3 Sustainable Management Criteria

3.1 Introduction to Sustainable Management Criteria and Definition of Terms

This section establishes the current and desired future SV Subbasin conditions through evaluation of the six sustainability indicators and outlines the analyses and processes used to define sustainable management criteria (SMC) for each sustainability indicator. Undesirable results, minimum thresholds (MTs), measurable objectives (MOs), and interim milestones (IMs) are defined for each sustainability indicator with respect the quantification and avoidance of potential impacts on beneficial groundwater uses and users.

The following terms, defined below, are described for the SV Subbasin in the following sections.

Sustainability Goal: The overarching, qualitative goal for the Subbasin with respect to maintaining or improving groundwater conditions and ensuring the avoidance of undesirable results.

Sustainability Indicators (SI): The six categories of impacts to groundwater conditions identified by SGMA: lowering groundwater levels, reduction of groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence, and surface water depletion. Undesirable results are defined as impacts determined as significant and unreasonable by the GSAs. Importantly, seawater intrusion is not applicable to the SV Subbasin and thus not discussed.

Sustainable Management Criteria (SMC): Minimum thresholds, measurable objectives, and interim milestones are quantitative criteria measured at a network of representative monitoring points (RMPs) that provide adequate coverage such that Undesirable Results, consistent with the sustainability goal, are avoided during the implementation period (through 2042) and beyond (after 2042).

Undesirable Results: Conditions, defined under SGMA as: *"… one or more of the following effects to Sustainability Indicators caused by groundwater conditions occurring throughout a basin:*

1. *Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon...*
2. *Significant and unreasonable reduction of groundwater storage.*
3. *Significant and unreasonable seawater intrusion.*
4. *Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.*
5. *Significant and unreasonable land subsidence that substantially interferes with surface land uses.*
6. *Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water."*

Minimum Thresholds (MTs): Quantitative values measured at RMPs that, if reached in accordance with the "Identification of Undesirable Results", define the occurrence of an undesirable result. Thus, the management goal is to avoid groundwater conditions that exceed

MTs defined by this GSP. The term “minimum threshold” is predominantly used in SGMA regulations and is applied to most sustainability indicators. The term “maximum threshold” is equivalent but is used for sustainability indicators with a defined maximum limit (e.g., groundwater quality).

Measurable Objectives (MOs): Quantitative values measured at RMPs that maintain or improve groundwater conditions and, if reached, represent the attainment of the basin’s Sustainability Goal.

Interim Milestones (IMs): Quantitative periodic goals (defined every five years) that measure progress towards the basin’s Sustainability Goal defined by the MOs.

Representative Monitoring Points (RMPs): For each SMC, RMPs are are a sub-component of the overall monitoring network which collectively “represent” hydrologic conditions that permit the evaluation of sustainable groundwater management. SMC are measured at RMPs.

3.2 Sustainability Goal (Reg. § 354.24)

The overall Sustainability Goal of groundwater management in the SV Subbasin is to maintain groundwater resources in ways that best support the continued and long-term health of the people, the environment, and the economy of the SV Subbasin for generations to come. This includes managing groundwater conditions for each of the applicable sustainability indicators in the Subbasin so that:

- Groundwater elevations and groundwater storage do not significantly decline below their historically measured range, protect the existing wells from outages, protect groundwater dependent ecosystems, and avoid additional streamflow depletion due to groundwater pumping.
- Groundwater quality is suitable for beneficial uses in the SV Subbasin and is not significantly or unreasonably degraded.
- Significant and unreasonable land subsidence is prevented in the SV Subbasin. Infrastructure and agriculture in the SV Subbasin remain safe from permanent subsidence of the land surface.
- Significant and undesirable streamflow depletion due to groundwater pumping is avoided through projects and management actions consistent with existing regulatory requirements.
- The GSA groundwater management is effectively integrated with other watershed and land use planning activities through collaborations and partnerships with local, state, and federal agencies, private landowners, and other organizations, to achieve the broader “watershed goal” of sufficient surface water flows that sustain healthy ecosystem functions.

The Sustainability Goal will be achieved by rigorous assessment of potential impacts to domestic, urban, agricultural, industrial, and environmental beneficial users, and scientifically-informed management that avoids significant and unreasonable impacts to beneficial uses and users of groundwater. This chapter defines and quantifies undesirable results for beneficial uses and users of groundwater, which informs the SMC designed to avoid these undesirable results.

3.3 Sustainable Management Criteria

3.3.1 Groundwater Elevation

3.3.1.1 Undesirable Results

Chronic lowering of groundwater levels is considered significant and unreasonable when a significant number of private, agricultural, industrial, or municipal production wells cannot pump pump enough groundwater to supply beneficial uses. SGMA defines undesirable results related to groundwater levels as chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. The lowering of water levels during a period of drought is not the same as (i.e., does not constitute) “chronic” lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage are offset by increases in groundwater levels or storage during other periods.

Potential impacts and the extent to which they are considered significant and unreasonable were determined by the GSAs with input by technical advisors and members of the public. During development of the GSP, potential undesirable results identified included:

- Excessive number of domestic, public, or agricultural wells going dry.
- Excessive reduction in the pumping capacity of existing wells.
- Excessive increase in pumping costs due to greater lift.
- Excessive need for deeper well installations or lowering of pumps.
- Excessive financial burden to local agricultural interests.
- Adverse impacts to environmental uses and users, including reduced interconnected surface water (ISW) and decline of groundwater-dependent ecosystems (GDEs), or undesirable levels of land subsidence.

To the best of our knowledge, never in the history of the SV Subbasin, even including the post-2015 period, have any of the above undesirable results occurred, with the exception of ISW, which has been impacted by groundwater pumping associated groundwater level declines. ISW depletion is addressed in **Section 3.3.3**.

3.3.1.1.1 Identification of Undesirable Results

Operationally, an undesirable result for groundwater level would occur if 25% of the fall low groundwater level observation (i.e., the minimum groundwater level in any given water year) in any of the RMPs fell below their respective MTs for two consecutive years.

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

3.3.1.1.2 Potential Causes of Undesirable Results

Potential causes of Undesirable Results related to Chronic Lowering of Groundwater Levels include increased pumping and/or reduced recharge.

The current primary use of groundwater in the SV Subbasin is for agriculture, thus increased groundwater pumping could occur if water use per acre on irrigated land increases or if new land is put into agricultural production. Similarly, although groundwater pumping for urban uses is relatively small, additional urban development is expected within the Subbasin that could lead to an increase in groundwater use.

Reduced recharge could occur due to increased agricultural irrigation efficiency and/or due to climate change that could result in decreased precipitation, decreased surface water inflows from contributing watersheds, reduced cross-boundary flows, and/or increased evapotranspiration (ET).

Climate change is expected to increase average annual temperatures and intensify rainfall events while also extending dry periods. Hence, during prolonged dry periods, climate change may reduce runoff from surrounding uplands, thus reducing stream recharge to the Subbasin, which may reduce groundwater levels provided constant extraction (**Chapter 2.2.3** Water Budget). However, during more intense wet periods, increased recharge and runoff in the surrounding uplands may have the opposite effect and increase groundwater levels.

The GSAs will coordinate with relevant agencies and stakeholders within the SV Subbasin and the larger watershed to implement management actions and projects to sustainably manage groundwater levels in the Subbasin, and to forecast and understand how our evolving understanding of climate change may inform and improve sustainable groundwater management.

3.3.1.2 Effects on Beneficial Uses and Users

Undesirable results would prevent private, agricultural, industrial, or municipal production wells from supplying groundwater to meet their water demands. Chronic well outages are not expected in the SV Subbasin due to the lack of long-term overdraft and seasonal replenishment of groundwater levels. These qualitative assessments are supported by quantitative well impact analysis that suggests minimal impacts at proposed MTs.

The following provides greater detail regarding the potential impact of temporary well outages on several major classes of beneficial users:

- **Municipal Drinking Water Users:** Undesirable results due to declining groundwater levels can adversely affect current and projected municipal users, causing increased costs for potable water supplies.

- **Rural and/or Agricultural Residential Drinking Water Users:** Seasonal low groundwater levels can cause shallow domestic and stock wells to go dry, which may cause seasonal well outages and restrict water access during periods of highest crop or pasture water demand.

- **Agricultural Users:** Excessive seasonal lowering of groundwater levels could require changes in irrigation practices and crop choice, which may cause adverse effects to property values and the regional economy.

- **Environmental Uses:** Deep groundwater levels may result in significant and unreasonable reduction of groundwater flow toward streams and impacts to groundwater dependent ecosystems. This would adversely affect ecosystem functions related to baseflow and stream temperature, as well as resident species.

3.3.1.3 Relationship to Other Sustainability Indicators

Minimum thresholds for groundwater elevation were designed to be consistent with the avoidance of undesirable results for the other sustainability indicators. Groundwater levels are directly related to groundwater storage, land subsidence, ISW depletion, and groundwater-dependent ecosystems. The relationship between groundwater level MTs, and the MTs for other sustainability indicators are discussed below.

- **Groundwater Storage:** Groundwater levels are closely tied to groundwater storage, with high groundwater levels associated with high groundwater storage. The undesirable result for groundwater storage is measured and thus defined as the occurrence of an undesirable result for groundwater elevations.

- **Depletions of Interconnected Surface Water:** The magnitude and direction of depletions of ISW depend on hydraulic gradients between the surface water and adjacent groundwater. Hence, lowering groundwater levels that propagate to streams may steepen hydraulic gradients and cause additional depletions of ISW that reduce in-stream flows, prevent fish migration and/or spawning, impact riparian ecosystems, and reduce surface water availability for downstream beneficial users of surface water with riparian or appropriative surface water rights. These beneficial users of surface water may be GSAs and associated users within or outside of the Subbasin.
- **Seawater Intrusion:** This sustainability indicator is not applicable in the SV Subbasin.
- **Groundwater Quality:** A significant and unreasonable condition for degraded water quality is exceeding drinking water standards for constituents of concern in supply wells due to projects and management actions proposed in the GSP. Although seasonal lowering of groundwater level minimum thresholds does not directly affect water quality, groundwater quality could potentially be affected by projects and management action-induced changes in groundwater elevations and gradients. These changes could potentially cause poor quality groundwater to flow towards supply wells that would not have otherwise been impacted.
- **Subsidence:** The groundwater level SMC ensures the avoidance of worsening future subsidence. Groundwater level MTs are sufficiently close to historic groundwater levels, and historically-observed land subsidence was not significant and unreasonable. Thus, significant subsidence resulting from lowering groundwater levels to MTs is not anticipated.

3.3.1.4 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives, and Interim Milestones

Groundwater level SMC represent the analysis of best-available data at the time of writing and will be evaluated in subsequent plan updates. In establishing MTs for groundwater level decline, the following information was considered:

- Feedback about groundwater level decline concerns from stakeholders.
- An assessment of available historical and current groundwater level data from monitoring wells in the Subbasin.
- An assessment of trends in groundwater level at selected wells with adequate data to perform the assessment.
- Potential impact to ISW, GDEs, and wells at various groundwater level conditions.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding MTs and associated management actions.

MTs for groundwater levels were then determined by historical analysis of groundwater level monitoring data from January 2000 to June 2021, setting preliminary SMC, evaluating the impact of those SMC on beneficial users of groundwater (e.g., ISW, GDEs, wells), and iterating on the SMC until significant and unreasonable impacts were avoided.

Importantly, undesirable results due to excessive lowering of groundwater levels have not been historically observed in the SV Subbasin, which implies that groundwater levels near historical lows should not cause undesirable results.

To establish SMC a three-step process was followed at each representative monitoring point (RMP). First, the January 2000 to current trend of groundwater levels were linearly projected to January 2032, corresponding to 10 years after GSP submission. Second, the projected groundwater level was compared to the lowest groundwater elevation observed after January 2015. Third, the minimum of the values compared in step two were then reduced by a buffer equal to 10% of the January 2000 to current range of groundwater levels observed at each monitoring point to arrive at the MT. MTs were then rounded down to the nearest integer to ease interpretability. RMPs that show an increase in groundwater level use the observed minimum level as the MT. These SMC effectively give the Subbasin time to respond to corrective action. The 10% buffer allows for operational flexibility to account for potential extreme climate conditions and to accommodate practicable triggers. The analysis for the RMPs is presented in **Figure 3.3.1-1**. On the figure, the measured groundwater levels are black solid lines, the MT is represented as a red horizontal solid line, the MO is shown as a blue horizontal solid line, and the IMs are grey horizontal dashed lines. The two vertical green dashed lines on each sub-plot demark January 2015 and January 2032. Note that all subplots share the same x-axis, but have different y-axis scales. RMPs capture the shallow and deep zones of the aquifer.

Next, these MTs were assessed in terms of potential impact to various beneficial users of groundwater including shallow wells (e.g., domestic, public, agricultural, and industrial), groundwater dependent ecosystems, and interconnected surface water.

1. ***Avoidance of impacts to shallow wells:*** An MT groundwater surface was simulated based on the projected groundwater level decline implied by MTs, and combined with well completion report data to estimate impacts to wells. Assuming all MTs are simultaneously reached across the basin – a theoretical worst case and unlikely scenario – only 6 to 10 domestic wells (2%) are impacted, and no other well types are impacted. This finding is consistent with the fact that most wells are relatively deep compared to present-day groundwater levels and groundwater level MTs. Thus, the MTs presented herein protect shallow wells. A detailed discussion of the well impact analysis is presented in Appendix 3A.

2. ***Avoidance of impacts to GDEs***: MOs and MTs for each well were evaluated in terms of their impact on GDEs. Where there were no GDEs within a 1-mile radius of the monitoring point the MO and MT were not changed. Because there is no record of the extent of GDEs through time, the NDVI of mapped GDE polygons was used to assess the linkage between groundwater elevation and GDE health. If a statistically significant relationship exists between depth to groundwater and NDVI the potential impact of MO and MT values was assessed for the monitoring well. For wells screened at more than one depth, only the shallowest screening interval was used. The degree to which NDVI recovered following water elevations close to the MT was investigated to ensure that historical water elevations near the MT did not negatively impact the GDEs (see Chapter 2 for details on GDE NDVI). Where possible, MTs were adjusted to be within the historical range of groundwater elevations so that the impact on GDEs was known. For riverine GDEs, the MT was adjusted to within 10 ft of the ground to promote ISW where reasonable.

   Based on a review of historical NDVI and water surface elevation, MOs and MTs were adjusted at 4 wells to conservatively limit impacts to GDEs (RMP IDs 93, 209, 291, and

300). The remainder of the wells either had no GDEs within 1 mile of the RMP, did not have a statistically significant relationship between NDVI and groundwater elevation, had groundwater depths > 30 ft below ground surface, or had relatively robust NDVI at the MO and MT. For RMP 93, groundwater elevations at or below the previous MT caused declines that persisted for more than 1 year. The MT was raised by 1 ft to a groundwater elevation above this threshold where impacts to NDVI did not persist. The MO was increased by 1 ft RMP 93 to more closely reflect the minimum groundwater elevation at which NDVI reached its highest value (0.6). Because RMP 93 is adjacent to the large wetland in the western portion of the basin, the MO and MT were conservatively adjusted to limit impacts to this GDE, despite the large depth of the well.

For RMP 209 the MO was adjusted to be within 10 ft of the ground surface to support ISW. For RMP 291 the MO and MT were adjusted by < 1ft. The MO was adjusted to 6 ft below ground surface to reflect high groundwater levels in 2006, 2017, and 2019. Finally, the MT was increased to 10ft below ground surface to support ISW. For RMP 300, the MT was adjusted to the 2010-2015 low value and the MO not changed. This well only has groundwater data from 2005-present and more detailed monitoring of GDE health relative to groundwater elevation will help to understand linkages between GDEs and groundwater elevation at this site.

3. ***Avoidance of impacts to ISW***: Groundwater level MTs near interconnected surface water (ISW) are set no lower than historically observed low groundwater levels to arrest hydraulic gradients and prevent ISW depletion that exceeds previously experienced depletion (**Section 3.3.3.4**). The difference between Fall 2015 groundwater levels and MTs varies by location in the basin, and ranges from 0 to 13 feet as displayed on Figure 3.3.1-2.

Next, measurable objectives (MOs) were defined as the average groundwater elevation observed after 2015-01-01, which correspond to present-day groundwater levels and imply a management goal to maintain these levels. MOs were rounded to the nearest integer to ease interpretability. Operational flexibility is defined as the difference between the MO and the MT. Interim milestones (IMs) were defined as regular five-year long intervals between the MT and MO at 2027, 2032, and 2037. The MO can be understood as the 4th and final IM. When the operational flexibility for and RMP is less than 3 feet, due to nearest-integer-rounding, one or more IMs will be equal to the MO.

3.3.1.4.1 Triggers

The primary trigger for management actions will be if groundwater levels fall below historic lows in any individual well for more than two consecutive years – notably, this does not constitute an undesirable result, but warrants attention. A secondary trigger for management actions will be if 2% (n = 6) of domestic well outage reports are received. This trigger value is based on findings that suggest 2% of domestic wells may be impacted assuming MTs across the entire basin are reached at the same time (Technical Appendix 3A). If either of these triggers occur, the GSAs will investigate and reassess SMC suitability and may use management actions to proactively avoid the occurrence of undesirable results.

Figure 3.3.1-1. Analysis of Historical Groundwater Levels at the Representative Monitoring Points and the Minimum Thresholds and Measurable Objectives

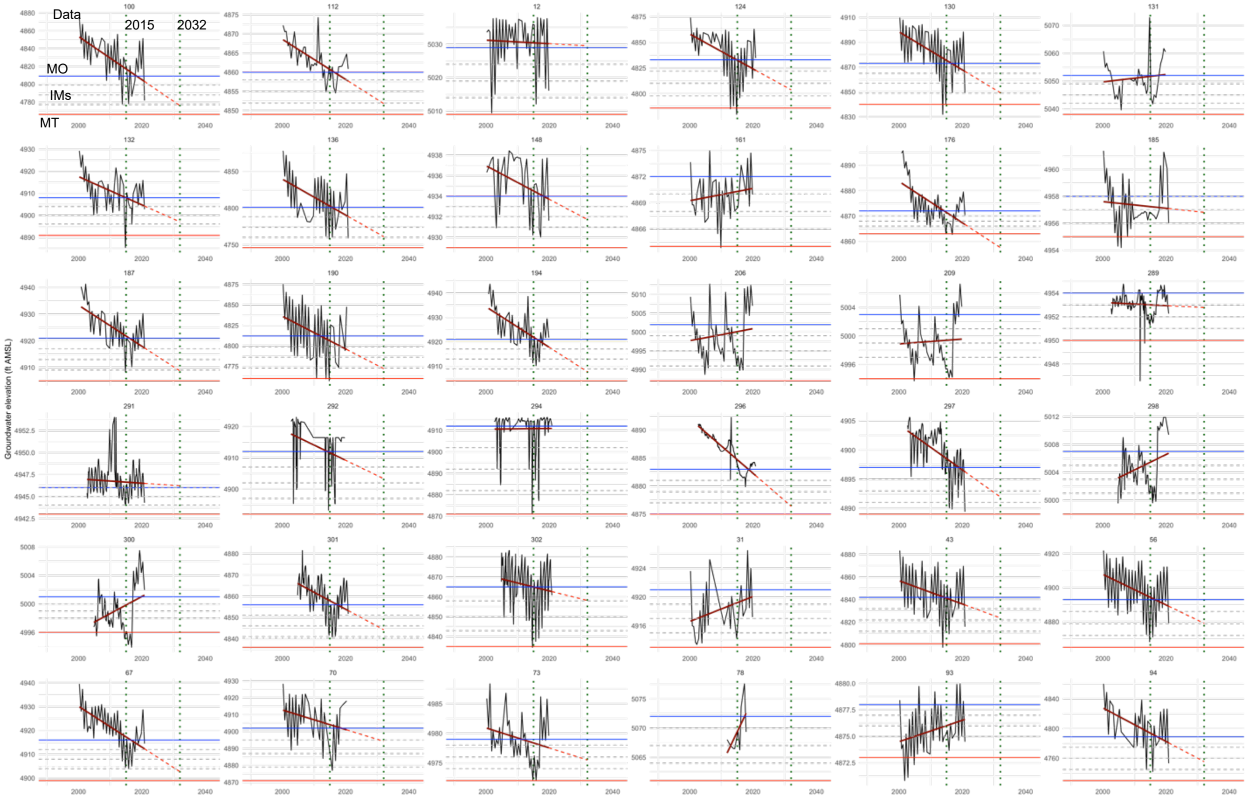
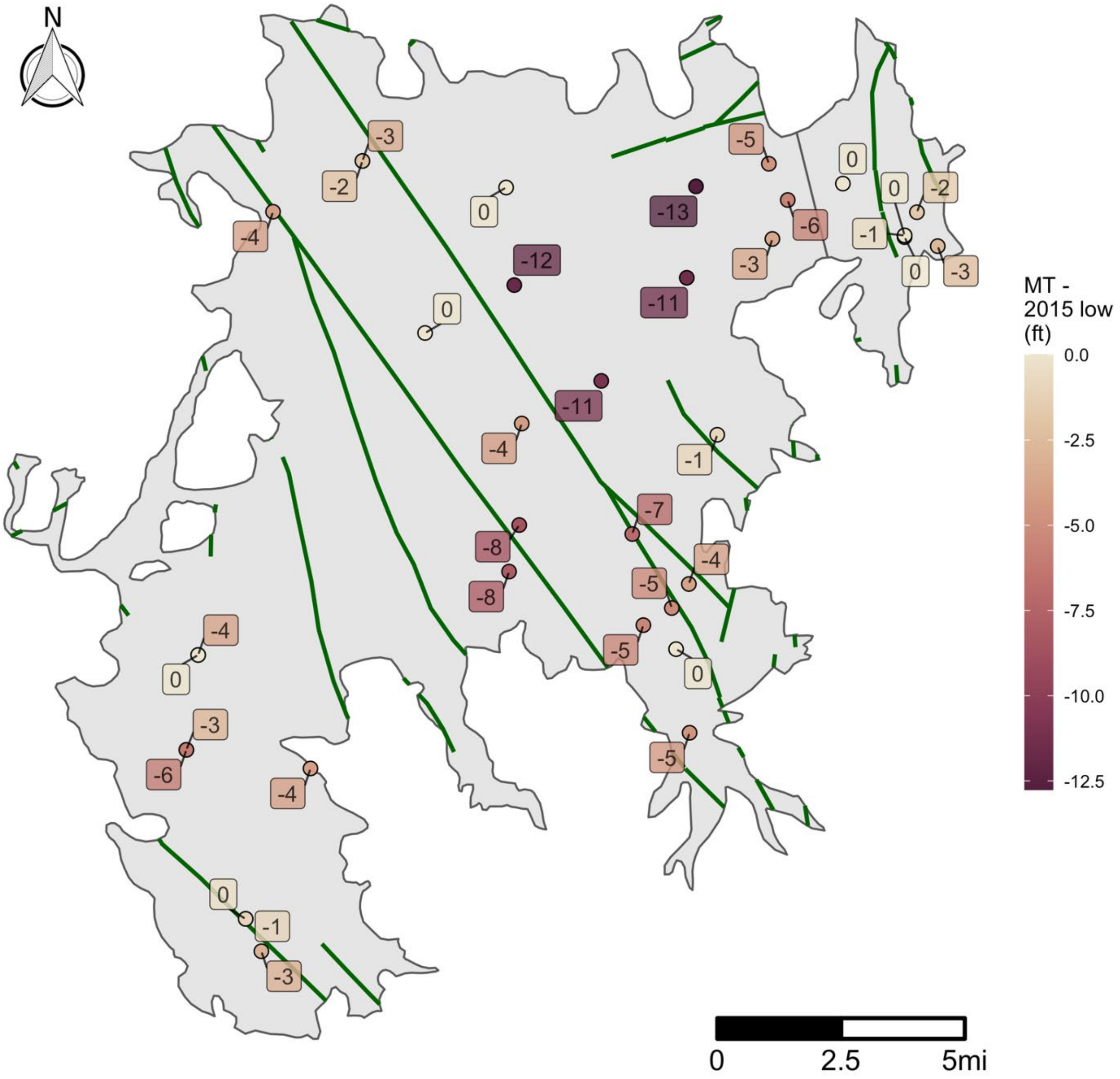


Figure 3.3.1-2. Minimum thresholds do not substantially lower groundwater elevations beyond the lowest recorded values (Fall 2015) and maintain elevations above historic lows near ISW.



3.3.1.4.2 *Method for Quantitative Measurement of Minimum Thresholds*

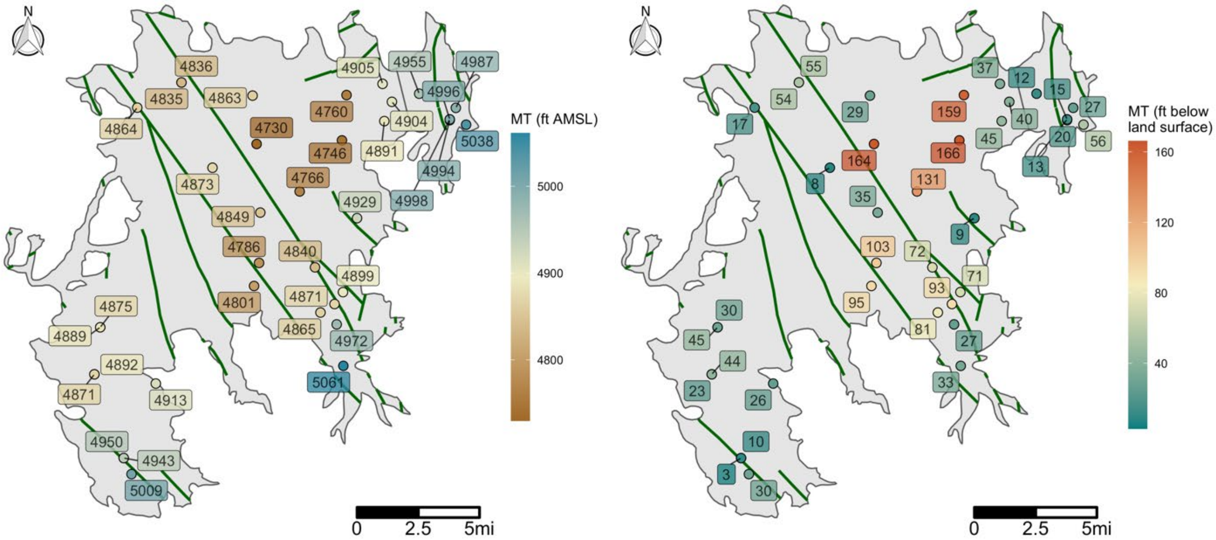
The groundwater elevation at each RMP will be monitored quarterly to directly assess the SMC. The RMPs and associated SMC are listed in **Table 3.3.1-1** and presented spatially in **Figure 3.3.1-3**. Note that in some instances, multiple wells are included at the same location (e.g., nested wells). These wells are denoted by duplicate labels in the figure and have unique RMP IDs as well as unique screened intervals. These monitoring locations are unique in that they capture shallow and deep aquifer zones.

Table 3.3.1-1. Representative Monitoring Point (RMP) Elevations and Minimum Thresholds (MTs) and Measurable Objectives (MOs)

RMP ID	Site Code	Ground Surface (ft AMSL)	Water Surface[1] (ft AMSL)	MO (ft AMSL)	MT (ft AMSL)
12	395808N1203851W001	5,038.6	5,016.1	5,029	5,009
31	396391N1203667W001	4,938.6	4,917.2	4,921	4,913
43	396970N1202916W001	4,895.6	4,816	4,842	4,801
56	396814N1202407W001	4,945.7	4,879	4,893	4,865
60	396718N1202721W001	5,003.7	4,916.2	4,915	4,904
67	396934N1202234W001	4,969.7	4,914.5	4,916	4,899
70	396864N1202299W001	4,963.7	4,918.1	4,902	4,871
73	396744N1202282W001	4,998.7	4,979.6	4,979	4,972
78	396599N1202229W001	5,093.8	5,069.35	5,072	5,061
93	397667N1203238W001	4,880.52	4,874.49	4,878	4,873
94	397808N1202893W001	4,894.33	4,753.24	4,789	4,730
100	397529N1202568W001	4,896.57	4,781.47	4,809	4,766
112	397403N1202870W001	4,884.47	4,860.87	4,860	4,849
124	397106N1202878W001	4,888.58	4,834.68	4,833	4,786
130	397081N1202449W001	4,911.59	4,848.79	4,873	4,840
131	397927N1201294W001	5,093.6	5,060.45	5,052	5,038
132	397945N1201920W001	4,935.6	4,902.8	4,908	4,891
136	397831N1202245W001	4,911.58	4,758.68	4,801	4,746
148	397372N1202128W001	4,938.22	4,931.62	4,934	4,929
161	398020N1203815W001	4,880.96	4,869.96	4,872	4,864
176	398094N1202932W001	4,891.83	4,870.33	4,872	4,863
185	398107N1201653W001	4,966.79	4,955.99	4,958	4,955
187	398165N1201934W001	4,942.09	4,917.29	4,921	4,905
190	398098N1202211W001	4,918.58	4,847.58	4,812	4,760
194	398059N1201862W001	4,943.59	4,921.74	4,921	4,904
206	398024N1201371W001	5,013.6	5,007	5,002	4,987
209	397951N1201418W001	5,013.6	5,004.1	5,003	4,994
289	395951N1203910W003	4,953.4	4,952.26	4,954	4,950
291	395951N1203910W001	4,953.3	4,944.29	4,946	4,943
292	396444N1204137W003	4,915.2	4,916.25	4,912	4,892
294	396444N1204137W001	4,915.2	4,912.25	4,912	4,871
296	396722N1204095W002	4,920.1	4,883.51	4,883	4,875
297	396722N1204095W001	4,919.4	4,889.41	4,897	4,889
298	397956N1201417W001	5,010.6	5,009.4	5,007	4,998
300	397956N1201417W003	5,010.6	5,001.95	5,001	4,996
301	398170N1203478W001	4,890.48	4,851.75	4,856	4,836
302	398170N1203478W002	4,890.48	4,860.68	4,865	4,835

(1) Water surface at last available measurement.

Figure 3.3.1-3. Minimum Thresholds in elevation above mean sea level (left) and below land surface (right) for the Representative Monitoring Points (duplicate labels indicate nested monitoring wells)



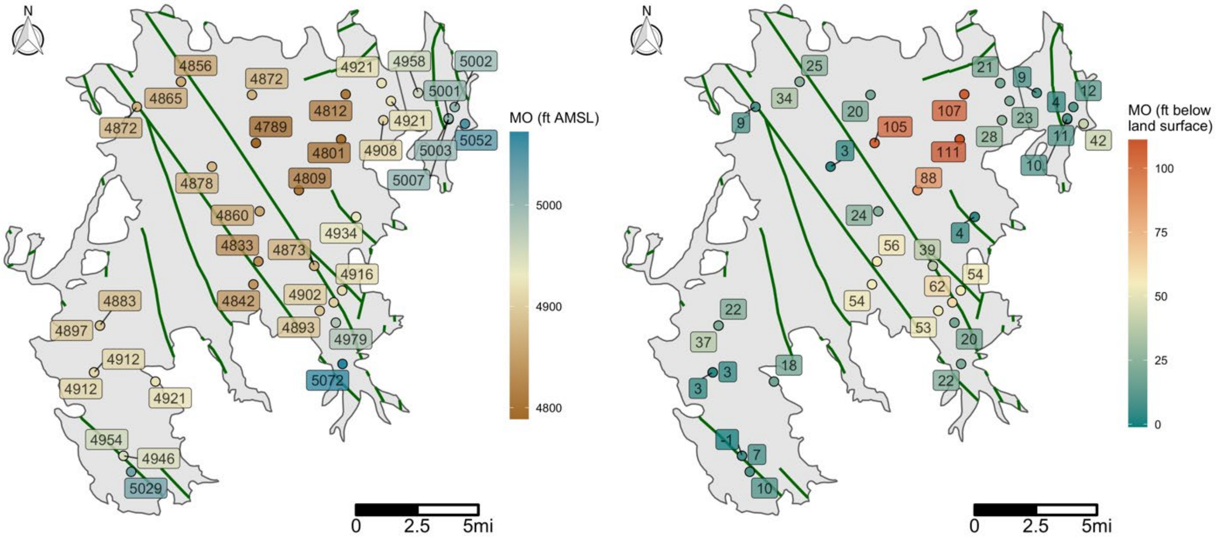
3.3.1.5 Measurable Objectives

The groundwater elevation MOs for the SV Subbasin are set to represent the current condition of the Subbasin and correspond to management goals that maintain these levels.

3.3.1.5.1 Description of Measurable Objectives

For all RMPs, MOs are set to the average water level observed from January 2015 to June 2021. Each MO was rounded to the nearest integer to ease interpretation. The MOs are listed for each RMP in **Table 3.3.1-1** and presented in **Figure 3.3.1-4**.

Figure 3.3.1-4. Measurable Objectives in elevation above mean sea level (left) and below land surface (right) for the Representative Monitoring Points (duplicate labels indicate shallow and deep wells at the same location)



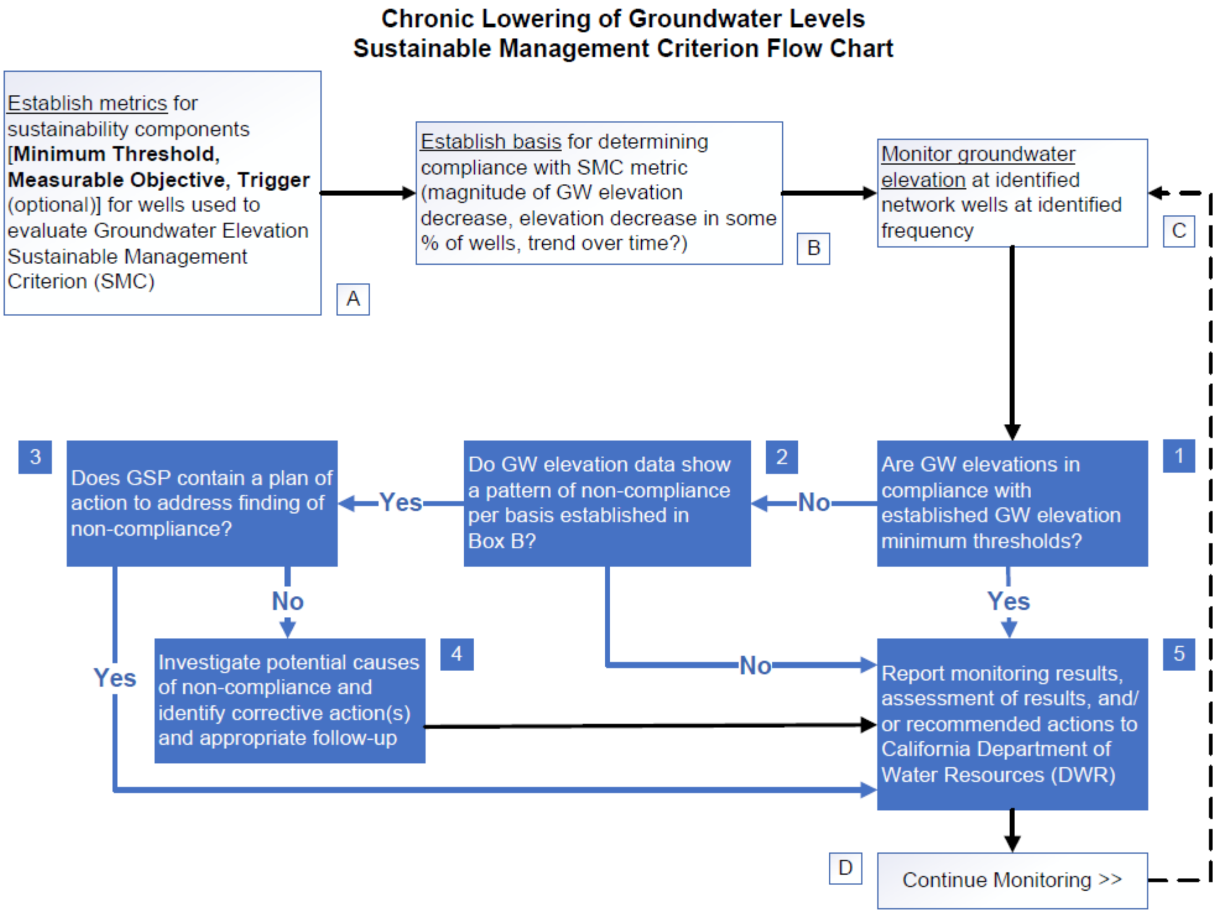
3.3.1.6 Path to Achieve Measurable Objectives

The GSAs will support achievement of the MOs by monitoring groundwater levels and coordinating with agencies and stakeholders within the Subbasin to implement projects and management actions. The GSAs will review and analyze groundwater level data to evaluate any changes in groundwater levels resulting from groundwater pumping or recharge projects in the Subbasin. Using monitoring data collected as part of GSP implementation, the GSAs will develop information (e.g., hydrograph plots) to demonstrate that projects and management actions are operating to maintain or improve groundwater level conditions and to avoid unreasonable groundwater levels. Should groundwater levels drop to a trigger or MT as the result of GSAs project implementation, the GSAs will implement measures to address this occurrence. This process is illustrated in **Figure 3.3.1-5** based on a combination of monitoring, reporting, investigation, and when necessary, corrective actions.

To manage groundwater levels, the GSAs will partner with local agencies and stakeholders to implement projects and management actions. Projects and management actions are presented in further detail in Chapter 4. Implementation timelines and approximate costs are discussed in Chapter 5. Examples of possible GSAs actions include stakeholder education and outreach and support for impacted stakeholders.

Where the cause of groundwater level decline is unknown, the GSAs may choose to conduct additional or more frequent monitoring or initiate additional modeling. The need for additional studies on groundwater levels will be assessed throughout GSP implementation. The GSAs may identify knowledge requirements, seek funding, and help to implement additional studies.

Figure 3.3.1-5: Groundwater Level Sustainable Management Criteria Flow Chart



3.3.1.6.1 *Interim Milestones*

Interim milestones (IMs) were defined as regular 5 year long intervals between the MT and MO at 2027, 2032, and 2037. The MO can be understood as the fourth and final IM. When the operational flexibility for and RMP is less than 3 feet, due to nearest-integer-rounding, one or more IMs will be equal to the MO.

3.3.2 Groundwater Storage

Chronic lowering of groundwater levels is directly correlated with reduction of groundwater storage. Groundwater storage is the three-dimensional equivalent of groundwater level (one-dimensional) over an area. Reduction in groundwater storage generally indicates groundwater level decline, and vice versa. Thus, groundwater levels may be used as a proxy for groundwater storage, and the potential causes and identification of Undesirable Results related to reduction in groundwater storage are identical to those related to chronic lowering of groundwater levels (**Section 3.3.1.1**).

GSAs will track and project groundwater storage with the Sierra Valley integrated hydrologic model, and calibrate groundwater storage estimates based on data collected throughout the Subbasin. As before, potential effects of Undesirable Results on beneficial uses and users of groundwater due to reduced groundwater storage are identical to those outlined due to chronic lowering of groundwater levels (**Section 3.3.1.2**), as are SMC (**Sections 3.3.1.4 - 3.3.1.6**).

3.3.3 Depletion of Interconnected Surface Waters

3.3.3.1 Undesirable Results – Depletion of Interconnected Surface Water

Significant and unreasonable depletion of interconnected surface water (ISW) due to groundwater extraction is identified if ISW depletion exceeds the maximum depletion rates indicated in the monitoring record from January 2000 to January 2021. Notably, these rates have not yet been calculated, pending the results of the Sierra Valley integrated hydrologic model. However, this GSP acknowledges that ISW depletion is occurring, but this depletion is not significant and unreasonable, and then takes the conservative approach of not worsening ISW gradients and hence, not causing unexperienced effects on the Subbasin. These management objectives are quantitatively achieved by arresting groundwater levels near ISW at historical levels, which thereby arrests hydraulic gradients and ISW depletion.

3.3.3.1.1 Potential Causes of Undesirable Results

Depletion of ISW is related to chronic lowering of groundwater levels via changes in the hydraulic gradient. Darcy's Law is a fundamental tenet of groundwater hydrogeology that explains this.[1] It states that the amount of water that flows through an aquifer (e.g., ISW depletion) is proportional to the hydraulic gradient (in this case, the difference between the water surface elevation in the stream ('stage') and adjacent groundwater elevation). Hence, declines in groundwater level which increase the hydraulic gradient between the ISW and the aquifer also increase ISW depletion.

Undesirable Results related to ISW depletion could be caused by increased pumping and/or reduced recharge (e.g., due to drought, climate change, or changes in irrigation rates or practices). Most of the pumped groundwater in the basin is used for agriculture; therefore, increased demand per irrigated acre or an increase in irrigated acreage could result in depletions to surface water. Natural and managed variability in the timing and magnitude of inter- and intra-basin diversions could also affect recharge and available surface water and lead to ISW depletion. Efforts to move from flood irrigation (commonly practiced on the south and west sides of the valley) to spray irrigation could increase irrigation efficiency but also potentially reduce recharge, leading to lower groundwater level and hence, ISW depletion. The inter-basin diversion from the Little Truckee River supplies substantial surface water (6,693 acre-feet on average from 1959 to 2020) to Sierra Valley during the irrigation season. In a warming climate, reduced snowpack and spring and summer runoff could affect the availability of water from the Little Truckee Diversion. Other factors related to climate change such as decreased precipitation and increased evapotranspiration could also lead to ISW depletion.

3.3.3.2 Effects on Beneficial Uses and Users

Undesirable Results would have the greatest impact to agricultural and environmental uses and users. Agricultural users in the southern and western portions of the valley rely heavily on surface water to irrigate pasture. Ongoing or increased groundwater pumping could alter the horizontal and vertical gradients that affect the rates and direction of groundwater flow. Streams and wetlands may switch from gaining to losing if groundwater levels decline past critical

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[1] Darcy's Law, $Q = K \cdot A \cdot i$ states that the volumetric rate of flow *Q* is proportional to the hydraulic conductivity (*K*, or resistance to flow), the cross-sectional area (*A*, in this case, of the streambed), and the hydraulic gradient *i* (in this case, the difference between water surface elevation in the stream ('stage') and adjacent groundwater level). Thus, as the difference between stream stage and groundwater level increases, the hydraulic gradient (*i*) increases, which makes streamflow depletion (*Q*) increase.

thresholds, which would result in less available surface water for irrigation, and stream losses into shallow aquifers.

ISW provides habitat for priority species, thus ISW depletion may impact these beneficial users. Late summer and early fall are particularly important, as some ISW streams may depend on late season groundwater discharge to support baseflow when snowmelt and surface runoff are at a minimum. ISW depletion would not only the availability, but also the quality of habitat. In late summer and fall conditions, upwelling of relatively cool groundwater helps maintain surface water temperature from warming excessively and negatively impacting priority species. In the Sierra Valley, how ISW depletion could impact sensitive species is poorly understood. Monitoring of species diversity, populations, and available habitat occurs, but is insufficient to fully understand the impacts of ISW depletion on such environmental systems. Widespread monitoring and documentation needs are discussed further in **Section 3.4.1.4**.

3.3.3.3 Relationship to Other Sustainability Indicators

Minimum thresholds (MTs) established for the depletion of interconnected surface water are the most conservative of the sustainability indicators, in that they do not allow for future conditions that exceed historically observed ISW depletion.

Increased ISW depletion results from chronic lowering of groundwater levels when lowering groundwater levels leads to an increase in the stream-aquifer hydraulic gradient, and hence, increased depletion. Therefore, by effectively managing groundwater levels that avoid lowering groundwater levels, ISW depletion can also be managed. Moreover, monitoring and forecasting basin-wide storage also provides a big picture view of how ISW depletion may be impacted, although spatially distributed changes in groundwater level are much more useful in isolating local-scale ISW impacts.

The chronic lowering of groundwater level SMC allows for lowering to the minimum level seen in a linear trend of groundwater levels since January 2000 and projected out to 2032 plus an additional 10% of the range. In contrast, in ISW zones, groundwater level MTs are adjusted consistent with ISW MTs, such that no additional groundwater level depletion occurs in excess of historical impacts (i.e., observed between January 2000 and January 2021).

3.3.3.4 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

3.3.3.4.1 Groundwater Elevations as a Proxy for Depletion of Interconnected Surface Water Minimum Thresholds

Depletion of Interconnected Surface Water as a volume or rate is difficult to quantify in Sierra Valley due to data gaps. Groundwater monitoring data is lacking near ISW, and there are no continuous streamflow or stage gages within the basin. Data collected by the DWR Watermaster for the Sierra Valley is only done in preparation for and during the irrigation season with periodic measurements on up to 12 different tributaries. Due to the discontinuous nature of these measurements, simple mass-balance approaches to ISW depletion estimation are infeasible.

Quantification of ISW depletion is in development and will be achieved through the use of the Sierra Valley integrated surface water-groundwater model. Two different scenarios will be evaluated: with and without pumping. All other model inputs will remain the same between the two scenarios. Streamflow results will be compared, and the difference, measured as a volume or rate, is the amount of surface water depletion due to groundwater pumping. In lieu of results from this integrated surface and groundwater model, we conservatively set ISW SMC to arrest hydraulic gradients near ISW.

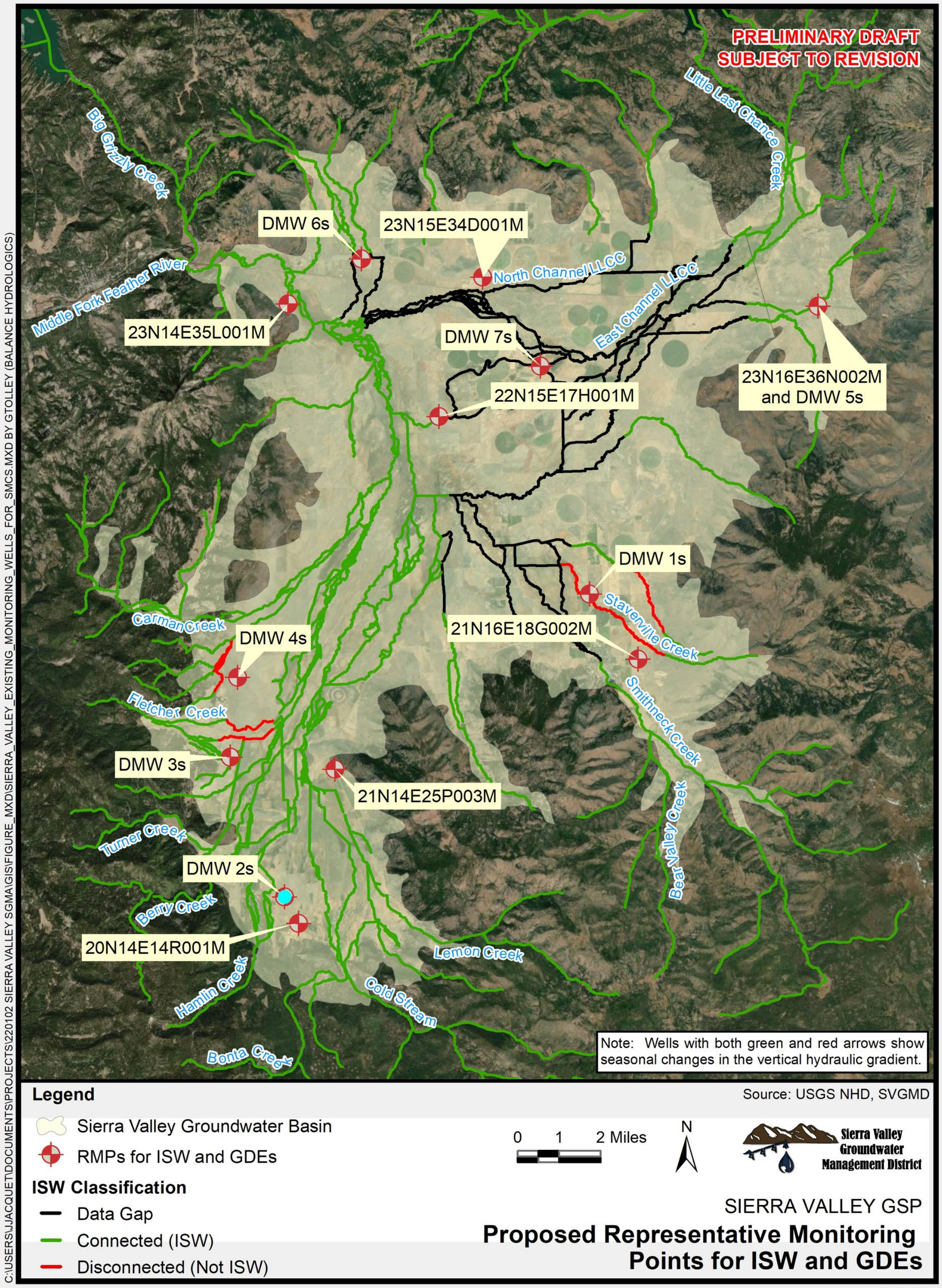
Groundwater elevations may be used as a proxy for a sustainability indicator if there is a significant correlation between the sustainability indicator in question and groundwater elevations. Groundwater elevations directly control the stream-aquifer hydraulic gradient, and thus, the magnitude of ISW depletion. In the absence of high-confidence estimates of streamflow depletion, but reasonable groundwater level data, we set conservative MTs near ISW and GDEs that would maintain groundwater elevations above historically observed lows and thus reduce the risk that hydraulic gradients between surface and groundwater do not reverse or steepen. In other words, these conservative groundwater level MTs protect ISW from experiencing depletion in excess of historically observed values by controlling stream-aquifer hydraulic gradients.

To protect priority species that rely on ISW, MTs are set for existing monitoring wells that are located nearest to sensitive GDEs and ISW. RMPs associated with ISW or GDEs that support priority species are assigned a groundwater level MT equal to the lowest reading since January 2000 (**Figure 3.3.3-1, Figure 3.3.3-2, and Table 3.3.3-1**). All ISW RMPs except 37 and 364 are contained in the groundwater level RMP network.

Table 3.3.3-1. MTs and MOs for select RMPs associated with GDEs and ISW

RMP ID	Well Name	Site Code	Water Surface (ft AMSL)	Ground Surface (ft AMSL)	MO (ft AMSL)	MT (ft AMSL)
12	20N14E14R001M	395808N1203851W001	5,016.1	5,038.6	5,029	5,009
37	DMW 1s	396976N1202492W001	4,898.2	4,916.6	4,898	4,895
31	21N14E25P003M	396391N1203667W001	4,917.2	4,938.6	4,921	4,913
73	21N16E18G002M	396744N1202282W001	4,979.6	4,998.7	4,979	4,972
161	23N14E35L001M	398020N1203815W001	4,869.96	4,880.96	4,872	4,864
176	23N15E34D001M	398094N1202932W001	4,870.33	4,891.83	4,872	4,863
209	23N16E36N002M	397951N1201418W001	5,004.1	5,013.6	5,003	4,994
291	DMW 2s	395951N1203910W001	4,944.29	4,953.3	4,946	4,943
294	DMW 3s	396444N1204137W001	4,912.25	4,915.2	4,911	4,871
297	DMW 4s	396722N1204095W001	4,889.41	4,919.4	4,897	4,889
300	DMW 5s	397956N1201417W003	5,001.95	5,010.6	5,001	4,996
301	DMW 6s	398170N1203478W002	4,860.68	4,890.48	4,864	4,835
364	DMW 7s	N/A	4,886.7	4,895.9	4,887	4,887

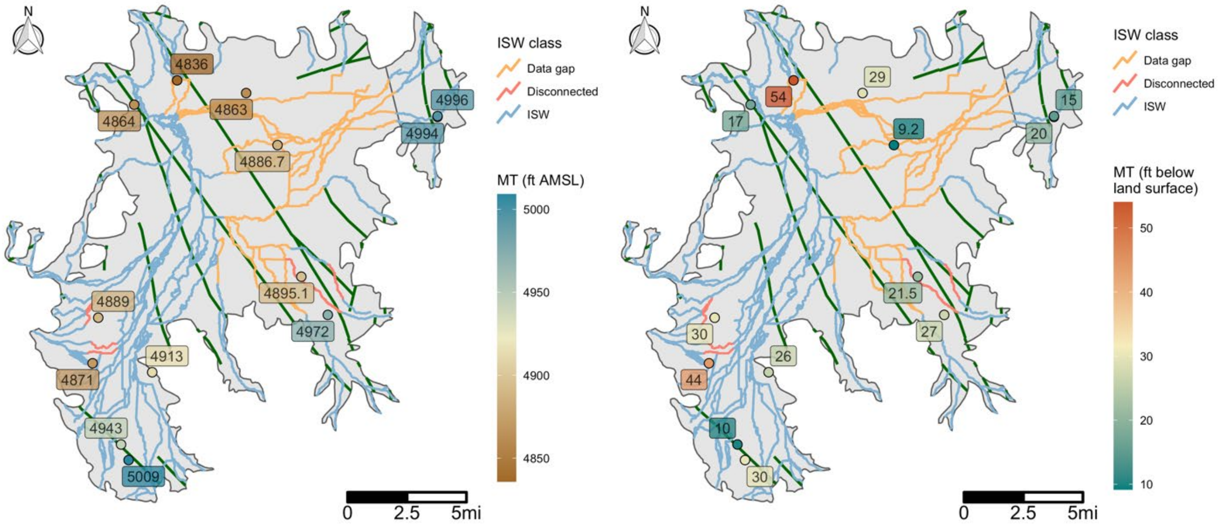
Figure 3.3.3-1. Proposed Representative Monitoring Points for ISW and GDEs



9/13/2021

Figure 3.3.3-1

Figure 3.3.3-2. MTs at ISW RMPs in terms of elevation above mean sea level (left) and depth below land surface (right). Faults are shown as dark green lines. ISW classification (Chapter 2) is shown for data gaps (orange), disconnected reaches (red), and ISW (blue).



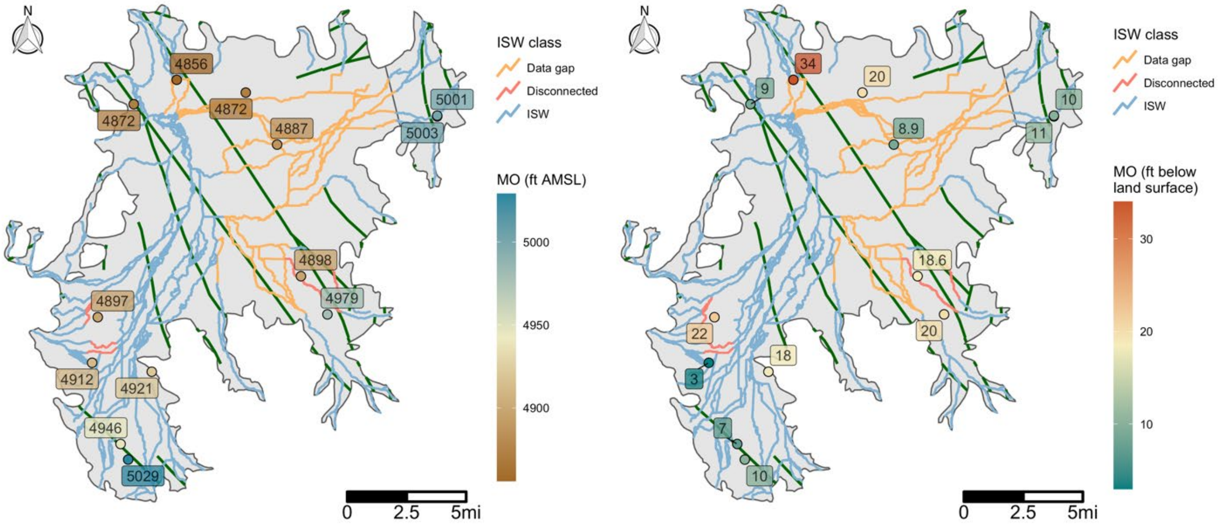
3.3.3.4.2 Triggers

The trigger for management action will be if the water level falls within…

3.3.3.5 Measurable Objectives

Measurable Objectives for the depletion of ISW are consistent with those for Groundwater Elevation. Thus, ISW MOs are based on the mean of the current (2015 to 2021) groundwater conditions in the basin at each RMPs (**Figure 3.3.3-3 and Table 3.3.3-1**).

Figure 3.3.3-3. MOs at ISW RMPs in terms of elevation above mean sea level (left) and depth below land surface (right). Faults are shown as dark green lines. ISW classification (Chapter 2) is shown for data gaps (orange), disconnected reaches (red), and ISW (blue).



3.3.3.6 *Path to Achieve Measurable Objectives*

The GSA will support achievement of the measurable objectives by monitoring groundwater levels and surface water elevations at RMPs and coordinating with agencies and stakeholders within the Basin to implement projects and management actions (PMAs). The GSA will review and analyze groundwater level data to evaluate any changes in groundwater levels resulting from groundwater pumping or recharge projects in the Basin. Using monitoring data collected as part of GSP implementation, the GSA will develop information (e.g., hydrographs) to demonstrate that projects and management actions are operating to maintain or improve groundwater level conditions in the Basin and to avoid unreasonable groundwater levels. Should groundwater levels drop to a trigger or minimum threshold, the GSAs will implement measures to address this occurrence.

3.3.3.7 *Interim Milestones*

Interim milestones are consistent with those set for groundwater level SMC (**Section 3.3.1.6.1**).

3.3.4 Degraded Groundwater Quality

Groundwater quality in the SV Subbasin is generally good and well-suited for the municipal, domestic, agricultural, and other existing and potential beneficial uses designated for groundwater in the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin (Basin Plan). Existing groundwater quality concerns within the SV Subbasin are identified in **Section 2.2.2.4**, and a detailed water quality assessment is included in Appendix ## of **Chapter 2**. Based on the water quality assessment, constituents of concern in the SV Subbasin were deemed to include nitrate, total dissolved solids (TDS), arsenic, boron, pH, iron, manganese, and MTBE. SMCs are defined for two constituents: nitrate and TDS.

Arsenic, boron, pH, iron, and manganese are impacted significantly by natural processes and local geological conditions that are not controllable by the GSAs through groundwater management processes. Therefore, SMCs are not defined for these constituents. Additionally, as detailed in **Section 2.2.2.4**, MTBE have diminished substantially over the last 10 years: from 2016 to 2020 no exceedances of the 5 µg/L SMCL occurred and the highest concentration measured during this period was 0.7 µg/L), and therefore no SMC is defined for this constituent, and moreover it is associated with contaminated sites that have dedicated monitoring and cleanup and is not likely a risk for future contamination.

In addition to conducting monitoring for the constituents with SMCs (nitrate and TDS), the GSA will monitor arsenic, boron, and pH to track any potential mobilization of elevated concentrations or exceedances of the Maximum Contaminant Levels (MCLs, provided in **Section 2.2.2.4, Table 2.2.2-1**). As the regional groundwater flow model becomes available, additional attention will be paid to how groundwater pumping may mobilize contaminant plumes.

Water quality degradation is typically associated with increasing constituent concentration, thus the GSAs have decided not to use the term “minimum threshold” in the context of water quality, but rather, “maximum threshold”.

3.3.4.1 Undesirable Results

An undesirable result under SGMA is defined as an impact that is determined to be significant and unreasonable, as previously defined in **Section 3.1**. Significant and unreasonable degradation of groundwater quality is the degradation of water quality that would impair beneficial uses of groundwater within the SV Subbasin or result in the failure to comply with groundwater regulatory thresholds including state and federal drinking water standards and Basin Plan water quality objectives. While others may be identified, undesirable results to groundwater quality that are currently of primary concern include:

- adverse groundwater quality impacts to safe drinking water,
- adverse groundwater quality impacts to irrigation water use,
- the spread of degraded water quality through old or abandoned wells; and,
- the spread of degraded groundwater quality.

Based on the State’s 1968 antidegradation policy[2], water quality degradation inconsistent with the provisions of this policy is degradation determined to be significant and unreasonable. Furthermore, the violation of water quality objectives is significant and unreasonable under the State’s antidegradation policy. The Central Valley Regional Water Quality Control Board (Regional Board) and the State Water Board are the two entities that determine if degradation is inconsistent with Resolution No. 68-16.

Federal and state water quality standards, water quality objectives defined in the Basin Plan, and the management of known and suspected contaminated sites within the Subbasin will continue to be the jurisdictional responsibility of the relevant regulatory agencies. The role of the GSAs is to provide additional local oversight of groundwater quality, collaborate with appropriate parties to implement water quality projects and actions, and to evaluate and monitor, as needed, water quality effects of projects and actions implemented to meet the requirements of other SMCs.

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[2] State Water Resources Control Board. “Resolution No. 68-16: Statement of Policy with Respect to Maintaining High Quality of Waters in California”, California, October 28, 1968.

Sustainable management of groundwater quality includes maintenance of water quality within regulatory and programmatic limits while executing GSP projects and actions. To achieve this goal, the GSAs will coordinate with the regulatory agencies that are currently authorized to maintain and improve groundwater quality within the Subbasin. This includes informing the Regional Board of any issues that arise and working with the Regional Board to address potential problems. All future projects and management actions implemented by the GSAs will be evaluated and designed to avoid causing undesirable groundwater quality outcomes. Monitoring should be included as part of the applicable project or management action to allow evaluation of any impacts. Historic and current groundwater quality monitoring data and reporting efforts have been used to document baseline groundwater quality conditions in the basin. These conditions provide a baseline to compare with future groundwater quality and identify any changes observed due to GSP implementation.

In addition to supporting agricultural and domestic water supply beneficial uses, groundwater also supports GDEs and instream environmental resources. These beneficial uses, among others, are protected in part by the Regional Board through the water quality objectives adopted in the Basin Plan. The constituents of concern in the Subbasin, and their associated regulatory thresholds, are listed in **Section 2.2.2.4**.

3.3.4.1.1 Potential Causes of Undesirable Results

Future monitored activities or conditions with potential to affect water quality may include significant changes in location and magnitude of groundwater pumping or changes to planned and incidental groundwater recharge mechanisms sufficient to change the flow and transport of subsurface contaminants. Altering the location or rate of groundwater pumping could change the direction of groundwater flow which may redirect existing contaminant plumes, or plumes that may develop in the future, thus potentially compromising ongoing remediation efforts. Similarly, recharge activities could alter hydraulic gradients which could result in the downward movement of contaminants into groundwater or move existing groundwater contaminant plumes towards supply wells.

Sources and activities that may lead to undesirable groundwater quality include industrial contamination, pesticides, sewage, animal waste, and other wastewaters, and natural causes. Fertilizers and other agricultural activities can elevate concentrations of constituents such as nitrate and TDS. Wastewater, such as sewage from septic tanks and animal waste, can also elevate nitrate and TDS concentrations. Natural causes, such as local volcanic geology and soils), can elevate concentrations of arsenic, boron, iron, manganese, pH, and TDS. The GSAs cannot control and are not responsible for natural causes of groundwater contamination but are responsible for how project and management actions may impact groundwater quality (e.g., through mobilization of naturally occurring contaminants).

Groundwater quality degradation associated with known sources will be primarily managed by the Regional Board which is the entity currently overseeing such sites. In the SV Subbasin, existing contaminant sites are currently being managed, and though additional degradation is not anticipated from known sources, new sites may cause undesirable results due to constituents that, depending on the contents, may include petroleum hydrocarbons, solvents, or other contaminants. The Subbasin is not currently categorized as a priority subbasin under the CV-SALTS program managed by the Regional Board.

Agricultural activities in the SV Subbasin primarily include pasture, grain and hay, and alfalfa. Alfalfa and pasture production have low risk for fertilizer-associated nitrate leaching into the groundwater (Harter et al., 2017). Grain production is rotated with alfalfa production, usually for one year, after which alfalfa is replanted. Grain production also does not pose a significant nitrate-leaching risk. Animal farming, a common source of nitrate pollution, is present but not at stocking densities of major concern. Changes or additions to land uses may require a re-examination of groundwater contamination risk.

3.3.4.2 Effects on Beneficial Uses and Users

Potential adverse water quality impacts to the beneficial uses of groundwater in the Subbasin are identified by elevated or increasing concentrations of constituents of concern, and the potential local or regional effects that degraded water quality can have on such beneficial uses. Potential adverse water quality impacts to the beneficial uses of groundwater in the Subbasin are identified by elevated or increasing concentrations of constituents of concern, and the potential local or regional effects that degraded water quality can have on such beneficial uses.

The potential impact of poor groundwater quality on major classes of beneficial users is now discussed:

- **Municipal Drinking Water Users:** Under California law, agencies that provide drinking water are required to routinely sample groundwater wells and compare the results to state and federal drinking water standards for individual constituents. Groundwater quality that does not meet state drinking water standards may render the water unusable or require additional treatment, carried out by the agency. Impacted municipal supply wells may potentially be taken offline until a solution is found, depending on the constituents detected and the configuration of the municipal system in question. This reduces the reliability of the overall water supply system during the rehabilitation period.

- **Rural and/or Agricultural Residential Drinking Water Users:** Residential structures not located within the service areas of a local municipal water agency or private water supplier will typically obtain water supply from private domestic groundwater wells. Unless on the number of connections serviced by the well is sufficiently large, the well will not have a regulatory groundwater quality testing requirement. Thus, groundwater quality at such wells may be unknown unless the landowner has initiated testing and shared the data with other entities. Degraded water quality in such wells can lead to rural residential groundwater use that does not meet potable water standards and results in the need for installation of new or modified domestic wells and/or well-head treatment that provides acceptable quality groundwater.

- **Agricultural Users:** Irrigation water quality bears importantly on crop production and has a variable impact on agriculture due to different crop sensitivities. Impacts from poor water quality (e.g., elevated salinity) may include declines in crop yields, crop damage, and alterations to the crops that can be grown in the area (e.g., depending on salt tolerance).

- **Environmental Uses:** In gaining streams, poor quality groundwater may result in contaminant migration which may impact groundwater dependent ecosystems or instream environments, and the species therein.

3.3.4.3 Relationship to Other Sustainability Indicators

Groundwater quality does not typically influence other sustainability indicators, which are more influenced by groundwater *quantity*. However, in some circumstances, groundwater quality can be affected by changes in groundwater levels and reductions in groundwater storage, because activities which alter basin groundwater flow patterns can also mobilize subsurface contaminants.

- **Groundwater Levels:** In some instances, declining groundwater levels can potentially lead to increased concentrations of constituents of concern in groundwater and may alter the existing hydraulic gradient, which can result in the movement of contaminated groundwater plumes. Changes in groundwater levels may also mobilize some contaminants that may be present in unsaturated soils. In such cases, the MTs established for groundwater quality may influence groundwater level minimum thresholds by limiting the location or number of projects (e.g., groundwater recharge), to avoid degradation of groundwater quality.
- **Groundwater Storage:** The groundwater quality MTs will not cause groundwater pumping to exceed the basin sustainability yield[3] and therefore will not cause exceedances of the groundwater storage minimum thresholds.
- **Depletion of Interconnected Surface Waters:** The groundwater quality MT does not promote additional pumping or lower groundwater levels near interconnected surface waters. The groundwater quality MT does not negatively affect interconnected surface waters.
- **Seawater Intrusion:** This sustainability indicator is not applicable in the SV Subbasin.
- **Subsidence:** The groundwater quality MT does not promote additional pumping or lower groundwater levels and therefore does not interfere with subsidence minimum thresholds. In some cases, and depending on the basin's subsurface composition, extreme land subsidence (e.g., similar to rates in California's Central Valley) can lead to elevated arsenic concentrations (Smith et al., 2018), although this effect is not expected in the SV Subbasin because the basin pumping is moderate and subsurface arsenic-rich clays are not abundant.

3.3.4.4 Information and Methodology Used to Establish Maximum Thresholds and Measurable Objectives

The two constituents of concern (nitrate and TDS) for which SMCs were considered were specifically selected due to stakeholder input and prevalence as a groundwater contaminant in California. Constituents of concern were identified using current and historical groundwater quality data; this list may be reevaluated during future GSP updates. In establishing MTs for groundwater quality, the following information was considered:

- Feedback about water quality concerns from stakeholders.
- An assessment of available historical and current groundwater quality data from wells in the Subbasin.
- An assessment of historical compliance with federal and state drinking water quality standards and water quality objectives.
- An assessment of trends in groundwater quality at selected wells with adequate data to perform the assessment.
- Information regarding sources, control options and regulatory jurisdiction pertaining to constituents of concern.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding MTs and associated management actions.

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[3] This will be confirmed by the integrated hydrologic model and updated as needed.

The historical and current groundwater quality data used to establish groundwater quality MTs are discussed in **Section 2.2.2.4**. Based on a review of these data, applicable water quality regulations, Subbasin water quality needs, and information from stakeholders, the GSAs determined that state drinking water standards (MCLs and Water Quality Objectives) are appropriate to define MTs for groundwater quality (**Table 3.3.4-1**). Hence, MTs for groundwater quality are set to the Title 22 primary MCL for nitrate (10 mg/L), and the Title 22 secondary MCL for TDS (500 mg/L). These MTs protect and maintain groundwater quality for existing and potential beneficial uses and users.

New constituents of concern may be added with changing conditions and as new information becomes available.

3.3.4.5 Maximum Thresholds

MTs for groundwater quality were defined in consultation with the GSA advisory committee and stakeholders, and consider of historical and present day groundwater quality data, beneficial uses of groundwater in the SV Subbasin, and existing regulations (**Section 2.2.2.4**). Existing regulations include water quality objectives in the Basin Plan, Title 22 Primary MCLs, and Secondary MCLs. As a result of this process, SMCs were developed for two constituents of concern in the Subbasin: nitrate, and TDS.

Although MTBE is identified as a potential constituent of concern in **Section 2.2.2.4**, no SMC is defined for this constituent as it is associated with contaminated sites that have dedicated monitoring and cleanup and is not likely a risk for future contamination. Recent MTBE data (2016-2020) resulted in no exceedances of the 5 µg/L SMCL; the highest concentration measured during this period was 0.7 µg/L. Arsenic, boron, iron, manganese, and pH were not assigned SMCs because they are naturally occurring, although they will be monitored as part of the GSP and Basin Plan.

The selected MTs for the concentration of TDS and nitrate, and their associated regulatory thresholds, are listed in **Table 3.3.4-1**. Importantly, ***Undesirable Results for groundwater quality occur when any well in the RMP exceeds MTs for nitrate or TDS at a number of wells greater than the number of wells that show exceedances at the time of writing (2021-09-01)***. Exceedances already exist at some RMPs and these exceedances will likely continue into the future. The MT for the number of allowed exceedance wells is therefore equal to the current number of wells with exceedances (none for nitrate, and three for TDS). The identification of Undesirable Results is therefore based on the *number* of wells to have exceedances for each nitrate and TDS, not necessarily the *same* wells. As denoted in **Table 3.3.4-1** and **Table 3.3.4-2**, there are no wells with exceedances of the nitrate MT, and three wells with exceedances of the TDS MT. For example, an MTs for nitrate and TDS are zero and three wells respectively, and an Undesirable Result would occur if one well showed a nitrate exceedance, or if four wells showed a TDS exceedance.

An average of water quality samples will be used for wells that are measured more than once a year. As MTs are currently based on only existing wells, the water quality monitoring network will be reassessed every five years to identify any new wells that should be added to the network. If future water quality data collected from the network results in exceedances of MCLs and SMCLs of additional constituents, MTs and MOs will be developed for these additional constituents.

As described in **Section 3.4.1.3**, the groundwater quality monitoring network is not currently finalized for this GSP due to data gaps in well construction information, and inadequate spatial coverage. However, an initial analysis of water quality data for the proposed network was conducted to establish the interim MTs and MOs that will be updated once the data gaps are filled and a more complete assessment of this monitoring network can be established.

3.3.4.5.1 Triggers

The GSAs will use concentrations of the identified constituents of concern (nitrate and TDS) below the MT as triggers for action to proactively avoid the occurrence of undesirable results. Triggers are warning concentrations defined to indicate that groundwater quality degradation may be occurring, and that additional attention or action may be needed to avoid an increase to the MT. If the triggers are exceeded, the GSAs will conduct an investigation and may use management actions. As listed in **Table 3.3.4-1** the trigger value for TDS is 55% of the Title 22 Secondary MCL (275 mg/L), while the trigger values for nitrate are half and 90% of the Title 22 MCL (5 mg/L and 9 mg/L, respectively).

3.3.4.5.2 Method for Quantitative Measurement of Maximum Thresholds

Groundwater quality will be measured in representative monitoring wells as discussed in **Section 3.4.1.3**. Statistical evaluation of groundwater quality data obtained from the monitoring network will be performed. The MTs for constituents of concern are shown in **Table 3.3.4-1** and

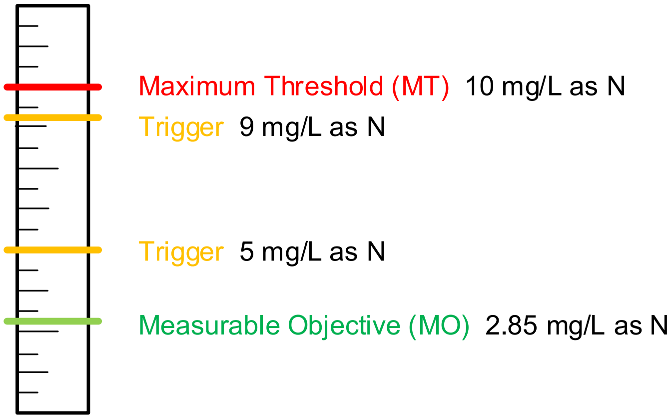
Figure 3.3.4-1, which show “rulers” for each of the two identified constituents of concern, with the associated MTs, MOs, and triggers. MOs are detailed in the following subsection.

Table 3.3.4-1. Constituents of Concern and the Associated Maximum Thresholds and Triggers

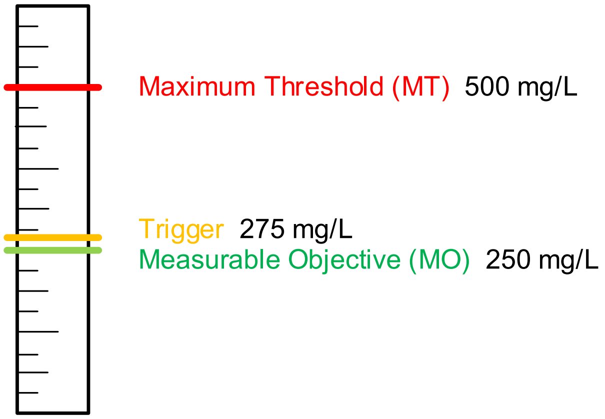
Constituent	Maximum Threshold (MT)	Regulatory Threshold	Maximum Threshold, Number of Wells Exceeding MT Concentration
Nitrate as Nitrogen	*5 mg/L, trigger only*	10 mg/L (Primary MCL – Title 22)	0
	9 mg/L, trigger only		
	10 mg/L, MT		
Total Dissolved Solids (TDS)	*275 mg/L, trigger only*	500 mg/L (Secondary MCL – Title 22)	3
	500 mg/L, MT		

Figure 3.3.4-1. Degraded water quality rulers for the constituents of concern in the Sierra Valley Subbasin (Measurable objectives are provided as an example and are specific to each well in the monitoring network)

Nitrate as Nitrogen



Total Dissolved Solids



3.3.4.6 Measurable Objectives

MOs are defined under SGMA as described previously in **Section 3.1** and represent the desired condition to be achieved to satisfy each Sustainability Indicator. Within the Subbasin, the MOs for water quality are established to provide an indication of desired water quality at levels that are sufficiently protective of beneficial uses and users. MOs differ from triggers in that they define concentrations that will allow the Subbasin to achieve its sustainability goal within 20 years of Plan implementation. For nitrate and TDS, MOs are defined on a well-specific basis, with consideration for historical water quality data.

3.3.4.6.1 Description of Measurable Objectives

The MOs for wells within the water quality monitoring network where concentrations have historically been below the MTs for water quality, are the highest measured concentrations during the period 1990 to July 2020. For wells where the concentrations have historically exceeded or equaled 90% of the MT, the MO is instead 90% of the MT. For newly installed or newly monitored wells, the MO will be preliminarily set to the first measured concentration until more data is available to set more informed SMC. As with wells that have historically been monitored, if this concentration exceeds or equals 90% of the MT, the MO will instead be 90% of the MT. In instances where the highest measured concentration of nitrate is a non-detect value, the MO is defined as 0.05 mg/L.

Specifically, for nitrate and TDS, the MO for the monitoring network is for individual wells not to exceed the MO for two consecutive years. The MOs for nitrate and TDS at proposed representative monitoring points within the SV Subbasin are listed in **Table 3.3.4-2**.

3.3.4.7 Path to Achieve Measurable Objectives

The GSAs will support the protection of groundwater quality by monitoring groundwater quality conditions and coordinating with the relevant regulatory agencies that work to maintain groundwater quality in the Subbasin. All future projects and management actions will be implemented by the GSAs with the intent to comply with state and federal water quality standards and Basin Plan water quality objectives and will be designed to maintain groundwater quality for all uses and users and avoid causing unreasonable groundwater quality degradation. The GSAs will review and analyze groundwater monitoring data as part of GSP implementation to evaluate any changes in groundwater quality resulting from groundwater pumping or recharge projects (anthropogenic recharge) in the Subbasin. The need for additional studies on groundwater quality will be assessed throughout GSP implementation. The GSAs may identify data gaps, seek funding, and help to implement additional studies.

Using monitoring data collected as part of project implementation, the GSAs will develop information (e.g., time-series plots of water quality constituents) to demonstrate that projects and management actions are operating to maintain or improve groundwater quality conditions in the Subbasin and to avoid unreasonable groundwater quality degradation. Should the concentration of a constituent of concern increase above its MO or trigger value as the result of GSAs project implementation, the GSAs will implement measures to address this occurrence. This process is illustrated in **Figure 3.3.4-2**, and depicts the high-level decision making that goes into developing SMCs, monitoring to determine if criteria are met, and actions to be taken based on monitoring results

If a degraded water quality trigger is exceeded, the GSAs will investigate the cause and source and implement management actions as appropriate. Where the cause is known, projects and management actions along with stakeholder education and outreach will be implemented. Examples of possible GSAs actions include notification and outreach to impacted stakeholders, alternative placement of groundwater recharge projects, and coordination with the appropriate water quality regulation agency. Projects and management actions are presented in further detail in **Chapter 4**.

Exceedances of nitrate, and TDS will be referred to the Regional Board. Where the cause of an exceedance is unknown, the GSAs may choose to conduct additional or more frequent monitoring.

Table 3.3.4-2. Potential Groundwater Quality Monitoring Wells and Associated Measurable Objectives

Well Description	Well ID	Measurable Objectives (mg/L)		Notes
		Nitrate as Nitrogen	TDS	
Potential (GAMA)	21N14E15J001M	0.05(a)	269	
Potential (GAMA)	21N14E32G001M	0.07	172	
Potential (GAMA)	21N15E05D001M	0.05(a)	450(b)	
Potential (GAMA)	22N15E21K001M	0.05(a)	450(b)	
Potential (GAMA)	22N15E35H001M	0.05(a)	175	
Potential (GAMA)	3200020-001	0.13	N/A	No historical monitoring of TDS, measurable objectives to be defined after monitoring begins
Potential (GAMA)	3200138-001	1.4	252	
Potential (GAMA)	3200193-001	0.4	450(b)	
Potential (GAMA)	3200618-002	2.85	190	
Potential (GAMA)	4600003-001	0.5	N/A	No historical monitoring of TDS, measurable objectives to be defined after monitoring begins
Potential (GAMA)	3200171-001	0.5	N/A	No historical monitoring of TDS, measurable objectives to be defined after monitoring begins
Potential (GAMA)	4600009-002	1.0	197	
Potential (GAMA)	4600037-001	0.5	N/A	No historical monitoring of TDS, measurable objectives to be defined after monitoring begins
Potential (GAMA)	4600083-001	0.75	N/A	No historical monitoring of TDS, measurable objectives to be defined after monitoring begins
Potential (GAMA)	4600092-001	0.5	169	
Potential (GAMA)	4610001-002	0.5	200	
Potential (GAMA)	4610001-004	0.5	234	
Community Volunteer Wells (8 potential wells)	N/A	N/A	N/A	Measurable objectives to be defined after monitoring begins
DWR New Installation	N/A	N/A	N/A	Measurable objectives to be defined after monitoring begins
5x New GSP Monitoring Wells to Cover Spatial Gaps	N/A	N/A	N/A	Measurable objectives to be defined after monitoring begins

(a) N measurable objective set to 0.05 mg/L due to no detected concentrations in historical results

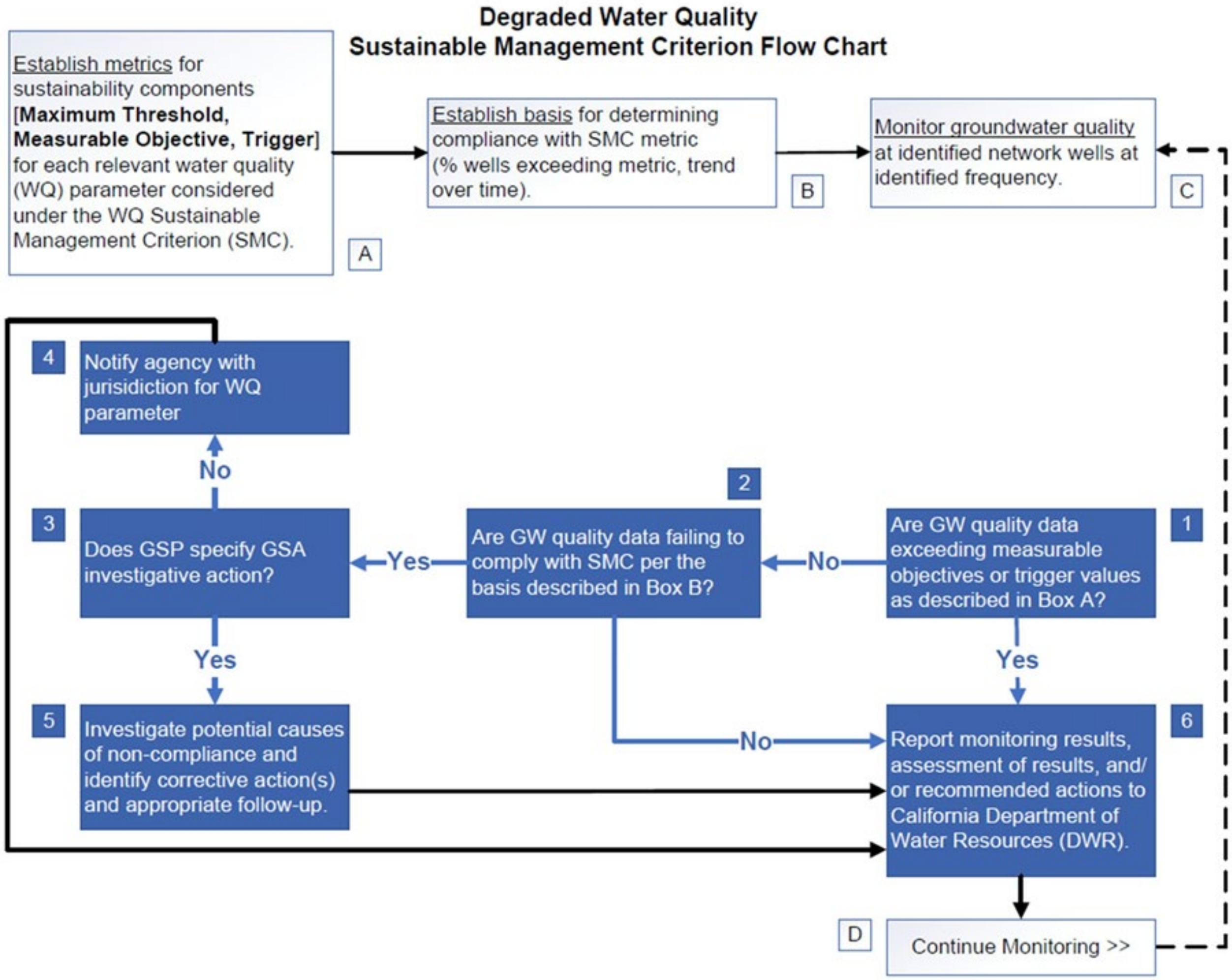
(b) TDS measurable objective set to 90% of maximum threshold due to historical exceedance of this value

N/A = the well has not been identified, and therefore historical monitoring data is not yet available

3.3.4.7.1 Interim Milestones

As existing groundwater quality data indicate that groundwater in the Subbasin generally meets applicable state and federal water quality standards for nitrate and TDS, the objective is to maintain existing groundwater quality. Interim milestones are therefore set to maintain groundwater quality equivalent to the MOs established for nitrate and TDS, with the goal of maintaining water quality within the historical range of observed values.

Figure 3.3.4-2. Degraded water quality sustainable management criteria flow chart



The flow chart depicts the high-level decision making that goes into developing SMCs, monitoring to determine if criteria are met, and actions to be taken based on monitoring results.

3.3.5 Land Subsidence

Sierra Valley has experienced land subsidence in the past and some land subsidence continues into the present day. Subsidence has occurred in varying areas in Sierra Valley over time, and has overlapped with areas of significant groundwater pumping. The Sierra Valley subsurface geology is typical of Californian mountain valleys, and predominantly composed of eroded, alluvial, sedimentary deposits (e.g., clay, silt, sand, and gravel). The clay deposits are particularly susceptible to inelastic compression resulting in land subsidence when significant levels of drawdown have occurred.

The first recorded account of subsidence in Sierra Valley was by the California Department of Water Resources (DWR; 1983). DWR (1983) and Plumas County Road Department surveys reported localized groundwater level decline and inelastic subsidence of about 1 to over 2 feet between 1960 and 1983 (i.e., an effective annual subsidence rate of about 0.05 to 0.1+ feet/year). Subsidence from 1983 to 2012 is unknown – records during this time are not available. During the severe 2012 to 2016 drought, the California Department of Transportation (CalTrans) surveyed areas of heavy groundwater pumping and water level drawdown corresponded to an estimated subsidence of 0.3 to 1.9 feet (i.e., approximately 0.08 to 0.48 feet/year). These results agree with another estimate made between 2015 and 2016: satellite-based Interferometric Synthetic Aperture Radar (InSAR) data from NASA JPL suggested subsidence in the northeastern Sierra Valley up to 0.5 feet/year (insert reference). From March of 2015 to November 2019, the same NASA JPL InSAR data suggests up to 1.2 feet of subsidence (i.e., about 0.3 feet/year). During the same period, DWR/TRE by Altamira (2020), estimated 0.15 ± 0.1 feet/year of subsidence, which is about half the land subsidence estimated by NASA JPL.

The above paragraph is less than ideal. Insert table of each of these land subsidence studies with columns “study”, “date range”, “average annual subsidence”.

3.3.5.1 Undesirable Results (Reg. § 354.26)

An undesirable result occurs when subsidence substantially interferes with beneficial uses of groundwater and surface land uses. Subsidence occurs when excessive groundwater pumping dewaters typically fine-grained sediments (e.g., clays and silts) causing them to compact, either temporarily (elastic subsidence) or permanently (inelastic subsidence). Clay and silt sediments are only moderately present in the eastern side of the Subbasin. Locations notably suspectable to detrimental impacts from subsidence are locations where differential subsidence occurs (subsidence transitions from little to no subsidence to moderate to heavy subsidence in a short lateral distance). Differential subsidence prone areas include zones along faults where drawdown effects are constrained on side of the fault, and zones of rapid transition from fine to coarse grained sediments, such as near alluvial fan transitions to valley floor sediments. Specific examples of undesirable results include substantial interference with land use, and significant damage to critical infrastructure, such as building foundations, roadways, other infrastructure elements, canals, pipes, and water conveyance infrastructure.

3.3.5.2 Effects on Beneficial Uses and Users

Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results could be:

- Financial impacts to all groundwater users and well owners for mitigation costs and supplemental supplies (including de minimis groundwater users and members of disadvantaged communities)
- Impacts to shallow wells (<100 ft deep) due to potentially degraded water quality, requiring well treatment or abandonment
- Land subsidence causing impacts to infrastructure, private structures, and/or land uses
- Irreversible losses to aquifer storage permeability and storage capacity
- Damage to wells (subsidence can case wellhead damage or casing failure)

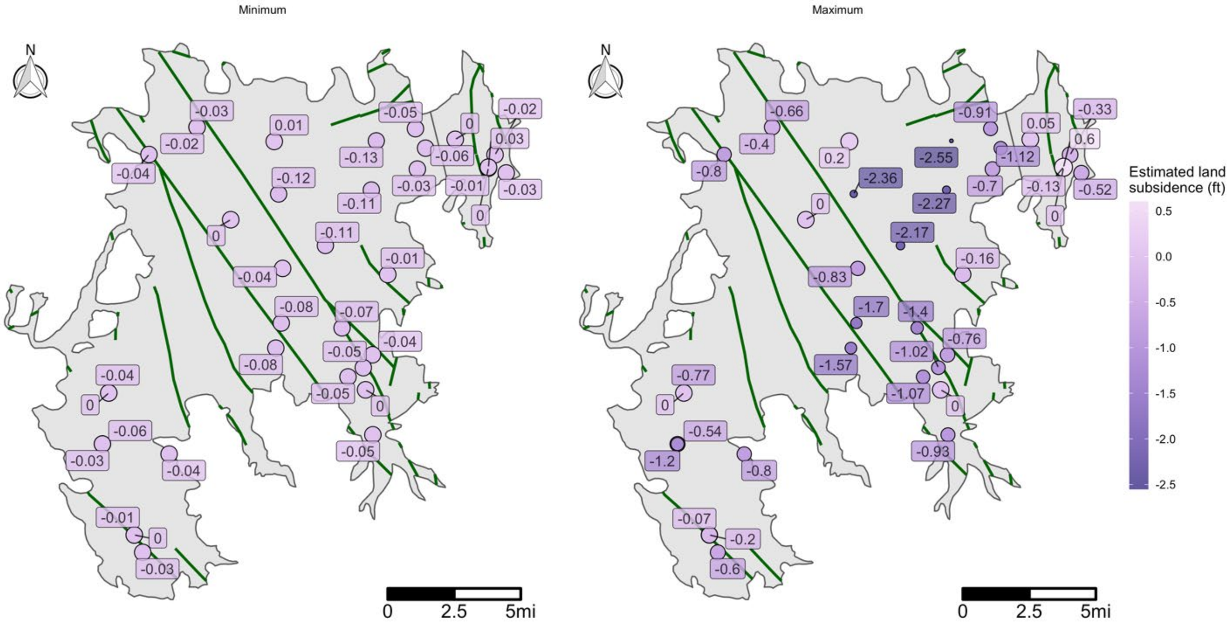
3.3.5.3 Relationship to Other Sustainability Indicators

By mainly managing groundwater pumping and avoiding the undesirable result of chronic lowering of groundwater levels (**Section 3.3.1**), the possibility of land subsidence will be mitigated. Mitigating land subsidence through sustainably managed groundwater levels in the Subbasin will also mitigate impacts to related undesirable groundwater storage declines.

3.3.5.4 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives (Reg. § 354.30)

Although InSAR satellite-based measures of land subsidence are available for the SV Subbasin, these data are relatively recent, do not show long-term trends, and indicate total subsidence which can represent a combination of elastic subsidence (reversable subsidence) and inelastic subsidence (irreversible subsidence). Furthermore, ground-based data do not conclusively determine the extent of long-term, inelastic subsidence. As such, adequate, Subbasin-specific information correlating the detailed, long-term connection between land subsidence and groundwater levels is lacking. However, Poland and Davis (1969) estimated the land subsidence to groundwater level decline ratio is approximately 0.01 to 0.2 feet of subsidence per foot of groundwater level decline. Potential land subsidence under specified MTs thus ranges from 0 to 2.55 feet depending on the location in the basin as shown in **Figure 3.3.5-1**. Ranges are calculated assuming 0.001 to 0.2 feet of subsidence per foot of groundwater level decline, consistent with Poland and Davis (1969). Larger distance between recent historic lows (around fall 2015) and groundwater level MTs leads to increased estimated land subsidence. At this time, significant and unreasonable impacts to beneficial uses and users are not anticipated under these land subsidence estimates. Substantial uncertainty is present in these estimates thus they should be cautiously interpreted. Importantly, due to the relatively long-time scales on which land subsidence occurs, land subsidence should be monitored, used to validate the work of Poland and Davis (1969), and adaptively managed. Impacts to roads and wells are of particular concern in the basin and will also be monitored.

Figure 3.3.5-1: Minimum (left) and maximum (right) range of land subsidence implied by the change in groundwater level between recent historic lows (fall 2015) and groundwater level MTs.



Currently, groundwater levels offer the only long-term measure that can serve as a proxy for land subsidence for the Subbasin, by using the correlations established by Poland and Davis. For the first five years, the GSP will use groundwater elevation proxy for land subsidence. Within the first five years of plan implementation, effort will be made to demonstrate more robust correlations with different subsidence data types, and an adaptive, composite methodology for assessing land subsidence will be developed to supplement the groundwater level proxy. This will incorporate groundwater levels, ground-based elevation surveys, and satellite-based InSAR data.

3.3.5.5 Minimum Thresholds (Reg. § 354.28)

The Sierra Valley basin lacks adequate information detailing aquifer lithology, aquitard units, and long-term land-subsidence trends. Satellite-based InSAR data are useful for assessing total land subsidence, these data have only been processed for 2015-2019. It is assumed that InSAR data will continue to be collected from agencies operating satellites during the implementation period by DWR. These measurements will be coupled with groundwater elevation and ground-based survey data to inform adaptive management and the development of more refined MTs in the next 5 year plan update.

23 CCR § 354.28(d) states: “An Agency may establish a representative MT for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual MTs as supported by adequate evidence.”

This GSP adopts groundwater level as a proxy for changes in land subsidence, using evidence of a linear and physical relationship between land subsidence and groundwater level change documented by Poland and Davis (1969) and detailed in **Section 3.3.5.4**. Thus, the MT for land subsidence for this GSP is the same as the MT for groundwater levels as detailed in **Section 3.3.1.4**.

There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Subbasin. Management areas are not planned for this GSP at this time. Land subsidence MTs apply to the entire subbasin area.

3.3.5.6 Measurable Objectives

Using groundwater level as a proxy, the MOs and IMs for land subsidence for this GSP are identical to groundwater level MOs and IMs, as detailed in **Section 3.3.1.4**. Protecting against chronic lowering of groundwater levels will directly protect against land subsidence.

Management areas are not planned for this GSP at this time. The MOs and associated interim milestones apply to the entire subbasin area.

3.3.5.7 Path to Achieve Measurable Objectives

GSAs will continue to monitor groundwater elevation and combine these data with InSAR and ground-based elevation surveys to measure progress towards MOs and to improve understanding of land subsidence in the basin. GSAs will coordinate with the relevant stakeholders to determine impacts to beneficial users and uses that may be impacted by land subsidence and take necessary actions to adaptively manage groundwater pumping and avoid significant and unreasonable impacts. Beyond these actions, the GSAs will approach groundwater level management as described in **Section 3.3.1.6**.

3.4 Monitoring Networks (Reg. § 354.26)

Monitoring is fundamental to measure progress towards Plan management goals. The monitoring networks described in this subsection support data collection to monitor the SV Subbasin's sustainability indicators which include the lowering of groundwater levels, reduction of groundwater storage, depletion of interconnected surface water, degradation of water quality, and land subsidence. Monitoring data will be used to track spatial and temporal changes in groundwater conditions that may result from projects and actions that are part of GSP implementation.

Per 23 CCR § 354.34, monitoring networks should be designed to:

- Demonstrate progress towards achieving MOs described in the Plan,
- Monitor impacts to the beneficial uses or users of groundwater,
- Monitor changes in groundwater conditions relative to MOs and minimum or maximum thresholds; and,
- Quantify annual changes in water budget components.

The monitoring network will have sufficient spatial density and temporal resolution to evaluate the effects and effectiveness of plan implementation and represent seasonal, short-term, and long-term trends in groundwater conditions and related surface conditions. For the purposes of this Plan, short-term is considered a time span of 1 to 5 years, and long-term is considered to be 5 to 20 years. The spatial densities and frequency of data measurement are specific to the monitoring objectives, parameter measured, degree of groundwater use, and SV Subbasin conditions.

Although "shallow" and "deep" aquifer terms have been historically used by DWR, analysis of data from drilling records, water level response, groundwater chemistry and groundwater temperature studies do not necessarily indicate two distinctive aquifers throughout the groundwater Subbasin (see **Section 2.2.1.6**). Regardless, monitoring wells with adequate vertical distribution are selected as RMPs to capture "shallow" and "deep" zones of the production aquifer.

Network Enrollment and Expansion

Except for streamflow, land subsidence, and ISW depletion due to groundwater pumping, monitoring is performed using networks of groundwater monitoring wells. In the case of land subsidence and ISW depletion, although other monitoring and assessment approaches exist (i.e., InSAR and elevation surveys; modeled ISW depletion rates and volumes), groundwater level is also used as a proxy. Thus, groundwater monitoring wells are critical.

Some groundwater wells will be monitored for water level, some for water quality, and some will be monitored for both. Each monitoring well in the network will be modified throughout GSP implementation as necessary to address monitoring objectives and support projects and management actions. Expansion of networks will involve identifying existing wells in the Subbasin that can potentially be added to the network, applying selection criteria, and ultimately approving the well for inclusion.

Evaluation of the monitoring networks will be conducted at least every 5 years to determine whether additional wells are required to achieve sufficient spatial density, whether wells are representative of Subbasin conditions, and whether wells cover key areas identified by stakeholders. Prior to enrolling wells into the GSA's monitoring network, wells are evaluated using the following selection criteria: well location, monitoring history, well information, and well access. These criteria are discussed below.

Well Location

Objectives for network design include sufficient coverage, density, and distribution of wells to monitor groundwater storage, flow directions, and hydraulic gradients. Where monitoring wells are not present, statistical methods are used to aid in extrapolating data from existing monitoring sites to the entire Subbasin. Beyond capturing general hydrologic trends in the Subbasin, it is important to monitor planned GSP projects and management actions, and locations where existing or legacy operations may threaten groundwater quality for beneficial uses and users.

Monitoring History

Wells with a long monitoring record provide valuable historical groundwater level and water quality data and enable the assessment of long-term trends. Such wells are preferentially selected over wells with limited monitoring data.

Well Information

Well construction information including well depth and screened interval are essential to interpret monitoring results and ensure adequate vertical monitoring coverage of the aquifer. At a minimum, selected wells should have well depth information. Although the perforated interval is not available for all wells, it is essential to include these wells as potential wells to provide adequate lateral coverage. For these wells, the GSAs will work to collect well information with site surveys during the first year of GSP implementation.

Well Access/Agency Support

Ability to gain access to a well to collect samples at the required frequency is critical. When necessary, the GSAs will coordinate with existing programs to develop an agreement for data collection responsibilities, monitoring protocols, and data reporting and sharing. For existing monitoring programs implemented by agencies, monitoring will be conducted by agency program staff or their contractors. For groundwater elevation monitoring, a subset of wells included in the California Statewide Groundwater Elevation Monitoring (CASGEM) Program for Plumas County and Sierra County was selected and incorporated to the GSP monitoring network administered by the GSA. For water quality monitoring, samples will be analyzed at contracted analytical laboratories.

3.4.1 Monitoring Networks in the Subbasin

Based on the SV Subbasin's historical and present-day conditions (**Section 2.2.2**), the sustainability indicators that will be monitored include groundwater level and storage, interconnected surface water, groundwater quality, and land subsidence. Seawater intrusion is not found in the Subbasin and is therefore not monitored (23 CCR § 354.34(j)). Existing and planned spatial density, and data collection frequency is now described for each monitoring network. Descriptions, assessments, and plans for future improvement of the well monitoring networks, along with protocols for data collection and monitoring are addressed for each sustainability indicator in its corresponding subsection.

As listed in **Table 3.4.1-1** there are four monitoring networks: a water level monitoring network, a streamflow depletion monitoring network, a land subsidence monitoring system, and water quality monitoring network (the groundwater storage network is monitored using the same wells included in the groundwater elevation monitoring network). The water level and water quality networks are independent but utilize some of the same wells. The land subsidence monitoring system utilizes satellite remote sensing along with land-based survey monuments, and the streamflow depletion monitoring network utilizes wells, streamflow gauges, and integrated hydrological model estimates adapted throughout the implementation period based on available data and tools.

Table 3.4.1-1. Summary of monitoring networks, metrics, and number of sites for sustainability indicators

Sustainability Indicator(1)	Metric	Number of RMPs in Current Network
Chronic Lowering of Groundwater Levels(2)	Groundwater level	36
Reduction of Groundwater Storage	Groundwater level as proxy; volume of water per year, computed by the forthcoming regional groundwater flow model	Uses chronic lowering of groundwater levels network
Stream Depletion due to Groundwater Pumping	Groundwater level as proxy; and ISW depletion rate and volume computed by the forthcoming regional groundwater flow model. Additionally, vertical hydraulic gradients will be measured at multi-completion wells and streamflow will be measured at stream gages.	13
Groundwater Quality	Concentration of selected water quality parameters	17 confirmed; 14 pending (**Table 3.3.4-2**)
Land Subsidence	Groundwater level as proxy; DWR's vertical displacement estimates derived	Spatially continuous

Sustainability Indicator(1)	Metric	Number of RMPs in Current Network
	from Interferometric Synthetic Aperture Radar (InSAR) data(3)	

(1) This table only includes monitoring networks used to measure sustainability indicators. It does not include additional monitoring necessary to monitoring the various water budget components of the Subbasin, described in Chapter 2, or to monitoring the implementation of projects and management actions, which are described in Chapter 4.

(2) The groundwater level monitoring network is also used for non-riparian groundwater dependent ecosystems.

(3) Land surface elevation changes are monitored through satellite remote sensing and data processing is assumed will be continued by DWR.

3.4.1.1 Groundwater Elevation Monitoring Network

The groundwater elevation monitoring network is designed to monitor groundwater occurrence, level, flow directions, and hydraulic gradients between the aquifers and surface water bodies.

The initial list of groundwater level monitoring wells included 130 wells. These wells were narrowed down based on the following criteria:

- Either depth or perforated interval are known, preferably both;
- Measured water level data are available through at least 2019 (this criterion was relaxed in locations where spatial coverage is lacking);
- A preference was given to wells with data prior to 2005; and,
- The well has at least five historical measurements.

Annual pumping in the subbasin is between 1,000 and 10,000 acre-feet/year per 100 square miles, resulting in a suggested density of 2 monitoring wells per 100 square miles to collect representative groundwater elevation measurements (Hopkins 1984; DWR, 2016). Based on this density consideration, and the Subbasin’s surface area of 195.1 square miles (combined area of the SV Subbasin and Chilcoot Subbasin), 4 monitoring wells are adequate to monitor representative groundwater elevations within the Subbasin.

Alternatively, Sophocleous (1983) estimates 6.3 monitoring wells are needed per 100 square miles, resulting in 12.3 monitoring wells needed in the Subbasin (Sophocleous, 1983; DWR, 2016). Based on this estimate, 13 wells will sufficiently monitor the Subbasin’s surface area of 195.1 square miles; equivalent to a lateral coverage of 15.0 square miles per well, or radius of 2.2-miles per well. The proposed groundwater elevation network (Error! Reference source not found. and **Table 3.3.1-1**) uses 36 monitoring wells and covers 82% of the Subbasin (160.4 of 195.1 square miles) according to spatial coverage estimates by Sophocleous (1983).

As stated, although “shallow” and “deep” aquifer terms have been historically used by DWR, analysis does not necessarily indicate the presence of two distinct aquifers throughout the Subbasin (**Section 2.2.1.6**); however, wells are selected to provide adequate vertical coverage throughout the aquifer to reflect trends in the depths that are pumped. Importantly, the proposed monitoring well density is appropriate to extrapolate seasonal groundwater elevation maps to support analysis of impacts to shallow domestic wells, GDE impact analysis, and to monitor seasonal changes in hydraulic gradients that may indicate changes in ISW depletion. Implementation actions are proposed to cover data gaps in the network and make improvements to existing RMPs

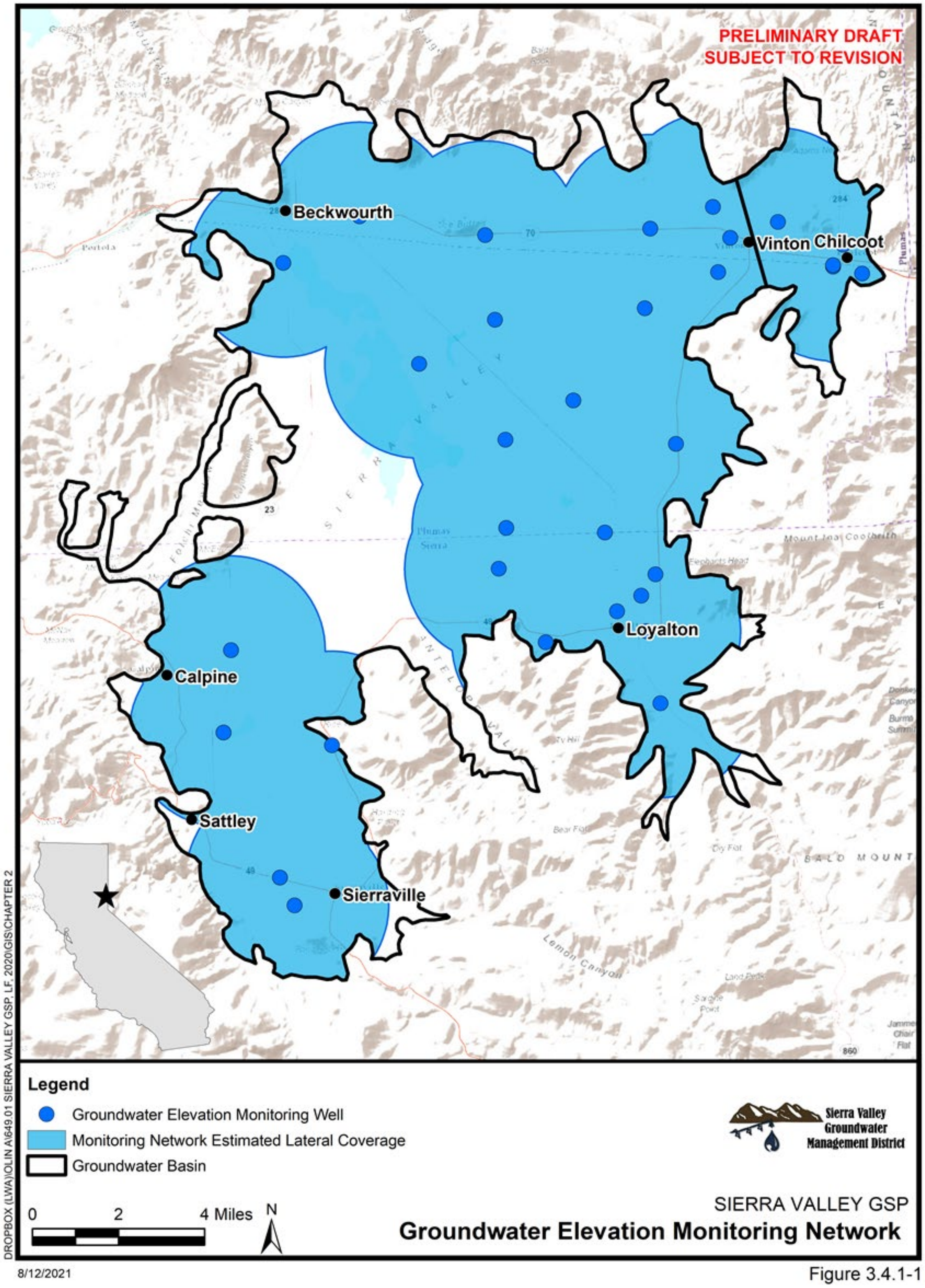
Monitoring frequency is important to characterize groundwater and surface water dynamics. All wells will collect at least biannual measurements in spring (mid-March) and fall (mid-October) in line with DWR Best Management Practices (DWR, 2016). Monitoring standards and conventions are consistent with 23 CCR § 352.4, which outline data and reporting standards for groundwater level measurements.

3.4.1.1.1 Protocols for Data Collection and Monitoring (23 CCR § 352.2)

This subsection briefly summarizes monitoring protocols. Groundwater level data collection may be conducted remotely via telemetry equipment, or with an in-person field crew. This subsection provides a brief summary of monitoring protocols. Establishment of protocols will ensure that data collected for groundwater elevation are accurate, representative, reproducible, and contain all required information. All groundwater data collection in support of this GSP is required to follow the established protocols for consistency throughout the basin and over time. These monitoring protocols will be updated as necessary and will be re-evaluated every five years. All groundwater elevation measurements are references to a consistent datum, known as the Reference Point (RP). For monitoring wells, the RP consists of a mark on the top of the well casing. For most production wells, the RP is the top of the well's concrete pedestal. The elevation of the RP of each well is surveyed to the National Geodetic Vertical Datum of 1929 (NDVD 29). The elevation of the RP is accurate to at least 0.5 feet.

Groundwater level measurements are taken to the nearest 0.01 foot relative to the RP using procedures appropriate for the measuring device. Equipment is operated and maintained in accordance with manufacturer's instructions, and all measurements are consistent units of feet, tenths of feet, and hundredths of feet.

Figure 3.4.1-1. RMPs for the Groundwater Level Monitoring Network (Network coverage is depicted with blue, circular 15.0 square mile buffers around each monitoring point that show the 82% lateral coverage of the network)



Groundwater elevation is calculated using the following equation:

$$GWE = RPE - DTW$$

Where GWE is the groundwater elevation, RPE is the reference point elevation, and DTW is the depth to water. When available, barometric pressure is also accounted for in the depth to water calculation.

In cases where the official RPE is a concrete pedestal, but the hand soundings are referenced off the top of a sounding tube, the measured DTW is adjusted by subtracting the sounding tube offset from the top of the pedestal.

All groundwater level measurements must include a record of the date, well identifier, time (in 24-hour military format), RPE, DTW, GWE, and comments regarding factors which may influence the recorded measurement such as nearby production wells pumping, weather, flooding, or well condition.

Manual Groundwater Level Measurement

Groundwater level data collected by an in-person field crew will follow the following general protocols:

- Prior to sample collection, all sampling equipment and the sampling port must be cleaned.
- Manual groundwater level measurements are made with electronic sounders or steel tape. Electronic sounders consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water. Some production wells may have lubricating oil floating on the top of the water column, in which case electric sounders will be ineffective. In this circumstance steel tape may be used. Steel tape instruments consist of simple graduated lines where the end of the line is chalked to indicate depth to water without interference from floating oil.
- All equipment is used following manufacturer specifications for procedure and maintenance.
- Measurements must be taken in wells that have not been subject to recent pumping. At least 2 hours of recovery must be allowed before a hand sounding is taken.
- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.
- Equipment is sanitized between well locations to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

Data Logger Groundwater Level Measurement

Telemetry equipment and data loggers can be installed at individual wells to record continuous water level data, which is then remotely collected via satellite to a central database and accessed on the Sierra Valley Database Portal in a web browser. Installation and use of data loggers must abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level to properly install and calibrate the transducer. This is done following the protocols listed above.

- All data logger installations follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.
- Data loggers are set to record only measured groundwater level to conserve data capacity; groundwater elevation is calculated later after downloading.
- In any log or recorded datasheet, site photographs, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are all recorded.
- The field staff notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for natural barometric pressure changes.
- All data logger cables are secured to the well head with a well dock or another reliable method. This cable is marked at the elevation of the reference point to allow estimates of future cable slippage.
- Data logger data is periodically checked against hand measured groundwater levels to monitor electronic drift, highlight cable movement, and ensure the data logger is operating correctly. This check occurs at least annually, typically during routine site visits.
- For wells not connected to a supervisory control and data acquisition (SCADA) system, transducer data is downloaded as necessary to ensure no data is overwritten or lost. Data is entered into the data management system as soon as possible. When the transducer data is successfully downloaded and stored, the data is deleted or overwritten to ensure adequate data logger memory.

3.4.1.2 Groundwater Storage Monitoring Network

Groundwater level is used as a proxy for groundwater storage (**Section 3.3.1.6.1**) and therefore the groundwater storage monitoring network is identical to the network for groundwater level. Observations obtained at the groundwater level monitoring network will directly inform integrated surface and groundwater modeling in the subbasin as model calibration targets.

3.4.1.3 Groundwater Quality Monitoring Network

The objective of the groundwater quality monitoring network design is to capture sufficient spatial and temporal detail to understand groundwater quality in the Subbasin. The purpose is also to adequately monitor groundwater conditions for all beneficial uses. The data from the network will provide an ongoing water quality record for future assessments of groundwater quality. The spatial and temporal coverage of the network is designed to allow the GSAs to take an effective and efficient adaptive management approach in protecting groundwater quality, to minimize the risk for exceeding maximum water quality thresholds, to support the GSAs in implementing timely projects and actions, and ultimately, to contribute to compliance with water quality objectives throughout the Subbasin.

Existing wells used to monitor groundwater quality in the Subbasin are primarily located within and near the semi-urban areas of the Subbasin. Additionally, members of the community volunteered eight wells to potentially be included in the network; these volunteered wells do not have a historical record of water quality data. There are data gaps in the Subbasin regarding the spatial and temporal distribution of groundwater quality data. For this reason, five new monitoring wells will be installed as part of the network. These new wells will be incorporated into the network to improve spatial coverage of the Subbasin; one additional well installed by DWR will also be incorporated into the network.

The monitoring network will use existing programs in the Subbasin that already monitor for specific constituents of concern for which SMCs are set (nitrate and TDS), and from other programs where these constituents could be added as part of routine monitoring efforts in support of the GSP. Coordination will be conducted between existing monitoring programs and the GSAs to develop an agreement for data collection responsibilities, monitoring protocols, and data reporting. Samples for nitrate, TDS, arsenic, boron, and pH will be collected at least annually from each well in the water quality network. To prevent bias associated with date of sample collection, all samples should be collected on approximately the same date (i.e., +/- 30 days of each other) each year. Groundwater quality samples will be collected and analyzed in accordance with the monitoring protocols outlined in below.

Using the geographic location of wells with historic groundwater quality records (June 1990 – July 2020), an initial list of wells with groundwater quality measurements was created for inclusion in the monitoring network. Water quality monitoring well locations were then reviewed to assess the spatial coverage obtained from the network. Information on the screened interval and well depth was scarce. This data gap will be addressed through further investigation of well completion reports and use of well video logs. Spatial data gaps, and potentially inadequate vertical coverage, will be addressed through the installation of new wells. Additionally, future project and management actions outlined in **Chapter 4** will be implemented to refine the water quality network as needed.

The initial list of groundwater quality monitoring wells was created using data downloaded 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)

Evaluating these data, the initial list of groundwater quality monitoring wells includes 53 wells with historical data for both nitrate and TDS. To further narrow down the number of wells, the following criteria were considered (it is noted criteria were relaxed in some instances so as to provide better spatial coverage):

- Both nitrate and TDS measured at the same well;
- Measured water quality data are available at least through 2019; and,
- The well has at least two historical measurements.

Wells that met this criterion were then narrowed down to avoid inclusion of redundant monitoring wells that were within proximity to each other. As shown in **Figure 3.4.1-2** and **Table 3.4.1-2**, the final network includes 17 GAMA wells for potential inclusion in the network. While there is no definitive rule for the appropriate density of groundwater quality monitoring points needed in a basin, Sophocleous (1983) estimates 6.3 monitoring wells are needed per 100 square miles to adequately monitor groundwater levels in a basin, resulting in an estimated 12.3 monitoring wells needed in the SV subbasin (Sophocleous, 1983; DWR, 2016). Based on Sophocleous (1983), 13 wells are needed to monitor the subbasin's surface area of

195.1 square miles; equivalent to a lateral coverage of 15.0 square miles per well, or radius of 2.2 miles per well.

Table 3.4.1-2. Potential GAMA Wells to be added to the Groundwater Quality Monitoring Network (Measurement period 1990-2020)

Well ID	Well Type (Owner)	Nitrate Measurements			TDS Measurements			Logic For Selection
		From	To	# of Records	From	To	# of Records	
21N14E15J001M	Unknown	10/30/07	10/30/07	1	12/7/99	10/30/07	2	Spatial
21N14E32G001M	Ag	10/30/07	10/30/07	1	12/7/99	10/30/07	2	Spatial
21N15E05D001M	Unknown	10/30/07	10/30/07	1	12/8/99	10/30/07	2	Spatial
22N15E21K001M	Unknown	10/31/07	10/31/07	1	10/31/07	10/31/07	1	Spatial
22N15E35H001M	Unknown	10/31/07	10/31/07	1	10/31/07	10/31/07	1	Spatial
3200020-001	Municipal (Caltrans Reststop)	4/16/96	5/19/20	20	-	-	-	Monitoring Record
3200138-001	Municipal (Meadow Edge Park)	12/1/92	6/9/20	20	12/1/92	8/20/19	6	Monitoring Record
3200171-001	Municipal (Sierra Valley RV Park)	11/28/95	8/20/19	15	-	-	-	Spatial
3200193-001	Municipal (Plumas National Forest; Nervino)	6/23/11	6/18/19	8	6/23/11	6/23/11	1	Spatial
3200618-002	Municipal	12/18/01	5/5/20	11	6/11/12	6/11/12	1	Spatial
4600003-001	Municipal (Treasure Mountain Camp)	6/6/95	7/17/19	21	-	-	-	Monitoring Record
4600009-002	Municipal (Sierra CSA #5, Sierra Brooks)	9/1/90	7/6/20	19	9/1/90	4/23/14	6	Monitoring Record
4600037-001	Municipal (New Age Church of Being, Sierraville)	6/27/95	6/8/20	19	-	-	-	Monitoring Record
4600083-001	Municipal	12/5/95	4/3/07	11	12/15/94	7/6/00	3	Spatial
4600092-001	Municipal	7/6/00	4/3/07	4	-	-	-	Spatial
4610001-002	Municipal (City of Loyalton)	5/5/92	12/18/17	13	5/5/92	12/18/17	4	Monitoring Record

Well ID	Well Type (Owner)	Nitrate Measurements			TDS Measurements			Logic For Selection
		From	To	# of Records	From	To	# of Records	
4610001-004	Municipal (Loyalton High School)	5/5/92	1/15/19	18	5/5/92	12/18/17	5	Monitoring Record

Figure 3.4.1-2. Potential Wells for Inclusion in the Groundwater Quality Monitoring Network

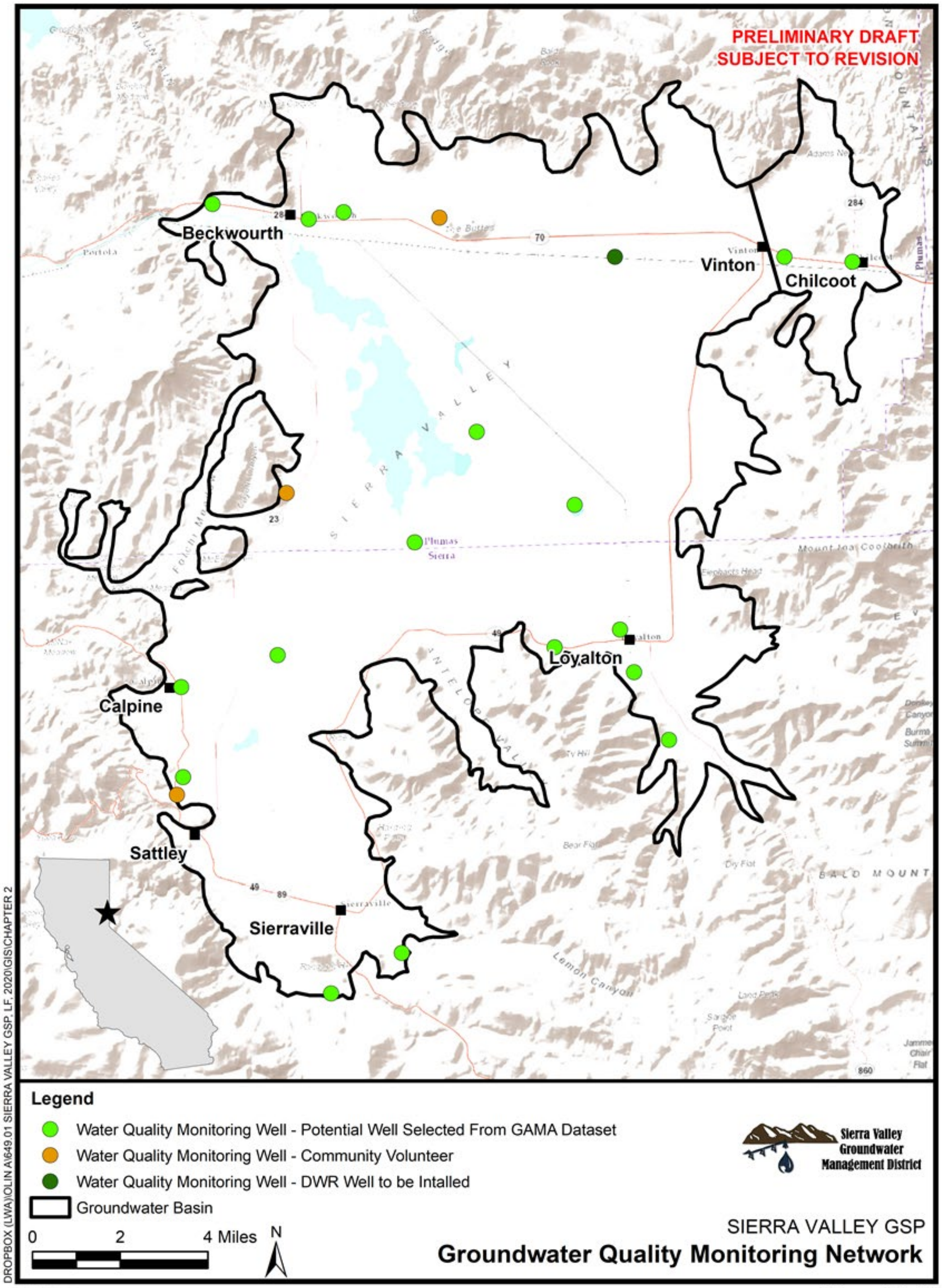


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Figure 3.3.1 2

3.4.1.3.1 Monitoring Protocols for Data Collection and Monitoring (Reg. § 352.2)

Sample collection will follow the USGS National Field Manual for the Collection of Water Quality Data (USGS 2015) and Standard Methods for the Examination of Water and Wastewater (Rice et al., 2012), as applicable, in addition to the general sampling protocols listed below.

The following section provides a summary of monitoring protocols for sample collection and analytical testing for evaluation of groundwater quality. Establishment of and adherence to these protocols will ensure that data collected for groundwater quality are accurate, representative, reproducible, and contain all required information. All sample collection and testing for water quality in support of this GSP are required to follow the established protocols for consistency throughout the Subbasin and over time. All testing of groundwater quality samples will be conducted by laboratories with certification under the California Environmental Laboratory Accreditation Program (ELAP). These monitoring protocols will be updated as necessary and will be re-evaluated every 5 years.

Wells used for sampling are required to have a distinct identifier, which must be located on the well housing or casing. This identifier will also be included on the sample container label to ensure traceability.

Event Preparation:

- Before the sampling event, coordination with any laboratory used for sample analysis is required. Pre-sampling event coordination must include the scheduling of the laboratory for sample testing and a review of the applicable sample holding times and preservation requirements that must be observed.
- Sample labels must include the sample ID, well ID, sample date and time, personnel responsible for sample collection, any preservative in the sample container, the analyte to be analyzed, and the analytical method to be used. Sample containers may be labelled prior to or during the sampling event.

Sample Collection and Analysis:

- Sample collection must occur at, or close to, the wellhead for wells with dedicated pumps and may not be collected after any treatment, from tanks, or after the water has travelled through long pipes. Prior to sample collection, the sample collector should clean all sampling equipment and the sampling port. The sampling equipment must also be cleaned prior to use at each new sample location or well.
- Sample collection in wells with low-flow or passive sampling equipment must follow protocols outlined in the EPA's Low-flow (minimal drawdown) ground-water sampling procedures (Puls and Barcelona, 1996) and USGS Fact Sheet 088-00 (USGS, 2000), respectively. Prior to sample collection in wells without low-flow or passive sampling equipment, at least three well casing volumes should be purged prior to sample collection to make sure ambient water is being tested. The sample collector should use best professional judgement to ensure that the sample is representative of ambient groundwater. If a well goes dry, this should be noted, and the well should be allowed to return to at least 90% of the original level before a sample is collected.
- Sample collection should be completed under laminar flow conditions.
- Samples must be collected in accordance with appropriate guidance and standards and should meet specifications for the specific constituent analyzed and associated data quality objectives.

- In addition to sample collection for the target analyte (e.g., nitrate), field parameters, including temperature, pH, and specific conductivity, must be collected at every site during well purging. Field parameters should stabilize before being recorded and before samples are collected. Field instruments must be calibrated daily and checked for drift throughout the day.
- Samples should be chilled and maintained at a temperature of 4° C and maintained at this temperature through delivery to the laboratory responsible for analysis.
- Chain of custody forms are required for all sample collection and must be delivered to the laboratory responsible for analysis of the samples to ensure that samples are tested within applicable holding limits.
- Laboratories must use reporting limits that are equivalent, or less than, applicable data quality objectives.

3.4.1.4 Depletions of Interconnected Surface Water Monitoring Network

The ISW depletion monitoring network, shown in **Figure 3.4.1-3**, is developed to document streamflow and hydraulic gradients within the Sierra Valley and incorporates groundwater level RMPs, and monitoring sites for streamflow, and stream stage. The combination of these monitoring networks will allow for a better understanding of the surface-groundwater interactions, permit calculation of streamflow depletion its spatial and temporal distribution, and will provide important context for understanding the effects of pumping on surface water that is critical for priority species. To evaluate the potential impacts of groundwater pumping on surface water depletion, groundwater level, stream stage, and streamflow conditions will be documented over time at representative monitoring points.

ISW depletion monitoring in the Sierra Valley will involve two approaches: 1) measuring relatively shallow groundwater and its relationship to surface water elevation (‘stage’) for calculation of hydraulic gradients between streams and groundwater, and 2) monitoring streamflow. As described in **subsection 3.3.3.4.1**, stage data are not currently being collected, so groundwater levels are proposed as a proxy for hydraulic gradients, and by extension, for ISW depletion, until surface water monitoring stations can be established. Similarly, the absence of near-continuous streamflow gaging stations prevents direct measurement of streamflow changes due to pumping under current conditions. The shallow groundwater monitoring network will therefore initially consist of existing wells which are screened at shallow depths (**Table 3.3.3-1**), some of which are also included in the groundwater level monitoring network.

Strategically located new wells and stream stage and/or streamflow monitoring stations are also proposed, so that each ISW RMP located in **Figure 3.3.3-1** consists of a coupled surface water and shallow groundwater monitoring station for eventual calculation and tracking of hydraulic gradients in the vicinity of representative ISWs. The proposed new wells are intended to provide shallow groundwater level data in data gaps, and where groundwater level declines due to pumping have been documented. This information, used in conjunction with the basin groundwater model, will allow for a spatial and temporal quantification of ISW depletion.

Table 3.4.1-3. Proposed stream stage gages and coupled wells to monitor ISW depletion

Stream Stage Gage	General Location	Coupled Well
Middle Fork Feather River	At Marble Hot Springs Road	RMP ID 106 (22N15E17H001M) if active or a proposed new well in a similar location
Middle Fork Feather River (Flow also measured here)	Downstream of Little Last Chance Creek confluence	RMP ID 161 (23N14E35L001M) and RMP ID 301 (DMW 6s)
Smithneck Creek	Between Highway 49 and Poole Lane	RMP ID 73 (21N16E18G002M) and RMP ID 37 (DMW 1s)
Central Wetland Complex	West of Harriet Lane south of Dyson Lane	Proposed new shallow well 1
Sierra Valley Channels	West of Highway 49 near Rice Hill	RMP ID 31 (21N14E25P003M) and RMP ID 294 (DMW 3s)
Carman Creek	Near Westside Road	RMP ID 297 (DMW 4s)
Hamlin Creek (Flow also measured here)	South of Willow Street on Forest Service Road 54020	RMP ID 291 (DMW 2s)
Cold Stream (Flow also measured here)	Downstream of Bonta Creek and upstream of diversions	RMP ID 12 (20N14E14R001M)
East Channel LLC Creek	At Sierra Valley Mc Nella Lane	Proposed new shallow well 1
East Channel LLC Creek	East of Roberti Ranch Road	RMP ID 364 (DMW 7s)
North Channel LLC Creek	South of Highway 70 near The Buttes	RMP 176 (23N15E34D001M)
Little Last Chance Creek East and West Branches (Flow also measured here)	At Highway 70	Proposed new shallow well 2, RMP ID 209 (23N16E36N002M), and RMP 300 (DMW 5s)

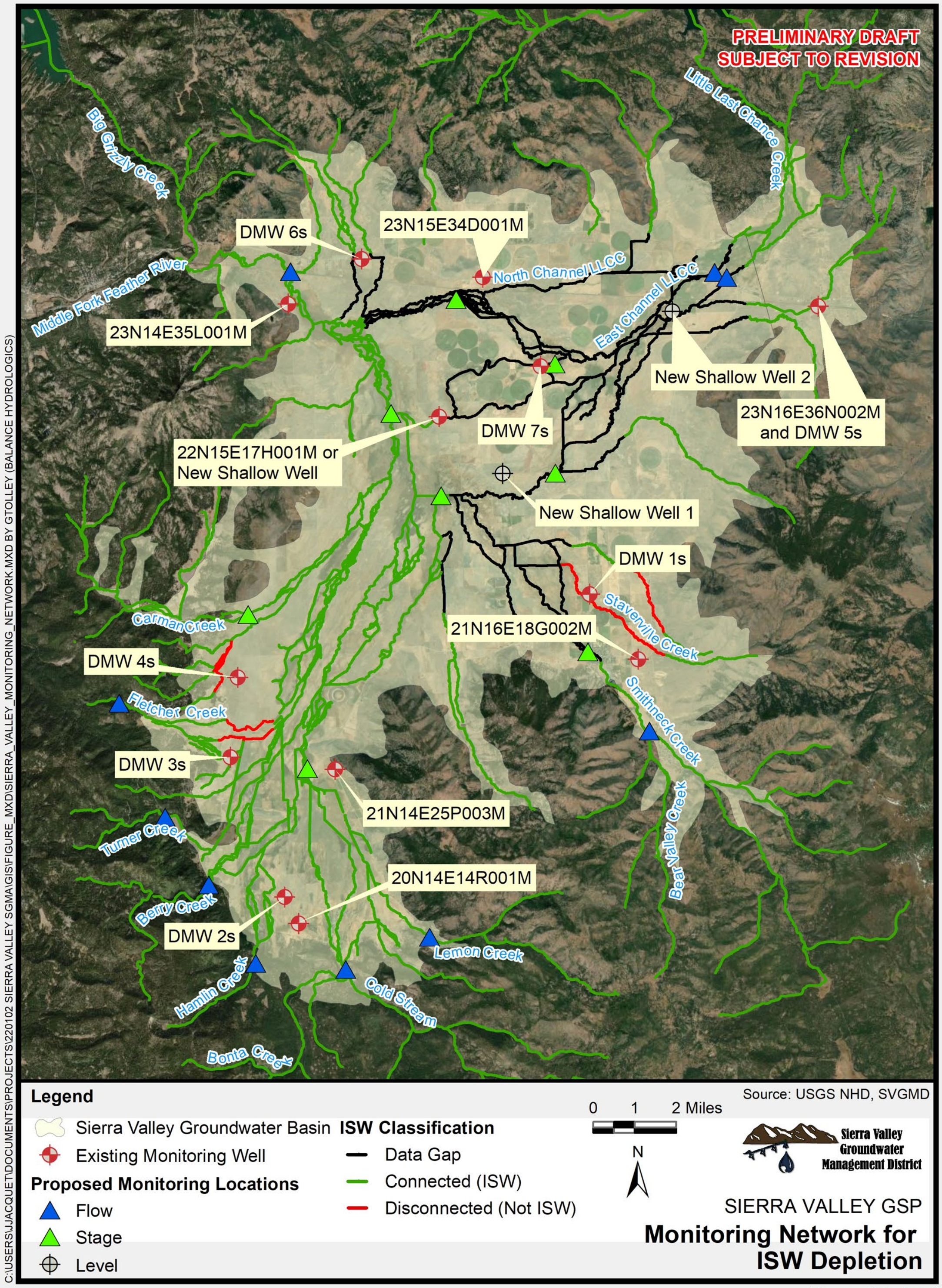
In addition to shallow groundwater and surface water stage monitoring, near-continuous recording streamflow gages are an integral part of the ISW depletion monitoring program. Streams and numerous diversion ditches are vast, and in-situ monitoring of every ISW is impractical. Therefore continuous streamflow monitoring gages are proposed as upgrades to the existing DWR streamflow monitoring stations (i.e., where major tributaries enter the Basin), and at select locations where flow concentrates. This approach captures much of the flow entering the basin and can be used to calibrate modeled estimates of total surface inflows, as well as depletion estimates as these streams cross the valley floor. Final locations of proposed wells, streamflow stages, and streamflow gages will be determined by a site suitability study, where physical characteristics of the stream and site accessibility will be evaluated.

Table 3.4.1-4. Proposed streamflow gages to monitor ISW depletion

Streamflow Gage	General Location	Notes
Little Last Chance Creek East and West Branches	At Highway 70	Two existing but inactive DWR gaging stations exist here and would be reoccupied and upgraded
Smithneck Creek	Upstream of Loyalton	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Fletcher Creek	West of Calpine	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Turner Creek	Northwest of Sattley	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Berry (Miller) Creek	West of Highway 49 in Wild Bill Canyon	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Hamlin Creek	South of Willow Street on Forest Service Road 54020	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Cold Stream	Downstream of Bonta Creek and upstream of diversions	This would combine the Bonta (Webber) Creek stations to one station below the confluence of the two creeks, provided that this would not interfere with Little Truckee Diversion operations.
Lemon Creek	At Lemon Canyon Road (650)	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station
Middle Fork Feather River	Downstream of Little Last Chance Creek confluence	Watermaster streamflow monitoring site would be upgraded to a near-continuous recording gaging station

Data collected from the monitoring network will allow for evaluation of minimum thresholds and undesirable results and whether adjustments will be needed at the five year GSP review. After this initial five years of GSP implementation, the use of groundwater levels and hydraulic gradients as a proxy for surface water depletion will also be reevaluated to determine if the approach is a beneficial addition to direct streamflow measurements and still an appropriate metric for the sustainability indicator. Minimum thresholds and measurable objectives will be reviewed and adjustments will be made as needed.

Figure 3.4.1-3. Existing ISW monitoring locations for flow, stage, and groundwater level are shown alongside ISW characterization at prominent surface water bodies



C:\USERS\JJACQUET\DOCUMENTS\PROJECTS\220102 SIERRA VALLEY SGMA\GIS\FIGURE_MXD\SIERRA_VALLEY_MONITORING_NETWORK.MXD BY GTOLLEY (BALANCE HYDROLOGICS)

9/13/2021

Figure 3.4.1.4-1

3.4.1.4.1 Protocols for Data Collection and Monitoring (23 CCR § 352.2)

Groundwater Level Measurement

See **subsection 3.4.1.1.1** for protocols for monitoring of groundwater levels.

Measurement of Continuous Stage and Streamflow

- Stream-gaging practices will follow the procedures used by the USGS, as outlined by Carter and Davidian (1968).
- Installation of streamflow gages will be based on reach specific characteristics and ideally located upstream of a natural or constructed grade control to maintain the relationship between stage and streamflow
- Installation and instrumentation will include a 'Style C' staff plate that displays stage in decimal feet and is secured to a wood or metal post driven into the bed of the stream. A near-continuous water level logger will accompany the staff plate and will measure water depths in 15-minute intervals. If an unvented logger is used, a barometer will need to be installed at one of the stream gaging locations to compensate data for changing barometric pressure
- Flow will be measured a minimum of 5 times annually over a range of different water depths ('stages').
- Based on these periodic site visits where staff plate readings and streamflow measurements are made, an empirical stage-to-discharge relationship will be developed and adjusted over time for each station, also referred to as a stage-discharge "rating curve." The rating curve will be used to convert the continuous-logging record of stage to flow.
- The data will be analyzed, and if necessary, stage shifts will be applied to account for local scour and fill during the monitoring period, and the effects of leaf and debris dams during low flows, or effects of snow and ice in the winter.

3.4.1.5 Subsidence Monitoring Network

As per 23 CCR § 354.36(b), this GSP adopts groundwater elevations as a proxy for monitoring changes in groundwater in land subsidence. Groundwater levels are the only long-term measure of land subsidence for the Subbasin at the time of writing. Poland and Davis (1969) report the land subsidence to groundwater level decline ratio as approximately 0.01 to 0.2 foot of subsidence per foot of groundwater level decline. These land subsidence SMC will be augmented by InSAR based land elevation change, and ground-based surveys. Throughout the GSP implementation period, the relationship between the change in groundwater levels and the change in the amount land subsidence (factoring in that total land subsidence is a composite of elastic and inelastic land subsidence) will be developed.

Management areas are not planned for this GSP at this time. The monitoring network applies to the entire Subbasin area.

3.4.1.5.1 Monitoring Protocols for Data Collection and Monitoring for Land Subsidence Sustainability Indicator (Reg. § 352.2)

As groundwater elevation measurements are to be used as a proxy for inelastic land subsidence in this GSP, the monitoring network for the land subsidence sustainability indicator is the same as the groundwater level monitoring network. The protocols used for the groundwater level monitoring network described in **Subsection 3.4.1.1** are the same for the land subsidence monitoring network.

Four (4) monument-based land surface elevation stations will be installed within the primary geographic area where subsidence is documented by DWR from InSAR data processing for

2015-2019. The subsidence monument placements will also be developed in consideration of geologic discontinuities, such and the Grizzly Valley Fault Zone. At these geologic discontinuities, there is the greatest potential for differential subsidence, which is normally the most damaging to structures and improvements such as roads or underground utilities.

A licensed Professional Surveyor in the state of California will install the monuments. The monuments will be a deep rod construction type applicable to soils and land surface conditions at installation locations. Monument installation will follow industry guidelines for vertical control monument installation as documented in the US Army Corps of Engineers Guidance Document EM 1110-1-1002, (USACE, March 2012). Monument vertical elevations will be measured annually using survey-grade GPS technology, with vertical resolution of 0.05 ft, with elevations reported as feet above sea level using a standardized datum. Initial elevation measurements will be made at least 28 days after installation.

The monument elevations will be used to gauge the accuracy of future InSAR data processing, and to calibrate the processing if needed. The data monument-based measurements may enable differentiation of inelastic and elastic components of land subsidence, if monuments are located near to monitoring well locations where depth to groundwater levels are being measured and some variance in depths to groundwater up and down is recorded (rebound in groundwater levels can be associated with rebound, or lack thereof, in land surface).

3.4.1.5.2 Representative Monitoring for Land Subsidence Sustainability Indicator (Reg. § 354.36)

As groundwater elevation measurements are to be used as a proxy for inelastic land subsidence in this GSP, the monitoring network for the land subsidence sustainability indicator is the same as the groundwater level monitoring network. Therefore, the representative monitoring sites within the groundwater elevation monitoring network, discussed in detail in **Subsection 3.4.1.1**, are identical to the monitoring network for the land subsidence sustainability indicator.

3.4.1.5.3 Assessment and Improvement of Monitoring Network for Land Subsidence Sustainability Indicator (Reg. § 354.38)

As groundwater elevation measurements are to be used as a proxy for inelastic land subsidence in this GSP, the monitoring network for the land subsidence sustainability indicator is the same as the groundwater level monitoring network discussed in detail in **Subsection 3.4.1.1**.

InSAR and ground-based elevation surveys will augment groundwater level measurements and contribute towards improved understanding of land subsidence in the basin. Pending results from these analyses, the monitoring network may be improved in the five-year plan update.

3.4.2 Assessment and Improvement of the Monitoring Network (23 CCR § 354.38)

The GSP and each five-year assessment report will include an evaluation of the monitoring networks, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the Subbasin. Evaluation of data gaps must consider whether the spatial and temporal coverage of data is sufficient and whether monitoring sites provide reliable and representative data. The description of identified data gaps will include the location and basis for determining data gaps in the monitoring network as well as local issues and circumstances that limit or prevent monitoring. These data gaps will be addressed by describing steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

3.4.3 Reporting Monitoring Data to the Department (23 CCR § 354.40, § 352.4)

Monitoring data will be stored in the data management system and a copy of the monitoring data will be included in each Annual Report submitted electronically to DWR. All reporting standards and information shall follow the guidelines outlined in 23 CCR § 352.4.

3.5 References

California Department of Water Resources (DWR). 2016. Best Management Practices for the Sustainable Management of Groundwater. Monitoring Network and Identification of Data Gaps. Sustainable Groundwater Management Program. December 2016. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps_ay_19.pdf

Harter, T., K. Dzurella, G. Kourakos, A. Hollander, A. Bell, N. Santos, Q. Hart, A. King, J. Quinn, G. Lampinen, D. Liptzin, T. Rosenstock, M. Zhang, G.S. Pettygrove, and T. Tomich, 2017. Nitrogen Fertilizer Loading to Groundwater in the Central Valley. Final Report to the Fertilizer Research Education Program, Projects 11-0301 and 150454, California Department of Food and Agriculture and University of California Davis, 333p., http://groundwaternitrate.ucdavis.edu

Hopkins, J., 1994. Explanation of the Texas Water Development Board groundwater level monitoring program and water-level measuring manual: UM-52, 53 p. http://www.twdb.texas.gov/groundwater/docs/UMs/UM-52.pdf

Smith R., Knight, R., Fendorf, S. 2018. Overpumping leads to California groundwater arsenic threat. Nature Communications. 9, Article number: 2089 (2018). June 5, 2018.

Sophocleous, M., 1983. Groundwater observation network design for the Kansas groundwater management districts, USA: Journal of Hydrology, vol.61, pp 371-389.