A.2 Component 3: Subsidence Workplan Implementation

Some areas of the Madera Subbasin (Subbasin) have experienced land subsidence in recent years, as documented in the four GSPs developed for the Subbasin (see Att4 Fig. 1-11). Much of the historical land subsidence in the Subbasin is believed to be caused by declining groundwater levels or piezometric head within the Lower Aquifer below the Corcoran Clay, and associated release of water from fine-grained sediments, ultimately resulting in compaction of these fine-grained sediments. In other areas of the San Joaquin Valley with long-term historical monitoring of both land subsidence and groundwater levels, land subsidence has been correlated with declining groundwater levels in the Lower Aquifer. Furthermore, considerable lag time between declining groundwater levels and land subsidence has been observed in other areas of the San Joaquin Valley. Within the Subbasin, limited long-term data are available for relating groundwater levels and land subsidence. Although there is considerable historical monitoring of land subsidence in the Subbasin, most of this monitoring has occurred at infrequent temporal intervals and with varying spatial resolution and distribution. As a result, there are gaps in the understanding of mechanisms and conditions related to land subsidence in the Subbasin, especially as it relates to how historical groundwater level decline may continue to cause ongoing residual land subsidence in the Subbasin, even as groundwater levels stabilize or rise in the future, as is planned for in the different GSPs. Att4 Fig. 1-13a through 1-13d show the spring and fall 2021 groundwater elevations in the upper/undifferentiated and lower aquifers.

The GSPs do not establish sustainable management criteria (SMC) for land subsidence. However, revisions to the GSPs (planned for completion in April 2023) will seek to provide additional information on subsidence and further consideration of land subsidence SMC in light of DWR review and input received in the initial consultation letter related to DWRs evaluation of the GSPs. Additional characterization of the relationship between groundwater levels and land subsidence and mechanisms for mitigating future land subsidence are important for considering as the land subsidence SMC are reviewed and revised in response to the DWR consultation letter. The Subbasin intends to develop a Subsidence Workplan that will outline future steps important for addressing land subsidence monitoring and management in the Subbasin. Implementation of the Subsidence Workplan is intended to provide additional field data and technical analyses as input to better characterizing land subsidence for informing the five-year updates to the Subbasin GSPs, starting in 2025. Additionally, information and monitoring facilities developed through completion of this component will inform adaptive management of groundwater in the Subbasin, including ongoing evaluation of projects and management actions necessary to achieve and maintain sustainable groundwater management.

This component consists of a series of tasks relating to implementation of the Subsidence Workplan for the Subbasin that is being planned in coordination with revisions to the GSPs that are currently being prepared. Implementation of the Subsidence Workplan will involve effort to compile and evaluate additional data, install additional monitoring facilities, conduct technical and modeling analyses, perform assessments to support development of policies to mitigate future subsidence in the Madera Subbasin (as needed), and evaluate subsidence SMC to be established in the revised GSP and in updates to the GSPs performed every five years.

The Subsidence Workplan will outline future efforts intended to address data gaps identified during revisions to the Subbasin GSPs through enhanced monitoring and improving understanding of relationships between groundwater conditions and land subsidence in the Subbasin. Implementing the Subsidence Workplan will also include tasks to further evaluate sustainable management criteria (SMC) for land subsidence and support development of a coordinated approach to implementation of projects and management actions (PMAs) presented in the Subbasin GSPs to address land subsidence and achieve sustainable groundwater management.

Key aspects of land subsidence in the Subbasin that are not well understood or quantified relate to:

- Residual land subsidence, specifically differentiating residual land subsidence caused by historical conditions from new land subsidence caused by current conditions, and
- The mechanisms and conditions causing land subsidence in the Subbasin, including the relationship between land subsidence and declining groundwater levels, especially in the Lower Aquifer, within the local context of the Subbasin.

Robust land subsidence monitoring coupled with well-defined groundwater level monitoring will be important for tracking the different mechanisms related to land subsidence.

Potential opportunities and benefits related to improving the understanding of relationships between groundwater levels and land subsidence will come from:

- Continued monitoring of existing benchmarks, including the many land subsidence benchmarks in the Subbasin that are monitored by the United States Bureau of Reclamation (USBR) as part of the SJRRP, and
- Coupling groundwater level monitoring in the vicinity of sites with historical and ongoing land subsidence monitoring.

This Workplan will outline a proposed scope of work to compile and review additional data and reports pertaining to land subsidence in the Subbasin, improve understanding of active production wells, establish or construct additional monitoring facilities, and conduct additional technical analyses. The Workplan will consider comments and guidance provided by DWR during the initial GSP review and consultation stages. The purpose of implementation of the Subsidence Workplan is to provide sufficient data and analyses to:

- Enhance monitoring and understanding of relationships between land subsidence and groundwater levels at different depths within the western part of the Subbasin;
- Refine mapping of geologic conditions related to land subsidence, including the thickness and extent of the Corcoran Clay and other clay units;
- Improve quantification of groundwater pumping within each of the two principal aquifers (Upper and Lower Aquifer) in the western part of the Subbasin;
- Develop estimates of the amount of expected residual land subsidence caused by historical groundwater conditions that cannot be avoided; and
- Assess the adequacy of the PMAs and sustainable management criteria (SMC) in the GSPs in addressing undesirable results related to land subsidence in the Subbasin, including evaluating groundwater level metrics used as a proxy for land subsidence.

The scope of work involved in implementation the Subsidence Workplan includes seven tasks described below.

Task 1: Compile Additional Existing Data and Update Assessment of Available Data

This task includes several aspects involving compiling and reviewing of supplemental existing data for incorporation in analyses and characterization of conditions relating to subsidence in the Subbasin. Additional available existing data will be compiled and reviewed from the following sources: other GSPs, specific local landowners, DWR Well Completion Reports, US Bureau of Reclamation San Joaquin River Restoration Project (SJRRP), USGS SJRRP modeling data, other reports and data, InSAR data provided by DWR, and aerial electromagnetic (AEM) surveys completed by DWR. The available data will be compiled and reviewed to inform subsequent field work and used as inputs for technical analyses. This task can be performed in coordination with similar efforts planned as part of implementation of the Interconnected Surface Water (ISW) Workplan proposed for the Subbasin.

Task 2: Complete Additional Field Work

Enhancements to groundwater level monitoring facilities and activities, specifically in proximity to sites with historical land subsidence monitoring (e.g., SJRRP benchmarks), are important for improving the understanding of the relationships between groundwater levels and land subsidence across the Subbasin. Developing continuous groundwater level monitoring at finer temporal scales and at different depths in key areas where land subsidence monitoring is conducted will support understanding of the relationship between groundwater levels at different depths and any associated land subsidence, and will help differentiate residual land subsidence caused by historical groundwater conditions from active land subsidence related to current and future conditions. This task will include identification and instrumentation of existing wells with automated and continuous groundwater level monitoring equipment. Additionally, the field work will include identifying and installing new monitoring wells in key areas of the Subbasin where data gaps exist. As many as five potential monitoring well sites are anticipated to be included in the Subsidence Workplan in locations where increasing amounts of recent subsidence have occurred (see Att4 Fig. 1-11) or where information on groundwater conditions is limited. The selection of sites for monitoring facilities to be installed through implementation of this component will be coordinated with any other monitoring enhancements occurring through completion of other components, including the ISW Workplan and Monitoring Network Enhancements efforts. This task will also include efforts to refine existing information on active wells in the western part of the Subbasin through completion of an inventory of active wells. This would be conducted through a combination of preliminary desktop analysis with field verification. The refinement of information on active wells will help in quantification of pumping by aquifer zone in the western part of the Subbasin.

Task 3: Technical Analyses

In this task, technical analyses will be conducted to synthesize the available information on dynamics between groundwater levels and land subsidence by evaluating fluctuations in groundwater levels and land subsidence and by evaluating relationships between groundwater pumping and land subsidence. This task will be completed in coordination with and utilizing new information from compilation of additional available data and field work related to additional monitoring and characterization of groundwater conditions and land subsidence. Field and monitoring data will be evaluated relative to the relationship between groundwater levels in both the Upper and Lower Aquifers and land subsidence and consideration of ongoing residual land subsidence. Technical analyses will consider information developed from monitoring of land subsidence in relation to groundwater levels in adjacent subbasins, especially in Chowchilla Subbasin to the north where greater amounts of historical subsidence have occurred. The technical work will also include conducting refinements to existing available information on the mapped extent and thickness of the Corcoran Clay and other clay layers.

Task 4: Groundwater Modeling

Distinguishing between residual land subsidence resulting from historical groundwater conditions and active land subsidence caused by current conditions is a challenging aspect of evaluating appropriate metrics for ensuring sustainable groundwater management. Modeling techniques represent one of the most robust approaches available for evaluating this aspect of groundwater conditions. Key objectives of the modeling to be conducted under this task include 1) estimating the amount, rate, and duration of residual land subsidence likely to occur resulting from historical groundwater conditions, and 2) estimating total anticipated future land subsidence. Two potential modeling approaches would help in evaluating historical

and projected land subsidence in the Subbasin and differentiation of residual land subsidence from active land subsidence. One modeling approach involves use of the existing numerical model developed for the Subbasin (MCSim) with incorporation of updates to simulate subsidence. Another approach includes use of a more simplified one-dimensional model to quantify residual and active subsidence. Both of these approaches will be considered during implementation of the groundwater modeling task of the Subsidence Workplan.

Task 5: Stakeholder Outreach and Interbasin Coordination

Implementation of the Workplan should involve outreach and coordination with key stakeholders and interested parties. Outreach efforts should focus on efforts related to the need and benefit from additional groundwater level or land subsidence monitoring and prioritization of efforts to expand monitoring. An additional objective of outreach efforts includes coordination related to the understanding of critical land subsidence thresholds related to damage to infrastructure or other adverse impacts to infrastructure. Furthermore, outreach efforts may also benefit considerations related to the feasibility of potential PMAs to achieve sustainability.

Task 6: Assess the Adequacy of Revised GSP SMC

An important outcome from efforts conducted as part of this Workplan will be an assessment of the adequacy of current land subsidence SMC and the associated RMS network and need for any revisions to these SMCs as part of updates and revisions to the GSPs. The assessment will consider data and analyses developed through implementation of Tasks 1 through 5 of this component and relationships between groundwater levels and land subsidence and the differentiation of residual land subsidence from new active subsidence established through that work. The review and assessment of SMC completed under this task will inform decisions on revisions to land subsidence SMC for incorporation in updates and revisions to the GSPs.

Task 7: Prepare a Technical Memorandum or Report

A technical memorandum (TM) or report will be prepared to document all the tasks completed as part of implementation of the Subsidence Workplan. An interim TM/Report deliverable will be prepared to inform the five-year GSP update efforts occurring prior to January 2025. A Final TM/Report will be prepared and submitted at the time of completion of all field work outlined in the Workplan.

Summary of Component Benefits

The **goal** of this component is to enhance the characterization of subsidence within the Subbasin. The **objectives** are to fill data gaps, improve and expand monitoring activities, engage stakeholders, and synthesize new and existing subsidence data. The **needs** for this component, in addition to funding, include support from GSA staff and participation by the Madera Subbasin community and stakeholders. The component will meet the goals, objectives and needs by implementing the scope of work, providing there is sufficient funding, based on the budget request, herein.

This component will provide benefits for Underrepresented Communities (URCs) in the Subbasin (Att4 Fig. 1-1 and 1-2) The Madera Subbasin includes URCs: Disadvantaged Communities (DACs) in Madera, Parksdale, and Parkwood, and a Severely Disadvantaged Community (SDAC) in the Fairmead area (shown in Att4 Fig. 1-1 and 1-12). This component would benefit these URCs by reducing risks associated with unsustainable groundwater conditions and improving management of groundwater resources through informed decision making and robust monitoring. Funding support for this component will reduce the financial burden on URCs in the Subbasin to fund the activities necessary to implement the GSPs, including implementation of the Subsidence Workplan. This component will also directly affect measurable objectives (MOs) and minimum thresholds (MTs) established for subsidence by informing the assessment of the sustainable management criteria and metrics included in the Subbasin GSPs. The work completed through this component will also support development of management actions and projects necessary to mitigate impacts from future land subsidence and avoid undesirable results in the Subbasin. Notably, information and monitoring facilities developed through implementation of the Subsidence Workplan will inform adaptive management of groundwater in the Subbasin to ensure sustainability is achieved and maintained. Implementation of this component will be completed by April 2026 and is **feasible** if funded. The component **benefits** include enhanced well and water information so the GSA can better manage the subbasin and stakeholder engagement to support monitoring and mitigation activities. Additionally, the component will assist in the GSP implementation, since it will improve characterization of subsidence and provide more robust monitoring data, both land subsidence and groundwater, for the Subbasin.