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LIST OF ACRONYMS

BMP	Best Management Practices
CASGEM	California Statewide Groundwater Elevation Monitoring
DMS	Data Management System
DO	Dissolve Oxygen
DQO	Data Quality Objective
DTW	Depth to Water
DWR	Department of Water Resources
EC	Electrical Conductivity
ft/yr	feet per year

GDE	Groundwater Dependent Ecosystem
GSA	Groundwater Sustainability Agency
GSE	Ground Surface Elevation
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
InSAR	Interferometric Synthetic Aperture Radar
MAs	Management Actions
Mg/L	Mlligrams per Liter
MO	Measurable Objectives
MT	Minimum Thresholds
NDVI	Normalized Difference Vegetation Index
ORP	Oxidation-Reduction Potential
PBO	Plate Boundary Observatory
PMA	Projects and Management Actions
QA	Quality Assurance
QC	Quality Control
RMS	Representative Monitoring Sites
RP	Reference Point
RPE	Reference Point Elevation
SGMA	Sustainable Groundwater Management Act
SMC	Sustainable Management Criteria
SMCL	Secondary Maximum Containment Level
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
UNAVACO	University NAVSTAR Consortium

LIST OF APPENDICES

3 SUSTAINABLE MANAGEMENT CRITERIA

This chapter of the Groundwater Sustainability Plan (GSP or Plan) defines sustainability goals, measurable objectives, interim milestones, minimum thresholds, undesirable results, and the monitoring network for each sustainability indicator within the Plan Area encompassed by the Bowman Subbasin GSP.

This is the fundamental chapter that defines sustainability in the Plan area, and it addresses significant regulatory requirements. The measurable objectives (MO), minimum thresholds (MT), and undesirable results presented in this chapter define the future sustainable conditions in the Plan area and commit Tehama County to actions that will achieve these future conditions.

Sustainable Management Criteria (SMC) are the quantitative metrics which collectively consist of sustainability goals, MO, interim milestones, MT, and undesirable results. The SMC definitions require considerable analysis and evaluation of many factors. This chapter presents the data and methods used to develop the SMC and demonstrates how they relate to beneficial uses and users. The SMC presented in this chapter are based on current available data and applications of the best available science.

The Groundwater Sustainability Agency (GSA) will periodically evaluate this GSP, assess changing conditions in the Plan area that may warrant modifications of the GSP or management objectives, and may adjust components accordingly. The GSA will focus their evaluation on the efficacy of actions under the GSP to meet the Plan's management objectives and the sustainability goal of the Plan area.

This chapter is organized to address all the Sustainable Groundwater Management Act (SGMA) regulations regarding SMC and is organized in accordance with Department of Water Resources' (DWR) GSP annotated outline. This chapter includes a description of:

- How locally defined significant and unreasonable conditions were developed
- How MT were developed, including:
  - The information and methodology used to develop MT
  - The relationship between MT and relationship of these MT to other sustainability indicators
  - The effect of MT on neighboring basins
  - The effect of MT on beneficial uses and users
  - How MT are related to relevant federal, state, or local standards
  - The method for quantifying measurable MT
- How MO were developed, including:
  - The methodology for setting MO
  - Interim milestones
- How undesirable results were developed, including:
  - The criteria defining when and where the effect of the groundwater conditions cause undesirable results based on a quantitative description of the combination of MT exceedances
  - The potential causes of undesirable results
  - The effect of these undesirable results on the beneficial uses and users

The SMC presented in this chapter were developed using information from stakeholder and public input, public meetings, hydrogeologic and groundwater dependent ecosystem analysis, and meetings with GSA representatives. The general process for establishing SMC includes:

- GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC.
- Conducting GSA public meetings to present proposed methodologies to establish MT and MO and receive additional public input.
- Reviewing public input on preliminary SMC methodologies with GSA representatives.
- Providing a Draft GSP for public review and comment.
- Establishing and modifying MT, MO, and definition of undesirable results based on feedback from public meetings, public/stakeholder review of the Draft GSP, and input from GSA staff/technical representatives.

To ensure the Plan area meets its sustainability goal by 2042, the GSA has proposed projects and management actions (PMA) to address undesirable results which are described in **Section 4**. The projects expected to be implemented can include recharge basins, flood water on agricultural land, and in-lieu recharge. Projects and management actions may include revised well permit ordinances and demand reduction efforts. The overarching sustainability goal and the absence of significant and unreasonable levels of undesirable results are expected to be achieved by 2042 through implementation of the PMA. The sustainability goals will be maintained through proactive monitoring and management by the GSA as described in this and the following chapters. **Table 3-1** presents a summary of the six (6) undesirable results and whether each has occurred, is occurring, or is expected to occur in the future without GSP implementation. The table also presents a summary of the proposed PMA that have been developed to address each of the undesirable results that may be presently occurring or have historically occurred in the Subbasin. Representative Monitoring Sites (RMS) are identified for monitoring of interim milestones, MO, and MT for each sustainability indicator and are shown in **Figure 3-1.**

Conditions within the Subbasin will be considered sustainable when all the following goals are met:

1. Long-term aggregate groundwater use is equal to the Subbasin's estimated sustainable yield.
2. The average annual rate of groundwater storage change within the Subbasin, averaged across RMS wells is generally stable when groundwater storage is equivalent to 2015 baseline conditions.
3. Groundwater levels are maintained at elevations necessary to avoid undesirable results. Lowering groundwater levels potentially leading to significant and unreasonable depletions of available water supply for beneficial use could occur if groundwater levels decline to levels that result in the loss of water availability for well users.
4. Groundwater quality will exhibit trends consistent with the existing Basin Plan and proposed Basin Plan Amendment and exhibit groundwater quality concentrations that significantly impact beneficial users of groundwater.
5. Subsidence is maintained at current levels or below current levels to avoid undesirable results such as impacts to critical infrastructure and inelastic subsidence.
6. Interconnected surface waters are maintained at levels needed to avoid impacts to beneficial users and the degradation of groundwater dependent ecosystems.

7. Sustainability goals for seawater intrusion are not provided because this undesirable result is highly unlikely to occur in the Subbasin.

Table 3-1. Summary of Undesirable Results Applicable to the Plan Area

Sustainability Indicator	Historical Period	Existing Condition	Future Conditions Without GSP Implementation	Projects and Management Actions Implemented to meet the GSP Sustainability Goal
Chronic Lowering of Groundwater Elevations	Yes	Yes	Yes	TBD
Reduction of Groundwater Storage	Yes	Yes	Yes	TBD
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Limited	Limited	Yes	TBD
Land Subsidence	No	No	No	TBD
Depletion of Interconnected Surface Water	Data Gap	Data Gap	TBD	TBD

3.1 Sustainability Goal (Reg §354.24)

The sustainability goal for the Subbasin has three (3) sections:

1. A description of the sustainability goal,
2. A discussion of the measures that will be implemented to ensure the Subbasin will operate within the sustainable yield, and
3. An explanation of the Subbasin's pathway to achieve the sustainability goal within 20 years of GSP implementation and maintained through the planning and implementation horizon (through 2072)

3.1.1 Goal Description

The goal of this GSP is to develop PMA that result in the sustainable management of the groundwater resources of the Subbasin for long-term community, financial, and environmental benefits of residents and businesses in the Subbasin. This GSP outlines the approach to achieve sustainable management of groundwater resources within 20 years, while maintaining the unique cultural, community, and agricultural aspects of the Subbasin. The GSA's sustainability goal is to ensure that by 2042, and thereafter within the planning and implementation horizon of this GSP (50 years to 2072), the Subbasin is operated within its sustainable yield and does not exhibit undesirable results considered significant and unreasonable.

3.1.2 Description of Measures

Meeting this goal requires achieving a balance of water demand with available water supply, while protecting groundwater quality, by the end of the GSP implementation timeframe, carrying through the SGMA planning and implementation horizon.

3.1.3 Description of Measures and Explanation of How the Goal Will Be Achieved in 20 Years

To ensure the Subbasin meets its sustainability goal by 2042, the GSA proposed several PMA, described in Chapter 4, to address undesirable results. The overarching sustainability goal as well as the absence of undesirable results are expected to be achieved by 2042 through implementation of the PMA. The sustainability goal will be maintained through proactive monitoring and management by the GSA as described in this GSP.

3.2 Measurable Objectives and Interim Milestones *(Reg. § 354.30)*

Measurable objectives, as well as interim milestones that represent the path to sustainability in 5-year increments, are detailed below. Measurable objectives represent the expected groundwater extraction operating conditions for the Subbasin. If the GSA successfully manages groundwater extraction that results in the achievement of the MO described, the Subbasin will be operating sustainably. A description of the MO and how they were established are provided, along with recognition of the anticipated fluctuations in basin conditions around the established MO. In addition, this section describes how the GSP helps to meet each measurable objective, how each measurable objective is intended to achieve the sustainability goal for the Plan area for the long-term beneficial uses, and how the interim milestones are intended to reflect the anticipated progress toward the MO during the 2022 to 2042 Implementation Period.

The GSP regulations (California Code Water Code - Division 6 - Conservation, Development, and Utilization of State Water Resources, Part 2.75 - Groundwater Management, Chapter 3 - Groundwater Management Plans) define MO as specific, quantifiable goals for the maintenance or improvement of specific groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin.

Per GSP Regulations (354.30):

1. Measurable objectives shall be established, "…including interim milestones in increments of 5 years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon." (354.30.a)
2. "Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metric and monitoring sites as are used to define the MT." (354.30.b)
3. "Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty." (354.30.c)
4. "…a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators…" may be established where "…the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual MO as supported by adequate evidence." (354.30.d)
5. "Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of 5 years." (354.30.e)

The MO developed for each applicable sustainability indicator in this GSP are based on the current understanding of the Plan Area and Basin Setting as discussed in detail in Chapter 2.

3.2.1 Measurable Objectives for Chronic Lowering of Water Levels

3.2.1.1 Description of Measurable Objectives

Measurable objectives for groundwater levels were established by analyzing historical groundwater level data and determining approximately how many domestic wells may be negatively impacted at different measurable thresholds. Both annual (variability from year to year) and seasonal variability were considered in the development of MO. Groundwater elevation SMC were developed based on historic measurements and a sustainability goal of preventing negative impacts to domestic wells. Measurable objectives were set at each of the monitoring sites (**Table 3-2 and Figure 3-2**). These sites were selected to provide an even distribution of coverage over the Subbasin and based on each individual well's ability to capture the general groundwater trend for other wells in their vicinity.

Specifically, to determine MO, historical water elevations and projected water level trends were analyzed. The Subbasin aims to become sustainable by 2042 and therefore, MO were set to spring 2042 projected elevations minus 5 feet for wells with a decreasing projected trend and at spring 2015 water levels minus 5 feet for wells with an increasing projected trend in water elevations. These MO allow for operational flexibility while maintaining sustainability within the Subbasin.

Groundwater level hydrographs showing MO for each groundwater level sustainability indicator well are provided in **Appendix 3.A** Measurable objectives for each groundwater level monitoring well in the upper and lower aquifers are summarized in **Tables 3-2 and 3-3.**

Table 3-2. Measurable Objectives and Interim Milestones for the Chronic Lowering of Groundwater Elevations – Upper Aquifer

Well Name	State Well Number (SWN)	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)
Bow-1	29N03W18M001M	391.67	389.88	388.09	386.3
Bow-2	29N04W28D001M	399.0675	397.745	396.4225	395.1
Bow-3	29N05W33A004M	490.87	488.88	486.89	484.9
Bow-4	28N04W04P001M	412.18	409.72	407.26	404.8

Table 3-3. Measurable Objectives and Interim Milestones for the Chronic Lowering of Groundwater Elevations - Lower Aquifer

Well Name	SWN	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)
Bow-1	29N04W20A002M	400.86	399.44	398.02	396.6
Bow-2	29N05W21H001M	472.1125	467.475	462.8375	458.2
Rio Alto 6	29N03W21	398.11	378.24	358.37	338.5

3.2.1.2 Interim Milestones (Reasonable Margin of Safety for Operational Flexibility)

Interim milestones at five (5), ten (10), and fifteen (15) years are summarized in **Table 3-2 and Table 3-3** above**.** Interim milestones demonstrate progress towards achieving sustainability as represented by the MO. The 2021 spring measurement was used as the starting point in the development of interim milestones for all the wells except LM-1 (upper). For LM-1 (upper) the most recent spring measurement available for use was from 2020. The interim milestones were set to split the difference between the MO and the starting point.

3.2.1.3 Path to Achieve and Maintain the Sustainability Goal

Considering historic trends, projected groundwater extraction, and planned PMA it appears that the subbasin will be on a reasonable path to maintain the sustainability goal with stable groundwater elevation. Recent water levels remain above the MO. Since recent groundwater levels are higher than the MO, a recovery of groundwater elevation is not needed to reach the sustainability goal. The interim milestones serve to maintain the existing sustainable conditions. The sustainability goal for groundwater elevation is to prevent a negative impact on more than 20% of the domestic wells within the upper aquifer. Planned PMA in conjunction with coordination of SMC with adjacent subbasins will ensure the MO for groundwater elevations are met.

The combination of interim milestones and MO reflect how the GSA anticipates achieving and maintaining sustainability. It should be noted that future projections require assumptions about future hydrologic conditions, including the sequence of wet, average, and dry climatic years. The future climatic assumptions for the Implementation Period (through 2042) used in this GSP incorporate sequences of wet, average, and dry years that represent overall long-term average historical climatic conditions over the Implementation Period, without any prolonged periods of extremely dry or extremely wet years.

3.2.1.4 Impact of Selected Measurable Objectives on Adjacent Basins

The MO established for the Subbasin provide a good basis for evaluation of anticipated impacts on adjacent subbasins from implementation of the GSP. This is because MO are set to reflect the average groundwater levels to be maintained during the Sustainability Period. Ultimately, the potential for impacts on adjacent subbasins will be primarily a function of average water levels in the Subbasin during the Sustainability Period, average water levels in adjacent subbasins during the Sustainability Period, and natural groundwater flow conditions that would be expected to occur at Plan area boundaries. The average groundwater levels expected for the Plan area are reflected in the Measurable Objectives. Tehama County is also the GSA for the surrounding Red Bluff Subbasin. The MO for these surrounding subbasins were set in a concurrent fashion using the same methodology as the Bowman Subbasin. Therefore, no adverse impact on adjacent basins is likely to occur. Measurable objectives for Bowman subbasin were also compared to Anderson subbasin to ensure no negative impacts would occur.

3.2.2 Measurable Objectives for Reduction in Groundwater Storage

3.2.2.1 Description of Measurable Objectives

The MO for storage were established using the chronic lowering of groundwater elevations MO. They are set to the amount of groundwater storage that exists when the groundwater elevations are at their MO.

3.2.2.2 Interim Milestones (Reasonable Margin of Safety for Operational Flexibility)

Interim milestones at five (5), ten (10), and fifteen (15) years are summarized in **Table 3-2 and Table 3-3** for groundwater levels and are calculated as the difference between MO and MT split in 5-year increments.

3.2.2.3 Path to Achieve and Maintain the Sustainability Goal

The combination of interim milestones and MO reflect how the basin will achieve and maintain sustainability. Since groundwater levels serve as a practical proxy for evaluating reduction in groundwater storage, achieving, and maintaining sustainability relative to this indicator is similar to that described above in the groundwater level section.

3.2.2.4 Impact of Selected Measurable Objectives on Adjacent Basins

The groundwater model used for Bowman also encompasses the neighboring subbasin, Red Bluff. Projections for future water levels in the Bowman Subbasin were generated while accounting for conditions at these surrounding subbasins. Therefore, no adverse impact to surrounding subbasins is anticipated.

3.2.3 Measurable Objectives for Subsidence

3.2.3.1 Description of Measurable Objectives

The MO for subsidence represent target subsidence rates in the Subbasin. The MO were set to vertical displacements of 0.25 feet ever 5 years or one foot over 20 years at each (zero inelastic subsidence, in addition to any measurement error) in each InSAR pixel. If InSAR data are used, the measurement error is 0.1 feet and any measurement 0.1 feet or less would not be considered inelastic subsidence. Prior to determining this value, subsidence data from three (3) different sources (PBO, DWR, InSAR) was analyzed for historical and current trends. The MO were set by examining the vertical displacement observed at the pixels from June 2015 to September 2019.

Because the measurable objective of subsidence on an annual basis is the best achievable outcome, the MO were set higher than the MT annual values. The current subsidence monitoring InSAR pixels are shown on **Figure 3-4**. Based on the existing monitoring system the subsidence MO are shown in **Table 3-4**.

Table 3-4. Measurable Objectives and Interim Milestones for Subsidence

InSAR Pixel	Interim Milestone 5 Years (ft)	Interim Milestone 10 Years (ft)	Interim Milestone 15 Years (ft)	Measurable Objective (ft)
DXF1N61	-1.75	-1.5	-1.25	-1.0
DXAA6E6	-1.75	-1.5	-1.25	-1.0
DWYYXU2	-1.75	-1.5	-1.25	-1.0
DWIASYT	-1.75	-1.5	-1.25	-1.0
DXNZ5CY	-1.75	-1.5	-1.25	-1.0
DXFN2X3	-1.75	-1.5	-1.25	-1.0

3.2.3.2 Interim Milestones (Reasonable Margin of Safety for Operational Flexibility)

Interim milestones at five (5), ten (10), and fifteen (15) years are summarized in **Table 3-4.**

3.2.3.3 Path to Achieve and Maintain the Sustainability Goal

Historic trends and planned groundwater extraction and PMA provide a reasonable path to maintain the sustainability goal with levels of subsidence that will not exceed historical trends. As discussed in the basin setting, subsidence has not been an issue for the Bowman Subbasin. Even so, continued monitoring at InSAR pixel locations will highlight and help to mitigate any increases in subsidence through PMA. The interim milestones served to maintain the existing sustainable conditions. The sustainability goal for subsidence is to prevent a trend of increasing rates of subsidence. Planned PMA will ensure the MO for subsidence are met.

3.2.3.4 Impact of Selected Measurable Objective on Adjacent Basins

The anticipated effect of the subsidence MO on each of the neighboring subbasins is not expected to be significant because of the following factors:

- The Subbasin has not been subject to large levels of subsidence in the past
- The neighboring subbasin of Red Bluff is also managed by the same GSA and sustainability efforts are to be coordinated between subbasins to avoid adverse impacts

3.2.4 Measurable Objectives for Degraded Water Quality

3.2.4.1 Description of Measurable Objectives

The MO for minimizing the degradation of groundwater quality are based on groundwater sample concentrations meeting water quality objectives and groundwater quality at concentrations similar to historical observations in the groundwater basin. Based on the review of groundwater quality in Chapter 2, the constituent being evaluated for all beneficial users is total dissolved solids (TDS). The basis for establishing the measurable objective is to minimize the additional contribution and migration of TDS. Measurable objectives for wells in the monitoring network are summarized in **Table 3-5** and shown on **Figure 3-5.** All water quality monitoring wells are constructed in the upper aquifer as TDS is not a concern in the lower aquifer and more pumping occurs from the upper aquifer. The MO for groundwater quality are concentrations of TDS that are generally representative of secondary drinking water standards for urban and domestic beneficial and tolerable for most crops grown in the Subbasin without blending with surface water supplies. The measurable objective is established at 500 mg/L which represents half of the upper limit of the secondary drinking water standards.

Table 3-5. Measurable Objectives and Interim Milestones for Groundwater Quality

Well Name	State Well Number (SWN)	Interim Milestone 5 Years (TDS mg/L)	Interim Milestone 10 Years (TDS mg/L)	Interim Milestone 15 Years (TDS mg/L)	Measurable Objective (TDS mg/L)
Bow-1	29N03W18M001M	TBD	TBD	TBD	500
Bow-2	29N04W28D001M	TBD	TBD	TBD	500
Bow-3	29N05W33A004M	TBD	TBD	TBD	500
Bow-4	28N04W04P001M	TBD	TBD	TBD	500

3.2.4.2 Interim Milestones (Reasonable Margin of Safety for Operational Flexibility)

Interim Milestones are summarized in **Table 3-5.**

3.2.4.3 Path to Achieve and Maintain the Sustainability Goal

The GSP monitoring program for groundwater quality will provide the GSA with a comprehensive understanding of groundwater quality in the Subbasin and identify areas with degraded water quality. This data will be used by the GSA to develop future PMA, as necessary, to address areas with degraded water quality.

3.2.4.4 Impact of Selected Measurable Objectives on Adjacent Basins

Currently, the state of migration of TDS is unknown and therefore it is not possible to quantify the impact from the MO on adjacent subbasins. As more data is collected, the impact to adjacent subbasins will be reassessed.

3.2.5 Measurable Objectives for Interconnected Surface Waters

3.2.5.1 Description of Measurable Objectives

Initial MO (**Table 3-6**) have been established for this indicator due to extensive data gaps which are discussed in **Section 3.7.8.7.** The MO for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used for monitoring groundwater levels (**Figure 3-6**)

3.2.5.2 Interim Milestones (Reasonable Margin of Safety for Operational Flexibility)

Temporary initial milestones have been established for this indicator due to extensive data gaps which are discussed in **Section 3.7.8.7**. The initial milestones for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used for monitoring groundwater levels.

Table 3-6. Initial Measurable Objectives and Interim Milestones for Interconnected Surface Water

Well Name	SWN	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)
Bow-1	29N03W18M001M	391.67	389.88	388.09	386.3
Bow-2	29N04W28D001M	399.0675	397.745	396.4225	395.1
Bow-3	29N05W33A004M	490.87	488.88	486.89	484.9
Bow-4	28N04W04P001M	412.18	409.72	407.26	404.8

3.2.5.3 Path to Achieve and Maintain the Sustainability Goal

No MO have been established for this indicator due to extensive data gaps which are discussed in **Section 3.7.8.7**. For the interim, MO for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used for monitoring groundwater levels.

3.2.5.4 Impact of Selected Measurable Objectives on Adjacent Basins

No MO have been established for this indicator due to extensive data gaps which are discussed in **Section 3.7.8.7**. For the interim, MO for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used for monitoring groundwater levels. As data gaps are bridged and more data becomes available, the GSA will continue to evaluate the MO and their potential impacts on adjacent subbasins.

3.3 Minimum Thresholds (*Reg. § 354.28)*

The regulations define undesirable results as occurring when significant and unreasonable effects are caused by groundwater conditions occurring throughout the Plan area for a given sustainability indicator. Significant and unreasonable effects occur when MT (MTs) are exceeded for one or more sustainability indicators. Minimum thresholds refer to a numeric value for each sustainability indicator used to define undesirable results. A GSP must establish MT that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site. The numeric value used to define the MT shall represent a point in the Subbasin that, if exceeded may cause significant and unreasonable undesirable results. A GSA may establish a representative MT, such as groundwater elevation (GWE) to serve as the value for multiple sustainability indicators, if the GSA can demonstrate the representative value is a reasonable proxy for multiple individual MT, as supported by adequate evidence. Minimum thresholds are not required for sustainability indicators that are not present and not likely to occur in the Subbasin.

The description of MT shall include the following:

1. The information and criteria relied upon to establish and justify the MT for each sustainability indicator. The justification for the MT shall be supported by information provided in the basin setting, and other data or models as appropriate and qualified by uncertainty in the understanding of basin setting.
2. The relationship between the MT for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each MT will avoid undesirable results from each sustainability indicator.
3. How MT have been selected to avoid causing undesirable results in adjacent basins or affecting adjacent basin's ability to achieve sustainability goals.
4. How MT may affect the interests of beneficial users and users of groundwater or land uses and property interests.
5. How state, federal, or local standards relate to the relevant sustainability indicator. If the MT differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.
6. How each MT will be quantitatively measured, consistent with the monitoring network requirements.

3.3.1 Minimum Thresholds for Chronic Lowering of Groundwater Elevations

3.3.1.1 Description of Minimum Threshold

Groundwater levels will be measured at existing or new monitoring wells to gauge if MT are being met. The groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.11. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the GSP regulations. As noted in Section 3.11, the current groundwater monitoring network includes four (4) wells in the Upper Aquifer and three (3) well in the Lower Aquifer (**Figure 3-2 and Figure 3-3**).

The GSP regulations provide that the “MT for chronic lowering of groundwater elevations shall be the groundwater level indicating a depletion of supply at a given location that may lead to undesirable results”. Chronic lowering of groundwater elevations in the Subbasin cause significant and unreasonable declines if they are sufficient in magnitude to lower the rate of production of pre-existing groundwater wells below that necessary to meet the minimum required to support overlying beneficial use(s) where alternative means of obtaining sufficient water resources are not technically or financially feasible. In addition, GWEs will be managed at levels above the MT to ensure the major aquifers in the Subbasin are not depleted in a manner to cause significant and unreasonable impacts to other sustainability indicators.

The MT are intended to protect against significant and unreasonable levels of chronic groundwater storage declines, water quality degradation, subsidence in areas where critical infrastructure is located. These MT are also being utilized as initial MT for interconnected surface waters and are intended to protect against negative impacts to GDEs and the depletion of interconnected surface waters. The development of MT for chronic lowering of groundwater elevations included a review of historical groundwater levels and the projected water levels trends in 2042. Minimum thresholds were established based on these historical and projected data and the GSA’s consideration of undesirable results. The MT for chronic lowering of groundwater elevations are based on documented screen intervals of key wells located both in the upper and lower aquifers in the Subbasin. The MT were set to the following:

- Upper Aquifer: Spring groundwater elevation where less than 10 - 20% (on average) of domestic wells could potentially be impacted.
- Lower Aquifer: Spring groundwater elevation plus 20 to 120 feet

RMS wells and the subsequent MT are listed in **Table 3-7 and Table 3-8**. Groundwater level hydrographs from which the MT were developed are provided in **Appendix 3.A**

Table 3-7. Minimum Thresholds and Interim Milestones for the Chronic Lowering of Water Elevations – Upper Aquifer

Well Name	SWN	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)	Minimum Threshold (ft NAVD88)
Bow-1	29N03W18M001M	391.67	389.88	388.09	386.3	318.5
Bow-2	29N04W28D001M	399.0675	397.745	396.4225	395.1	372.5
Bow-3	29N05W33A004M	490.87	488.88	486.89	484.9	419.6
Bow-4	28N04W04P001M	412.18	409.72	407.26	404.8	377.5

Table 3-8. Minimum Threshold and Interim Milestones for the Chronic Lowering of Water Elevations - Lower Aquifer

Well Name	SWN	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)	Minimum Threshold (ft NAVD88)
Bow-1	29N04W20A002M	400.86	399.44	398.02	396.6	351.8
Bow-2	29N05W21H001M	472.1125	467.475	462.8375	458.2	417.6
Rio Alto 6	29N03W21	398.11	378.24	358.37	338.5	294

3.3.1.2 Quantitative Measurement

The quantitative measurement for chronic lowering of groundwater elevations will be the annual spring measurements taken at the RMS wells. The data obtained will be appended to existing data to generate hydrographs for the wells. These hydrographs will be analyzed for changing trends in water elevations and compared to established MT to ensure they are not exceeded.

3.3.1.3 Existing Local, State, or Federal Standards

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

3.3.1.4 Avoidance of Undesirable Results

A prolonged period of extracting groundwater in excess of the sustainable yield can cause chronic lowering of groundwater elevations in the Subbasin and could cause an undesirable result in the future. Impacts of declining groundwater levels would be considered undesirable results if 25% or more of the RMS wells are below the MT for two (2) consecutive measurements. If the water year is dry or critically dry, then the levels below the MT are not undesirable if groundwater management allows for recover in average or wetter years. The undesirable results are based on the Sacramento Valley Index (SVI) as calculated in 2021. The water year index is currently calculated by the following formula:

Sacramento Valley Water Year Index = 0.4 * Current Apr-Jul Runoff Forecast (in maf) + 0.3 * Current Oct-Mar Runoff in (maf) + 0.3 * Previous Water Year's Index (if the Previous Water Year's Index exceeds 10.0, then 10.0 is used).

3.3.1.5 Effects of the Beneficial Uses and Users of Groundwater

The primary detrimental effect to beneficial users from allowing a multi-year (more than two (2) years of fall readings in 25% or more of the RMS wells) exceedance would be loss of well capacity, increased costs due to higher pumping lifts, lack of groundwater extraction due to groundwater levels declining below the pump setting, or subsidence impacts on well structures and above ground infrastructure.,

3.3.2 Minimum Thresholds for Reduction in Groundwater Storage

3.3.2.1 Description of Minimum Threshold

GSP Regulation §354.28 (c)(2) states that the MT for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be calculated based on historical trends, water year type and projected water use in the Subbasin. Reduction in groundwater storage is not a parameter that can be directly measured; rather, change in storage is calculated from change in groundwater levels and aquifer material storage coefficients. Change in groundwater storage will be regularly estimated based on either the Subbasin water budget or monitoring results derived from analysis of groundwater elevations and aquifer properties. The MT for groundwater storage is set to the amount of groundwater storage when groundwater elevations are at their measurable objective.

3.3.2.2 Quantitative Measurement

The MT for reduction in groundwater storage is a single value of average groundwater elevation over the entire Subbasin. Therefore, the potential conflict between MT at different locations in the Subbasin is not applicable. The reduction in groundwater storage MT was selected to avoid undesirable results for other sustainability indicators as outlined below:

1. Chronic lowering of groundwater elevations. Since groundwater elevation will be used for estimating changes in groundwater storage, the reduction in groundwater storage would not cause undesirable results for this sustainability indicator.
2. Degraded water quality. Exceedances of the MT for declines in groundwater storage is not expected to lead to a degradation of groundwater quality.
3. Subsidence. Future average groundwater levels and changes in long-term aquifer storage will be stable and will not induce any additional subsidence within the Subbasin.
4. Interconnected surface water. Groundwater elevations will also be used for interconnected surface waters for the interim. Therefore, the MT for groundwater storage is not anticipated to cause undesirable results for this indicator. The GSA will work to bridge the data gaps for this indicator and continue to reassess any potential impacts from the storage MT.

Groundwater levels will be measured at existing and new monitoring wells. The groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.11. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the SGMA regulations. As noted in Section 3.11, the current groundwater monitoring network includes four (4) wells in the Upper Aquifer and three (3) well in the Lower Aquifer. The change in groundwater elevations from year to year will be determined and multiplied by the storage coefficients associated with the specific aquifer being measured and multiplied by the areal extent of the Subbasin to derive the annual change in storage.

3.3.2.3 Existing Local, State, or Federal Standards

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

3.3.2.4 Avoidance of Undesirable Results

A prolonged period of extracting groundwater in excess of the sustainable yield can cause groundwater storage declines when coupled with reductions in imported water supplies and could lead an undesirable result in the future. Conditions that may lead to an undesirable result include the following:

- Over-pumping of groundwater. High levels of extractions from the aquifers can cause excessive drawdowns that can lead to undesirable results by dropping monitoring well levels below the MT.
- Extensive, unanticipated drought and associated drastic curtailments of imported surface water supplies. Minimum thresholds were established based on historical groundwater elevation and reasonable estimates of future groundwater elevations. Extensive, unanticipated droughts and associated curtailment of imported water supplies will likely lead to excessively low groundwater elevations and undesirable results.

3.3.2.5 Effects of the Beneficial Uses and Users of Groundwater

The practical effect of the reduction in groundwater storage undesirable result encourages no net change in groundwater elevation and storage during long-term average hydrologic conditions. Therefore, during average, long-term hydrologic conditions, beneficial uses, and users will have access to the same amount of groundwater in storage that currently exists, and the undesirable result will not have a significant negative effect on the beneficial users and uses of groundwater. Pumping during dry years will temporarily lower groundwater elevations, reduce the amount of groundwater in storage and could result in short-term impacts from a reduction in groundwater in storage on all beneficial uses and users of groundwater. However, the GSP is designed to promote conjunctive use in the Subbasin and acknowledges the sustainable yield as an average value that can experience annual variations in storage.

3.3.3 Minimum Thresholds for Subsidence

3.3.3.1 Description of Minimum Threshold

GSP regulations state that the MT for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Information used to establish the land subsidence MT include:

- Historical land surface elevation data from GPS locations in the Subbasin and satellite imagery of subsidence.

Subsidence monitoring in and adjacent to the Subbasin includes several different data collection programs:

- PBO UNAVCO continuous subsidence monitoring stations
- 2017 GPS survey of the Sacramento Valley Subsidence Network (DWR)
- InSAR satellite-based subsidence monitoring

Data collected by the programs listed above was evaluated against water levels observed at the monitoring network wells. The compiled data was also compared to observe historical trends against current conditions. This analysis showed that the Subbasin had experienced minimal levels of subsidence historically and there was no indication of changes in that trend in current conditions. Past subsidence is likely elastic. Minimum thresholds were set at InSAR pixel locations near water level monitoring network wells based on these trends. The InSAR pixel MT was established by calculating the vertical displacement from June 2015 to September 2019 and doubling the value. These pixels and their corresponding monitoring wells are depicted in **Figure 3-4**. InSAR vertical displacement data is currently provided by DWR. The GSP anticipates that DWR will continue to provide this data in the future for use in GSP updates. The MT for subsidence are set to two feet over 20 years (i.e., no more than 0.5 feet of cumulative subsidence over a five-year period (beyond the measurement error), solely due to lowering of groundwater elevations.

These measurable thresholds are listed in **Table 3-9**.

Table 3-9. Minimum Thresholds and Interim Milestones for Subsidence

InSAR Pixel	Interim Milestone 5 Years (ft)	Interim Milestone 10 Years (ft)	Interim Milestone 15 Years (ft)	Measurable Objective (ft)	Minimum Threshold (ft)
DXF1N61	-1.75	-1.5	-1.25	-1.0	-2.0
DXAA6E6	-1.75	-1.5	-1.25	-1.0	-2.0
DWYYXU2	-1.75	-1.5	-1.25	-1.0	-2.0
DWIASYT	-1.75	-1.5	-1.25	-1.0	-2.0
DXNZ5CY	-1.75	-1.5	-1.25	-1.0	-2.0
DXFN2X3	-1.75	-1.5	-1.25	-1.0	-2.0

3.3.3.2 Quantitative Measurement

The quantitative metric for assessing compliance will be to continue to use vertical displacement data from InSAR at the individual pixels (**Table 3-9**) which will be downloaded annually. This data will be appended to existing data and plotted. Both quantitative and qualitative assessments of the data will be performed to assess if any trends are apparent, and if the annual subsidence is greater than the MT.

3.3.3.3 Existing Local, State, or Federal Standards

No federal, other state, or local standards exist for currently exist for subsidence reduction.

3.3.3.4 Avoidance of Undesirable Results

Undesirable results are considered to occur at a 50% exceedance of a MT over a 5-year period that is irreversible and is caused by lowering of groundwater elevations.

Conditions that may lead to an undesirable result of a significant and unreasonable amount for land subsidence arise due to groundwater extraction that causes reductions in the viability of the use of water conveyance and flood control infrastructure over the planning and implementation horizon of this GSP.

3.3.3.5 Effects of the Beneficial Uses and Users of Groundwater

The subsidence MT are set to prevent subsidence that could lead to significant and unreasonable results. Unchecked subsidence can impact critical water conveyance and flood control infrastructure. Damages to water conveyance systems impacts all agricultural and urban users retrieving water from such systems. The impact is primarily manifested in increased cost and loss of flexibility in water conveyance operations. Higher levels of subsidence can also damage public infrastructure such as roadways and highways causing impacting populations outside of immediate beneficial users. Damages such as these can result in costly repairs and long-term traffic issues. Subsidence also has the capacity to increase flooding by causing damage to flood control infrastructure and creation of low elevation land. Potential impact on residents in flood prone areas may cause extensive financial hardships to those affected.

3.3.4 Minimum Thresholds for Groundwater Quality

3.3.4.1 Description of Minimum Threshold

The MT for degraded water quality is protective of existing and potential beneficial uses and users in the Subbasin. SGMA's water quality objective focuses on a constituent's contribution due to activities at the land surface rather than on the presence of naturally occurring constituents. Based on the review of groundwater quality in Chapter 2, the constituent of concern for beneficial users in the Subbasin is TDS. TDS is being monitored as an overall indicator of groundwater quality within the Subbasin. The basis for establishing a MT is to minimize the additional contribution and migration of high concentrations of TDS. The MT for TDS is 750 milligrams per liter (mg/L). This threshold is lower than the California State Water Resources Control Board (SWRCB) upper secondary maximum containment level (SMCL) of 1,000 mg/L as set by SWRCB for taste and odor. Minimum thresholds for all wells are summarized in **Table 3-10.**

Table 3-10. Minimum Thresholds, Measurable Objectives, and Interim Milestones for Groundwater Quality

Well Name	Interim Milestone 5 Years (TDS mg/L)	Interim Milestone 10 Years (TDS mg/L)	Interim Milestone 15 Years (TDS mg/L)	Measurable Objective (TDS mg/L)	Minimum Threshold (TDS mg/L)
Bow-1	TBD	TBD	TBD	500	750
Bow-2	TBD	TBD	TBD	500	750
Bow-3	TBD	TBD	TBD	500	750
Bow-4	TBD	TBD	TBD	500	750

3.3.4.2 Quantitative Measurement

Groundwater quality will be monitored on an annual basis at representative monitoring wells (listed in **Table 3-10**). All measurements will comply with the Sampling and Analysis Plan and Quality Project Plan and be recorded in the GSA's data management system. The monitoring network and monitoring protocols are described in **Section 3.11** (Monitoring Network and Monitoring Protocols for Data Collection). **Table 3-10** includes each well being monitored in the GSP monitoring program for groundwater quality, along with the MT, measurable objective, and interim milestones. The MT of 750 milligrams per liter (mg/L) are tolerable for most crops grown in the Subbasin without blending with surface water supplies. However, the GSA will continue to monitor TDS concentrations and changes in spatial or temporal trends to ensure MT are not being exceeded and undesirable results are not being experienced by beneficial users.

3.3.4.3 Existing Local, State, or Federal Standards

The MT for TDS is based on current background data in the Subbasin and set at 750 mg/L. This threshold is lower than the SWRCB upper secondary maximum containment level (SMCL) set by SWRCB for taste and odor of 1,000 mg/L.

3.3.4.4 Avoidance of Undesirable Results

Undesirable results will have occurred when:

- at least 25% of RMS exceed the MT for water quality for 2 consecutive years at each well where it can be established that GSP implementation is the cause of the exceedance

Changes in land use practices involving increased leaching of TDS into the groundwater system or increased extractions leading to dropping water levels and migrations of elevate TDS waters can lead to undesirable results. Through the monitoring network, the GSA aims to prevent such outcomes by analyzing long-term trends in water quality and deploying appropriate projects and managements to mitigate or deter undesirable results.

3.3.4.5 Effects of the Beneficial Uses and Users of Groundwater

The effect of degraded groundwater quality on agricultural beneficial users is manifested in crop damage and reduced yields, and a reduction in the use of land for irrigated agriculture if the sole water supply is groundwater.

Urban and domestic beneficial uses are impacted if degraded water is the only source for potable use. The impacts include the need to use alternative sources of water that may be more expensive than groundwater and potential undesirable aesthetic qualities without pre-treatment of the degraded water prior to use.

3.3.5 Minimum Thresholds for Interconnected Surface Water Depletions

3.3.5.1 Description of Minimum Threshold

Minimum thresholds are interim and will be the same water levels used in for the chronic lowering of groundwater elevations described in **Section 3.3.1.1.** Extensive data gaps are discussed in **Section 3.7.8.7.** The GSA will continue to evaluate new monitoring information and determine these thresholds later. For the interim, MT for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used. The MT are summarized in **Table 3-11**.

Table 3-11. Initial Minimum Thresholds and Interim Milestones for Interconnected Surface Water Depletions

Well Name	SWN	Interim Milestone 5 Years (ft NAVD88)	Interim Milestone 10 Years (ft NAVD88)	Interim Milestone 15 Years (ft NAVD88)	Measurable Objective (ft NAVD88)	Minimum Threshold (ft NAVD88)
Bow-1	29N03W18M001M	391.67	389.88	388.09	386.3	318.5
Bow-2	29N04W28D001M	399.0675	397.745	396.4225	395.1	372.5
Bow-3	29N05W33A004M	490.87	488.88	486.89	484.9	419.6
Bow-4	28N04W04P001M	412.18	409.72	407.26	404.8	377.5

3.3.5.2 Quantitative Measurement

No MT have been established for this indicator due to data gaps. For the interim, MT for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used.

3.3.5.3 Existing Local, State, or Federal Standards

No current local, other state, or federal standards currently exist for this indicator.

3.3.5.4 Avoidance of Undesirable Results

Undesirable results have not been established for this indicator due to data gaps. For the interim, MT for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used.

3.3.5.5 Effects of the Beneficial Uses and Users of Groundwater

No MT have been established for this indicator due to data gaps. For the interim, MT for the chronic lowering of groundwater elevations will be used as a proxy for interconnected surface waters. Wells within one mile of interconnected surface water features will be used.

3.3.6 Relationship Between the Established Minimum Threshold and Sustainability Indicator(s)

The monitoring sites described in **Tables 3- 2** through **Table 3-9** are in locations that reflect a wide cross section of Subbasin groundwater conditions. These locations are representative of the overall Subbasin conditions because they are spatially distributed throughout the Subbasin both vertically (across the upper and lower aquifers) and laterally. The GSA determined that use of the minimum elevation thresholds at each of the listed wells will help avoid the undesirable results of chronic lowering of groundwater elevations because it should preserve access to adequate water resources for beneficial users within the Subbasin.

Groundwater elevation MT can influence other sustainability indicators. The groundwater elevation MT were selected to avoid undesirable results for other sustainability indicators.

1. Change in groundwater storage. A significant and unreasonable condition for change in groundwater storage is a decrease in the total volume of groundwater that can be withdrawn without causing undesirable results. The sustainable yield of the Subbasin can be affected by excess pumping leading to the chronic lowering of groundwater elevations. Minimum thresholds have been set at levels to avoid a decline in sustainable yield. This Subbasin has not yet been fully developed and MT reflect this lack of development. However, the MT also account for the maintenance of groundwater storage.
2. Degraded water quality. Preserving groundwater quality is important to the groundwater resource. A significant and unreasonable condition of degraded water quality is exceeding regulatory limits for constituents of concern in groundwater due to actions proposed in the GSP. Water quality could be affected by low groundwater elevations if they caused deeper, poor-quality groundwater (saline groundwater located below the base of freshwater) to flow upward into existing wells.
3. Subsidence. A significant and unreasonable condition for subsidence is any measurable permanent subsidence that results in severe impacts to the operations of existing infrastructure to a degree that would require design and construction projects to mitigate the impact. Subsidence is caused by dewatering and compaction of clay-rich sediments in response to lowering groundwater levels. Continued exceedances of water level MT could result in subsidence over time. Minimum thresholds have been established based on historical data and GSA consideration of unreasonable and significant results and are not expected to lead to increased levels of subsidence.
4. Depletion of interconnected surface waters. Due to data gaps, MT for interconnected surface waters have been established at groundwater level monitoring wells within one mile of these sites. Chronic lowering of groundwater can sever the connection between groundwater and surface water. Water level declines can also result in the depletion of these surface waters. Interim MT have been established at groundwater level monitoring sites in the vicinity of interconnected surface waters. Once data gaps are filled, MT will be established at new monitoring sites to prevent undesirable results.

3.3.7 Minimum Thresholds Impacts to Adjacent Basins

The MT established at the Bowman Subbasin are not expected to impact the surrounding subbasins. The county is also developing the GSP for Red Bluff and the MT in that subbasin were developed in conjunction with those in Bowman. Furthermore, the MT for Bowman were compared to those for the Anderson subbasin and the established minim thresholds are similar to those developed for Anderson. Bowman and its adjacent subbasins are accounted for when establishing MT. Due to this interconnectedness and comparison of the GSPs, MT in Bowman are not likely to have adverse impacts on adjacent subbasins. Instead, the co-development of the GSPs will result in cooperative sustainability goals.

3.3.8 Minimum Thresholds Impacts on Beneficial Users

The MT established for the sustainability indicators that are present in the Subbasin may have several effects on beneficial users and land use in the Subbasin. The Bowman Subbasin has not been fully developed and its extraction potential has yet to be realized. Therefore, although in some cases MT may be set at water levels not previously experienced in the Subbasin, they are not anticipated to cause adverse impacts to most sectors.

Historical water level trends, future water level projections, and domestic well water levels were all considered when establishing MT. No more than 20% of Upper aquifer wells are expected to go dry under MT conditions set for the Upper aquifer This impact does not apply to the MT set for the lower aquifer. If MT are met for two (2) consecutive fall readings, PMA will be triggered to raise water levels.

3.4 Undesirable Results *(Reg. § 354.26)*

According to GSP Regulations, the GSP's description of undesirable results is to include the following:

1. The cause of groundwater conditions occurring throughout the basin that would lead to or has led to the undesirable results based on information described in the basin setting, and other data or models as appropriate.
2. The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of MT exceedances that cause significant and unreasonable effects in the basin.
3. 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.

Under SGMA, undesirable results occur when the effects caused by groundwater conditions occurring throughout the basin cause significant and unreasonable impacts from any of the six (6) sustainability indicators on beneficial users of groundwater. That is "significant and unreasonable occurrence of any of the six (6) sustainability indicators constitutes an undesirable result". These sustainability indicators are:

1. Chronic lowering of groundwater elevations,
2. Reduction of groundwater storage,
3. Seawater intrusion,
4. Degraded water quality,
5. Land subsidence, and
6. Depletion of interconnected surface water

A summary of criteria used to define undesirable results is provided below in **Table 3-12**, and detailed discussion of each sustainability indicator is provided in subsequent sections of this chapter.

Table 3-12. Summary of Minimum Thresholds, Measurable Objectives, and Undesirable Results

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result
Chronic Lowering of Groundwater Elevations	**Upper Aquifer:** Spring groundwater elevation where less than 10 - 20% (on average) of domestic wells could potentially be impacted. **Lower Aquifer:** Spring groundwater elevation plus 20 to 120 feet	**Upper & Lower Aquifer:** Spring 2015 groundwater elevation minus 5 feet (for wells with increasing or no groundwater trends) or projected Spring 2042 groundwater elevation minus 5 feet for wells with declining groundwater elevations	25% of groundwater elevations measured at same RMS wells exceed the associated MT for 2 consecutive measurements. *If the water year is dry or critically dry, then levels below the MT are not undesirable if groundwater management allows for recovery in average or wetter years*
Reduction of Groundwater Storage	**Upper & Lower Aquifer:** Amount of groundwater in storage when groundwater elevations are at their MT	**Upper & Lower Aquifer:** Amount of groundwater storage when groundwater elevations are at their measurable objective	Same as chronic lowering of groundwater levels
Land Subsidence	Two feet over 20 years (i.e., no more than 0.5 feet of cumulative subsidence over a five-year period (beyond the measurement error), solely due to lowering of groundwater elevations	One foot over 20 years (Zero inelastic subsidence, in addition to any measurement error). If InSAR data are used, the measurement error is 0.1 feet and any measurement 0.1 feet or less would not be considered inelastic subsidence	50% of RMS exceed the MT over a 5-year period that is irreversible and is caused by lowering of groundwater elevations
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	**Upper & Lower Aquifer:** TDS concentration of 750 mg/L at all RMS wells	**Upper & Lower Aquifer:** California lower limit secondary MCL concentration for TDS of 500 mg/L measured at RMS wells	At least 25% of RMS exceed the MT for water quality for 2 consecutive years at each well where it can be established that GSP implementation is the cause of the exceedance
Depletion of Interconnected Surface Water	Same as chronic lowering of	Same as chronic lowering of	25% of groundwater elevations measured at RMS wells drop below the associated threshold

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result
	groundwater levels (Initial)	groundwater levels (Initial)	during 2 consecutive years in the Upper Aquifer. *If the water year is dry or critically dry, then levels below the MT are not undesirable if groundwater management allows for recovery in average or wetter years (Initial)*

3.4.1.1 Groundwater Elevation

Significant and unreasonable levels of the chronic lowering of groundwater elevations is defined as a fraction of the groundwater elevations measured in the GSP monitoring well network that are less than the MT values. For the Bowman Subbasin, this fraction is estimated as 25% of groundwater elevations measured at same RMS wells exceed the associated MT for 2 consecutive measurements. If the water year is dry or critically dry, then levels below the MT are not undesirable if groundwater management allows for recovery in average or wetter years.

3.4.1.2 Groundwater Storage

Undesirable results for the levels of groundwater storage would occur when 25% of groundwater elevations measured at same RMS wells exceed the associated MT for two (2) consecutive measurements. If the water year is dry or critically dry, then levels below the MT are not undesirable if groundwater management allows for recovery in average or wetter years. For the Bowman Subbasin, this exceedance will result significant and undesirable levels of groundwater level declines that could impact the use of existing wells and beneficial users of groundwater. The significant and unreasonable decline in storage would result in limiting the volume of groundwater available for agriculture, municipal, industrial, and domestic uses without any PMA to mitigate the impact by new and deeper wells.

3.4.1.3 Subsidence

For the Bowman Subbasin, historical data indicates minimal levels of subsidence has occurred and this trend has not changed when analyzing current conditions. Therefore, undesirable results are considered to occur at a 50% of RMS exceed the MT over a five-year period that is irreversible and is caused by lowering of groundwater elevations.

3.4.1.4 Groundwater Quality

Water quality degradation will lead to an undesirable result when at least 25% of RMS wells exceed the MT for water quality for two (2) consecutive years at each well where it can be established that GSP implementation is the cause of the exceedance. This result will be considered unreasonable and significant if it causes reduction in the long-term viability of domestic, agriculture, municipal wells, or environmental uses over the planning and implementation of the GSP.

3.4.1.5 Interconnected Surface Waters

Initial undesirable results for depletion of interconnected surface water were developed for this GSP due to data gaps. These interim undesirable results mirror those established for chronic lowering of groundwater elevations. Therefore, undesirable results will occur when 25% of groundwater elevations measured at RMS wells drop below the associated threshold during two (2) consecutive years in the Upper Aquifer. If the water year is dry or critically dry, then levels below the MT are not undesirable if groundwater management allows for recovery in average or wetter years.

3.4.2 Potential Effects on the Beneficial Users of Groundwater

For agricultural beneficial users of groundwater, the most significant undesirable results are groundwater levels, groundwater storage, groundwater quality, and subsidence. The undesirable results for interconnected surface waters will not have a direct impact on agriculture. Undesirable results for any of the sustainability indicators of concern will limit the ability of agricultural users to extract groundwater and irrigate crops.

For domestic beneficial users of groundwater, the most significant undesirable results are groundwater levels, groundwater storage, and groundwater quality. Undesirables results for any of these three (3) sustainability indicators could potentially restrict the ability of households to use water for domestic purposes. Subsidence and interconnected surface waters will not have direct impact on domestic users.

For environmental beneficial uses of groundwater in the Subbasin, the most significant undesirable results are subsidence and the depletion of interconnected surface water. High levels of subsidence can damage flood control infrastructure which can cause damage to the surrounding environment through landslides and soil loss. The depletion of interconnected surface waters could damage groundwater dependent ecosystems and other vegetation and native species reliant on these surface water sources.

3.5 Management Areas

Management areas have not been established in the Subbasin.

3.6 Monitoring Network

This section describes the proposed monitoring network, including GSA monitoring objectives monitoring protocols, and data reporting requirements. This section has been prepared in accordance with GSP Regulations. The monitoring network has been developed to collect enough data to characterize groundwater and related surface water conditions in the Subbasin and evaluate changing conditions and GSP implementation. The monitoring network has been designed to collect data to allow for the analysis of short- and long-term trends, seasonal variations and estimate annual changes in aquifer storage. The monitoring sites have been distributed across the Subbasin to provide a comprehensive analysis of current and ongoing conditions within the plan area. This widespread distribution coupled with the monitoring frequency will allow the GSA to chart its progress towards the established sustainability goals and ensure real time tracking of any impacts on beneficial users. Specifically, the monitoring program will allow the GSA to quantify changes in groundwater storage, elevations, and quality and assess the efficacy of any implemented management programs. This data will facilitate changes to management programs to maintain continued progress towards the GSA's sustainability objectives.

The GSP regulations require monitoring networks to be developed to promote the collection of a data set of enough quality, frequency, and spatial distribution to characterize groundwater and related surface water conditions in the Subbasin and to evaluate changing conditions that occur through implementation of the GSP. The monitoring network should accomplish the following:

- Demonstrate progress towards achieving MO described in the GSP;
- Monitor impacts to the beneficial uses and users of groundwater;
- Monitor changes in groundwater conditions relative to MO and MT; and
- Quantify annual changes in water budget components

The MT and MO for the network are described above.

GSP regulations require that if management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the Subbasin setting sustainable management criteria specific to that area. At this time, management areas have not been defined for the Subbasin. If management areas are developed in the future, the monitoring network will be reevaluated to ensure that there is sufficient monitoring to evaluate conditions.

3.6.1 Description of Monitoring Network (*Reg. § 354.34*)

The GSP monitoring network is composed of aquifer specific wells that are screened in the Upper or Lower Aquifers. The network will not include composite wells that span both the Upper and Lower aquifers. The network will enable the collection of data to assess sustainability indicators, the effectiveness of PMA to achieve sustainability and evaluate the MO of each applicable sustainability indicator (i.e., chronic lowering of groundwater elevations, reduction in groundwater storage, degraded water quality, land subsidence, interconnected surface water depletion). The Subbasin is isolated from the Pacific Ocean; therefore, this GSP does not provide monitoring for seawater intrusion sustainability indicators.

Within the Bowman Subbasin, 33 monitoring wells were found to have water level data. However, for the purposes of the GSP monitoring program, a subset of these wells was identified that represent geographical variation along with a historical data record if possible. This effort resulted in the selection of four (4) wells in the Upper Aquifer and three (3) well in the Lower Aquifer as documented in **Table 3-13** (the selection process is described further below). The GSA has complete well construction information for these wells, which allows the GSA to determine the aquifer being monitored with certainty. Furthermore, composite wells that span both the upper and lower aquifers were not selected for this GSP monitoring program to provide aquifer specific data. The same representative monitoring wells were selected as part of the groundwater quality monitoring network **(Table 3-13).** As previously described in this Chapter, subsidence monitoring will be conducted using InSAR satellite data. Six (6) pixels from the satellite data have been selected for subsidence monitoring. Currently, the groundwater level monitoring network is serving as a proxy for interconnected surface waters, using only wells within 1 mile of the sites of concern. This proxy network was established due to extensive data gaps in the availability of monitoring sites. This data gap is discussed further in Section 3.7.8.7.

These wells are distributed throughout the Bowman Subbasin to provide ample coverage of the entire area. This coverage allows for the collection of data to evaluate groundwater gradients and flow directions over time and the annual change in storage. Furthermore, the monitoring frequency of the wells will allow for the monitoring of seasonal highs and lows. Because wells were chosen with the existing length of historical data record in mind, future groundwater data will be able to be compared to historical data.

Table 3-13. Proposed Monitoring Network

Well Name	Latitude	Longitude	Aquifer	Groundwater Elevation	Groundwater Storage	Groundwater Quality	Subsidence	Inter-Connected SW
Bow-1 **SWN: 29N03W18M001M**	40.3672	-122.255	Upper	X	X	X		X
Bow-2 **SWN: 29N04W28D001M**	40.345354	-122.332	Upper	X	X	X		X
Bow-3 **SWN: 29N05W33A004M**	40.329012	-122.426	Upper	X	X	X		X
Bow-4 **SWN: 28N04W04P001M**	40.304065	-122.323	Upper	X	X	X		X
Rio Alto 6 **SWN: 29N03W21**	40.354478	-122.212	Lower	X	X			
Bow-1 (lower) **SWN: 29N04W20A002M**	40.358539	-122.334	Lower	X	X			
Bow-2 (lower) **SWN: 29N05W21H001M**	40.353213	-122.43	Lower	X	X			
DXF1N61	40.3672	-122.255					X	
DXAA6E6	40.345354	-122.332					X	
DWYYXU2	40.329012	-122.426					X	
DWIASYT	40.304065	-122.323					X	
DXNZ5CY	40.358539	-122.334					X	
DXFN2X3	40.354478	-122.212					X	

3.6.2 Groundwater Elevation Monitoring Network

The MT and MO for the chronic lowering of groundwater elevations sustainability indicator are evaluated by monitoring groundwater levels. The SGMA GSP Regulations require a network of monitoring wells to demonstrate groundwater occurrence, flow direction and hydraulic gradients between principal aquifer and surface water features.

The objectives of the groundwater level monitoring program include the following:

- Improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, especially in areas where short-term and long-term development of groundwater resources are planned;
- Detect the occurrence of, and factors attributable to, natural recharge (e.g., direct infiltration of precipitation), irrigation, and surface water seepage to groundwater or recharge project and management actions (recharge basins, aquifer storage and recovery) that affect groundwater levels and trends;
- Identify appropriate monitoring sites to further evaluate groundwater-surface water interaction, and recharge/discharge mechanisms, including whether groundwater utilization is affecting surface water flows;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

Figures 3-2 and **3-3** illustrate the locations of the wells selected for monitoring of groundwater levels in the upper and lower aquifers, respectively. **Tables 3-14** and **3-15** list the well identification, location, monitoring frequency, well construction data (which includes well depth, perforation intervals, and ground surface elevation (GSE)), and measurement years, and number of measurements for the Upper and Lower Aquifer, respectively.

In order to assist local agencies with the preparation of their GSP's, DWR released a series of best management practices (BMPs). The BMPs document for monitoring networks provides guidance on determining an appropriate number of monitoring wells. The method developed by Hopkins (1984) was applied to the Bowman Subbasin. This methodology states that for districts pumping more than 10,000 ac-ft/yr per 100 square miles, they should have 1 monitoring wells for every 25 square miles. The Bowman Subbasin is approximately 192 square miles, yielding 1 monitoring well at the minimum per aquifer. Additional wells were added based on informational needs resulting from PMA and historical trends in groundwater levels.

After computing the appropriate number of monitoring wells for the Subbasin based on the Hopkins method, a hexagonal tessellation was generated in ArcPro for the Bowman and three (3) nearby subbasins (Antelope, Los Molinos, and Red Bluff) **(Figure 3-8)**. Portions of eight (8) different hexagons overlapped with the Bowman Subbasin.

All available wells with complete construction data and aquifer assignment were then mapped onto this grid. Water level data from each well was evaluated on the following criteria:

- evidence of recent monitoring
- length of historical record
- overlap with model timeframe

The wells were then plotted against the hexagons and each hexagon was examined separately for both the upper and lower aquifers. Wells were selected based on the evaluation criteria listed above. When possible, preference was given to wells that not only met the criteria but were also apart of either the California State Groundwater Elevation Monitoring (CASGEM) or Tehama County Monitoring Network. The final selection of wells for the monitoring network is presented in **Tables 3-14 and 3-15** for the upper and lower aquifers, respectively. The selection rationale for all water level monitoring wells is summarized in **Table 3-16.**

Table 3-14. Groundwater Level Monitoring Well Network – Upper Aquifer

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Bow-1 SWN: 29N03W18M001M	40.3672	-122.255	Bi-annual (Fall/Spring)	234 (ft, bgs)	N/A (ft, bgs)	418.54	7/7/2004	3/12/2020	17	98
Bow-2 SWN: 29N04W28D001M	40.345354	-122.332	Bi-annual (Fall/Spring)	134 (ft, bgs)	114 - 134 (ft, bgs)	502.54	10/19/1978	3/13/2020	43	113
Bow-3 SWN: 29N05W33A004M	40.329012	-122.426	Bi-annual (Fall/Spring)	210 (ft, bgs)	110 - 210 (ft, bgs)	534.56	9/13/2000	3/13/2020	21	67
Bow-4 SWN: 28N04W04P001M	40.304065	-122.323	Bi-annual (Fall/Spring)	270 (ft, bgs)	200-270 (ft, bgs)	537.54	10/12/1994	3/13/2020	24	60

Table 3-15. Groundwater Level Monitoring Well Network – Lower Aquifer

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Rio Alto 6 SWN: 29N03W21	40.354478	-122.212	Bi-annual (Fall/Spring)	N/A (ft, bgs)	N/A (ft, bgs)	624	3/28/2014	9/22/2020	6	21
Bow-1 (lower) SWN: 29N04W20A002M	40.358539	-122.334	Bi-annual (Fall/Spring)	451 (ft, bgs)	360 - 430 (ft, bgs)	451.75	5/22/2007	3/12/2020	14	72
Bow-2 (lower) SWN: 29N05W21H001M	40.353213	-122.43	Bi-annual (Fall/Spring)	280 (ft, bgs)	250 - 280 (ft, bgs)	622.55	4/20/2000	3/13/2020	21	60

Table 3-16. Summary of Rationale for Selection for Wells Using Groundwater Levels

Site	Aquifer	Basis for Selection
Bow-1 **SWN: 29N03W18M001M**	Upper	Period of record, CASGEM and TC Well
Bow-2 **SWN: 29N04W28D001M**	Upper	Period of record, CASGEM and TC Well
Bow-3 **SWN: 29N05W33A004M**	Upper	Period of record, CASGEM and TC Well
Bow-4 **SWN: 28N04W04P001M**	Lower	Period of record, CASGEM and TC Well
Rio Alto 6 **SWN: 29N03W21**	Lower	Period of record, CASGEM and TC Well
Bow-1 (lower) **SWN: 29N04W20A002M**	Lower	Period of record, CASGEM and TC Well
Bow-2 (lower) **SWN: 29N05W21H001M**	Lower	Period of record, CASGEM and TC Well

3.6.3 Groundwater Storage Monitoring Network

The objectives of the monitoring program are:

- Use groundwater level data and knowledge of aquifer storage coefficients to calculate changes in groundwater storage.
- Improve the understanding of the occurrence and movement of groundwater.
- Monitor local and regional groundwater levels including seasonal and long-term trends.
- Monitor groundwater levels where projects and s are planned.

Changes in groundwater storage cannot be measured directly, therefore this GSP adopts groundwater levels as a proxy for assessing change in storage, as described previously in Chapter 3. The wells selected for monitoring changes in groundwater storage will be the same wells used for groundwater level monitoring. **Figures 3-2** and **3-3** illustrate the locations of the wells selected for monitoring of groundwater levels for the Upper and Lower Aquifers, respectively. **Tables 3-17** and **3-18** list the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the Upper and Lower Aquifer, respectively. The same wells for water level monitoring are proposed for groundwater storage monitoring and the selection process and rationale for selection is consistent with section 3.11.1.1 (**Table 3-19**).

Table 3-17. Groundwater Storage Monitoring Network – Upper Aquifer

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Bow-1 SWN: 29N03W18M001M	40.3672	-122.255	Bi-annual (Fall/Spring)	234 (ft, bgs)	N/A (ft, bgs)	418.54	7/7/2004	3/12/2020	17	98
Bow-2 SWN: 29N04W28D001M	40.345354	-122.332	Bi-annual (Fall/Spring)	134 (ft, bgs)	114 - 134 (ft, bgs)	502.54	10/19/1978	3/13/2020	43	113
Bow-3 SWN: 29N05W33A004M	40.329012	-122.426	Bi-annual (Fall/Spring)	210 (ft, bgs)	110 - 210 (ft, bgs)	534.56	9/13/2000	3/13/2020	21	67
Bow-4 SWN: 28N04W04P001M	40.304065	-122.323	Bi-annual (Fall/Spring)	270 (ft, bgs)	200-270 (ft, bgs)	537.54	10/12/1994	3/13/2020	24	60

Table 3-18. Groundwater Storage Monitoring Network – Lower Aquifer

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Rio Alto 6 SWN: 29N03W21	40.354478	-122.212	Bi-annual (Fall/Spring)	N/A (ft, bgs)	N/A (ft, bgs)	624	3/28/2014	9/22/2020	6	21
Bow-1 (lower) SWN: 29N04W20A002M	40.358539	-122.334	Bi-annual (Fall/Spring)	451 (ft, bgs)	360 - 430 (ft, bgs)	451.75	5/22/2007	3/12/2020	14	72
Bow-2 (lower) SWN: 29N05W21H001M	40.353213	-122.43	Bi-annual (Fall/Spring)	280 (ft, bgs)	250 - 280 (ft, bgs)	622.55	4/20/2000	3/13/2020	21	60

Table 3-19. Summary of Rationale for Selection for Wells Used for Storage

Site	Aquifer	Basis for Selection
Bow-1 SWN: 29N03W18M001M	Upper	Period of record, CASGEM and TC Well
Bow-2 SWN: 29N04W28D001M	Upper	Period of record, CASGEM and TC Well
Bow-3 SWN: 29N05W33A004M	Upper	Period of record, CASGEM and TC Well
Bow-4 SWN: 28N04W04P001M	Lower	Period of record, CASGEM and TC Well
Rio Alto 6 SWN: 29N03W21	Lower	Period of record, CASGEM and TC Well
Bow-1 (lower) SWN: 29N04W20A002M	Lower	Period of record, CASGEM and TC Well
Bow-2 (lower) SWN: 29N05W21H001M	Lower	Period of record, CASGEM and TC Well

3.6.4 Subsidence Monitoring Network

Data from several different monitoring programs for subsidence is available for the Bowman Subbasin. These programs include four (4) PBO stations within the vicinity of the Subbasin, 2017 GPS Survey Data from DWR, and InSAR satellite vertical displacement data. None of the PBO stations exist inside the Subbasin so these sites were not selected for the monitoring program. The data collected by DWR showed minor levels of subsidence, but these readings fell within their margin of error of 0.17 ft. These stations were also not included in the final monitoring program. Lastly, InSAR data spanned the entirety of the Subbasin, and data pixels were available at or near each groundwater level monitoring well. This data has a relatively small error margin (18 mm or 0.06 ft) and is available to download on a monthly or annual basis with continuous measurements.

Therefore, the sustainability indicator for land subsidence is evaluated by monitoring land surface elevation at select InSAR data pixels near groundwater level monitoring wells. Specifically, six (6) pixels are monitored for vertical displacement. Selecting pixels near the groundwater monitoring wells will allow the GSA to study the impact of falling and rising water levels on subsidence in the same location and develop a relationship between water levels and subsidence over time. The pixels and rationale for selection are presented in **Table 3-20 and Table 3-21.**

Table 3-20. Land Subsidence Monitoring Network

Site ID	Site Type	Measurement Type	Years of Record
DXF1N61	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019
DXAA6E6	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019
DWYYXU2	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019
DWIASYT	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019
DXNZ5CY	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019
DXFN2X3	InSAR pixel	Vertical Ground Surface Displacement	2015 - 2019

Table 3-21. Summary of Rationale for Selection of Subsidence Monitoring Sites

Site	Site Type	Basis for Selection
DXF1N61	InSAR pixel	Proximity to GWL well
DXAA6E6	InSAR pixel	Proximity to GWL well
DWYYXU2	InSAR pixel	Proximity to GWL well
DWIASYT	InSAR pixel	Proximity to GWL well
DXNZ5CY	InSAR pixel	Proximity to GWL well
DXFN2X3	InSAR pixel	Proximity to GWL well

3.6.5 Groundwater Quality Monitoring Network

The sustainability indicator for degraded water quality is evaluated by monitoring groundwater quality at a network of existing monitoring wells.

The objectives of the groundwater quality monitoring program for the Subbasin include the following:

- Evaluate groundwater quality conditions in the various areas of the basin, and identify differences in water quality spatially between areas in the aquifer system;
- Detect the occurrence of and factors attributable to natural (e.g., general minerals and trace metals) constituents of concern as represented by total dissolved solids (TDS);
- Assess the changes and trends in groundwater quality (seasonal, short- and long-term trends); and
- Identify the natural and human factors that affect changes in water quality

Figures 3-5 illustrates the locations of the wells selected for monitoring of groundwater quality.

Table 3-22. Groundwater Quality Monitoring Network

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Bow-1 SWN: 29N03W18M001M	40.3672	-122.255	Bi-annual (Fall/Spring)	234 (ft, bgs)	N/A (ft, bgs)	418.54	N/A	N/A	N/A	N/A
Bow-2 SWN: 29N04W28D001M	40.345354	-122.332	Bi-annual (Fall/Spring)	134 (ft, bgs)	114 - 134 (ft, bgs)	502.54	N/A	N/A	N/A	N/A
Bow-3 SWN: 29N05W33A004M	40.329012	-122.426	Bi-annual (Fall/Spring)	210 (ft, bgs)	110 - 210 (ft, bgs)	534.56	N/A	N/A	N/A	N/A
Bow-4 SWN: 28N04W04P001M	40.304065	-122.323	Bi-annual (Fall/Spring)	270 (ft, bgs)	200-270 (ft, bgs)	537.54	N/A	N/A	N/A	N/A

Table 3-22 lists the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the monitoring wells.

Similar to the approach for groundwater level monitoring above, monitoring wells were distributed across the Subbasin using the Hopkins method to provide thorough coverage. Although spatial and temporal data gaps exist in groundwater quality data, this network will allow for a comprehensive mapping of TDS trends. Continuous monitoring at the sites selected will establish a temporal record moving forward and assist in evaluating PMA implemented moving forward. The distribution of wells across the Subbasin will not only help delineate spatial differences in TDS concentration but will also highlight areas in need of project and management actions in the future. Subsequent updating of the groundwater quality constituents will be developed in future GSP updates based on annual evaluation of TDS concentrations. The groundwater quality monitoring wells were ultimately chosen to be the same wells as the groundwater level monitoring wells. This approach will allow for ease of sampling and allow for future comparisons of changing water levels with water quality.

The selection rationale for groundwater quality monitoring wells is summarized in **Table 3-23.** Each site will comply with the data and reporting standards that are described in **Section 3.5.2.**

Table 3-23. Summary of Rationale for Selection for Wells Used Groundwater Quality

Site	Aquifer	Basis for Selection
Bow-1 **SWN: 29N03W18M001M**	Upper	CASGEM and Tehama County Well
Bow-2 **SWN: 29N04W28D001M**	Upper	CASGEM and Tehama County Well
Bow-3 **SWN: 29N05W33A004M**	Upper	CASGEM and Tehama County Well
Bow-4 **SWN: 28N04W04P001M**	Upper	CASGEM and Tehama County Well

3.6.6 Interconnected Surface Water Monitoring Network

Groundwater level monitoring wells within 1 mile of water bodies will be used as a proxy for monitoring. These wells are summarized in **Table 3-24** below. The basis for the selection of these wells in the interim is summarized in **Table 3-25**. There are extensive data gaps in the availability of monitoring sites. This data gap is discussed further in **Section 3.7.8.7.**

Table 3-24. Interconnected Surface Water Monitoring Network

Well ID	Latitude	Longitude	Monitoring Frequency	Well Depth	Well Screen Interval	Ground surface Elevation	First Year of Data	Last Year of Data	Years Measured	Number of Measurements
Bow-1 SWN: 29N03W18M001M	40.3672	-122.255	Bi-annual (Fall/Spring)	234 (ft, bgs)	N/A (ft, bgs)	418.54	7/7/2004	3/12/2020	17	98
Bow-2 SWN: 29N04W28D001M	40.345354	-122.332	Bi-annual (Fall/Spring)	134 (ft, bgs)	114 - 134 (ft, bgs)	502.54	10/19/1978	3/13/2020	43	113
Bow-3 SWN: 29N05W33A004M	40.329012	-122.426	Bi-annual (Fall/Spring)	210 (ft, bgs)	110 - 210 (ft, bgs)	534.56	9/13/2000	3/13/2020	21	67
Bow-4 SWN: 28N04W04P001M	40.304065	-122.323	Bi-annual (Fall/Spring)	270 (ft, bgs)	200-270 (ft, bgs)	537.54	10/12/1994	3/13/2020	24	60

Table 3-25. Summary of Rationale for Selection for Wells for Interconnected Surface Waters

Site	Aquifer	Basis for Selection
Bow-1 SWN: 29N03W18M001M	Upper	Upper aquifer well
Bow-2 SWN: 29N04W28D001M	Upper	Upper aquifer well
Bow-3 SWN: 29N05W33A004M	Upper	Upper aquifer well
Bow-4 SWN: 28N04W04P001M	Upper	Upper aquifer well

3.7 Description of Monitoring Protocols (*Reg. § 354.34)*

3.7.1 Protocols for Monitoring Sites

The monitoring protocols that will be used by the GSA as part of implementing this Groundwater Sustainability Plan are largely based on the *Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites* produced by the DWR. The recommended monitoring protocols were adjusted and added to fit the specific monitoring needs of the Subbasin to achieve sustainability. Monitoring protocols for interconnected surface waters are the same as those for groundwater levels due to the proxy network. Also, monitoring protocols for seawater intrusion were not necessary as the Subbasin is not connected to the coast. The monitoring protocols that are described in this document will provide the necessary data to track the MT and MO for each of the sustainability indicators. The monitoring protocols established herein will be reviewed every 5 years as a part of periodic GSP updates. The following protocols will be applied to all monitoring sites:

- Long-term access agreements. Access agreements should include year-round site access to allow for increased monitoring frequency.
- A unique identifier that includes a written description of the site location, date established, access instructions, type(s) of data to be collected, latitude, longitude, and elevation.
- A modification log is to be kept to track all modifications to the monitoring site.

3.7.2 Groundwater Level Elevation

3.7.2.1 Protocols for Measuring Groundwater Levels

Protocols for measuring groundwater levels including the following:

- Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the Reference Point (RP).
- For measuring wells that are under pressure, allow time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. If a well is artesian, site-specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in the well. Record the dimension of the extension and document measurements and configuration.
- The groundwater elevation should be calculated using the following equation.

  GWE= RPE−DTW

  Where:
  GWE = Groundwater Elevation in NAVD88 datum
  RPE = Reference Point Elevation in NAVD88 datum
  DTW = Depth to Water

- The measurements of depth to water should be consistent in units of feet, to an accuracy of tenths of feet or hundredths of feet.
- The well caps or plugs should be secured following depth to water measurement.
- Groundwater level measurements are to be made on a semi-annual basis at a minimum during periods which will capture seasonal highs and lows.

3.7.2.2 Recording Groundwater Level Measurements

- The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted. Standardized field forms should be used for all data collection.
- All data should be entered into the GSA data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person.

3.7.2.3 Installing Pressure Transducers and Downloading Data

The following procedures will be followed in the installation of a pressure transducer and periodic data downloads:

- The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated later after downloading.
- The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.
- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment will be exercised to ensure that the data being collected is meeting the Data Quality Objectives (DQO) and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.
- The sampler must note whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Vented cables are preferred, but non-vented units provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.
- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.
- Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.

- The transducer data should periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually to maintain data integrity.
- The data should be downloaded as necessary to ensure no data is lost and entered into the basin's DMS following the quality assurance/quality control (QA/QC) program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.

3.7.3 Groundwater Storage Measurements

The monitoring protocols for evaluating change in groundwater storage are the same as the protocols described above for groundwater levels.

3.7.4 Groundwater Quality Measurements

Annual monitoring of groundwater quality will include sampling and laboratory analysis of TDS. Additional constituents will be considered in the future as additional information becomes available. During the first sampling event, these wells will also be tested for major anions (carbonate, bicarbonate, chloride, sulfate) and major cations (boron, calcium, sodium, magnesium, potassium). Following the first sampling event, these anions and cations will be tested for every 5 years. During sampling events, measurement of select water quality parameters will take place in the field. These field parameters should be measured at an annual frequency and include electrical conductivity at 25 °C (EC) in µS/cm, pH, temperature (in °C), and dissolved oxygen (DO) in mg/L. The annual testing is summarized in **Table 3-26**.

The GSP monitoring program will use the following protocols for collecting groundwater quality samples:

- Prior to sampling, the analytical laboratory will be contacted to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well used for groundwater quality monitoring will have a unique identifier. This identifier will appear on the well housing or the well casing to verify well identification.
- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead following purging.
- Prior to sampling, the sampling port and sampling equipment will be cleaned of any contaminants. The equipment will be decontaminated between each sampling locations or wells to avoid cross-contamination.
- The groundwater elevation in the well should be measured following appropriate protocols described above in the groundwater level measuring protocols.
- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three (3) well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be

evacuated (go dry), document the condition and allow well to recover to within 90 percent of original level prior to sampling.

- Field parameters of pH, electrical conductivity and temperature should be collected during purging and prior to the collection of each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Measurements of pH should only be measured in the field; lab pH analysis are typically unachievable due to short hold times. Other parameters, such as Oxidation-Reduction Potential (ORP), Dissolved Oxygen (DO) (in situ measurements preferable), or turbidity, may also be useful for assessing purge conditions. All field instruments will be calibrated daily and evaluated for drift throughout the day.
- Sample containers should be labeled prior to sample collection. The sample label must include sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.
- Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.
- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field filtered prior to preservation; do not collect an unfiltered sample in a preserved container.
- Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.
- Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.
- Groundwater quality samples shall be collected annually.
- All data will be entered into the GSA data management system (DMS) as soon as possible. Data entries should be checked by a second person to avoid incorrect data.

Table 3-26. Summary of Groundwater Quality Monitoring Constituents and Measurement Frequency for Representative Monitoring Sites

Site	Field Measurements	Laboratory Measurements (Annual)	Laboratory Measurements (5-Year)
All Wells	Specific Conductance pH Dissolved Oxygen ORP Temperature	TDS	Carbonate Bicarbonate Chloride Sulfate Calcium Sodium Magnesium Potassium Nitrate

3.7.5 Subsidence Measurements

Subsidence monitoring for WWD will include the following protocols:

- Download and review subsidence data from the six (6) pixels designated as monitoring points for subsidence.
- Review groundwater level data collected at monitoring wells near each pixel. Analyze both datasets to determine if any meaningful correlations can be identified.

3.7.6 Interconnected Surface Water Measurements

Groundwater level monitoring wells within the upper aquifer will be used as a proxy for this indicator.

3.7.7 Representative Monitoring (*Reg. § 354.36*)

Representative Monitoring Sites (RMS) are defined in the GSP regulations as a subset of monitoring sites that are representative of conditions in the Subbasin. All the monitoring sites in this section are considered RMS using methods of selection consistent with best management practices described above under the groundwater level protocols. Groundwater elevation monitoring will be used to determine changes in groundwater storage. As previously stated in Chapter 3, reduction in groundwater storage cannot be directly measured. However, groundwater level data will be used in conjunction with aquifer parameters and the groundwater model to compute changes in groundwater storage subbasin wide. In the case of subsidence, no highly susceptible areas exist in the Subbasin. However, six (6) InSAR pixels will be monitored for vertical displacement and over time, the GSA will examine this data in conjunction with water level data collected to determine whether changes in water levels can be used as an early detection method for compaction, if possible.

3.7.8 Assessment and Improvement of Monitoring Network ((*Reg. § 354.38*)

As described in section 354.38 of the GSP Regulations, each agency is required to analyze the monitoring network for improvements as follows:

- Each GSA shall review the monitoring network and include an evaluation in the Plan and each 5 -year assessment, 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 basin.
- Each GSA shall identify data gaps wherever the basin does not contain enough monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the GSA.
- If the monitoring network contains data gaps, the Plan shall include a description of the following:
    - The location and reason for data gaps in the monitoring network
    - Local issues and circumstances that limit or prevent monitoring
- Each GSA shall describe steps that will be taken to fill data gaps before the next 5-year assessment, including the location and purpose of newly added or installed monitoring sites

- Each GSA shall adjust the monitoring frequency and distribution of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of PMA under circumstances that include the following:
    - Minimum threshold exceedances
    - Highly variable spatial or temporal conditions
    - Adverse impacts to beneficial uses and users of groundwater
    - The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin

Monitoring frequency and density of sites for all sustainability indicators are described in previous sections in Chapter 3 of this Plan.

3.7.8.1 Review and Evaluation of the Monitoring Network

The monitoring networks described above for each of the applicable sustainability indicators will be evaluated on a yearly basis. This evaluation will involve a review of the described MT and MO and their comparison to observed trends in the networks. Furthermore, a more comprehensive review of the monitoring networks will be conducted every five (5) years as part of the GSP updates. During this review, projects and s will be evaluated, and the monitoring networks will be assessed for their efficacy in tracking progress based on the actions and projects. These evaluations and assessments also will highlight any additional data gaps and recommended changes to the monitoring networks.

3.7.8.2 Identification and Description of Data Gaps

Identification and description of data gaps for the monitoring networks described above for each of the applicable sustainability indicators are described below.

3.7.8.3 Groundwater Elevation

Groundwater elevation data has been extensively collected within the Subbasin over the past several decades therefore no data gaps were identified for this indicator.

3.7.8.4 Groundwater Quality

Data gaps in water quality monitoring exist on a temporal basis but not a spatial basis. During well selection, the limiting criteria was the record of TDS measurements. Historical data related to TDS was not continuously collected for a long period of time at any monitoring wells and no wells had TDS data spanning the base period of the model. The RMS wells were chosen to monitor groundwater quality within the Subbasin. The GSA plans to monitor these wells on a yearly basis and will establish a continuous monitoring record moving forward. This data collection will enable the GSA to identify any additional data gaps or noticeable trends in water quality.

3.7.8.5 Groundwater Storage

Groundwater storage data gaps are described in the groundwater elevation section as water levels are being used as a proxy for groundwater storage.

3.7.8.6 Subsidence

No data gaps are presently evident in the Subbasin for subsidence monitoring; however, the network will be reevaluated on a yearly basis for any emerging data gaps.

3.7.8.7 Interconnected Surface Waters

The interconnected surface water indicator had the most prominent data gaps compared to all other indicators. The two (2) contributors to this data gap were the lack of shallow (< 50 feet) monitoring wells in the vicinity of interconnected surface waters and critical groundwater dependent ecosystem (GDEs) and the lack of stream gages. Additionally, shallow well and stream gage based historical measurements were another form of data gap.

All GDEs within the Bowman Subbasin were examined and high priority GDEs were identified based on the change in the normalized difference vegetation index (NDVI). The high priority GDEs were mapped alongside shallow monitoring wells (**Figure 3-7**). However, no suitable monitoring wells for these GDEs could be identified due to the distance of wells from the GDEs (> 1 mile), the depth of the wells(> 50 feet), or the lack of correlation between the water level data to GDE health indicators.

Model results were used to identify interconnected surface waters within the Subbasin. The locations of these surface waters were compared to shallow monitoring wells. However, this analysis did not yield any viable monitoring wells within a one-mile radius of the surface waters (**Figure 3-8**). Furthermore, many surface water features lacked stream gages. Therefore, no meaningful comparisons could be made between surface water feature levels and groundwater levels if shallow monitoring wells were available.

Due to these extensive data gaps, groundwater level monitoring wells within the upper aquifer will be used as a proxy for monitoring.

3.7.8.8 Description of Steps to Remedy Data Gaps

Data gaps have been presented in the groundwater elevation, groundwater quality, and groundwater storage monitoring networks. The GSA will take the following steps, prior to the first 5-year GSP update in 2027 to address these data gaps:

- Sampling events will be coordinated with well owners to prevent pumping and access issues.
- Although no monitoring network is currently in place for interconnected surface water, the GSA will look at the data gaps brought forth in the GDE and surface water data assessment and aim to bridge these gaps through the installation of shallow monitoring wells and stream gages near areas of concern. Also, it will consider conducting synoptic stream gaging where conditions are safe to do so.

In addition to these steps, the monitoring networks will be evaluated on a yearly and 5-year basis. If additional data gaps arise, the GSA will consider the implications of these gaps, associated costs, and importance to the continued implementation of the GSP and take appropriate actions to address the gaps.