2 Plan Area and Basin Setting

NOTE TO REVIEWERS: Section 2.1 and and the beginning of section 2.2 will be completed later and are provided mostly as an outline to provide context for the full content of Chapter 2. We are only asking you to review Sections 2.2.2.4 (Groundwater Quality) and 2.2.2.5 (Subsidence) at this time. In addition, the Water Quality Appendix that is referenced in 2.2.2.4 is also provided for review.

2.1 Description of the Plan Area (Reg. § 354.8)

The SV Subbasin is located within the Sierra Valley, a valley renowned for its beauty, habitat (nationally designated Important Bird Area and largest wetland in the Sierra Nevada Mountains; FRLT, 2018), biodiversity (one of the most biodiverse landscape in the United States; FRLT, 2018), and size (commonly regarded as the largest high-alpine valley in the United States; Vestra, 2005). Sierra Valley is an irregularly shaped, complexly faulted valley located in eastern Plumas and Sierra Counties of northeastern California. The outer boundaries of the SV Subbasin and Chilcoot Subbasin (excluding the straight-line boundary held in common) approximately parallel the boundaries of Sierra Valley (defined by the interface of the valley floor and surrounding mountains), with some minor exceptions. The SV Subbasin has a surface area of 184 square miles (DWR, 2004a) and the Chilcoot Subbasin has a surface area of 12 square miles (DWR, 2004b). The hydrologic connection between the Sierra Valley Subbasin and the Chilcot Subbasin is known to be significant, with some level of surface water hydrology and groundwater interaction, but is not well understood. The subbasins are to some extent discontinuous at depth due to a bedrock sill (DWR, 2004b).

2.1.1 Summary of Jurisdictional Areas and Other Features *(Reg. § 354.8 b)*

The Sierra Valley Watershed is spread across three counties including: Plumas, Sierra, and a small portion in Lassen The Sierra Valley Watershed has one legislative district for the Assembly and the Congressional and is located in District 3 for the Assembly and District 4 for the Congressional.

2.1.1.1 Plan Area, Exclusive Agencies, and Adjacent Basins

The Plan Area is the area within the SV Subbasin as most recently defined in the Bulletin 118 February 2019 Update (following 2019 Basin Boundary Modification) and viewable on the SGMA Basin Prioritization Dashboard tool[1].

[1] https://gis.water.ca.gov/app/bp-dashboard/final/

2.1.1.2 Adjudicated Areas, Other Agencies, and Areas Covered by Alternative

2.1.1.3 Jurisdictional Boundaries

2.1.1.4 Land Use and Water Sources

2.1.1.5 Groundwater Well Density and Groundwater Dependent Communities

2.1.2 Water Resources Monitoring and Management Programs *(Reg. § 354.8 c, d, e)*

2.1.2.1 Existing Water Resources Monitoring Programs

2.1.2.1.1 Groundwater Conditions Studies

2.1.2.1.2 Groundwater Level Monitoring

2.1.2.1.3 Agricultural Groundwater Extraction Monitoring

2.1.2.1.4 Stream and Channel Surface Water Flow Monitoring

2.1.2.1.5 Water Quality Monitoring

2.1.2.2 Existing Water Resources Management Programs

2.1.2.3 Conjunctive Use Programs

2.1.2.4 Incorporating Existing Water Resources Monitoring and Management Programs to the GSP

2.1.2.5 Limits to Operational Flexibility from Existing Water Resources Monitoring and Management Programs

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans *(Reg. § 354.8 f)*

2.1.3.1 Summary of General Plans and Other Land Use Plans

2.1.3.2 Description of How Land Use Plan Implementation May Change Water Demands or Affect Achievement of Sustainability and How the GSP Addresses Those Effects

2.1.3.3 Description of How Implementation of GSP May Affect the Water Supply Assumptions of Relevant Land Use Plans

2.1.3.4 Summary of Processes for Permitting New or Replacement Wells in the SV Subbasin

2.1.3.5 Information Regarding the Implementation of Land Use Plans Outside the SV Subbasin that could Affect the Ability of the GSAs to Achieve Sustainable

2.1.4 Additional GSP Elements *(Reg. § 354.8 g)*

- Groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects
- Efficient water management practices
- Relationships with State and federal regulatory agencies
- Land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity
- Impacts on groundwater dependent ecosystems

2.1.4.1 Control of Saline Water Intrusion

2.1.4.2 Wellhead Protection

2.1.4.3 Migration of Contaminated Groundwater

2.1.4.4 Well Abandonment and Well Destruction Program

2.1.4.5 Replenishment of Groundwater Extraction

2.1.4.6 Conjunctive Use Programs and Underground Storage

2.1.4.7 Well Construction Policies

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

2.1.4.9 Efficient Water Management Practices

2.1.4.10 Relationships with State and Federal Regulatory Agencies

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

2.1.4.12 Impacts on Groundwater Dependent Ecosystems

2.1.5 Notice and Communication *(Reg. § 354.10)*

2.1.5.1 Beneficial Uses and Users

2.1.5.2 Decision-Making Processes

2.1.5.3 Public Engagement Opportunities

2.1.5.4 Encouraging Active Involvement

2.1.5.5 Informing the Public on GSP Implementation Progress

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model *(Reg. § 354.14)*

2.2.1.1 Physiography

2.2.1.2 Climate

2.2.1.3 Vegetation and Land Use

2.2.1.4 Soils

2.2.1.5 Geology

2.2.1.6 Hydrogeologic Framework

2.2.1.7 References

2.2.2 Current and Historical Groundwater Conditions *(Reg. § 354.16)*

Per Reg. § 354.16, this section includes:

- Groundwater elevation data
- Estimate of groundwater storage

- Seawater intrusion conditions
- Groundwater quality issues
- Land subsidence conditions
- Identification of interconnected surface water systems
- Identification of groundwater-dependent ecosystems including potentially related factors such as instream flow requirements, threatened and endangered species, and critical habitat.

Each of the issues require discussion.

2.2.2.1 Groundwater elevation data

2.2.2.2 Estimate of groundwater storage

2.2.2.3 Seawater intrusion conditions

2.2.2.4 Groundwater quality issues

SGMA regulations require that the following be presented in the GSP, per §354.16 (d): Groundwater quality issues that may affect the supply and beneficial uses of groundwater including a description and map of the location of known groundwater contamination sites and plumes.

2.2.2.4.1 Basin Groundwater Quality Overview

Water quality includes the physical, biological, chemical, and radiological quality of water. The most important property of water quality is temperature. An example of a biological water quality constituent is E. coli bacteria, commonly used as an indicator species for fecal waste contamination. Radiological water quality parameters measure the radioactivity of water. Chemical water quality refers to the concentration of thousands of natural and inorganic and organic chemicals. All groundwater naturally contains some microbial matter, chemicals, and usually has a low level of radioactivity. Inorganic chemicals that make up more than 90% of the total dissolved solids (TDS) in groundwater include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}) and sulfate (SO_4^{2-}) ions. Water with a TDS content of less than 1,000 mg/L is generally referred to as “freshwater”. Brackish water has a TDS concentration between 1,000 mg/L and 10,000 mg/L. In saline water, TDS exceeds 10,000 mg/L. Water hardness typically refers to the concentration of calcium and magnesium cation in water.

When one or multiple constituents become a concern for either ecosystem health, human consumption, industrial or commercial uses, or for agricultural uses, the water quality constituent of concern becomes a “pollutant” or “contaminant”. Groundwater quality is influenced by many factors – polluted or not – including elevation, climate, soil types, hydrogeology, and human activities. Water quality constituents are therefore often categorized as “naturally occurring”, “point source”, or “non-point source” pollutants, depending on whether water quality is the result of natural processes, of contamination from anthropogenic point sources, or originates from diffuse (non-point) sources that are the result of human activity.

Groundwater in the Subbasin is generally of good quality and meets local needs for municipal, domestic, and agricultural uses. Ongoing monitoring programs show that some constituents, including TDS, boron, arsenic, and manganese exceed water quality standards in parts of the Subbasin. Exceedances may be caused by localized conditions and may not be reflective of regional water quality. Two points of concern raised by stakeholders within the Subbasin include: 1) higher levels of naturally occurring arsenic and manganese near Calpine; and, 2) possible water quality impacts from septic systems.

A summary of information and methods used to assess current groundwater quality in the Subbasin as well as key findings, are presented below. A detailed description of information, methods, and all findings of the assessment can be found in Appendix ## – Water Quality Assessment.

2.2.2.4.2 Existing Water Quality Monitoring Networks

Water quality data for at least one constituent – sometimes many - are available for some wells in the Subbasin but not most. Of those wells for which water quality data are available, most have only been tested three times or less, but some have been tested more than three times, and in few cases are tested on a regular basis (e.g. annually). The same well may have been tested for different purposes (e.g., research, regulatory, or to provide owner information), but most often, regulatory programs drive water quality testing. For this GSP, all available water quality data, obtained from the numerous available sources, are first grouped by the well from where the measurements were taken.

2.2.2.4.3 Data Sources for Characterizing Water Quality

The assessment of groundwater quality for the Subbasin was prepared using available information obtained from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program Database, which for the Sierra Valley Subbasin includes water quality information collected by the following agencies:

- Department of Water Resources (DWR)
- State Water Board, Division of Drinking Water public supply well water quality (DDW)
- State and Regional Water Board Regulatory Programs (Electronic Deliverable Format (EDF) and Irrigated Agricultural Land Waiver (AGLAND))
- U.S. Geological Survey (USGS)

Groundwater quality data, as reported by GAMA, has been collected in the Subbasin since 1955. Within the Subbasin, a total of 200 wells were identified and used to characterize existing water quality based on a data screening and evaluation process that identified constituents of interest important to sustainable groundwater management. Figures in Appendix ## show the Subbasin boundary, as well as the locations and density of all wells with available water quality data for the GSP constituents of interest collected in the past 30 years (1990-2020). In addition to utilizing GAMA for basin-wide water quality assessment, GeoTracker was also searched to identify possible data associated with groundwater contaminant plumes.

2.2.2.4.4 Classification of Water Quality

To determine what groundwater quality constituents in the Subbasin may be of current or near-future concern, a reference standard was defined to which groundwater quality data were compared. Numeric thresholds are set by state and federal agencies to protect water users (environment, humans, industrial and agricultural users). The numeric standards selected for the current analysis represent all relevant state and federal drinking water standards, and state water quality objectives, for the constituents evaluated and are consistent with state and

Regional Water Board assessment of beneficial use protection in groundwater. The standards are compared against groundwater quality data to determine if a constituent's concentration exists above or below the threshold and is currently impairing or may impair beneficial uses designated for groundwater at some point in the foreseeable future.

Although groundwater is utilized for a variety of purposes, the use for human consumption requires that supplies meet strict water quality regulations. The federal Safe Drinking Water Act (SDWA) protects surface water and groundwater drinking water supplies. The SDWA requires the United States Environmental Protection Agency (USEPA) to develop enforceable water quality standards for public water systems. The regulatory standards are named maximum contaminant levels (MCLs) and they dictate the maximum concentration at which a specific constituent may be present in potable water sources. There are two categories of MCLs: Primary MCLs (1º MCL), which are established based on human health effects from contaminants and are enforceable standards for public water supply wells and state small water supply wells; and Secondary MCLs (2º MCL; or SMCL), which are unenforceable standards established for contaminants that may negatively affect the aesthetics of drinking water quality, such as taste, odor, or appearance.

The State of California has developed drinking water standards that, for some constituents, are stricter than those set at the federal level. The Basin is regulated under the Central Valley Regional Water Quality Control Board (Regional Water Board) and relevant water quality objectives (WQOs) and beneficial uses are contained in the Water Quality Control Plan for the Central Valley Region (Basin Plan). For waters designated as having a Municipal and Domestic Supply (MUN) beneficial use, the Basin Plan specifies that chemical constituents are not to exceed the Primary and Secondary MCLs established in Title 22 of the California Code of Regulations (CCR) (hereafter, Title 22). The MUN beneficial use applies to all groundwater in the Sierra Valley subbasin.

Constituents may have one or more applicable drinking water standard or WQOs. For this GSP, a prioritization system was used to select the appropriate numeric threshold. This GSP used the strictest value among the state and federal drinking water standards and state WQOs specified in the Basin Plan for comparison against available groundwater data. Constituents that do not have an established drinking water standard or WQO were not assessed. The complete list of constituents, numeric thresholds, and associated regulatory sources used in the water quality assessment can be found in Appendix ##. Basin groundwater quality data obtained for each well selected for evaluation were compared to a relevant numeric threshold.

Groundwater quality data were further categorized by magnitude of detection as 1) not detected, 2) detected below half of the relevant numeric threshold, 3) detected below the relevant numeric threshold, and 4) detected above the relevant numeric threshold. Maps were generated for each constituent of interest showing well locations, the maximum value measured at each well, and the number of measurements for each category of detection (Appendix ##). Wells designated as municipal in the GAMA dataset are indicated on this map.

To analyze groundwater quality that is representative of current conditions in the Basin, several additional filters were applied to the dataset. Though groundwater quality data are available dating back to 1955 for some constituents, the data evaluated were limited to those collected from 1990 to 2020. Restricting the time span to data collected in the past 30 years increases confidence in data quality and focuses the evaluation on information that is considered reflective of current groundwater quality conditions. A separate series of maps was generated for each constituent of interest showing the location of wells with two or more measurements collected during the past 30 years (1990-2020). This series of maps also indicates the maximum value measured at each well.

Finally, for each constituent, an effort was undertaken to examine changes in groundwater quality over the period 1990-2020. Constituent concentrations were plotted as “box and whisker” plots, where the box represents the concentration range for the middle 50 percent of the data (first quartile to third quartile, or interquartile range), the mean is represented as an ‘x’, and the median is shown as the line in the center of the box. The top whisker extends to the highest concentration that is less than or equal to the sum of the third quartile and 1.5 times the interquartile range; and the bottom whisker extends to the lowest concentration that is greater than or equal to the difference of the first quartile and 1.5 times the interquartile range. Regulatory limits are displayed as a dashed red line, and the concentration is displayed on the left side of each plot. These maps and timeseries plots for each constituent of interest are provided in Appendix ##.

The approach described above was used to consider all constituents of interest and characterize groundwater quality in the Subbasin. Appendix ## contains additional detailed information on the methodology used to assess groundwater quality in the Subbasin.

2.2.2.4.5 Subbasin Groundwater Quality

All groundwater quality constituents monitored in the Basin that have a numeric threshold were initially considered. Results of the evaluation process described above is summarized in Table xx in Appendix ## and the following parameters were determined to be important to sustainable groundwater management in the Subbasin: nitrate, TDS, arsenic, boron, pH, iron, manganese, MTBE. Data from the GAMA database was analyzed for these constituents and they are included as Constituents of concern (COCs) because they were cited in previous studies of the Subbasin, or they were discussed during public meetings as being of concern to stakeholders in the Subbasin. Sustainable management criteria, consistent with GSA responsibilities, are developed for nitrate and TDS only, and monitoring under this GSP will be conducted for nitrate, TDS, arsenic, boron, and pH. The constituents, manganese, iron, and MTBE, will be assessed and described below but, as these constituents were determined to either be naturally occurring, or regulated by other entities, they will likely not be managed under the GSP.

The following subsections present information on these water quality parameters in comparison to their relevant regulatory thresholds and how the constituent may potentially impact designated beneficial uses in different regions of the Subbasin. Table 2.2.2-1 contains the list of constituents of interest identified for the Subbasin and their associated regulatory threshold.

Table 2.2.2-1. Regulatory water quality thresholds for constituents of interest in the Sierra Valley Subbasin

Constituent	Water Quality Threshold	Regulatory Basis
Arsenic (µg/L)	10	Primary MCL - Title 22
Boron (mg/L)	1.0	Cal. Notification Level
Iron (µg/L)	300	Secondary MCL - Title 22
Manganese (µg/L)	50	Secondary MCL - Title 22
MTBE (µg/L)	13 5	Primary, Basin Plan Secondary MCL - Title 22
Nitrate (mg/L as N)	10	Primary MCL - Title 22

pH	7.0 – 8.5	Basin Plan
Total Dissolved Solids (mg/L)	500	Secondary MCL - Title 22

NITRATE

Nitrate is one of the most common groundwater contaminants and is generally the water quality constituent of greatest concern. Natural concentrations of nitrate in groundwater are generally low. In agricultural areas, application of fertilizers or animal waste containing nitrogen can lead to elevated nitrate levels in groundwater. Other anthropogenic sources, including septic tanks, wastewater discharges, and agricultural wastewater ponds may also lead to elevated nitrate levels. Nitrate poses a human health risk, particularly for infants under the age of 6 months who are susceptible to methemoglobinemia, a condition that affects the ability of red blood cells to carry and distribute oxygen to the body. The Primary MCL (Title 22) for nitrate is 10 mg/L as N.

Recent nitrate data collected in the Subbasin (1990-2020) show that only 1 sample of 366 resulted in a concentration between 5-10 mg/L. No samples were above the MCL of 10 mg/L. The highest concentration during the period was 5.2 mg/L, and the average concentration during the last ten years (2011-2020) was 1.5 mg/L. Samples are primarily collected near Loyalton and Beckworth. Box and whisker plots for seven periods show that nitrate concentrations have been relatively stable during the period of analysis, with increasing concentrations from 2011-20. As stated, average and median concentration remain relatively low during these years.

TOTAL DISSOLVED SOLIDS

The TDS concentration in water is the sum of all the substances, organic and inorganic, dissolved in water. The dissolved ions calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and nitrate typically make up most of the TDS in water. Natural and anthropogenic sources contribute to variations TDS in groundwater. Increases of TDS in groundwater can be due to dissolution of rock and organic material and uptake of water by plants, as well as anthropogenic activities including the application of fertilizers, discharges of wastewater and discharges from septic systems or industrial facilities. High TDS can be problematic as it can have adverse effects on plant growth and drinking water quality. The Title 22 SMCL for TDS is 500 mg/L, and the Upper SMCL is 1,000 mg/L. While the recommended SMCL of 500 mg/L is desirable for a higher degree of consumer acceptance, concentrations below the Upper SMCL of 1,000 mg/L are also deemed to be acceptable.

Recent TDS data collected in the Subbasin (1990-2020) show that only 11 of 216 samples resulted in a concentration between 500-1,000 mg/L, while the vast majority (175) resulted in a concentration less than 250 mg/L. No samples were above 1,000 mg/L. The highest concentration during this period was 864 mg/L, and the average concentration during the last ten years (2011-2020) was 200 mg/L. Spatial distribution of TDS samples is good, as samples are collected throughout the Subbasin. Spatial analysis shows that elevated concentrations are collected from wells located in the central and northwestern portion of the Subbasin. Box and whisker plots for seven periods show that average and median TDS concentrations have remained relatively stable since 1986.

ARSENIC

Arsenic is a naturally occurring element in soils and rocks and has been used in wood preservatives and pesticides. Classified as a carcinogen by the USEPA, the International Agency for Research on Cancer (IARC) and the Department of Health and Human Services

(DHHS), arsenic in water can be problematic for human health. Drinking water with levels of inorganic arsenic from 300 to 30,000 parts per billion (ppb; 1 ppb = 1 µg/L) can have effects including stomach irritation and decreased red and white blood cell production (CITE ASTDR). Long-term exposure can lead to skin changes and may lead to skin cancer. The Primary MCL (Title 22) for arsenic is 10 µg/L.

Recent arsenic data collected in the Subbasin (1990-2020) show that only 16 of 128 samples resulted in a concentration between 5-10 µg/L, while the vast majority (112) resulted in a concentration less than 5 µg/L. No samples were above the MCL of 10 µg/L. The highest concentration during this period was 10 µg/L, and the average concentration during the last ten years (2011-2020) was 0.5 µg/L. Samples are primarily collected near Loyalton and Beckworth. Box and whisker plots for seven periods show that average concentrations have a decreasing trend. It is noted that there are municipal wells near Calpine with elevated levels of arsenic (great than 20 µg/L); however, these wells are located outside the boundaries of the Subbasin, and tap groundwater that is not hydrologically connected to the Sierra Valley Subbasin.

BORON

Boron in groundwater can come from both natural and anthropogenic sources. As a naturally occurring element in rocks and soil, boron can be released into groundwater through natural weathering processes. Boron can be released into the air, water or soil from anthropogenic sources including industrial wastes, sewage, and fertilizers. If ingested at high levels, boron can affect the stomach, liver, kidney, intestines, and brain (Agency for Toxic Substances and Disease Registry (ATSDR) 2010). The California Notification Level provides a threshold for boron of 1.0 mg/L as for groundwater in the Sierra Valley.

Recent boron data collected in the Subbasin (1990-2020) show that 14% of samples (15 of 104) resulted in a concentration greater than the Notification Level of 1.0 mg/L, while 78% of samples (81 of 104) have resulted in a concentration below 0.5 mg/L. The highest concentration during this period was 5.4 mg/L. High reporting limits (typically 0.1 mg/L) are typical during the analytical assessment of boron and make analysis of average concentration imprecise. Spatial distribution of boron samples is good, as samples are collected throughout the Subbasin. Box and whisker plots for seven periods show that average and median boron concentrations have fluctuated since 1986. Since 2011, concentrations have decreased, with median values falling below the MCL.

pH

The pH of groundwater is determined by a number of factors including the composition of rocks and sediments through which water travels in addition to pollution caused by human activities. Variations in pH can affect the solubility and mobility of constituents. Acidic or basic conditions can be more conducive for certain chemical reactions to occur; arsenic is generally more likely to mobilize under a higher pH while iron and manganese are more likely to mobilize under more acidic conditions. High or low pH can have other detrimental effects on pipes and appliances including formation of deposits at a higher pH and corrosion at a lower pH, along with alterations in the taste of the water. The Basin Plan specifies a pH range of 7.0-8.5 as a water quality objective for groundwater in the Sierra Valley.

Recent pH data collected in the Subbasin (1990-2020) show that 2 of 71 samples resulted in a pH above the MCL range of 7.0-8.5, while four samples resulted in a pH below the MCL range. The highest concentration during this period was 8.7, while the lowest was 6.4. Spatial distribution of pH samples is good, as samples are collected throughout the Subbasin.

IRON AND MANGANESE

Iron and manganese in groundwater are primarily from natural sources. As abundant metal elements in rocks and sediments, iron and manganese can be mobilized under favorable geochemical conditions. Iron and manganese occur in the dissolved phase under oxygen-limited conditions. Anthropogenic sources of iron and manganese can include waste from human activities including industrial effluent, mine waste, sewage, and landfills. As essential nutrients for human health, iron and manganese are only toxic at very high concentrations. Concerns with iron and manganese in groundwater are commonly related to the aesthetics of water and the potential to form deposits in pipes and equipment. The Title 22 SMCLs, for iron and manganese are 300 μg/L and 50 μg/L, respectively.

Recent iron data collected in the Subbasin (1990-2020) show that 6 of 125 samples resulted in a concentration above the SMCL of 300 μg/L, while the vast majority (116) resulted in a concentration less than 150 μg/L. The highest concentration during this period was 2,400 μg/L, and the average concentration during the last ten years (2011-2020) was 82 μg/L. Except for the northeast portion of the Subbasin near Vinton where little data is available, the spatial distribution of iron samples is good. Spatial analysis shows that elevated concentrations are collected from wells located near Loyalton and Beckworth. Box and whisker plots for seven periods show that average concentrations have remained relatively stable since 1986, with median concentrations decreasing from 2001-2020.

Recent manganese data collected in the Subbasin (1990-2020) show that 28 of 99 samples resulted in a concentration above the SMCL of 50 μg/L, while 71 of 99 samples resulted in a concentration below 50 μg/L. The highest concentration during this period was 1,200 μg/L, and the average concentration during the last ten years (2011-2020) was 119 μg/L. These elevated concentrations were sampled from monitoring wells less than 100 feet in depth located to the east of Loyalton. If these monitoring wells are removed from the data, the highest concentration during the period 1990-2020 decreases to 439 μg/L, and the average concentration during the last ten years (2011-2020) decreases to 25 μg/L. Except for the northeast portion of the Subbasin near Vinton where little data is available, the spatial distribution of manganese samples is good. Wells sampled on the southern boundary of the Subbasin appear to contain lower concentrations of manganese compared to wells sampled near Beckworth or the central portion of the Subbasin. Box and whisker plots for seven periods show that average concentrations were elevated during the periods 2001-05 and 2006-10 in comparison to other periods. As stated, these high concentrations are attributed to monitoring wells east of Loyalton.

MTBE

Methyl Tertiary Butyl Ether (MTBE) does not occur naturally in the environment, and is synthesized from methanol, a compound derived from natural gas, and isobutylene or other petroleum refinery products. It is a fuel oxygenate added to gasoline to reduce air pollution and increase octane ratings. MTBE can be released to groundwater by leaking underground storage tanks and piping, spills during transportation, and leaks at refineries. A minor amount can be attributed to atmospheric deposition. Underground storage tank or piping releases comprise the majority of the releases that have impacted groundwater. As of January 1, 2004, California has prohibited the use of MTBE in gasoline. Low levels of MTBE can make drinking water supplies undrinkable due to its offensive taste and odor. Although breathing small amounts of MTBE for short periods may cause nose and throat irritation, there are no data available on the effects in humans of ingesting MTBE. The primary MCL for drinking water is 13 μg/L, and the Title 22 SMCL is 5 μg/L.

Recent MTBE data collected in the Subbasin (1990-2020) show that 109 of 558 samples resulted in a concentration above the primary MCL of 13 µg/L, and 144 samples resulted in a concentration above the SMCL of 5 µg/L. The highest concentration during this period was 44,000 µg/L and average concentration during the last ten years (2011-2020) was 3 µg/L. All samples resulting in a concentration greater than 1,000 µg/L were collected during the period 2001-2005. Samples are primarily collected near Loyalton, Sierraville, and Beckworth, with primary MCL exceedances occurring near Loyalton and Sierraville. Box and whisker plots for seven periods show that concentrations were elevated during the period 2001-2005 and 2006-2010. Since 2011, concentrations have generally declined.

2.2.2.4.6 Contaminated Sites

Groundwater monitoring activities also take place in the Subbasin in response to known and potential sources of groundwater contamination, including underground storage tanks. These sites are subject to oversight by regulatory entities, and any monitoring associated with these sites can provide opportunities to improve the regional understanding of groundwater quality. To identify known plumes and contamination within the Subbasin, SWRCB GeoTracker was reviewed for active clean-up sites of all types. The GeoTracker database shows one open land disposal site and one cleanup program site with potential or active groundwater contamination located within the Subbasin. In addition to sites located within the Subbasin boundary, three sites are in close proximity to the Boundary. These include two land disposal sites (one open – closed/with Monitoring; and one open – inactive), and one cleanup program site (complete – case closed).

A brief overview of notable information related to open contaminated sites in the Subbasin is provided below; however, an extensive summary for each of the contamination sites is not presented. The location of the contaminated sites is shown in Figure 2.2.2-1.

Loyalton Sanitary Landfill

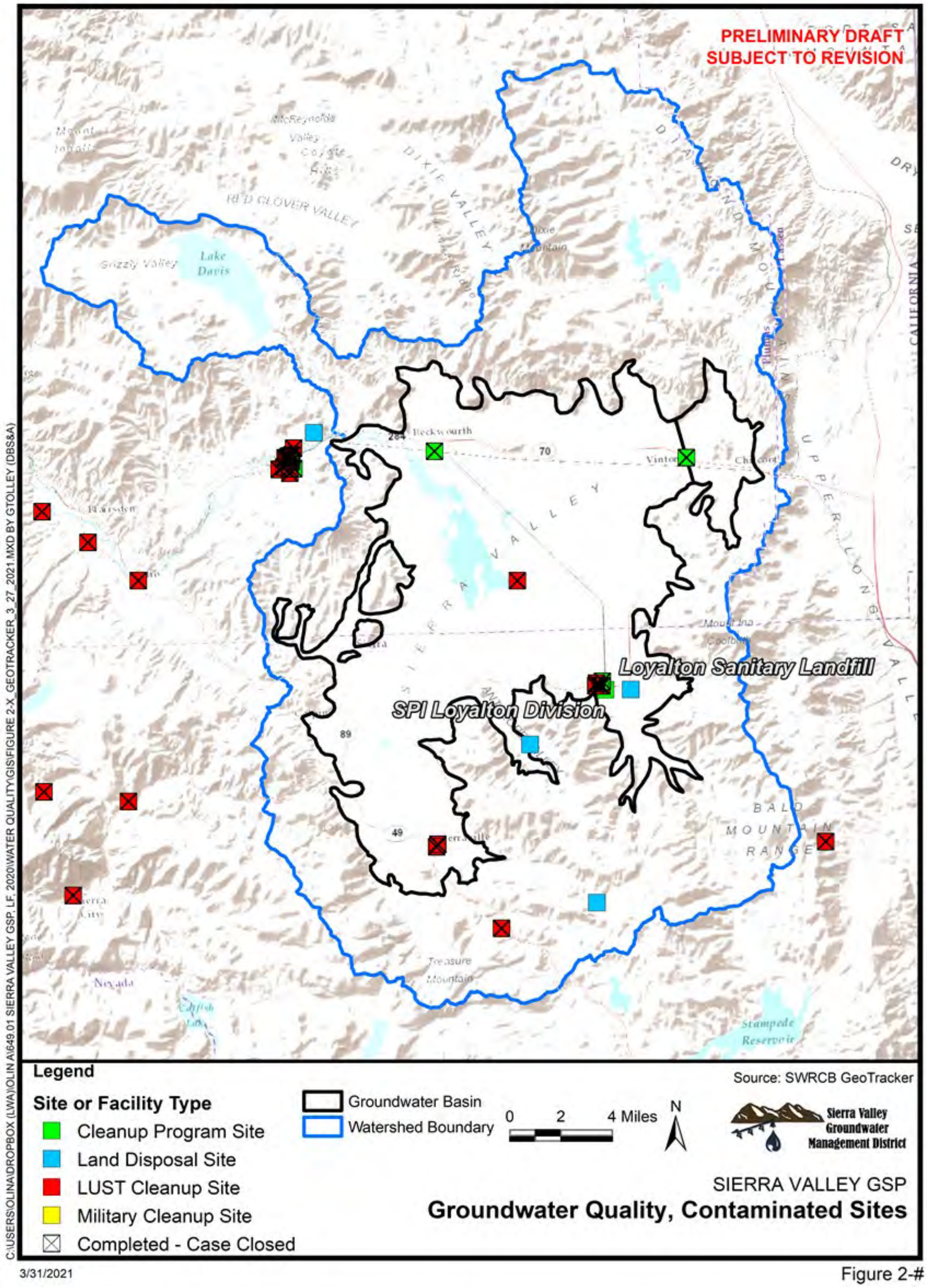
The case (No. 5A460300001) for this cleanup site was opened in January of 1965. This site is a Title 27 municipal solid waste landfill site. Substances released from the site, and contaminants of concern are not specified by GeoTracker.

SPI Loyalton Division

The leak associated with this case was reported in January of 1965, and the case for this cleanup site was opened in November 2004 and is currently listed as open and inactive. GeoTracker does not provide a case number for this site. Potential contaminants of concern associated with the site include waste oil (motor, hydraulic, lubricating).

While current data is useful to determine local groundwater conditions, additional monitoring is necessary to develop a basin-wide understanding of groundwater quality and greater spatial and temporal coverage would improve evaluation of trends. From a review of all available information, none of the sites listed above have been determined to have an impact on the aquifer, and the potential for groundwater pumping to induce contaminant plume movement towards water supply wells is negligible.

444 **Figure 2.2.2-1. Contaminated Sites**



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2.2.2.5 Land subsidence conditions

The basic process of land subsidence caused by groundwater overdrafting can be described as follows: the weight of materials overlying an aquifer (the rocks and sediments, water, soil, vegetation, and structures on the land surface) is borne within an aquifer system by both the water in the pore spaces (pore pressure) and by the clay, silt, sand, and gravel that form the granular mineral skeleton of the aquifer; when pumping lowers groundwater levels thereby reducing pore pressure, the weight of overlying materials must be increasingly supported by the mineral skeleton of the aquifer (increasing effective stress); increased effective stress causes some elastic compression of the aquifer system skeleton (elastic subsidence) and, if the stresses are large enough, some rearrangement of mineral grains and permanent consolidation of the aquifer system (inelastic subsidence).

The various data available for Sierra Valley show that inelastic subsidence has occurred in the recent past and likely continues to the present. While the subsidence has occurred in varying areas in Sierra Valley over time, it has overlapped with areas known to have significant groundwater pumping. The geology present in Sierra Valley are dominantly eroded alluvial sediment deposits consisting of clay, silt, sand, and gravel, which is typical of mountain valleys in California. The clay deposits are particularly susceptible to inelastic subsidence when heavy groundwater pumping is present.

2.2.2.5.1 Ground-based measurements of land subsidence

The first account of recorded subsidence in Sierra Valley was by the California Department of Water Resources (DWR, 1983). DWR (1983), along with Plumas County Road Department surveys, reported that inelastic subsidence occurred in the Sierra Valley and was consistent within the expected range considering the amount of groundwater decline observed (about 1-2 feet of subsidence during the period of approximately 1960-1983). The subsidence during the period of 1983-2012 is unaccounted for as we have not found any reports accounting for subsidence during this period. The California Department of Transportation (CalTrans, 2016) conducted a survey where they collected data suggesting subsidence of about 0.3 to 1.9 feet occurring during the period of 2012 to 2016, which also coincided with areas of heavy groundwater pumping.

There are no known Continuous Global Positioning System (CGPS) stations or extensometers installed in Sierra Valley. However, there are survey monuments remaining from previous ground elevation surveys.

2.2.2.5.2 Satellite observations of land subsidence

Satellite-based Interferometric Synthetic Aperture Radar (InSAR) data from a NASA JPL study shows widespread subsidence in the northeast part of Sierra Valley with up to 0.5 feet of vertical displacement during the period of 2015-2016 alone and up to 1.2 feet of vertical displacement (at least) during the period of March 2015 to November 2019 in large areas, but is likely to be more in smaller areas (Farr et al., 2017; T. Farr, personal communications, Oct.-Dec., 2020). These data are shown in Figure 2.2.2-2 for the whole basin, and focused on the area with greatest subsidence in Figure 2.2.2-3. Time series of subsidence for six select locations are presented in Figure 2.2.2-4.

To produce the subsidence dataset, NASA JPL obtained and analyzed data from ESA's satellite-borne Sentinel-1A from the period March 2015 – September 2016 and the NASA airborne UAVSAR for the period March 2015 – June 2016, and produced maps of total subsidence from the two data sets. These data add to the earlier data processed from the Japanese PALSAR for 2006 – 2010, Canadian Radarsat-2 for the period May 2014 – January 2015, and UAVSAR for July 2013 - March 2015, for which subsidence measurements were reported previously (Farr et al., 2015). They also present results for the South-Central coast of California including Ventura, Oxnard, Santa Barbara and north to the San Joaquin Valley as well as the Santa Clara Valley from colleagues who have processed Sentinel-1A data covering March 2015 – March 2016 (included are portions of the Sacramento Valley and various intermontane valleys in the Sierras, like Sierra Valley). As multiple scenes were acquired during these periods, they also produce time histories of subsidence at selected locations and transects showing how subsidence varies both spatially and temporally. Geographic Information System (GIS) files were furnished to DWR for further analysis of the 4-dimensional subsidence time-series maps.

A similar InSAR study from DWR/TRE Altamira (TRE Altamira, 2020; Towill, 2020) shows subsidence of up to 0.6 +/-0.1 feet over widespread areas, potentially higher in smaller areas, during the period of June 2015 to September 2019. They estimated an annual subsidence rate of up to 0.15 +/-0.1 feet/year in this same study. These data are shown in Figure 2.2.2-5.

The TRE Altamira InSAR dataset represents measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across the State of California between June of 2015 and September of 2019. Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA, Inc. (TRE), under contract with DWR as part of its SGMA technical assistance to provide important SGMA-relevant data to GSAs for GSP development and implementation. Sentinel-1A InSAR data coverage began in late 2014 for parts of California, and coverage for the entire study area began in June 13, 2015. Included in this dataset are point data that represent average vertical displacement values for 328 ft by 328 ft areas, as well as GIS rasters (i.e., spatial datasets formatted as a matrix of rectangular grid cells) that were interpolated from the point data; rasters for total vertical displacement relative to June 13, 2015, and rasters for annual vertical displacement rates with earlier coverage for some areas, both in monthly time steps. Towill, Inc. (Towill), also under contract with DWR as part of DWR's SGMA technical assistance, conducted an independent study comparing the InSAR-based vertical displacement point time series data to data from CGPS stations. The goal of this study was to ground-truth the InSAR results to best available independent data.

Regarding the similarities in InSAR data products from both organizations, TRE and JPL, they both process the same data set (Sentinel-1 satellite mission from the European Space Agency [ESA]) with slightly different techniques, so the results are pretty similar but not exactly the same. It is also important to note that InSAR data reflect both elastic and inelastic subsidence and it can be difficult to isolate a signal solely for only the elastic subsidence amplitude. Visual inspection of monthly changes in ground elevations typically suggest that elastic subsidence is largely seasonal and can potentially be factored out of the signal, if necessary. Finally, the DWR/TRE InSAR data are the only InSAR data that can be used for estimating subsidence going forward as they are the only known subsidence-related data provided to and available for this basin by DWR for an indefinite period of time during the GSP implementation period.

2.2.2.5.3 DWR/TRE Altamira InSAR subsidence data quality

DWR has made Interferometric Synthetic Aperture Radar (InSAR) satellite data available on their SGMA Data Viewer web map as well as downloadable raster datasets to estimate subsidence. The TRE Altamira InSAR data provided by DWR are subject to compounded measurement and raster conversion errors. DWR has stated that for the total vertical displacement measurements, the errors are as follows (B. Brezing, personal communication, February 27, 2020):

1. The error between InSAR data and continuous GPS data is 0.052 ft (0.016 m) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the mapsprovided by DWR is 0.048 ft (0.015 m) with 95% confidence level.

The addition of the both of these errors results in the combined error is 0.1 ft (0.03 m). While not a robust statistical analysis, it does provide a potential error estimate for the TRE Altamira InSAR maps provided by DWR. A land surface change of less than 0.1 ft (0.03 m) is within the same magnitude of the noise of the data and is likely not indicative of groundwater-related subsidence in the basin. DWR contracted Towill, Inc. to complete a data accuracy report, and found similar results to the error presented above. The full report is included in Appendix ## (subsidence appendix).

Figure 2.2.2-2 InSar-based land subsidence for the period of March 2015 to November 2019

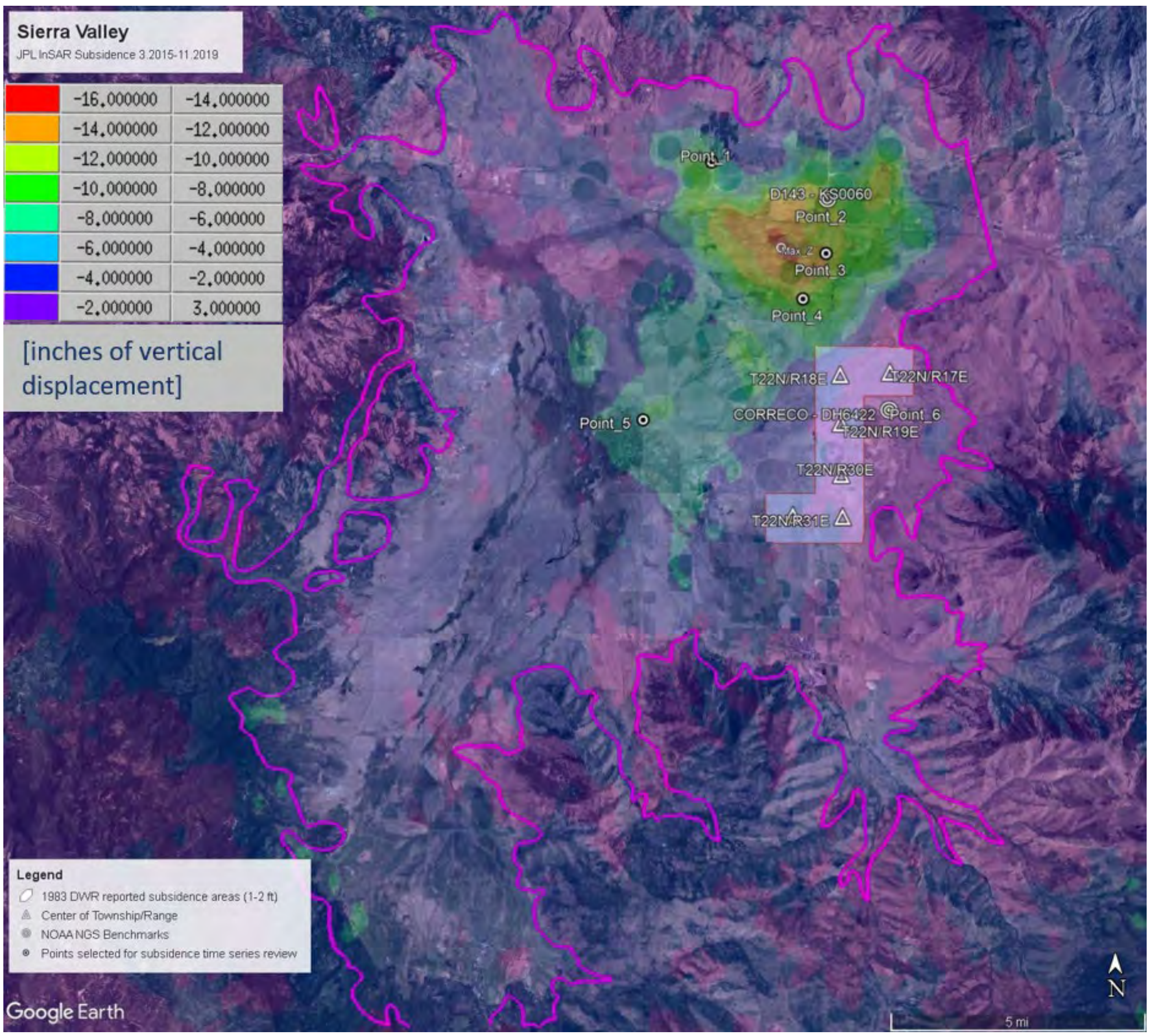


Figure 2.2.2-3 InSar-based land subsidence for the period of March 2015 to November 2019, focused on the portion of the basin with the greatest measured subsidence.

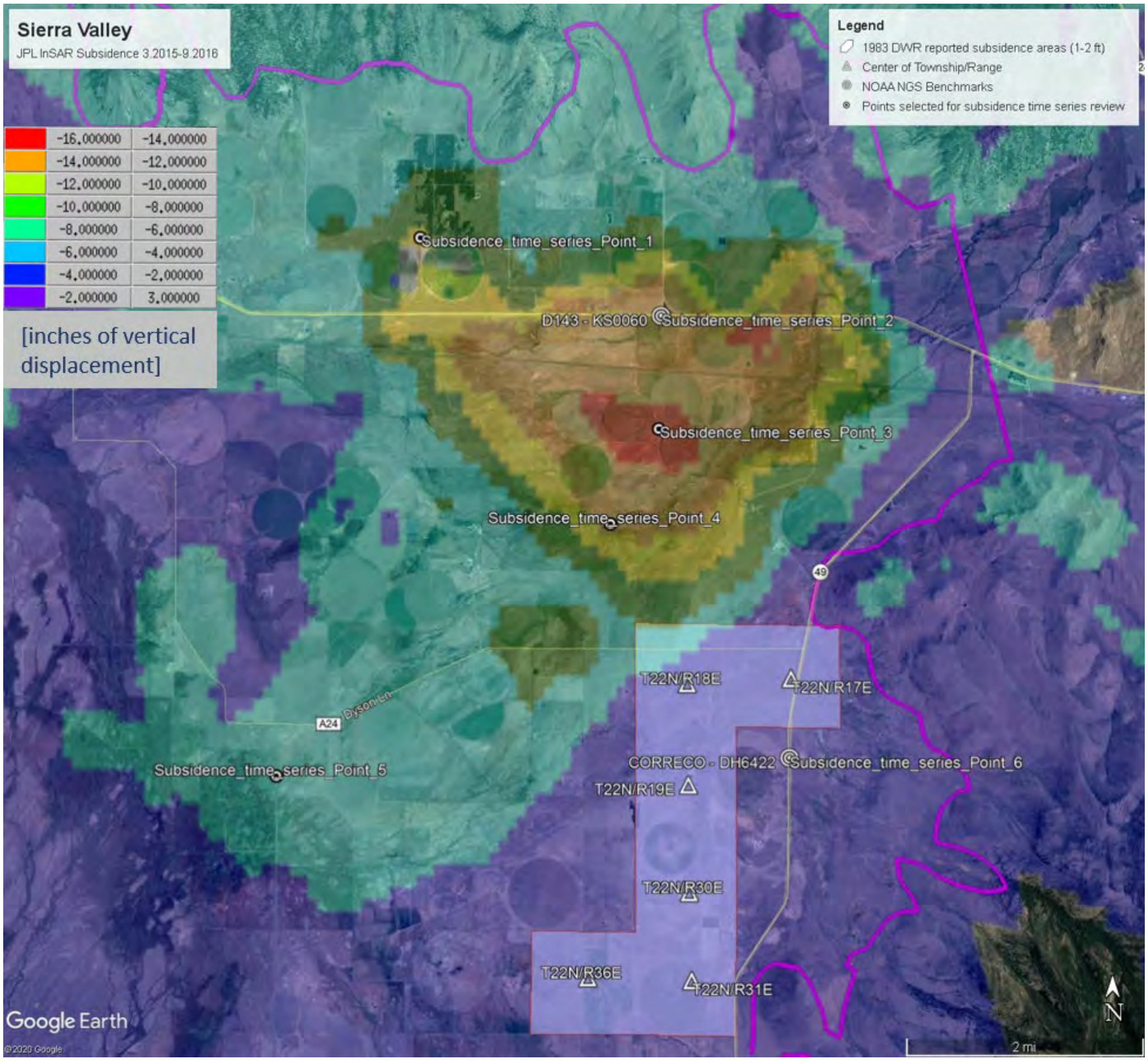


Figure 2.2.2-4 Time series of JPL InSAR land subsidence data for the locations called out in Figure 2.2.2-3

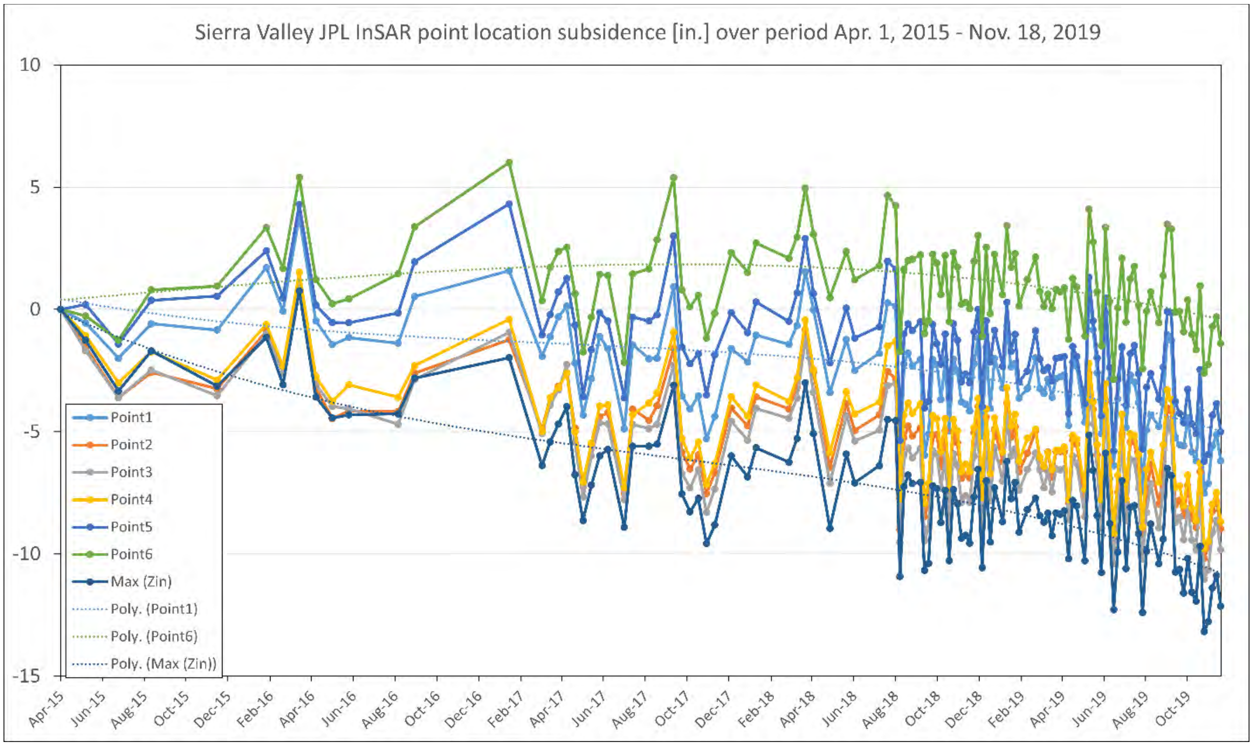
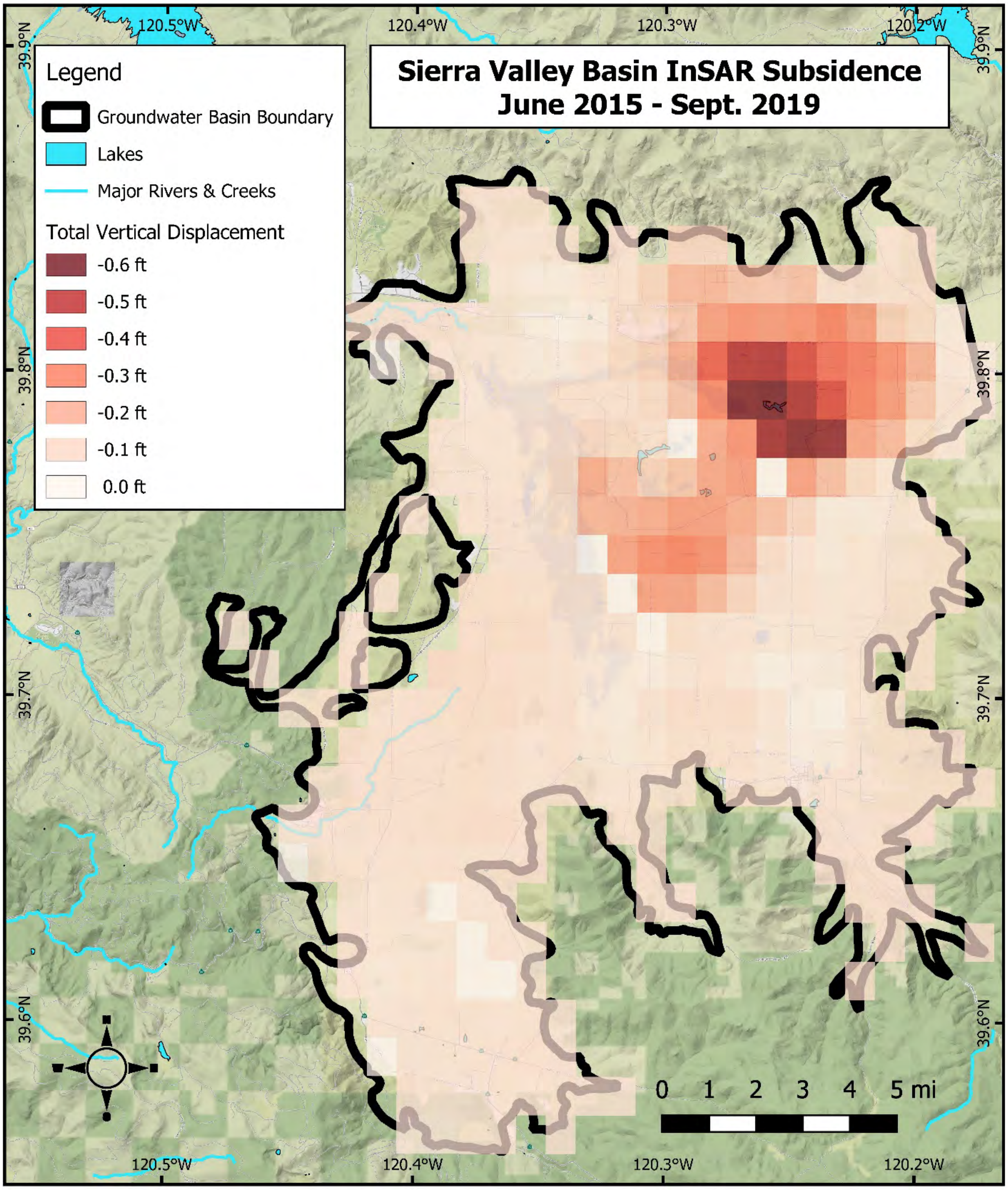


Figure 2.2.2-5 DWR/TRE Altamira InSAR land subsidence for the period June 2015 to September 2019.



2.2.2.6 Identification of interconnected surface water systems

2.2.2.7 Identification of groundwater-dependent ecosystems

- Including potentially related factors such as instream flow requirements, threatened and endangered species, and critical habitat.

2.2.3 Water Budget Information *(Reg. § 354.18)*

- Description of inflows, outflows, and change in storage
- Quantification of overdraft (as applicable)
- Estimate of sustainable yield
- Quantification of current, historical, and projected water budget
- Description of surface water supply used or available for use for groundwater recharge or in-lieu use

2.2.4 Management Areas (as Applicable) *(Reg. § 354.20)*

- Reason for creation of each management area
- Level of monitoring and analysis
- Description of management areas
- Explanation of how management of management areas will not cause undesirable results outside the management area