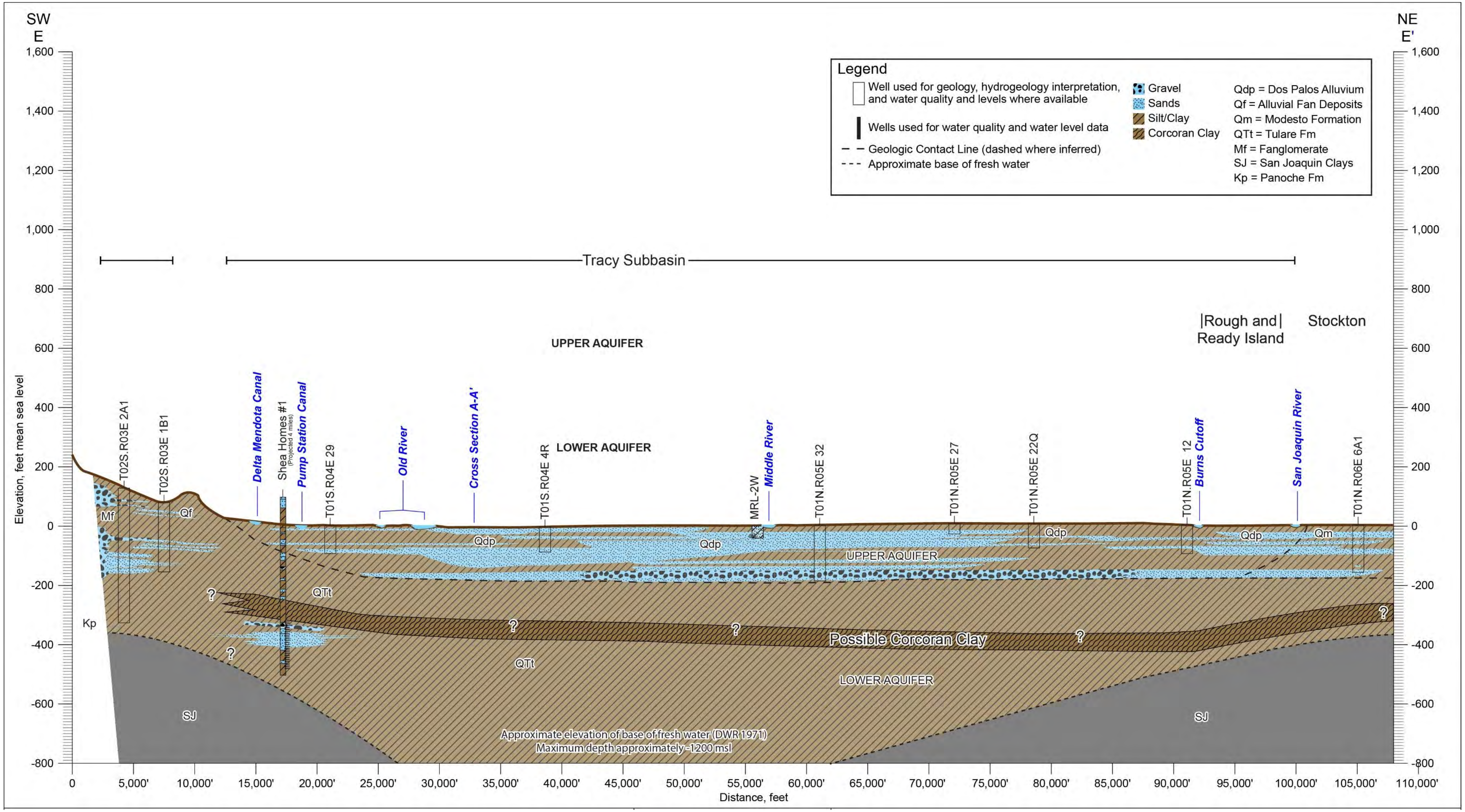


**Figure 4-14. Geologic Section E-E'**

**Figure 4-10** shows Geologic Section A-A', a regional northwest-southeast profile through the non-Delta and Delta portions of the Subbasin. Section A-A' shows that the area generally has clays and silts (shown in brown color), low permeability sediments near surface but permeable sediments (sands and gravels shown in light blue) throughout the depth profile. Continuous layers of sand and gravels, other than one at the top of the Corcoran Clay are not identified likely due the sinusoidal nature of the river channels, and flood deposits associated with these types of sediments. The Corcoran Clay or its equivalent appears to extend to the west and into the East Contra Costa Subbasin, based on three new well logs. In the southern non-Delta portion of the Subbasin, fine-grained sediments are more prevalent and, supported by groundwater levels and water quality information, suggest that the shallow aquifer is unconfined and separate from the deeper confined aquifer.

Geologic sections B-B' through E-E' (**Figures 4-11 through 4-14**) are all sections with a northeast-south west orientation across the entire subbasin, including Delta and non-Delta areas. They show the types of sediments, relationship between the Coastal Range mountains and the valley sediments as affected by the Black Butte Fault, the base of freshwater, as well as portraying the extent of the Corcoran Clay. The sections show:

The Corcoran Clay extends from near the western edge of the Subbasin across the Subbasin, Geologic Sections B-B' through D-D', in agreement with historic projections but there are no well logs to confirm the clay's present on Geologic Section D-D'. Section E-E' shows the location of the Corcoran Clay or its equivalent near the southern margin of the Subbasin. Within the northern portions of the Subbasin, where the clay location is uncertain, no wells were present that penetrated deep enough to confirm its presence or absence.

Sand and gravel are exposed at ground surface in the southern edge of the Subbasin adjacent to the foothills and represent the older fanglomerates (Mf). There are only a few wells in this area to confirm whether the Mf are continuous and can convey recharge water to beneath the Corcoran Clay.

Sand layers beneath the Corcoran Clay, Geologic Sections B-B' and C-C', show sand layers are in contact with the underlying San Joaquin Formation (SJ) marine sediments that could allow saline marine water to migrate into the freshwater aquifers. They also show the Vernalis Fault is located in the area, potentially providing a vertical conduit for saline water to move vertically into the freshwater bearing aquifers.

The bottom of the Flood Basin Deposits was selected based on a relatively continuous sand and gravel bed, although it may be as much as 1,400-feet deep according to some authors.

The base of fresh water varies throughout the Subbasin and is shown on the sections. It is as shallow as -400 feet msl to as much as -2,000 feet msl.

## 4.10 Principal Aquifers

All sediments, to some extent, contain groundwater in the pores between the particles. Near ground surface sediment pores are filled with mostly air but have some moisture. This moisture will gradually migrate down to the groundwater-surface interface where the pores will be entirely filled with water. At times there are low permeability sediment layers with a limited horizontal extent, where the moisture accumulates and fully fills the sediment pores, but the underlying sediments and pores are not filled with water. These occurrences are called perched water and do not constitute a principal aquifer. At the edges of these low permeability sediments, the water may then resume its vertical path to the groundwater surface. Aquifers are those coarse-grained sediment layers whose pores are completely filled with water and can be managed.

Sand and gravel beds are generally grouped together to form aquifers that may display similar characteristics. The aquifers are separated by single or multiple clay layers (or aquitards) that can slow or prevent vertical movement of groundwater between aquifers. The Corcoran Clay acts as a regional low permeability layer that limits vertical movement of groundwater.

The Tracy Subbasin has two principal aquifers; an Upper unconfined to semi-confined aquifer and a Lower confined aquifer that are separated by the Corcoran Clay. Where the clay is absent, which is the condition within most of the Delta area, only the Upper aquifer is present. However, the assessment is limited due to the lack of deep wells to fully define the aquifers in the Delta areas.

The Upper and Lower aquifers merge where the Corcoran Clay is absent, near the southwestern portion of the subbasin adjacent to the foothills, in the area where the Mf are present. In this area the aquifers would be unconfined and are considered to be part of the Upper aquifer. The Upper and Lower aquifers also merge north of the Old River in the northern portion of the Subbasin.

**Upper Aquifer**

The Upper aquifer is an unconfined to semi-confined aquifer above the Corcoran Clay or where the clay is absent. It is present in the Alluvial Fan Deposits, Intertidal Deposits, Modesto Formation, Flood Basin Deposits and the upper portions of the Tulare Formation and the Fanglomerate.

Although there are multiple coarse-grained sediment layers that make up the unconfined aquifer, the water levels are generally similar. Generally, with depth the aquifer confinement may increase to semi-confined conditions. There is generally a downward gradient in the aquifers (Hotchkiss and Balding 1971) in the non-Delta areas and range from a few feet bgs to as much as 70 feet bgs. The groundwater levels in the Upper aquifer are typically higher than in the Lower aquifer, by about 10 to 30 feet. In the Delta groundwater levels are typically at sea level and artesian flowing wells are common in the center of the islands (Hydrofocus 2015).

Aquifer characteristics are few. Using undisturbed cores collected on Twitchell Island, north of the Subbasin, within 10 feet of land surface, the USGS estimated horizontal hydraulic conductivity values for organic sediments ranging from 0.0098 ft/d to 133.86 ft/d (Hydrofocus 2015). The hydraulic characteristics of the unconfined aquifer are highly variable. Wells in the unconfined aquifer produce 6 to 5,300 gpm; however, pumping test data are limited. The transmissivity of the unconfined aquifers, including the recent alluvium and upper portions of the Tulare Formation, ranges between 600 to greater than 2,300 gallons per day per foot (gpd/ft). The storativity is about 0.05. Where thicker sequences of sand are present, the transmissivity may be higher.

Water quality in the Upper aquifer is mostly transitional types of water with no single predominate anion. Most water are characterized as sulfate bicarbonate and chloride bicarbonate type (Hotchkiss and Balding 1971). The TDS of these transitional water ranges between 400 to 4,200 mg/L. Nitrate is typically high in the Upper aquifer in the non-Delta portions of the Subbasin while in the Delta portions it is low.

The Upper aquifer is typically used by domestic, small community and community water systems and for agriculture. The Upper aquifer also supports native vegetation where groundwater levels are less than 30 feet bgs.

**Lower Aquifer**

The Lower aquifer is primarily comprised of the lower portions of the Tulare Formation and is below the Corcoran Clay and extends to the base of fresh water. The clay is present in the southern third of the basin and its extent to the west and north is uncertain and has been estimated to have a vertical permeability ranging from 0.01 to 0.007 feet per day (Burow et al. 2004).

The groundwater levels are generally deeper than water levels in the Upper aquifer (Hotchkiss and Balding 1971). The City of Tracy is the principal water agency that actively monitors water levels in the confined aquifer. Groundwater levels in the confined aquifer are about -25 to -75 feet msl. The groundwater levels are always above the top of the Corcoran Clay by about 60 to 200 feet.

Aquifer characteristic in for the Lower aquifer are few. Wells in the Lower aquifer produce about 700 to 2,500 gpm. The transmissivity ranges from about 12,000 to 37,000 gpd/ft and could go as high as 120,000 gpd/ft. The storage coefficient or storativity, obtained through aquifer tests, was measured as 0.0001 (Padre 2004).

Water quality in the Lower aquifer in the western portions are chloride type water but mostly transitional type of sulfate chloride near the valley margins and sulfate bicarbonate and bicarbonate sulfate near the San Joaquin River (Hotchkiss and Balding 1971). In general, the TDS ranges between 400 and 1,600 mg/L. Nitrate is typically low in the Lower aquifer. Wells completed below the Corcoran Clay sometimes have elevated levels sulfate and total dissolved solids above the drinking water MCLs. Only at one deep location, east of Tracy, are chloride levels elevated.

The Lower aquifer is typically used by community water systems (City of Tracy) and possibly by some agriculture.

## 4.11 Naturally Occurring Elements

The concentration of the naturally occurring elements varies widely over the Subbasin and also with depth at any given location. Groundwater quality in the Subbasin has locally exceeded the MCLs for drinking water for specific elements, some exceedances are scattered, and some are clustered. Poor groundwater quality has been noted in the following general areas:

- Salinity, as represented by TDS, is high in both the Upper and Lower aquifers with a few areas with good quality water.

- Elevated concentrations of sulfate are present near the foothills in both the Upper and Lower aquifers potentially as a result of recharge water originating from the Coast Ranges.
- Elevated concentrations of arsenic are only in the Upper aquifer and within the Delta area and not in the Lower aquifer.
- Boron is present in the Upper aquifer. Most elevated concentrations are present in the non-Delta areas and in the northern portions of the Delta area.

## 4.12 Groundwater Recharge and Discharge Areas

Groundwater recharge occurs throughout the Subbasin with varying amounts based on the SAGBI hydrologic classification for soils, as shown on **Figure 4-5**. The soil's ability to allow water to migrate to the aquifers is significantly reduced if the soils have been covered by impermeable surfaces such as roads and houses, in suburban areas such as the cities of Tracy, Lathrop, and the community of Mountain House. In some cases, although the soils may be classified as being more permeable, recharge may be limited due to underlying low permeability sediments (clays), especially along the delta rivers and creeks.

Recharge areas in the Subbasin have been defined based on the soils' hydrologic classifications along with a variety of techniques, including water quality, groundwater levels correlated to the river or creek stages, well logs and geologic sections showing coarse-grained sediments near ground surface, crop types, and groundwater modeling. Overall, no geologic sediments within the Subbasin are impermeable, so some recharge occurs in all areas that are not covered by impermeable surfaces.

### 4.12.1 *Delta Area Recharge*

Soil investigations throughout the San Joaquin valley have been performed, providing detailed soil profiles that allow for assessment of where coarse-grained sediments are present and the relative permeability of the soil to allow for percolation of water into the Upper aquifer. **Figure 4-15** shows the combination of these studies, referenced sources and recharge areas, including reaches of the rivers and some creeks. **Figure 4-15** shows a concentration of these soil-based recharge areas adjacent to rivers near the transition zone between the Delta and non-Delta areas.

### 4.12.2 *Non-Delta Recharge Areas*

Soils investigations (SAGBI) were used in the non-Delta areas to identify recharge areas, areas with coarse grained soils or those finer grained soils that may have had the permeability modified through agricultural processes as shown on **Figure 4-15**. No soils are impermeable, so some recharge can occur, even where soils are classified as poor for recharge. These areas can recharge the Upper aquifer with water from precipitation, stormwater runoff and excess agriculturally applied water along with where canals cross those coarser grained soil areas.

Beneath the non-Delta areas of the Subbasin is the Corcoran Clay which separates the unconfined Upper aquifer from the confined Lower aquifer. This means that sands and gravels that make up the Lower aquifer are not in direct connection with the land surface or potential sources of recharge from the coarse-grained topsoils that may lie on the ground surface above them, except for area where the Mf are exposed along the foothills, where the clay is absent. Water recharge sources in these areas is limited to precipitation and perennial streams.

Groundwater recharge to the Lower confined aquifer occurs in the foothills adjacent to the Coast Ranges through the fanglomerate, a geologic formation of coarse-grained materials that acts to bypass the confining nature of the Corcoran Clay and infiltrate water into the Lower aquifer. Although there are some areas where the soil permeability is suitable for recharge, the extent of the Corcoran Clay acts as a barrier to recharge from these sources, and therefore only recharges the Upper aquifer. Recharge also occurs in some areas through wells that are screened in both the unconfined and confined aquifers. **Figure 4-16** shows the potential recharge area to the Lower aquifer. Groundwater recharge areas within the Delta can also contribute water to the Lower aquifer where the Corcoran Clay is not present, but the natural gradient would have to be reversed by pumping.

Aquifers in the Subbasin extend beyond the Subbasin boundary and into adjacent subbasins and, dependent upon the groundwater gradients, groundwater may flow into or leave the Subbasin. Therefore, recharge could occur outside of the subbasin and is based on groundwater contours and groundwater flow direction, which will be completely described in **Chapter 5 – Groundwater Conditions**. Groundwater contours developed for the Subbasin, show:

- Subsurface inflow in the Upper aquifer from the Contra Costa Subbasin within the Delta area is due to a pumping depression in the Eastern San Joaquin Subbasin, therefore a recharge area in the Contra Costa Subbasin is present that is contributing water to the Subbasin. Other than this area, the rest of the recharge areas to the Upper aquifer are within the Subbasin where the soils have moderately good to excellent hydrologic properties, as shown on **Figure 4-5**.
- Groundwater in the Lower Aquifer is leaving the Tracy subbasin into the Delta Mendota Subbasin (Woodard & Curran 2019) therefore, no recharge areas to the Lower Aquifer beneath the Tracy Subbasin occur in that subbasin.
- The groundwater flow direction in the Lower aquifer, south of Lathrop, show some groundwater is entering the is Subbasin from recharge areas outside and southeast of the Subbasin, possibly from the Eastern San Joaquin Subbasin but more likely from the Modesto Subbasin.

### 4.12.3 *Groundwater Discharge Areas*

Groundwater discharge occurs along the islands, creeks, drains, sloughs, canals, and rivers in the Subbasin. The conditions may change seasonally from recharge to discharge conditions. **Figure 4-15** shows this area, which extends over the northern subbasin as it represents topographic lows where the groundwater surface from the non-Delta highland areas drains towards these low land areas and may intersect the ground surface, except where soil permeability may allow percolation to the upper aquifer.

Groundwater discharges to ditches and drainage canals in the Delta islands where it is collected and pumped back to adjacent surface water bodies. It is common to have artesian flowing wells in the center of the islands. Artesian conditions are defined by groundwater levels in wells screened in the aquifer underlying the organic deposits that rise above the bottom of the organic deposits. Artesian conditions are a clear demonstration of the influence of adjacent channels on island groundwater levels and upward flowing groundwater (Hydrofocus 2015). Outside the artesian areas, where groundwater elevations are below sea level, there is also upward flowing groundwater. Where land-surface elevations are about 5feet above sea level or less, groundwater flows upward towards drainage ditches from tens of feet below land surface.

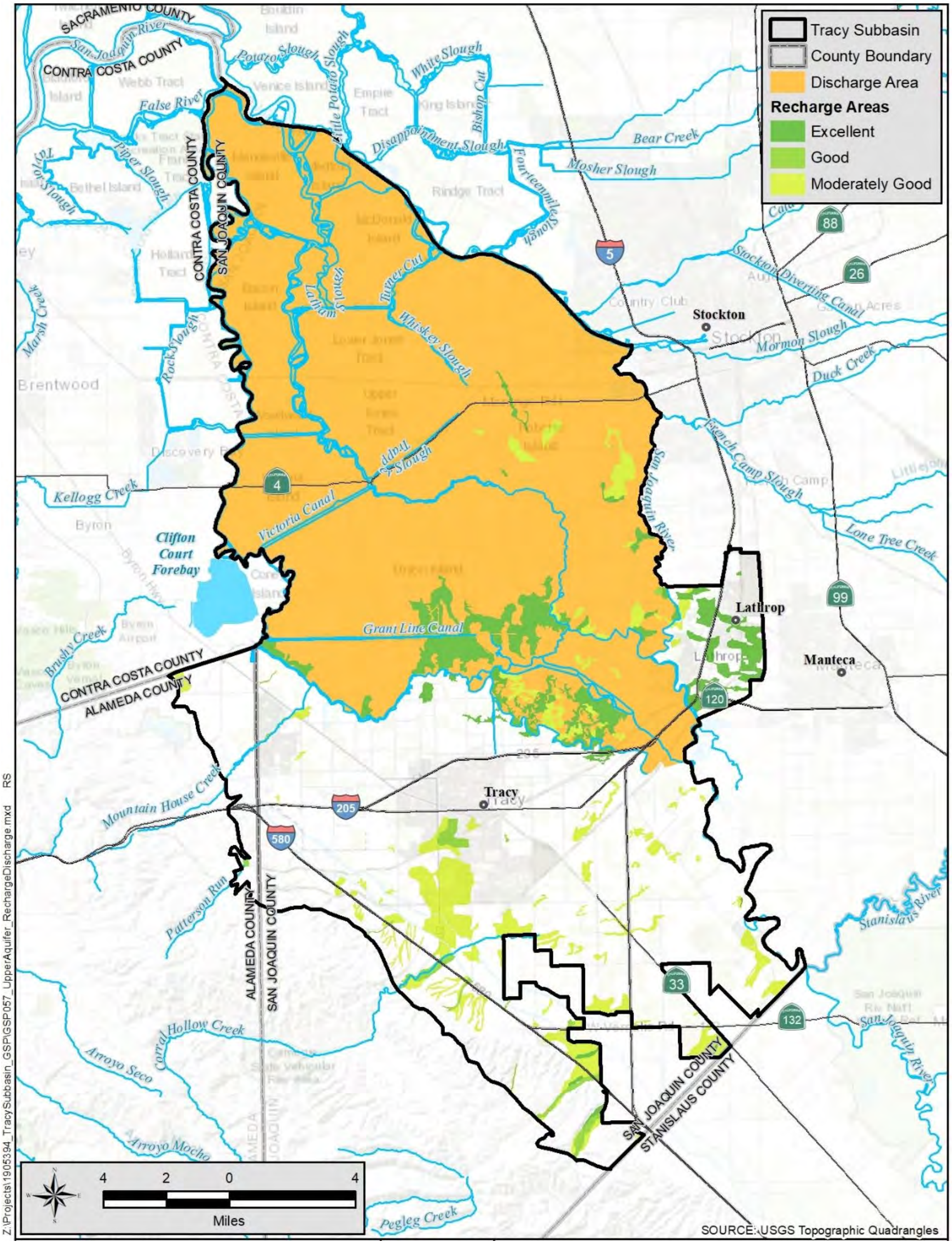


**Figure 4-15. Upper Aquifer Recharge and Discharge Areas**

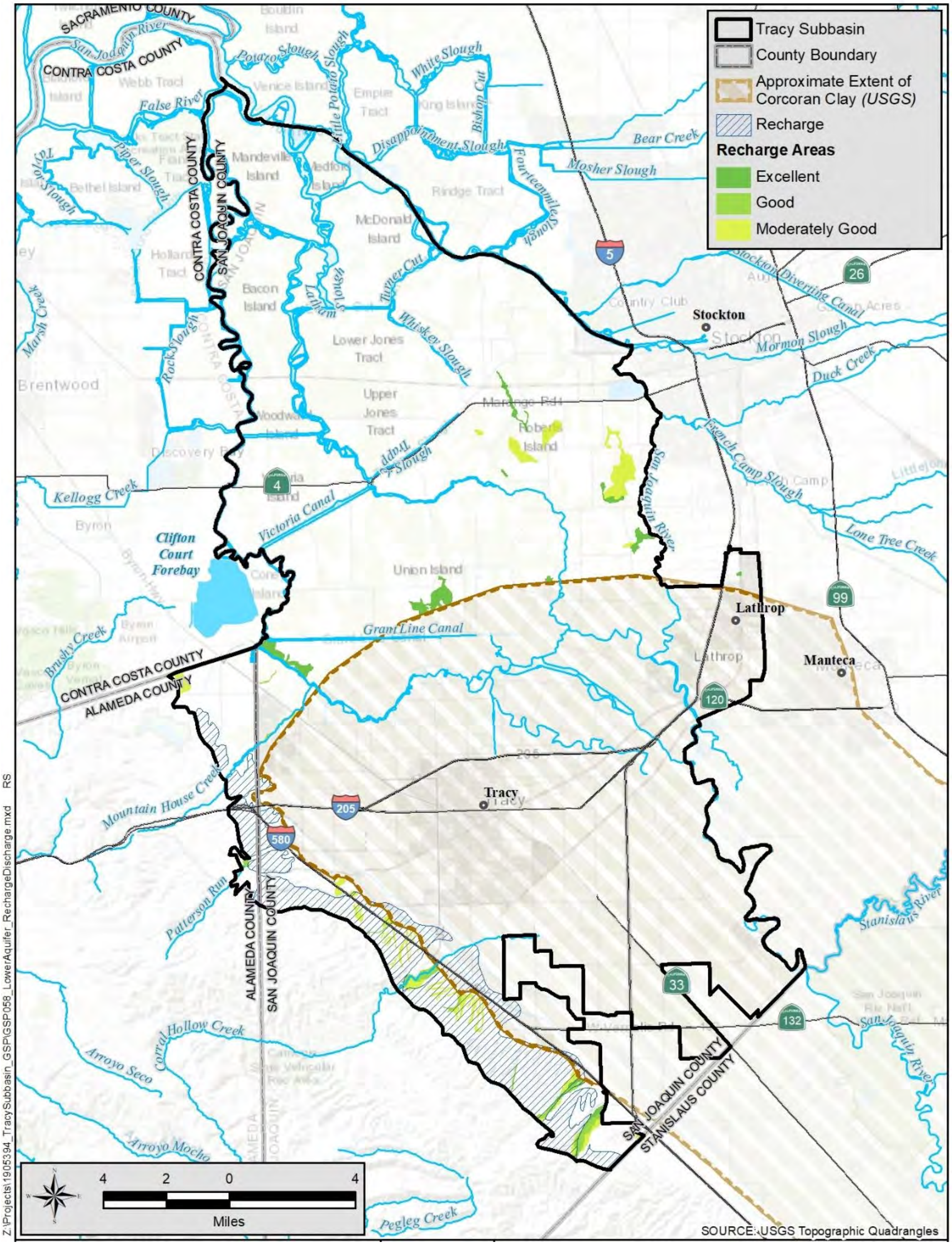


**Figure 4-16. Lower Aquifer Recharge and Discharge Areas**

## 4.13 Imported Water Supplies

For purposes of this GSP, "imported water" is defined as water that is brought in from areas outside of the Subbasin, in contrast to "diversions" that represent water diverted from rivers or tributaries within and adjacent to the Subbasin. There are over one-hundred riparian and appropriative diversions throughout the Delta area (DWR 1995). Diversions from local waterways also occur and used to serve non-Delta regions. Water from the DMC is also considered to be a diversion and not imported water.

Water is imported into the area from the Stanislaus River, via Woodward Reservoir, to the cities of Lathrop and Tracy where it is used by their customers within their service area. The points of delivery are shown on **Figure 4-17**.

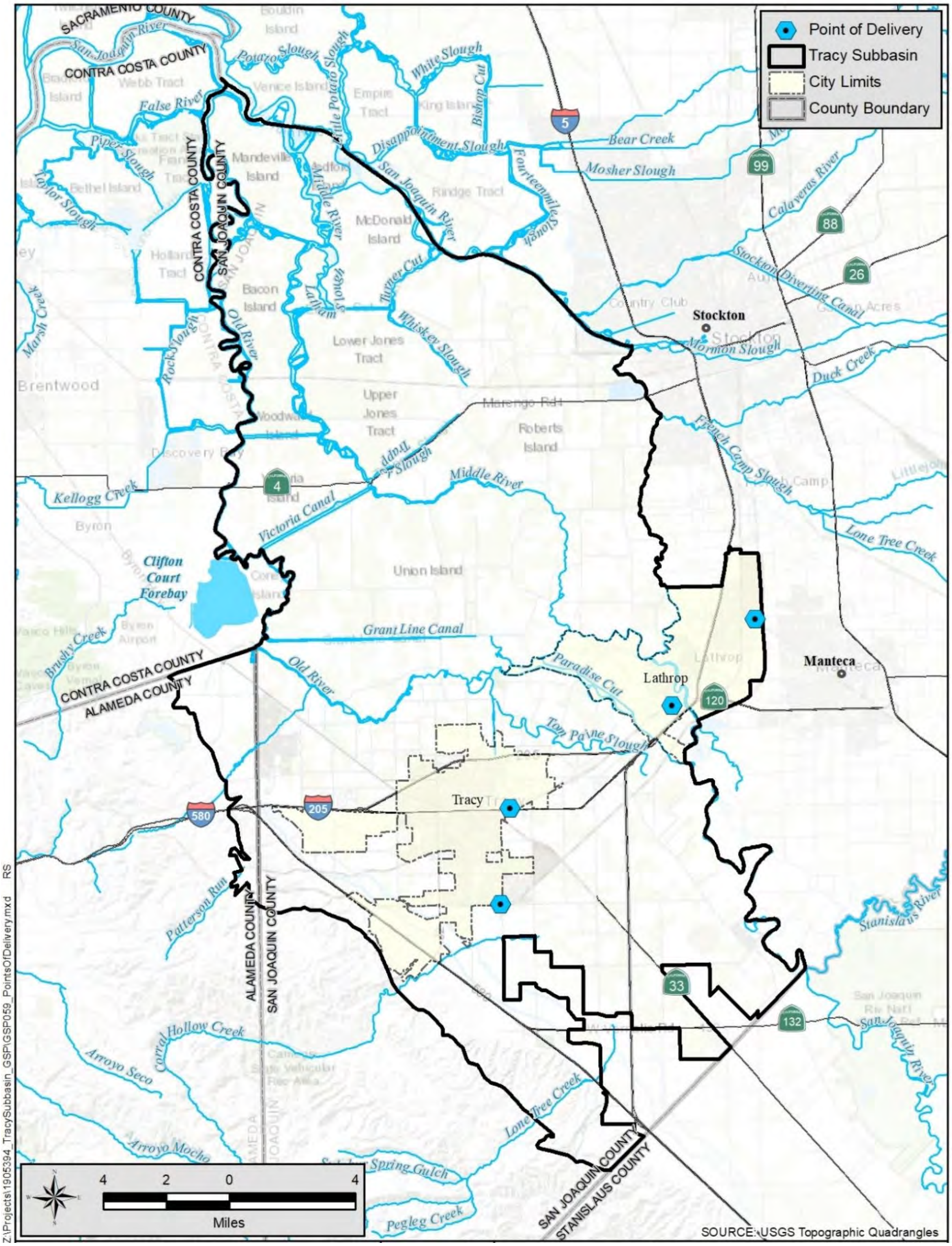


**Figure 4-17. Imported Water Points of Delivery**

## 4.14 Data Gaps

The hydrogeologic conditions in the Subbasin have been investigated and documented since the early 20th century and continues through the present. Improvement plans have been made for construction of new monitoring wells in strategic areas in the subbasin to improve the quality and extent of groundwater level data collection. At this time there are no data gaps that would affect the ability to sustainably manage the Subbasin. Data collection that would improve the hydrogeologic understanding of the Subbasin are:

- Improving the characterization of water quality in each principal aquifer. There are over 120 public water supply (PWS) wells with water quality data with water quality data that could not be assigned to a principal aquifer. Further evaluation of the public supply wells is warranted to make better use of this data and to provide a more complete picture of the water quality in each aquifer.
- Further research of boring logs for the Delta Tunnel project is warranted. The extent of the Corcoran Clay beneath the Delta is unconfirmed due to the lack of deep wells.
- Construction of monitoring wells screened within the Upper and Lower aquifers near the west side of the Subbasin, to confirm the presence of the Corcoran Clay and to provide additional groundwater level control in this area.

# 5. Groundwater Conditions

This chapter provides a description of historic and current groundwater conditions in the Tracy Subbasin. From a water resources standpoint, the Subbasin can be divided into two areas (Delta and non-Delta) based on the differences in groundwater conditions. Groundwater conditions between areas vary due to a number of reasons, the primary reason being the extent of the Corcoran Clay and the extent of surface water and groundwater interconnection.

In the Delta areas, groundwater is continuously fed by the surrounding water ways and has to be pumped out of the islands to allow the land to be used for agriculture purposes. Groundwater use is minimal, as evidenced by the low density of wells which are mostly for domestic purposes as shown on **Figures 3-12 through 3-17**. As a result, groundwater levels typically fluctuate by less than 10 feet and coincident with oceanic tides. In the non-Delta areas, surface water is also available in most areas which means groundwater use is minimal, primarily for domestic purposes. Urban and industrial areas rely on a combination of groundwater and surface water.

## 5.1 Groundwater Levels

Groundwater levels (water table and peizometric heads) have been recorded at over 226 wells in the Subbasin and reported to DWR's CASGEM or Water Data Library systems; however, some wells were only measured a few times or measurements were discontinued many years ago, resulting in a partial record of groundwater conditions. Only wells with known total depths or that have construction details and that were assigned to a principal aquifer were used to evaluate groundwater levels for this GSP. To supplement these wells, additional monitoring wells were located that are being used for other regulatory driven programs: environmental site assessment and cleanup, irrigated lands regulatory program, and monitoring of applied treated wastewater. A few wells in adjacent subbasins were used to provide additional information near the subbasin boundaries. This GSP evaluated groundwater levels at 95 CASGEM and additional monitoring wells to illustrate groundwater conditions.

**Figure 5-1** shows the location of wells in the Subbasin that have long-term records and dedicated monitoring wells with shorter-term records. The locations of the wells and their names, coded by principal aquifer, are shown on **Figure 5-1**. A table correlating the well names to CASGEM identification numbers is provided in **Appendix C** with well construction details and the principal aquifer monitored. **Appendices E and F** contain time-series groundwater level measurements (hydrographs) for wells by principal aquifer.

The extent of the principal aquifers is not consistent across the Subbasin. Both the Upper and Lower aquifers are present in the non-Delta portions of the Subbasin whereas only the Upper aquifer is present in the Delta areas. **Figure 5-2** provides a schematic of the general locations of the aquifers.

### 5.1.1 *Upper Aquifer*

The depths to groundwater and trends vary based on location in the Subbasin. In general, the groundwater levels in the Delta portions of the subbasin are near ground surface, indicating an abundance of surface water and groundwater that are interconnected. Conversely, groundwater levels are much deeper in the non-Delta upland portions of the Subbasin where groundwater levels are affected by pumping, discontinuous recharge disconnect from streams and channels, and deep percolation of water from agricultural fields.

In the Delta areas, groundwater levels are stable and have historically been near the surface. Groundwater levels typically range from about ground surface to 15 feet bgs (**Figure 5-3**). In the islands, groundwater levels can be above ground surface and some wells flow artesian, due to the Delta islands being surrounded by waterways and some islands being below msl. The groundwater levels typically fluctuate by about 5 feet due to tidal influence (**Figure 5-4**). In 2010, groundwater levels declined by about 5 feet, near the southern edge of the Delta, and have remained at this level ever since, possibly due to lowering of a drain.

In the non-Delta areas, groundwater levels are deeper towards the south and shallower near the San Joaquin and Old rivers (**Figure 5-2**). Currently, the groundwater levels in the Upper aquifer range from 80 feet bgs near the foothills to within 5 feet of ground surface near the San Joaquin River. Groundwater levels typically have greater seasonal fluctuations, locally up to 40 feet, due to groundwater pumping and seasonal recharge. Even with these seasonal changes the depths to groundwater have remained similar, except for those near the southeastern portion of the Subbasin where groundwater levels started to decline around 2010 (to present), due to increased and apparent continued reliance of groundwater since the drought (**Figure 5-4**). The declines are not exceeding 15 feet. Long-term groundwater level trends (1998-2020) were developed (DWR 2021) for wells with levels throughout this period (**Figure 5-5**). Four wells are confirmed to be in the Upper aquifer with two of the wells near the Old River are showing declining water levels by about 4 feet; in a predominately agricultural area with most of the area provided surface water by BBID. The other two wells, in the City of Lathrop, have stable groundwater levels.

### 5.1.2 *Lower Aquifer*

The depths to groundwater in the Lower confined aquifer are typically deeper than those in the Upper aquifer. Groundwater levels (piezometric heads) range from about 20 to 270 feet bgs (**Figure 5-6**) and in some locations, are below sea level. **Figure 5-7** shows the groundwater level trends in the Lower aquifer. Groundwater elevations in the Lower aquifer are about -60 to 80 feet. The groundwater levels are always above the top of the Corcoran Clay by about 200 to 240 feet.

The groundwater levels vary by up to 30 feet seasonally. Groundwater levels trended upward from 2004 through 2012, declined during the subsequent drought, and regained an upward trend in 2017 (**Figure 5-7)**. The upward trend during the 2004 to 2012 included years when the City of Tracy increased pumping from 5,800 to nearly 8,000 AFY (2001-2005) and reduced pumping at the start of imported surface water from SSJID in 2005. Groundwater levels in the Lower aquifer increased by about 30 feet near the foothills in 2017, in response to recharge from precipitation during the wet hydrologic conditions in winter of 2017. The long-term hydrographs shown on **Figure 5-7** do show some lowering of groundwater levels, by about 15 feet in the southern portion of the Subbasin, adjacent to the Delta-Mendota Subbasin.

Long-term groundwater level trends (1998-2020) were developed (DWR 2021) for wells with levels throughout this period (**Figure 5-5**). Wells with shorter periods of records, as those wells near the City of Tracy, were not used in their trend analysis. Two wells in the Lower aquifer both near the southern end of the basin in the non-Delta area, show either no trend or a downward trend. The well with the downward trend is not sealed through the Corcoran clay. A new monitoring well is planned in this area to verify if the downward trend is in the Upper or Lower aquifers.

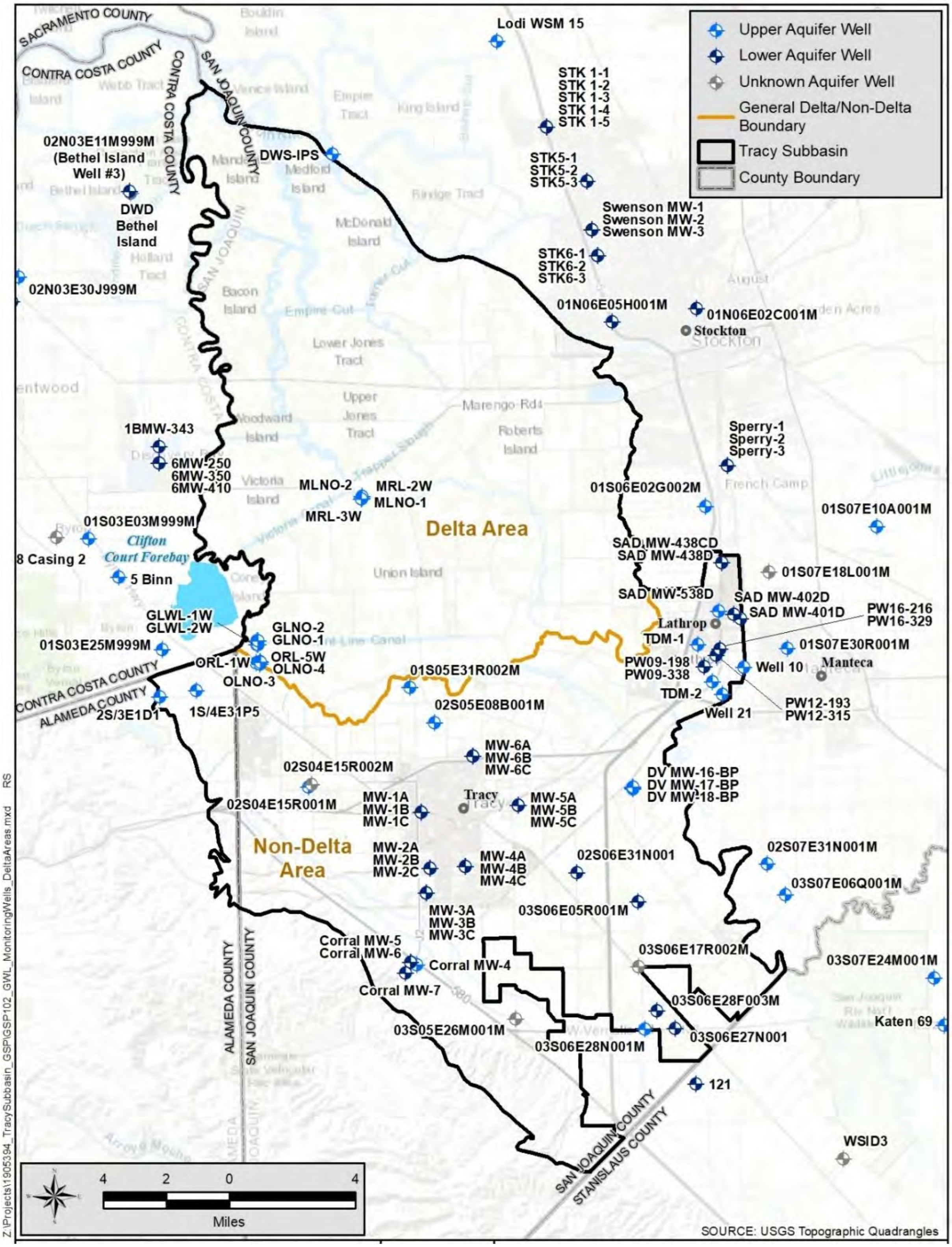


**Figure 5-1. Groundwater Level Monitoring Wells**

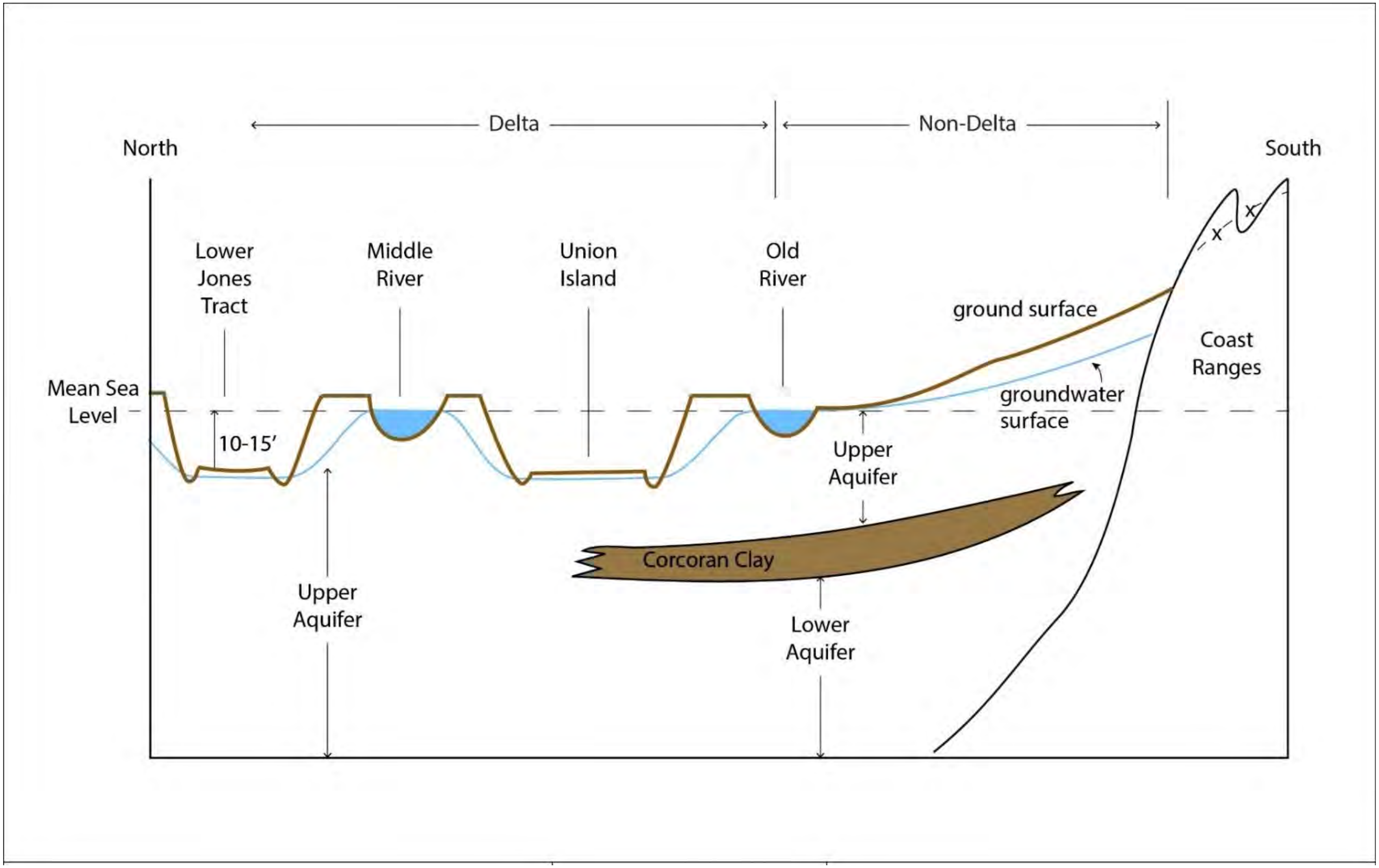


**Figure 5-2. Principal Aquifer Schematic**

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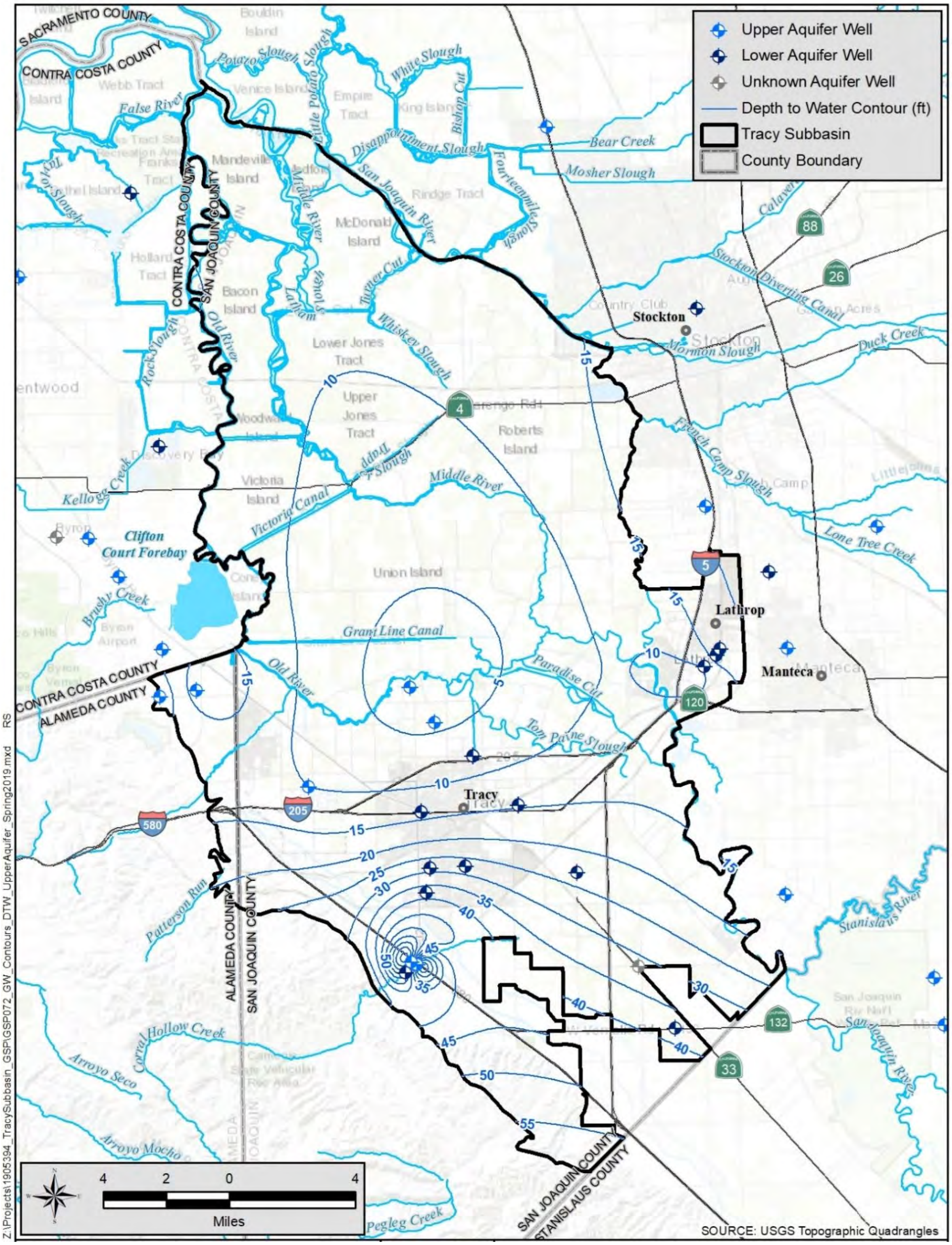


**Figure 5-3. Upper Aquifer Depth to Groundwater – Spring 2019**

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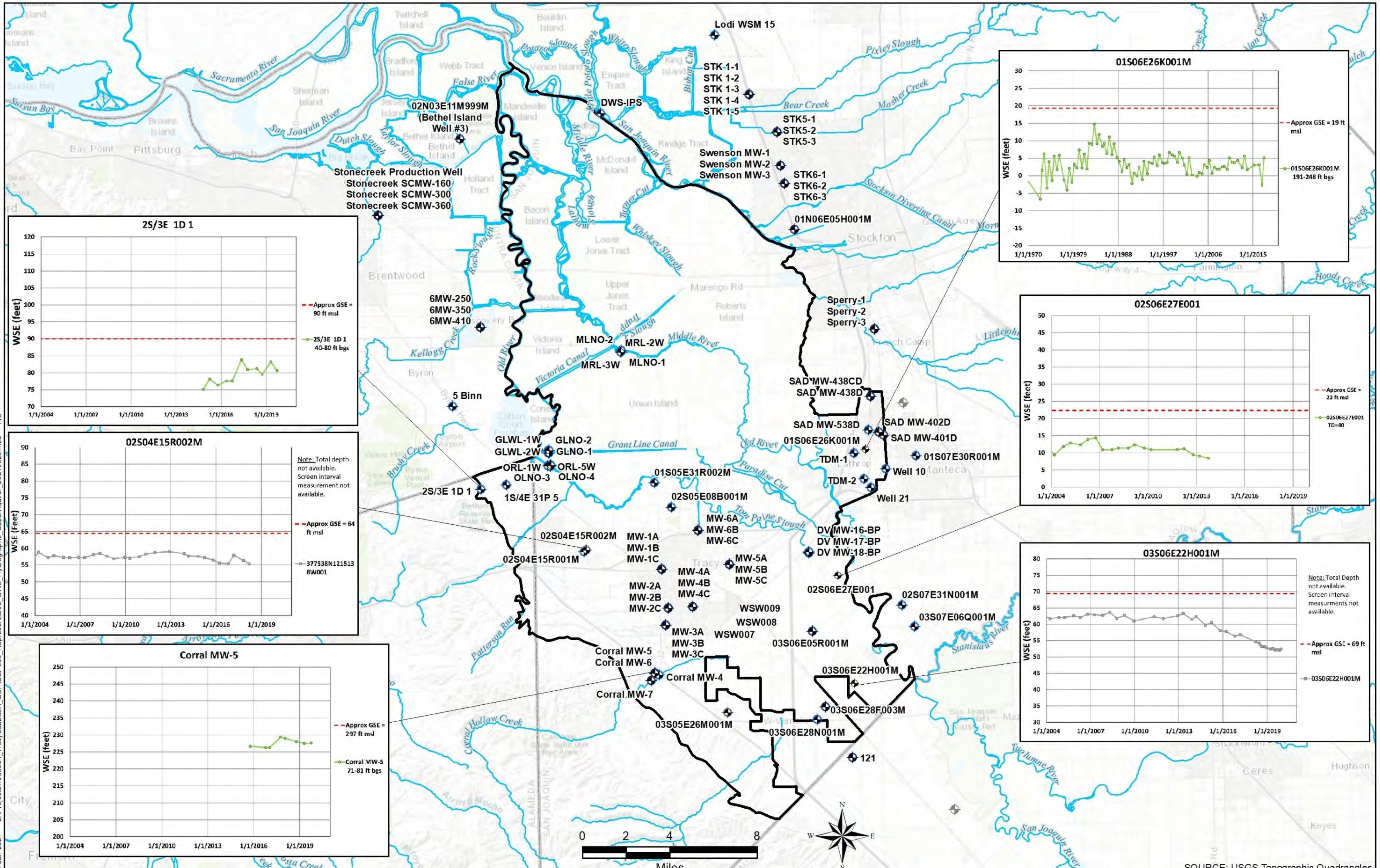


**Figure 5-4. Selected Upper Aquifer Groundwater Level Hydrographs**

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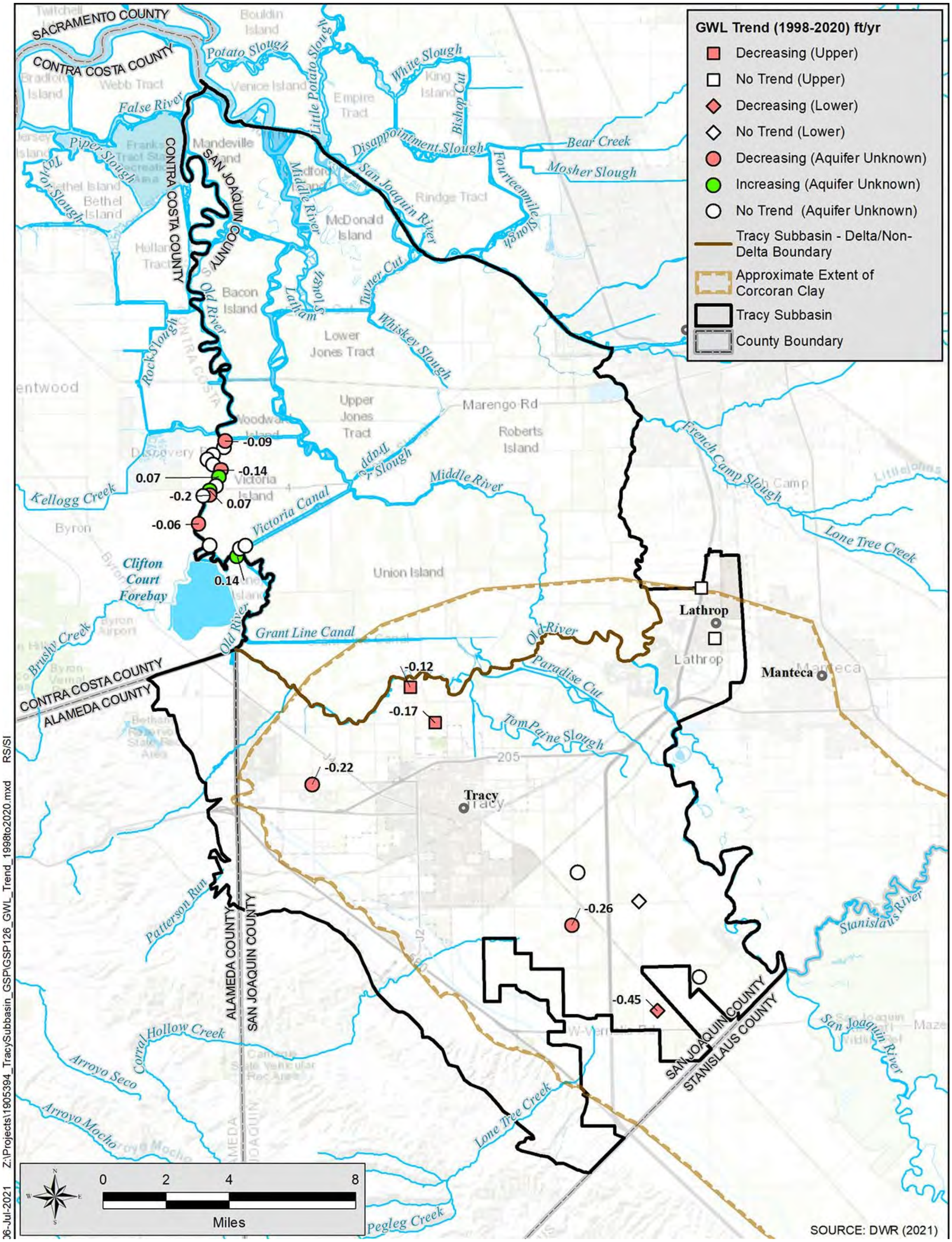


**Figure 5-5. Groundwater Level Trends**

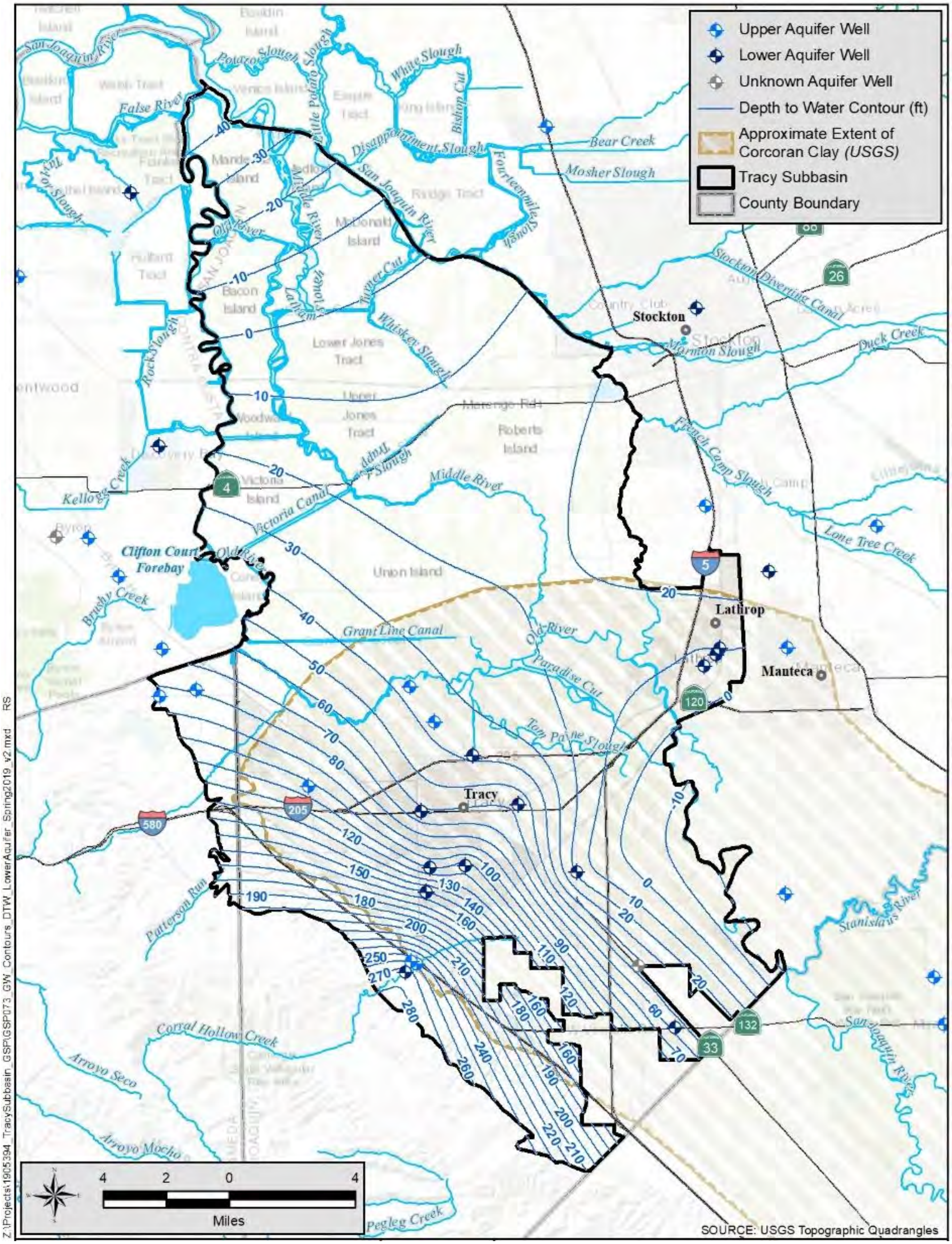


**Figure 5-5. Lower Aquifer Depth to Groundwater – Spring 2019**

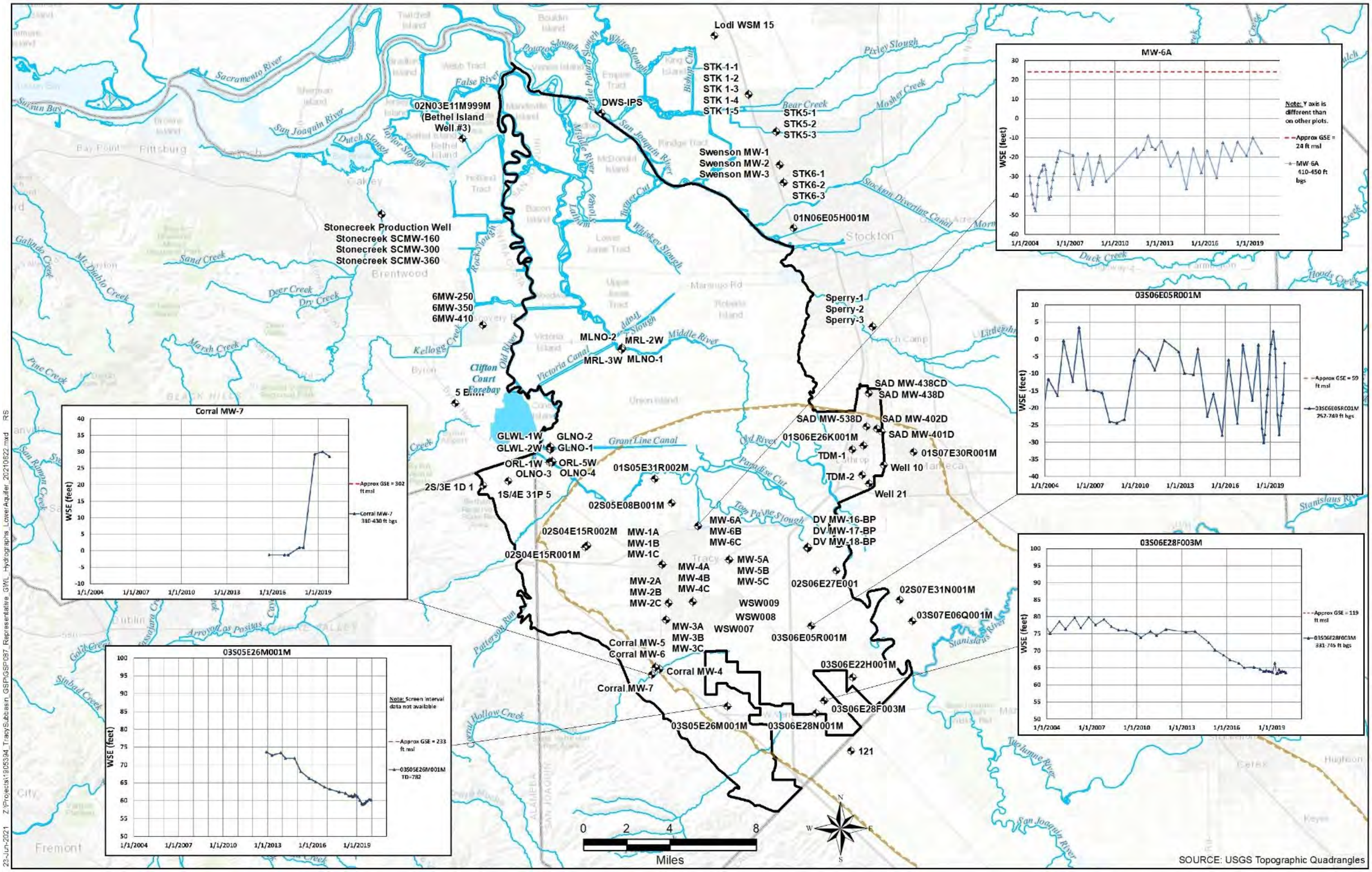


Figure 5-6. Selected Lower Aquifer Groundwater Level Hydrographs

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## 5.2 Current Groundwater Contours

Groundwater elevation contours were developed to show the current seasonal high and lows, groundwater flow directions, and regional pumping effects for both the Upper and Lower aquifers. The contours were developed using wells in the Subbasin and wells near the fringes of surrounding subbasins adjacent to the Tracy Subbasin, after receiving further confirmation of the aquifers monitored. Groundwater contours were developed for both the Upper and Lower aquifers for spring and fall 2015, the historic low since the start of SGMA, and for spring and fall 2019, to illustrate current groundwater conditions and groundwater high conditions (**Figures 5-8 through 5-15**). The contours were compared to surrounding subbasins with completed GSPs for general comparison and to support future evaluations.

**Upper Aquifer**

In the Delta area, groundwater elevations are mostly below sea level due to two main factors: the ground surface in the islands having subsided to below sea level, and the drains within the island which keep groundwater levels bgs to allow for farming. **Figure 5-2** generally illustrates the groundwater surface, in profile, expected at each island. Each island has its own unique groundwater elevations and contours, but similar hydraulics are present on all islands. **Figure 5-16** shows a detailed groundwater contour map for a Stewart Tract island, where some crops are being irrigated with recycled water. Groundwater contours are higher near the island edges adjacent to waterways and generally deepen coincident with the deepest land surface and drain. This type of pattern is expected at each island, but the depth will vary dependent on the elevations of the drains. Groundwater elevations in the islands are managed by the elevations of the drains and canals and there is very little to no pumping of wells for agriculture. Because drains and canals control the groundwater elevations and gradients, groundwater contours were not developed for each of the Delta islands. Information from the Stewart Tract island is used as representative for the conditions of the other islands. Although groundwater contours produced for the adjacent Eastern San Joaquin Subbasin show a groundwater pumping depression that extends from the subbasin across the Tracy Subbasin and into the East Contra Costa Subbasin, such a depression is unlikely due to all of the recharge provided by the waterways and does not correlate with the groundwater contours within each island, as described above.

In the non-Delta areas west of the San Joaquin River, groundwater contours for the Upper aquifer indicate groundwater elevations are highest near the Coast Ranges and decrease toward the Delta. Flow directions suggest that recharge areas are present along the foothills and that groundwater discharges into the Old River or Tom Paine Slough. Evidence of recharge is observed near Corral Hollow where apparently perched groundwater is present, as indicated by groundwater levels being 140 feet higher than adjacent wells (**Figure 5-10 and 5-12**). Groundwater gradients in the non-Delta portions of the Subbasin are the steepest, at about 0.008 foot/foot. East of the San Joaquin River, near Lathrop, the river recharges the Upper aquifer beneath the City and aquifers in the Eastern San Joaquin Subbasin, towards a pumping depression near Stockton (**Figure 5-17**). Groundwater contours at the southeastern edge of the Subbasin, adjacent to the Delta Mendota Subbasin, are perpendicular to the Stanislaus-San Joaquin County line, indicating there is no flow in the Upper aquifer between the subbasins, other than the finger areas of the Delta Mendota Subbasin north of the County line, where water flows into and out of both subbasins.

**Lower Aquifer**

The Corcoran Clay extends throughout most of the, if not all, of the non-Delta areas and only slightly into the Delta area, at Union Island. Groundwater contours for the Lower aquifer were developed with data from CASGEM monitoring wells constructed below the Corcoran Clay and supplemented by data from municipal wells to provide additional details. Groundwater monitoring well data from the adjacent Delta Mendota Subbasin were also used to assist in the contouring.

Two wells (376129N1212942W001 and 376388N1213056W001) from the Delta Mendota Subbasin showed elevations similar to the Upper aquifer. Upon further evaluation, the one well was found to be screened in both the Upper and Lower aquifers and the other well had a gravel pack that extended across both aquifers. Therefore, the two wells were removed from the contouring set. This resulted in a different, and more representative, pattern and flow direction than those presented in the Northern & Central Delta-Mendota GSP (Woodard and Curran, 2019).

Reference point elevations for Corral Hollow MW-7 in CASGEM were found to be about 50 feet different than in monitoring reports for the landfill that originally constructed the well. Reference point elevations were adjusted accordingly to match landfill records.

Groundwater contours in the Lower aquifer suggest groundwater is entering the subbasin from the south (Delta Mendota Subbasin) and from the east (Eastern San Joaquin Subbasin). Pumping in the vicinity of the City of Tracy has modified this overall regional flow gradient resulting in a pumping depression which is creating radial flow towards the City. Near the northern edge of the Corcoran Clay extent, the groundwater levels are expected to be at sea level, suggesting groundwater from the Delta could recharge the Lower aquifers.

The groundwater gradient in Fall 2019 from the Delta Mendota and the Eastern San Joaquin subbasins is about 0.0009 foot/foot into the Tracy Subbasin. The gradient increases around the City of Tracy due to the pumping depression. The gradient near the western edge of the subbasin cannot be determined at this time due to the lack of monitoring wells constructed below the Corcoran Clay.

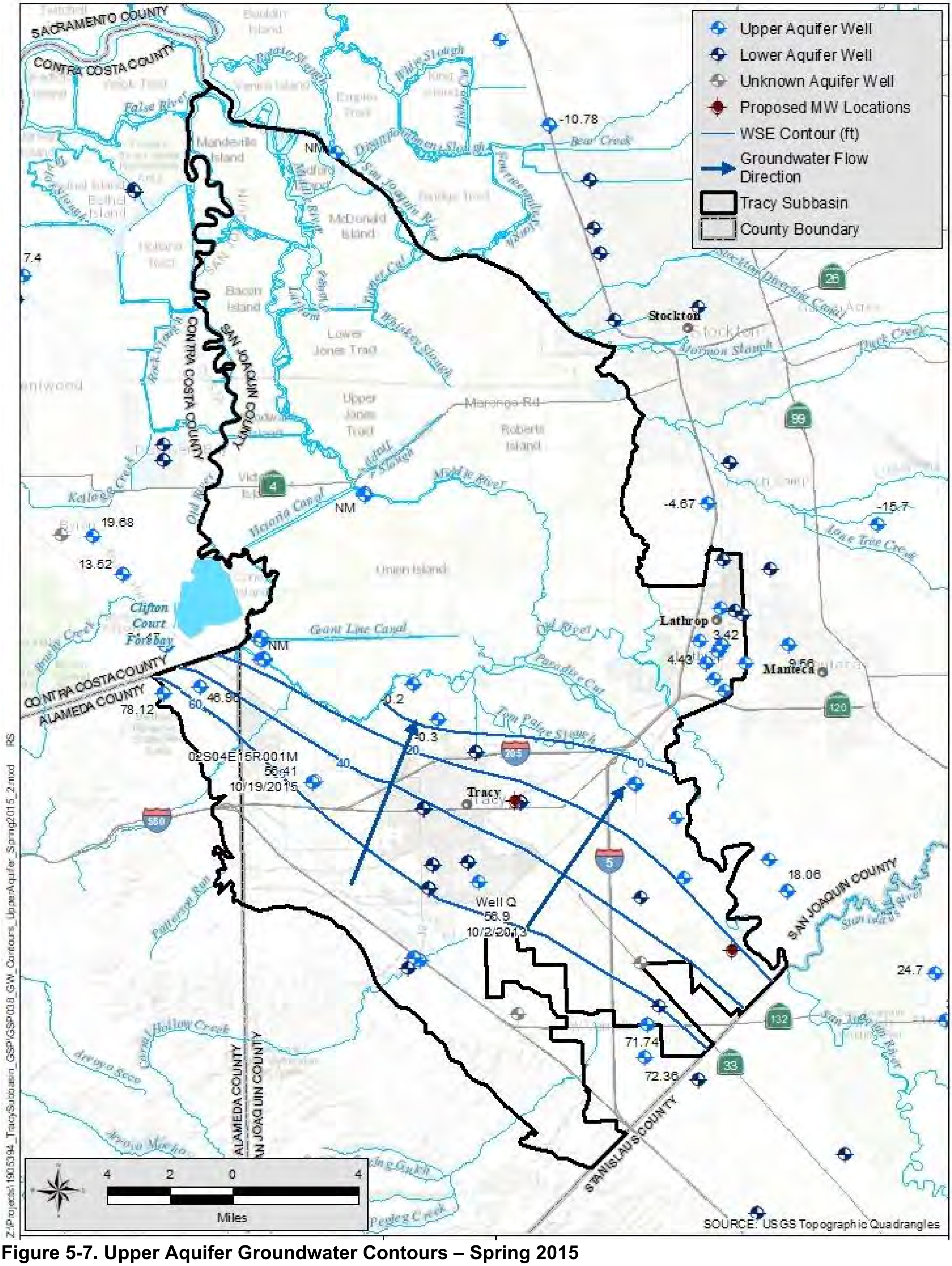


Figure 5-7. Upper Aquifer Groundwater Contours – Spring 2015

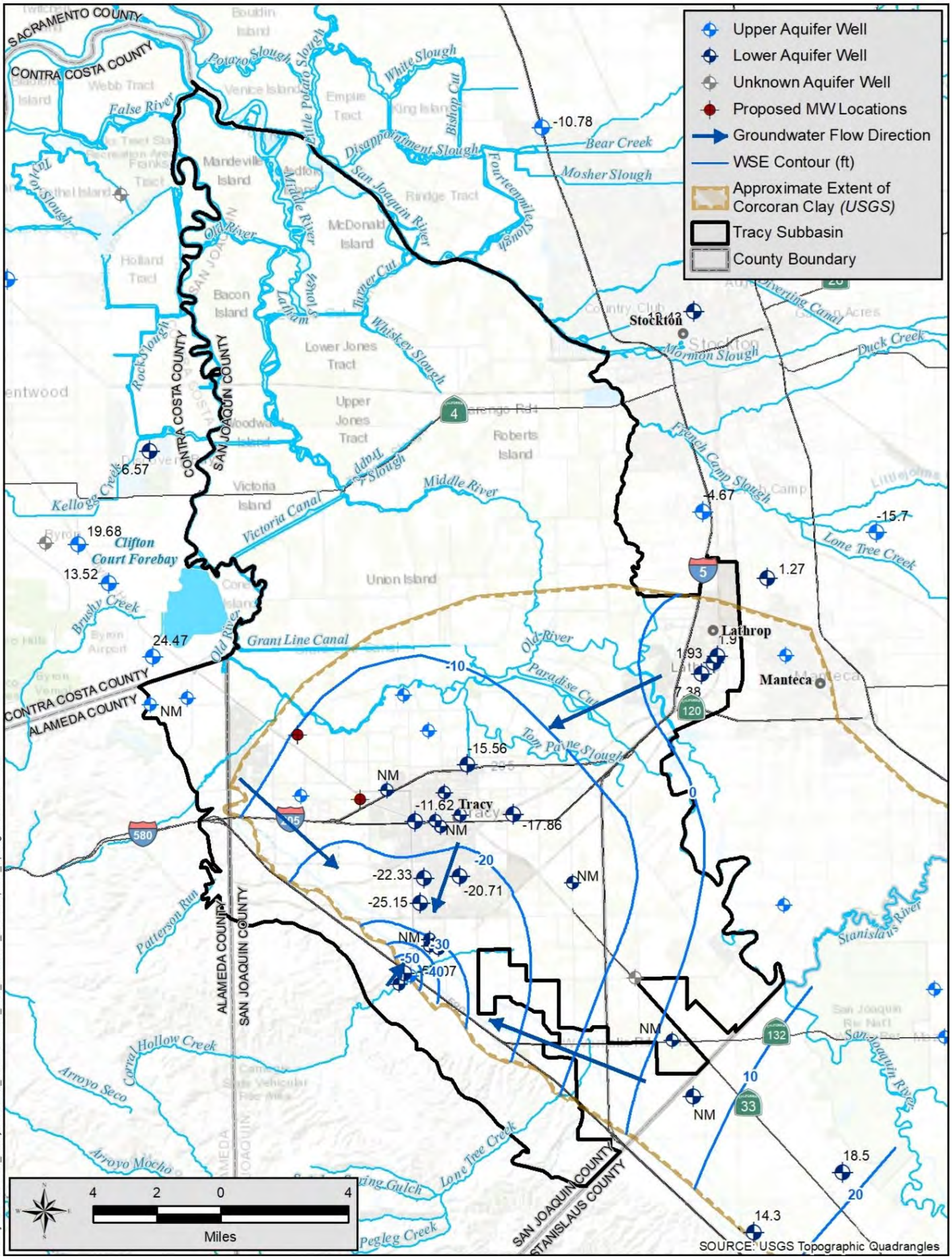


**Figure 5-8. Lower Aquifer Groundwater Contours – Spring 2015**

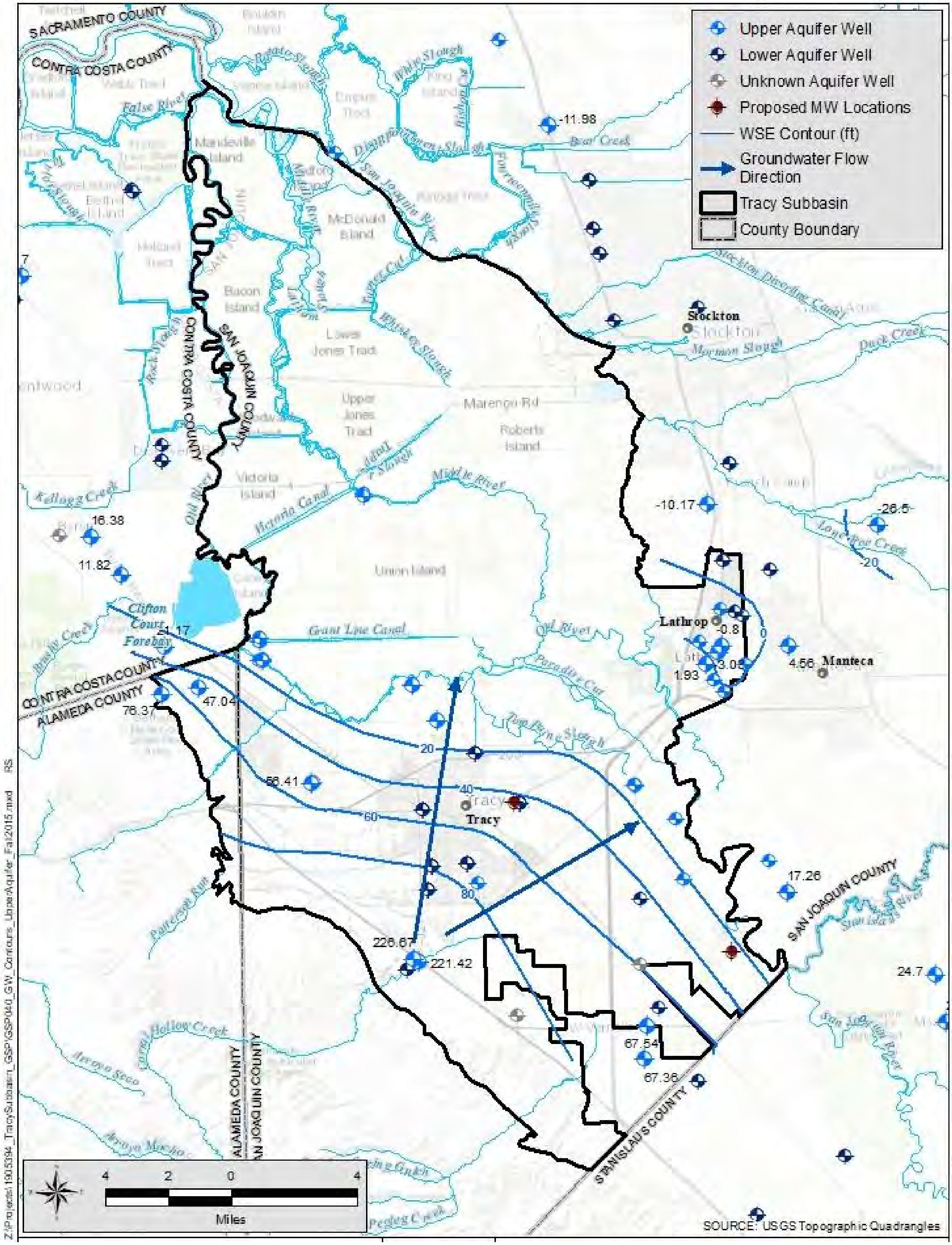


**Figure 5-9. Upper Aquifer Groundwater Contours – Fall 2015**

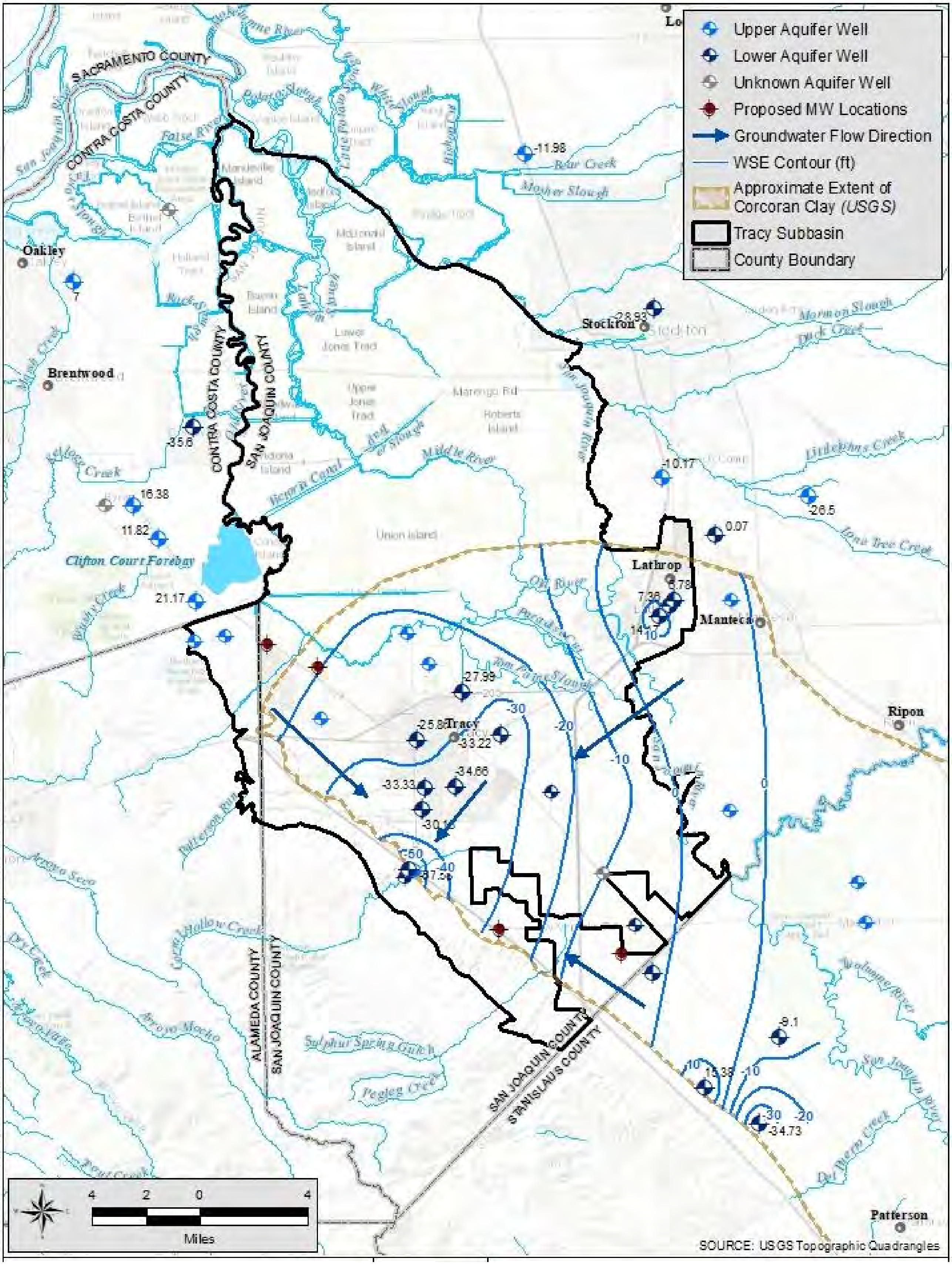


**Figure 5-10. Lower Aquifer Groundwater Contours – Fall 2015**

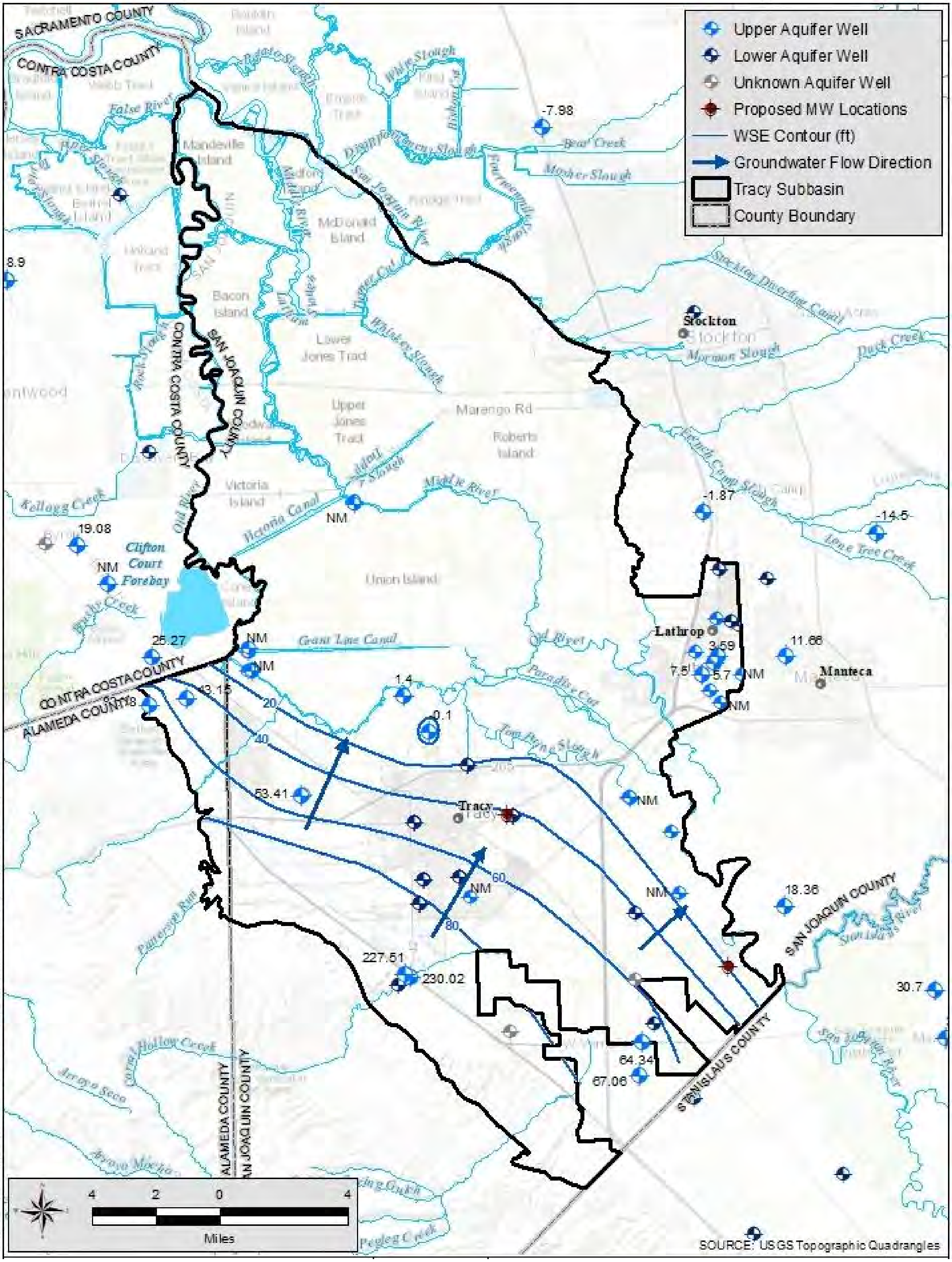


**Figure 5-11. Upper Aquifer Groundwater Contours – Spring 2019**

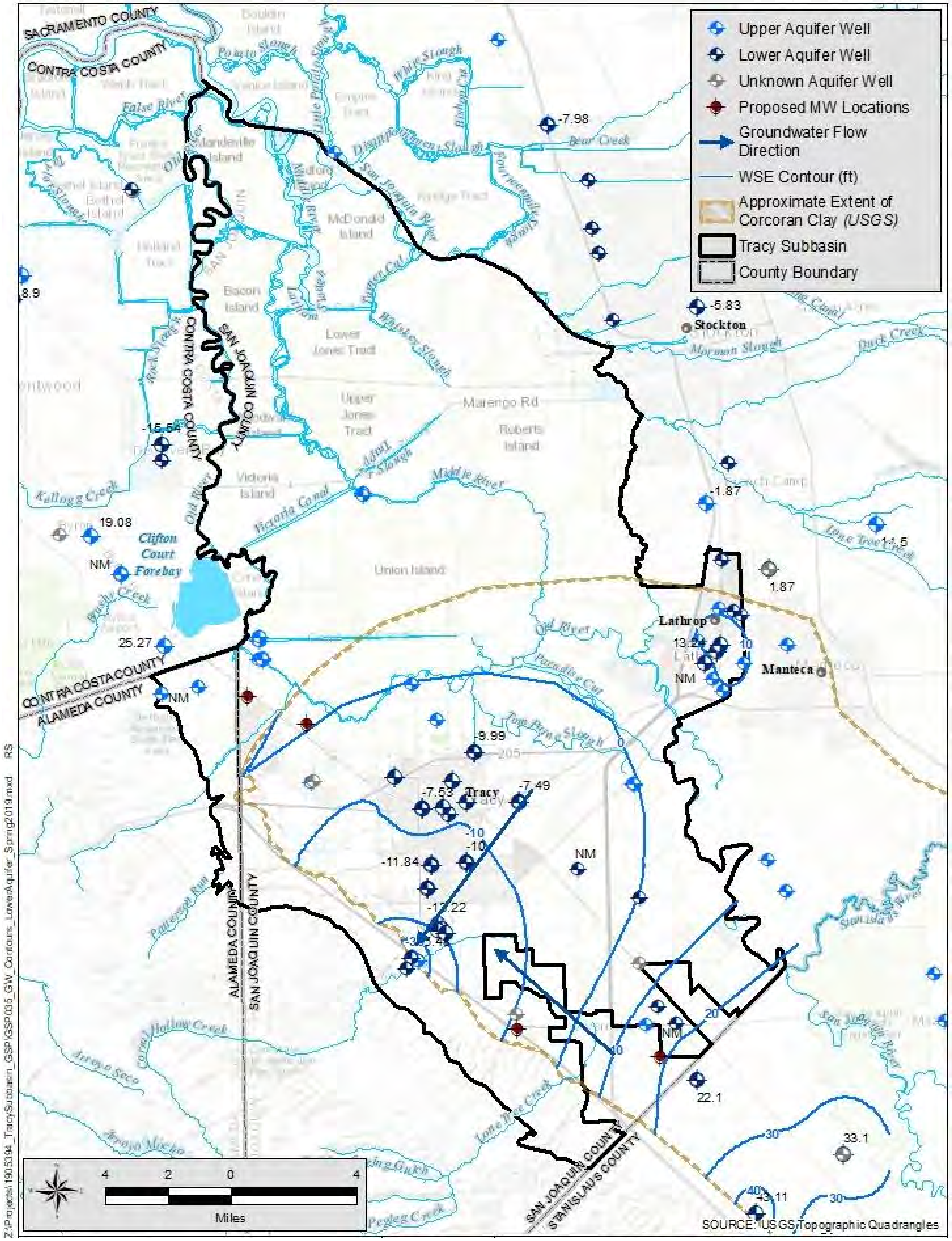


**Figure 5-12. Lower Aquifer Groundwater Contours – Spring 2019**

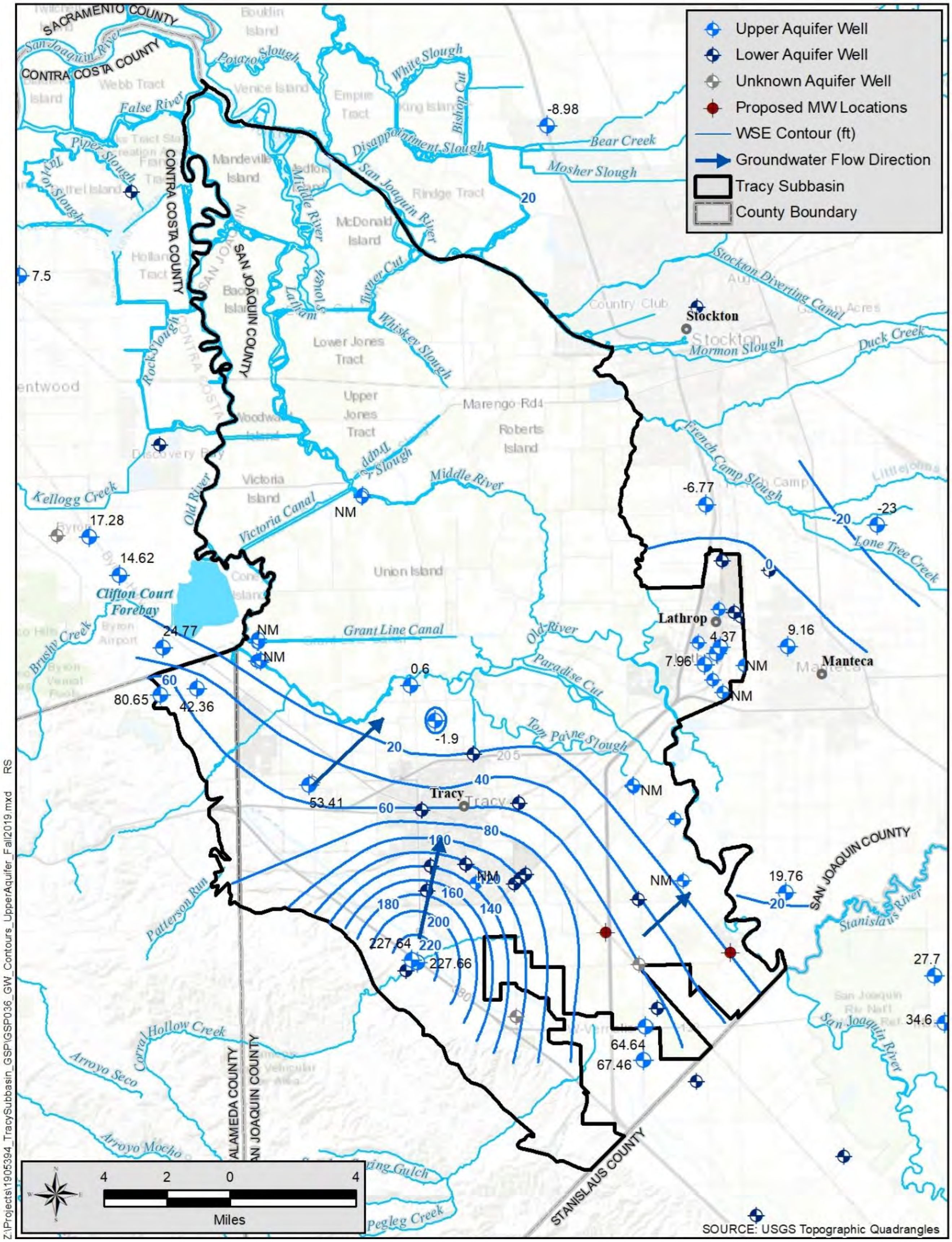


**Figure 5-13. Upper Aquifer Groundwater Contours – Fall 2019**

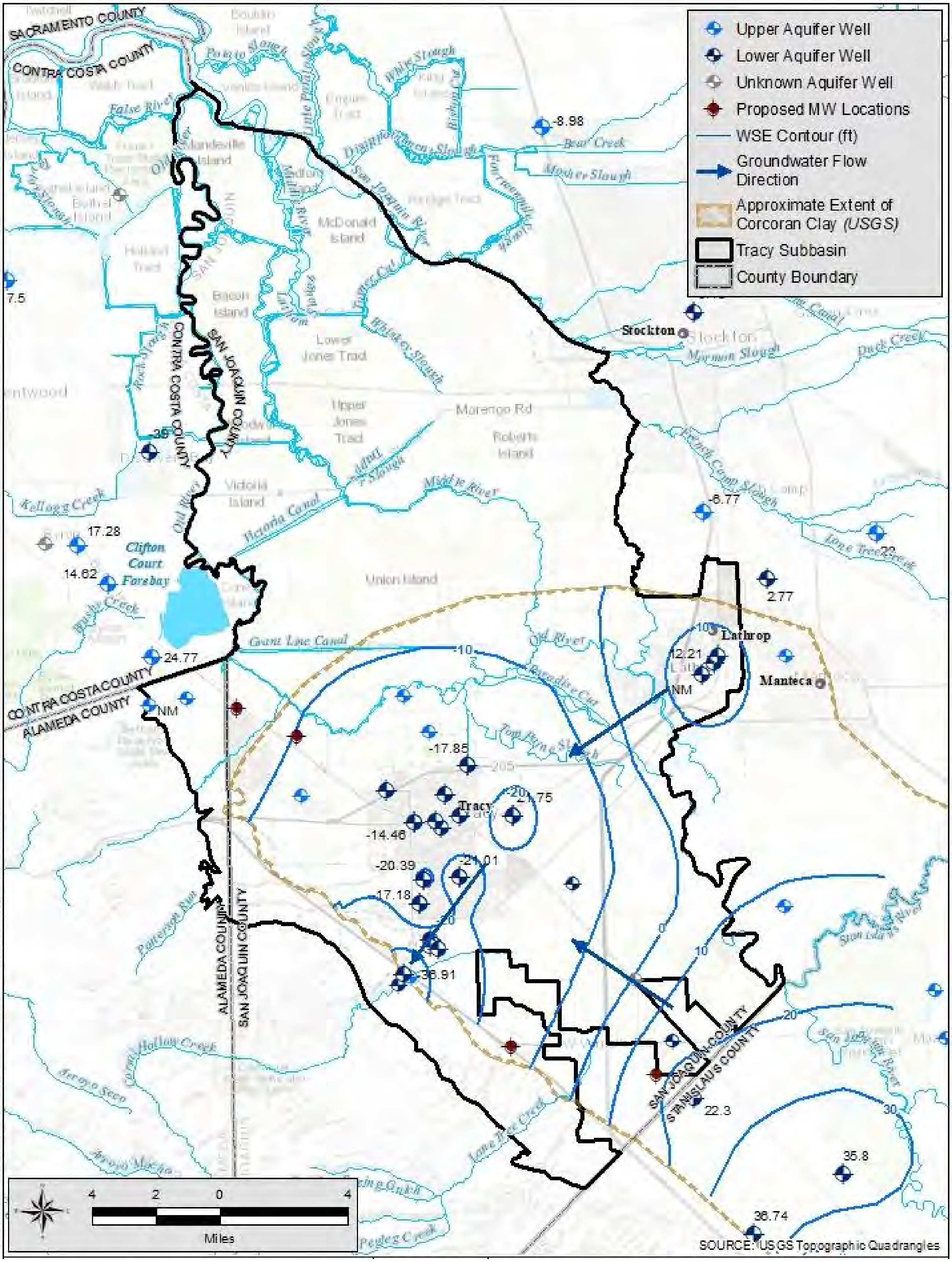


Figure 5-14. Lower Aquifer Groundwater Contours – Fall 2019

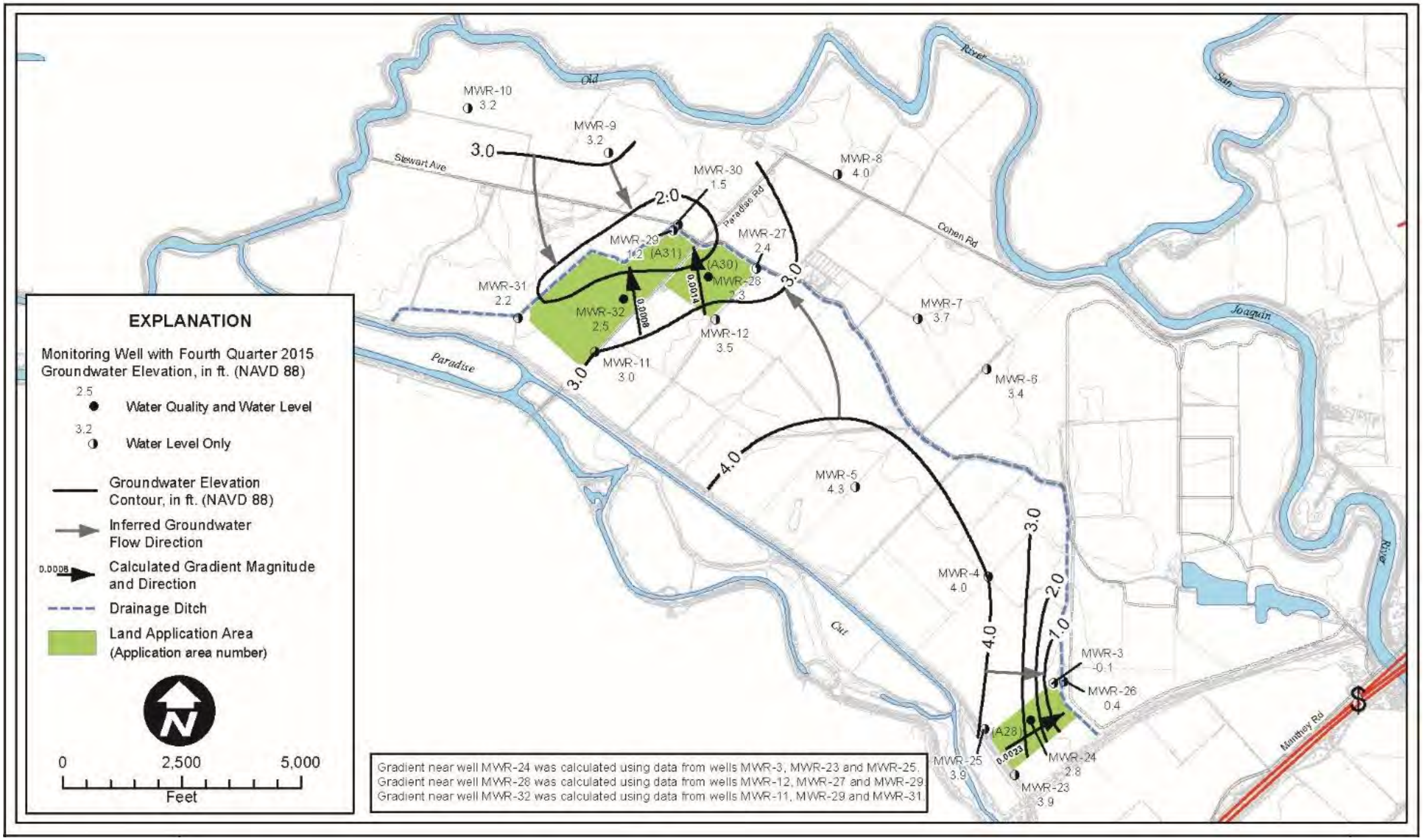


**Figure 5-15. Stewart Tract Groundwater Contours – November 2015**

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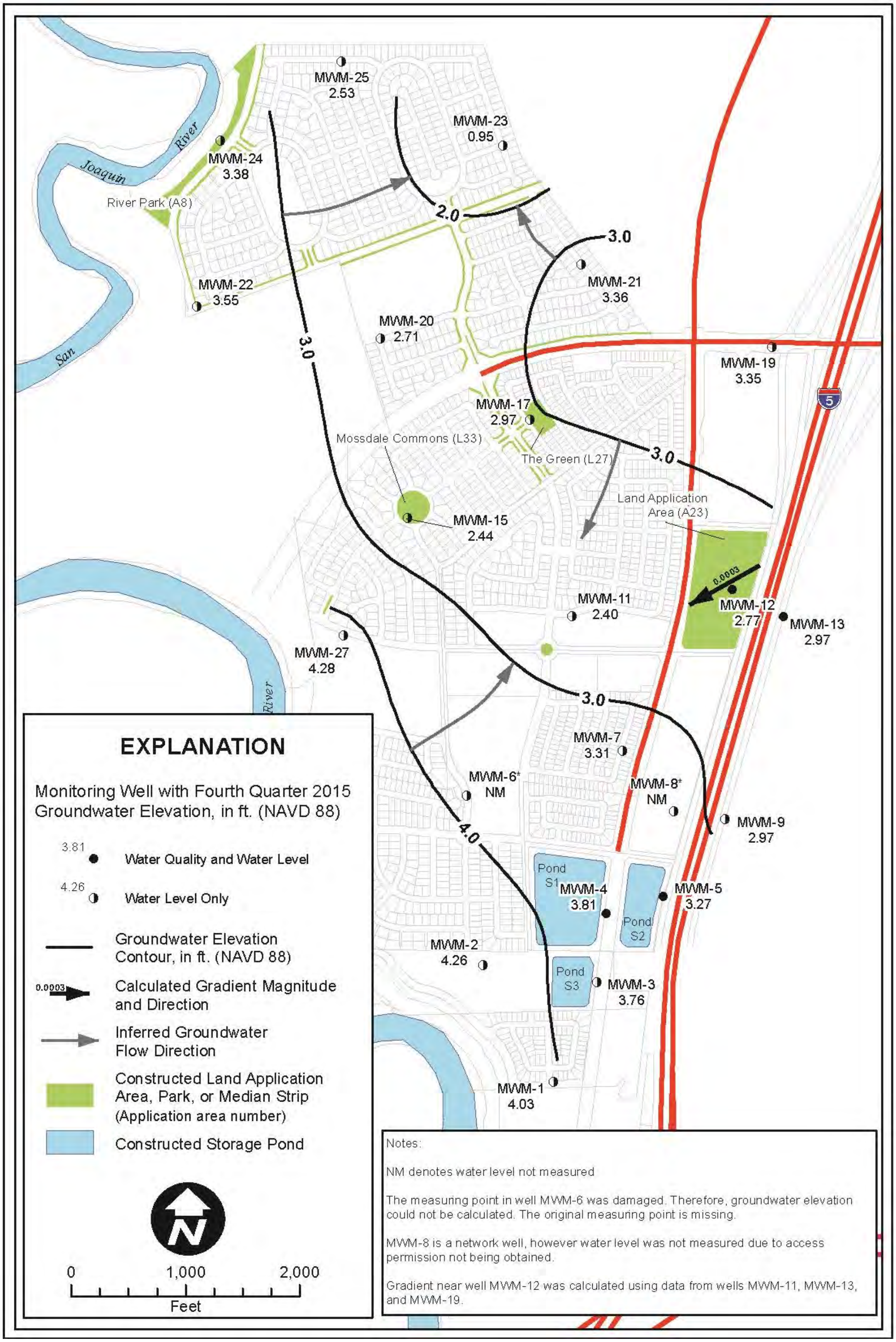


**Figure 5-16. Groundwater Contours – Lathrop (Mossdale) November 2015**

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## 5.3 Hydraulic Gradients Between Aquifers

Dedicated monitoring wells were constructed to monitor discrete intervals within the aquifers. These monitoring wells were used to evaluate vertical groundwater gradients within and between the aquifers. There are 16 nested and clustered monitoring well locations in the Subbasin that measure groundwater levels at up to four depths in the aquifers. **Appendix G** contains the hydrographs for each set of nested or clustered wells. In some cases, the clustered or nested wells are all in the same aquifer.

**Upper Aquifer**

Four sets of clustered monitoring wells are present in the Upper aquifer. Vertical gradients within the Upper aquifer vary in direction (upward or downward) based on their location in the subbasin and time.

- In the Delta area, MRL-2W, MRL-3W, MLNO-1, and MLNO-2 hydrographs show there is a downward gradient ranging from 1–10 feet.
- In the Delta area, ORL-1W, ORL-5W, OLNO-3, and OLNO-4 hydrographs show a mixture of upward and downward gradients with upward gradient present in the early 2000s and downward gradients of 5–10 feet since about 2010.
- In the non-Delta area, clustered well 02S04E15R001 and 02S04E15R002M hydrographs show a downward gradient of 2–7 feet.

**Lower Aquifer**

Six sets of clustered monitoring wells (MW-1A, B, and C through MW-6A, B, and C) are present in the Lower aquifer, around the City of Tracy. These wells monitor groundwater levels at different depths below the Corcoran Clay.

- Groundwater levels in the Lower aquifer show a mixture of downward and upward gradients that range from 1–9 feet between each coarse-grained sedimentary layer.
- There is a consistent downward gradient between the individual aquifers (MW-1, -2, and -4) in the southern and western portions of the City, with an upward gradient (MW-5 and -6) between the deeper two aquifers in the eastern and northern portions of the City.
- The gradients at MW-3 occasionally reverse but are mostly downward.

The upward gradients could be an indicator of upwelling of water from deeper marine sediments. Downward gradients may indicate potential recharge areas.

**Upper to Lower Aquifers**

**Figure 5-18** provides a graphic representation of the vertical groundwater gradients (heads) between the Upper and Lower aquifers in Fall 2019, just after high groundwater use in the summer months, when the difference in groundwater levels are typically the greatest. **Appendix G** provides the hydrographs.

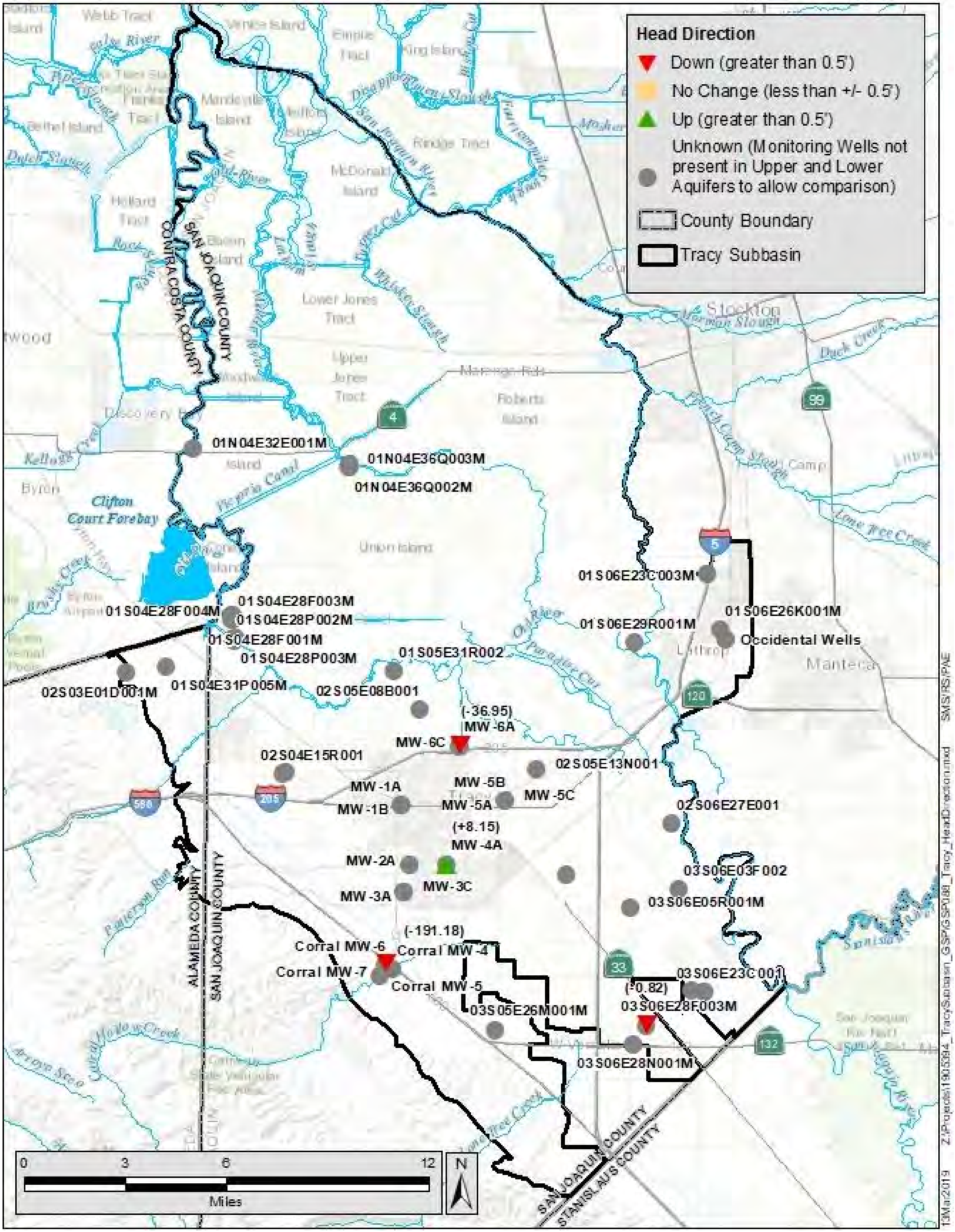


Figure 5-17. Vertical Gradients Between Upper and Lower Aquifers

Five sets of clustered monitoring wells are present in the non-Delta region of the Subbasin. The wells show a variety of conditions and vertical gradients:

- Near the foothills, where the clay is believed to be absent, the Corral Hollow wells show a downward gradient of with groundwater levels in the Upper aquifer at around 220 to 230 feet msl, while the deeper wells, are between -20 to -60 feet msl, a downward gradient of about 200 feet.
- In the central portion of the City of Tracy, where the Corcoran Clay is present, wells MW-4A and BC-19 show the Upper aquifer groundwater levels are about 55 feet msl while the Lower aquifer groundwater elevations are between 55 and 75 feet msl, an upward gradient of about 0 to 20 feet.
- In the northern portion of the City of Tracy, where the Corcoran Clay is present, wells MW-6A and BW-4 show the Upper aquifer groundwater levels are about 5 feet msl while the confined aquifer groundwater elevations at between -20 to -50 feet msl, a downward gradient of about 20 to 50 feet.
- Near the southern end of the Subbasin, where the Corcoran Clay is present, wells 03S06E26N001M and 03S06E28F003M show a slight downward gradient of about 1 to 3 feet and at times the heads are equal with no vertical gradient.
- Near the City of Lathrop, at the former Occidental chemical site where the Corcoran Clay is present, show there is an upward vertical gradient.

Even though the vertical gradient may change locally, the groundwater levels (piezometric) in the Lower aquifer are always above the Corcoran Clay, except near the foothills, indicating the aquifer is confined. Near the foothills the clay is absent and recharge to the confined aquifer can occur.

## 5.4 Hydraulic Characteristics

The hydraulic characteristics of sediments and aquifers provide the foundation for predicting the potential effects of groundwater management options. They are used to estimate speed and direction of groundwater movement, groundwater storage, and the potential effects of groundwater pumping on groundwater levels. Several hydraulic characteristic terms are used.

- **Hydraulic conductivity** is the ability of the sediments to transmit water in sediments.
- **Transmissivity** is the hydraulic conductivity multiplied by the thickness of the sediments capable of storing water.
- **Porosity** is the void space between the particles of sediments. Water in the void spaces cannot be entirely removed.
- **Storage coefficient** is the percentage of water that can be removed from the pores by gravity drainage and is applied when describing unconfined aquifers.
- **Storativity** is similar to storage coefficient but is the percentage of water that can be released from the pores by a decrease in pressure. Storativity is used when referring to semi-confined or confined aquifers.

The hydraulic characteristics of the Upper unconfined aquifer are highly variable. Wells in the unconfined aquifer produce 6 to 5,300 gpm; however, pumping test data are limited. The transmissivity of the unconfined aquifers, including the recent alluvium and upper portions of the Tulare Formation, ranges from 600 to greater than 2,300 gpd/ft (DWR 2006). The storativity is about 0.05. Where thicker sequences of sand are present, the transmissivity may be higher. Wells in the Lower confined aquifer produce about 700 to 2,500 gpm. The transmissivity ranges from about 12,000 to 37,000 gpd/ft and may go as high as 120,000 gpd/ft. The storage coefficient or storativity, obtained through aquifer tests, was measured as 0.0001 (Padre 2004).

The Corcoran Clay is a regional layer, a confining bed, that restricts movement between the Upper unconfined and Lower confined aquifers. Because the clay is permeable to some degree, water can migrate vertically through the layer but typically at very slow rates and only in areas where there is a downward gradient. Although this migration rate is very slow, the amount of water moving through the clay can be significant given the large area covered by the clay and head differences across the clay. No test data are available for the Corcoran Clay but estimates of the vertical permeability range from 0.01 to 0.007 feet per day (Burow et al. 2004). Modern wells are typically screened either above or below the Corcoran Clay which preserves the clay's low permeability nature. This is a good practice and protects the aquifers from cross-contamination. However, some wells have been constructed with screens or gravel packs across the clay which provides a vertical conduit that creates an opportunity for groundwater of poor quality to mix with groundwater of better quality.

## 5.5 Change in Storage

The change in groundwater storage was estimated for the entire Subbasin using DWR's California Central Valley Groundwater-Surface Water Simulation Model (C2VSim-FG_v1.0) groundwater model data. The model includes estimated groundwater pumping from municipal water purveyors and agricultural areas, as well as relevant climate data, simulated surface water deliveries, and streamflow.

**Figure 5-19** shows the cumulative change in groundwater storage for the entire Subbasin for the water years 1975 through 2015 along with the San Joaquin River Index for the same years. The water year types as defined by the San Joaquin River Index (SJRI) are noted on the right-hand side of the chart. As the chart illustrates, there is a strong correlation between the SJRI and the changes in groundwater storage; periods of declining groundwater storage reflect the dry hydrologic cycles, and periods of gaining groundwater storage reflect the wet hydrologic cycles. Generally, groundwater levels trends would also mimic the change in storage. The cumulative change in storage during this period, which included most of the recent drought, increased on average by about 3,000 AF per year.

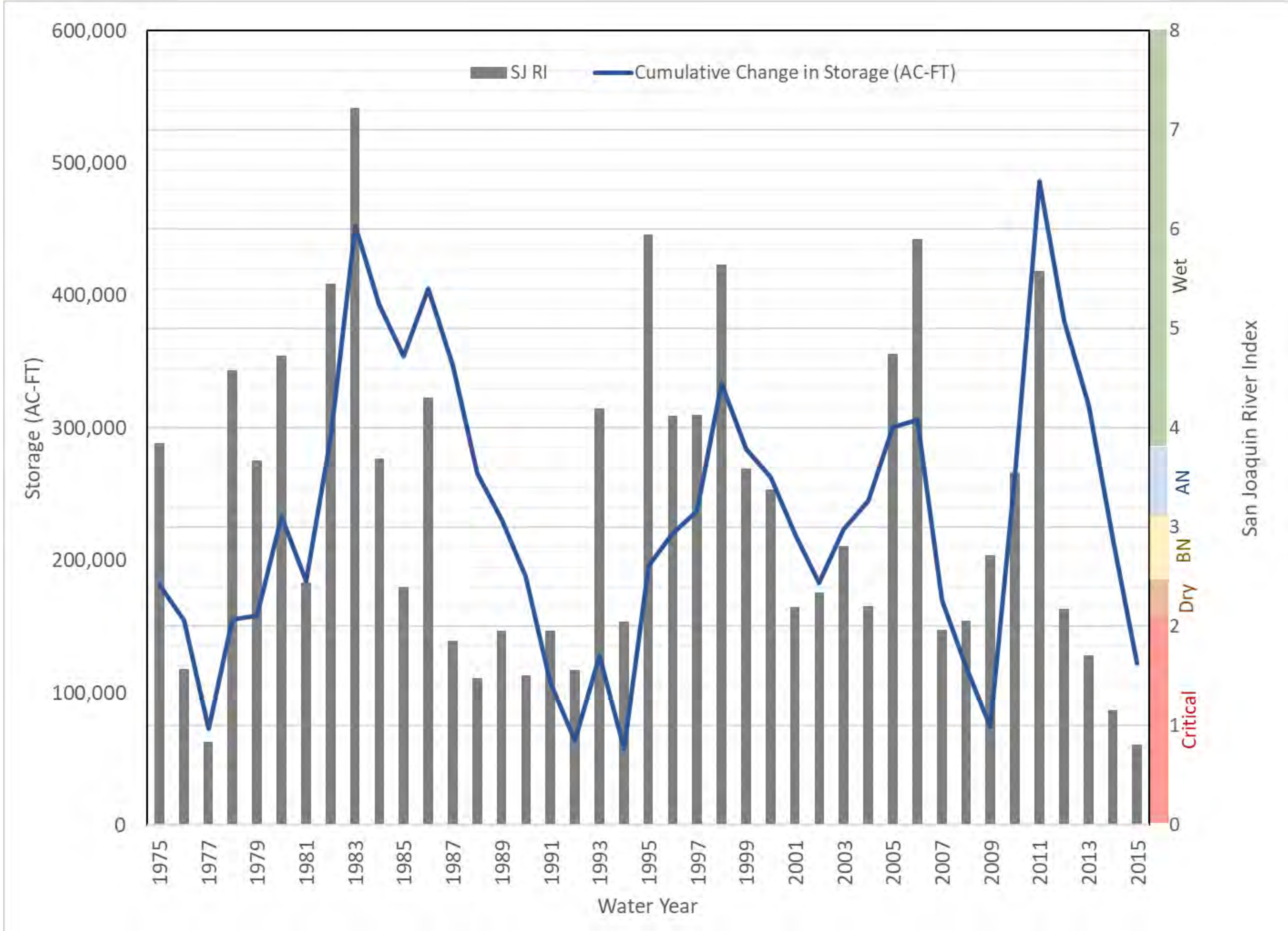

**Figure 5-18. Cumulative Change in Groundwater Storage**

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## 5.6 Groundwater Quality

Groundwater quality in the Tracy Subbasin is variable. Good quality water, from a salinity aspect (TDS) being below the recommended drinking water standard, is locally present in both the confined and unconfined aquifers in the southern portion of the Subbasin. In the remaining portions of the Subbasin, groundwater quality is marginal to poor due to naturally occurring high concentrations of salts from various sources and is part of the reason that the cities have obtained surface water supplies. The concentration of the other naturally occurring constituents varies widely over the Subbasin and also with depth at any given location. This may affect the supply, beneficial uses, and potential management of groundwater in the Subbasin.

Local occurrences of PFAS, uranium, nitrates, manganese have been detected above the MCL, as discussed in **Chapter 4 – Hydrologic Conceptual Model**. Although these elements and compounds may have been detected, the community water systems only supply drinking water that meets all water quality standards. When an element is detected above the MCL, the wells have been brought offline until treatment or remediation has been implemented to meet the drinking water standards.

### 5.6.1 *General Water Quality*

Groundwater in the Tracy subbasin is variable with some localized areas of good quality. Good quality water is locally present in both the confined and unconfined aquifers near the southwestern margin of the Subbasin, near the foothills. In the remaining portions of the Subbasin the groundwater is marginal to poor. The concentration of the naturally occurring constituents varies widely over the Subbasin and also with depth at any given location.

Problem constituents (constituents of concern [COCs]) include:

- In the non-Delta portion of the Subbasin (generally south of the Old River) TDS, nitrates, boron, chloride, and sulfate (GEI 2007). In addition to these constituents, localized areas of manmade contamination, including trihalomethanes, volatile organic compounds (solvents), and gasoline are present. In the City of Lathrop, uranium and PFASs are present in the groundwater above their MCLs.
- In the Delta portions of the Subbasin (generally north of the Old River), the key COCs are dissolved organic carbon, methyl mercury, and salts which originate from the oxidation of drained peat soils (Hydrofocus 2015).
- Domestic wells are present in both Delta and non-Delta regions of the Subbasin. Water quality test results from domestic wells are very limited. Where public supply well water quality data is available it can be used as a proxy for domestic well water quality, but most domestic wells obtain water from shallow aquifers while public supply wells are typically constructed into deeper aquifers. Approximately 25 percent of domestic wells may have water quality risks for one or more constituents with an MCL. Four constituents (arsenic, 1,2,3- TCP, nitrate, and gross alpha [radioactive elements]) account for 80 percent of elevated water quality risk (State Water Board SAFER Workshop 2020).

Testing for EDB, DBCP, and simazine in the Subbasin have been at less than detectable levels, except near the former Occidental Chemical site, based on Geotracker database 2009 through 2013 (Hydrofocus 2015). No further assessment for pesticides was performed during GSP development, other than for 1,2,3 TCP.

The types of sediments composing the geologic formations can affect groundwater quality. Some soils and sediments in the Subbasin are derived from marine rocks in the Coast Range have notably high concentrations of naturally occurring nitrogen, with particularly higher nitrate concentrations in younger alluvial sediments (Strathouse and Sposito 1980, and Sullivan et al. 1979). These naturally occurring nitrogen sources may contribute to nitrate concentrations in groundwater within the Subbasin, although it is not well known where this may occur and to what degree. Naturally high concentrations of TDS in groundwater are known to have existed historically within parts of the Subbasin due to:

- The types of Coast Range rocks (e.g., marine sediments, volcanics)
- The resulting naturally high TDS of recharge derived from Coast Range streams
- The dissolvable materials within the alluvial fan complexes
- The naturally poor draining conditions which tend to concentrate salts in the system

The water quality and chemical makeup in westside streams can be highly saline, especially in more northern streams, including Corral Hollow Creek, where historical baseflow TDS concentrations, from representative shallow wells, have typically exceeded 350 mg/L with measured concentrations as high as 1,500 mg/L (Davis et al 1959). The contribution of water associated with these Coast Range sediments has resulted in naturally high salinity in groundwater within and around the Tracy Subbasin, which has been recognized as early as the 1900s (Mendenhall et al. 1916).

Groundwater in some areas within the immediate vicinity of the San Joaquin River, near Lathrop, is influenced by lower-salinity surface water discharging from the east side of the San Joaquin Valley Groundwater Basin (Davis et al. 1959).

Groundwater quality in this GSP was developed from the State Water Board's DDW, which maintains a database of public water systems' water quality analyses (referred to hereafter as the "DDW database"). State Water Board's DDW requires each public water system to analyze water quality for over 300 elements at intervals ranging from weekly to every 3 years. Because large portions of the Subbasin are agricultural, public water systems are scarce; therefore, the State Water Board's DDW database was supplemented with wells monitored by DWR, City of Tracy, NWIS database, and from the Irrigated Lands Regulatory Program (2 wells). Pesticides (EDB and DBCP) extent and concentrations were assessed using the California Department of Pesticide Regulations. The database of wells was then assigned to its principal aquifers if total depth of the well or well logs were available.

**Table 5-1** provides a list of these elements, the number of samples analyzed, their minimum and maximum concentrations, the number of wells with samples exceeding the MCL, and the classification of analyses by principal aquifer. Most of the analyses were performed in wells with unknown depths, although some of these can be assigned once well construction logs are located. Further analyses of the water quality by principal aquifer excluded the use of these wells with unknown depths, but their locations are shown on the maps. Also, due to the lack of or limited number of wells with detections that could be identified by principal aquifer, gross alpha, hexavalent chromium and selenium were not plotted.

**Figures 5-20 through 5-28** show the most recent analyses and distribution of these elements in the Subbasin by principal aquifer. Where multiple nested wells are present at a single location, only the shallowest well water quality is shown. The most recent analysis was extracted from the datasets for each well to demonstrate current conditions. The analyses dates range from 1944 to 2020. **Appendix H** provides a detailed list of the water quality analyses and wells used to create the figures. The figures show:

- Salinity as represented by TDS (**Figure 5-20**) is high in both the Upper and Lower aquifers with a few areas with good quality water.
- Elevated concentrations of chloride (**Figure 5-21**) and sulfate (**Figure 5-22**) are present in the Upper aquifer but do not show a distinct pattern. Chloride and sulfate concentrations in the Lower aquifer are quite variable. Chloride concentrations are for the most part all low except for one deep nested monitoring well located on the east side of Tracy (not shown on **Figure 5-20**) where the most recent concentration is 460 mg/L. Elevated concentrations of sulfate are present near the foothills potentially as a results of recharge water originating from the Coast Ranges.
- Nitrate (**Figure 5-23**) concentrations are low in the basin and other than a few wells, nitrate does not appear to be adversely impacting water quality.
- Elevated concentrations of arsenic (**Figure 5-24**) are only in the Upper aquifer and within the Delta area and not in the Lower aquifer.
- Boron (**Figure 5-25**) is present in the Upper aquifer. Most elevated concentrations are present in the non-Delta areas and in the northern portions of the Delta area.
- Elevated concentrations of iron and manganese (**Figures 5-26 and 5-27**) are found randomly in the Subbasin in both aquifers. Elevated concentrations of manganese appear to be more prevalent in the Upper aquifer in the Delta area.
- 1,2,3 TCP (**Figure 5-28**) was detected in both the Upper and Lower aquifers, but at concentrations below the MCL.

It should be noted that water quality beneath the Corcoran Clay is limited to the area around Tracy which could affect the interpretation of water quality beneath the clay.

## Table 5-1. General Water Quality Summary

| Element | Units | MCL or Notification Level (NL) | Number of Wells with Analytical Results | Minimum Concentration[4] | Maximum | Number of Wells with Analyses Exceeding MCL or NL | Analyses Date Range | | Number of Wells with Analytical Results by Aquifer | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Upper Aquifer Wells | Lower Aquifer Wells | Unknown Aquifer |
| **Plotted** | | | | | | | | | | | |
| Arsenic | ug/L | 10 | 195 | <2.0 | 54 | 32 | 7/1/59 | 1/14/20 | 28 | 26 | 141 |
| Boron | mg/L | 1[1] | 584 | <0.1 | 10 | 227 | 6/5/45 | 12/2/19 | 90 | 26 | 468 |
| Chloride | mg/L | 250[3] | 664 | 1.1 | 2,400 | 210 | 6/5/45 | 1/14/20 | 91 | 26 | 547 |
| Iron | ug/L | 300 | 206 | <0.03 | 25,700 | 34 | 6/28/53 | 1/14/20 | 38 | 26 | 142 |
| Manganese | ug/L | 50 | 190 | <0.01 | 17,600 | 67 | 5/4/50 | 1/14/20 | 29 | 26 | 135 |
| Nitrate as Nitrogen | mg/L | 10 | 537 | <0.02 | 81 | 21 | 11/26/47 | 2/14/20 | 71 | 26 | 440 |
| TDS | mg/L | 500[3] | 376 | 82 | 4,500 | 269 | 3/29/44 | 1/14/20 | 68 | 26 | 282 |
| Sulfate | mg/L | 250[3] | 465 | 0.2 | 1,420 | 122 | 3/29/44 | 12/9/19 | 72 | 26 | 367 |
| 1,2,3TCP | ug/L | 0.005 | 126 | <0.001 | 0.500 | 25 | 8/27/84 | 2/11/20 | 9 | 8 | 109 |
| **Not Plotted** | | | | | | | | | | | |
| Gross Alpha | pCi/L | 15 | 118 | 0 | 36 | 2 | 1/19/88 | 2/4/20 | 5 | 26 | 87 |
| Selinum | ug/L | 50 | 136 | 0 | 35 | 0 | 7/1/59 | 12/9/19 | 10 | 8 | 118 |
| Hexavalent Chromium | ug/L | 10[2] | 75 | <0.05 | 29 | 5 | 5/1/01 | 10/5/18 | 5 | 8 | 62 |

Notes:

1 = Notification Level, no MCL

2 = No MCL, previous MCL shown

3 = Secondary Standard, Recommended level shown

4 = Current Reporting Limit, may vary with historic analysis

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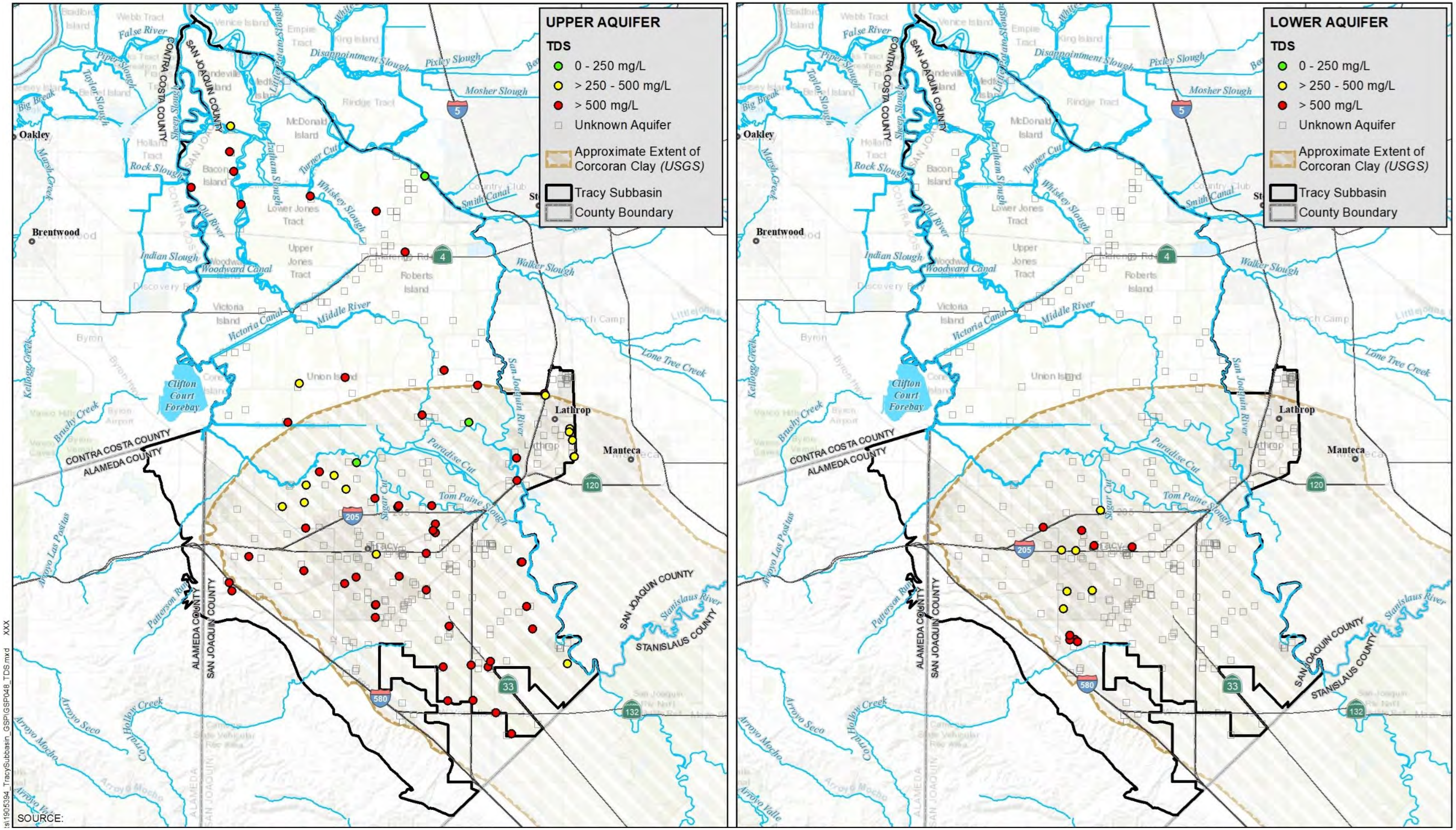


**Figure 5-19. Distribution of TDS Concentrations**

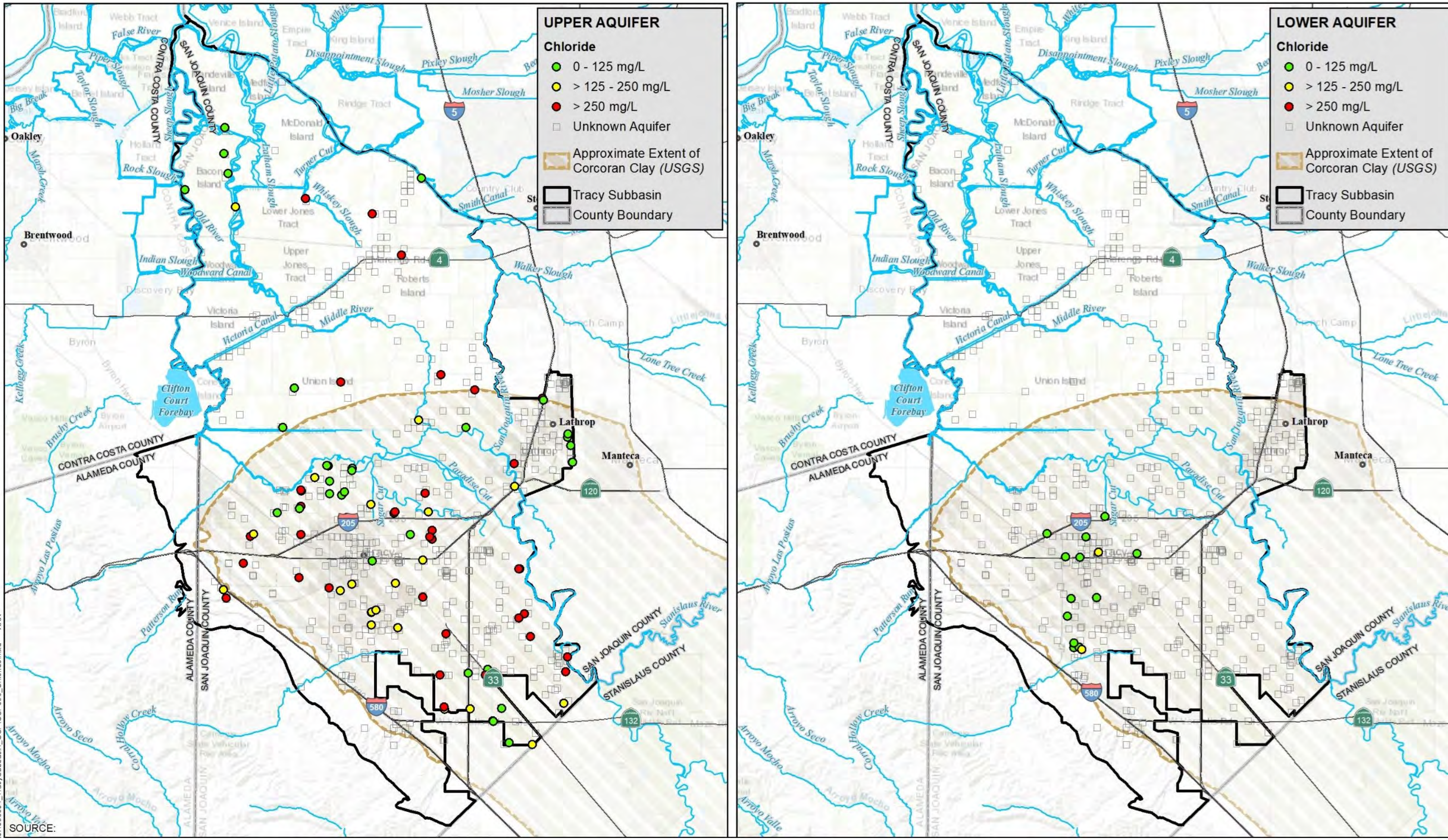


**Figure 5-20. Distribution of Chloride Concentrations**

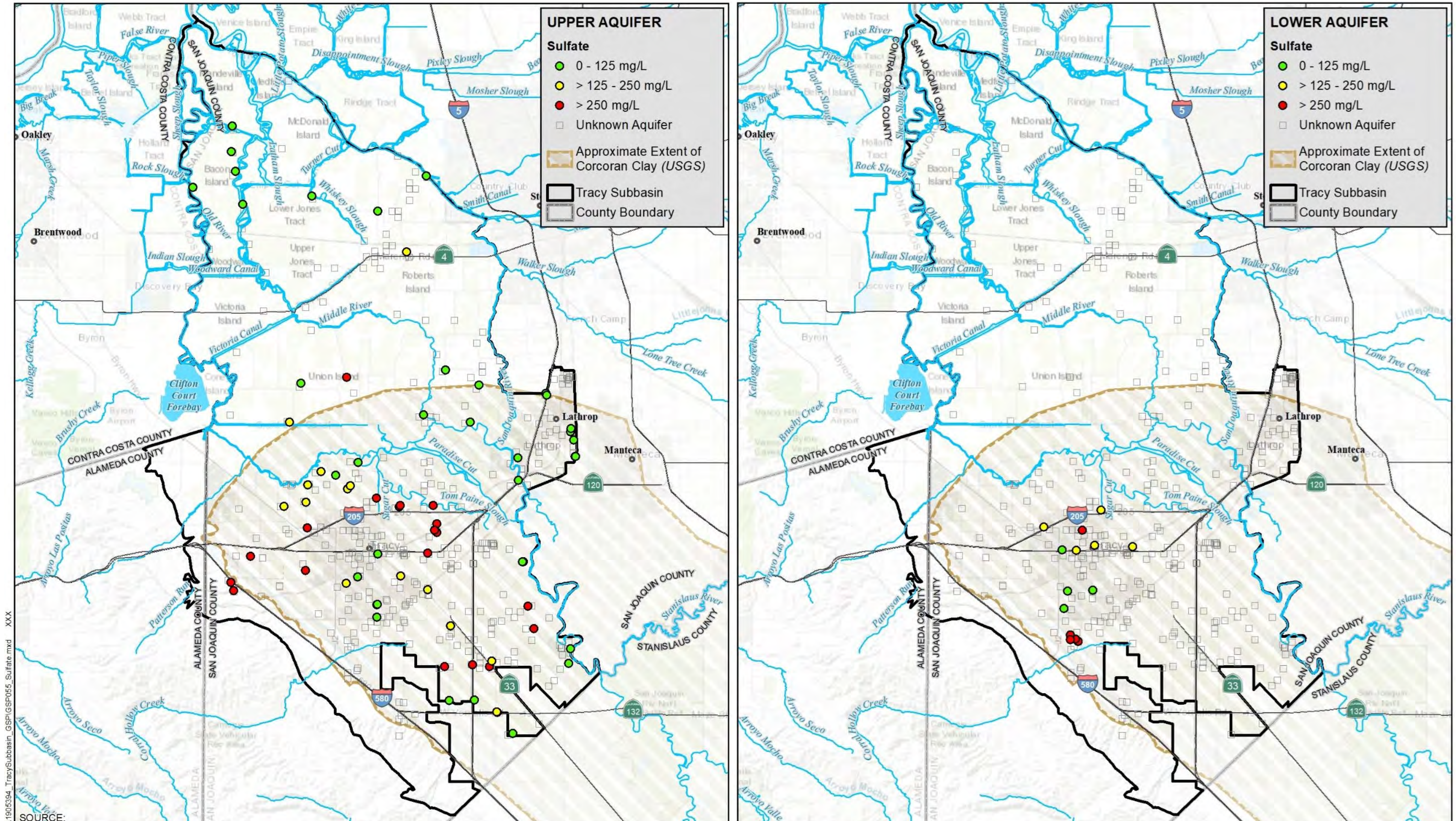


**Figure 5-21. Distribution of Sulfate Concentrations**

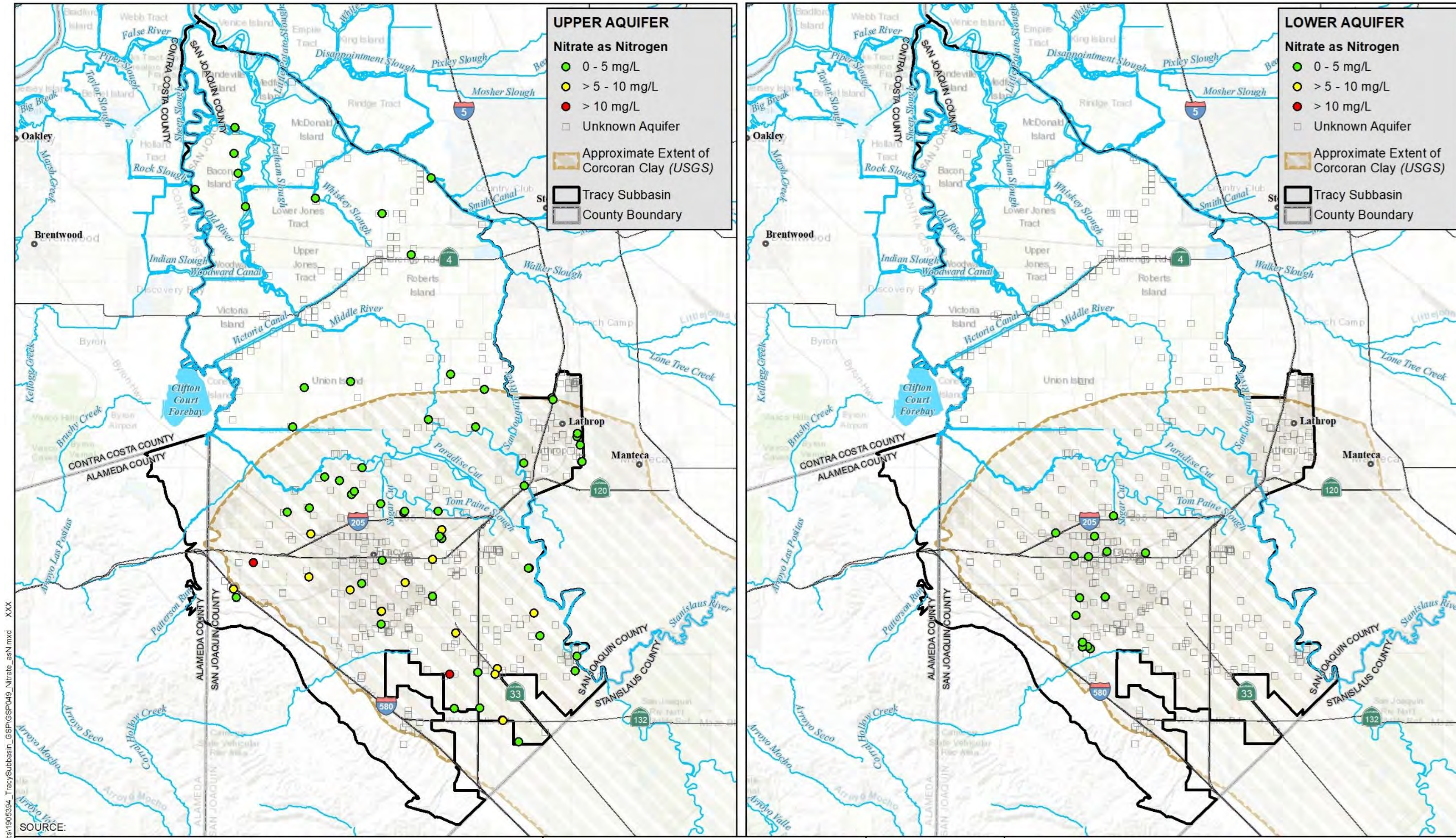


**Figure 5-22. Distribution of Nitrate as Nitrogen Concentrations**

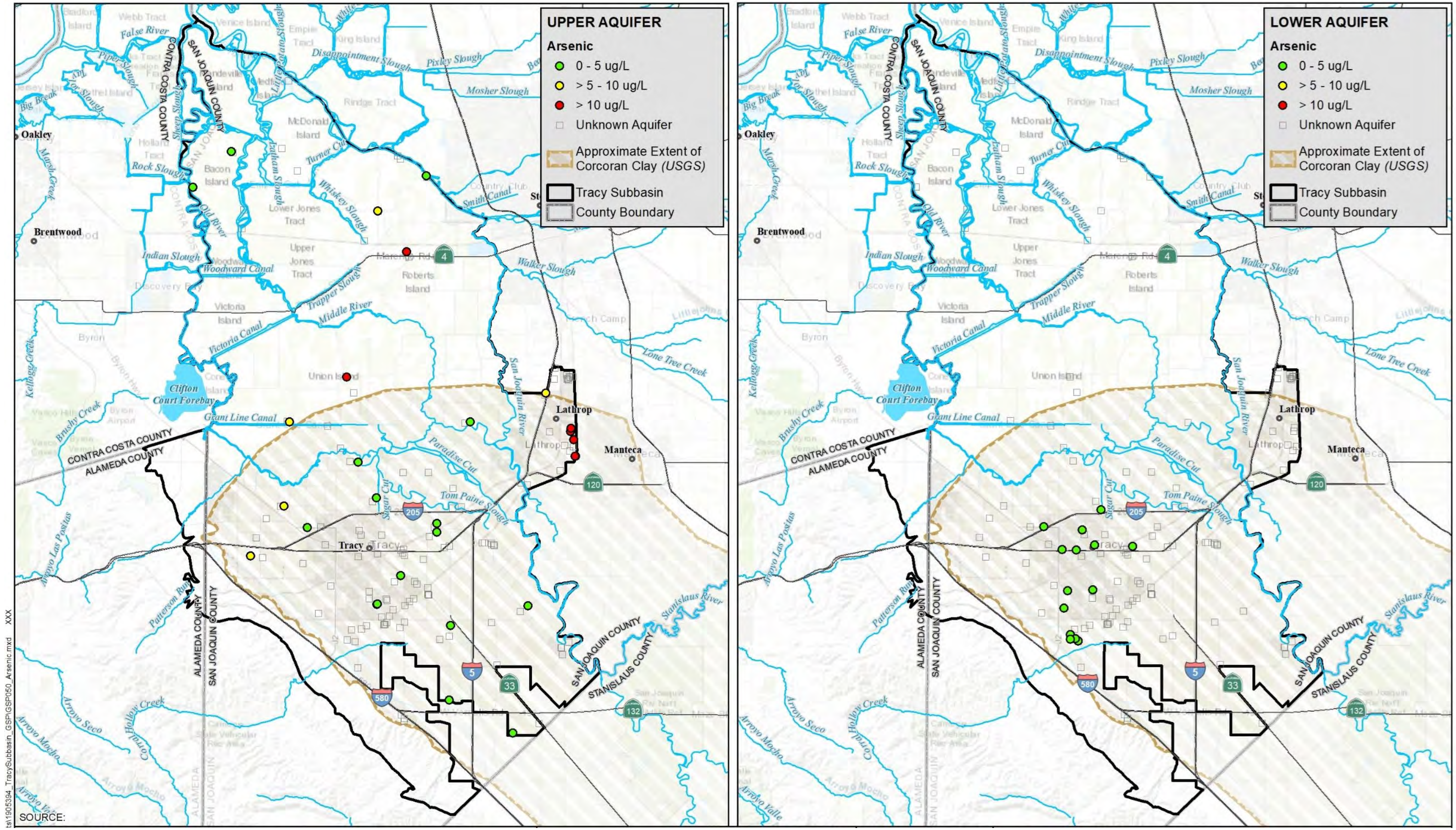


**Figure 5-23. Distribution of Arsenic Concentrations**

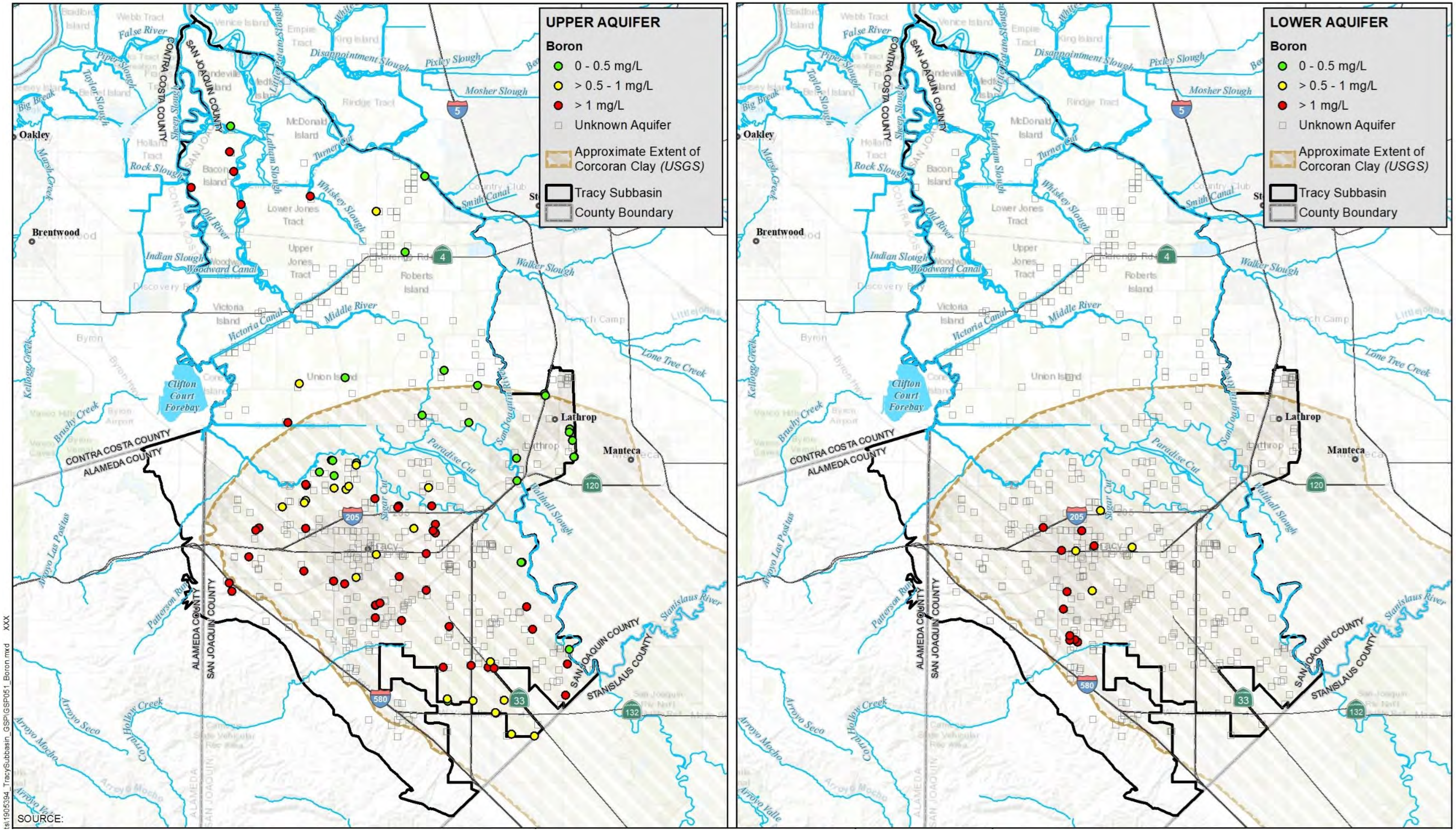


**Figure 5-24. Distribution of Boron Concentrations**

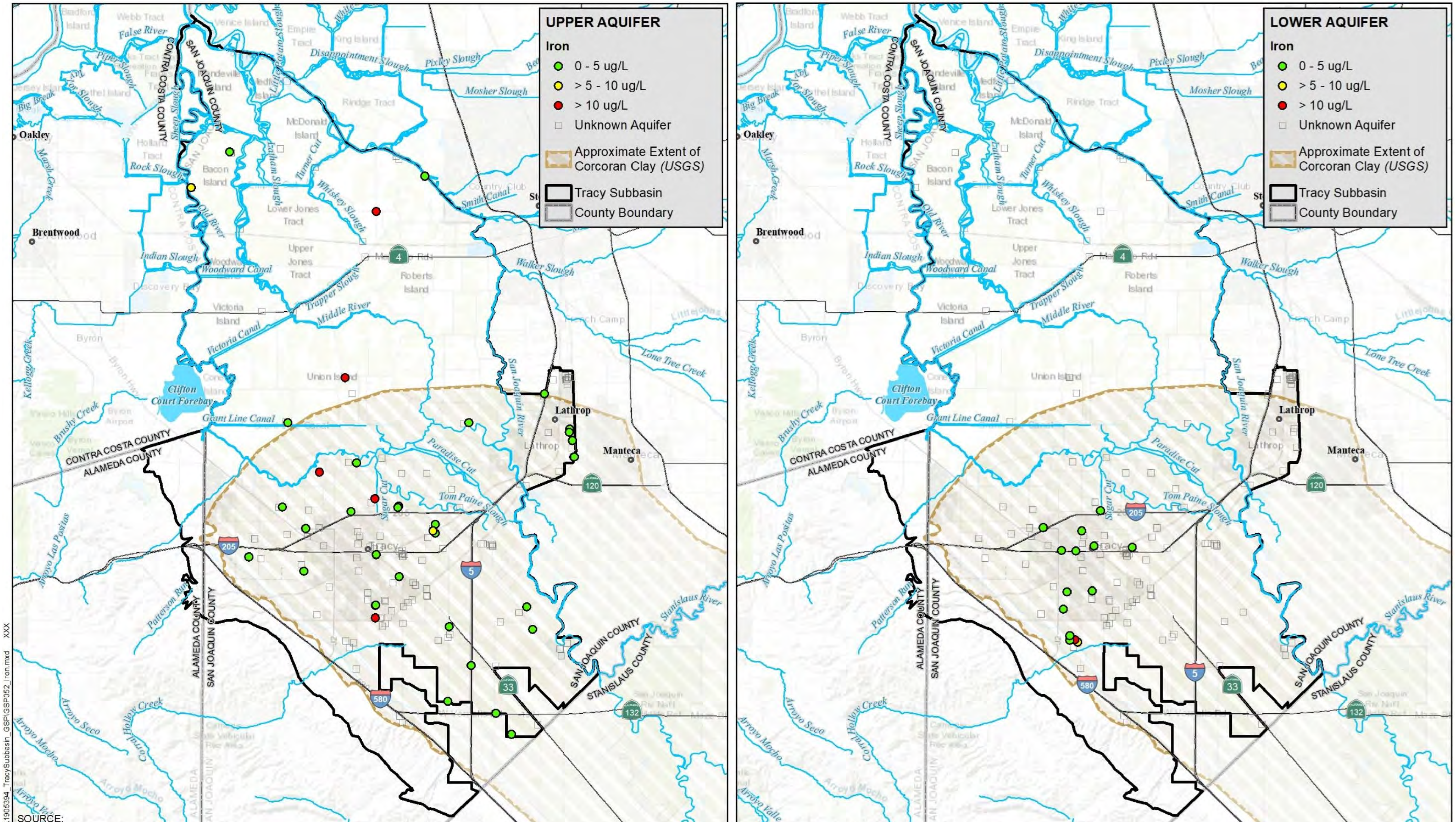


**Figure 5-25. Distribution of Iron Concentrations**

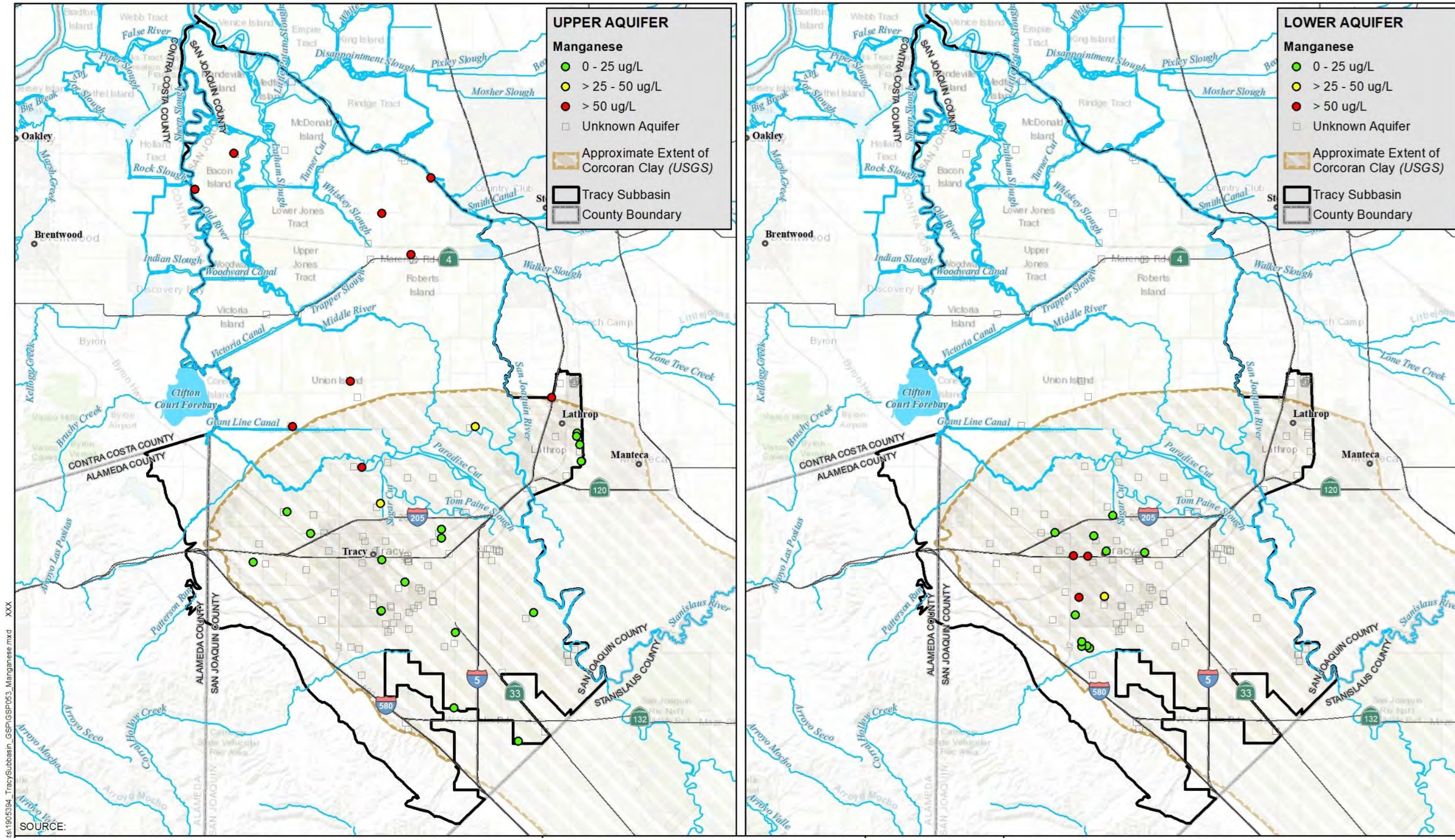


**Figure 5-26. Distribution of Manganese Concentrations**

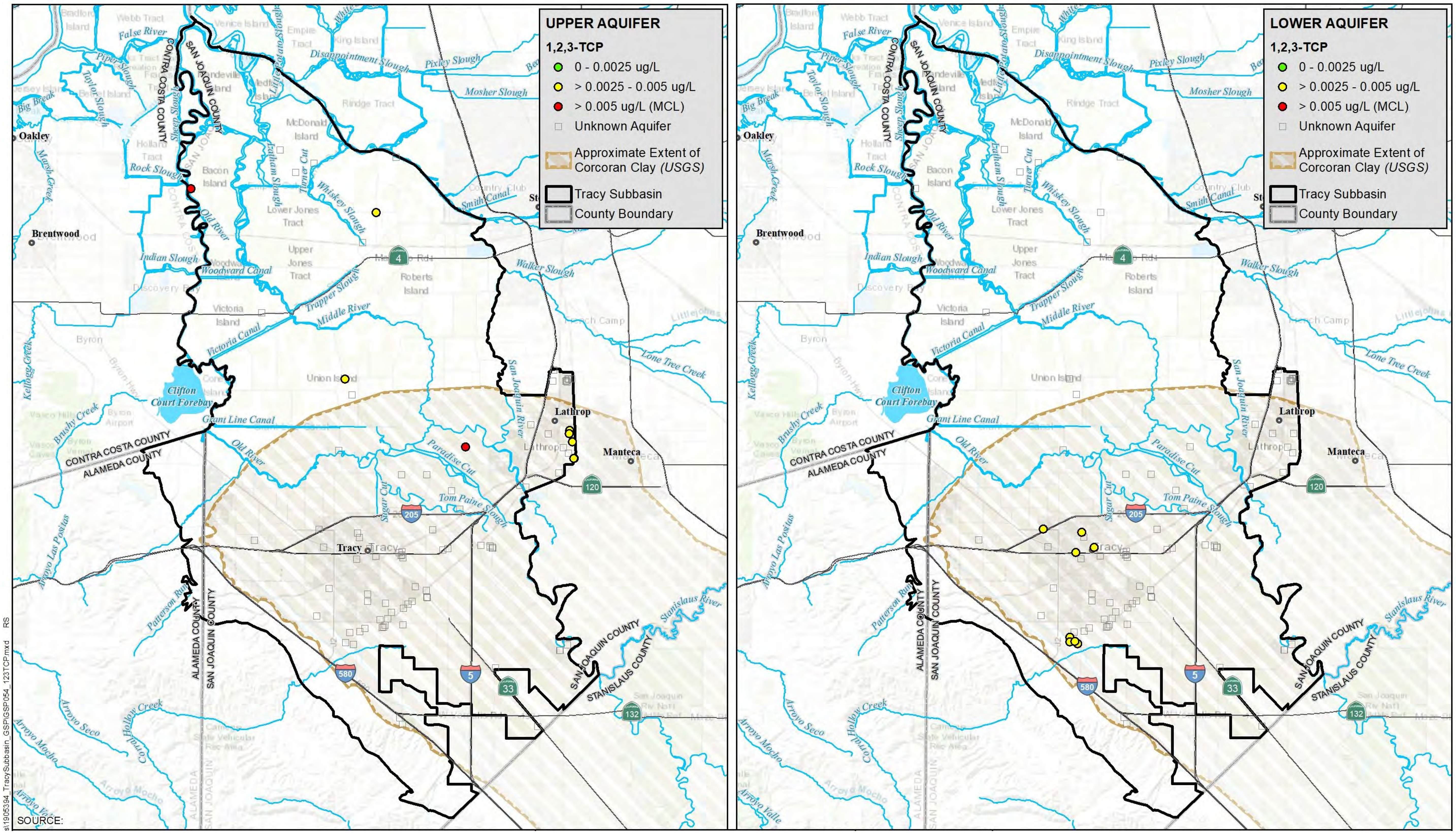


**Figure 5-27. Distribution of 1,2,3 TCP Concentrations**

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### 5.6.2 *Groundwater Quality Trends*

Water quality trends in the Subbasin have been evaluated only by a few studies. These studies indicate the following trends:

- In the City of Tracy, an evaluation of their Production Well #5 showed concentrations of manganese below the Corcoran Clay have been increasing.
- Recent studies by the City of Lathrop have also shown nitrate, manganese and iron are increasing.
- A Groundwater Assessment Report for most of the Westside San Joaquin River Watershed Coalition was performed as part of the Irrigated Lands Regulatory Program, and extends into the San Joaquin County, in the finger portion of the Delta Mendota Subbasin. The analysis used all wells in the GAMA data files (Luhdorff and Scalmanini 2015). It used a linear regression to assess trends. Only one well was present in this area and showed, a mildly increasing trend for both TDS and nitrate.

Groundwater quality trends were developed using data from PWS wells, and USGS and DWR wells and City of Tracy monitoring wells with known construction details and that could be assigned to the principal aquifer. A statistical trend analysis of the data was performed using the Mann-Kendall method when the well had more than five samples for a given element. This method is a non-parametric (for example, does not assume a distribution in the data) test for identifying trends in time-series data. **Appendix I** provides the analysis and trend graphs for each constituent and are grouped by principal aquifer**. Figures 5-28 through 5-36** show the trends for each element by principal aquifer. **Table 5-2** provides a summary of the analysis. The analysis shows that most wells with water quality data could not be assigned to an aquifer. Increasing trends are most prevalent for arsenic, iron, and manganese. Concentrations of 1,2,3 TCP are also rising in a few wells.

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**Table 5-2. Water Quality Trend Summary**

| Element | Units | Number of Wells with +5 Samples | | | Number of Wells Known Aquifers | |
|---|---|---|---|---|---|---|
| | | Unkown Aquifer | Upper Aquifer | Lower Aquifer | Increasing Trends | No or Decreasing Trends |
| Arsenic | ug/L | 49 | 5 | 26 | 11 | 69 |
| Boron | mg/L | 25 | 6 | 26 | 3 | 54 |
| Chloride | mg/L | 35 | 9 | 26 | 9 | 61 |
| Iron | ug/L | 38 | 4 | 26 | 12 | 56 |
| Manganese | ug/L | 38 | 4 | 26 | 15 | 53 |
| Nitrate as Nitrogen | mg/L | 111 | 7 | 26 | 24 | 120 |
| TDS | mg/L | 36 | 5 | 26 | 11 | 56 |
| Sulfate | mg/L | 33 | 7 | 26 | 7 | 59 |
| 1,2,3 TCP | ug/L | 49 | 5 | 8 | 5 | 57 |

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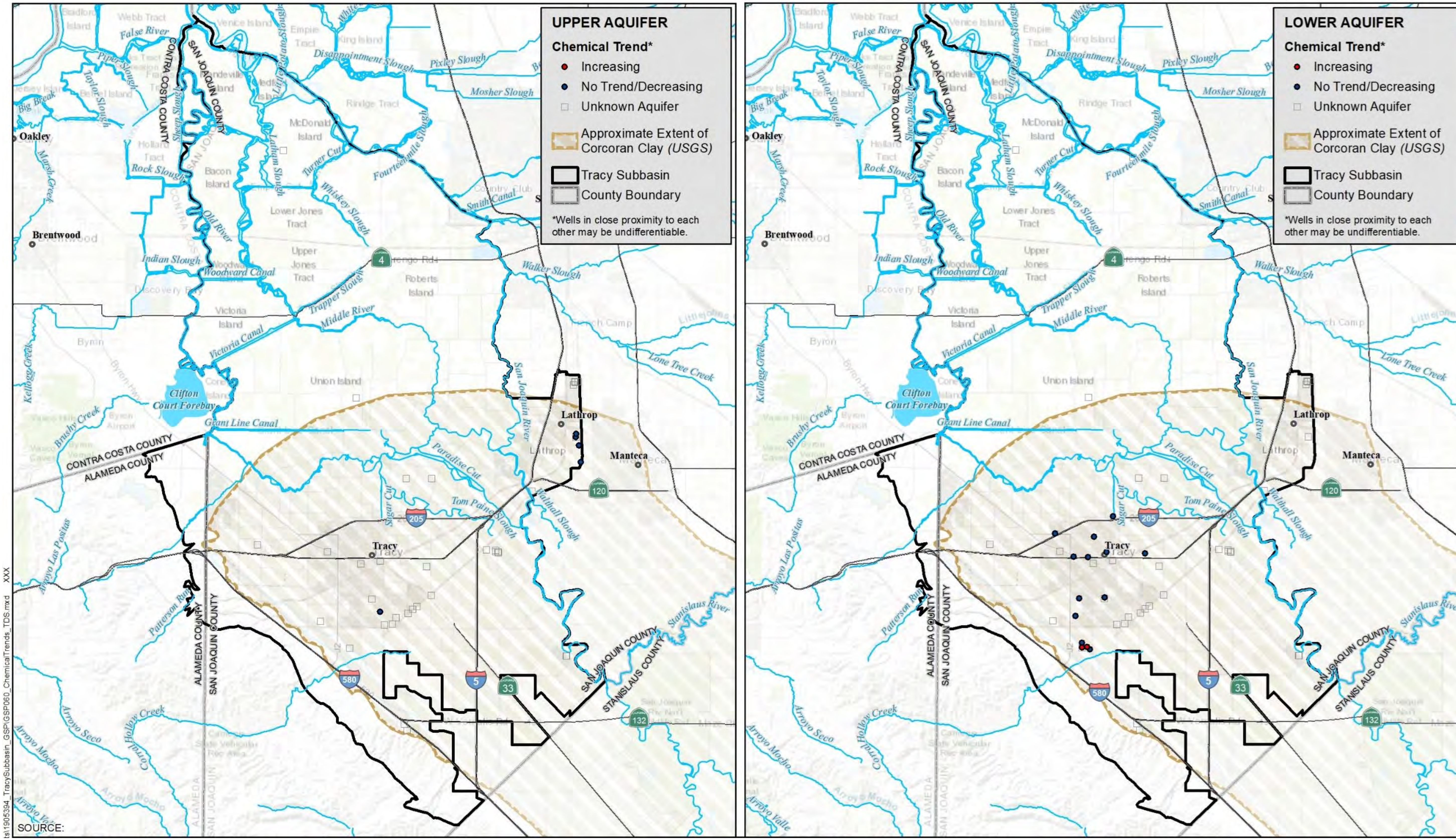


**Figure 5-28. TDS Trends by Principal Aquifer**

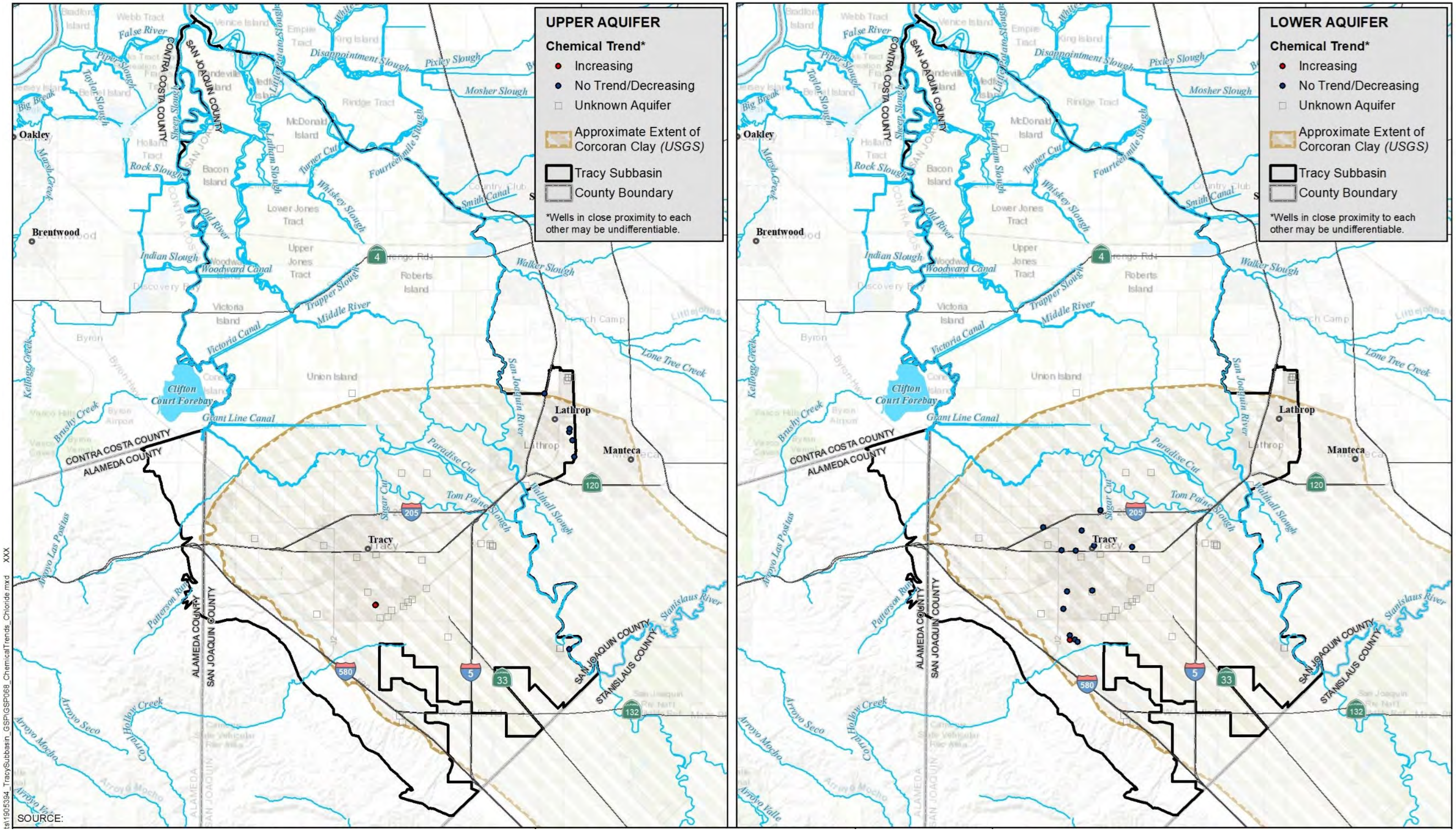

**Figure 5-29. Chloride Trends by Principal Aquifer**

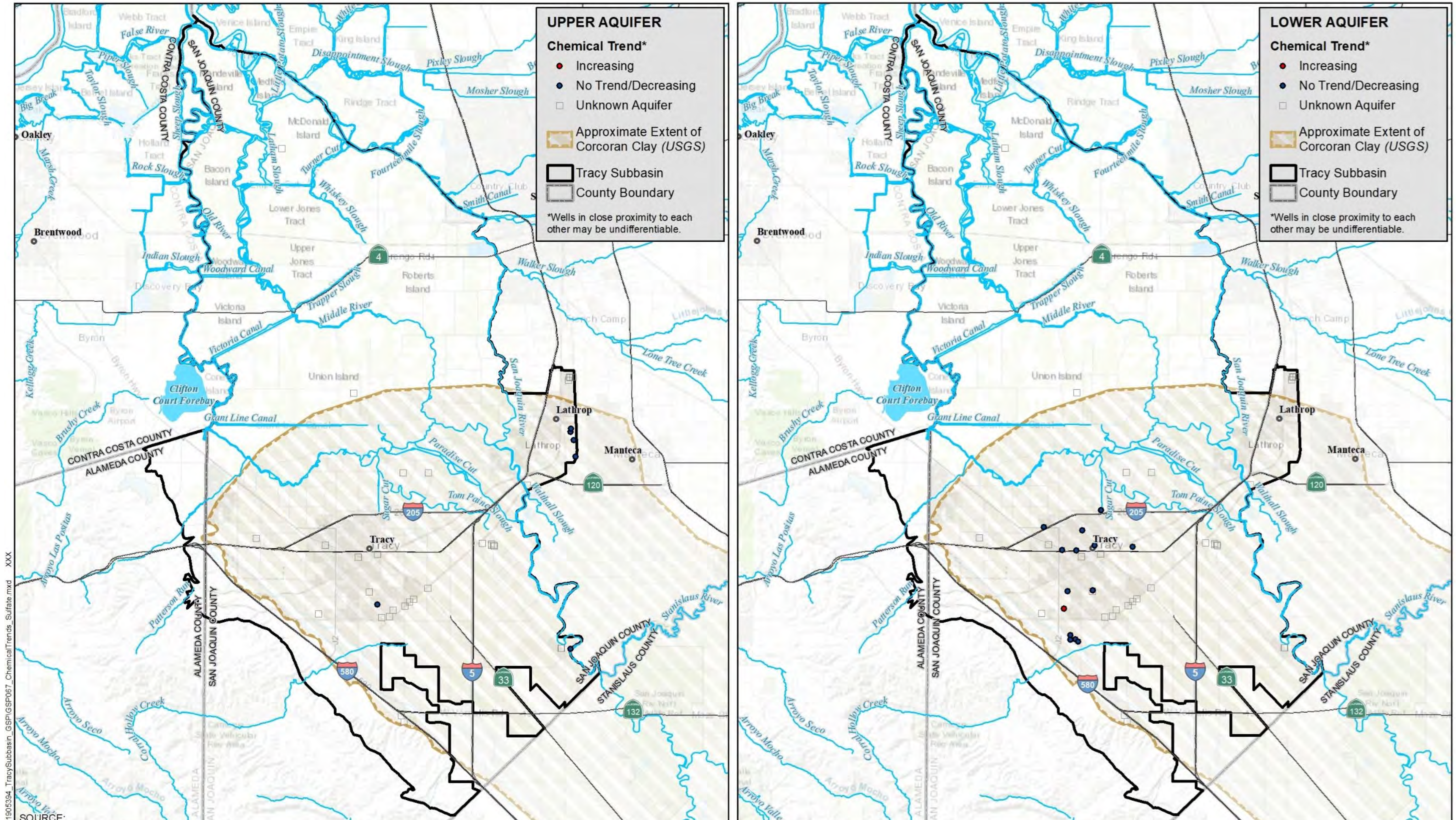


**Figure 5-30. Sulfate Trends by Principal Aquifer**

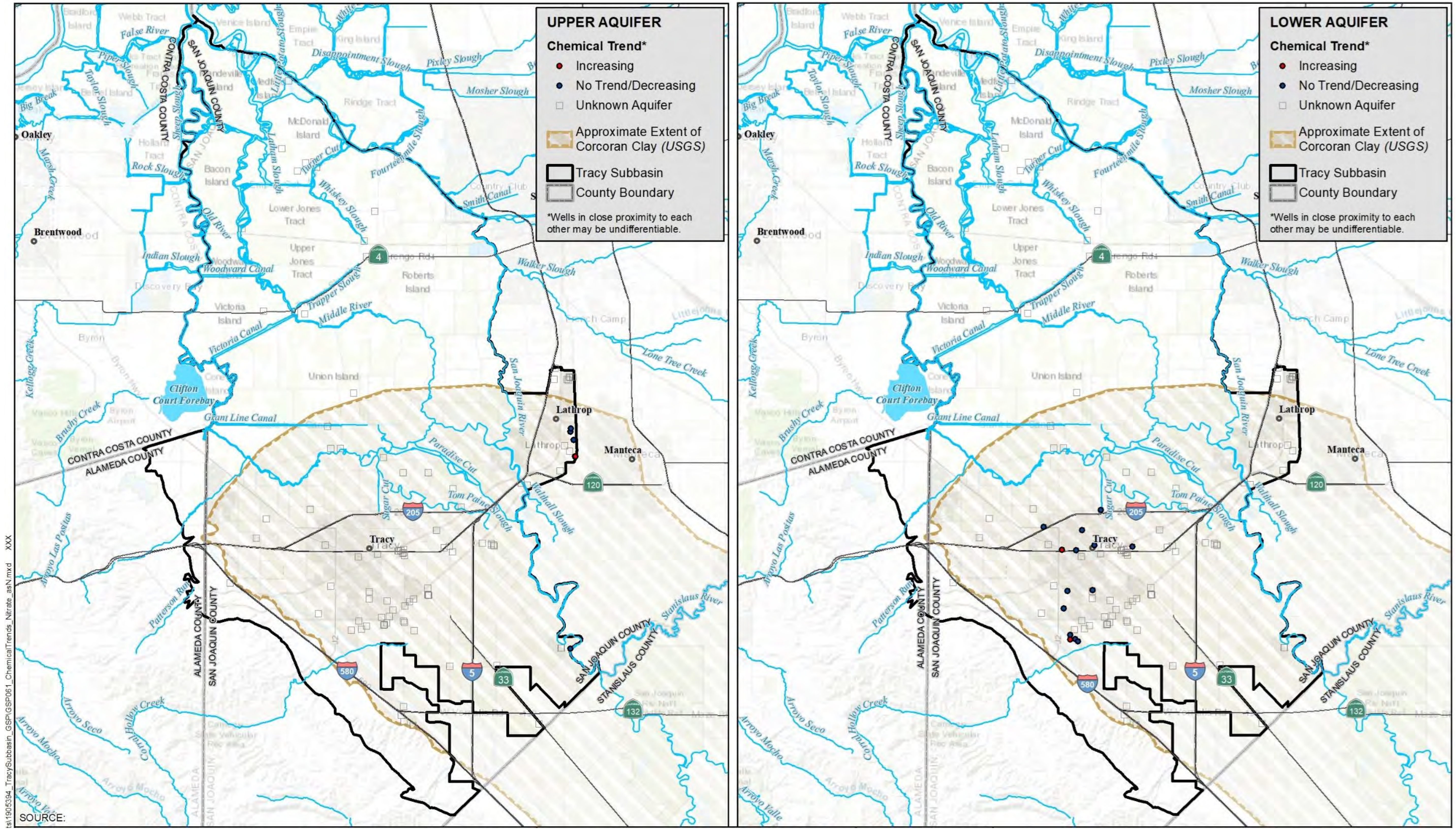


**Figure 5-31. Nitrate as Nitrogen Trends by Principal Aquifer**

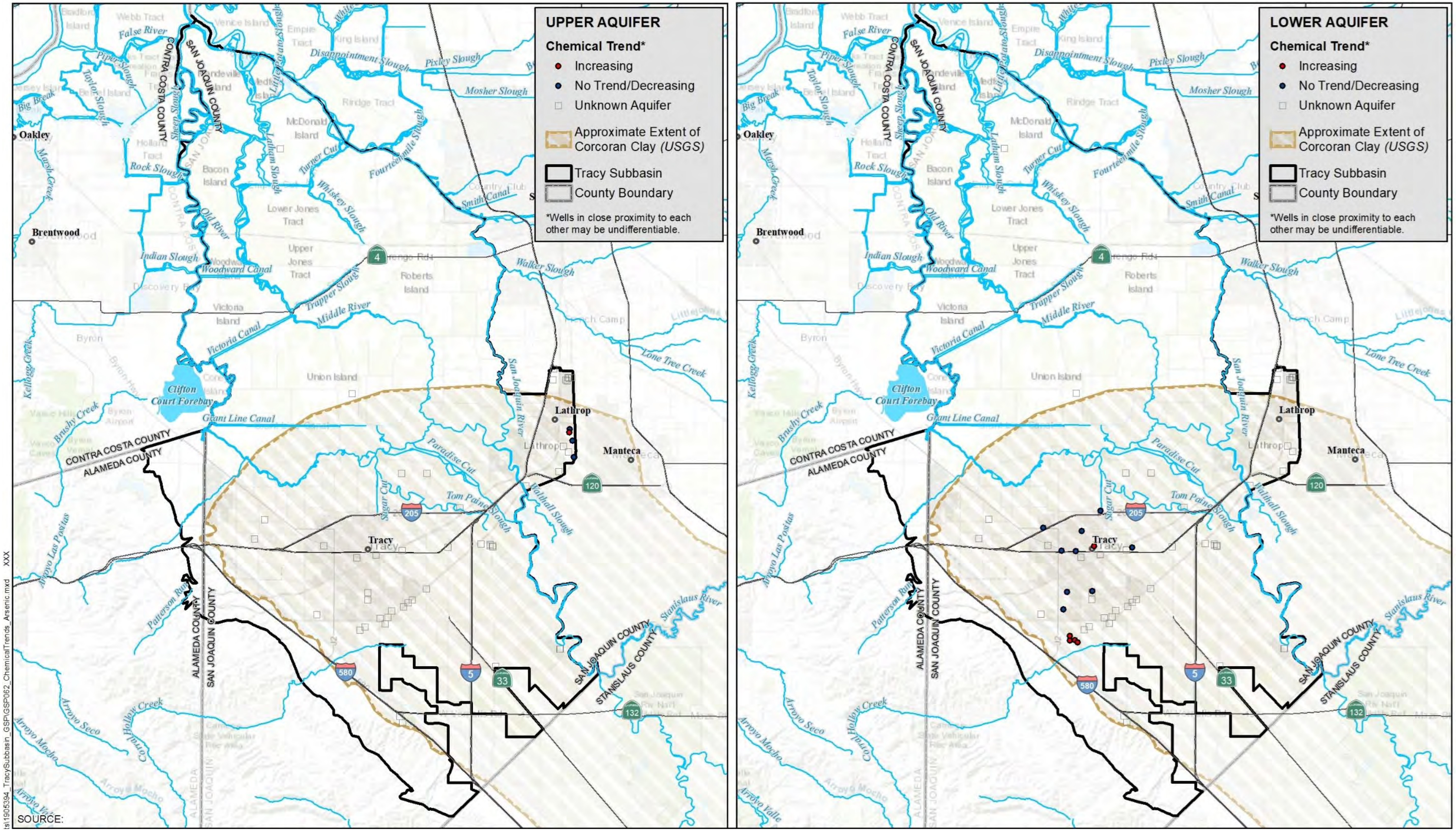


**Figure 5-32. Arsenic Trends by Principal Aquifer**

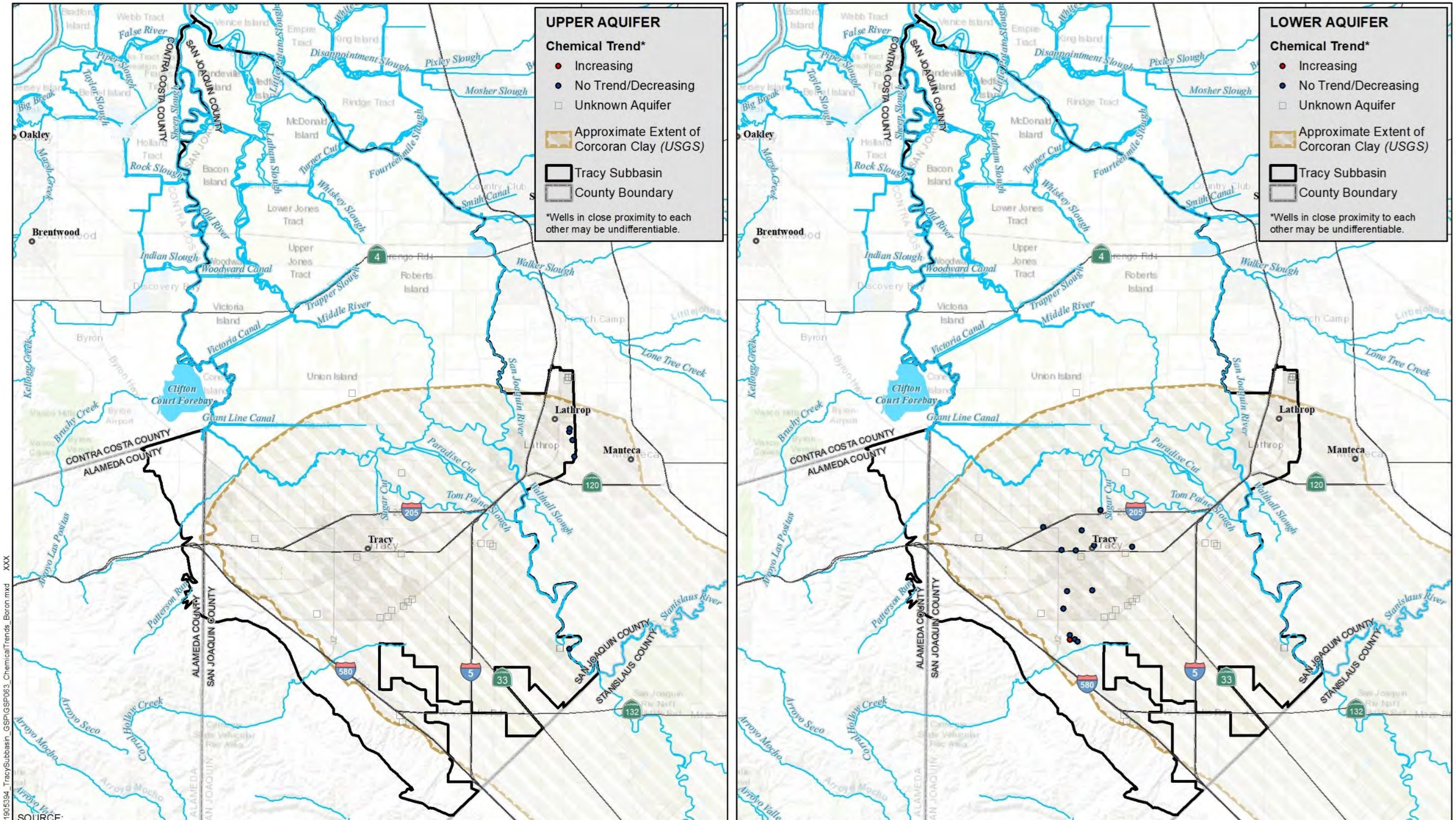


**Figure 5-33. Boron Trends by Principal Aquifer**

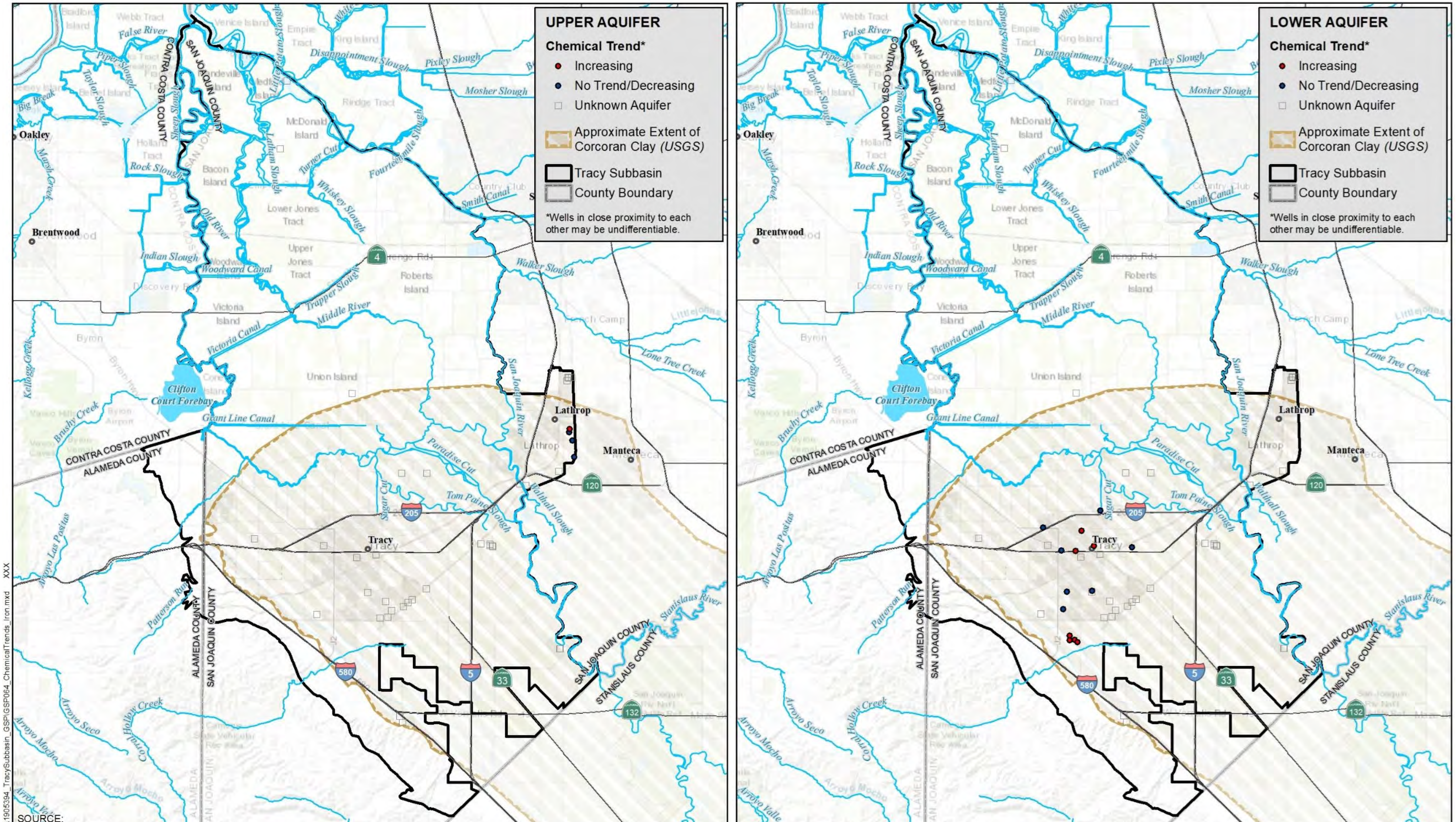


**Figure 5-34. Iron Trends by Principal Aquifer**

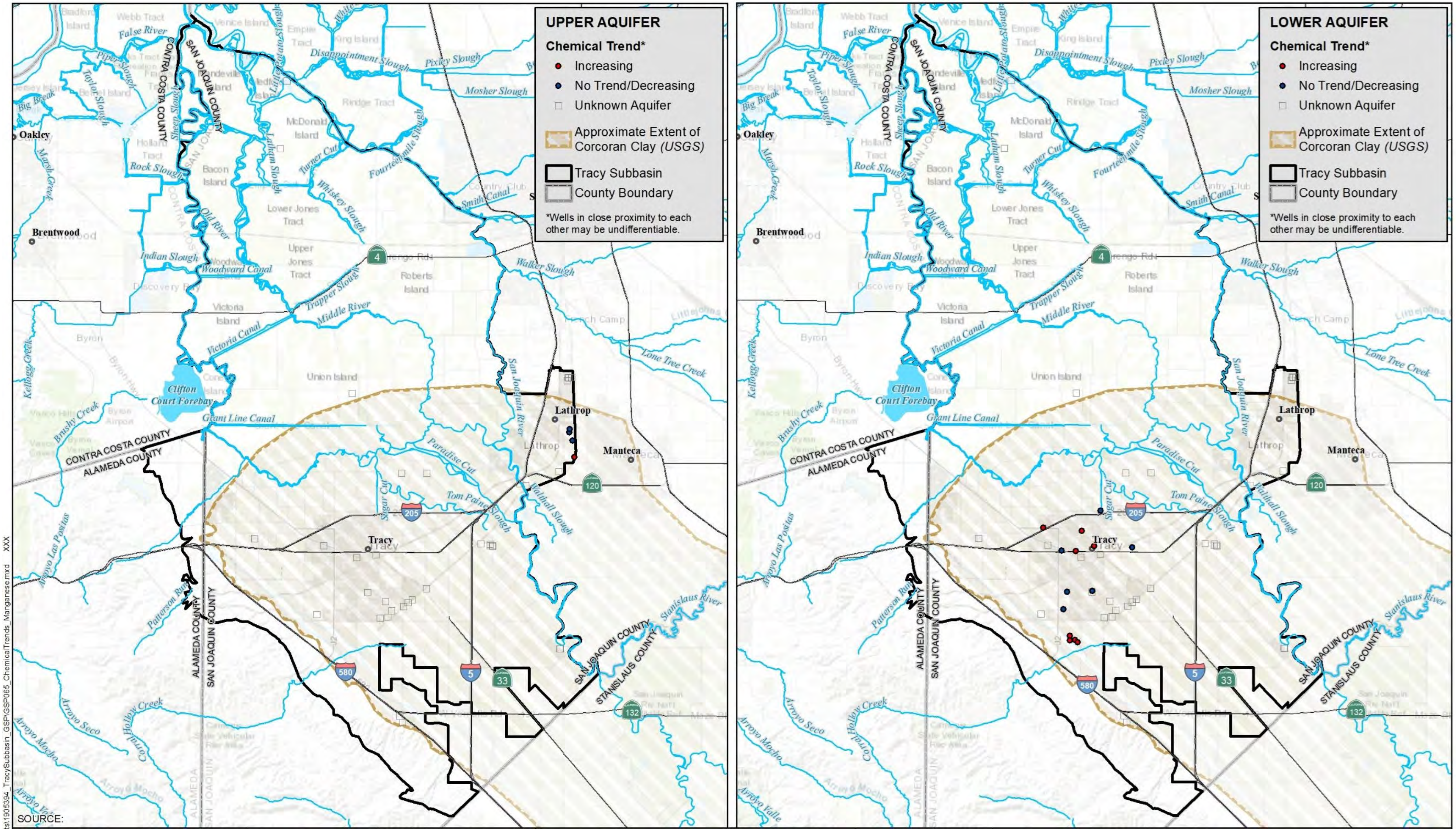


Figure 5-35. Manganese Trends by Principal Aquifer

### 5.6.3 *Groundwater Contamination Sites and Plumes*

In the Tracy Subbasin there are a few large and known groundwater contamination sites that could affect supply and beneficial uses of groundwater in the Subbasin. The most significant of these sites are former Occidental Chemical Corporation site, Sharpe Army Depot site, and the Army Tracy Depo (**Figure 5-37**). Cleanup activities have been in progress for multiple years and contaminants appear to be contained, although off site at some locations, based on reports submitted for regulatory purposes.

There are over 100 small sites that may present threats to local groundwater quality. These sites may have leaking underground storage tanks, improperly stored pesticides, leaking dry cleaning solvents, or other point sources of contamination. While the threat from many of these sites can be mitigated, the aggregate impact from undetected point-source contamination of groundwater quality in the basin cannot be determined.

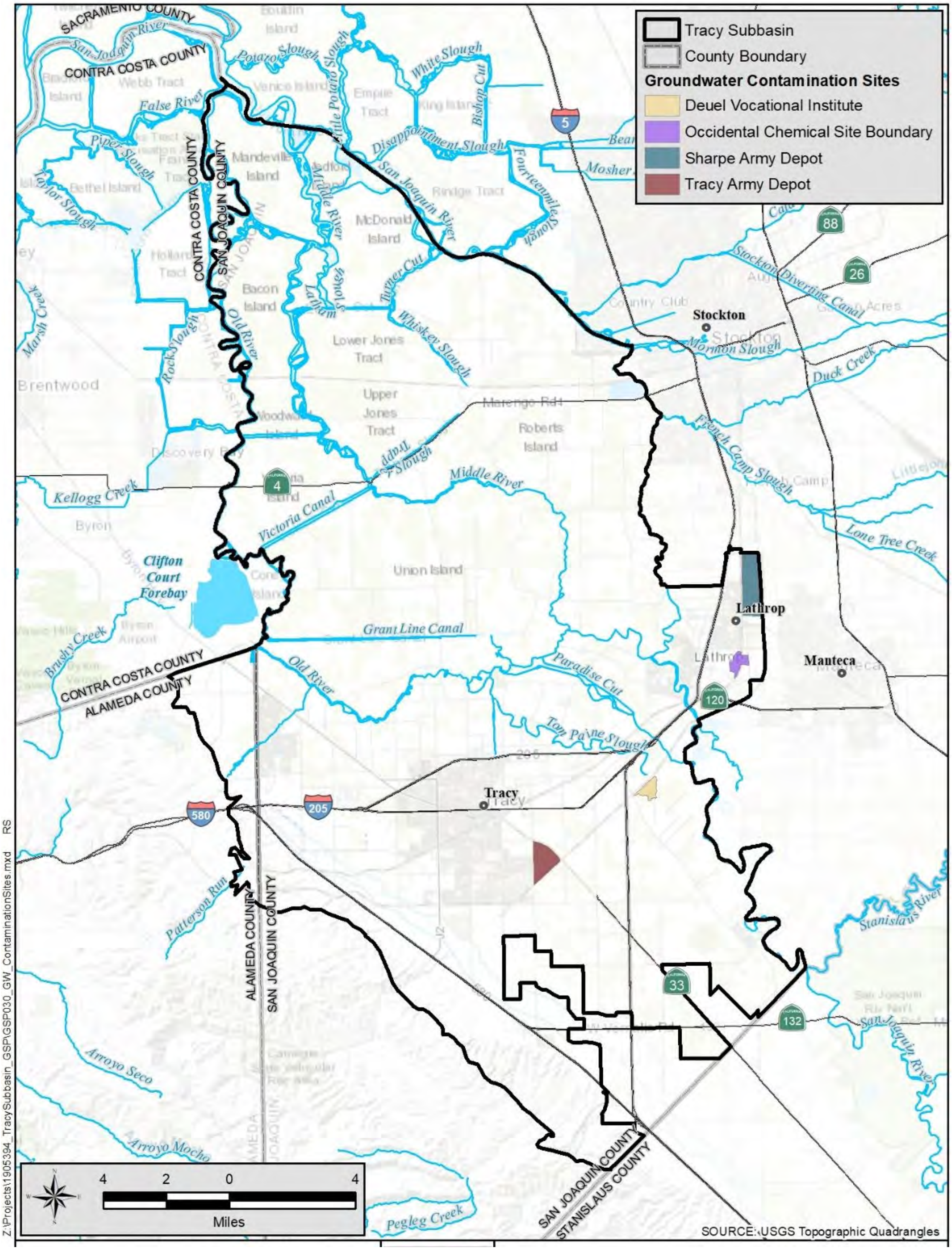


**Figure 5-36. Groundwater Contamination Sites**

## 5.7 Seawater Intrusion

Seawater enters the San Francisco Bay estuary and mixes with freshwater from the Sacramento and San Joaquin Rivers to become brackish water. Brackish water salt concentrations can vary greatly but in the Delta area those concentrations are typically far less salty than pure seawater. The Tracy Subbasin is in the Delta area where brackish water (chloride levels greater than 1,000 mg/L) has migrated into the Delta waterways and potentially infiltrated into the aquifers prior to construction of Shasta Dam in 1943. Prior to 1943, brackish water had entered the surface waterways throughout the Delta areas of the Subbasin, except for portions of Union Island, Upper Roberts Island, and the Stewart Tract (DWR 1995). While the Delta ecosystem evolved with a natural salinity cycle that brought brackish tidal water in from the San Francisco Bay, levees installed to allow development of agriculture, followed by development and operation of the Central Valley Project and the State Water Project, have altered the inward movement of seawater through the Delta. Current management practices endeavor to maintain freshwater flows through a combination of hydraulic and physical barriers and alterations to existing channels (Water Education Foundation 2019). Seawater in the Delta waterways since 1943 has been limited to the areas west of the Subbasin, west of Discovery Bay. With saltwater in surface water, some saltwater may have historically infiltrated into the aquifers and locally affected groundwater quality.

Portions of the Tracy Subbasin and neighboring Eastern San Joaquin Subbasin do, however, experience groundwater quality issues related to elevated levels of chloride and TDS (salinity). The elevated levels in the Eastern San Joaquin Subbasin, and likely in the Tracy Subbasin, are due to three causes (Izbicki, et al. 2006):

- Evaporated irrigation return water in shallow wells. However, increases in chloride concentrations from evaporation of irrigation water are small compared to chloride inputs from the Delta and underlying deposits.
- Entrainment of seawater in Delta deposits during deposition of Delta sediments or more recently.
- Groundwater in deeper aquifers being affected by underlying marine sediments.

Although there may be migration of groundwater from underlying marine sediments, it is important to note that this is not considered sea water intrusion but would be water quality degradation, if occurring.

## 5.8 Subsidence

Subsidence monitoring in the Tracy Subbasin consists of a continuously recording CGPS station and over 30 benchmarks or stations that are surveyed on an irregular basis. UNAVCO's Plate Boundary Observatory Program (formerly University Navigation Satellite Timing and Ranging or NAVSTAR Consortium), constructed a continuous recording CGPS station (P257) in the Subbasin for precise determination of plate motion, transient deformation related to earthquakes and subsidence along with multiple other potential uses. The SLDMWA makes periodic surveys using GPS along the DMC to identify key areas of active land subsidence and to estimate subsidence rates. When the City of Tracy increased their pumping from 5,800 to nearly 8,000 AFY (2001-2005), six benchmarks were installed near their monitoring wells and annually surveyed during this period. **Figure 5-38** shows these benchmark station locations. **Appendix J** contains benchmark elevation correlations to groundwater levels.

The TRE Altamira InSAR subsidence dataset also provides subsidence monitoring in California and the results are displayed on DWR's SGMA Data Viewer. The tested accuracy of the InSAR was 0.06 feet (18 millimeters) vertical accuracy at a 95 percent confidence level. This statement of accuracy applies to the state-wide dataset and may vary for regional or localized area subsets. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95 percent confidence level. Therefore, adding to two accuracy factors together, the error factor in the InSAR data is about 0.1 feet. A land surface change of less than 0.1 feet is therefore within the noise of the data and is not evidence of subsidence in the Subbasin.

Based on the geologic conditions and causes, the subsidence discussion below is divided into the Delta and non-Delta areas.

**Delta Area**

Delta peat and mud deposits formed during the last 7,000 years under tidal wetland conditions (Atwater 1982). The area of peat soils encompasses about 200,000 acres (Deverel and Leighton 2010). Plant material decayed and accumulated under anaerobic conditions as sea level increased (Shlemon and Begg 1975). Peat thicknesses generally decrease from the west to east and towards the periphery of the Delta. Peat thickness ranges from less than 3 feet on the eastern, southern, and northern margins of the Delta to over 30 feet in the western Delta.

Oxidation of the peat deposits (organic carbon), the primary cause of subsidence (Deverel and Rojstaczer 1996), began in the late 1800s as the nutrient-rich soils were cleared and dewatered for agriculture. Since then, island elevations have decreased to as much as 25 feet below sea level. Drainage of soils for agriculture has increased microbial oxidation of organic carbon which resulted in land subsidence at rates of less than 0.5 to over 1 inch per year (Deverel and Leighton 2010). Based on the NASA JPL data, the Delta area of the Subbasin subsided between 4 and 8 inches (~0.25 to 0.5 feet per year) between May 2015 and September 2016 (Farr et al 2016). As there is little to no groundwater pumping in the Delta, this subsidence is related to peat oxidization.

**Non-Delta Area**

There are a series of GPS benchmark stations along the DMC, with subsidence monitoring data that extends from 1984 to 2018. **Figure 5-38** shows locations of the stations and changes in ground surface as they relate to subsidence in the area. Over the 34-year data period, the ground surface level has dropped about 0.25 feet in the western portion of the Subbasin, (~0.01 feet per year) to as much as 0.71 feet (0.022 feet per year) near the southeastern end of the Subbasin. Within San Joaquin County, but outside of the Subbasin, there has been as much as 1.27 feet (0.035 feet per year) of subsidence at one station near the Stanislaus county line. **Appendix J** provides groundwater levels as they relate to subsidence at these benchmarks.

Between 2007 and 2010 land-surface deformation measurements indicated that much of the northern portion of the Delta-Mendota Canal was minimally subsiding on an annual basis; some areas showed seasonal periods of subsidence and of uplift, which resulted in either no longer-term elevation change or a slight loss in elevation. However, many wells in this area did not reach historical lows during this time period (Sneed et al. 2013).

DWR SGMA Data Viewer for land subsidence summarizes the annual (12-month periods) vertical displacement during selected time periods ranging from January 1, 2015 through October 1, 2020 (DWR 2020). **Figure 5-39** shows the vertical displacements from 2015 through 2020. Vertical displacements within the non-Delta portion of the Subbasin for the first 12 months shortly after SGMA was passed, from January 1, 2015 through January 1, 2016, ground surface elevation changes ranged from +0.014 to -0.025 feet. For the total period of record January 1, 2015 through October 1, 2020 subsidence ranged from +0.006 to -0.128 feet, or about +0.001 to -0.03 feet per year. The highest values were near the Delta-Mendota canal near the southern edge of the Subbasin and are likely real due to the values exceeding the error factor, in the InSAR data. As shown on **Figure 5-7** groundwater levels in the Lower aquifer have only declined in this area by about 15 feet and are still above the top of the Corcoran Clay, suggesting the subsidence in this area may not be related to groundwater level declines. A new monitoring well is proposed for this area better assess groundwater level changes.

The continuous recording CGPS station P257 provides for a relatively long-term assessment, 2006 through present, including the recent drought when reliance on groundwater was higher. **Figure 5-40** shows the measurements along with groundwater levels in a nearby monitoring well screened below the Corcoran Clay. From 2006 thru 2012 there was no apparent inelastic subsidence. During the drought groundwater levels in the Lower aquifer declined by about 15 feet, but were still above historic low levels, and there was an apparent subsidence of about 0.04 feet. The land surface has not rebounded to pre-2012 levels but groundwater levels are slowly rising. Since 2016, there does not appear to be any inelastic subsidence, only elastic, even though groundwater levels have recovered to within 5 feet of 2012 levels. Because groundwater levels are rising it does not appear that the subsidence is related to groundwater pumping.

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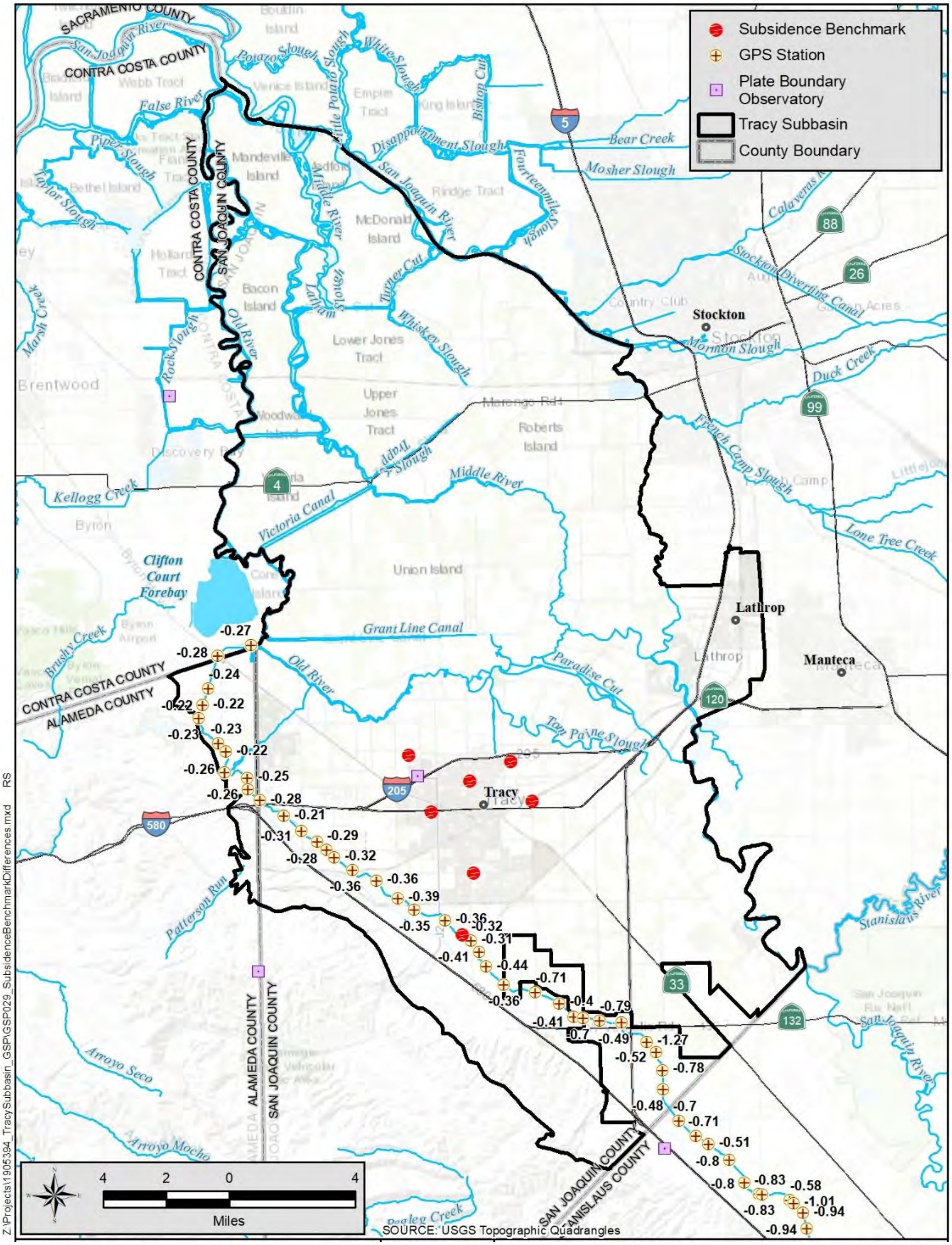


**Figure 5-37. Benchmark Differences 1984-2018 (in Feet)**

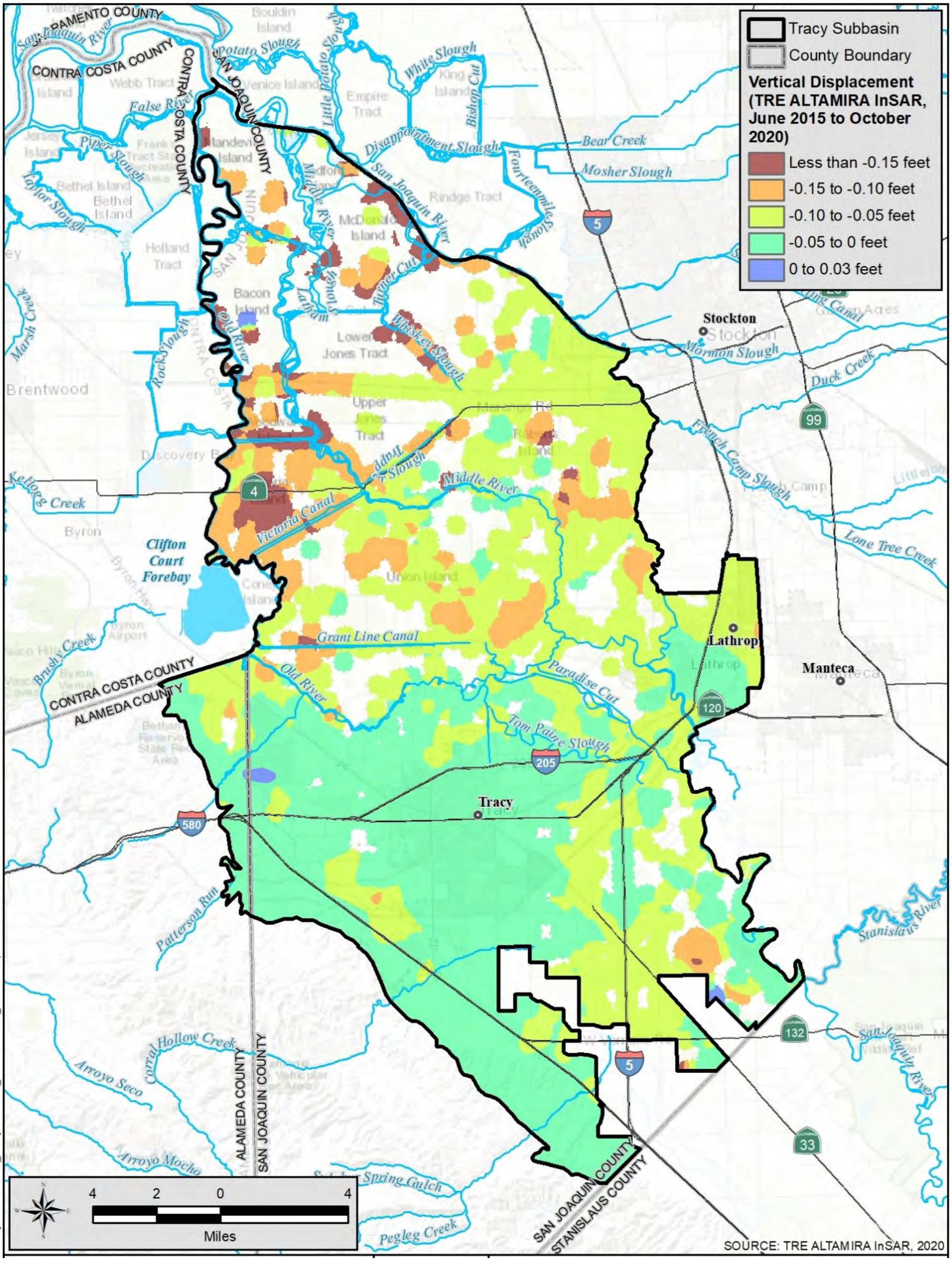


**Figure 5-38 InSAR Imagery Subsidence**

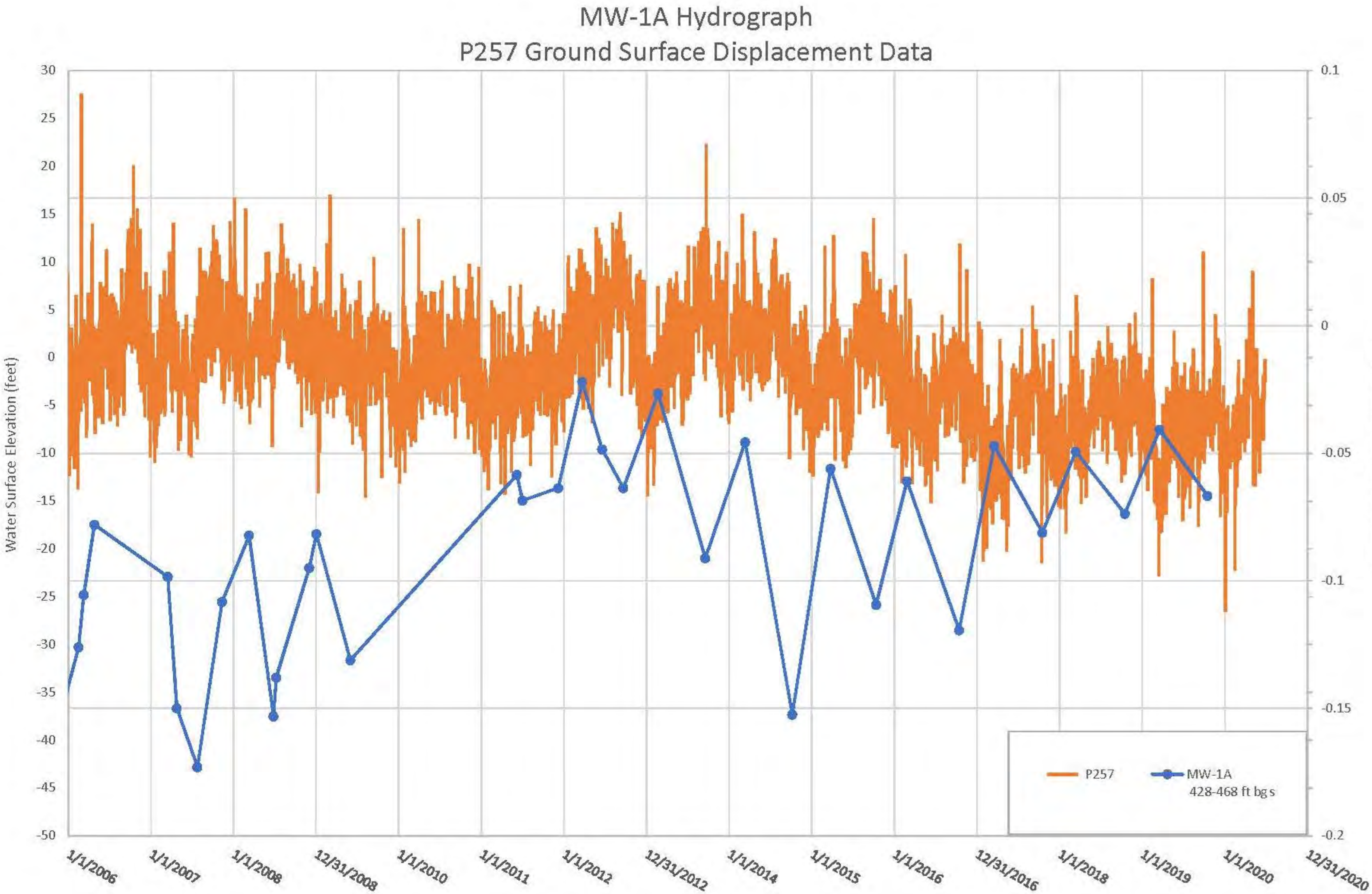


**Figure 5-39 Continuous Reading CGPS Station *versus* Groundwater Levels**

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## 5.9 Interconnected Surface Water

Interconnected surface water refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (CCR 2014). The groundwater elevation map for the Upper aquifer provides an initial indication of whether the rivers and creeks are interconnected or disconnected in the Tracy Subbasin. For purposes of this GSP the rivers and creeks were assumed to be interconnected to the aquifers when the depth to water is less than 20 feet bgs.

**Delta Area**

In general, surface water and groundwater are interconnected along the San Joaquin and Old rivers, channels, and within the Delta islands portion of the Tracy Subbasin.

**Non-Delta Area**

As discussed in **Chapter 4 – Hydrogeologic Conceptual Model**, the non-Delta area of the Subbasin are the lands south of the Old River and Tom Paine Slough, where ground surface is higher in elevation and groundwater surface elevations are lower. As shown on **Figure 5-41**, along the rivers and sloughs groundwater is interconnected with some areas gaining and loosing. Although the data set for interconnectedness along Old River has "no groundwater data", there are sufficient groundwater level measurements (01S05E31R002 and 2S05E08B001) to indicate the conditions along this portion of the river, but it is likely to be likely connected and is a losing interval based on groundwater elevations. **Appendix K** hydrographs for the non-Delta area shows most areas with monitoring wells are losing intervals, where groundwater levels are lower than the surface water elevations. In some cases, where multiple wells can show the gradient, near GLC river gage, the gradient from the non-Delta area is toward the river suggesting a gaining interval. The creeks in the non-Delta are intermittent, not flowing year-round, and along with the depth to water, surface water in Corral Hollow and Lone Tree Creek are considered to be disconnected from groundwater. Gages are not present along these creeks to illustrate when they cease to flow.

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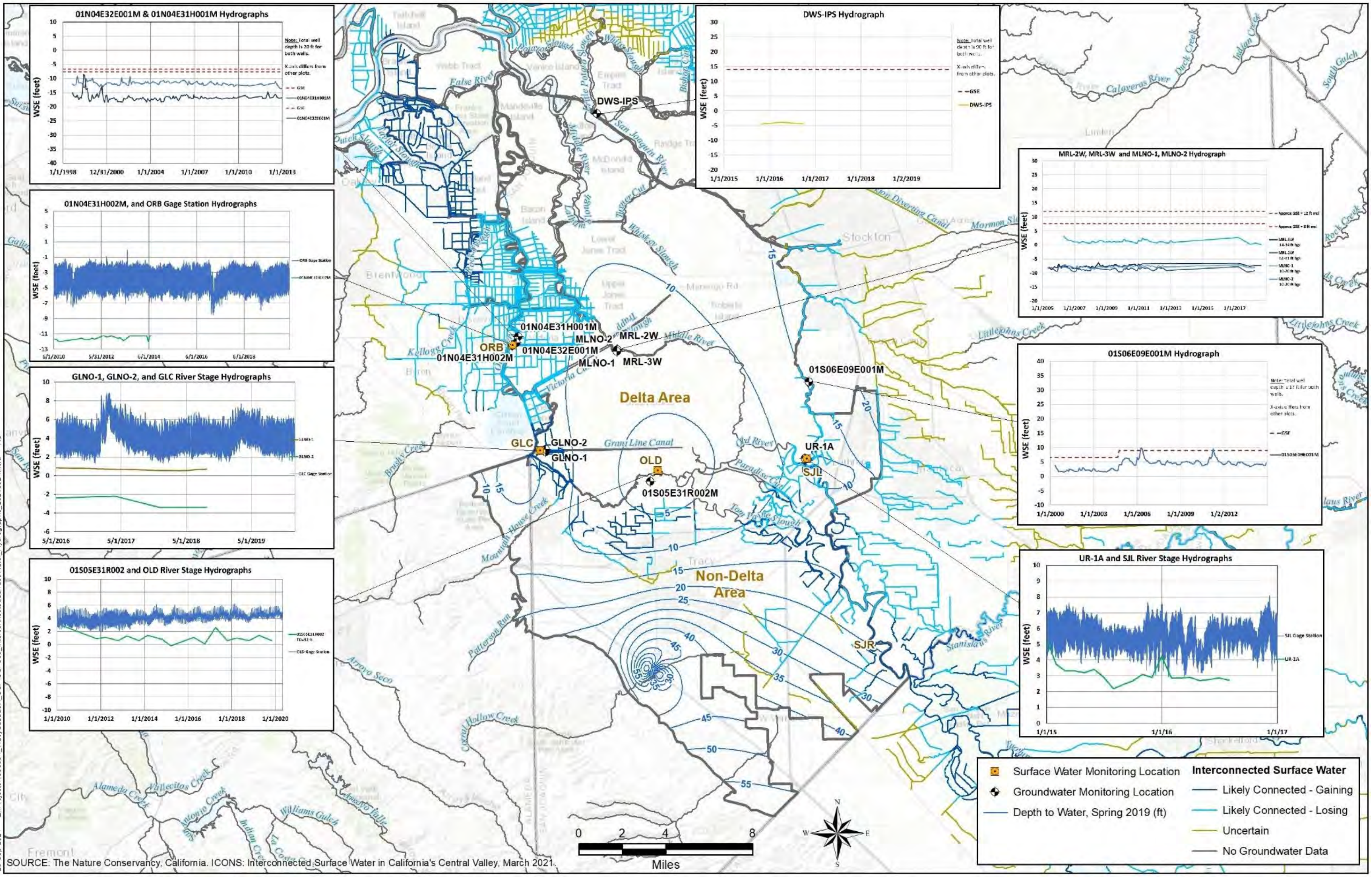


**Figure 5-40 . Interconnected Surface Water**

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## 5.10 Groundwater Dependent Ecosystems

Groundwater-dependent ecosystems (GDEs) are defined in the GSP regulations as, "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." GDEs, species and native vegetation, are a beneficial user of groundwater. Managed wetlands may also be GDEs or may be supported by pumped groundwater or delivered surface water supplies.

GDEs exist where native vegetation accesses shallow groundwater for survival. This GSP identifies GDEs within the Tracy Subbasin based on a determination of the areas where vegetation is dependent on groundwater.

The Natural Communities Commonly Associated with Groundwater (NCCAG) database was used as a starting point to identify potential GDEs within the Subbasin. The NCCAG database was developed by a working group comprised of DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC). The working group reviewed publicly available datasets which mapped California vegetation, wetlands, springs, and seeps and conducted a screening process to retain communities known to be commonly associated with groundwater. The NCCAG database defines two habitat classes: wetland and vegetative. The wetland class includes wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions. The vegetative class includes vegetation types commonly associated with the shallow subsurface presence of groundwater (phreatophytes). Potential GDEs were identified from NCCAG Vegetation and Wetlands mapping are shown on **Figure 5-42**. Managed wetlands were also added to this figure from the Land IQ dataset (2017) and those provided by the Audubon Society. All potential GDEs identified from NCCAG were kept at this time but may be revisited in the future.

Most potential GDEs are located adjacent to the San Joaquin River and other waterways and within the Delta islands and as such are supported by both surface water and groundwater. No further assessments were made to better quantify potential or actual GDEs. Few potential GDEs are located in the non-Delta areas where depths to groundwater are greater than 20 feet and may be evaluated in the future to more clearly demonstrate whether the GDEs are groundwater dependent.

The distribution of freshwater fish and wildlife species that may be dependent on GDEs is not well known and is not included in this analysis. A list of threatened and endangered species that may be in the Tracy Subbasin or its waterways is provided in **Appendix L**.

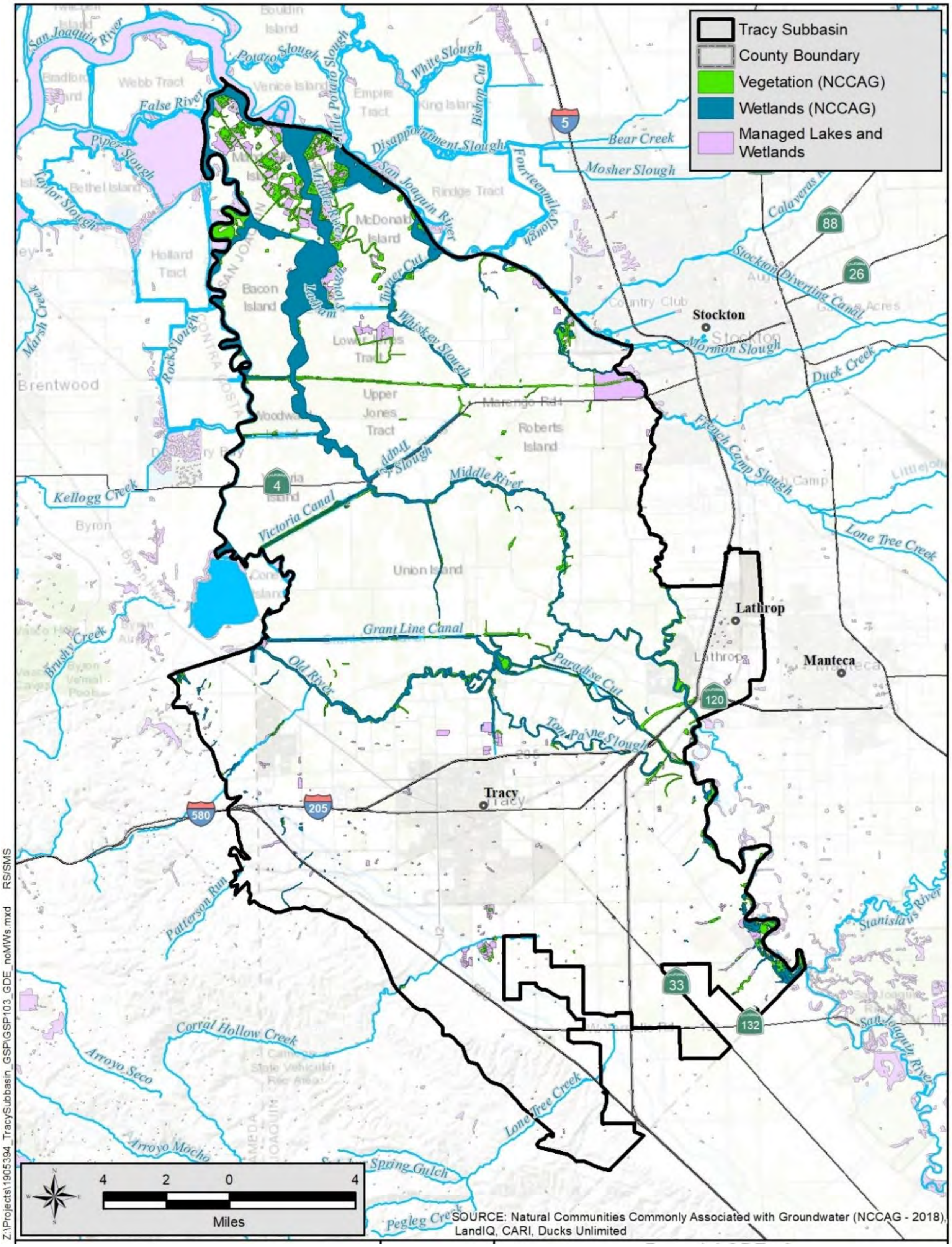


**Figure 5-41. Potential Groundwater Dependent Ecosystems**

## 5.11 Data Gaps

Groundwater conditions in the Tracy Subbasin have been investigated and documented since the early 20th century and through the present. Data collection may be improved with the following monitoring network enhancements:

- Construction of monitoring wells screened in the Lower aquifer near the west side of the Subbasin will confirm the presence of the Corcoran Clay and provide additional groundwater level control in this area.
- Evaluate, purchase and installation of transducers into monitoring well ORL-1W to improve the correlation of groundwater to surface water. Currently, groundwater levels in monitoring wells near gaging stations are only being measured semi-annually whereas surface water gages are monitored every 15 minutes. The difference in frequency makes it difficult to correlate groundwater and surface water data which is necessary for assessment of surface water depletion. Although other wells are being considered for surface water depletion monitoring, transducers cannot be installed into domestic wells due to their lack of access.
- The areas (NCCAG dataset) identified as GDEs have not been validated. In the 5-year update the groundwater elevations will be subtracted from land surface elevations from a digital elevation model (DEM) to estimate depth to groundwater contours across the landscape to further refine determination of GDEs and interconnected surface water (Mountain House Creek). The evaluation may consider seasonal data to different water year types if available.

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# 6. Management Areas

As described in the previous chapters, the Delta and non-Delta areas at the Tracy Subbasin have different hydrogeologic and hydraulic conditions. In consideration of these different conditions, two management areas are defined for the Tracy Subbasin. The following information from the GSP Emergency Regulations are provided for guidance for the development of Management Areas and whether monitoring would be required along with establishment of sustainability criteria. According to the GSP's Emergency Regulations Monitoring Network and Sustainable Management Criteria Subarticles, monitoring networks, minimum thresholds, and measurable objectives do not have to be established if undesirable results are not present or likely to occur:

> *Section 354.20. Management Areas.*
>
> *(a) …Management areas may define different minimum thresholds and be operated to differently measurable objects than the basin at large, provided that undesirable results are defined consistently throughout the basin.*
>
> *(b) A basin that includes one or more management areas shall describe the following in the Plan:*
>
> > *(1) The reason for the creation of each management area.*
> >
> > *(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.*
> >
> > *(3) The level of monitoring and analysis appropriate for each management area.*
> >
> > *(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area*
>
> *(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps and other information required by this Subarticle sufficient to describe conditions in those areas.*
>
> *Subarticle 4. Monitoring Networks. Section 354.34 (j) An agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26 shall not be required to establish a monitoring network related to those sustainability indicators.*
>
> *Subarticle 3. Sustainable Management Criteria. Section 354.26(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators and are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

## 6.1 Reason for Management Areas

The Tracy Subbasin encompasses an area of about 370 square miles in San Joaquin and Alameda counties. The Delta area consists of numerous islands within an area of about 187 square miles. Waterways surrounding each island provide a constant source of recharge to the groundwater system. Most of the Tracy Subbasin is within the legally defined Delta Boundary (**Figure 6-1**).

In the previous sections, Delta and Non-Delta areas were described for this GSP. These areas are similar to the definition of the legal Delta in Water Code 12200, Delta Primary and Secondary Zones. The Delta Protection Commission was established by the Delta Protection Act (Act) of 1992. The Commission is to develop a long-term resources management plan for the Delta Primary Zone. As stated in the Act the goals of this regional plan are to "protect, maintain and, where possible enhance and restore the overall quality of the delta environment, including, but not limited to, agriculture, wildlife habitat and recreational activities." The Act acknowledges that agricultural land within the Delta is of significant value as open space and habitat for waterfowl using the Pacific Flyway. As such, the regional plan is to protect agricultural land within the Primary Zone from intrusion of non-agricultural uses (DWR 1995). Therefore, land use within the Delta Primary Zone, are not expected to change. Flows in the Delta waterways are maintained at levels to maintain freshwater in these waterways and prevent salinity intrusion. For this GSP, the Delta area is similar to Primary Zone within the Legal Delta Boundary, but the Non-Delta area includes both the Secondary Zone areas and those areas that extend outside of the Legal Delta Boundary to the edge of the Subbasin.

## 6.2 Delta Management Area

The Delta islands are a unique area in the state of California, where groundwater has to be drained or pumped away to maintain groundwater levels bgs. Most of the Delta islands ground surfaces are below sea level. The water is pumped back from the islands into the adjacent waterways. There is always a direct and constant connection between surface water and groundwater, requiring management of groundwater levels (dewatering) within the islands. There are hundreds of diversions that divert surface water from the adjacent waterways surrounding the islands for agricultural purposes, as shown on **Figure 6-2**, and therefore groundwater use in these areas is minimal.

Beneficial users of groundwater in the Delta islands are agriculture, domestic, municipal, and environmental uses. However, the users of groundwater are sparse:

- About 50% of the area (~ 91 square miles) have no domestic wells and another 20% of the area (38 square miles) have only one domestic well per square mile (**Figure 3-12**).
- Over 80% of the area (155 square miles) have no agricultural wells. Where present, 15% of the area has a density of 1 well per square mile (29 square miles) and only 6 square miles have 2 to 3 wells per square mile (**Figure 3-14**).
- Over 96% of the area (187 square miles) have no municipal supply wells (only 7 wells in the entire area and where present occur at a frequency of 1 per square mile) (**Figure 3-16**).

- Most potential GDEs and managed wetlands in the Subbasin occur in this area, due to the shallow and stable groundwater and plentiful surface water (**Figure 5-41**).
- Most of the DACs in the Subbasin are in this area and rely upon domestic wells or are importing water as many areas have no domestic wells. No wells were reported to have gone dry during the 2012 to 2016 drought years.

There are no foreseeable significant changes to land use in the Delta area other than expansion of ecosystem restoration. No new urban area developments will occur within the islands (per the Act) other than the current planned River Islands development in the Stewart Tract which is in the Non-Delta area. If the Delta Tunnels are constructed, dewatering and increased groundwater use will have to be mitigated by the owners.

There have been no undesirable results in the Delta area (as defined in **Chapter 9 – Sustainable Management Criteria**) as related to sustainability indicators and no undesirable results are likely to occur in this management area due to the Act:

- There has been <u>no chronic lowering of groundwater levels</u>. Groundwater levels fluctuate with tidal levels in the adjacent waterways, always remaining within a narrow range. Because of the adjacent waterways the groundwater level (shown in yellows and green colors) trends are flat (**Figure 6-3**). River gage stage data are also shown on some of these hydrographs (blue color) to illustrate the relatively constant heads.
- There has been <u>no reduction in storage</u> (as shown by hydrographs on **Figure 6-3**).
- There is <u>no surface water depletion</u>. The entire area is connected to surface water and water that is pumped out of the islands is returned to the adjacent waterways. Otherwise, the islands would become submerged.
- <u>Land subsidence has not occurred</u> due to groundwater extraction. Subsidence is due to natural oxidization of naturally occurring peat (decaying organic layers) (as described in **Chapter 5.8 – Subsidence**).
- <u>Groundwater quality</u> is naturally poor quality (TDS exceeding the secondary recommended MCL, along with other elements as shown on **Figures 5-19 through 5-26**) due to natural conditions (peat deposits). There are no known manmade contamination plumes within the Delta and therefore groundwater would not be degraded with Projects or Management Actions.
- <u>No seawater intrusion.</u> The area is not in a coastal area near sea water. Surface water invasion of brackish water has been resolved by construction and managed releases from dams to maintain freshwater in the waterways (as discussed in **Chapter 5.7 – Seawater Intrusion**) and is not likely to reoccur in the future.

Because there have been no undesirable results for each of the sustainability indicators in the Delta area and none are likely to occur in the future, groundwater monitoring is not necessary in this portion of the Subbasin for it to remain sustainable. As such, minimum thresholds and measurable objectives will not be established for the Delta management area.

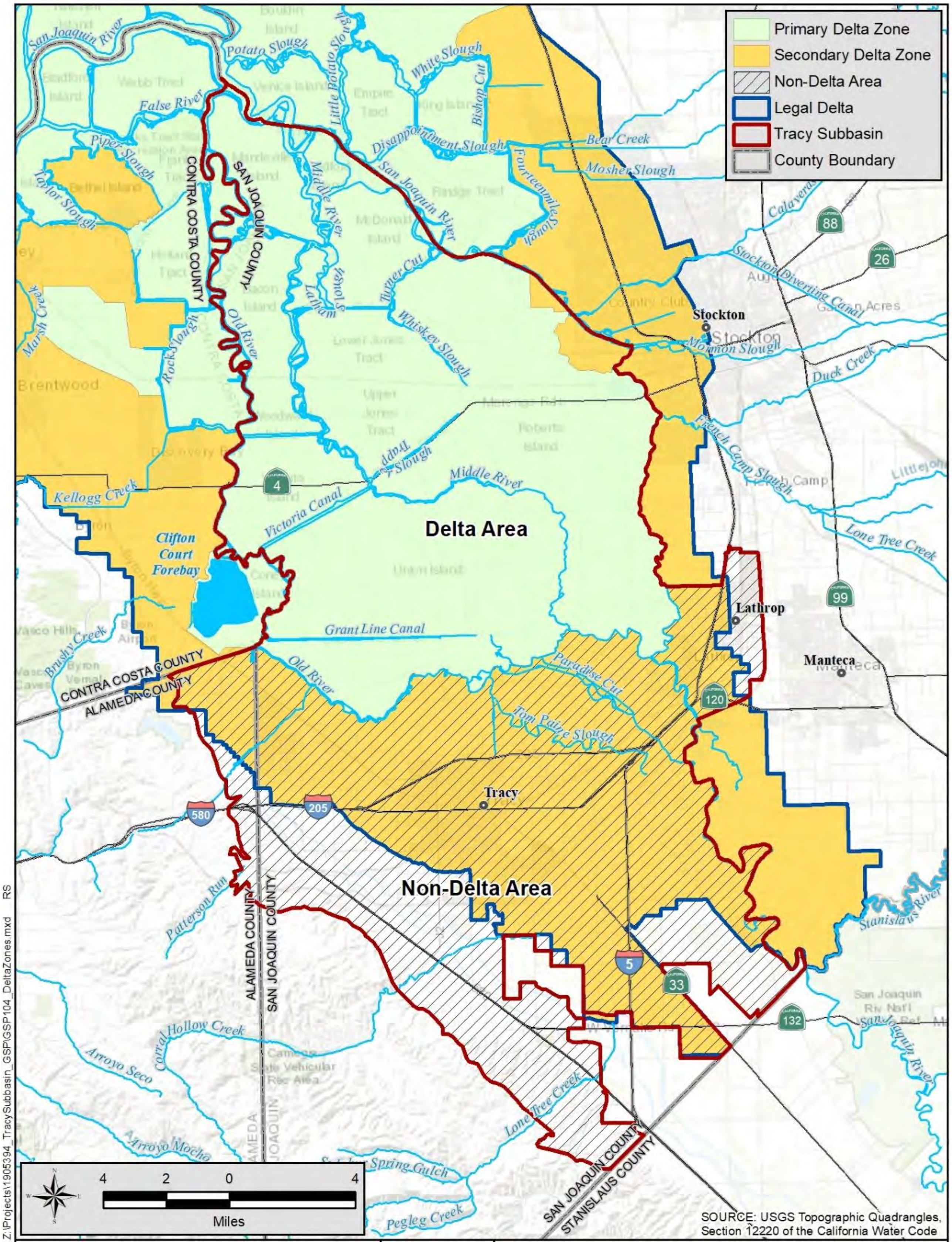


**Figure 6-1. Delta and Non-Delta Areas**

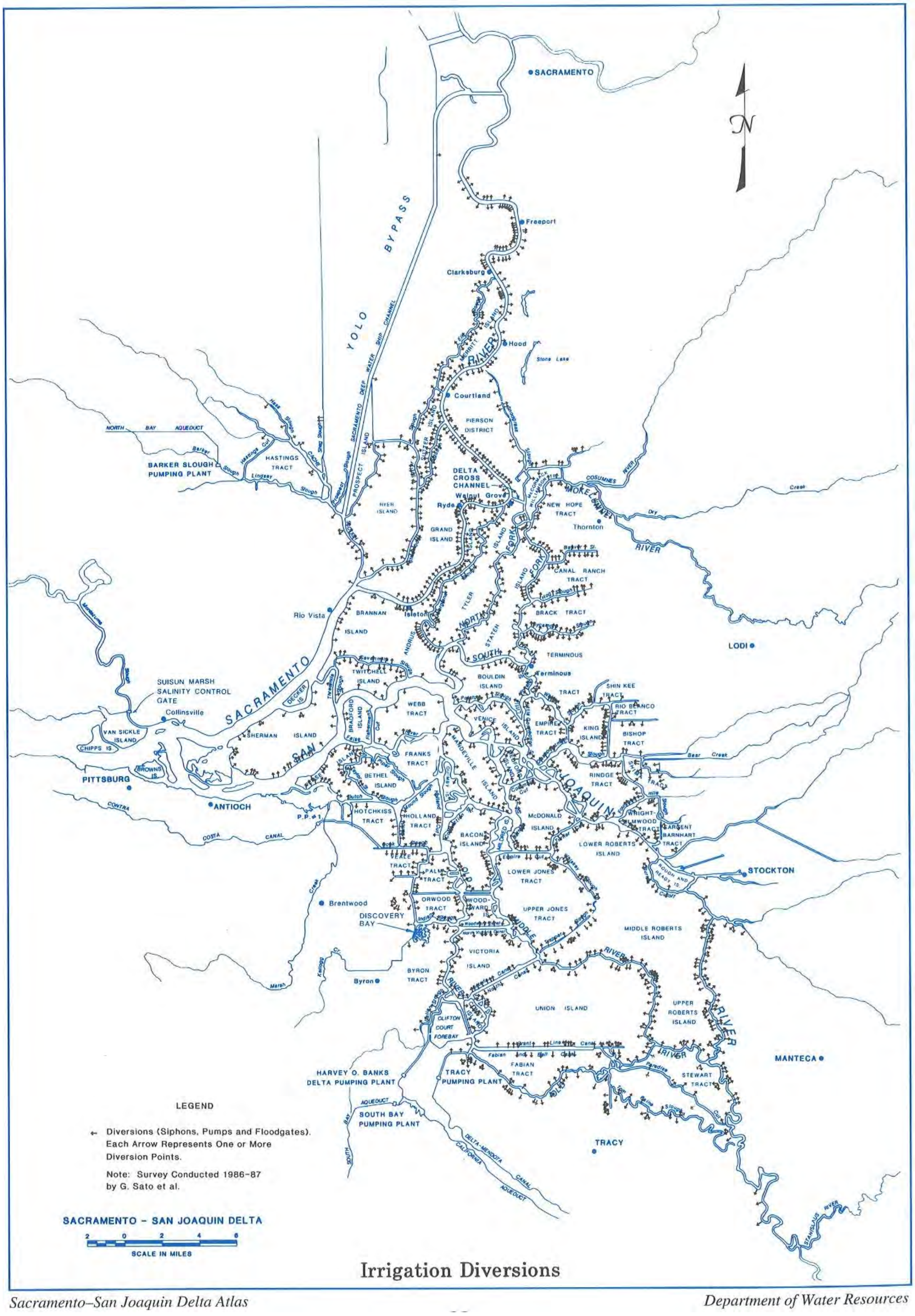


**Figure 6-2. Surface Water Diversions**

## 6.3 Non-Delta Management Area

The Non-Delta areas of the Subbasin is where most agricultural, domestic and municipal wells are present and where groundwater is used. The area may have had potential impacts from groundwater use.

Each of the sustainability indicators in the Non-Delta Management area are summarized below and described in detail in **Chapter 9 – Sustainable Management Criteria**:

- There has been some lowering of groundwater levels and some areas are experiencing a downward trend.
- There has been a slight reduction in storage, but this has been refilling and is being used for aquifer storage and recovery program.
- There may be surface water depletion. The Upper aquifer is interconnected with groundwater along the Old River and Tom Payne Slough and the Lower aquifer is interconnected potentially north of the Corcoran Clay extent. Groundwater pumping in these aquifers could deplete surface water.
- Land subsidence has occurred due to groundwater extraction.
- Groundwater quality is of naturally poor quality (TDS exceeding the secondary recommended MCL, along with other elements) due to natural conditions.
- No seawater intrusion has occurred.

As such, excessive groundwater use in the Non-Delta area could have undesirable results on beneficial groundwater uses such as domestic, agricultural and municipal well owners, along with surface water, and GDEs. A groundwater monitoring network with representative wells with minimum thresholds and measurable objectives will be established for this management area as described in **Chapter 8 – Monitoring Network** and **Chapter 9 – Sustainable Management Criteria**.

Minimum thresholds and measurable objectives for this area can be different than in the adjacent Delta area. For the Non-Delta areas, groundwater gradients in the Upper aquifer will be maintained to continue contributions to Old River, Tom Payne Slough, and the San Joaquin River. In the Lower aquifer, groundwater levels will be maintained to prevent additional surface water depletion from the Delta area, in those areas beyond the extent of the Corcoran Clay.

## 6.4 Summary

In conclusion, the Delta area will not require active groundwater management to maintain sustainability while the Non-Delta areas will require management to be sustainable. **Table 6-1** compares Delta and Non-Delta areas as related to the sustainability indicators.

**Table 6-1. Delta and Non-Delta Comparison of Sustainability Indicators**

| Sustainability Indicators | Delta Area | Non-Delta Area |
|---|---|---|
| Chronic Lowering of Groundwater Levels | No chronic lowering | Some lowering of groundwater levels |
| Reduction of Storage | No reduction in storage | Slight reduction in storage |
| Surface Water Depletion | No surface water depletion | May be surface water depletion |
| Degraded Water Quality | Naturally poor quality | Naturally poor quality |
| Sea Water Intrusion | No sea water intrusion | No sea water intrusion |
| Subsidence | No land subsidence due to groundwater extraction | Land subsidence due to groundwater extraction |

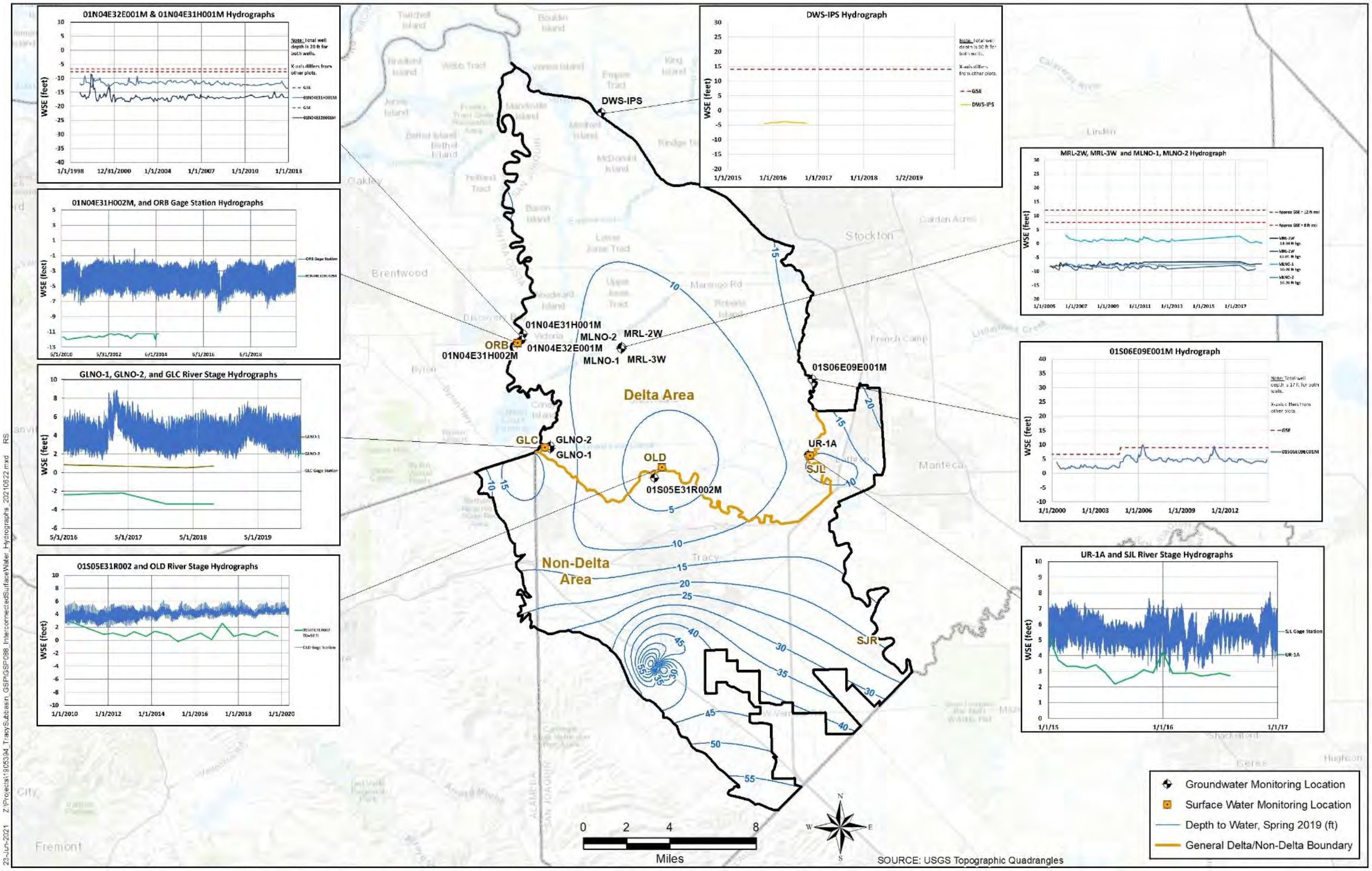


**Figure 6-3. Delta Area Hydrographs**

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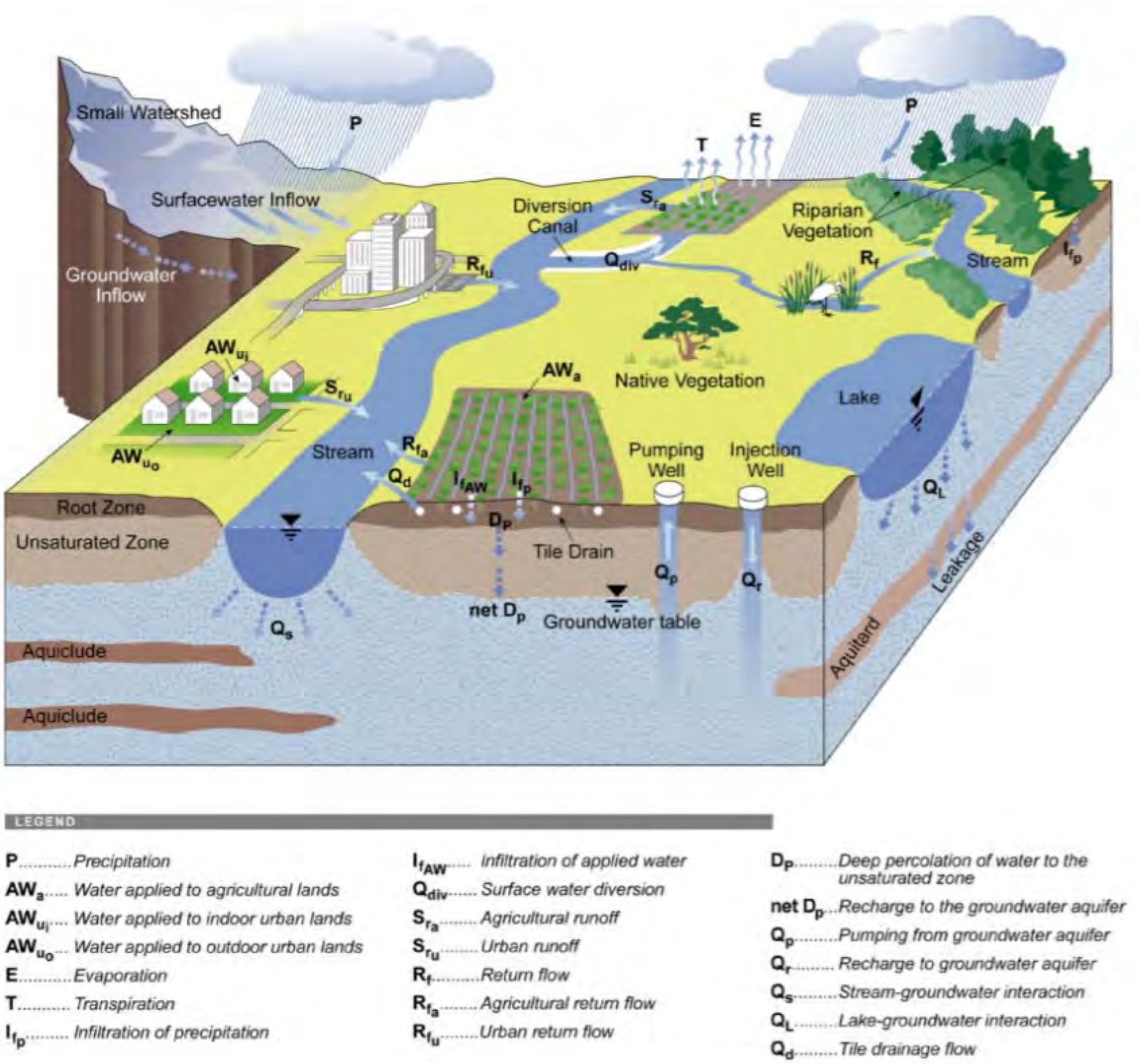
# 7. Water Budgets

Water budgets were developed to provide a quantitative accounting of surface water and groundwater entering and leaving the Subbasin. Water entering the Subbasin includes both water entering at the surface and through the subsurface. Similarly, water leaving the Subbasin leaves both at the surface and through the subsurface. Water enters and leaves naturally, through precipitation and streamflow, and through human activities, such as pumping and recharge from irrigation. **Figure 7-1** presents a schematic of a vertical slice through the land surface and aquifer to summarize the water balance components used in this analysis.




Source: DWR 2014

**Figure 7-1. Water Budget Components**

The values presented in the water budget provides information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate change, groundwater and surface water interaction, and subsurface groundwater flow. The water budgets are presented by water years (the 12 months spanning from October 1 of the previous year to September 30 of the following year). The annual water budgets are based on monthly estimates. The water budgets assist in management of the Subbasin by identifying whether the water budget is in surplus or deficit and to identify potential opportunities to improve water supply conditions and availability.

The water budgets were developed using a model developed by DWR for the entire Central Valley called the C2VSim and was used to extract a water budget for the Subbasin (described below). A base period was also selected so the water budget would be representative of long-term average climatic conditions to estimate the sustainable yield of the Subbasin.

## 7.1 Hydrologic Periods

Hydrologic periods were selected to meet the needs of developing historical, current, and projected water budgets. Precipitation data from the Tracy Carbona precipitation station (Station number 048999) were used to identify hydrologic periods that would provide a balance of wet and dry periods and long-term average conditions needed for budget analyses. Analysis of a period that is unusually wet or unusually dry would provide information that is not indicative of long-term conditions.

The annual rainfall for the Tracy Carbona Station from 1951 to 2019 is shown in **Figure 7-2**. The average annual precipitation during this period was 10.83 inches, and the average annual temperatures ranged from 54 to 56 degrees Fahrenheit (NOAA 2016).

For the calibration of the C2VSim Fine Grid Version 1.0 (C2VSim-FG_v1.0) model, DWR used the period of 1974 to 2015. This period was used based on the quality and availability of various datasets, such as land-use surveys, groundwater elevations, and surface water diversions. The data quality and availability are critical for the model calibration process. The historical water balance for the Subbasin uses this calibration period as the simulation period. The average precipitation in the Subbasin for the period of 1974 to 2015 was 11.37, which is about 0.5 inches (or 5%) greater than the long-term average.

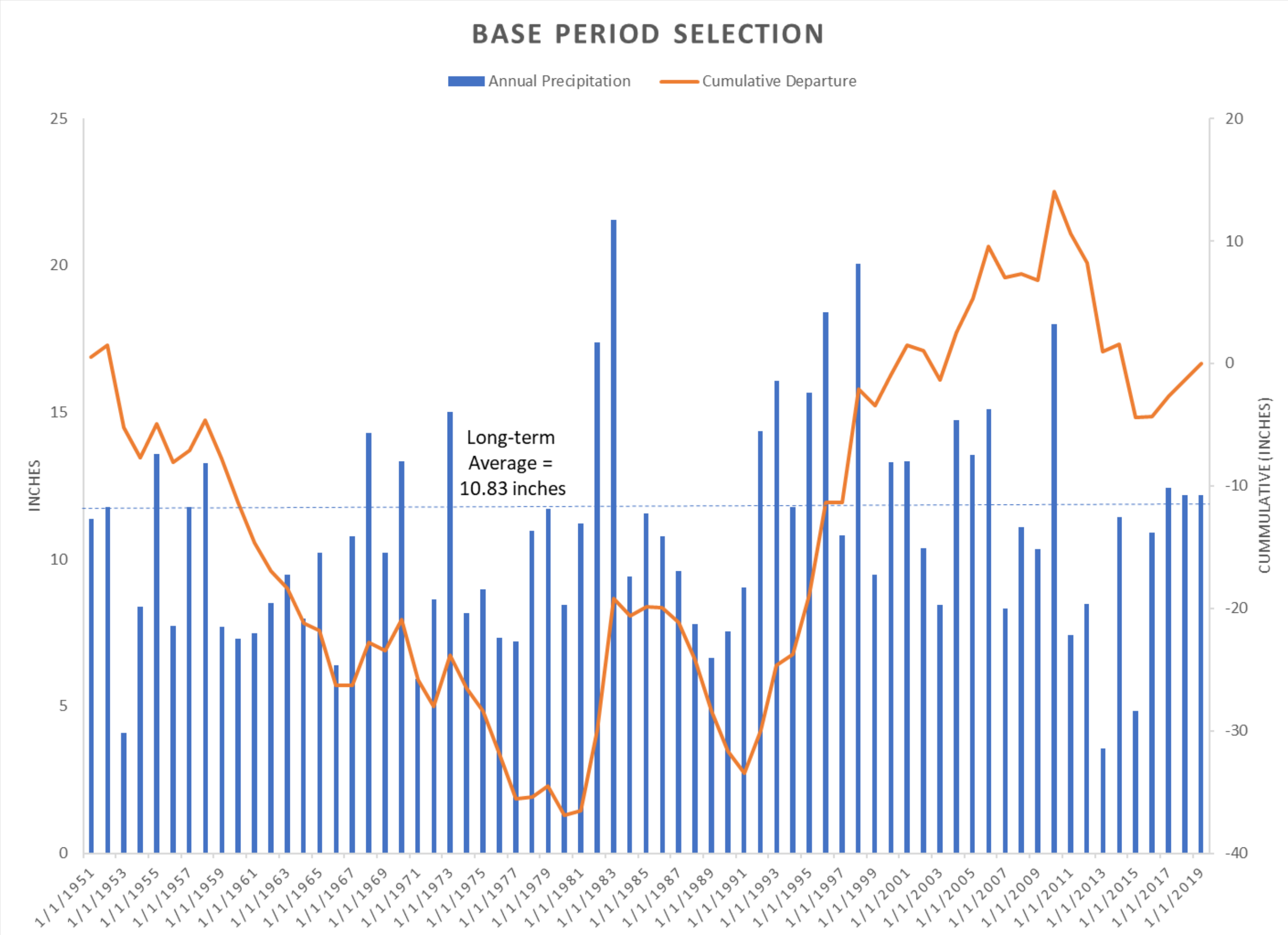


**Figure 7-2. Tracy Carbona Precipitation**

## 7.2 Groundwater Model

In 1990, DWR, Reclamation, and the State Water Board joined together to develop the Central Valley Groundwater Surface Water Model (CVGSM). In 2005, the CVGSM model was upgraded to the Integrated Water Flow Model platform and was renamed the C2VSim Coarse Grid (C2VSim-CG) model. The C2VSim-CG model was adopted by DWR and many other regional and State-wide agencies, as well as non-governmental organizations, to evaluate various water management scenarios throughout the Central Valley.

The C2VSim-CG model dynamically calculates crop water demands; allocates contributions from precipitation, soil moisture, and surface water diversions; and calculates the groundwater pumpage required to meet the remaining demand. Agricultural groundwater pumping is typically not metered in the Central Valley, and the C2VSim-CG model provides some of the best estimates of this pumping because the pumping is constrained spatially and temporally by estimated demand and by surface water supplies. The model can also be used to calculate the changes in aquifer storage and can be used to estimate the water flows between rivers and groundwater aquifers.

The model has gone through numerous upgrades and refinements over the last couple of decades. DWR currently maintains the C2VSim-FG_v1.0 groundwater flow model.

- The latest version of the C2VSim-FG_v1.0 was released by DWR in November 2020 and was used to develop the water budget for the Subbasin. The C2VSim-FG_v1.0 consist of a finite element grid covering the entire Central Valley that uses 30,179 nodes to form 32,537 irregular elements over an area of 20,742 square miles, and 4,634 river nodes to delineate 110 river reaches. The C2VSim-FG_v1.0 model simulates the aquifer system of the Central Valley using three aquifer layers. Aquifer layer one represents the unconfined portion of the aquifer, and aquifer layers two and three represent the confined portions. Layer 3 generally represents the portion of the aquifer that is not pumped. In addition, the model includes an aquiclude layer between aquifer one and two that represents the Corcoran Clay layer present intermittently within the Central Valley.
- C2VSim-FG_v1.0 has a finer resolution along the major streams and canals to simulate stream-aquifer interaction and assessment of impacts of groundwater pumping on stream flows. The C2VSim-FG_v1.0 also provides more detailed water budget information for some surface processes, including land and water use system, stream and canal systems, groundwater system and soil system that are useful for illustrating some of the issues of interest.
- Model data include input files from 1922 to 2015, but the calibrated simulation spans from 1974-2015.
- C2VSim is anticipated to be DWR's primary tool for evaluating water management in the Central Valley and is specifically referenced in the GSP regulations for application to GSP water budgets.

As described in the previous chapters, the Delta and Non-Delta Management Areas in the Subbasin have different hydrogeologic and hydraulic conditions. In consideration of these different conditions, the Delta and Non-Delta Management Areas were defined as shown in **Figure 7-3**. The Delta area will not require active groundwater management to maintain sustainability, while the Non-Delta area will require management to be sustainable. Water budgets were created for the entire Subbasin and for each of these management areas to allow for better quantification of the water budget in each management area to be able to develop projects and management actions to solve any deficit, if present.

Four water budgets were developed using the model for historical, current, projected, and projected with climate change conditions, which are discussed in the following sections:

- For the historical water budget, the historical simulation, which covers water years 1974 to 2015 was used. This historical simulation is a calibrated numerical model representation of historical hydrologic, land use, and water demand conditions within the Subbasin.
- For the current water budget, a base period of 2003-2013 was selected as representative of current conditions. This period is representative of the historical rainfall, as shown in **Figure 7-2**, and is consistent to the base period selected by the Delta-Mendota Subbasin.
- For the projected water budget, the model was modified to represent foreseeable future level of development (2065 level of demands) over long-term hydrologic and climate conditions. The simulation was performed to represent the 2016-2065 hydrologic period (a 50-year projection).

- For the projected with climate change water budget, the model was modified using publicly available climate change projections for evapotranspiration (ET) and precipitation, while maintaining the projections for development and corresponding surface water deliveries. As with the projected water budget, this simulation was performed to represent the 2016-2065 hydrologic period (a 50-year projection).

Water budgets for each of these projections were developed for the entire Subbasin. A breakdown of the water budgets for projected with climate change for each of the management areas, and by principal aquifer is also provided.

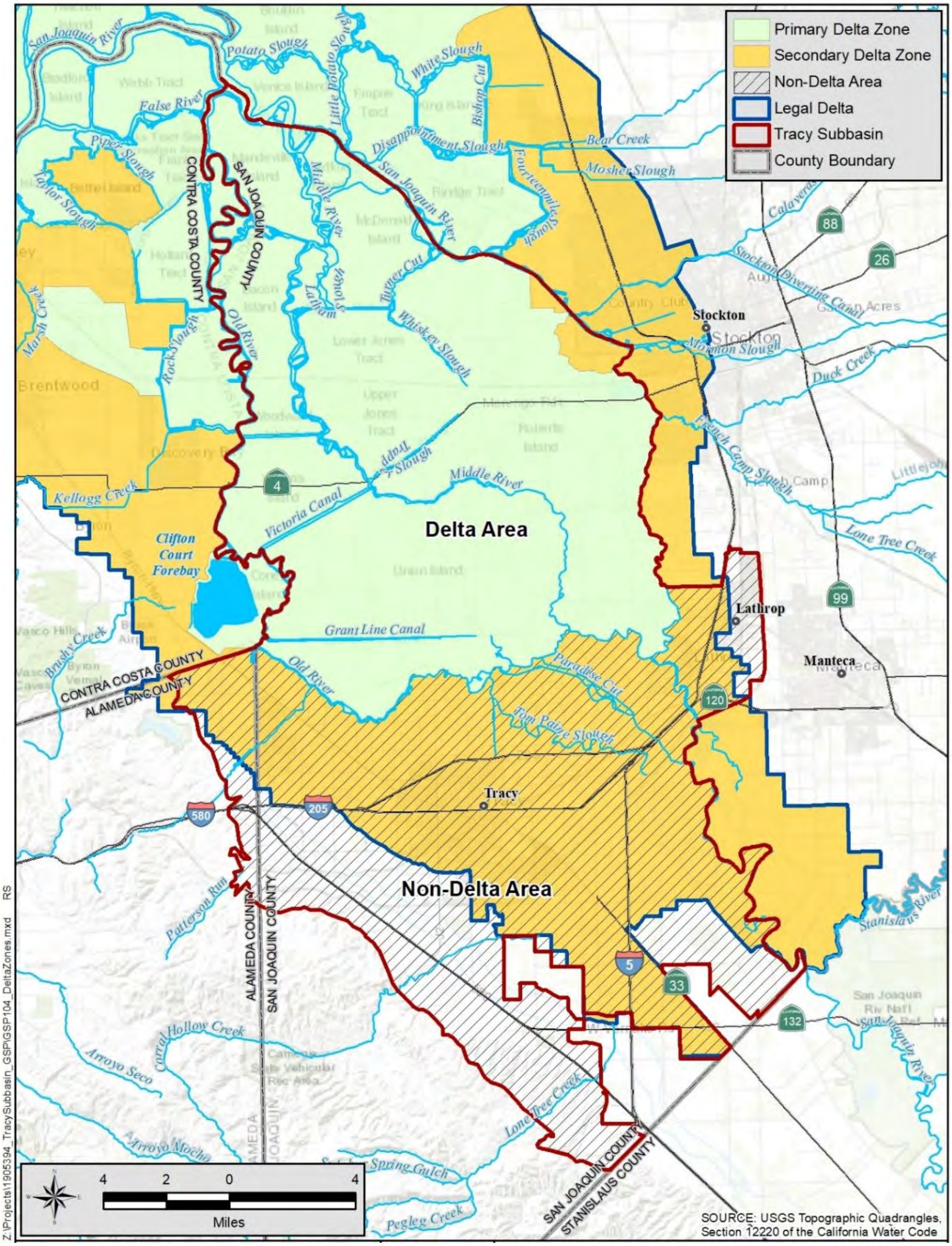



**Figure 7-3. Delta and Non-Delta Areas**

## 7.3 Historical Water Budget

The water budget for the historical period was obtained from the calibrated C2VSim-FG_v1.0 groundwater model and was selected to demonstrate sustainability from 1974 to 2015, a period of 40 years. During the historical simulation, urban demands increased steadily from around 20,000 AFY in 1974 to a maximum of 48,000 AFY in 2007 before dropping down to 36,000 AFY in 2015. Agricultural demands oscillated between periods of weather and cropping pattern changes but averaged around 360,000 AFY.

Detailed documentation for the C2VSIM-FG_v1.0 development, data collection, and methods can be found in the model documentation.[1] A summary of the data included in the model is provided below:

- State Data Sources: CalSim II, CalSim 3.0, Cal-SimETAW, DWR land Use Program, and the California Water Plan.
- Federal Data Sources: Stream inflows, groundwater level observations, land use data, and data included in the Central Valley Hydrologic Model.
- Local Data Sources and Models: Groundwater Management Plans, Integrated Regional Water Management Plans, AWMPs, and Groundwater Sustainability Plans.

The water balances for the Subbasin were developed by post-processing the outputs from C2VSim-FG_v1.0 model and summarizing the results for the elements within the Subbasin boundaries. The elements used for the Subbasin water budget are provided in **Appendix M**. It should be noted that some of the elements extend beyond the Subbasin boundaries.

The annual total inflows, outflows, and cumulative change in storage for the historical period are shown on **Figure 7-4**. **Table 7-1** contains the summary of the annual water budget averages from 1974 to 2015. Detailed tables showing annual inflows and outflows are include in **Appendix M**.

[1] https://data.cnra.ca.gov/dataset/c2vsimfg-version-1-0

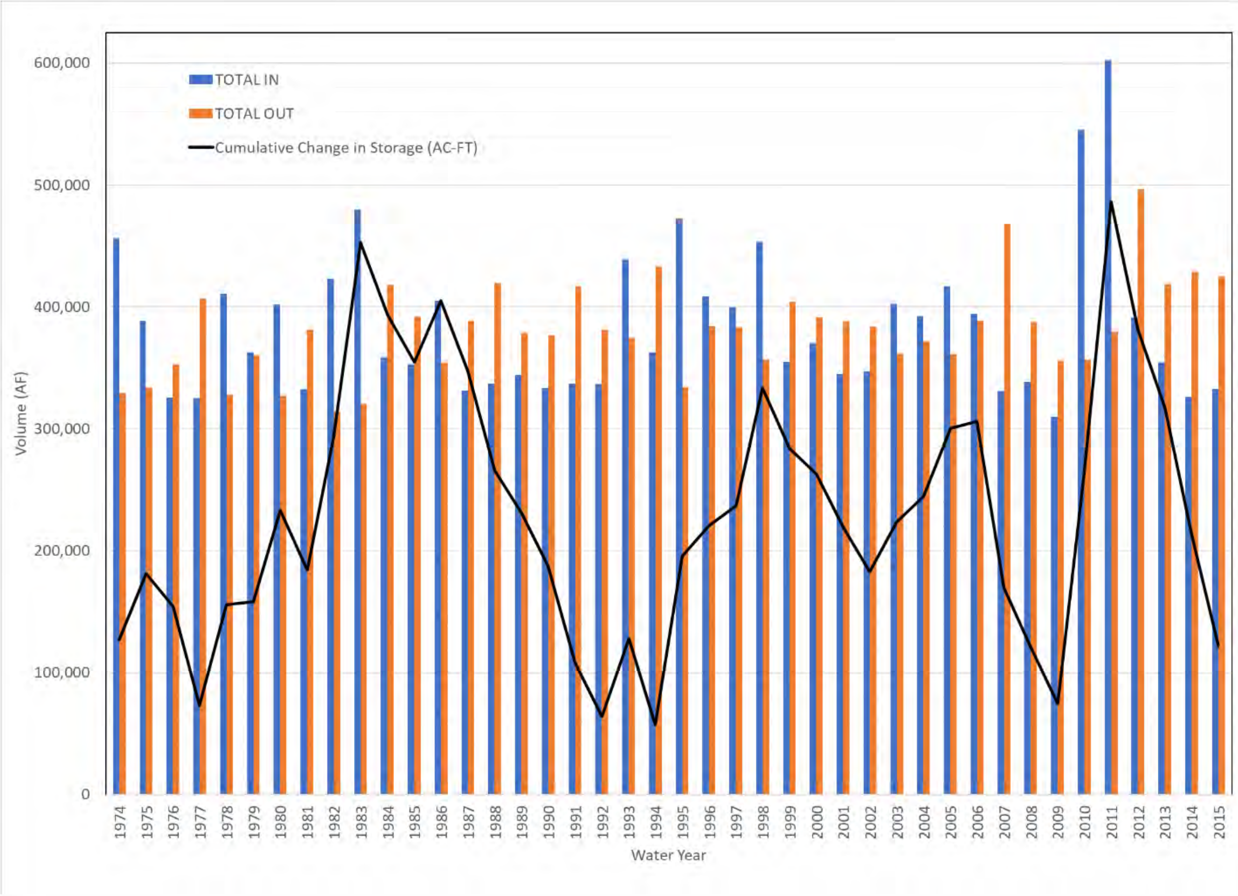



**Figure 7-4. Historical Tracy Subbasin Water Budget – 1974-2015**

**Table 7-1. Historical Tracy Subbasin Water Budget – Annual Averages – 1974-2015**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams/Rivers* | 40,183 | *Streams/Rivers* | 103,997 |
| *Deep Percolation* | 173,537 | *Pumping* | 167,378 |
| *Small Watersheds* | 6,423 | | |
| *Diversion Recharge* | 62,035 | | |
| *Subsidence* | 1,366 | | |
| *Subsurface* | 100,608 | *Subsurface* | 109,868 |
| ***Total IN*** | **384,151** | ***Total OUT*** | **381,243** |

On average, almost 90 percent of the total inflow to the Subbasin is from three sources of water: net deep percolation, subsurface inflow, and diversion recoverable gains (losses from canals). The water budget shows the largest inflow component is deep percolation (a combination of deep percolation from rain and agricultural activities). Deep percolation constitutes about 45 percent of total inflow and ranges from 122,000 to 253,000 AFY. Pumping is the largest outflow component and constitutes 44 percent of the total outflow. *The resulting average surplus for the historical water budget is about 2,900 AFY.*

**Table 7-2** below provides an overview of the variability of surface water and groundwater in relationship to the water year types as defined by the SJRI. Within the simulation period, there were 15 years that were classified as "wet" and 14 years that were classified as "critical." As the table shows, drier periods tend to result in more groundwater extraction as compared to wet periods.

**Table 7-2. Historical Tracy Subbasin Water Budget – Annual Averages – 1974-2015**

| | **Water Year Type (San Joaquin River Index)** | | | | | |
|---|---|---|---|---|---|---|
| Component | ***Wet*** | ***Above Normal*** | ***Below Normal*** | ***Dry*** | ***Critical*** | ***42-Year*** |
| Number of years | 15 | 5 | 2 | 6 | 14 | 42 |
| ***Total Demand (AFY)*** | ***363,090*** | ***379,703*** | ***356,239*** | ***400,306*** | ***430,139*** | ***392,407*** |
| Urban | 31,969 | 33,679 | 40,281 | 34,437 | 33,347 | 33,381 |
| Agricultural | 331,121 | 346,023 | 315,958 | 365,869 | 396,791 | 359,027 |
| ***Total Water Supplies[1] (AFY)*** | ***426,915*** | ***440,740*** | ***409,969*** | ***457,965*** | ***489,354*** | ***453,002*** |
| *Total Surface Water Supplies* | *277,530* | *279,349* | *257,007* | *279,357* | *303,248* | *285,603* |
| Urban Surface Water | 6,065 | 6,642 | 15,125 | 7,565 | 9,446 | 7,906 |
| Agricultural Surface Water | 271,464 | 272,707 | 241,882 | 271,792 | 293,802 | 277,696 |
| *Total Groundwater Supplies* | *149,385* | *161,391* | *152,962* | *178,608* | *186,106* | *167,400* |
| Urban Groundwater | 25,887 | 27,033 | 25,172 | 26,878 | 23,908 | 25,471 |
| Agricultural Groundwater | 123,498 | 134,358 | 127,790 | 151,730 | 162,198 | 141,928 |
| ***Change in Groundwater Storage*** | ***85,555*** | ***12,240*** | ***-2,502*** | ***-42,052*** | ***-68,934*** | ***2,908*** |

**Notes**: C2VSim-FG_v1.0 shows the total annual water supplies exceeding the basin demands in the Subbasin. The excess water supplies are a feature of the C2VSim_FG_v1.0 model and not necessarily reflective of water management.
*See* **Chapter 7.8 – Opportunities for Improvement**.

The water agencies in the Subbasin have very reliable surface water supplies, with all having senior, pre-1914 water rights. **Table 7-3** shows the most recent 10 years of surface water supply deliveries, by surface water source and water year type (based on the SJRI) for deliveries in the Non-Delta Management Area. This 10-year period only had 2 water years which were classified as "wet" and the rest are below normal, dry, and three critically dry years. In this 10-year period an additional source of water has been added from SSJID, starting in 2017. During the 10-year period water supplies in years with below normal SJRI averaged about 62,890 AF. Even during the most recent drought surface water supplies were only 9,600 to 12,700 AF less than average, a reduction of supplies by 15 to 20 percent.

**Table 7-3. Historical Surface Water Deliveries in Tracy Subbasin**

| Water Years | Water Year Type (SJRI) | Total Annual (Water Year) | Water Agency: BCID - Service Area | BCID - Kasson Area | BBID - Bethany | BBID - MHCSD | BBID | The West Side ID | The West Side ID | Tracy | SSJID to Lathrop | SSJID to Tracy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water Source | | | S.J. River | S.J. River | | | | DMC | Old River | DMC CVP | Stanislaus | Stanislaus |
| Units | | AF | AF | AF | AF | AF | AF | AF | AF | AF | AF | AF |
| 2008-09 | C | 75,641 | 44,693 | 7,262 | 17,675 | 2,705 | 1,697 | | | 0 | 1,609 | 0 |
| 2009-10 | D | 64,784 | 41,851 | 6,267 | 10,371 | 2,508 | 2,414 | | | 0 | 1,374 | 0 |
| 2010-11 | BN | 61,476 | 40,921 | 5,522 | 8,547 | 2,590 | 2,824 | | | 0 | 1,072 | 0 |
| 2011-12 | W | 83,170 | 50,954 | 7,538 | 15,999 | 2,982 | 4,931 | | | 0 | 767 | 0 |
| 2012-13 | BN | 70,841 | 45,975 | 6,331 | 11,346 | 3,207 | 3,403 | | | 0 | 580 | 0 |
| 2013-14 | D | 63,748 | 38,799 | 6,863 | 10,301 | 2,905 | 4,353 | | | 0 | 527 | 0 |
| 2014-15 | C | 53,557 | 34,190 | 4,146 | 9,322 | 2,386 | 3,286 | | | 0 | 226 | 0 |
| 2015-16 | C | 50,435 | 32,525 | 6,493 | 5,584 | 2,652 | 2,932 | | | 0 | 248 | 0 |
| 2016-17 | BN | 62,559 | 30,164 | 5,031 | 5,039 | 3,123 | 5,139 | | | 4,455 | 300 | 9,308 |
| 2017-18 | W | 72,638 | 35,054 | 7,497 | 3,436 | 3,238 | 5,795 | | | 5,465 | 921 | 11,234 |
| 2018-19 | BN | 68,576 | 30,084 | 6,101 | 4,318 | 3,898 | 4,638 | | | 8,954 | 2,892 | 7,691 |

**Notes**: Westside Irrigation District deliveries unavailable.
SSJID deliveries began in water year 2004-2005.
Surface water deliveries do not include riparian diversions

## 7.4 Current Water Budget

The current water budget is based on the historical C2VSim-FG_v1.0 simulation period of 2003 to 2013. This period is representative of the long-term average for precipitation and is consistent with the Delta Mendota Subbasin. The average precipitation for the 2003 to 2013 was 10.82 inches, which is consistent with the long-term average of 10.83 inches (1951-2019). Were the current period to be extended to include 2015, the information would be skewed by the recent drought and not representative of current conditions. The Delta Mendota Basin submitted their GSP in 2020 and selected the same period to represent their current budget.

The annual total inflows, outflows, and cumulative change in storage for the current period are, along with the historical period, shown on **Figure 7-4**. **Table 7-4** contains the summary of the annual water budget averages from 2003 to 2013. The composition of inflows and outflows is very similar to the historical period. *The average surplus for the current water budget is 12,200 AFY.*

**Table 7-4. Current Tracy Subbasin Water Budget – Annual Averages – 2003-2013**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams/Rivers* | 42,349 | *Streams/Rivers* | 96,702 |
| *Deep Percolation* | 178,805 | *Pumping* | 178,281 |
| *Small Watersheds* | 1,488 | | |
| *Diversion Recharge* | 79,301 | | |
| *Subsidence* | 137 | | |
| *Subsurface* | 105,141 | *Subsurface* | 120,006 |
| ***Total IN*** | **407,221** | ***Total OUT*** | **394,989** |

## 7.5 Projected Water Budget

The projected water budget was developed using the C2VSim-FG_v1.0 model and adjusting the historical data, along with expectations of future developments and population growth, to estimate future conditions in the Subbasin using a 50-year planning period. A summary of the data sources and adjustments is provided below:

- *Land Use and Cropping Patterns*: The non-urban areas in the model, which include agricultural, native, and riparian areas, were represented by using the land use designations as simulated at the end of the historical period. Urban areas were expanded within the cities of Tracy and Lathrop sphere of influence for planned future developments. Additionally, the urban populations were increased based on the 2015 UWMP plans projections for population at buildout. The land-use and populations were then held constant for the 50-year simulation.
- *Stream Flows*: The stream flows from the historical period of 1953 to 2003 were used to represent future hydrologic conditions.
- *Surface Water Deliveries*: Surface water deliveries within the Tracy Subbasin were represented by using data from the historical simulation. However, the periods used to project a 50-year planning period varied based on the history of each respective diversion. There were municipal and industrial diversions that were formalized after 2000, while there are agricultural diversions that date back to the 1980's. Each diversion data set was assessed, and periods were selected for projection. Additionally, surface water diversions for the City of Tracy were increased based on projections in the UWMP and the known dependence of the increased urbanization on increased surface water availability (i.e., the development will not proceed without securing the additional surface water).
- *Climate Data*: The precipitation and ET data from the historical simulation for the period of 1953–2003 were used to project conditions for the 50-year period.

The annual total inflows, outflows, and cumulative change in storage for the projected period are shown on **Figure 7-5**. **Table 7-5** contains the summary of the annual water budget averages from 2016 to 2065. Detailed tables showing annual inflows and outflows are include in **Appendix M**.

Recharge from net deep percolation, subsurface inflow and diversion recoverable gains made up about 85 percent of the subbasin inflows (similar to the historical water budget). The water budget shows the largest inflow component is deep percolation. Similarly, pumping is again the largest outflow component and constitutes 47 percent of the total outflow. *The resulting average surplus for the projected water budget is 4,800 AFY.*

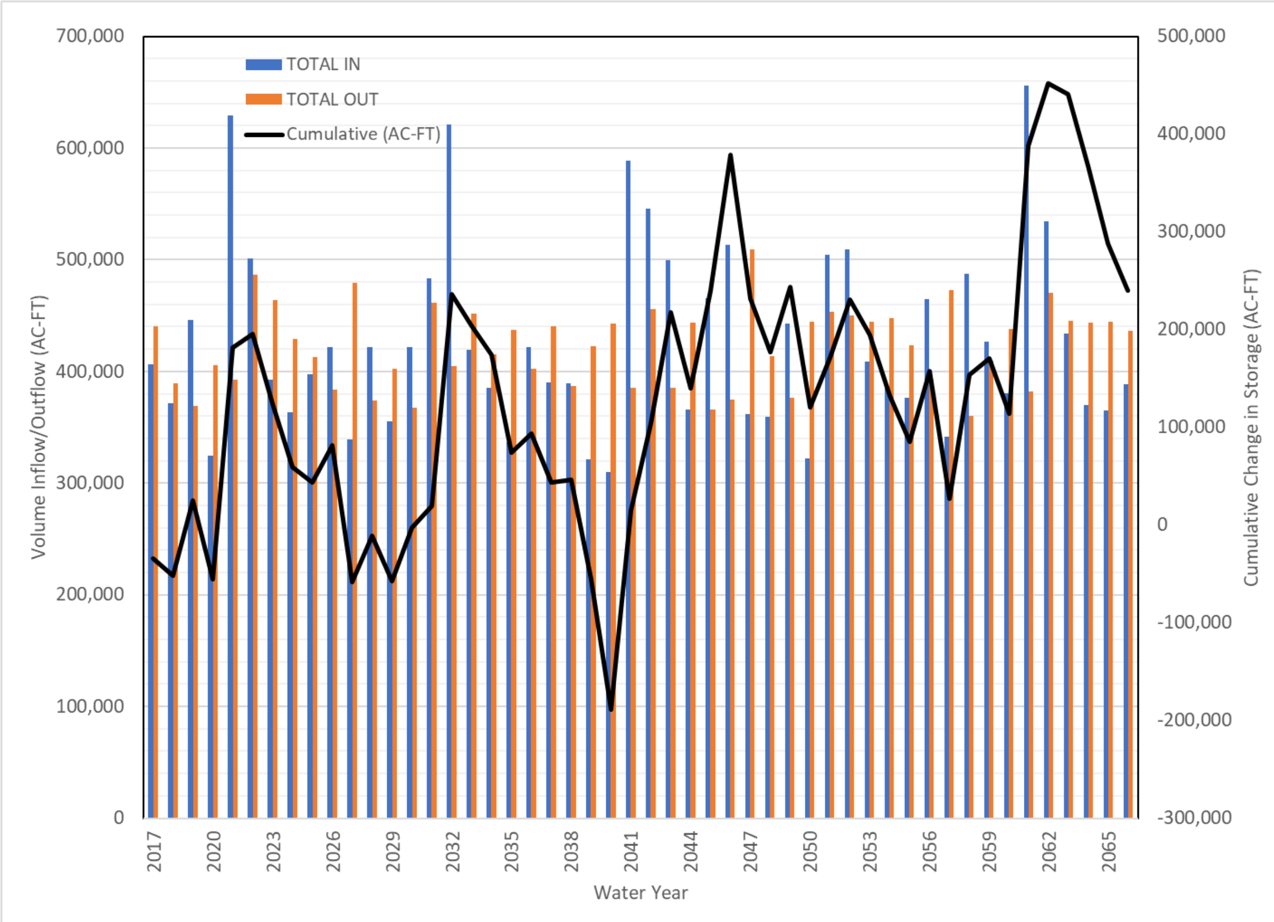



**Figure 7-5. Projected Tracy Subbasin Water Budget - 2016-2065**

**Table 7-5. Projected Tracy Subbasin Water Budget – Annual Averages – 2016-2065**

| **INFLOWS (AFY)** | | **OUTFLOWS (AFY)** | |
|---|---|---|---|
| *Streams/Rivers* | 58,633 | *Streams/Rivers* | 93,446 |
| *Deep Percolation* | 180,334 | *Pumping* | 199,549 |
| *Small Watersheds* | 6,458 | | |
| *Diversion Recharge* | 74,015 | | |
| *Subsidence* | 608 | | |
| *Subsurface* | 107,290 | *Subsurface* | 129,538 |
| ***Total IN*** | **427,338** | ***Total OUT*** | **422,532** |

## 7.6 Projected Water Budget with Climate Change Approach

The projected with climate change water budget was developed using much of the same data and assumptions as the projected simulation, but with considerations for climate change. The key differences between the projected and projected with climate change scenarios are described below:

- *Climate Data:* The precipitation and ET data from the historical simulation for the period of 1953 to 2003 were again used, but the data was adjusted based on outputs from a DWR study using climate models to predict future changes (DWR 2018). The DWR datasets provided precipitation and reference ET packaged as monthly change factor ratios to be used to perturb historical data to represent projected future conditions. The change factors are provided spatially and were applied to the historical data in the C2VSim-FG_v1.0 model.
    - DWR provided two future climate period conditions for use, including one scenario for 2030 and three scenarios for 2070 (wet conditions, central tendency, and extreme warming). The 2070 central tendency of the ensemble of general circulation models was used for this analysis. The 2070 scenarios were preferred for a long-term planning horizon, and the central tendency was selected as a reasonable projection. The other two scenarios for 2070 included wetter conditions and extreme warming. The central tendency scenario also included warmer, drier conditions, and changes in precipitation patterns, but to a less extreme degree than the extreme warming scenario.

The annual total inflows, outflows, and cumulative change in storage for the projected period are shown on **Figure 7-6**. **Table 7-6** contains the summary of the annual water budget averages from 2016 to 2065 with climate change. Detailed tables showing annual inflows and outflows are include in **Appendix M**. The composition of inflows and outflows is very similar to the projected period. However, the key difference is the average annual pumping increased to over 50 percent of the total outflows (up from 45%), and the deep percolation decreased to 40 percent (from 45%). The reasons for this shift in the water budget are attributed to increases in ET (due to warmer and drier temperatures) and shifting patterns in precipitation. *The resulting average surplus for the projected with climate change water budget is 1,000 AFY.*

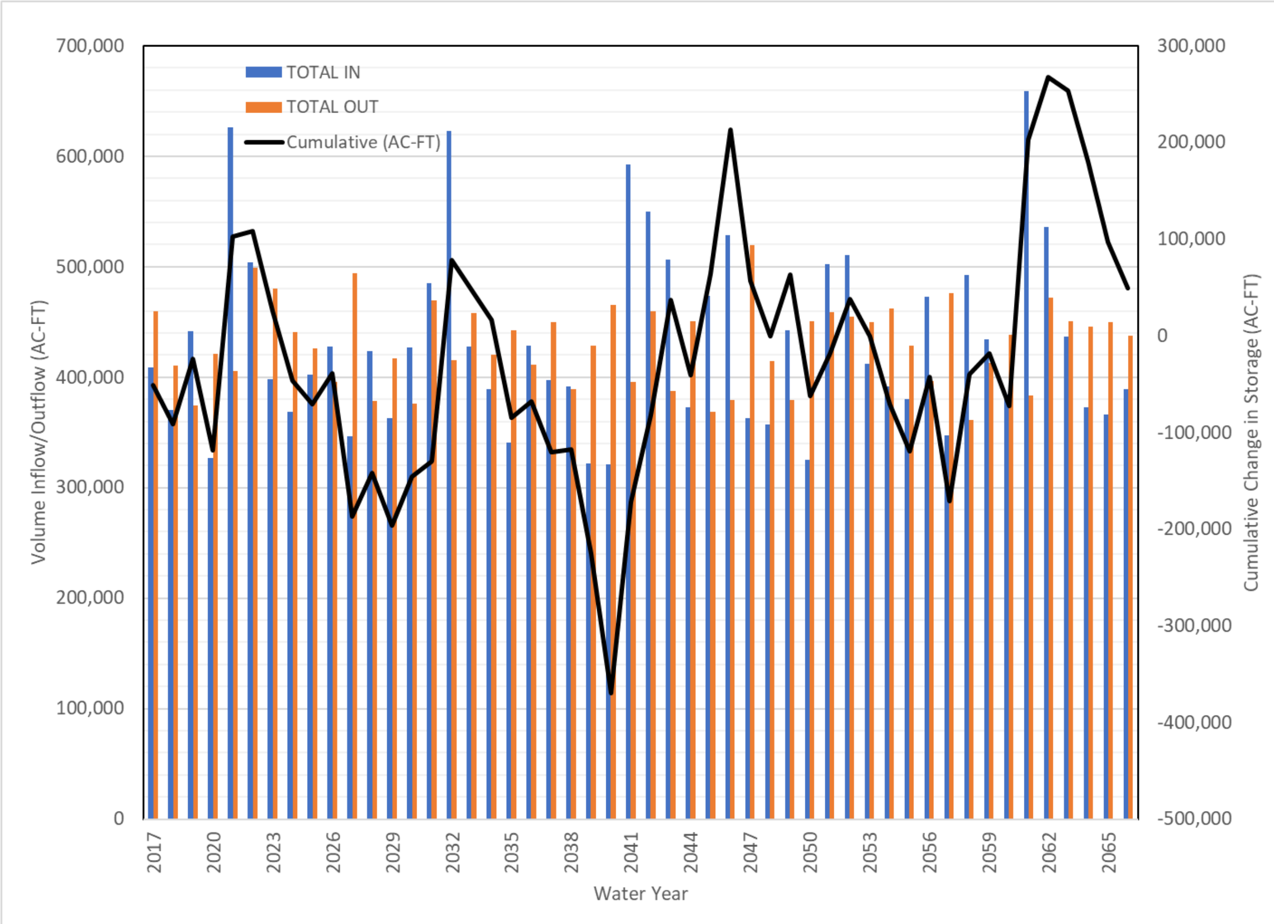



**Figure 7-6. Projected with Climate Change Tracy Subbasin Water Budget – 2016-2065**

**Table 7-6. Projected with Climate Change Tracy Subbasin Water Budget – Annual Averages – 2016-2065**

| **INFLOWS (AFY)** | | **OUTFLOWS (AFY)** | |
|---|---|---|---|
| *Streams/Rivers* | 65,375 | *Streams/Rivers* | 85,610 |
| *Deep Percolation* | 176,342 | *Pumping* | 221,393 |
| *Small Watersheds* | 6,458 | | |
| *Diversion Recharge* | 73,972 | | |
| *Subsidence* | 1,552 | | |
| *Subsurface* | 107,543 | *Subsurface* | 123,251 |
| ***Total IN*** | **431,242** | ***Total OUT*** | **430,254** |

### 7.6.1 *Water Budgets by Management Areas*

This section provides the projected with climate change conditions broken down by the Delta and Non-Delta Management Areas to specifically assess the conditions within the Non-Delta Management Area to understand if projects and management actions are needed to maintain the sustainability in this area where groundwater can be managed.

For the Non-Delta Management Area, the water budgets were also separated into the Upper unconfined aquifer (Layer 1), and Lower confined aquifer (Layer 2) to be able to further assess if either aquifer has a deficit, which may be being masked by a combined water budget. The Lower aquifer is below the Corcoran Clay layer.

#### 7.6.1.1 **Delta Management Area – Projected with Climate Change**

**Figure 7-7** shows the annual inflows and outflows, and the cumulative change in storage for the Delta Area for the projected with climate change scenario. Within the Delta Management Area for the projected with climate change scenario, there is an annual average groundwater surplus of around 1,700 AFY. The main contributor to inflow is deep percolation, and the primary source of outflow is pumping. Much of the pumping in the Delta is likely being simulated to represent the current operations employed in the Management Area to maintain groundwater levels bgs and the water is being returned to the adjacent waterways. The summary of the annual water budget averages from 2016 to 2065 are shown in **Table 7-7**.

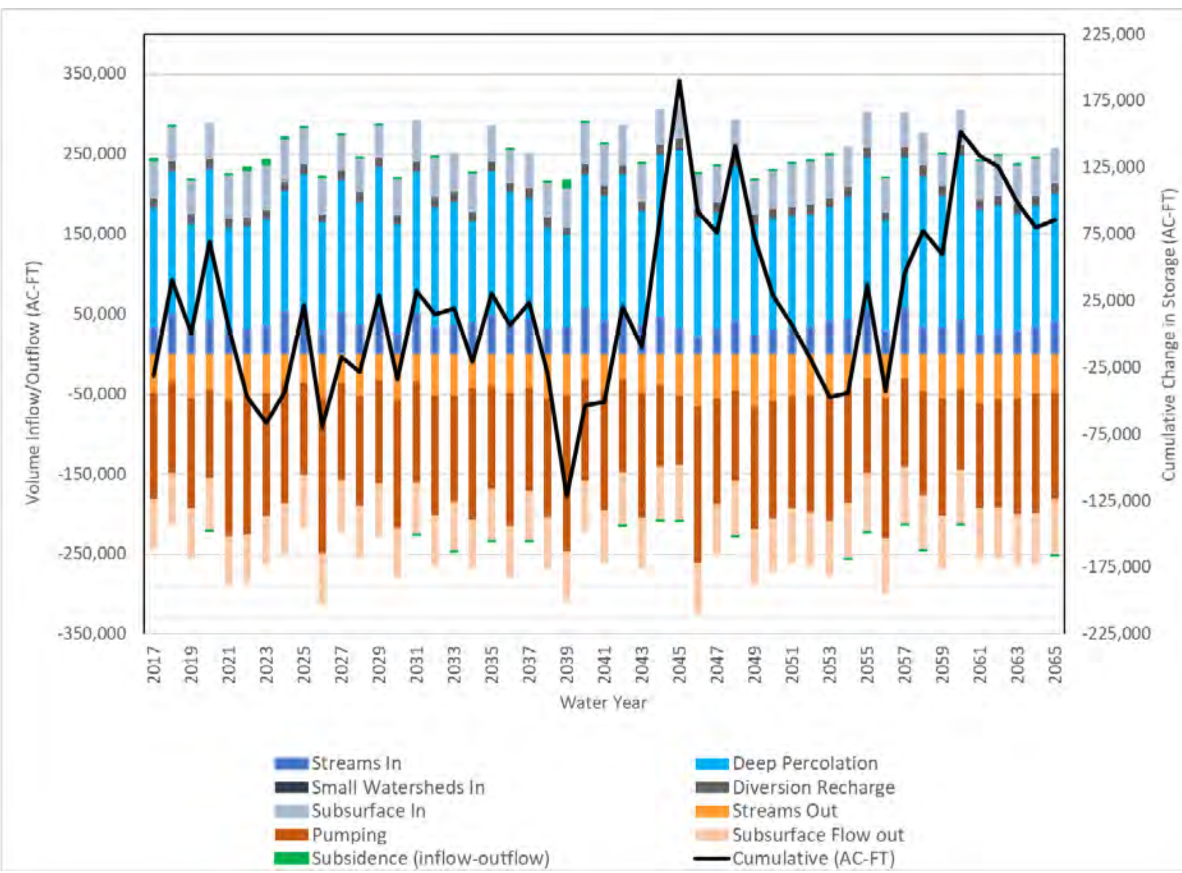



**Figure 7-7. Projected with Climate Change Delta Area Water Budget - 2016-2065**

**Table 7-7. Projected with Climate Change Delta Area Water Budget – Annual Averages – 2016-2065**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams/Rivers* | 38,710 | *Streams/Rivers* | 47,927 |
| *Deep Percolation* | 157,086 | *Pumping* | 140,806 |
| *Small Watersheds* | 60 | | |
| *Diversion Recharge* | 13,044 | | |
| *Subsidence* | 829 | | |
| *Subsurface* | 46,099 | *Subsurface* | 65,383 |
| ***Total IN*** | **255,828** | ***Total OUT*** | **254,116** |

### 7.6.1.2 Non-Delta Management Area – Projected with Climate Change

**Figure 7-8** shows the annual inflows and outflows, and the cumulative change in storage for the Non-Delta Area for the projected with climate change scenario. Within the Non-Delta Management Area for the projected with climate change scenario there is an annual average groundwater deficit of approximately 700 AFY. The primary sources for both inflow and outflow are subsurface flows to and from the neighboring areas. The summary of the annual water budget averages from 2016 to 2065 are shown in **Table 7-8**. To better understand the projected groundwater deficit, the unconfined (Upper) and the confined (Lower) aquifers were also analyzed.

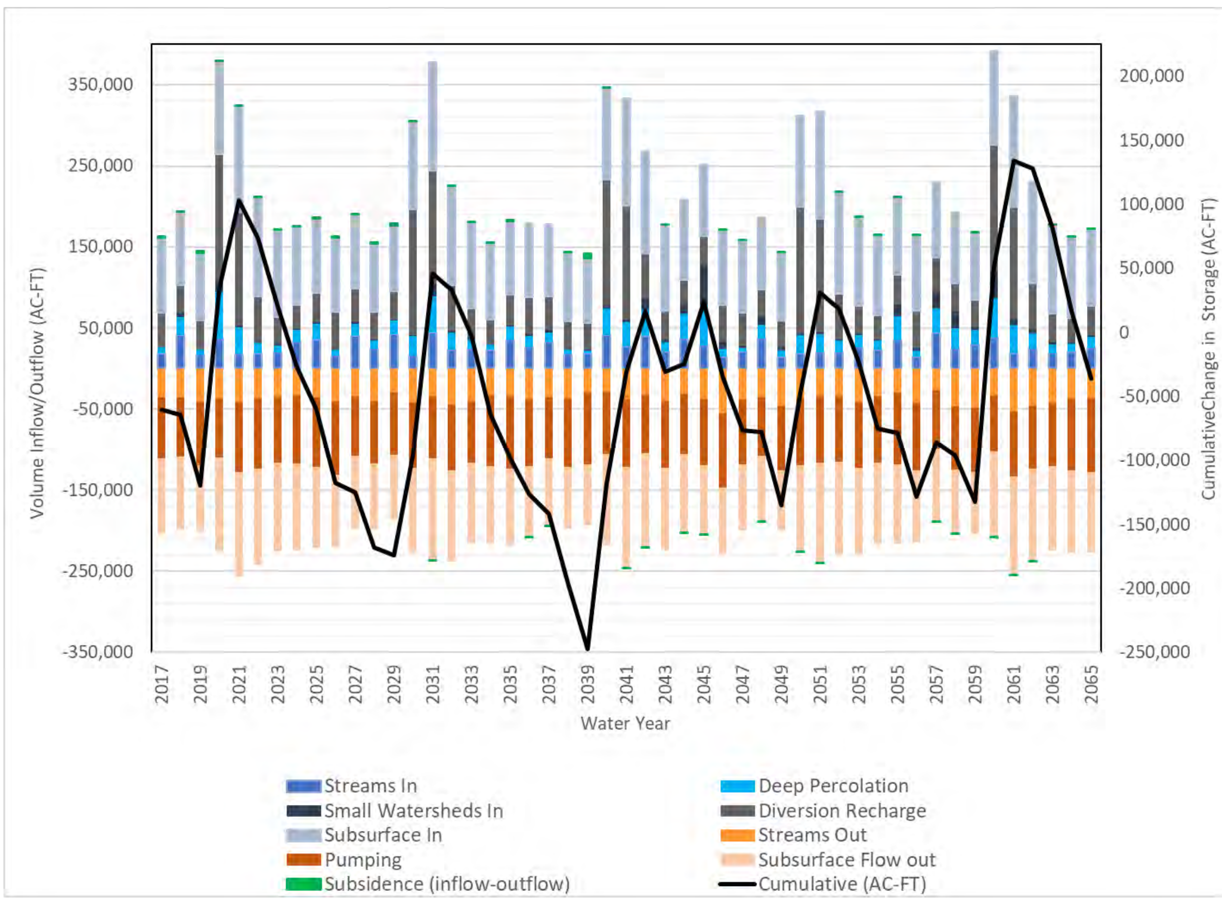



**Figure 7-8. Projected with Climate Change Non-Delta Area Water Budget – 2016-2065**

**Table 7-8. Projected with Climate Change Non-Delta Area Water Budget – Annual Averages – 2016-2065**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams* | 26,665 | *Streams* | 37,682 |
| *Deep Percolation* | 19,255 | *Pumping* | 80,586 |
| *Small Watersheds* | 6,398 | | |
| *Diversion Recharge* | 60,928 | | |
| *Subsidence* | 723 | | |
| *Subsurface* | 101,912 | *Subsurface* | 98,337 |
| ***Total IN*** | **215,881** | ***Total OUT*** | **216,605** |

**Figure 7-9** shows the annual average inflows and outflows for each layer within the Non-Delta Management Area. Layer one in the model represents the unconfined Upper aquifer and shows an annual deficit of 800 AFY, while layer two, the confined Lower aquifer, has a surplus of 100 AFY. The water budgets illustrate that the Upper aquifer (Layer 1) has connectivity with waterways and channels through inflows and outflows to streams, as well as the rootzone with deep percolation. The Lower aquifer (Layer 2) is disconnected from these processes as it is below the Corcoran Clay layer. It appears the modelers extended the Corcoran Clay or another low permeability layer beneath the Delta Management Area, from the previous known extent (*refer to* **Figure 4-7)**. Within both layers subsurface flows are the driving forces behind the inflows and outflows. Pumping is present in both layers but is a larger component in layer one. The summaries of the annual water budget averages from 2016 to 2065 for both layers are shown in **Tables 7-9** and **7-10**.

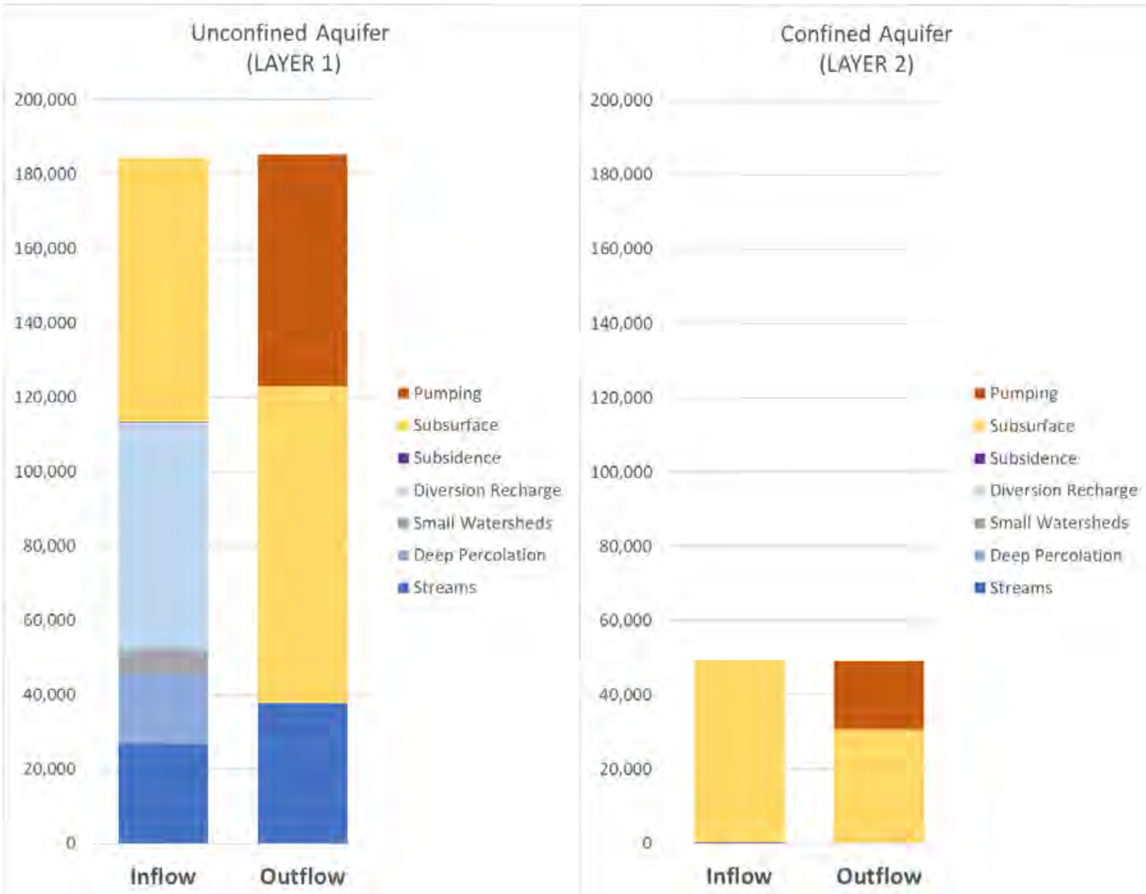



**Figure 7-9. Projected with Climate Change Non-Delta Area Water Budget- Annual Averages by Layer – 2016-2065**

**Table 7-9. Projected with Climate Change Non-Delta Area Water Budget Layer 1 – Annual Averages – 2016-2065**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams* | 26,665 | *Streams* | 37,682 |
| *Deep Percolation* | 19,255 | *Pumping* | 62,161 |
| *Small Watersheds* | 6,398 | | |
| *Diversion Recharge* | 60,927 | | |
| *Subsidence* | 76 | | |
| *Subsurface* | 71,054 | *Subsurface* | 85,381 |
| ***Total IN*** | **184,375** | ***Total OUT*** | **185,224** |

**Table 7-10. Projected with Climate Change Non-Delta Area Water Budget Layer 2 – Annual Averages – 2016-2065**

| INFLOWS (AFY) | | OUTFLOWS (AFY) | |
|---|---|---|---|
| *Streams* | | *Streams* | |
| *Deep Percolation* | | *Pumping* | 18,424 |
| *Small Watersheds* | | | |
| *Diversion Recharge* | | | |
| *Subsidence* | 226 | | |
| *Subsurface* | 49,066 | *Subsurface* | 30,731 |
| ***Total IN*** | **49,292** | ***Total OUT*** | **49,155** |

**Table 7-11** shows a comparison of inflows and outflows for the Non-Delta Management Area water budget results for historic (H1), projected (P1) and projected with climate change (P1+CC) to assess changes. The percent difference from historic to projected with climate change is also shown to help assess where significant changes are occurring. It shows surface water depletion (a combination of increased inflow and decreased outflow) will increase, into and from the Upper aquifer. It also shows that subsurface inflow is expected to increase by about 5,000 AFY. Adjacent subbasins are not expected to be impacted as the subsurface outflow is expected to increase by about 18,000 AFY.

**Table 7-11. Non-Delta Management Area Scenario Comparisons**

| Non-Delta Management Area Groundwater Inflow/Outflows (AFY) | | | | |
|---|---|---|---|---|
| | **H1** | **P1** | **P1+CC** | **H1 - P1+CC % Change** |
| ***Inflow*** | ***187,327*** | ***216,108*** | ***215,881*** | ***15%*** |
| *Streams* | 16,435 | 24,668 | 26,665 | 62% |
| *Deep Percolation* | 19,486 | 20,608 | 19,255 | -1% |
| *Small Watersheds* | 6,352 | 6,398 | 6,398 | 1% |
| *Diversion Recharge* | 47,821 | 60,875 | 60,928 | 27% |
| *Subsidence* | 971 | 315 | 723 | -26% |
| *Subsurface* | 96,261 | 103,245 | 101,912 | 6% |
| ***Outflow*** | **189,730** | **215,107** | **216,605** | **14%** |
| *Streams* | 50,048 | 40,737 | 37,682 | -25% |
| *Pumping* | 69,618 | 75,832 | 80,586 | 16% |
| *Subsurface* | 70,064 | 98,537 | 98,337 | 40% |
| ***Total*** | ***-2,403*** | ***1,001*** | ***-724*** | ***-70%*** |

## 7.7 Sustainable Yield

SGMA of 2014 defined sustainable yield as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." An undesirable result means one or more of the following effects caused by groundwater conditions occurred throughout the basin: chronic lowering of groundwater levels, depletion of interconnected surface water, significant and unreasonable loss of storage, subsidence, saltwater intrusion, and degradation of water quality. None of these undesirable results have been observed in the Subbasin in the recent past.

A base period was selected to estimate the sustainable yield that have the following conditions:

- As recent time period as possible to reflect current conditions.
- Precipitation is close to the long-term average.
- Prior to the start and end of the base period the cumulative departure from normal has a similar slope such that water in transit in the vadose zone is approximately equal and the period contains at least one wet period and dry period.

These conditions were met, based on **Figure 7-2**, and a base period of 2003 to 2013 was selected. This base period was also selected by the Northern Delta-Mendota GSP as their representative base-period. Other adjacent subbasins selected other base periods due to local climatic conditions.

The average quantity of groundwater extracted during the base period was 178,000 AFY for the entire Subbasin. The average quantity of groundwater extracted during the base period for just the Non-Delta Management Area was 62,100 AFY. During this period undesirable results, as currently defined, were not observed by the GSAs. Groundwater levels provided in **Appendices G and H** show stable or upward trends in groundwater levels during this period of time.

The sustainable yield can be increased if conjunctive use projects are implemented to increase recharge to the Subbasin. The annual reports and 5-year update will document any conjunctive use changes or revisions to this GSP.

## 7.8 Opportunities for Improvement

As discussed in earlier sections, DWR's C2VSim-FG_v1.0 was used to develop the water budgets described in this chapter. The goal with using this particular tool was to rely on the efforts and expertise of DWR (best available science) to model the Subbasin to provide a conceptual understanding of current conditions in the subbasin and potential future conditions. There is a general acknowledgement by stakeholders in the subbasin that there are minimal concerns for groundwater overdraft, and that this initial round of the GSP process can serve to improve understanding and knowledge and to potentially vet and improve existing tools. C2VSim-FG performs reasonably well in the Subbasin in terms of the agreement of the simulated water budget components as compared to historical data, and the simulated groundwater levels provide a reasonable approximation of observed groundwater levels.

Through the process of post-processing the historical model run and preparing data and input files for the projected simulations, there were items in the model and associated data that were noted within the Subbasin as areas of uncertainty and identified as potential future improvements. These items are described briefly below and discussed in greater detail in **Appendix M**. Future GSP updates will refine some of these uncertainties and improve the modeling representation of the Subbasin. However, overall, the C2VSim-FG_v1.0 is a reliable and defensible tool to support planning future groundwater conditions and estimating the potential hydrological impacts of future climate conditions and management actions at the subbasin level. It is currently the best available quantitative tool for assessing projected future groundwater conditions under SGMA. This model and water budget needs to be further proofed at a subbasin level.

**Opportunities for Future Improvements**:

- Historical Diversion Data: The C2VSim model includes diversion files with specifications for locations, quantities, timing, and distribution of surface water deliveries. Examining the diversion data for the Subbasin area specifically highlighted questions related to the representation of the actual diversion points, delivery locations, and quantities of water delivered. This will be explored in future GSP updates.
- Historical Agricultural Demands: Agricultural demands in the Subbasin were based on land-use surveys and climate data. Review of agricultural demands in some areas of the Subbasin and comparing with relevant planning documents revealed there may be a need to refine the data used for estimating demands to better match the agricultural demands.
- Historical Urban Land Use: The areas designated as urban developments in the historical model are held constant for the entire simulation period (1974-2015). The urban demands do increase over time due to population growth and the related water use per capita, but the land-use does not change. Since 1974, there has been increased urbanization in the areas surrounding Tracy and Lathrop where areas previously utilized for agriculture have been developed. This land-use trend and associated impacts to water management should be considered for future refinements to the model.
- Historical Pumping and Groundwater Elevations: There are areas in the Subbasin that the C2VSim-FG_v1.0 is simulating pumping where it is known that little or no pumping is occurring, (i.e., south of Highway 580 where aerial photographs show no agricultural development) and is also pumping water in excess of the simulated demands. Due to a combination of the increased demands and various simulated aquifer parameters, the model results show excessive drawdown (pumping depressions) and groundwater extraction far more than known agricultural demands for groundwater. Further examination of the model files and physical land use conditions should be considered in future refinements of the model.
- Model Elements: Realign the elements to conform with the Subbasin boundaries and to the extent possible aligning the nodes by GSA areas.
- Groundwater Pumping: Groundwater pumping for the entire Subbasin, as shown in Appendix M, ranges from 150,000 to 220,000 AFY, while the Basin Prioritization files indicate the groundwater pumping to be 12,000 AFY. Check of the urban pumping generally agrees with the Basin Prioritization volumes. The higher pumping may be resolved during the Historical Agricultural Demands improvements.

# 8. Monitoring Networks

The Tracy Subbasin groundwater-level monitoring program has evolved over the years to include only wells that with adequate construction details, including wells in the CASGEM program and monitoring wells constructed by the City of Tracy and local agencies. The groundwater level monitoring network is supplemented with monitoring wells constructed by various parties as part of compliance regulatory programs overseen by the State Board. Groundwater levels in these wells are monitored by various agencies including each of the GSAs, DWR, USGS, County and other parties. Separately, groundwater quality is monitored (PWS agencies) as part of compliance with drinking water standards and the ILRP.

For purposes of monitoring SGMA sustainability indicators as defined in this GSP, representative monitoring wells were selected from this broader network to assess groundwater levels and groundwater quality. The representative monitoring well network are those wells that will be used to track changes for each of the sustainability indicators in the Subbasin to assess short- and long-term trends for lowering of groundwater levels, reduction in storage, depletion of interconnected surface water, subsidence and water quality degradation. A monitoring network was not selected for sea water intrusion, as it is not likely to occur in the future (*refer to* **Chapter 5.7 – Seawater Intrusion** for further details).

Representative monitoring wells are only in the Non-Delta Management Area for each of the sustainability indicators where minimum thresholds and measurable objectives will be established (*see* **Chapter 9 – Sustainable Management Criteria**). Representative monitoring wells are not included in the Delta Management Area for the reasons discussed in **Chapter 6 –Management Areas**. Representative monitoring wells are discussed for each of the sustainability indicators in the following sections along with evidence that the wells are reflective of conditions in the principal aquifers.

## 8.1 Objectives

The objectives of the monitoring well network, for the Non-Delta Management Area, are:

- Have monitoring wells distributed throughout the Subbasin and in the two principal aquifers to assess changing conditions that could affect beneficial users or uses and evaluate the effects of or need for projects and management actions.
- Monitoring protocol with standard and repeatable methods to obtain accurate measurements.
- Provide physical measurements of the groundwater conditions to demonstrate if the Subbasin is being sustainably managed within the locally established minimum thresholds and measurable objectives.
- Provide measurements for future refinements of the groundwater models and water budgets.

## 8.2 Chronic Lowering of Groundwater Levels

The groundwater monitoring network for the Tracy Subbasin is organized to demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers. Well selection is based on having a sufficient number of wells in each principal aquifer to show groundwater flow directions. A summary of the groundwater conditions in each principal aquifer is provided along with areas of interest.

The principal aquifers and monitoring network are based on the USGS definition of the extent of the Corcoran Clay as shown on **Figure 4-7**.

Groundwater levels in the Upper aquifer show a consistent trend of groundwater levels higher near the foothills and shallower near the Old River (see **Figure 5-3**). The Upper aquifer is interconnected to surface water and locally supports potential GDEs (groundwater dependent ecosystems). Two areas are showing groundwater level declines in the Upper aquifer, one near the northwestern corner of the Subbasin (near well 04S01E31P005M as shown on **Figure 8-1**), within Alameda County and near GDEs, and a second area near the southeastern corner of the Subbasin (near well 03S06E28N001M) near an area where subsidence is occurring.

Groundwater levels in the Lower aquifer show a pumping depression has formed beneath the City of Tracy, which is creating radial flow towards this location. In the early 2000s, this depression also included areas beneath the central portions of the City of Tracy. Since the mid-2000s groundwater levels in the central portions of the City have risen by over 20 feet (GEI, 2007). Because there is radial flow into the depression, some groundwater migrates into the area from the north, from the Delta area where, due to unknown extent of the Corcoran Clay, the rivers may also provide recharge to the Lower aquifer.

### 8.2.1 *Monitoring Network*

The groundwater level monitoring network has changed over the years with mostly a reduction in the number of production wells and some movement towards dedicated monitoring wells. The initial groundwater level monitoring network for the Subbasin was developed by DWR in 1952 and generally consisted of monitoring existing agricultural water supply wells. In the 1960's San Joaquin County developed a monitoring network and has continued to monitor most of these wells since that time. In 2002, the City of Tracy constructed dedicated monitoring wells to monitor groundwater levels in the Lower aquifer, below the Corcoran Clay. In 2012, with the advent of CASGEM the monitoring network was reviewed and only those wells with known construction details or at least total depth were identified for each of the principal aquifers with the attempt to keep wells with long-term groundwater levels. DWR, is currently reviewing and revising their monitoring network. The wells have been used for decades to illustrate groundwater flow directions, change in storage, and their relationship to surface water. As has been the practice in the Subbasin, additional monitoring wells were selected from groundwater quality monitoring programs overseen by the Regional Water Quality Control Board and other agencies to supplement the CASGEM monitoring network.

The current groundwater level monitoring network for the Subbasin, which only includes wells with known construction details and/or at least the total depth of the well, consists of a total of 41wells at 22 locations. There are 18 monitoring wells in the Upper aquifer and 23 wells in the Lower aquifer in the non-Delta area which covers an area of about 186 square miles. Groundwater level measurements from these wells can be used for multiple purposes including to show groundwater occurrence, flow directions, and horizontal and vertical gradients. Establishing groundwater levels in these wells can be used to be protective of sensitive beneficial uses and users including surface water depletion, GDEs, and domestic wells. The locations of these monitoring wells are shown on **Figures 8-1 and 8-2**, but it should be noted that many of the monitoring wells are at the same location (nested or clustered), therefore the figures show fewer wells than the total actually present.

**Table 8-1** provides a summary of the groundwater level monitoring well types, distribution, and protection of beneficial users in the Subbasin. **Table 8-2** provides a table with the monitoring well attributes, their purpose, and other pertinent details. The monitoring wells are sufficient to monitor and demonstrate groundwater occurrence and flow directions, both horizontal and vertical gradients (seven sets nested and clustered wells), and water table levels near surface water.

**Table 8-1. Monitoring Well Types and Distribution**

| Monitoring Wells | Non-Delta Area |
|---|---|
| Total Upper Aquifer Monitoring Wells | 22 |
| Observation/Monitoring Wells [1] | 11 |
| Voluntary Wells | 11 |
| Total Lower Aquifer Monitoring Wells | 26 |
| Observation/Monitoring Wells [1] | 23 |
| Voluntary Wells | 3 |
| Total Wells without Construction Details or Depths | 0 |
| Vertical Gradient Nested or Clustered Well Loctions | 7 |

Notes: [1] Dedicated monitoring wells owned by GSA or other agencies under regulatory programs

## Table 8-2. Groundwater Level Monitoring Well Network

| CASGEM ID | Local Name | Latitude | Longitude | Reference Point Elevation (ft) | Screened Interval (ft bgs) | Total Depth (ft bgs) | Period of Record | Well Type | Current Monitoring Frequency |
|---|---|---|---|---|---|---|---|---|---|
| **Upper Aquifer Wells** | | | | | | | | | |
| 377341N1213039W001 | Well N | 37.7341 | -121.3039 | 23.36 | Unknown | 40 | 1960-2019 | R | Semi-Ann |
| 377061N1214199W001 | Well Q | 37.7061 | -121.4199 | 121.41 | 120-140 | 140 | 1972-2020 | R | Semi-Ann |
| 377951N1216011W001 | 02S03E01D001M | 37.79512 | -121.60111 | 90 | 40-80 | 80 | 2014-2020 | I | Semi-Ann |
| 377813N1214420W001 | 02S05E08B001M | 37.7813 | -121.442 | 4.3 | 50-80 | 80 | 1960-2019 | R | Semi-Ann |
| 377976N1214560W001 | 01S05E31R002M | 37.7976 | -121.456 | 4.6 | Unknown | 92 | 1960-2019 | R | Semi-Ann |
| 376388N1213233W001 | 03S06E28N001M | 37.6388 | -121.3233 | 148.24 | 107-128 | 128 | 2012-2020 | O | Semi-Ann |
| 377528N1215156W001 | 02S04E15R001M | 37.7528 | -121.5156 | 63.41 | 0.1-45 | 45 | 2011-2019 | U | Semi-Ann |
| 378103N1215449W001 | ORL-1W | 37.81031 | -121.54489 | 16.6 | 86-106 | 106 | 2005-2018 | O | None |
| 377979N1215800W001 | 01S04E31P005M | 37.79791 | -121.58003 | 60 | 8-23 | 24 | 2014-2020 | O | Semi-Ann |
| 376713N1214580W001 | Corral MW-5 | 37.67134 | -121.45799 | 297.89 | 71-81 | 87 | 2015-2019 | O | Active |
| 376700N1214547W001 | Corral MW-4 | 37.66997 | -121.45466 | 243.74 | 16.5-26.5 | 27 | 2015-2019 | O | Active |
| | Glori MW-2 | 37.68056 | -121.34394 | 77.83 | 20-35 | 35 | 2020-future | O | Quarterly/Cont. |
| | DV MW-16-BP | 37.74927 | -121.32764 | 18 | 60-85 | 85 | 1995-2020 | O | Quarterly |
| | MWM-24 | 37.81657 | -121.31459 | 16.88 | 10-20 | 21 | 2005-2020 | O | Quarterly |
| | MWR-25 | 37.78232 | -121.33303 | 16.25 | 11-21 | 22 | 2005-2020 | O | Quarterly |
| | PW11-031 | 37.81163 | -121.28417 | 20.42 | 23-28 | 31 | 1980-2019 | O | Quarterly |
| | PW16-216 | 37.81305 | -121.27582 | 23.26 | 208-213 | 216 | 1980-2019 | In | Quarterly |
| | SJCDW00034 | 37.6891 | -121.3607 | | Unknown | 180 | 2018-2020 | O | Annual |
| | SJCDW00032 | 37.766 | -121.5308 | | Unknown | 125 | 2018-2020 | O | Annual |
| | SAD MW-438D | 37.85253 | -121.27371 | 21.42 | 260-280 | 280 | Unknown | O | Semi-Ann |
| | SAD MW-401D | 37.82681 | -121.26346 | 24.46 | 230.25-240 | 240 | Unknown | O | Semi-Ann |
| | SAD MW-402D | 37.82872 | -121.26737 | 24.52 | 260-270 | 270.5 | 2004-2020 | O | Semi-Ann |
| **Lower Aquifer Wells** | | | | | | | | | |
| 376713N1214581W001 | Corral MW-6 | 37.67127 | -121.45809 | 303.33 | 455-475 | 477 | 2015-2018 | O | Quarterly |
| 376664N1214612W001 | Corral MW-7 | 37.66645 | -121.46123 | 304.97 | 310-330, 360-380, 410-430 | 430 | 2015-2019 | O | Quarterly |
| 377402N1214508W001 | MW-1A | 37.74019 | -121.45076 | 49.25 | 428-468 | 480 | 2012-2019 | O | Semi-Ann |
| 377402N1214508W003 | MW-1C | 37.74019 | -121.45076 | 51.2 | 748-788 | 800 | 2012-2019 | O | Semi-Ann |
| 377402N1214508W002 | MW-1B | 37.74019 | -121.45076 | 50.09 | 618-658 | 670 | 2012-2019 | O | Semi-Ann |
| 377143N1214459W001 | MW-2A | 37.71431 | -121.44591 | 92.58 | 426-466 | 480 | 2012-2019 | O | Semi-Ann |
| 377143N1214459W002 | MW-2B | 37.71431 | -121.44591 | 92.53 | 634-674 | 690 | 2012-2019 | O | Semi-Ann |
| 377143N1214459W003 | MW-2C | 37.71431 | -121.44591 | 92.53 | 770-810 | 820 | 2012-2019 | O | Semi-Ann |
| 377031N1214485W001 | MW-3A | 37.70306 | -121.44854 | 137.86 | 382-402 | 415 | 2012-2019 | O | Semi-Ann |
| 377031N1214485W002 | MW-3B | 37.70306 | -121.44854 | 138.08 | 540-580 | 595 | 2012-2019 | O | Semi-Ann |
| 377031N1214485W003 | MW-3C | 37.70306 | -121.44854 | 138.22 | 770-810 | 820 | 2012-2019 | O | Semi-Ann |
| 377149N1214257W001 | MW-4A | 37.71487 | -121.42567 | 104.08 | 450-490 | 505 | 2012-2019 | O | Semi-Ann |
| 377149N1214257W002 | MW-4B | 37.71487 | -121.42567 | 102.75 | 680-700 | 715 | 2012-2019 | O | Semi-Ann |
| 377149N1214257W003 | MW-4C | 37.71487 | -121.42567 | 103.11 | 770-810 | 820 | 2012-2019 | O | Semi-Ann |
| 377427N1213943W001 | MW-5A | 37.74266 | -121.39432 | 48.39 | 406-446 | 460 | 2012-2019 | O | Semi-Ann |
| 377427N1213943W002 | MW-5B | 37.74266 | -121.39432 | 47.82 | 576-616 | 640 | 2012-2019 | O | Semi-Ann |
| 377427N1213943W003 | MW-5C | 37.74266 | -121.39432 | 48.06 | 770-810 | 820 | 2012-2019 | O | Semi-Ann |
| 377656N1214199W001 | MW-6A | 37.76563 | -121.41992 | 26.52 | 410-450 | 465 | 2012-2019 | O | Semi-Ann |
| 377656N1214199W002 | MW-6B | 37.76563 | -121.41992 | 26.65 | 590-630 | 645 | 2012-2019 | O | Semi-Ann |
| 377656N1214199W003 | MW-6C | 37.76563 | -121.41992 | 26.8 | 755-795 | 810 | 2012-2019 | O | Semi-Ann |
| 376444N1213980W001 | 03S05E26M001M | 37.6444 | -121.398 | 234.09 | Unknown | 782 | 2012-2020 | I | Semi-Ann |
| 376974N1213258W001 | 03S06E05R001M | 37.6974 | -121.3258 | 59.69 | 252-275, 295-340, 395-436, 487-537, 589-597, 623-698, 724-749 | 775 | 1959-2020 | U | Semi-Ann |
| 376470N1213162W001 | 03S06E28F003M | 37.647 | -121.3162 | 119.82 | 331-715, 726-745 | 745 | 1999-2020 | I | Semi-Ann |
| | PW12-315 | 37.81006 | -121.2779 | 21.62 | 307-312 | 315 | 2009-2019 | O | Quarterly |
| | PW16-329 | 37.81305 | -121.27582 | 23.25 | 321-326 | 329 | 2009-2019 | O | Quarterly |
| | PW20-500 | 37.8076 | -121.2997 | 15.82 | 300-500 | 497.5 | 2009-2019 | O | Quarterly |

Notes: I = Irrigation well; O = Observation/Monitoring well; U = Unknown; In = Industrial; R = Residential well

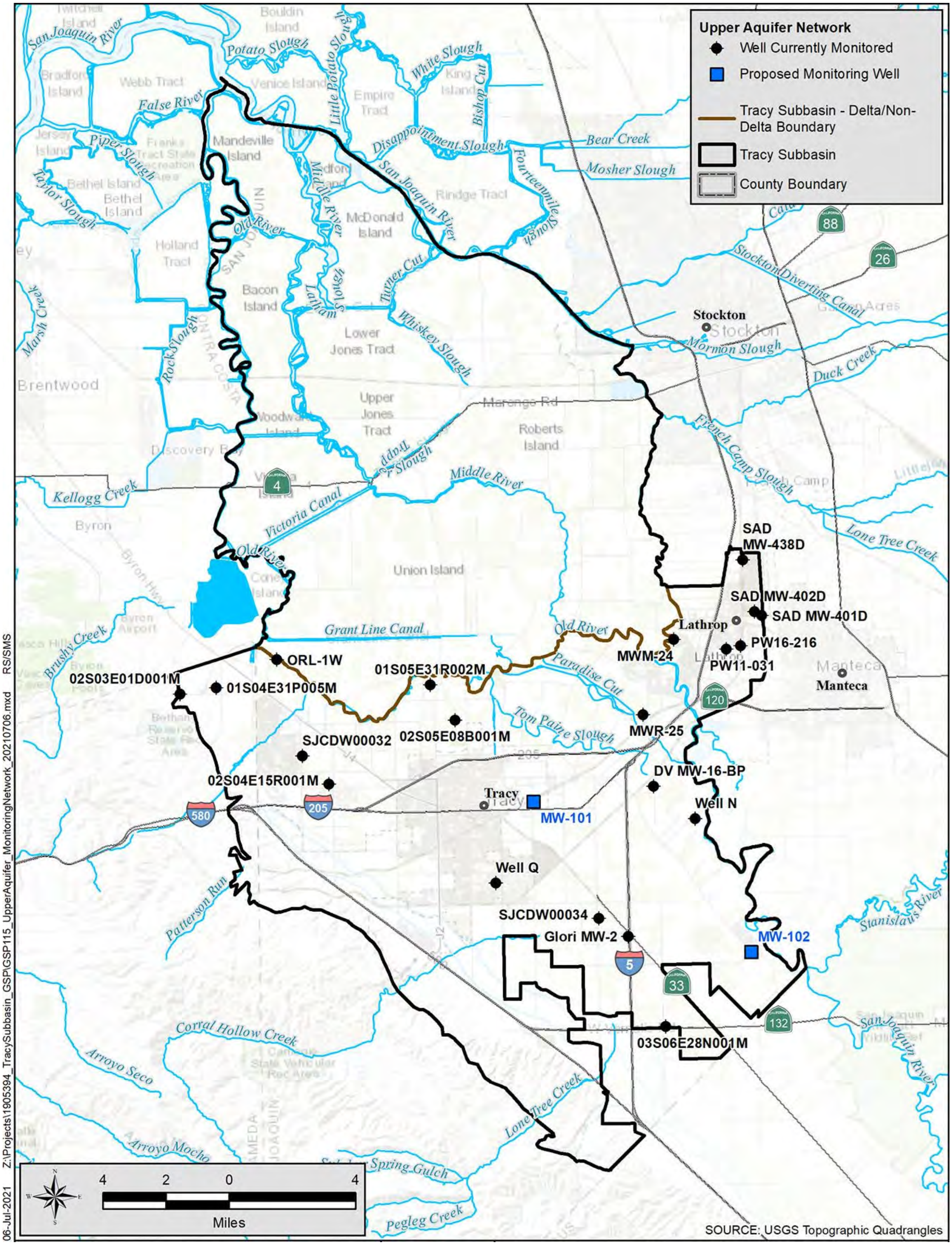



Figure 8-1. Upper Aquifer Groundwater Level Monitoring Wells

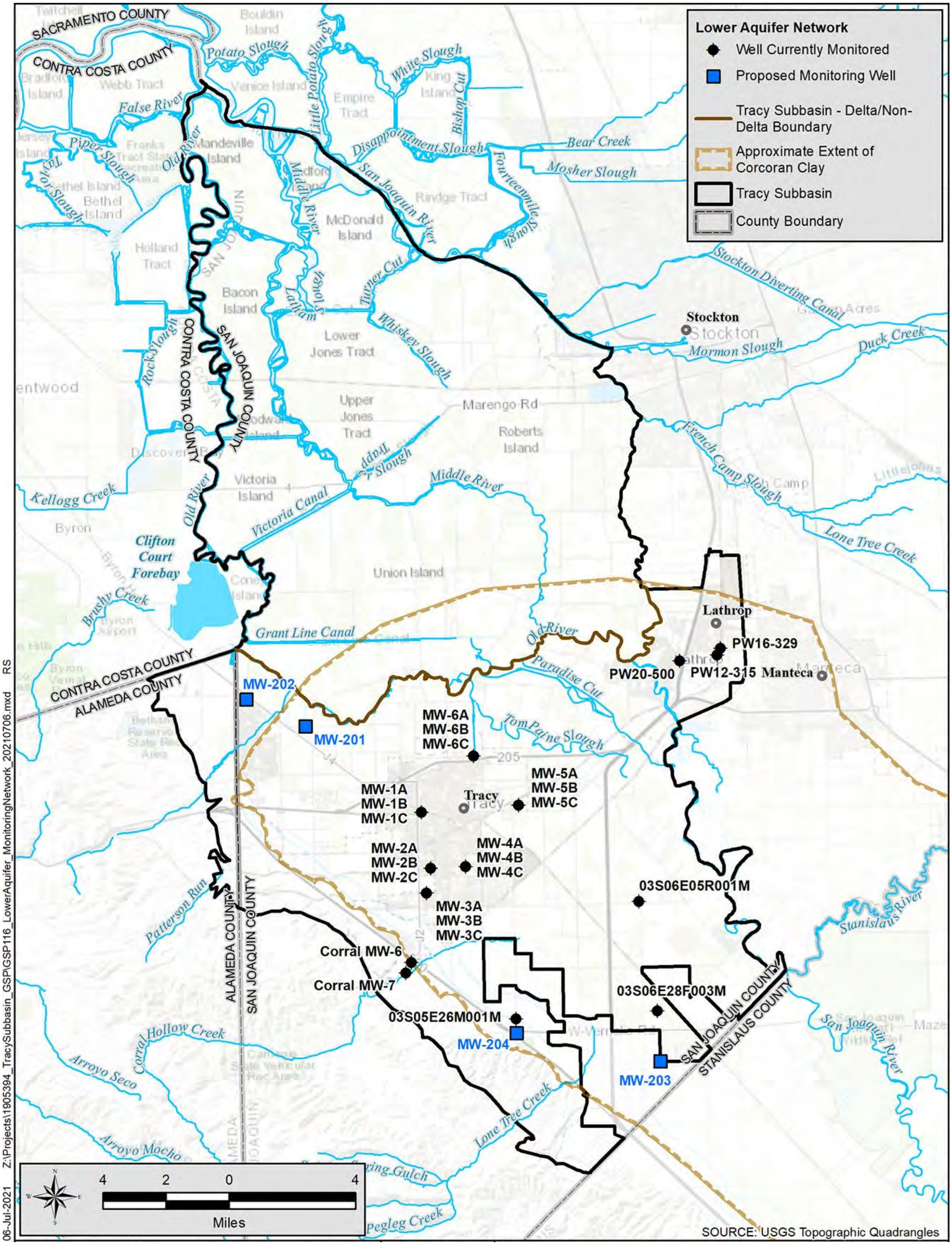



**Figure 8-2. Lower Aquifer Groundwater Level Monitoring Wells**

### 8.2.2 *Representative Monitoring Wells*

The entire monitoring well network as shown on **Figures 8-1 and 8-2** was evaluated and a subset of the monitoring sites were selected to be representative of the groundwater level conditions in the Non-Delta Management Area portions of the Subbasin. **Figures 8-3 through 8-9** illustrate the distribution of the representative groundwater level monitoring wells. Criteria considered for selecting the wells included the following:

- Wells having construction information or total well depth to confirm which principal aquifer the wells are monitoring
- Ability to monitor changes in groundwater levels in the two principal aquifers, in areas where potential undesirable results may occur
- Dedicated monitoring wells as opposed to voluntary wells which may be being used for water supply and affected by pumping

Groundwater level representative monitoring wells were selected to be protective of the sensitive beneficial users (domestic well owners, GDEs and wells in areas solely supplied by groundwater). Protection of these sensitive beneficial users would then be protective of agriculture and municipal well owners as their wells are typically deeper. Wells were also selected near Subbasin boundaries to track inflow and outflow from adjacent subbasins and in areas where groundwater levels are declining. A brief discussion of the criteria used for selection of the monitoring wells for each aquifer is provided below.

#### 8.2.2.1 **Upper Aquifer**

The criteria used to select groundwater level representative monitoring wells in the Upper aquifer was to select wells near sensitive beneficial users (domestic well owners, GDEs and wells in areas solely supplied by groundwater). Protection of these sensitive beneficial users would then be protective of agriculture and municipal well owners as their wells are typically deeper.

The representative groundwater level monitoring well network was selected to be protective of domestic well owners. **Figure 8-3** shows the density of the domestic wells in the Non-Delta Management Area portion of the Subbasin, locations of selected representative monitoring wells to be protective of these users and a radius of 2.5 miles around each monitoring well, which is equivalent to five wells per 100 square miles, to illustrate whether the Subbasin has an adequate monitoring network. **Figure 8-4** provides the minimum depths of these domestic wells (indicating all are in the Upper aquifer except near the foothills) along with the depths of the representative monitoring wells, illustrating the selected monitoring wells are at similar depths as the domestic well owners. **Figure 8-5** shows domestic well minimum depths in comparison to both agriculture and municipal well depths to illustrate that selection of representative monitoring well using domestic wells would be protective of municipal and agricultural wells. It should be noted that Corral MW-6, by which depth is in the Lower aquifer, and was selected because it has similar depths as the domestic wells in the area. It was selected to be a representative monitoring well for protection of domestic well owners and its location is shown on **Figure 8-7**.

GDEs are a sensitive beneficial user and their locations are shown on **Figure 8-6**, along with managed wetlands (that may or may not be GDEs). Since GDEs typically have shallow rooting depths (less than

30 feet), Upper aquifer representative monitoring wells were selected near the GDEs that monitor water table conditions (well depths less than 100 feet).

Some portions of the Tracy Subbasin rely solely on groundwater as their source of water (**Figure 8-7)**. Representative monitoring wells, in the Upper aquifer since the shallowest wells are the most susceptible, were confirmed to be present near these areas (similar wells as developed and shown on **Figure 8-3**).

The combination of the representative monitoring wells for the Upper aquifer for tracking of lowering of groundwater levels is shown on **Figure 8-8**. **Table 8-3** provides a list of representative monitoring wells for the Upper aquifer.

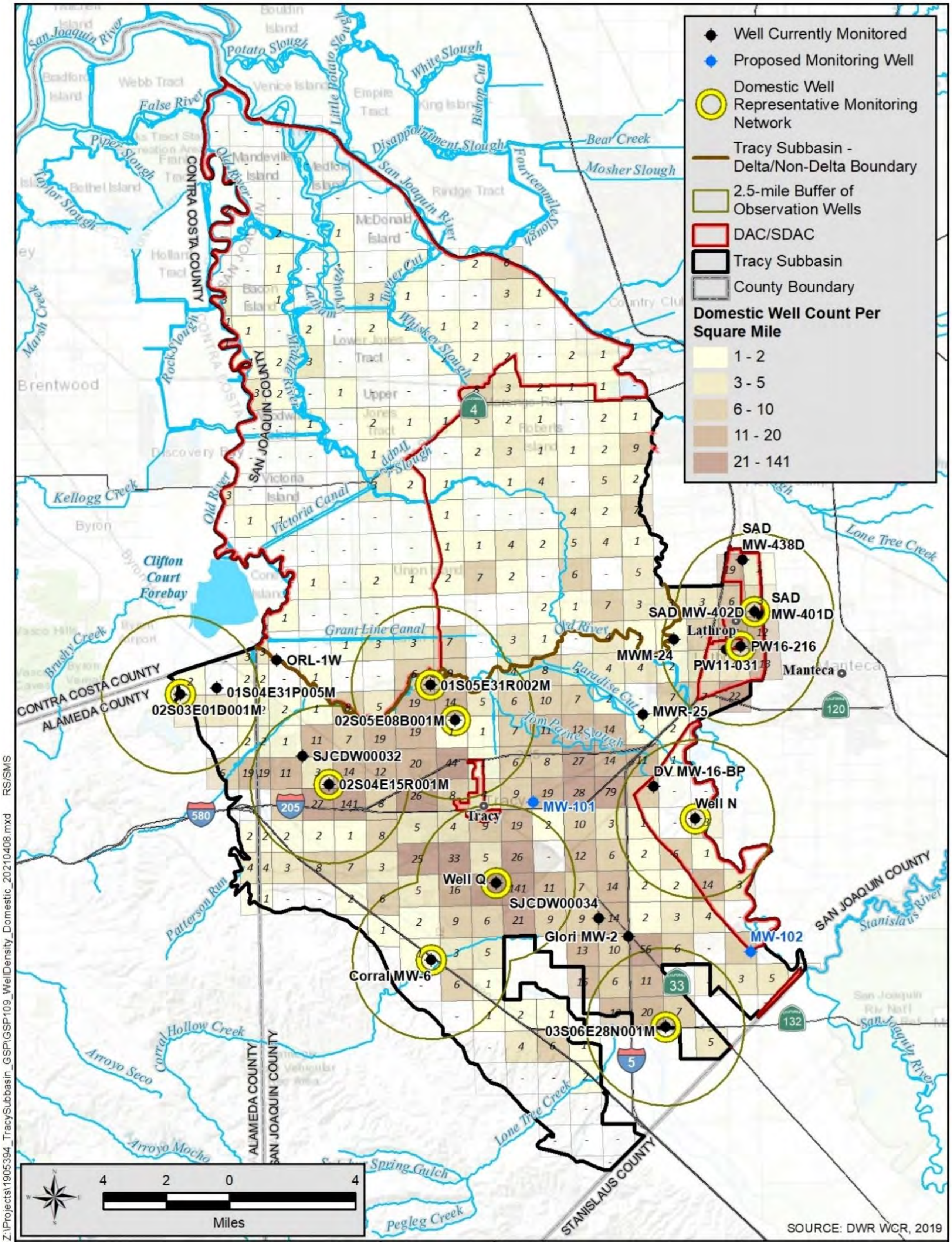


**Figure 8-3. Groundwater Level Representative Monitoring Wells for Domestic Wells**

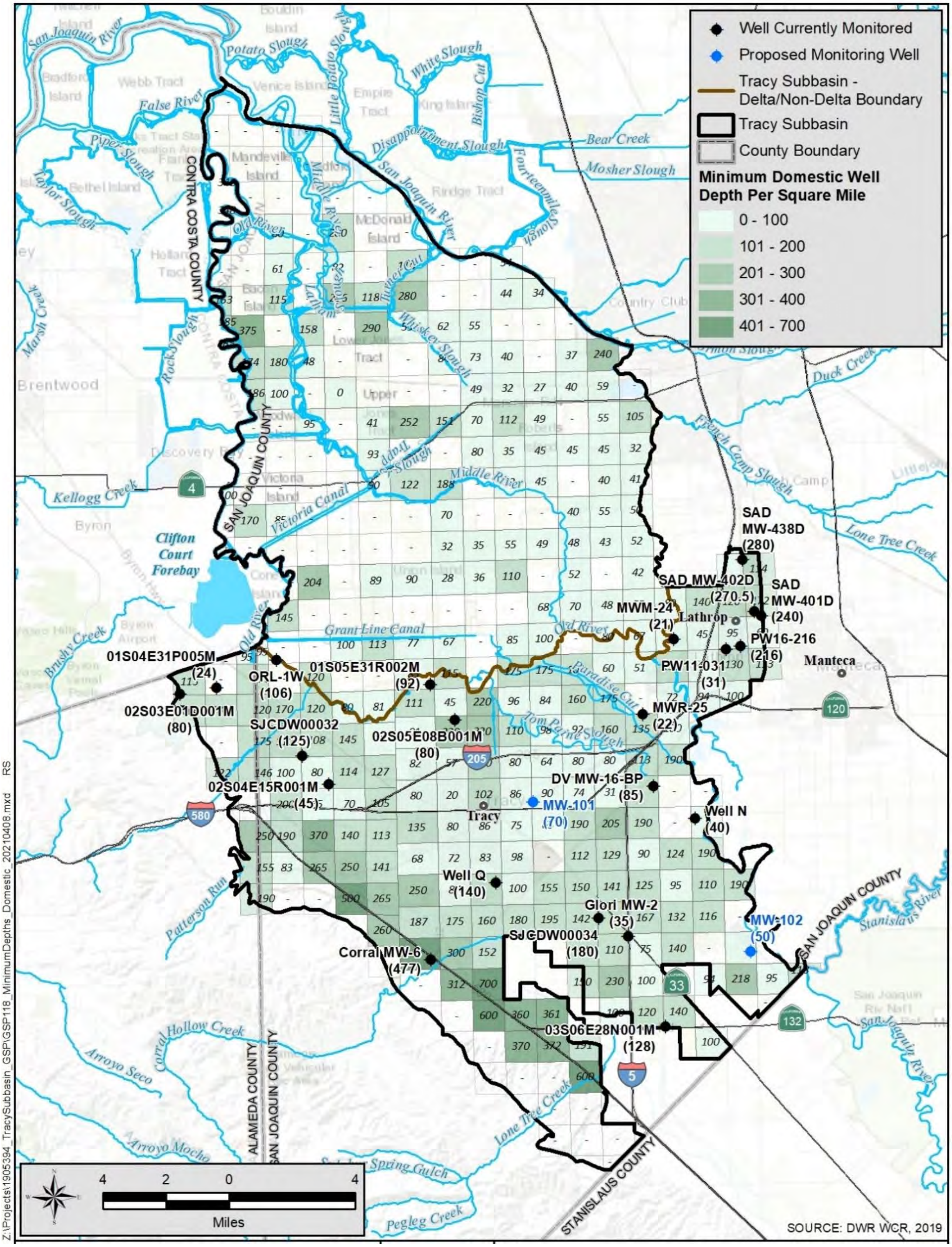


Figure 8-4. Groundwater Level Representative Monitoring Well Depths to Domestic Wells

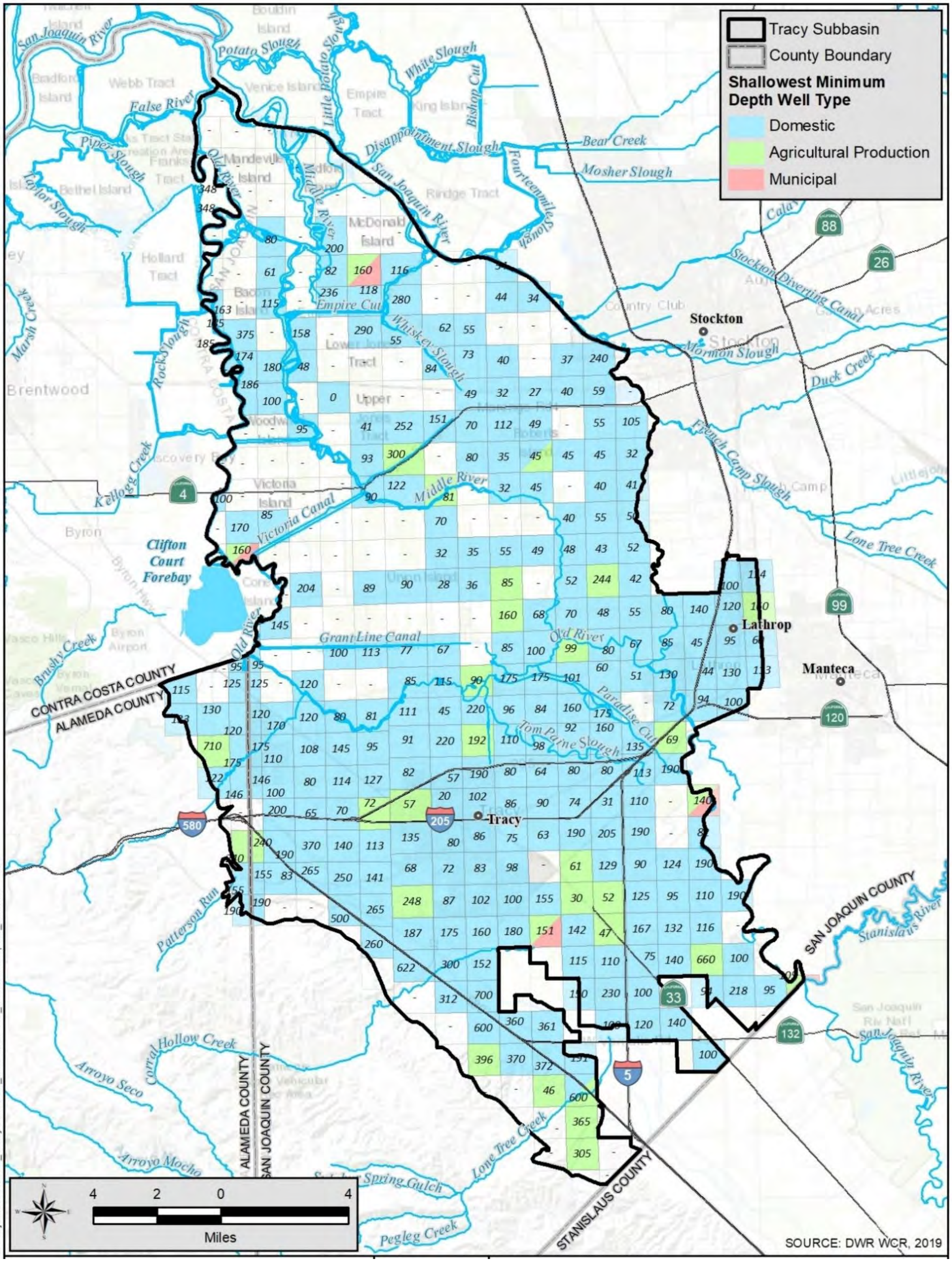



**Figure 8-5. Comparison of Domestic Minimum Depths to Agricultural and Municipal Wells**

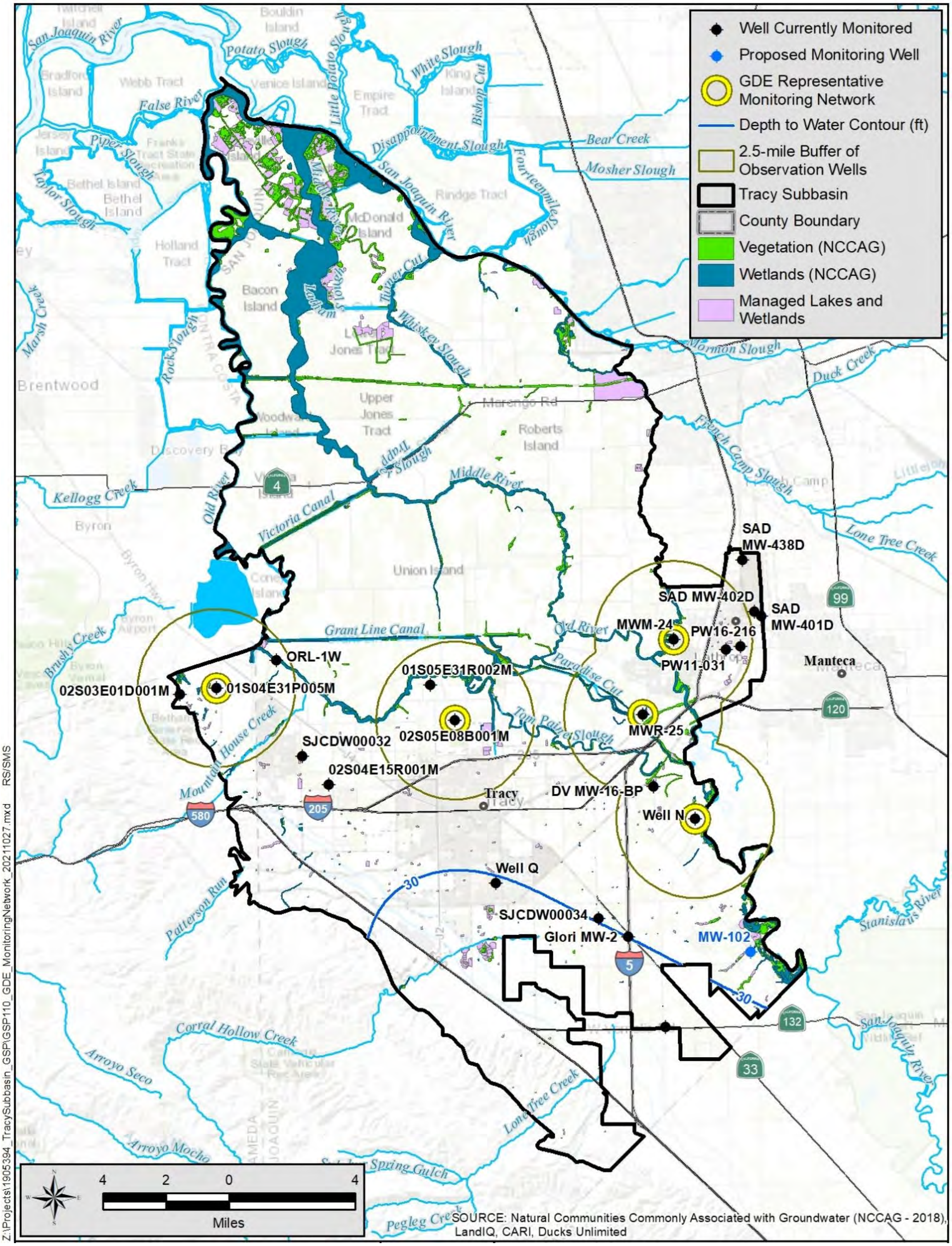



**Figure 8-6. Groundwater Level Representative Monitoring Well for Potential GDEs**

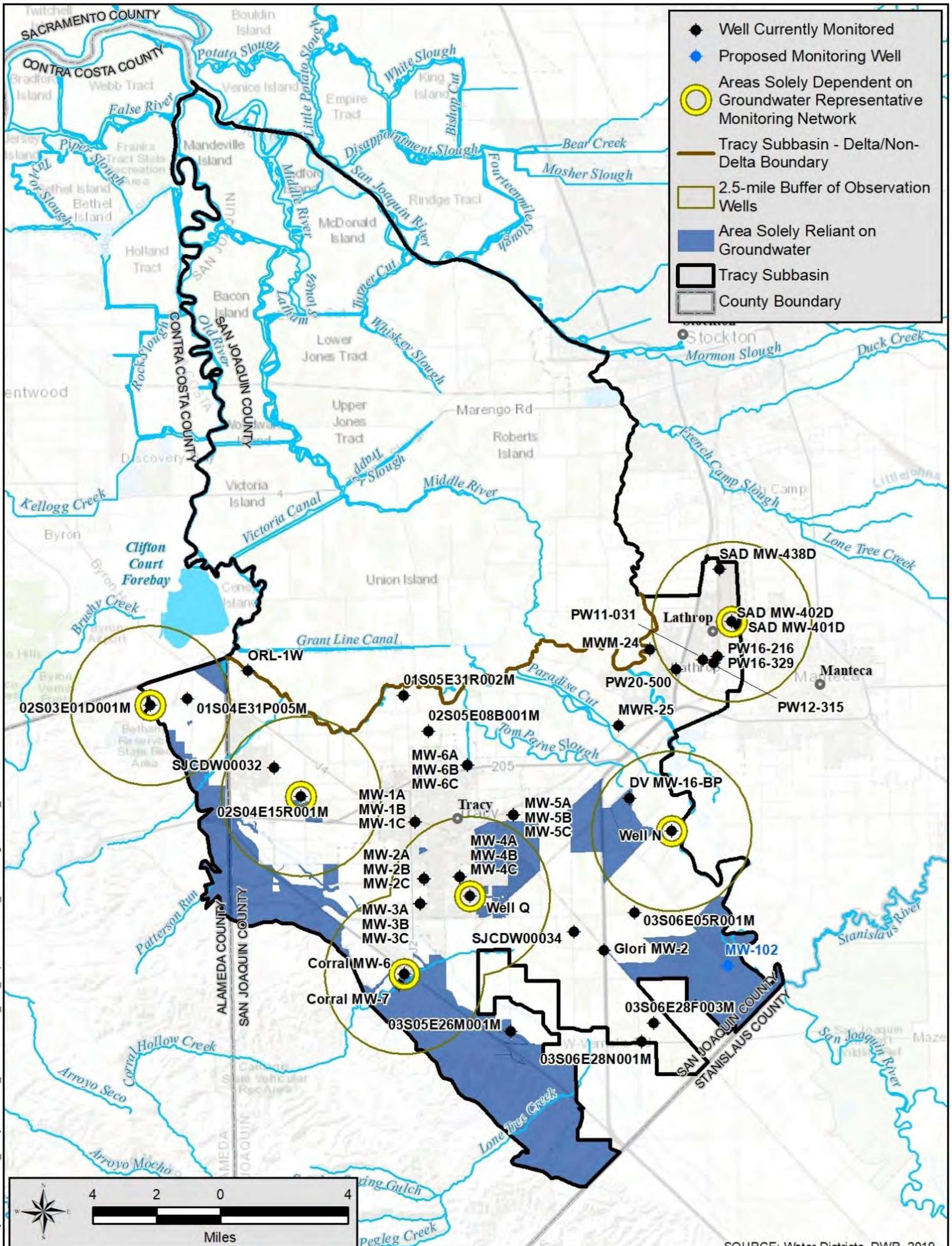



**Figure 8-7. Groundwater Level Representative Monitoring Wells for Areas Solely Reliant on Groundwater**

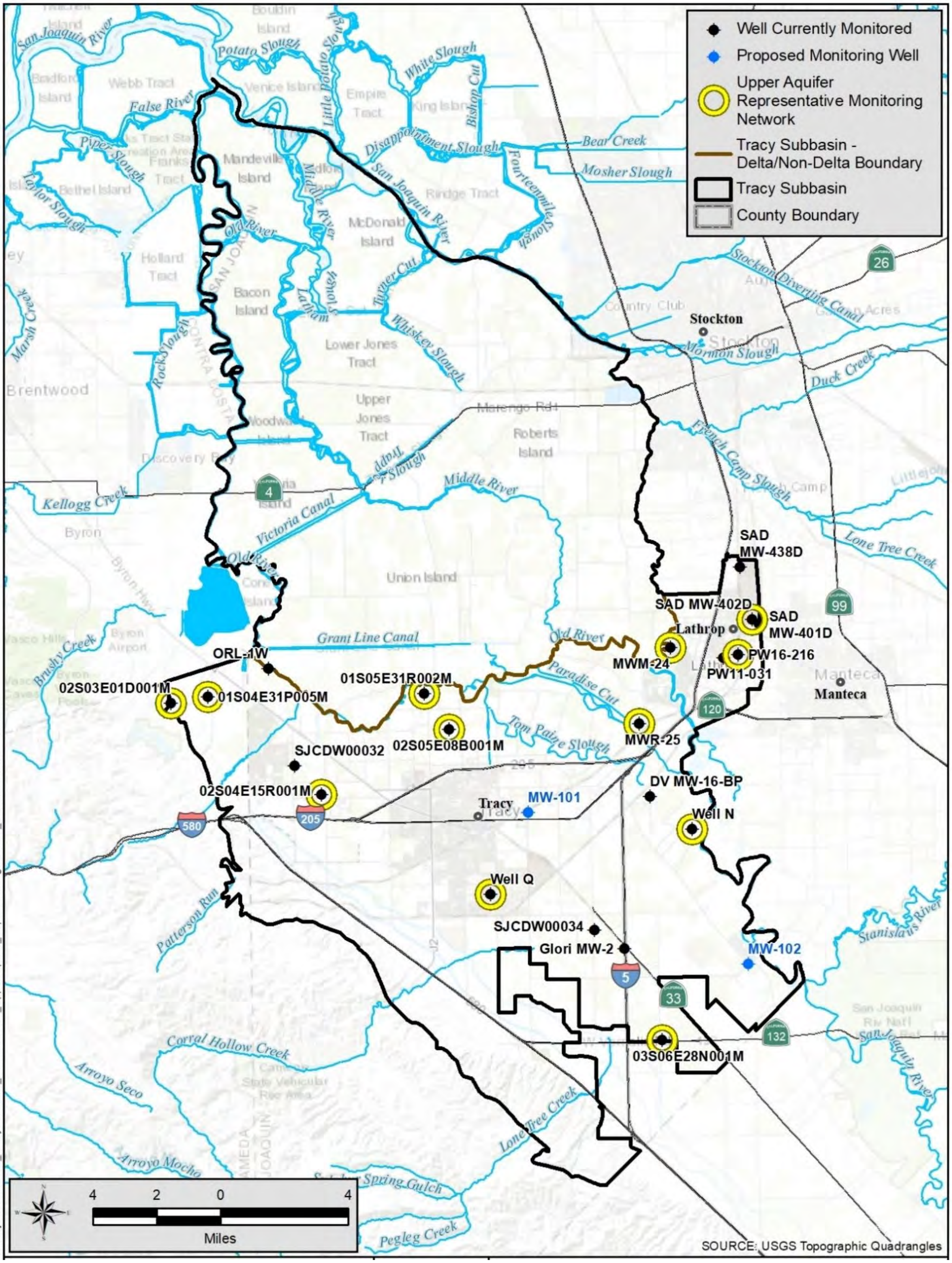



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**Figure 8-8. Upper Aquifer Groundwater Level Representative Monitoring Wells**

**Table 8-3. Representative Monitoring Wells for Chronic Lowering of Groundwater**

| Representative Wells for Chronic Lowering of Groundwater Levels | | | | | | Purpose for Monitoring | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CASGEM ID | Local Name | Latitude | Longitude | Screened Interval (ft bgs) | Total Depth (ft bgs) | Domestic Wells | GDE | Areas Soley Dependent On GW | Agricultural, Municipal, and Industral Wells | Frequency of Monitoring |
| **Upper Aquifer Wells** | | | | | | | | | | |
| 377341N1213039W001 | Well N | 37.7341 | -121.3039 | Unknown | 40 | X | X | X | X | Monthly |
| 377061N1214199W001 | Well Q | 37.7061 | -121.4199 | 120-140 | 140 | X | | X | X | Semi-Annual |
| 377951N1216011W001 | 02S03E01D001M | 37.79512 | -121.6011 | 40-80 | 80 | X | | X | X | Semi-Annual |
| 377813N1214420W001 | 02S05E08B001M | 37.7813 | -121.442 | 50-80 | 80 | X | X | | X | Monthly |
| 377976N1214560W001 | 01S05E31R002M | 37.7976 | -121.456 | Unknown | 92 | X | | | X | Semi-Annual |
| 376388N1213233W001 | 03S06E28N001M | 37.6388 | -121.3233 | 107-128 | 128 | X | | | X | Semi-Annual |
| 377528N1215156W001 | 02S04E15R001M | 37.7528 | -121.5156 | 0.1-45 | 45 | X | | X | X | Semi-Annual |
| 377979N1215800W001 | 01S04E31P005M | 37.79791 | -121.58 | 8-23 | 24 | | X | | X | Monthly |
| | MWM-24 | 37.81657 | -121.3146 | 10-20 | 21 | | X | | | Monthly |
| | MWR-25 | 37.78232 | -121.333 | 11-21 | 22 | | X | | | Monthly |
| | PW16-216 | 37.81305 | -121.2758 | 208-213 | 216 | X | | | X | Semi-Annual |
| | SAD MW-402D | 37.82872 | -121.2674 | 260-270 | 270.5 | X | | X | X | Semi-Annual |
| **Lower Aquifer Wells** | | | | | | | | | | |
| 376713N1214581W001 | Corral MW-6 | 37.67127 | -121.4581 | 455-475 | 477 | X | | X | X | Semi-Annual |
| 377402N1214508W002 | MW-1B | 37.74019 | -121.4508 | 618-658 | 670 | | | | X | Semi-Annual |
| 377031N1214485W002 | MW-3B | 37.70306 | -121.4485 | 540-580 | 595 | | | | X | Semi-Annual |
| 377427N1213943W002 | MW-5B | 37.74266 | -121.3943 | 576-616 | 640 | | | | X | Semi-Annual |
| 377656N1214199W002 | MW-6B | 37.76563 | -121.4199 | 590-630 | 645 | | | | X | Semi-Annual |
| | PW20-500 | 37.8076 | -121.2997 | 300-500 | 498 | | | | X | Quarterly |
| 376974N1213258W001 | 03S06E05R001M | 37.6974 | -121.3258 | 252-749 | 775 | | | | X | Semi-Annual |

#### 8.2.2.2 Lower Aquifer

Groundwater in the Lower aquifer does not support GDEs and typically are not used by domestic wells except near the foothills. Most of the use of the Lower aquifer is by agriculture, municipal users (City of Tracy), and some industrial users.

There are several clustered monitoring wells in the City of Tracy, below the Corcoran Clay, which monitor distinct intervals (distinguished by A, B, and C). The groundwater levels from the various depths in the monitoring wells are relatively similar (*see* **Appendix E**) and therefore only the “B” level at each well was included in the representative monitoring network. The Lower aquifer representative monitoring wells were selected to be able to show the groundwater occurrence, flow directions, recharge areas, and monitor pumping below the clay. **Figure 8-9** shows representative monitoring wells for the Lower aquifer. **Table 8-3** lists the representative monitoring wells.

Although voluntary irrigation wells, 03S05E26M001M and 03S06E28F003M (*refer to* **Table 8-3**) total well depths are below the Corcoran Clay and at least in one case appears to be screened just below the Corcoran Clay, groundwater levels are more similar to the Upper aquifer and suggest the wells may not be sealed through the Corcoran Clay. Well 03S06E28F003M does not have a sanitary seal and is gravel packed across the clay. These wells may not be representative of the Lower aquifer water levels. However, both wells are showing declining groundwater levels (*see* **Appendix E**). These wells have not been selected as part of the representative monitoring network at this time but in the future may be replaced with dedicated monitoring wells. Well 03S06E05R0001M well type is unknown but due to its highly variable groundwater levels suggest that it is being pumped and levels may not be representative of static conditions.

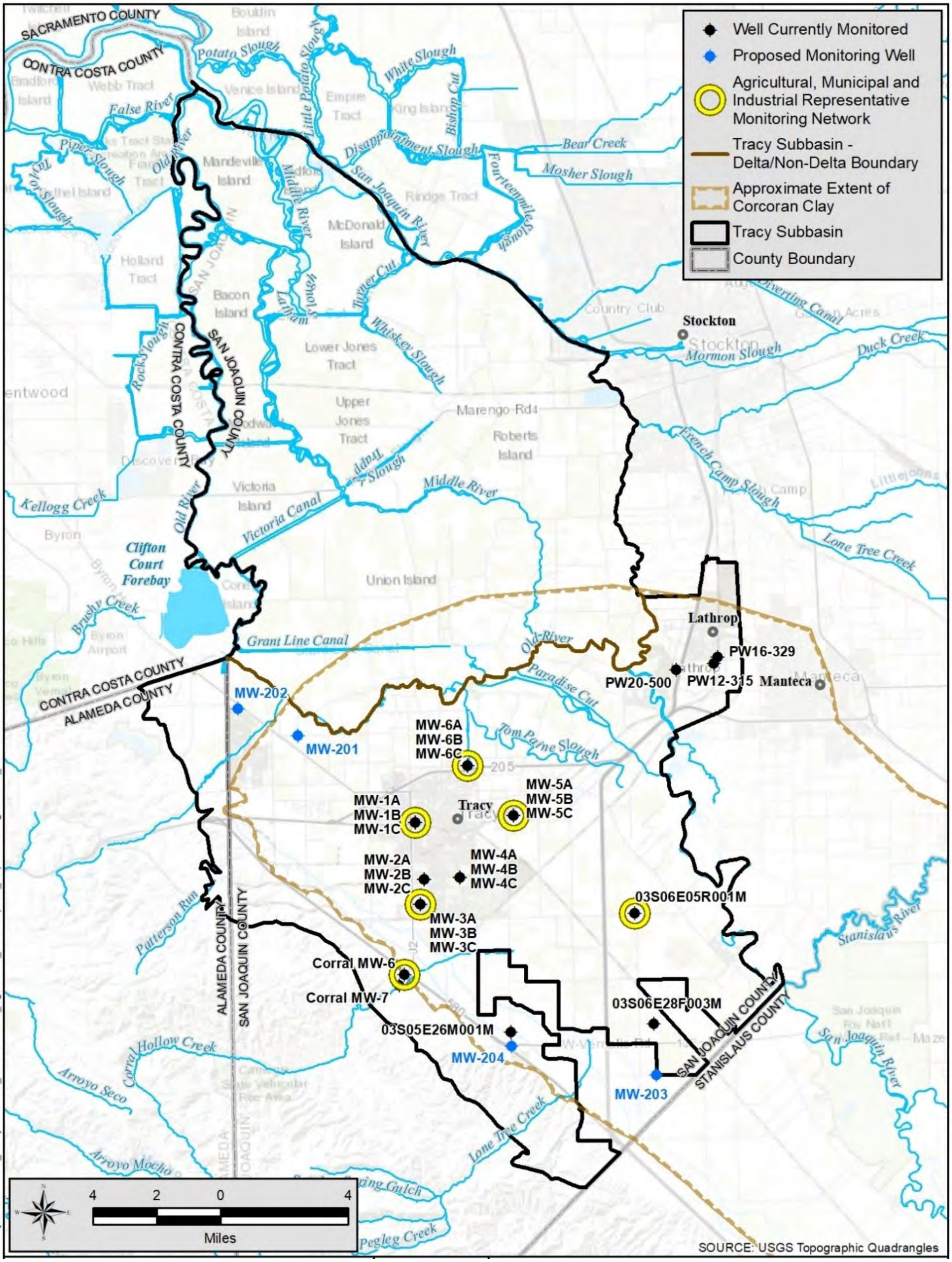


**Figure 8-9. Lower Aquifer Groundwater Level Representative Monitoring Wells**

### 8.2.3 *Groundwater Level Monitoring Frequency*

Frequency of groundwater level monitoring is cited in the Monitoring Networks and Identification of Data Gaps Best Management Practice (BMP) (DWR 2016a) which presents guidance on monitoring frequency based on the type of monitoring, aquifer type, confinement, recharge rate, hydraulic conductivity, and withdrawal rate. Historically, DWR has monitored groundwater levels on a semi-annual basis. Because groundwater levels are being used to assess sustainability indicators, more frequent monitoring at some locations is warranted. Sampling frequencies were developed based on this guidance in combination with a consideration of monitoring costs.

Based on the analysis of groundwater level monitoring data in the Subbasin, dating back several decades, the GSA's have determined that semi-annual groundwater level measurements are sufficient to identify groundwater level trends that may threaten the sustainability of the Subbasin's for most beneficial users. Monthly monitoring is proposed for wells that have been identified near GDEs. **Table 8-3** provides the monitoring schedule by representative well.

Semi-annual groundwater levels will be collected by the GSAs or DWR in the spring and fall. In the spring groundwater levels are typically higher than any other time of the year and groundwater pumping stresses are usually minimal. Therefore, measurements at individual wells may be more representative of regional conditions than at times when nearby wells are producing more water. Likewise, fall measurements are taken after the heaviest pumping has occurred for the dry season and before substantial recharge has occurred from precipitation. The fall measurement can be considered to be the regional minimum groundwater level for a given year, indirectly measuring the effects of annual groundwater use. The work will be completed during a 2-week window on either side of target dates (March 15 & October 15) to accommodate inclement weather and scheduling conflicts. This frequency of monitoring is more than sufficient to demonstrate seasonal, short-term (1-5 years), and long-term (5-10 years) trends in groundwater and related surface conditions and yield representative information about groundwater conditions.

Depending on the needs of the beneficial users of a well, the monitoring frequency maybe adjusted to better track the data. Wells monitoring in more sensitive areas, such as GDE's and surface water interaction areas, may require more frequent monitoring and would be equipped appropriately.

### 8.2.4 *Groundwater Level Monitoring Spatial Density*

The Tracy Subbasin extends over an area of about 373 square miles (238,429 acres) and supplies 11,797 acre-feet of groundwater annually for drinking water and irrigation (DWR, BP 2019). Most of the pumping occurs in the Non-Delta Management Area portion of the Subbasin, in an area of about 186 square miles.

A groundwater level well monitoring density goal ranges from 0.2 to 10 wells per 100 square miles (DWR 2016). The monitoring well density goals can also be based on the amount of groundwater use. For basins where groundwater pumping is between 1,000 and 10,000 AFY per 100 square miles, two wells per 100 square miles is recommended. Professional judgement will be essential to determining an adequate level of monitoring, frequency, and density based on the need to observe aquifer response near high pumping areas, cones of depression, significant recharge areas, and specific projects.

There are 13 representative monitoring wells for the Upper aquifer or a density of about seven wells per 100 square miles in just the Non-Delta Management Area. In the Lower aquifer, seven representative monitoring wells were selected, equating to a density of about three wells per 100 square miles. The density of the representative monitoring wells meets the density goal, but as illustrated on the previous figures, there are areas where additional wells are needed based on professional judgement.

### 8.2.5 *Data Gaps*

As illustrated on **Figures 8-3 through 8-7**, there are some areas where new monitoring wells are needed in both the Upper and Lower aquifers to protect beneficial uses and users and to be representative monitoring wells. New monitoring wells are proposed:

- In the Lower aquifer (MW-201 through -204) are needed to be protective of agricultural users and to resolve gradients (subsurface inflow and outflow) near the edges of the Subbasin. Two of these proposed monitoring wells are scheduled for the replacement of wells 03S05E26M001M and 03S06E28F003M to resolve questionable measurements.

- In the Upper aquifer (MW-101) to monitor groundwater levels to track changes near and protect domestic well owners.

- In the Upper aquifer (MW-102) to monitor groundwater levels to track changes near GDEs near the San Joaquin River. The well is positioned to also be used for surface water depletions when coupled with the SJR river gage. This well can also be used to assess conditions and be protective of domestic well owners. A transducer, capable of recording measurements frequently, is planned to be installed in this well to track seasonal changes.

**Table 8-4** lists these new monitoring wells and their purpose. These wells may be constructed by DWR as part of their Technical Support Services or as local funding becomes available. Once completed and along with at least 5 years of measurements minimum thresholds and measurable objectives may be established at these wells.

Two existing wells (SJCDW00032, and SJCDW00034), listed in **Table 8-2,** may be added in the future as representative wells to supplement the monitoring network to protect domestic well owners and track groundwater levels near GDEs. However, currently the wells have only a few groundwater level measurements. During the 5-year GSP update measurements minimum thresholds and measurable objectives may be established at these wells. Well DVMW-16-BP is located at the Deuel Vocational Institution, but the facility is scheduled to be de-activated in September 2021. The well is in an ideal location for protection of domestic wells, but at this time cannot be relied upon for long-term monitoring.

In addition to the new monitoring wells further refinement of potential GDEs is needed and potentially inclusion of ecological monitoring to further refine significant and undesirable definition. A thorough review of all GDEs vegetation types and rooting zone depths in the Non-Delta Management Areas has not been completed to assess rooting zone in each different polygon. The health of the vegetation also has not been assessed. A review of the vegetation types, rooting zone depths, health, and depth to groundwater using a digital elevation model will be performed during the next 5 years to improve the selection of minimum thresholds.

**Table 8-4. Data Gap Monitoring Wells**

| Figure No. | Total Depth (feet bgs) | Location | Benefit |
|---|---|---|---|
| **Upper Aquifer** | | | |
| 8-3 shown as MW-101 (new) | 70 | Install on City of Tracy Property, adjacent to Lower aquifer nested well MW-5. | Provides monitoring for protection of domestic well owners. Provides for vertical heads between Upper and Lower Aquifers. |
| 8-6 shown as MW-102 (new) | 50 | Install in San Joaquin County Road easement. | Provides monitoring for protection of groundwater dependent ecosystems and assessement of surface water depletion when compared with SJC River gage. |
| **Lower Aquifer** | | | |
| 8-9 shown as MW-201 (new) | 805 | Install in Banta-Carbona canal easement. | Provides monitoring for protection of agriculture wells. Needed to define extent of Corcoran clay and gradient leaving basin. |
| 8-9 shown as MW-202 (new) | 1100 | Install in Mountain House water treatment facility. | Provides monitoring for protection of agriculture wells. Needed to define extent of Corcoran clay and gradient leaving basin. |
| 8-9 shown as MW-203 (new) | 750 | Install in south portion of the subbasin, to replace 03S05E26M001M. Approximate location. | Provides monitoring for protection of agriculture wells. Needed to resolve gradient between subbasins (TSb and DMSb). |
| 8-9 shown as MW-204 (new) | 800 | Install in south portion of the subbasin to replace 03S06E28F003M. Approximate location. | Provides monitoring for protection of agriculture wells. Needed to resolve gradient between subbasins (TSb and DMSb). |

## 8.3 Reduction in Groundwater Storage Monitoring Network

Change in groundwater storage monitoring network will use the groundwater level representative monitoring network described above in **Chapter 8.2.2 – Representative Monitoring Wells**. The DWR has utilized for decades changes in groundwater elevations along with specific yield estimates to estimate changes in storage annually.

Because groundwater levels are used in the calculations, they will be used as a proxy for groundwater storage changes, discussions of monitoring frequency and spatial density will be the same as for chronic lowering of groundwater levels as described in **Chapter 8.2.3 – Groundwater Level Monitoring Frequency and Chapter 8.2.4 – Groundwater Level Monitoring Spatial Density**.

## 8.4 Seawater Intrusion Monitoring Network

As stated previously, the Subbasin is not located near the Pacific Ocean which precludes the consideration of seawater intrusion as a sustainability indicator. The closest area where saline water intrusion is present is about 20 miles west of the Subbasin boundary, near the City of Antioch. Therefore, seawater intrusion is not present and is not likely to occur in the Subbasin and a monitoring network and monitoring is not required.

## 8.5 Degraded Groundwater Quality Monitoring Network

The groundwater quality in the basin is generally adequate to meet the needs of urban, municipal, industrial and agricultural uses in the basin. The concentration of the naturally occurring elements varies widely over the Subbasin and also with depth at any given location. Groundwater quality in the Subbasin has locally exceeded the MCLs for drinking water for specific elements, some exceedances are scattered, and some are clustered. Poor groundwater quality has been noted in the following general areas:

- Salinity, as represented by TDS, is high in both the Upper and Lower aquifers with a few areas with good quality water. Sources of high salinity are from the Coast Ranges, underlying marine sediments, and from agricultural practices.
- Nitrate concentrations are low in the subbasin and other than a few scattered wells, nitrate does not appear to be adversely impacting water quality.
- Elevated concentrations of sulfate are present near the foothills in both the Upper and Lower aquifers potentially as a result of recharge water originating from the Coast Ranges.
- Elevated concentrations of arsenic are only in the Upper aquifer and mostly within the Delta area (arsenic is present in the Lathrop area) and not in the Lower aquifer.
- Boron is present in the Upper aquifer. Most elevated concentrations are present in the Non-Delta Management Area and in the northern portions of the Delta area.
- PFAS and uranium are present in the groundwater in some wells in the City of Lathrop. PFAS have also been detected in City of Tracy wells. Both PFAS and uranium are widespread throughout the Central Valley and are not unique to Lathrop or Tracy.

It should be noted that in the event that any contaminants are detected above the MCL in a municipal water supply well, the water is treated to meet drinking water standards or the source is taken off-line until treatment is available.

### 8.5.1 *Monitoring Network Groundwater Quality*

Groundwater quality in the Subbasin is monitored in 125 PWS wells and in two wells designated for the ILRP (wells SJCDW00032 and SJCDW00034). **Figure 8-10** shows the locations of the PWS wells and ILRP wells (light gray boxes are those wells with unknown construction details, colored wells have construction details). Construction details for most wells have yet to be acquired. Water quality is monitored for various other regulatory programs regulated by State Water Board but typically for just specific water quality contaminants of concern. As demonstrated in **Chapter 4 – Hydrogeologic**

**Conceptual Model**, the network is sufficient to identify groundwater level trends that may threaten the sustainability of the basin's groundwater resources.

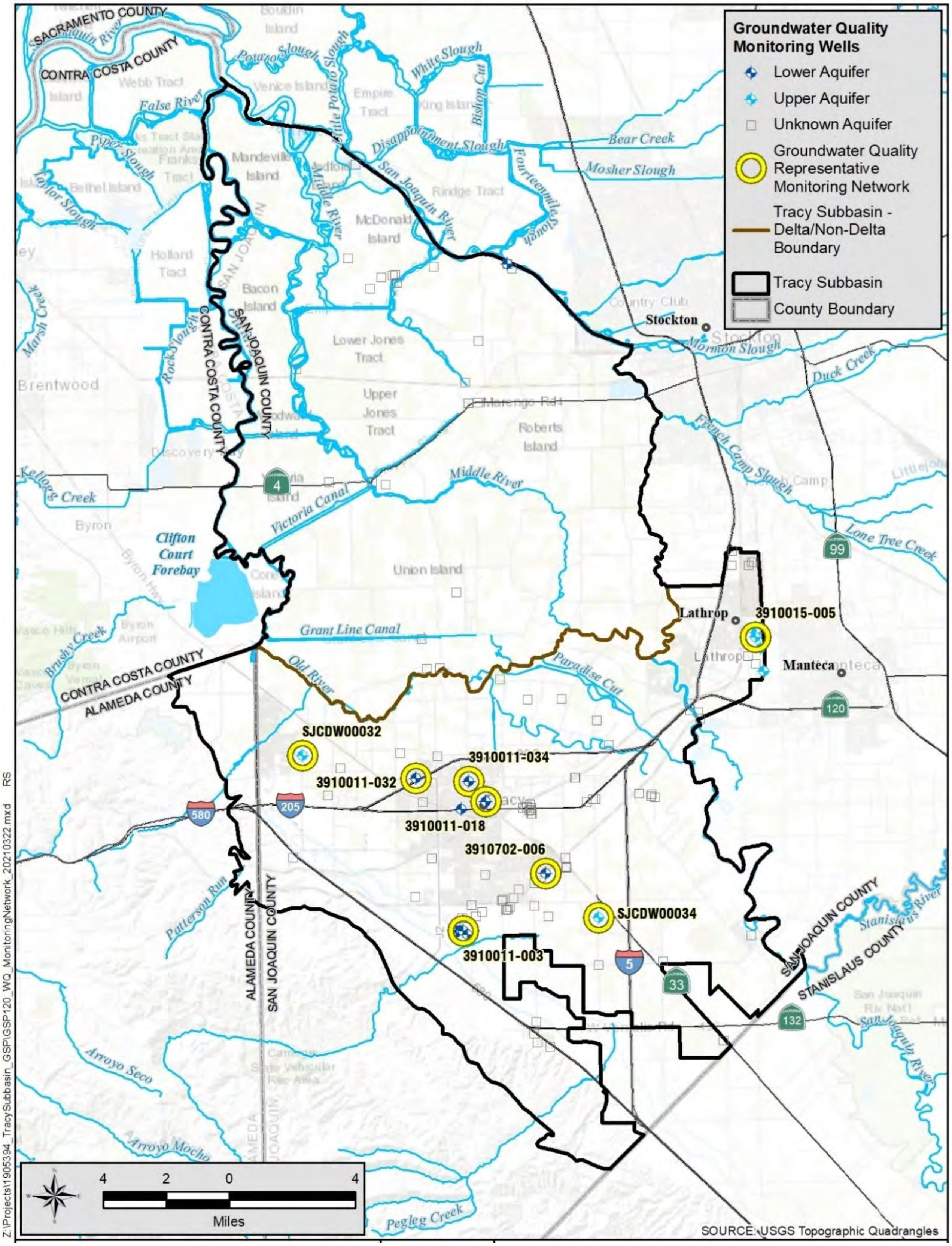


**Figure 8-10. Water Quality Monitoring Network and Representative Monitoring Network**

### 8.5.2 *Degraded Groundwater Quality Representative Monitoring Wells*

Criteria used to select the representative monitoring well network selected for the Tracy Subbasin is based on the availability of well construction details and whether the wells could be assigned to a principal aquifer. Nine representative monitoring wells (PWS and ILRP) were selected to assess groundwater quality degradation as listed in **Table 8-5** and shown on **Figure 8-10**.

**Table 8-5. Degraded Water Quality Representative Monitoring Wells**

| PWS Code | Local Name | Total Depth (ft bgs) | Frequency of Monitoring |
|---|---|---|---|
| **Upper Aquifer Wells** | | | |
| | SJCDW00032 | 125 | Annual |
| | SJCDW00034 | 180 | Annual |
| 3910015-005 | WELL 06 | 270 | 3-years |
| **Lower Aquifer Wells** | | | |
| 3910702-006 | WSW009 | 930 | 3-years |
| 3910011-003 | PRODUCTION WELL 01 | 980 | 3-years |
| 3910011-018 | WELL 04R - NEW LINCOLN | 980 | 3-years |
| 3910011-032 | PRODUCTION WELL 06 | 1196 | 3-years |
| 3910011-034 | PRODUCTION WELL 07 | 874 | 3-years |

**Table 8-6** provides a summary of the groundwater quality monitoring well types, distribution, and whether the ILRP and PWS wells are representative of water quality for other beneficial users, namely domestic well users in the Subbasin. Based on the depth of domestic wells in the Subbasin, **Figure 8-4** shows that most domestic wells are constructed to depths of about 80 to 200 feet in the Non-Delta Management Area, with depths increasing towards the higher topography of the foothills and coastal mountain ranges to the south-west portion of the Subbasin. The select representative monitoring network is representative and protective of domestic wells.

**Table 8-6. Water Quality Monitoring Well Summary**

| Description | Non-Delta Area |
|---|---|
| Representative Groundwater Quality Wells | 9 |
| Range of Public Water Service Well Depths | 125-1,196 ft bgs |
| Range of Domestic Well Minimum Depths | 32-622 feet bgs |
| Number of Wells less than 200 Feet Deep | 3 |
| Number of Wells greater than 200 Feet Deep | 6 |
| Number of Wells with Unknown Depths | 116 |

### 8.5.3 *Groundwater Quality Monitoring Frequency*

The State Water Board's DDW requires monitoring of PWS wells for Title 22 requirements (such as organic and inorganic compounds, metals, microbial, and radiological analytes). Data is available for active and inactive drinking water sources for water systems that serve the public: defined as serving 15 or more connections or more than 25 people per day.

Each of the PWS wells is used to produce drinking water and is required to be monitored for water quality by the State Water Board's DDW. The monitoring schedule and constituent varies by public water system but for TDS and boron but typically at least once every 3 years, and nitrate typically not less than annually. ILRP wells are monitored on an annual basis. The frequency of monitoring is provided in **Table 8-5**.

### 8.5.4 *Groundwater Quality Monitoring Well Spatial Density*

DWR's Monitoring Networks and Identification of Data Gaps BMP identifies different sources and calculations for establishing monitoring network densities on a Subbasin-specific case (DWR 2016a). A specific density of water quality monitoring wells was not provided by DWR, but methods are available based by performing a water quality needs assessment.

The Groundwater Assessment Report prepared for the ILRP and subsequent Water Quality Trends Monitoring Program designated two monitoring wells in the Upper aquifer in the Non-Delta Management Area, or two wells per 100 square miles, and no wells in the Lower aquifer. This GSP has three wells per 100 square miles for the Upper aquifer. Six wells were selected to monitor water quality in the Lower aquifer or three wells per 100 square miles. The water quality well density in the Subbasin, as shown in **Table 8-7**, is sufficient to assess trends for water quality indicators at this time, but more regional distribution of the monitoring is needed.

### 8.5.5 *Data Gaps*

At this time, there is abundant water quality data through State Water Board's DDW, but the well construction details are currently unknown for more than 50 PWS wells, within the Non-Delta Management Area. Within the next 5 years, construction details will be located so that water quality results can be sorted by principal aquifers to improve the distribution of representative monitoring wells for water quality and trend assessment in the Subbasin. As necessary groundwater quality sampling in monitoring wells may be added.

## 8.6 Land Subsidence Monitoring Network

There are two land subsidence monitoring networks that are publicly available: (1) a CGPS station in the Subbasin that is part of the UNAVCO Plate Boundary Observatory network of CGPS stations, and (2) Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency Sentinel-1A satellite and processed by TRE Altamira Inc..

1. The CGPS data are a subset of Plate Boundary Observatory GPS with near real-time data streams made available by UNAVCO. The data is provided as elevation (Z) and longitude

(X) and latitude (Y). There is one CGPS stations (P-257) in the Non-Delta Management Area, on the west side of the City of Tracy that can be used to assess subsidence.

2. Through a contract with TRE Altamira Inc. and as part of DWR's SGMA technical assistance for GSP development and implementation, DWR has made available measurements of vertical ground surface displacement in the Subbasin (https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence). Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency Sentinel-1A satellite and processed by TRE Altamira. The InSAR dataset has also been checked to best available independent data. The current data covers the months between January 2015 and October 2020, and DWR is planning on supporting updating the dataset on an annual basis through 2022.

In addition to these datasets, the Delta-Mendota Water Authority surveys the Delta-Mendota Canal alignment, and the City of Tracy has established benchmarks, that have been historically used to assess subsidence related to groundwater pumping.

### 8.6.1 *Subsidence Monitoring Network*

The InSAR subsidence dataset will be the monitoring network for the Subbasin.

### 8.6.2 *Land Subsidence Representative Monitoring Locations*

The InSAR subsidence dataset will be used by the Subbasin GSAs annually to evaluate this sustainability criteria. Should the InSAR data indicate subsidence greater than the minimum threshold then a review of CPGS data and groundwater elevations will be performed to confirm that subsidence has occurred and if it is related to groundwater pumping. As necessary, benchmarks along the Delta-Mendota Canal alignment and the City of Tracy benchmarks may also be resurveyed.

### 8.6.3 *Land Subsidence Monitoring Frequency*

The InSAR subsidence dataset will be used by the Subbasin GSAs annually (October 1 of any given year through October 1 of the following year) to roughly match water years.

### 8.6.4 *Land Subsidence Monitoring Spatial Density*

The InSAR subsidence dataset covers the entire Subbasin.

### 8.6.5 *Data Gaps*

Since the InSAR dataset covers the entire Subbasin there are no data gaps.

## 8.7 Surface Water Depletion Monitoring Network

Groundwater levels measurements will be used as a proxy for surface water depletion. Temporal changes in river flows volumes from gaging stations cannot be used to assess surface water depletion due to the relatively small volumes of groundwater gains and losses in comparison to the volume of water in the rivers. The uncertainty in the accuracy of the volume increases due to the complex nature of merging rivers and canals, ungagged small tributaries, subdrains and tailwater releases.

As described and illustrated in **Chapter 5.9 – Interconnected Surface Water**, groundwater levels in monitoring wells in the Upper aquifer near rivers correlate to changes in elevations of surface water at river gages. Increasing the depth to groundwater will increase groundwater gradient away from the rivers and increase the amount of surface water depletions. Therefore, use of groundwater levels as a proxy for surface water depletion is appropriate. Gage station data on Mountain House and Corral Hollow creeks is not available to correlate for temporal changes and groundwater extraction although only a small portion of the creeks may be interconnected.

The groundwater flow direction in the Lower aquifer shows a radial pattern with potential recharge from the Delta area where the Corcoran Clay maybe absent. Increasing the depth to groundwater will increase groundwater gradient and may increase the amount of surface water depletions.

### 8.7.1 *Surface Water Depletion Representative Monitoring Locations*

Recommended monitoring components for a surface water depletion monitoring network (DWR 2016) should include:

- Use of existing stream gaging and groundwater level monitoring networks to the extent possible.
- Establish stream gaging along sections of known surface water groundwater connection.
- Establish a shallow groundwater monitoring well network to characterize groundwater levels adjacent to connected streams and hydrogeologic properties.
- Identify and quantify both timing and volume of groundwater pumping within approximately 3 miles of the stream or as appropriate for the flow regime.

Representative monitoring wells were selected near and within 3 miles of the rivers to assess the groundwater gradient towards or away from the rivers. Monitoring wells along tributaries were not selected as the tributaries only flow for short periods after rain events and are not connected by a continuous saturated interval with the principal aquifers, other than possibly near the rivers.

Four existing Upper aquifer shallow monitoring wells are located along the San Joaquin and Old rivers and near river gages. These wells can be clustered into three groups to develop gradients towards or away from the rivers. **Table 8-7** provides the well construction details, attributes, and monitoring frequencies. **Figure 8-11** shows the locations of the surface water depletion representative monitoring wells for the Upper aquifer.

Three existing Lower aquifer monitoring wells are located south of the Old River and can be used to develop gradients towards or away from the Delta area rivers, canals and sloughs where the Corcoran Clay may be absent allowing interconnection of the Upper and Lower aquifers and the possibility that use of groundwater from the Lower aquifer could deplete surface water. These wells can also be clustered into a group to develop gradients towards or away from the rivers. **Table 8-7** provides the well construction details and attributes. **Figure 8-12** shows the locations of the surface water depletion monitoring wells for the Lower aquifer.

**Table 8-7. Surface Water Depletion Representative Monitoring Wells**

| CASGEM ID | Local Name | Latitude | Longitude | Screened Interval (ft bgs) | Total Depth (ft bgs) | Frequency of Monitoring |
|---|---|---|---|---|---|---|
| **Upper Aquifer Wells** | | | | | | |
| 377341N1213039W001 | Well N | 37.7341 | -121.3039 | Unknown | 40 | Monthly |
| 377813N1214420W001 | 02S05E08B001M | 37.7813 | -121.442 | 50-80 | 80 | Monthly |
| 377976N1214560W001 | 01S05E31R002M | 37.7976 | -121.456 | Unknown | 92 | Monthly |
| 377979N1215800W001 | 01S04E31P005M | 37.79791 | -121.58 | 8-23 | 24 | Monthly |
| 378103N1215449W001 | ORL-1W | 37.81031 | -121.5449 | 86-106 | 106 | Monthly |
| 377979N1215800W001 | 01S04E31P005M | 37.79791 | -121.58 | 8-23 | 24 | Monthly |
| | MWM-24 | 37.81657 | -121.3146 | 10-20 | 21 | Monthly |
| | MWR-25 | 37.78232 | -121.333 | 11-21 | 22 | Monthly |
| | PW11-031 | 37.81163 | -121.2842 | 23-28 | 31 | Quarterly |
| **Lower Aquifer Wells** | | | | | | |
| 377402N1214508W002 | MW-1B | 37.74019 | -121.4508 | 618-658 | 670 | Monthly |
| 377427N1213943W002 | MW-5B | 37.74266 | -121.3943 | 576-616 | 640 | Monthly |
| 377656N1214199W002 | MW-6B | 37.76563 | -121.4199 | 590-630 | 645 | Monthly |

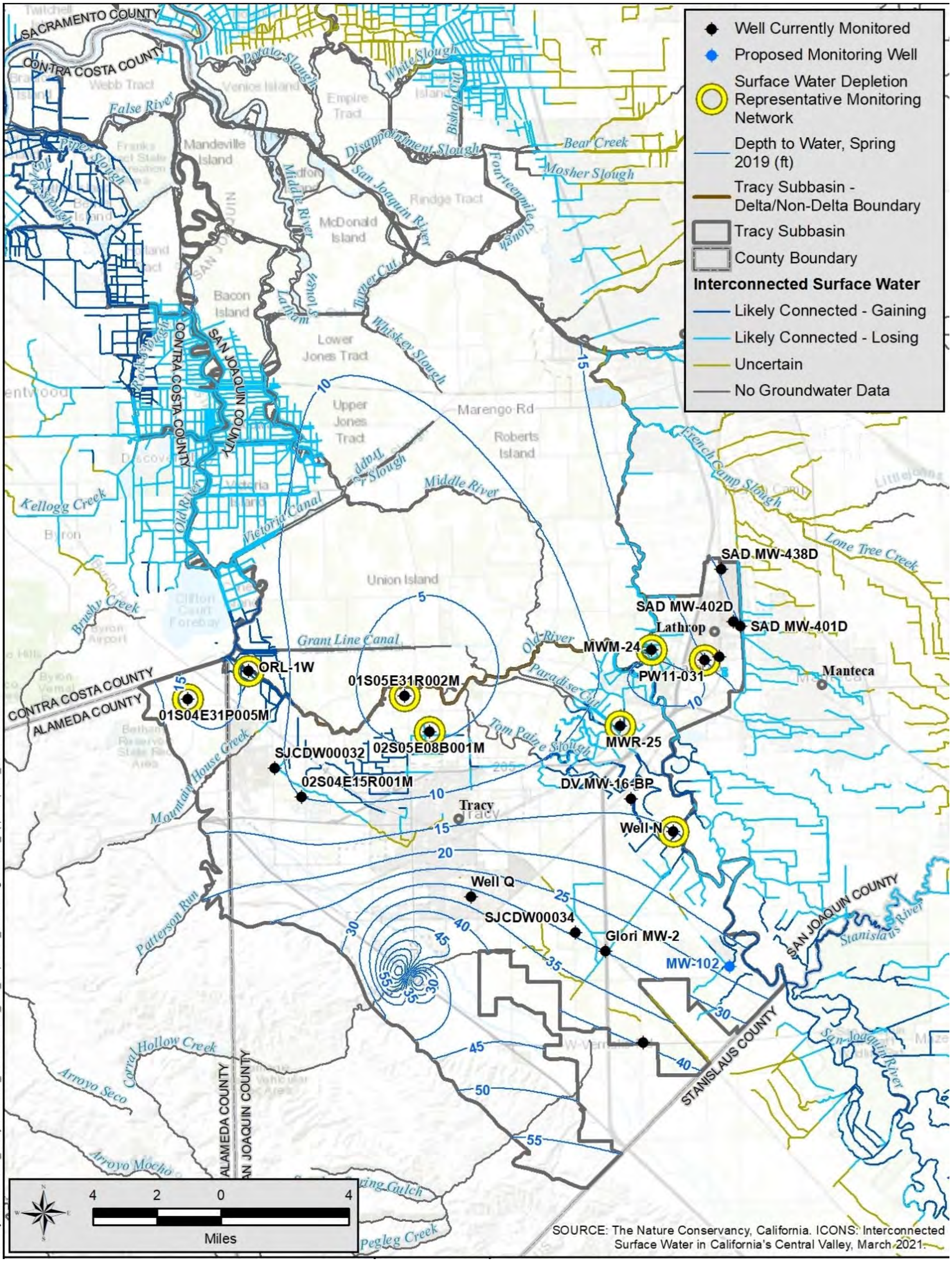


**Figure 8-11. Upper Aquifer Surface Water Depletion Representative Monitoring Wells**

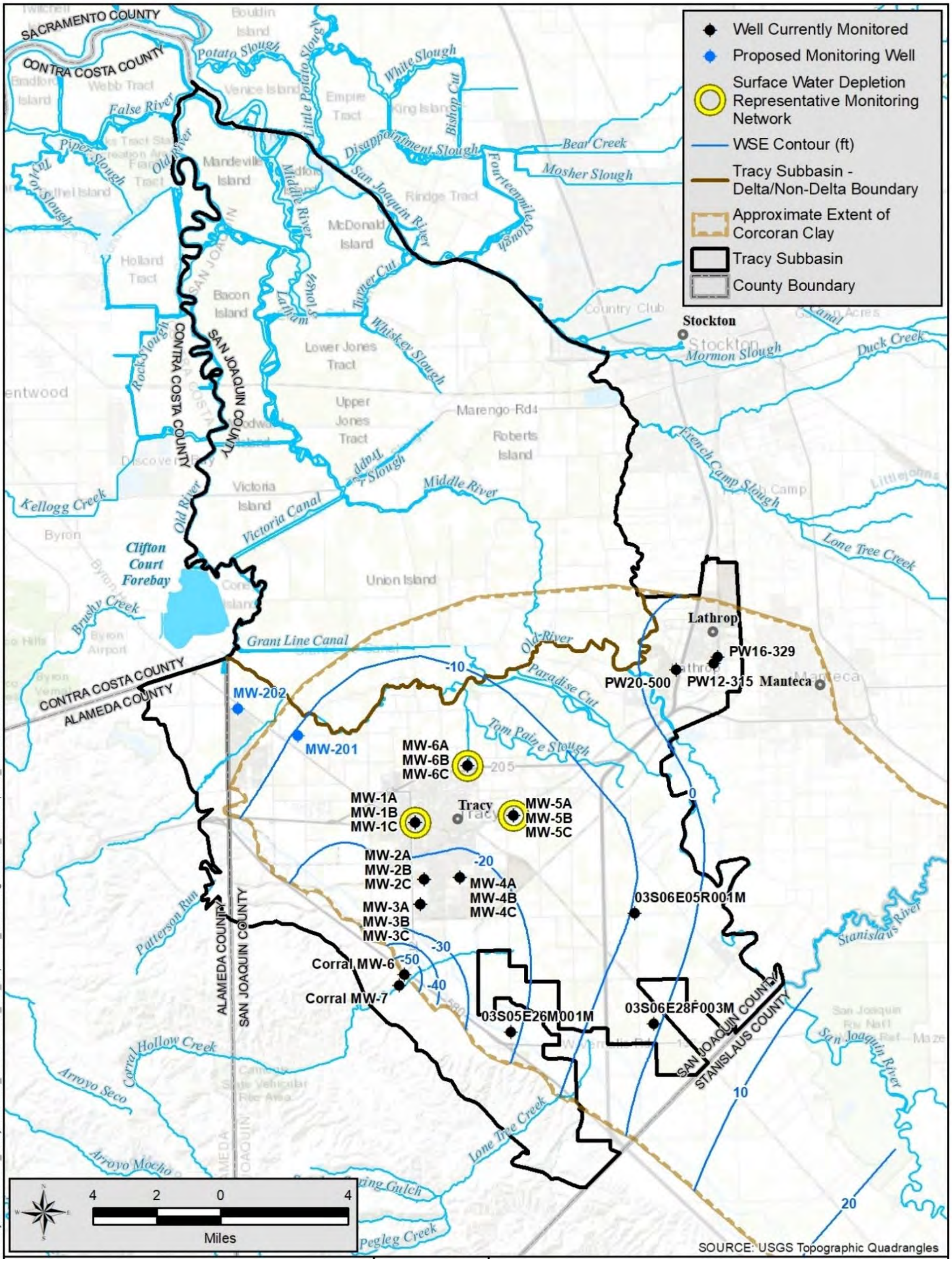


**Figure 8-12. Lower Aquifer Surface Water Depletion Representative Monitoring Wells**

### 8.7.2 *Surface Water Depletion Monitoring Frequency*

Groundwater levels in the selected monitoring wells are being monitored by DWR and San Joaquin County staff to obtain measurements on a semi-annual frequency, quarterly at wells in regulatory monitoring programs. Since the wells being monitored are residential or irrigation wells, installation of transducers is not feasible. The frequency of monitoring at these wells will be increased to monthly to better evaluate gradients during the summer months.

### 8.7.3 *Surface Water Depletion Monitoring Spatial Density*

No specific density of monitoring well spatial density guidance has been provided by DWR.

There are about 30 miles of rivers (San Joaquin and Old Rivers) along the Non-Delta Management Area boundary. Four monitoring wells in the Upper aquifer are located within 1 mile of the rivers. These four wells monitoring wells are paired with inland wells to establish gradients resulting in about one well per every 8 miles of river frontage.

### 8.7.4 *Data Gaps*

Proposed new monitoring well MW-102 is needed to address depletion along the southern end of the San Joaquin River and will be used in conjunction with surface water gaging station SJC to assess the groundwater flow to or from the San Joaquin River. This well was proposed in **Chapter 8.25 – Data Gaps, Table 8-4,** for lowering of groundwater levels and could be used for dual purposes to address surface water depletion and groundwater dependent ecosystems to fill this monitoring gap. During the 5-year GSP update additional wells may be recommended.

## 8.8 Monitoring Protocols

The following technical protocols provide guidance based upon existing professional standards and are commonly adopted in various groundwater-related programs. The protocols provide clear techniques to yield quality data for use in the various components of this GSP. The following monitoring protocol were developed using DWR's BMPs for Monitoring Protocols, Standards and Sites (Monitoring Protocols), (DWR 2016b) with additions from other existing programs.

### 8.8.1 *Groundwater Levels*

The following monitoring protocol was developed for the CASGEM monitoring programs by San Joaquin County and the San Luis Delta Mendota Water Authority and will be used to measure groundwater levels in the monitoring wells using a water level sounder or pressure transducers.

#### 8.8.1.1 **Water Level Sounders**

Groundwater level measurements must be collected with consistency and with sufficient additional data that those who use the data understand its usefulness and limitations. Field notes which document the data collection are therefore required.

To assure that the same well is being measured each time, the monitoring entity will create a Well Identification Sheet, which will be used to track the monitoring at each well site. The following information will be recorded on the Well Identification Sheet: well number, date of survey, latitude and longitude, reference point (RP) elevation and description, location description and map, well type and use, well completion type, and, if available, total depth, screened intervals, and well completion report number. A close-up photo of the well showing the access port for measuring groundwater levels and a photo of the well from a distance should be included for confirmation that the correct well is being monitored and that measurements are made consistently at the same locations.

The following data is collected on standard forms in the field to establish a dependable groundwater level measurement:

- Name of person collecting data and agency association
- Well name/identification
- Date and time of measurement
- Type of equipment used to measure the depth to water
- RP used at each well
- Nearby conditions which confirm (or not) that measurement is static water level and are noted by a Questionable Measurement Code
- Measurement from the RP to the water surface
- Weather and other conditions that may affect the ability to obtain a good measurement
- If a measurement cannot be made information is provided using a No Measurement Code

Additional steps are taken in the field to:

- Ensure the safety of staff collecting the data.
- Ensure the integrity of the data collection process.
- Maintain hygienic conditions in the wells.
- Maintain good relations with property owners.

Groundwater level measurements will be made using the following protocol (DWR 2016b):

- Depth to groundwater will be measured from an established RP on the well casing. The RP will be identified with a permanent marker, paint spot, or a notch in the lip of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.
- The sampler will remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a pressure release is evident, the measurement will be delayed for a short period of time to allow the water level to equilibrate.
- Measurements of depth to groundwater and land surface will be measured and reported in feet to an accuracy of at least 0.01 feet and the method of measurement will be noted on the record (i.e., electric sounder, steel tape, acoustic sounder).

- The sampler will replace any well caps or plugs and lock any well buildings or covers after taking a measurement.
- The water level probe should be cleaned after measuring each well.
- All data will be entered into the Tracy Subbasin data management system (DMS) as soon as possible. Care will be taken to avoid data entry mistakes and the entries will be checked by a second person for accuracy.

By following these monitoring protocols, the GSAs ensure that its groundwater level measurements are appropriate for use in conjunction with other groundwater level data from other groundwater management entities. Monitoring protocols shall be reviewed at least every 5 years as part of the periodic evaluation and update of this Plan and modified as necessary.

#### 8.8.1.2 **Pressure Transducers**

Groundwater levels may be measured using pressure transducers. When relying on pressure transducers and data loggers, manual measurements of groundwater levels will be taken during installation to synchronize the transducer system and, periodically (semi-annually), to ensure monitoring equipment does not allow a "drift" in the actual values.

The following protocols from DWR's BMP for Monitoring Protocols, Standards and Sites, (DWR, 2016b) will be followed when installing a pressure transducer in a monitoring well and during routine monitoring and downloads:

- The sampler will use an electronic sounder or chalked steel tape to measure the depth to groundwater level from the RP. The groundwater elevation will be calculated by subtracting the depth to groundwater from the RP elevation. These values will be used as references to synchronize the transducer system in the monitoring well.
- The sampler will record the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and other pertinent information in the log.
- The sampler will record whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Vented cables are preferred, but non-vented cables are acceptable if the transducer data are properly corrected for natural fluctuations in barometric pressure, which requires commensurate logging of barometric pressures.
- Transducers will be able to record groundwater levels with an accuracy of at least 0.1 feet. Various factors will be considered in the selection of the transducer system, including battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers.
- Follow manufacturer specifications for installation, calibration, battery life, correction procedure (for non-vented cables), and anticipated life expectancy to ensure optimal use of the equipment.
- Secure the cable to the wellhead with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker to allow estimates of future cable slippage.

- The transducer data will be checked periodically against hand-measured groundwater levels to monitor electronic drift or cable movement. This check will not occur during routine site visits, but at least annually.
- The data will be downloaded regularly to ensure data are not lost and entered into the DMS following the quality assurance and quality control program established for the GSP. Data from non-vented cables will be corrected for atmospheric barometric pressure changes, as appropriate. After ensuring the transducer data have been downloaded and stored in the DMS, the data will be deleted from the data logger to ensure that adequate data logger memory remains for future measurements.

### 8.8.2 *Water Quality*

All designated water quality monitoring wells are part of PWS systems. The state of California requires that public water systems maintain a level of water quality monitoring that ensures the public is provided with a safe, reliable drinking water supply. Specifically, public water systems must collect and analyze samples from their producing wells to determine the concentration of a broad range of constituents on a scheduled basis as detailed in Title 22 of the California Code of Regulations. The sampling events are carried out under detailed sampling plans which comply with state requirements. All analyses will be performed by a laboratory certified under the State Environmental Laboratory Accreditation Program.

Laboratory bottles labels are filled out prior to collection of the samples. The labels are to include: the well name, sampler initials, date and time of collection of the samples, preservative used, and the type of analysis to be performed.

All public water system operators have been trained for water quality sampling and required to obtain certifications by the State. Public water supply wells are purged for about 15 minutes prior to collection of samples, the samples are collected from dedicated sampling ports near the well head, the samples will be collected directly into laboratory prepared bottles, cooled to 4 degrees Celsius and then transported (shipped) to an Environmental Laboratory Accreditation Program certified laboratory under standard chain of custody.

## 8.9 Data Reporting

All of the groundwater level measurements collected by the GSAs and DWR will either be reported to CASGEM and or stored in the DMS developed for the Subbasin. Water quality data will be reported to the GAMA database.

A DMS has been developed for the Subbasin that access publicly available data (DWR, CASGEM, GAMA, and USGS databases) and to store historic and future local data including water supply information. All data is recorded in standard units for water volumes and flow and depths and elevations (NAVD88). All measurement locations are geographic referenced. Monitoring data stored in the DMS will be submitted electronically to DWR annually.

The data will be analyzed and reported in Annual Reports and shared with Stakeholders. The data will be used to update the groundwater model.

## 8.10 Monitoring Network Improvements

An assessment of the existing monitoring network shows the following improvements will need to be made to improve the accuracy and extent of the monitoring network. The following items will be accomplished, assuming DWR Technical Support Services can construct the proposed monitoring wells, within the next 5 years:

- Two new Upper aquifer monitoring wells are needed to assess conditions and be protective of beneficial users, domestic wells and GDEs as described in **Table 8-4**.
- Four additional Lower aquifer monitoring wells are needed to assess inflow and outflow from adjacent subbasins and for refinement of the groundwater model as described in **Table 8-4**.
- Well construction details are currently unknown for 116 PWS wells. A search of the County well files will be performed and if details are not found State Water Board's DDW will be requested to provide Drinking Water Source Assessment Program, Well Data Sheets to obtain the information.
- Obtain groundwater level measurements from IRLP wells SJCDW00032 and SJCDW00034.

The Tracy Subbasin agencies have already received general approval for construction of the new monitoring wells. Site specific information is being prepared and will be submitted shortly.

Every 5-years the agencies will re-evaluate the monitoring network for uncertainties and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goals for the Subbasin. As necessary the Subbasin GSAs may adjust the monitoring frequency to provide an adequate level of detail to assess the effectiveness of its projects and management actions. They may also adjust the monitoring network to adaptively manage minimum threshold exceedances, varying temporal conditions, reported adverse impacts to beneficial uses and users and effects from adjacent subbasins.

# 9. Sustainable Management Criteria

This chapter describes the criteria and the approach by which the GSAs and stakeholders established sustainability goals for the entire Subbasin; and for each of the six sustainability indicators, selected significant and undesirable results, developed minimum thresholds, and measurable objectives. The six sustainability indicators are chronic lowering of groundwater levels, reduction of storage, land subsidence, seawater intrusion, degradation of water quality, and surface water depletion.

A section for each of the sustainability indicator is provided that presents justification for locally defined, significant and undesirable results, minimum thresholds and measurable objectives, and interim milestones. Included is a discussion of how these thresholds and objectives affects other sustainability indicators.

The development of thresholds and measurable objectives took into consideration various components such as historical, current and future water budgets, seasonal and long-term trends, and periods of drought, while being commensurate with levels of uncertainty. The thresholds and objectives considered various approaches. Ultimately, thresholds and levels were established to protect the beneficial uses and users which are directly linked to the six sustainability indicators.

Sustainable management criteria for the Tracy Subbasin were developed based on:

- Technical information included in:
    - Chapter 4 – Hydrogeologic Conceptual Model
    - Chapter 5 – Groundwater Conditions
    - Chapter 6 – Management Areas
    - Chapter 7 – Water Budgets
    - Chapter 8 – Monitoring Networks
- Input from interested parties at workshops, public meetings and from comments to draft GSP chapters

Specific definitions are provided in GSP regulations for undesirable results, minimum thresholds and measurable objectives:

- Undesirable results occur when long-term levels are detrimental to beneficial users
- Minimum thresholds are established at quantifiable levels at a site that when exceeded, either individually or at a combination of sites that may cause undesirable results
- Measurable objectives are established at quantifiable levels for the maintenance or improvements of groundwater conditions to achieve the sustainability goal for the Subbasin

Local definition of undesirable results, minimum thresholds and measurable objectives were developed only for the Non-Delta Management Areas as undesirable results are not expected to occur in the Delta Management Area (*see* **Chapter 6 – Management Areas**).

## 9.1 Sustainability Goals

The sustainability goals for the Tracy Subbasin are:

> *To provide reliable and sustainable groundwater resources for existing and future needs of all beneficial users in the Subbasin that does not degrade or decrease over-time and will continue to be sustained through continued local adaptive management of the resources.*

Implementing projects and management actions to achieve these goals will avoid the occurrence of undesirable results during the 20-year implementation period and will result in long-term sustainable groundwater in the Non-Delta Management Area of the Subbasin.

All of the GSAs intend to implement measures such that undesirable results are avoided and such that the overall groundwater elevations remain relatively stable over time as compared to current conditions in the Subbasin. The Subbasin will be managed such that the groundwater levels may vary and be drawn down during drier years when surface water supplies may be reduced and temporarily replaced by increased relative use of groundwater supplies; and allowing for recovery of groundwater levels when above normal conditions exist and surface water is available. This type of conjunctive use operation will maximize use of available surface and groundwater supplies and has historically been practiced. The goal remains to avoid undesirable results as discussed in this chapter.

Measures to be implemented in the Subbasin to ensure its sustainability include:

- Routine monitoring and analysis of groundwater levels and quality along with a comparison to minimum thresholds and measurable objectives
- Regular meetings with GSAs to discuss monitoring findings and, as necessary, adaptively adjust management activities to resolve adverse or undesirable groundwater conditions
- Implementation of necessary projects and management actions (*see* **Chapter 10 – Projects and Management Actions**), as necessary, based on physical measurements of groundwater conditions at representative monitoring wells
- Continued implementation of conjunctive use programs

## 9.2 Sustainability Indicators

Groundwater sustainability indicators, as defined by SGMA legislation, are one of six effects caused by groundwater conditions that, when significant and unreasonable, cause undesirable results. The six sustainability indicators are:

1. **Chronic lowering of groundwater levels** – indicating a significant and unreasonable depletion of supply, exceeding the sustainable yield of the Subbasin, 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 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. **Reduction of groundwater storage** – resulting from chronic lowering of groundwater levels.
3. **Seawater intrusion** – the advancement of seawater into a groundwater supply that results in degradation of water quality in the basin and includes seawater from any source.
4. **Degraded water quality** – including the migration of contaminant plumes that impair water supplies.
5. **Land subsidence** – caused by groundwater declines that substantially interferes with surface land uses.
6. **Depletions of interconnected surface water** – reductions in flow or levels of surface water that is hydrologically connected to the principal aquifers such that the reduced surface water flow or levels caused by groundwater pumping have a significant and unreasonable adverse impact on beneficial uses of the surface water.

Each of these sustainability indicators are discussed in detail in the following sections for the Non-Delta Management Area. A general discussion of the conditions in the Subbasin is provided to define the current state of the Subbasin and potential issues. For each sustainability indicator a description of how locally defined significant and undesirable results, and how minimum threshold and measurable objectives were established for each of the sustainability criteria. Evidence from previous chapters is provided to demonstrate that groundwater levels can and will be used as a proxy for land subsidence, reduction of storage, and depletion of interconnected surface water.

## 9.3 Chronic Lowering of Groundwater Levels

The chronic lowering of groundwater elevations can have adverse impacts ranging from increased energy costs to the need to deepen existing wells or even construct new ones. Lowering of groundwater levels can also increase depletion from surface water and potentially create adverse impacts to groundwater dependent ecosystems, fishery resources, and riparian or related habitats. Lower groundwater elevations can also create groundwater quality problems by accelerating the migration of poor-quality groundwater or contaminant plumes. Lowering of groundwater levels could also lead to invasion of brackish connate water from underlying marine sediments into freshwater aquifers.

Groundwater levels are related to maintaining sustainable conditions without undesirable results for reduction of groundwater storage, land subsidence, and depletion of surface water. They were considered during development of this section but are discussed separately in subsequent sections.

### 9.3.1 *General Conditions*

The groundwater conditions in the Subbasin vary based on location and by principal aquifer. Groundwater use in the Subbasin is low, only about 12,000 AFY or about 3 percent of the total water use in the Subbasin and is only expected to increase by 4,400 AFY by 2040, based on projected urban growth (*refer to* **Table 3-3**).

**Upper Aquifer**

In the Non-Delta Management Area west of the San Joaquin River, groundwater levels are deeper towards the foothills and shallower near the San Joaquin and Old rivers (*refer to* **Figure 5-3**). Currently, the groundwater levels in the Upper aquifer range from 80 feet bgs near the foothills to within 5 feet of ground surface near the San Joaquin River. Groundwater levels typically have greater seasonal fluctuations, locally up to 40 feet, due to groundwater pumping and seasonal recharge. Even with these seasonal pumping and recharge fluctuations the depths to groundwater have remained stable.

East of the San Joaquin River, near Lathrop, the river recharges the Upper aquifer beneath the City and aquifers in the Eastern San Joaquin Subbasin, towards a pumping depression near Stockton.

**Lower Aquifer**

The Lower aquifer is present beneath the Corcoran Clay, but the clay may not extend across the entire Subbasin, allowing the Lower aquifer to become hydraulically connected to the Upper aquifer. Pumping of the Lower aquifer could therefore transfer groundwater impacts to the Upper aquifer.

The depths to groundwater in the Lower confined aquifer are typically deeper than those in the Upper aquifer. Groundwater levels (piezometric heads) range from about 20 to 270 feet bgs (*refer to* **Figure 5-5**) and in some locations, are below sea level. The groundwater levels vary by up to 30 feet seasonally. Pumping by agriculture and the City of Tracy and has resulted in a pumping depression. Regionally groundwater levels have been consistently above the top of the Corcoran. Groundwater levels beneath the clay have generally been rising over the past 20 years, except for those near the southeastern portion of the Subbasin where groundwater levels have been declining since around 2010 due to pumping in the Subbasin or adjacent northern portions of the Delta-Mendota Subbasin.

### 9.3.2 *Undesirable Results*

Groundwater beneficial users include humans, groundwater dependent ecosystems, and aquatic species. Groundwater in the Subbasin is used by rural homeowners, agricultural users, and municipal entities for drinking water, industrial users for manufacturing or processing food, and environmental uses for ecosystems supporting groundwater dependent plants and species.

The GSAs approached definition of undesirable results and what is considered to be significant and unreasonable, through a discussion of potential undesirable results by the GSAs and along with a workshop to seek stakeholder input on January 21, 2021, as documented in **Chapter 11 – Notices and Communications**.

The causes of chronic lowering of groundwater levels could be over-pumping of the groundwater within the Subbasin or from over-pumping of groundwater in adjacent subbasins depleting the subsurface inflow into the Subbasin. Reduction of recharge caused by various natural and man-created actions (climatic changes, urban development paving over recharge areas, agricultural irrigation practices changing to drip irrigation) could also lead to lowering of groundwater levels during extended periods of droughts if pumping is not reduced to match these changes or projects and management actions are not implemented to increase recharge and maintain a balance of pumping to recharge.

The criteria used to define significant and undesirable results by chronic lowering of groundwater levels are:

- Domestic and irrigation wells go dry (lowering pumps, cost to construct new wells)
- Increased costs to pump groundwater (including power, lowering or replacement of pumps, and new motors)
- Surface water is depleted such that creeks go dry (in periods other than severe climate conditions)
- Groundwater supported vegetation die or cannot repopulate (reduction or elimination of GDEs)
- Groundwater quality is degraded by increasing the salt content (lowering of groundwater levels increases and changes in pressure allows saline water from underlying marine sediments to increase and intrude into freshwater aquifers
- Groundwater quality becomes unusable because contaminants spread vertically and horizontally (contaminants from the large and known plumes spread and degrade water quality so that it cannot be used without treatment)

The potential effects of chronic lowering of groundwater levels are provided in the bullet list above.

Based on the criteria that could result in undesirable results, significant and undesirable results identified for the Subbasin for chronic lowering of groundwater levels will occur when groundwater levels exceed 30 feet bgs in areas currently supporting GDEs or when groundwater levels decline that cause domestic wells to go dry. The level when there would be a significant undesirable result will be:

*When 25 percent or more of the representative monitoring wells (5 out of 21 wells) record groundwater levels that exceed the minimum thresholds for more than 2 consecutive years that are categorized as non-dry years (below-normal, above-normal, or wet), according to the San Joaquin Valley Water Year Hydrologic Classification. The lowering of groundwater levels during consecutive dry or critically-dry years is not considered to be unreasonable, and would therefore not be considered an undesirable result, unless the levels do not rebound to above the thresholds following those consecutive non-dry years.*

The consecutive 2-year period allows time to assess the conditions and to potentially develop actions to resolve the declining levels. After the initial detection of a minimum threshold exceedance the GSAs will:

- Take a confirmation measurement
- If the measurement is confirmed, notify the GSAs
- If the measurement is confirmed, initiate an investigation to assess the cause of the exceedance
- Provide the results to the GSAs and adaptively manage

If groundwater levels were to reach levels causing undesirable results, the effects to beneficial users could include replacement of wells and pumps and higher energy cost to pump the water, potential land subsidence, and migration of poor-quality water. This could cause adverse effects personal and reginal economy and affect property values and the regional economy. The effects would also lead to increased depletion of surface and loss of GDE habitat.

### 9.3.3 *Criteria Considered to Establish Minimum Thresholds*

Criteria considered by the GSAs and stakeholders to establish minimum thresholds were based on the protection of the most sensitive beneficial users in the Subbasin. The criteria selected for the development of minimum thresholds for lowering of groundwater levels (or the maximum allowable groundwater level depth/elevation) were based on:

- The minimum depths of domestic wells (*refer to* **Figure 3-13**) to maintain groundwater levels 20 feet above the bottom of the well to allow for submergence of a pump and to allow continued use of the wells. No wells in the Subbasin were reported to have gone dry during the 2012 to 2016 drought. All wells do fail at some point due to corrosion of the casing or plugging of the well screens which are not related to groundwater levels. These selection criteria for minimum thresholds may be modified if the minimum well depth well was found to be:
    - Less than the current or historic groundwater levels during the drought years, 2012 to 2016.
    - Less than 40 feet because state and local ordinances require a 20-foot minimum sanitary seal depth for domestic wells and allowance for 20 feet for pump submergence.
- Rooting zone depths of GDEs vary based on types of species. A thorough review of all GDEs vegetation types has not been completed to assess rooting zone depths, due to budget constraints and the overall limited presence of GDEs within the Non-Delta Management Area. Minimum thresholds will typically vary with shallower levels near water bodies and decreasing with depth away from the water bodies. The selection criteria for minimum thresholds were established:
    - At up to 3 feet below historical groundwater levels (2010-2020) where current groundwater levels are less than 10 feet bgs
    - At an average depth of 30 feet bgs for California phreatophytes, and when groundwater levels (2010 to 2020) are greater than 10 feet bgs

It should be noted that the minimum well depth dataset has not been thoroughly vetted and may contain data about wells that are improperly located, no longer present, misclassified, or were constructed using cable tool methods where an open borehole provides water to the well from greater depths. Minimum thresholds may be re-evaluated and modified in the next 5 years as the datasets are reviewed and proofed.

Groundwater modeling results for projected conditions and with climate change were also considered during the development of minimum thresholds. Many of the model calibration wells are representative wells selected for this GSP and thus their projected difference in groundwater levels were also used during consideration to establish minimum levels. The model projected some groundwater levels to decline by 1 to 7 feet. Some selected representative monitoring wells were not in the model calibration and therefore to remain similar to other modeling results the groundwater levels were forecasted to be lower by 2 to 3 feet.

### 9.3.4 *Minimum Thresholds*

Minimum thresholds for chronic lowering of groundwater levels were established at varying levels throughout the Subbasin to achieve sustainable conditions and avoid undesirable results. The minimum thresholds were established at representative monitoring wells where well construction details are known and in monitoring wells with similar depths to protect beneficial users as described in **Chapter 8 – Monitoring Network**. **Figures 8-8 and 8-9** show the representative monitoring network for lowering of groundwater levels for the Upper and Lower aquifers.

**Table 9-1** provides a list of these representative monitoring wells and selected minimum thresholds based on the criteria described above to avoid undesirable results for chronic lowering of groundwater levels as well as how these relate to other sustainability indicators and their selection of minimum thresholds and measurable objectives. **Appendix N** provides hydrographs of these wells illustrating the minimum thresholds to historical groundwater levels. Where more than one sensitive beneficial user is present, the more conservative level was selected. Minimum thresholds selected in adjacent subbasins are also provided for reference and comparison to those established for the Tracy Subbasin.

**Figures 9-1 and 9-2** illustrates the minimum thresholds in representative wells as a contoured surface across the Subbasin in comparison to current groundwater levels (fall 2019). Minimum thresholds for representative wells in adjacent subbasins are also included to assess the effects on adjacent subbasins. As shown, the difference of the proposed minimum thresholds results in a groundwater surface similar to current conditions and without sharp differences in groundwater levels and therefore is reasonable.

The selection of the minimum thresholds was based on evaluating the individual and multiple beneficial users and selection of the shallowest level established for all users which establishes a conservative level to prevent undesirable results in the Subbasin, as shown in **Table 9-1**. Final selected minimum thresholds at each representative monitoring well, combining all sustainability indicators, are provided on the right side of the **Table 9-1**. Overall, in areas with GDEs and surface water minimum thresholds were established within 1-foot of historic groundwater levels and therefore potential impacts to GDEs and surface water depletion should be minimal. Minimum thresholds selected for subsidence, as discussed in **Chapter 9.7 – Land Subsidence**, are based on historic groundwater lows in the Subbasin. The minimum thresholds selected for surface water depletion, as discussed in **Chapter 9.8 – Depletion of Surface Water**, uses similar wells for chronic lowering of groundwater levels, GDEs in the Upper aquifer and wells in the Lower aquifer.

## Table 9-1. Minimum Thresholds and Measurable Objectives – Groundwater Levels

| Representative Wells | | | Purpose for Monitoring | | | | | Selection Criteria | | | | | | | | | | | | | Final Selection | | MO Interim Milestones (ft msl or rates of subsidence ft/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lowering of Groundwater Levels | | | | | Lowering of Groundwater Level | | | | | | | | | | | Surface Water Depletion | | | | | | |
| CASGEM ID | Local Name | Reference Point Elevation (ft) | Domestic Wells | GDE | Areas Soley Dependent On GW | Agricultural, Municipal, and Industral Wells | Surface Water Depletion | GWL Ave Spring (2010-2020) (ft msl) | GWL Historic Low Fall (2010-2020) (ft msl) | GWL Modeled Spring Low (ft msl) | GWL Modeled Fall Low (ft msl) | Minimum Domestic or Ag Well Depth (ft bgs) | Minimum Depth with Pump (ft bgs) | Minimum Domestic or Ag + Pump (ft msl) | GDEs GWL Min (2010-2020) (ft msl) | GDEs GWL Max (ft msl) | Groundwater Sole Areas Minimum Well Depths (ft bgs) | Groundwater Sole Areas Minimum Well + Pump (ft msl) | GWL Ave Spring (2010-2020) -1 feet (ft msl) | Historical Groundwater Level Low - 1 feet (ft msl) | Selected MTs (ft msl) | Selected MOs (ft msl) | Year 5 (ft msl) | Year 10 (ft msl) | Year 15 (ft msl) |
| **Upper Aquifer Wells** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 377341N1213039W001 | Well N | 23.36 | | X | | | X | 8 | 6 | 7 | 3 | 82 | 62 | -39 | 8 | -3 | | | 7 | 5 | **5** | **7** | **7** | **7** | **7** |
| 377061N1214199W001 | Well Q | 121.41 | X | | X | | | 60 | 58 | 57 | 55 | 103 | 83 | 17 | | | 83 | 17 | | | **55** | **57** | **57** | **57** | **57** |
| 377951N1216011W001 | 02S03E01D001M | 90 | X | | X | | | 82 | 75 | 80 | 73 | 113 | 93 | -3 | | | 113 | -3 | | | **73** | **80** | **82** | **82** | **82** |
| 377813N1214420W001 | 02S05E08B001M | 4.3 | X | X | | | X | 0 | -6 | -1 | -7 | 45 | 25 | -21 | 0 | -36 | | | 0 | -7 | **-7** | **0** | **0** | **0** | **0** |
| 377976N1214560W001 | 01S05E31R002M | 4.6 | X | | | | X | 1 | 0 | -6 | -7 | 85 | 65 | -61 | | | | | 0 | -1 | **-1** | **0** | **0** | **0** | **0** |
| 376388N1213233W001 | 03S06E28N001M | 148.24 | X | | | | | 68 | 64 | 64 | 58 | 100 | 80 | 53 | | | | | | | **58** | **64** | **68** | **68** | **68** |
| 377528N1215156W001 | 02S04E15R001M | 63.41 | X | | X | | | 53 | 48 | 48 | 43 | 65 | 45 | 18 | | | 65 | 18 | | | **43** | **48** | **48** | **48** | **48** |
| 377979N1215800W001 | 01S04E31P005M | 60 | | X | | | X | 46 | 42 | | | | | | 47 | 30 | | | 45 | 41 | **41** | **45** | **45** | **45** | **45** |
| 378103N1215449W001 | ORL-1W | 16.6 | | | | | X | 0 | -2 | -1 | -3 | | | | | | | | -1 | -3 | **-3** | **-1** | **-1** | **-1** | **-1** |
| | MWM-24 | 16.88 | | X | | | X | 4 | 0 | | | | | | 4 | -13 | | | 3 | -1 | **-1** | **3** | **3** | **3** | **3** |
| | MWR-25 | 16.25 | | X | | | X | 5 | 4 | | | | | | 10 | -14 | | | 4 | 3 | **3** | **4** | **4** | **4** | **4** |
| | SAD MW-402D | 24.52 | X | | | | | 5 | 0 | 3 | -2 | 60 | 40 | -15 | | | | | | | **-2** | **3** | **5** | **5** | **5** |
| | PW11-031 | 20.42 | | | | | X | 5 | 1 | | | | | | | | | | 4 | 0 | **0** | **4** | **4** | **4** | **4** |
| | PW16-216 | 23.26 | X | | | | | 2 | -17 | 0 | -19 | 85 | 65 | -42 | | | | | | | **-19** | **0** | **0** | **0** | **0** |
| **Lower Aquifer Wells** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 376713N1214581W001 | Corral MW-6 | 303.33 | X | | X | X | | -36 | -58 | -38 | -60 | 600 | 580 | -280 | | | 600 | -280 | | | **-60** | **-38** | **-38** | **-38** | **-38** |
| 377402N1214508W002 | MW-1B | 50.09 | | | | X | X | -19 | -68 | -21 | -35 | 155 | 135 | -80 | | | | | -20 | -69 | **-69** | **-20** | **-15** | **-20** | **-20** |
| 377031N1214485W002 | MW-3B | 138.08 | | | | X | | -20 | -59 | -22 | -40 | 248 | 228 | -92 | | | | | | | **-40** | **-22** | **-22** | **-22** | **-22** |
| 377427N1213943W002 | MW-5B | 47.82 | | | | X | X | -16 | -59 | -18 | -42 | 235 | 215 | -160 | | | | | -17 | -60 | **-60** | **-17** | **-17** | **-17** | **-17** |
| 377656N1214199W002 | MW-6B | 26.65 | | | | X | X | -19 | -66 | -21 | -46 | 658 | 400 | -329 | | | | | -20 | -67 | **-67** | **-20** | **-20** | **-20** | **-20** |
| 376974N1213258W001 | 03S06E05R001M | 59.69 | | | | X | | -5 | -31 | -7 | -33 | 300 | 280 | -220 | | | | | | | **-33** | **-7** | **-7** | **-7** | **-7** |
| | PW20-500 | 119.82 | | | | X | | 2 | -8 | 0 | -10 | 62 | 42 | -27 | | | 62 | -27 | | | **-10** | **0** | **0** | **0** | **0** |

Notes: Used to select MTs, MOs, and Interim Milestones

Well not used in calibration of model, no hydrograph to assess projected future conditions, estimated for projected with climate change. Vaulue subject to change.

All modeled hydrograph levels subject to change based on model revisions

| Corresponding Tracy Rep Well Local Name | Other Subbasin Well Name | Selected MTs (ft msl) | Selected MOs (ft msl) | Year 5 (ft msl) | Year 10 (ft msl) | Year 15 (ft msl) |
|---|---|---|---|---|---|---|
| **Delta Mendota Subbasin - Upper Aquifer** | | | | | | |
| 03S06E28N001M | 06-004 | **14.8** | **38.9** | | | |
| | | | | | | |
| **Lower Aquifer** | | | | | | |
| 03S06E05R001M | 01-007 | **-12** | **15.5** | | | |
| 03S06E05R001M | 04-001 | **-6.1** | **7.8** | | | |
| **Eastern San Joaquin Subbasin - Upper Aquifer** | | | | | | |
| PW16-216 | Manteca 18 | **-16** | **5.8** | **9.1** | **9.1** | **7.5** |
| Well N | 02S07E31N001 | **1.5** | **13** | **13.8** | **13.8** | **13.4** |
| | Swenson-3 | **-26.6** | **-19.3** | **-19.3** | **-19.3** | **-19.3** |

Notes: Only one principal aquifer defined. Lower aquifer not defined in this Subbasin

Notes: The minimum threshold is set at the deeper of 1992 and 2015-2016 groundwater levels with a buffer of 100 percent of historical range applied, or the 10th percentile domestic well depth, whichever is shallower. In municipalities with ordinances requiring the use of City water, the 10th percentile municipal well depth is used in place of the 10th percentile domestic well depth criteria.

Notes: 5-year milestones are assumed to remain similar to current for the first 10 years and then follow along a linear trend between the current condition and the measurable objective

| Corresponding Tracy Rep Well Local Name | Other Subbasin Well Name | Selected MTs (ft msl) | Selected MOs (ft msl) | Year 5 (ft msl) | Year 10 (ft msl) | Year 15 (ft msl) |
|---|---|---|---|---|---|---|
| **East Contra Costa Subbasin - Upper Aquifer** | | | | | | |
| 5 Binn (about 4 miles west of 31P05) | | **-4** | **16** | | | |
| | | | | | | |
| **Lower Aquifer (not defined in GSP)** | | | | | | |
| | None | | | | | |
| | | | | | | |

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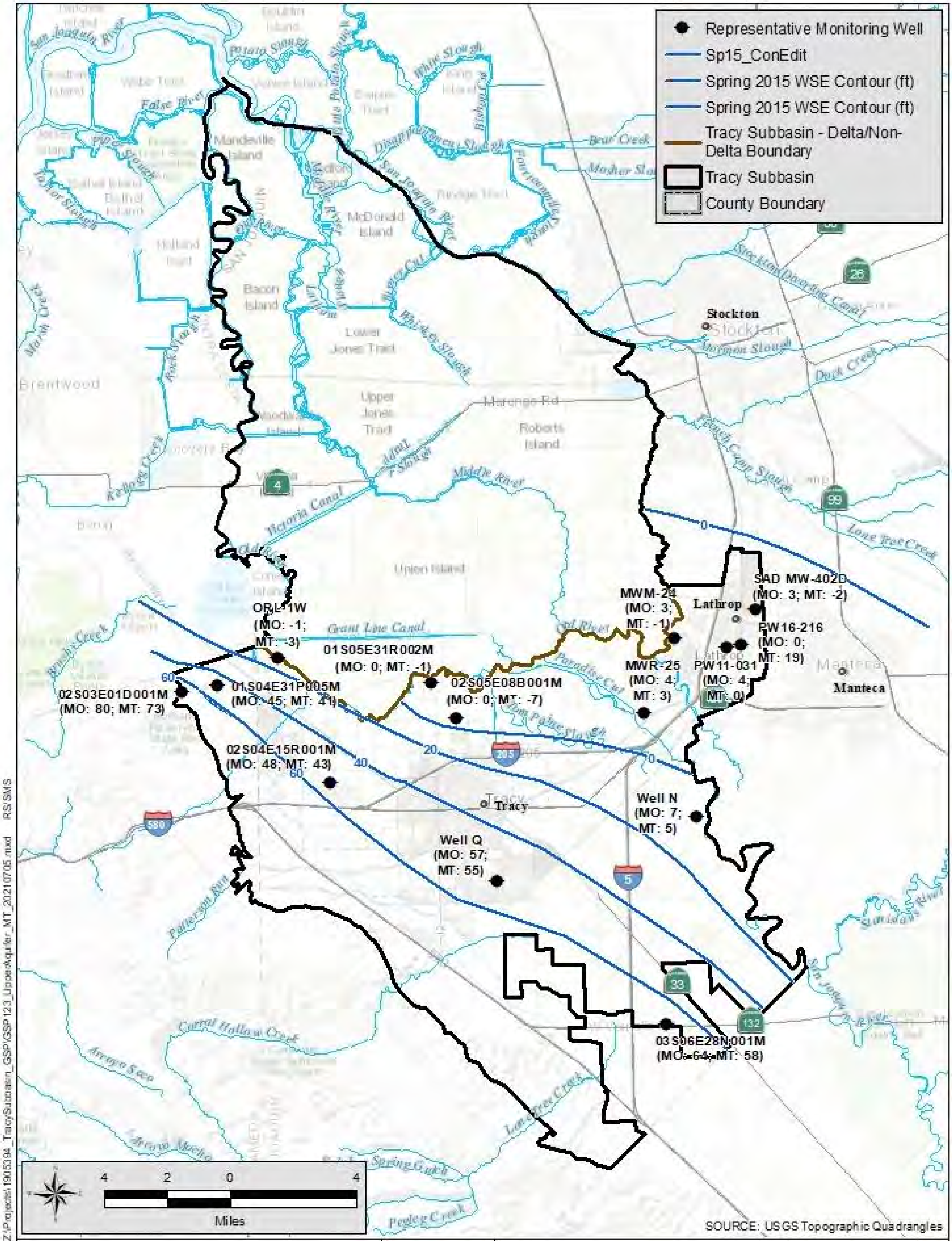


Figure 9-1. Upper Aquifer Groundwater Levels to Minimum Thresholds

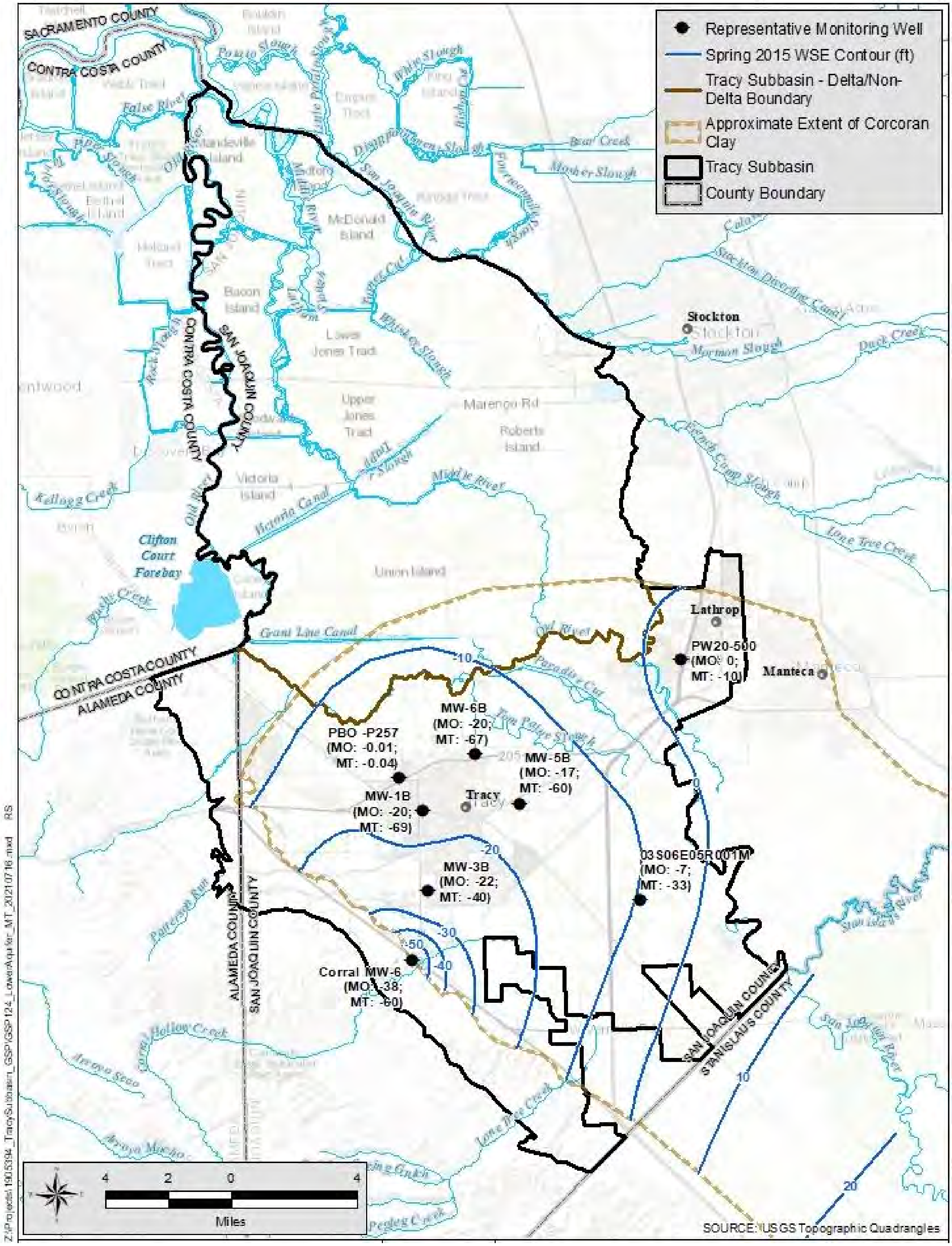

**Figure 9-2. Lower Aquifer Groundwater Levels to Minimum Thresholds**

### 9.3.5 *Minimum Thresholds Effects*

Because the establishment of these minimum thresholds were based on beneficial users, and are similar to historic groundwater levels, there should be no adverse effects on beneficial uses and users, land uses, or property interests in the Subbasin.

The potential effects of establishing minimum thresholds for chronic lowering of groundwater on other sustainability indicators, as shown in **Table 9-1**, were considered with the minimum threshold being set at the most conservative level preventing conflicts.

Groundwater minimum thresholds for adjacent subbasins were obtained for wells in adjacent subbasins near the commonly shared boundaries. Similar minimum thresholds are present in the Eastern San Joaquin and East Contra Costa subbasins. Minimum thresholds for the Lower Aquifer are much deeper in the Northern & Central Delta-Mendota subbasin than are projected in the Tracy Subbasin due to uses of different wells for contouring and the need to install dedicated monitoring wells to resolve groundwater levels in this area, as described in **Section 5.2. Current Groundwater Contours** for the Lower aquifer.

### 9.3.6 *Relevant State, Federal and Local Standards*

No federal, state, or local standards exist for chronic lowering of groundwater elevations.

### 9.3.7 *Measurable Objectives*

Groundwater levels measurable objectives were set above the minimum threshold to meet the water needs of a multi-year drought. The measurable objectives groundwater levels were established based on:

- Average historical spring groundwater level within the last 10 years (2010-2020 to reflect current conditions and as some wells were not measured in 2015 at the start of SGMA), because at these levels:
    - There were sufficient groundwater reserves that undesirable results (no dry wells) were not reported during the recent drought
    - Near potential GDEs, groundwater levels were shallow enough to allow for continued growth and promote regrowth
    - Agriculture can still maintain unsaturated root zones and allow farming to continue

**Table 9-1** provides a listing of the selected measurable objectives at each representative monitoring well. Using average historical spring groundwater levels (2010 through 2020) rather than historic spring low levels provides a margin of safety.

Interim milestones were established at the average spring groundwater levels for the next 15 years (similar to time frame projections as the Eastern San Joaquin Subbasin GSP). As illustrated in **Table 9-1**, interim milestones likely be achieved as the current groundwater levels are similar to current levels. Interim milestones through 2042 will be developed after the initial years of GSP implementation and additional knowledge is obtained by filling of data gaps.

## 9.4 Reduction of Storage

For decades the DWR has utilized changes in groundwater elevations along with specific yield estimates to estimate changes in storage. In **Chapter 5.5 – Change in Storage**, groundwater levels were demonstrated to be directly correlated to reduction of groundwater storage. Therefore, groundwater levels will be used as a proxy to establishing minimum thresholds and measurable objectives rather than attempting to quantify volumes or acceptable rates.

### 9.4.1 *General Conditions*

The entire Tracy Subbasin has been estimated to contain over 42 million acre-feet, (MAF) based on the C2VSIM groundwater model, but only a fraction of this groundwater can be used without potentially creating undesirable results. Based on the same groundwater model, groundwater storage in the Non-Delta Management Area portions of the Subbasin has averaged almost 16 MAF, without creating historic undesirable results, or about 37 percent of the groundwater in the Subbasin.

The average quantity of groundwater extracted during the base period of 2003 to 2013, the sustainable yield, was for just the Non-Delta Management Area was 62,100 AFY (**Chapter 7.7 – Sustainable Yield**). During this period undesirable results, as currently defined, were not observed by the GSAs. Groundwater levels provided in **Appendices G and H** show stable or upward trends in groundwater levels during this period of time.

### 9.4.2 *Undesirable Results*

Significant and undesirable result for the reduction of groundwater storage in the Tracy Subbasin is experienced if groundwater storage volumes are insufficient to satisfy beneficial uses within the Subbasin over the planning and implementation horizon of this GSP.

Significant and undesirable results from chronic lowering of groundwater levels (**Chapter 9.3.2 – Undesirable Results**) were established to protect beneficial users and would create similar undesirable results for change in storage. A long-term reduction of groundwater in storage may result in deepening wells and increases in pumping costs for groundwater users. Undesirable results defined for chronic lowering of groundwater apply and are not repeated.

### 9.4.3 *Criteria Considered to Establish Minimum Thresholds*

The sustainable yield is the total volume of groundwater that can be pumped annually from the basin without leading to undesirable results. The water budget information included in **Chapter 5 – Groundwater Conditions**, was used to establish the sustainable yield for the basin and identify associated groundwater levels. Using groundwater levels as a proxy, the potential groundwater storage minimum thresholds criteria considered were:

- Historical deepest groundwater levels in wells throughout the Subbasin
- Groundwater levels at the start of SGMA, in spring 2015
- Groundwater levels at the end of the drought in fall 2016

- Groundwater levels that protect beneficial uses and users

Criteria selected for reduction in storage were the groundwater levels in the Subbasin that are protective of beneficial uses and users, similar to those for selected for chronic lowering of groundwater levels.

### 9.4.4 *Minimum Thresholds*

The minimum threshold for reduction of groundwater storage is a volume of groundwater that can be withdrawn from a basin or management area, based on measurements from multiple representative monitoring sites, without leading to undesirable results. Contrary to the general rule for setting minimum thresholds, the reduction of groundwater storage minimum threshold is not set at individual monitoring sites. Rather, the minimum threshold is set for the Subbasin or management area (DWR 2017).

The sustainable yield is the total volume of groundwater that can be pumped annually from the basin without leading to undesirable results. The water budget information included in **Chapter 7 – Water Budgets** was used to establish the sustainable yield for the basin and identify associated groundwater levels. Using groundwater levels as a proxy, the minimum thresholds for reduction in storage for the Tracy Subbasin are the same as those developed for chronic lowering of groundwater levels provided in **Table 9-1**.

### 9.4.5 *Minimum Thresholds Effects*

Because the establishment of these minimum thresholds were based on beneficial users, and are similar to historic groundwater levels, there should be no adverse effects on beneficial uses and users, land uses or property interests in the Subbasin.

### 9.4.6 *Relevant State, Federal and Local Standards*

No federal, state, or local standards exist for reduction of groundwater storage.

### 9.4.7 *Measurable Objectives*

The measurable objective groundwater levels for reduction of storage are the same as those developed for chronic lowering of groundwater levels, as provided in **Table 9-1**. Using average historical groundwater levels rather than historic high levels provides an operational margin of safety.

Interim milestones for reduction of storage are the same as those developed for chronic lowering of groundwater levels, as provided in **Table 9-1.**

## 9.5 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator as the nearest occurrence of saline water intrusion into surface waterways is about 20 miles west of the northern Subbasin boundary near the City of Antioch. The Delta has been protected from saline water intrusion for nearly 80 years due to construction of dams and sustained inflow of water to the Delta from the San Joaquin and Sacramento rivers. Seawater intrusion is unlikely to occur during the planning horizon of this GSP.

### 9.5.1 *Undesirable Results*

No locally defined significant and undesirable results for sea water intrusion were developed for the Subbasin.

### 9.5.2 *Minimum Thresholds*

No locally minimum thresholds were developed for sea water intrusion for the Subbasin.

### 9.5.3 *Measurable Objectives*

No locally measurable objectives were developed for sea water intrusion for the Subbasin.

## 9.6 Degraded Water Quality

Groundwater beneficial users in the Subbasin include domestic well owners, agriculture, and municipal entities for drinking water, industrial for manufacturing or processing food, native plants, aquatic species and crop water requirements. Groundwater quality can affect surface water if the groundwater is discharging to surface water and contains high concentrations of nutrients (e.g., nitrate).

### 9.6.1 *General Conditions*

The groundwater quality in the basin is generally adequate to meet the needs of environmental, domestic, municipal, industrial and agricultural uses in the basin. The concentration of the naturally occurring elements varies widely over the Subbasin and also with depth at any given location. Groundwater quality in the Subbasin has locally exceeded the MCLs for drinking water for specific elements, some exceedances are scattered, and some are clustered. Because of the generally poorer groundwater quality surface water is used for most water supplies and groundwater use is small, about 3 percent of the total annual water use in the Subbasin. **Chapter 5.6 – Groundwater Quality**, provide a detailed description of the water quality, concentrations, trends and distribution. Salinity is generally high across the Subbasin and can affect the use of the water for both agricultural and drinking water. Nitrate concentrations are generally low but can be used as an indicator of effects of farming, confined animal operations and septic systems. Boron is present at levels that could affect agriculture.

**Salinity**

Salinity, as represented by TDS, is relatively high in the Subbasin ranging from 82 mg/L to as high as 4,500 mg/L (*see* **Appendix H**) using samples collected by DWR, USGS and from PWS wells. Upward trends are present in 11 out of 56 monitoring and public supply wells (*refer to* **Chapter 5.6.2 - Groundwater Quality Trends**).

TDS has established secondary drinking water MCLs which were established for aesthetic reasons such as taste, odor, and color and are not based on public health concerns. TDS has a recommended drinking water MCL of 500 mg/L, an upper level of 1,000 mg/L and a short-term standard of 1,500 mg/L. TDS tolerance levels for agricultural is generally less than 1,000 mg/L as shown in **Table 9-2.** TDS in the Subbasin is mostly above the recommended MCL in both the Upper and Lower aquifers except for a few areas with good quality water as shown on **Figure 5-19**. TDS in some areas is above the upper MCL but mostly less than the agricultural tolerance levels.

There are over 120 public supply wells in Subbasin that are overseen by the State Water Board's DDW, but currently well construction details are few to be able to sort the data by aquifer. Water purveyors have managed to find aquifers that provide water that is above the recommended secondary MCL of 500 mg/L but below the upper MCL of 1,000 mg/L in most of the Subbasin, but in the City of Lathrop water quality is better and is typically below the recommended MCL. The average TDS in PWS wells in the Subbasin is 766 mg/L. Sources of high salinity are from stormwater runoff from the Coast Ranges, underlying marine sediments, evaporation of shallow groundwater and from agricultural activities.

TDS is monitored in PWS wells under drinking water quality programs administered under the State Water Board's DDW and by the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) and the ILRP.

**Nitrate**

Nitrate concentrations are low in the Subbasin, as shown on **Figure 5-23**, and other than a few wells, nitrate does not appear to be adversely impacting water quality, but upward trends are present in 24 out of 120 monitoring and public supply wells (*refer to* **Chapter 5.6.2 – Groundwater Quality Trends**). The primary drinking water standard is 10 mg/L. Both salinity and nitrates are being managed through existing management and regulatory programs within the Subbasin, such as the CV-SALTS and the ILRP, which focus on improving water quality by managing septic and agricultural sources of salinity and nitrate.

**Boron**

The most prevalent sources of boron in drinking water are from the leaching of rocks and soils, wastewater, and fertilizers/pesticides. In the Non-Delta Management Area, portions of the Upper and Lower aquifers boron commonly exceed 1.0 mg/L. Boron is an unregulated chemical without an established MCL but has a Notification Level of 1.0 mg/L.

Boron is essential to plant growth but may be toxic to many sensitive plants. The agricultural water quality objective for boron in irrigation water is 0.7 mg/L (Ayers and Westcot, 1985). **Table 9-2** provides a summary of the crop types grown in the Subbasin and boron tolerances to irrigation water containing boron. As shown in the table there is no one predominant crop type in the Subbasin.

The average boron concentration from PWS wells used for drinking water is 0.1 mg/L. Upward trends are present in only 3 out of 57 wells (*refer to* **Chapter 5.6.2 – Groundwater Quality Trends**).

Fertilizers and pesticide applications are regulated under the California Department of Pesticide Regulations and use is reported to county agricultural commissioners and CV-SALTS. Naturally occurring sources of boron in the Subbasin is from marine sediments in the Coast Ranges and volcanic rocks potentially imported into the Subbasin as sediments were deposited. Subsurface inflow from the Delta-Mendota Subbasin could also bring boron into the Subbasin.

**Point Source Contamination Sources**

Point-source contamination and plume migration are managed and regulated through a variety of programs by the Regional Water Quality Control Board, Department of Toxic Substances Control, and the EPA. The locations of major contaminant sources are described in **Chapter 6.6.3 – Groundwater Contamination Sites and Plumes**. Through coordination with these agencies and continuing monitoring, the Subbasin GSAs will know if existing regulations are being met or groundwater pumping activities in the Subbasin are contributing to significant and unreasonable undesirable effects related to degraded water quality.

**Table 9-2. Crop Types and Water Quality Tolerance Levels**

| Land Use | Acres | Percent of Subbasin | Salinity Tolerance Levels (mg/L) | Boron Tolerance Levels (mg/L) |
|---|---|---|---|---|
| **Agriculture** | **143,117** | **60.02%** | | |
| Citrus and Subtropical | 477 | 0.20% | 900 | 1.0 |
| Deciduous Fruits and Nuts | 13,604 | 5.71% | 1,000 | 0.5-0.75 |
| Field Crops | 30,374 | 12.74% | 1,100 | 0.75-15.0 |
| Grain and Hay Crops | 9,488 | 3.98% | 1,400 | 0.75-15.0 |
| Idle | 9,688 | 4.06% | | |
| Pasture | 45,246 | 18.98% | | 0.75-15.0 |
| Rice | 75 | 0.03% | 1,700 | 0.75-15.0 |
| Truck Nursery and Berry Crops | 31,065 | 13.03% | | |
| Vineyard | 2,886 | 1.21% | 1,100 | |
| Young Perennial | 213 | 0.09% | | |

Source: TDS values are estimated based on applied irrigation water electrical conductivity values for a 90 percent crop yield potential (Texas A&M AgriLife Extension, 2003, adapted from Ayers and Westcott, 1976).

## 9.6.2 *Undesirable Results*

The GSAs approached definition of undesirable results for water quality and what is considered to be significant and unreasonable, through a discussion of potential undesirable results by the GSAs and along with a workshop to seek stakeholder input.

An undesirable result for degraded water quality in the Tracy Subbasin is experienced if SGMA-related groundwater management activities cause significant and unreasonable impacts to the long-term viability of domestic, agricultural, municipal, environmental, or other beneficial uses over the planning and implementation horizon of this GSP. Undesirable results may result from increases of salinity, nitrate and boron to above upper, secondary or primary drinking water standards, notification limits or agricultural irrigation water quality objectives for crops grown in the Subbasin.

The criteria used to define when and where groundwater conditions cause undesirable results for degraded water quality are the California secondary (Upper) or primary drinking water standards, notification limits or agricultural irrigation water quality objectives, where the groundwater concentrations have not been already exceeded, that prevent the water for being used for drinking water or agricultural purposes.

*Undesirable results, that were determined to be significant and unreasonable for degraded water quality are:*

- *The average TDS concentration in representative monitoring wells increases and exceed the secondary upper drinking water MCL of 1,000 mg/L unless the concentration is already above the MCL*
- *The average nitrate concentration in representative monitoring wells to exceed the primary MCL of 10 mg/L*
- *The average boron concentrations to exceed the Long-Term Health Advisory level of 2.0 mg/L, in representative monitoring wells unless concentrations already are above this level*
- *When concentrations of TDS and nitrate in more than 25% of the representative monitoring wells increase above the MCL, agricultural water objective or Health Advisory level, unless the concentration already have been exceeded*

Other constituents such as arsenic and uranium are scattered occurrences and although may locally affect groundwater quality cannot be managed on a regional basis. Therefore, undesirable results were not considered for these elements.

The potential causes leading to undesirable results would be retainage of salts within the Subbasin due to lowering of groundwater levels and a reduction of storage that could lead to accumulation of salts, nitrate and boron in the Subbasin. If groundwater quality were to reach levels causing undesirable results, effects could include requiring well head water quality treatment and loss of the ability to grow crops resulting in economic burden on domestic well owners and loss of revenue and agricultural jobs. This could cause adverse effects to property values and the regional economy Potential salinization or nitrification of groundwater discharging to the tributaries could cause loss of habitat for GDEs and aquatic species.

### 9.6.3 *Criteria Considered to Establish Minimum Thresholds*

Criteria considered by GSAs and stakeholders for the development of minimum thresholds for groundwater quality are:

- Groundwater quality objectives contained in the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (CVRWQCB, 2018 and subsequent amendments)
- Drinking water quality standards for PWS wells with published primary and secondary MCLs and Notification Levels (as listed in California Code of Regulations, Title 22)
- Irrigation water quality objectives for agricultural vary by crop but generally crop yields are not affected until TDS concentrations exceed 1,000 mg/L as illustrated in **Table 9-2** and when boron exceeds 0.7 mg/L
- Plants and species water quality standards (State Water Board 2017)

The highest beneficial use and water quality protection in the Subbasin is for agricultural, municipal and domestic uses (CVRWQCB 2018) and therefore drinking water regulations were applied to establish measurable objectives, but much of the groundwater in the Subbasin already exceeds these standards. Maintaining salinity concentrations below the drinking water standards (Secondary Maximum Contaminant Level, upper recommended level) would be protective of most agriculture uses, which cover about 60 percent of the entire Subbasin. Using agricultural water quality objectives for boron is more protective of beneficial users than using the drinking water Notification Levels.

### 9.6.4 *Minimum Thresholds*

Salinity (as represented by TDS), nitrate and boron are relatively high in the Subbasin and are the only water quality constituents for which minimum thresholds were established in the Tracy Subbasin. **Table 9-3** provides a listing of the historic concentrations at each representative well along with minimum thresholds. **Appendix O** contains the graphs showing the historic data and selected representative minimum thresholds.

Because water quality varies throughout the Subbasin, the minimum thresholds for degraded groundwater quality also vary throughout the Subbasin. Where concentrations are:

- Below the MCL or agricultural water quality objective, the minimum threshold concentrations were established at the MCL or agricultural water quality objective
- Above the MCL or agricultural water quality objective, minimum thresholds were established at the 10% higher than the maximum concentrations historically found representative monitoring wells. The increase of 10% above the historical levels was developed based on uncertainty in concentrations and in some cases due to only one sample being obtained

This approach was taken because maximum historical concentrations at representative wells were used due to most wells having concentrations already above the MCLs or Notification Levels and would be consistent with the State Water Board Anti-degradation Policy (State Water Board 1968) which is to preserve water quality at the observed levels, even when these levels are above the MCL.

It should be noted that wells SJCDW00032 and SJCDW00034 have only one measurement, and therefore both the historic maximum and minimum concentrations are the same.

Minimum thresholds may need to be adjusted in the future, after more samples are analyzed and a more representative dataset is acquired. The approach to setting the minimum thresholds for these wells were established using the same approach described above.

Concentrations will be obtained and evaluated from the State Water Board GAMA database website.

### 9.6.5 *Minimum Thresholds Effects*

The practical effect of the degraded groundwater quality undesirable result is that it may reduce or limit the potential uses for groundwater to meet the beneficial users or land uses.

Groundwater quality minimum thresholds for adjacent subbasins are provided in **Table 9-3** for comparison to those established for the Tracy Subbasin. Because of the highly variable water quality in adjacent subbasins, the concentrations selected in those subbasins are higher than those selected for the Tracy Subbasin. Subsurface inflow from these adjacent subbasins, based on groundwater contours provided in **Chapter 5 – Groundwater Conditions**, and with their higher concentrations could affect minimum thresholds in the Tracy Subbasin, which may require future revisions of the water quality minimum thresholds.

### 9.6.6 *Relevant State, Federal and Local Standards*

Th degraded groundwater quality MTs specifically incorporate state drinking water standards.

### 9.6.7 *Measurable Objectives*

The measurable objectives for degraded water quality were established at the maximum concentration at each representative monitoring well, with the goal of maintaining, to the extent possible, groundwater quality at its current concentrations. This approach is being conservative and consistent with State Water Board Anti-degradation Policy, rather than using the average of all concentrations.

**Table 9-3** provides a listing of the historic concentrations at each representative well and selected measurable objectives. **Appendix O** contains the graphs showing the historic data and selected representative minimum thresholds and measurable objectives.

Interim milestones were set at the current concentrations for TDS, nitrate and boron to maintain water quality in the Subbasin, as shown in **Table 9-3**. As such, the concentrations are likely to be maintained over the planning horizon and allow for some operational flexibility to allow concentrations to increase by up to 10%. This approach was also taken by adjacent subbasins with available information.

## Table 9-3. Minimum Thresholds and Measurable Objectives – Water Quality

| PWS Code | Local Name | TDS (Secondary Upper MCL = 1,000 mg/L) Historical Maximum (mg/L) | Historical Minimum (mg/L) | Selected MTs (mg/L) | Selected MOs (mg/L) | Nitrate (mg/L) (Primary MCL = 10 mg/L) Historical Maximum (mg/L) | Historical Minimum (mg/L) | Selected MTs (mg/L) | Selected MOs (mg/L) | Boron (Irrigation Objective 0.7 mg/L) Historical Maximum (mg/L) | Historical Minimum (mg/L) | Selected MTs (mg/L) | Selected MOs (mg/L) | MO Interim Milestones (TDS, Nitrate, Boron) Year 5 (mg/L) | Year 10 (mg/L) | Year 15 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Upper Aquifer Wells** | | | | | | | | | | | | | | | | |
| | SJCDW00032 | 1100 | 1100 | **1210** | **1100** | 7.8 | 7.8 | **10** | **7.8** | 3.8 | 3.8 | **4.2** | **3.8** | **1100, 7.8, 3.8** | **1100, 7.8, 3.8** | **1100, 7.8, 3.8** |
| | SJCDW00034 | 1200 | 1200 | **1320** | **1200** | 13.0 | 13.0 | **14** | **13** | 0.9 | 0.9 | **1.0** | **0.9** | **1200, 13, 0.9** | **1200, 13, 0.9** | **1200, 13, 0.9** |
| 3910015-005 | WELL 06 | 470 | 350 | **500** | **470** | 6.3 | 2.6 | **10** | **6.3** | 0.2 | 0 | **0.7** | **0.2** | **470, 6.3 , 0.2** | **470, 6.3 , 0.2** | **470, 6.3 , 0.2** |
| **Lower Aquifer Wells** | | | | | | | | | | | | | | | | |
| 3910702-006 | WSW009 | 733 | 460 | **1000** | **733** | 2.0 | <1.0 | **10** | **2.0** | 1.5 | 0.3 | **1.7** | **1.5** | **733, 10, 1.5** | **733, 10, 1.5** | **733, 10, 1.5** |
| 3910011-003 | PRODUCTION WELL 01 | 910 | 728 | **1000** | **910** | 4.6 | <1.0 | **10** | **4.6** | 2.6 | 2.3 | **2.9** | **2.6** | **910, 10, 2.6** | **910, 10, 2.6** | **910, 10, 2.6** |
| 3910011-018 | WELL 04R -NEW LINCOLN | 850 | 740 | **1000** | **850** | 3.0 | <1.0 | **10** | **3.0** | 1.3 | 1.2 | **1.4** | **1.3** | **850, 10, 1.3** | **850, 10, 1.3** | **850, 10, 1.3** |
| 3910011-032 | PRODUCTION WELL 06 | 760 | 538 | **1000** | **760** | 1.3 | 0.7 | **10** | **1.3** | 1.4 | 0.9 | **1.5** | **1.4** | **760, 10, 1.4** | **760, 10, 1.4** | **760, 10, 1.4** |
| 3910011-034 | PRODUCTION WELL 07 | 830 | 290 | **1000** | **830** | 1.9 | 0.4 | **10** | **1.9** | 1.8 | 0.45 | **2.0** | **1.8** | **830, 10, 1.8** | **830, 10, 1.8** | **830, 10, 1.8** |
| **Upper Aquifer Wells - Delta Mendota Subbasin** | | | | | | | | | | | | | | | | |
| | 06-004 | | | **4000** | **4000** | | | **80** | **80** | | | **3.0** | **3.0** | Current groundwater quality | | |
| **Lower Aquifer Wells - Delta Mendota Subbasin** | | | | | | | | | | | | | | | | |
| | 01-007 | | | **2000** | **2000** | | | **50** | **50.0** | | | **3.0** | **3.0** | Current groundwater quality | | |
| | 04-001 | | | **4000** | **4000** | | | **70** | **70.0** | | | **0.7** | **0.6** | Current groundwater quality | | |

Notes: Interim milestones for degraded water quality are set for years 5 through 15 to maintain current groundwater quality.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wells - Eastern San Joaquin Subbasin** | | | | | | | | | | | | | | | | |
| | Well 16 | | | **280** | **600** | | | | | | | | | **360** | **440** | **520** |
| | Stockton SSS-8 | | | **370** | **600** | | | | | | | | | **427** | **485** | **543** |

Notes: Only one principal aquifer defined. Lower aquifer not defined in this Subbasin.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Upper Aquifer Wells - East Contra Costa Subbasin** | | | | | | | | | | | | | | | | |
| | No wells near boarder | | | **1000** | **---** | | | **10** | **---** | | | **5** | **---** | | | |
| | | | | | | | | | | | | | | | | |
| **Lower Aquifer Wells - East Contra Costa Subbasin** | | | | | | | | | | | | | | | | |
| | None | | | **---** | **---** | | | **---** | **---** | | | **---** | **---** | | | |
| | | | | | | | | | | | | | | | | |

Notes: MOs = average concentrations 2013 to 2017

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# 9.7 Land Subsidence

Historical land surface subsidence within the Non-Delta Management Area of the Subbasin has been minimal except for in the southern portions of the Tracy Subbasin and northern portions of the Delta-Mendota Subbasin as discussed in **Chapter 5.8 – Subsidence**. Because the Tracy Subbasin and Delta-Mendota Subbasin interfinger, minimum thresholds and measurable objectives from the Northern & Central Delta-Mendota Region GSP (Woodard and Curran, 2019) were reviewed, and applicable portions were documented in this section.

## 9.7.1 *General Conditions*

Subsidence is currently being monitored by satellite-based surveys (InSAR), benchmark surveys along the Delta-Mendota canal and a continuous recording global position radar station (CGPS) established for plate boundary observations.

In the San Joaquin Valley, where the Corcoran Clay is present, lowering of groundwater levels due to pumping below the clay has resulted in large amounts of subsidence (up to about 30 feet). The Corcoran Clay is present in much of the Non-Delta portions of the Subbasin. Therefore, the subsidence could occur in the Subbasin.

The highest rates of subsidence, based on satellite data, are within in the Delta portions of the Subbasin and is due to oxidization of peat, not due to lowering of groundwater levels. Some high rates are also present in the Non-Delta Management Area, near the margins of the Delta and are likely due to peat layers in these areas based on NASA JPL satellite data.

Groundwater levels in the Lower aquifer in the Tracy Subbasin are above the Corcoran Clay reducing the potential for subsidence. Groundwater levels below the Corcoran Clay are stable and rising in most areas other than in the southern area of the Subbasin (area where Delta-Mendota Subbasin interfingers with Tracy Subbasin) and where groundwater levels may have (measured in wells not fully sealed just within the Lower aquifer) declined but only by up to 15 feet.

In this southern area, according to the Northern and Central Delta-Mendota Region GSP, minimal land subsidence has previously been observed in the West Side Irrigation District-Patterson Irrigation District Management Areas (WSID-PID MA). Both WSID and PID receive sufficient surface water supplies via the San Joaquin River and the CVP to meet demands within the districts, meaning Lower aquifer groundwater pumping (which may result in inelastic land subsidence) within this management area is minimal (Woodard & Curran 2019). As shown on **Figure 5-38**, subsidence along the canal was 1.27 feet, outside of the Subbasin but near the boundary with the Northern & Central Delta-Mendota Region GSP (Woodard and Curran 2019), using data from the San Luis Delta-Mendota Water Authority and also up to -1.28 feet over a 5-year period based on InSAR data.

Satellite-based surveys (NASA JPL) of the Central Valley from May 2015 to September 2016 showed 0.07 to 0.8 feet subsidence occurred in about 16 months, or an annual rate of about 0.06 to 0.5 feet per year, (*refer to* **Figure 5-39**).

InSAR data showed low rates of annual subsidence, within the instrument and processing error factor of the dataset, but after 5 years the data showed potential subsidence, which exceeded the error factor near the southern margin of the Subbasin and is likely real. Groundwater levels in the area have only declined by about 15 feet in that area suggesting it may not be related to groundwater pumping. Two new monitoring wells are proposed for that area.

At the plate boundary station (*refer to* **Figure 5-39**) during the drought, between 2012 and 2016, groundwater levels declined by about 15 feet, but were still above historic low levels, and there was an apparent subsidence of about 0.04 ft/yr. It is possible the subsidence was due to a delayed reaction caused by lowering of groundwater levels between 2006 and 2009. The slight change in groundwater levels, especially when they are not lowering groundwater levels below the Corcoran clay does not suggest the decline in levels are related to subsidence due to groundwater pumping.

**Table 9-3** provides a summary of the historic rates of subsidence in the Subbasin along with minimum thresholds and measurable objectives established in adjacent basins. It shows the variance of subsidence estimates based on the various methods.

**Table 9-3. Rates of Subsidence**

| Source | Historical Rate of Subsidence (ft/yr) | Selected Subsidence Rates | | MO Interim Milestones (rates of subsidence ft/yr) | | | |
|---|---|---|---|---|---|---|---|
| | | MT Rate of Subsidence (ft/yr) | MO Rate of Subsidence (ft/yr) | Year 5 | Year 10 | Year 15 | Year 20 |
| **PBO Station (P257) Subsidence Rates** | | | | | | | |
| 2006 to 2012 | 0 | | | | | | |
| 2014 to 2015 | -0.04 | | | | | | |
| 2006 to 2020 | -0.03 | | | | | | |
| **Satellite-Based Subsidence Rates** | | | | | | | |
| May 2015 to Sep 2016 | -0.08 to -0.70 | | | | | | |
| **InSAR Subsidence Rates in Tracy Subbasin** [2] | | | | | | | |
| January 2015 to January 2016 | +0.014 to -0.025 | -0.03 | -0.03 | -0.03 | -0.03 | -0.03 | -0.03 |
| January 2015 to October 2020 | +0.006 to -0.128 | | | | | | |
| **Delta-Mendota Canal Benchmarks in Tracy Subbasin** | | | | | | | |
| 1984-2018 | -0.21 to -0.71 | | | | | | |
| **Delta-Mendota Canal Benchmarks in Delta-Mendota Subbasin** [1] | | | | | | | |
| 01-010 (Subsidence Monitoring Point #1) | -0.13 | -0.13 | -0.11 | -0.12 | -0.12 | -0.11 | |
| 01-013 (Subsidence Monitoring Point #4) | -0.13 | -0.13 | -0.11 | -0.12 | -0.12 | -0.11 | |

Notes: 1 = From Northern & Central Delta-Mendota Subbasin GSP
2 = The estimated error in the InSAR data is 0.1 foot

### 9.7.2 *Undesirable Results*

**Figure 5-37** show the locations of some of the infrastructure (canals and highways) in the Subbasin that could be affected by subsidence. Over 60 percent of the land use in the area is agriculture, as shown on **Figure 3-6,** which would not be significantly impacted by subsidence, but may require releveling of fields and deepening of earthen canals.

The criteria used to define significant and undesirable results for subsidence (due to groundwater extractions) are:

- The ability to deliver surface water supplies in the Delta-Mendota Canal and California Aqueduct
- Impacts to sewer and storm drains preventing proper drainage
- Replacement of pavement on Highway 580 and Interstate 5 due to cracking induced by subsidence
- Lowering of levee crowns adjacent to rivers allowing flooding to occur

*For the Tracy Subbasin, undesirable results would be an increase from historic rates of subsidence (refer to **Table 9-3**) in the Non-Delta Management Area caused by lowering of groundwater levels that impacts infrastructure.*

Potential causes that may create these undesirable results could be from groundwater pumping below the Corcoran Clay resulting in groundwater levels dropping below historic lows which may result in inelastic land subsidence.

The potential effects of this undesirable result occurring would be cracking of road pavement, damage to buildings, cracking and loss of capacity in the Delta-Mendota canal and California Aqueduct and flooding which could all affect property values.

### 9.7.3 *Criteria Considered to Establish Minimum Thresholds*

There are multiple sources of data (satellite-based surveys, benchmark surveys along the Delta-Mendota canal and a continuous recording global position radar established for plate boundary observations) that could be used to evaluate subsidence and establish minimum thresholds. The InSAR tool is currently the only tool available which provides Subbasin wide subsidence consistently each year.

Criteria considered for development of subsidence minimum thresholds include:

- Subsidence data across the entire Subbasin and not at just single points
- Timely availability of data to assess if undesirable results may occur
- Other information that can be used to evaluate if subsidence is due to groundwater pumping
- Acknowledgement that inelastic subsidence is occurring in the Subbasin due to natural conditions (oxidization of peat, plate tectonics) and that is not necessarily related to groundwater extraction

### 9.7.4 *Minimum Thresholds*

The minimum threshold for land subsidence in the Subbasin is set at nor more than -0.03 feet (rounded up from -0.025 feet observed in 2015-2016) in any single year (October 1 – October 1 to match the water year) and a cumulative -0.13 feet in any 5-year period, similar to historic subsidence levels. The cumulative amount would exceed the estimation error in the InSAR data of 0.1 foot and would therefore be valid. The InSAR tool is currently the only tool available which provides Subbasin wide subsidence consistently each year.

The InSAR subsidence dataset will be used by the Subbasin GSAs annually (October 1 – October 1 to match the water years) to evaluate this sustainability criteria. Should the InSAR data indicate subsidence greater than the minimum threshold then a review of CPGS data and groundwater elevations will be performed to confirm that subsidence has occurred and if it is related to groundwater pumping. As necessary, benchmarks canal alignment along the Delta-Mendota canal alignment and the City of Tracy benchmarks may also be resurveyed.

### 9.7.5 *Minimum Thresholds Effects*

Staying above the minimum threshold will avoid the subsidence and undesirable results and protect the beneficial uses and users in the Tracy Subbasin from impacts to infrastructure and interference with surface land uses.

Based on information provided in **Table 9-3**, annual subsidence rates selected by the Delta-Mendota Subbasin are higher than in the Tracy Subbasin. The minimum thresholds in the Tracy Subbasin are more conservative and should have no adverse effects on the Delta-Mendota Subbasin.

### 9.7.6 *Relevant State, Federal and Local Standards*

No federal, state, or local standards exist for land subsidence.

### 9.7.7 *Measurable Objectives*

The guiding measurable objective of this GSP for land subsidence in the Subbasin is the maintenance of subsidence rates as present at the start of SGMA, at less than -0.25 feet/year. The measurable objective avoids significant and unreasonable rates of land subsidence in the Subbasin, which could lead to permanent subsidence that impacts infrastructure and agricultural production. As this subsidence measurable objective is essentially already being met, the specific goal is to maintain this level of land subsidence, through the GSP implementation.

The measurable objective established by the Northern and Central Delta-Mendota Region GSP, in the fingered areas with the southern portions of the Tracy Subbasin, "…is set as no loss in distribution capacity as a result of subsidence resulting from groundwater pumping. Numerical values for this criterion to be determined based on data collection between 2020 and 2025." Measurable objectives and interim milestones as rates of depletion were set at benchmark stations along the canal and are provided in **Table 9-3**.

Interim milestones are the same as the current rate of subsidence based on InSAR data and are likely to be maintained due to the low groundwater pumping in the Subbasin.

## 9.8 Depletion of Surface Water

Depletions of surface water are a reduction in flow or levels of surface water caused by groundwater extraction. The reduction in surface water flow or levels, at certain magnitudes or timing, may have adverse impacts on beneficial uses of surface water and related resources, and could lead to undesirable results.

The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of surface water and may lead to undesirable results (CCR, 2016). An equally effective tool is to use groundwater levels as a proxy to surface water depletion rates or volumes. By lowering of groundwater levels, the gradient away from rivers increases and so does the depletion from the river. Using groundwater levels to assess surface water depletion is an equally effective method.

### 9.8.1 *General Conditions*

Beneficial users in the Subbasin have reliable good quality surface water supplies. Overall, there are limited numbers of agricultural or municipal groundwater wells near the rivers that could lower groundwater levels and increase surface water depletion because most growers in these areas have surface water riparian rights. As shown on **Figure 3-13**, most agricultural wells are at least 2 miles from the rivers and waterways. Municipal supply wells, shown on **Figure 3-16** are also removed from the waterways by 1 to 2 miles. Surface water in the rivers and waterways are controlled by releases of water from dams to maintain salinity intrusion in the rivers near Antioch.

Interconnected surface water refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.

Creeks in the Subbasin, from the foothills to the rivers, are seasonal, only flowing after rains and therefore are not connected by a continuous saturated zone to the principal aquifers (*refer to* **Chapter 5.9 – Interconnected Surface Water**), except for potentially Mountain House Creek. Along the San Joaquin and Old rivers and waterways, hydrographs of wells and surface water gaging stations were shown to correlate and therefore the surface water in these rivers and waterways are hydraulically connected to the principal aquifers (*refer to* **Figure 5-41**). Water in the rivers and sloughs are from reservoir releases that the GSAs cannot control, with minor contribution from groundwater in comparison to the total flow in the rivers and sloughs.

Historical and future surface water depletion were evaluated using a groundwater model (*refer to* **Chapter 7 – Water Budgets**). The groundwater model for projected with climate change suggests that surface water depletion will increase (combination of increased surface water inflow and a decrease of surface water discharges). As discussed in this chapter there are some uncertainties in the model (**Chapter 7.8 – Opportunities for Improvements**) that once resolved may reduce this projected surface water depletion. Until the groundwater model and water budget are validated the amount of projected surface water depletion cannot be relied upon and minimum thresholds and measurable objectives were established near historic levels.

Because the Corcoran Clay may not extend entirely across the Subbasin, the Lower aquifer pumping could potentially deplete surface water in the Delta management area where the Upper and Lower aquifers are hydraulically connected. Therefore, minimum thresholds and measurable objectives using groundwater levels at representative monitoring wells (in the Non-Delta Management Area) will be established for the Lower aquifer.

As illustrated in **Chapter 5 – Groundwater Conditions**, for the Upper aquifer, groundwater levels near the rivers fluctuate with river stage levels and therefore groundwater levels can be used as a proxy to determine the rate or volume of surface water depletion.

### 9.8.2 *Undesirable Results*

Depletions of interconnected surface water significant and undesirable results were developed based on available technical information included in the draft GSP, input to the Sustainable Management Criteria Worksheet, a public meeting, and discussions with GSA staff. In discussions of interconnected surface water, GSA staff and stakeholders did not indicate any observed undesirable results from historical depletions.

The criteria used to define significant and undesirable result for depletions of interconnected surface water in the Tracy Subbasin are:

- Rivers dry up and cannot support aquatic species, water supply and recreation.
- Allow saline water to intrude into waterways in the Tracy Subbasin, allowing for recharge of degrade water quality to the aquifers
- Increased surface water depletion that would require additional releases of surface water from dams or a reduction of surface water diversions in order to repel saline water
- If groundwater extraction resulted in a depletion of surface water that causes significant impacts to aquatic species or wildlife

The potential causes of increased surface water depletion are an increase of groundwater pumping and lowering of groundwater levels near the surface water bodies leading to additional surface water depletion.

*Significant and undesirable results would be if groundwater levels in 25 percent of the representative wells in normal years, excluding drought years, would decline below the minimum thresholds for 2 consecutive years.*

If depletions of interconnected surface water were to reach levels causing undesirable results, effects could include reduced flow and stage within rivers and streams in the Subbasin to the extent that insufficient surface water would be available to support diversions for agricultural or urban uses or to support regulatory environmental requirements. This could result in increased groundwater production, changes in irrigation practices and crops grown, and could cause adverse effects to property values and the regional economy. Reduced flows and stage, along with potential associated changes in water temperature, could also negatively impact aquatic species in the rivers and streams. Such impacts are tied to the inability to meet minimum flow requirements, which are defined for the San Joaquin River, which in turn, are managed through operations of multiple reservoirs and would have far greater effect on flows than groundwater discharges.

### 9.8.3 *Criteria Considered to Establish Minimum Thresholds*

Criteria considered by the GSAs and stakeholders to establish minimum thresholds were:

- Timely availability of data to assess if undesirable results may occur (groundwater modeling or measurements of groundwater levels)

- Most wells only have semi-annual measurements limiting the ability to fully assess the groundwater lows that may occur in the spring and summer months when groundwater pumping would be at its maximum
- Setting minimum thresholds near the river but also inland to develop gradients
- Selection of minimum thresholds at the historical low groundwater levels or in 2015 near the end of the recent drought
- Depletion of surface water by lowering of groundwater levels could also affect GDEs

### 9.8.4 *Minimum Thresholds*

This GSP uses historic low groundwater levels as a proxy to establish minimum thresholds for the depletions of interconnected surface water and as the sustainability indicator as groundwater levels have been confirmed to react similarly to river stages (*see* **Section 5.9. Interconnected Surface Water**). **Table 9-1** lists the minimum thresholds at representative monitoring wells in both the Upper and Lower aquifers. The minimum thresholds rely on historic fall measurements with allowance for one foot of additional decline until there are sufficient monthly measurements to better quantify the range of groundwater levels. As shown in the table, selected groundwater levels in the Upper aquifer are similar to those selected for GDEs.

In the unlikely event that groundwater level minimum thresholds are exceeded, groundwater gradients calculated by using up to three monitoring wells will be used to assess if the gradient exceeds historical ranges. Calculation of gradients can be used as a proxy to groundwater levels as long as the rivers remain in constant hydraulic communication with the groundwater. If the gradients are steeper this could lead to undesirable results. **Table 9-4** lists the groundwater gradients based on available data.

Every 5 years the groundwater model will be run and estimates of annual rates and volumes of surface water depletion will be developed and compared to historical data to confirm that maintaining groundwater levels at the established minimum thresholds has indeed not increased surface water depletions significantly.

### 9.8.5 *Minimum Thresholds Effects*

Based on this input, this GSP assumes that historical conditions are protective of beneficial uses related to interconnected surface water. If groundwater levels were to fall lower than historical levels, there is an associated level of additional depletions that could occur which could affect aquatic species. The increase in surface water depletion would not affect property interests.

**Table 9-4. Groundwater Gradients**

| Date | River Stage (ft msl) | Groundwater Elevation (ft msl) | Groundwater Elevation (ft msl) | Groundwater Elevation (ft msl) | Approximate Hydraulic Gradient (ft/ft) | Flow Direction (Degrees) | Toward or Away from River |
|---|---|---|---|---|---|---|---|
| | ODM [2] | ORL-1W | 01S04E31P005M [1] | ---- | | | |
| 9/20/2019 | 0.88 | | 42.36 | | 0.0038 | | Toward |
| 10/24/2014 | 0.88 | | 47.72 | | 0.0043 | | Toward |
| | OLD | 01S05E31P002M | 02S05E08B001M | ---- | | | |
| 10/19/2011 | 5.9 | 0.9 | -1.2 | | 0.0016 | 225 | Away |
| 10/18/2017 | 3.4 | 0.6 | -2.3 | | 0.0009 | 206 | Away |
| | MSD [2] | Well N | Glori MW-2 | MW-102 (Proposed) | | | |
| 10/18/2018 | 5 | 6.0 | | | 0.0005 | | Away |
| 10/4/1960 | 5 | 19.63 | | | 0.0069 | | Away |
| | ---- | MW-6B | MW-1B | MW-5B | | | |
| 10/6/2014 | | -45.85 | -52.05 | -41.35 | 0.0007 | 266 | Away |
| 2/25/2016 | | -18.84 | -21.15 | -18.64 | 0.0002 | 234 | Away |

Notes: 1 = Only 11 measurements available to estimate range, none at same date as ORL-1W.
2= Approximate surface water elevation at time of groundwater level measurement

### 9.8.6 *Relevant State, Federal and Local Standards*

No federal, state, or local standards exist for surface water depletion.

### 9.8.7 *Measurable Objectives*

As groundwater levels are being used as a proxy for depletions of interconnected surface water, the measurable objectives and interim milestones for the depletions of interconnected surface water are the same as the measurable objectives developed for the chronic lowering of groundwater levels developed to be protective of GDEs, as listed in **Table 9-1**. Using average historical spring groundwater levels (2010 through 2020) rather than historic spring low levels provides a margin of safety.

Interim milestones for surface water depletion are the same as those developed for chronic lowering of groundwater levels, as provided in **Table 9-1.**

## 9.9 Effect of Minimum Thresholds on Neighboring Subbasins

As displayed throughout this chapter minimum thresholds established by the Tracy Subbasin are not expected to produce adverse effects on adjacent subbasins as the minimum thresholds established are similar to historic levels and are more conservative than in adjacent subbasins.

The Subbasin coordinated with the Northern & Central Delta-Mendota Region GSP technical team to attempt to resolve whether groundwater in the Lower aquifer is flowing from the Subbasin into the Delta-Mendota Subbasin or the reverse. This GSP performed a detailed examination of several wells being used by the Delta-Mendota subbasin for their contouring and based on construction details, that the groundwater levels were similar to Upper aquifer levels, and that the use of these wells created a sharp decline of groundwater levels in the Lower aquifer at the Subbasin boundary this GSP did not use these wells measurements for contouring purposes. As a result, this approach, there is a discrepancy of whether subsurface inflow is to or from the Delta-Mendota subbasin but should be resolvable once new dedicated monitoring wells are constructed. The minimum threshold established by the Subbasin maintain groundwater levels near historic levels and should not affect the inflow or outflow from the Delta-Mendota subbasin.

The Subbasin also coordinated with the Eastern San Joaquin subbasin where that subbasin is projecting for an additional 6,000 AFY of subsurface outflow from the Subbasin. Additional modeling in the Eastern San Joaquin subbasin is needed to evaluate where this additional subsurface outflow is occurring and whether this subsurface outflow may affect the minimum threshold established by the Subbasin. Once identified and along with suggested improvements to the C2VSim-FG_v1.0 model, minimum threshold effects will need to be re-evaluated during the 5-year update.

Currently, minimum thresholds in the Eastern Contra Costa subbasin were not available to evaluate potential effects from those established by the Subbasin.

As discussed in **Chapter 11 – Notices and Communications**, the Subbasin plans to continue to coordinate with adjacent subbasins during implementation of the GSPs. BBID and County Subbasin GSAs also have representatives in two of the surrounding subbasins making this coordination and communication easy.

# 10. Projects and Management Actions

Projects and management actions were selected by the GSAs for implementation to meet measurable objectives by 2042 and to maintain groundwater levels above minimum thresholds. The Subbasin Non-Delta Management Area is projected to have a deficit of about 700 AFY based on projected changes in the Subbasin including climate change forecasted for 2065. Assessing the deficit by principal aquifer has shown the Upper aquifer has a deficit of about 800 AFY while the Lower aquifer is in surplus by 100 AFY. Because the aquifers are so close to being in balance and within the uncertainty of the model, projects are proposed for both aquifers. The project selected is to augment water supplies to resolve chronic lowering of groundwater levels and change in storage in the Upper aquifer. Management actions have been selected to limit the potential to increase surface water depletion with additional benefits towards GDEs.

## 10.1 Groundwater Management

The GSAs have been managing their groundwater and surface water resources for decades through development of UWMP plans, AWMPs, and General Plans. Below are some highlights of these activities:

- The City of Tracy has planned and constructed recycled water pipeline infrastructure, including recycled water transmission pipelines and pump stations, to provide recycled water to parks, professionally managed landscape areas, and other non-potable uses. The pipeline will eventually be extended to connect to the Central Valley Project Delta Mendota Canal. The recycled water pipeline and pump stations have been constructed but a permit has not yet to be obtained to use and distribute the recycled water. The City of Lathrop has planned and constructed advanced wastewater treatment and recycled water infrastructure to provide recycled water to new development areas for parks, streetscapes, and other non-potable uses to reduce groundwater pumping
- Both the cities of Tracy and Lathrop obtained contracts for SSJID surface water to augment their water supplies and reduce groundwater pumping
- Both the cities of Tracy and Lathrop have improved water efficiency by requiring new developments to have low flow toilets and other water conservation measures
- The City of Tracy has been implementing ASR at one well of nine wells for nearly 10 years
- Many agricultural users have converted from flood irrigation to drip irrigation to use water supplies more efficiently
- The County an approved Proposition 218 tax for benefiting groundwater management

These management activities were incorporated into the water budgets if the activities were identified in the current UWMP, AWMPs, and General Plans and have already been implemented. Projects and management actions presented in this chapter are those that have evolved since the latest publication (prior to 2020) of these plans.

## 10.2 List of Projects and Management Actions

The GSAs created a list of 18 initial projects that were refined to the current list that could be implemented to resolve shortfalls in either the Upper or Lower aquifers. These projects or the ones contained in **Table 10-1** were not listed in the Westside-San Joaquin Integrated Regional Water Management Plan (Woodard and Curran 2019). Each GSA member agency listed as the Owner will manage the permitting, design, and construction and operation of the project or management action shown on **Table 10-1** along with their measurable objectives, potential implementation timeline, groundwater recharge potential, and estimated costs. The location of the projects is illustrated on **Figure 10-1**.

**Table 10-1 Projects and Management Actions**

| Project or Management Action No. | Owner | Project or Management Action Description | Potential Implementation Time (yrs) | Measurable Objective | Potential Recharge (AFY) | Potential Cost |
|---|---|---|---|---|---|---|
| **Projects** | | | | | | |
| P1 | BCID | Conjunctive Use - Expansion of distribution facilities to provide surface water to areas previously reliant on groundwater. Benefits Upper Aquifer. | 2023-2030 | Chronic Lowering of Groundwater Levels | 1,000 | $1,500,000 |
| **Management Actions** | | | | | | |
| MA-1 | County | Modify Well Ordinance - 1) Create surface water depletion protection zones near rivers and sloughs. Minimum sanitary seal and screen depth requirements to limit direct interconnection to surface water. Benefits Upper Aquifer and potentially to GDE's. 2) Well spacing requirements for high-capacity irrigation or municipal wells from domestic wells. Benefits domestic well owners. | 2023-2025 | Surface Water Depletion | | $20,000 |

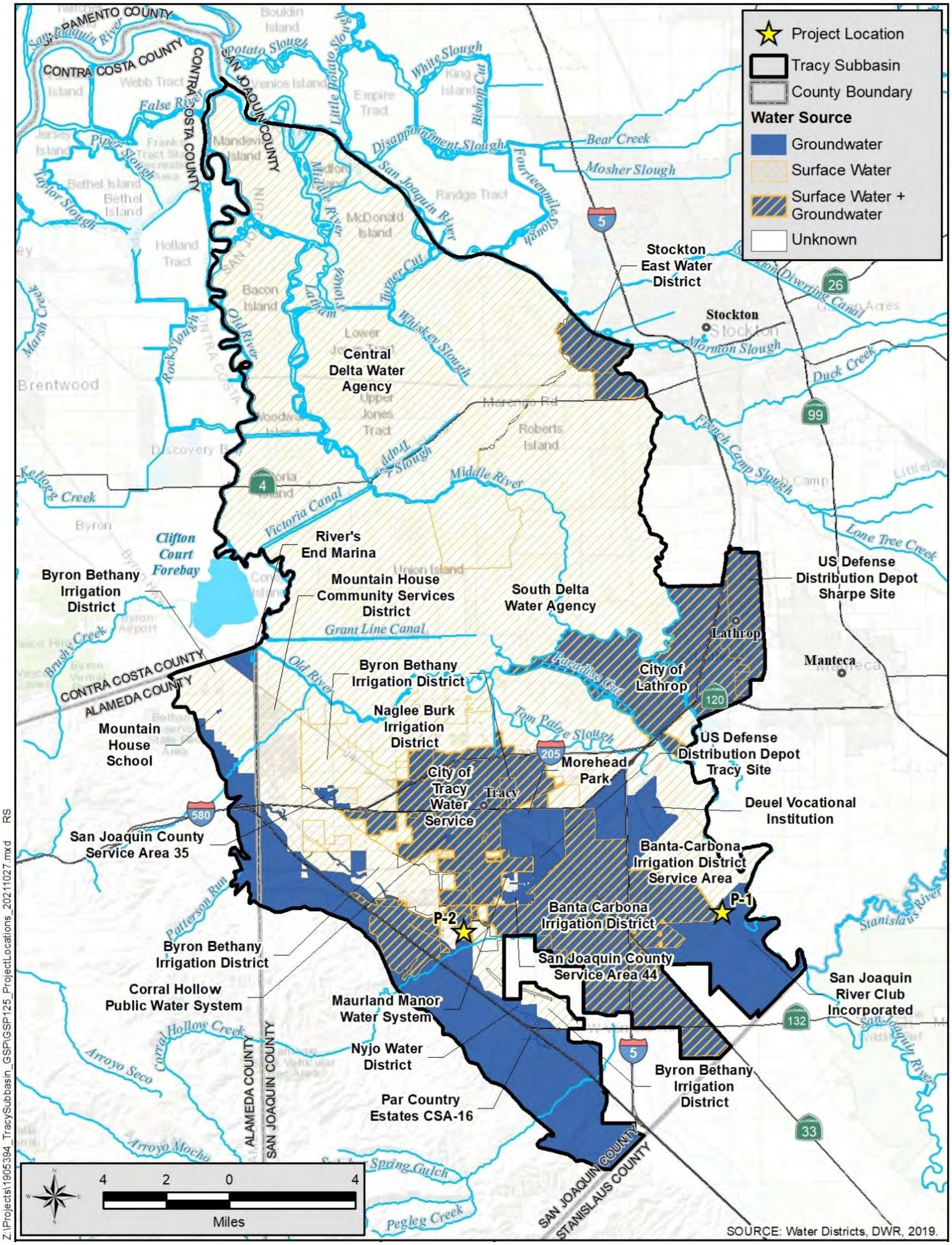

**Figure 10-1 Locations of Projects**

### 10.2.1 *Project 1: Reduction of Groundwater Pumping*

Project Description: This project will consist of expansion of the BCID distribution facilities to provide surface water to up to about 500 acres of agricultural land that is currently solely reliant on groundwater. The project requires construction of new lateral pipelines, establishment of new turnouts to deliver water to the agricultural properties, and enlargement of a pump station tied to an existing main lift canal.

Measurable Objective Expected to Benefit: This project addresses chronic lowering of groundwater levels in the Subbasin by reducing groundwater pumping by up to 1,000 AFY.

Project Status: The expansion of the distribution facilities project is currently under review by BCID Board of Directors. Construction is expected to begin in 2023 and be completed by 2030.

Permitting and Regulatory Process: Permitting for the project is on-going. Required permits and approvals will be obtained prior to the project starting construction.

Public Noticing: This project is on the agenda of the monthly BCID Board meetings which occur on a monthly basis and all meetings are open to the public. All Board meeting Agendas are publicly noticed in accordance with the Ralph M. Brown Act (Brown Act).

Timetable for Implementation: Completion of construction is anticipated to occur by about 2030.

Expected Benefits and Evaluation: This project is anticipated to reduce groundwater demand by up to 1,000 AFY in an area adjacent to BCID service area and within 3 miles of the San Joaquin River. Benefits are expected to accrue for 50 years or more as the area is as defined by San Joaquin County General Plan is agriculture. Benefits to groundwater levels will be evaluated by quantifying the volume of surface water delivered.

Potential Impacts: The existing groundwater supply will be replaced with surface water delivered through a pressurized pipeline which will allow growers to use highly efficient drip irrigation which will limit overapplication of water and deep percolation to the groundwater. Therefore, the potential impacts are less than significant when considering potential changes to water quality and affecting domestic well owners.

How the Project will be Accomplished: BCID will be the owner and use construction contractors, engineers, and consultants to construct the project.

Legal Authority: BCID is a public special district formed under California law and has pre-1914 water rights to draw water from the San Joaquin River to serve the lands on the westerly side of the San Joaquin River.

Estimated Costs and Funding Plan: Estimated costs to build the pumping plant and pipeline to 500 acres is approximately $1,500,000. Grants will be applied for and the landowners in the project area will provide the cost share portion of any grants awarded. GSAs may also contribute funding.

Circumstances for Implementation: This project is in the planning process and is anticipated to move forward once grant funds are secured.

Trigger for Implementation and Termination: The trigger for implementation is when funds have been secured for design and construction of the project.

Process for Determining Conditions Requiring the Project to Occur: This is a project in the planning process that is anticipated to move forward.

### 10.2.2 *Management Action 1: Modify Well Ordinance*

Management Action Description: This management action may consist of revising the existing San Joaquin County Well Ordinance to create surface water protection zones near rivers, canals, and sloughs in the Non-Delta Management Area. Minimum sanitary seal and screen depth requirements will be developed to limit wells from using shallow aquifers directly connected to surface water. The project will require development of technical information to support the development of protection zones and modification of the Well Ordinance. Exemptions may be allowed for replacement of existing wells. The well ordinance may also be modified to include special study requirements for high-capacity wells to assess their potential effects on nearby domestic wells.

Measurable Objective Expected to Benefit: This project prevents future increases in surface water depletion by restricting direct connection of wells to rivers, canal, and sloughs. It also reduces the potential impacts to domestic well owners from newly constructed wells.

Project Status: The new California Well Standards are expected to be released in 2022 and will require revisions and adoption of local well ordinances to meet the minimum standards. The proposed surface water protection zones and special studies can be incorporate developed into this revised document.

Permitting and Regulatory Process: As part of the well standard revision CEQA documentation will be prepared and posted for public review and comment prior to adoption.

Public Noticing: This management action will be on the San Joaquin County Board of Supervisors monthly Board meetings which are open to the public and are publicly noticed in accordance with the Brown Act. The management action will be noticed to the public in accordance with CEQA requirements.

Timetable for Implementation: Completion of development of the new San Joaquin County well ordinance is anticipated to occur by about 2024.

Expected Benefits and Evaluation: This project is anticipated to maintain surface water depletion at current levels. Benefits are expected to accrue for 50 years or more.

How the Project will be Accomplished: San Joaquin County staff prepare the well ordinance revisions by initially assessing other permitting agencies rules. The staff may use the technical resources to develop evidence to prove the protection zones are reasonable around the water ways and domestic wells.

Legal Authority: The County has land use management and planning authority granted through the State of California. This power allows the County to establish land use and zoning laws that govern development. The County is an existing well permitting agency under the California Water Code Section 13801; Ordinance Code of San Joaquin County Section 9-1115, Municipal Codes of Stockton, Lodi, Manteca, Tracy, Escalon, Ripon and Lathrop.

Estimated Costs and Funding Plan: Estimated costs to revise the existing well ordinance to include a surface water protection zone is approximately $20,000 when included with required revisions of the California Well Standards. San Joaquin County will use administrative funds collected under Proposition 218. Fees generated by the well permitting will pay for administrative costs of this program.

Circumstances for Implementation: This management action will be implemented once the California Well Standards are released, the ordinance has been through CEQA and has been adopted by the Board of Supervisors.

Trigger for Implementation and Termination: The trigger for implementation is when the public draft of the California Well Standards is released. The trigger for termination may occur if a new California Well Standard is developed. Updates to the standard occurs about every 10 to 20 years.

Process for Determining Conditions Requiring the Management Action to Occur: This management action is based on best available science but must obtain CEQA approval for the management action to occur.

## 10.3 List of Supplemental Projects

The GSAs have additional supplemental projects that could be implemented if groundwater level monitoring were to show groundwater levels are declining and have a potential to exceed minimum thresholds. The supplemental projects that could be implemented to resolve shortfalls in either the Upper or Lower aquifers as listed in **Table 10-2.** Project PS-1 is a further expansion of BCID's service area to 1,500 acres with a reduction in groundwater pumping of 3,000 AFY. The second supplemental project is the expansion of the City of Tracy's ASR program. This project could address chronic lowering of groundwater levels in the Subbasin by injecting an approximate volume of water equal to the City's groundwater pumping, by up to an average of 3,000 AFY. At full buildout, and with the addition of four new planned wells the recharge could approach 16,000 AFY. The location of the supplemental projects is illustrated on **Figure 10-1**.

**Table 10-2 Supplemental Projects**

| Supplemental Projects | Owner | Project or Management Action Description | Potential Implementation Time (yrs) | Measurable Objective | Potential Recharge (AFY) | Potential Cost |
|---|---|---|---|---|---|---|
| **Projects** | | | | | | |
| SP1 | BCID | Conjunctive Use - Expansion of distribution facilities to provide surface water to areas previously reliant on groundwater. Benefits Upper Aquifer. | 2023-2030 | Chronic Lowering of Groundwater Levels | 3,000 | $2,500,000 |
| SP2 | City of Tracy | Conjunctive Use – Convert existing Production Wells to Aquifer Storage and Recovery wells to store surface water in the Aquifer for later use. Benefits Lower Aquifer. | 2025-2040 | Chronic Lowering of Groundwater Levels | 3,000 to 16,000 | $2,000,000 |

# 11. Notices and Communications

The GSAs in the Tracy Subbasin conducted a number of activities to engage beneficial users of groundwater, interested parties, and the general public in the development of the GSP. Each GSA was responsible for conducting outreach and engagement related to SGMA within its service area. Recognizing efficiencies in pooling resources and the importance of consistent messaging, the GSAs also coordinated basin-wide outreach activities. This chapter describes the coordinated tools, methods, and activities the GSAs used to inform and engage stakeholders in development of the GSP.

## 11.1 GSAs Decision Making Process

The GSAs executed a MOU for development of the GSP on September 4, 2019. The MOU formed the GSP Coordination Committee, which oversees development and implementation of the GSP. The GSP Coordination Committee includes participation from each of the GSAs. In accordance with the MOU, each GSA has designated a principal contact person to participate in the Committee and undertake actions on the GSA's behalf. Each GSA is entitled to one vote in decisions made by the GSP Coordination Committee, except for decisions that will have a disproportionate effect on the financial obligations of the GSA. In this case, votes are cast in weighted proportion to the financial obligation or benefit of the GSA.

To provide a venue for discussion of technical topics related to development of the GSP, the GSAs also formed a Technical Committee. The Technical Committee provides recommendations to the GSP Coordination Committee. Membership of the Technical Committee is not defined in the MOU, but generally includes one participating representative from each of the Subbasin GSAs.

Both GSP Coordination Committee and Technical Committee meetings are open to the public. These meetings are further described in **Chapter 11.4 – List of Public Meetings**.

## 11.2 Groundwater Beneficial Use and Users

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

Beneficial users and uses of groundwater were identified and engaged by the GSAs based on the place- and interest-based categories described in SGMA and codified in Water Code Section 10723.2:

(a) Holders of overlying groundwater rights, including:

    (1) Agricultural users, including farmers, ranchers, and dairy professionals

    (2) Domestic well owners

(b) Municipal well owners

(c) Public water systems

(d) Local land use planning agencies

(e) Environmental users of groundwater

(f) Surface water users, if there is a hydrologic connection between surface water bodies and groundwater

(g) The federal government, including, but not limited to, the military and managers of federal lands

(h) California Native American tribes

(i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems

(j) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency

Beneficial users and uses representing these categories and nature of consultation with these users are further described below and identified in **Table 11-1**.

## Table 11-1. Nature of Consultation with Beneficial Users of Groundwater

| Beneficial User Category | Beneficial Users | Nature of Consultation: Membership on GSP Coordination Committee | Interested Parties Database | GSP Coordination and Technical Committee Meetings | Public Workshops | Other Public Meetings | Targeted Outreach to Representatives of Beneficial Users |
|---|---|---|---|---|---|---|---|
| Agricultural | Agricultural water users (farmers, ranchers) | | X | X | X | X | X |
| Domestic | Domestic well owners | | X | X | X | X | X |
| Municipal | City of Lathrop | X | X | X | X | X | |
| | City of Tracy | X | X | X | X | X | |
| | Small community water systems | | X | X | X | | X |
| Industrial | Sharpe Army Defense Depot | | X | X | X | | X |
| | Tracy Defense Distribution Depot | | X | X | X | | X |
| | Deuel Vocational Institution | | X | X | X | | X |
| | Independent gravel mining operations | | | X | X | | |
| Public Water Systems | Cal Water | | X | X | X | | |
| | City of Lathrop | X | X | X | X | X | |
| | City of Tracy | X | X | X | X | X | |
| | Corral Hallow Public Water System | | | X | X | | |
| | CSA 50 (Patterson Irrigation Park) | | X | X | X | | |
| | Morehead Park | | | X | X | | |
| | Maurland Manor Water System | | | X | X | | |
| | Mountain House Community Services District | | X | X | X | | X |
| | Par County Estates CSA-16 | | | X | X | | |
| | San Joaquin Service Area 35 | | | X | X | | |
| | San Joaquin Service Area 44 | | | X | X | | |
| | San Joaquin River Club | | | X | X | | X |
| | Tracy Defense Distribution Depot | | X | X | X | | |
| Local Land Use Planning Agencies | City of Lathrop Planning Commission | | X | X | X | | X |
| | City of Tracy Planning Commission | | X | X | X | | X |
| | County of San Joaquin Planning Commission | | | X | X | | X |
| | San Joaquin County Local Agency Formation Commission | | | X | X | | X |
| Environmental Users of Groundwater | California Department of Fish and Wildlife | | | X | X | | |
| | California Sportfishing Protection Alliance | | X | X | X | | |
| | The Nature Conservancy | | X | X | X | | |
| Surface Water Users | Banta-Carbona Irrigation District | X | X | X | X | X | |
| | Byron-Bethany Irrigation District | X | X | X | X | X | |
| | Island Reclamation District 2062 | X | X | X | X | X | |
| | City of Lathrop | X | X | X | X | X | |
| | City of Tracy | X | X | X | X | X | |
| | Individual landowners | | X | X | X | | |
| Federal Government | Sharpe Army Defense Depot | | X | X | X | | X |
| | Tracy Defense Distribution Depot | | X | X | X | | X |
| | US Department of the Interior, Bureau of Reclamation | | | X | X | | |
| Disadvantaged Communities (Census Designated Tracts) | Census Designated Tract GeoID 06077003900 | | | X | X | | |
| | Census Designated Tract GeoID 06077000801 | | | X | X | | |
| | Census Designated Tract GeoID 6077000900 | | | X | X | | |
| | Census Designated Tract GeoID 06077003803 | | | X | X | | |
| | Census Designated Tract GeoID 06077003803 | | | X | X | | |
| | Census Designated Tract GeoID 06077005303 | | | X | X | | |
| | Census Designated Tract GeoID 6077005501 | | | X | X | | |
| Groundwater Monitoring and Reporting Entities | County of San Joaquin | X | X | X | X | X | |
| | San Joaquin County Flood Control and Water Conservation District | | | X | X | | |

### 11.2.1 *Agricultural Users*

Farmland accounts for about 60 percent of the land area within the entire Subbasin. Agricultural water users primarily include farmers and ranchers. They are represented in the Subbasin by agricultural and irrigation water providers, including the Banta-Carbona Irrigation District, Byron-Bethany Irrigation District, Central Delta Water Agency, Island Reclamation District 2062, Naglee-Burk Irrigation District, South Delta Water Agency, and various Reclamation Districts.

Agricultural interests are represented on the GSP Coordination Committee by the Banta-Carbona Irrigation District GSA, Byron-Bethany Irrigation District GSA, County of San Joaquin GSA (County), and Stewart Tract GSA. Representatives from the County consulted with the Central Delta Water Agency and South Delta Water Agency through personal communications with agency staff and presentations at meetings of the agencies' boards of directors. The GSAs coordinated with San Joaquin Farm Bureau Federation to promote workshops and other opportunities for public engagement.

### 11.2.2 *Domestic Well Owners*

Private domestic well operators within the Subbasin primarily include rural residents interspersed with active farmlands. There are considerably more wells in the non-Delta area, south of the Old River, than in the Delta area of the Subbasin. These wells are concentrated in and around the cities of Tracy and Lathrop and unincorporated areas of the County. Domestic well owners within the cities of Tracy and Lathrop are represented on the GSP Coordination Committee by their respective GSAs. Owners in the unincorporated areas are represented by the County.

Domestic well owners had the opportunity to consult on the GSP during public workshops and monthly GSP Coordination Committee and Technical Committee meetings. All interested parties were also provided the opportunity to comment on the GSP during the public comment periods, further described in **Chapter 11.5 – GSP Comments and Responses**.

### 11.2.3 *Municipal and Industrial Well Owners*

Municipal well owners within the Subbasin include the cities of Lathrop and Tracy and several small community water systems primarily located with the County jurisdiction. The Sharpe Army Defense Depot, Tracy Defense Distribution Depot, and Deuel Vocational Institute provide water for both municipal and industrial facilities and use groundwater as their source of supply. Other industrial groundwater users include seven gravel mines within the Subbasin with active mining operations.

Municipal well owners are represented on the GSP Coordination Committee by the City of Lathrop GSA, City of Tracy GSA, and the County. Industrial water users are included on the Interested Parties Database and had to opportunity to consult on the GSP during GSP Coordination Committee and Technical Committee meetings and public workshops. Representatives of the Sharpe and Tracy Defense depots attended Committee meetings and consulted with GSA representatives.

### 11.2.4 *Public Water Systems*

Public water systems in the Subbasin include the cities of Tracy and Lathrop, Corral Hollow Public Water System, CSA 50 (Patterson Industrial Park), Maurland Manor Water System, Morehead Park, Mountain

House Community Services District, Par County Estates CSA-16, San Joaquin CSA 44, San Joaquin Service Area 35, San Joaquin River Club, and Tracy Defense Distribution Depot System. Cal Water also provides water to a small area of the City of Stockton that extends west of the San Joaquin River in the Subbasin.

The cities of Lathrop and Tracy are represented on the GSP Coordination Committee and Technical Committee. The County represents CSAs within the County's jurisdiction and public water systems within the County area. The GSAs consulted with the Mountain House Community Services District through meetings and personal communications with District staff. Representatives of public water systems were also invited to participate in monthly committee meetings and public workshops and had the opportunity to provide comment on draft GSP chapters.

### 11.2.5 *Local Land Use Planning Agencies*

Local land use and planning agencies in the Subbasin include the Planning Commissions of the cities of Lathrop and Tracy, the County, and the San Joaquin County Local Agency Formation Commission. These agencies are represented on the GSP Coordination Committee by the cities of Lathrop and Tracy GSAs, and the County. The GSAs kept local Planning Commissions informed about development of the GSP through staff briefings and individual communications.

### 11.2.6 *Environmental Users of Groundwater*

Organizations representing environmental and ecosystem interests in Subbasin include the CDFW, California Sportfishing Protection Alliance, and TNC. Representatives from the California Sportfishing Protection Alliance and TNC are included in the Interested Parties Database. Representatives from organizations representing environmental uses of groundwater were provided the opportunity to participate in monthly meetings and public workshops and provide comment on draft GSP chapters.

### 11.2.7 *Surface Water Users*

Surface water is used in the Subbasin to meet demands for urban, agricultural, and environmental purposes. In many areas of the Subbasin, surface water is also used conjunctively with groundwater to manage groundwater in those areas. Surface water users include the cities of Lathrop and Tracy, farmers and ranchers, and municipal and industrial water users in the unincorporated area of the County.

The cities and Lathrop and Tracy receive supplies from the South San Joaquin Irrigation District through the South County Water Supply Program. Surface water purveyors with water rights include in the Banta-Carbona Irrigation District, Byron-Bethany Irrigation District, and Island Reclamation District 2062. The Central and South Delta Water Agencies also represent surface water rights holders in the Delta area of the Subbasin.

Surface water users are represented on the GSP Coordination Committee by all six GSAs. The County consulted the Central and South Delta Water Agencies through staff briefings and presentations at meetings of the agencies' boards of directors. Individuals representing agencies and Reclamation Districts in the Delta area also participated in GSP Coordination Committee meetings and workshops.

### 11.2.8 *Federal Government*

The Tracy and Sharpe Army Defense Distribution depots are located within the Subbasin boundaries. Reclamation owns the CVP canals, including the Delta-Mendota Canal which crosses the entire length of the Subbasin south of Highway 580.

Representatives from the depots participated in GSP Coordination Committee meetings and are on the Interested Parties Database. Federal agencies were also provided the opportunity to consult in development of this GSP through commenting on draft GSP chapters and participating in public workshops and committee meetings.

### 11.2.9 *California Native American Tribes*

There are no California Native American Tribes with tribal lands located within the Subbasin.

### 11.2.10 *Disadvantaged Communities*

Data published by the U.S. Census Bureau in 2018 show seven Census Designated Tracts within the Subbasin that meet the annual Median Household Income (MHI) criteria[2] to be considered a DAC or SDAC by the state. A map and description of these communities is provided in **Chapter 3.5 – Disadvantaged Communities**. Two of these areas are located within and receive water from the cities of Lathrop and Tracy. These communities are represented by the cities Lathrop and Tracy GSAs. The other communities are located within the County unincorporated area and receive water from small community water systems or domestic wells. These communities are represented by their local water purveyor and were represented on the GSP Coordination Committee by the County.

Water users in DACs and SDACs were notified about development of the GSP through notices distributed by the GSA representing the area and information posted on the GSA and the Subbasin website. They also had the opportunity to participate in monthly public meetings and public workshops and provide comment on draft GSP chapters. In addition, the San Joaquin County GSA distributed a bilingual (English-Spanish) postcard in July 2021 to over 360 landowners in communities designated as disadvantaged and with a concentration of domestic wells. The postcard notified landowners about development the GSP and directed them about who to contact for more information. The GSAs also followed best practices for engaging underrepresented and disadvantaged communities, such as holding public workshops in the evening, providing language interpretation at public workshops, translating materials into languages other than English, and conducting targeted outreach to local and regional community organizations.

### 11.2.11 *Groundwater Elevation Monitoring and Reporting Entities*

The County is the designated reporting agency in the Subbasin for the CASGEM. San Joaquin County Flood Control and Water Conservation District publishes semiannual groundwater reports covering

[2] A DAC is defined as a census geography community with an annual MHI that is less than 80% of the statewide annual MHI (PRC Section 75005(g))]. A SDAC is a census geography community with an annual MHI that is less than 60% of the statewide annual MHI. The statewide MHI for the U.S. Census Bureau American Community Survey 5-Year Data: 2014 – 2018 is **$71,228.** Therefore, the calculated DAC and SDAC thresholds are **$56,982**and **$42,737**, respectively.

groundwater conditions in San Joaquin County. The County represents groundwater elevation monitoring and reporting entities on the GSP Coordination Committee.

# 11.3 Public Engagement

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

The GSAs utilized a variety of tools and activities to encourage the active involvement of diverse social, cultural, and economic elements of the population within the Subbasin. These activities were guided by the Tracy Subbasin Communication and Engagement Plan, which is provided in **Appendix P.** The activities identified in the Communication and Engagement Plan were adapted in accordance with state and local social distancing requirements resulting from the COVID-19 pandemic.

To support execution of the activities identified in the plan and ensure a collaborative and inclusive GSP development process, the GSAs utilized DWR's Facilitation Support Services. Facilitation and outreach support were provided by Stantec Consulting Services, Inc.

## 11.3.1 *Outreach Tools*

The GSAs used several tools to support communication and engagement activities with stakeholders in the Subbasin. These tools include the following:

- **Subbasin Website**: The Subbasin website (tracysubbasin.org) is the primary location for beneficial users and interested parties to stay informed about GSP development and opportunities for engagement. The website serves a repository for public workshop and meeting materials, outreach collateral, draft and final GSP chapters and appendices, and other key documents. During GSP development, members of the public could review and provide comments on draft GSP chapters using a virtual public comment form. The public comment process is described further in **Chapter 11.5 – GSP Comments and Responses**.
- **Interested Parties Database**: Pursuant to the requirements of SGMA, the GSAs developed and maintained an Interested Parties Database (Database). Beneficial users and members of the public can self-subscribe to the Database by signing up on the Tracy Subbasin website. The Database is used to notify beneficial users of public meetings and workshops, opportunities for public comment, and other GSA outreach actions. It is also used to distribute meeting agendas and other key materials.
- **Informational Materials**: The GSAs developed a suite of materials aimed at informing interested parties about topics related to SGMA and GSP development. These materials include a fact sheet, frequently asked questions, and recorded presentations on SGMA and sustainable management criteria.

## 11.3.2 *Outreach Activities*

The GSAs conducted variety of outreach activities to provide opportunities for interested parties and stakeholders to stay informed and engaged in the development of the GSP. These activities sought to build public awareness of the GSAs and SGMA and to actively engage key stakeholder groups to coordinate and collaborate on technical issues important for GSP development. Outreach activities included:

- **Public Meetings:** The primary way for members of the public to provide input on development of the GSP was by attending and providing public comment at regular GSP Coordination Committee and Technical Committee meetings. In addition, GSA representatives and consultant staff conducted periodic presentations at public meetings of the GSA governing bodies and organizations and agencies representing beneficial users in the Subbasin. These meetings are described in more detail in **Chapter 11.4 – List of Public Meetings**.
- **GSP Development Workshops:** In support of GSP development, the GSAs hosted public workshops aimed at informing members of the public about key GSP topics and to solicit input on technical content and draft GSP chapters. These workshops are described in more detail about **Chapter 11.4.2 – Public Workshops**.
- **Partnerships with Trusted Messengers:** The Subbasin GSAs utilized partnerships with trusted messengers in the Subbasin to broaden the dissemination of SGMA information and connect with hard-to-reach stakeholder groups. This included disseminating information through the Mountain House Community Services District, San Joaquin Farm Bureau Federation, Sikhs of Tracy, and Stockton East Water District. San Joaquin County staff also provided updates on development of the GSP at monthly San Joaquin County Advisory Water Commission meetings. The Advisory Water Commission includes representation from local cities, water agencies, flood control districts, environmental organizations, and the construction industry.

## 11.4 List of Public Meetings

To consult beneficial users in development of the GSP and make decisions in a transparent and inclusive setting, the GSAs coordinated monthly Subbasin public meetings and annual public workshops. In addition, the GSA representatives provided presentations on the GSP at public meetings of their governing bodies and parties representing beneficial users. **Table 11-2** provides a list of the public meetings where the GSP was discussed or considered by the GSAs.

**Table 11-2. List of Public Meetings**

| Date | Format | Topic(s) | Location |
|---|---|---|---|
| 07/10/2019 | BCID Board of Directors | GSP development update | BCID |
| 07/17/2019 | BCID Board of Directors | GSP development update | BCID |
| 08/14/2019 | BCID Board of Directors | GSP development update | BCID |
| 09/11/2019 | BCID Board of Directors | GSP development update | BCID |
| 10/16/2019 | BCID Board of Directors | GSP development update | BCID |
| 11/13/2019 | BCID Board of Directors | GSP development update | BCID |
| 12/18/2019 | BCID Board of Directors | GSP development update | BCID |
| 01/15/2020 | BCID Board of Directors | GSP development update | BCID |
| 03/05/2020 | Lathrop City Council | GSP development update | Lathrop |

| Date | Format | Topic(s) | Location |
|---|---|---|---|
| 03/19/2020 | Technical Committee | GSP development | BCID |
| 04/15/2020 | BCID Board of Directors | GSP development update | Virtual |
| 04/16/2020 | Technical Committee | GSP development | Virtual |
| 05/06/2020 | South Delta Water Agency Board of Directors | GSP development | Virtual |
| 05/13/2020 | BCID Board of Directors | GSP development update | Virtual |
| 05/21/2020 | GSP Coordination Committee | GSP development | Virtual |
| 06/17/2020 | BCID Board of Directors | GSP development update | Virtual |
| 06/18/2020 | GSP Coordination Committee | GSP development, Subbasin governance | Virtual |
| 07/15/2020 | BCID Board of Directors | GSP development update | Virtual |
| 07/16/2020 | Technical Committee | GSP development, HCM | Virtual |
| 07/21/2020 | Stockton East Water District Board of Directors | GSP development update, public workshop promotion | Virtual |
| 07/21/2020 | Public workshop | Introduction to SGMA, GSP development process | Virtual |
| 08/12/2020 | BCID Board of Directors | GSP development update | Virtual |
| 08/20/2020 | Coordination Committee | GSP development, HCM | Virtual |
| 09/02/2020 | South Delta Water Agency | GSP development update | Virtual |
| 09/16/2020 | BCID Board of Directors | Banta-Carbona Irrigation District Board of Directors | Virtual |
| 09/17/2020 | Technical Committee | HCM, groundwater monitoring network, SMC | Virtual |
| 10/14/2020 | BCID Board of Directors | Banta-Carbona Irrigation District Board of Directors | Virtual |
| 10/15/2020 | Technical Committee | Management areas, groundwater monitoring network, SMC | Virtual |
| 11/11/2020 | BCID Board of Directors | Banta-Carbona Irrigation District Board of Directors | Virtual |
| 11/19/2020 | GSP Coordination Committee | Management areas, groundwater monitoring network, SMC | Virtual |
| 12/16/2020 | BCID Board of Directors | Banta-Carbona Irrigation District Board of Directors | Virtual |
| 12/17/2020 | Technical Committee | Inter-basin coordination, groundwater monitoring network, SMC, water budgets, projects. and management actions | Virtual |
| 01/13/2021 | BCID Board of Directors | GSP development update | Virtual |
| 01/21/2021 | Technical Committee | SMC | Virtual |
| 01/21/2021 | Public workshop | SMC | Virtual |
| 02/16/2021 | Tracy City Council | GSP development update | Virtual |
| 02/17/201 | BCID Board of Directors | GSP development update | Virtual |
| 02/18/2021 | GSP Coordination Committee | SMC, water budgets, projects, and management actions | Virtual |

| Date | Format | Topic(s) | Location |
|---|---|---|---|
| 03/17/2021 | BCID Board of Directors | GSP development update | Virtual |
| 03/18/2021 | Technical Committee | Water budgets, projects, and management actions | Virtual |
| 04/14/2021 | BCID Board of Directors | GSP development update | Virtual |
| 04/15/2021 | GSP Coordination Committee | Water budgets, management actions, GSP implementation funding, and governance | Virtual |
| 05/12/2021 | BCID Board of Directors | GSP development update | Virtual |
| 05/20/2021 | GSP Coordination Committee | Water budgets, projects and management actions, GSP implementation funding | Virtual |
| 06/16/2021 | BCID Board of Directors | GSP development update | Virtual |
| 06/17/2021 | GSP Coordination Committee | Water budgets, projects and management actions, MOA | Virtual |
| 07/12/2021 | City of Lathrop City Council | GSP development update | Virtual |
| 07/14/2021 | BCID Board of Directors | GSP development update | Virtual |
| 07/15/2021 | GSP Coordination Committee | GSP and groundwater modeling, MOA, GSP implementation funding | Virtual |
| 08/10/2021 | Public Workshop | Draft GSP content and public comment process | Virtual |
| 08/11/2021 | BCID Board of Directors | GSP development update | Virtual |
| 08/19/2021 | GSP Coordination Committee | Public comments on Draft GSP, MOA | Virtual |
| 09/15/2021 | BCID Board of Directors | GSP development update | Virtual |
| 09/16/2021 | GSP Coordination Committee | Responses to public comments, GSP implementation funding, MOA | Virtual |
| 10/05/2021 | GSP Coordination Committee | Responses to public comments Draft GSP, GSP implementation funding, MOA | Virtual |
| 10/13/2021 | BCID Board of Directors | GSP development update | Virtual |
| 10/21/2021 | GSP Coordination Committee | Responses to public comments Draft GSP, GSP implementation funding, MOA | Virtual |

**Key**:
BCID = Banta-Carbona Irrigation District, GSP = Groundwater Sustainability Plan, HCM = Hydrologic Conceptual Model, MOA = Memorandum of Agreement, SMC = Sustainable Management Criteria, SGMA = Sustainable Groundwater Management Act

### 11.4.1 *Groundwater Sustainability Plan Coordination Committee and Technical Meetings*

GSP Coordination Committee and Technical Committee meetings served as key opportunities for beneficial users and interested parties to track the process and consult in development of the GSP. Both committee meetings were open for members of the public to listen and provide comments. Comments on items on the agenda may be provided after GSA discussion on the item. There was also a set aside time for members of the public to provide comment on items not on the agenda. Public comments are recorded in the meeting minutes, which are posted on the Subbasin website. Comments were also recorded and considered by the planning team when developing and revising the GSP chapters.

The GSP Coordination Committee met, at a minimum, once a quarter during GSP development. GSP Coordination Committee meetings were held and noticed in accordance with the Brown Act. The Technical Committee met every third month or in months without a GSP Coordination Committee meeting. Although not subject to the Brown Act, Technical Committee meetings were held following Brown Act best practices for public noticing and engagement.

The meetings were initially held in-person at the BCID office at 3514 W Lehman Rd, Tracy, CA 95304. In April 2020, the meetings were shifted to a virtual platform due to local social distancing requirements and temporary changes in Brown Act requirements resulting from the COVID-19 pandemic. Members of the public were able to provide comment at the meetings *via* calling into the meeting or typing comments in the chat box in the virtual meeting platform.

The GSAs noticed the meetings *via* a posting on the Subbasin website and email distributed to the Interested Parties Database. A notice was also posted at the BCID office for in-person meetings. Meeting agendas and materials were distributed to the Interested Parties Database and posted on the Subbasin website prior to each meeting.

### 11.4.2 *Public Workshops*

The GSAs held three public workshops to inform beneficial users and interested parties about the GSP development process and collect input on topics central to the development of the GSP and groundwater management practices. Workshops were held in July 2020 (focus was on the GSP development process), and January 2021 (focus was the Sustainable Management Criteria) and August 2021 (focus was on the Public Draft GSP and public comment process). **Table 11-2** identifies the workshop dates, topics, and locations.

Due to state and local social distancing requirements, both workshops were held virtually using virtual meeting and webinar platforms. Members of the public could submit comments verbally using their computer or phone audio; or submit written comments in the virtual meeting platform or texting the workshop facilitator. Questions and comments submitted by members of the public was recorded by the planning and outreach staff and included in the workshop summaries. A summary of feedback provided by workshop participants was provided at GSP Coordination Committee and Technical Committee meetings.

The GSAs noticed the public workshops *via* a bilingual Spanish and English flyer posted on the Subbasin and GSAs' websites, GSAs' social media sites, and distributed to the Interested Parties Database. The GSAs also reached out directly to organizations representing beneficial users inviting them to the upcoming workshops and requesting that the organizations distribute the flyer to their contact database. This included targeted outreach to the Mountain House Community Services District, Reclamation Districts, San Joaquin County Farm Bureau Federation, San Joaquin River Club, Sikhs of Tracy, Stockton East Water District, and individual landowners in areas dependent on groundwater.

### 11.4.3 *Other Public Meetings*

In addition to monthly public meetings and annual workshops, the GSA representatives also discussed the GSP at public meetings of their governing bodies, local and regional planning commissions, and other agencies or organizations representing beneficial users within the Subbasin. **Table 11-2** provides a list of other public meetings during which the GSP was discussed.

## 11.5 GSP Comments and Responses

This section describes the process the GSAs used to solicit and respond to comments on the draft GSP. The draft GSP chapters were released for public review and comment as they were developed. In addition, the GSAs held a 30-day public comment period on the Public Draft GSP from August 9, 2021 through September 9, 2021. Public comments were collected *via* a virtual public comment form, email, and US mail. In addition, interested parties could provide input during monthly GSP Coordination Committee meetings and public workshops. Comments that raised substantive technical or policy issues resulted in revisions to the Draft GSP and are reflected in the final plan.

### 11.5.1 *Public Comment Process*

The GSAs used a serial public comment process to provide beneficial users and member of the public multiple opportunities to review and provide comment on the draft GSP. Draft GSP chapters were released for public review and comment as they were completed. Each chapter was posted on the Subbasin website (tracysubbasin.org) for public comment for a minimum of 30 days. Members of the public were notified of the public comment period through an email distributed to the Interested Parties Database.

Comments were collected in a virtual public comment form, which could be accessed on the front-page of the website. Comments were also collected at regular GSP Coordination Committee and Technical Committee meetings and public workshops. At the close of the GSP chapter public comment period, received comments were reviewed by the planning staff and chapter was revised to address comments that raised credible technical or policy issues.

After all individual chapters had been reviewed, a complete Public Draft GSP was released for public review on August 9, 2021 and followed by a 30-day public comment period. The public comment period ended on September 9, 2021. Interested parties could submit comments on the Public Draft GSP *via* the virtual public comment form, US mail, or email.

The release of the Public Draft GSP and public comment period were noticed *via* an email sent to the Interested Parties Database, postings on the Tracy Subbasin website, and notices distributed by each of the GSAs via their email lists, social media accounts, and websites. Two additional emails were sent to the Interested Parties Database to remind individuals of the comment deadline. The GSAs also held an informational public workshop on August 10, 2021 to inform interested parties about the content of the draft GSP, explain the public comment process, and answer questions about the plan. A recording of the workshop was posted on the Tracy Subbasin website, Additional outreach was conducted to promote the workshop, including targeted outreach to individuals and organizations representing beneficial users of groundwater in the Subbasin.

### 11.5.2 *Comments Received*

The GSAs received three comment letters during the Public Draft GSP public comment period (August 9 – September 9, 2021). Two comments were received via email. A second comment letter was received via the virtual public comment form. The list of comment letters received is provided in **Table 11-3.**

Planning staff reviewed the letters and identified 37 unique comments. A summary of topics addressed by the comments is provided in **Appendix Q**. A copy of the comment response matrix is provided in **Appendix Q**.

**Table 11-3. Comments Received on the Public Draft GSP**

| Name of Author | Agency/Organization | Submission Method | Date Received/Post Marked |
|---|---|---|---|
| Jenny Wood | None provided | Virtual public comment form | 08/28/2021 |
| Ngodoo Atume, Samantha Arthur, E.J. Remson, Melissa M. Rohde, J. Pablo Ortiz-Partida, Danielle V. Dolan | Clean Water Action/Clean Water Fund, Audubon California, The Nature Conservancy, Union of Concerned Scientists, Local Government Commission | Email | 09/03/2021 |
| Bobby Pierce | West Stanislaus Irrigation District GSA on behalf of Northern & Central Delta-Mendota GSP Group Northern Management Committee | Email | 09/09/2021 |
| Aaron Barcellos | Central Delta-Mendota Multi-Agency GSA on behalf of Northern & Central Delta-Mendota GSP Group Central Management Committee | | |

### 11.5.3 *Comment Review and Response*

Public comments on the individual GSP chapters and Public Draft GSP were handled in three different ways depending on how the information was submitted. Verbal comments provided at public meetings or workshops were recorded in the meeting minutes or workshop summary and reviewed by planning staff. If a comment was specific to an individual section of the GSP, the GSP text was revised. General comments that raised substantial technical or policy issues may have resulted changes to multiple GSP sections.

Comments submitted using the virtual comment form were collated into a database. Comments received in a letter format were dissected and input into the comment database. Planning staff reviewed each comment and provided a response in the database. A copy of the comment response database is provided in **Appendix Q**. The database and draft comment responses were reviewed by each GSA in the Subbasin and discussed at public GSP Coordination Committee meetings. If a change was made to the GSP to respond to the comment, a note was provided in the database indicating where the change was made. Comments general in nature or that did raise substantial issues were noted, but no changes were made.

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### 11.5.2 *Resolution to Adopt GSP*

The GSAs agreed to an Intent to Adopt the Tracy Subbasin GSP on August 6, 2021 and notified by email and U.S. mail Alameda County, City of Lathrop, City of Tracy and San Joaquin County. No responses were received from any party after a 90-day period. **Appendix R** contains the Intent to Adopt the GSP

Following incorporation of public comments into the GSP each GSA board or supervisors, in a public meeting, approved to adopt the GSP. **Appendix R** contains the resolutions to adopt the GSP.

## 11.6 Inter-Basin Coordination

The Tracy Subbasin GSAs also engaged GSAs in adjacent groundwater basins during development of the GSP. Representatives of the Tracy and Delta-Mendota Subbasins met in November 2020 to discuss inflows and outflows between the two subbasins and monitoring near the basin boundaries. The Tracy Subbasin GSAs plan to meet with representatives of the Delta-Mendota and East Contra Costa Subbasins in Fall/Winter 2021 to continue to discuss data sharing, groundwater monitoring, and practices for long-term coordination between the basins. In the Eastern San Joaquin Subbasin, San Joaquin County staff and Tracy Subbasin consultants provided updates about development of the Tracy Subbasin GSP at meetings of the Eastern San Joaquin Groundwater Authority. In addition, representatives from adjacent subbasins regularly attended and had the opportunity to provide input during monthly GSP Coordination Committee meetings and public workshops. The GSAs will continue to coordinate with the adjacent subbasins throughout GSP implementation.

## 11.7 Public Involvement During GSP Implementation

The GSAs will keep members of the public and interested parties informed about progress implementing the GSP *via* email to the Interested Parties Database, quarterly public meetings, and annual workshops. The GSAs will continue to maintain the Subbasin website (tracysubbasin.org) and Interested Parties Database. Emails will be distributed to the Interested Parties Database on regular basis to inform interested parties about upcoming meetings and public workshops, GSP implementation milestones, and the status of projects and management actions. The website will be updated on an as-needed basis to include information on and announcements pertaining to GSP implementation. The website will also serve as a repository for copies of the Tracy Subbasin Annual Reports and other materials developed during GSP implementation.

It is anticipated that the GSP Coordination Committee will continue to meet on a quarterly basis. Committee meetings will be noticed on the Subbasin website (tracysubbasin.org) and *via* an email to the Interested Parties Database. The GSAs will also hold annual public workshops to keep members of the public and interested parties informed about progress implementing the GSP. It is anticipated that the workshops will be aligned with completion of the Annual Reports. The GSAs will notice the workshops *via* posting on the website, email, and targeted outreach to organizations and agencies representing beneficial users in the Subbasin.

Additional public outreach activities may be conducted to support planning, design, and construction activities related to the groundwater management projects. Such activities will be noticed on the website and *via* email to the Interested Parties Database.

# 12. Interagency Agreements

The Tracy Subbasin GSAs have elected to develop one-GSP for the entire Subbasin. The Subbasin GSAs have reached out to and formed relationships with adjacent subbasins. This section provides the status of agreements for both interbasin and intrabasin agreements.

## 12.1 Interbasin Agreements

The Tracy Subbasin GSAs have been communicating and sharing information with adjacent Subbasins since 2018. The Tracy Subbasin GSAs sent letters of support for the Northern Delta Mendota and Eastern San Joaquin Subbasins GSPs in 2019.

During preparation of the Tracy Subbasin GSP interbasin coordination meetings to share approaches and information were held with the neighboring subbasins as follows:

- East Contra Costa Subbasin – Groundwater modeling approach discussion, Feb 12, 2020 and August 30, 2020
- Eastern San Joaquin County Groundwater Authority – Summary of Tracy Subbasin GSP findings August 11, 2021
- Northern Delta Mendota Groundwater Subbasin – Groundwater levels, November 6, 2020

In addition to these coordinating activities Tracy GSA representatives or communications coordinator have also attended and have shared pertinent information with other adjacent subbasins during their monthly to quarterly meetings and have brought information back to the Subbasin Technical Coordination Committee as follows:

- Eastern San Joaquin Groundwater Authority - 2018 to present (Matt Zidar, San Joaquin County)
- East Contra Costa Subbasin – (Rick Gilmore or Greg Young, BBID)
- Northern Delta Mendota Subbasin – (Kirsten Pringle, Stantec)

At this time, all subbasins have agreed that formal interbasin agreements are not needed. All GSAs have agreed to coordinate to share information about groundwater conditions, water quality, and well permitting activity.

## 12.2 Intrabasin Coordination Agreements

The Tracy Subbasin GSAs have elected to develop one-GSP and entered into a Memorandum of Agreement to develop and implement this Plan. Because only one GSP was developed for the entire Subbasin intrabasin coordinating agreements are not required. **Chapter 2 - Agency Information** provides further details about the MOA agreement by the six GSAs.

# 13. References

## Chapter 1 – Introduction

California Code of Regulations (CCR), Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans. 2016. https://cawaterlibrary.net/document/california-code-of-regulations-title-23-waters-division-2-department-of-water-resources-chapter-1-5-groundwater-management-subchapter-2-groundwater-sustainability-plans/

California Department of Water Resources (DWR). 2019a. 2019 Basin Prioritization https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization

California Department of Water Resources (DWR). 2019b. Well Completion Report Map Application. https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

## Chapter 2 – Agency Information

None.

## Chapter 3 – Description of Plan Area

Alameda County, California -Code of Ordinances, Title 6- Health and Safety, Chapter 6.88 – Water Wells. https://library.municode.com/ca/alameda_county/codes/code_of_ordinances?nodeId=TIT6HESA_CH6.88WAWE

California Department of Water Resources (DWR). 1990. California Water Well Standards, DWR Bulletin 74-90 (Supplement to Bulletin 74-81). https://water.ca.gov/Programs/Groundwater-Management/Wells/Well-Standards/Combined-Well-Standards

_____. DWR. 2018. DAC Mapping Tool. https://gis.water.ca.gov/app/dacs/

_____. DWR. 2019a. 2019 Basin Prioritization https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization

_____. DWR. 2019b. Well Completion Report Map Application. https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

_____. DWR WCR. 2020. SGMA Data Viewer, Land Subsidence. https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2018. Water Quality Control Plan for the Sacramento and San Joaquin Rivers. https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/

Delta Stewardship Council. 2013. The Delta Plan. https://deltacouncil.ca.gov/pdf/delta-plan.pdf

EKI Environment & Water. 2015. 2015 Urban Water Management Plan for the City of Lathrop. https://www.ci.lathrop.ca.us/sites/default/files/fileattachments/public_works/page/19251/city_of_lathrop_uwmp_2015.pdf

Farr, Tom G. and Cathleen E. Jones, Zhen Liu, Jet Propulsion Laboratory, California Institute of Technology JPL. 2016. Progress Report: Subsidence in the Central Valley, California. 2016. https://cawaterlibrary.net/wp-content/uploads/2017/05/JPL-subsidence-report-final-for-public-dec-2016.pdf

Land IQ. 2017. Draft Report-2014 Statewide Land Use Mapping. https://gis.water.ca.gov/app/CADWRLandUseViewer/images/2014%20Statewide%20Land%20Use%20Mapping%20-%20Report%20-%2020170727.pdf

Natural Communities Commonly Associated with Groundwater Dataset (NCCAG). 2018. Klausmeyer, K., Howard J., Keeler-Wolf T., Davis-Fadtke K., Hull R., and Lyons A. (2018). Mapping Indicators of Groundwater Dependent Ecosystems in California. https://data.cnra.ca.gov/dataset/natural-communities-commonly-associated-with-groundwater

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan. 2000. San Joaquin County of Government, November 14, 2000. https://www.sjcog.org/DocumentCenter/View/5/Habitat-Planpdf?bidId=

Sneed, Michelle, Brandt, Justin, and Solt, Mike, 2013., Land subsidence along the Delta-Mendota Canal in the northern part of the San Joaquin Valley, California, 2003–10: U.S. Geological Survey Scientific Investigations Report 2013–5142, 87 p., : https://pubs.usgs.gov/sir/2013/5142/

## Chapter 4 – Hydrogeologic Conceptual Model

Bartow. 1985. Maps showing Tertiary stratigraphy and structure of the Northern San Joaquin Valley, California. United States Geological Survey (USGS). https://pubs.er.usgs.gov/publication/mf1761

Berkstresser, C.F. Jr. 1973. Base of Fresh Ground-Water -- Approximately 3,000 micromhos -- in the Sacramento Valley and Sacramento-San Joaquin Delta, California. U.S. Geological Survey Water-Resource Inv. 40-73. 1973. https://pubs.er.usgs.gov/publication/wri7340

Bertoldi, G., Johnston, R., & Evenson, K.. 1991. Groundwater in the Central Valley, California - A Summary Report. USGS Professional Paper 1401-A. https://doi.org/10.3133/pp1401A.

Burow, Karen R., Jennifer L. Shelton, Joseph A. Hevesi, and Gary S. Weissmann. 2004. Hydrologic Characterization of the Modesto Area, San Joaquin Valley, California. Preliminary Draft. U.S. Geological Survey. Water-Resources Investigation Report. Prepared in cooperation with Modesto Irrigation District. Sacramento, California. https://pubs.er.usgs.gov/publication/sir20045232

California Department of Water Resources (DWR). 1995. Sacramento Delta San Joaquin Atlas. https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/spprt_docs/nmfs_exh4_dwr_1995.pdf

_____. DWR. 2006. San Joaquin Valley Groundwater Basin Tracy Subbasin. California's Groundwater, Bulletin 118. Last updated 1/20/06. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/2003-Basin-Descriptions/5_022_15_TracySubbasin.pdf

Davis G.H., J.H. Green, S.H. Olmstead, and D.W. Brown 1959. Davis, G. H., J.H. Green, S.H. Olmstead, and D.W. Brown. 1959. Ground water conditions and storage capacity in the San Joaquin Valley, California. U.S. Geological Survey Water Supply Paper No. 1469, 287 p. https://doi.org/10.3133/wsp1469.

GEI Consultants, Inc. 2007. Tracy Regional Groundwater Management Plan.

Hotchkiss, W. R., and G.O. Balding. 1971. Geology, hydrology, and water quality of the Tracy-Dos Palos area, San Joaquin Valley, California. U.S. Geological Survey. Open-File Report. Hotchkiss and Balding. 1971. https://pubs.er.usgs.gov/publication/ofr72169

Hydrofocus, 2015. San Joaquin County and Delta Quality Coalition Groundwater Quality Assessment Report, April 27, 2015. https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/sanjoaquin_delta/ground_water/2015_0427_sjdwqc_gar.pdf

O'Green, M Saal, H Dahlke, D Doll, R Elkins. 2015. Soil suitability index identifies potential areas for groundwater banking on agricultural lands. http://calag.ucanr.edu/archive/?article=ca.v069n02p75

Padre and Associates, Inc. 2004. personnel communication with Mike Burke regarding aquifer testing at City of Tracy Well 8.

Page. 1986. Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections. USGS Professional Paper 1401-C. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C38&as_vis=1&q=Page.+1971&btnG=

Soil Survey Staff, Natural Resources Conservation Service (SSURGO). 2019. United States Department of Agriculture. Soil Survey Geographic Database. https:\\www.nrcs.usda.gov

Nature Conservancy, California. ICONS: Interconnected Surface Water in California's Central Valley, Version 1.0.1. https://icons.codefornature.org/ . March 2021.

Wagner, D.L., Bortugno, E.J., and Mc Junkin, R.D. 1991. Geologic Map of the San Francisco – San Jose Quadrangle. California Geological Survey, Regional Geologic Map No. 5A, 1:250,000 scale. https://www.conservation.ca.gov/cgs/maps-data/rgm

Woodard & Curran. 2019. Northern & Central Delta-Mendota Region Groundwater Sustainability Plan. http://deltamendota.org/wp-content/uploads/2019/11/Final_Draft_GSP_Nov19/RevExecSum_Nov19_Final.pdf

## Chapter 5 – Groundwater Conditions

Atwater, B.F.. 1982. Geologic Maps of the Sacramento-San Joaquin Delta, U.S. Geological Survey, Miscellaneous Field Studies Map MF – 1401. https://pubs.er.usgs.gov/publication/mf1401

Burow, Karen R., Jennifer L. Shelton, Joseph A. Hevesi, and Gary S. Weissmann. 2004. Hydrologic Characterization of the Modesto Area, San Joaquin Valley, California. Preliminary Draft. U.S. Geological Survey. Water-Resources Investigation Report. Prepared in cooperation with Modesto Irrigation District. Sacramento, California. https://pubs.er.usgs.gov/publication/sir20045232

California Department of Water Resources (DWR). 1995. Sacramento Delta San Joaquin Atlas.

_____. DWR. 2006. San Joaquin Valley Groundwater Basin Tracy Subbasin. California's Groundwater, Bulletin 118. Last updated 1/20/06. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/2003-Basin-Descriptions/5_022_15_TracySubbasin.pdf

_____. DWR. 2020. SGMA Data Viewer https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub

_____. DWR. 2021. California's Groundwater Update 2020, Bulletin 118. CalGW Online datasets, water level trend data (Groundwater Level Estimated Trends Dashboard (arcgis.com)).

California Code of Regulations (CCR). 2014. Title 23. Waters. https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf

California State Water Resources Control Board (State Water Board). 2020. SAFER Workshop 2020. https://www.waterboards.ca.gov/safer/calendar.html

Farr, Tom G. and Cathleen E. Jones, Zhen Liu, Jet Propulsion Laboratory (JPL), California Institute of Technology (CIT). 2016. Progress Report: Subsidence in the Central Valley, California. 2016. https://data.cnra.ca.gov/dataset/nasa-jpl-insar-subsidence

Davis, G., Green, J., Olmsted, F., & Brown, D. 1959. Ground-Water Conditions and Storage Capacity in the San Joaquin Valley California. USGS. https://doi.org/10.3133/wsp1469

Deverel, S.J. and S. Rojstaczer. 1996. Subsidence of agricultural lands in the Sacramento-San Joaquin Delta, California: Role of aqueous and gaseous carbon fluxes. Water Resources Research 32(8):2359–2367. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/96WR01338

Deverel, Steven J, and Leighton, David A. 2010. Historic, Recent, and Future Subsidence, Sacramento-San Joaquin Delta, California, USA. San Francisco Estuary and Watershed Science, 8(2). https://escholarship.org/uc/item/7xd4x0xw

GEI Consultants, Inc. (GEI). 2007. Tracy Regional Groundwater Management Plan.

Hydrofocus, 2015. San Joaquin County and Delta Quality Coalition Groundwater Quality Assessment Report, April 27, 2015. https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/sanjoaquin_delta/ground_water/2015_0427_sjdwqc_gar.pdf

Izbicki, John A. and Loren F. Metzger, Kelly R. McPherson, Rhett R. Everett, George L. Bennett, 2006. Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California. https://pubs.usgs.gov/of/2006/1309/

Land IQ. 2014. Draft Report. 2014 Statewide Land Use Mapping. June 7, 2017. https://map.dfg.ca.gov/metadata/ds2677.html

Luhdorff and Scalmanini Consulting Engineers, 2015. Western San Joaquin River Watershed Groundwater Quality Assessment Report. May 2015. Revised 2017. https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/westside_sjr/ground_water/2017_0608_wsjr_gqmp.pdf

Mendenhall W.C., Dole, R.B., and Stabler, Herman. 1916. Groundwater in the San Joaquin Valley, California. USGS Water-Supply Paper 494. https://pubs.usgs.gov/wsp/0398/report.pdf

Padre and Associates. 2004. personnel communication with Mike Burke regarding aquifer testing at City of Tracy Well 8.

Shlemon, R.J. and Begg, E.L. 1975. Late Quaternary Evolution of the Sacramento-San Joaquin Delta, California in Suggate, R.P and Cressel, M.M. (Eds) Quaternary Studies, Bulletin 13, The Royal Society of New Zealand, Wellington, New Zealand, pp. 259- 266. https://www.researchgate.net/publication/298432349_Late_Quaternary_evolution_of_the_Sacramento-San_Joaquin_Delta_California

Sneed, Michelle, Brandt, Justin, and Solt, Mike, 2013., Land subsidence along the Delta-Mendota Canal in the northern part of the San Joaquin Valley, California, 2003–10: U.S. Geological Survey Scientific Investigations Report 2013–5142, 87 p., http://dx.doi.org/10.3133/sir20135142 ISSN 2328-0328

Strathouse S, Sposito G. 1980. Geologic nitrogen in soils may pose hazard. Calif Agriculture, August-September 1980. http://calag.ucanr.edu/archive/?type=pdf&article=ca.v034n08p20.

Sullivan, P.J., G. Sposito, S.M. Strathouse, and C.L. Hansen. 1979. Geologic nitrogen and the occurrence of high nitrate soils in western San Joaquin Valley, California. Hilgardia, Vol. 47, No. 2, 15-49 p. http://hilgardia.ucanr.edu/fileaccess.cfm?article=152819&p=WXIALI.

Water Education Foundation. 2019. 2019 Annual Report. https://www.watereducation.org/sites/main/files/file-attachments/2019annualreport.pdf

Woodard and Curran. 2019. Northern & Central Delta-Mendota Region Groundwater Sustainability Plan. http://deltamendota.org/wp-content/uploads/2019/11/Final_Draft_GSP_Nov19/RevExecSum_Nov19_Final.pdf

## Chapter 6 – Management Areas

California Code of Regulations (CCR), Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans. 2016. https://cawaterlibrary.net/document/california-code-of-regulations-title-23-waters-division-2-department-of-water-resources-chapter-1-5-groundwater-management-subchapter-2-groundwater-sustainability-plans/

California Department of Water Resources (DWR). Reprinted 1995. Sacramento Delta San Joaquin Atlas. https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/exhibit3/rdeir_sdeis_comments/RECIRC_2646_ATT%203.pdf

## Chapter 7 – Water Budgets

California Department of Water Resources (DWR). 2014. Integrated Water Flow Model Theoretical Documentation. https://og-production-open-data-cnra-892364687672.s3.amazonaws.com/resources/e5cfdff9-2f58-4e39-975c-0160d0c65955/iwfmv40331theoreticaldocumentation.pdf?Signature=LtY%2FrdTVL%2B7sp9cHP8V2cBn%2BGsQ%3D&Expires=1625778436&AWSAccessKeyId=AKIAJJIENTAPKHZMIPXQ

______. 2018. DWR “Guidance Document for the Sustainable Management of Groundwater: Guidance for Climate Change Data Usage During Groundwater Sustainability Plan Development.” July 2018. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents

National Oceanic and Atmospheric Administration (NOAA). 2016. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8560

## Chapter 8 – Monitoring Networks

California Department of Water Resources (DWR). 2016a. Best Management Practices for the Sustainable Management of Groundwater, Monitoring Networks and Identification of Data Gaps. https://groundwaterexchange.org/wp-content/uploads/2020/09/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps_ay_19.pdf

_____DWR. 2016b. Best Management Practices for the Sustainable Management of Groundwater, Monitoring Protocols, Standards and Sites. December 2016. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents

## Chapter 9 – Sustainable Management Criteria

California Code of Regulations (CCR), Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans. 2016. https://cawaterlibrary.net/document/california-code-of-regulations-title-23-waters-division-2-department-of-water-resources-chapter-1-5-groundwater-management-subchapter-2-groundwater-sustainability-plans/

California Department of Water Resources (DWR). 2017. Best management Practices for the Sustainable Management of Groundwater, Sustainable Management Criteria DRAFT. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf

California Department of Water Resources, (DWR). Access July 14, 2021. California Data Exchange Center. https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

California State Water Resources Control Board (State Water Board). 1968. Statement of Policy with Respect to Maintaining High Quality of Waters in California. Resolution No. 68-16. https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf

_____. 2017. A Compilation of Water Quality Goals. https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/

Central Valley Region Regional Water Quality Control Board (CVRWQCB). 2018. Water Quality Control Plan for the Sacramento and San Joaquin Rivers. https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/

Woodard and Curran. 2019. Northern & Central Delta-Mendota Region GSP. http://deltamendota.org/wp-content/uploads/2019/11/Final_Draft_GSP_Nov19/RevExecSum_Nov19_Final.pdf

## Chapter 10 – Projects and Management Actions

Woodard and Curran. 2019. San Luis & Delta-Mendota Water Authority, Westside-San Joaquin Integrated Regional Water Management Plan. https://sldmwa.org/IRWMP/WSJ%20IRWMP%202019%20Final_ADA-OK.pdf

## Chapter 11 – Notices and Communications

None.

## Chapter 12 – Interagency Coordination

None.

# Appendix A – Memorandum of Agreement

(copy provided in separate pdf)

# Appendix B – GSP Implementation Fiscal Budgets

(copy provided in separate pdf)

## Appendix C – Monitoring Well Construction Details

(copy provided in separate pdf)

# Appendix D – Geologic Section Well Logs

(copy provided in separate pdf)

# Appendix E – Upper Aquifer Hydrographs

(copy provided in separate pdf)

## Appendix F – Lower Aquifer Hydrographs

(copy provided in separate pdf)

# Appendix G – Vertical Gradients

(copy provided in separate pdf)

# Appendix H – Summary of Water Quality Detections

(copy provided in separate pdf)

# Appendix I – Water Quality Trend Graphs

(copy provided in separate pdf)

# Appendix J – Subsidence

(copy provided in separate pdf)

## Appendix K – Surface Water Interaction

(copy provided in separate pdf)

# Appendix L – Potential GDE Species

(copy provided in separate pdf)

# Appendix M – Detailed Water Budgets

(copy provided in separate pdf)

# Appendix N – Groundwater Level Minimum Thresholds and Measurable Objectives

(copy provided in separate pdf)

# Appendix O – Water Quality Minimum Thresholds and Measurable Objectives

(copy provided in separate pdf)

# Appendix P – Public Outreach

(copy provided in separate pdf)

# Appendix Q – Public Comments

(copy provided in separate pdf)

# Appendix R – Resolutions to Adopt GSP

(copy provided in separate pdf)