Technical Memorandum

To: Mr. Sean Geivet
Porterville Irrigation District

From: Thomas Harder, P.G., CH.G.
Benjamin Lewis, P.G., CH.G.
Thomas Harder & Co.

Date: 20-Dec-23

Re: Potential Groundwater Changes Associated with Proposed Groundwater Banking in the Porterville and Saucelito Irrigation Districts – Hydrogeological Analysis

1. Introduction

This Technical Memorandum (TM) summarizes an analysis of potential groundwater level changes from proposed groundwater banking operations within Porterville Irrigation District (PID) and Saucelito Irrigation District (SID) (the Project) near Porterville, California (see Figure 1). The proposed Project includes the construction and operation of recharge basins by landowners within PID and SID. The source of water for recharge in the basins would be imported water delivered via the Friant-Kern Canal or Tule River water via the Tule River. Recovery of banked water is planned to be from existing agricultural wells within the Tule Subbasin. This work is being conducted in support of the Draft Environmental Impact Report (DEIR) for the Project.

1.1. Purpose and Scope

The purpose of the analysis presented herein is to:

1. Identify conceptual locations for recharge basins within the PID and SID.
2. Estimate the annual recharge capacity of the proposed recharge facilities.
3. Evaluate the capacity of the aquifer system to accommodate the storage of recharge water associated with the Project.
4. Evaluate potential changes in groundwater levels associated with recharge at the facilities.

5. Evaluate potential changes in groundwater levels and subsidence associated with recovery by existing agricultural wells.
6. Assess groundwater recharge limitations for the Project in the context of groundwater levels.

The scope of work to address the objectives included:

1. Compiling and reviewing hydrogeological data for the immediate Project area.
2. Developing estimates of recharge capacity at the recharge basins.
3. Identifying the location and conceptual construction of new basins for use in analysis of groundwater level impacts.
4. Identifying conceptual locations for recovery for use in analysis of groundwater level impacts.
5. Developing recharge and recovery scenarios for analysis.
6. Analyzing the scenarios using a calibrated groundwater flow model.
7. Evaluating potential groundwater level and subsidence changes from model results.
8. Preparing this TM describing the analysis and summarizing the results.

1.2. Conceptual Project Description

The proposed Project includes the construction of managed recharge basins to "bank" surface water in the groundwater system. Project recharge operations would occur within PID and SID, both within the Eastern Tule Groundwater Sustainability Agency (ETGSA) (see Figure 1). The basins would be utilized during wet periods when surface water is available. The Project envisions developing up to half of the PID and SID areas into basins. However, the maximum recharge capacity of the aquifer system in the Project Area is evaluated herein. For the analysis, locations of the Project basins are conceptual, with the actual locations dependent on landowners that participate in the Project. Groundwater recovery is anticipated to be conducted by existing agricultural wells within the Tule Subbasin with conceptual areas assumed in this analysis.

1.3. Analysis Methodology

Potential changes in groundwater levels and subsidence predicted for Project recharge and recovery scenarios were analyzed using a calibrated numerical groundwater flow model. The groundwater model used for the analysis was previously developed to evaluate the sustainable yield of the Tule Subbasin. The model was developed using MODFLOW, a block centered, finite difference groundwater flow modeling code developed by the United States Geological Survey

(USGS) for simulating groundwater flow (McDonald and Harbaugh, 1988).[1] MODFLOW is one of the most widely used and critically accepted model codes available (Anderson and Woessner, 2002).[2]

The model was based on the most recent Tule Subbasin Groundwater Flow Model[3] which includes a historical calibration period (monthly stress periods from October 1986 through September 2019) and future projection period (originally annual stress periods from 2019/20 through 2069/70). The baseline scenario was a modified version of the future projection of Tule Subbasin groundwater recharge and discharge, including planned projects and management actions described in each Tule Subbasin Groundwater Sustainability Agency (GSA) Groundwater Sustainability Plan (GSP) and as simulated for the Tule Subbasin Coordination Agreement.[4]

1.4. Types and Sources of Data

The calibrated groundwater flow model used in the analysis of groundwater level changes incorporates a comprehensive hydrogeological database of the Project Area, as summarized in TH&Co (2020)[5] and TH&Co (2021).[3] The types of data used to develop the model included geology, soils/lithology, groundwater levels, hydrogeology, surface water hydrology, and groundwater recharge and pumping.

Supplemental shallow groundwater levels, recharge volumes, and banking operations in and near the PID/SID areas were also obtained from the following:

- Water Solutions, 2023. Tule River – Friant Kern Canal Water Bank Project 2022 Annual Report Monitoring and Operational Constraint Plan (MOCP). Prepared for Porterville Irrigation District.
- GSI Water Solutions, 2023. Deer Creek – Friant Kern Canal Water Bank Project 2022 Annual Report Monitoring and Operational Constraint Plan (MOCP). Prepared for Saucelito Irrigation District.
- Partner Engineering and Science, 2021. 2019 through September 2020 Annual Report Monitoring and Operational Constraint Plan (MOCP), Deer Creek - Friant Kern Canal Water Bank Project. Prepared for Saucelito Irrigation District.

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[1] McDonald, M.G., and Harbaugh, A.W., 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model: in Techniques of Water-Resources Investigations of the United States Geological Survey; Book 6 Modeling Techniques.

[2] Anderson, M.P., and Woessner, W.W., 2002. Applied Groundwater Modeling, Simulation of Flow and Advective Transport. Academic Press.

[3] TH&Co, 2021. Update to the Groundwater Flow Model of the Tule Subbasin. Technical Memorandum prepared for the Tule Subbasin Technical Advisory Committee.

[4] Tule Subbasin Coordination Agreement, v. 2022, Attachment 3.

[5] TH&Co, 2020. Groundwater Flow Model of the Tule Subbasin. January 2020.

- State Water Control Resources Board’s GeoTracker Database, https://geotracker.waterboards.ca.gov
- City of Porterville wastewater treatment plant (WWTP) groundwater level and recharge data provided by the City of Porterville

2. Hydrogeologic Setting

A detailed description of the hydrogeologic setting of the Tule Subbasin, including the Project Area, is provided in TH&Co (2017)[6] and the Tule Subbasin Setting section of the Tule Subbasin Coordination Agreement.[7] This section provides an overview of the hydrogeologic setting as it relates to the Project.

2.1. Existing Surface Water Features

Existing surface water features within the PID portion of the Project Area include the Tule River, Friant-Kern Canal (FKC), turn outs, local canals, and pipelines (see Figure 2). The Tule River approximately bisects the district in the east-west direction and the FKC trends north-south along the east side of the district north of the Tule River and through the center of the District south of the Tule River. Existing recharge basins associated with other water banks include the Tule River-Friant Kern Canal Water Bank (TR-FKC), Falconer East Banking Site, and others.

Existing surface water features within the SID portion of the Project Area include Deer Creek, FKC, turn outs, and pipelines (see Figure 3). Deer Creek crosses through the southern part of the District in an approximate northeast-southwest direction. The FKC runs along the eastern border of the district until Terra Bella Avenue where it trends to the southwest. Existing recharge basins associated with water banks include the Deer Creek-Friant Kern Canal Water Bank and others. The Deer Creek-Tule River Association (DCTRA) Deer Creek basins and City of Porterville Wastewater Treatment Plant (WWTP) effluent basins are located east of SID.

2.2. Hydrogeologic Setting

In the Project area, the aquifer system is divided into a generally unconfined Upper Aquifer and a semi-confined to confined Lower Aquifer. For groundwater modeling purposes, the Upper and Lower Aquifers are separated by a transition layer of lower permeability deposits. Thus, model Layer 1 represents the Upper Aquifer and model Layer 3 the Lower Aquifer in the Project area. As the banking recharge associated with the Project will have the greatest impact on groundwater levels in the Upper Aquifer, the focus of the analysis presented herein is on this aquifer.

The Upper Aquifer is conceptualized to be approximately 100 to 150 ft thick in the PID area with relatively high horizontal hydraulic conductivities (permeability) ranging from approximately 15 to 80 ft/day. In the SID area, the Upper Aquifer is conceptualized to be approximately 200 ft thick

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[6] TH&Co, 2017. Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin.
Prepared for the Tule Subbasin MOU Group.
[7] Tule Subbasin Coordination Agreement, v. 2022, Attachment 2.

with horizontal hydraulic conductivities ranging from approximately 10 to 50 ft/day. Detailed descriptions of the aquifer system are provided in TH&Co (2017)[8] and TH&Co (2020a)[9] and detailed descriptions of model properties are provided in TH&Co (2020b)[10] and TH&Co (2021)[11].

2.3. Upper Aquifer Groundwater Levels

Upper Aquifer groundwater levels in the PID area are relatively shallow. Historical groundwater levels at the City of Porterville R-11 well (see Figure 4) ranged from approximately 25 to 120 ft bgs from 1990 to 2022 (see Figure 5). Groundwater levels at any given location may be influenced by regional hydrologic conditions (e.g. recharge in the Tule River, reduced agricultural pumping when surface water is available) or localized conditions (e.g. basin recharge).

Upper Aquifer groundwater levels in the SID area are deeper and more stratified than in PID. Historical groundwater levels at the Tea Pot Dome Landfill monitoring wells (see Figure 6) are approximately 100 to 120 ft bgs in M-8 (perforated from 101 to 121 ft bgs) and approximately 120 to 180 ft bgs in M-15C (perforated from 215 to 225 ft bgs)(see Figure 7). The 10 to 50 ft head difference in the wells indicates there may be finer-grained deposits at depths between the perforated intervals that may restrict downward flow.

2.3.1. Groundwater Level Changes in Response to Existing Basin Recharge in the PID Portion of the Project Area

Managed groundwater recharge has been periodically occurring at the TR-FKC Water Bank since spring 2017 (see Figure 4). Between 2017 and 2022, recharge rates were as high as 70 acre-ft/day with recharge volumes as high as approximately 5,850 acre-ft in any given 6-month period (see Figure 8).

Groundwater levels have been monitored at the TR-FKC Water Bank from a combination of onsite shallow piezometers, onsite shallow aquifer monitoring wells, one onsite deep agricultural well, and offsite downgradient monitoring wells.

Groundwater levels were measured in very shallow (i.e. <15 ft deep) piezometers located near the agricultural well during a recharge period from February to July 2019. Monthly recharge rates during this time were 1,515 acre-ft in March, 1,189 acre-ft in May and 611 acre-ft in June (see

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[8] TH&Co, 2017. Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin. Prepared for the Tule Subbasin MOU Group.

[9] TH&Co, 2020. Tule Subbasin Setting. Prepared for the Tule Subbasin Technical Advisory Committee. Dated January 2020.

[10] TH&Co, 2020. Groundwater Flow Model of the Tule Subbasin. January 2020.

[11] TH&Co, 2021. Update to the Groundwater Flow Model of the Tule Subbasin. Technical Memorandum prepared for the Tule Subbasin Technical Advisory Committee.

Figure 9). Groundwater level rise in the shallow piezometers ranged from 2 to 6 feet during the period of recharge. However, it is not known what the groundwater levels were in these piezometers prior to the recharge event. Given the shallow groundwater levels observed in the piezometers (generally within 10 ft of the land surface), it is possible that the recharge rate decrease observed over time was due to the rising groundwater levels although this reduction could also be due to some other factor such as reduced deliveries to the basins.

During periodic managed recharge events in 2020 and 2022, groundwater levels in onsite shallow monitoring wells rose approximately 20 to 30 ft. Recharge volumes during these events ranged from 325 to 1,018 and acre-ft. Groundwater levels in a deeper agricultural well on the south side of the basins do not show a correlation with the managed recharge during this time period and are likely influenced by regional groundwater level trends.

Groundwater levels in City of Porterville R-11 and Village Market MW-1, which are approximately 400 and 1,100 ft downgradient of the TR-FKC Water Bank, respectively, show changes that are correlated with recharge events. Following recharge events in 2017 and 2019, groundwater levels in both wells rose approximately 30 feet (see Figure 10). Groundwater levels in these wells do not appear to respond to smaller recharge events, such as those that occurred in 2020 and 2022.

2.3.2. Groundwater Level Changes in Response to Existing Basin Recharge in the SID Portion of the Project Area

Managed groundwater recharge has been periodically occurring at the DC-FKC Water Bank since early 2019 (see Figure 11). Daily recharge rates have been as high as 100 acre-ft/day and recharge volumes as high as approximately 3,300 acre-ft in a 6-month time period.

Groundwater levels for the DC-FKC Water Bank are measured via three shallow monitoring wells (generally perforated from 15 to 50 ft bgs), one intermediate monitoring well (perforated from 75 to 150 ft bgs) and one agricultural well with an unknown perforation interval but presumed to be perforated in the Lower Aquifer based on the groundwater elevation. Depth to groundwater in the shallow monitoring wells (MW-1B, MW-2, and MW-3) were within 25 ft of the land surface during the 2019 and 2020 recharge periods. Shallow groundwater levels rose by as much as 30 feet during recharge and, despite their shallow depth, did not appear to limit ongoing recharge at the facility. Groundwater levels in the intermediate monitoring well (MW-1A) rose by approximately 60 ft during 2019 recharge (see Figure 11). Groundwater levels in the agricultural well were on the order of 100 ft bgs from February 2019 through March 2020 and 250 to 400 ft bgs from July 2020 through September 2022.

Groundwater level response from recharge has also been observed in the vicinity of the City of Porterville WWTP discharge basins along the Old Deer Creek channel. The City of Porterville discharges 1,000 to 2,000 acre-ft of treated effluent to these unlined basins in the winter months. Groundwater levels in MW-107, a shallow monitoring well located adjacent to the basins, rise as much as approximately 35 ft in response to the recharge and then return to pre-recharge levels (see Figure 12).

2.4. Estimates of Upper Aquifer Storage Capacity

As the Project is expected to recharge water during wet periods when available aquifer storage capacity is lower than dry periods, the available storage capacity of the upper aquifer was estimated for three representative wet-year time periods in the Baseline: 2023/24, 2026/27, and 2033/34. The analysis estimates available storage of layer 1 only (i.e. doesn’t include layer 2 if layer 1 is dry). The analysis assumes available storage space is from the top of the water table or the bottom of the layer, whichever is higher, to within 10 feet of the land surface. The estimates are for July 1 of that year which is the predicted high groundwater level after the peak of a spring/early summer hydrologic cycle.

As shown in Table 1, the estimated upper aquifer storage capacity in PID is approximately 84,000 to 126,000 acre-ft when groundwater levels are high. It’s noted that more aquifer storage is available on the western portion of PID compared to the central and eastern portions. The estimated upper aquifer storage capacity in SID is approximately 211,000 to 221,000 acre-ft (see Table 1).

3. Project Scenarios for Analysis Using the Model

3.1. Baseline Hydrologic Conditions

TH&Co developed a potential future "Baseline" condition which was used to compare with a future model scenario that includes the Project. The Baseline is a modified version of the 2020 Tule Groundwater Flow model future projection which includes the Tule Subbasin GSA's planned projects and management actions as well as adjustments for climate change. Modifications to the 2020 Tule Groundwater Flow model future projections included:

- Revising the simulated timeframe and stress periods from water years 2019/20 to 2069/70 to monthly stress periods from October 2019 through September 2040.
- Revising the hydrology assumptions (i.e., surface water supplies) from an average condition to a repeated condition of wet and dry periods (variable hydrology).

As shown in Table 2, surface water supplies in the Baseline condition for PID are based on historical imported deliveries, Tule River Diversions, and Projects that are planned to result in additional supplies. Annual PID surface water supplies are projected to average approximately 34,300 acre-ft/yr. During wet years, surface water supplies are anticipated to range from approximately 40,000 to 93,000 acre-ft/yr.

Surface water supplies in the Baseline condition for SID (see Table 3) are projected to average approximately 36,100 acre-ft/yr. During wet years, surface water supplies are anticipated to range from approximately 20,000 to 75,000 acre-ft/yr.

3.2. Conceptual Recharge Facilities

The locations for conceptual recharge basins within the Project were selected using the following criteria:

- In areas with relative available aquifer storage (i.e. deeper baseline groundwater levels)
- In areas where the relative permeability was expected to be highest
- In areas where subsurface losses from the Tule Subbasin to other subbasins would be limited
- Adequate distance from the Friant-Kern Canal to avoid mounding impacts to the canal structure

In the PID portion of the Project Area, conceptual basins were generally placed in the western part to take advantage of maximum available storage and limit underflow losses to the Kaweah Subbasin to the north (see Figure 13). Groundwater levels in the western part of the PID area are deeper than in the east and in the vicinity of the Tule River. Basins on the west are also topographically downgradient of the Friant-Kern Canal enabling delivery by gravity flow and eliminating the need for more expensive pumping stations to deliver the water from the canal to the basins.

In the SID portion of the Project Area, conceptual basins were placed roughly evenly across the area (see Figure 14). Groundwater levels are generally lower than in PID and the area doesn't border neighboring basins so losses is not a concern. Providing adequate distance between conceptual basins and the Friant-Kern Canal, which borders the eastern part of the area, was taken into consideration as shallow groundwater levels at the canal could cause damage.

3.3. Conceptual Groundwater Recovery Areas

The conceptual locations for recovery of banked water were selected based on input from the PID and SID on likely potential end users of the water. All recovery was assumed to be in agricultural areas near the recharge facilities (see Figure 15). Areas included Lower Tule River Irrigation District (LTRID), Pixley Irrigation District (Pixley ID), SID, and "white areas" within the ETGSA (i.e. areas with no surface water supplies). Recovery was assigned to the model agricultural wells within those areas to simulate existing agricultural wells that would be used for the Project.

3.4. Project Operational Scenarios

TH&Co developed three Project recharge and recovery scenarios for analysis with the groundwater flow model. For the recharge portion of each scenario, monthly artificial recharge for the Project was superimposed on the baseline condition that represents a potential range of groundwater level conditions that could be expected in the future. Each scenario incorporated a range of recharge per year throughout the forecast depending on the hydrologic conditions of the baseline condition. Maximum volumes of water were simulated to be recharged in hydrologically "very wet" years when the most surface water would typically be available. Minimum recharge volumes were simulated during hydrologically above average "wet" years but below the maximum. Simulated minimum and maximum recharge were increased with each subsequent Scenario as follows (see Tables 2 and 3):

1. Scenario 1 – 4,000 to 8,000 acre-ft/yr
2. Scenario 2 – 8,000 to 16,000 acre-ft/yr
3. Scenario 3 –16,000 to 32,000 acre-ft/yr

Recharge ranges for each scenario were simulated at PID and SID conceptual facilities simultaneously.

Recharge volumes for each scenario were accommodated through the conceptual recharge basins described in Section 3.2 herein and located as shown on Figures 13 and 14. The number of basins used in each scenario accounted for the peak simulated volume, wetted days (assumed to be 150 days per year), infiltration rate, and percent of a facility used as wetted basins. An individual facility size was assumed to be one model cell (22.96 acres). With these assumptions, the number of required basins to accommodate the simulated recharge rates ranged from 4 to 16 for PID and 8 to 32 for SID, depending on the scenario. The infiltration rate for PID basins was assumed to be 1 ft/day. The infiltration rate for SID basins was assumed to be 0.5 ft/day. The annual recharge volumes were applied over a 5 month (i.e. 150 day) period from February through June of each year.

For the recovery portion of each scenario, monthly recovery for the Project was superimposed on the baseline condition that represents the projected consumptive use, including demand "ramp downs", surface water deliveries, and pumping be expected in the future. Recovery volumes were limited to 85% of recharged water. For the scenarios, increases in consumptive use in the target recovery area was the basis for estimating the volume of recovered Project water which is consistent with previous estimates of groundwater pumping in the Tule Subbasin. Groundwater pumping is calculated by the model as consumptive use divided by irrigation efficiency. The difference between pumping and consumptive use is return flow which returns to the aquifer. Recoveries in LTRID were assumed to only occur during dry years. Recoveries in SID, Pixley ID, and "white areas" were assumed to occur during both wet and dry years. The analysis tracks the "cumulative storage balance" which increased during wet periods when water would be available for recharge and decreased during dry periods when the water would be needed for irrigation. At no time was the account balance allowed to decrease to zero. Simulated recovery volumes and locations of recovery for each Scenario are summarized in Tables 4 and 5 and summarized as follows:

1. Scenario 1 – 1,000 to 5,500 acre-ft/yr (recovery of PID recharged water)
   3,000 acre-ft/yr (recovery of SID recharged water)
2. Scenario 2 – 2,000 to 11,000 acre-ft/yr (recovery of PID recharged water)
   6,000 acre-ft/yr (recovery of SID recharged water)
3. Scenario 3 – 4,000 to 22,000 acre-ft/yr (recovery of PID recharged water)
   12,000 acre-ft/yr (recovery of SID recharged water)

4. Findings and Recommendations

4.1. Recommended Implementation of Recharge Basins

TH&Co divided the PID and SID areas of the Project into Recharge Management Sections to provide a prioritized basis for implementing the Project. Six Management Sections were identified in the PID area (A through F; see Figure 16) and four Management Sections were identified in the SID area (A through D; see Figure 17). Priority for constructing new recharge basins is highest in the A Management Sections and becomes increasingly lower priority for Sections B, C, etc. In the PID area, highest priority sections are areas that:

- Have the highest subsurface storage for managed recharge,
- Are away from existing banking operations,
- Are downslope of potential surface water sources (i.e. Friant-Kern Canal),
- Provide distance from the Friant-Kern Canal to avoid mounding impacts to the canal structure, and
- Are away from the northern boundary of the Tule Subbasin to limit losses of banked water.

In the SID area, the highest priority sections are areas:

- Where land subsidence has been observed and managed recharge would have the greatest impact on maintaining groundwater levels to avoid future land subsidence,
- Away from existing banking operations,
- Downslope of potential surface water sources (i.e. Friant-Kern Canal), and
- That provide distance from the Friant-Kern Canal to avoid mounding impacts to the canal structure.

4.2. Estimates of Annual and Long-Term Recharge Capacity

For this analysis, annual recharge capacity is defined as the maximum volume of water that each Project facility can infiltrate into the subsurface in a year. Recharge capacity was evaluated based on the maximum volume of water that can be recharged in any given year while maintaining groundwater levels below 10 ft bgs.

For the PID portion of the Project Area (Figure 13), the aquifer system can accommodate Scenarios 1 and 2 recharge rates (up to 16,000 acre-ft/yr) at the simulated basin locations and still maintain groundwater levels below 10 ft bgs in the area of maximum mounding (see Figure 18). Scenario 3 recharge rates (greater than 16,000 acre-ft/yr) are estimated to be feasible during average and wet hydrologic periods but not very wet hydrologic conditions.

For the SID portion of the Project Area (Figure 14), the aquifer system can accommodate recharge rates for all scenarios (up to 32,000 acre-ft/yr) except in the northeast quarter where Scenario 3 recharge rates do not appear to be feasible under very wet hydrologic conditions (see Figure 17).

In summary, the aquifer system in the PID portion of the Project Area is estimated to be able to accommodate up to 16,000 acre-ft/yr of recharge in spatially distributed basins such as shown on Figure 13 without raising groundwater levels within 10 ft of the land surface. Over the 20-yr future simulation period, the analysis estimates that up to 120,000 acre-ft of water can be banked in PID. The SID portion of the Project Area can likely accommodate more than 32,000 acre-ft/yr of recharge in spatially distributed recharge basins (see Figure 14). However, the capacity of basins in the northeast quarter of the SID area are estimated to be more limited as the highest recharge rates could result in groundwater levels within 10 ft of the land surface. Over the 20-yr future simulation period, the analysis estimates that between 120,000 and 240,000 acre-ft of water can be banked in the SID.

Annual maximum recharge rates in individual management zones will vary according to groundwater level conditions. To avoid potential impacts and/or excessive losses, it is recommended to implement a groundwater level monitoring program specific to Project banking operations. Information from such a program will allow the Project proponents to optimize recharge operations and minimize impacts and losses. If groundwater levels near the FKC or Tule River are within 15 ft below the land surface, recharge should be reduced in those areas; if groundwater levels rise to within 10 ft of the land surface recharge should be discontinued to avoid damaging the canal. It is noted that the analyses presented herein did not include recharge in PID Zones D, E and F to reduce the risk of localized impacts to the FKC, avoid excess underflow losses, and avoid interference with existing banking operations. During implementation, it may be possible to recharge water in these areas as informed from the groundwater level conditions from the groundwater level monitoring network. It is our understanding that the United States Bureau of Reclamation has already established a groundwater monitoring network for the FKC, which can be used for this purpose.

4.3. Predicted Changes in Groundwater Levels due to Recovery

Groundwater pumping in the conceptual areas associated with recovery of banked water is expected to primarily occur from the lower aquifer. As shown on Figures 18 and 19, lower aquifer groundwater levels in the conceptual recovery areas are predicted to be 5 to 20 ft lower in the scenarios compared to the baseline.

While groundwater pumping is expected to primarily occur from the lower aquifer, return flow associated with increased applied water will recharge the upper aquifer. As shown on Figures 20 and 21, upper aquifer groundwater levels in LTRID, White Area A, and Pixley ID are predicted to be 1 to 10 ft higher in the scenarios compared to the baseline. The upper aquifer is dry in White Area B and therefore not shown.

4.4. Predicted Land Subsidence

As noted above, groundwater pumping in the conceptual areas associated with recovery of banked water primarily occurs from the Lower Aquifer which may induce land subsidence. As shown on Figure 22, land subsidence due to Project groundwater recovery in White Area A is predicted to be approximately 0.2 ft in Scenario 1, 0.5 ft in Scenario 2, and 2.0 ft in Scenario 3. Land subsidence associated with Project recovery in the LTRID, Pixley ID, and White Area B areas is predicted to range from 0.2 to 0.5 ft in the scenarios.

Land subsidence along the FKC associated with Project recovery is predicted to be approximately 0.1 to 0.4 ft immediately northeast of SID (see Figure 21). This simulated land subsidence is a result of scenario recovery pumping in the white area east of the canal, which is within the managed area of the ETGSA Land Subsidence Management Plan. It is noted actual pumping within this area would be required to follow the rules and regulations of the ETGSA Land Subsidence Management Plan.

Based on the results of analyses presented herein, land subsidence impacts can be minimized if the banked water is recovered in proximity to where recharge occurs. Further, prioritizing pumping from the upper aquifer to capture recharged water would also minimize land subsidence.

4.5. Predicted Underflow Losses from the Tule Subbasin

Managed recharge at the simulated amounts has the potential to result in increased outflow to the Kaweah Subbasin to the north from the PID portion of the Project Area. Conceptual basins and recovery areas used in the analysis for this study were located to avoid losses out of the Tule Subbasin to the extent possible. Comparison of underflow out of the Tule Subbasin from the baseline scenario with underflow out from the scenarios shows that these losses would be less than 5% of the total water recharged.