- The hydrograph for AZ-3 indicates no direct hydraulic connection with AZ-1 and AZ-2. The hydrograph for AZ-3 also indicates drawdown to regional pumping. This aquifer zone also exhibits artesian conditions during wet periods (e.g., 2017; **Appendix 5-E**).

Sutter County Well MW-6 (13N03E06A002M): This well contains three separate screen zones: one within AZ-1 and two within AZ-2. **Figure 5-20** shows the hydrograph for the year 2015. Observations from this hydrograph are summarized below:

- The hydrographs indicate that AZ-1 and AZ-2 are not in direct hydraulic connection.
- Primary pumping appears to occur within AZ-2, with both AZ-2 wells showing drawdown patterns consistent with nearby pumping wells. The hydrographs for the two AZ-2 wells also show a downward vertical gradient in this aquifer zone and the patterns are consistent with a confined aquifer. Data from other years (e.g., 2017; **Appendix 5-E**) indicate that pumping from this zone does not occur every year.
- The hydrograph for the AZ-1 well suggests response to surface water flows from the nearby Gilsizer Slough and that there is some leakage to the lower aquifer zone.

Flood Well MW-1 (13N01E24G002M): This well contains three separate screen zones: two within AZ-1 and one within AZ-2. **Figure 5-21** shows the hydrograph for the year 2018. Observations from this hydrograph are summarized below:

- The hydrographs show that all three zones screened are in direct hydraulic connection, indicating AZ-1 and AZ-2 are one aquifer zone in this area.
- Primary pumping appears to occur within the lower part of AZ-2, where significant drawdown occurs in this zone during the period from May through August. The other two wells show a similar pattern but to a lesser degree, suggesting the presence of some lower permeability zones between the depths. The patterns shown indicate these wells are within the zone of influence of pumping wells in the area.
- The full hydrographs indicate that pumping does not occur every year (e.g., 2017; **Appendix 5-E**). During these years, drawdown does occur consistent to regional pumping and possibly leakage to lower aquifer zones.

Sutter County Well MW-4 (13N03E26J00XM): This well contains four separate screen zones: one within AZ-1, one within AZ-2, and two within AZ-3. **Figure 5-22** shows the hydrograph for the year 2015. Observations from this hydrograph are summarized below:

- The hydrographs show that AZ-1 and AZ-2 are hydraulically connected. The AZ-1 well is screened near the bottom (145 to 165 feet bgs) and may be part of AZ-2.
- There is a downward vertical hydraulic gradient between the AZ-1 and AZ-2 well. Both AZ-1 and AZ-2 show responses between January and April that may indicate connection to surface water in the Feather River.

- Primary pumping appears to occur within the interval screened by both the AZ-1 and AZ-2 wells, where significant drawdown occurs in this zone during the period from June through October. The patterns shown indicate these wells are within the zone of influence of pumping wells in the area.
- The hydrographs for the two AZ-3 wells also indicate hydraulic connection with a downward vertical gradient. The hydrographs also show response to regional pumping and response from leakage upward due to pumping in AZ-2. The initial response to pumping in AZ-2 from the shallower of the two AZ-3 wells is an increase in water level. This response is referred to as a Noordbergum effect that occurs because pumping instantly compresses the aquifer to force water up the well (Verruijt, 1969).

Sutter County Well MW-2 (12N02E23H002M): This well contains four separate screen zones: one within AZ-1, one within AZ-2, and two within AZ-3. **Figure 5-23** shows the hydrograph for the year 2014. Observations from this hydrograph are summarized below:

- The hydrographs show that AZ-1 and AZ-2 are hydraulically connected and that there is an upward vertical gradient between these zones. The hydrographs for these wells also show response to regional pumping and may be showing response that indicates they are on the fringes of the influence of pumping wells.
- The hydrographs for the two AZ-3 wells also indicate hydraulic connection between the upper and lower zones but with a downward vertical gradient. The hydrographs also indicate response to regional changes and not direct response to pumping wells.

5.1.6.3 Physical Properties of Aquifers and Aquitards

Limited aquifer tests with observation wells are available to provide reliable estimates of the aquifer characteristics. The aquifer tests available were conducted in 2007 for SEWD Wells #1 and #2 (GEI, 2016). The results of these tests are summarized in **Table 5-1**.

Table 5-1. Aquifer Zone Hydraulic Characteristics from Aquifer Tests, Sutter Subbasin

Aquifer Zone	Transmissivity (ft^2/day)	Specific Yield or Storativity (unitless)	Source
AZ-1	N/A	N/A	N/A
AZ-2	N/A	N/A	N/A
AZ-3	7,619 to 8,957	0.000556 to 0.000898	SEWD, Well #1, 2007
	7,352 to 8,556	0.00108 to 0.000978	SEWD, Well #2, 2007

N/A = No aquifer tests available. ft^2/day = square feet per day.

To provide an additional assessment of aquifer properties in the basin, transmissivity (T) values were calculated using an empirical equation where T is calculated by multiplying the specific capacity by an assumed value estimated using the Theis equation. The multiplying factor can be based on unconfined or confined assumptions. As a general rule, T in units of gallons per day per foot (gpd/ft) is calculated by multiplying the specific capacity by 2,000 for a confined aquifer and by 1,500 for an unconfined aquifer (Driscoll, 1986). Specific capacities were obtained from data obtained at DWR's web page for well completion reports[1] that includes data if reported for pumping rates and total drawdowns.

Appendix 5-F provides all of the wells that included this information in the DWR's well completion report database for the Sutter Subbasin, along with calculated T values using the empirical formulas stated above (units of T converted to square feet per day [ft^2/day]). As seen in this table, calculated specific capacities ranged from 0.45 to 189 gallons per minute per foot of drawdown (gpm/ft) with an average value of about 19 gpm/ft. This table also separates calculations by aquifer zones based on completed depths and estimates hydraulic conductivity (K) values using average thickness of each of aquifer zones, as discussed in **Section 5.1.6**. **Table 5-2** summarizes the results of calculations for T and K using the empirical equation for specific capacities.

Table 5-2. Summary of Calculated T and K Values

Aquifer Zone	# of Records	Min T Value (ft^2/day)	Max T Value (ft^2/day)	Average T Value (ft^2/day)	Min K Value (ft/day) [3]	Max K Value (ft/day)	Average K Value (ft/day)
1 [1]	58	90	14,964	1,975	1	100	13
2 [2]	71	141	50,501	6,407	1	230	30
3 [2]	10	1,205	16,825	9,303	5	76	42

ft/day = feet per day.

[1] Uses empirical value for unconfined aquifer, multiplies specific capacity by 1,500 for units of gpd/ft. See Appendix 5-F for range of calculated specific capacities.

[2] Uses empirical value for confined aquifer, multiplies specific capacity by 2,000 for units of gpd/ft. See Appendix 5-F for range of calculated specific capacities.

[3] K Values calculated using aquifer zone thickness of 150 feet for AZ-1 and 220 feet for AZ-2 and AZ-3.

As shown in **Table 5-3**, the average K value for each aquifer zone is consistent with well sorted sands and gravels. Typically, T values of less than 100 ft^2/day will supply only enough water for domestic wells or other low-yield purposes. In wells with T values greater than 1,300 ft^2/day, the production yields are typically sufficient for industrial, municipal, or irrigation use.

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[1] Well completion reports obtained from DWR's Well Completion Report Map Application (https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37)

Table 5-3. Hydraulic Conductivity Values of Common Aquifer Materials (Modified from Bear, 1972)

K Values in units of feet per day (ft/day)	Aquifer Quality	Typical Aquifer Material
100,000	Good	Well Sorted Gravel
10,000	Good	Well Sorted Gravel
1,000	Good	Well Sorted Sand or Sand and Gravel
100	Good	Well Sorted Sand or Sand and Gravel
10	Good	Well Sorted Sand or Sand and Gravel
1	Poor	Very Fine Sand
0.1	Poor	Very Fine Sand
0.01	Poor	Very Fine Sand
0.001	Poor	Very Fine Sand
0.0001	None	Clay
0.00001	None	Clay

5.1.7 Groundwater Recharge Areas

Groundwater recharge to the Subbasin occurs from various areas within and outside of the Subbasin. The location of groundwater recharge areas is based on groundwater flow contours and geologic profiles. Groundwater contours and flow directions are discussed in detail in **Section 5.2**. For those areas outside of the Subbasin, the recharge areas are discussed in the narrative but not shown on the maps. As GSPs are developed for the adjacent subbasins, recharge areas will become better refined.

5.1.7.1 Recharge Areas Outside of the Subbasin

Groundwater contours show recharge to the Subbasin occurs predominantly in the northern and eastern portions of the Subbasin. Recharge areas present in the North Yuba and Butte Subbasins would contribute groundwater to the connected principal aquifer of the Sutter Subbasin.

The amount of subsurface inflow to the Sutter Subbasin from these recharge areas outside of the Subbasin is presented in **Section 5.3**.

5.1.7.2 Recharge Areas Inside of the Subbasin

Significant areas likely to contribute groundwater to shallow aquifer zones include creeks, rivers, and applied water where the water can move vertically through the sediments. The entire area of the Subbasin provides recharge to the groundwater system to some extent and at variable rates depending upon soil types and availability of water. **Figure 5-24** shows the Soil Agricultural Groundwater Banking Index (SAGBI) map of the Subbasin. This index provides a composite evaluation of soil suitability to accommodate groundwater recharge while maintaining healthy soils, crops, and a clean groundwater supply. 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. As shown in **Figure 5-24**, most soils across the Sutter Subbasin are rated as poor to very poor for accommodating groundwater recharge. Areas that are rated as moderately good to good are located around the Sutter Buttes and adjacent to the Feather River on the east and the Sacramento River on the west.

In response to California Executive Order D-5-99, California State Water Board staff created a map where published hydrogeologic information indicates soil or rock conditions that may be more vulnerable (or susceptible) to groundwater contamination, referred to as Hydrogeological Vulnerable Areas (HVAs). The map was created due to groundwater concerns over releases of methyl-tert-butyl ether (MTBE), primarily from leaking underground storage tank sites. The map was created in 2000 using DWR and USGS publications. Data from these publications were used to identify areas where geologic conditions are more likely to allow recharge at rates substantially higher than in lower permeability or confined areas of the same groundwater basin. **Figure 5-25** shows the HVA map for the Sutter Subbasin, indicating what appears to be highly permeable sediments in similar areas as the SAGBI map; however, the HVA mapping does show some areas where recharge could occur in the southern areas of the Sutter Subbasin.

Some of the major sources of groundwater recharge in the area include agricultural lands, the area around the Sutter Buttes, and rivers and bypasses. Much of the water applied for irrigation of agricultural areas in the Sutter Subbasin is surface water diverted from the Feather and Sacramento Rivers, with applied water being supplemented by precipitation. The average annual recharge of applied water in the area covered by the Feather River Regional Agricultural Water Management Plan is 1.25 acre-feet per acre (AF/ac), while comparable recharge of precipitation is 0.35 AF/ac (Davids Engineering, 2014).

The most prominent agricultural land use in the Sutter Subbasin is rice production, followed by fruit and nut orchards and a variety of other crops. Rice production is characterized by flooding of relatively impermeable soils, while irrigation of other crops is performed either by traditional irrigation techniques or by newer low-volume methods including drip and micro-jet systems.

In recent years, growers have been changing orchards from fruits to nuts (almonds). Fruit and nut orchards have an average crop evapotranspiration (ETc) of about 36.3 inches per year which converts to 3.0 AF/ac. Therefore, shifts between fruit and nut crops have little impact on water use; however, changes in irrigation practices have been accompanying these changes in cropping. For example, new orchards are being irrigated almost exclusively with drip and micro-jet systems. This shift away from flood irrigation practices applies less water to fields, so while crop consumption may actually increase due to better timing of applications, deep percolation diminishes. In addition, the low-volume systems are often supplied by wells, which can be turned on and off, rather than from canal deliveries. Both the reduction in deep percolation from newly established orchards and the increased reliance on groundwater to irrigate these lands have implications on the water budget.

The Sutter Buttes Rampart Formation is exposed in an apron surrounding Sutter Buttes, allowing precipitation and agricultural applied water to migrate horizontally along the principal aquifer beds. The amount of recharge, based on surface exposure of the Sutter Buttes Rampart Formation and an average precipitation of 18 inches per year (about 10 percent recharged), is about 220 acre-feet per year (AFY), or less than 1 percent of the total inflow to the basin based on the water budget.

Detailed geotechnical investigations along the rivers and bypasses show multiple sand and gravel layers are present which could allow surface water to recharge the shallow aquifer zone at a relatively high rate. Water can still recharge through silt and clayey layers, but at a much slower rate. The amount of water recharge, based on C2VSimFG-Sutter, is presented in **Section 5.3**.

Prior to 2013, some areas along the rivers and bypasses had low permeability slurry walls installed to stabilize the levees (on the order of 10 percent or less of the total leveed area). Starting in 2013 and continuing through 2016, slurry walls have been installed just north of the confluence of the Feather and Bear Rivers, as shown on the profiles contained in **Appendices 5-C** through **5-E**. This ongoing work has extended the slurry wall coverage to about 50 percent of the river. The depths of the slurry walls have ranged/will range between 21 and 105 feet and reduce, though not stop surface water recharge or portions of the subsurface inflow from the Yuba Subbasins to the east. Estimates on the of reduction of groundwater recharge were not described in the California Environmental Quality Act documentation for the slurry wall installations (ICF International, 2013).

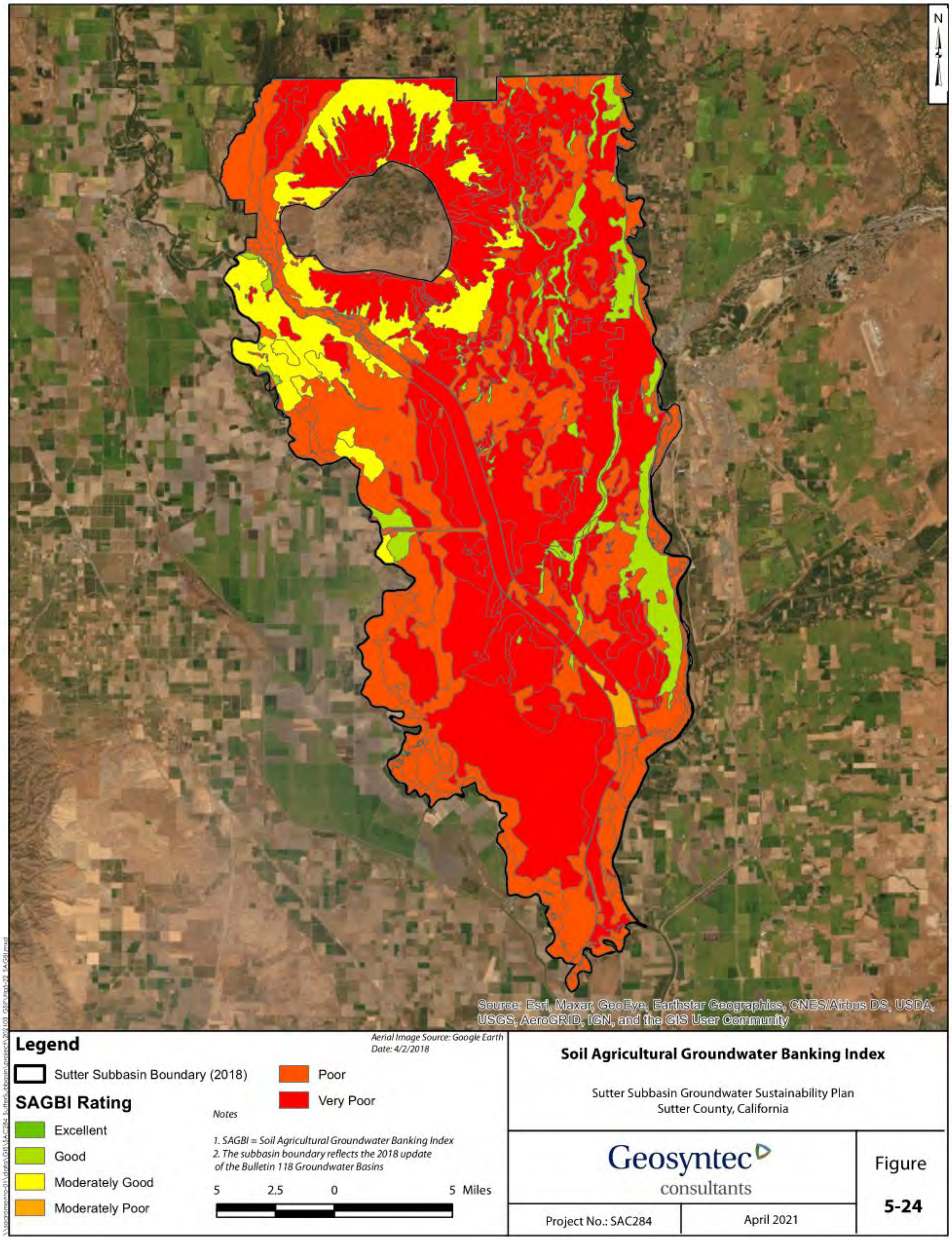


Figure 5-24. SAGBI Map, Sutter Subbasin

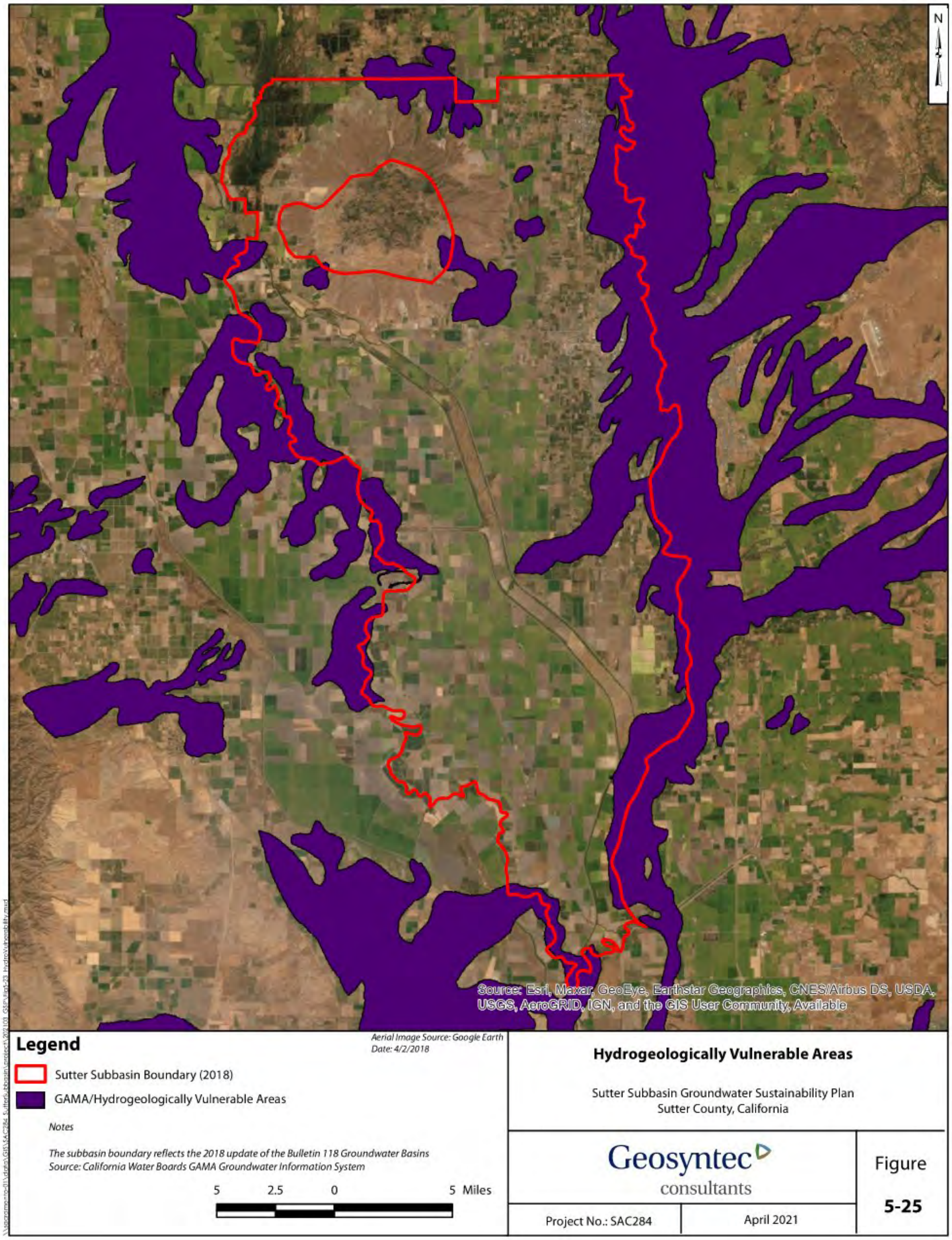


Figure 5-25. Hydrologically Vulnerable Areas, Sutter Subbasin

5.1.8 Groundwater Discharge Areas

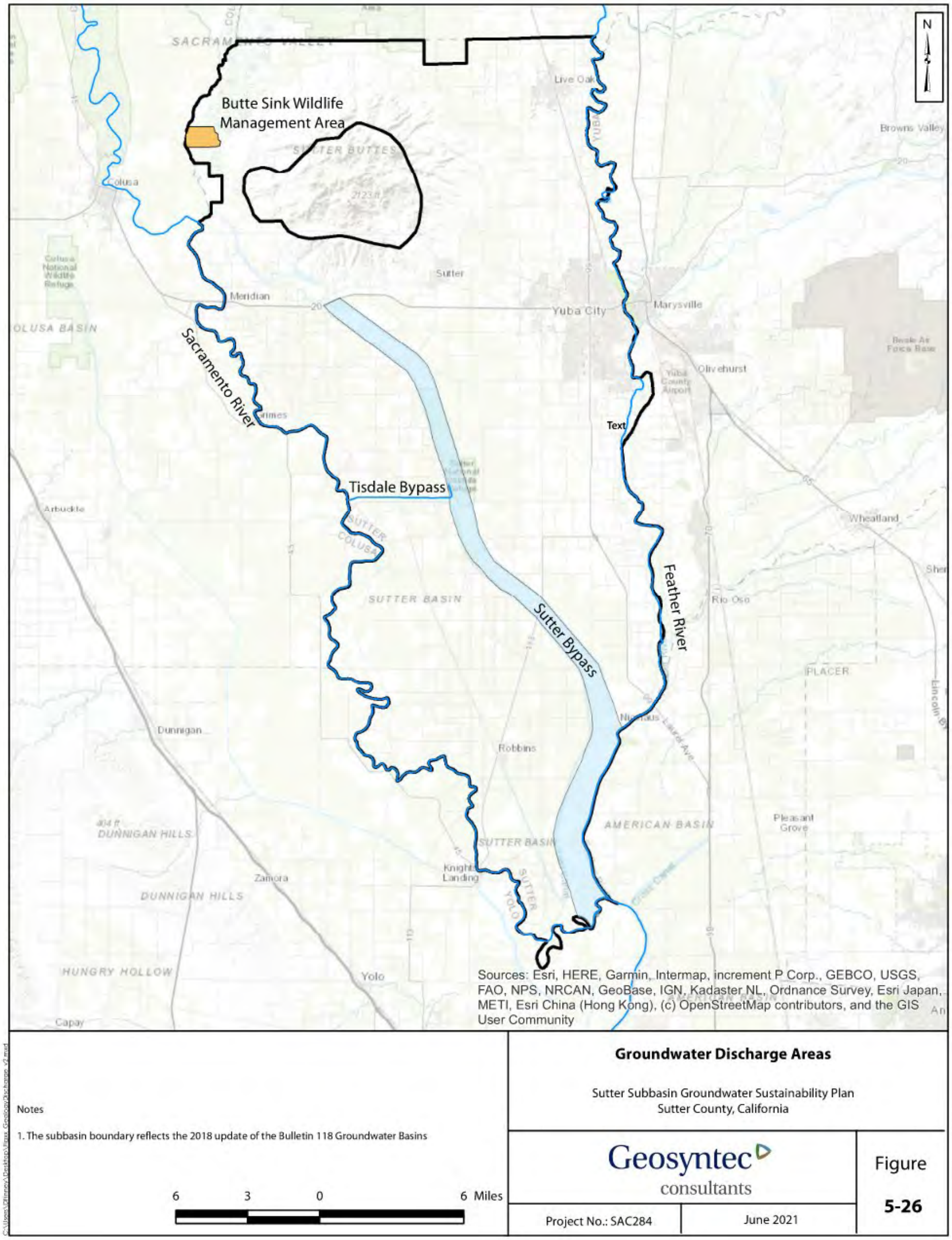
Significant sources of groundwater discharge in the Sutter Subbasin include the Sacramento and Feather Rivers, the Butte Sink Wildlife Management Area, and Sutter and Tisdale Bypasses (**Figure 5-26**). Groundwater discharge also occurs along creeks and sloughs though are not considered to be substantial sources of groundwater discharge.

The Sacramento River is topographically at the bottom of the basin and therefore would act under predevelopment conditions as a drain for groundwater within the shallow aquifer zones. Groundwater also may discharge to the Feather River along the southern portion where slurry walls and levee improvements are not planned. The low-lying Butte Sink Wildlife Management Area, located around the Sutter Buttes, constitutes an area of significant groundwater discharge (CH2MHill, 2014).

Detailed geotechnical investigations along the Sacramento River and the Sutter and Tisdale Bypasses, as discussed in the **Section 5.1.5**, showed that multiple sand and gravel layers are present adjacent to the surface water courses. These permeable layers could allow groundwater to discharge to surface water from the shallow aquifer at a relatively high rate. Water can still discharge through silt and clayey layers, but at a much slower rate. The average discharge from the basins is presented in **Section 5.3**.

5.1.9 Water Quality

Groundwater quality was evaluated in the Alternative Plan, in the Sutter County Groundwater Management Plan (Wood Rodgers, 2012), and during the preparation of the Rice Coalition Groundwater Assessment Report (CH2M, 2016). The Alternative Plan utilized available data and developed water quality profiles for three general depths that generally correspond to the three aquifer zones defined in this GSP. For the Alternative Plan, AZ-1 extends to 150 feet bgs, AZ-2 to 400 feet bgs, and AZ-3 to greater than 400 feet bgs. This water quality compilation is a composite of sampling events that span almost 40 years and includes data from DWR and the USGS Shallow Rice, Shallow Domestic, and Groundwater Ambient Monitoring and Assessment Program (GAMA) well networks. To support these data, this GSP also assessed data from DWR's Water Data Library located at https://wdl.water.ca.gov/waterdatalibrary/WaterQualityDataLib.aspx for wells completed in all three aquifer zones across the Sutter Subbasin. Many of these wells are nested wells, with separate screen zones within each aquifer zone. The location of the wells used for this assessment are provided in **Figure 5-27** and well construction details for these wells are provided in **Table 5-4**.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Notes

1. The subbasin boundary reflects the 2018 update of the Bulletin 118 Groundwater Basins

Groundwater Discharge Areas

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Geosyntec consultants

Project No.: SAC284

June 2021

Figure

5-26

Figure 5-26. Groundwater Discharge Areas

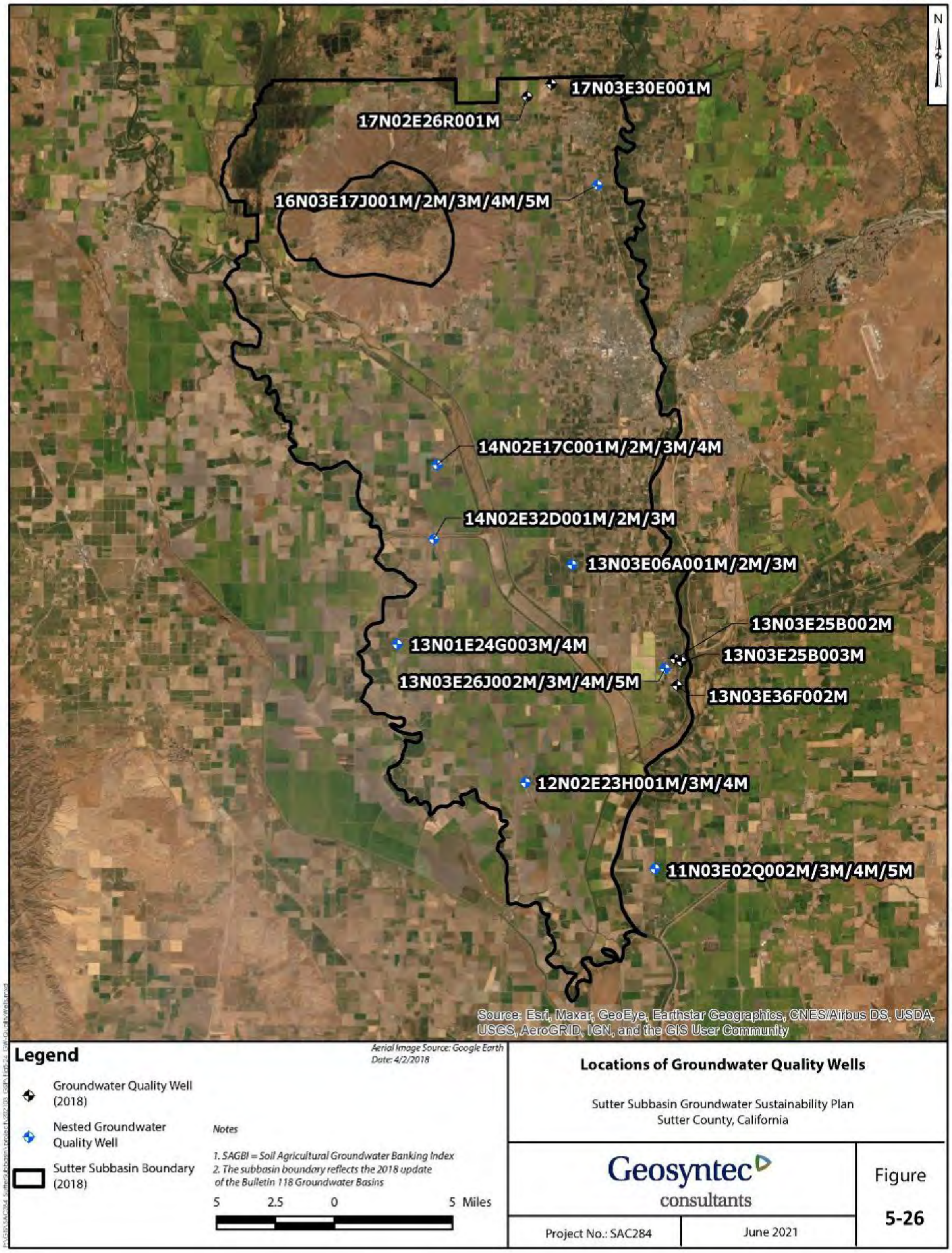


Figure 5-27. Locations of Groundwater Quality Wells

Table 5-4. Well Construction Details for Wells with Water Quality Information

Well ID	Latitude	Longitude	Total Depth	Screen Interval	Aquifer Zone
12N02E23H001M	38.8761	-121.709	150	120-140	1
12N02E23H003M	38.8761	-121.709	600	570-590	3
12N02E23H004M	38.8761	-121.709	705	655-695	3
16N03E17J001M	39.2394	-121.651	85	65-75	1
16N03E17J004M	39.2394	-121.651	615	595-605	3
16N03E17J005M	39.2394	-121.651	785	765-775	3
16N03E17J002M	39.2394	-121.651	315	285-305	2
16N03E17J003M	39.2394	-121.651	430	400-420	2
13N03E26J002M	38.945159	-121.599	175	145-165	1
13N03E26J003M	38.945159	-121.599	445	425-435	2
13N03E26J004M	38.945159	-121.599	610	590-600	3
13N03E26J005M	38.945159	-121.599	1005	985-995	3
11N03E02Q002M	38.823236	-121.6076	170	130-160	1
11N03E02Q003M	38.823236	-121.6076	675	655-675	3
11N03E02Q004M	38.823236	-121.6076	930	910-920	3
11N03E02Q005M	38.823236	-121.6076	1225	1205-1215	3
13N01E24G003M	38.9605	-121.81	160	130-160	1
13N01E24G004M	38.9605	-121.81	100	70-90	1
14N02E32D001M	39.024429	-121.781	64	34-54	1
14N02E32D002M	39.024429	-121.781	210	170-200	1
14N02E32D003M	39.024429	-121.781	500	460-490	3
13N03E06A001M	39.008641	-121.672	65	45-55	1
13N03E06A002M	39.008641	-121.672	175	155-165	1
13N03E06A003M	39.008641	-121.672	265	245-255	2
14N02E17C001M	39.0696	-121.778	60	30-50	1
14N02E17C002M	39.0696	-121.778	245	205-235	2
14N02E17C003M	39.0696	-121.778	425	395-415	2
14N02E17C004M	39.0696	-121.778	755	725-745	3
17N02E26R001M	39.2935	-121.706	601	279-601	2 and 3
17N03E30E001M	39.3012	-121.687	610	263-610	2 and 3
13N03E25B002M	38.951044	-121.5913	248	148-168	1
13N03E36F002M	38.934758	-121.5896	365	160-170	1
13N03E25B003M	38.9494	-121.5863	200	115-200	1

California Code of Regulations Title 22 establishes water quality standards for drinking water contaminants. A primary maximum contaminant level (MCL) or secondary MCL (SMCL) is defined for a variety of parameters. The Alternative Plan identified several constituents within the Sutter Subbasin that exceed these standards for drinking water, the highest beneficial use category. Although groundwater quality in the Sutter

Subbasin is generally sufficient to meet beneficial uses, these constituents of concern are either currently impacting groundwater use or have the potential to impact it in the future. Depending on the water quality constituent, the source may be anthropogenic in origin or naturally occurring, and the issue may be widespread or localized. The primary naturally-occurring water quality constituents of concern are arsenic, boron, salinity, iron, and manganese. Primary water constituents detected related to human activity include salinity, nitrates, and various point-source contaminants.

The sections herein provide information on the historical and current groundwater quality conditions starting with the general water quality within the Sutter Subbasin followed by trends for specific constituents, including:

- Arsenic
- Boron
- Salinity
- Nitrate
- Iron and manganese
- Point-source contamination, which includes petroleum hydrocarbons, solvents, and emerging contaminants

For the purposes of this GSP, comparing parameter concentrations to their MCL or SMCL is used as the basis for describing groundwater quality concerns in the Sutter Subbasin. Comparisons to the MCL or SMCL must be considered in context, as the measured concentrations represent raw water that may be treated or blended prior to delivery to meet the standard or may not be used for potable uses.

5.1.9.1 General Water Quality

As stated above, several nested monitoring wells, along with irrigation wells with longer screens, within the Subbasin have been monitored for general water quality issues since 2009 by DWR (see **Figure 5-27** for location and **Table 5-4** for well construction details). The nested wells sampled by DWR have separate well screens within each of the three aquifer zones discussed in **Section 5.1.6**, allowing an overall assessment of general water quality changes with depth across the Sutter Subbasin. **Table 5-5** summarizes the general chemical parameters collected from each of these wells.

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Table 5-5. Summary of Water Quality Data Used for General Chemical Analysis

Well ID	Sample Date	Boron (mg/L)	Total Alkalinity (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Specific Conductance (µS/cm)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	TDS (mg/L)	Sulfate (mg/L)	pH	Temperature (Degrees C)
12N02E23H001M	5/18/2010	0.8	198	0.021	44	517	1938	0.008	37	0.154	<0.1	3.7	290	1060	2	7.54	18.80
12N02E23H003M	5/18/2010	0.8	209	0.048	13	151	922	0.021	5	0.073	<0.1	4.2	173	596	26	8.23	21.50
12N02E23H004M	5/18/2010	0.9	194	0.084	15	191	1004	0.032	7	0.088	<0.1	6.1	185	585	20	8.05	20.60
16N03E17J004M	8/12/2010	0.5	134	0.09	19	111	625	0.038	9	0.191	<0.1	5.5	81	386	4	7.69	20.84
16N03E17J005M	8/12/2010	1.8	108	0.013	65	488	1801	0.036	14	0.194	<0.1	12	309	1060	24	7.64	20.42
13N03E26J002M	8/12/2010	0.9	120	0.006	63	472	1728	<0.005	22	0.155	<0.1	26.2	256	951	5	8.91	20.25
13N03E26J003M	8/12/2010	0.7	157	0.008	88	355	1528	0.01	28	0.178	0.3	9.2	178	901	23	7.77	20.22
13N03E26J004M	8/12/2010	1.4	141	0.007	10	116	691	0.01	3	0.042	<0.1	3	126	403	8	8.39	20.90
13N03E26J005M	8/12/2010	2.4	109	0.012	70	920	3229	0.038	22	0.16	<0.2	11.9	483	1850	8	7.38	20.67
16N03E17J001M	8/12/2010	<0.1	70	0.002	13	2	150	<0.005	11	<0.005	3.8	<0.5	4	115	3	7.37	19.75
16N03E17J002M	8/12/2010	0.3	132	0.201	12	9	278	<0.005	11	0.329	<0.1	3.7	35	210	<1	7.39	20.04
16N03E17J003M	8/12/2010	0.3	143	0.101	17	13	310	0.039	8	0.145	<0.1	4	41	225	1	7.78	20.47
11N03E02Q002M	3/9/2011	0.3	327	0.02	55	198	1262	0.18	23	0.242	<0.1	3.1	163	716	9	8.05	18.40
11N03E02Q003M	3/9/2011	0.4	112	0.014	125	951	3279	0.062	30	0.289	<0.1	7.3	416	1880	15	8.07	19.40
11N03E02Q004M	3/9/2011	0.5	95	0.012	129	1040	3515	0.029	28	0.151	<0.1	9.2	473	2160	14	8.03	19.20
11N03E02Q005M	3/9/2011	0.5	124	0.014	38	369	1508	0.075	10	0.198	<0.1	4.6	218	866	9	8.02	18.50
13N01E24G003M	9/12/2012	0.1	112	0.011	7	4	250	0.047	8	0.07	<0.1	1.3	37	189	6	7.28	18.64
13N01E24G004M	9/12/2012	0.3	341	0.013	42	12	692	0.974	39	0.039	0.1	2.1	60	428	22	7.15	18.66
14N02E32D003M	6/20/2012	0.5	169	0.022	49	355	1502	0.021	25	0.254	0.1	11.3	221	874	32	7.67	22.13
14N02E32D002M	6/20/2012	0.3	245	0.008	20	84	784	0.184	12	0.161	<0.1	5.1	139	496	26	7.21	21.90
14N02E32D001M	6/20/2012	<0.1	276	0.006	46	11	566	<0.005	41	0.271	<0.1	2.1	20	318	15	7.18	23.87
13N03E06A001M	3/9/2011	0.3	260	0.009	117	606	2461	0.06	85	0.775	<0.1	2.6	186	1370	2	7.27	18.10
13N03E06A002M	3/9/2011	0.5	134	0.01	154	1000	3501	0.082	106	1.17	<0.1	7.6	286	2200	<1	7.18	18.40
13N03E06A003M	3/9/2011	0.7	130	0.023	148	1110	3803	0.137	99	1.42	<0.1	15.4	386	2290	<1	7.28	19.10
14N02E17C001M	3/17/2010	<0.1	408	0.011	57	16	797	<0.005	60	0.125	7	2.1	36	492	26	7.27	19.50
14N02E17C002M	3/17/2010	0.1	143	0.026	18	7	328	<0.005	9	0.074	<0.1	3.1	41	231	17	6.99	20.30
14N02E17C003M	3/17/2010	0.2	122	0.03	18	36	380	<0.005	7	0.029	0.1	3.8	51	228	12	6.78	20.30
14N02E17C004M	3/17/2010	0.7	142	0.017	127	994	3337	0.026	53	0.573	<0.333	27.7	431	2100	9	5.86	20.70
17N02E26R001M	6/17/2009	0.2	119	0.127	12	14	264	0.0161	11	0.228	1.1	4.4	30	201	<1	7.10	21.50
17N02E26R001M	9/23/2009	0.2	118	0.134	12	16	278	0.06	10	0.00022	1.1	4.2	35	202	<1	7.02	22.10
17N03E30E001M	6/17/2009	0.2	121	0.0681	10	9	250	0.0064	9	0.212	0.4	4.4	33	191	<1	7.20	21.50
17N03E30E001M	9/23/2009	0.3	120	0.0686	10	11	265	0.0318	9	0.192	0.4	4.3	38	197	<1	7.30	21.80
13N03E25B002M	8/26/2009	2.2	120	0.007	78	673	2519	0.064	17	0.574	<0.1	7.5	369	1510	<1	7.65	19.80
13N03E36F002M	8/26/2009	2.2	148	0.01	64	632	2246	0.078	17	0.451	<0.1	6.3	344	1290	<1	7.59	20.50
13N03E25B003M	8/26/2009	1.4	146	0.005	9	98	606	0.05	2	0.074	<0.1	2.1	107	361	<1	8.17	19.00

µS/cm – micro-Siemens per centimeter
Degrees C – Degrees Celsius
mg/L – milligrams per liter
TDS – Total dissolved solids
See Table 5-4 for well construction details

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To assess general chemical trends within the Sutter Subbasin, the cations (metals such as calcium and sodium) and anions (such as chloride and sulfate) were plotted on a piper diagram. A piper diagram is a graphical representation of the chemistry of a water sample or samples. As shown in **Figure 5-28**, piper diagrams are a combination cation triangle (lower left) and anion triangle (lower right) that lie on a common baseline. A diamond shape is placed between them. Information that can be assessed from this diagram includes water type. **Figure 5-28** was developed by USGS (presentation from http://inside.mines.edu/~epoeter/_GW/18WaterChem2 /WaterChem2pdf.pdf) that lists general interpretations for specific water types.

Figure 5-29 presents the piper diagram constructed from the groundwater quality data available for the wells listed in **Table 5-5**. As seen in this figure and listed in **Table 5-5**, water types reported for these samples include magnesium (Mg) – bicarbonate (HCO_3), sodium (Na)-chloride (Cl), and Na-HCO^3. The Mg-HCO_3 is similar to the calcium (Ca) HCO_3 water type shown in **Figure 5-25** and is typical of shallow fresh groundwaters. The Na-Cl water type is typical of marine or ancient groundwaters, but anthropogenic sources could also change waters to this type. The Na-HCO_3 water type is typical of groundwaters that have been in contact with aquifer materials for a longer time period and are influenced by ion exchange processes.

Figure 5-30 through **Figure 5-32** shows the water types reported for each of the aquifer zones at each nested well location. As seen in **Figure 5-30**, within the shallow aquifer zone, AZ-1, the northern to central part of the Subbasin is characterized by Mg-HCO_3 waters that suggests shallow fresh groundwater. From the central part to the southern area of the Sutter Subbasin, water types are classified by Na-HCO_3 and Na-Cl waters. These water types suggest these areas are influenced by ion exchange processes (Na-HCO_3) or typical of marine or ancient groundwaters (Na-Cl). For the shallow groundwater zone, the Na-Cl water type is more likely the result of interactions with agricultural practices within the area. As discussed below for salinity, the wells classified as Na-Cl in the shallow aquifer zone also have total dissolved solids (TDS) reported at values greater than 1,000 milligrams per liter (mg/L), whereas the other wells in the shallow zone with different water types have TDS values below 1,000 mg/L.

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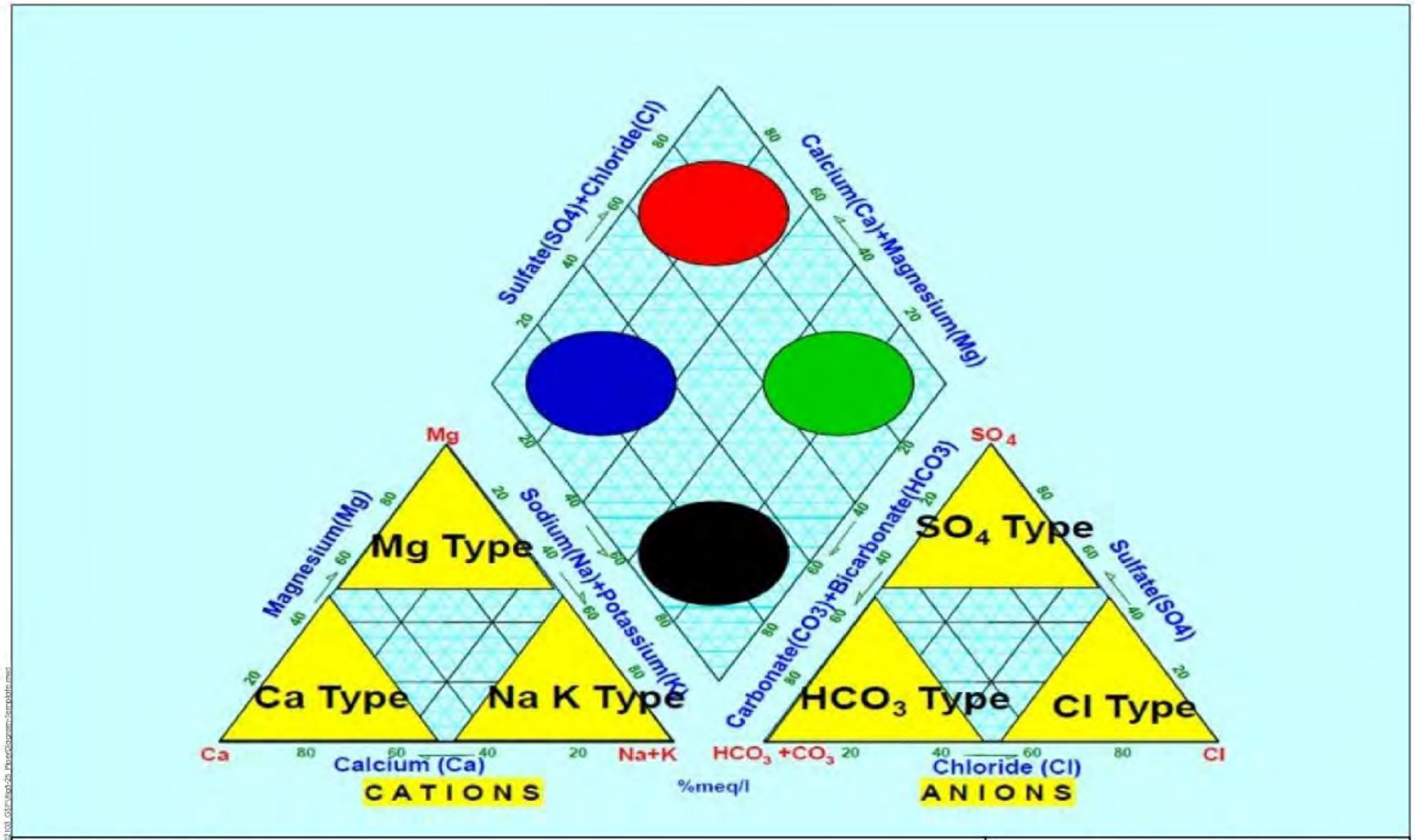

Classification of Water Types

- 🔴 Ca-SO_4 waters - typical of gypsum ground waters and mine drainage
- 🔵 Ca-HCO_3 waters - typical of shallow, fresh ground waters
- 🟢 Na-Cl waters - typical of marine and deep ancient ground waters
- ⚫ Na-HCO_3 waters - typical deeper ground waters influenced by ion exchange

Piper Diagram Template

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Sutter County, California

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Figure 5-28

Figure 5-28. Piper Diagram Template

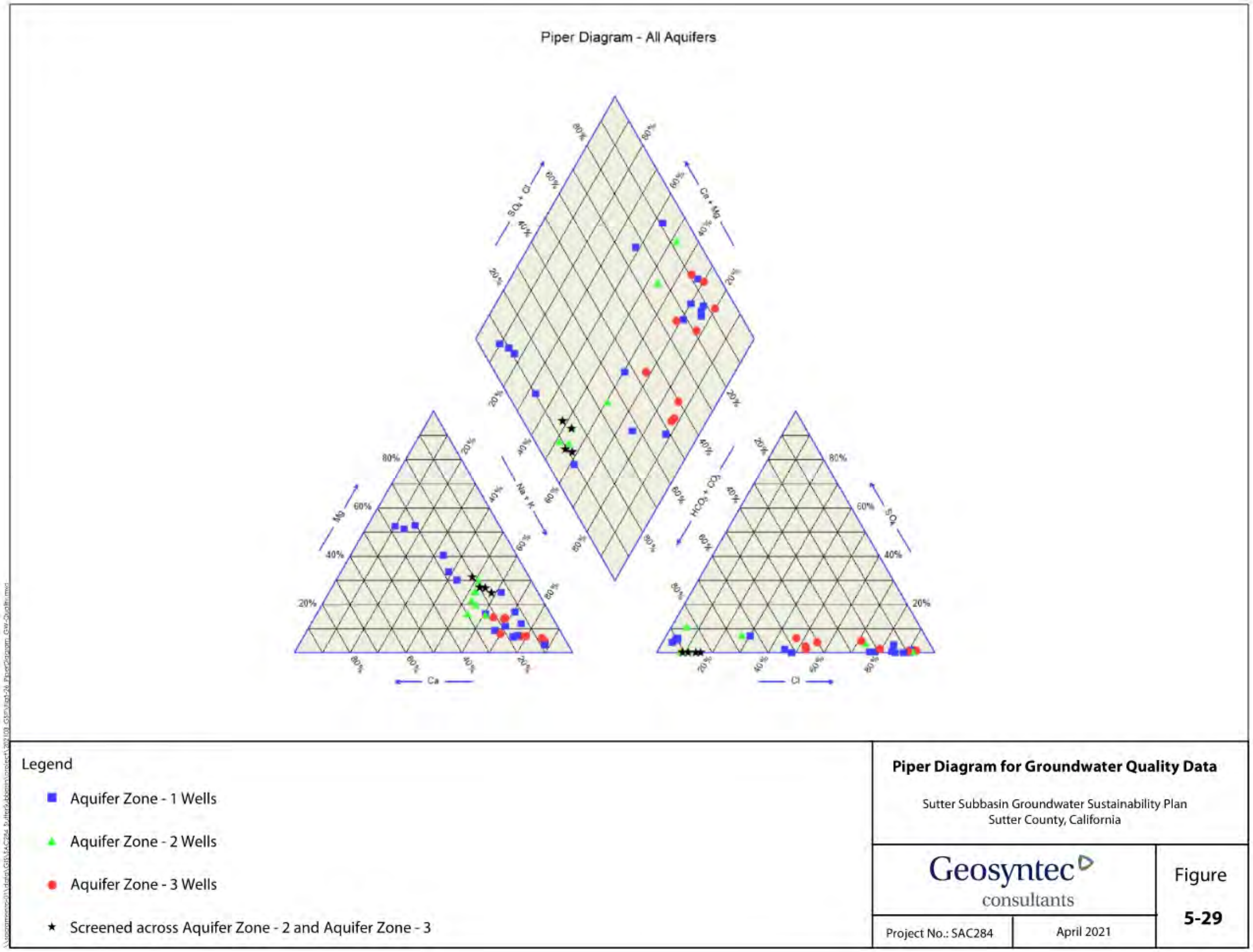
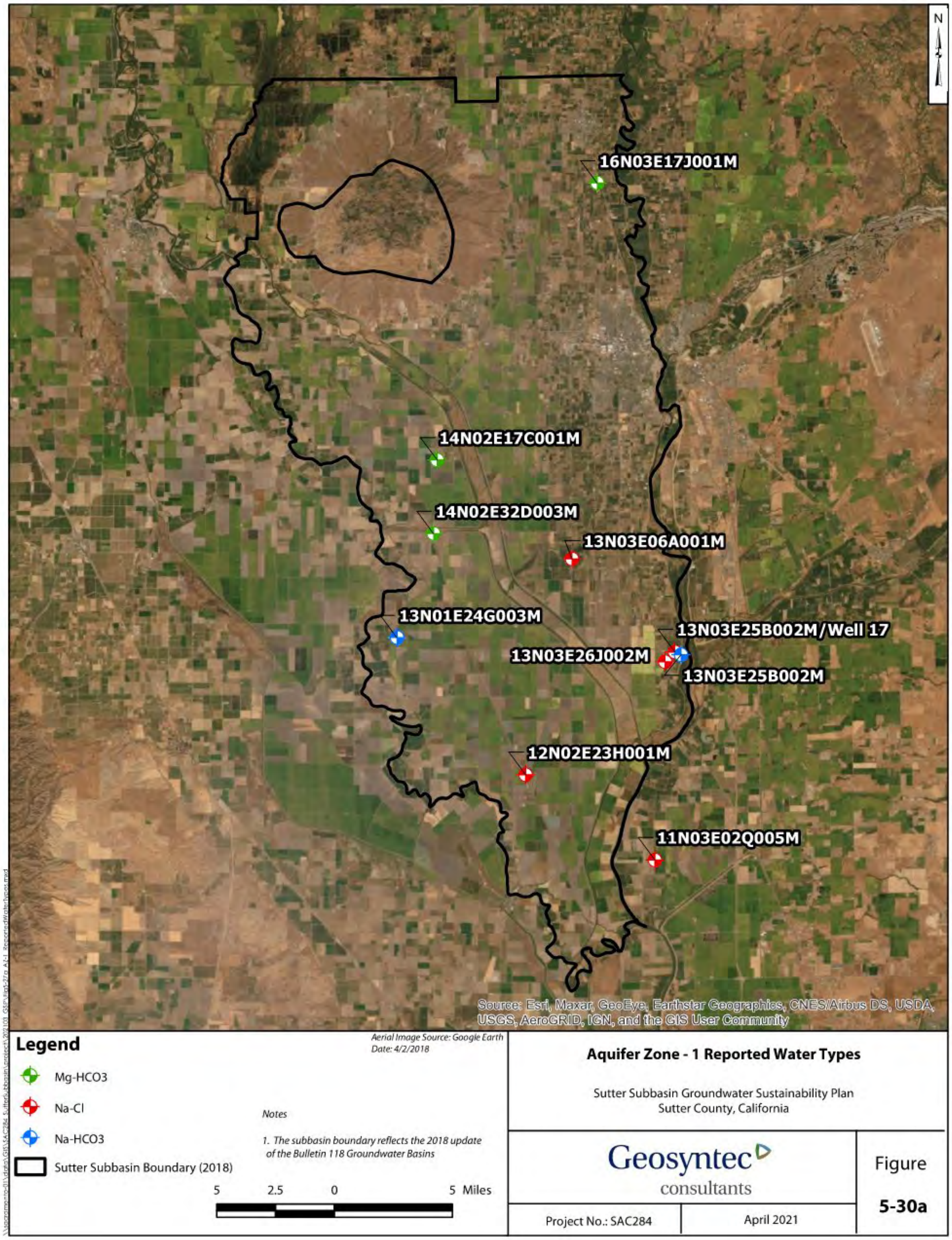


Figure 5-29. Piper Diagram for Water Quality Data by Aquifer Zone



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Aerial Image Source: Google Earth
Date: 4/2/2018

Notes

1. The subbasin boundary reflects the 2018 update of the Bulletin 118 Groundwater Basins

Figure 5-30. Aquifer Zone-1 Reported Water Types

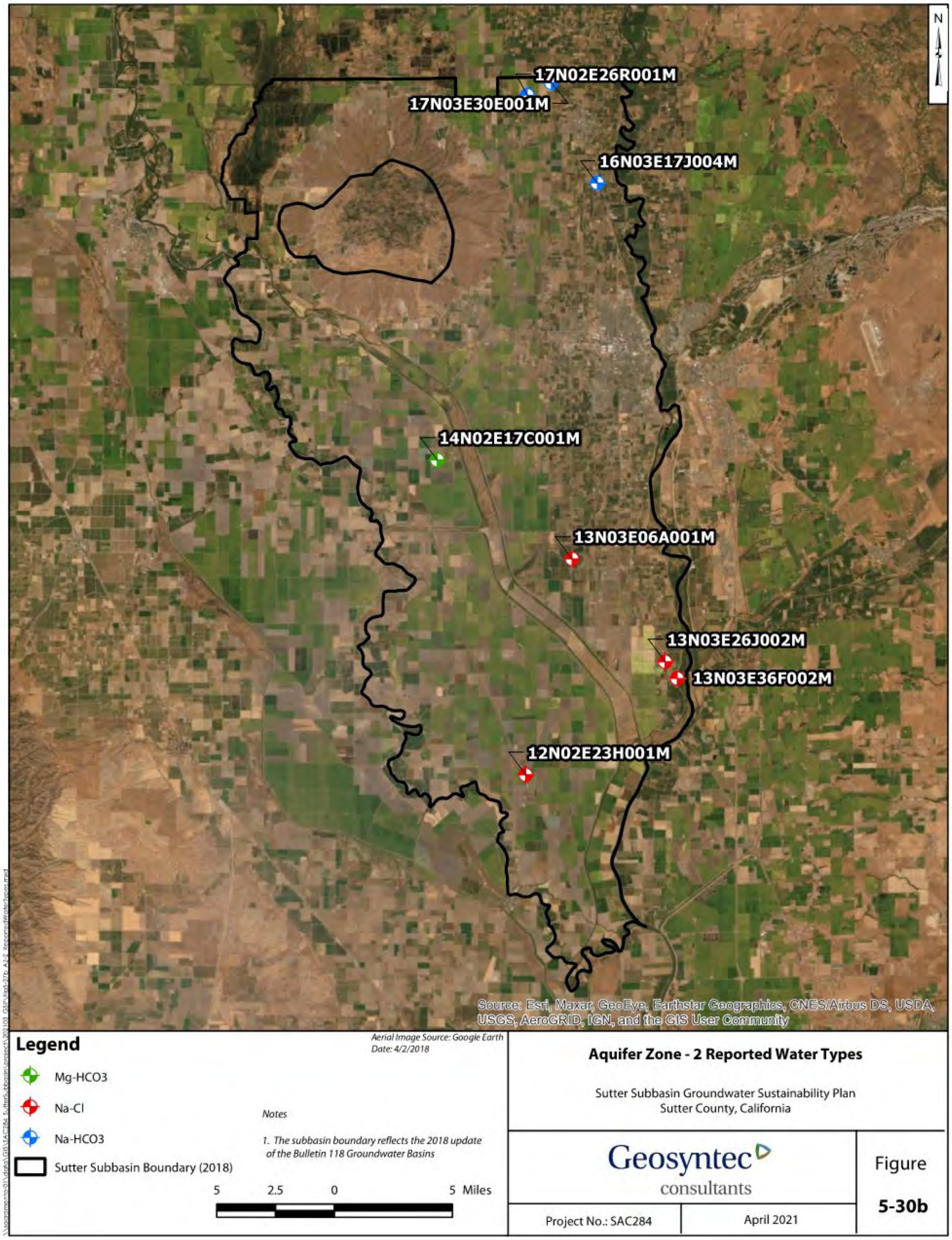


Figure 5-31. Aquifer Zone-2 Reported Water Types

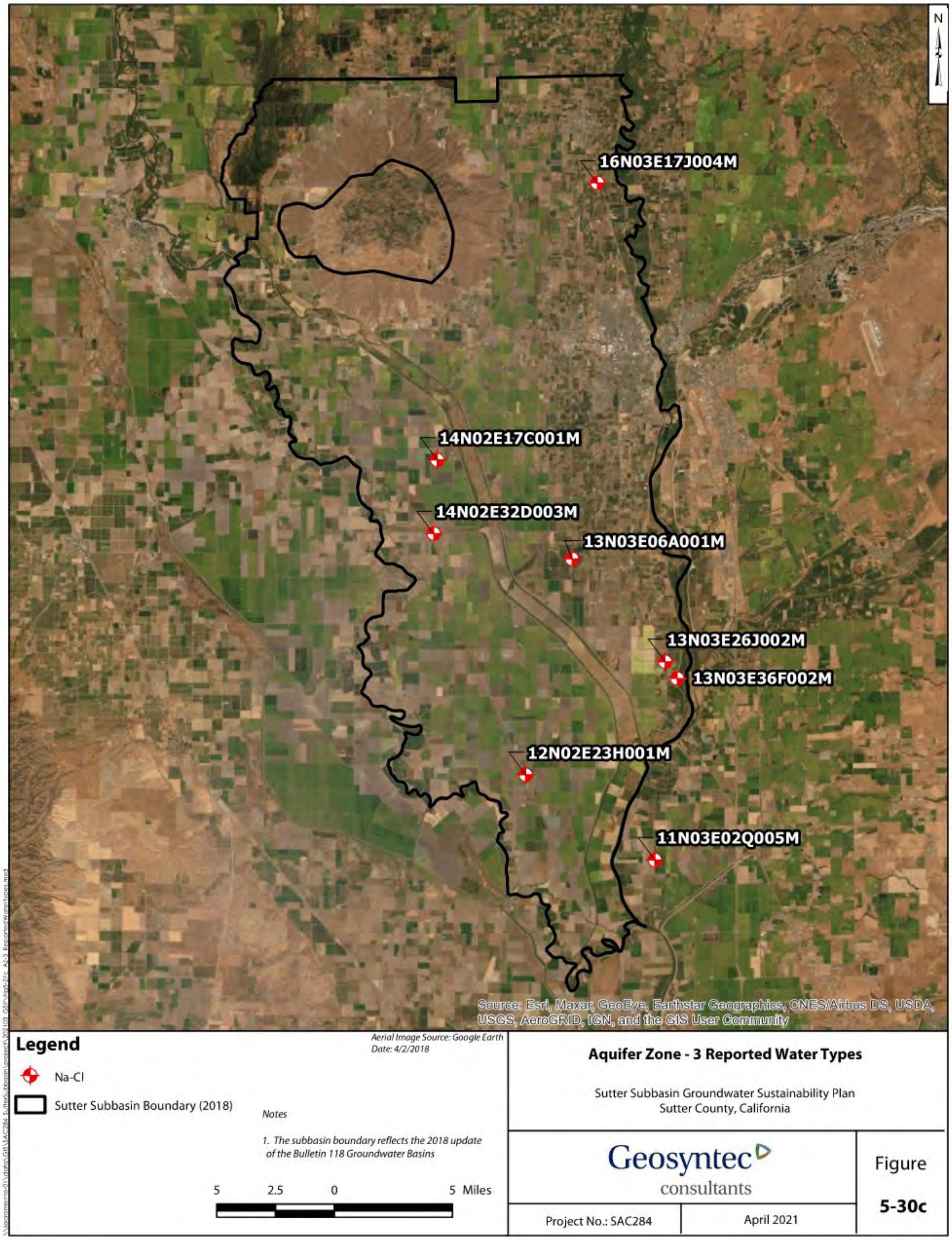


Figure 5-32. Aquifer Zone-3 Reported Water Types

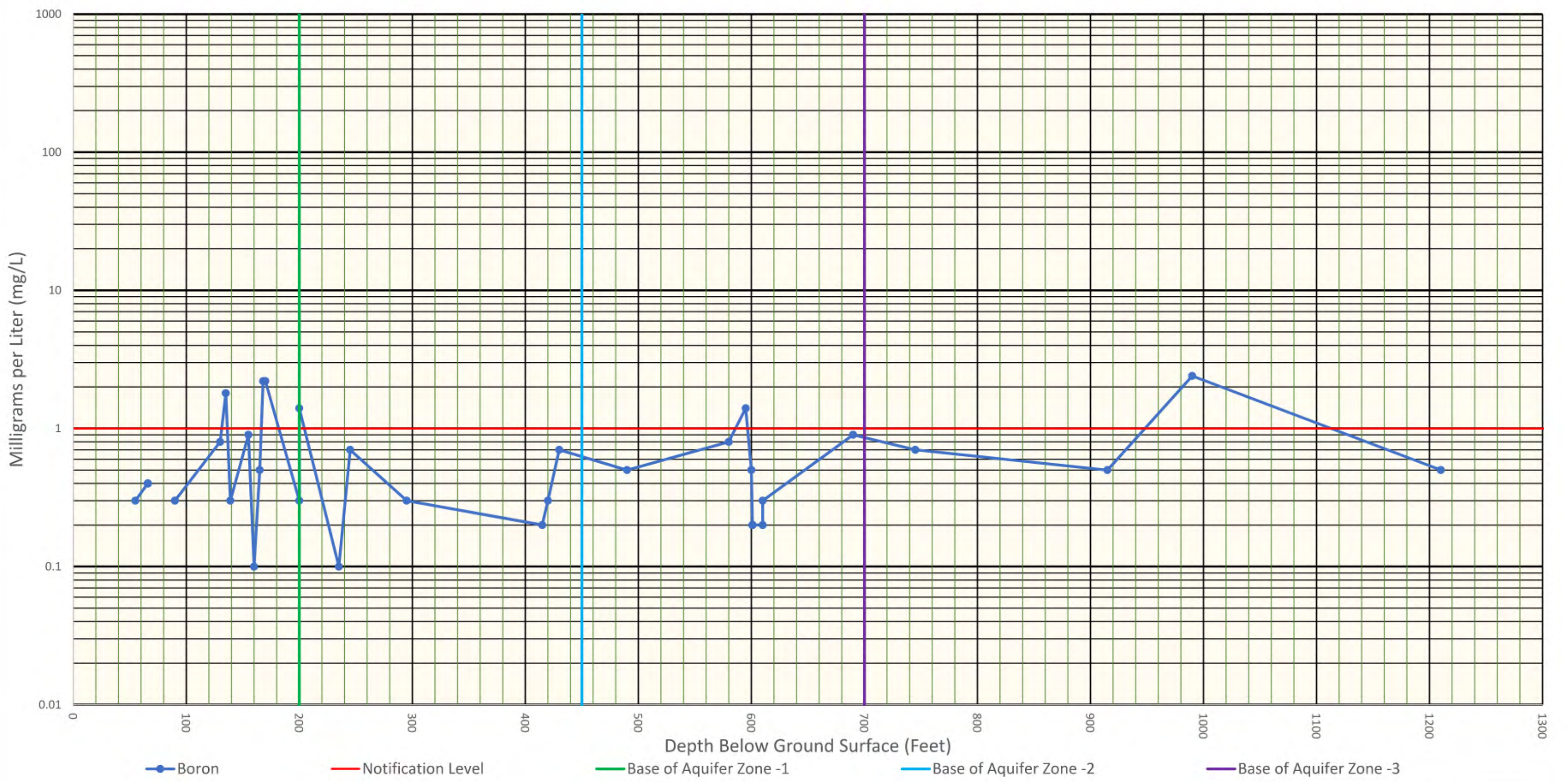
For AZ-2, water types (**Figure 5-31**) in the northern to central part of the Sutter Subbasin are Na-HCO_3, indicative of influence from ion exchange processes. Water types for the central to southern part of the Sutter Subbasin are Na-Cl, suggesting influence from marine or ancient groundwaters or anthropogenic sources. As discussed below for salinity, except for one well screened near the boundary with AZ-1 (06A003M), the TDS values with Na-Cl values are below 1,000 mg/L. All the wells completed within AZ-3 or deeper (screens deeper than 700 feet bgs) have reported water types of Na-Cl (**Figure 5-32**), suggesting influence from marine or ancient groundwaters. As discussed in **Section 5.1.3**, the base of fresh water is encountered between approximately 700 feet bgs to 1,000 feet bgs across the basin. The only well in AZ-3 with reported TDS values above 1,000 mg/L (02Q003M) is screened near this boundary. Only the deepest well screened below AZ-3 (02Q005M – 1,215 feet bgs) had TDS values below 1,000 mg/L.

5.1.9.2 Boron

Boron is a naturally occurring element and, similar to arsenic, is commonly found in alluvial sediments derived from volcanic sources such as the Sutter Buttes Rampart, Mehrten, and Tuscan Formations that make up the intermediate and deep aquifer zones. High concentrations of boron can also be associated with old marine deposits that are known to exist within the basin (USGS, 2011). An MCL has not been established for drinking water, but a Notification Level of 1 mg/L has been established.

Figure 5-33 provides a cross plot of boron versus depth of the bottom of screen interval for the well for the wells shown in **Figure 5-27**. As seen in this figure, most reported boron values are below the 1 mg/L value. However, four wells from AZ-1(17J005M, 25B002M, 36F002M, and 25B003M) and two wells from AZ-3 (26J004M and 26J005M) are above the Notification Level of 1 mg/L. The two AZ-3 locations are located adjacent to the Feather River in the northern part of the Sutter Subbasin. The four AZ-1 wells are located adjacent to the Feather River in the southern part of the Sutter Subbasin.

Figure 5-34 displays the boron concentration distribution by aquifer zone as presented in the Alternative Plan. For these figures, developed as part of the Groundwater Management Plan for the Subbasin (Wood Rodgers, 2012), the AZ-1 zones extends from 0 to 150 feet bgs, the AZ-2 zone from 150 to 400 feet bgs, and the AZ-3 zone from greater than 400 feet bgs. As shown in this figure, boron concentrations in the Sutter Subbasin are generally acceptable, except for some deeper wells which likely encounter more marine sediments. Boron concentrations were not monitored as part of the Rice Coalition Groundwater Assessment Report.



Boron Cross Plot

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Figure 5-31

Figure 5-33. Boron Cross Plot

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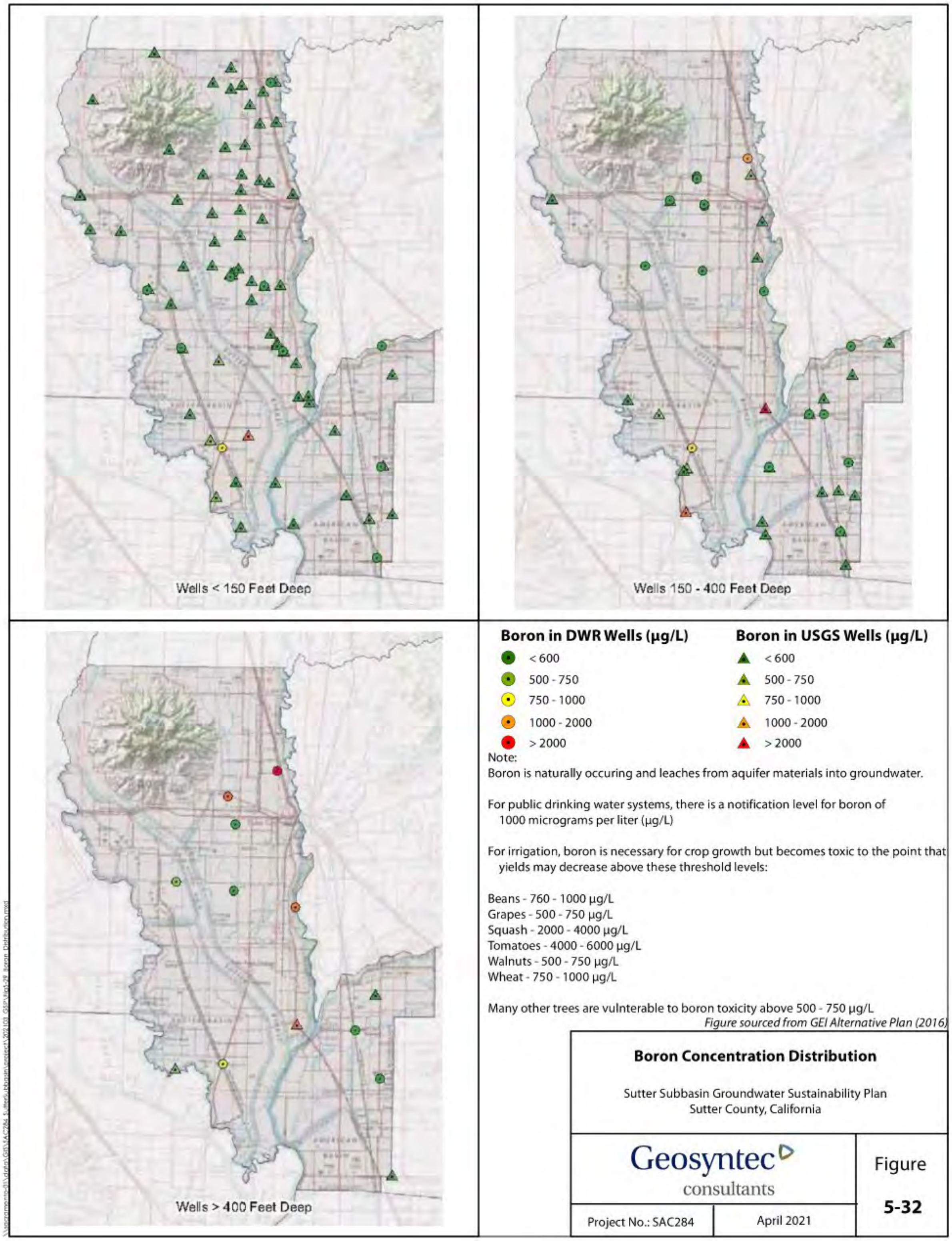


Note:
Boron is naturally occuring and leaches from aquifer materials into groundwater.

For public drinking water systems, there is a notification level for boron of 1000 micrograms per liter (µg/L)

For irrigation, boron is necessary for crop growth but becomes toxic to the point that yields may decrease above these threshold levels:

Beans - 760 - 1000 µg/L
Grapes - 500 - 750 µg/L
Squash - 2000 - 4000 µg/L
Tomatoes - 4000 - 6000 µg/L
Walnuts - 500 - 750 µg/L
Wheat - 750 - 1000 µg/L

Many other trees are vulnterable to boron toxicity above 500 - 750 µg/L

Figure sourced from GEI Alternative Plan (2016)

Boron Concentration Distribution

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Geosyntec consultants

Project No.: SAC284

April 2021

Figure

5-32

Figure 5-34. Boron Concentration Distribution by Aquifer Zone, Sutter Subbasin

5.1.9.3 Arsenic

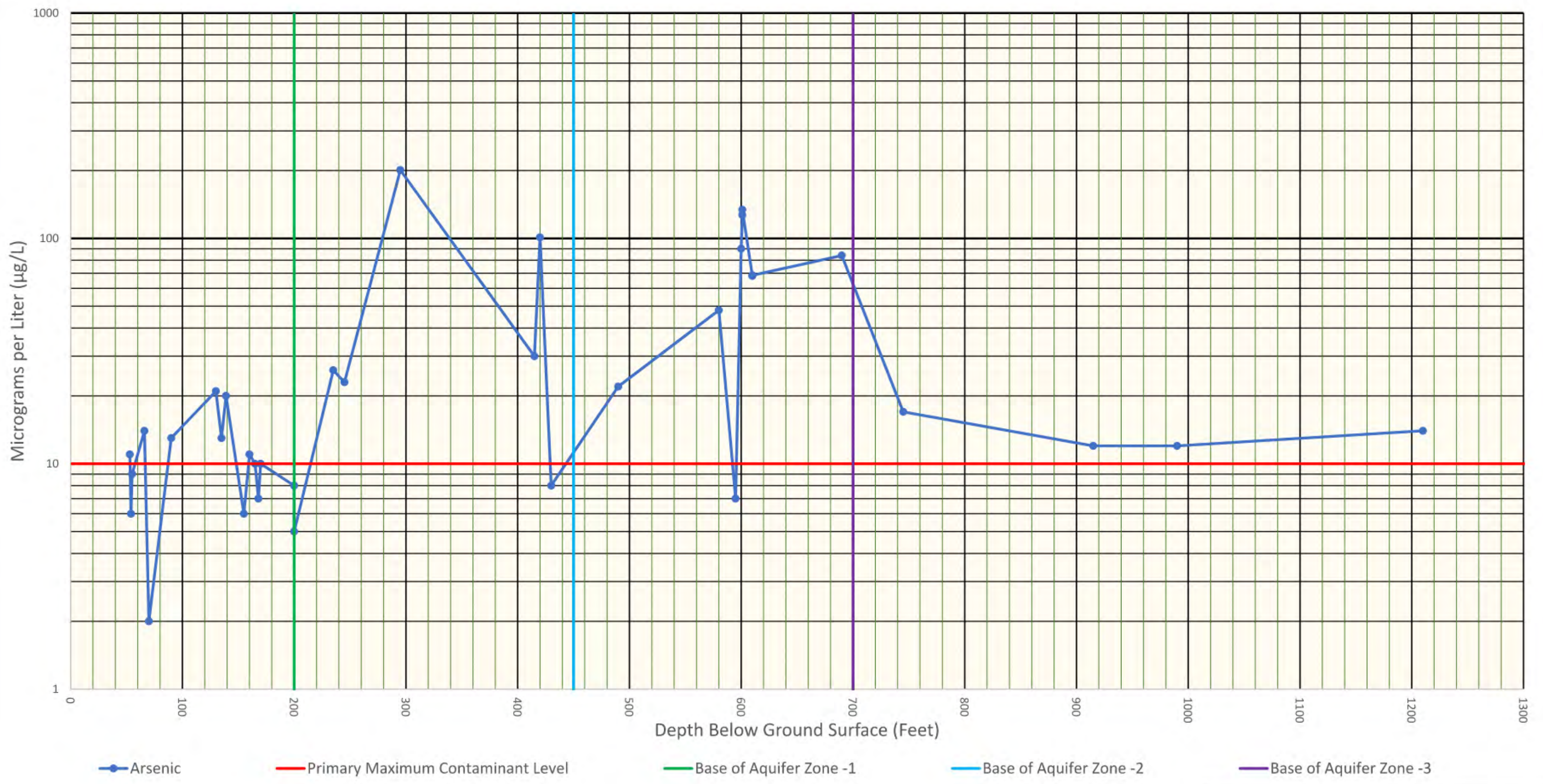
As with boron, arsenic is a naturally occurring element commonly found in alluvial sediments derived from volcanic sources such as the Sutter Buttes Rampart, Mehrten, and Tuscan Formations that make up the intermediate and deep aquifer zones. The oxidation-reduction (redox) state of water can affect which compounds are present in that water. Water with chemistry indicating oxidizing chemical reactions is referred to as toxic; water with chemistry indicating reducing chemical reactions is referred to as anoxic. The elevated levels of arsenic within the Sutter Subbasin are most likely the result of the sediments being in contact with groundwaters under reduced conditions that have been correlated with elevated arsenic concentrations in the Sacramento Valley (USGS, 2001). As indicated in USGS (1984), reducing conditions in the Sutter Subbasin most likely produce higher concentrations of arsenic, manganese, and iron. These same conditions reduced nitrate concentrations, probably reflecting denitrification reactions.

Because of the origin of the sediments, arsenic at elevated concentrations is detected throughout the Sutter Subbasin and much of the northern Central Valley. Although oxidation-reduction data were not available for groundwater samples assessed for this GSP, USGS (2011) states that groundwater in the Quaternary alluvium along the Sacramento River and in the Delta commonly has low dissolved oxygen content that reflect reducing conditions. As indicated in the Alternative Plan, arsenic is not a component of materials applied to farmland. The primary MCL for arsenic is 10 micrograms per liter (µg/L).

Figure 5-35 provides a cross plot of arsenic versus depth of the bottom of screen interval for the well for the wells shown in **Figure 5-27**. As seen in this figure, the majority of reported arsenic values are above the MCL of 10 µg/L. The highest levels are reported for wells screened from about 300 feet bgs to 420 feet bgs (AZ-2) and 600 feet bgs to 700 feet bgs (AZ-3).

Figure 5-36 displays the arsenic distribution in the Sutter Subbasin and **Figure 5-37** shows the distribution by aquifer zone as presented in the Alternative Plan. Arsenic concentrations presented in **Figure 5-36** and **Figure 5-37** are from the USGS Rice Wells, Shallow Domestic Wells and from GAMA Well networks, as presented in the Rice Coalition Groundwater Assessment Report (CH2M, 2016). The GAMA well network was used to focus on the deeper portions of the aquifer. These figures divide AZ-1 through AZ-3 as described for boron.

As seen in these figures, arsenic concentrations vary in the shallow aquifer. Most (50 percent) of the locations show arsenic between half the MCL and the MCL and several locations (29 percent) exceed the MCL. Typically, arsenic concentrations increase with depth, in the intermediate and deep aquifer zones, with concentrations exceeding the MCL. Several locations show concentrations are below the MCL along the eastern side of the Sutter Subbasin.



Arsenic Cross Plot Sutter Subbasin Groundwater Sustainability Plan Sutter County, California		Figure
Geosyntec consultants		5-33
Project No.: SAC284	April 2021	

Figure 5-35. Arsenic Cross Plot

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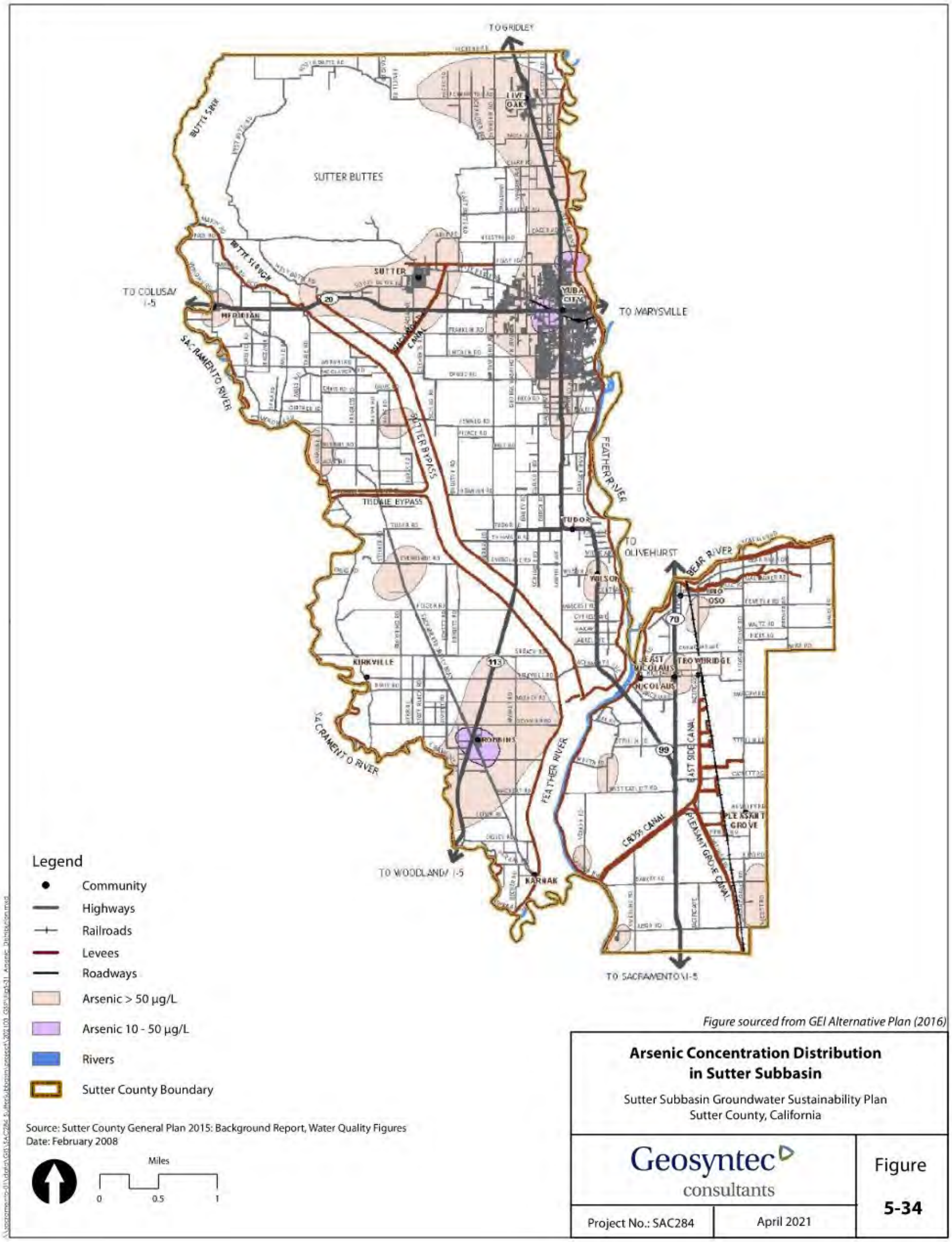


Source: Sutter County General Plan 2015: Background Report, Water Quality Figures
Date: February 2008

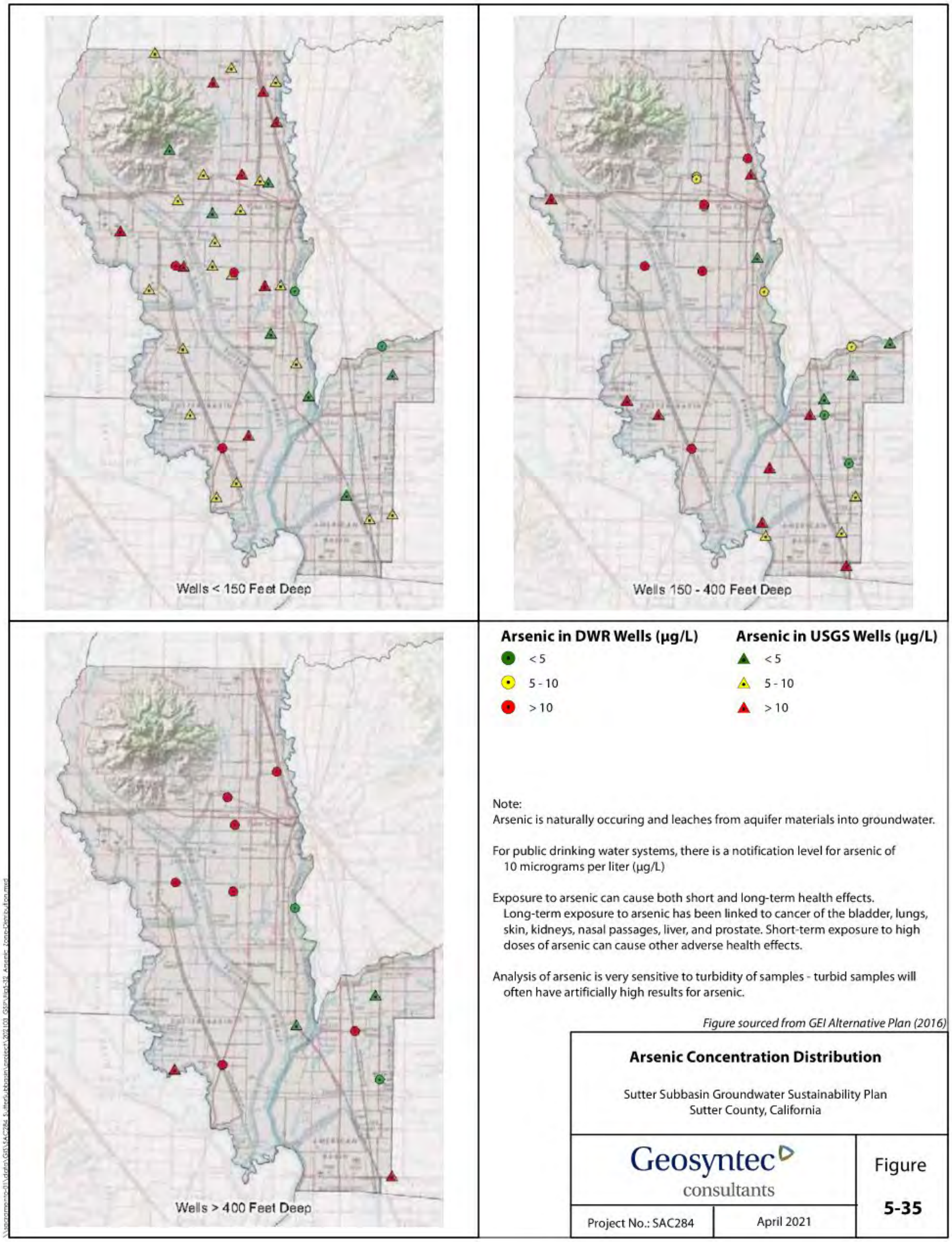
Figure sourced from GEI Alternative Plan (2016)

Arsenic Concentration Distribution in Sutter Subbasin

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Geosyntec consultants

Figure 5-36. Arsenic Concentration Distribution, Sutter Subbasin



Note:
Arsenic is naturally occuring and leaches from aquifer materials into groundwater.

For public drinking water systems, there is a notification level for arsenic of 10 micrograms per liter (µg/L)

Exposure to arsenic can cause both short and long-term health effects. Long-term exposure to arsenic has been linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver, and prostate. Short-term exposure to high doses of arsenic can cause other adverse health effects.

Analysis of arsenic is very sensitive to turbidity of samples - turbid samples will often have artificially high results for arsenic.

Figure sourced from GEI Alternative Plan (2016)

Arsenic Concentration Distribution

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

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Figure 5-35

Figure 5-37. Arsenic Concentration Distribution by Aquifer Zone, Sutter Subbasin

5.1.9.4 Salinity

Salinity in groundwater is often caused by the dissolution of soluble minerals, the presence of seawater deposited with marine sediments, in particular geologic formations and/or the presence of mineral springs. The USGS (1984) indicated that a major source of salinity within the Sutter Subbasin is thought to be connate marine water moving upward along fault zones created when Sutter Buttes was emplaced.

Salinity can be assessed using different parameters, including specific conductance, TDS, and chloride. Specific conductance or electrical conductivity is a measure of how effectively water will conduct electricity. When soluble salts dissolve in water, the resulting ions behave as conductors. Therefore, specific conductance provides an indirect measurement of the amount of dissolved solids (salts). This parameter is reported in microSiemens per centimeter (µS/cm) or the equivalent unit micro mhos per centimeter (µmhos/cm). Chloride is often used to identify saline water and can be representative of where high specific conductance water is present.

The recommended SMCL for specific conductance is 900 µS/cm, with an upper SMCL of 1,600 µS/cm and short-term secondary MCL of 2,200 µS/cm. The corresponding TDS SMCLs are 500 mg/L, 1,000 mg/L, and 1,500 mg/L. Constituent concentrations lower than the recommended SMCL (500 mg/L for TDS) are desirable for a higher degree of consumer acceptance. Constituent concentrations ranging to the Upper SMCL are acceptable if it is neither reasonable nor feasible to provide more suitable waters. Constituent concentrations ranging to the short-term SMCL are acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources. The SMCL for chloride is 250 mg/L.

Figure 5-38 provides cross plots of specific conductance, TDS, and chloride versus depth of the bottom of screen interval for the wells shown in **Figure 5-27**. As seen in this figure, high salinity values exist from about 50 feet bgs to 245 feet bgs and from below 700 feet bgs. Wells completed between 300 feet bgs and 700 feet bgs have reported specific conductance and TDS values below their respective upper SMCL, although the two wells between 430 feet and 490 feet bgs have chloride values above the SMCL.

Figure 5-39 presents the distribution of specific conductance by aquifer zone as divided in the Alternative Plan. As seen in this figure, specific conductance values in the shallow aquifer zone in the northern half of the Sutter Subbasin are mostly below the SMCL. Elevated values of specific conductance are near to and/or exceed the recommended SMCL in the shallow aquifer between the Feather and Sacramento Rivers, in the intermediate aquifer at one location, and at two locations in the deep aquifer. The Alternative Plan stated that it is unclear why elevated specific conductance occur in the shallow aquifer zone (which suggests an agricultural source), but because nitrate concentrations do not correlate with areas of elevated specific conductance, the salinity does not appear to be related to agriculture. However, as discussed previously discussed, the existence of reducing conditions in the shallow zone could result in lower levels of nitrate due to denitrification suggesting that the high salinity values in the shallow zone are from agricultural sources. In groundwater below 700 feet, the poor water quality is likely due to the underlying marine sediments being in direct contact with the deeper aquifer zones and potentially due to faults that have created pathways that allow water from the older marine sediment to migrate upward (USGS, 1984).

The Rice Coalition Groundwater Assessment Report (CH2M, 2016) also assessed trends in salinity across the Subbasin using trends in TDS. **Figure 5-40** is a snapshot of Figure 5-5 from CH2M (2016) showing trends of TDS within the Sutter Subbasin. As shown in this figure, several areas show increasing trends in salinity across the Subbasin, although many of these areas are still below the upper SMCL of 1,000 mg/L.

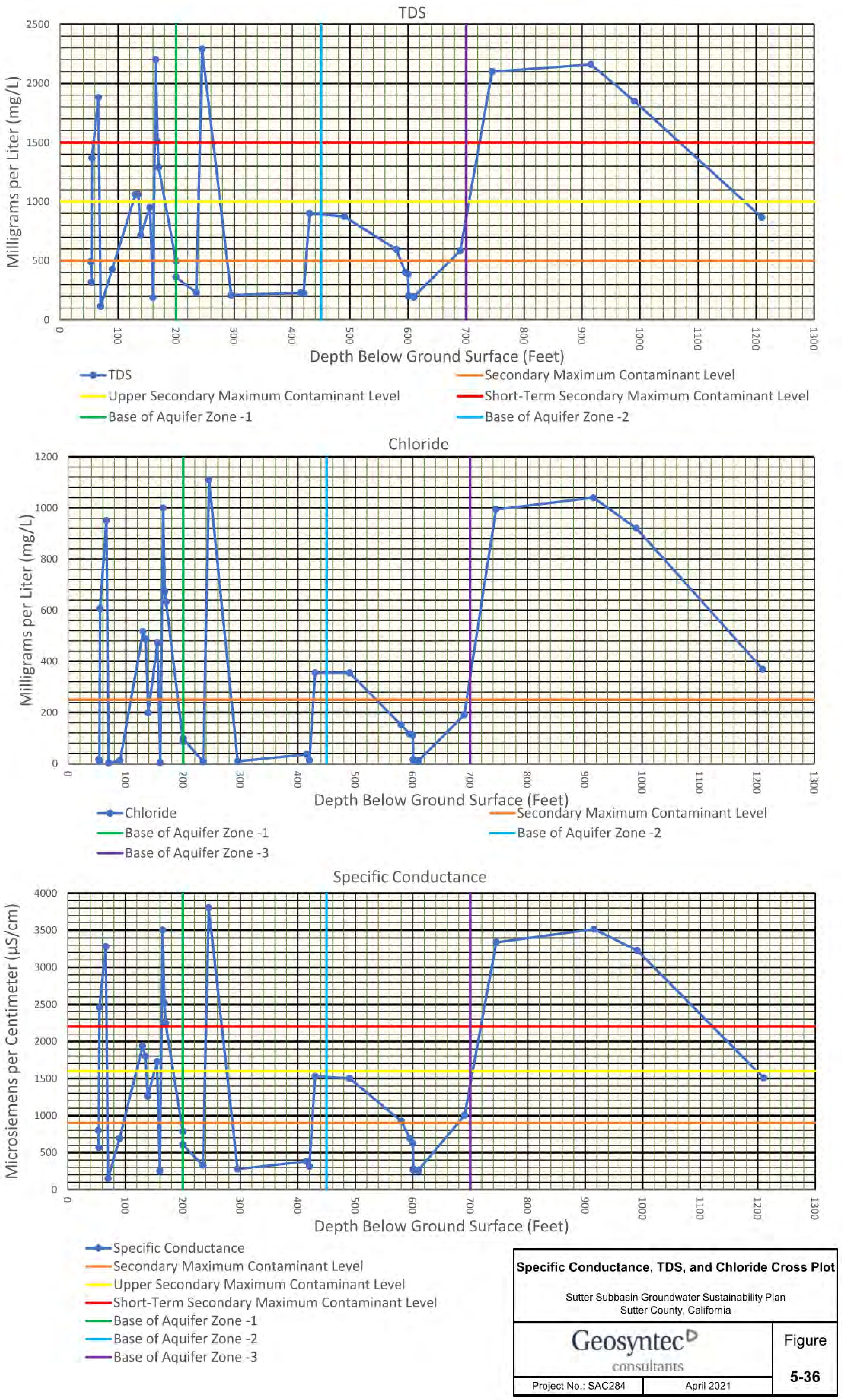

Figure 5-38. Specific Conductance, TDS, and Chloride Cross Plot

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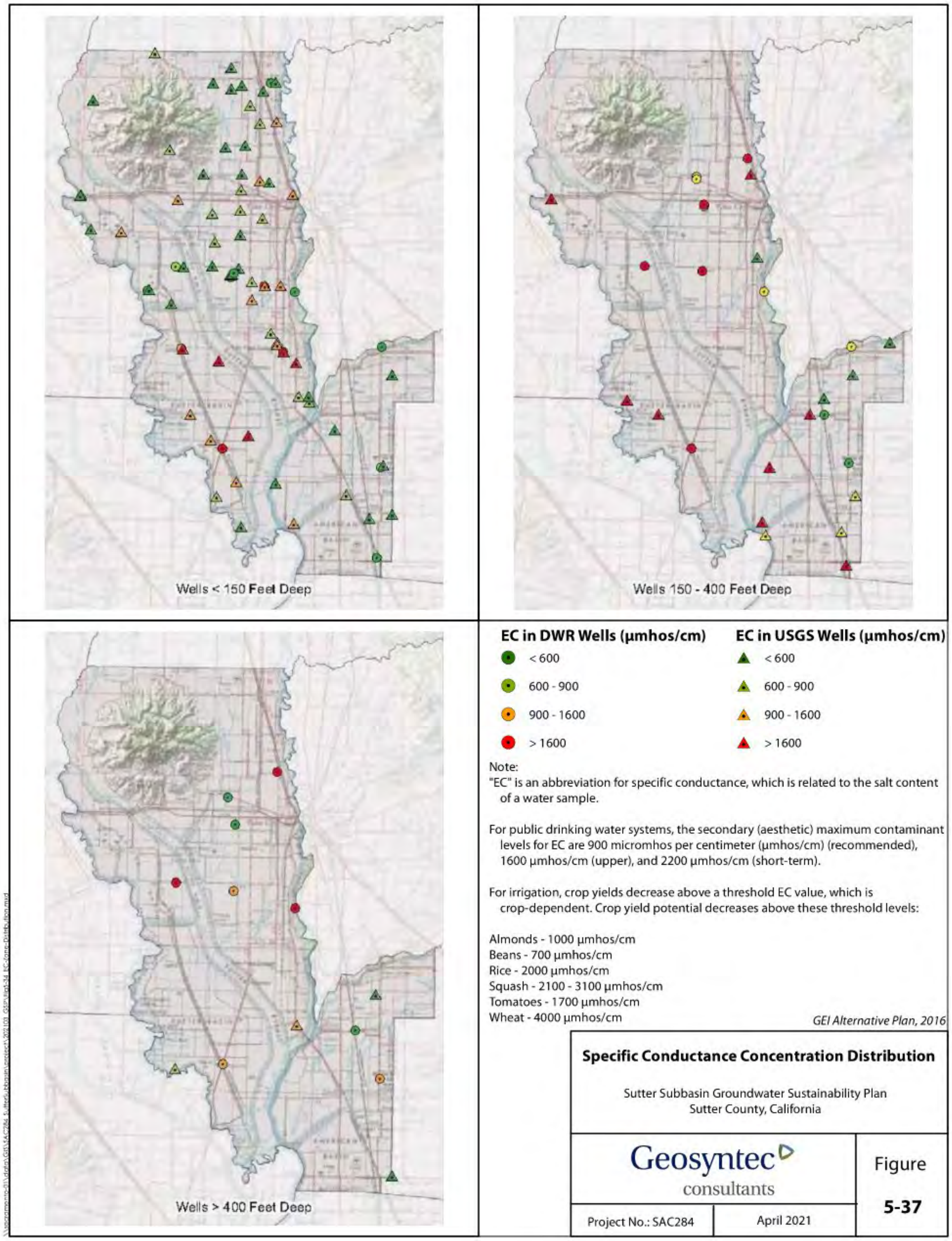

EC in DWR Wells (µmhos/cm)

- ● < 600
- ● 600 - 900
- ● 900 - 1600
- ● > 1600

EC in USGS Wells (µmhos/cm)

- ▲ < 600
- ▲ 600 - 900
- ▲ 900 - 1600
- ▲ > 1600

Note:
"EC" is an abbreviation for specific conductance, which is related to the salt content of a water sample.

For public drinking water systems, the secondary (aesthetic) maximum contaminant levels for EC are 900 micromhos per centimeter (µmhos/cm) (recommended), 1600 µmhos/cm (upper), and 2200 µmhos/cm (short-term).

For irrigation, crop yields decrease above a threshold EC value, which is crop-dependent. Crop yield potential decreases above these threshold levels:

Almonds - 1000 µmhos/cm
Beans - 700 µmhos/cm
Rice - 2000 µmhos/cm
Squash - 2100 - 3100 µmhos/cm
Tomatoes - 1700 µmhos/cm
Wheat - 4000 µmhos/cm

GEI Alternative Plan, 2016

Specific Conductance Concentration Distribution

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Figure
5-37

Figure 5-39. Specific Conductance Concentration Distribution by Aquifer Zone, Sutter Subbasin

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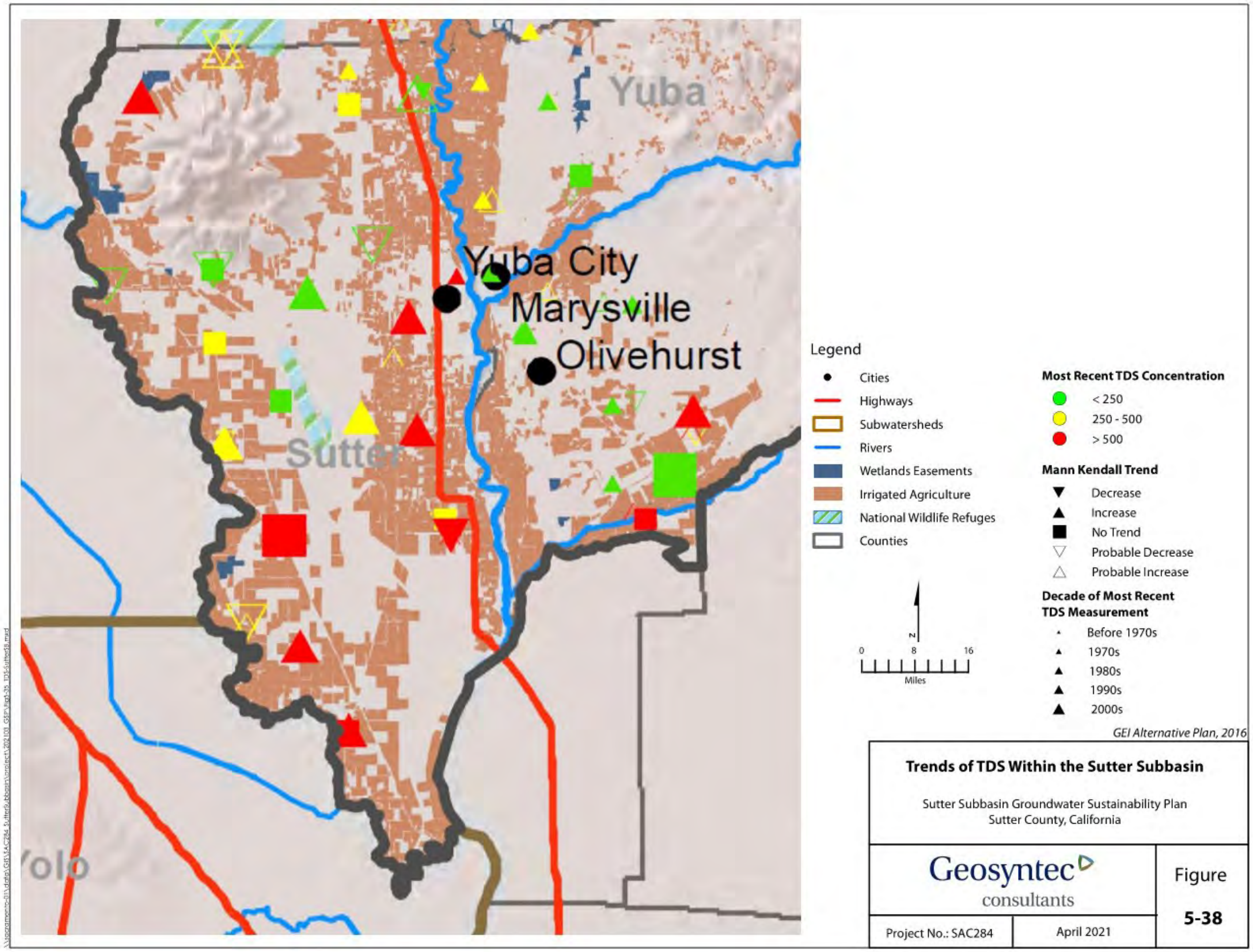

Figure 5-40. TDS Trends, Sutter Subbasin

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5.1.9.5 Nitrate

Nitrogen is present in water bodies in the following forms that are measured to characterize water quality: nitrate (NO_3), ammonia (NH_3), and organic (Total Kjeldahl nitrogen [TKN] minus NH3). The sum of the concentration of these compounds is referred to as total nitrogen. The primary drinking water MCL for nitrate (as nitrate) is 45 mg/L.

Nitrogen is of particular concern when assessing water quality impacts from agriculture as it is frequently applied as fertilizer. Nitrate concentrations at or exceeding 3 mg/L are generally thought to be caused by anthropogenic sources. Nitrate can occur naturally in groundwater from leaching of soils or bedrock. Nitrate does not generally react with soil particles or sediment and tends to move with groundwater due to its high solubility in water and its generally stable condition. Ammonia is less mobile and is subject to sorption and conversion to nitrate under oxidized conditions (USGS, 2001). Anthropogenic groundwater nitrate sources include synthetic fertilizer, animal manure (including poultry facilities), wastewater treatment plant effluent and biosolids, and septic systems (Esser et al., 2003).

Figure 5-41 provides the cross plot of nitrate versus depth of the bottom of screen interval for the wells shown in **Figure 5-27**. As seen in this figure, all the reported nitrate values are significantly below the MCL of 45 mg/L.

Figure 5-42 shows the distribution of nitrate across the Sutter Subbasin by aquifer zone as presented in the Alternative Plan. Near the Sutter Buttes and Yuba City, nitrate concentrations in several wells in the shallow aquifer (less than 150 feet) exceed the MCL. Some of these populated areas have septic systems that might be the source of the nitrate. Concentrations in the shallow aquifer in the southern portion of the Sutter Subbasin are below the MCL. Concentrations in the intermediate and deep aquifer zones are also below the MCL.

The Alternative Plan further stated that eighty-four percent of the USGS Rice Wells' (CH2M, 2016) samples had nitrate concentrations below 3 mg/L, which is the level generally considered to be indicative of potential impacts by human activities. Therefore, this report states that nitrate levels in these wells are likely to be naturally occurring. However, as indicated in USGS (1984), reducing conditions in the Sutter Subbasin most likely produce higher concentrations of arsenic, manganese, and iron, whereas these conditions reduced nitrate concentrations probably reflecting denitrification reactions. As such, even these lower nitrate levels in these areas could be the result of anthropogenic sources.

The Rice Coalition Groundwater Assessment Report (CH2M, 2016) also assessed trends in nitrate across the Subbasin. **Figure 5-43** is a snapshot of Figure 5-3 from CH2M (2016) showing trends of nitrate within the Sutter Subbasin. As shown in this figure, several areas within the central portion of the Subbasin show increasing trends in nitrate concentration, although many of these areas are below the MCL of 45 mg/L.

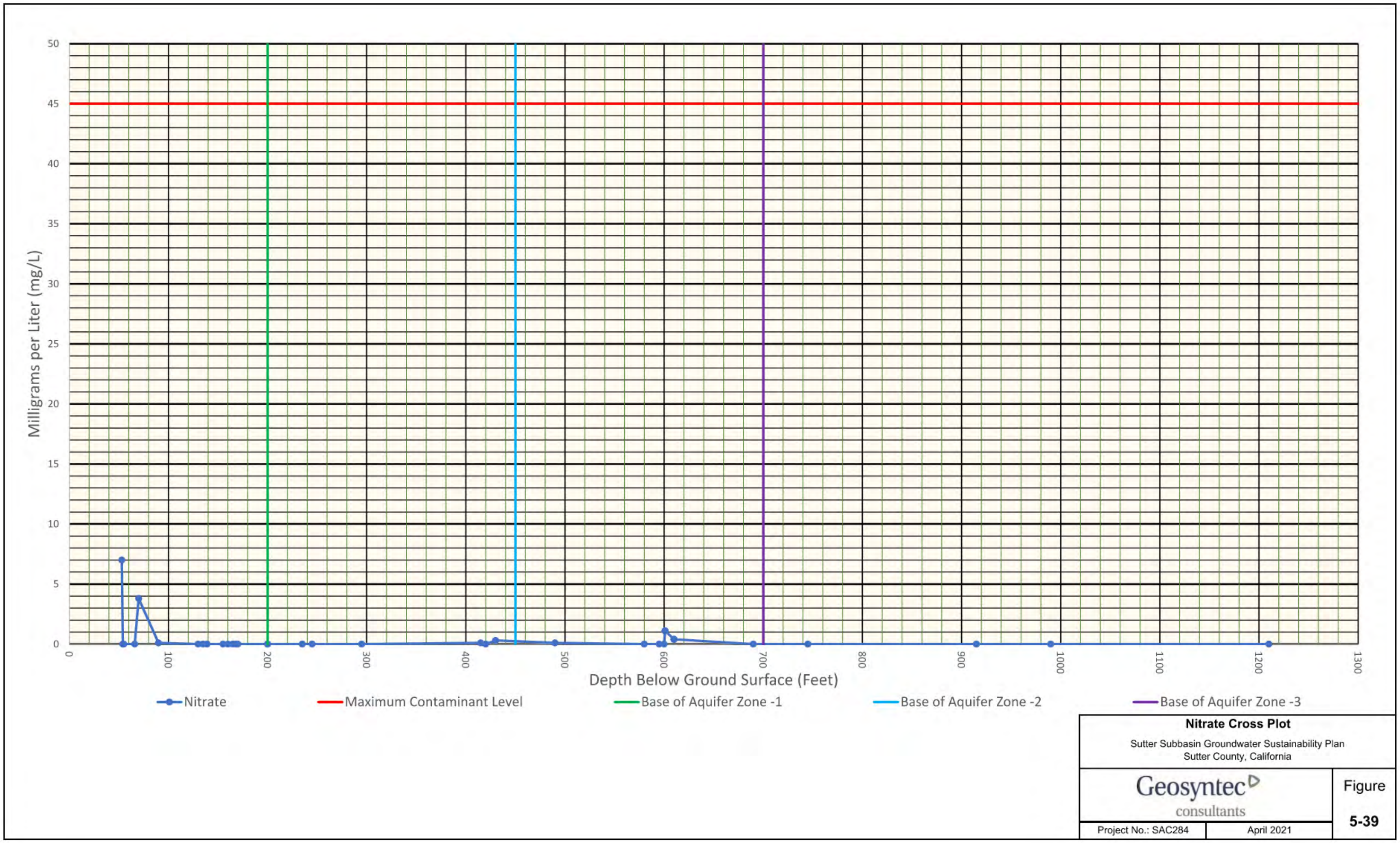

Figure 5-41. Nitrate Cross Plot

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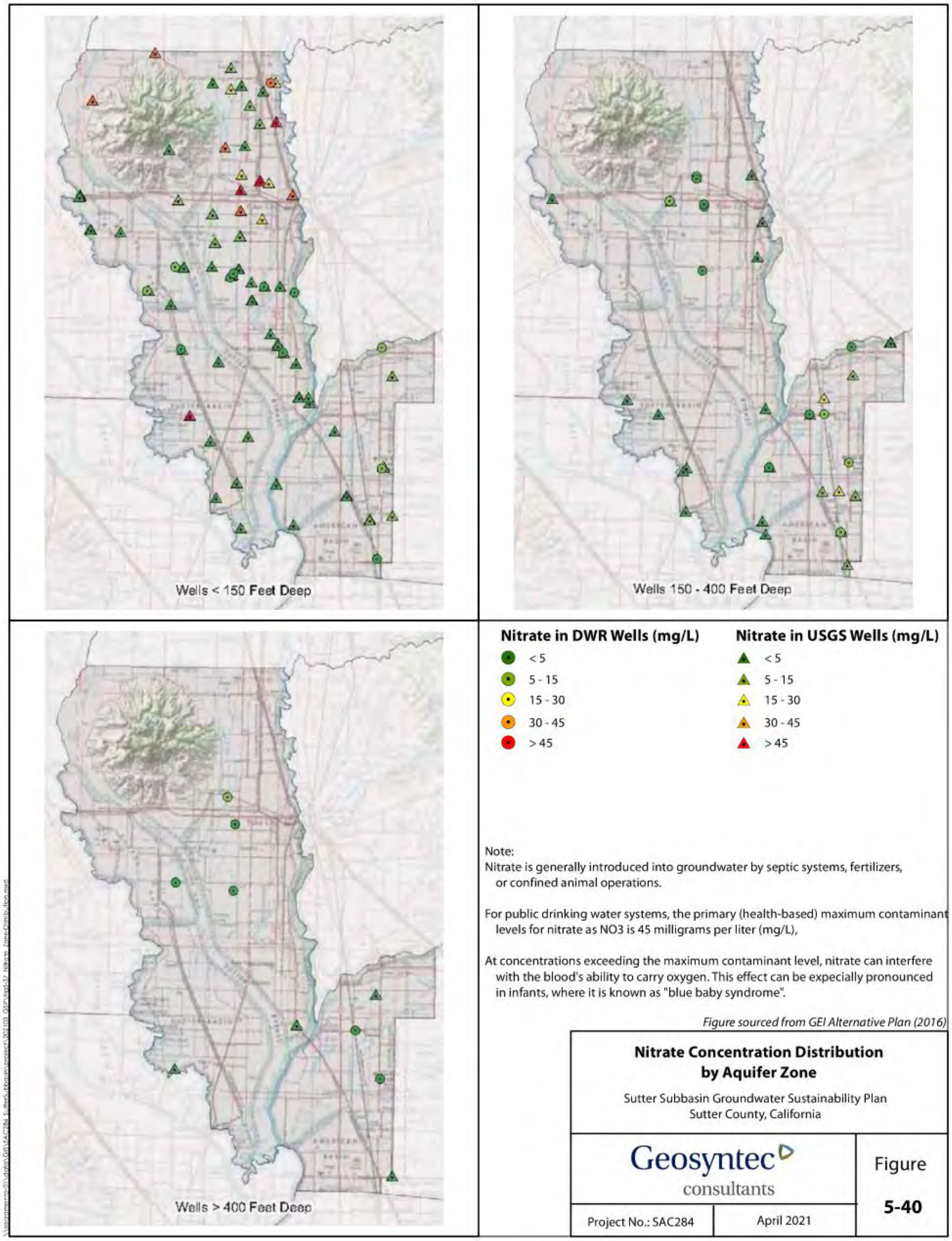

Note:
Nitrate is generally introduced into groundwater by septic systems, fertilizers, or confined animal operations.

For public drinking water systems, the primary (health-based) maximum contaminant levels for nitrate as NO3 is 45 milligrams per liter (mg/L),

At concentrations exceeding the maximum contaminant level, nitrate can interfere with the blood's ability to carry oxygen. This effect can be expecially pronounced in infants, where it is known as "blue baby syndrome".

Figure sourced from GEI Alternative Plan (2016)

Nitrate Concentration Distribution by Aquifer Zone

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Geosyntec consultants

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Figure 5-40

Figure 5-42. Nitrate Concentration Distribution by Aquifer Zone, Sutter Subbasin

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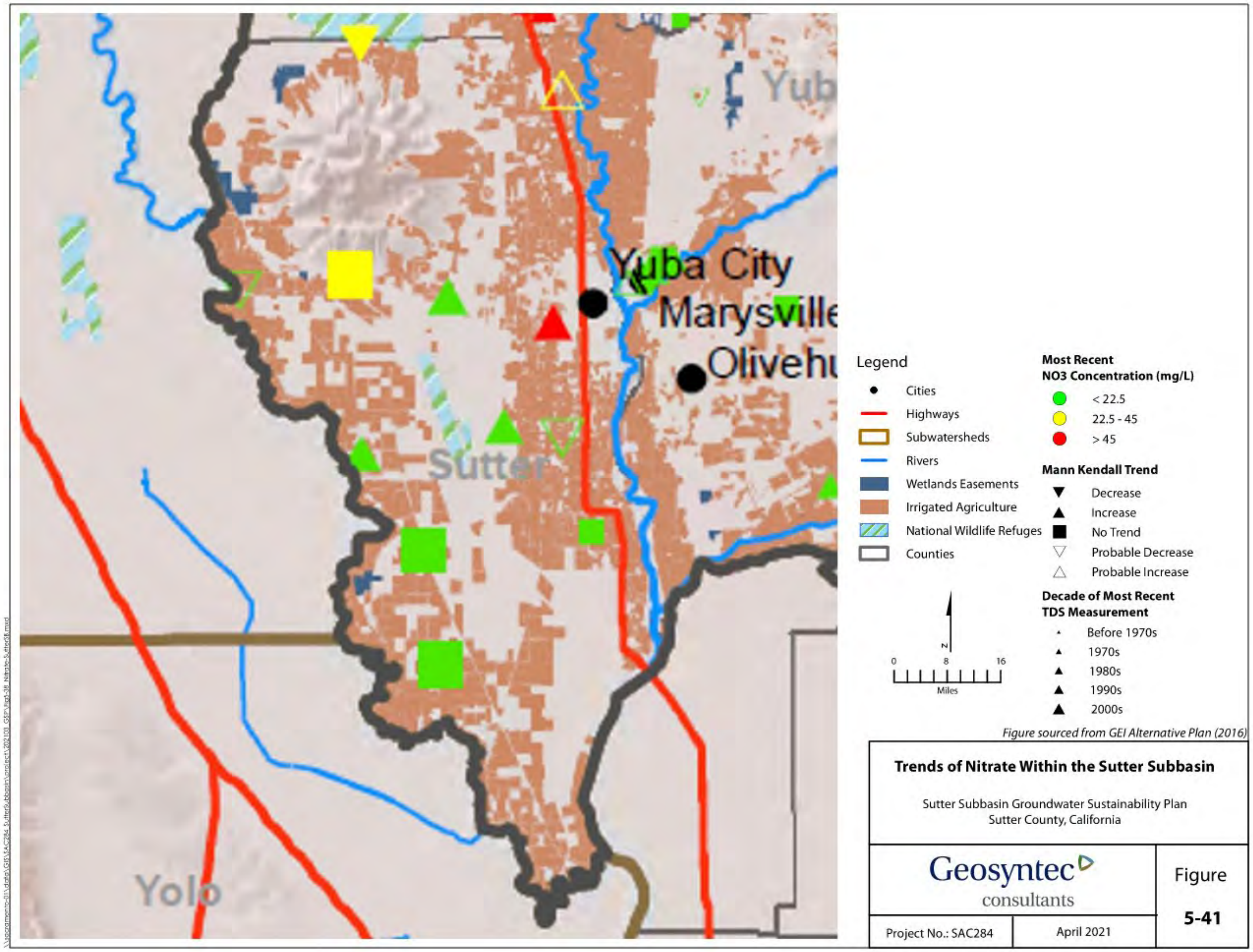

Figure sourced from GEI Alternative Plan (2016)

Figure 5-43. Nitrate Trends, Sutter Subbasin

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5.1.9.6 Iron and Manganese

Iron and manganese are naturally occurring elements in rocks and minerals and the dissolution of these materials can mobilize them into groundwater. These minerals are commonly associated with volcanic derived sediments that form the Sutter Buttes Rampart, Mehrten, and Tuscan Formations. The SMCL for iron is 0.3 mg/L and for manganese is 0.05 µg/L.

Figure 5-44 provides the cross plots for iron and manganese versus depth of the bottom of screen interval for the wells shown in **Figure 5-27**. As seen in this figure, only one well completed at 90 feet bgs (24G004M, **Figure 5-27**) had a reported iron concentration above the SMCL whereas almost all the wells had reported manganese levels above the SMCL. The highest reported manganese levels were within the upper 250 feet. USGS (1984) indicated that reducing conditions in the Sutter Subbasin most likely produce higher concentrations of iron and manganese, and the USGS (2011) has reported that groundwater in the Quaternary alluvium along the Sacramento River and in the Delta commonly has low dissolved oxygen content that reflect reducing conditions.

Figure 5-45 shows the manganese distribution by aquifer zones as presented in the Alternative Plan. As seen in this figure, manganese concentrations in the shallow aquifer are typically below the SMCL in the northern portion of the County, but in the southern half, concentrations typically exceed the SMCL; this trend is consistent with the USGS (2011) report that reducing conditions exist in this area. Manganese concentrations in the deeper aquifer zones typically exceed the SMCL, but there are some occurrences where their concentrations are below the MCL. There are no data (oxidation-reduction potential or dissolved oxygen) to indicate if reducing conditions exist in these areas, but high concentrations of manganese especially above 1 mg/L are indicative of reducing conditions.

Iron concentrations were not monitored as part of the Rice Coalition Groundwater Assessment Report and a figure showing iron distribution by aquifer zones was not included in the Assessment Report. However, **Figure 5-46** shows the iron distribution across the Subbasin as presented in the Alternative Plan and shows elevated iron concentrations above the SMCL in areas along the Feather and American Rivers reported to have reducing conditions (USGS, 2011).

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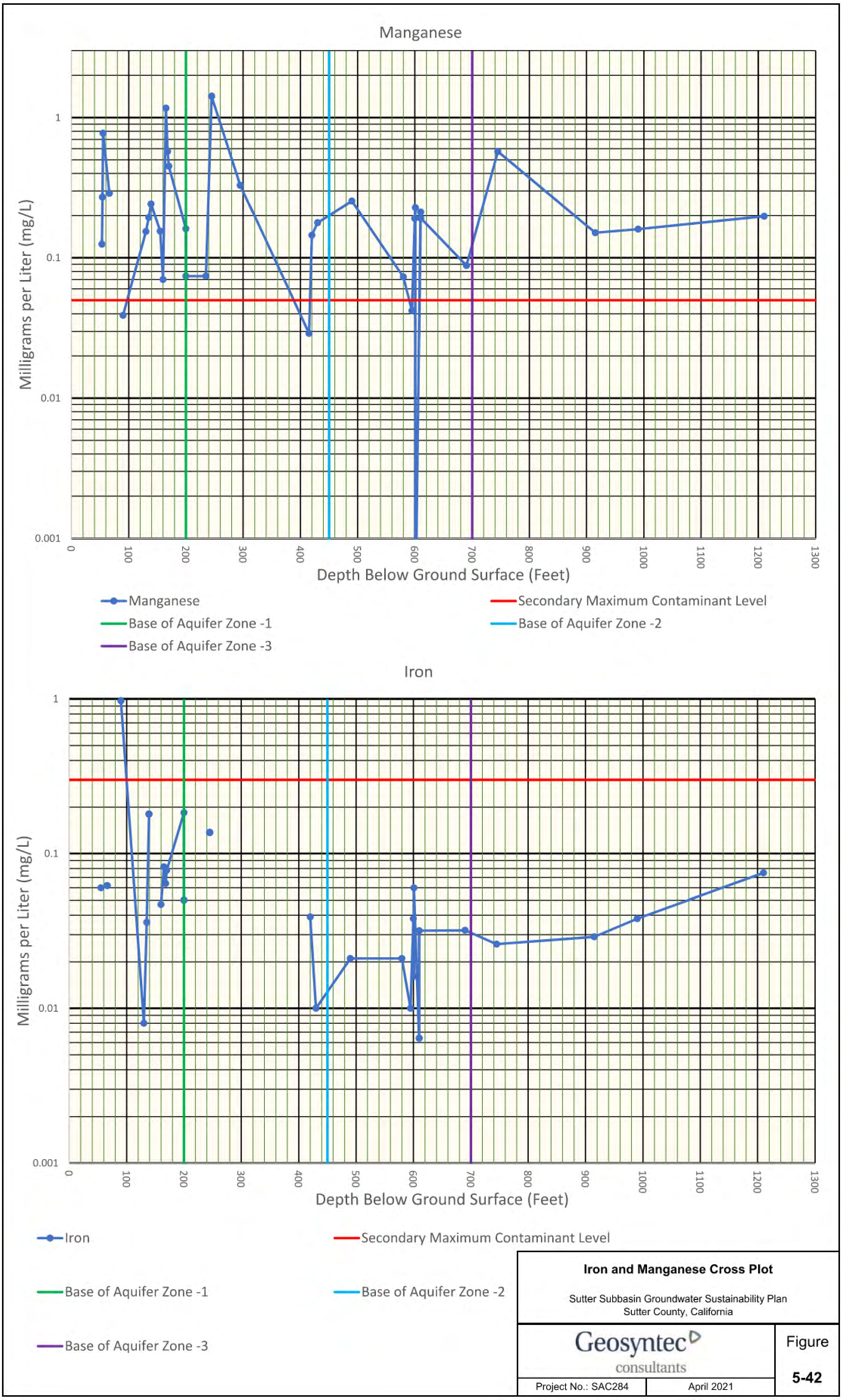

Iron and Manganese Cross Plot

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Project No.: SAC284 April 2021

Figure
5-42

Figure 5-44. Iron and Manganese Cross Plot

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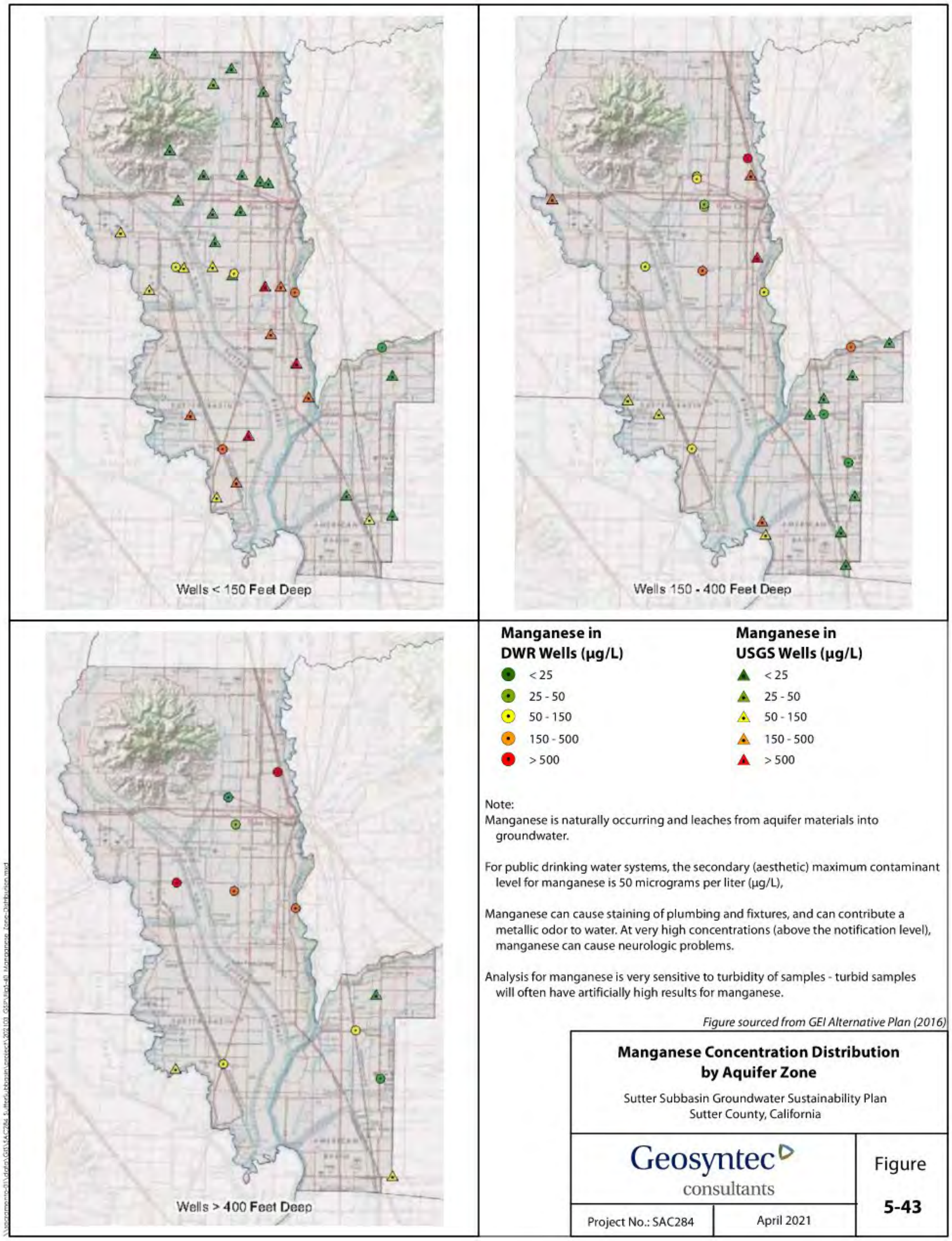


Note:
Manganese is naturally occurring and leaches from aquifer materials into groundwater.

For public drinking water systems, the secondary (aesthetic) maximum contaminant level for manganese is 50 micrograms per liter (µg/L),

Manganese can cause staining of plumbing and fixtures, and can contribute a metallic odor to water. At very high concentrations (above the notification level), manganese can cause neurologic problems.

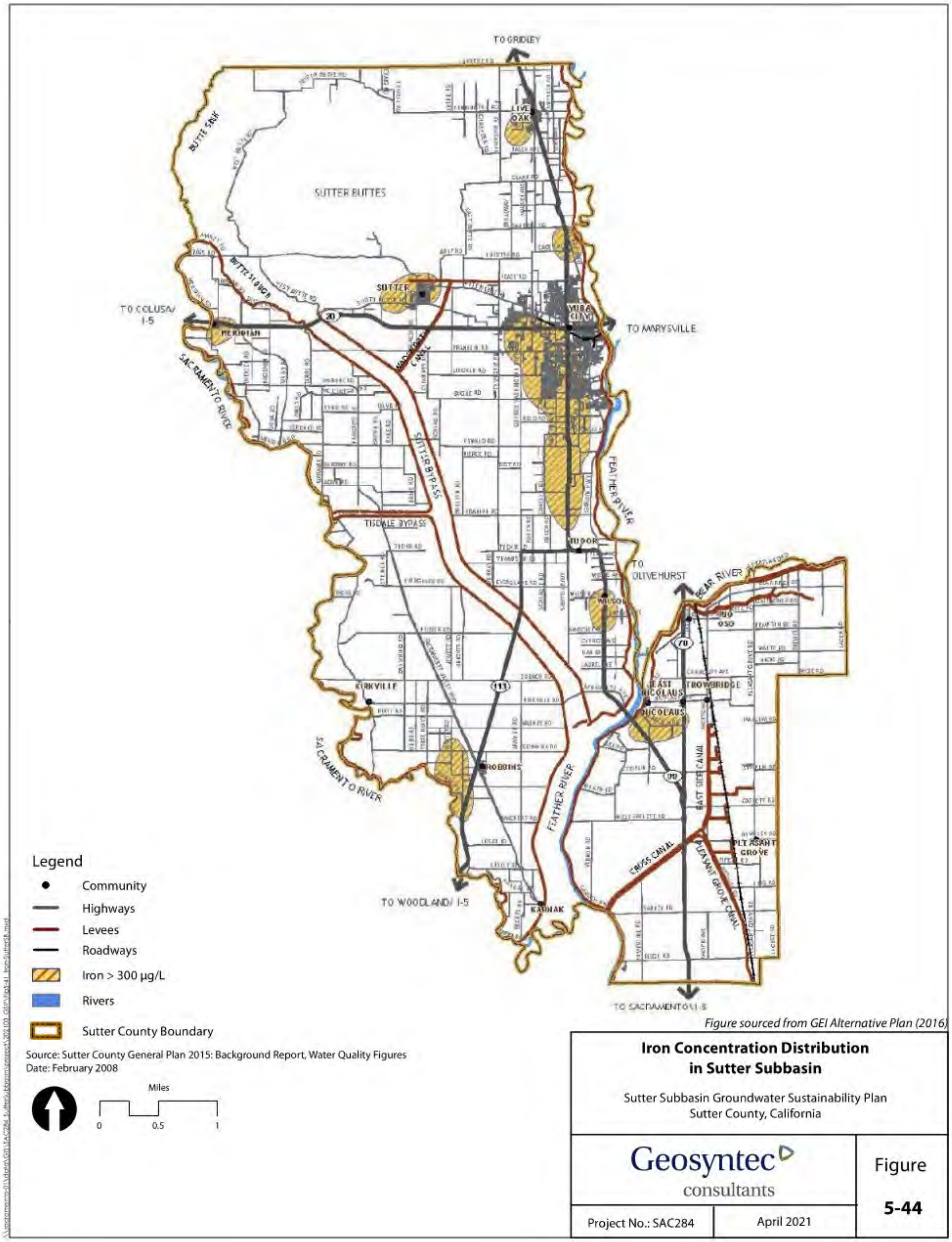
Analysis for manganese is very sensitive to turbidity of samples - turbid samples will often have artificially high results for manganese.

Figure sourced from GEI Alternative Plan (2016)

Manganese Concentration Distribution by Aquifer Zone

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Figure 5-45. Manganese Concentration Distribution by Aquifer Zone, Sutter Subbasin



Source: Sutter County General Plan 2015: Background Report, Water Quality Figures
Date: February 2008

Figure sourced from GEI Alternative Plan (2016)

Figure 5-46. Iron Concentration Distribution, Sutter Subbasin

5.1.9.7 Point Sources

The goal of groundwater quality management under SGMA is to supplement information available from other sources with data targeted to assist GSAs in the Sutter Subbasin to comply with the requirements of SGMA. Development of groundwater quality-related sustainable management criteria for the Sutter Subbasin is not intended to duplicate or supplant the goals and objectives of ongoing programs including those by the USGS Rice, Shallow Domestic, and GAMA well programs, Sacramento Valley Water Quality Coalition (SVWQC), and the State Drinking Water Information System (SDWIS).

Because irrigated agriculture is the predominant land use in the Sutter Subbasin, monitoring of the groundwater quality data developed through the Groundwater Quality Trend Monitoring Work Plan (GQTMWP) being implemented by the SVWQC for compliance with the Central Valley Regional Board's Irrigated Lands Regulatory Program (ILRP) will be an important source of information to GSAs in the Subbasin. Pesticides are included in this program as well as part of the Rice Coalition Groundwater Assessment program.

Among the contaminants that may affect groundwater conditions in the future are chemicals of emerging concern (CECs). These are contaminants having toxicities not previously recognized, which may have the potential to cause adverse effects to public health or the environment and are found to be building up in the environment or to be accumulating in humans or wildlife. CECs such as perfluorooctanesulfonic acid (PFOS) and per- and polyfluoroalkyl substances (PFAS) will not be monitored under the groundwater quality monitoring program established for SGMA. However, GSAs will have access to data on CECs collected by other agencies and will be attentive to the effect the presence of CECs may have on groundwater management in specific locations.

The SGMA regulations require that GSPs describe locations, identified by regulatory agencies, where groundwater quality has been degraded due to industrial and commercial activity. Locations of impacted groundwater were identified by reviewing information available on the State Water Resources Control Board GeoTracker/GAMA website, the California Department of Toxic Substances Control (DTSC) EnviroStor website, and the Environmental Protection Agency's (EPA) National Priorities List (NPL). Cases that have been closed by the supervisory agency are not considered.

Figure 5-47 provides the locations of active sites listed in California's EnviroStor and GeoTracker/GAMA databases that could potentially impact groundwater in the Sutter Subbasin. Links to each of these databases that also include locations of National Priorities List (NPL) or "Superfund" sites are as follows:

- EnviroStor - https://www.envirostor.dtsc.ca.gov/public/
- GeoTracker/GAMA - https://geotracker.waterboards.ca.gov/

Table 5-6 lists the information available for these sites from these databases. As shown in **Table 5-6**, only 10 active sites are listed within the Sutter Subbasin.

Under SGMA, GSAs are only responsible for groundwater quality issues related to pumping. Other programs and agencies are responsible for enforcing groundwater quality violations for sites located in the Subbasin. However, GSAs will coordinate with these other agencies if water quality degradation is associated with groundwater pumping.

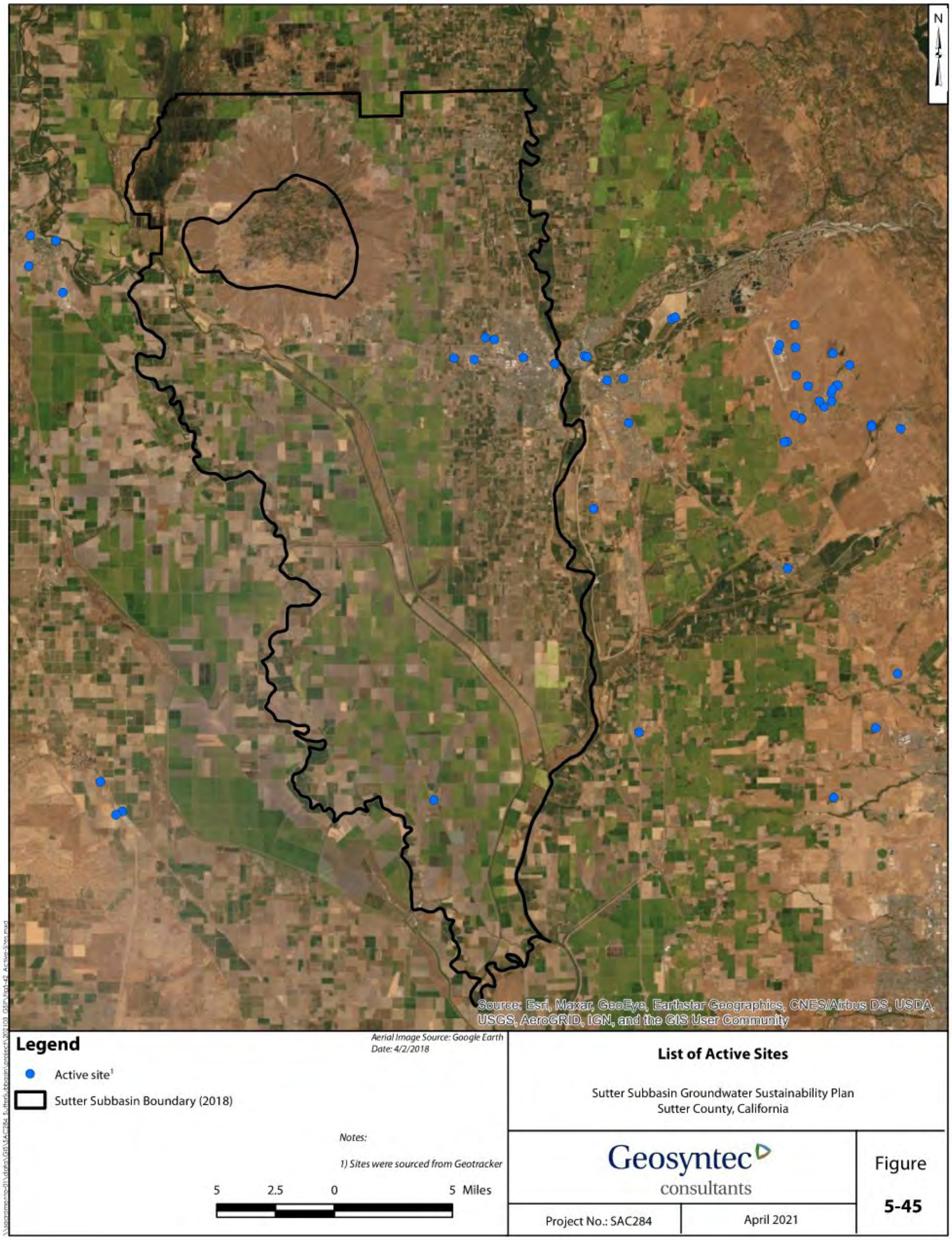


Figure 5-47. Active GeoTracker Sites

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Table 5-6. Active GeoTracker Sites, Sutter Subbasin

Site Name	Site Type	Status	Address	City	Latitude	Longitude
1st Stop	LUST Cleanup Site	Open - Site Assessment	248 Bridge Street	Yuba City	39.13729214	-121.6092432
Costa Property	Cleanup Program Site	Open - Eligible For Closure	1716 Elmer Road	Yuba City	39.15226123	-121.6567183
John Taylor Fertilizers - Yuba City	Cleanup Program Site	Open – Verification Monitoring	900 North George Washington Boulevard	Yuba City	39.13997456	-121.6728107
Puregro	Cleanup Program Site	Open - Assessment & Interim Remedial Action	4900 Del Monte Avenue	Robbins	38.86930099	-121.7056203
Question Market	LUST Cleanup Site	Open - Verification Monitoring	973 North Township Road (AKA: 937)	Yuba City	39.1408459	-121.6887884
Quick-N-Shop	LUST Cleanup Site	Open - Remediation	2590 Butte House Road	Yuba City	39.1535168	-121.663992
Zelie's Cleaners	Cleanup Program Site	Open - Site Assessment	1222 Colusa Avenue	Yuba City	39.141059	-121.634054
Custom Chrome And Bumper	State Response	Active	335 Garden Highway	Yuba City	39.12433545	-121.6102366
Lomo Airstrip	State Response	Certified O&M - Land Use Restrictions Only	1111 Koch Lane	Yuba City	39.22527814	-121.6341798
Union Pacific Railroad Right-of-way Yuba City	Voluntary Cleanup	Active	Railroad Right-of-Way from Feather River east to Harter Parkway (a distance of 2.8 miles), including a former switching yard and railroad spur lines in the block bounded by Cooper Avenue to the west, Reeves Avenue to the north, and Bridge Street to the southeast	Yuba City	39.13485575	-121.6188626

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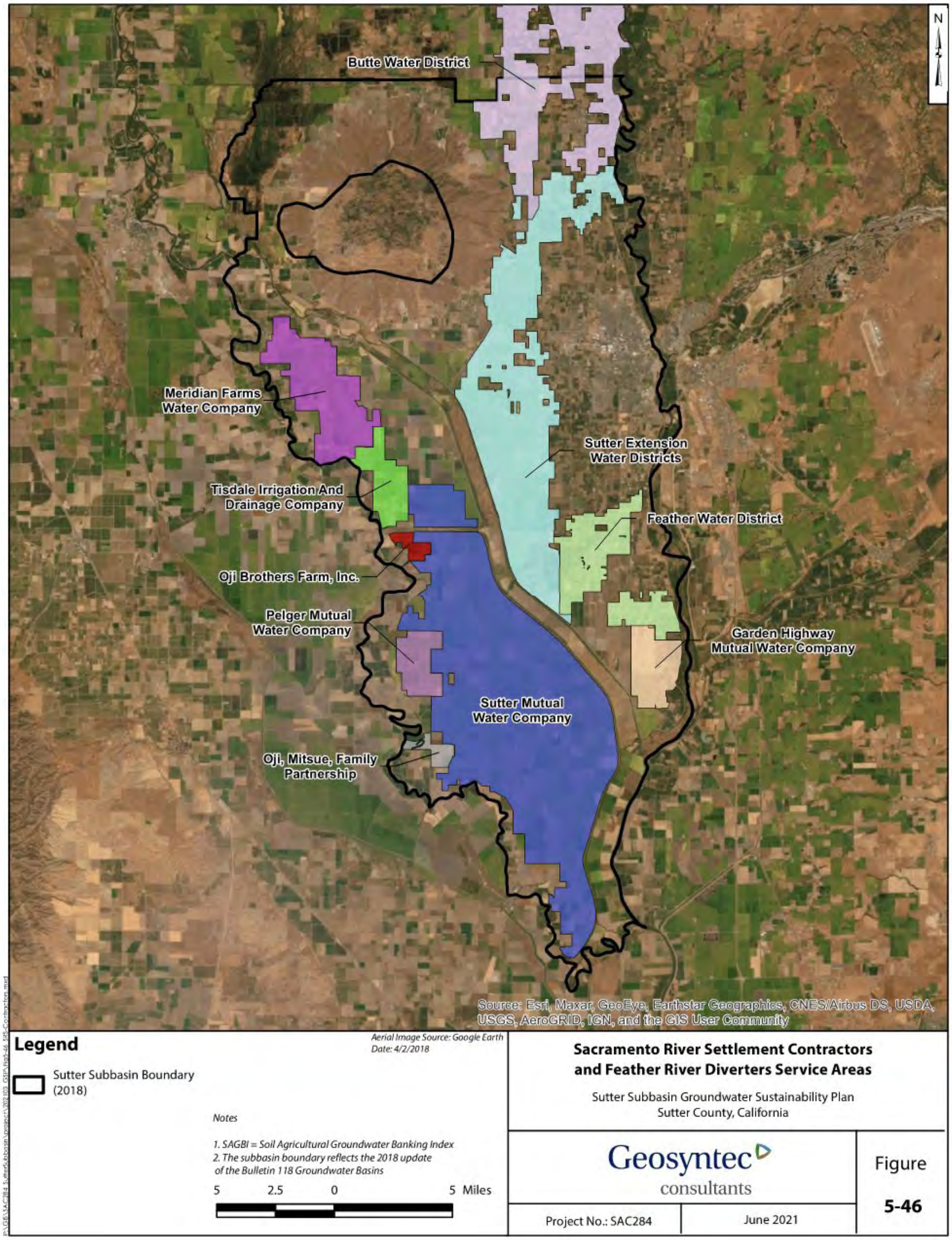
5.1.10 Surface Water Bodies

There are no reservoirs within the Subbasin. The Feather and Sacramento Rivers due to their lengths do, on a dynamic basis, contain surface water in excess of 100 acre-feet (AF). **Figure 2-1** shows these surface water bodies.

5.1.11 Imported Surface Water Supplies

Surface water is primarily used for agricultural purposes within the Sutter Subbasin and obtained through Sacramento River Settlement Contracts Central Valley Project (CVP) contractors, Feather River diverters, and surface water rights held by individual users. For more information about Sacramento River Settlement Contractors and Feather River diverters, refer to **Section 2.1.3.2.3**. Sacramento River Settlement Contractors include Sutter Mutual Water Company, Meridian Farms Water Company, Tisdale Irrigation & Drainage Company, Pelger Mutual Water Company, Oji Brothers Farm, Inc., and Oji Family Partnership (**Figure 5-48**). Imported water is diverted directly from the Sacramento River by the Settlement Contractors in the Sutter Subbasin. Feather River diverters hold diversion agreements with DWR to transport water from the Feather River using State Water Project facilities for both diversion and storage. Butte Water District and Sutter Extension Water District entered into agreement with DWR in May 1969 along with Biggs-West Gridley Water District and Richvale Irrigation District. Feather Water District and Garden Highway Mutual Water Company hold separate contracts with DWR for diversion of Feather River water.



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Aerial Image Source: Google Earth
Date: 4/2/2018

Notes

1. SAGBI = Soil Agricultural Groundwater Banking Index
2. The subbasin boundary reflects the 2018 update of the Bulletin 118 Groundwater Basins

Sacramento River Settlement Contractors and Feather River Diverters Service Areas

Sutter Subbasin Groundwater Sustainability Plan
Sutter County, California

Project No.: SAC284
June 2021

Figure 5-48. Imported Water Supplies, Sutter Subbasin

5.1.12 HCM Data Gaps

The HCM forms the framework for understanding the movement of water from the surface to the subsurface and at the boundaries of the Subbasin based on the available information. An important function of the HCM is the identification of data gaps and uncertainties within this framework that will form the basis for development of future data collection efforts. For successful management of the Subbasin, it is critical that as new data are collected this HCM is updated.

The following presents data gaps identified for the Sutter Subbasin HCM that will be updated with future monitoring, modeling, and data refinement efforts.

5.1.12.1 Interactions between Sacramento, Feather, and Other River Stage Response to Changes in Groundwater Levels

Data needed to develop appropriate sustainable management criteria for interconnected surface waters includes definition of stream reaches and associated priority habitat, streamflow measurements to develop profiles at multiple time periods, and corresponding measurements of groundwater levels directly adjacent to stream channels, for the first water bearing aquifer zone, and for deeper aquifer zones. These data are not available and are a data gap for the GSP. Currently, Sutter County is negotiating with DWR to install 15 nested monitoring wells (**Figure 5-49**) at selected surface water gage locations near rivers and wetlands to collect the data needed to assess these interactions.

Expansion of stream gaging locations should also occur to document and better understand changes in stream-aquifer interactions. In addition to the stream gaging, a series of shallow dedicated monitoring wells equipped with temperature sensors should be installed along stream courses in the recharge corridor and downstream to the Sacramento and Feather Rivers that may help identify what sections of streams are losing or gaining.

5.1.12.2 Source of elevated Salinity within Shallow Aquifer Zone

As noted in **Section 5.1.9**, the Alternative Plan stated that it is unclear why elevated salinity (reported as specific conductance) occurring in the shallow aquifer zone (which suggests an agricultural source) does not appear to correlate with elevated nitrate concentrations as is often found for groundwater impacts related to agriculture. However, the existence of reducing conditions in the shallow zone could result in lower levels of nitrate due to denitrification, suggesting that the high salinity values in the shallow zone are, in fact, from agricultural sources. As such, the source of the elevated salinity in the shallow aquifer is unknown at this time. Studies to address this data gap should include collection of nitrogen isotopes and oxidation-reduction values that will allow assessment of areas with reducing conditions in addition to isotopic analysis.

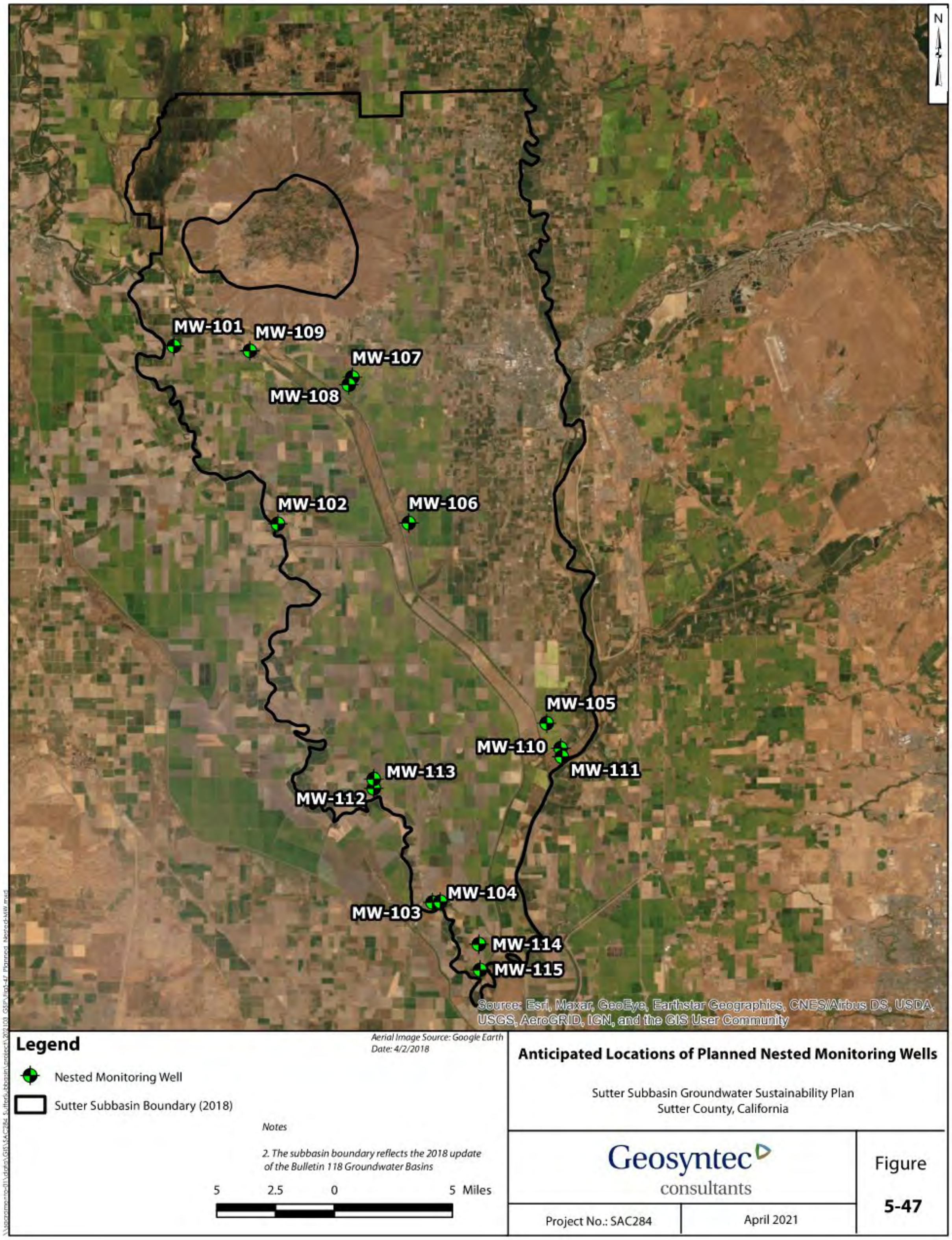


Figure 5-49. Anticipated Locations of Planned Nested Monitoring Wells

5.1.12.3 Aquifer Properties

Only one limited aquifer pumping test was identified to assess aquifer properties for the Sutter Subbasin. This information could be collected by conducting pumping tests as part of existing irrigation practices within the Subbasin by monitoring groundwater elevations in and around pumping wells during pumping start up and following the cessation of pumping. For such a program, existing nested monitoring wells as observation wells would be used to assess groundwater pumping-aquifer interactions. This type of test program will eliminate the need for discharge permits and handling of extracted water and will allow an assessment of the actual stresses on the aquifer during the agricultural season.

5.1.12.4 Further Assess Groundwater Recharge

Future recharge and aquifer studies should include the collection and interpretation of stable isotope data. Methodology considerations include: 1) seasonal sampling should be performed as part of future surface water and groundwater isotope studies for purposes of assessing groundwater recharge; 2) using the existing nested monitoring wells with multiple screened intervals are recommended to assess stable isotope data at different depths; and 3) monitoring wells with relatively short screened zones (20 feet or less) to minimize mixing between aquifer zones or between aquifer zones and residual water retained within the aquitard zones.

5.1.12.5 Recharge Rate

Most well locations and depths should be sampled and analyzed for presence of tritium to help distinguish whether recharge to individual aquifer zones is occurring over periods shorter than about 60 years, or whether recharge is occurring over longer timeframes. This can help better understand the nature of hydraulic connection between different zones in the aquifer system.

5.1.12.6 Hydrogeologic Conceptual Model

Additional data to better understand the hydrogeology of the basin will assist in identifying and improving the understanding of recharge mechanisms and connectivity between aquifer layers and refining the water budget for the Subbasin. Using aerial electromagnetic (AEM) surveys is recommended to help address these uncertainties and the structure of the subbasin.

5.1.12.7 Definition of Stratigraphic Zones

It is recommended that a uniform set of criteria for logging of cuttings from soil boring drilled in the Subbasin be developed. Such an effort would need the participation and cooperation of various agencies and researchers in the region. The criteria adopted should be such that the contacts between geologic formations are easily identifiable from the drill cuttings, such as developed by Blair and others (1991) for the Oroville area. The different studies reviewed for this project use a wide range of definitions and terminology that are not consistent from one investigation to the next. This lack of consistency presents a challenge when attempting to correlate the definition of stratigraphic sequences, aquifer zones, and even geologic formations between different studies. As described in **Section 5.1.4**, many previous studies do not follow USGS standards and the North American Stratigraphic Code, resulting in confusing and sometimes incorrect naming of geologic units. Future studies would benefit from development of a uniform methodology and clearly defined set of stratigraphic terminology so that studies conducted by different investigators can be correlated and the value of the data maximized.

5.2 Groundwater Conditions

This section describes the current and historic groundwater conditions within the Sutter Subbasin and presents data from January 1, 2015 through 2021 as publicly available during the development of this GSP. The current and historic conditions of the following parameters are described herein: groundwater elevations, groundwater storage, groundwater quality, land subsidence, interconnected surface water systems, and groundwater dependent ecosystems (GDEs). Seawater intrusion is not discussed herein as the Sutter Subbasin is inland from the Pacific Ocean and distant from the Sacramento-San Joaquin Delta (Delta) and is not impacted by seawater intrusion.

Baseline conditions are established in this section in order to facilitate the monitoring of changes relative to established sustainable management criteria, and will help support monitoring to demonstrate measurable efforts in achieving the sustainability goal for the Sutter Subbasin. For the purposes of this GSP, “current conditions” are represented by Water Year (WY) 2013 conditions as it is the most recent year with complete data considered “normal” in terms of water use (i.e., not heavily impacted by drought or wet conditions). Data post-WY 2013 through present day are presented when available. This section has been developed pursuant to §354.16 of the GSP Emergency Regulations.

5.2.1 Useful Terminology

This section includes descriptions of the amounts, quality, and movement of groundwater, among other related components. A list of technical terms and a description of those terms are listed below. The terms and their descriptions are identified here to guide readers through the section and are not a definitive definition of each term:

- **Depth to Groundwater** – The distance from the ground surface to first-detected non-perched groundwater, typically reported at a well.
- **Horizontal gradient** – The slope of the groundwater surface from one location to another when one location is higher or lower than the other.
- **Vertical gradient** – Describes the movement of groundwater perpendicular to the ground surface. Vertical gradient is measured by comparing the elevations of groundwater in wells that are screened at different depths. A downward gradient is one where groundwater is moving down into the ground towards deeper aquifers, and an upward gradient is one where groundwater is upwelling towards the ground surface.
- **Contour Map** – A contour map shows changes in groundwater elevations by interpolating groundwater elevations between monitoring sites. The elevations are shown on the map with the use of a contour line, which represents groundwater being at the indicated elevation along the contour line. Contour maps can be presented in two ways:

  - Elevation of groundwater above mean sea level (MSL), which can be used to identify the horizontal gradients of groundwater, and
  - Depth to water (i.e., the distance from the ground surface to groundwater), which can be used to identify areas of shallow or deep groundwater.
- **Hydrograph** – A graph that shows changes in groundwater elevation or depth to groundwater over time at a specific location. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater is rising or descending over time.
- **Maximum Contaminant Level (MCL)** – MCLs are standards that are set by the State of California and the U.S. Environmental Protection Agency for drinking water quality. MCLs are legal threshold limits on the amount (concentration) of an identified constituent that is allowed in public drinking water supplies. At both the State and Federal levels, there are Primary MCLs, set to be protective of human health, and Secondary MCLs (SMCLs) for constituents that do not pose a human health hazard but do pose a nuisance through either smell, odor, taste, and/or color. MCLs differ for different constituents and not all constituents found in groundwater currently have either a federal or state Primary or Secondary MCL.
- **Elastic Land Subsidence** – Reversible and temporary fluctuations in the elevation of the earth’s surface in response to seasonal periods of groundwater extraction and recharge.
- **Inelastic Land Subsidence** – Irreversible and permanent decline in the elevation of the earth’s surface resulting from the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system.
- **Gaining Stream** – A stream in which groundwater flows into a streambed and contributes to a net increase in surface water flows across an identified reach.
- **Losing Stream** – A stream in which surface water is lost through the streambed to the underlying groundwater aquifer, resulting in a net decrease in surface water flows across an identified reach.

5.2.2 Groundwater Elevations

Historic and current groundwater conditions within the Sutter Subbasin are assessed to determine flow directions, lateral and vertical gradients, and regional pumping patterns, both spatially and temporally, as depicted in groundwater elevation contour maps and hydrographs.

5.2.2.1 Historic Conditions

Groundwater in the Sutter Subbasin generally follows the topography of the land surface, flowing from the Sierra Nevada on the east toward the center of the Sacramento Valley (east to west) and north to south within the valley (Wood Rodgers, 2012), eventually flowing toward the Sacramento-San Joaquin Delta. Seasonal and short-term fluctuations in groundwater elevations have been observed in the Sutter Subbasin due to irrigation requirements and hydrologic conditions but have generally remained relatively stable for more than 70 years.

One of the earliest groundwater contour maps for the Sutter Subbasin area was prepared in 1923 (Bryan 1923), as shown in **Figure 5-50**, for Fall 1912 and Fall 1913 conditions (prior to the development of the deep well turbine pump). The contours in **Figure 5-50** presents depth to groundwater and show groundwater entering the Subbasin from the north and east, ranging from 70 feet above mean sea level (MSL) to 20 feet above MSL in the southern end of the Subbasin. Groundwater appears to have historically flowed through and beneath the Feather River. The groundwater contours show groundwater discharges to the Sacramento River and to the south towards the Delta.

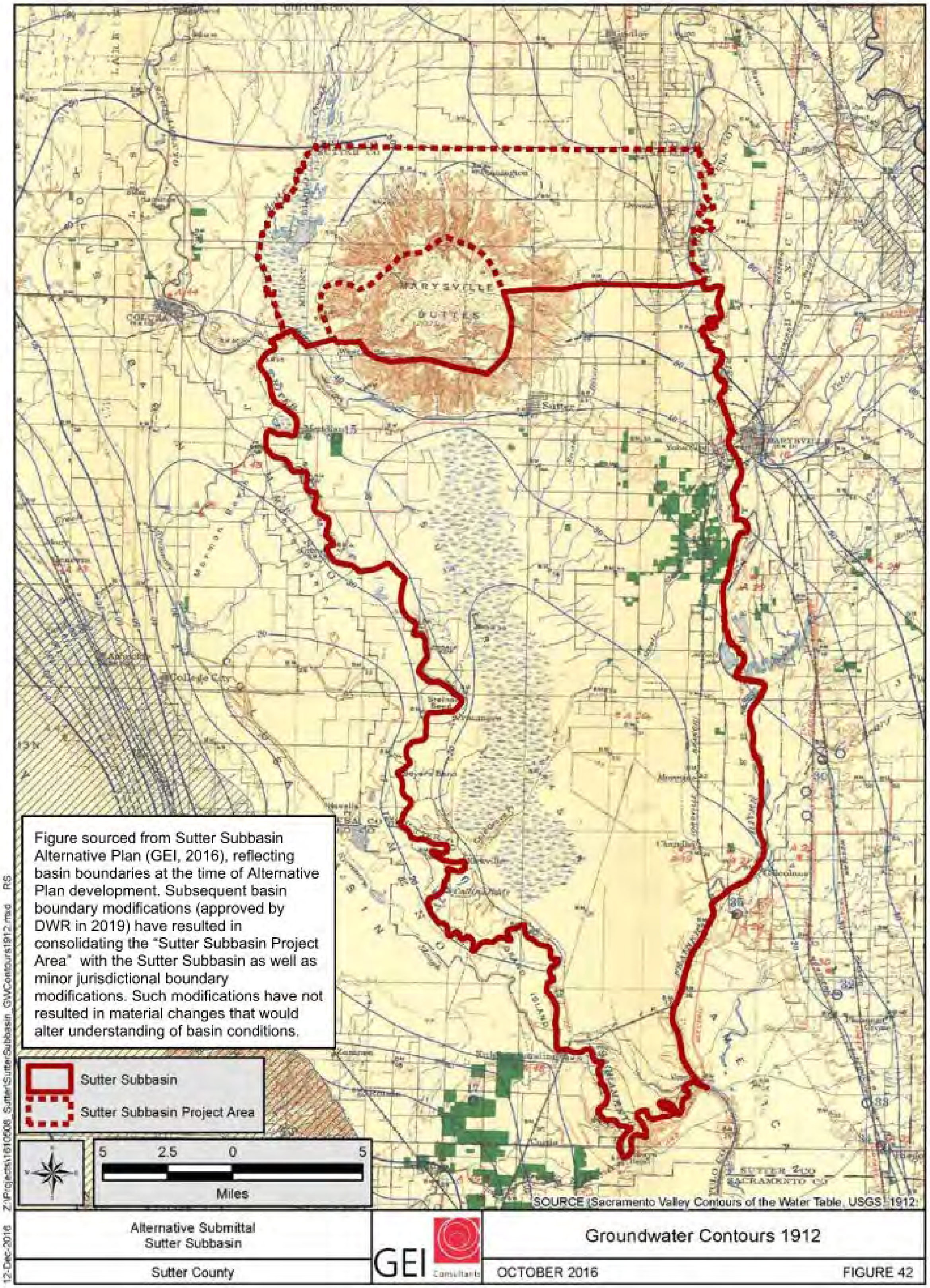


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

SOURCE (Sacramento Valley Contours of the Water Table, USGS, 1912)

Alternative Submittal
Sutter Subbasin
Sutter County

GEI Consultants

Groundwater Contours 1912

OCTOBER 2016

FIGURE 42

Figure 5-50. Groundwater Elevation Contours, Fall 1912 and Fall 1913

As discussed in the Hydrogeologic Conceptual Model (**Section 5.1**), three aquifer zones have been delineated for the Sutter Subbasin and defined as follows:

- **Aquifer Zone-1 (AZ-1)** roughly aligns with the “shallow aquifer” zone defined in the Sutter Subbasin Alternative Plan (GEI, 2016), extending from the ground surface to a depth of about 50 feet below ground surface (bgs) near the Sutter Buttes and up to 190 feet bgs further away from the Sutter Buttes;
- **Aquifer Zone-2 (AZ-2)** generally aligns with the “intermediate aquifer” zone identified in the Alternative Plan, ranging from 150 to 400 feet bgs; and
- **Aquifer Zone-3 (AZ-3)** generally aligns with the “deep aquifer” zone identified in the Alternative Plan and covers the zone deeper than 400 feet bgs.

Additionally, maps of historic conditions presented in this section represent the Bulletin 118 basin boundaries for the Sutter Subbasin and East Butte Subbasin as available during Alternative Plan development. Basin boundaries modifications have taken place since the Alternative Plan development as part of DWR’s Basin Boundary Modification Request System in 2018, including consolidating the East Butte Subbasin within the Sutter Subbasin and jurisdiction boundary modifications to include Biggs-West Gridley Water District GSA entirely within the Butte Subbasin, and aligning the Sutter Subbasin boundary with the Sutter County jurisdictional boundary. Such boundary modifications have not resulted in material changes that would alter understanding of historic basin conditions within the current Sutter Subbasin boundary but should be noted.

Figure 5-51 through **Figure 5-53** show groundwater elevations within the Sutter Subbasin in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones during Spring 1998, representing the highest groundwater elevations during a Wet year (as classified by the Sacramento River Water Year Index). Groundwater elevations in the shallow aquifer zone range from 21 feet above MSL along the central portion of the western boundary of Subbasin to 75 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-51**). In the intermediate aquifer zone, groundwater elevations range from 15 feet above MSL in the southern portion of the Subbasin to 69 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-52**). Groundwater elevation data are limited for Spring 1998 in the deep aquifer zone, but ranges from approximately 67 feet above MSL in the northern portion of the Subbasin to approximately 14 feet above MSL in the southern portion of the Subbasin (**Figure 5-53**). In all aquifer zones in Spring 1998, the general direction of groundwater flow is from the north and east portion of the Subbasin towards the south.

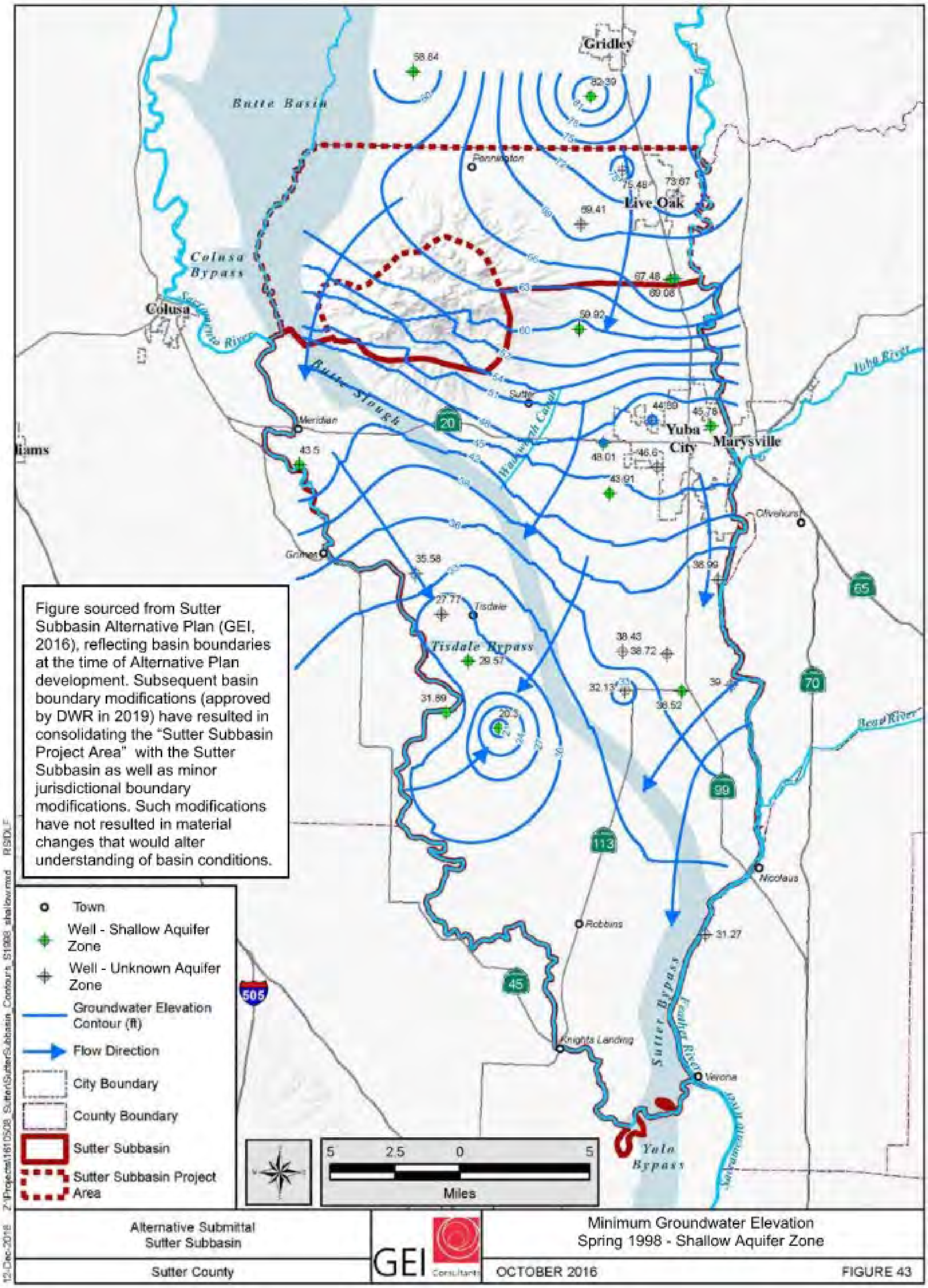


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-51. Groundwater Elevation in Shallow Aquifer Zone, Spring 1998

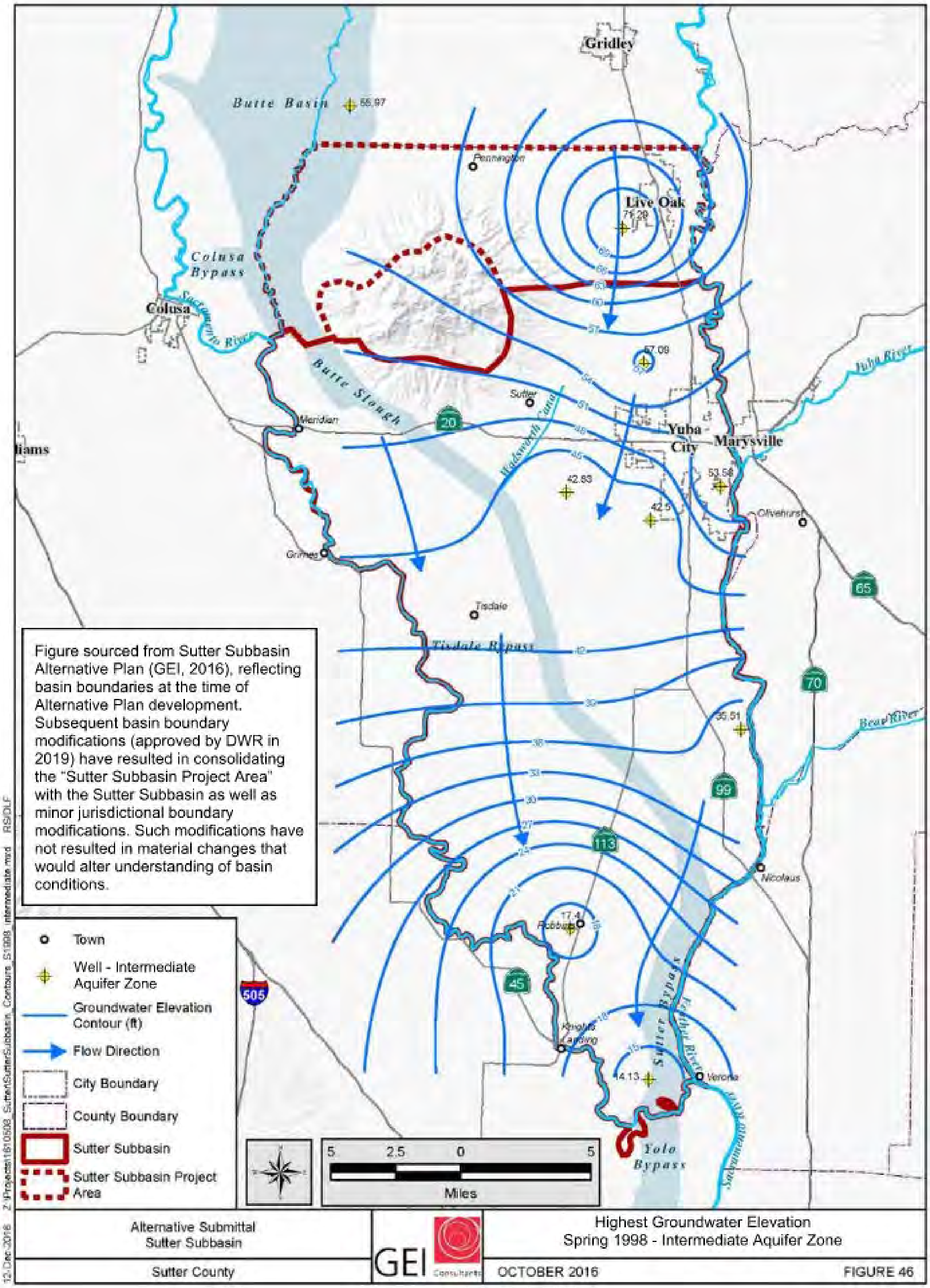


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Alternative Submittal
Sutter Subbasin

Sutter County

GEI Consultants

Highest Groundwater Elevation
Spring 1998 - Intermediate Aquifer Zone

OCTOBER 2016

FIGURE 46

Figure 5-52. Groundwater Elevation in Intermediate Aquifer Zone, Spring 1998

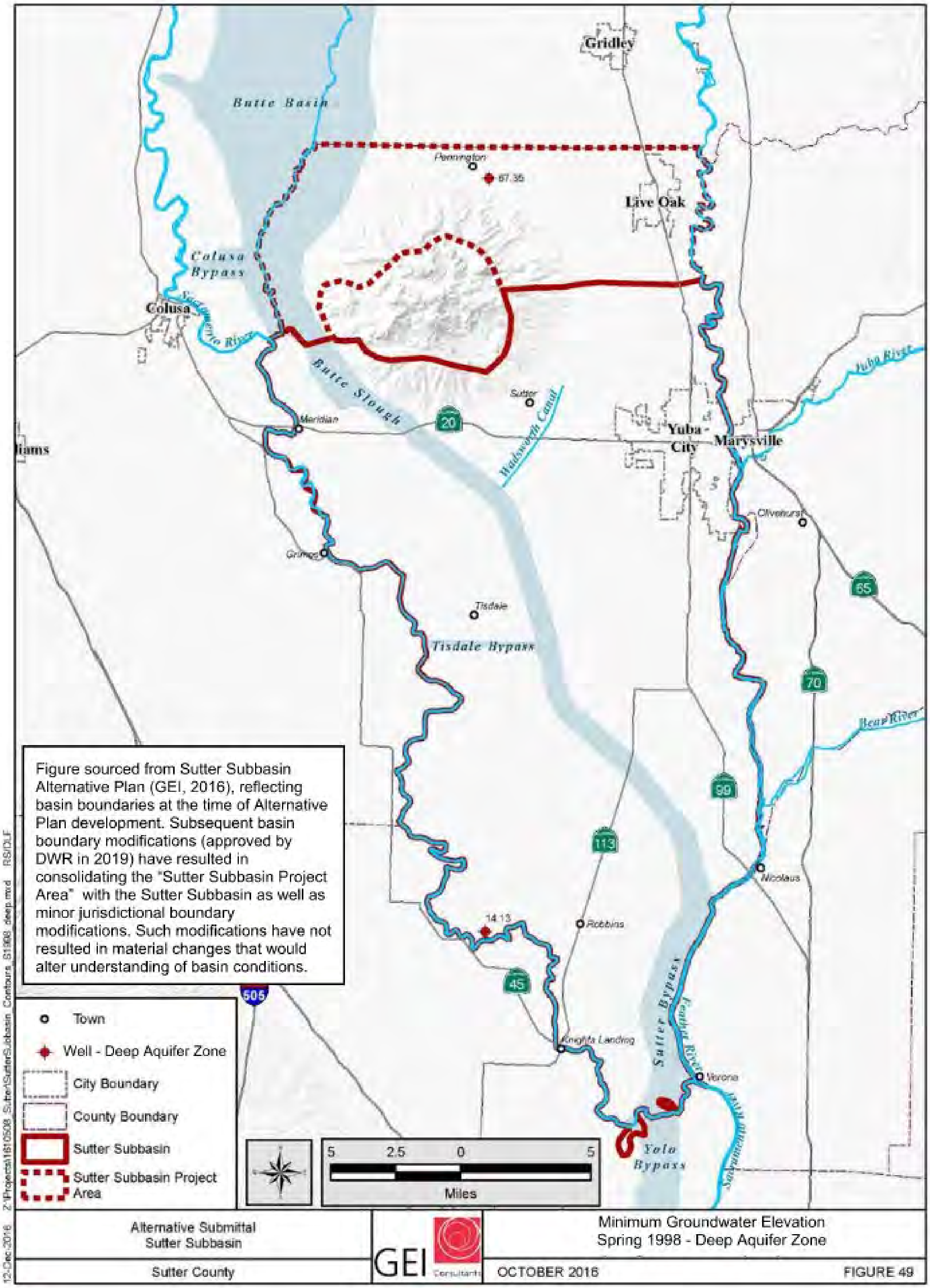


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Alternative Submittal
Sutter Subbasin

Sutter County

Minimum Groundwater Elevation
Spring 1998 - Deep Aquifer Zone

OCTOBER 2016

FIGURE 49

Figure 5-53. Groundwater Elevation in Deep Aquifer Zone, Spring 1998

Figure 5-54 through **Figure 5-56** show groundwater elevations in the Subbasin in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones during Fall 2009, representing the lowest groundwater elevations during a Dry year (as classified by the Sacramento River Water Year Index). Groundwater elevations in the shallow aquifer zone range from 12 feet above MSL in the southern portion of the Subbasin to 69 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-54**). In the intermediate aquifer zone, groundwater elevations range from 15 feet above MSL in the southern portion of the Subbasin to 63 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-55**). Groundwater elevations in the deep aquifer zone range from 15 feet above MSL in the southern portion of the Subbasin to 45 feet above MSL along the northern boundary of the Subbasin (**Figure 5-56**). In all aquifer zones during Fall 2009, the general direction of groundwater flow is similar to Spring 1998, with groundwater entering the Subbasin from the north and east and leaving the Subbasin to the south.

The difference in groundwater elevations from the highest groundwater level in Spring 1998 to the lowest groundwater elevation in Fall 2009 within each zone of the principal aquifer are summarized below:

- **Shallow Aquifer Zone (AZ-1; Figure 5-57)** – East of the Sutter Buttes along the northern Subbasin boundary, the groundwater level difference between Spring 1998 and Fall 2009 is about 6 feet. Along the Feather River (the eastern side of the Subbasin), the differences in groundwater elevations vary between 6 and 20 feet. Along the western edge of the Subbasin, the difference in groundwater elevation is about 10 feet.
- **Intermediate Aquifer Zone (AZ-2; Figure 5-58)** – Groundwater levels between Spring 1998 and Fall 2009 differ by about 10 feet along the northern Subbasin boundary near the Sutter Buttes. Along the Feather River, the differences in groundwater elevation vary between 12 and 22 feet. Along the southern end of the Subbasin, the difference in groundwater elevation is about 0.5 feet.
- **Deep Aquifer Zone (AZ-3; Figure 5-53 and Figure 5-56)** – Only two measurement points were available in Spring 1998 and eight measurement points available in Fall 2009. The northern well in Fall 2009 appears to have been pumping, which results in almost a 20-foot decline in groundwater levels. Comparison of data from the southern well between Spring 1998 and Fall 2009 shows a rise in groundwater levels of about 0.6 feet.

Localized pumping depressions are observed in all zones of the principal aquifer during Spring 1998 and Fall 2009, as shown in **Figure 5-51** through **Figure 5-56.** These localized pumping depressions are primarily located within the northeastern corner and central portion of the Sutter Subbasin.

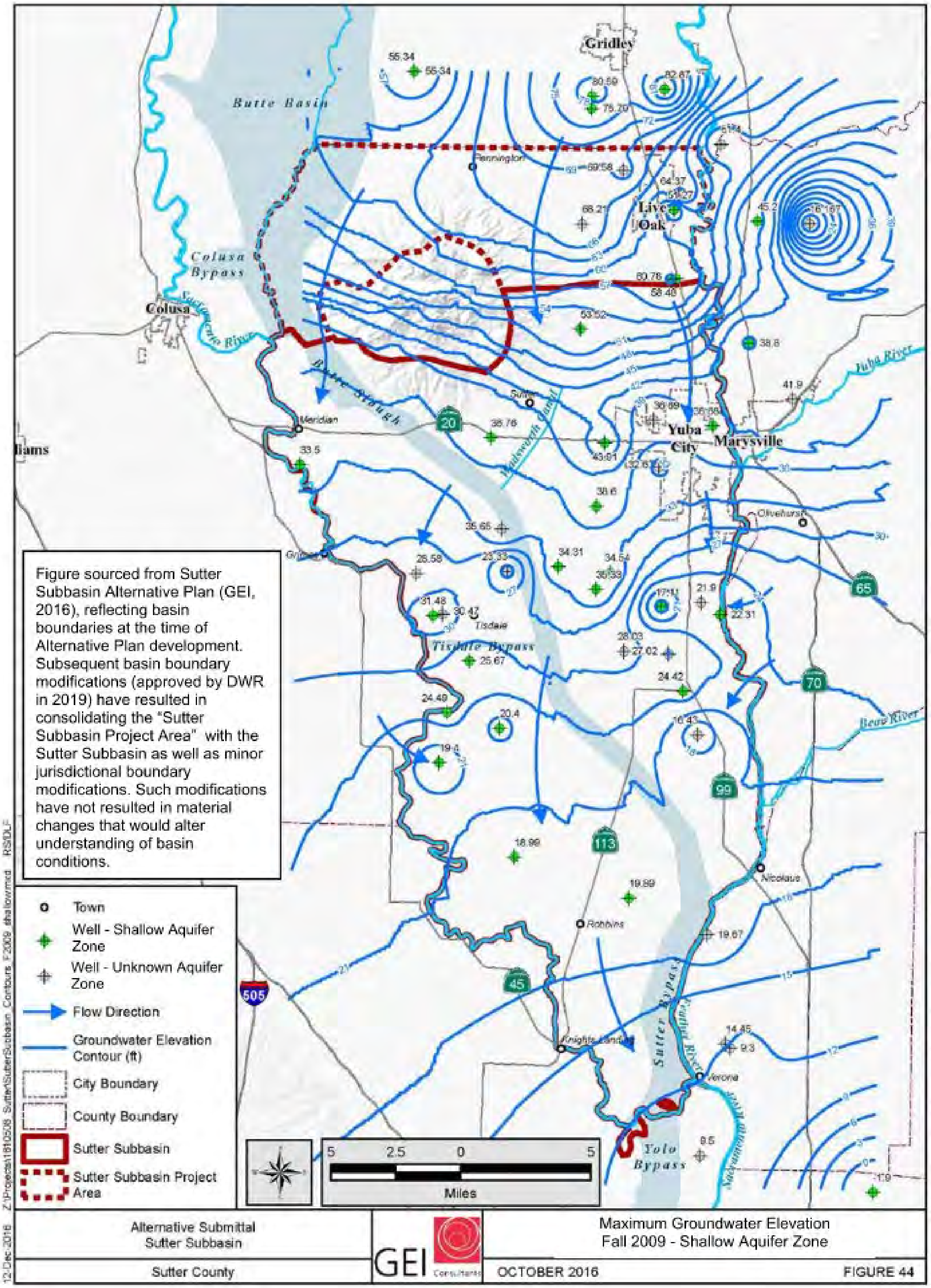


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-54. Groundwater Elevation in Shallow Aquifer Zone, Fall 2009

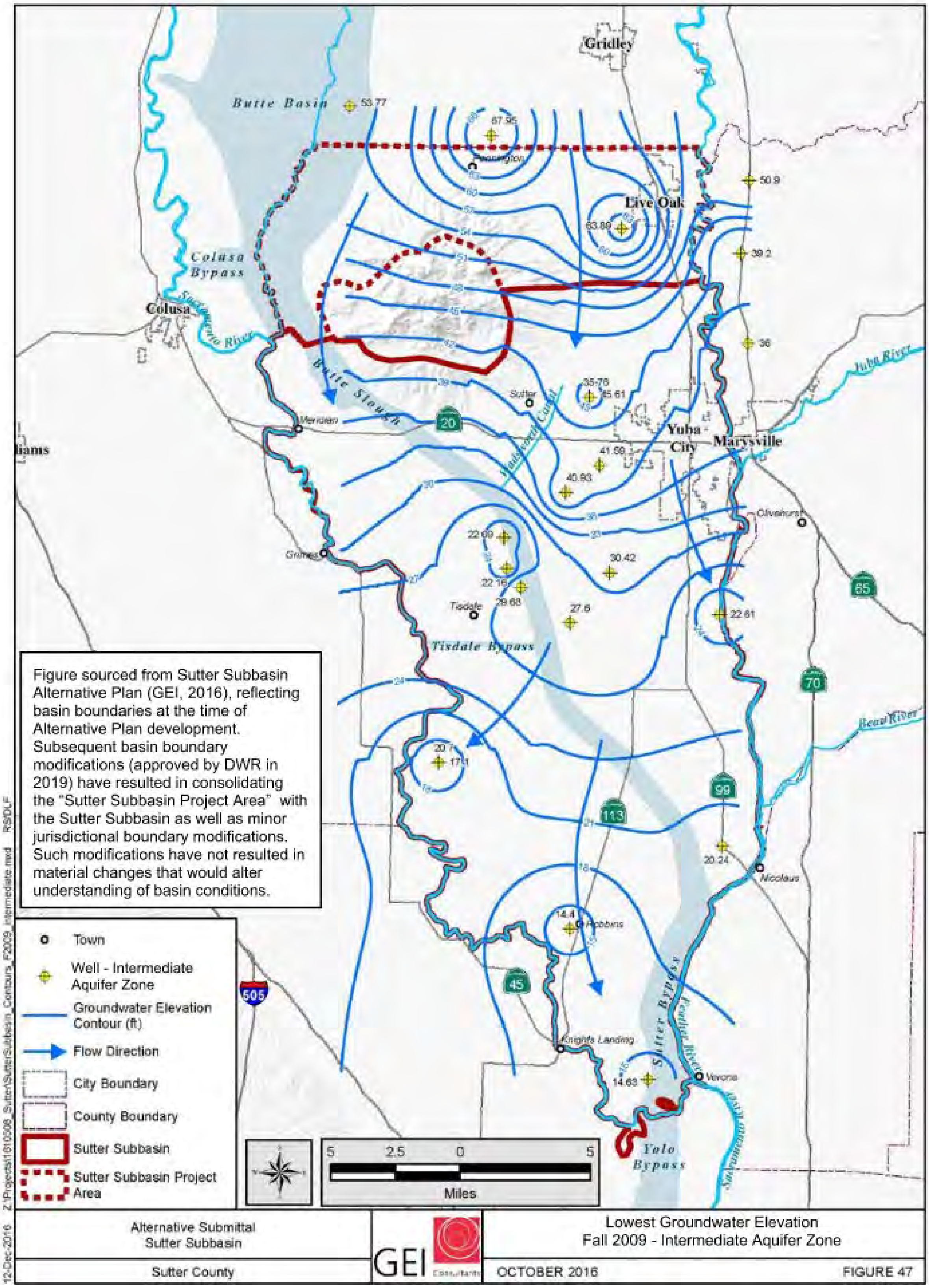


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-55. Groundwater Elevation in Intermediate Aquifer Zone, Fall 2009

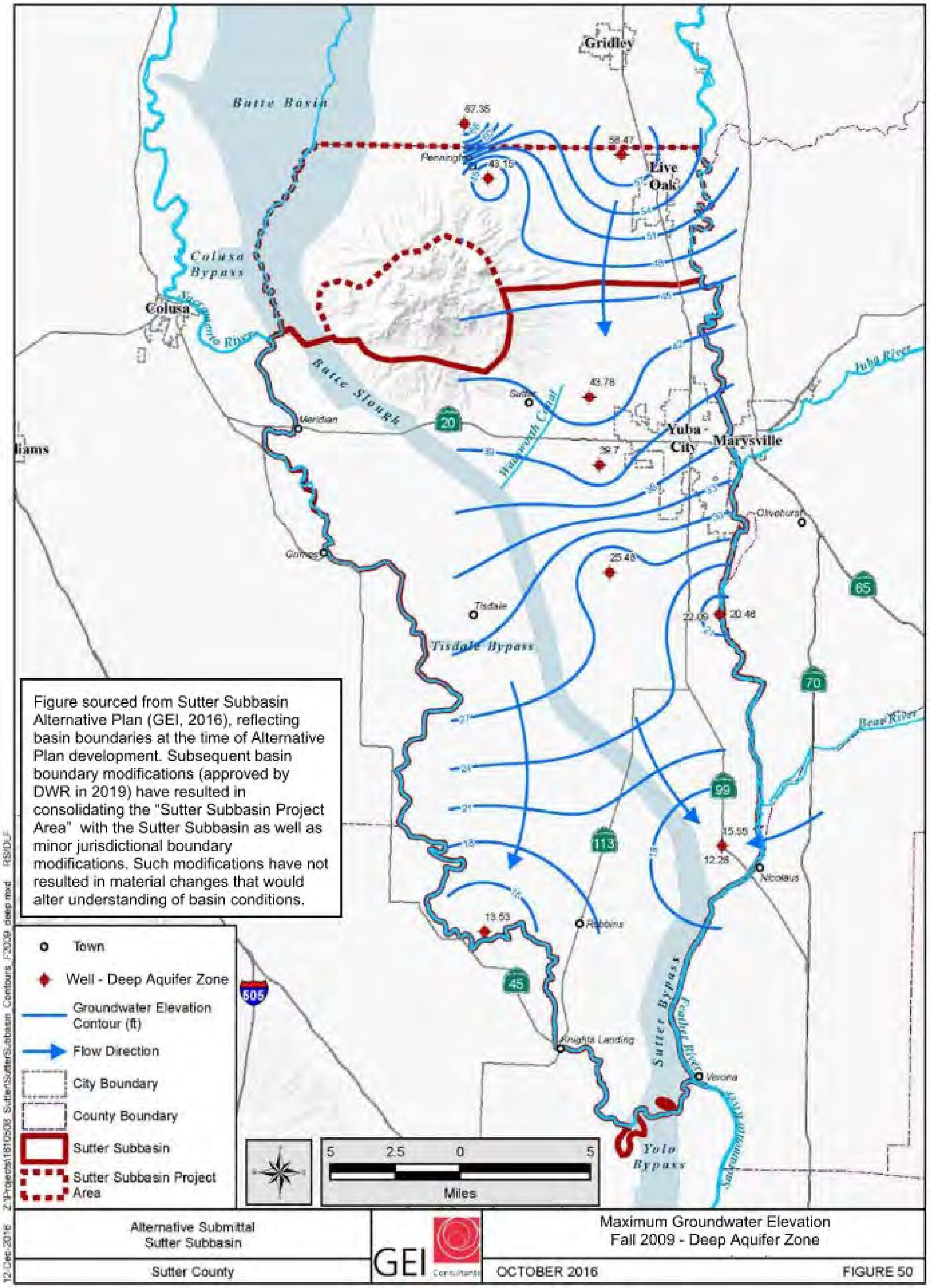


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Alternative Submittal
Sutter Subbasin

Sutter County

GEI Consultants

Maximum Groundwater Elevation
Fall 2009 - Deep Aquifer Zone

OCTOBER 2016

FIGURE 50

Figure 5-56. Groundwater Elevation in Deep Aquifer Zone, Fall 2009

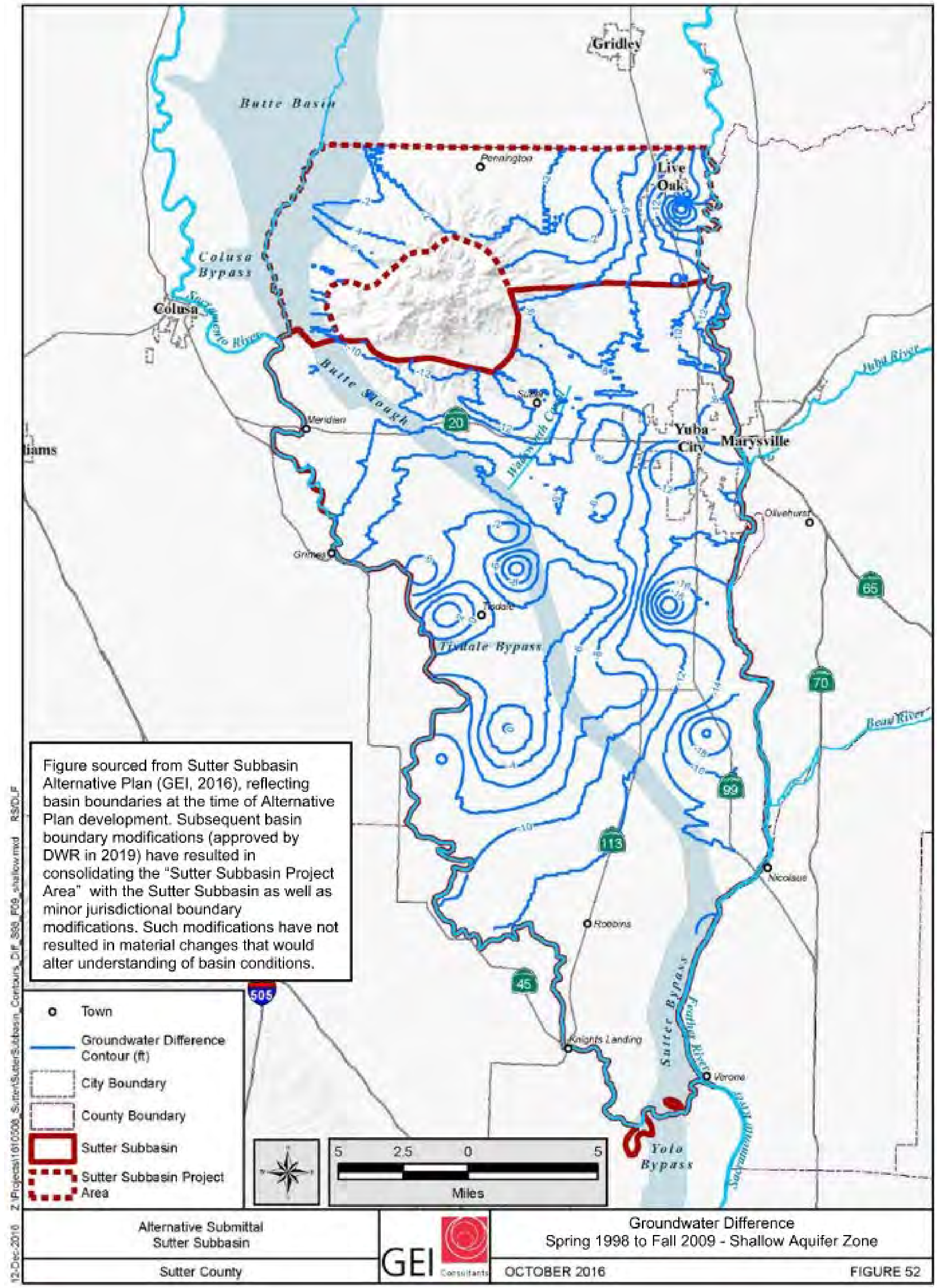


Figure 5-57. Difference in Groundwater Elevation in Shallow Aquifer Zone, Spring 1998 to Fall 2009

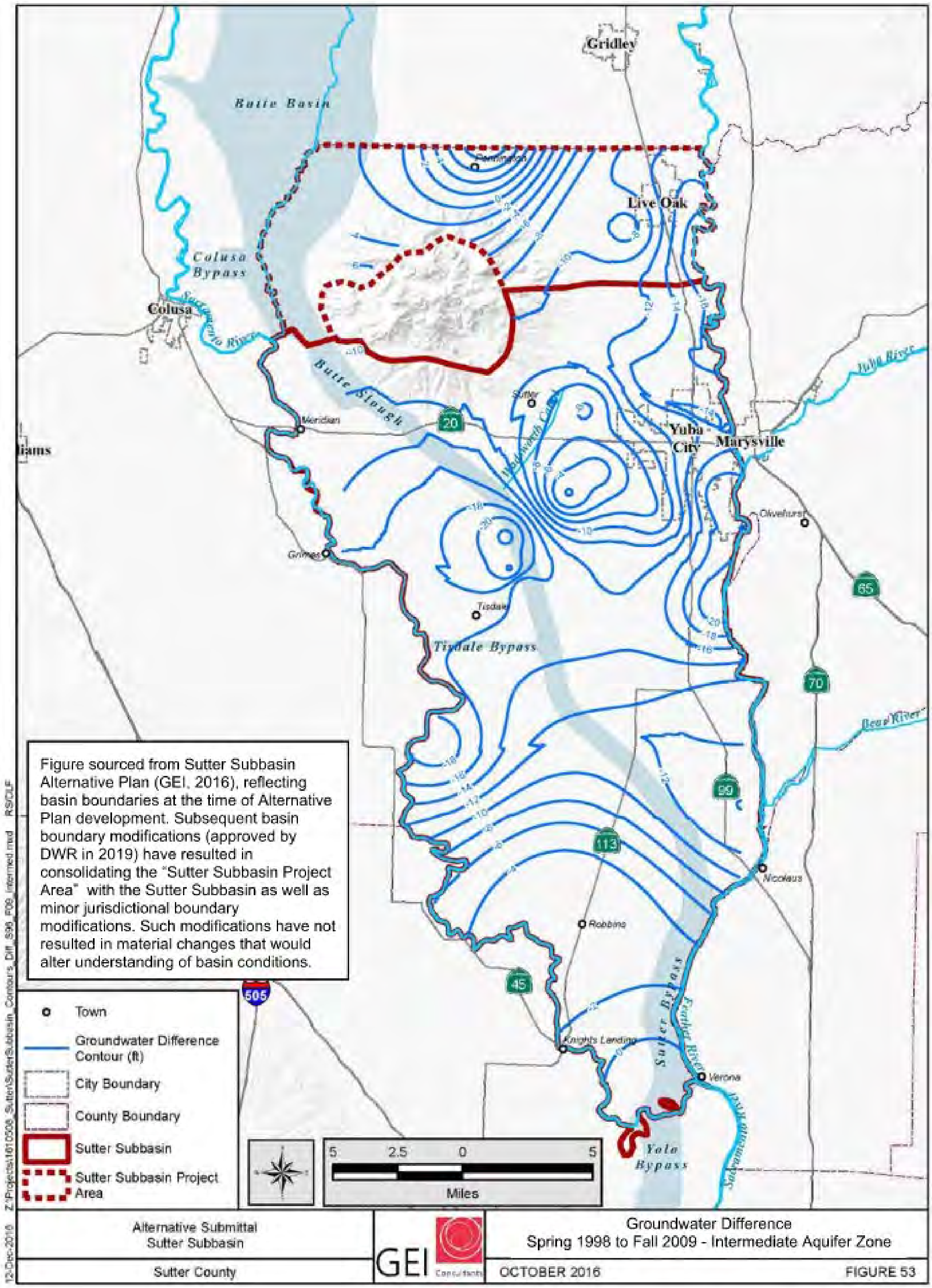


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-58. Difference in Groundwater Elevation in Intermediate Aquifer Zone, Spring 1998 to Fall 2009

Hydrographs depicting long-term groundwater elevations, historic highs and lows, and hydraulic gradients are shown in **Figure 5-59** through **Figure 5-68**. Groundwater elevations from nine nested wells with 33 perforation intervals with measurements ranging from 2004 through early 2021 are shown. Shallow groundwater levels, largely within the shallow aquifer zone (AZ-1), are relatively stable over time and indicate that most groundwater production is occurring below this zone. More groundwater appears to be produced from the deeper aquifer zones (deeper portion of AZ-1 as well as the intermediate [AZ-2] and deep [AZ-3] aquifer zones) as indicated by large fluctuations in groundwater elevations where responses to groundwater pumping are observed (drawdown) with rebound following the irrigation season as the aquifer recharges and returns to pre-pumping levels on a seasonal basis. Overall, groundwater level trends are largely flat over time, indicating sustainable conditions in the Sutter Subbasin as the aquifer rebound is observed during all water year types.

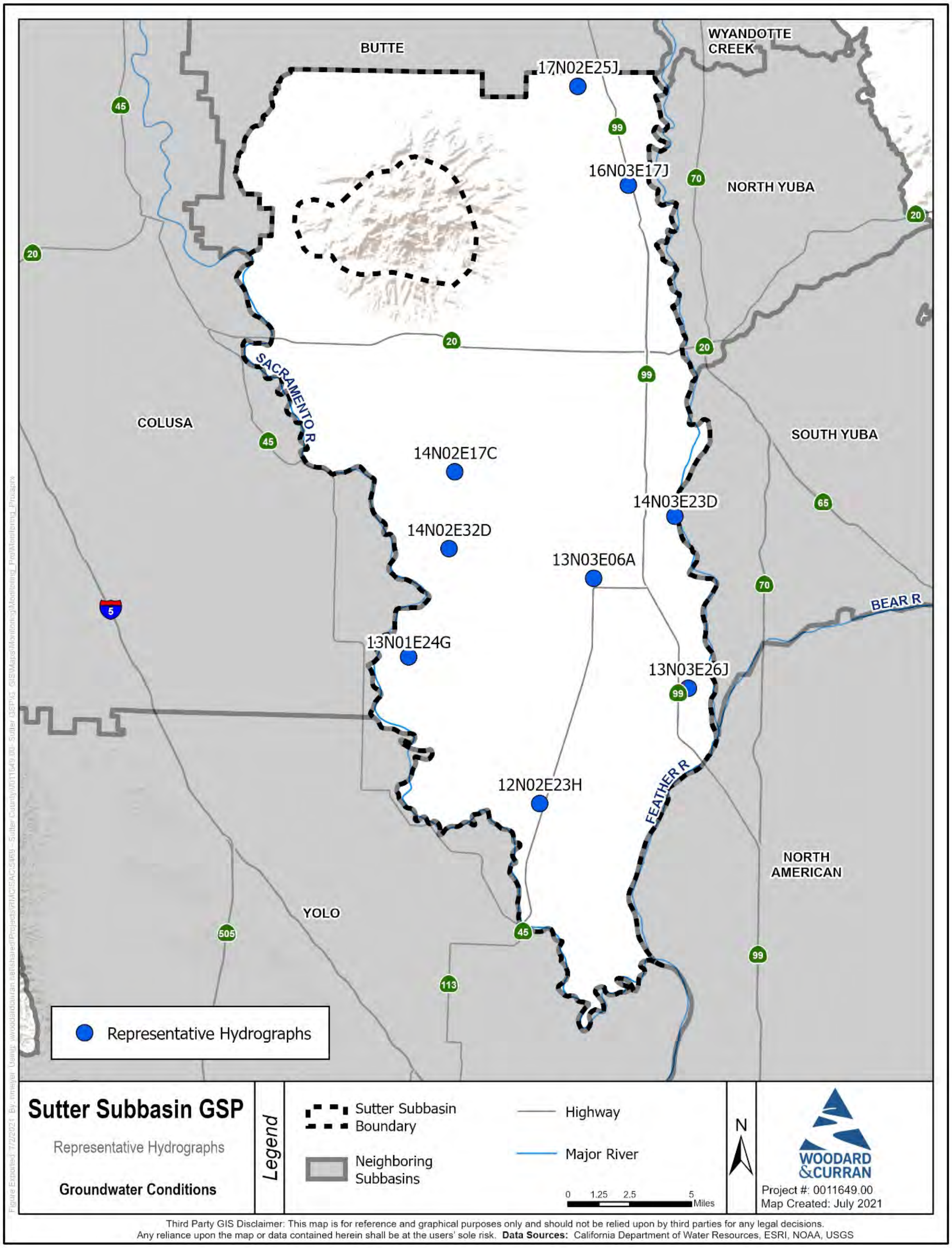


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Figure 5-59. Representative Hydrograph Locations

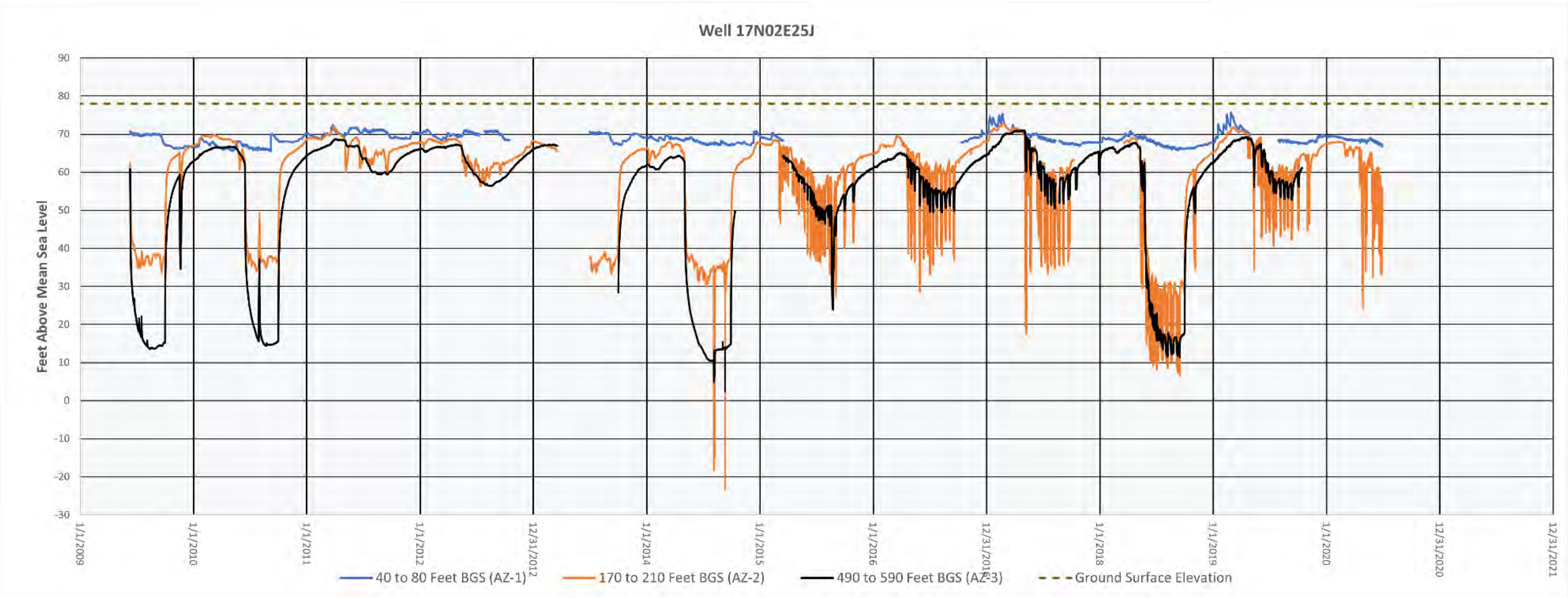

Figure 5-60. Well 17N02E25J Hydrograph

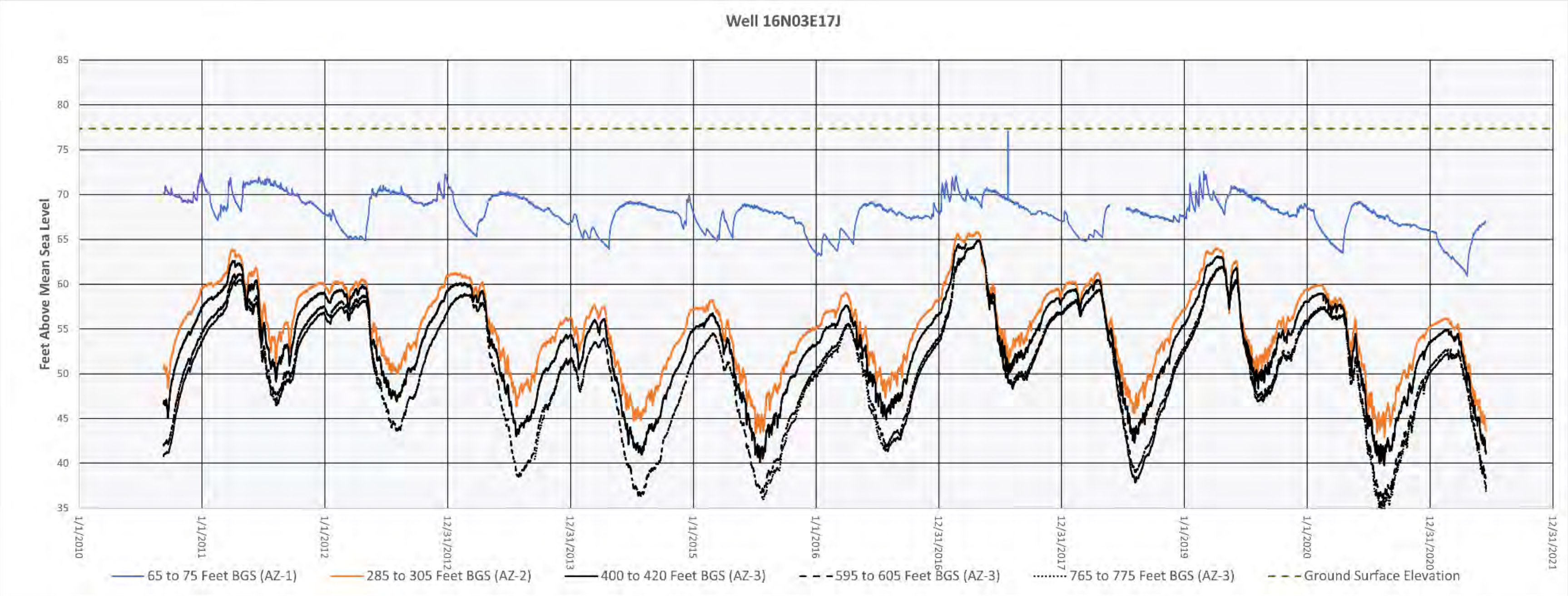

Figure 5-61. Well 16N03E17J Hydrograph

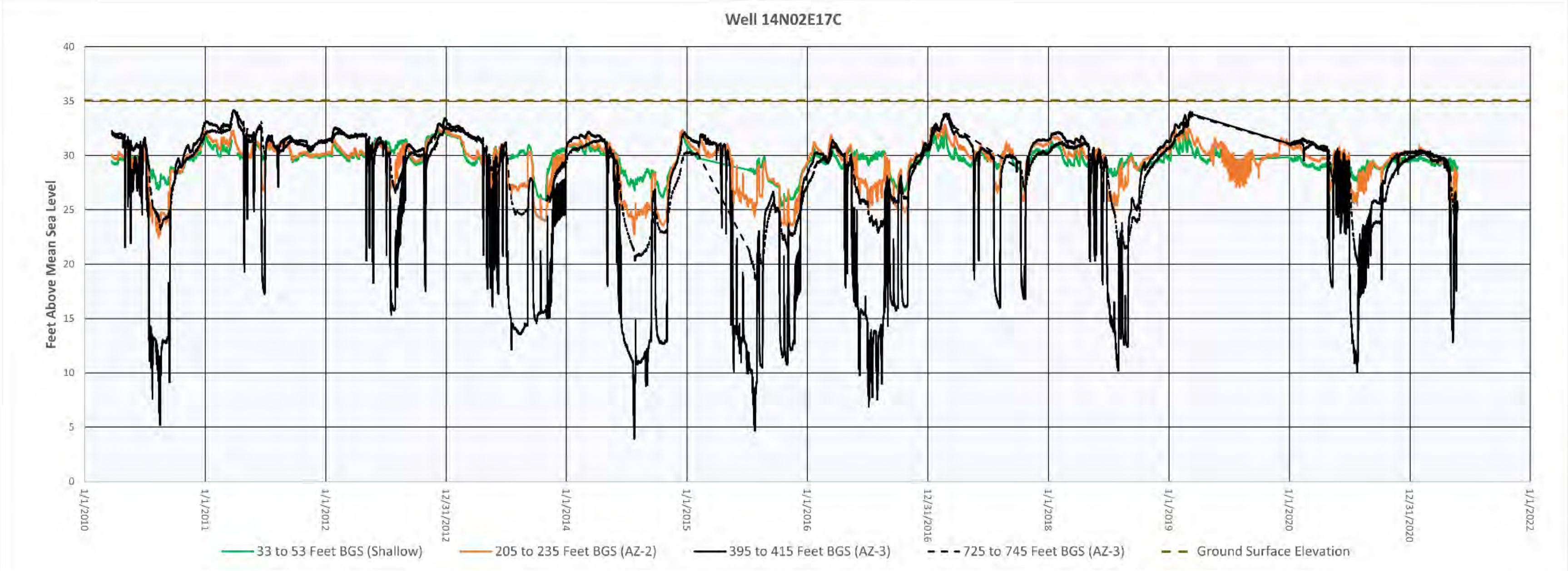

Figure 5-62. Well 14N02E17C Hydrograph

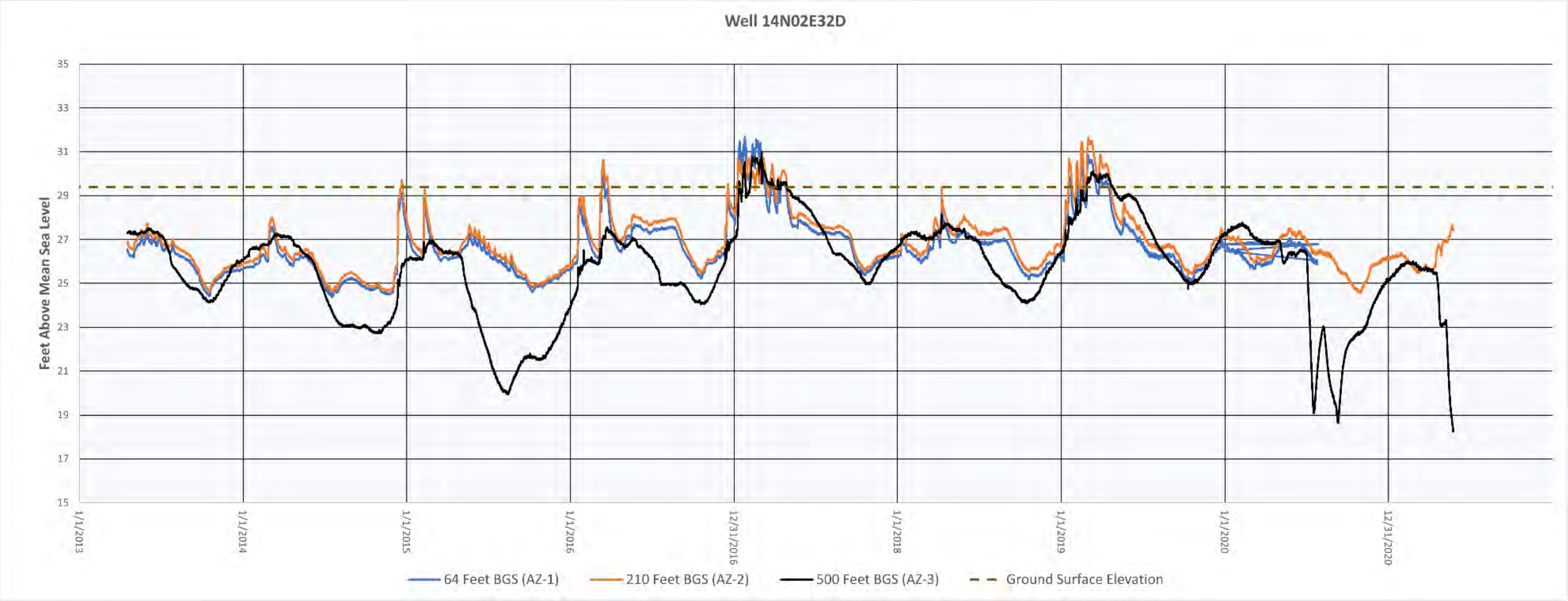

Figure 5-63. Well 14N02E32D Hydrograph

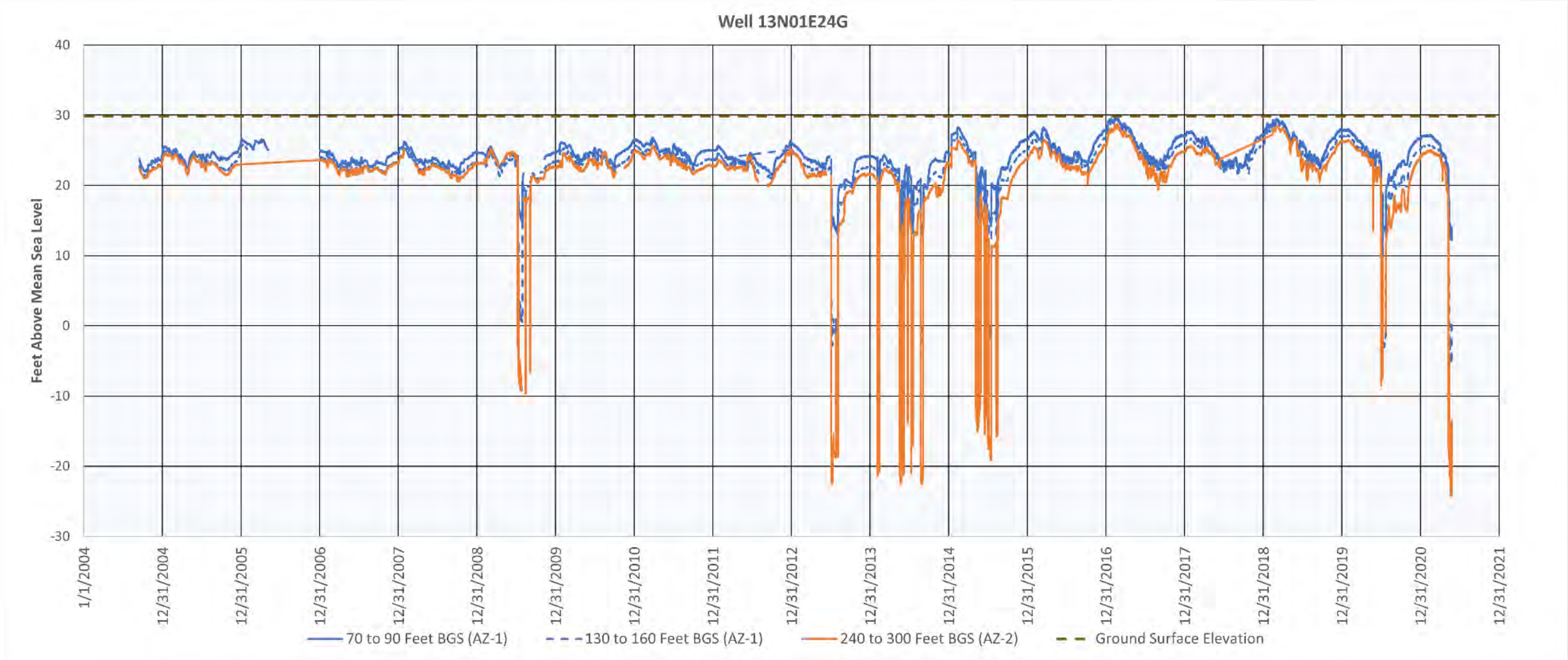

Figure 5-64. Well 13N01E24G Hydrograph

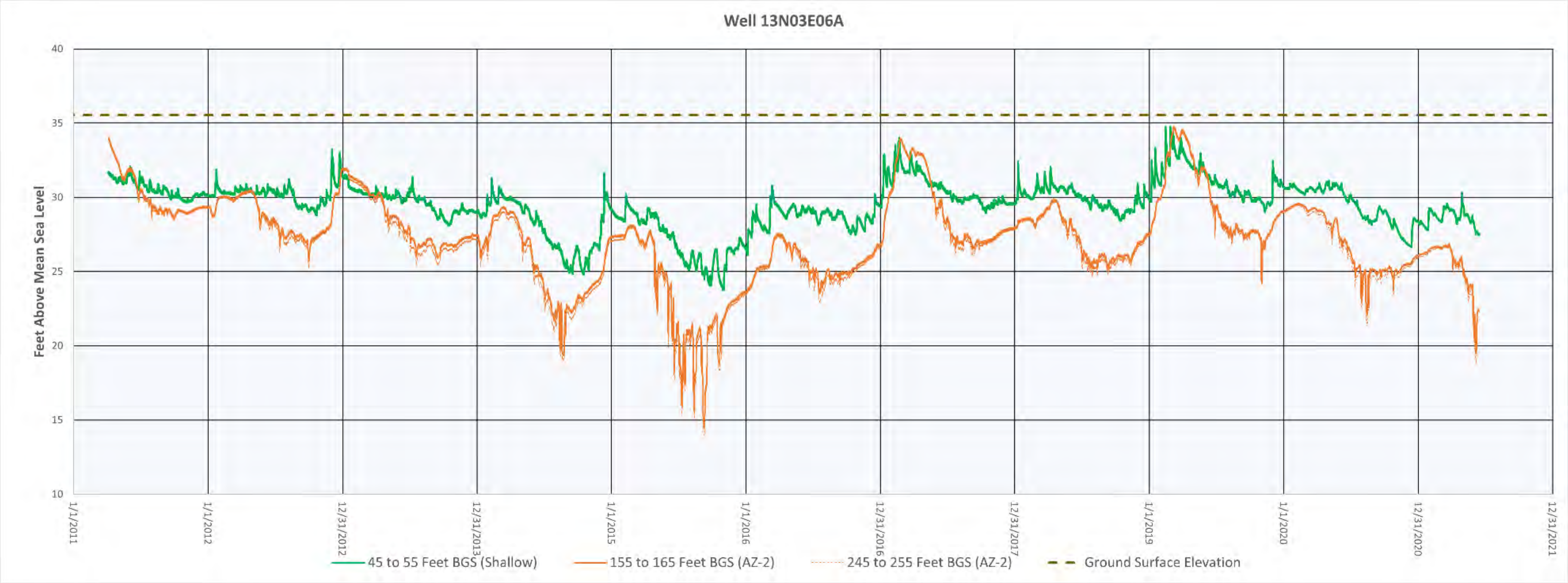

Figure 5-65. Well 13N03E06A Hydrograph

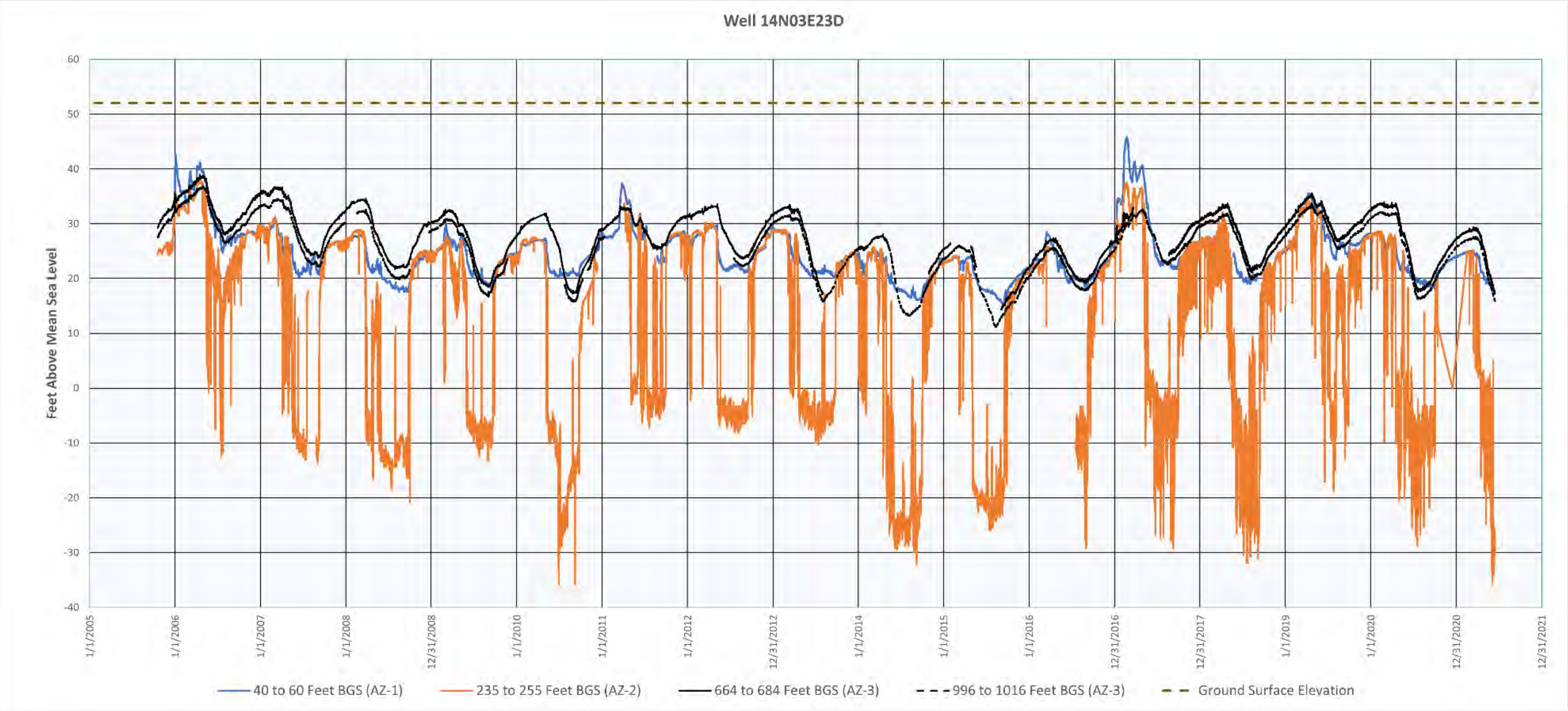

Figure 5-66. Well 14N03E23D Hydrograph

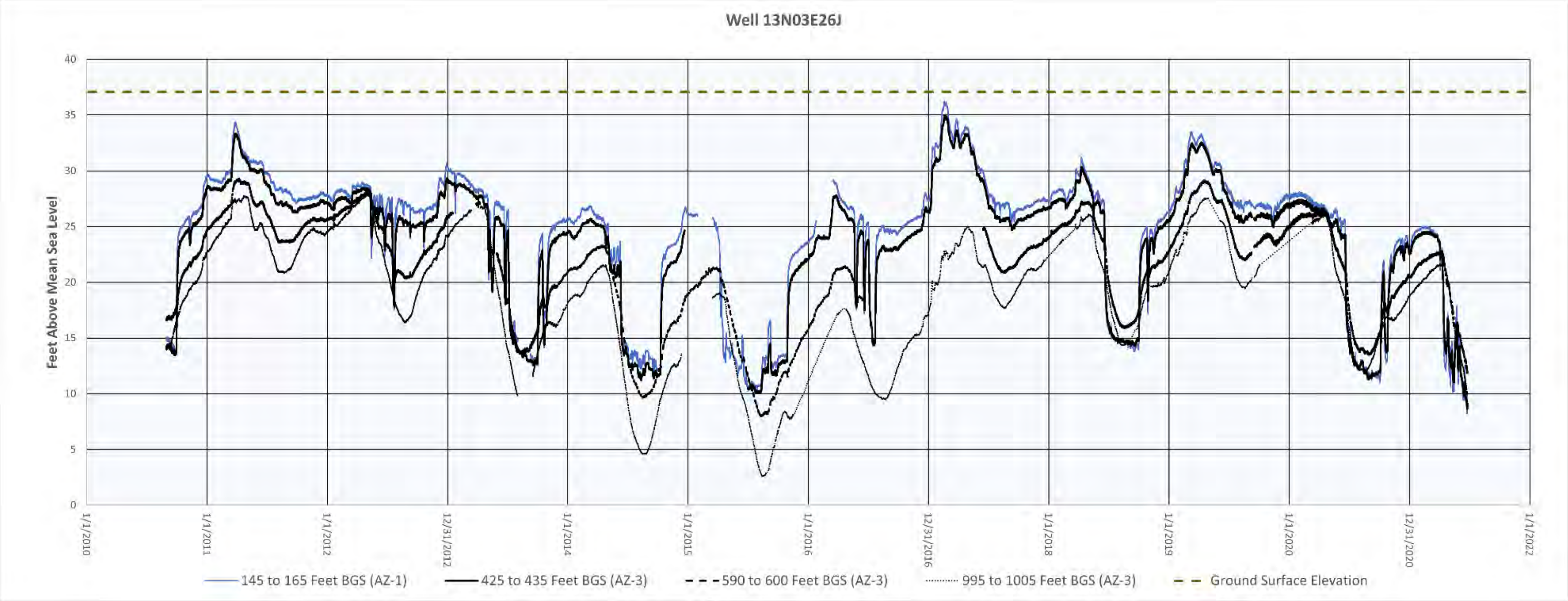

Figure 5-67. Well 13N03E26J Hydrograph

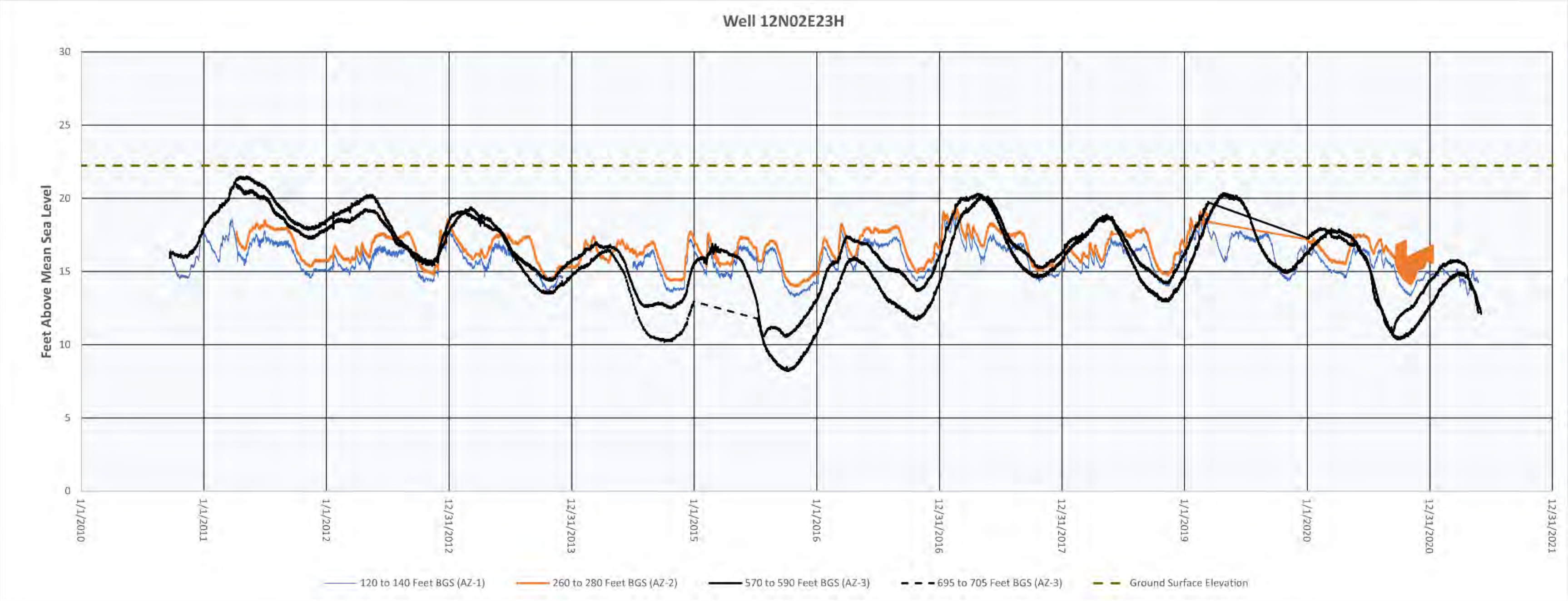

Figure 5-68. Well 12N02E23H Hydrograph

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5.2.2.2 Current Conditions

As previously noted, WY 2013 was selected to represent “current conditions” as it is the most recent year with complete data considered “normal” in terms of water use (not heavily impacted by drought or wet conditions). Groundwater elevation contour maps for March 2013, representing seasonal high conditions, are shown in **Figure 5-69** through **Figure 5-72**. Groundwater elevation contour maps for October 2013, representing seasonal low conditions following the end of WY 2013, are shown in **Figure 5-73** through **Figure 5-76**. Maps are presented for the following aquifer zones, which together comprise a single principal aquifer:

- **Shallow Aquifer Zone**– up to 50 feet bgs
- **AZ-1** – between 50 feet and 150 feet bgs
- **AZ-2** – between 150 feet and 400 feet bgs
- **AZ-3** – deeper than 400 feet bgs

During March 2013, limited data were available for the Shallow Aquifer Zone. Based on data that are available, groundwater elevations ranging from 40 to 60 feet above MSL and groundwater flows from east to west directly south of the Sutter Buttes (**Figure 5-69**). Groundwater elevations in AZ-1 range from 20 to 70 feet above MSL (**Figure 5-70**), and between 20 and 60 feet above MSL in AZ-2 (**Figure 5-71**) and AZ-3 (**Figure 5-72**) with flow in the general north to south direction in all three AZs.

During October 2013, limited data are available in the Shallow Aquifer Zone, with groundwater elevations ranging from 40 to 50 feet above MSL and groundwater flowing from east to west directly south of the Sutter Buttes, similar to March 2013 (**Figure 5-73**). In AZ-1, groundwater elevations are approximately 10 feet lower in October 2013 as compared to March 2013, ranging from 10 to 60 feet above MSL with similar flow patterns as March 2013 (**Figure 5-74**). Groundwater elevations in AZ-2 range from 20 to 40 feet above MSL in October 2013, with the highest elevation approximately 20 feet lower than in March 2013 and flowing in the southerly direction (**Figure 5-75**). In AZ-3, groundwater elevations range from 10 to 40 feet above MSL, with the lowest elevation approximately 10 feet lower and the highest elevation approximately 20 feet lower as compared to March 2013 measurements; groundwater follows a similar general flow patterns observed in October 2013 as in March 2013 (**Figure 5-76**).

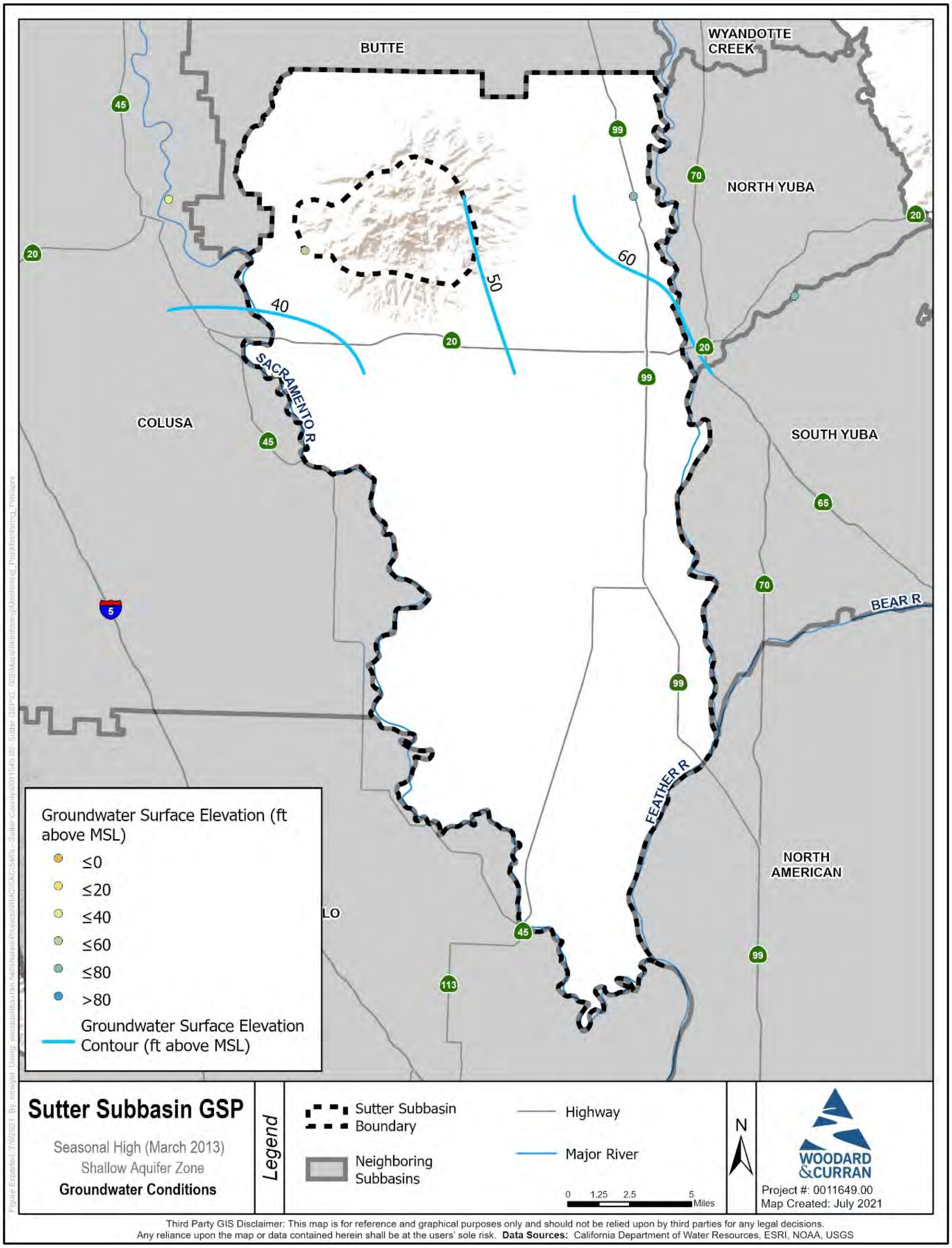

Figure 5-69. March 2013 Groundwater Elevations, Shallow Aquifer Zone

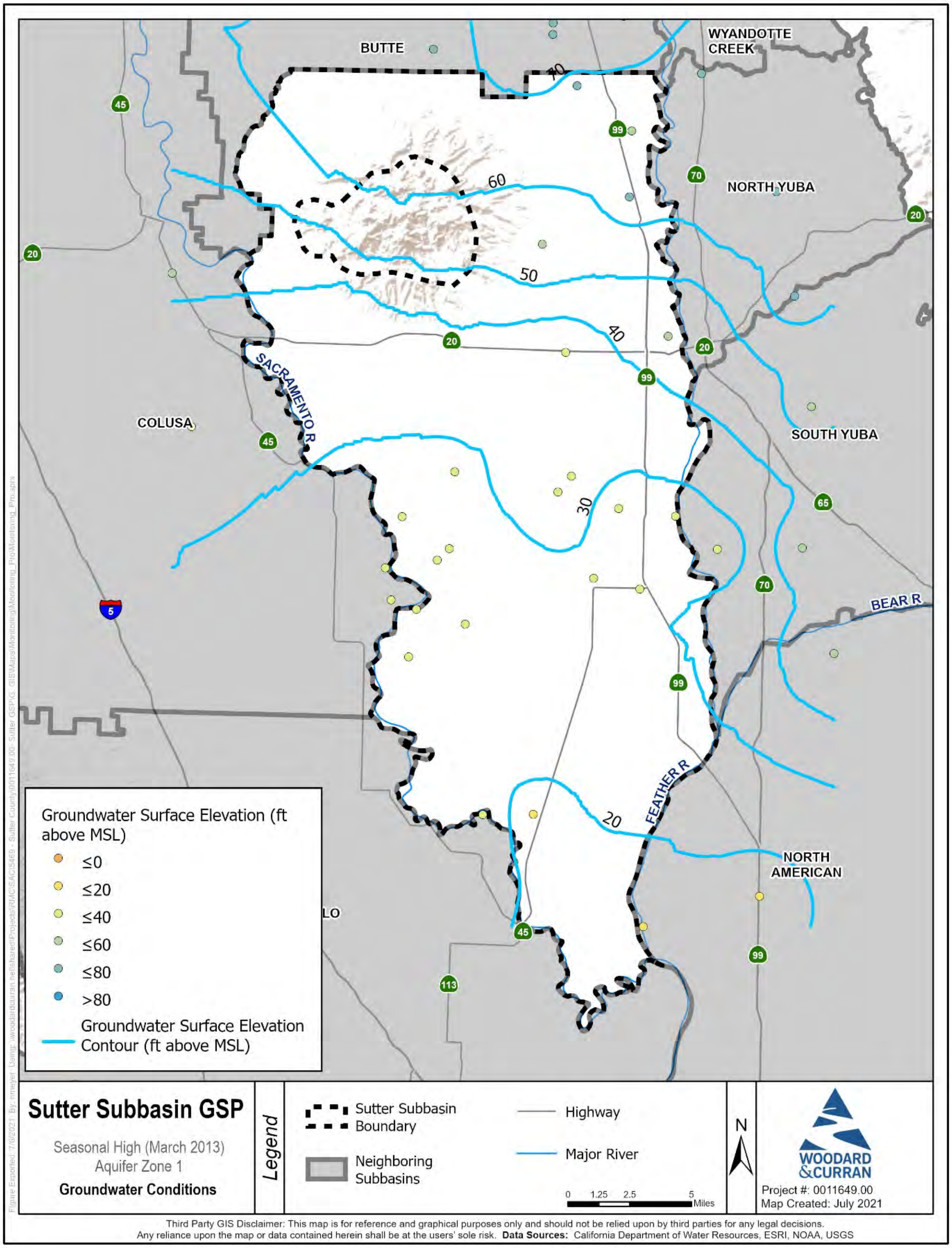

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Figure 5-70. March 2013 Groundwater Elevations, AZ-1

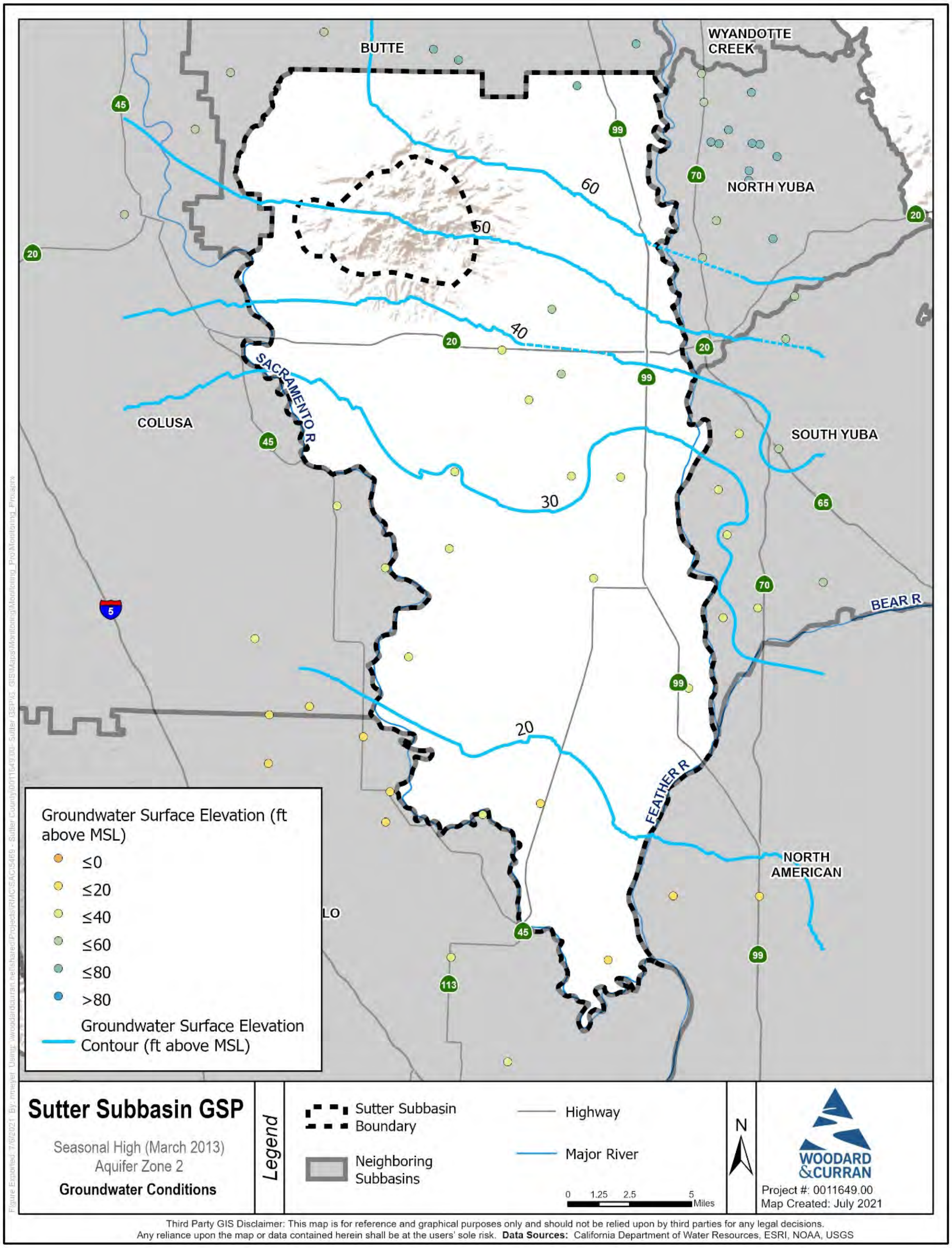
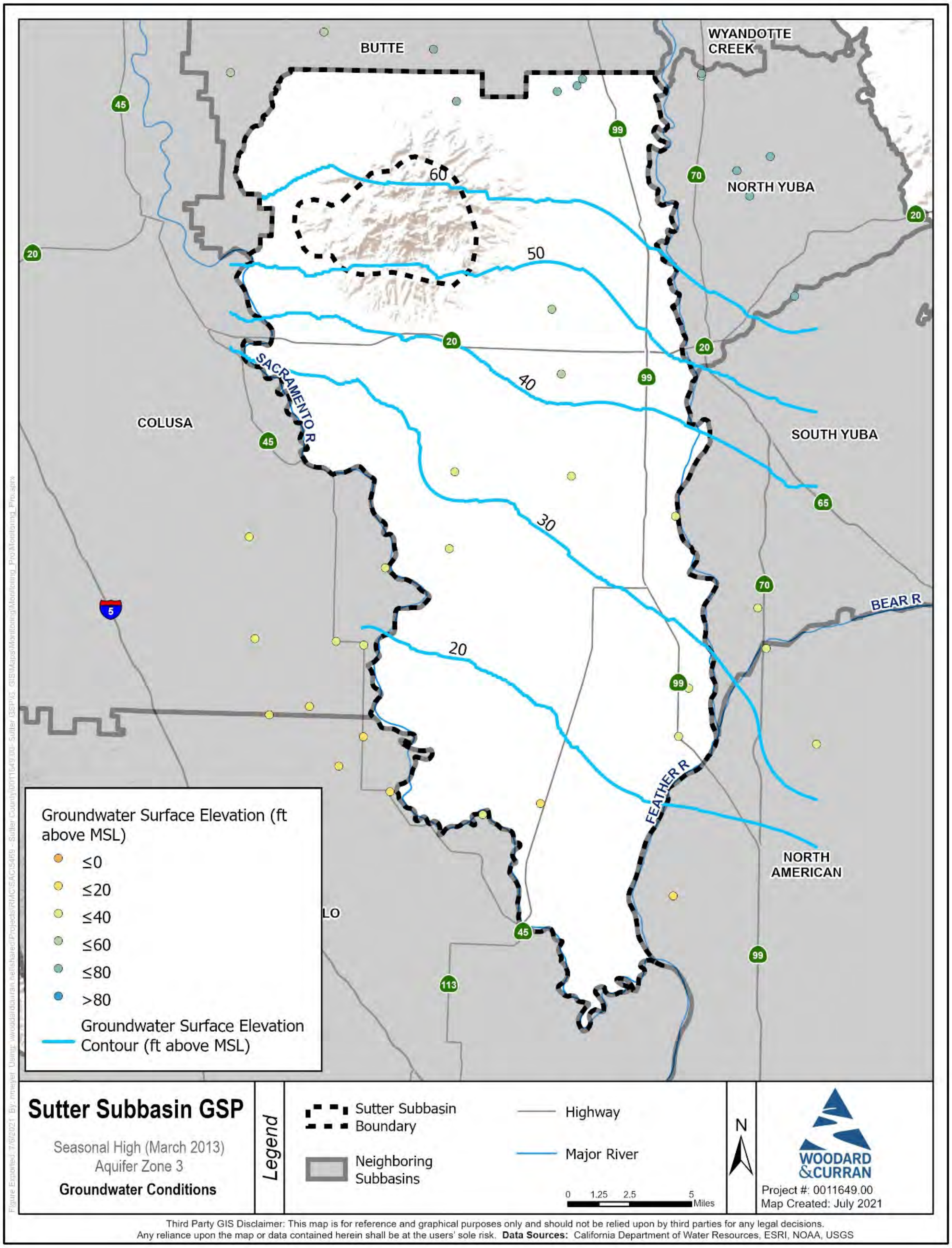


Figure 5-71. March 2013 Groundwater Elevations, AZ-2



Data Sources: California Department of Water Resources, ESRI, NOAA, USGS

Figure 5-72. March 2013 Groundwater Elevations, AZ-3

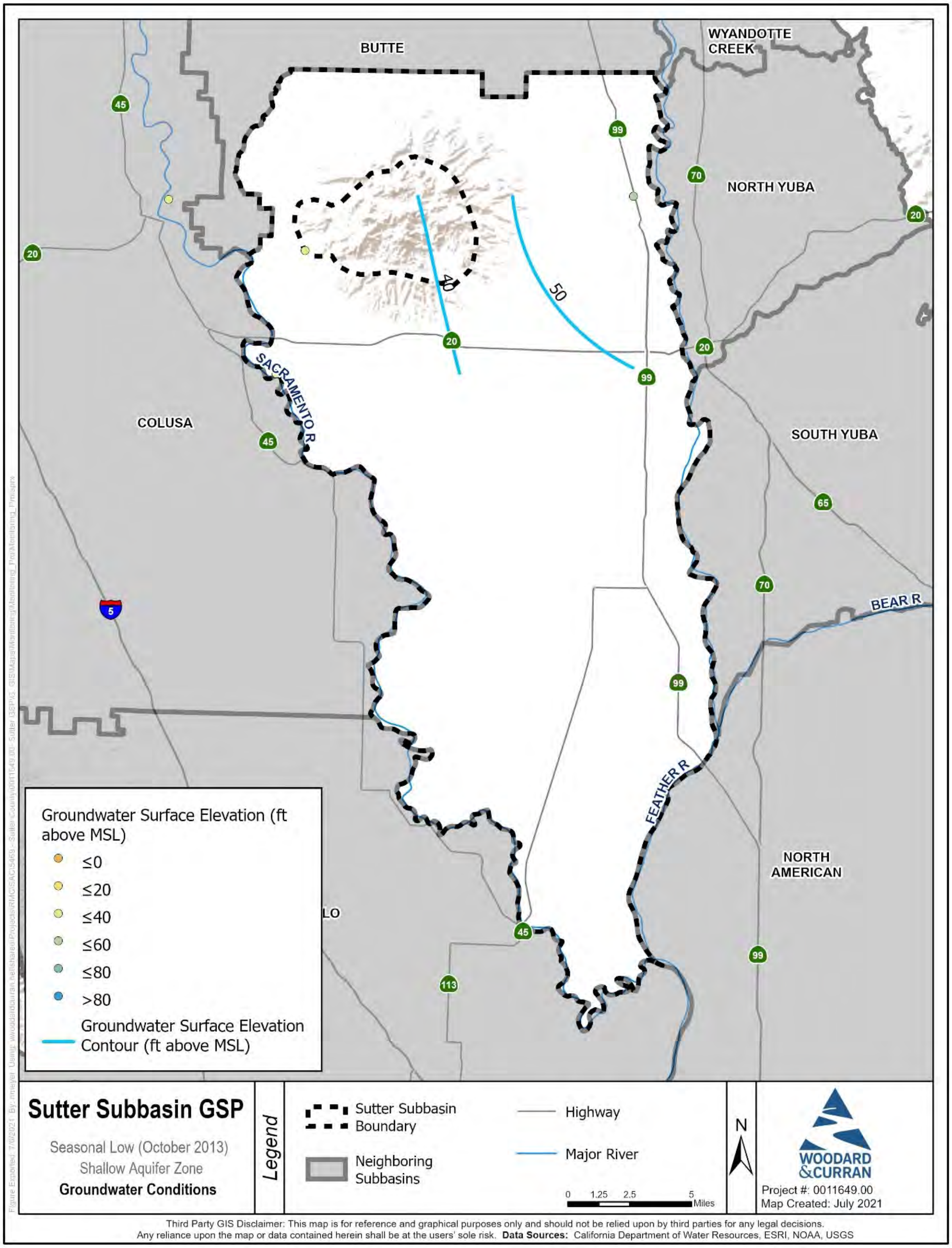


Figure 5-73. October 2013 Groundwater Elevations, Shallow Aquifer Zone

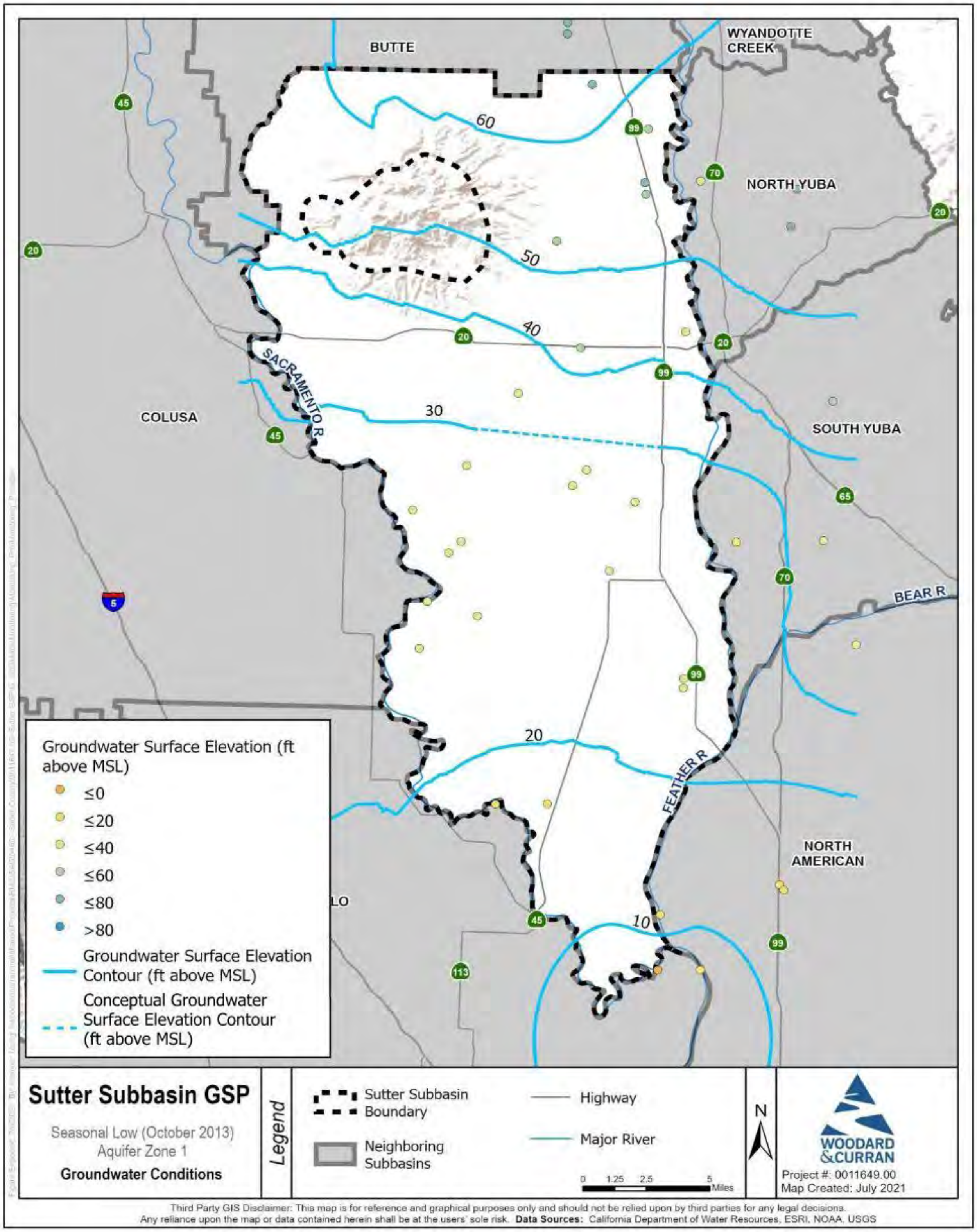
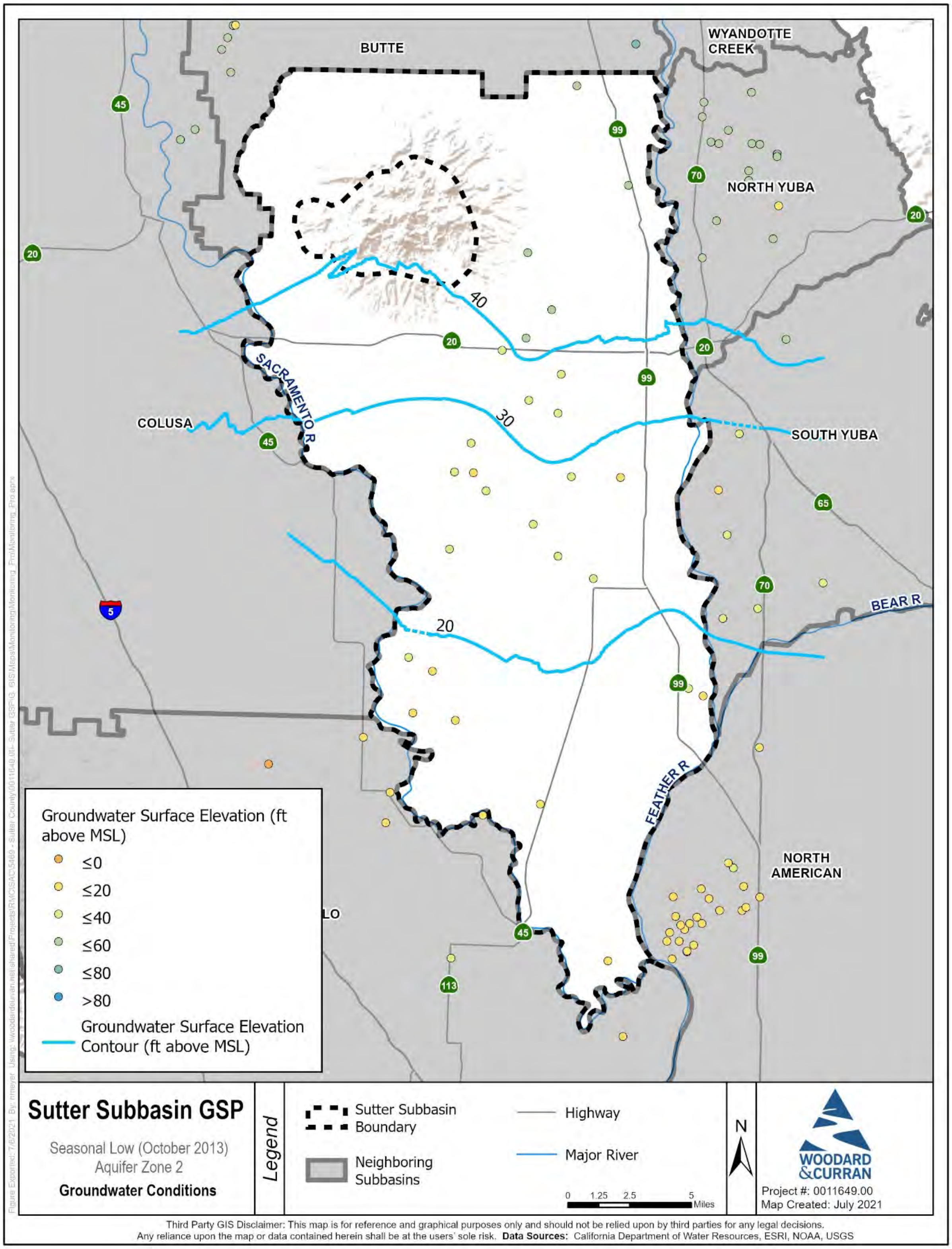


Figure 5-74. October 2013 Groundwater Elevations, AZ-1



Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources:** California Department of Water Resources, ESRI, NOAA, USGS

Figure 5-75. October 2013 Groundwater Elevations, AZ-2

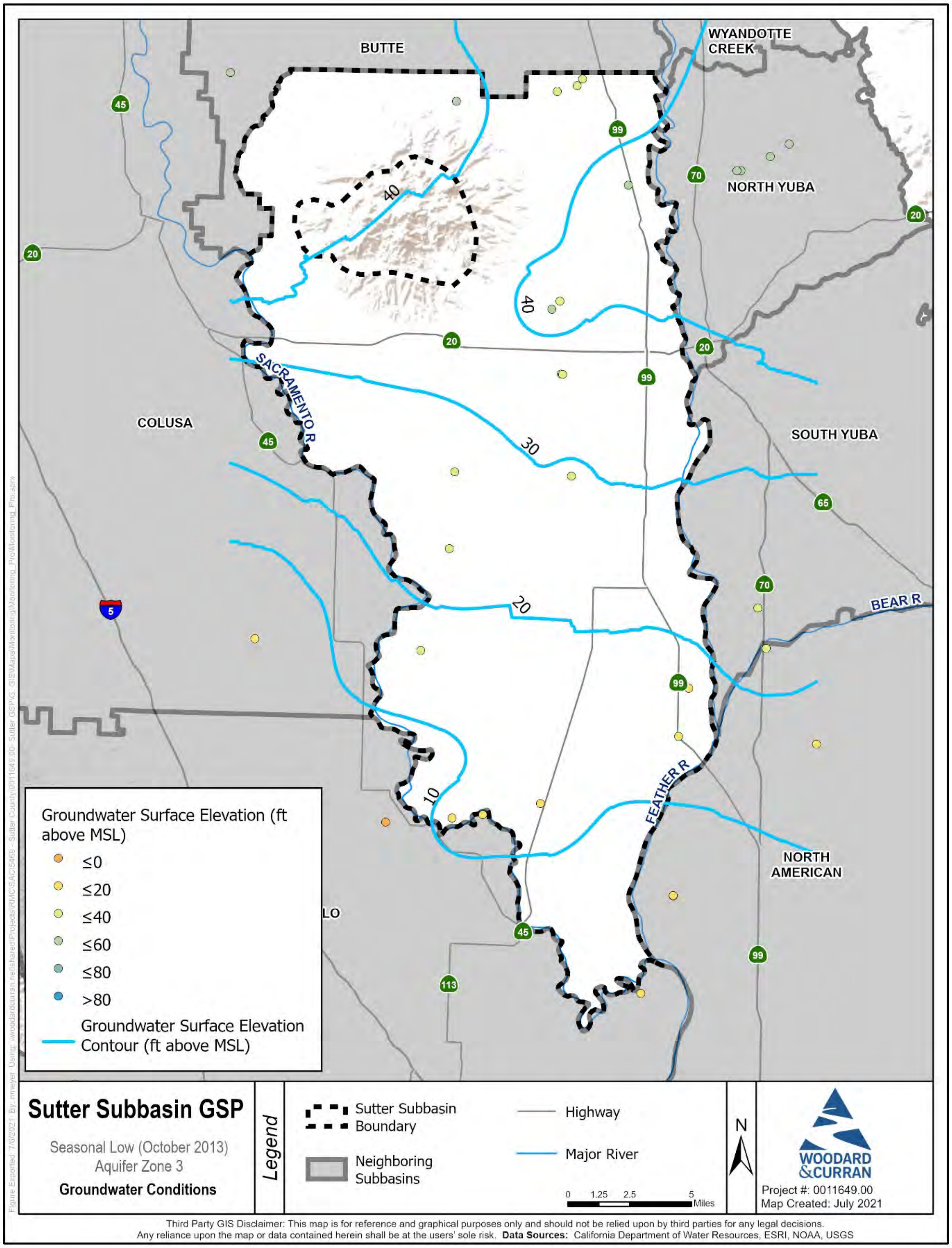


Figure 5-76. October 2013 Groundwater Elevations, AZ-3

Figure 5-77 through **Figure 5-79** present available groundwater elevation contour maps for Fall 2015 in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones, respectively, representing seasonal low groundwater elevations during a Critical year (as classified by the Sacramento Water Year Index). In the shallow aquifer zone (defined in this figure, **Figure 5-77**, as being between the ground surface and a depth of about 50 feet bgs nearest the Sutter Buttes, and to a depth of about 150 to 190 feet bgs at wells furthest from the Sutter Buttes), groundwater elevations range from 18 to 66 feet above MSL with pumping depressions mostly observed along the central portion of the eastern Subbasin boundary. Within the intermediate aquifer (defined in this figure, **Figure 5-78**, as being between 150 to 400 feet bgs), groundwater elevations range from 63 feet below MSL to 57 feet above MSL with a cone of depression observed along the central portion of the eastern Subbasin boundary causing a reversal of groundwater flow from west to east. In the deep aquifer (defined in this figure, **Figure 5-79**, as being at depths below 400 feet bgs), groundwater elevations range from 3 feet below MSL to 54 feet above MSL with a cone of depression observed along the central portion of the western boundary of the Subbasin.

Compared to Fall 2009 groundwater levels, as presented in **Figure 5-54** through **Figure 5-56**:

- **Shallow Aquifer Zone** (defined in these figures as depths from ground surface to around 50 feet bgs near the Sutter Buttes and up to 190 feet bgs at wells distant from the Sutter Buttes) – Groundwater elevations were approximately 1 to 3 feet deeper during Fall 2015.
- **Intermediate Aquifer Zone** (defined in these figures as depths between 150 and 400 feet bgs) – Groundwater elevations were about 1 to 6 feet deeper during Fall 2015, with the exception of a pumping depression near the confluence of the Bear and Feather rivers observed in Fall 2015.
- **Deep Aquifer Zone** (defined in these figures as depths below 400 feet bgs) – Groundwater elevations were about 1 to 3 feet deeper during Fall 2015.

As previously stated, representative hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients (**Figure 5-59** through **Figure 5-68**) show similar trends post-WY 2013 as shown in the available historical record. Shallow groundwater levels, largely within AZ-1, are relatively stable over time. Higher amounts of groundwater production are observed during short periods of time in the deeper portion of AZ-1, as well as AZ-2 and AZ-3, with greater seasonal fluctuations during the 2012 to 2016 drought and seasonal rebound to pre-pumping levels still observed. Post-WY 2013 overall trends are similar to the overall historical trends.

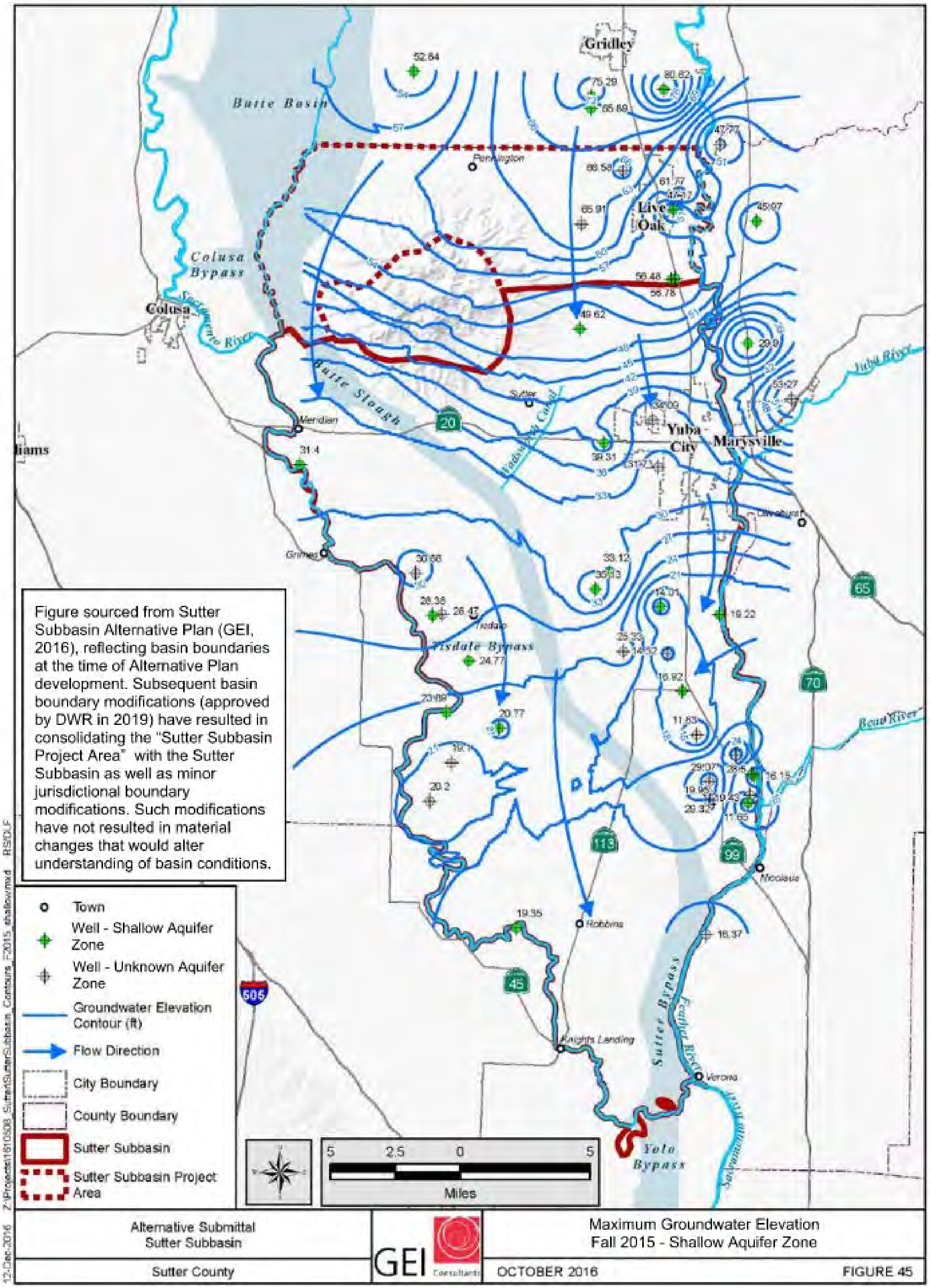


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-77. Groundwater Elevation in Shallow Aquifer Zone, Fall 2015

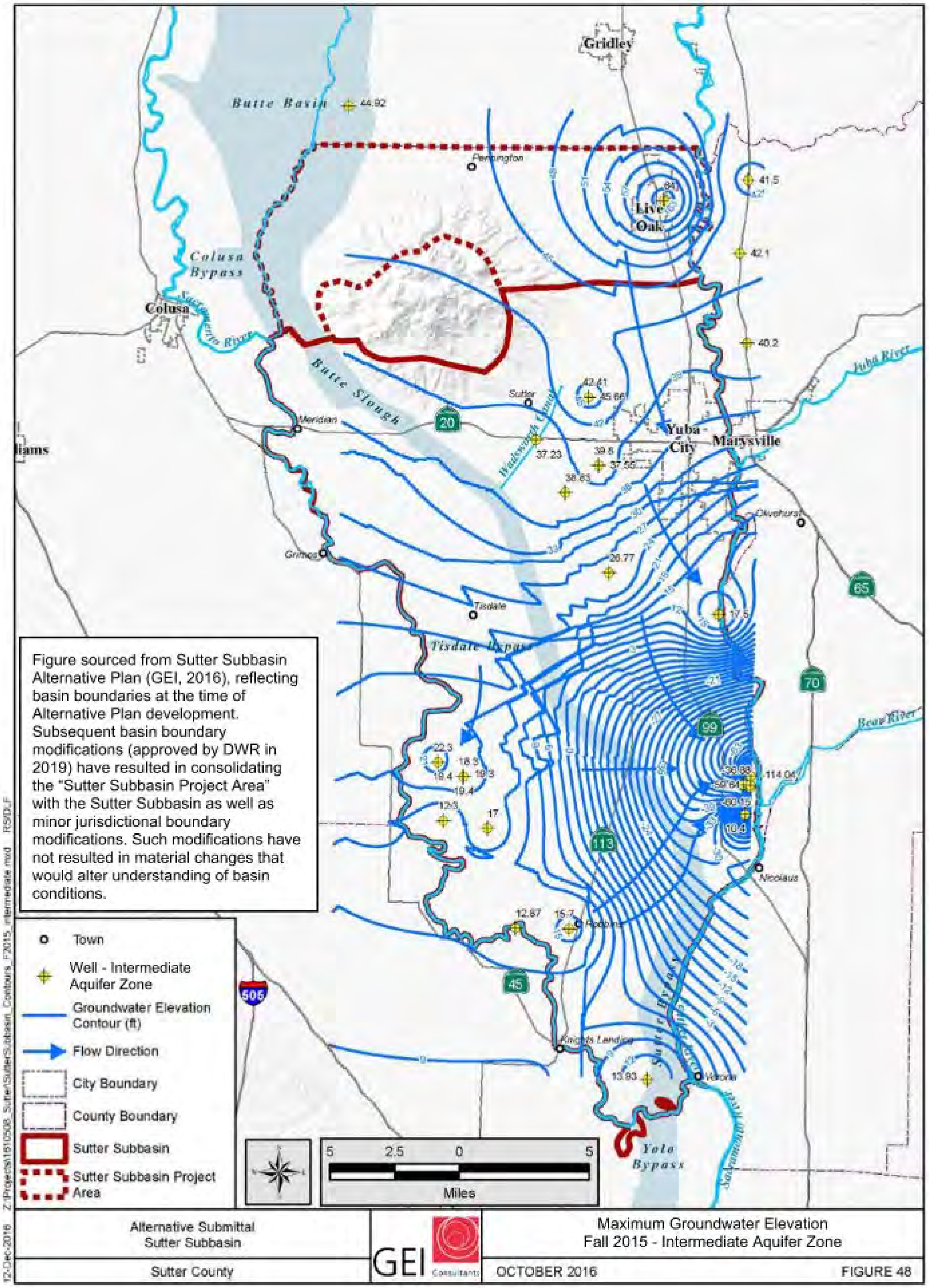


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-78. Groundwater Elevation in Intermediate Aquifer Zone, Fall 2015

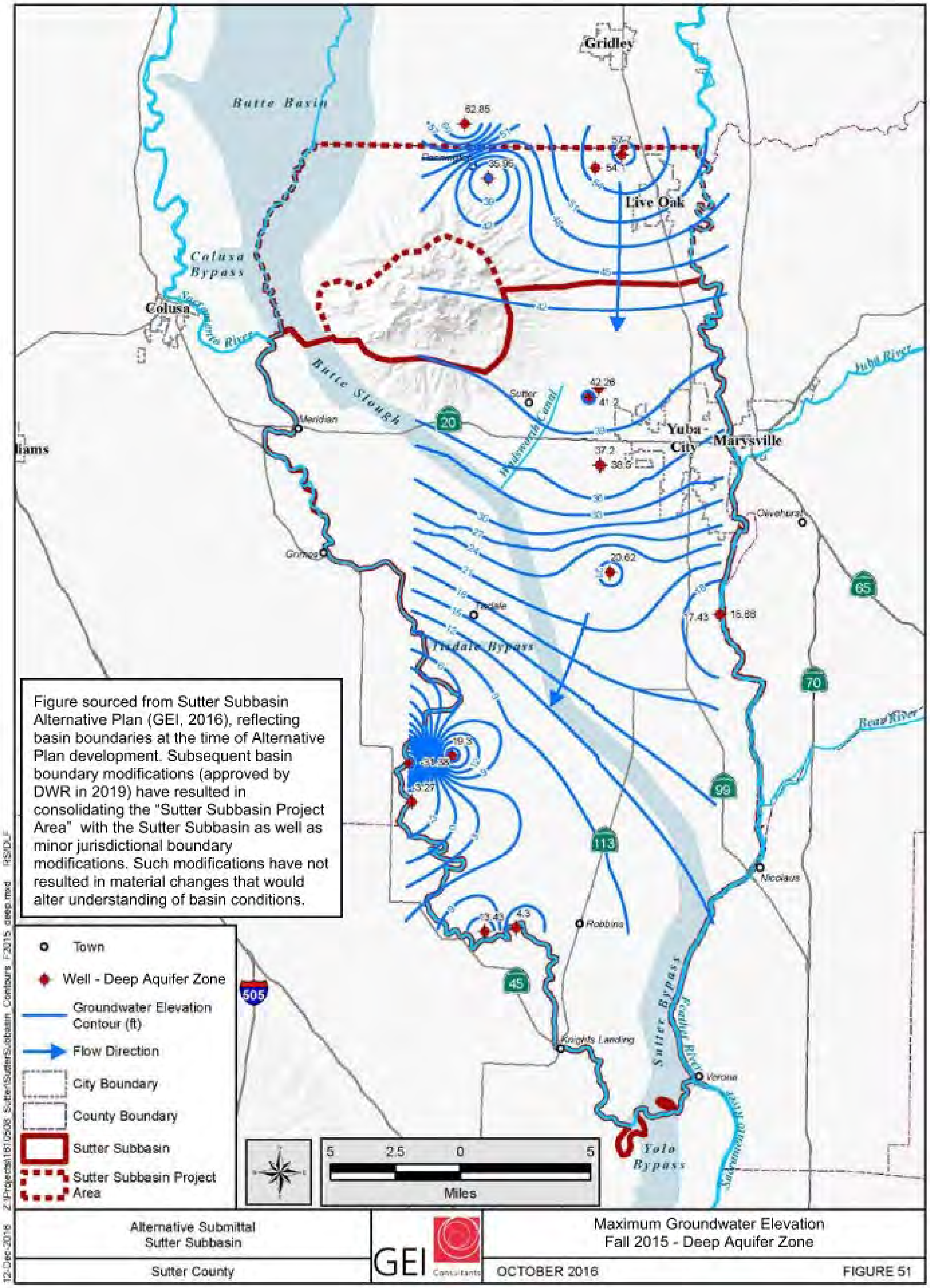


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-79. Groundwater Elevation in Deep Aquifer Zone, Fall 2015

5.2.2.3 Groundwater Trends

Hydrographs within the Sutter Subbasin show two distinct patterns, the first where groundwater levels in the shallowest portion of the principal aquifer (upper portion of AZ-1) are constantly higher than groundwater levels in the intermediate and deeper portions of the aquifer (deeper portion of AZ-1 as well as AZ-2 and AZ-3) indicating a downward gradient, and the second where groundwater levels in the deeper portion of the aquifer are higher than groundwater levels in the intermediate and shallow portion of the principal aquifer indicating an upward gradient. **Figure 5-80** shows where the upward and downward gradients occur. There is no distinct pattern as to where and when each of these patterns are observed within the Sutter Subbasin. The head differences are typically on the order of a few feet, but may be up to 10 to 20 feet during the summer months (GEI, 2016).

Upward gradients in the deeper portion of the aquifer appear to exist in the southern half of the Sutter Subbasin. In these areas, the base of fresh water is relatively shallow. Pumping in the deeper portion of the aquifer could reduce heads and allow migration of brackish water into the freshwater aquifer. The hydrographs show that pumping is occurring in AZ-3 (deeper than 400 feet bgs) and/or in wells that are screened across all aquifer zones as seasonal reversals of gradients are observed and groundwater levels decline in all of the aquifer zones.

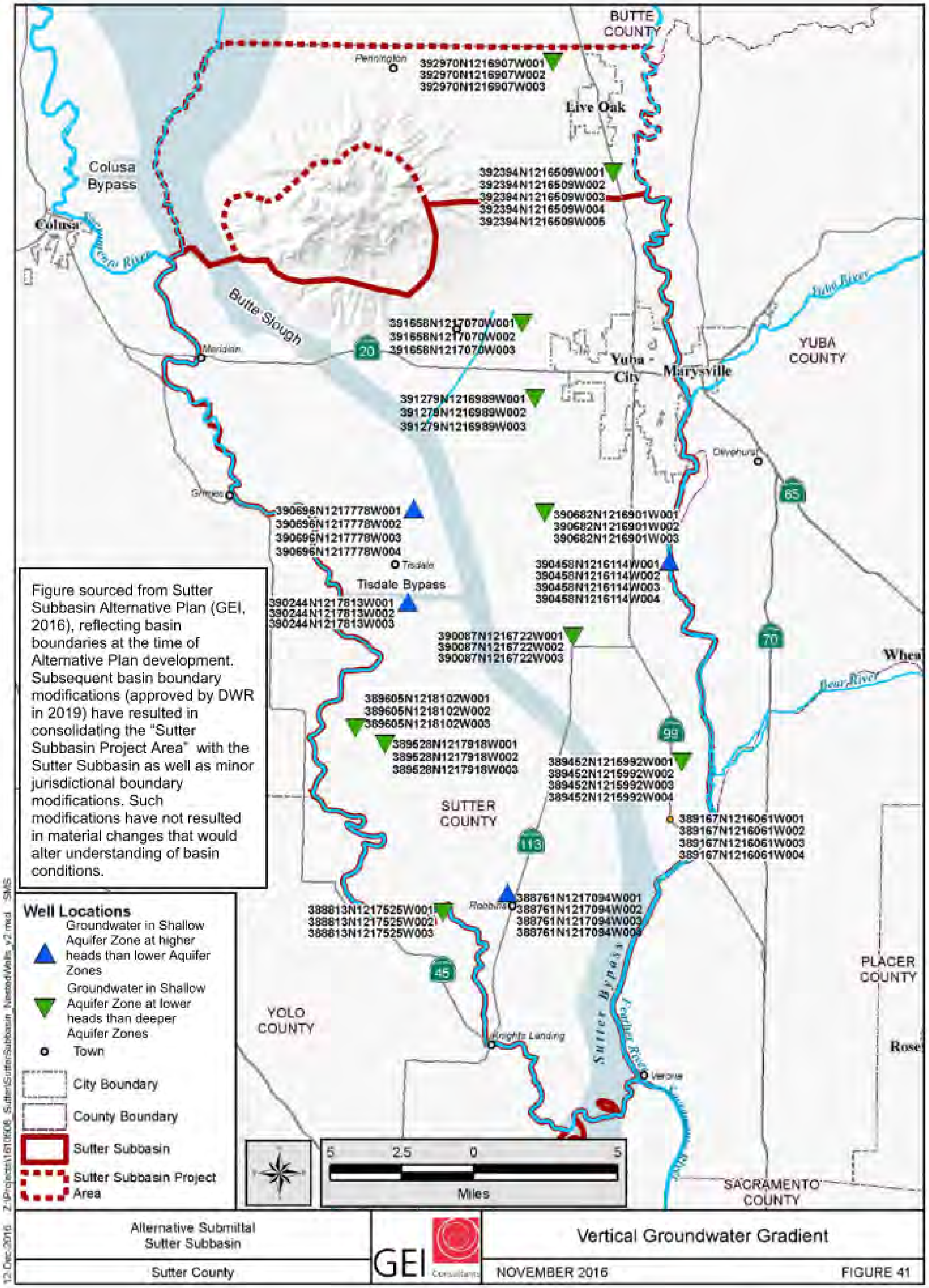


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-80. Vertical Groundwater Gradients

5.2.3 Groundwater Storage

As with groundwater levels, groundwater storage volumes in the Sutter Subbasin have been generally stable over at least the past 30 years (the length of available record). The volume of groundwater in storage increases as groundwater levels rise and decreases as groundwater levels fall; thus, stable groundwater level conditions also result in stable groundwater storage conditions. Change in storage volumes have been estimated for the Sutter Subbasin using C2VSimFG-Sutter integrated flow model. **Figure 5-81** shows annual (pink) and cumulative change in storage (black line) plotted together for WY 1986 to WY 2015 for all aquifer layers combined (i.e., for the entire principal aquifer). DWR's Sacramento Valley Water Year Type Index is indicated in parenthesis for each year where:

- "C" indicates a Critical Year
- "D" indicates a Dry Year
- "BN" indicates a Below Normal Year
- "AN" indicates an Above Normal Year
- "W" indicates a Wet Year

Annual total groundwater pumping is also plotted in grey (**Figure 5-81**). In drier years, more groundwater is pumped from the Subbasin, which results in reduction of groundwater available in storage (i.e., a negative change in storage bar and a downward sloping cumulative change in storage line). In wetter years, that storage reduction has typically replenished as pumping is reduced (i.e., a positive change in storage bar and an upward sloping cumulative change in storage line). The total available groundwater in storage in the Subbasin was estimated by C2VSimFG-Sutter to be approximately 49 million acre-feet (MAF). Details on the use of C2VSimFG-Sutter for water budgeting purposes is further discussed in **Section 5.3**.

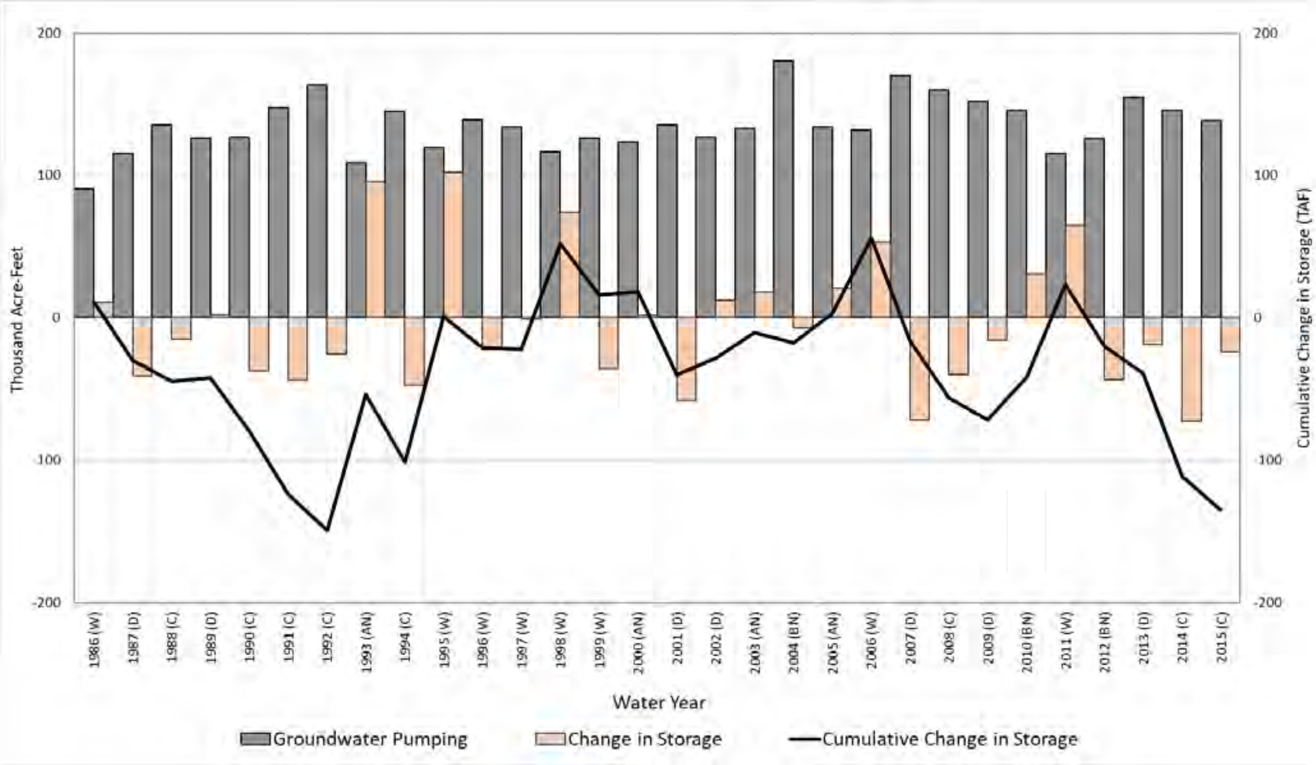


Figure 5-81. Annual and Cumulative Groundwater Storage

5.2.4 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indictor for the Sutter Subbasin as the Subbasin is located inland from the Pacific Ocean and is set back from the Sacramento-San Joaquin Delta. Therefore, groundwater conditions related to seawater intrusion are not applicable to the Sutter Subbasin.

5.2.5 Groundwater Quality

As discussed in **Section 5.1.9**, groundwater quality in the Sutter Subbasin was primarily evaluated via data from the Groundwater Ambient Monitoring and Assessment Program (GAMA) well network (SWRCB, 2021). The *Sutter County Groundwater Management Plan* (Wood Rodgers, 2012) identifies several constituents within the Sutter Subbasin that are at levels that exceed the MCL for drinking water. These constituents include arsenic, boron, total dissolved solids (TDS), and nitrate as N. As discussed in **Section 5.1.9**, all of the constituents, except nitrate, were detected in historic studies but were later found to be naturally occurring. Areas of elevated nitrate and chloride (a measure of salinity) were delineated as part of the *Sutter Subbasin Alternative Plan* (GEI, 2016) and are presented in **Figure 5-82**. Nitrate detections are few and scattered throughout the Subbasin, whereas chloride detections are predominantly in the southern portion of the Sutter Subbasin.

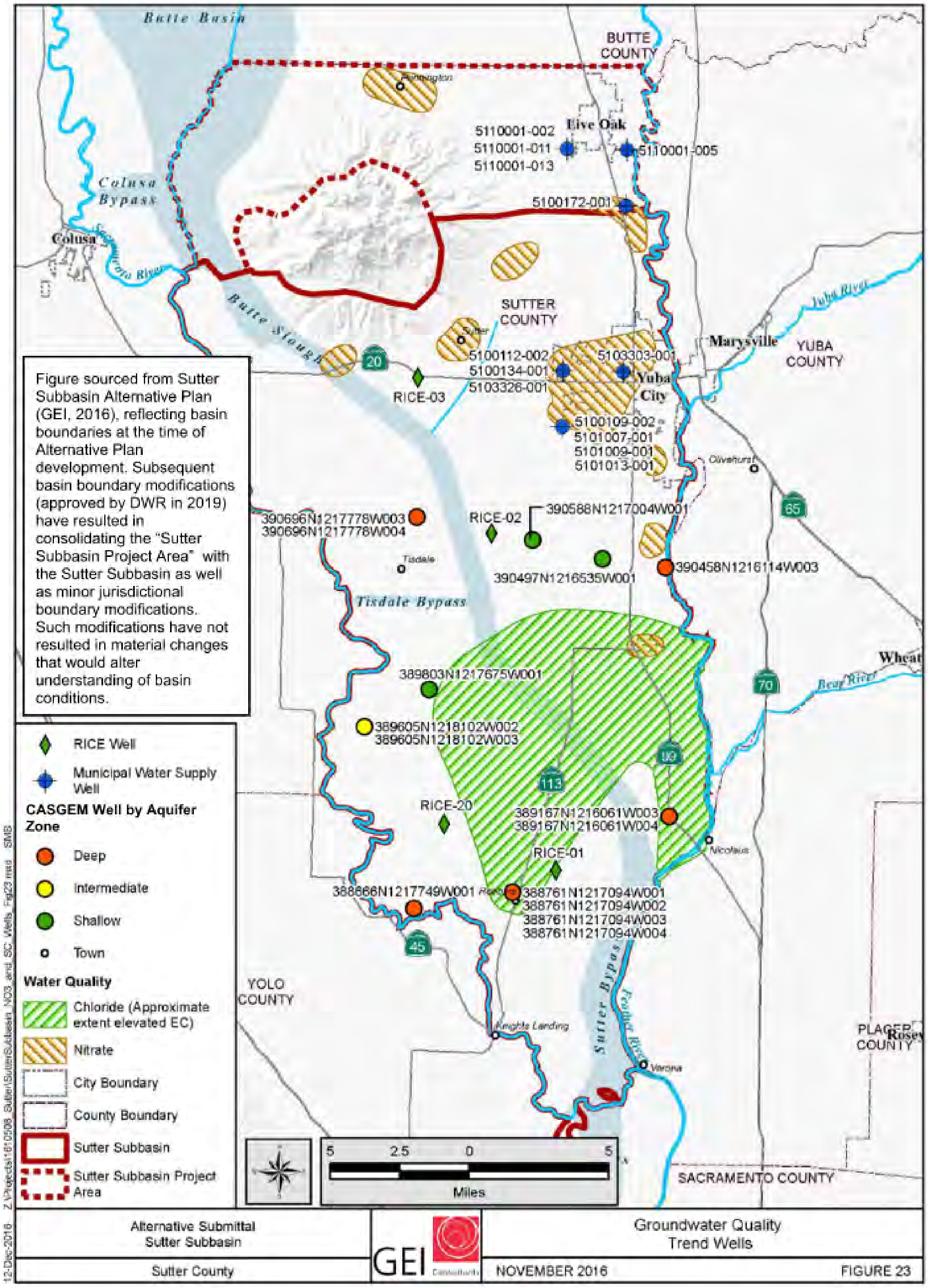


Figure sourced from Sutter Subbasin Alternative Plan (GEI, 2016), reflecting basin boundaries at the time of Alternative Plan development. Subsequent basin boundary modifications (approved by DWR in 2019) have resulted in consolidating the "Sutter Subbasin Project Area" with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such modifications have not resulted in material changes that would alter understanding of basin conditions.

Figure 5-82. Areas of Elevated Nitrate and Chloride Detections

An analysis of the state of these constituents over time is presented in **Table 5-7,** broken into three time periods using data available from the GAMA Program (SWRCB, 2021): 1952 to 2008, 2009 to 2012, and 2013 to 2020. Time periods were selected based on the beginning of the period of record in the GAMA data set (SWRCB, 2021), the general water quality analysis presented in **Section 5.1**, and from the beginning of the current condition water budget (see **Section 5.3** for more information about water budgets) through the latest available water quality data.

Median concentrations of arsenic have decreased since 1952 and most recently are below the Primary MCL. The maximum concentration detected in most recent years (0.190 milligrams per liter or mg/L) does exceed the MCL of 0.01 mg/L.

Median concentrations of boron peaked between 2009 and 2012 but remained below the agricultural water quality objective of 0.7 mg/L. Maximum concentrations of boron have decreased over time with the most recently observed concentrations at 1.0 mg/L.

Maximum TDS concentrations have substantially decreased since 1952, peaking at 8,200 mg/L (in 2006), with the most recently observed maximum concentration (occurring at 1,220 mg/L) below the upper SMCL of 1,500 mg/L.

Median nitrate concentrations have increased since 1952 and have been detected above the Primary MCL as of 2012. The most recently observed maximum concentration of 137 mg/L exceeds the Primary MCL of 10 mg/L by over 10 times.

Groundwater quality varies across the Subbasin based on location and depth by constituent. GAMA data available from 2000 through 2020 (SWRCB, 2021) by well location and aquifer zone for arsenic, boron, TDS, and nitrate as N are presented in **Figure 5-83** through **Figure 5-86**. It should be noted that GAMA data are reflective of ambient groundwater quality prior to treatment. Data are evaluated against the water quality objectives identified in **Table 5-7** for the purpose of using a common metric for the highest beneficial use, which is drinking water. Further treatment or blending may be required prior to groundwater use.

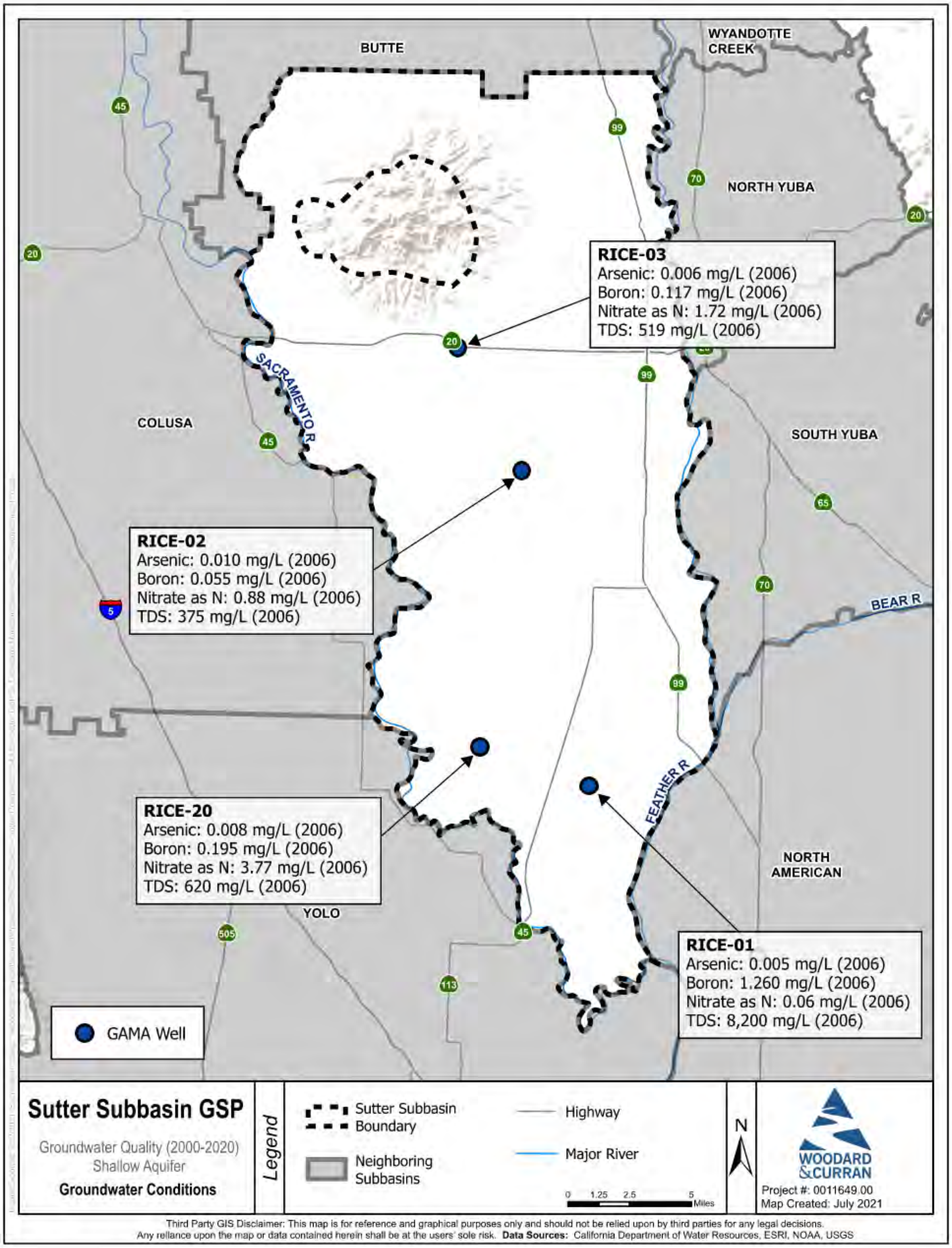
In the Shallow Aquifer Zone (defined as extending from the ground surface to 50 feet bgs), groundwater quality data are limited to a single monitoring event in 2006. All constituents evaluated were at or below their respective water quality objective with the exception of one exceedance of the agricultural water quality objective for boron at 1.26 mg/L in the southern portion of the Subbasin and two exceedances of TDS above the recommended SMCL but below the upper SMCL (**Figure 5-83**). One exceedance of TDS well above the short-term SMCL was observed in the southern portion of the Subbasin at 8,200 mg/L. This measurement may be an outlier, but insufficient data at the site are available to make this determination.

Table 5-7. Summary of Sutter Subbasin Water Quality Constituents

Constituent	Water Quality Limit (mg/L)	Median Measurement (mg/L) (minimum – maximum measurements)		
		1952-2008	2009-2012	2013-2020
Arsenic	0.01 (1)	0.010 *(0.001 – 0.350)* *77 measurements*	0.019 *(0.002 – 0.201)* *38 measurements*	0.007 *(0.001 – 0.190)* *28 measurements*
Boron	0.7 (2)	0.1 *(ND – 5.4)* *225 measurements*	0.5 *(ND – 2.4)* *30 measurements*	0.1 *(ND – 1.0)* *11 measurements*
TDS	500-1,500 (3)	351 *(95 – 8,200)* *344 measurements*	505 *(115 – 2,290)* *46 measurements*	600 *(180 – 1,220)* *47 measurements*
Nitrate as N	10 (1)	2 *(ND – 280)* *199 measurements*	11 *(ND – 92)* *52 measurements*	15 *(ND – 137)* *91 measurements*

(1) Primary drinking water MCL (SWRCB, October 2017; SWRCB, November 2017a)
(2) Agricultural objective (Ayers and Westcot, 1985 [Table 21])
(3) Recommended SMCL is 500 mg/L, Upper SMCL is 1000 mg/L, and Short-Term SMCL is 1500 mg/L (SWRCB, November 2017b)

Key:
mg/L = milligrams per liter
ND = Non-detect (concentration in sample is below detection limit)
Source: GAMA (SWRCB, 2021)



RICE-03
Arsenic: 0.006 mg/L (2006)
Boron: 0.117 mg/L (2006)
Nitrate as N: 1.72 mg/L (2006)
TDS: 519 mg/L (2006)

RICE-02
Arsenic: 0.010 mg/L (2006)
Boron: 0.055 mg/L (2006)
Nitrate as N: 0.88 mg/L (2006)
TDS: 375 mg/L (2006)

RICE-20
Arsenic: 0.008 mg/L (2006)
Boron: 0.195 mg/L (2006)
Nitrate as N: 3.77 mg/L (2006)
TDS: 620 mg/L (2006)

RICE-01
Arsenic: 0.005 mg/L (2006)
Boron: 1.260 mg/L (2006)
Nitrate as N: 0.06 mg/L (2006)
TDS: 8,200 mg/L (2006)

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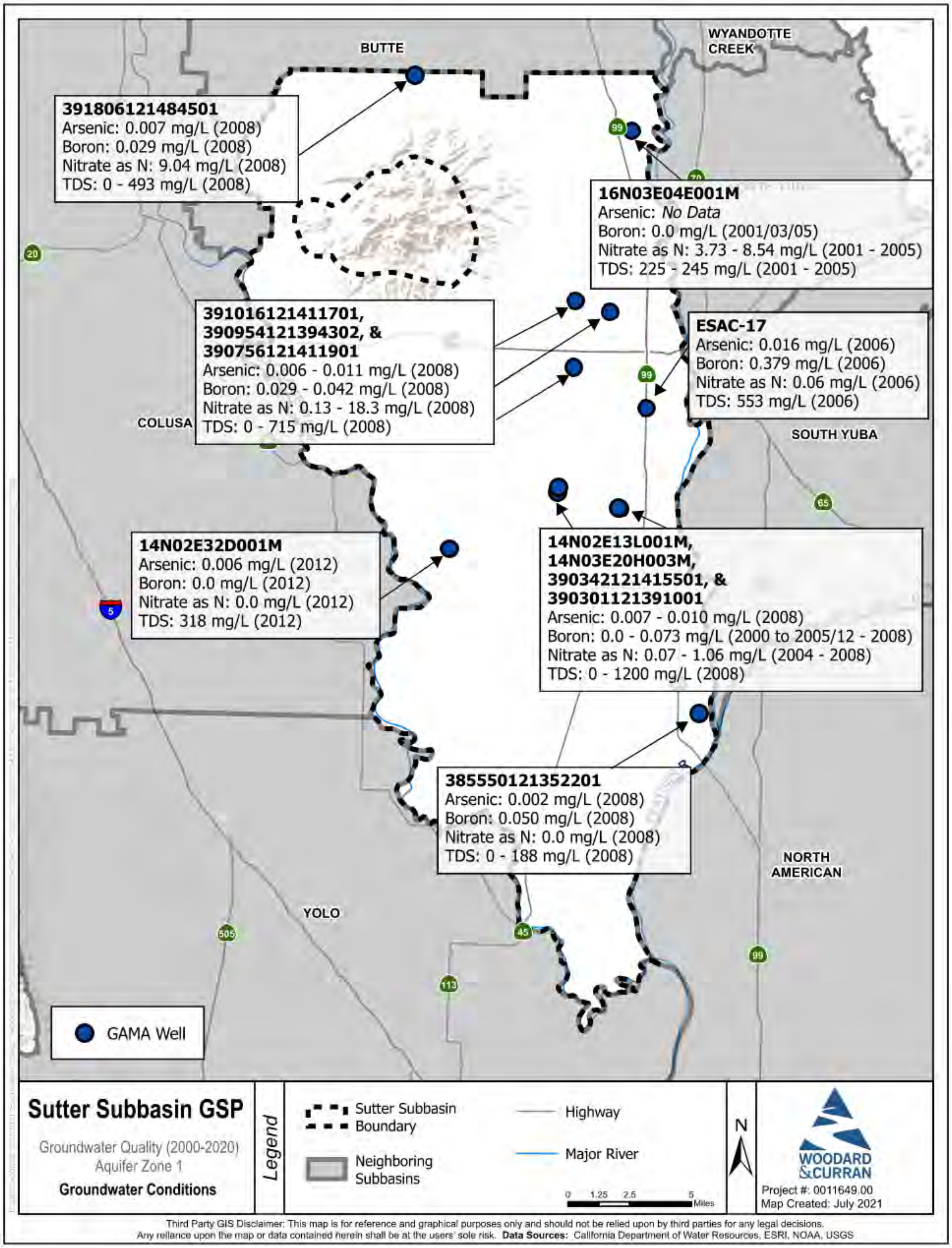
Figure 5-83. Current Groundwater Quality (2000-2020), Shallow Aquifer Zone



391806121484501
Arsenic: 0.007 mg/L (2008)
Boron: 0.029 mg/L (2008)
Nitrate as N: 9.04 mg/L (2008)
TDS: 0 - 493 mg/L (2008)

16N03E04E001M
Arsenic: *No Data*
Boron: 0.0 mg/L (2001/03/05)
Nitrate as N: 3.73 - 8.54 mg/L (2001 - 2005)
TDS: 225 - 245 mg/L (2001 - 2005)

391016121411701, 390954121394302, & 390756121411901
Arsenic: 0.006 - 0.011 mg/L (2008)
Boron: 0.029 - 0.042 mg/L (2008)
Nitrate as N: 0.13 - 18.3 mg/L (2008)
TDS: 0 - 715 mg/L (2008)

ESAC-17
Arsenic: 0.016 mg/L (2006)
Boron: 0.379 mg/L (2006)
Nitrate as N: 0.06 mg/L (2006)
TDS: 553 mg/L (2006)

14N02E32D001M
Arsenic: 0.006 mg/L (2012)
Boron: 0.0 mg/L (2012)
Nitrate as N: 0.0 mg/L (2012)
TDS: 318 mg/L (2012)

14N02E13L001M, 14N03E20H003M, 390342121415501, & 390301121391001
Arsenic: 0.007 - 0.010 mg/L (2008)
Boron: 0.0 - 0.073 mg/L (2000 to 2005/12 - 2008)
Nitrate as N: 0.07 - 1.06 mg/L (2004 - 2008)
TDS: 0 - 1200 mg/L (2008)

385550121352201
Arsenic: 0.002 mg/L (2008)
Boron: 0.050 mg/L (2008)
Nitrate as N: 0.0 mg/L (2008)
TDS: 0 - 188 mg/L (2008)

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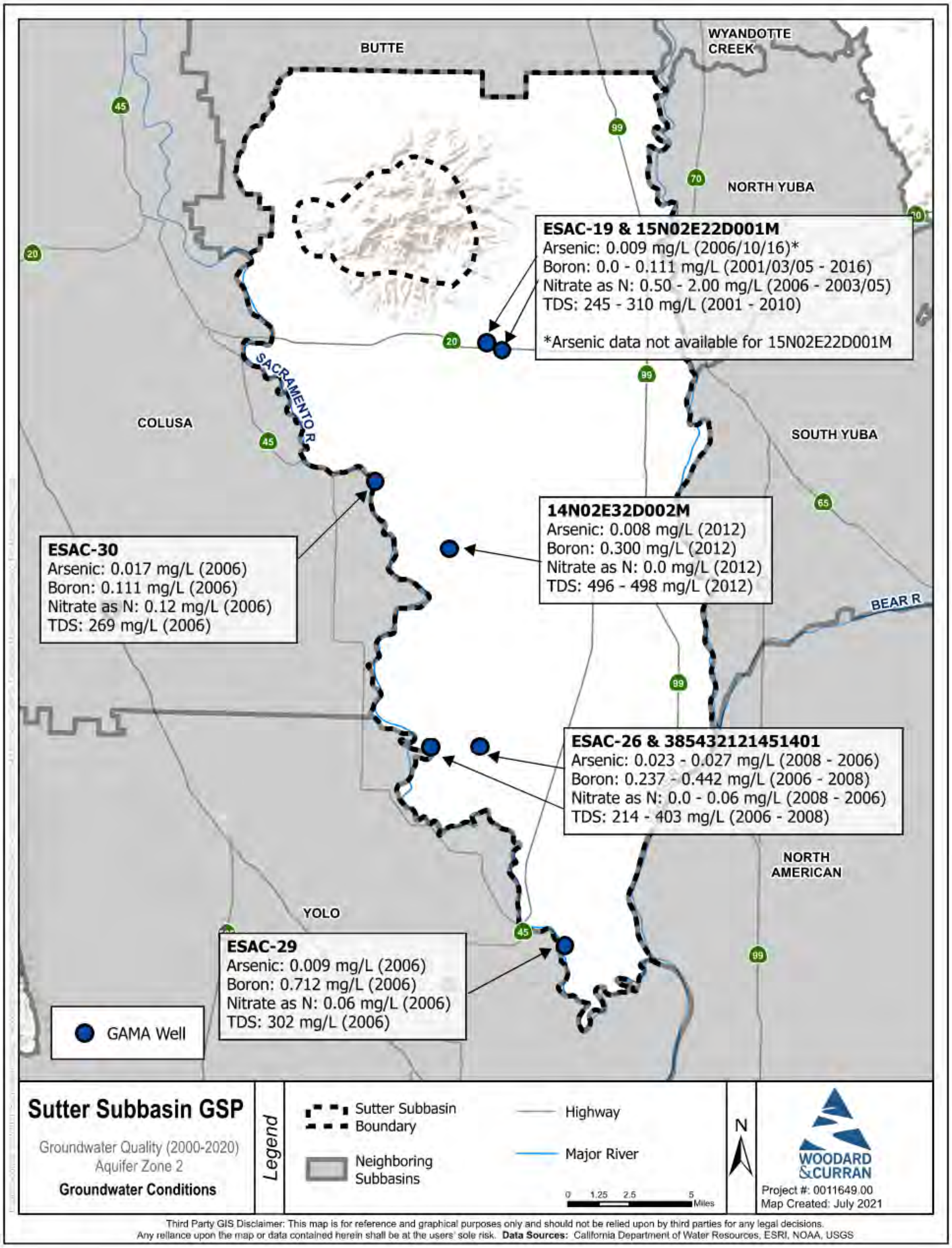
Figure 5-84. Current Groundwater Quality (2000-2020), AZ-1



ESAC-19 & 15N02E22D001M
Arsenic: 0.009 mg/L (2006/10/16)*
Boron: 0.0 - 0.111 mg/L (2001/03/05 - 2016)
Nitrate as N: 0.50 - 2.00 mg/L (2006 - 2003/05)
TDS: 245 - 310 mg/L (2001 - 2010)

*Arsenic data not available for 15N02E22D001M

ESAC-30
Arsenic: 0.017 mg/L (2006)
Boron: 0.111 mg/L (2006)
Nitrate as N: 0.12 mg/L (2006)
TDS: 269 mg/L (2006)

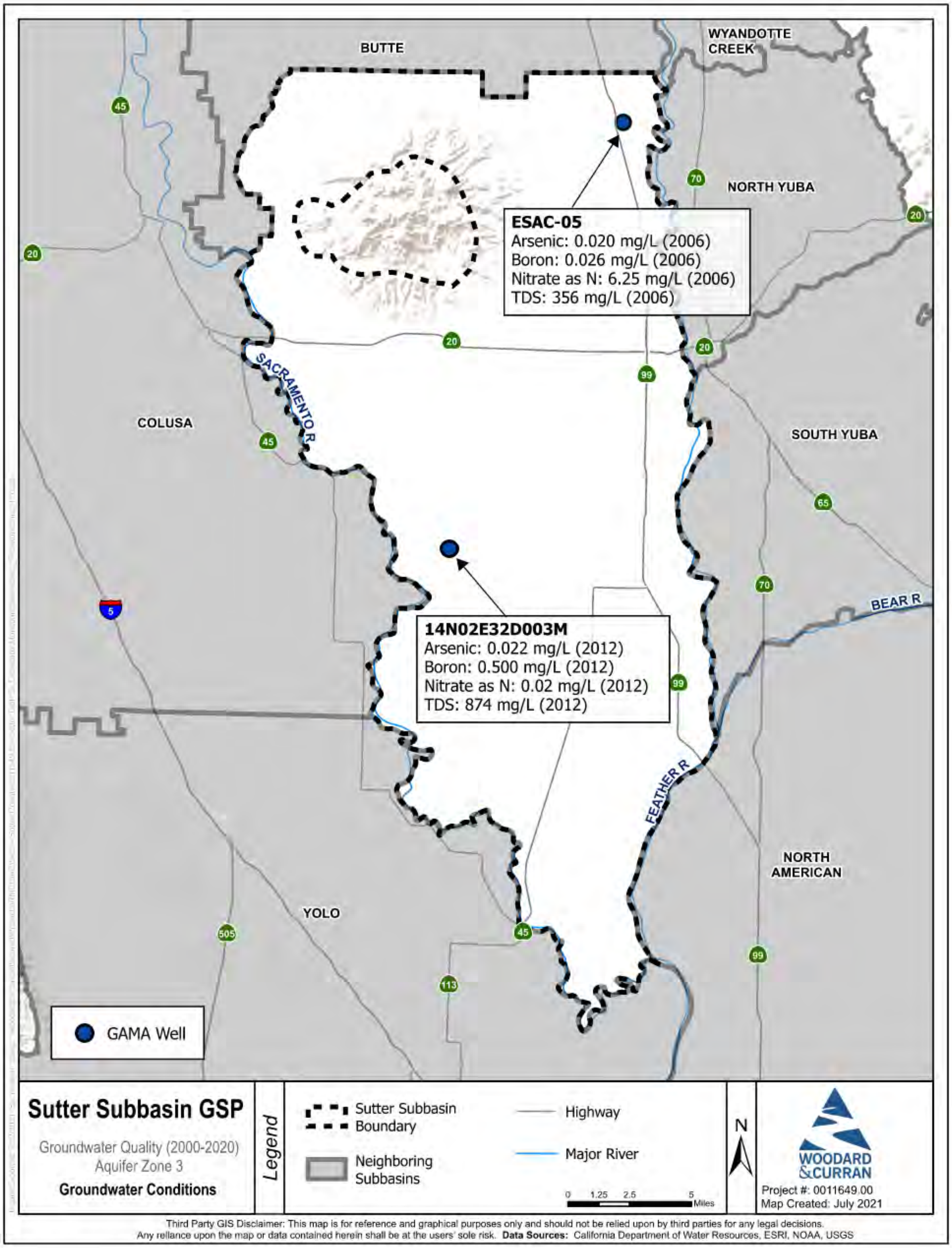
14N02E32D002M
Arsenic: 0.008 mg/L (2012)
Boron: 0.300 mg/L (2012)
Nitrate as N: 0.0 mg/L (2012)
TDS: 496 - 498 mg/L (2012)

ESAC-26 & 385432121451401
Arsenic: 0.023 - 0.027 mg/L (2008 - 2006)
Boron: 0.237 - 0.442 mg/L (2006 - 2008)
Nitrate as N: 0.0 - 0.06 mg/L (2008 - 2006)
TDS: 214 - 403 mg/L (2006 - 2008)

ESAC-29
Arsenic: 0.009 mg/L (2006)
Boron: 0.712 mg/L (2006)
Nitrate as N: 0.06 mg/L (2006)
TDS: 302 mg/L (2006)

Data Sources: California Department of Water Resources, ESRI, NOAA, USGS

Figure 5-85. Current Groundwater Quality (2000-2020), AZ-2



ESAC-05
Arsenic: 0.020 mg/L (2006)
Boron: 0.026 mg/L (2006)
Nitrate as N: 6.25 mg/L (2006)
TDS: 356 mg/L (2006)

14N02E32D003M
Arsenic: 0.022 mg/L (2012)
Boron: 0.500 mg/L (2012)
Nitrate as N: 0.02 mg/L (2012)
TDS: 874 mg/L (2012)

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Figure 5-86. Current Groundwater Quality (2000-2020), AZ-3

In AZ-1 (defined as extending from 50 to 150 feet bgs), arsenic concentrations were at or below the Primary MCL except along the eastern boundary of the Sutter Subbasin near the Yuba Subbasins where exceedances of 0.011 mg/L (in 2008) and 0.016 mg/L (in 2006) were recorded (**Figure 5-84**). Similar patterns were observed for boron, where concentrations throughout much of the Subbasin were below the agricultural water quality objective except for exceedances of 0.379 mg/L (in 2006) and 0.073 mg/L (in 2008) along the eastern boundary near the South Yuba Subbasin. Nitrate was below the Primary MCL throughout the Subbasin except along the eastern portion of the Subbasin near the North Yuba Subbasin where a concentration of 18.3 mg/L was recorded in 2008. Exceedances above the recommended SMCL for TDS occurred along the eastern boundary of the Subbasin near the North Yuba Subbasin at 715 mg/L (in 2008) and near the South Yuba Subbasin at 1,200 mg/L (in 2008). An additional TDS exceedance above the short-term SMCL was observed near the South Yuba Subbasin at 5,553 mg/L. For the remainder of the Subbasin in AZ-1, recorded concentrations of TDS were all below the recommended SMCL.

In AZ-2 (defined as extending from 150 to 400 feet bgs), only exceedances of arsenic and boron were recorded (**Figure 5-85**). All nitrate concentrations were below the Primary MCL and all TDS concentrations were below the recommended SMCL. Arsenic concentrations above the Primary MCL were recorded along the Sacramento River bordering the Colusa Subbasin at 0.017 mg/L (in 2006) and near the Yolo Subbasin boundary at a maximum of 0.027 mg/L (in 2008). Boron concentrations above the agricultural water quality objective were observed in the southern portion of the Subbasin along the Yolo Subbasin boundary at 0.712 mg/L.

In AZ-3 (defined as depths deeper than 400 feet bgs), arsenic concentrations exceedances occurred at both sampled sites in the northeast corner and central portion of the Subbasin at 0.02 mg/L (in 2006) and 0.022 mg/L (in 2012), respectively (**Figure 5-86**). Boron concentrations were below the agricultural water quality objective and nitrate concentrations were below the Primary MCL at both sites. In the central portion of the Subbasin, observed TDS concentrations were above the recommended SMCL but below the upper SMCL at 874 mg/L (in 2012).

5.2.5.1 Contaminated Sites

A review of active sites listed in California’s EnviroStor and GeoTracker/GAMA databases that could potentially impact groundwater in the Sutter Subbasin is included in **Section 5.1.9**. **Table 5-6** lists the open/active sites in the Subbasin and the type of program the site is managed under, and **Figure 5-45** shows their locations. Typically, the Clean-up Program Sites and leaking underground storage tank (LUST) Clean-up Sites are associated with leaky underground fuel tanks (LUFTs) and underground storage tanks (USTs). Their typical constituents of concern are fuel hydrocarbons and/or chlorinated solvents and the contaminant extent is small.

No large groundwater contamination plumes are known to be present in the Subbasin (GEI, 2016).

5.2.6 Land Subsidence

Land subsidence and its associated impacts have not been recorded within the Sutter Subbasin (Wood Rodgers, 2012). While elastic land subsidence is observed as a result of seasonal fluctuations in groundwater levels and associated aquifer pressure, inelastic land subsidence has not been recorded within the Sutter Subbasin. Sutter County actively coordinates with DWR to monitor for potential land subsidence within the county boundaries as part of the Sacramento Valley Subsidence Network (DWR North Region Office, 2018). Land subsidence has also been measured within the Sutter Subbasin by the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) using Interferometric Synthetic Aperture Imagery (InSAR), available through DWR's SGMA Data Viewer (DWR, 2021b).

5.2.6.1 Historic and Current Conditions

Land subsidence monitoring within the Sutter Subbasin has a relatively short period of record. DWR, in cooperation with federal, state, and local agencies, installed and surveyed monuments to measure and monitor ground surface elevations over time in the Sacramento Valley. The Sacramento Height-Modernization Project consists of 339 monuments, spaced approximately 7 kilometers apart in 10 counties (Wood Rodgers, 2012). The network is intended to be monitored on a 5-year schedule and was initially surveyed in 2008. DWR was unable to survey the monuments in 2013 due to budgetary limitations and the second survey was completed in 2017. Twenty-two monuments are located within the Sutter Subbasin (**Figure 5-87**) with recorded subsidence values between 2008 and 2017 ranging from 0.05 to 0.33 feet of subsidence (**Table 5-8**).

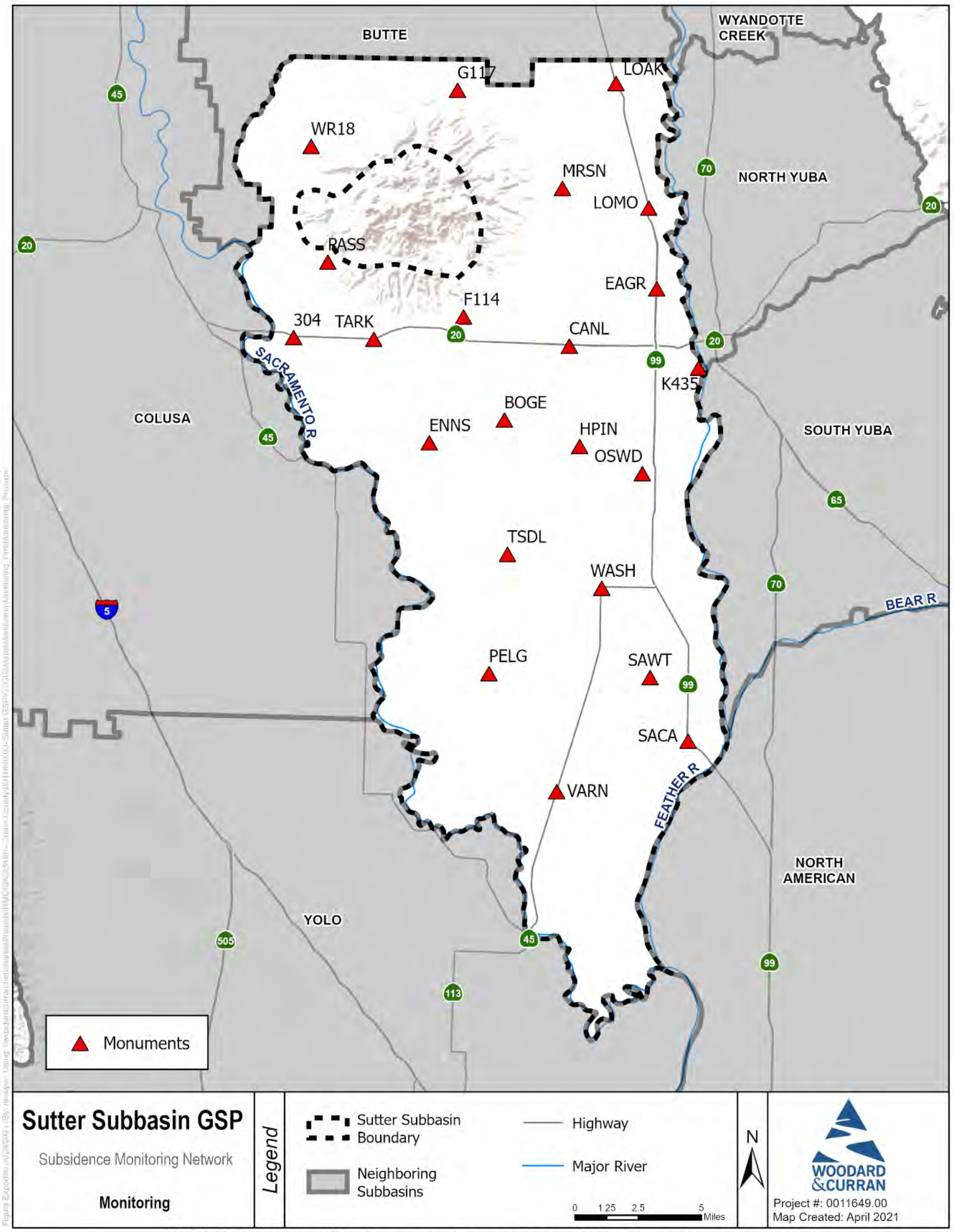

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Figure 5-87. Sacramento Valley Subsidence Monitoring Network, Sutter Subbasin

Table 5-8. DWR Sacramento Valley Subsidence Network in the Sutter Subbasin, Ellipsoid Height Difference from 2008 to 2017

DWR Station ID	DWR Station Name	Station Differences* in Ellipsoid Height from 2008 to 2017 (feet)
304	HPGN CA 03 04	-0.203
BOGE	BOGUE	-0.227
CANL	CANAL KS1836	-0.139
EAGR	EAGER	-0.109
ENNS	ENNIS	-0.231
F114	F 114	-0.188
G117	G 1175	-0.046
HPIN	HOPPIN	-0.185
K435	K 1435	-0.131
LOAK	LIVE OAK	-0.078
LOMO	LOMO	-0.089
MRSN	MORRISON	-0.112
OSWD	OSWALD	-0.148
PASS	PASSBUTTE	-0.22
PELG	PELGER	-0.168
SACA	SACRAMENTO AVENUE	Data not available
SAWT	SAWTELLE	-0.098
TARK	TARKE	-0.334
TSDL	TISDALE	-0.196
VARN	VARNEY	-0.118
WASH	WASHINGTON	-0.137
WR18	DWR18	-0.082

*Negative values indicate that elevations were lower in 2017 compared to 2008. The Department of Water Resources, North Central Region Office (2018) noted an error of uncertainty of approximately 0.17 feet and that any change of less than 0.17 feet was not considered to be statistically significant.

NASA’s JPL uses InSAR to evaluate land surface fluctuations from satellite imagery. Between June 2015 and October 2020, between -0.25 and +0.25 feet of vertical displacement was observed within much of the Sutter Subbasin, with a small area of between -0.5 to -0.75 feet of vertical displacement observed along the Colusa Subbasin boundary just north of the Yolo Subbasin (**Figure 5-88**). Similar vertical displacement measurements (-0.25 to +0.25 feet) were also observed between October 2019 and October 2020 (**Figure 5-89**). Therefore, land subsidence within the Sutter Subbasin has been minimal in recent years and there has been no reported negative impacts of land subsidence on critical infrastructure.

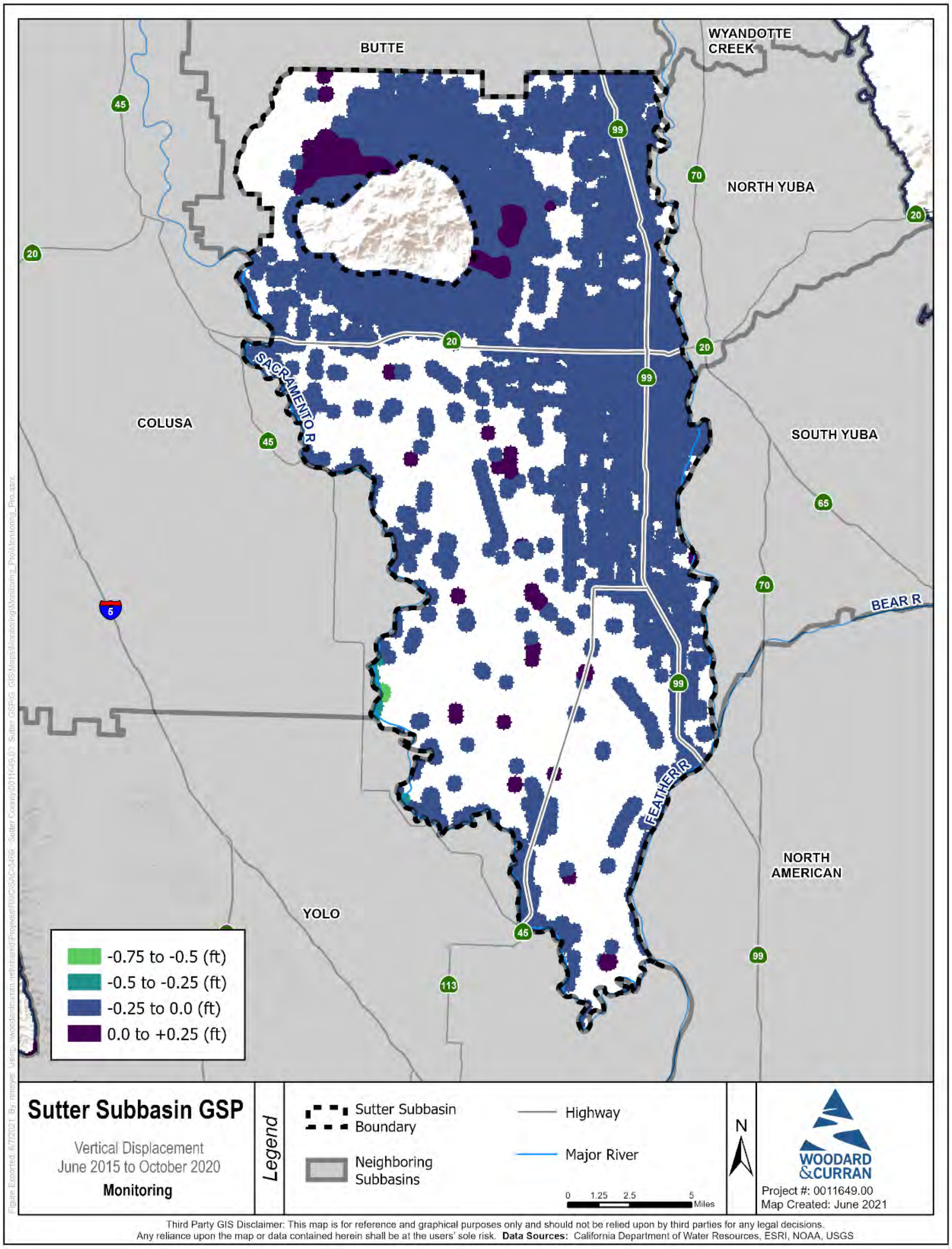

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Figure 5-88. Vertical Displacement in the Sutter Subbasin, June 2015 to October 2020

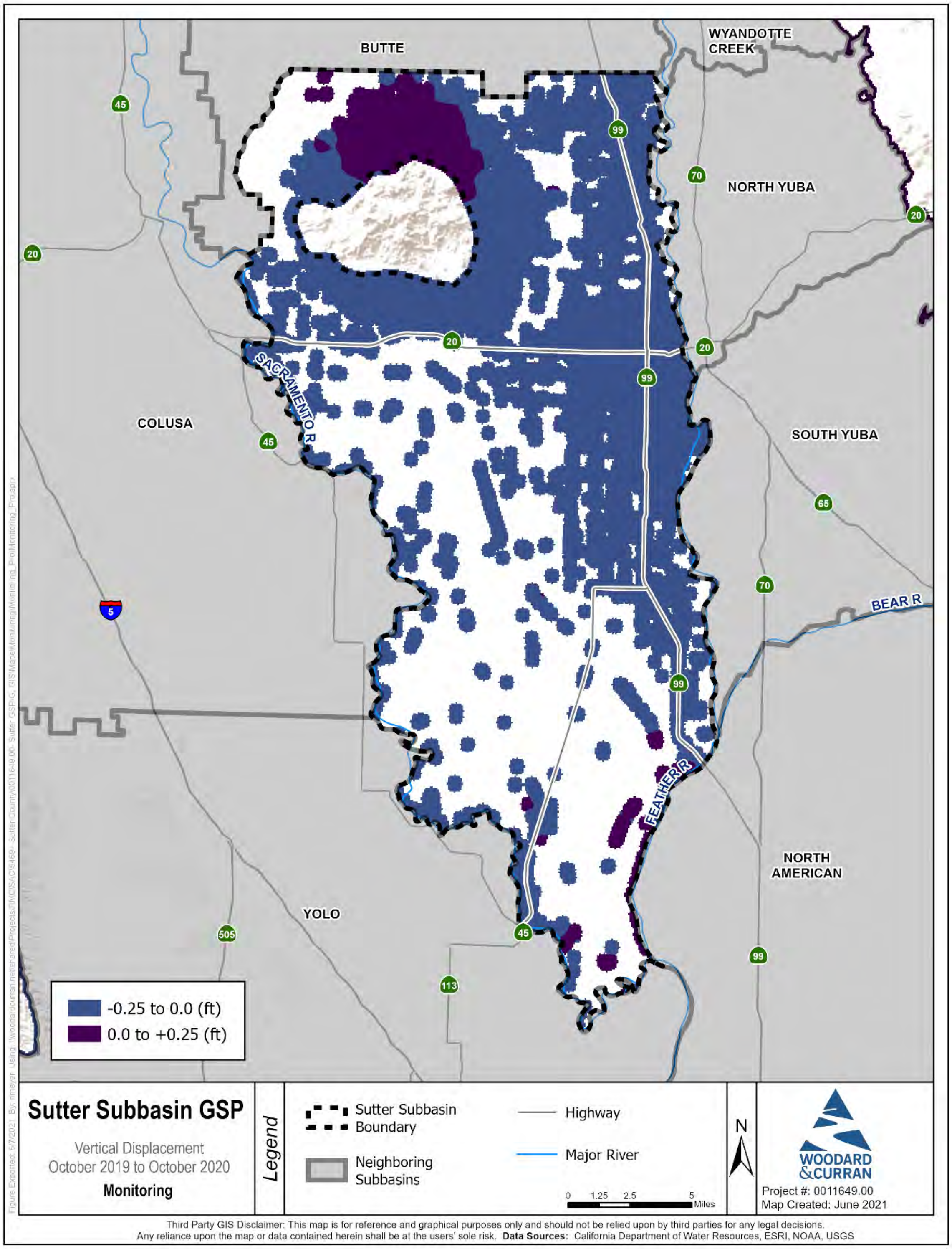

Figure 5-89. Vertical Displacement in the Sutter Subbasin, October 2019 to October 2020

5.2.7 Interconnected Surface Water Systems

Interconnected surface waters are surface water features that are hydraulically connected by a saturated zone to the groundwater system. Interconnected surface waters can be categorized as gaining (when the surface water feature is gaining water from the aquifer system) or losing (when the surface water feature is losing water to the aquifer system) (**Figure 5-90**).

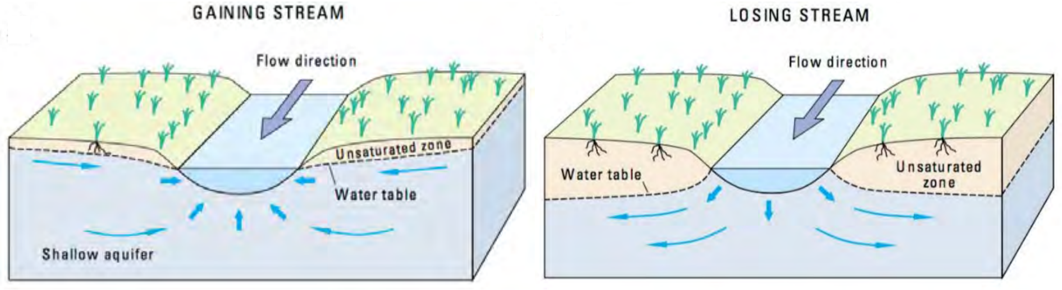

Figure 5-90. Gaining and Losing Surface Water Features

Interactions between groundwater and surface water in the Sutter Subbasin were analyzed by comparing water table elevations to streambed elevations. As in most areas of California, the direct measurement of the gain or loss to groundwater from surface water bodies is not feasible in the Sutter Subbasin. Therefore, the C2VSimFG-Sutter integrated flow model was used to characterize the interconnected surface waters of simulated streams and to approximate the rates of gains and losses. The elevation of the water table was calculated by the historical model for the Sacramento River, Feather River, and Sutter Bypass, represented by 316 stream nodes that touch the Sutter Subbasin boundary. The gradient created by the difference in elevation between the groundwater and surface water feature was evaluated at the stream node scale. The portions of the stream that were found to be gaining or losing in at least 80% of the simulated months from WY 1996 to WY 2015 were categorized as such (gaining or losing nodes), while stream nodes that did not meet the 80% threshold for either categorization were classified as having mixed conditions (**Figure 5-91**). Average monthly streamflow gains and losses from WY 1996 to 2015 as estimated from C2VSimFG-Sutter are shown in **Table 5-9** for the Sacramento River, Feather River, and Sutter Bypass. Positive values indicate average gains to stream from groundwater and negative values indicate average loses to stream from groundwater. These averages cover all nodes with monthly gaining and losing conditions. Since no stream has all nodes behaving consistently in any month, the averages follow the trends of the majority of the nodes. Various thresholds were assessed, but an 80% threshold was determined to best align with local knowledge of the Subbasin and The Nature Conservancy's Interconnected Surface Water in the Central Valley (ICONS) dataset (**Figure 5-92**) (TNC, 2021), which was used as an independent check in assessing the stream reaches.

Table 5-9. Average Monthly Streamflow Gains and Losses, Water Year 1996 to 2015 (AF)

Stream/ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Overall Annual
Sacramento River	153	99	-101	29	31	101	152	130	132	113	142	129	93
Feather River	27	47	-7	28	23	34	48	25	15	-31	-1	28	20
Sutter Bypass	-13	-32	-86	-74	-55	-28	44	46	69	45	30	-1	-5

The ICONS dataset utilizes groundwater elevation data from DWR for WY 2011 to WY 2018. Disconnected streams, where groundwater depth is greater than 50 feet below the stream surface, will always be losing streams, whereas connected streams may be either losing or gaining depending on the surface water and groundwater conditions.

Both the model results and ICONS datasets indicate that Sutter Bypass has mostly mixed or gaining conditions throughout Sutter Subbasin. The Feather River at the border near North Yuba Subbasin has fluctuating gaining and losing conditions as it moves southward, while near the South Yuba Subbasin, the Feather River has longer, more distinct stretches of either gaining or losing conditions. For the Sacramento River, model results show more variable conditions at the node scale than the ICONS dataset. This difference may be due to differing thresholds for which gaining or losing conditions are defined. The C2VSimFG-Sutter model does not contain stream nodes in the Sutter Buttes foothills, and therefore the interaction between those streams and the underlying water table were not evaluated.

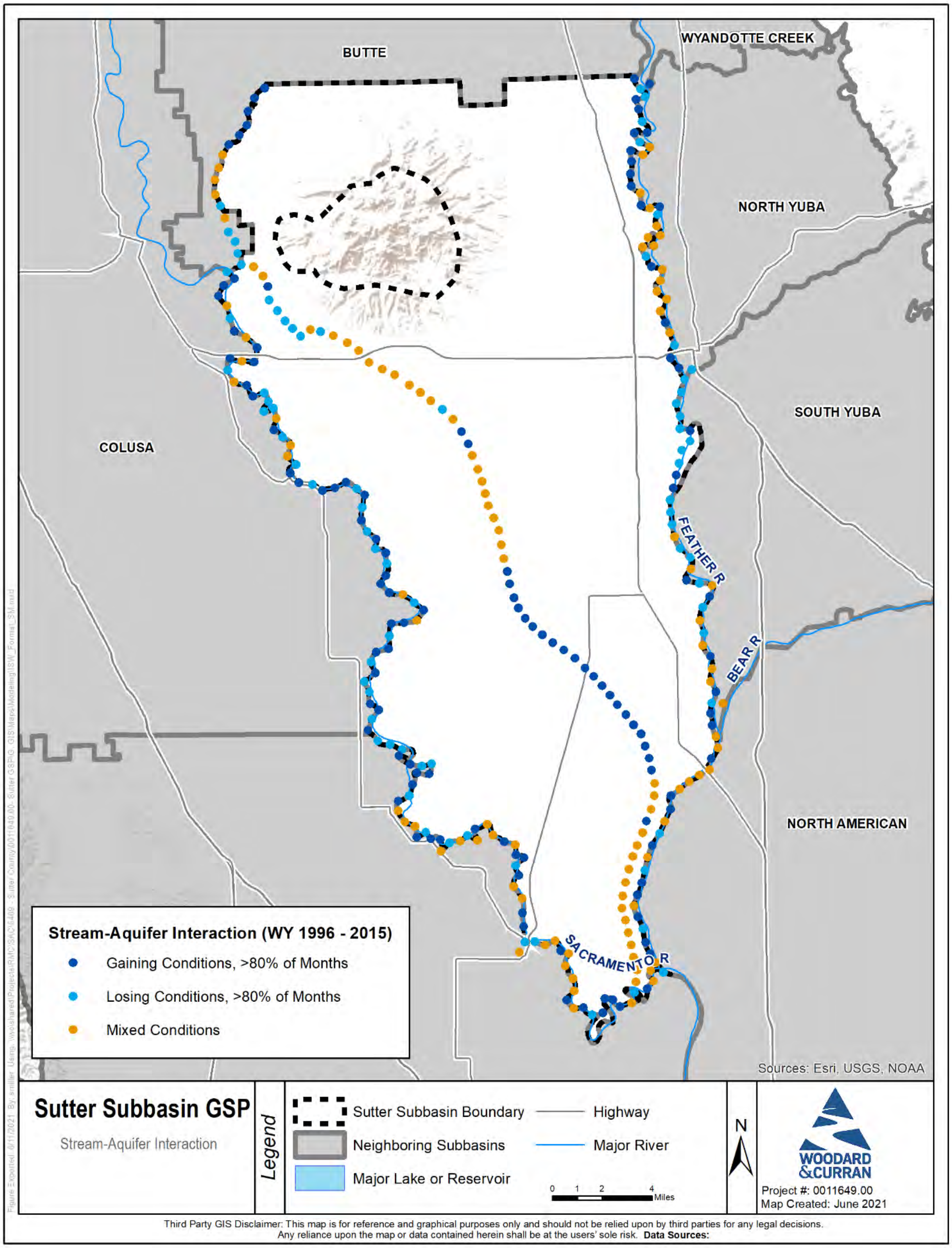

Figure 5-91. Losing and Gaining Streams, C2VSimFG-Sutter Model

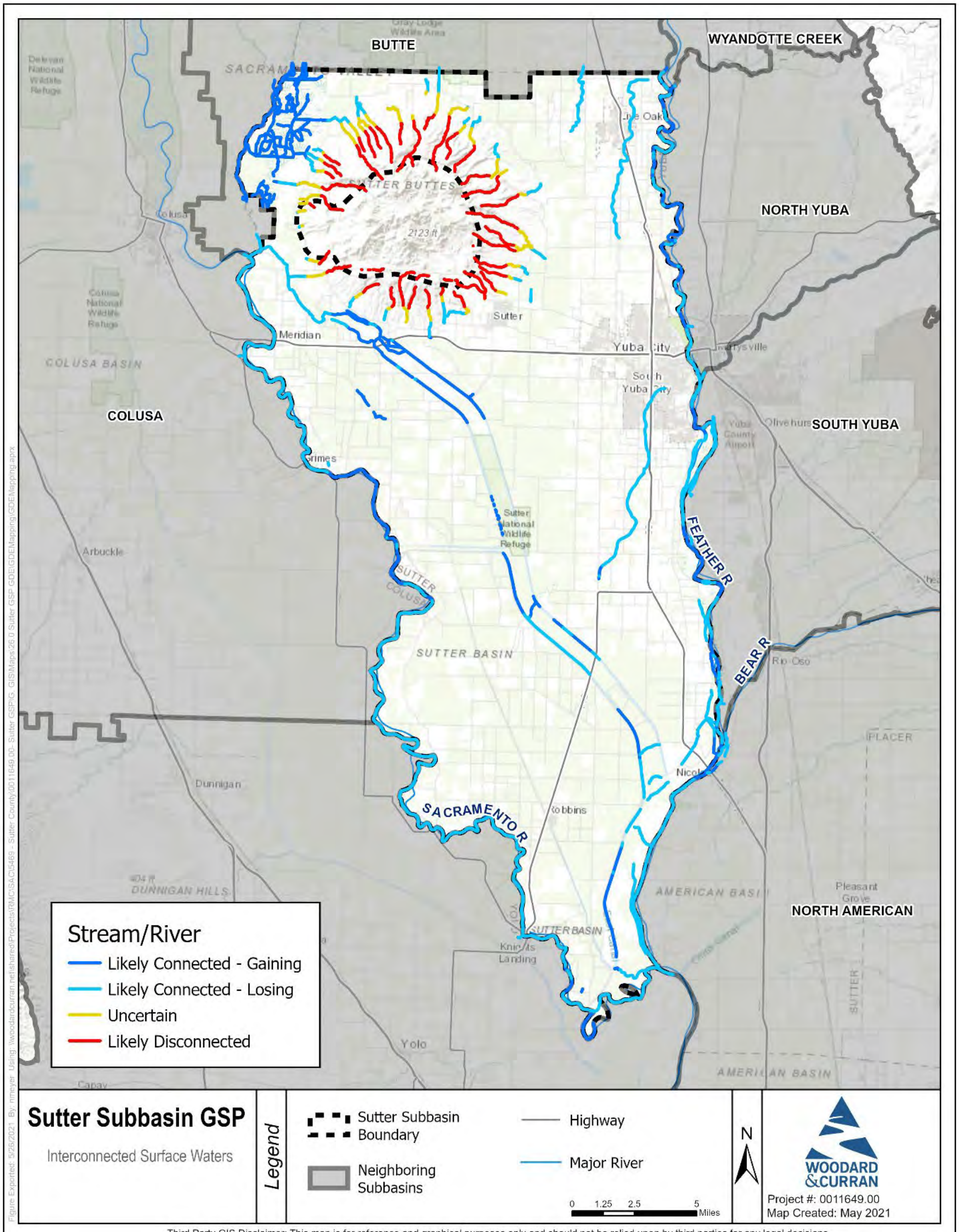

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Figure 5-92. Losing and Gaining Streams, ICONS

5.2.8 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (GSP Emergency Regulations § 351(m)). Identification of GDEs is used to assess whether groundwater management could affect the beneficial uses of groundwater associated with GDEs.

In the Sutter Subbasin, GDEs exist primarily where vegetation is reliant on shallow groundwater supply for survival. Therefore, the identification of GDEs in the Sutter Subbasin was based on the following question: "Would the ecosystem exist if groundwater levels were deeper?" If the answer is "no," then it was determined to be a GDE; if "yes," then it was not selected as a GDE. This analysis demonstrates the nature of shallow groundwater as critical to maintaining ecosystem health.

To identify GDEs, an analysis of the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset was performed (DWR, 2018). Developed by DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy, the NCCAG database was created by reviewing publicly available state and federal agency maps of California vegetation, wetlands, springs, and seeps and by conducting a screening process to retain types and locations commonly associated with groundwater. Two classes of the results were defined: 1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions and 2) vegetation types commonly associated with the subsurface presence of groundwater (i.e., phreatophytes).

Noting that no land use protections are conferred on GDEs or NCCAGs through this document or other documents, the distinction between GDEs and NCCAGs that are not GDEs is important from a management perspective. As noted above, SGMA focuses on beneficial uses, rather than on the simple existence of surface water and other possible GDEs. Management of NCCAGs may require more focus on land use or irrigation activities more so than groundwater management. The analysis methodology to identify GDEs was developed to focus groundwater management activities on the most appropriate areas.

Potential GDEs in normal (2013), dry (2015), and wet (2017) years in the Sutter Subbasin were identified through the creation of elimination criteria. The following criteria identify NCCAG areas with likely access to non-groundwater supplies that were removed from consideration as potential GDEs, as shown in **Figure 5-93** through **Figure 5-95**:

1. **Areas with a depth to groundwater greater than 30 feet during winter months (January through March) –** Oak trees are considered the deepest-rooted plant in the region with a root zone of roughly 25 to 30 feet, with mature trees reaching rooting depths of up to 80 feet. Groundwater depths deeper than 80 feet are highly unlikely to support vegetative growth dependent on groundwater, as groundwater

in such areas would be inaccessibly deep. In evaluating available groundwater level data during the winter (January through March) of 2013, 2015, and 2017 used in this analysis, all groundwater levels in the Sutter Subbasin were shallower than 30 feet with the exception of a depression anomaly observed near the Sutter Buttes in 2017 (a wet year). NCCAGs in the area impacted by the depression anomaly in 2017 are retained as potential GDEs until further evaluation is performed.

2. **Areas adjacent to losing surface water bodies –** Rivers and streams recharge groundwater systems in the Sutter Subbasin. It was assumed that vegetation within 150 feet of such areas would be accessing this surface water recharge and therefore dependent on surface water flows, not groundwater. As such, NCCAGs within 150 feet of rivers and streams were eliminated from consideration as a GDE.
3. **Areas adjacent to irrigated lands –** Irrigated areas benefit not only targeted crops but surrounding vegetation through the recharge of groundwater systems with applied surface water. Therefore, NCCAGs within 50 feet of Fish and Wildlife Service-irrigated land, State-irrigated land, and irrigated farmland were eliminated from consideration as a GDE. A 150-foot elimination buffer was used for irrigated rice cropland due to extent of percolation and lateral seepage associated with rice fields that apply surface water, resulting in more extensive recharge of the underlying aquifer and adjacent areas than typical irrigation methods for other crops.

Based on the screening process above, all remaining NCCAG areas were identified as potential GDEs, as shown in **Figure 5-96** through **Figure 5-98**. The results of the GDE analysis are shown in the two NCCAG habitat classes: vegetation and wetlands. Potential GDEs have been identified along the Feather River and the most northeastern portion of the Sutter flyway. Due to potential inaccuracies in the wet year groundwater depth data in 2017, NCCAGs within the area of depression anomalies (as shown by the hatched area in **Figure 5-95** and **Figure 5-98**) in the northwestern portion of the Subbasin were assumed to be potential GDEs in the wet year, as they had qualified in the normal and dry years, until further evaluation is performed. **Table 5-10** includes all species within the Sutter Subbasin region, as identified by TNC, that have been observed or have the potential to exist within the region and may be reliant on groundwater (TNC, n.d.). Further efforts in GDE mapping will be performed as part of subsequent 5-Year GSP Updates to further confirm the presence of and refine the delineation of GDEs in the Sutter Subbasin, using the preliminary analyses contained in this multi-year evaluation approach as a starting point for further analyses (refer to **Section 7.1.6.3.1** for more information about GDE mapping confirmation).

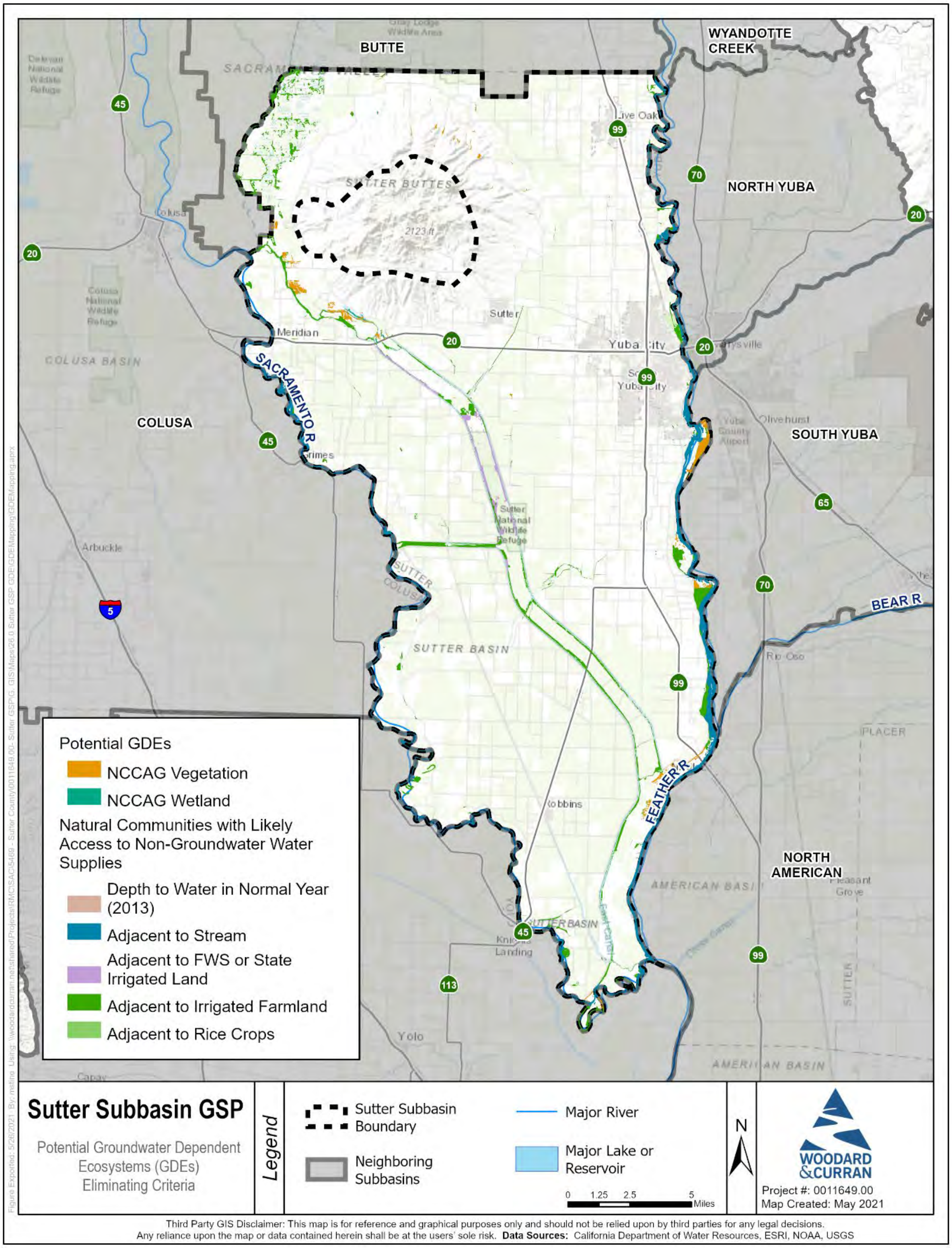

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Figure 5-93. GDE Elimination Criteria in Sutter Subbasin, Normal Year (2013)

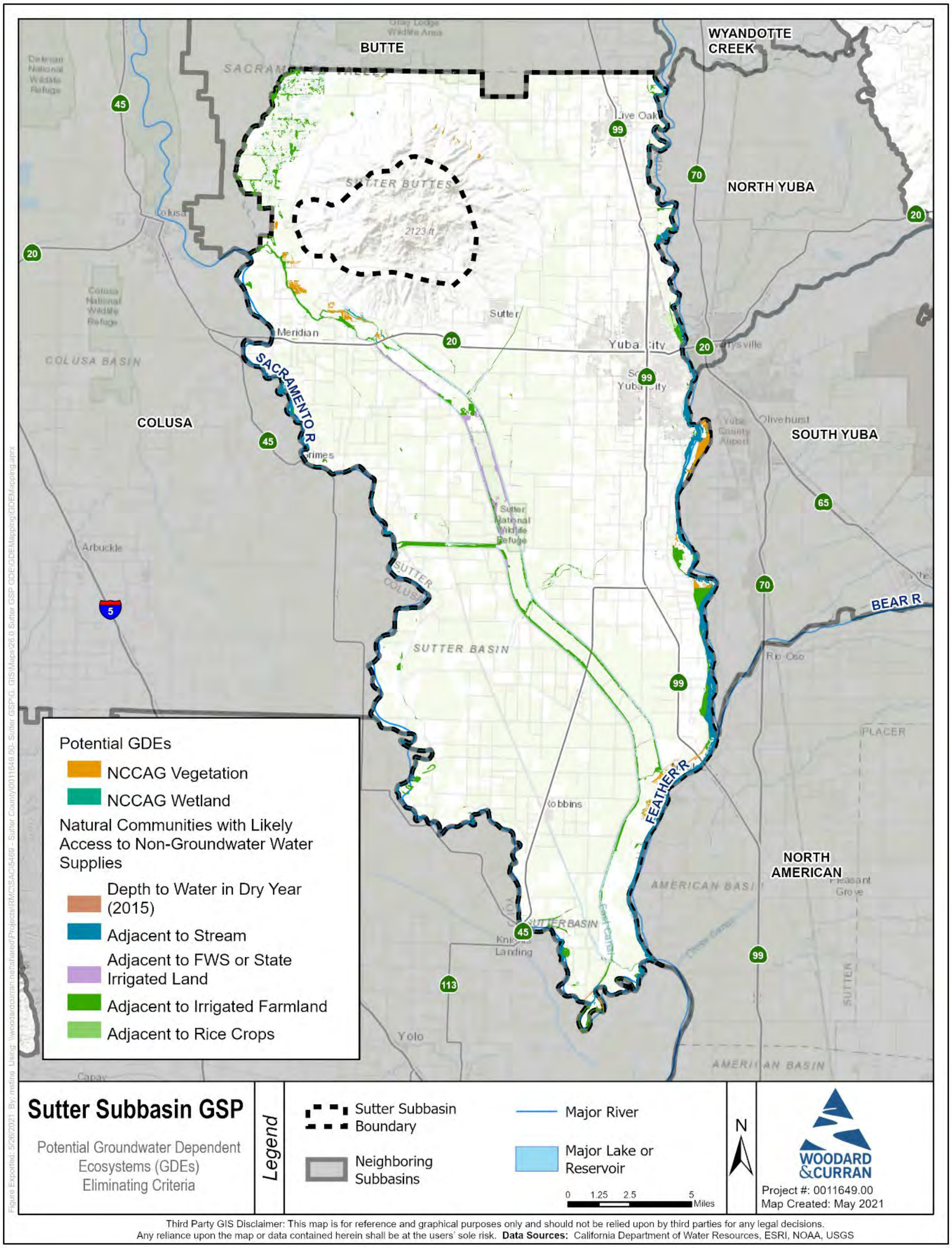

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Figure 5-94. GDE Elimination Criteria in Sutter Subbasin, Dry Year (2015)

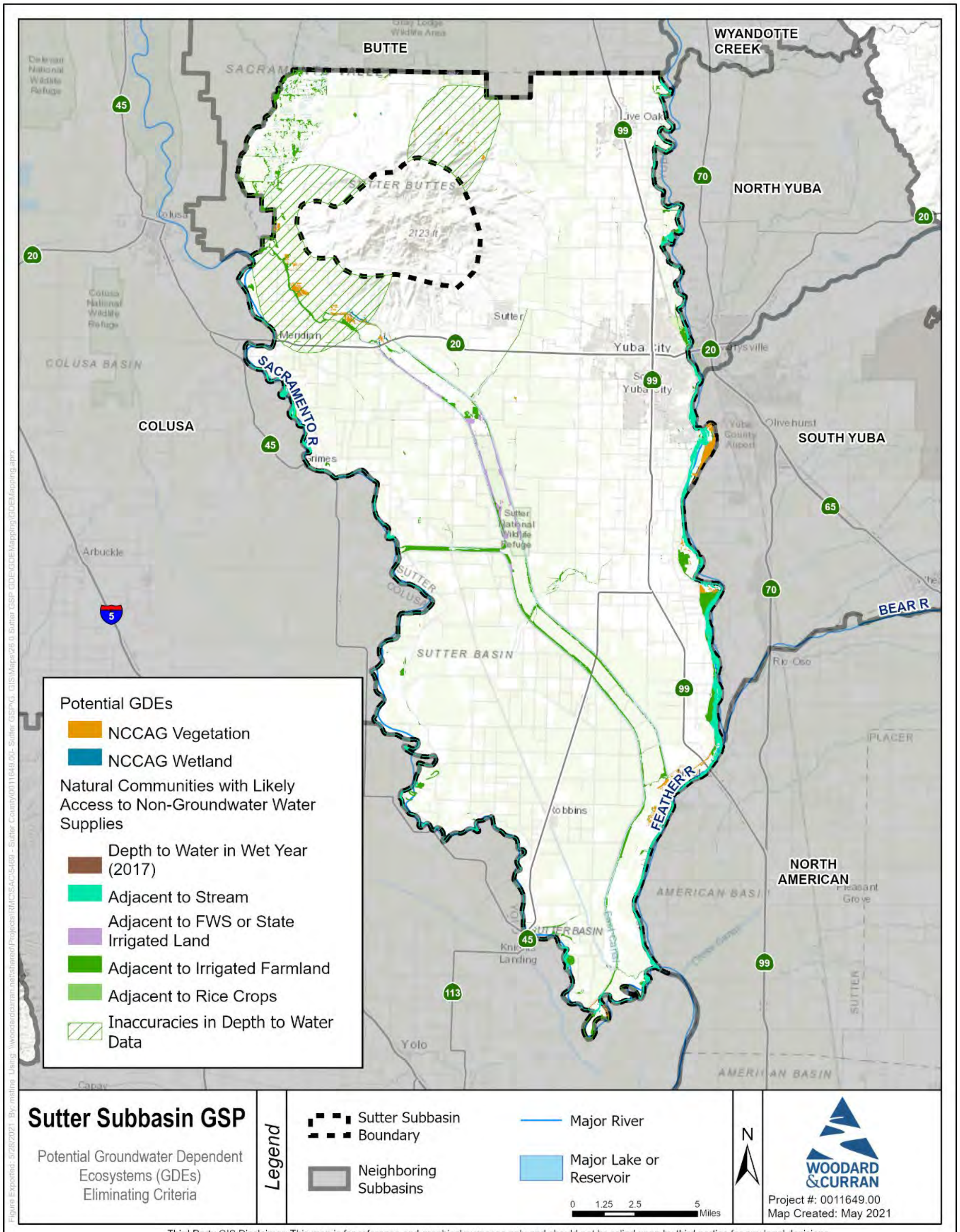

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Figure 5-95. GDE Elimination Criteria in Sutter Subbasin, Wet Year (2017)

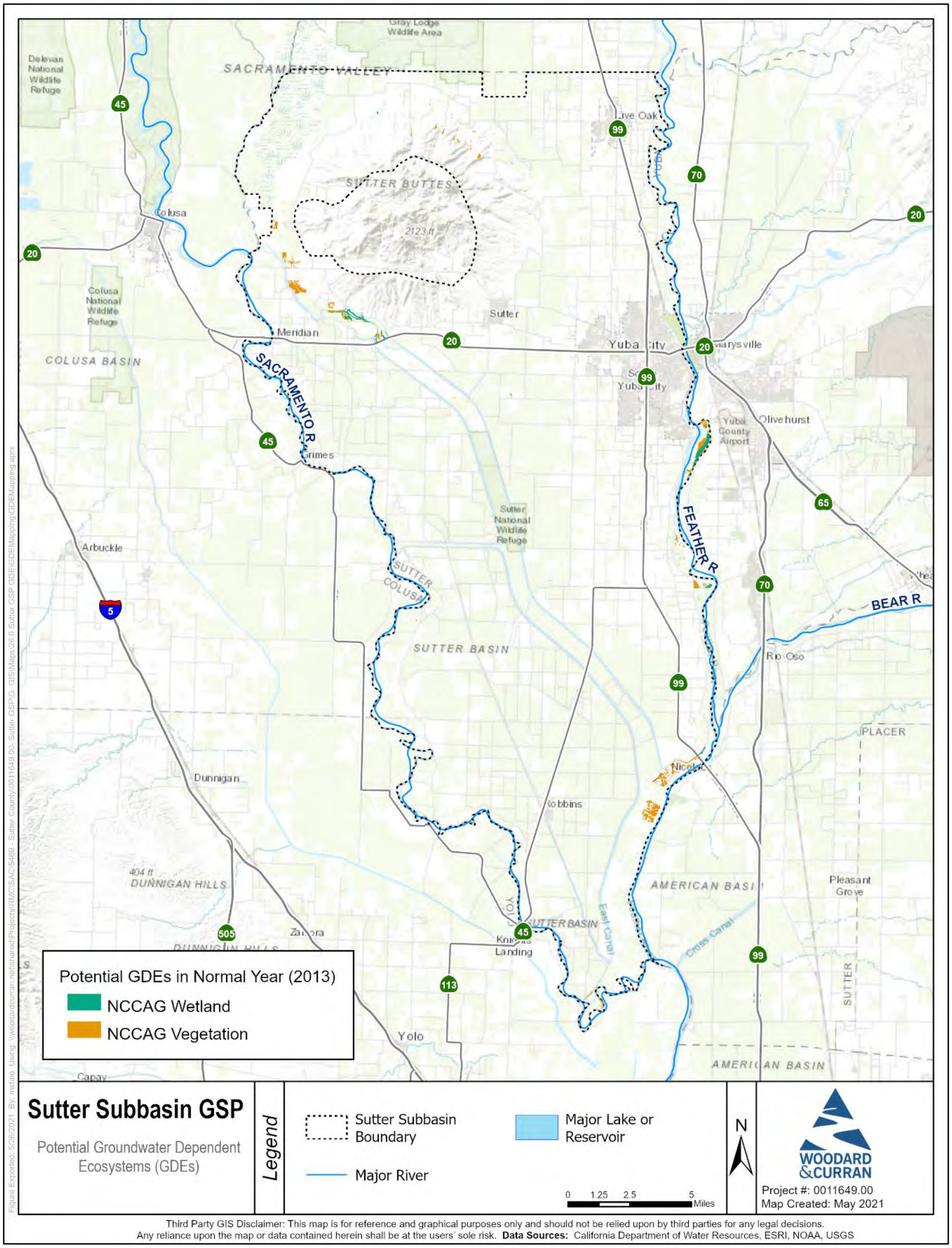

Figure 5-96. Potential GDEs in Sutter Subbasin, Normal Year (2013)

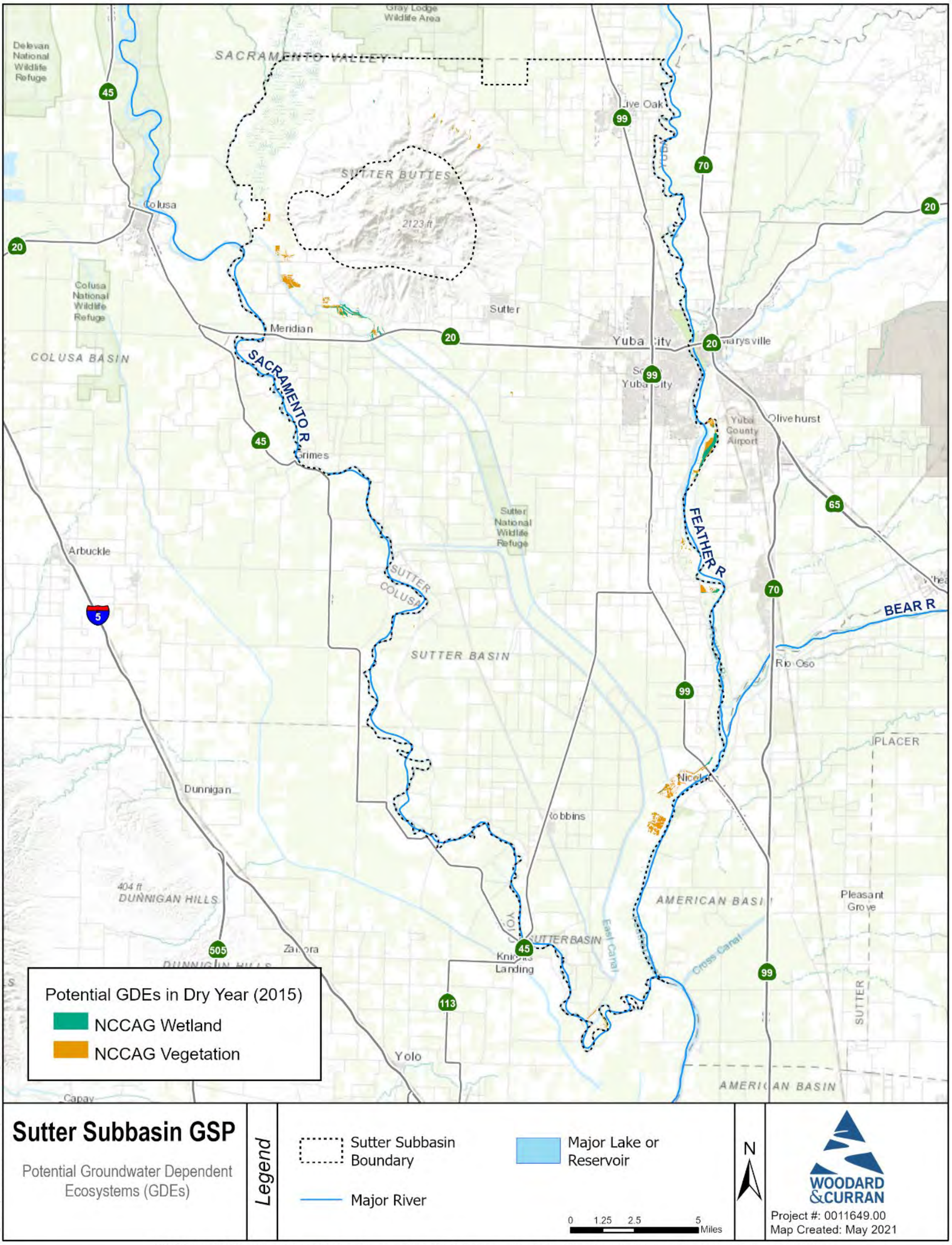

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Figure 5-97. Potential GDEs in Sutter Subbasin, Dry Year (2015)

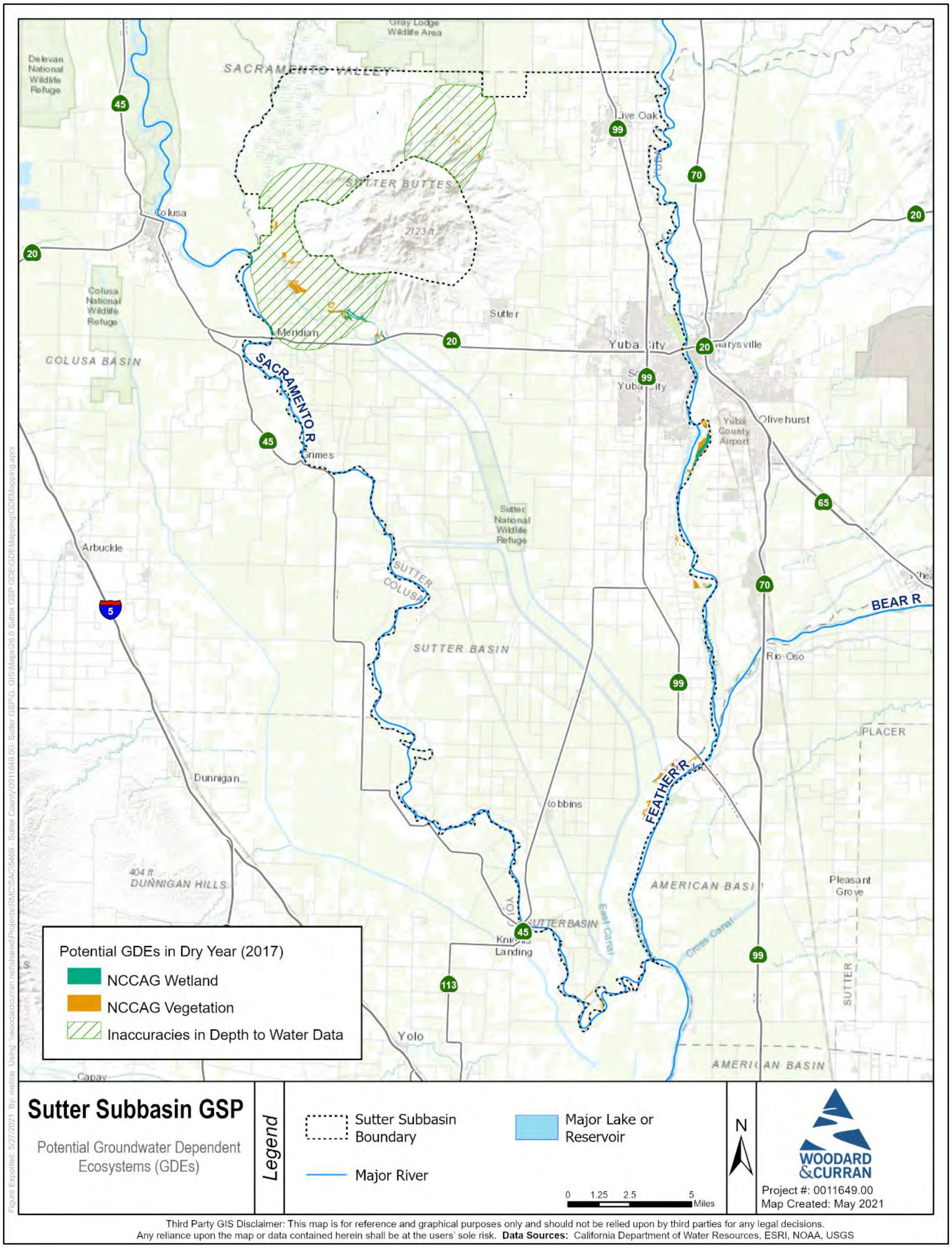

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Figure 5-98. Potential GDEs in Sutter Subbasin, Wet Year (2017)

Table 5-10. List of Potential Freshwater Species, Sutter Subbasin

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Ambystoma californiense	California tiger salamander	Amphibians	Threatened	Threatened
Rana boylii	foothill yellow-legged frog	Amphibians	None	Endangered
Agelaius tricolor	tricolored blackbird	Birds	None	Threatened
Antigone canadensis tabida	greater sandhill crane	Birds	None	Threatened
Athene cunicularia	burrowing owl	Birds	None	None
Branta hutchinsii leucopareia	cackling (Aleutian Canada) goose	Birds	Delisted	None
Buteo swainsoni	Swainson's hawk	Birds	None	Threatened
Coccyzus americanus occidentalis	western yellow-billed cuckoo	Birds	Threatened	Endangered
Laterallus jamaicensis coturniculus	California black rail	Birds	None	Threatened
Melospiza melodia	song sparrow ("Modesto" population)	Birds	None	None
Nycticorax	black-crowned night heron	Birds	None	None
Riparia	bank swallow	Birds	None	Threatened
Spinus lawrencei	Lawrence's goldfinch	Birds	None	None
Vireo bellii pusillus	least Bell's vireo	Birds	Endangered	Endangered
Branchinecta lynchi	vernal pool fairy shrimp	Crustaceans	Threatened	None
Lepidurus packardi	vernal pool tadpole shrimp	Crustaceans	Endangered	None
Linderiella occidentalis	California linderiella	Crustaceans	None	None
Amsinckia lunaris	bent-flowered fiddleneck	Dicots	None	None
Astragalus tener var. ferrisiae	Ferris' milk-vetch	Dicots	None	None
Brasenia schreberi	watershield	Dicots	None	None
Cuscuta obtusiflora var. glandulosa	Peruvian dodder	Dicots	None	None
Delphinium recurvatum	recurved larkspur	Dicots	None	None
Hibiscus lasiocarpos var. occidentalis	woolly rose-mallow	Dicots	None	None
Layia septentrionalis	Colusa layia	Dicots	None	None

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Monardella venosa	veiny monardella	Dicots	None	None
Navarretia leucocephala ssp. bakeri	Baker's navarretia	Dicots	None	None
Pseudobahia bahiifolia	Hartweg's golden sunburst	Dicots	Endangered	Endangered
Trichocoronis wrightii var. wrightii	Wright's trichocoronis	Dicots	None	None
Oncorhynchus mykiss irideus pop. 11	steelhead - Central Valley DPS	Fish	Threatened	None
Oncorhynchus tshawytscha pop. 11	chinook salmon - Central Valley spring-run ESU	Fish	Threatened	Threatened
Pogonichthys macrolepidotus	Sacramento splittail	Fish	None	None
Spirinchus thaleichthys	longfin smelt	Fish	Candidate	Threatened
Thaleichthys pacificus	eulachon	Fish	Threatened	None
Northern Hardpan Vernal Pool	Northern Hardpan Vernal Pool	Herbaceous	None	None
Anthicus antiochensis	Antioch Dunes anthicid beetle	Insects	None	None
Anthicus sacramento	Sacramento anthicid beetle	Insects	None	None
Cicindela hirticollis abrupta	Sacramento Valley tiger beetle	Insects	None	None
Desmocerus californicus dimorphus	valley elderberry longhorn beetle	Insects	Threatened	None
Antrozous pallidus	pallid bat	Mammals	None	None
Dipodomys californicus eximius	Marysville California kangaroo rat	Mammals	None	None
Erethizon dorsatum	North American porcupine	Mammals	None	None
Lasiurus blossevillii	western red bat	Mammals	None	None
Lasiurus cinereus	hoary bat	Mammals	None	None
Perognathus inornatus	San Joaquin pocket mouse	Mammals	None	None
Coastal and Valley Freshwater Marsh	Coastal and Valley Freshwater Marsh	Marsh	None	None
Gonidea angulata	western ridged mussel	Mollusks	None	None
Heteranthera dubia	water star-grass	Monocots	None	None
Sagittaria sanfordii	Sanford's arrowhead	Monocots	None	None

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Wolffia brasiliensis	Brazilian watermeal	Monocots	None	None
Emys marmorata	western pond turtle	Reptiles	None	None
Thamnophis gigas	giant gartersnake	Reptiles	Threatened	Threatened
Great Valley Cottonwood Riparian Forest	Great Valley Cottonwood Riparian Forest	Riparian	None	None
Great Valley Mixed Riparian Forest	Great Valley Mixed Riparian Forest	Riparian	None	None
Great Valley Willow Scrub	Great Valley Willow Scrub	Riparian	None	None

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5.3 Water Budget

5.3.1 Water Budget Background

Water budgets are developed to provide a quantitative account of water entering and leaving the Sutter Subbasin. Water entering and leaving the Subbasin includes flows at the surface and in the subsurface environment. Water enters and leaves due to natural conditions, such as precipitation and streamflow, and/or through human activities, such as groundwater pumping or recharge from applied water. Additionally, the interconnection between the groundwater system and rivers/streams accounts for other components of the water budget. **Figure 5-99** depicts the major components of a water budget and their interconnection as presented in the context of surface and groundwater systems.

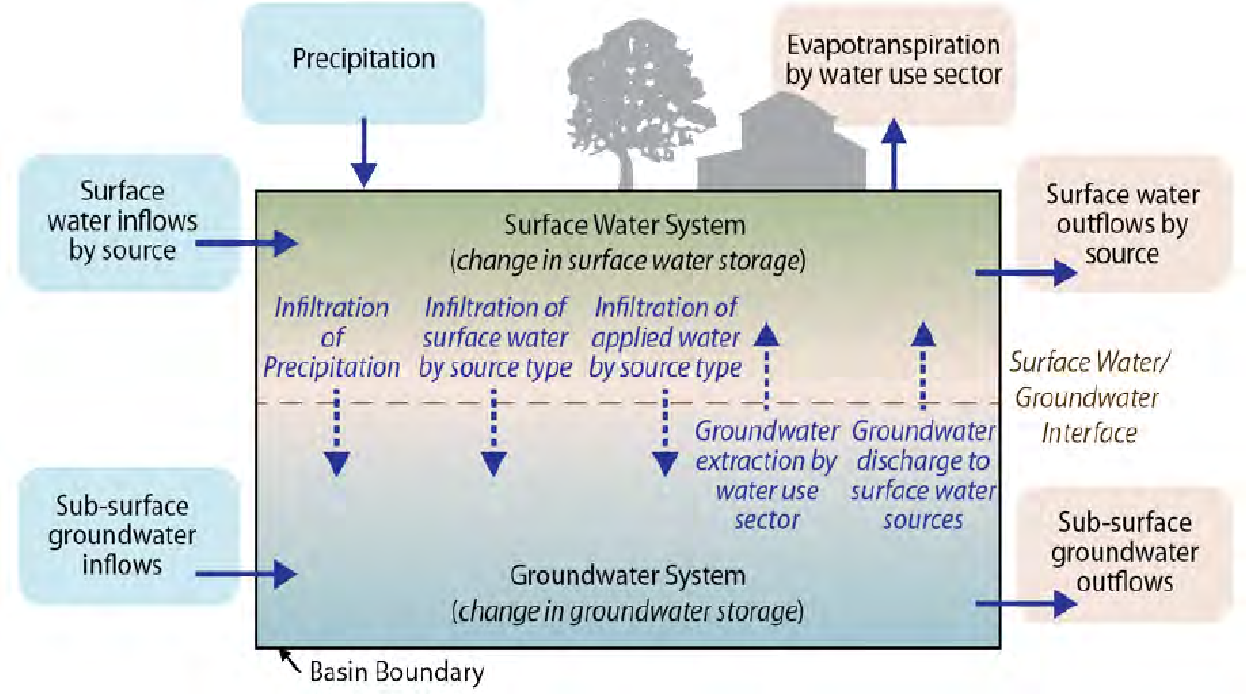

Figure 5-99. Generalized Water Budget Diagram

Quantities presented for the water budget components of the Sutter Subbasin provide information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate variability, groundwater and surface water interaction, and groundwater flow. This information can assist in the management of the Subbasin by identifying the relationship between different components affecting the water budget in the Subbasin, which provides context in the development and implementation of strategies and policies to achieve and maintain Subbasin groundwater sustainability conditions. Water budget quantities presented are based on the simulation results from the California Central Valley Groundwater-Surface

Water Simulation Model – Fine Grid, Sutter Subbasin (C2VSimFG-Sutter) integrated water flow model.

C2VSimFG-Sutter was developed to be the primary analytical tool supporting the development of the GSP water budgets and simulates water years (WY) 1986 through 2015. The C2VSimFG-Sutter model was adapted from C2VSimFG v1.0, released by DWR in December 2020, with updates to better represent local conditions (SGMO, 2020). C2VSimFG-Sutter model includes the entire C2VSimFG model extent of the California Central Valley, but with data updates and calibration focused only on the area within and immediately surrounding Sutter Subbasin. The Subbasin, plus a five-mile buffer around the Subbasin boundaries, was chosen as the groundwater level and water budget calibration area for the model. More details regarding the local refinements and calibration of C2VSimFG-Sutter model are included in the model report (**Appendix 5-G**). Water budget results shown in this section of the GSP represent only the water budgets of the Subbasin and do not include the five-mile calibration buffer. Simulated flows from Sutter Subbasin to surrounding groundwater subbasins are also derived from C2VSimFG-Sutter.

Consistent with the GSP Emergency Regulations §354.18, the water budgets presented in this document encompass the combined surface and groundwater system of the Sutter Subbasin. The Subbasin water budget focuses on the full water year (12 months spanning October 1 of the previous year to September 30 of the year in question), with some consideration of monthly variability.

The GSP Regulations require that the annual water budget quantify three different conditions: historical, current, and projected. Budgets are developed to capture typical conditions during these time periods. Typical conditions are developed by selecting historical hydrologic periods that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions within the budgets, the Subbasin is analyzed under varying hydrologic conditions, such as drought or very wet events, along with long-term averages.

This GSP relies on historical hydrology to identify time periods for water budget analysis and uses the C2VSimFG-Sutter model and associated data to develop the water budget and resulting budget estimates. The water budget components developed for the Sutter Subbasin are based upon estimates developed from historical and projected data as well as modeling assumptions. As both the C2VSimFG and C2VSimFG-Sutter models are updated and the availability of data continues to improve, the water budget assumptions may be refined in the future, the water budget may change, and the conclusions and recommendations derived from the water budget may also change.

5.3.2 Identification of Hydrologic Periods

The historical hydrologic periods used in this GSP were selected to meet the SGMA requirements for developing historical, current, and projected conditions water budgets.

The GSP Regulations require that the projected conditions water budget reflect at least a 50-year hydrologic period in order to project how the Subbasin's surface and groundwater systems may react under long-term average hydrologic conditions. Consistent with the Regulations, the minimum 50-year historical record characterizes future conditions with respect to precipitation, evapotranspiration, and streamflow. Historical precipitation or rainfall in the Sutter Subbasin was used to identify a hydrologic period that would provide a representation of wet and dry periods and long-term average conditions needed for water budget analyses. Rainfall data for the Subbasin are derived from C2VSimFG v1.0 and are from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset of DWR's California Simulation of Evapotranspiration of Applied Water (CALSIMETAW) model. PRISM is a spatial estimation of rainfall data developed using monitoring network point data and interpolated using a variety of factors (OSU, 2021).

Wet and dry hydrologic periods were identified by evaluating various historical periods between which average precipitation was similar to the long-term average precipitation conditions and that had representative water year type distributions using the Sacramento Valley Water Year Hydrologic Classification (DWR, 2021a). Ultimately, the 20-year period between Water Year (WY) 1996-2015 was found to have the same 18.8 inches of average precipitation as the 99-year long-term average from 1922-2020. During this period, there was also a similar distribution of water year types as the 99-year long-term average.

The latest year in the historical simulation that is still representative of conditions in the Subbasin today is WY 2013, which has an annual average rainfall of 17.3 inches, but still has land use, demands, and surface water supplies similar to current values. For this reason, WY 2013 in the historical calibration was selected to best represent the Subbasin current conditions.

Figure 5-100 shows the Subbasin annual precipitation, average precipitation, and cumulative departure from mean precipitation in each year. This plot represents the spatially-averaged precipitation across Sutter Subbasin elements. The long-term average precipitation is subtracted from annual precipitation within each water year to develop the departure from average precipitation for each water year. Wet years have a positive departure and dry years have a negative departure. Subsequently, a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, the departures are added cumulatively for each year. For example, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (5 plus -2) for Year 2. The figure includes bars displaying annual precipitation for each water year from 1922 through 2020 and a horizontal line representing the mean precipitation of 18.8 inches. The cumulative departure from average precipitation is based on these data sets and is displayed as a line that highlights wet periods with upward slopes (positive departure) and dry periods with downward slopes (negative departure). More severe events are shown by steeper slopes and greater changes. For example, the most recent drought period can be observed as a decline between 2011 and 2016 where there is approximately a 3.7-inch decline per year in cumulative departure within that 5-year period.

The PRISM estimates for rainfall in the Subbasin were confirmed by comparing the cumulative departure from mean precipitation results to the water year types in the Sacramento Valley Water Year Hydrologic Classification (DWR, 2021a), which classifies WYs 1901 through 2020 as wet, above normal, below normal, dry, and critical based on inflows to major reservoirs or lakes. Wet (W) or Above Normal (AN) years generally show upward sloping cumulative departures, while Below Normal (BN), Dry (D), or Critical (C) water year types show downward trending cumulative departures (**Figure 5-100**).

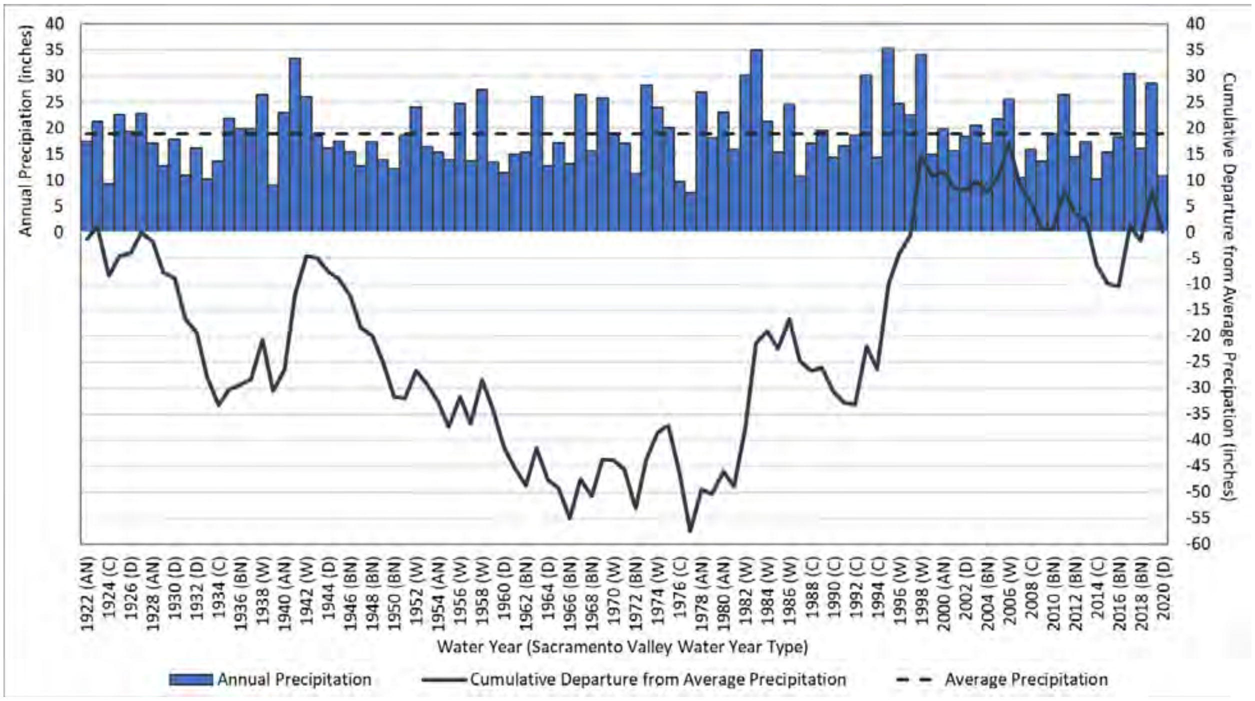

Figure 5-100. 99-Year Historical Precipitation and Cumulative Departure from Mean Precipitation

5.3.3 Use of C2VSimFG-Sutter and Associated Data in Water Budget Development

This GSP includes water budgets developed utilizing the C2VSimFG-Sutter model, a fully integrated surface and groundwater flow model covering the entire Central Valley, calibrated to the Sutter Subbasin area.

With C2VSimFG-Sutter as the underlying framework, three model scenarios were developed representing historical, current, and projected conditions in the Sutter Subbasin, as discussed below:

- **Historical conditions water budget** represents the average over the historical model period from WYs 1996 through 2015 (20 years).
- Current conditions water budget is a single year in the historical model calibration that represents current trends in level of development, water supply, and water demand. WY 2013 was selected for demands and supplies that were not yet heavily impacted by the drought and land use that is still comparable to present land use.
- Projected conditions water budget represents estimated long-term conditions of the Subbasin under the foreseeable future level of development over a long-term period of hydrologic conditions (20-year period from WYs 1996 through 2015 repeated three times).
- Projected conditions water budget with climate change represents estimated long-term conditions of the Subbasin under the foreseeable future level of development over a long-term period of hydrologic conditions (20-year period from WYs 1996 through 2015 repeated three times) with additional modifications to precipitation, evapotranspiration, and streamflow to reflect impacts of climate change.

5.3.4 Water Budget Definitions and Assumptions

Definitions and assumptions for the historical, current, and projected conditions water budgets are provided in the sections below and summarized in **Table 5-11**.

Table 5-11. Summary of Water Budget Assumptions – Historical, Current, and Projected Periods

Water Budget Type	Historical	Current	Projected Conditions	Projected Conditions with Climate Change
Tool	C2VSimFG-Sutter	C2VSimFG-Sutter	C2VSimFG-Sutter	C2VSimFG-Sutter
Scenario	Historical Calibration	Current Conditions	Projected Conditions	Projected Conditions with Climate Change
Hydrologic Years (WYs)	1996-2015	2013	1996-2015 [3]	1996-2015 [3]
Level of Development	Historical [2]	Current (2013)	Projected 2040 conditions based on local information [1]	Projected 2040 conditions based on local information [1]

Water Budget Type	Historical	Current	Projected Conditions	Projected Conditions with Climate Change
Agricultural Demand [2]	Historical [2]	Current (2013)	Projected based on recent historical local data	Projected based on recent historical local data, increased to reflect 2070 climate change conditions
Urban Demand	Historical [2]	Current (2013)	Projected based on recent historical population growth rates	Projected based on recent historical population growth rates
Managed Wetlands Demand	Historical	Current (2013)	Projected based on recent historical local data and for Sutter NWR, monthly ideal delivery schedule for Level 4 water supply demand through the Refuge Water Supply Program provided by USBR.	Projected based on recent historical local data and for Sutter NWR, monthly ideal delivery schedule for Level 4 water supply demand through the Refuge Water Supply Program provided by USBR.
Water Supplies	Historical [2]	Current (2013)	Projected based on recent historical local data	Projected based on recent historical local data, modified to reflect 2070 climate change conditions

[1] Yuba City and Live Oak are assumed to buildout to sphere of influence boundaries.
[2] For more information on historical assumptions, see the model report (Appendix 5-G).
[3] Hydrologic years WYs 1996-2015 are repeated 3 times for a total of 60 years of projected conditions hydrology.

5.3.4.1 Assumptions Used in the Historical Water Budget

The historical water budget is intended to evaluate availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. The historical water budget period of the C2VSimFG-Sutter model reflects the historical conditions in the Sutter Subbasin over WYs 1996 through 2015. The hydrologic period has an average annual precipitation of approximately 18.8 inches and includes the recent 2012-2015 drought, the wetter years of 1996-2000, and periods of normal precipitation. Furthermore, the GSP Regulations require the use of a minimum of 10 years to develop the historical water budget.

Calibration of the historical model was focused on the Sutter Subbasin within the C2VSimFGv1.0 model area. Calibration of groundwater levels was focused on the Sutter Subbasin in addition to a five-mile buffer around the Subbasin to ensure interbasin flows were simulated accurately. Additional details of the data used in the development of the historical calibration can be found in the model report (**Appendix 5-G**).

The historical water budget includes the following:

- **Hydrologic Period**: WYs 1996 through 2015 (20-year hydrology)
- **Stream Flows**: Based on the published C2VSimFG v1.0
- **Reservoir Operations**: Based on the published C2VSimFG v1.0. While Oroville Dam, Nimbus Dam, Shasta Dam, among others, lie upstream and mediate flow into the Sacramento and Feather Rivers, there are no reservoir operations modeled within the Sutter Subbasin boundary or the five-mile calibration buffer.
- **Land Use and Cropping Patterns**: Based on the published C2VSimFG v1.0. Since 1998, the only area of recent agricultural expansion is near the Sutter Buttes. Otherwise, land use is considered to have changed relatively little since 1998.
- **Urban Water Demand**: Calculated for the Subbasin’s urban areas, including the cities of Yuba City and Live Oak. Demands for other domestic areas are estimated based on rural population. Urban water demand is based on:
    - Urban water use is based on the published C2VSimFG v1.0.
    - Urban center population was estimated based on data from the U.S. Census and updated using local data.
- **Surface Water Deliveries**: Deliveries to agricultural and urban areas based on the published C2VSimFG v1.0 with refinements due to local agency information.
- **Groundwater Pumping**: Simulated by C2VSimFG-Sutter.
    - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter model.

5.3.4.2 Assumptions Used in the Current Conditions Water Budget

The current conditions water budget represents a recent level of development and agricultural demand.

The current conditions water budget includes the following assumptions:

- **Hydrologic Period**: WY 2013

- **Stream Flows**: WY 2013
- **Reservoir Operations**: Based on the published C2VSimFG v1.0. While Oroville Dam, Nimbus Dam, Shasta Dam (among others) lie upstream and mediate flow into the Sacramento and Feather Rivers, there are no reservoir operations modeled within the Sutter Subbasin boundary or the five-mile calibration buffer.
- **Land Use and Cropping Patterns**: Consistent with the historical model for WY 2013. Land use from WY 2013 is considered to represent current conditions based on local knowledge that land use changed relatively little between 2013 and 2021.
- **Urban Water Demand**: Urban water demands are consistent with the historical model WY 2013 and calculated for all the urban areas in the model, including the cities of Yuba City and Live Oak.
- **Surface Water Deliveries**: Consistent with the historical model for WY 2013.
- **Groundwater Pumping**: Simulated by C2VSimFG-Sutter.
  - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter model.

5.3.4.3 Assumptions Used in the Projected Conditions Water Budget

The projected conditions water budget is intended to assess the conditions of the Subbasin under future conditions of water supply and agricultural and urban demand, including quantification of uncertainties in the components. The projected conditions scenario applies future land and water use conditions and uses a 60-year hydrologic period simulated by using WY 1996 through 2015 hydrology repeated three times. The model is assumed to represent 2040 conditions in progress toward full buildout. These conditions are represented using projected population, land use, and water demand and supply projections. Results of the projected conditions scenario under potential climate change conditions (changes to precipitation, stream flows, and evapotranspiration) are presented in **Section 5.3.5.3**.

The projected conditions scenario includes the following conditions:

- **Hydrologic Period**: WYs 1996 through 2015, repeated three times for a 60-year projected hydrology.
- **Stream Flows**: Historical model WYs 1996 through 2015, repeated three times for 60-year projected hydrology.
- **Reservoir Operations**: Unchanged from historical model.
- **Land Use and Cropping Patterns**: Based on local information received from the Sutter Subbasin Groundwater Sustainability Agencies (GSAs) on expected changes to their crop distribution at the end of the historical model (WY 2015). The cities of

Live Oak and Yuba City are assumed to buildout to their sphere of influence boundaries.

- **Urban Water Demand**: Calculated for all the urban areas in the model, including the cities of Yuba City and Live Oak, based on growth applied to the last year of the historical simulation (WY 2015). Population in Sutter Subbasin is assumed to grow at the same rate as it did in the last 12 years of the historical simulation, projected out to 2040.
- **Agricultural Operations**: Operations in the projected model are based on the conditions simulated at the end of the historical model.
- **Surface Water Deliveries**: Based on historical diversion time series. The most recent 12 years of diversions were averaged by water year type. These diversions were projected into the future using the 60-year hydrologic period to determine the pattern of water year types.
    - Sutter National Wildlife Refuge (NWR) Diversions: Projected model simulates Sutter NWR Diversions at monthly ideal delivery schedule for full Level 4 water supply demand through the Refuge Water Supply Program (RWSP) provided by US Bureau of Reclamation (G. Young, personal communication, February 24, 2021)[1]. This monthly schedule is used for all years in the projected model.
- **Groundwater Pumping**: Simulated by C2VSimFG-Sutter.
    - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter model.

5.3.4.4 Assumptions Used in the Projected Conditions with Climate Change Water Budget

The projected conditions water budget with climate change is intended to assess the impact of climate change under future conditions of water supply and agricultural and urban demand. The projected conditions with climate change scenario applies the same future land and water use conditions as the projected conditions scenario and uses the simulated 60-year hydrologic period (WYs 1996 through 2015 repeated three times) that is used in the projected conditions scenario. The climate change impacts evaluated in the model are assumed to represent 2070 precipitation, evapotranspiration, and streamflow conditions. Climate change conditions were estimated using 2070 central tendency datasets provided by DWR. These datasets were derived from output produced by an ensemble of global climate models chosen by DWR to best represent

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[1] Sutter NWR ideal delivery schedule for Full Level 4 water supply demand was received through email communication from Greg Young of Tully & Young.

impacts of climate change in California. Further detail on how these datasets were developed and adapted to the Sutter Subbasin can be found in **Appendix 5-H**.

The projected conditions with climate change scenario includes the following conditions:

- **Hydrologic Period**: WYs 1996 through 2015, repeated three times for a 60-year projected hydrology.
- **Stream Flows**: Historical model WYs 1996 through 2015, repeated three times for a 60-year projected hydrology, modified by watershed-specific perturbation factors reflecting 2070 climate change conditions provided by DWR.
- **Reservoir Operations**: Unchanged from historical model.
- **Land Use and Cropping Patterns**: Same as projected conditions model.
- **Urban Water Demand**: Same as projected conditions model. Urban landscape evapotranspiration is increased to reflect increasing temperatures under 2070 climate change conditions using the Variable Infiltration Capacity (VIC) model-derived perturbation factors provided by DWR.
- **Agricultural Operations**: Operations in the projected model are based on the conditions simulated at the end of the historical model. Agricultural evapotranspiration is increased to reflect increasing temperatures under 2070 climate change conditions using VIC model-derived perturbation factors provided by DWR.
- **Surface Water Deliveries**: Same as projected conditions model.
- **Groundwater Pumping**: Simulated by the C2VSimFG-Sutter model.
    - Data on private pumping was not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter model

5.3.5 Water Budget Estimation

The C2VSimFG-Sutter model simulates the major hydrologic processes that affect the surface and groundwater systems in the Sutter Subbasin. The major hydrologic processes can be represented by separate water budgets which detail inflows and outflows occurring at the surface scale (budget balancing how demands on urban, agricultural, and native lands are met by rainfall, surface water deliveries available from streamflow, or groundwater pumping) and at the groundwater scale (budget detailing flows occurring within the groundwater aquifers of the Subbasin).

The primary components of the surface system are:

- **Inflows**:
    - Precipitation

  - Surface water supplies to meet agricultural, urban, or managed wetlands uses
  - Groundwater pumping (i.e., groundwater supplies to meet agricultural, urban, industrial, and managed wetlands uses)
  - Riparian intake from streams
- **Outflows**:
  - Evapotranspiration
  - Runoff to the stream system
  - Return flow to the stream system
  - Deep percolation from precipitation, applied water (surface water and groundwater) for agricultural lands, and applied water (surface water and groundwater) for outdoor use in the urban areas or industrial purposes

The primary components of the groundwater system are:

- **Inflows**:
  - Deep percolation from precipitation, applied water (surface water and groundwater) for agricultural lands, and applied water (surface water and groundwater) for refuge use
  - Stream seepage (i.e., losses from Sacramento River, Feather River, and Sutter Bypass to the groundwater system)
  - Land subsidence inflow
  - Conveyance seepage
  - Subsurface inflow
- **Outflows**:
  - Groundwater outflow to streams (i.e., loss from the groundwater system to or stream gains for Sacramento River, Feather River, and Sutter Bypass)
  - Groundwater pumping
  - Subsurface outflow (i.e., to surrounding subbasins)
- **Change in Groundwater Storage (Inflows Minus Outflows)**: This reflects average annual change in groundwater storage.

The estimated water budgets for the historical, current conditions, projected conditions, and projected conditions with climate change scenarios are provided below, with results summarized in **Table 5-12** and **Table 5-13**.

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Table 5-12. Average Annual Surface System Water Budget Components

Component	Historical Calibration (AF/year)	Current Conditions (AF/year)	Projected Conditions (AF/year)	Projected Conditions With Climate Change (2070 CT) (AF/year)
Hydrologic Period	**WY 1996-2015**	**WY 2013**	**WY 1996-2015 Repeated 3 Times**	**WY 1996-2015 Repeated 3 Times with Climate Change**
Inflows				
Precipitation	455,000	417,000	454,000	480,000
Surface Water Delivery [1]	572,000	629,000	579,000	578,000
Agricultural	522,000	584,000	479,000	479,000
Urban	14,000	18,000	15,000	15,000
Managed Wetlands	36,000	27,000	85,000	84,000
Groundwater Pumping	139,000	155,000	138,000	157,000
Agricultural	130,000	149,000	105,000	123,000
Urban	8,000	5,000	22,000	22,000
Managed Wetlands	1,000	1,000	11,000	12,000
Riparian Intake from Streams [2]	27,000	28,000	14,000	15,000
Total Inflow	***1,193,000***	***1,229,000***	***1,185,000***	***1,230,000***
Outflows				
Evapotranspiration [3]	604,000	627,000	645,000	690,000
Agricultural	509,000	538,000	548,000	588,000
Urban	9,000	9,000	24,000	25,000
Managed Wetlands	6,000	6,000	20,000	21,000
Native and Riparian Vegetation	80,000	74,000	53,000	56,000
Runoff to Streams [4]	150,000	136,000	143,000	166,000
Return Flow to Streams [5]	252,000	257,000	218,000	200,000
Agricultural	186,000	190,000	107,000	90,000
Urban	13,000	13,000	22,000	22,000
Managed Wetlands	27,000	18,000	57,000	56,000
Pond Drain	26,000	36,000	32,000	32,000
Deep Percolation [6]	189,000	203,000	179,000	174,000
Precipitation	57,000	54,000	54,000	52,000
Applied Surface Water [7]	106,000	120,000	101,000	96,000
Applied Groundwater [8]	26,000	29,000	24,000	26,000
Total Outflow [9]	***1,195,000***	***1,223,000***	***1,185,000***	***1,230,000***
Change in Storage [10]	**-2,000**	**6,000**	**0**	**0**

[1] Surface water deliveries shown in this table are the volumes of water delivered to the different areas of the Subbasin. These totals are after losses due to evaporation and canal seepage. Differences between scenarios are due to differences in current and planned surface water deliveries.

[2] Riparian intake from streams is the portion of the riparian vegetation evapotranspiration met by stream flows. Differences between scenarios may be due to availability of stream flows or extent of riparian vegetation, which may be affected by growth in urban areas.

[3] Evapotranspiration is the demand required by agricultural land (i.e., crops); municipal and domestic areas (i.e., urban demands); and refuge, native, and riparian areas. Differences in evapotranspiration are largely related to differences in urban areas between the scenarios and the loss of agricultural or native/riparian land as urban growth occurs. Temperature increases under climate change account for higher evapotranspiration rates under the projected conditions climate change scenario.

[4] Runoff to the stream system is due to precipitation. As urban areas are assumed to have greater runoff of precipitation (resulting from more paved area), the changes in runoff between the model scenarios are largely due to differences in the size of urban areas and the amount of precipitation the occurs in the historical/current/projected scenarios.

[5] Return flow to the stream system is due to applied water, either surface water or groundwater used for agricultural, urban, or managed wetland purposes. Differences between the scenarios is primarily related to the urban growth in the projected conditions scenario causing higher urban demand in relation to agricultural demand. This results in less applied water to irrigable lands that can return to the streams. Increases in surface water flows to Sutter National Wildlife Refuge in the projected conditions scenario also accounts for some of the differences.

[6] Deep percolation is the amount of infiltrated water ultimately reaching the groundwater system. The source of the water may be from precipitation or applied water used for agricultural, urban, or managed wetland purposes. Differences between scenarios are related to differences already noted between these sources of water and differences in the infiltration parameters related to land use.

[7] Applied surface water is the volume of delivered surface water that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences between scenarios are due to differences in current and planned surface water deliveries and crop types.

[8] Applied groundwater is the volume of delivered groundwater that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences in demand largely drive the amount of groundwater pumped and therefore applied.

[9] Summations in table may not match the numbers in the table. This is due to the rounding of model results.

[10] Change in storage in the surface system water budget refers to the change in root zone soil moisture.

Table 5-13. Average Annual Groundwater System Water Budget Components

Component	Historical Calibration (AF/year)	Current Conditions (AF/year)	Projected Conditions (AF/year)	Projected Conditions With Climate Change (2070 CT) (AF/year)
Hydrologic Period	**WY 1996-2015**	**WY 2013**	**WY 1996-2015 Repeated 3 Times**	**WY 1996-2015 Repeated 3 Times with Climate Change**
Inflows				
Deep Percolation [1]	189,000	203,000	179,000	174,000
Precipitation [2]	57,000	54,000	54,000	52,000
Applied Surface Water [3]	106,000	120,000	101,000	96,000
Applied Groundwater [4]	26,000	29,000	24,000	26,000
Stream Seepage[5]	143,000	127,000	125,000	137,000
Sacramento River	63,000	60,000	64,000	69,000
Feather River	32,000	28,000	19,000	21,000
Sutter Bypass	48,000	39,000	42,000	47,000
Land Subsidence Inflow	0	0	0	0
Conveyance Seepage	36,000	39,000	37,000	37,000
Subsurface Inflow [6]	88,000	83,000	145,000	152,000
Butte Subbasin	26,000	26,000	36,000	37,000
Colusa Subbasin	21,000	19,000	21,000	20,000
North American Subbasin	1,000	0	15,000	16,000
North Yuba Subbasin	7,000	5,000	16,000	18,000
South Yuba Subbasin	9,000	10,000	28,000	29,000
Wyandotte Creek Subbasin	0	0	0	0
Yolo Subbasin	17,000	17,000	23,000	25,000
Sutter Buttes	7,000	6,000	6,000	7,000
Total Inflow	***456,000***	***452,000***	***486,000***	***500,000***
Outflows				
Groundwater Outflow to Streams [5]	224,000	212,000	268,000	263,000
Sacramento River	125,000	124,000	139,000	141,000
Feather River	54,000	52,000	80,000	77,000
Sutter Bypass	45,000	36,000	49,000	45,000
Groundwater Pumping [7]	139,000	155,000	138,000	157,000
Agricultural	130,000	149,000	105,000	123,000
Urban	8,000	5,000	22,000	22,000
Managed Wetlands	1,000	1,000	11,000	12,000
Subsurface Outflow [6]	100,000	104,000	79,000	79,000
Butte Subbasin	15,000	15,000	13,000	12,000
Colusa Subbasin	34,000	36,000	35,000	36,000
North American Subbasin	13,000	15,000	1,000	1,000
North Yuba Subbasin	7,000	7,000	3,000	3,000
South Yuba Subbasin	5,000	4,000	2,000	2,000
Wyandotte Creek Subbasin	2,000	2,000	2,000	2,000
Yolo Subbasin	24,000	25,000	23,000	23,000
Total Outflow [8]	**463,000**	**471,000**	**485,000**	**499,000**
Change in Groundwater Storage	**-7,000**	**-19,000**	**1,000**	**1,000**

[1] Deep percolation is the amount of infiltrated water ultimately reaching the groundwater system. The source of the water may be from precipitation or applied water used for agricultural, urban, or managed wetland purposes. Differences between scenarios are related to differences already noted between these sources of water and differences in the infiltration parameters related to land use.

[2] Precipitation includes the amount of precipitation that ultimately enters the groundwater system as deep percolation. Table 5-12 shows the total precipitation that falls in the Sutter Subbasin on an average annual basis.

[3] Applied surface water is the volume of delivered surface water that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences between scenarios are due to differences in current and planned surface water deliveries and crop types.

[4] Applied groundwater is the volume of delivered groundwater that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences in demand largely drive the amount of groundwater pumped and therefore applied.

[5] Streams interacting with Sutter Subbasin include Feather River, Sacramento River, and Sutter Bypass. Stream gain from groundwater and stream seepage represent the interactions between surface water and groundwater. Differences between the scenarios are related to differing hydrologic periods and differences in stream flows and long-term average groundwater elevations.

[6] Subsurface inter-basin flows are estimated by the C2VSimFG-Sutter model to maintain a reasonable balance between the neighboring groundwater subbasins. Continuing inter-basin coordination may refine these numbers.

[7] Groundwater pumping is estimated by the C2VSimFG-Sutter model based on the need for additional water to meet remaining demands after surface water deliveries occur. Differences in demand largely drive the amount of groundwater pumped.

[8] Summations in table may not match the numbers in the table. This is due to the rounding of model results.

5.3.5.1 Historical Conditions Water Budget Estimates

The historical water budget in **Table 5-12** and **Table 5-13** is a quantitative tabulation of the historical surface and groundwater systems as represented in the historical simulation of the C2VSimFG-Sutter model covering the 20-year period of WYs 1996 through 2015. The historical calibration is discussed in detail in the historical model documentation (**Appendix 5-G**). Per the GSP Emergency Regulations §354.18, the water budget includes estimates for supply and demand while summarizing flows within the Subbasin, including the movement of all primary sources of water such as precipitation, agricultural water supplies, stream interaction, and subsurface flows. The stream network that borders the Sutter Subbasin supplies water to multiple agricultural water users as well as Yuba City. Stream interactions and managed operations in adjacent groundwater subbasins that share a stream boundary with Sutter Subbasin may impact water budget estimations within Sutter Subbasin. The largest boundary is shared with North and South Yuba Subbasins along Feather River and the Colusa Subbasin along Sacramento River.

The surface system water budget in the historical calibration of the Sutter Subbasin, shown in **Figure 5-101**, estimates almost 1.19 million acre-feet per year (MAF/year) of inflows resulting from a combination of precipitation (455,000 acre-feet [AF]/year), surface water supply (572,000 AF/year), groundwater supply (139,000 AF/year), and riparian intake from streams (27,000 AF/year). The outflow from the surface system in the historical calibration (also estimated to be around 1.19 MAF/year) is comprised of evapotranspiration (close to 604,000 AF/year), runoff to the stream system (150,000 AF/year), return flow of applied water to the stream system (252,000 AF/year), and deep percolation of precipitation or applied water (189,000 AF/year). Approximately 91% of surface water deliveries are used for agricultural use, with 6% for managed wetlands and 2% for urban. The historical model indicates that approximately 84% of evapotranspiration losses occur from agriculture and 13% from native and riparian vegetation, with the remaining 3% for urban and managed wetlands.

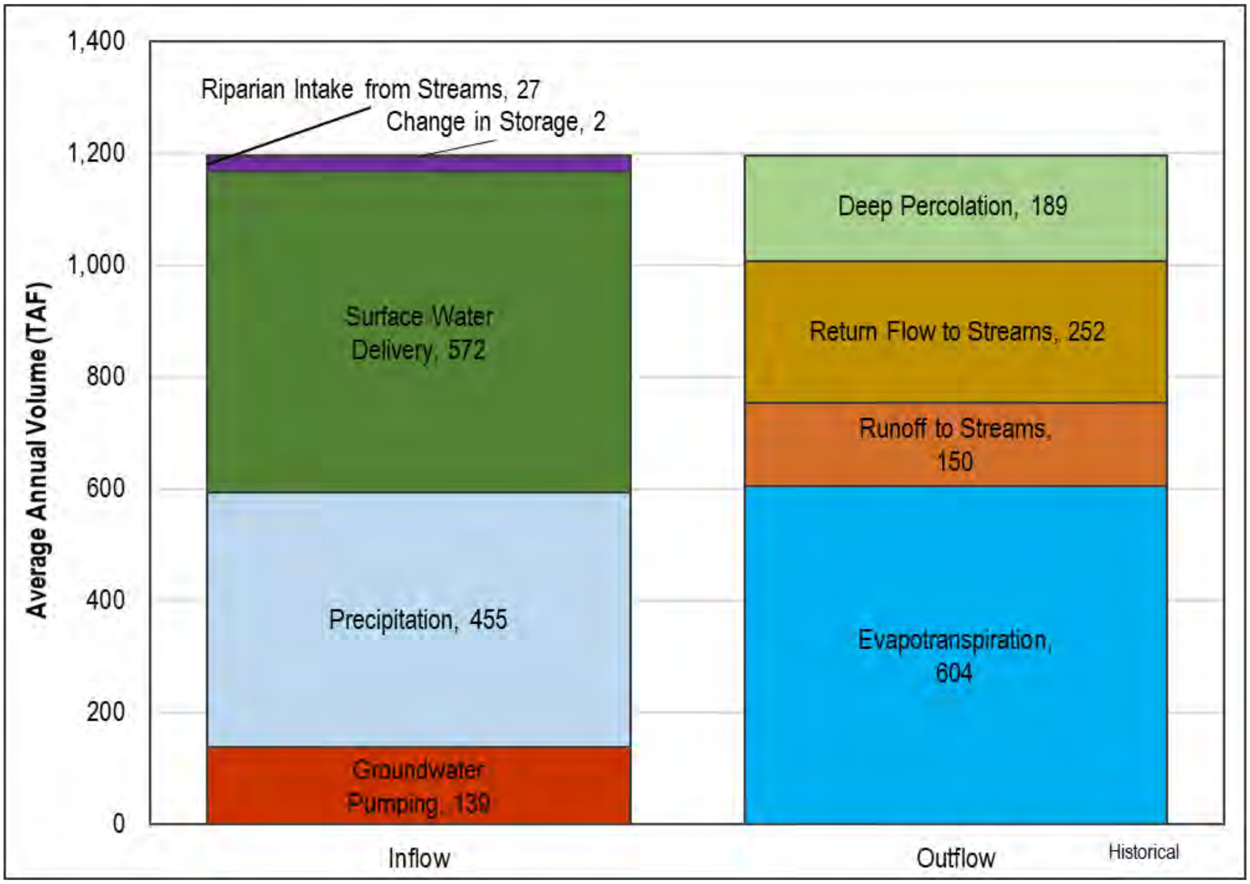

Figure 5-101. Historical Average Annual Water Budget – Surface System

The groundwater system of the Sutter Subbasin includes 456,000 AF/year of inflows in the historical calibration (not including change in groundwater storage), of which 189,000 AF/year is deep percolation of precipitation or applied water (groundwater and surface water). There is also stream seepage (143,000 AF/year), and subsurface inflows (88,000 AF/year) from the neighboring groundwater subbasins of Colusa, Yolo, North American, North and South Yuba, Butte, and a very small portion from Wyandotte Creek Subbasin. Sutter Buttes also contributes subsurface inflows. The primary outflow from the groundwater system is groundwater pumping (139,000 AF/year), followed by loss to streams (net 81,000 AF/year). Subsurface outflow to the neighboring groundwater subbasins is approximately 100,000 AF/year. Approximately 93% of the groundwater pumping from the groundwater system is for agricultural use and 6% for urban use.

The Sutter Subbasin average historical groundwater budget has slightly greater outflows than inflows, leading to an estimated average annual decrease in groundwater storage of approximately 7,000 AF/year. **Figure 5-102** summarizes the average historical calibration groundwater inflows and outflows of the Sutter Subbasin.

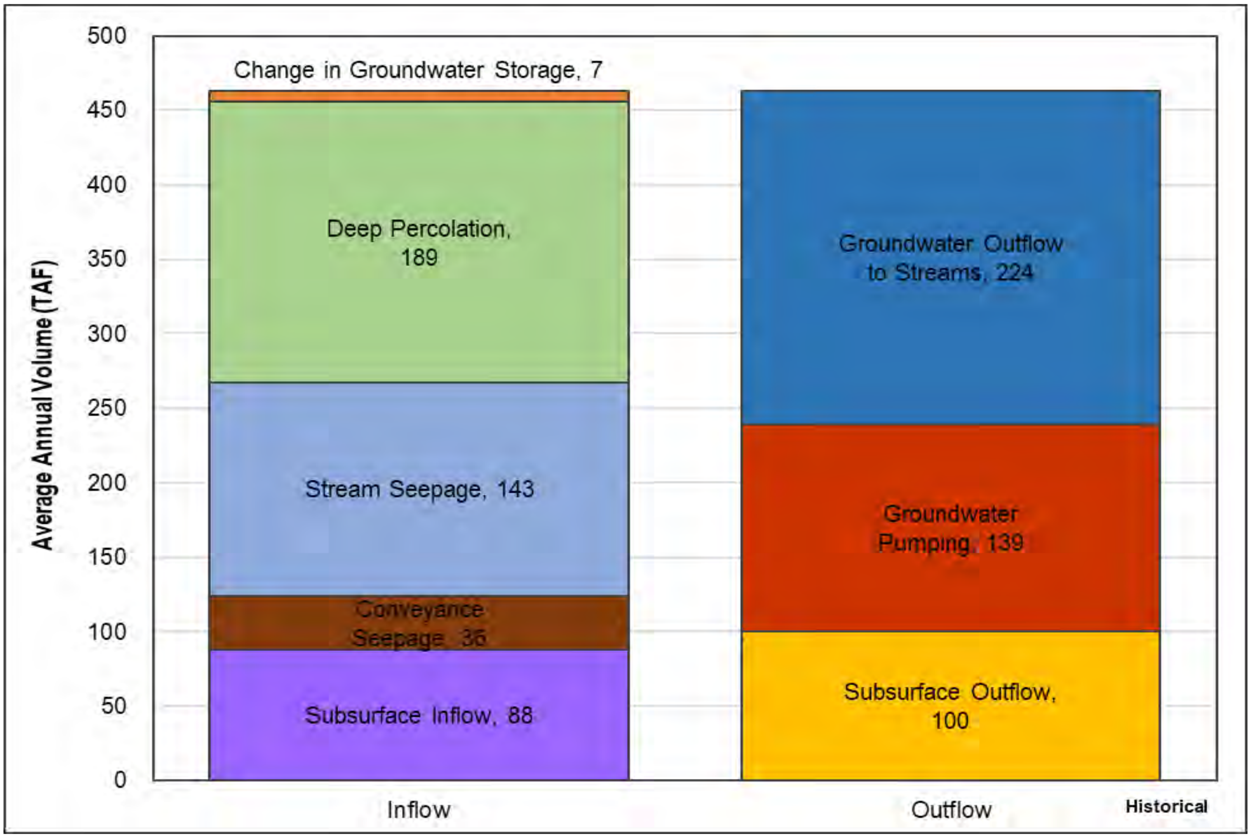

Figure 5-102. Historical Average Annual Water Budget – Groundwater System

Table 5-14 shows a breakdown of the major water budget components of the surface and groundwater systems by percentage use, including a change in overall groundwater storage of 7,000 AF/year. This constitutes a 0.014% change as a percent of the 49 MAF of total storage available.

Figure 5-103 shows the urban, agricultural (ponded and non-ponded crops), and managed wetlands supplies and demands from the previous tables broken down annually. Supplies are divided out by water source, either groundwater or surface water. Supplies are displayed as positive and demands as negative. **Figure 5-104** shows groundwater pumping annually plotted with annual change in storage. The cumulative change in storage is included throughout the water budget calibration period. In dry years with high groundwater pumping, there is a negative annual change in storage and the cumulative change in storage drops. This can be observed during the most recent 2012-2015 drought. In wetter years, the groundwater gains storage and therefore the change in storage is positive and there is an increase in the cumulative change in storage.

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Table 5-14. Average Annual Water Budget Surface Water and Groundwater Major Components by Use

Component	Historical Calibration (thousand acre-feet [TAF]/year)	Current Conditions (TAF/year)	Projected Conditions (TAF/year)	Projected Conditions With Climate Change (2070 CT) (TAF/year)
Hydrologic Period	**WY 1996-2015**	**WY 2013**	**WY 1996-2015 Repeated 3 Times**	**WY 1996-2015 Repeated 3 Times with Climate Change**
Surface System Major Components				
Precipitation	455	417	454	480
Surface Water Delivery	572	629	579	578
Agricultural	91%	93%	83%	83%
Urban	2%	3%	3%	3%
Managed Wetlands	6%	4%	15%	15%
Evapotranspiration	604	627	645	690
Agricultural	84%	86%	85%	85%
Urban	2%	2%	4%	4%
Managed Wetlands	1%	1%	3%	3%
Native and Riparian Vegetation	13%	12%	8%	8%
Groundwater System Major Components				
Net Groundwater Outflow to Streams	81	85	143	126
Groundwater Pumping	139	155	138	157
Agricultural	93%	96%	77%	79%
Urban	6%	3%	16%	14%
Managed Wetlands	1%	1%	8%	7%
Change in Groundwater Storage	7	19	-1	-1
As Percent of Overall Groundwater Storage (~49 MAFY)	0.014%	0.039%	-0.002%	-0.002%

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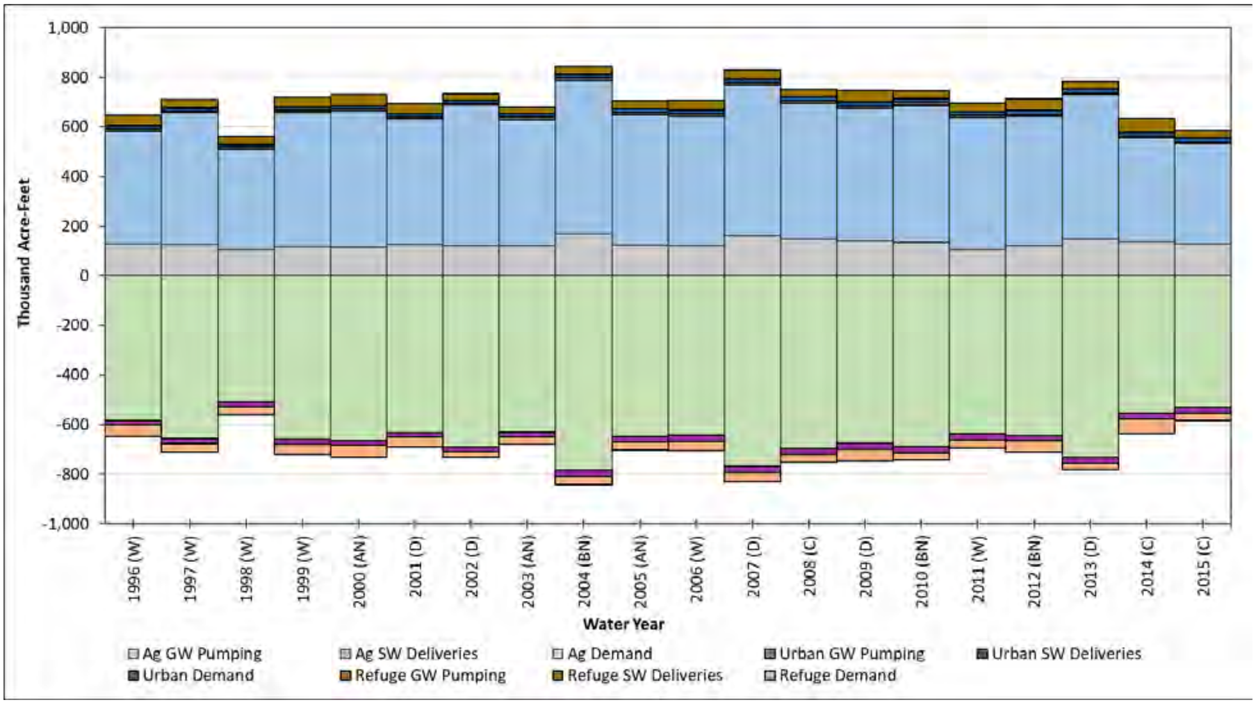

Figure 5-103. Urban, Agricultural, and Refuge Demand and Supply [1]

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[1] Refuge in this figure refers to managed wetlands in Sutter Subbasin.

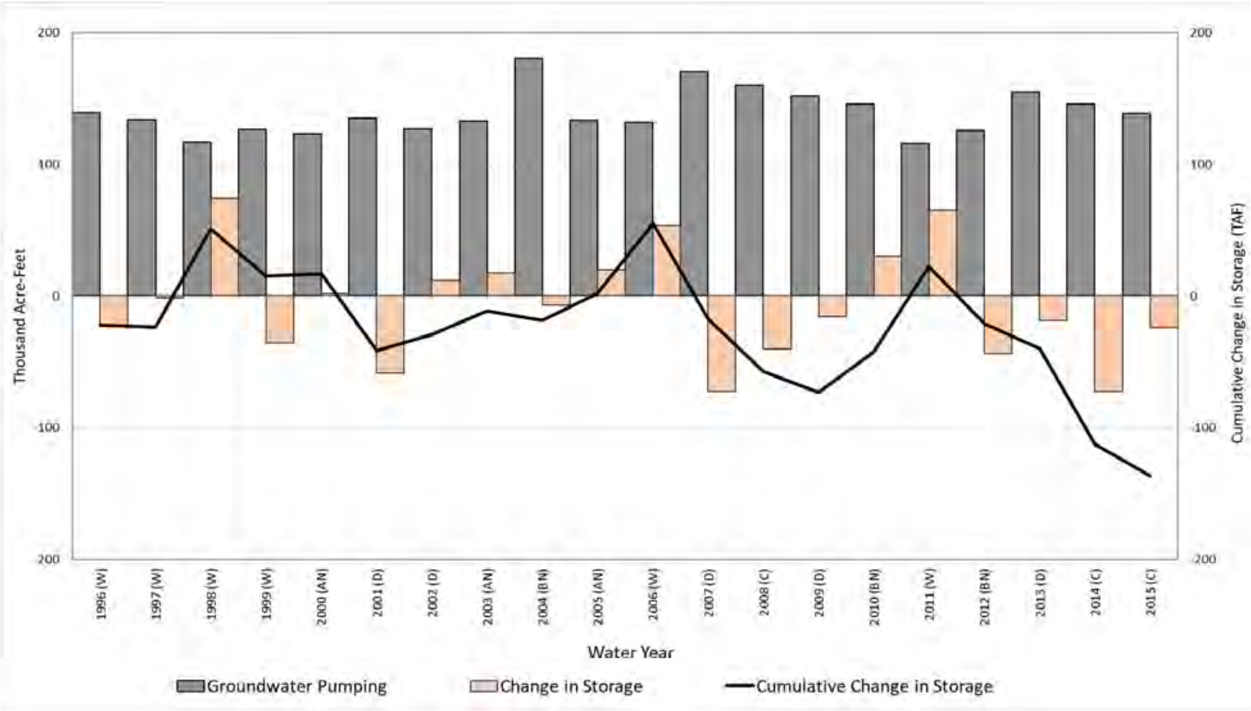

Figure 5-104. Groundwater Pumping and Change in Storage

5.3.5.2 Current Conditions Water Budget Estimates

The current conditions water budget in **Table 5-12** and **Table 5-13** represents a quantitative tabulation of WY 2013 extracted from the historical calibration of the C2VSimFG-Sutter model. As described in **Section 5.3.4**, the current conditions scenario is meant to simulate the most representative conditions available in the model at the time this GSP was written.

The surface system water budget in the current conditions scenario is shown below in **Figure 5-105**. There are an estimated 1.23 MAF/year of inflows, approximately 40,000 AF/year higher than the historical model. This total is a combination of precipitation (417,000 AF/year), surface water supply (629,000 AF/year), groundwater supply (155,000 AF/year), and riparian intake from streams (28,000 AF/year). The outflow from the land surface system in the current conditions scenario estimates evapotranspiration (627,000 AF/year), runoff to the stream system (36,000 AF/year), return flow of applied water to the stream system (257,000 AF/year), and deep percolation of precipitation or applied water (203,000 AF/year). Approximately 93% of surface water deliveries are used for agricultural use, 4% for managed wetlands, and 3% for urban.

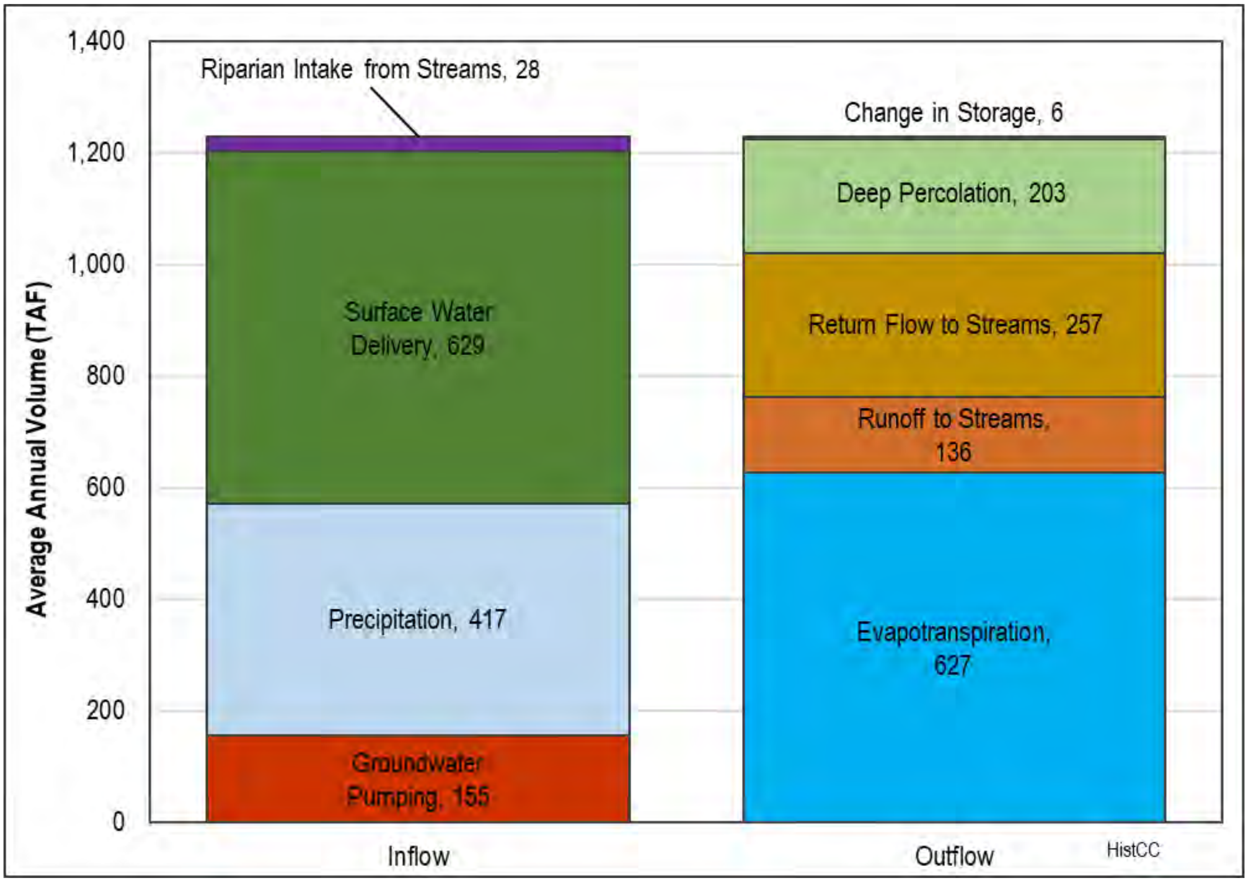

Figure 5-105. Current Conditions Average Annual Water Budget – Surface System

The groundwater system of the Sutter Subbasin (**Figure 5-106**) includes 471,000 AF/year of inflows in the current conditions (not including change in groundwater storage), of which 203,000 AF/year is deep percolation of precipitation or applied water (groundwater and surface water). There is also stream seepage (127,000 AF/year), and subsurface inflows (144,000 AF/year) from the neighboring groundwater subbasins of Colusa, Yolo, North American, North and South Yuba, Butte, and a very small portion from Wyandotte Creek Subbasin. Sutter Buttes also contributes subsurface inflows. Conveyance seepage also contributes water to the groundwater system, estimated to be approximately 39,000 AF/year. The primary outflow from the groundwater system is loss to streams (net 86,000 AF/year), followed by groundwater pumping (155,000 AF/year). Subsurface outflow to the neighboring groundwater subbasins is approximately 104,000 AF/year. Approximately 96% of the groundwater pumping from the groundwater system is for agricultural use and 3% for urban use.

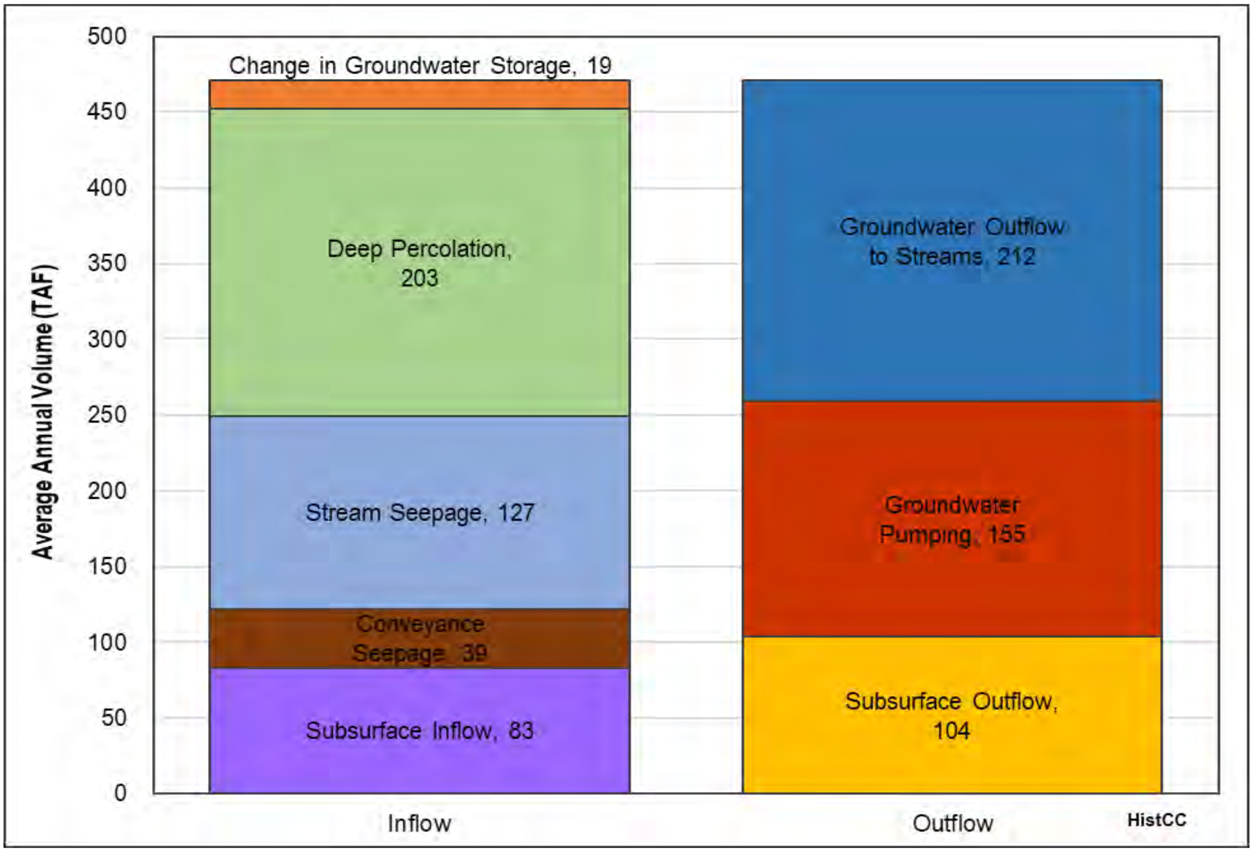

Figure 5-106. Current Conditions Average Annual Water Budget – Groundwater System

The Sutter Subbasin average current conditions groundwater budget has slightly greater outflows than inflows, leading to an estimated average annual decrease in groundwater storage of approximately 19,000 AF/year. This change is storage is approximately 0.039% of the estimated 49 MAF of groundwater in storage, a relatively small change in comparison to the total overall available groundwater storage. **Table 5-14** includes this change is storage as compared to the historical model as well as the surface and groundwater major components broken down by use.

5.3.5.3 Projected Conditions Water Budget Estimates

The projected conditions water budget is used to estimate future baseline conditions of supply, demand, and aquifer response to GSP implementation. The projected conditions scenario of the C2VSimFG-Sutter model is used to evaluate the projected conditions water budget assuming a 2040 level of development and using hydrology from WYs 1996 through 2015, repeated three times to meet the minimum 50-year projection requirement. Results of the projected conditions scenario under potential climate change conditions (changes to precipitation, stream flows, and evapotranspiration) are presented in **Section 5.3.5.4**.

Development of the projected water demand is based on historical population growth trends projected into the future and urban per capita water use consistent with projections in 2015. An important assumption made in the projected conditions water budget analysis is that, due to projected urban buildout in the cities of Live Oak and Yuba City, agricultural acreage is expected to decrease by approximately 15,000 acres over the projected period. This buildout and population growth drives more urban pumping in the projected conditions compared to the historical or current conditions.

The surface water budget for the projected conditions scenario has annual average inflows and outflows of 1,185,000 AF/year. Inflows consist of precipitation (454,000 AF/year), surface water supply (579,000 AF/year), groundwater supply (138,000 AF/year), and riparian intake from streams (14,000 AF/year). The balance of this is the summation of average annual evapotranspiration (645,000 AF/year), runoff of precipitation to the stream system (143,000 AF/year), return flow of applied water to the stream system (218,000 AF/year), and deep percolation (179,000 AF/year). A summary of these flows can be seen below in **Figure 5-107**.

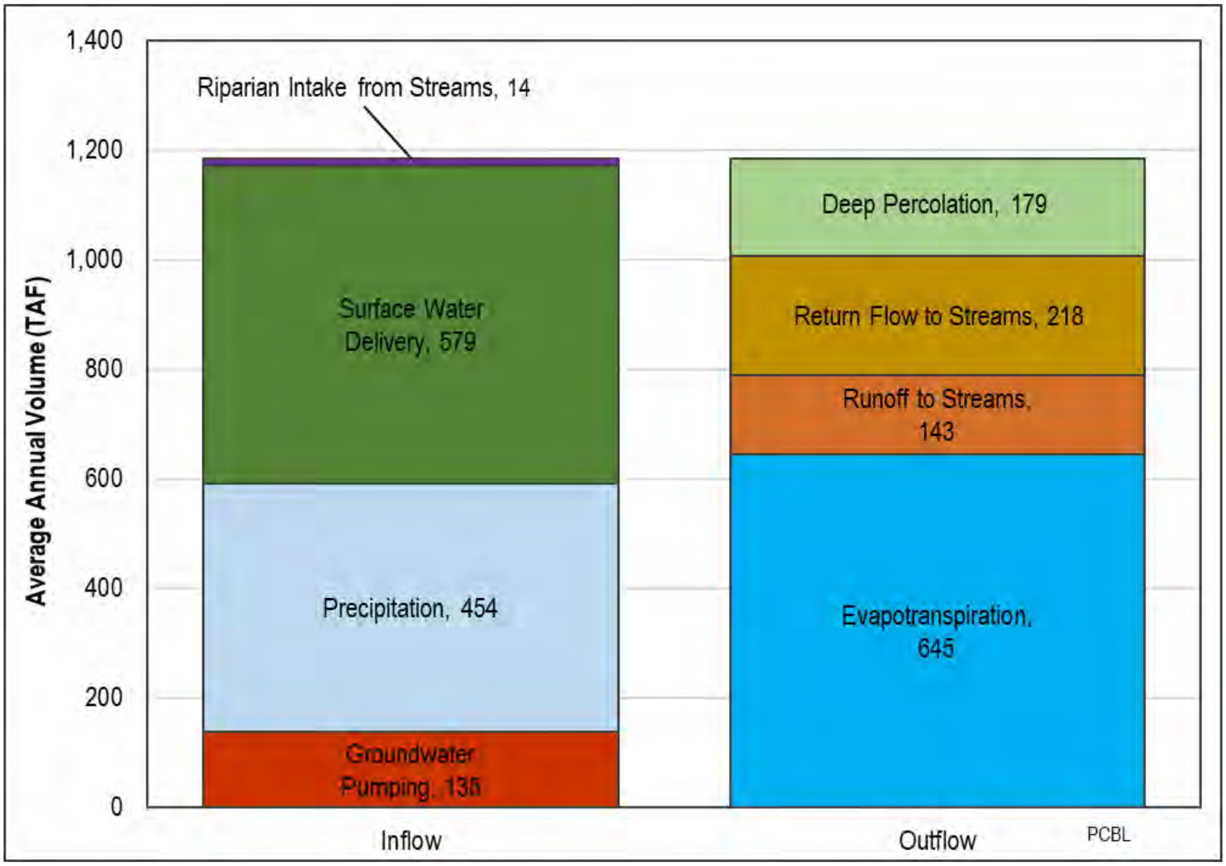

Figure 5-107. Projected Conditions Average Annual Water Budget – Surface System

Figure 5-108 summarizes the average projected groundwater inflows and outflows in Sutter Subbasin under projected conditions. The groundwater system experiences an average of 485,000 AF/year of inflows each year, of which 179,000 AF/year is deep percolation under projected conditions. There is estimated to be 125,000 AF/year of stream seepage inflow, which is less than historical conditions, and subsurface inflows from neighboring subbasins are estimated to be 144,000 AF/year, a significant increase from historical model estimations. Groundwater outflows to streams is approximately 268,000 AF/year and subsurface outflow are estimated to be 80,000 AF/year. Groundwater pumping is not expected to change significantly from historical levels (138,000 AF/year) under projected future conditions.

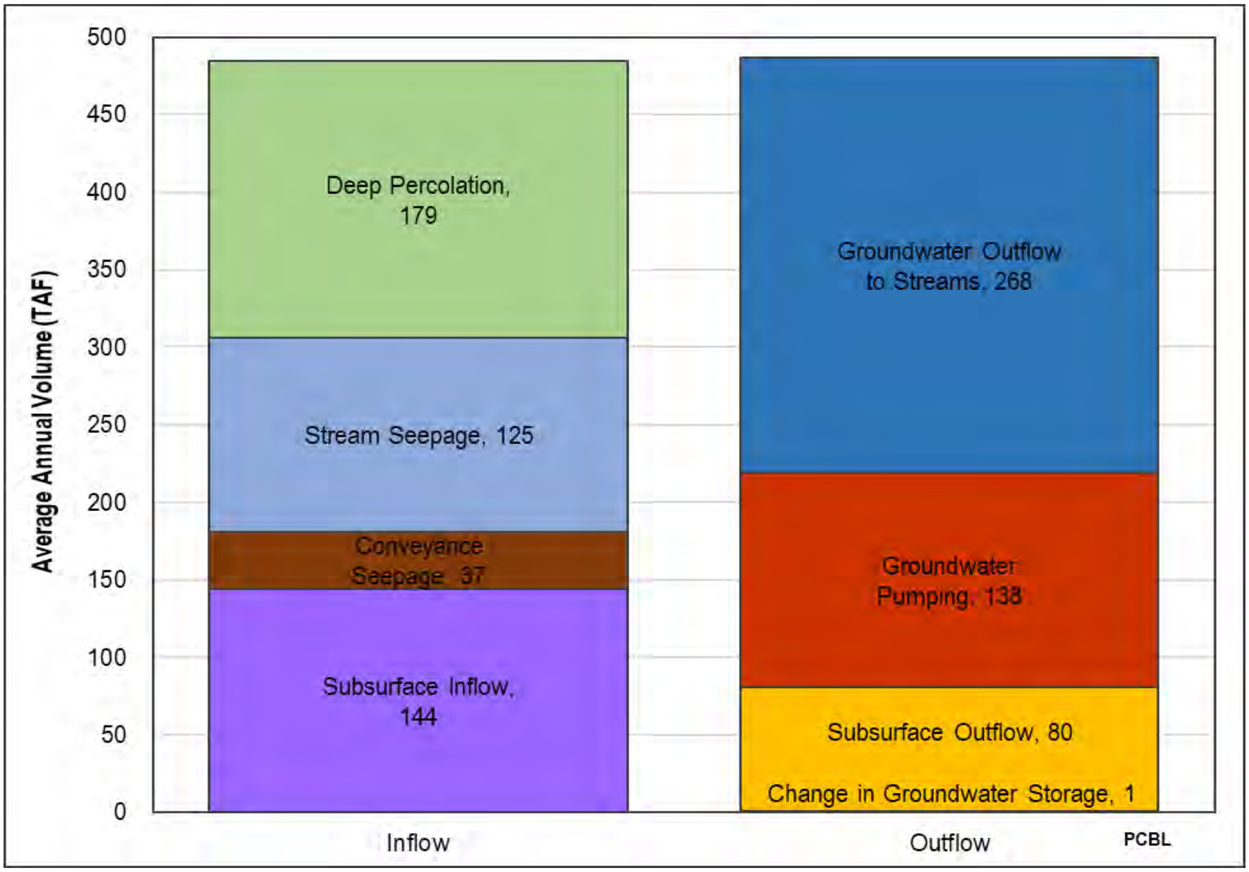

Figure 5-108. Projected Conditions Average Annual Water Budget – Groundwater System

The projected conditions water budget has only slightly greater outflows than inflows, resulting in an average annual increase in groundwater storage of 1,300 AF/year. This is a negligible change in comparison to the overall 49 MAF of groundwater in storage. **Table 5-14** shows the major water budget components of the surface and groundwater systems discussed above for all scenarios. Under projected conditions, only 77% of the groundwater pumping is expected to be for agricultural use in comparison to the historical model's 93% average. There are also decreases in the proportion of surface water delivered for agricultural use in comparison to historical conditions and corresponding increases in the proportion delivered to managed wetlands. Increased urban demand is expected to be met by increasing the proportion of supply from groundwater pumping. Under an ideal delivery schedule to Sutter National Wildlife Refuge, the increased demand for water is expected to come from both groundwater pumping and surface water deliveries. Overall, however, pumping and surface water delivery volumes are not expected to change significantly under projected conditions.

5.3.5.4 Projected Conditions with Climate Change Water Budget Estimates

Consistent with Section 354.18(d)(3) and Section 354.18(e) of the GSP Emergency Regulations, an analysis was performed for the Sutter Subbasin evaluating the projected conditions water budget under the influence of climate change. The regulations require that at least one climate change scenario is incorporated into the GSP. Sutter Subbasin elected to use the datasets DWR developed and provided for SGMA purposes. The following four possible scenarios were provided by DWR:

- 2030 Central Tendency
- 2070 Central Tendency
- 2070 Dry, Extreme Warming
- 2070 Wet, Moderate Warming

The projected conditions in the C2VSimFG-Sutter model were modified to include adjustments to precipitation, evapotranspiration, and streamflow to simulate the impacts of climate change using the 2070 central tendency scenario. This scenario was chosen for its useful long-term planning horizon (about 50 years) and moderate climate change impact estimations. The projected conditions with climate change water budget includes all of the assumptions of the projected conditions water budget, along with more variable precipitation and streamflow and increased evapotranspiration due to increasing temperatures.

The surface water budget for the projected conditions with climate change scenario has annual average inflows and outflows of 1,230,000 AF/year. Inflows consist of precipitation (480,000 AF/year), surface water supply (578,000 AF/year), groundwater supply (157,000 AF/year), and riparian intake from streams (15,000 AF/year). The balance of this is the summation of average annual evapotranspiration (690,000 AF/year), runoff of precipitation to the stream system (166,000 AF/year), return flow of applied water to the stream system (200,000 AF/year), and deep percolation (174,000 AF/year). A summary of these flows can be seen below in **Figure 5-109**.

Results from a comparison between the projected conditions with and without climate change show that the C2VSimFG-Sutter model estimates precipitation to increase by

6% on average and evapotranspiration to increase by 7% on average in the surface system under the 2070 central tendency climate scenario. **Appendix 5-H** includes more detail on how the datasets provided by DWR were derived as well as further explanation regarding the methods used in this analysis.

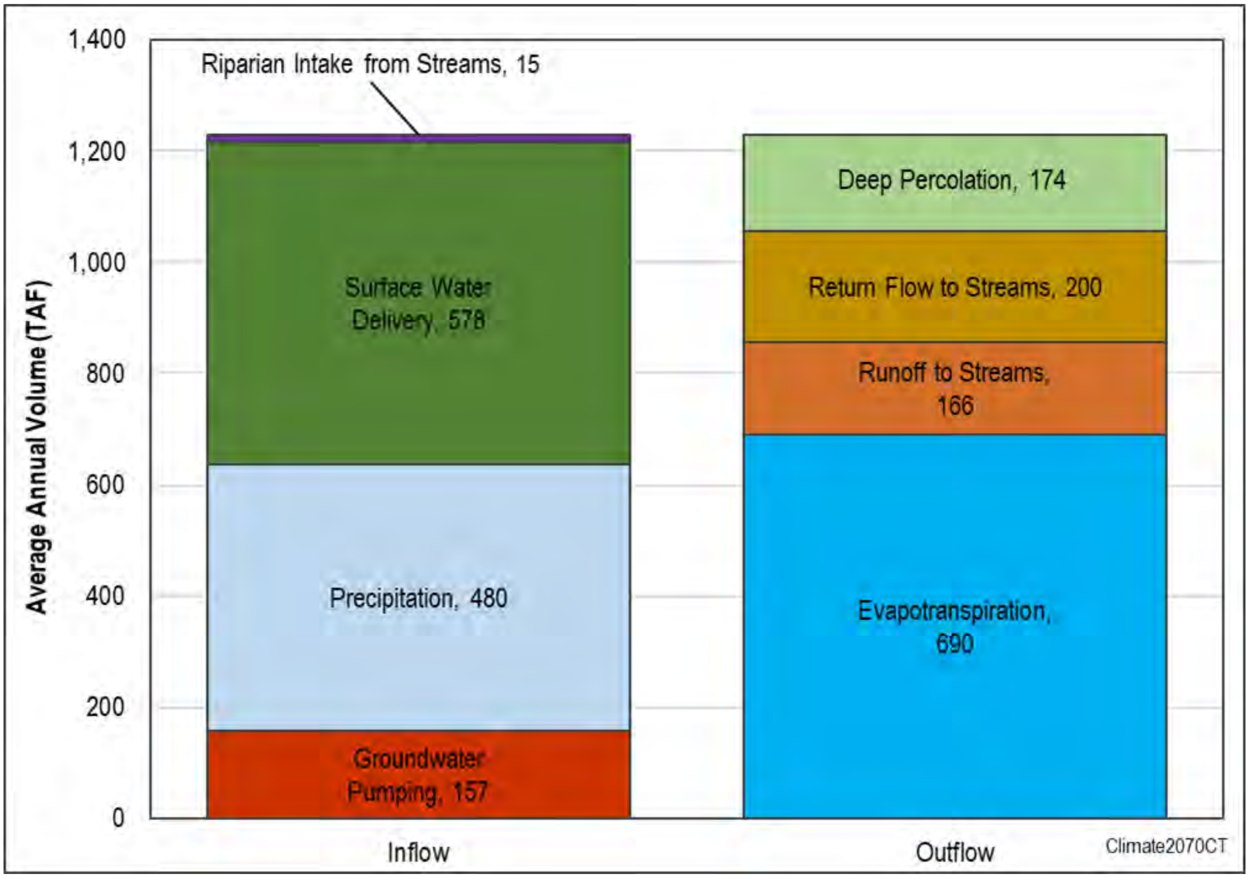

Figure 5-109. Projected Conditions with Climate Change Average Annual Water Budget – Surface System

Figure 5-110 summarizes the average projected groundwater inflows and outflows in Sutter Subbasin under projected conditions with climate change. The groundwater system experiences an average of 499,000 AF/year of inflows each year, of which 174,000 AF/year is deep percolation under projected conditions with climate change - slightly less than projected conditions without climate change. The projected conditions with climate change scenario also shows slightly less stream seepage (137,000 AF/year) than historical conditions, and subsurface inflows of 152,000 AF/year from neighboring subbasins, a significant increase from historical model estimations and also higher than projected conditions without climate change. Groundwater outflows to streams is approximately 263,000 AF/year and subsurface outflow 79,000 AF/year. Groundwater pumping is expected to increase as a result of shifting availability of streamflow and higher agricultural demand (157,000 AF/year).

The principal groundwater budget elements that are impacted by climate change are seepage to groundwater from streams (11% average increase) and groundwater pumping (14% increase), based on C2VSimFG-Sutter's estimates under the 2070 central tendency climate scenario.

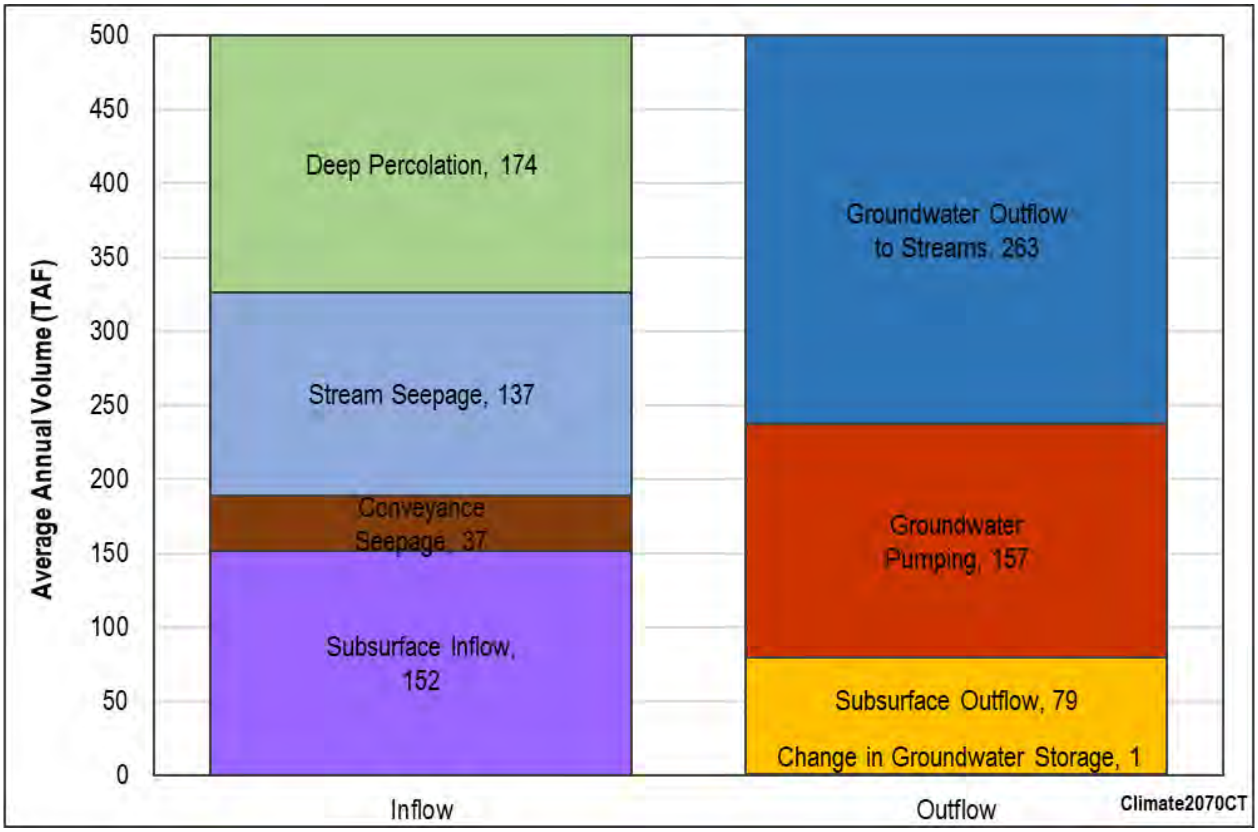

Figure 5-110. Projected Conditions with Climate Change Average Annual Water Budget – Groundwater System

Table 5-14 tabulates each of the major surface system and groundwater system components discussed in this section by the proportion of their use. Most notable may be the shifting distribution of use of groundwater pumping and surface water deliveries between historical conditions and projected conditions with climate change. Groundwater pumping for agricultural use from historical conditions to projected conditions with climate change changes from 93% to 79%. For urban use, groundwater pumping changes from a historic use of 6% to a projected use of 14%, and for managed wetlands, from 1% to 7%. Surface water deliveries change from 91% agricultural to 83% and 6% to 15% for managed wetlands. Only a small amount of surface water is used for urban use and it is not expected to change significantly with climate change conditions.

5.3.6 Estimation of Sustainable Yield

Sustainable yield is defined for SGMA purposes as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.” (CWC §10721(w)).

Sustainable yield for the Sutter Subbasin was calculated by increasing the demand over the 60-year hydrology of the projected conditions model to analyze where the change in storage is close to zero and at what point undesirable results begin to occur and impact the overall water budget balance. Increased demand was simulated in using the C2VSimFG-Sutter model by increasing evapotranspiration in the C2VSimFG model subregions that overlap the Sutter Subbasin. Various scenarios of increased demand were simulated and their water budgets compared to see what level of groundwater production resulted in a long-term change in storage of, or very close to, zero.

The increase in demand that resulted in a change in groundwater storage of almost zero was a 20% increase in evapotranspiration in C2VSimFG subregions 4 and 5. This increased demand leads to a 33% increase in groundwater pumping over the projected conditions scenario. The sustainable conditions scenario results in groundwater outflows almost equal to groundwater inflows, bringing the long-term (60-year) average change in groundwater storage to close to zero. Based on this analysis, the sustainable yield of the Subbasin is 182,000 AF/year. This level of groundwater pumping is higher than what is simulated in all four water budget scenarios - historical, current conditions, projected conditions, and projected conditions with climate change. Therefore, it can be reasonably stated that the Subbasin is currently operating under sustainable conditions and is expected to continue to be sustainable if changes estimated in the projected conditions scenario hold true into the future.

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CHAPTER SIX

Sustainability Management Criteria

SUTTER SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN

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6. SUSTAINABLE MANAGEMENT CRITERIA

Sustainable Management Criteria define conditions that constitute sustainable groundwater management for the Sutter Subbasin. Sustainable Management Criteria, or SMC, include establishing the Subbasin's sustainability goal and establishing definitions of undesirable results, minimum thresholds, measurable objectives, and interim milestones for each sustainability indicator. This chapter contains information pursuant to the Groundwater Sustainability Plan (GSP) Emergency Regulations Article 5 *Plan Contents*, Subarticle 3 *Sustainable Management Criteria* (§354.22 through 354.30).

The Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" (California Water Code Section 10721). Sustainable Management Criteria were developed using information presented in **Chapter 5** *Basin Setting*. Input from Subbasin stakeholders was accepted and incorporated into the established SMC through discussion and presentation at public workshops and meetings of the Sutter Subbasin Groundwater Management Coordination Committee (SSGMCC).

Developed SMC will be used to assess progress toward achieving the sustainability goal for the Sutter Subbasin. The quantitative nature of the SMC allows for demonstrated achievement of the sustainability goal for the Sutter Subbasin on or before the 20-year GSP implementation mark (established in the SGMA legislation at 2042 for non-critically overdrafted subbasins such as the Sutter Subbasin). The Sutter Subbasin GSAs will continue to coordinate with adjacent subbasins regarding SMC and related monitoring and ensure that subbasin management activities do not cause undesirable results in either the Sutter Subbasin or for adjacent subbasins.

6.1 Useful Terms

A list and description of technical terms used throughout this section to discuss SMC are presented below. **Figure 6-1** shows a graphic demonstrating the relationship between the SMC terms such as minimum thresholds and measurable objectives using groundwater elevation as an example. The terms and their descriptions are identified here to guide readers through this section and are not a definitive definition of each term.

- **Sustainability Goal** – The sustainability goal qualitatively describes the objectives and desired conditions for the Sutter Subbasin and how the goal will be met through implementation of the GSP.
- **Undesirable Result** – Condition at which for each applicable sustainability indicator significant and unreasonable impacts are likely to be observed. Avoidance of these conditions is used to guide development of GSP components.

- **Minimum Threshold** – Quantitative guidance levels established at each representative monitoring site set just above conditions that could generate an undesirable result for an applicable sustainability indicator.
- **Measurable Objective** – Quantitative target that represents the desired condition at each representative monitoring site for an applicable sustainability indicator. The measurable objective must be reached within 20 years of GSP implementation for all applicable sustainability indicators for the basin or subbasin to be considered sustainable.
- **Interim Milestones** – Targets set in increments of five years over the 20-year implementation period of the GSP to reach the measurable objective by 2042 (as required for the Sutter Subbasin). These ‘check-in’ points are used to put the basin on a path towards achieving or maintaining sustainability.
- **Margin of Operational Flexibility or Operating Range** – The range of active management between the measurable objective and minimum threshold.

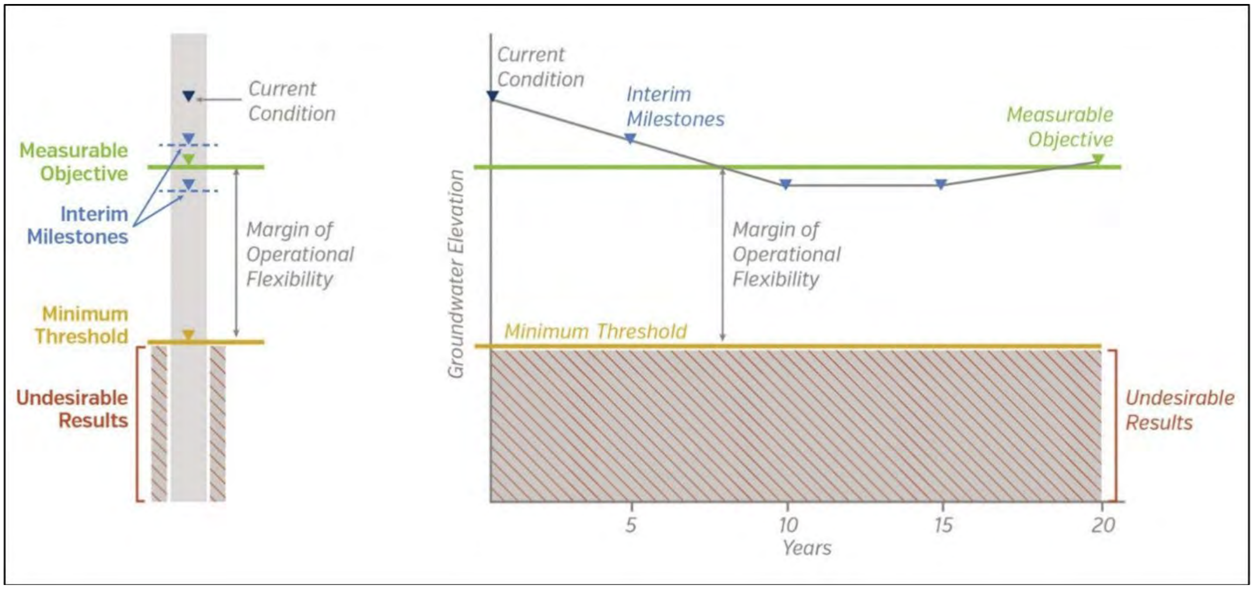

Figure 6-1. Sustainable Management Criteria Definitions Graphic

6.2 Sustainability Indicators

A sustainability indicator is defined under SGMA as one of six effects caused by groundwater conditions that, when significant and unreasonable, cause undesirable results. Undesirable results are one or more of the following effects:

- **Chronic lowering of groundwater levels** indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods

- Significant and unreasonable **reduction of groundwater storage**
- Significant and unreasonable **seawater intrusion**
- Significant and unreasonable **degraded water quality**, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable **land subsidence** that substantially interferes with surface land uses
- **Depletions of interconnected surface water** that have significant and unreasonable adverse impacts on beneficial uses of the surface water

SGMA allows several pathways to meet the distinct local needs of each basin or subbasin, including development of SMC, use of other sustainability indicators as proxy, and identification of indicators that are not applicable to the basin or subbasin. Details of these approaches are included in the following sections. Continued data collection and improved understanding of basin conditions in the future may lead to changes in the SMC discussed herein.

Future changes to SMC calculations or methodologies will be detailed in Annual Reports and 5-Year GSP assessments and updates and will be evaluated using the same criteria contained herein to ensure that undesirable results are not caused as a result of revised SMC in the Sutter Subbasin or adjacent subbasins.

6.3 Sustainability Goal

The sustainability goal provides a succinct qualitative description of the objectives and desired conditions that culminates in the absence of undesirable results by 2042 in the Sutter Subbasin. It is supported by the SMC established herein.

The sustainability goal for the Sutter Subbasin is as follows:

> *The Sutter Subbasin will maintain locally-managed groundwater resources for existing and future beneficial uses and users that are economically viable and sustainable by managing groundwater use within the sustainable yield, resulting in the avoidance of undesirable results. This goal will be achieved through implementation of proposed projects and management actions and monitoring activities aiding in reaching or maintaining established interim milestones and measurable objectives culminating in the absence of undesirable results by 2042. Water managers in the Sutter Subbasin will work together and collaboratively with stakeholders and neighboring subbasins through GSP implementation and beyond to achieve this goal.*

The sustainability goal was developed based on information presented in **Chapter 5** *Basin Setting*. As discussed in further detail in the **Section 5.3** *Water Budgets*, the

Sutter Subbasin is anticipated to be sustainable relative to the chronic lowering of groundwater levels, reduction of groundwater storage, and depletions of interconnected surface water sustainability indicators over the 50-year planning horizon of this GSP even with the potential impacts of climate change. Limited recent data relative to the degraded water quality sustainability indicator are available, and improvements to comprehensive groundwater quality monitoring throughout the Sutter Subbasin are detailed in **Section 7.1**. As noted in **Section 5.2** *Groundwater Conditions*, available land subsidence data indicates that inelastic land subsidence has not historically been observed in the Sutter Subbasin.

In order to make progress in meeting the sustainability goal, locally-defined minimum thresholds and measurable objectives have been established for the Sutter Subbasin to define the operating range of the groundwater subbasin and ensure that the Subbasin will be operated within its sustainable yield. These criteria were developed in a coordinated fashion with adjacent subbasins by reviewing public drafts and final drafts of their respective SMC chapters, as well as through discussion by consultant staff throughout the Sacramento Valley. Projects and management actions, as detailed in **Section 7.1**, were selected to avoid undesirable results, provide for adaptive management of the groundwater subbasin, and to fill identified data gaps within the Sutter Subbasin. For more information about sustainable yield and the projects and management actions to be implemented during the 20-year implementation period, refer to **Section 5.3** and **Section 7.1**, respectively.

Over the GSP planning and implementation horizon, Subbasin conditions are expected to fluctuate relative to minimum thresholds, measurable objectives, and interim milestones due to fluctuations in hydrologic conditions (both natural and human-influenced), future changes in land use, modification of basin operations, and implementation of projects and management actions. It is anticipated that, despite seasonal and short-term fluctuations, the Subbasin will be managed to prevent undesirable results. Demonstration of the absence of undesirable results will support a determination that the Subbasin is operating within its sustainable yield (discussed in **Section 5.3**) and support the conclusion that the sustainability goal has been achieved by 2042 and maintained beyond 2042.

6.4 Undesirable Results

Undesirable results are defined under SGMA as one or more significant and unreasonable effects caused by groundwater conditions occurring throughout a basin based on the six sustainability indicators of SGMA: chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletions of interconnected surface water. A description of undesirable results as defined under SGMA and by the Sutter Subbasin GSAs, identification of undesirable results, potential causes for undesirable results, and potential effects of undesirable results relative to all applicable sustainability indicators for the Sutter Subbasin are detailed below.

6.4.1 Chronic Lowering of Groundwater Levels

The undesirable result related to groundwater levels is defined under SGMA as:

> *Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels in storage during other periods (California Water Code [CWC] Section 10721(x)(1)).*

6.4.1.1 Description of Undesirable Results

An undesirable result for chronic lowering of groundwater levels in the Sutter Subbasin is experience through groundwater levels dropping to a level at which domestic or irrigation wells go dry or lose functional pumping capacity, result in significantly higher pumping costs, and/or the significant and unreasonable effort is required to maintain or deepen production wells.

6.4.1.2 Identification of Undesirable Results

An undesirable result is observed when groundwater elevations drop below the minimum threshold criteria at 25% of representative monitoring locations (16 out of 63 representative wells) concurrently over two consecutive seasonal high water level measurements. Impacts relating to this SMC will be evaluated both by aquifer zone and for the principal aquifer as a whole. Minimum threshold exceedance patterns by aquifer zone will also be monitored and addressed as appropriate. For more information about how identification of undesirable results for chronic lowering of groundwater levels was determined, refer to **Appendix 6-B**.

6.4.1.3 Potential Causes of Undesirable Results

Based on available information about projected changes in the land use in the Subbasin, it is anticipated that the long-term average groundwater use in the Sutter Subbasin is not likely to change to the point where groundwater levels are impacted resulting in undesirable results. Significant increased groundwater pumping as a result of reduced surface water supplies due to instream flow requirements could impact groundwater levels to the point where undesirable results are observed. Other potential localized impacts to groundwater levels could be caused by increases in consumptive use of groundwater due to increased agricultural productivity and changes in the hydrologic system, such as increases in impervious surfaces or significant changes to upstream reservoir releases.

Since groundwater use in the Sutter Subbasin has historically been considered sustainable and conditions are anticipated to remain sustainable even with the effects of climate change (as concluded from the projected water budgets in **Section 5.3**), undesirable results are not expected to occur for the chronic lowering of groundwater levels sustainability indicator.

6.4.1.4 Potential Effects of Undesirable Results

If groundwater levels were to reach levels indicating undesirable results, potential effects could include the following:

- Dewatering of shallow wells
- Increased costs to pump groundwater
- Adverse effects on groundwater dependent ecosystems (GDEs) resulting from losses of connection with the principal aquifer, including difficulty for plants and animals to access groundwater
- Changes in irrigation practices and crops grown
- Adverse effects on property values and the regional economy

6.4.2 Reduction of Groundwater Storage

The undesirable result related to reduction of groundwater storage is defined under SGMA as:

> *Significant and unreasonable reduction of groundwater storage (CWC Section 10721(x)(2)).*

6.4.2.1 Identification of Undesirable Results

The same trigger for an undesirable result for the chronic lowering of groundwater levels is applicable to the long-term reduction of groundwater storage. Long-term reductions in storage are not anticipated as the Sutter Subbasin is already sustainable and due to the large volume of water currently in storage in the Subbasin. Therefore, as long as groundwater levels are managed above minimum thresholds, changes in storage should not be significant.

6.4.2.2 Potential Causes of Undesirable Results

Although groundwater has historically been used sustainably in the Sutter Subbasin, dramatic increases in the reliance on groundwater, severe drought, or other major changes in groundwater management over time could cause the volume of fresh groundwater in storage to decline to a significant and unreasonable level. Additionally, regulatory requirements placed on the Central Valley Project (CVP) and State Water

Project (SWP) operations could impact the Sacramento River Settlement Contractors and Feather River diverters, respectively, as well as instream flow requirements on the Sacramento and/or Feather Rivers and their tributaries may result in negative impacts to surface water supplies. Reductions in surface water supplies would result in increased reliance on groundwater resources within the Sutter Subbasin and potentially result in the long-term reduction in groundwater storage.

This undesirable result is driven by the chronic lowering of groundwater levels sustainability indicator and established SMC, which have been determined to be protective of possible undesirable results for the long-term reduction of groundwater storage.

6.4.2.3 Potential Effects of Undesirable Results

If groundwater levels were to reach the point where undesirable results are observed, undesirable effects could include shallow wells going dry and/or losing production capacity resulting in the need to deepen or replace wells; increased pumping costs as deeper wells are required to access groundwater; and an overall reduction in beneficial uses of groundwater.

6.4.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Sutter Subbasin as the Subbasin is located inland from the Pacific Ocean and is not adjacent to the Sacramento-San Joaquin Delta. Therefore, SMC for seawater intrusion will not be established for the Sutter Subbasin GSP.

6.4.4 Degraded Water Quality

The undesirable result related to degraded water quality is defined under SGMA as:

> *Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies (CWC Section 10721(x)(4)).*

6.4.4.1 Description of Undesirable Results

An undesirable result for degraded water quality in the Sutter Subbasin would be the result stemming from a causal nexus between groundwater-related activities, such as groundwater extraction or recharge, and a degradation in groundwater quality that causes a significant and unreasonable reduction in long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP. The causal nexus reflects that the undesirable results are water quality issues associated with groundwater pumping and other groundwater management-related activities rather than water quality issues resulting from land use practices, naturally-occurring water quality issues, or other issues not associated with groundwater pumping and other groundwater-related activities.

Within the Sutter Subbasin, the causal nexus would be related to increased salinity (measured as total dissolved solids [TDS]) and nitrate (measured as nitrate as N) concentration resulting from groundwater pumping or implementation of projects and/or management actions. It should be noted that water quality issues outside of the causal nexus are generally covered by other regulatory frameworks. Contamination sites are regulated by the Regional Water Quality Control Board (RWQCB), California Department of Toxic Substances Control, and the U.S. Environmental Protection Agency (EPA). Drinking water quality is regulated by the State Water Resources Control Board, Division of Drinking Water (SWRCB-DDW). Potential contamination by agricultural practices is regulated through Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), Irrigated Lands Regulatory Program (ILRP), and California Department of Pesticide Regulation (DPR).

Aside from TDS and nitrate related to anthropogenic activities (such as agricultural activities or septic systems), the Sutter Subbasin GSAs do not have control over the presence of naturally-occurring constituents in aquifer materials. In the event that there is a causal nexus determined between elevated concentrations of other constituents of concern (COCs, or other COCs not presently identified) and groundwater management activities, the Sutter Subbasin GSAs will consider establishing SMCs for such COCs. Management actions and studies are presented in **Section 7.1**. Because the Subbasin is considered sustainable, these are, for the most part, identified for adaptive basin management or to meet other needs. As such, implementation of these projects, management actions, and studies will be implemented pending the availability of grant or other funding, as appropriate research partners are identified and partnerships formed, or as needed for Subbasin management with the goal of further evaluating the fate and transport of COCs in the Sacramento Valley as a whole.

6.4.4.2 Identification of Undesirable Results

An undesirable result for degraded water quality is triggered, or considered “significant and unreasonable,” when 50% of representative monitoring wells (14 out of 28 representative wells) across all aquifer zones exceed the minimum threshold for two consecutive measurements at each location during non-drought years and where these minimum threshold exceedances can be tied to a causal nexus between SGMA-related activities and water quality. As with groundwater levels, water quality data will be assessed on an annual basis by both principal aquifer and by aquifer zones. Such criteria in identifying an undesirable result for degraded water quality would provide sufficient data to establish a trend in potential worsening groundwater level as a result of GSP-related activities.

6.4.4.3 Potential Causes of Undesirable Results

TDS and nitrate have been identified as COCs in the Sutter Subbasin and are largely the result of non-point sources. Elevated TDS concentrations are primarily the result of a combination of land use practices, the upwelling of seawater (connate) deposits within marine sediments, dissolvable materials within the alluvial fan complexes, and the naturally poor-draining conditions which tend to result in accumulation of salts. Elevated nitrate is largely the result of anthropogenic sources such as agricultural applications of fertilizer and septic systems in the Sutter Subbasin. For more information about groundwater quality in the Sutter Subbasin, refer to **Sections 5.1.9** and **5.2.5** of the *Basin Setting* chapter.

Conditions that may cause an undesirable result for degraded water quality include changes in the location (both vertically and horizontally) and volume of groundwater pumping or managed groundwater recharge, both resulting in the contribution to and/or potential mobilization of COCs as a result of these activities.

6.4.4.4 Potential Effects of Undesirable Results

If an undesirable result for degraded water quality were to occur, the effect could cause a reduction in economically usable groundwater supply for all beneficial users of groundwater and/or an increased need for groundwater treatment prior to use, with domestic wells being most vulnerable as costs for treatment or access to alternate supplies can be high for small users. For agricultural groundwater users, degraded water quality may cause potential changes in irrigation practices, crops grown, agricultural efficiencies, adverse effects on property values, and other economic impacts, with the potential to adversely impact the larger economy throughout the Subbasin. Water quality degradation could also impact GDEs and impact surface water quality and health of aquatic species. Additionally, reaching undesirable results levels for groundwater quality could adversely affect current and projected municipal uses, which could have to install treatment systems or seek alternate supplies.

6.4.5 Land Subsidence

The undesirable result related to land subsidence is defined under SGMA as:

> *Significant and unreasonable land subsidence that substantially interferes with surface land uses (CWC Section 10721(x)(5)).*

6.4.5.1 Description of Undesirable Results

An undesirable result for land subsidence would be a result due to groundwater extraction that causes a significant reduction in the viability of the use of infrastructure for water distribution and flood control, including impacts to laterals from differential settlement that reduces the ability to deliver surface water supplies or inadequate freeboard on levee systems in wet years impacting conveyance of flood waters.

6.4.5.2 Identification of Undesirable Results

There are 22 monuments surveyed in the Sutter Subbasin on a 5-year schedule as part of the Sacramento Valley Subsidence Network by DWR and its partner agencies.

Undesirable results are considered to occur when at least 25% of representative subsidence monitoring sites (6 out of 22 sites) exceed the minimum threshold for subsidence over the 5-year monitoring period. InSAR data published by DWR via the SGMA Data Viewer (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions) will also be reviewed on an annual basis to ensure subsidence does not become a concern over the 5-year monitoring period.

6.4.5.3 Potential Causes of Undesirable Results

As noted in **Section 5.2.6**, inelastic land subsidence has not historically been observed in the Sutter Subbasin. Potential causes of undesirable results for land subsidence would be tied to significant increases in groundwater production combined with the necessary hydrogeologic conditions that are conducive to land subsidence. Inelastic land subsidence is typically caused by dewatering of compressible clay layers, which are not known to be present in significant quantities of in the Sutter Subbasin.

6.4.5.4 Potential Effects of Undesirable Results

Undesirable results related to land subsidence could potentially cause differential changes in land surface elevation resulting in damage to water conveyance infrastructure, flood control facilities and other infrastructure, and/or causing decreased capacity to convey water or control flood waters. The cost to convey surface water or control flood waters would likely increase as gradients of gravity-driven conveyance and/or flood control structures would require repair and modification or increased energy to pump and move surface or flood waters. These potential effects could result in significant economic costs and adversely impact property value as well as public safety.

6.4.6 Depletions of Interconnected Surface Water

The undesirable result related to depletions of interconnected surface water is defined under SGMA as:

> *Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water (CWC Section 10721(x)(6)).*

6.4.6.1 Description of Undesirable Results

The undesirable result for depletions of interconnected surface water is a result that causes significant and unreasonable adverse effects on beneficial uses and users of interconnected surface water within the Sutter Subbasin over the GSP planning and implementation horizon.

6.4.6.2 Identification of Undesirable Results

Groundwater elevations dropping below the minimum threshold criteria at 25% of representative monitoring locations (6 out of 23 representative wells) concurrently over two consecutive seasonal high water level measurements resulting in a significant loss of aquifer contribution to the interconnected water course (if currently a gaining stream) and/or a reversal of stream connection from gaining to losing streams.

6.4.6.3 Potential Causes of Undesirable Results

The potential causes of undesirable results for the depletions of interconnected surface water include increased groundwater demand along interconnected corridors, specifically the Sacramento and Feather Rivers and Sutter Bypass, and/or significant changes in upstream reservoir releases (as both the Sacramento and Feather Rivers are controlled rivers). See **Section 5.2.7** for identification of interconnected surface waters.

6.4.6.4 Potential Effects of Undesirable Results

If depletions of interconnected surface water were to reach levels causing undesirable results, the adverse effects could potentially include reduced ability of surface water flows to meet instream flow requirements or to deliver surface water supplies to users in the Subbasin. Fisheries, riparian habitat, and recreational opportunities within the Sutter Subbasin could also be impacted by lower instream flows and by increased temperatures. This could also result in increased groundwater production to offset the availability of surface water, changes in irrigation practices and crops grown, and could cause adverse effects on property values and the Subbasin-wide economy.

6.5 Minimum Thresholds

Minimum thresholds are the quantitative values that represent groundwater conditions at a representative monitoring site that, when exceeded in combination with minimum thresholds at other monitoring sites, may cause an undesirable result in the basin or subbasin. This section establishes the numeric minimum thresholds for all applicable sustainability indicators in the Sutter Subbasin by describing how minimum thresholds were identified and different methodologies considered; the relationship of other applicable sustainability indictors in the Subbasin; effects on neighboring subbasins and beneficial uses/users; relevant local, state, or federal standards; and the method of quantitative measurement selected.

6.5.1 Chronic Lowering of Groundwater Levels

6.5.1.1 Identification and Methodology

The minimum threshold for chronic lowering of groundwater levels is established as the deepest of the following:

1. The historic low for the available record at each representative monitoring site; or
2. 90% of the average groundwater elevation from the projected water budget (baseline condition over 60-year period using C2VSimFG-Sutter) at each representative monitoring site with an artificial increase in evapotranspiration (ET) of 50%; or
3. The average operating range (difference between measurable objective and minimum threshold) for all representative monitoring sites using the above criteria for the following aquifer zones (AZs), applied based on the available screen interval or well depth information for each representative monitoring site:
    a. Shallow AZ and AZ-1 = 8.0 feet
    b. AZ-2 and AZ-3 = 16.5 feet

Table 6-1 reflects the minimum thresholds for chronic lowering of groundwater levels at each representative monitoring site. Refer to **Appendix 6-A** for hydrographs for all representative monitoring sites for chronic lowering of groundwater levels plotted with the established minimum thresholds and measurable objectives.

In the Sutter Subbasin, groundwater levels have been sustainable over time as the aquifer rebounds during all water year types following the irrigation season, returning to pre-pumping levels on a seasonal basis (see **Section 5.2** *Groundwater Conditions*). Therefore, undesirable results relative to chronic lowering of groundwater levels have not historically been observed in the Sutter Subbasin.

At each representative monitoring site, the C2VSimFG-Sutter integrated flow model was used to simulate groundwater elevations from the projected water budget to derive an average groundwater elevation over the 60-year simulation period assuming an artificial increase in ET by 50% to induce additional groundwater pumping to meet overlying land use demands to the point where interconnected streams that are gaining become losing. The Sacramento and Feather Rivers act as regulating reservoirs in the Sutter Subbasin, feeding water into the Subbasin as groundwater levels are lowered through natural fluctuations or groundwater pumping. A factor of 90% of the average simulated groundwater levels, where ET is increased by 50%, was applied to be conservative and avoid changes in the direction of stream interconnection while providing for additional operating range in the Sutter Subbasin.

Table 6-1. Minimum Thresholds for Chronic Lowering of Groundwater Levels

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold (feet above MSL, NAVD88)
-	12N02E09B002M	USGS-385431121451401	Shallow	12.30
-	12N03E18H001M	USGS-385314121401701	Shallow	13.32
-	14N02E10R001M	-	Shallow	25.09
-	15N02E20D001M	USGS-390832121463601	Shallow	29.50
391975N1218937W001	16N01E31H001M	-	Shallow	29.90
392328N1216469W001	16N03E21D002M	-	Shallow	44.44
390696N1217778W001	14N02E17C001M	Sutter County MW-1A	Shallow	21.50
390426N1218166W001	14N01E24N001M	USGS-390416121433601	AZ-1	23.58
390588N1217004W001	14N02E13L001M	-	AZ-1	15.93
390176N1217902W001	14N02E31K001M	-	AZ-1	19.08
391051N1217012W001	15N02E36L001M	-	AZ-1	22.54
392712N1216493W001	16N03E04E001M	-	AZ-1	43.18
392970N1216907W003	17N02E25J003M	BWD MW-1C	AZ-1	60.03
390458N1216114W001	14N03E23D003M	Feather River MW-1A	AZ-1	15.78
389605N1218102W003	13N01E24G004M	Flood MW-1C (shall)	AZ-1	13.00
389453N1216159W001	-	GH Well 2	AZ-1	22.09
391456N1218904W001	-	MFWC Prop 50	AZ-1	27.72
387859N1216565W001	11N03E20H003M	RD 1500 Karnak	AZ-1	10.51
390682N1216901W001	14N02E13A003M	SEWD MW-3A	AZ-1	31.57
390244N1217813W001	14N02E32D001M	SMWC MW-1A	AZ-1	18.34
388761N1217094W001	12N02E23H001M	Sutter County MW-2A	AZ-1	7.58
392394N1216509W001	16N03E17J001M	Sutter County MW-3A	AZ-1	45.80
390087N1216722W001	13N03E06A001M	Sutter County MW-6A	AZ-1	21.13

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold (feet above MSL, NAVD88)
-	-	Hillcrest Well #5	AZ-1 and AZ-2	15.47
391414N1217442W001	15N02E22D001M	-	AZ-2	24.00
391283N1218286W001	-	BS2-Franklin	AZ-2	16.77
392970N1216907W002	17N02E25J002M	BWD MW-1B	AZ-2	3.90
390458N1216114W002	14N03E23D004M	Feather River MW-1B	AZ-2	-30.19
389605N1218102W001	13N01E24G002M	Flood MW-1A (deep)	AZ-2	7.20
389605N1218102W002	13N01E24G003M	Flood MW-1B (int)	AZ-2	-7.90
-	-	Hillcrest Well #8	AZ-2	17.34
-	-	Hillcrest Well #9	AZ-2	14.35
391658N1217070W001	15N02E12E001M	SEWD MW-1A	AZ-2	15.66
391658N1217070W002	15N02E12E002M	SEWD MW-1B	AZ-2	23.14
391279N1216989W001	15N02E24P001M	SEWD MW-2A	AZ-2	24.51
391279N1216989W002	15N02E24P002M	SEWD MW-2B	AZ-2	-16.30
390682N1216901W002	14N02E13A004M	SEWD MW-3B	AZ-2	16.81
390244N1217813W002	14N02E32D002M	SMWC MW-1B	AZ-2	10.01
390696N1217778W002	14N02E17C002M	Sutter County MW-1B	AZ-2	12.33
388761N1217094W002	12N02E23H002M	Sutter County MW-2B	AZ-2	-0.08
392394N1216509W002	16N03E17J002M	Sutter County MW-3B	AZ-2	36.89
389452N1215992W001	13N03E26J002M	Sutter County MW-4A	AZ-2	5.09
390087N1216722W002	13N03E06A002M	Sutter County MW-6B	AZ-2	10.21
390087N1216722W003	13N03E06A003M	Sutter County MW-6C	AZ-2	9.91
-	-	WTP well	AZ-2 and AZ-3	21.51
392867N1217825W001	17N02E31A001M	-	AZ-3	21.35
392970N1216907W001	17N02E25J001M	BWD MW-1A	AZ-3	10.10

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold (feet above MSL, NAVD88)
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	11.05
390458N1216114W004	14N03E23D006M	Feather River MW-1D	AZ-3	9.49
391658N1217070W003	15N02E12E003M	SEWD MW-1C	AZ-3	22.91
391279N1216989W003	15N02E24P003M	SEWD MW-2C	AZ-3	-13.80
390682N1216901W003	14N02E13A005M	SEWD MW-3C	AZ-3	13.06
390244N1217813W003	14N02E32D003M	SMWC MW-1C	AZ-3	8.85
390696N1217778W003	14N02E17C003M	Sutter County MW-1C	AZ-3	5.77
390696N1217778W004	14N02E17C004M	Sutter County MW-1D	AZ-3	11.91
388761N1217094W003	12N02E23H003M	Sutter County MW-2C	AZ-3	-0.12
388761N1217094W004	12N02E23H004M	Sutter County MW-2D	AZ-3	-0.41
392394N1216509W003	16N03E17J003M	Sutter County MW-3C	AZ-3	34.68
392394N1216509W004	16N03E17J004M	Sutter County MW-3D	AZ-3	31.78
392394N1216509W005	16N03E17J005M	Sutter County MW-3E	AZ-3	31.21
389452N1215992W002	13N03E26J003M	Sutter County MW-4B	AZ-3	4.12
389452N1215992W003	13N03E26J004M	Sutter County MW-4C	AZ-3	2.82
389452N1215992W004	13N03E26J005M	Sutter County MW-4D	AZ-3	0.34

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For representative monitoring sites with small operating ranges as a result of the application of the first two minimum threshold methodologies listed above, a minimum operating range was applied based on values calculated by applying those methodologies. The average operating range for the Shallow AZ and AZ-1 were combined with the goal of being protective of interconnected surface waters, GDEs, and shallow domestic wells, where the average operating range of AZ-2 and AZ-3 were combined because most groundwater is pumped from these aquifer zones by municipal and agricultural production wells in the Sutter Subbasin. A minimum operating range is applied where applicable in order to allow for a reasonable use of groundwater by all beneficial users in the Sutter Subbasin.

Throughout GSP implementation, additional data collected at each representative monitoring site will be evaluated to determine that the minimum operating range applied does not cause an undesirable result in the Sutter Subbasin or adjacent subbasins. At the time of GSP development, it is not anticipated this method will cause an undesirable result based on the projected absence of undesirable results using the first two calculation methods presented above.

Three other methodologies were considered in establishing minimum thresholds for chronic lowering of groundwater levels: use of Thiessen polygons with consideration of the number of impacted domestic wells in each polygon, minimum saturated thickness required to maintain domestic and/or agricultural groundwater pumping, and operating range using proxy wells where minimal data was available in the historic record for representative monitoring wells. Refer to **Appendix 6-B** for more information about development of minimum thresholds for chronic lowering of groundwater levels and a comparison of considered methodologies.

6.5.1.2 Relationship to Other Sustainability Indicators

The relationship between minimum thresholds for each sustainability indicator, including an explanation of how it was determined that basin conditions at the minimum thresholds for chronic lowering of groundwater levels will avoid undesirable results for each of the other applicable sustainability indictors to the Sutter Subbasin, are described herein. Minimum thresholds for chronic lowering of groundwater levels are selected to avoid undesirable results for the other applicable sustainability indicators in the Sutter Subbasin as follows.

- **Reduction of Groundwater Storage.** Groundwater levels are used as a proxy for the reduction of groundwater storage sustainability indicator, where the chronic lowering of groundwater levels monitoring network and numeric SMC are also used to evaluate conditions relative to reduction of groundwater storage. In the Sutter Subbasin, there is approximately 49 million acre-feet of groundwater in storage. Pumping of groundwater in storage is not projected to reach unsustainable levels in the Sutter Subbasin, even with anticipated impacts of climate change (refer to

Section 5.3 for more information about projected conditions in the Sutter Subbasin). As such, the lowering of groundwater levels is more likely to result in undesirable conditions than the loss of groundwater in storage, and these impacts would be felt sooner. For example, lowered groundwater levels could result in shallow domestic wells going dry without causing any significant impact on the overall amount of groundwater in storage. This typically would occur due to potential localized effects described in **Section 6.5.1.4**.

- **Seawater Intrusion.** This sustainability indicator is not applicable to the Sutter Subbasin.
- **Degraded Water Quality.** Currently, there are limited groundwater quality data available in the Sutter Subbasin to support a connection between groundwater pumping and elevated concentrations of COCs that would cause an undesirable result or exceed drinking water standards or agricultural water quality objectives. Through implementation of the Sutter Subbasin GSP, groundwater quality could potentially be affected by implementation of projects and management actions that have a direct impact on groundwater resources, such as groundwater recharge projects that could potentially result in localized changes in groundwater elevations or gradients and result in mobilization of contaminants. Overall, current groundwater quality in the Sutter Subbasin is considered to be generally good and suitable for all beneficial uses.
- **Land Subsidence.** Land subsidence as a result of groundwater pumping has not historically been observed in the Sutter Subbasin. Therefore, based on current understanding and the best available science at the time of GSP development, the chronic lowering of groundwater levels and land subsidence sustainability indictors are not considered to be related and unlikely to cause undesirable results for the other sustainability indicator.
- **Depletions of Interconnected Surface Water.** Minimum thresholds are established for the depletions of interconnected surface water sustainability indicator using the same methodology as the chronic lowering of groundwater levels sustainability indicator and are intended to be protective of interconnected surface waters to avoid reversing the direction of interconnected surface waters from gaining to losing. Therefore, management of groundwater levels is anticipated to be most protective of beneficial uses of groundwater in the Sutter Subbasin.

6.5.1.3 Effects on Neighboring Subbasins

All seven of the groundwater subbasins adjacent to the Sutter Subbasin (the Butte, Wyandotte Creek, North Yuba, South Yuba, North American, Yolo, and Colusa Subbasins) are required to develop and adopted GSPs by January 31, 2022. A GSP for the North Yuba and South Yuba Subbasins, collectively referred to as the Yuba Subbasins, was adopted by Yuba Water Agency and submitted to DWR ahead of the regulatory deadline for non-critically overdrafted high- and medium-priority basins in early 2020. The remaining adjacent subbasins have developed their respective GSPs in tandem with the Sutter Subbasin, releasing draft GSP chapters for public review as complete. The limited information presently available about neighboring subbasin conditions does not indicate that the Sutter Subbasin or adjacent subbasin activities may negatively impact areas along the common basin boundaries. Data about subbasin conditions along the common subbasin boundaries will be shared as part of GSP implementation.

Minimum thresholds for chronic lowering of groundwater levels in the Sutter Subbasin have been selected to avoid causing undesirable results in adjacent subbasins or affect the ability of adjacent subbasins to achieve sustainability goals, where a description of such is contained herein. The Sutter Subbasin GSAs will continue to coordinate with neighboring subbasins throughout GSP development and implementation to ensure groundwater management activities and established minimum thresholds do not cause undesirable results or affect the ability of adjacent subbasins to achieve their sustainability goals.

6.5.1.3.1 Butte Subbasin

In the Butte Subbasin, minimum thresholds for the primary aquifer were established using a stepwise process:

1. Shallower of:
    a. 100% of range (or 20 feet, whichever is greater) below the historical low
    b. Shallowest 7% of nearby domestic wells
2. Deeper of:
    a. Step 1
    b. Measured historic low + 10 feet

A similar methodology was used to establish minimum thresholds for the very deep aquifer in the Butte Subbasin:

1. Shallower of:
    a. 100% of range below historic low
    b. Shallowest 7% of nearby water supply wells
2. Deeper of:
    a. Step 1
    b. Measured historic low + 10 feet

Overall, it appears that the thresholds established for the Butte Subbasin are comparable to those for the Sutter Subbasin. As such, minimum thresholds for chronic lowering of groundwater levels in the Sutter Subbasin are not anticipated to cause undesirable results or affect the ability of the Butte Subbasin from achieving its sustainability goal relative to chronic lowering of groundwater levels.

6.5.1.3.2 Wyandotte Creek Subbasin

The Sutter and Wyandotte Creek Subbasins share a boundary less than one mile in length and comprised roughly of the Feather River in the very northeastern corner of the Sutter Subbasin where groundwater-related activities are not known to occur. Therefore, it is not anticipated that activities in the Sutter Subbasin will cause an undesirable result for chronic lowering of groundwater levels in the Wyandotte Creek Subbasin.

6.5.1.3.3 North Yuba and South Yuba Subbasins

In the North Yuba and South Yuba Subbasins, the minimum threshold for chronic lowering of groundwater levels is set at the deeper of (1) the bottom of the shallowest domestic well near a monitoring well, adjusted for March measurements, or (2) the historical low March groundwater level from 1985 to present at the monitoring well, where a 75-foot minimum value was applied to the threshold. The Yuba Subbasins are currently in the GSP implementation phase and have not yet experienced an undesirable result for chronic lowering of groundwater levels. Given the role of the Feather River as a ‘regulating reservoir’ that largely forms the boundary between the Sutter Subbasin and Yuba Subbasins, it is not anticipated that minimum thresholds in the Sutter Subbasin for chronic lowering of groundwater levels will cause an undesirable result or affect the ability of the Yuba Subbasins to achieve their sustainability goal.

6.5.1.3.4 North American Subbasin

In the North American Subbasin, the minimum thresholds for the chronic lowering of groundwater levels were established by numerical modeling of expected future conditions. The simulated groundwater elevations at representative monitoring locations under this expected future scenario were then compared to baseline conditions (as approximated as the average of Fall 2014 and 2015 groundwater elevations) to estimate potential changes to Fall water level conditions should these expected projected future conditions occur. For each representative monitoring location, the difference between the projected future water levels and the baseline (Average Fall 2014/2015) water levels was then subtracted from the average Fall baseline water level to calculate the minimum threshold at that location. As a final step, the calculated minimum thresholds were then compared to beneficial uses and users to ensure that potential negative impacts would be avoided.

Given the role of the Feather River as a ‘regulating reservoir’ that forms the boundary between the Sutter Subbasin and North American Subbasin, and the fact that groundwater use in the North American Subbasin, like the Sutter Subbasin, is presently under its sustainable yield, it is not anticipated that minimum thresholds in the Sutter

Subbasin for chronic lowering of groundwater levels will cause an undesirable result or affect the ability of the North American Subbasin to achieve its sustainability goal.

6.5.1.3.5 Yolo Subbasin

In the Yolo Subbasin, management areas have been established for the chronic lowering of groundwater levels sustainability indicator and minimum thresholds have been defined for each management area. The North Yolo management area borders the Sutter Subbasin. The minimum threshold value for the North Yolo management area is equal to the historic minimum groundwater elevation plus 20% of the depth between the historic maximum and historic minimum elevation for the period of record at each representative monitoring well.

Based on a similar methodology used to establish minimum thresholds in the North Yolo management area as compared to the Sutter Subbasin (using the minimum historic elevation plus some additional operating buffer) and the role of the Sacramento River (adjoining both subbasins) in maintaining groundwater elevations in the Sutter Subbasin, minimum thresholds in the Sutter Subbasin are not anticipated to cause undesirable results or affect the ability of the Yolo Subbasin in achieving its sustainability goal relative to chronic lowering of groundwater levels.

6.5.1.3.6 Colusa Subbasin

In the Colusa Subbasin, minimum thresholds for chronic lowering of groundwater levels were calculated at each representative monitoring site by finding the deeper value of: (1) 20th percentile of shallowest domestic well depths in the monitoring well's Thiessen polygon or (2) 50% of range below the historic low groundwater elevation.

Overall, it appears that the minimum thresholds established for the Colusa Subbasin are comparable to those for the Sutter Subbasin. As such, the minimum thresholds for the chronic lowering of groundwater levels in the Sutter Subbasin are not anticipated to cause undesirable results or affect the ability of the Colusa Subbasin from achieving its sustainability goal relative to chronic lowering of groundwater levels.

6.5.1.4 Effects on Beneficial Uses and Users

Beneficial uses and users of groundwater are identified in **Section 4.1** of the *Outreach and Communication* chapter and generally include the following uses or users: domestic, municipal, agricultural, and environmental. All beneficial uses and users of groundwater, and their associated land uses and property interests, were considered in establishing minimum thresholds for chronic lowering of groundwater levels. Stakeholders, including the public, were invited to provide feedback on minimum thresholds during SSGMCC meetings (held bi-weekly and noticed according to the Brown Act) and a public workshop held on August 11, 2021. Municipal and agricultural representatives are members of the SSGMCC and participated in the development of minimum thresholds.

A description of how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests is contained herein.

- **Domestic.** Minimum thresholds for chronic lowering of groundwater levels are established to avoid undesirable results for domestic well users, where domestic wells are typically screened in the Shallow AZ or AZ-1. If minimum thresholds are exceeded (even if an undesirable result is not observed), there may be some areas of the Subbasin where shallow domestic wells temporarily go dry. This may require the lowering of well pumps in these shallow wells, access to alternative water supplies until water levels recover (in emergency situations only), or the deepening of domestic wells.
- **Municipal.** Municipal wells tend to be deeper than domestic wells, with groundwater pumped typically from the lower portion of AZ-1 as well as AZ-2 and AZ-3. Municipal water supply systems are also designed to include redundancy to adapt to changes in groundwater conditions. Minimum thresholds for chronic lowering of groundwater levels are established to be protective of municipal groundwater production needs. Additionally, exceedances of minimum thresholds are not anticipated to negatively impact municipal groundwater production due to the redundancy and operating flexibility designed into municipal systems.
- **Agricultural.** Similar to municipal users of groundwater, minimum thresholds for chronic lowering of groundwater levels are established to be protective of agricultural groundwater production needs as the primary user of groundwater in the Sutter Subbasin. Minimum threshold exceedances are not anticipated to negatively impact groundwater production for agricultural uses due to seasonal aquifer rebound and the availability of surface water supplies for agricultural purposes.
- **Environmental.** Environmental users of groundwater typically rely on shallow groundwater (within 50 feet of ground surface or less) for recharge to interconnected streams and access by GDEs. If minimum thresholds for chronic lowering of groundwater levels are exceeded (even if an undesirable result is not observed), reduced groundwater recharge to streams and groundwater levels too deep for GDE species to access may be observed.

6.5.1.5 Relevant Federal, State, or Local Standards

Currently, there are no other federal, state, or local standards that relate to the chronic lowering of groundwater levels sustainability indicator in the Sutter Subbasin. SGMA is the prevailing legislation dictating requirements and standards for the chronic lowering of groundwater levels sustainability indicator. Any future federal, state, or local standards relating to chronic lowering of groundwater levels will be evaluated and considered in potential modifications to minimum thresholds during subsequent GSP updates.

6.5.1.6 Method for Quantitative Measurement

For information regarding how minimum thresholds for chronic lowering of groundwater levels will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to **Section 7.2** *Monitoring*.

6.5.2 Reduction of Groundwater Storage

The Sutter Subbasin GSP uses minimum thresholds for the chronic lowering of groundwater levels as a proxy for the reduction of groundwater storage sustainability indicator. As such, the minimum thresholds for the reduction of groundwater storage are with the same as the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator.

GSP regulations allow GSAs to use groundwater levels as a proxy metric for any sustainability indicator provided the GSP demonstrates that there is a significant correlation between groundwater levels and other metrics. In order to rely on groundwater levels as a proxy, one approach suggested by DWR is to:

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site (DWR, 2017).*

Minimum thresholds for the chronic lowering of groundwater levels sustainability indicator will effectively avoid undesirable results for reduction of groundwater in storage by ensuring that groundwater elevations (and therefore the volume of groundwater in storage) does not chronically decline in the future and has a demonstrated ability to rebound annually, with greater cumulative increases in storage during wetter years. The minimum thresholds can therefore be used as a proxy for reduction of groundwater storage because the minimum thresholds set for groundwater levels are sufficiently protective against occurrences of significant and unreasonable reductions of groundwater storage and, given the large volume of water in storage in the Sutter Subbasin, it is likely that significant declines in groundwater elevations are likely to result in undesirable results before the loss of groundwater storage is considered significant.

6.5.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Sutter Subbasin as the Subbasin is located inland from the Pacific Ocean and is not adjacent to the Sacramento-San Joaquin Delta. Therefore, SMC for seawater intrusion will not be established for the Sutter Subbasin GSP.

6.5.4 Degraded Water Quality

6.5.4.1 Identification and Methodology

The minimum threshold for degraded water quality is established as the highest of: (1) the upper SMCL for TDS (1,000 mg/L) and Primary MCL for nitrate as N (10 mg/L) or (2) current water quality conditions for TDS and nitrate as N based on data available from 2000 to the time of GSP development (Summer 2021) at the representative monitoring well or nearby well within the same aquifer zone, as described in **Section 5.2.5** of the *Basin Setting* chapter, using maximum concentration detected of each constituent. **Table 6-2** reflects the minimum thresholds for degraded water quality at each representative monitoring site.

Minimum thresholds for degraded water quality are established consistent with California drinking water standards and California’s Antidegradation Policy (State Board Resolution 68-16). Local input through SSGMCC meetings, as well as the August 11, 2021 public workshop, were applied in setting the minimum threshold for degraded water quality. The selected minimum thresholds reflect input from local water purveyors as well as the local agricultural community and is expected to avoid undesirable results in the Sutter Subbasin. It should be noted that the concentrations presented for minimum thresholds reflect ambient groundwater quality, where additional treatment may be necessary to meet state and federal MCLs for drinking water.

Table 6-2. Minimum Thresholds for Degraded Water Quality

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold - TDS (mg/L)	Minimum Threshold - Nitrate as N (mg/L)
391975N1218937W001	16N01E31H001M	-	Shallow	1,000	10
-	-	RICE-01	Shallow	8,200[1]	10
-	-	RICE-02	Shallow	1,000	10
-	-	RICE-03	Shallow	1,000	10
-	-	RICE-20	Shallow	1,000	10
388761N1217094W001	12N02E23H001M	Sutter County MW-2A	AZ-1	1,000	10
389605N1218102W003	13N01E24G004M	Flood MW-1C (shall)	AZ-1	1,000	10
389803N1217675W001	13N02E17A001M	-	AZ-1	1,000	10
390588N1217004W001	14N02E13L001M	-	AZ-1	1,000	10
390497N1216535W001	14N03E20H003M	-	AZ-1	1,081	10
-	-	Hillcrest Well #5	AZ-1 and AZ-2	1,000	10
388761N1217094W002	12N02E23H002M	Sutter County MW-2B	AZ-2	1,000	10
389167N1216061W004	12N03E02G003M	-	AZ-2	1,000	10
389605N1218102W002	13N01E24G003M	Flood MW-1B (int)	AZ-2	1,000	10
-	-	Hillcrest Well #8	AZ-2	1,000	10
-	-	Hillcrest Well #9	AZ-2	1,000	10
-	-	Well-1A / 5110001-011	AZ-2	1,000	10
-	-	Well-2A / 5110001-013	AZ-2	1,000	11
-	-	WTP well	AZ-2 and AZ-3	1,000	10
388666N1217749W001	12N02E20P001M	-	AZ-3	1,000	10
388761N1217094W003	12N02E23H003M	Sutter County MW-2C	AZ-3	1,000	10
388761N1217094W004	12N02E23H004M	Sutter County MW-2D	AZ-3	1,000	10
389167N1216061W003	12N03E02G002M	-	AZ-3	1,000	10

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold - TDS (mg/L)	Minimum Threshold - Nitrate as N (mg/L)
390696N1217778W003	14N02E17C003M	Sutter County MW-1C	AZ-3	1,000	10
390696N1217778W004	14N02E17C004M	Sutter County MW-1D	AZ-3	1,000	10
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	1,000	10
-	-	5100172-001	Unknown	1,000	10
-	-	5101007-001	Unknown	1,000	10

[1] Only one data TDS measurement is available at this well. There is little confidence in this data point. As data is collected as part of GSP implementation, the minimum threshold for TDS may be revised.

6.5.4.2 Relationship to Other Sustainability Indicators

Described below are the relationship between minimum thresholds for each sustainability indicator, including an explanation of how it was determined that basin conditions at the minimum thresholds for degraded water quality will avoid undesirable results for each of the other applicable sustainability indicators to the Sutter Subbasin. Minimum thresholds for degraded water quality are selected to avoid undesirable results for the other applicable sustainability indicators in the Sutter Subbasin.

- **Chronic Lowering of Groundwater Levels and Reduction of Groundwater Storage.** As previously stated, there are limited groundwater quality data available in the Sutter Subbasin to support a connection between groundwater pumping and elevated concentrations of COCs. Additionally, projects and management actions are not required in order to maintain sustainability in the Sutter Subbasin. However, the minimum thresholds established for degraded water quality could impact direct use of supplemental water supplies for groundwater recharge projects, where ambient water quality may constrain supplies available for recharge or require additional treatment prior to land application or injection, and could thus limit the ability to maintain the measurable objectives established for the chronic lowering of groundwater levels or reduction of groundwater storage sustainability indicator if such projects were to be deemed necessary.
- **Seawater Intrusion.** This sustainability indicator is not applicable to the Sutter Subbasin.
- **Land Subsidence.** Based on local knowledge and the best available science, degraded water quality and land subsidence minimum thresholds are not related. Therefore, minimum thresholds for degraded water quality are not anticipated to cause undesirable results for land subsidence.
- **Depletions of Interconnected Surface Water.** Minimum thresholds for degraded water quality are established to be protective of drinking water standards or current water quality (based on available data from 2000 to present) where current conditions exceed drinking water standards (the highest beneficial use of water in California), consistent with California’s Antidegradation Policy. Additionally, the volume of surface water in the interconnected surface water courses is much larger than the volume of water the aquifer is contributing to those streams. As such, while surface water quality is not within the purview of SGMA, the minimum thresholds for degraded water quality are not anticipated to degrade the quality of interconnected surface water.

6.5.4.3 Effects on Neighboring Subbasins

As noted in **Section 6.5.1.3**, there are seven groundwater subbasins adjacent to the Sutter Subbasin. Yuba Water Agency adopted and submitted the Yuba Subbasins GSP covering the North Yuba and South Yuba Subbasins to DWR in early 2020, ahead of the regulatory deadline for non-critically overdrafted high- and medium-priority basins. Butte, Wyandotte Creek, North American, Yolo, and Colusa Subbasins have developed their respective GSPs in tandem with the Sutter Subbasin, releasing draft GSP chapter for public review as complete, and therefore limited information is presently available about their proposed SMC.

Minimum thresholds for degraded water quality in the Sutter Subbasin have been selected to avoid causing undesirable results in adjacent subbasins or affect the ability of adjacent subbasins to achieve sustainability goals. The Sutter Subbasin GSAs will continue to coordinate with neighboring subbasins throughout GSP development and implementation to ensure groundwater management activities and established minimum thresholds do not cause undesirable results or affect the ability of adjacent subbasins to achieve their sustainability goals.

6.5.4.3.1 Butte Subbasin

In the Butte Subbasin, a minimum threshold for degraded water quality has been set at the higher of 900 microSiemens per centimeter (μS/cm) for electrical conductivity (EC; the recommended SMCL) or measured historical high EC concentration at each representative monitoring site. The methodology used to establish the minimum thresholds for degraded water quality in the Butte Subbasin is similar to that of the Sutter Subbasin, using drinking water standards and California's Antidegradation Policy. Therefore, it is not anticipated that minimum thresholds for degraded water quality in the Sutter Subbasin will cause undesirable results or affect the ability of the Butte Subbasin to achieve its sustainability goal.

6.5.4.3.2 Wyandotte Creek Subbasin

The Sutter and Wyandotte Creek Subbasins share a less than one mile boundary, comprised roughly of the Feather River in the very northeastern corner of the Sutter Subbasin where groundwater-related activities are not known to occur. Therefore, it is not anticipated that activities in the Sutter Subbasin will cause an undesirable result for degraded water quality in the Wyandotte Creek Subbasin.

6.5.4.3.3 North Yuba and South Yuba Subbasins

In the North Yuba and South Yuba Subbasins, EC, as a measure of salinity, is established at 1,000 μS/cm at each representative monitoring well, a value similar to the recommended SMCL of 900 μS/cm but below the Upper SMCL of 2,200 μS/cm. The methodology used to establish the minimum thresholds for degraded water quality in the Yuba Subbasins is similar to that of the Sutter Subbasin; therefore, it is not anticipated that minimum thresholds for degraded water quality in the Sutter Subbasin will cause undesirable results or affect the ability of the Yuba Subbasins to achieve its sustainability goal.

6.5.4.3.4 North American Subbasin

In the North American Subbasin, minimum thresholds are established for TDS and nitrate as N, where the minimum threshold is a concentration that exceeds the recommended SMCL of 500 mg/L for TDS and the Primary MCL of 10 mg/L for nitrate as N. This methodology is similar to that used by the Sutter Subbasin in establishing their minimum thresholds.

The Sutter Subbasin GSAs will continue to coordinate with the North American Subbasin GSAs to ensure that the effects of groundwater management activities on groundwater quality do not cause undesirables results or impact achievement of the respective sustainability goal in either subbasin.

6.5.4.3.5 Yolo Subbasin

The Yolo Subbasin Groundwater Agency will rely on current and future water quality standards established for drinking water and agricultural water uses by State and county regulatory agencies. The Yuba Subbasin Groundwater Agency plans to annually review water quality monitoring data, in collaboration with regulating agencies, to determine if water quality is being negatively affected by groundwater management activities. Where future significant impacts to water quality and associated groundwater management activities are identified, the Yuba Subbasin Groundwater Agency will coordinate with stakeholders and regulatory agencies to establish appropriate sustainable management criteria to avoid the occurrence of basin-wide undesirable results.

The Sutter Subbasin GSAs will continue to coordinate with the Yolo Subbasin Groundwater Agency to ensure that the effects of groundwater management activities on groundwater quality do not cause undesirable results or impact achievement of the respective sustainability goals in either subbasin.

6.5.4.3.6 Colusa Subbasin

In the Colusa Subbasin, a similar methodology is used as in the Butte Subbasin for establishing minimum thresholds for degraded groundwater quality (using either the higher of 900 µS/cm for EC or the pre-2015 historical maximum recorded EC value). The methodology used to establish the minimum thresholds for degraded water quality in the Colusa Subbasin is similar to that of the Sutter Subbasin; therefore, it is not anticipated that minimum thresholds for degraded water quality in the Sutter Subbasin will cause undesirable results or affect the ability of the Colusa Subbasin to achieve its sustainability goal.

6.5.4.4 Effects on Beneficial Uses and Users

As noted in **Section 6.5.1.4**, beneficial uses and users of groundwater in the Sutter Subbasin generally include domestic, municipal, agricultural, and environmental uses and users, where all beneficial uses and users of groundwater are identified in **Section 4.1** of the *Outreach and Communication* chapter. All beneficial uses and users of groundwater, and their associated land uses and property interests, were considered in establishing minimum thresholds for degraded water quality.

Stakeholders, including the public, were invited to provide feedback on minimum thresholds during SSGMCC meetings (held bi-weekly and noticed according to the Brown Act) and a public workshop held on August 11, 2021. Municipal and agricultural representatives are members of the SSGMCC and participated in the development of minimum thresholds, indicating that ambient groundwater quality consistent with drinking water standards or current water quality were sufficiently protective of beneficial uses of groundwater as they are consistent with regulatory requirements.

A description of how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests is contained herein.

- **Domestic.** Minimum thresholds for degraded water quality will protect groundwater quality accessed by domestic well users in some areas of the Sutter Subbasin, ensuring that the groundwater quality is maintained such that treatment is not required to meet drinking water standards. In areas of the Sutter Subbasin where ambient water quality is above drinking water standards for TDS and nitrate as N, minimum thresholds are established to be consistent with California's Antidegradation Policy and not result in additional burden of treatment for domestic well users.
- **Municipal.** Similar to domestic uses and users, minimum thresholds established for degraded water quality will preserve groundwater quality accessed by municipal well users in some areas of the Sutter Subbasin, ensuring that treatment is not necessary to meet drinking water standards, and are consistent with California's Antidegradation Policy, and reduce the need for additional treatment of TDS and/or nitrate as N in areas where groundwater quality currently exceeds drinking water standards.
- **Agricultural.** Drinking water standards for TDS and nitrate as N tend to require higher quality water than for many agricultural uses, which can vary by crop type. Growers in the Sutter Subbasin have adapted to current groundwater quality by either blending groundwater with surface water to dilute elevated concentrations of constituents of concern, installing wellhead treatment, or changing crop types grown. Therefore, minimum thresholds for degraded water quality are not anticipated to negatively impact agricultural uses and users of groundwater and will preserve the quality of groundwater for agricultural use.
- **Environmental.** Similar to domestic uses and users, environmental users of groundwater typically rely on shallow groundwater where accumulation of salts from applied water or nitrates from applied fertilizers or septic systems are most likely to impact these users. As with agricultural uses, drinking water standards for TDS and

nitrate as N typically result in higher quality water than what is required for environmental uses. Therefore, minimum thresholds for degraded water quality will maintain ambient groundwater quality in areas with elevated ambient concentrations and will preserve groundwater quality for its highest and best use as a drinking water supply.

6.5.4.5 Relevant Federal, State, or Local Standards

Minimum thresholds for degraded water quality incorporate state drinking water standards, including Primary and Secondary MCLs, and California's Antidegradation Policy (State Board Resolution 68-16), where existing groundwater quality will be maintained to ensure the highest water quality to the maximum benefit to the people of the State (SWRCB, 1968). Under the Central Valley Regional Water Quality Control Board's (CV-RWQCB) *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (or Basin Plan) (SWRCB, May 2018), beneficial use designations are assigned to water bodies denoting the water quality objectives for ambient water quality consistent with drinking water standards which are passed down through the various regulatory permitting programs (such as in Waste Discharge Requirements). The Statewide Recycled Water Policy Regulations sets forth water quality standards for recycled-water related projects, in the event recycled water is utilized for groundwater recharge projects. Finally, CV-SALTS sets forth discharge standards for salts and nitrate as part of the Central Valley-wide salt and nutrient management program as does the Irrigated Lands Regulatory Program.

6.5.4.6 Method for Quantitative Measurement

For information regarding how minimum thresholds for degraded water quality will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to **Section 7.2** *Monitoring*.

6.5.5 Land Subsidence

6.5.5.1 Identification and Methodology

As discussed in **Section 5.2.6** of the *Basin Setting* chapter, inelastic land subsidence has not historically been observed in the Sutter Subbasin. The minimum thresholds for land subsidence have been established for the Sutter Subbasin based on the Sacramento Valley Subsidence Network developed and monitored jointly by DWR, the U.S. Bureau of Reclamation (USBR), and local partners.

The minimum threshold for land subsidence is directly tied to avoiding undesirable results, which is the point at which differential settlement reduces the ability to delivery surface water supplies or inadequate freeboard on levee systems in wet years impacting conveyance of flood waters. A value of 0.5 feet of subsidence over a 5-year period was selected to represent the point at which water conveyance and levee infrastructure become sensitive to land subsidence within the Sutter Subbasin.

Additionally, 0.5 feet is approximately twice the operational error of measurements taken by DWR and USBR [0.17 feet margin of error (DWR North Region Office, 2018)] in monitoring the Sacramento Valley Subsidence Network, allowing for operational flexibility in the event subsidence is observed in the future in the Sutter Subbasin.

Table 6-3 reflects the minimum thresholds for land subsidence at each representative monitoring site.

Table 6-3. Minimum Threshold for Land Subsidence

DWR Station ID	DWR Station Name	Minimum Threshold (feet of subsidence per 5-year period)
304	HPGN CA 03 04	0.5
BOGE	BOGUE	0.5
CANL	CANAL KS1836	0.5
EAGR	EAGER	0.5
ENNS	ENNIS	0.5
F114	F 114	0.5
G117	G 1175	0.5
HPIN	HOPPIN	0.5
K435	K 1435	0.5
LOAK	LIVE OAK	0.5
LOMO	LOMO	0.5
MRSN	MORRISON	0.5
OSWD	OSWALD	0.5
PASS	PASSBUTTE	0.5
PELG	PELGER	0.5
SACA	SACRAMENTO AVENUE	0.5
SAWT	SAWTELLE	0.5
TARK	TARKE	0.5
TSDL	TISDALE	0.5
VARN	VARNEY	0.5
WASH	WASHINGTON	0.5
WR18	DWR18	0.5

6.5.5.2 Relationship to Other Sustainability Indicators

The relationship between minimum thresholds for each sustainability indicator, including an explanation of how it was determined that basin conditions at the minimum threshold for land subsidence will avoid undesirable results for each of the other applicable sustainability indicators to the Sutter Subbasin, are described herein. Minimum thresholds for land subsidence are selected to avoid undesirable results for other applicable sustainability indicators in the Sutter Subbasin.

- **Chronic Lowering of Groundwater Levels.** Minimum thresholds established for the chronic lowering of groundwater levels are also protective of levels of subsidence that could cause an undesirable result in the Sutter Subbasin, as no historic subsidence has been observed in the Sutter Subbasin.

- **Reduction of Groundwater Storage.** The minimum threshold for land subsidence does not directly impact the reduction of groundwater storage sustainability indicator.
- **Seawater Intrusion.** This sustainability indicator is not applicable to the Sutter Subbasin.
- **Degraded Water Quality.** The minimum threshold for land subsidence does not directly impact the degraded water quality sustainability indicator.
- **Depletions of Interconnected Surface Water.** The minimum threshold for land subsidence does not directly impact the depletions of interconnected surface water sustainability indicator.

6.5.5.3 Effects on Neighboring Subbasins

As noted in **Section 6.5.1.3**, there are seven groundwater subbasins adjacent to the Sutter Subbasin. Yuba Water Agency adopted and submitted the Yuba Subbasins GSP covering the North Yuba and South Yuba Subbasins to DWR in early 2020, ahead of the regulatory deadline for non-critically overdrafted high- and medium-priority basins. Butte, Wyandotte Creek, North American, Yolo, and Colusa Subbasins have developed their respective GPSs in tandem with the Sutter Subbasin, releasing draft GSP chapters for public review as complete. Therefore, limited information may be currently available as to the SMCs set for land subsidence for these subbasins.

Minimum thresholds for land subsidence in the Sutter Subbasin have been selected to avoid causing undesirable results in adjacent subbasins or affect the ability of adjacent subbasins to achieve sustainability goals, where a description of such is included herein. The Sutter Subbasin GSAs will continue to coordinate with neighboring subbasins throughout GSP development and implementation to ensure groundwater management activities and established minimum thresholds do not cause undesirable results or affect the ability of adjacent subbasins to achieve their sustainability goals.

6.5.5.3.1 Butte Subbasin

The minimum threshold for the Sutter Subbasin is the same value in the Butte Subbasin – 0.5 feet of subsidence over a 5-year period using the Sacramento Valley Subsidence Network. Therefore, no undesirable result in the Butte Subbasin is anticipated as a result of the established minimum threshold for land subsidence in the Sutter Subbasin.

6.5.5.3.2 Wyandotte Creek Subbasin

The Sutter and Wyandotte Creek Subbasins share a less than one mile boundary, comprised roughly of the Feather River, in the very northeastern corner of the Sutter Subbasin where groundwater-related activities are not known to occur. Therefore, it is not anticipated that activities in the Sutter Subbasin will cause an undesirable result for land subsidence in the Wyandotte Creek Subbasin.

6.5.5.3.3 North Yuba and South Yuba Subbasins

The minimum threshold for the Sutter Subbasin is the same value in the North Yuba and South Yuba Subbasins – 0.5 feet of subsidence over a 5-year period using the Sacramento Valley Subsidence Network. Therefore, no undesirable result in the North Yuba and South Yuba Subbasins is anticipated as a result of the established minimum threshold for land subsidence in the Sutter Subbasin.

6.5.5.3.4 North American Subbasin

Groundwater levels are used as proxy for minimum thresholds for land subsidence in the North American Subbasin, where at each representative monitoring site either the minimum recorded low groundwater elevation or the projected low groundwater elevation (whichever is lower) is used. Since inelastic land subsidence has not historically been observed in the Sutter Subbasin, it is not anticipated that minimum thresholds for land subsidence in the Sutter Subbasin would cause an undesirable result or affect the ability to reach the established sustainability goal in the North American Subbasin.

6.5.5.3.5 Yolo Subbasin

As previously noted, the North Yolo management area of the Yolo Subbasin borders the Sutter Subbasin. The minimum threshold value for land subsidence in the North Yolo Subbasin has been established as 5.0 cm/year over 25% of the management area using a 5-year running average, consistent with historic conditions. The Yuba Subbasin Groundwater Agency is committed to continued evaluation of subsidence and identification of impacts associated with subsidence. The Sutter Subbasin GSAs will continue to coordinate with the Yuba Subbasin Groundwater Agency to ensure minimum thresholds for subsidence does not cause undesirable results in the Sutter Subbasin.

6.5.5.3.6 Colusa Subbasin

In the Colusa Subbasin, subsidence data available through the Sacramento Valley Height Modernization Project between 2006 and 2017 (monitored using the Sacramento Valley Subsidence Network) was used to establish minimum thresholds for land subsidence. As noted in the public draft version of the Colusa Subbasin GSP, for representative monitoring sites that have experienced more than 1 foot of inelastic subsidence between 2006 and 2017, the minimum threshold has been set at 0.6 feet per year (or 7.2 inches per year). For representative monitoring sites that have experienced less than 1 foot of inelastic subsidence between 2006 and 2017, the minimum threshold has been set at 0.5 feet per year (or 6 inches per year). Since the minimum threshold for land subsidence has been set at a more conservative 0.5 feet per 5-year period in the Sutter Subbasin, minimum thresholds for the Sutter Subbasin are not anticipated to cause undesirable results or affect the Colusa Subbasin from achieving its sustainability goal. The Sutter Subbasin GSAs will continue to coordinate with GSAs in the Colusa Subbasin to ensure additional allowable subsidence in the Colusa Subbasin does not cause undesirable results in the Sutter Subbasin.

6.5.5.4 Effects on Beneficial Uses and Users

As noted in **Section 6.5.1.4**, beneficial uses and users of groundwater in the Sutter Subbasin generally include domestic, municipal, agricultural, and environmental uses and users, where all beneficial uses and users of groundwater are identified in **Section 4.1** of the *Outreach and Communication* chapter. All beneficial uses and users of groundwater, and their associated land uses and property interests, were considered in establishing minimum thresholds for land subsidence.

Stakeholders, including the public, were invited to provide feedback on minimum thresholds during SSGMCC meetings (held bi-weekly and noticed according to the Brown Act) and a public workshop held on August 11, 2021. Municipal and agricultural representatives are members of the SSGMCC and participated in the development of minimum thresholds.

A description of how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests is contained herein. The minimum threshold for land subsidence is established to avoid undesirable results for all beneficial uses and users of groundwater. Inelastic subsidence has not been observed in the Sutter Subbasin. Potentially effects on beneficial uses and users as a result of minimum threshold exceedances are unlikely but are considered in the event such impacts are observed.

- **Domestic.** Failure of well casings from land subsidence may impact domestic well owners as a result of compaction of fine-grained materials due to groundwater pumping, resulting in well repairs or well replacement.
- **Municipal.** Similar to domestic well owners, effects on municipal users may also result in failure of well casings. Additionally, differential settlement of the land surface may negatively impact distribution of water to customers in gravity-fed distribution systems or reduced ability to divert or convey flood water away from population centers.
- **Agricultural.** Effects on agricultural users may also result in failure of well casings, similar to domestic well owners and municipal users. Additionally, differential settlement of the land surface may negatively impact gravity-fed water conveyance systems. Flood management may also be impacted by differential settlement with the reduced ability to protect against, divert, or convey flood water, impacting crop production and/or resulting in flood-related damages.

- **Environmental.** The slope of streambeds may be impacted as a result of minimum threshold exceedances, causing changes in flow regimes and the creation of pools that can change in-stream temperatures.

6.5.5.5 Relevant Federal, State, or Local Standards

Currently, there are no other federal, state, or local standards within the Sutter Subbasin related to the land subsidence sustainability indicator. SGMA is the prevailing legislation dictating requirements and standards for land subsidence monitoring and management, as they related to GSP implementation.

6.5.5.6 Method for Quantitative Measurement

For information regarding how minimum thresholds for land subsidence will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to **Section 7.2** *Monitoring*.

6.5.6 Depletions of Interconnected Surface Water

6.5.6.1 Identification and Methodology

The same methodology that was applied in calculating the minimum thresholds for chronic lowering of groundwater levels is also used for depletions of interconnected surface water.

The minimum threshold for depletions of interconnected surface water is established as the deepest of the following:

1. The historic low for the available record at each representative monitoring site; or
2. 90% of the average groundwater elevation from the project water budget (baseline condition over 60-year period using C2VSimFG-Sutter) at each representative monitoring site with an artificial increase in ET of 50%; or
3. The average operating range (difference between measurable objective and minimum threshold) for all representative monitoring sites using the above criteria for the following AZs, applied based on the available screen interval or well depth information for each representative monitoring site:
    a. Shallow AZ and AZ-1 = 8.0 feet
    b. AZ-2 and AZ-3 = 16.5 feet

Table 6-4 reflects the minimum thresholds for depletions of interconnected surface water at each representative monitoring site. Refer to **Appendix 6-A** for hydrographs for all representative monitoring sites for depletions of interconnected surface water plotted with the established minimum threshold and measurable objectives. Additionally, refer to **Appendix 6-B** for more information about development of minimum thresholds for chronic lowering of groundwater levels and a comparison of considered methodologies, where the same methodologies were also considered for depletions of interconnected surface water.

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Table 6-4. Minimum Thresholds for Depletions of Interconnected Surface Water

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Minimum Threshold (feet above MSL, NAVD88)
-	12N03E18H001M	USGS-385314121401701	Shallow	13.32
-	14N02E10R001M	USGS-390416121433601	Shallow	25.09
-	15N02E20D001M	USGS-390832121463601	Shallow	29.50
391975N1218937W001	16N01E31H001M	-	Shallow	29.90
392328N1216469W001	16N03E21D002M	-	Shallow	44.44
389563N1215843W001	-	GH East MW Site	Shallow	13.03
389571N1215858W001	-	GH North MW Site	Shallow	14.39
389233N1218022W001	12N01E01A001M	-	AZ-1	15.11
389937N1218240W001	13N01E11A001M	-	AZ-1	18.69
390458N1216114W001	14N03E23D003M	Feather River MW-1A	AZ-1	15.78
389453N1216159W001	-	GH Well 2	AZ-1	22.09
389398N1216162W001	-	GH Well 3	AZ-1	17.04
389410N1215884W001	-	GH Well 18	AZ-1	5.65
388869N1216445W002	-	Ma-1	AZ-1	14.36
388813N1217525W001	12N02E21Q001M	SR-1A	AZ-1	14.74
392394N1216509W001	16N03E17J001M	Sutter County MW-3A	AZ-1	45.80
390458N1216114W002	14N03E23D004M	Feather River MW-1B	AZ-2	-30.19
392394N1216509W002	16N03E17J002M	Sutter County MW-3B	AZ-2	36.89
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	11.05
390458N1216114W004	14N03E23D006M	Feather River MW-1D	AZ-3	9.49
392394N1216509W003	16N03E17J003M	Sutter County MW-3C	AZ-3	34.68
392394N1216509W004	16N03E17J004M	Sutter County MW-3D	AZ-3	31.78
392394N1216509W005	16N03E17J005M	Sutter County MW-3E	AZ-3	31.21

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In the Sutter Subbasin, groundwater levels have been sustainable over time as the aquifer rebounds during all water year types following the irrigation season, returning to pre-pumping levels on a seasonal basis (see **Section 5.2** *Groundwater Conditions*). The Sacramento and Feather Rivers act as 'regulating reservoirs' in the Sutter Subbasin, feeding water into the Subbasin as groundwater levels are lowered through natural fluctuations and groundwater pumping. Therefore, undesirable results relative to depletions of interconnected surface water have not historically been observed in the Sutter Subbasin.

At each representative monitoring site, the C2VSimFG-Sutter flow model was used to simulate groundwater elevations from the projected water budget to estimate average groundwater elevations over the 60-year simulation period with an artificial increase in ET by 50% to induce additional groundwater pumping to meet overlying land use demands to the point where interconnected streams that are gaining become losing. A factor of 90% of the average simulated groundwater levels, where ET is increased by 50%, was applied to be conservative and avoid changes in the direction of stream interconnection while providing for additional operating range in the Sutter Subbasin.

For representative monitoring sites with small operating ranges as a result of the application of the first two methodologies for calculating minimum thresholds, a minimum operating range was applied based on values estimated by those two other methods. The average operating range for the Shallow AZ and AZ-1 were combined with the goal of being protective of interconnected surface waters and GDEs, where the average operating range of AZ-2 and AZ-3 were combined because most groundwater is pumped from these aquifer zones in the Sutter Subbasin for municipal and agricultural supply. A minimum operating range is applied where applicable in order to allow for a reasonable use of groundwater by all beneficial users in the Sutter Subbasin.

Throughout GSP implementation, additional data collected at each representative monitoring site will be evaluated to ensure that the minimum operating range applied does not cause an undesirable result in the Sutter Subbasin or adjacent subbasins. At the time of GSP development, it is not anticipated this method will cause an undesirable result based on the projected absence of undesirable results using the first two calculation methods previously described.

6.5.6.2 Relationship to Other Sustainability Indicators

Described below is the relationship between minimum thresholds for each sustainability indicator, including an explanation of how it was determined that basin conditions at the minimum thresholds for depletions of interconnected surface water will avoid undesirable results for each of the other applicable sustainability indicators to the Sutter Subbasin. Minimum thresholds for depletions of interconnected surface water are selected to avoid undesirable results for the other applicable sustainability indicators in the Sutter Subbasin.

- **Chronic Lowering of Groundwater Levels and Reduction of Groundwater Storage.** Minimum thresholds for depletions of interconnected surface water were calculated using the same methodology as for the chronic lowering of groundwater level minimum thresholds (and used as proxy for reduction of groundwater storage). As previously noted, the Sacramento and Feather Rivers are key interconnected surface water sources in the Sutter Subbasin, feeding water into the Subbasin as groundwater levels are lowered through natural fluctuations and groundwater pumping. As minimum thresholds are designed to be protective of interconnected surface water and maintain groundwater levels at sustainable levels for the chronic lowering of groundwater levels and reduction of groundwater in storage SMC, minimum thresholds for depletions of interconnected surface water are not anticipated to cause undesirable results for the chronic lowering of groundwater levels or reduction of groundwater storage sustainability indicators.
- **Seawater Intrusion.** This sustainability indicator is not applicable to the Sutter Subbasin.
- **Degraded Water Quality.** Minimum thresholds for depletions of interconnected surface water are intended to maintain current, sustainable conditions relative to the direction of interconnection and volume exchanged between surface water and groundwater. There is no current evidence indicating that connection between interconnected surface waters and groundwater has any impact on groundwater quality. And the volume of surface water flowing through the interconnected surface water courses is much larger than the volume of water the aquifer is contributing to those streams. Therefore, based on local knowledge and best available science, it is not anticipated that minimum thresholds for depletions of interconnected surface water will cause undesirable results for degraded water quality.
- **Land Subsidence.** Based on local knowledge and the best available science, depletions of interconnected surface water and land subsidence minimum thresholds are not related. Historically, minimal inelastic subsidence has been observed in the Sutter Subbasin. There is no evidence to support large-scale compaction of clay layers in the Sutter Subbasin that may impact interconnection between groundwater and surface water. Therefore, minimum thresholds for depletions of interconnected surface water are not anticipated to cause undesirable results for land subsidence.

6.5.6.3 Effects on Neighboring Subbasins

As noted in **Section 6.5.1.3**, there are seven groundwater subbasins adjacent to the Sutter Subbasin. Yuba Water Agency adopted and submitted the Yuba Subbasins GSP covering the North Yuba and South Yuba Subbasins to DWR in early 2020, ahead of the regulatory deadline for non-critically overdrafted high- and medium-priority basins. Butte, Wyandotte Creek, North American, Yolo, and Colusa Subbasins have developed their respective GPSs in tandem with the Sutter Subbasin, releasing draft GSP chapter for public review as complete and therefore limited information may be available at this time about the established SMC for those subbasins.

Minimum thresholds for depletions of interconnected surface water in the Sutter Subbasin have been selected to avoid causing undesirable results in adjacent subbasins or affect the ability of adjacent subbasins to achieve sustainability goals, where a description of such is contained herein. The Sutter Subbasin GSAs will continue to coordinate with neighboring subbasins throughout GSP development and implementation to ensure groundwater management activities and established minimum thresholds do not cause undesirable results or affect the ability of adjacent subbasins to achieve their sustainability goals.

6.5.6.3.1 Butte Subbasin

In the Butte Subbasin, minimum thresholds for depletion of interconnected surface water were set at 10 feet below the measured historical low for each representative monitoring well. This method was selected to be protective of beneficial use of interconnected surface water and shallow groundwater near streams and rivers, including those of shallower domestic users and potential groundwater dependent ecosystems. The additional 10 feet in depth below the measured historical low is intended to provide an appropriate margin of operational flexibility during GSP implementation. Since the portion of the Feather River bordering the Butte Subbasin is located upstream from the Sutter Subbasin, it is not anticipated that minimum thresholds set for depletions of interconnected surface water along the Feather River in the Sutter Subbasin will cause undesirable results or impact the ability of the Butte Subbasin to achieve its sustainability goal.

6.5.6.3.2 Wyandotte Creek Subbasin

The Sutter and Wyandotte Creek Subbasins share a less than one mile boundary, comprised roughly of the Feather River in the very northeastern corner of the Sutter Subbasin where groundwater-related activities are not known to occur. Therefore, it is not anticipated that activities in the Sutter Subbasin will cause an undesirable result for depletions of interconnected surface water in the Wyandotte Creek Subbasin.

6.5.6.3.3 North Yuba and South Yuba Subbasins

In the North Yuba and South Yuba Subbasins, management of depletions of interconnected surface water are performed using groundwater levels as a proxy, using the same monitoring network and numeric SMC as chronic lowering of groundwater levels to identify undesirable results relative to depletions of interconnected surface water. Since numeric SMC for depletions of interconnected surface water and chronic lowering of groundwater levels were developed using the same methodology for the Sutter Subbasin GSP, minimum thresholds in the Sutter Subbasin are anticipated to avoid causing an undesirable result or affect the ability of the North Yuba and South Yuba subbasins to achieve their sustainability goal.

6.5.6.3.4 North American Subbasin

In the North American Subbasin, minimum thresholds for depletions of interconnected surface water are established using groundwater levels as proxy using the same values as established for the chronic lowering of groundwater sustainability indicator, using a subset of representative monitoring sites considered to be interconnected with the surface water system. Since numeric SMC for depletions of interconnected surface water and chronic lowering of groundwater levels were developed using the same methodology for the Sutter Subbasin GSP, minimum thresholds in the Sutter Subbasin are anticipated to avoid causing an undesirable result or affect the ability of the North American Subbasin in achieving its sustainability goal.

6.5.6.3.5 Yolo Subbasin

Minimum thresholds for the depletions of interconnected surface water sustainability indicator along the Upper Sacramento River (defined in the Yolo Subbasin GSP as from the northern subbasin boundary to the southern boundary of the North Yolo management area, which borders the Sutter Subbasin) are established using the same criteria as for the chronic lowering of groundwater levels sustainability indicator in the North Yolo management area. The minimum threshold value is equal to the historic minimum groundwater elevation plus 20% of the depth between the historic maximum and historic minimum elevation for the period of record at each representative monitoring well.

Based on similar methodologies used to establish minimum thresholds along the Upper Sacramento River portion of the North Yolo management area as compared to the Sutter Subbasin (the use of historic minimum groundwater elevations plus some additional buffer) and the role of the Sacramento River (adjoining both subbasins) as a ‘regulating reservoir’ in the Sutter Subbasin, minimum thresholds in the Sutter Subbasin are not anticipated to cause undesirable results or affect the ability of the Yolo Subbasin in achieving its sustainability goal relative to depletions of interconnected surface water.

6.5.6.3.6 Colusa Subbasin

In the Colusa Subbasin, a similar methodology to the Butte Subbasin was used to set minimum thresholds for depletions of interconnected surface water, where the groundwater elevation at each representative monitoring well closest to October 15, 2015 (considered to be the lowest groundwater elevations during the last drought based on review of historical groundwater levels and hydrologic data) was selected with an additional 10 feet added to this groundwater elevation to provide an appropriate margin of operational flexibility in the future during GSP implementation. In the Sutter Subbasin monitoring network, only one representative monitoring site is available along the

Sacramento River (forming the Colusa-Sutter Subbasins boundary) and it is the same site in both GSPs (13N01E11A001). The minimum threshold in the Colusa Subbasin GSP at 13N01E11A001 is set at 13 feet above mean seal level (MSL) and 18.69 feet above MSL in the Sutter Subbasin (**Table 6-4**). Since 13N01E11A001 is located in the Colusa Subbasin across the Sacramento River, it is not anticipated that localized groundwater pumping in the Sutter Subbasin will impact this monitoring site. Therefore, it is not anticipated that the minimum threshold established at 13N01E11A001 for the Sutter Subbasin GSP will cause an undesirable result or impact the ability of the Colusa GSP to achieve its sustainability goal.

6.5.6.4 Effects on Beneficial Uses and Users

As noted in **Section 6.5.1.4**, beneficial uses and users of groundwater in the Sutter Subbasin generally include domestic, municipal, agricultural, and environmental uses and users, where all beneficial uses and users of groundwater are identified in **Section 4.1** of the *Outreach and Communication* chapter. All beneficial uses and users of groundwater, and their associated land uses and property interests, were considered in establishing minimum thresholds for depletions of interconnected surface water.

Stakeholders, including the public, were invited to provide feedback on minimum thresholds during SSGMCC meetings (held bi-weekly and noticed according to the Brown Act) and a public workshop held on August 11, 2021. Municipal and agricultural representatives are members of the SSGMCC and participated in the development of minimum thresholds.

A description of how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests is contained herein.

- **Domestic.** Minimum thresholds for depletions of interconnected surface water are established to avoid undesirable results for domestic well users as domestic wells are typically screened in the Shallow AZ or AZ-1. Domestic well users are typically considered to be *de minimis* groundwater users (2 acre-feet or less per year) and are not anticipated to cause an undesirable result for depletions of interconnected surface water. Alternatively, due to the interconnection of the Sacramento and Feather Rivers with the Sutter Subbasin, it is not anticipated that negative impacts on domestic well users near interconnected surface waters will be observed if established minimum thresholds are exceeded.
- **Municipal.** As previously noted, municipal water supply systems are designed to include redundancy to adapt to changes in groundwater conditions. Minimum thresholds for depletions of interconnected surface water are established to be protective of municipal groundwater and surface water production needs. If an undesirable result were observed, a reversal of gaining to losing streams could result in decreased water supply available in streams utilized for municipal use in the Sutter Subbasin.

- **Agricultural.** Similar to municipal users, minimum thresholds for depletions of interconnected surface water are established to be protective of agricultural water needs as the primary use of water in the Sutter Subbasin. If an undesirable result were observed, a reversal of gaining to losing streams could result in decreased water supply available in streams utilized for agricultural purposes in the Sutter Subbasin.
- **Environmental.** If an undesirable result for depletions of interconnected surface water is observed and presently gaining streams become losing streams, this reversal of stream interconnection would affect aquatic systems and potentially GDEs. Overall water supply utilized by environmental beneficial users of water would be reduced, thereby reducing suitable habitat through reduced stream depth, flow velocity, cover, and dissolved oxygen as well as increased temperature.

6.5.6.5 Relevant Federal, State, or Local Standards

Currently, there are no federal, state, or local standards directly related to the depletions of interconnected surface water sustainability indicator. SGMA is the prevailing legislation dictating requirements and standards for the depletions of interconnected surface water sustainability indicator.

In December 2010 the State Water Resources Control Board (SWRCB) adopted Order WQ 2010-0016, a water quality certification that contains instream flow and temperature requirements for the Feather River's reaches downstream of Oroville Dam (NCWA, November 2019). For the High Flow Channel, which is the reach between the Thermalito Afterbay's outlet and the Feather River's confluence with the Sacramento River, instream flow requirements are required to be maintained so long as they are not projected to cause Oroville Reservoir to be drawn below 733 feet (or approximately 1.5 million acre-feet in storage), with reduced instream flow requirements to prevent drawdown below 733 feet provided stream flows would not be reduced more than 25% below requirements. The certification also requires DWR to operate the Oroville project to meet temperature standards in Feather River.

In April 1960, a Memorandum of Agreement (MOA) between USBR and California Department of Fish and Game (now California Department of Fish and Wildlife) originally established flow objectives in the Sacramento River for protection and preservation of fish and wildlife resources, providing for minimum releases into the natural channel of the Sacramento River at Keswick Dam for normal and critically dry years. Modifications to the flow schedule in the MOA were made in October 1981. In 1990 and 1991, the SWRCB issued Water Rights Orders 90-05 and 91-01 modifying USBR's water rights for the Sacramento River. The orders states USBR shall operate Keswick and Shasta Dams and the Spring Creek Powerplant to meet temperature requirements as far downstream in the Sacramento River as practicable during periods when high temperature would be harmful to fisheries. Pursuant to these orders, USBR configured and implemented the Sacramento-Trinity Water Quality Monitoring Network to monitor temperature and other parameters at key locations in the Sacramento and Trinity Rivers.

6.5.6.6 Method for Quantitative Measurement

For information regarding how minimum thresholds for depletions of interconnected surface water will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to **Section 7.2** *Monitoring*.

6.6 Measurable Objectives and Interim Milestones

Measurable objectives are quantitative goals that reflect the subbasin's desired groundwater conditions and allow the Sutter Subbasin GSAs to achieve the sustainability goal within 20 years. Measurable objectives are set such that there is a reasonable margin of operational flexibility that will accommodate droughts, climate change, conjunctive use operations, and other groundwater management activities. Given that the Sutter Subbasin is currently considered sustainable, projects and management actions are not considered necessary to achieve the measurable objectives. However, projects and management actions are included in **Section 7.1** and designed to allow for adaptive management of the groundwater basin, maintain sustainable conditions and improve overall groundwater conditions.

Interim milestones are target values representing measurable groundwater conditions, in increments of 5 years, set to help move a basin towards the sustainability goal over a 20-year period. Interim milestones are set equal to the measurable objective for each applicable sustainability indicator, as the Sutter Subbasin is in a sustainable state, as a means of maintaining that sustainability.

This section describes the methodology used to develop numeric measurable objectives/interim milestones and how the established values will maintain sustainable conditions in the Sutter Subbasin.

6.6.1 Chronic Lowering of Groundwater Levels

The measurable objective for the chronic lowering of groundwater levels is set at the average of the available historical record at each representative monitoring site. The average groundwater level calculated over the historic record for each representative monitoring site reflects a long-term, varied hydrologic record and, along with the identification of undesirable results, is anticipated to maintain sustainable conditions in the Sutter Subbasin as the Subbasin is shown to currently be in a sustainable state (see **Section 5.3** of the *Basin Setting* chapter for more information about sustainable conditions in the Sutter Subbasin). Refer to **Appendix 6-A** for hydrographs for all representative monitoring sites for chronic lowering of groundwater levels plotted with the established measurable objective.

In the process of developing the measurable objectives for the chronic lowering of groundwater levels, several other methods were considered. Other methods considered included the average of measurements between Water Year 2015 and 2020, average of seasonal high groundwater levels over the historic record at each representative monitoring site, and 10 feet below ground surface elevation as established in the Sutter Subbasin Alternative Plan (GEI, 2016). Refer to **Appendix 6-B** for more information about development of measurable objectives for chronic lowering of groundwater levels and a comparison of considered methodologies.

Table 6-5 reflects the measurable objectives and interim milestones for chronic lowering of groundwater levels at each representative monitoring site.

Table 6-5. Measurable Objectives and Interim Milestones for the Chronic Lowering of Groundwater Levels

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone (feet above MSL, NAVD88)
-	12N02E09B002M	USGS-385431121451401	Shallow	20.30
-	12N03E18H001M	USGS-385314121401701	Shallow	21.32
-	14N02E10R001M	-	Shallow	36.63
-	15N02E20D001M	USGS-390832121463601	Shallow	37.50
391975N1218937W001	16N01E31H001M	-	Shallow	41.46
392328N1216469W001	16N03E21D002M	-	Shallow	61.53
390696N1217778W001	14N02E17C001M	Sutter County MW-1A	Shallow	29.50
390426N1218166W001	14N01E24N001M	USGS-390416121433601	AZ-1	31.58
390588N1217004W001	14N02E13L001M	-	AZ-1	35.80
390176N1217902W001	14N02E31K001M	-	AZ-1	27.08
391051N1217012W001	15N02E36L001M	-	AZ-1	41.09
392712N1216493W001	16N03E04E001M	-	AZ-1	51.18
392970N1216907W003	17N02E25J003M	BWD MW-1C	AZ-1	68.03
390458N1216114W001	14N03E23D003M	Feather River MW-1A	AZ-1	25.14
389605N1218102W003	13N01E24G004M	Flood MW-1C (shall)	AZ-1	23.33
389453N1216159W001	-	GH Well 2	AZ-1	30.09
391456N1218904W001	-	MFWC Prop 50	AZ-1	35.72
387859N1216565W001	11N03E20H003M	RD 1500 Karnak	AZ-1	18.51
390682N1216901W001	14N02E13A003M	SEWD MW-3A	AZ-1	39.57
390244N1217813W001	14N02E32D001M	SMWC MW-1A	AZ-1	26.34
388761N1217094W001	12N02E23H001M	Sutter County MW-2A	AZ-1	15.58
392394N1216509W001	16N03E17J001M	Sutter County MW-3A	AZ-1	67.82
390087N1216722W001	13N03E06A001M	Sutter County MW-6A	AZ-1	29.13

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone (feet above MSL, NAVD88)
-	-	Hillcrest Well #5	AZ-1 and AZ-2	31.97
391414N1217442W001	15N02E22D001M	-	AZ-2	40.50
391283N1218286W001	-	BS2-Franklin	AZ-2	33.27
392970N1216907W002	17N02E25J002M	BWD MW-1B	AZ-2	43.89
390458N1216114W002	14N03E23D004M	Feather River MW-1B	AZ-2	13.00
389605N1218102W001	13N01E24G002M	Flood MW-1A (deep)	AZ-2	24.50
389605N1218102W002	13N01E24G003M	Flood MW-1B (int)	AZ-2	21.89
-	-	Hillcrest Well #8	AZ-2	33.84
-	-	Hillcrest Well #9	AZ-2	30.85
391658N1217070W001	15N02E12E001M	SEWD MW-1A	AZ-2	46.28
391658N1217070W002	15N02E12E002M	SEWD MW-1B	AZ-2	39.64
391279N1216989W001	15N02E24P001M	SEWD MW-2A	AZ-2	41.01
391279N1216989W002	15N02E24P002M	SEWD MW-2B	AZ-2	29.31
390682N1216901W002	14N02E13A004M	SEWD MW-3B	AZ-2	33.31
390244N1217813W002	14N02E32D002M	SMWC MW-1B	AZ-2	26.51
390696N1217778W002	14N02E17C002M	Sutter County MW-1B	AZ-2	28.83
388761N1217094W002	12N02E23H002M	Sutter County MW-2B	AZ-2	16.42
392394N1216509W002	16N03E17J002M	Sutter County MW-3B	AZ-2	53.39
389452N1215992W001	13N03E26J002M	Sutter County MW-4A	AZ-2	21.59
390087N1216722W002	13N03E06A002M	Sutter County MW-6B	AZ-2	26.71
390087N1216722W003	13N03E06A003M	Sutter County MW-6C	AZ-2	26.41
-	-	WTP well	AZ-2 and AZ-3	38.01
392867N1217825W001	17N02E31A001M	-	AZ-3	50.35

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone (feet above MSL, NAVD88)
392970N1216907W001	17N02E25J001M	BWD MW-1A	AZ-3	35.01
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	27.55
390458N1216114W004	14N03E23D006M	Feather River MW-1D	AZ-3	25.99
391658N1217070W003	15N02E12E003M	SEWD MW-1C	AZ-3	39.41
391279N1216989W003	15N02E24P003M	SEWD MW-2C	AZ-3	29.80
390682N1216901W003	14N02E13A005M	SEWD MW-3C	AZ-3	29.56
390244N1217813W003	14N02E32D003M	SMWC MW-1C	AZ-3	25.35
390696N1217778W003	14N02E17C003M	Sutter County MW-1C	AZ-3	25.72
390696N1217778W004	14N02E17C004M	Sutter County MW-1D	AZ-3	28.41
388761N1217094W003	12N02E23H003M	Sutter County MW-2C	AZ-3	16.38
388761N1217094W004	12N02E23H004M	Sutter County MW-2D	AZ-3	16.09
392394N1216509W003	16N03E17J003M	Sutter County MW-3C	AZ-3	51.18
392394N1216509W004	16N03E17J004M	Sutter County MW-3D	AZ-3	48.28
392394N1216509W005	16N03E17J005M	Sutter County MW-3E	AZ-3	47.71
389452N1215992W002	13N03E26J003M	Sutter County MW-4B	AZ-3	20.62
389452N1215992W003	13N03E26J004M	Sutter County MW-4C	AZ-3	19.32
389452N1215992W004	13N03E26J005M	Sutter County MW-4D	AZ-3	16.84

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Local input through SSGMCC meetings as well as public workshops was considered in setting the measurable objectives for chronic lowering of groundwater levels. The selected measurable objectives reflect input from local water purveyors as well as the agricultural community and is expected to maintain economically-viable groundwater levels for all beneficial users of groundwater. Interim milestones are equal to the measurable objective for chronic lowering of groundwater levels.

6.6.2 Reduction of Groundwater Storage

Since chronic lowering of groundwater levels is used as a proxy for reduction in groundwater storage, the measurable objectives and interim milestones for the reduction of groundwater storage sustainability indicator are the same as the measurable objectives and interim milestones for the chronic lowering of groundwater levels sustainability indicator as set forth in **Section 6.6.1** and will utilize the same monitoring networks and collected data (in addition to C2VSimFG-Sutter) to evaluate performance and sustainability metrics.

6.6.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Sutter Subbasin as the Subbasin is located inland from the Pacific Ocean and is not adjacent to the Sacramento-San Joaquin Delta. Therefore, SMC for seawater intrusion will not be established for the Sutter Subbasin GSP.

6.6.4 Degraded Water Quality

The measurable objective for degraded water quality is set as the current water quality conditions for TDS and nitrate as N based on data available from 2000 to the time of GSP development (Summer 2021) at the representative monitoring well or nearby well within the same aquifer zone (as described in **Section 5.2.5** of the *Basin Setting* chapter) using maximum concentration detected of each constituent. In the event that well-specific data or nearby well data in the same aquifer zone are not present, the measurable objective has been set at 500 mg/L for TDS (the recommended SMCL) and 7 mg/L for nitrate as N [70% of the Primary MCL, per the adaptive management trigger system described in the *Framework for a Drinking Water Well Impact Mitigation Program* (Self-Help Enterprises et al., n.d.)]. **Table 6-6** reflects the measurable objectives and interim milestones for degraded water quality at each representative monitoring site.

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Table 6-6. Measurable Objectives and Interim Milestones for Degraded Water Quality

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone - TDS (mg/L)	Measurable Objective / Interim Milestone - Nitrate as N (mg/L)
391975N1218937W001	16N01E31H001M	-	Shallow	< 500	< 7
-	-	RICE-01	Shallow	8,200[1]	1
-	-	RICE-02	Shallow	375	1
-	-	RICE-03	Shallow	519	1.72
-	-	RICE-20	Shallow	620	3.77
388761N1217094W001	12N02E23H001M	Sutter County MW-2A	AZ-1	< 500	< 7
389605N1218102W003	13N01E24G004M	Flood MW-1C (shall)	AZ-1	< 500	< 7
389803N1217675W001	13N02E17A001M	-	AZ-1	799	1
390588N1217004W001	14N02E13L001M	-	AZ-1	367	1
390497N1216535W001	14N03E20H003M	-	AZ-1	1,081	1
-	-	Hillcrest Well #5	AZ-1 and AZ-2	< 500	1
388761N1217094W002	12N02E23H002M	Sutter County MW-2B	AZ-2	< 500	< 7
389167N1216061W004	12N03E02G003M	-	AZ-2	< 500	< 7
389605N1218102W002	13N01E24G003M	Flood MW-1B (int)	AZ-2	< 500	< 7
-	-	Hillcrest Well #8	AZ-2	< 500	1
-	-	Hillcrest Well #9	AZ-2	< 500	4
-	-	Well-1A / 5110001-011	AZ-2	420	8
-	-	Well-2A / 5110001-013	AZ-2	450	11
-	-	WTP well	AZ-2 and AZ-3	170	1
388666N1217749W001	12N02E20P001M	-	AZ-3	< 500	< 7
388761N1217094W003	12N02E23H003M	Sutter County MW-2C	AZ-3	< 500	< 7
388761N1217094W004	12N02E23H004M	Sutter County MW-2D	AZ-3	< 500	< 7

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone - TDS (mg/L)	Measurable Objective / Interim Milestone - Nitrate as N (mg/L)
389167N1216061W003	12N03E02G002M	-	AZ-3	< 500	< 7
390696N1217778W003	14N02E17C003M	Sutter County MW-1C	AZ-3	874	1
390696N1217778W004	14N02E17C004M	Sutter County MW-1D	AZ-3	874	1
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	< 500	< 7
-	-	5100172-001	Unknown	< 500	3
-	-	5101007-001	Unknown	< 500	< 7

[1] Only one data TDS measurement is available at this well. There is little confidence in this data point. As data is collected as part of GSP implementation, the minimum threshold for TDS may be revised.

Local input through SSGMCC meetings as well as public workshops were also applied in setting the measurable objectives for degraded water quality. The selected measurable objectives reflect input from local drinking water purveyors as well as the local agricultural community and is expected to maintain beneficial uses of groundwater. It should be noted that concentrations presented for measurable objectives reflect ambient groundwater quality, where additional treatment may currently be necessary to meet state and federal MCLs for drinking water. Interim milestones are equal to the measurable objective for degraded water quality. Measurable objectives/interim milestones have been established consistent with California’s Antidegradation Policy.

6.6.5 Land Subsidence

The measurable objective for land subsidence reflects the desired conditions and is set at 0.25 feet of subsidence per 5-year period at each site (0.05 feet over 1 year or 1 foot over 20 years), a rate that is small but reflects the range of error inherent in measurements collected for the subsidence monitoring network [measured with an accuracy of 0.17 feet (DWR North Region Office, 2018)]. Because subsidence has not historically been detected in the Sutter Subbasin, interim milestones are set at the measurable objective value of 0.25 feet per 5-year period. **Table 6-7** reflects the measurable objectives and interim milestones for the land subsidence sustainability indicator.

Local input through SSGMCC meetings as well as public workshops were applied in setting the measurable objective for land subsidence. The selected measurable objective reflects input from local water purveyors, reclamation districts, and the agricultural community who operate and maintain critical infrastructure within the Subbasin that would be directly impact by inelastic land subsidence. Interim milestones are equal to the measurable objective for land subsidence.

Table 6-7. Measurable Objective and Interim Milestone for Land Subsidence

DWR Station ID	DWR Station Name	Measurable Objective / Interim Milestone (feet of subsidence per 5-year period)
304	HPGN CA 03 04	0.25
BOGE	BOGUE	0.25
CANL	CANAL KS1836	0.25
EAGR	EAGER	0.25
ENNS	ENNIS	0.25
F114	F 114	0.25
G117	G 1175	0.25
HPIN	HOPPIN	0.25
K435	K 1435	0.25
LOAK	LIVE OAK	0.25
LOMO	LOMO	0.25
MRSN	MORRISON	0.25
OSWD	OSWALD	0.25
PASS	PASSBUTTE	0.25
PELG	PELGER	0.25
SACA	SACRAMENTO AVENUE	0.25
SAWT	SAWTELLE	0.25
TARK	TARKE	0.25
TSDL	TISDALE	0.25
VARN	VARNEY	0.25
WASH	WASHINGTON	0.25
WR18	DWR18	0.25

6.6.6 Depletions of Interconnected Surface Water

The measurable objective for depletions of interconnected surface water is set at the average of the available historical record at each representative monitoring site. The average groundwater level calculated over the historic record for each representative monitoring site reflects a long-term, varied hydrologic record and, along with the identification of undesirable results, is anticipated to maintain sustainable conditions in the Sutter Subbasin as the Subbasin is shown to currently be in a sustainable state (see **Section 5.3** of the *Basin Setting* chapter for more information about sustainable conditions in the Sutter Subbasin). Refer to **Appendix 6-A** for hydrographs for all representative monitoring sites for depletions of interconnected surface water plotted with the established measurable objective.

The same methodology for establishing measurable objectives for the chronic lowering of groundwater levels is used for depletions of interconnected surface water (see **Appendix 6-B** for more information about development measurable objectives and comparison of considered methodologies). Interconnected surface waters are a key controlling factor for groundwater levels in the Sutter Subbasin, and the Sacramento and Feather Rivers (along with the Sutter Bypass) are the principal surface water courses in connection with the Subbasin.

The average of the historical record at each representative monitoring site was selected to establish the measurable objectives and interim milestones for depletions of interconnected surface water because historically undesirable results relative to this sustainability indicator have not been observed in the Sutter Subbasin, and maintaining current, sustainable conditions is anticipated to avoid undesirable results. **Table 6-8** reflects the measurable objectives and interim milestones for the depletion of interconnected surface water sustainability indicator.

Local input through SSGMCC meetings as well as public workshops were applied in setting the measurable objectives for depletions of interconnected surface water. The selected measurable objectives reflect input from local water purveyors as well as the agricultural community and is expected to maintain sustainable conditions relative to surface water-groundwater interaction. Interim milestones are equal to the measurable objective for depletions of interconnected surface water.

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Table 6-8. Measurable Objectives and Interim Milestones for Depletions of Interconnected Surface Water

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone (feet above MSL, NAVD88)
-	12N03E18H001M	USGS-385314121401701	Shallow	21.32
-	14N02E10R001M	USGS-390416121433601	Shallow	36.63
-	15N02E20D001M	USGS-390832121463601	Shallow	37.50
391975N1218937W001	16N01E31H001M	-	Shallow	41.46
392328N1216469W001	16N03E21D002M	-	Shallow	61.53
389563N1215843W001	-	GH East MW Site	Shallow	21.03
389571N1215858W001	-	GH North MW Site	Shallow	22.39
389233N1218022W001	12N01E01A001M	-	AZ-1	23.11
389937N1218240W001	13N01E11A001M	-	AZ-1	27.50
390458N1216114W001	14N03E23D003M	Feather River MW-1A	AZ-1	25.14
389453N1216159W001	-	GH Well 2	AZ-1	30.09
389398N1216162W001	-	GH Well 3	AZ-1	25.04
389410N1215884W001	-	GH Well 18	AZ-1	19.08
388869N1216445W002	-	Ma-1	AZ-1	22.36
388813N1217525W001	12N02E21Q001M	SR-1A	AZ-1	22.74
392394N1216509W001	16N03E17J001M	Sutter County MW-3A	AZ-1	67.82
390458N1216114W002	14N03E23D004M	Feather River MW-1B	AZ-2	13.00
392394N1216509W002	16N03E17J002M	Sutter County MW-3B	AZ-2	53.39
390458N1216114W003	14N03E23D005M	Feather River MW-1C	AZ-3	27.55
390458N1216114W004	14N03E23D006M	Feather River MW-1D	AZ-3	25.99

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Measurable Objective / Interim Milestone (feet above MSL, NAVD88)
392394N1216509W003	16N03E17J003M	Sutter County MW-3C	AZ-3	51.18
392394N1216509W004	16N03E17J004M	Sutter County MW-3D	AZ-3	48.28
392394N1216509W005	16N03E17J005M	Sutter County MW-3E	AZ-3	47.71

6.7 References

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CHAPTER SEVEN

Sustainability Implementation

SUTTER SUBBASIN
GROUNDWATER SUSTAINABILITY PLAN

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