# White Paper

## Estimated Numbers of Californians Reliant on Domestic Wells Impacted as a Result of the Sustainability Criteria Defined in Selected San Joaquin Valley Groundwater Sustainability Plans and Associated Costs to Mitigate Those Impacts

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### SUMMARY

This White Paper summarizes the assessment of the numbers of Californians reliant on domestic wells and the estimated associated costs to mitigate anticipated impacts to these wells as a result of the water level measurable objectives ("MOs") and minimum thresholds ("MTs"), collectively the "Sustainable Management Criteria" ("SMCs") defined in selected Groundwater Sustainability Plans ("GSPs"). The analysis presented herein was conducted for twenty-six GSPs that were submitted to the California Department of Water Resources ("DWR") in January 2020 and collectively encompass the majority of ten critically overdrafted groundwater basins in the San Joaquin Valley (referred to as the "study area" and shown on Figure 1).[1]

The findings of the analysis conducted herein suggest that the potential impacts to domestic wells and the associated mitigation costs are substantial. Within the study area, it is estimated that if water levels reach the MOs, 17% to 23% of domestic wells will be partially or fully dewatered, impacting the drinking water source for approximately 45,700 to 62,500 people. The costs to mitigate these impacts, including increased operations and maintenance costs and the replacement of failed wells, are estimated to be on the order of $88 million to $137 million. If water levels reach the MTs within the study area, it is estimated that 20% to 49% of domestic wells will be partially or fully dewatered, impacting the drinking water source for approximately 106,000 to 126,600 people. The costs to mitigate these impacts are estimated to be on the order of $272 million to $359 million.

Given the data limitations, the domestic wells directly included in this analysis represent only a subset of the domestic wells within the study area. Adjusting for the proportion of domestic wells within the 26 GSPs that were excluded from this analysis due to data limitations (i.e.,

[1] Only GSP areas with significant overlap with the DWR Groundwater Information Center Interactive Map Application ("GICIMA") dataset were considered. Therefore, certain GSP areas within the San Joaquin Valley critically overdrafted subbasins, generally along the western boundary of the San Joaquin Valley basin, were not included in this analysis.

those wells with no available construction information),[2] the affected population may be on the order of 48,000 to 66,000 people at MO water levels and 112,000 to 133,000 people at MT water levels. The associated costs may then be on the order of $93 million to $144 million at MO water levels and $286 million to $378 million at MT water levels, although this remains a likely underestimate as an additional 27% of domestic wells within these basins are located outside of the study area.

## 1 INTRODUCTION

With the adoption of the Sustainable Groundwater Management Act ("SGMA"), Groundwater Sustainability Agencies ("GSAs") are, among other things, required to establish SMCs for basin management as part of their GSPs. As defined in the GSP Emergency Regulations, an MO "refer[s] to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (California Code of Regulations ["CCR"] § 351(s)) and an MT "refers to a numerical value for each sustainability indicator used to define undesirable results" (23-CCR § 351(t)). The MOs and MTs defined and adopted by the GSAs will be used to determine how basins will be managed into the future, and will have implications for all groundwater users. Vulnerable populations, like low-income communities of colors and/or domestic well owners, are at particular risk of impact.

This White Paper presents a high-level impacts analysis of the SMCs based on information included in the 26 submitted GSPs and other readily available public sources. Section 2 presents an analysis of the number and locations of the domestic wells that would be anticipated to be impacted if groundwater levels reach the MOs and MTs, respectively. Section 3 presents an estimate of the costs to mitigate these impacts. The various limitations and uncertainties associated with the data and methodologies used for these analyses are identified in Section 4, and should be considered as context for the results presented herein. Because of data limitations and because this estimate does not attempt to include costs associated with treating potentially degraded water quality, administrative costs associated with implementing a well impact mitigation program, or short-term emergency response costs, the impacts presented herein may be underestimated for many basins. The data and information sources used to develop these analyses, including a list of the GSPs, are provided in the references section.

[2] Of the domestic wells identified within the study area (i.e., within the DWR GICIMA water level contour area and the areas covered by the 26 GSPs included herein) and not identified as fully dewatered under Fall 2018 conditions, approximately 5% of the domestic wells did not have sufficient well construction information to include in this assessment.

## 2 DOMESTIC WELL IMPACT ANALYSIS

Domestic wells are typically shallower than irrigation and municipal supply wells and therefore tend to be more susceptible to water level declines that result from groundwater over-pumping and resource management decisions (Gailey, 2020).

Declining groundwater levels in the vicinity of domestic wells can result in: (1) increased well maintenance demands; (2) increased energy costs due to pumping lift; and (3) the need to deepen or fully replace wells (Gailey, 2020).[3] Many of the water level MOs and MTs adopted by the GSAs in the study area are lower than current (i.e., Fall 2018) groundwater levels.[4] In some GSP areas, the adopted MOs represent over 150 feet of water level decline from current conditions, and the adopted MTs represent over 300 feet of water level decline from current conditions.

The sections below discuss the data sources and methodology used to estimate the number of domestic wells and population that may be affected if groundwater levels were to reach the MOs and MTs established by each GSA.

### 2.1 Data Sources

To support the domestic well impact analysis, the following data were compiled and processed:

- **Study area boundary** (Figure 1) is defined as the area covered by the 26 GSPs prepared for ten critically overdrafted subbasins in the San Joaquin Valley that also have significant coverage by DWR's Groundwater Information Center Interactive Map Application ("GICIMA") dataset.[5,6] Section 5 includes a complete list of the GSPs. Figure 1 presents the GSA boundaries as mapped in their respective GSPs and are based on DWR SGMA Portal GSA boundary shapefiles. The subbasin boundaries are shown as defined by DWR in the Final 2018 Basin Boundary Modifications, released February

[3] Lowering of groundwater levels can also result in additional costs, such as treatment needed to address degraded water quality. However, those impacts are difficult to quantify or predict, and are beyond the scope of this assessment. Gailey (2020) does not clearly specify whether well replacement cost assumptions include destruction and abandonment of the existing, original well, or only construction of a new well. Thus, the costs estimated herein may not be inclusive of well abandonment.

[4] Fall 2018 groundwater levels are used to represent "current" conditions because that was the most recent DWR dataset available at the time of the analysis.

[5] Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.

[6] Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

2019. Figure 1 also shows the boundaries of the California State Senate and Assembly Districts that overlie the study area.

- **Current depth to groundwater** is interpolated based on Fall 2018 depth to groundwater contours, available from the DWR-GICIMA dataset[7] (Figure 2). See *Appendix A* for the methodology used to convert contour data to raster format.
- **MOs and MTs at Representative Monitoring Wells ("RMWs")** as established in GSPs within the study area.
    - As required by 23-CCR § 352.4(a)(5) and 352.4(b)(3), the GSPs must present location coordinates of all RMWs. However, 13 GSPs did not provide tabular location information. In these instances, location information was obtained either through DWR's California Statewide Groundwater Elevation Monitoring ("CASGEM") system or by approximating RMW locations based on maps presented in the GSPs. In some instances, RMWs are proposed in GSPs, but not yet constructed and location information is not yet available; these RMWs were not included in this analysis.
    - As required by 23-CCR § 354.28(c)(1) and 23-CCR § 354.30(b), the GSPs present the MOs and MTs as groundwater elevations (i.e., in units of feet above mean sea level). Four GSPs also present the MOs and MTs as depth below ground surface (i.e., depth to groundwater). In order to compare groundwater elevations with Fall 2018 depth to groundwater, the groundwater elevations provided in most GSPs were converted to depths (i.e., feet below ground surface, or "ft bgs") by subtracting the reported MO and MT elevations from the ground surface elevation, either as reported in the GSP or as estimated from the United States Geological Survey ("USGS") 10-meter Digital Elevation Model ("DEM").
    - In some instances, the RMWs did not have MO or MT values assigned to them. These RMWs were not included in this analysis.
- **Domestic well dataset** (University of California ["UC"] Berkeley Water Equity Science Shop ["WESS"], 2019) containing approximate locations of 44,739 domestic wells within the study area. The WESS domestic well dataset is based on DWR's Online System for Well Completion Reports ("OSWCR") records, and does not include non-domestic wells (UC Berkeley WESS, 2020). The WESS domestic well dataset contains complete well construction information for approximately 59% of the identified domestic wells and partial construction information for approximately 38% of the wells.

[7] To develop the GICIMA groundwater contours, "water level measurements are selected based on measurement date and well construction information (where available) and approximate groundwater levels in the unconfined to uppermost semi-confined aquifers," per https://gis.water.ca.gov/app/gicima/.

- **Estimated population that is reliant on domestic wells,** aggregated by Public Land Survey System ("PLSS") section (UC Berkeley WESS, 2019). The WESS population dataset is based on 2010 United States Census data and includes the estimated population located outside of the service areas of active community or other public water systems (UC Berkeley WESS, 2020).

## 2.2 Methodology

### 2.2.1 Depth to Groundwater at MOs and MTs

Water level MOs and MTs were compiled for RMWs within the study area. Based on these values, groundwater levels at the MOs and MTs were interpolated for the study area using the methodology discussed in *Appendix B*. In instances where a GSP delineated multiple principal aquifers, RMWs with screened intervals identified as being entirely within the lower aquifer were not included in the water level contours because domestic wells are typically constructed within the upper aquifer. In order to assess whether lower aquifer RMWs should be included in the calculation of MO and MT water level contours, a sensitivity analysis was performed and is presented in *Appendix C.*

Figure 3 shows the contours for depth to groundwater at the MOs and MTs. The MOs generally range between 50 and 300 ft bgs with a maximum of 878 ft bgs. The MTs generally range between 100 and 400 ft bgs, with a maximum of 1,035 ft bgs. The RMWs that were identified in GSPs as "composite" (i.e., screened across both the upper and lower aquifers) were included in the contour dataset. The inclusion of these RMWs may contribute to the steep gradients observed between RMWs in some areas. Additionally, given that the MOs and MTs were uniquely established by each GSA, the use of different methods to identify MOs and MTs can also result in steep gradients across GSA and subbasin boundaries.

The change in water levels relative to current groundwater levels (i.e., Fall 2018, as shown in Figure 2) for both MOs and MTs are shown in Figure 4. In some areas, the MOs and MTs are above current groundwater levels, generally in the northernmost subbasins. In some areas, the MOs represent over 150 feet of water level decline from current conditions, and the MTs represent over 300 feet of water level decline.

### 2.2.2 Domestic Well Dataset Processing

The WESS domestic well dataset, consisting of 44,739 domestic wells within the subbasins included in the study area, was processed using the following criteria and assumptions:

- Domestic wells that fall outside the extent of the DWR GICIMA Fall 2018 depth to groundwater contours (Figure 2) were not included in the analysis. As such, 11,914 wells (27% of the WESS domestic well dataset) were not included due to insufficient water level data coverage.

- Domestic wells without screen interval or depth information were not included in the analysis. Wells with implausible completion depth and or screen depth information (such as wells where the reported top of screen was deeper than the reported bottom of screen) were also not included in the analysis. For wells where only completion depth information was available, the top and bottom screen intervals were estimated based on a regression between the available screened interval information and the completion depth for other San Joaquin Valley wells included in the WESS domestic well dataset. Specifically, the bottom of the screened interval was estimated to be located at 92% of the total well completion depth and the top of the screened interval was estimated to be located at 71% of the completion depth. Based on this screening, 1,382 wells (3% of the WESS domestic well dataset) were eliminated due to incomplete, infeasible, or conflicting well completion information.

- Another 6,996 wells (16% of the WESS domestic well dataset) were eliminated because they are assumed to be currently fully dewatered. For this analysis, wells are identified as fully dewatered when the Fall 2018 depth to groundwater (Figure 2) is less than 25-feet above the bottom of the screen, or greater than the well completion depth for wells without screened interval information. This designation is made to account for the operational limitations that result before water levels reach the physical bottom of the well (Gailey, 2020). Figure 5 shows a conceptual diagram of the well dewatering definitions used in this study.[8]

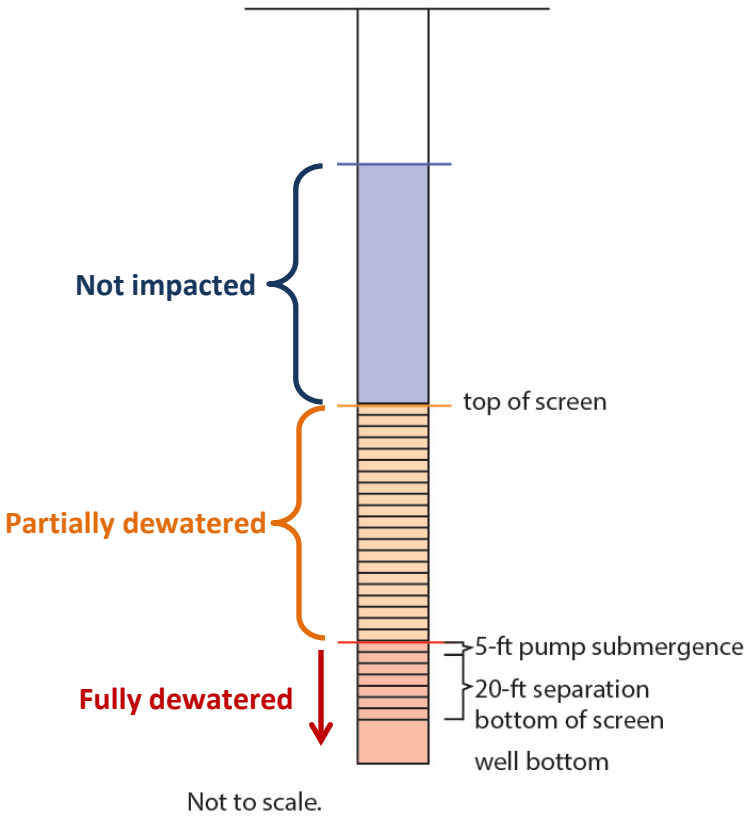
- An additional 2,381 wells (5% of the WESS domestic well dataset) included in this study are estimated to currently be partially dewatered. For this analysis, partially dewatered is defined as the Fall 2018 depth to groundwater (Figure 2) being below the top of the screen, but greater than 25-feet above the bottom of the screen (see Figure 5).

- Consistent with the assumptions identified in Gailey (2020), no wells were excluded from this analysis based on well installation date.

As shown in Table 1 and on Figure 6(a), based on the above screening process, approximately 20,292 domestic wells (45%) were eliminated from the original WESS domestic well dataset due to insufficient data or construction depth relative to Fall 2018 groundwater levels. As explained in Section 4, exclusion of these wells can result in an underestimation of actual impacts. As shown in Table 1 and on Figure 6(b), the refined domestic well dataset contains 24,447 domestic wells located within the study area (including 2,381 that are partially dewatered at Fall 2018 groundwater levels). These wells are located in areas where Fall 2018 depth to groundwater data are readily available, have known or inferred well construction information, and have screened intervals at or below Fall 2018 groundwater levels.

[8] Figure adapted from Gailey (2020).

**Figure 5**
**Conceptual Diagram of Well Dewatering Definitions**




### 2.2.3 Domestic Well Evaluation

For each domestic well included in the study, estimated MO and MT depths were assigned based on values from the interpolated groundwater depths (Figure 3). As described in more detail in Section 4, many wells within the WESS domestic well dataset plot at the center of the PLSS section (one square mile). This is because the DWR OSWCR well completion report dataset identifies well locations in this manner for privacy reasons. To quantify the uncertainty associated with well locations within a PLSS section, the minimum and maximum MOs and MTs within each PLSS section were evaluated for each domestic well within the study area. Figure 7 shows the distribution of the difference between MOs and MTs within a PLSS section at each domestic well point. The largest discrepancy occurs in the areas with steep gradients, generally in the southernmost subbasins.

Domestic wells are determined to be fully or partially dewatered if water levels reach the MOs and MTs using the definitions identified in Section 2.2.2 above and illustrated on Figure 5.

The WESS population dataset summarizes estimated population by PLSS section. For PLSS sections that fall across boundaries (i.e., GSA, subbasin, or legislative district boundaries),

population is attributed based on the location of the polygon centroid. Based on the estimated population dependent on domestic wells provided in the WESS dataset, the population affected by well dewatering was estimated by dividing the population in a given PLSS section by the number of wells in that section, and multiplying by the number of partially and fully dewatered wells. For example, if 20% of the wells in a given PLSS section were dewatered, 20% of the estimated population in that section was assumed to be affected.

### 2.3 Results

Across the study area, between 17% and 23% of domestic wells are anticipated to be impacted by dewatering at MO water levels and between 20% and 49% of domestic wells are anticipated to be impacted by dewatering at MT water levels.[9] Figures 8 and 9 show the locations of the domestic wells anticipated to be impacted by dewatering at the MOs and MTs, respectively. Tables 2 and 3 summarize the number of domestic wells anticipated to be impacted by dewatering at the MOs and MTs, respectively.[10] Tables 2 and 3 are presented in four parts, with well impacts aggregated by GSP (Tables 2a and 3a), subbasin (Tables 2b and 3b), California Senate District (Tables 2c and 3c), and California Assembly District (Tables 2d and 3d). As discussed previously, these are conservative estimates and likely underestimate the potential impacts.

Based on this analysis, it is estimated that between approximately 45,700 and 62,500 people reliant on domestic wells for drinking water will be impacted by domestic well dewatering if water levels reach the MO water levels across the study area, which is anticipated as the long-term management conditions under SGMA. It is estimated that between approximately 106,000 and 126,600 people reliant on domestic wells for drinking water will be impacted by domestic well dewatering if water levels reach the MT water levels across the study area. Figures 10 and 11 show where the population is anticipated to be impacted by domestic well dewatering at the MOs and MTs, respectively. Table 4 summarizes the estimated population anticipated to be impacted by dewatering at the MOs and MTs. As above, Table 4 is presented in four parts, with population impacts aggregated by GSP (Table 4a), subbasin (Table 4b), California Senate District (Table 4c), and California Assembly District (Table 4d). Again, these are conservative estimates and likely underestimate the potential impacts.

[9] The range of number of impacted wells reflects the uncertainty of the location of domestic wells within a given PLSS section, as illustrated in Figure 7.

[10] Tables 2 and 3 tabulate the domestic wells impacted at MOs and MTs, including those that would be impacted when MOs and MTs are greater than current groundwater levels.

# 3 WELL MITIGATION COST ANALYSIS

Declining water levels can result in economic costs to domestic well owners associated with, but not limited to, the following issues:

- Lowering the well pump so that adequate water column volume is available for pump operation;
- Well cleaning and/or redevelopment when groundwater levels decrease below the top of the well screen resulting in well screen clogging due to bacterial or mineral encrustation;
- Well replacement when groundwater levels decrease to a point at which the pump can no longer be lowered, and/or below the total well depth; and
- Increased energy costs to operate the well associated with increased pump lift.

The costs estimated in this study are limited to the increased costs to domestic well owners associated with well operation, maintenance, and replacement. Other costs, such as those associated with treating potentially degraded water quality, additional administrative costs associated with implementing a well impact mitigation program, or short-term emergency response, are not included in this assessment. Therefore, actual costs to address and prevent impacts may be significantly higher than estimated herein.

In addition, decommissioning of a defunct well requires appropriate permitting and contractor costs. Gailey (2020) does not clearly specify whether well replacement cost assumptions include the destruction and abandonment of the original well, or only construction of a new well. Thus, the costs estimated herein may not be inclusive of well abandonment, and may therefore be higher than estimated here.

## 3.1 Methodology

Gailey (2020) presents a framework to estimate the increased costs of well operation, maintenance, and replacement costs associated with declining groundwater levels. This framework was applied to domestic wells within the study area to estimate the costs to domestic well users if water levels reach the MOs and MTs. Table 5 summarizes the key assumptions used in the calculations detailed in Sections 3.1.1 through 3.1.4 below.

**Table 5**
**Domestic Well Cost Analysis Assumptions**

| Mitigation | Estimated Cost | Assumptions (Based on Gailey, 2020) |
|---|---|---|
| Pump Lowering | $2,000/20 feet | - Pump initially located 60 feet below Fall 2018 depth to groundwater or at the mid-point between Fall 2018 depth to groundwater and the bottom of the well screen<br>- Pump submerged 5 feet below depth to groundwater at MO or MT<br>- Must maintain at least 20 feet between pump and well bottom (assumed margin of operation)<br>- Required pumping drawdown of 0.25 feet<br>- Pump lowered in 20-foot increments |
| Well Maintenance/ Refurbishment | $10,000 per well | - Depth to groundwater at MO or MT is below the top of well screen |
| Well Replacement | $115/foot | - Estimated pump depth at MO or MT is less than 20 feet above the well bottom<br>- Replacement well is 100 feet deeper than original well, or 50 feet deeper than the MO or MT value |
| Increased Pump Lift Energy Costs | $0.16/kW-hr | - Pumping rate of 5 gpm<br>- Specific capacity of 20 gpm/foot<br>- 60% pump efficiency<br>- Pumping volume of 0.5 AFY<br>- 20 year period |

**Abbreviations**:

AFY = acre-feet per year
gpm = gpm
kW-hr = kilowatt-hour
MO = measurable objective
MT = minimum threshold

### 3.1.1 Pump Lowering

Pump lowering is required when the groundwater level decreases below either the initial pump depth or to a depth within the pump's operational margin. Using the Gailey (2020) framework assumptions (see Table 5), a pump must: (1) be submerged by at least 5.25 feet of water, and (2) have at least 20 feet of separation between the pump depth and bottom of the well for operational flexibility. The initial pump depth was assumed to be 60 feet below Fall 2018 depth to groundwater. For instances in which this initial estimate of pump depth fell below the well bottom, the pump depth was assumed to be located at the mid-point between Fall 2018 depth to groundwater and the well bottom.

If the depth to groundwater at the MO or MT was less than the Fall 2018 depth to groundwater plus 25.25 feet (i.e., 5 feet of pump submergence, 0.25 feet of pumping drawdown, and 20 feet

of operating margin), the pump was assumed to require lowering. The new pump depth was estimated following using the following methodology, per Gailey (2018):

*Pump depth at MO or MT = Depth to groundwater at MO or MT + pumping drawdown + required pump submergence + operating margin*

Pump lowering was assumed to occur in 20-foot increments and estimated to cost $2,000 per 20-feet of lowering (Gailey, 2020). For example, if a pump depth at the MO or MT was calculated as 30 feet below the initial pump depth, it was assumed that the pump will be lowered a total of 40 feet, which would cost $4,000. Pump lowering was assumed to occur until there is no longer 20 feet of separation between the pump depth and the well bottom, at which point it was assumed that well failure occurs and replacement is needed.

### 3.1.2 Well Maintenance/Refurbishment

When the depth to groundwater at either the MO or MT is below the top of the well screen, it is assumed that well cleaning will need to occur. This is estimated as a one-time cost of $10,000 per well (Gailey, 2020).

### 3.1.3 Well Failure and Replacement

As mentioned above in Section 3.1.1, well failure is assumed to occur when the estimated pump depth at the MO or MT would result in less than 20 feet of separation to the well bottom. Well failure also occurs if the bottom of the well screen is shallower than the MO or MT plus 20 feet of operational margin. The replacement well is assumed to be 100 feet deeper than the bottom of the original well's screen. In cases where the MT is lower than 100 feet deeper than the bottom of the original well's screen, it is assumed that the replacement well depth is 50 feet below the MO or MT.

Gailey (2020) assumes that well replacement costs $115 per foot of new well. For purposes of this study, it is assumed that increased pump lift energy costs (see Section 3.1.4) are additive to the $115 per foot well replacement cost.

### 3.1.4 Increased Pump Lift Energy Costs

As water levels decline, pumps use more energy to pump water to the well head. Therefore, as water levels decline, even if a well is not dewatered, operational costs increase due to increased pump lift. Using the equations presented in Gailey (2018), increased energy costs over 20 years were calculated as follows:

*Energy Cost = pump power (kW) * operation time (hr) * cost ($/kW-hr)*

*Pump power = (0.746 * pumping rate * (depth to groundwater at MO or MT – current depth to water + pumping rate/specific capacity))/(3956 * efficiency)*

*Operation time = pumping volume / (60 * pumping rate)*

Assumed pumping rate, specific capacity, pump efficiency, and pumping volume values are specified in Table 5.

### 3.2 Results

Tables 6 and 7 summarize the estimated mitigation costs associated with domestic well dewatering for the study area at the MOs and MTs, respectively. As with Tables 2 through 4, Tables 6 and 7 are presented in four parts, with well impacts aggregated by GSP (Tables 6a and 7a), subbasin (Tables 6b and 7b), California Senate District (Tables 6c and 7c), and California Assembly District (Tables 6d and 7d).

Based on this analysis, it is estimated that the costs to mitigate impacts to domestic wells if water levels reach the MOs will be between $88 million and $137 million for the study area, inclusive of dewatered well mitigation costs and increased operation and maintenance costs.[11] The costs to mitigate domestic well impacts if water levels reach the MTs across the study area are estimated to be between $272 million and $359 million. These are current year costs, and inflation is not considered. Many of these costs will accrue in future years and thus cost more than what is estimated in this study. It is also noted that costs may increase due to market demand forces (e.g., limited well contractor availability during a drought when there is high demand for well construction and rehabilitation).

Due to data availability limitations, this analysis represents only a subset of the domestic wells likely in use in these subbasins, and thus the actual mitigation costs may be higher. Adjusting for the number of domestic wells within the 26 GSPs that were not included in the study due to data limitations,[12] costs may be on the order of $93 million to $144 million at MO water levels and $286 million to $378 million at MT water levels and the affected population may be on the order of 48,000 to 66,000 people at MO water levels and 112,000 to 133,000 people at MT water levels.

## 4 Data Considerations, Uncertainties, and Opportunities for Study Refinements

Below is a summary of the key data considerations and uncertainties associated with this analysis, as well as opportunities for future refinements to the study. While the assessment presented in this study is rigorous and conservative within the limitations of the available data, the results presented herein should be considered in context with these limitations.

- Well impacts and associated costs are estimated for MO conditions. In many areas, GSAs anticipate that water levels will decline below MO levels before reaching sustainability

[11] The range of well impact costs reflects the uncertainty of the location of domestic wells within a given PLSS section, as illustrated in Figure 7.

[12] Of the domestic wells identified within the study area (within the DWR GICIMA water level contour area and the areas covered by the 26 GSPs included herein) and not identified as fully dewatered under Fall 2018 conditions, approximately 5% of the domestic wells did not have sufficient well construction information to include in this assessment.

by 2040. This decline may occur more rapidly in the near-term as GSAs work to develop and implement projects and management actions. Thus, domestic well impacts would be expected to be greater than estimated at the MOs in many areas, before sustainability is reached.

- This analysis was conducted based on the MOs and MTs included in the adopted GSPs that were submitted to DWR in January 2020. DWR will go through a process to review and evaluate the GSPs per 23-CCR § 355.2. Following its review, DWR may determine that a GSP is incomplete and allow the GSA to make applicable revisions, or that the GSP is inadequate and designate the subbasin as probationary under California Water Code § 10735.2. Therefore, the MOs and MTs identified in the adopted GSPs could be subject to change or become irrelevant in the future.
- The UC Berkley WESS (2020) domestic well dataset is based on well completion report data provided by DWR. This dataset is known to have limitations, but is accepted to be the most complete dataset currently available. However, it is likely that: (1) additional permitted and unpermitted domestic wells exist and are not included in this dataset; (2) not all domestic wells included in the dataset are in use for domestic well purposes; (3) well locations may not always be accurate; and (4) well construction information may not always be accurate. Based on these uncertainties, the actual impacts may be greater or less than estimated herein.
- Fall 2018 depth to groundwater contours, as available through DWR's GICIMA, do not cover all GSA/GSP areas or subbasins within the San Joaquin Valley. Therefore, potentially impacted domestic wells that fall outside the extent of the GICIMA-based contours were not included in this analysis and the total number of impacted domestic wells is likely greater than presented herein. In particular, this analysis excluded wells and GSAs located along the westernmost and easternmost sides of the San Joaquin Valley. Thus, the actual number of wells, affected population, and mitigation costs would be expected to be higher than estimated herein.
- Water levels at the MOs and MTs were interpolated across the study area using RMWs, and included only RMWs that were *not* identified in the GSPs as being screened in a lower, confined aquifer. In areas where multiple aquifers are present due to a significant confining layer, domestic wells tend to be shallow, and constructed within the uppermost aquifer. However, even when a confining layer is present, the degree to which aquifers are hydraulically separated into discrete upper and lower aquifer units can be spatially variable due to differing thickness and permeability of the confining layer, the prevalence of wells screened across the aquifers, and other factors, and is often the subject of differing professional opinions. A sensitivity analysis was performed to evaluate the effect of including lower aquifer RMWs in the estimation of water levels at MOs and MTs, which is documented in *Appendix C*. If deep aquifer RMWs were

included in the MO and MT contours, the impacts to domestic well users would be estimated to be greater than estimated herein.

- Uncertainties exist in the UC Berkley WESS domestic well dataset, such as well status, lack of construction information, and accurate well locations. Many well locations are mapped at the center of the PLSS section and are therefore potentially mapped as much as +/- 3,700 feet from their actual location. For areas in which MOs or MTs vary significantly across short distances, this could impact the estimate of the MO or MT water levels and associated well impacts at the well location. In order to quantify a portion of this uncertainty, a range of impacts were calculated based on the difference in contoured water levels within a PLSS section, as identified on Figure 7.
- Near GSA, subbasin, and legislative district boundaries, well locations mapped based on PLSS sections may result in wells being assigned to the incorrect GSA or subbasin. Therefore, wells located near these boundaries may be incorrectly attributed to a specific GSA, subbasin, or legislative district.
- No wells were excluded from the WESS domestic well dataset based on well age. Additionally, economic impacts do not account for well age. Well and pump efficiency decrease over time as the equipment ages. A well's lifespan varies depending on its construction, intensity of operation, and how it is maintained. Therefore, some of the wells included in this analysis may be past their usable lifespan and not in current use. Thus, costs to mitigate impacts to domestic wells may be lower than estimated herein.
- The UC Berkeley WESS population dataset was based on 2010 Census data. Depending on population changes that have occurred since 2010, the population dependent upon domestic wells for drinking water purposes may therefore be under- or over-estimated.
- Population was apportioned spatially within Census blocks[13] in the UC Berkeley WESS population dataset. The estimates of population dependent on domestic wells is likely overestimated in areas around the edges of service areas for public water systems when Census block boundaries do not coincide with service area boundaries. Thus, the population dependent upon domestic wells for drinking water purposes may be over-estimated in these areas.
- The Gailey (2020) methodology assumes pumping drawdown in the well is equal to 0.25 feet based on pumping rate/specific capacity using the assumptions presented in Table 5. Drawdown within domestic wells could be higher depending on the pumping

[13] Census blocks are the smallest geographic area for which aggregated Census data are available. Census blocks are "generally small in area. In a city, a census block looks like a city block bounded on all sides by streets. Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features, such as roads, streams, and transmission lines. In remote areas, census blocks may encompass hundreds of square miles" (Census, 2011).

rate and local geology. Therefore, the mitigation costs presented herein may be under-estimated.

- The Gailey (2020) methodology currently does not account for inflation. The current annual U.S. inflation rate is 1.8% based on the Consumer Price Index between October 2018 and October 2019 (Bureau of Labor Statistics, 2019). If the current inflation rate is considered, domestic well mitigation costs would be approximately 43% greater if they are incurred in 2040 than presented herein.
- Gailey (2020) identified that the initial pump depth was a sensitive parameter with a likely bounding range of +/- 20 feet. Gailey (2020) used an assumption of an initial pump depth of 60 feet. If an initial pump depth of 40 feet below Fall 2018 depth to groundwater was used as the assumption, costs would be estimated to be approximately $9.5 to $13.8 million (10% to 11%) higher at MOs and approximately $25 to $25.7 million (7% to 9%) higher at MTs. If an initial pump depth of 80 feet below Fall 2018 depth to groundwater was used as the assumption, costs would be estimated to be approximately $3.7 to $6.7 million (4% to 5%) lower at MOs and approximately $13.7 to $16 million (5%) lower at MTs. Therefore, the mitigation costs presented herein may be under- or over-estimated.
- Gailey (2020) assumes a one-time cost for screen cleaning. Prolonged periods of partial dewatering may require more frequent cleaning and therefore the mitigation costs presented herein may be under-estimated.
- As mentioned in Section 3.1.3, this study has assumed that increased pump lift energy costs are additive to the assumed well replacement cost of $115 per foot.
- Decommissioning of a defunct well requires appropriate permitting and contractor costs. Gailey (2020) does not clearly specify whether well replacement cost assumptions include the destruction and abandonment of the original well, or only construction of a new well. Thus, well replacement costs estimated herein may not be inclusive of well abandonment, and may be under-estimated.
- Gailey (2020) well replacement costs do not consider treatment of potentially degraded water quality in which a deep well may pump water with higher concentrations of dissolved constituents, such as arsenic. Therefore, the mitigation costs presented herein are likely under-estimated.
- The estimated costs presented herein do not include planning or administrative costs associated with establishing well mitigation programs or emergency actions such as water supply replacement efforts. Therefore, the mitigation costs presented herein are likely under-estimated.

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UC Berkeley WESS, 2020. Locating Domestic Well Communities in California: A Methodological Overview, Domestic Well Layer (version 1.0), UC Berkeley Water Equity Science Shop, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch, updated 14 January 2020.

USGS, 2019. USGS NED 1/3 arc-second n37w120 1 x 1 degree ArcGrid 2019, 3D Elevation Program https://nationalmap.gov/elevation.html accessed 9 December 2019.


**Groundwater Sustainability Plans:**


Aliso Water District Groundwater Sustainability Agency Groundwater Sustainability Plan, Final. Prepared by: Provost & Pritchard Consulting Group, dated January 2020.

Cawelo Groundwater Sustainability Agency Groundwater Sustainability Plan, Final. Prepared by: TODD Groundwater, dated 20 January 2020.

Central Kings Groundwater Sustainability Agency Groundwater Sustainability Plan in compliance with the Sustainable Groundwater Management Act. Prepared by: Provost & Pritchard Consulting Group, adopted 11 December 2019.

Chowchilla Subbasin Sustainable Groundwater Management Act Groundwater Sustainability Plan, Final. Prepared for: Chowchilla Subbasin GSP Advisory Committee. Prepared by: Davis Engineering. Inc, Luhdorff & Scalmanini, ERA Economics, Stillwater Sciences, California State University, Sacramento, dated January 2020.

County of Fresno GSA Management Area A & Management B Delta-Mendota Subbasin Groundwater Sustainability Plan. Prepared by: Luhdorff and Scalmanini, Consulting Engineers, dated January 2020.

Delano-Earlimart Irrigation District Groundwater Sustainability Agency Sustainable Groundwater Management Act Groundwater Sustainability Plan, dated January 2020.

East Kaweah GSP Groundwater Sustainability Plan. Prepared for: East Kaweah Groundwater Sustainability Agency Tulare County. Prepared by: Provost & Pritchard Consulting Group, dated January 2020.

Eastern San Joaquin Groundwater Subbasin Groundwater Sustainability Plan. Prepared by: Eastern San Joaquin Groundwater Authority, dated November 2019.

Eastern Tule Groundwater Sustainability Agency Tule Subbasin Sustainable Groundwater Management Act Groundwater Sustainability Plan, dated January 2020.

Eastside Water Management Area Kern County Sub-basin Management Area Plan Chapter. Prepared for: Eastside Water Management Area, Inc. Prepared by: EKI Environment & Water, Inc., dated 13 December 2019.

Farmers Water District Groundwater Sustainability Plan Delta-Mendota Subbasin. Prepared by Luhdorff and Scalmanini, Consulting Engineers, dated January 2020.

Grassland Groundwater Sustainability Agency Groundwater Sustainability Plan, in Cooperation with: Merced County Delta-Mendota Groundwater Sustainability Agency. Prepared by: Provost & Pritchard Consulting Group, dated December 2019.

Greater Kaweah Groundwater Sustainability Agency Groundwater Sustainability Plan. Prepared by: GEI Consultants, Inc. and GSI Water Solutions, Inc., dated 22 January 2020.

James Groundwater Sustainability Agency Groundwater Sustainability Plan in compliance with the Sustainable Groundwater Management Act. Prepared by: Provost & Pritchard Consulting Group, adopted 12 December 2019.

Kern-Tulare Water District Groundwater Sustainability Plan, dated 12 December 2019.

Kern Groundwater Authority Groundwater Sustainability Plan Kern County, CA. Prepared by: GEI Consultants, Inc., dated January 2020.

Kings River East Groundwater Sustainability Agency Groundwater Sustainability Plan. Prepared by: Provost & Pritchard Consulting Group, adopted 13 December 2019.

Lower Tule River Irrigation District Groundwater Sustainability Agency Tule Subbasin Sustainable Groundwater Management Act Groundwater Sustainability Plan, dated January 2020.

Madera Subbasin Sustainable Groundwater Management Act Joint Groundwater Sustainability Plan. Prepared for: Madera Subbasin Coordination Committee. Prepared by: Davids Engineering, Inc., Luhdorff & Scalmanini, ERA Economics, Stillwater Sciences, California State University, Sacramento, dated January 2020.

McMullin Area Groundwater Sustainability Agency Groundwater Sustainability Plan. Prepared by: Provost & Pritchard Consulting Group, 2020.

Merced Groundwater Subbasin Groundwater Sustainability Plan. Prepared by: Woodard & Curran, dated November 2019.

Mid-Kaweah Groundwater Sustainability Agency Groundwater Sustainability. Prepared under the Kaweah Subbasin Coordination Agreement with Greater Kaweah GSA and East Kaweah GSA. Prepared by: GEI Consultants, Inc., dated 18 December 2019.

North Fork Kings Groundwater Sustainability Agency Groundwater Sustainability Plan in compliance with the Sustainable Groundwater Management Act. Prepared by: Provost & Pritchard Consulting Group, adopted 18 December 2019.

North Kern W.S.D and Shafter-Wasco I.D Management Area Plan Kern County, CA. Prepared by: GEI Consultants, Inc., dated December 2019.

Northern & Central Delta-Mendota Groundwater Sustainability Plan. Prepared for: the Northern and Central Delta Mendota Regions. Prepared by: Provost & Pritchard Consulting Group and Woodard & Curran, dated November 2019.

Pixley Irrigation District Groundwater Sustainability Agency Tule Subbasin Sustainable Groundwater Management Act Groundwater Sustainability Plan, dated January 2020.

Rosedale-Rio Bravo Management Area Groundwater Sustainability Plan Chapter Kern Groundwater Authority Groundwater Sustainability Agency, dated 10 December 2019.

San Joaquin River Exchange Contractors GSA Groundwater Sustainability Plan. Prepared for: the San Joaquin River Exchange Contractors GSP Group in the Delta-Mendota Subbasin (5-022.07), dated December 2019.

Semitropic Water Storage District Groundwater Sustainability Agency 2020 Groundwater Sustainability Plan Kern County, CA. Prepared by: GEI Consultants, Inc., dated December 2019.

Shafter-Wasco Irrigation District 7th Standard Annex Management Area Kern County Subbasin Management Area Plan. Prepared for: Shafter-Wasco Irrigation District 7th Standard

Annex Management Area of the Kern County Subbasin. Prepared by: EKI Environment & Water, dated December 2019.

Southern San Joaquin Municipal Utility District Management Area Plan Kern County CA. Prepared by: GEI Consultants, Inc., dated December 2019.

South Kings Groundwater Sustainability Agency Groundwater Sustainability Plan. Prepared by: Provost & Pritchard Consulting Group, adopted 19 December 2019.

Tulare Lake Subbasin Groundwater Sustainability Plan Volume 1, dated January 2020.

## ATTACHMENTS

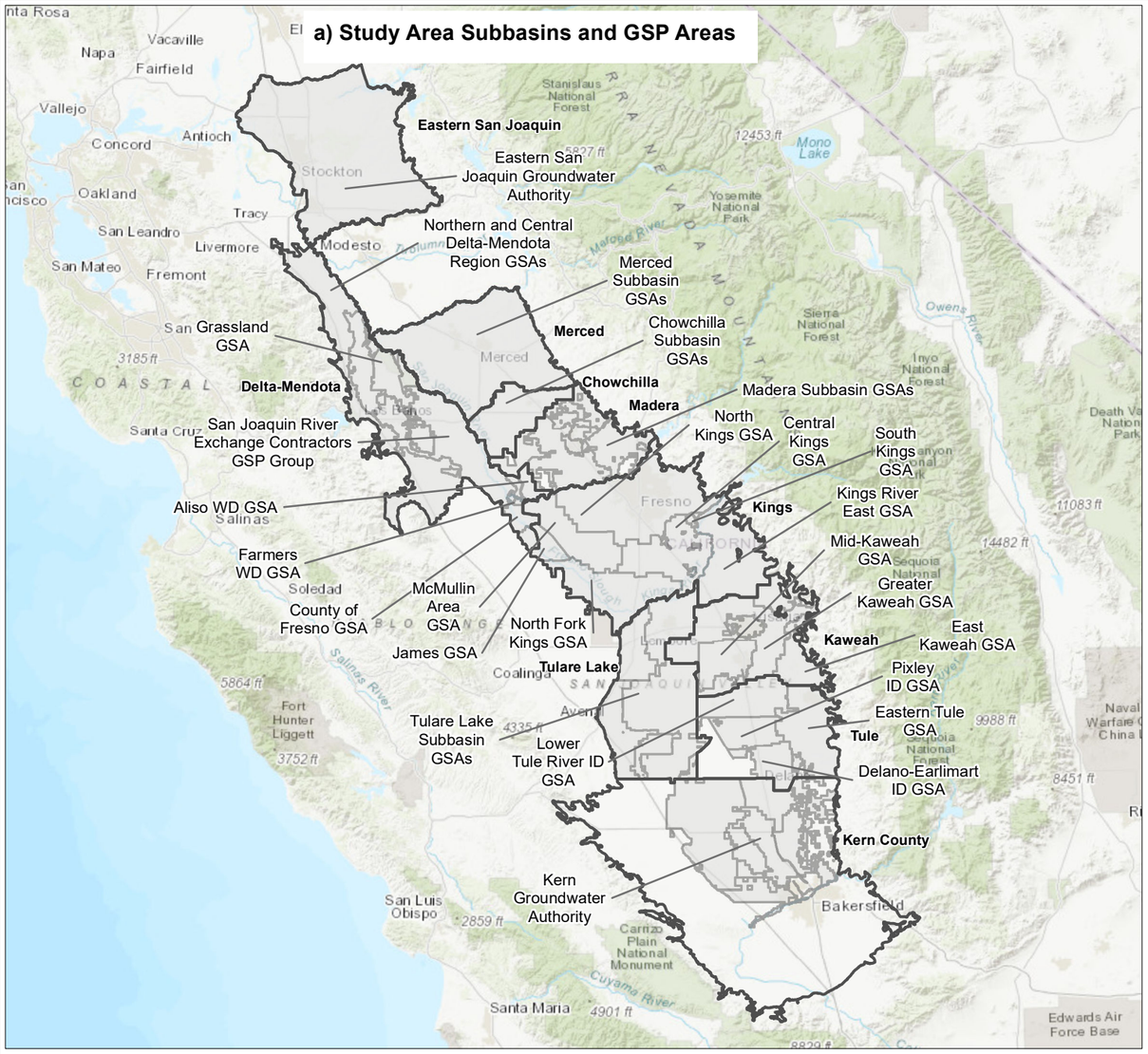
### FIGURES



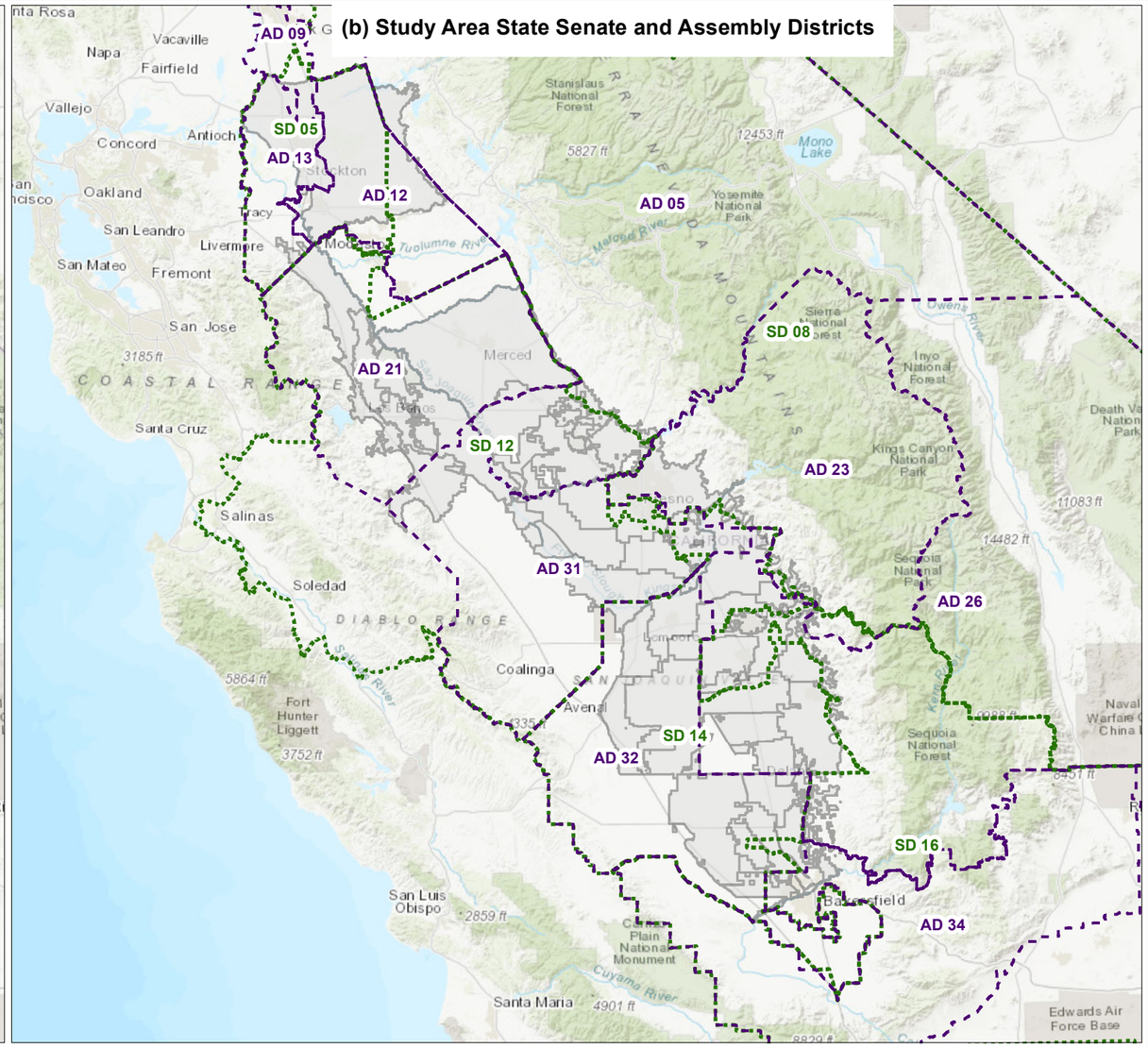
### TABLES

**APPENDICES**

## a) Study Area Subbasins and GSP Areas




## (b) Study Area State Senate and Assembly Districts




### Legend

- Groundwater Subbasins
- Study Area GSP Areas
- State Assembly Districts
- State Senate Districts

### Abbreviations

AD = Assembly District
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
ID = Irrigation District
SD = Senate District
WD = Water District

### Notes

1. All locations are approximate.
2. Selected groundwater subbasins are part of the greater San Joaquin Valley groundwater basin.

### Sources

1. GSP areas as mapped in their respective GSPs (see references section for list).
2. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.
3. Basemap provided by ESRI.
4. State and Assembly districts aquired from https://wedrawthelines.ca.gov.

N

0 35 70

(Scale in Miles)

**Study Area**

Water Foundation
April 2020
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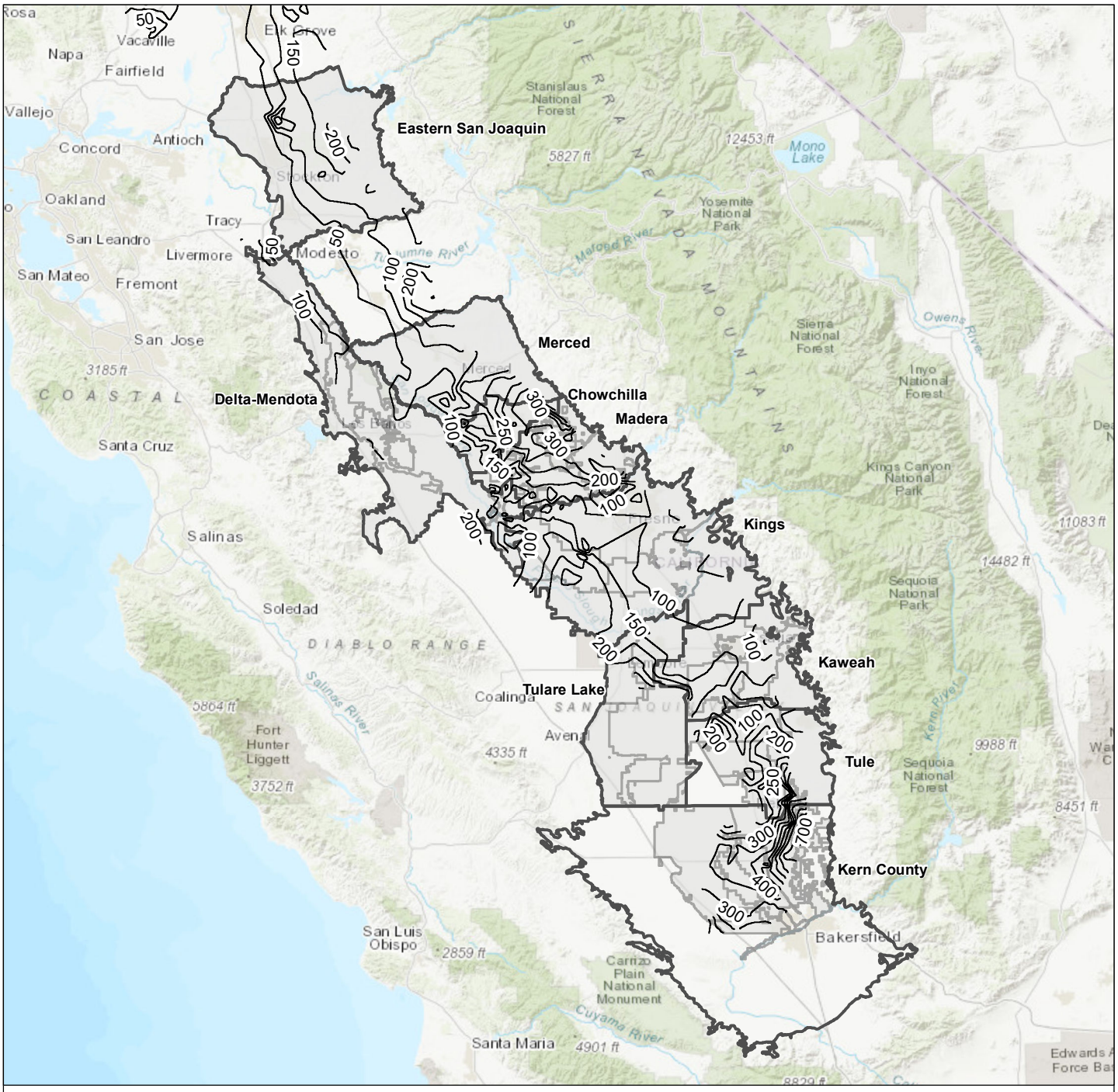
**Figure 1**

eki environment & water

Path: X:\B90087.02\Maps\20200903\Fig1_StudyArea.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas
- Fall 2018 Depth to Groundwater Contour (ft bgs)

## Abbreviations

DWR = California Department of Water Resources
ft bgs = feet below ground surface
GICIMA = Groundwater Information Center Interactive Map Application
GSP = Groundwater Sustainability Plan

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(Scale in Miles)

## Notes

1. All locations are approximate.
2. Contours are mapped at 50-foot intervals.

## Sources

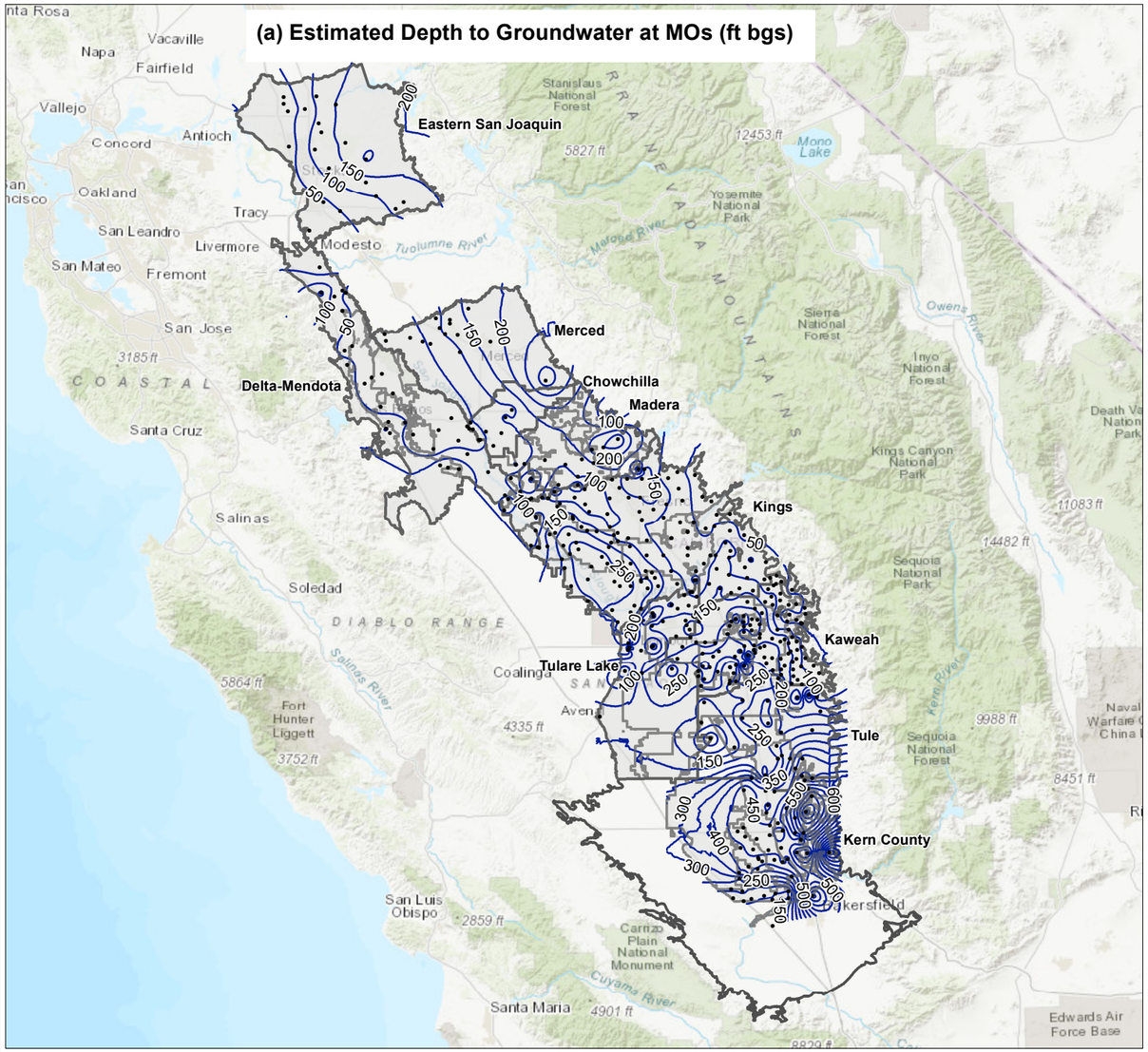
1. DWR (2019) Fall 2018 depth to groundwater contours, GICIMA https://gis.water.ca.gov/app/gicima/ accessed 5 December 2019.
2. GSP areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

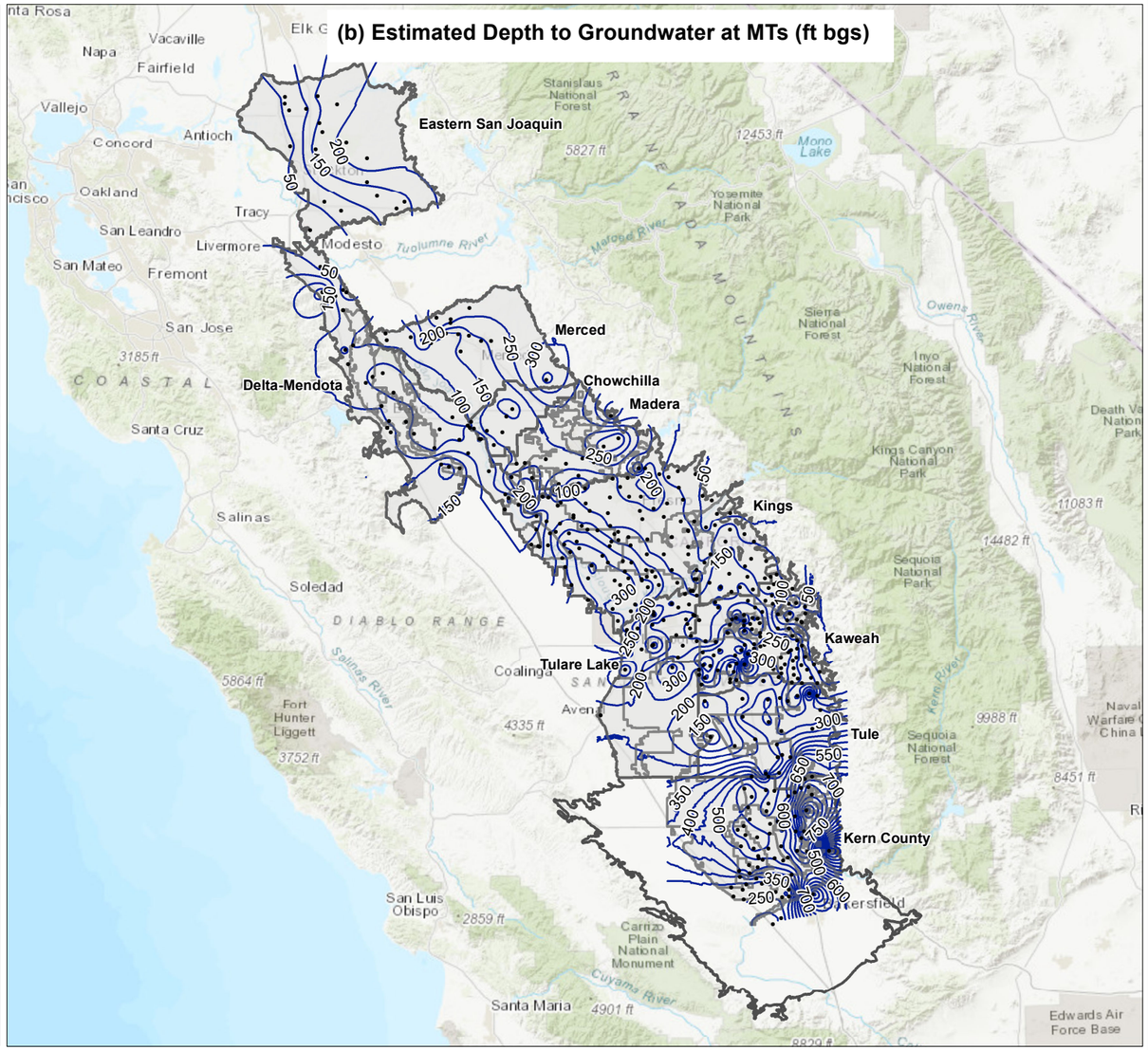
# Fall 2018 Depth to Groundwater

Water Foundation
April 2020
EKI B90087.01

**Figure 2**

Path: X:\B90087.02\Maps\2020\03\Fig2_Fall2018 Contours.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas
- Depth to Groundwater Contours (ft bgs)
- Representative Monitoring Wells (Note 1)

## Abbreviations

ft bgs = feet below ground surface
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
MT = Minimum Threshold
RMW = representative monitoring well

## Notes

1. All locations are approximate.
2. This map reflects contours of depth to groundwater if water levels at all RMWs (excluding those identified as lower aquifer wells) reached their associated MOs and MTs.
3. Contours are mapped at 50-foot intervals.

## Sources

1. RMWs and associated MO and MT values as identified in their respective GSPs (see references section for list).
2. GSP areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

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(Scale in Miles)

**Estimated Depth to Groundwater at Measurable Objectives and Minimum Thresholds**

Water Foundation
April 2020
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**Figure 3**

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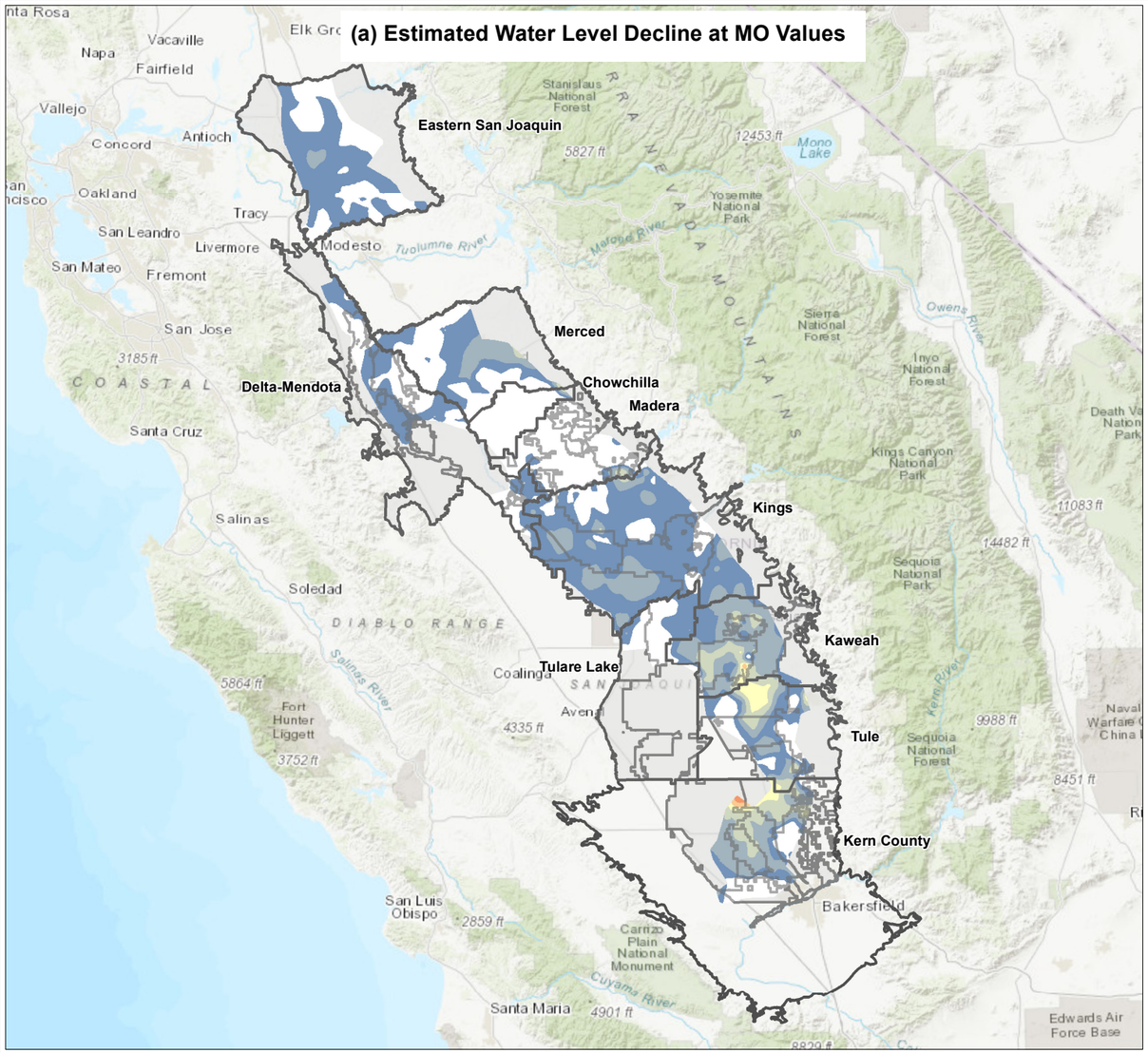
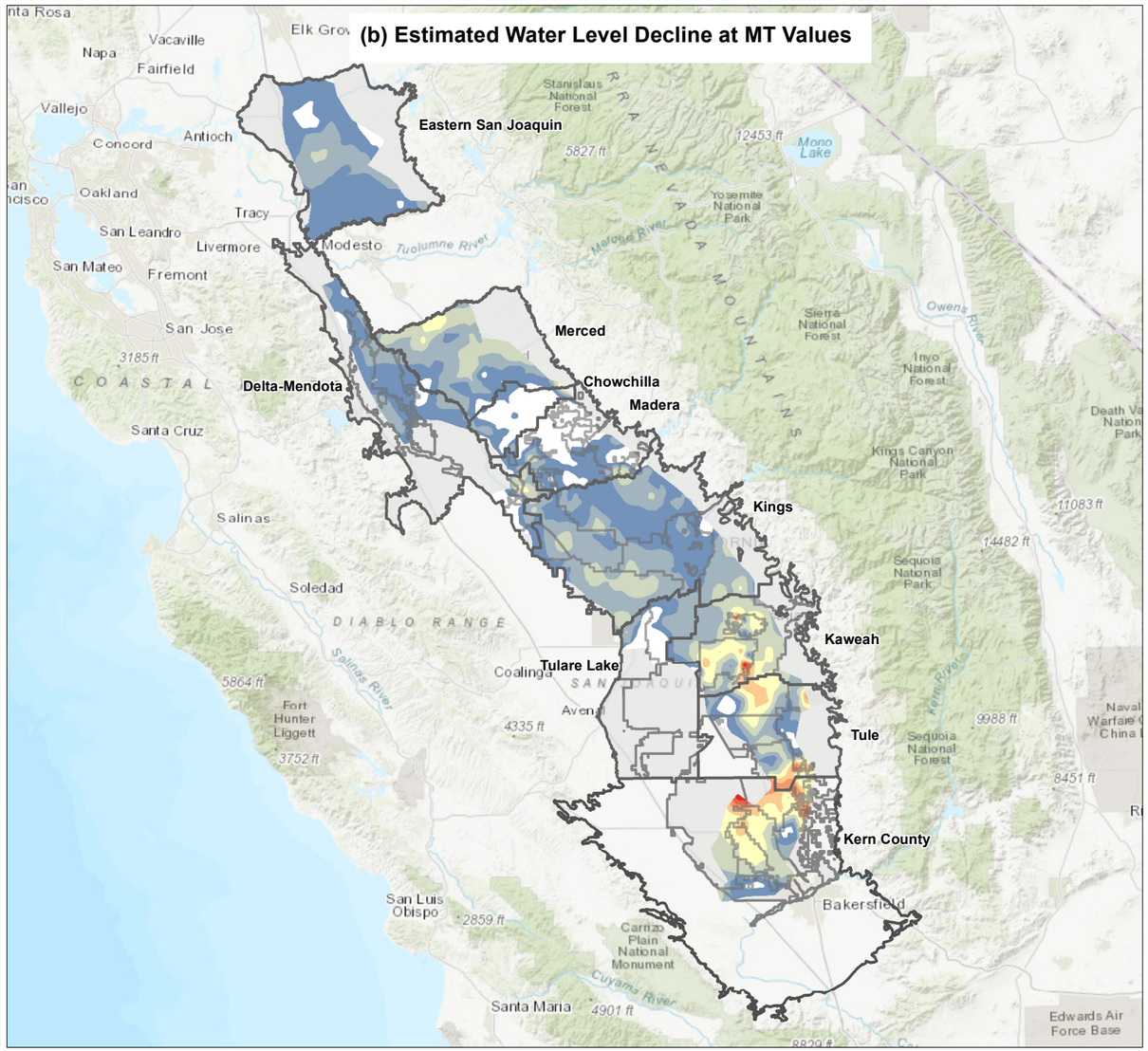
Path: X:\B90087.02\Maps\20201003\Fig3_EstimatedDepthtoGroundwateratMOsandMTs.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Water Level Decline (feet)**

- Above Current (Fall 2018) DTW
- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- > 350

## Abbreviations

DTW = depth to groundwater
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
MT = Minimum Threshold

## Notes

1. All locations are approximate.
2. This map reflects the water level decline anticipiated to occur if current (Fall 2018) DTW were to reach their associated MOs or MTs.

## Sources

1. Fall 2018 depth to groundwater contours (Figure 2).
2. Estimated depth to groundwater at MOs and MTs (Figure 3).
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

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(Scale in Miles)

**Estimated Water Level Decline between Depth to Groundwater from Fall 2018 Water Levels to MOs and MTs**

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**Figure 4**

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Path: X:\B90087.02\Maps\2020\03\Fig4_WLVLdecline.mxd

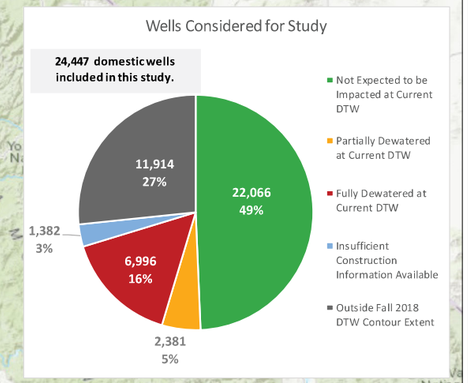
## (a) Domestic Wells Not Included in Study

## (b) Domestic Wells Included in Study

Eastern San Joaquin
Merced
Chowchilla
Madera
Delta-Mendota
Kings
Kaweah
Tulare Lake
Tule
Kern County

**Domestic Wells Not Included in Study (Note 3)**
- Fully Dewatered at Current (Fall 2018) DTW
- Insufficient Construction Information Available
- Outside Fall 2018 DTW Contour Extent

**Domestic Wells Included in Study**
- Not Expected to be Impacted at Current (Fall 2018) DTW
- Partially Dewatered at Current (Fall 2018) DTW




### Legend
- GICIMA Fall 2018 Depth to Groundwater Contour Extent
- Groundwater Subbasins
- Study Area GSP Areas

### Abbreviations
DTW = depth to groundwater
DWR = California Department of Water Resources
GICIMA = Groundwater Information Center Interactive Map Application
GSP = Groundwater Sustainability Plan
PLSS = Public Land Survey System
WESS = Water Equity Science Shop

### Notes
1. All locations are approximate.
2. Only domestic wells located within the selected groundwater subbasins and GSP areas are shown. Domestic wells are frequently plotted at the center of the PLSS Section. Domestic wells were selected based on their mapped location and thus may be incorrectly attributed to the neighboring groundwater subbasin or GSP area.
3. Domestic wells were eliminated for purposes of this study based on:
   - Being located outside the extent of the GICIMA Fall 2018 depth to groundwater contours.
   - Insufficient well construction information available. Wells with missing or implausible screened interval depths were eliminated if screened interval depths could not be reasonably estimated.
   - Fall 2018 depth to groundwater was greater than the minimum separation distance from the bottom of the well screened interval (i.e., fully dewatered at current DTW).

### Sources
1. Domestic well dataset from UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well locations version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
2. DWR (2019) Fall 2018 depth to groundwater contours, Groundwater Information Center Interactive Map Application (GICIMA) https://gis.water.ca.gov/app/gicima/ accessed 5 December 2019.
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

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(Scale in Miles)

**Domestic Well Dataset Screening**

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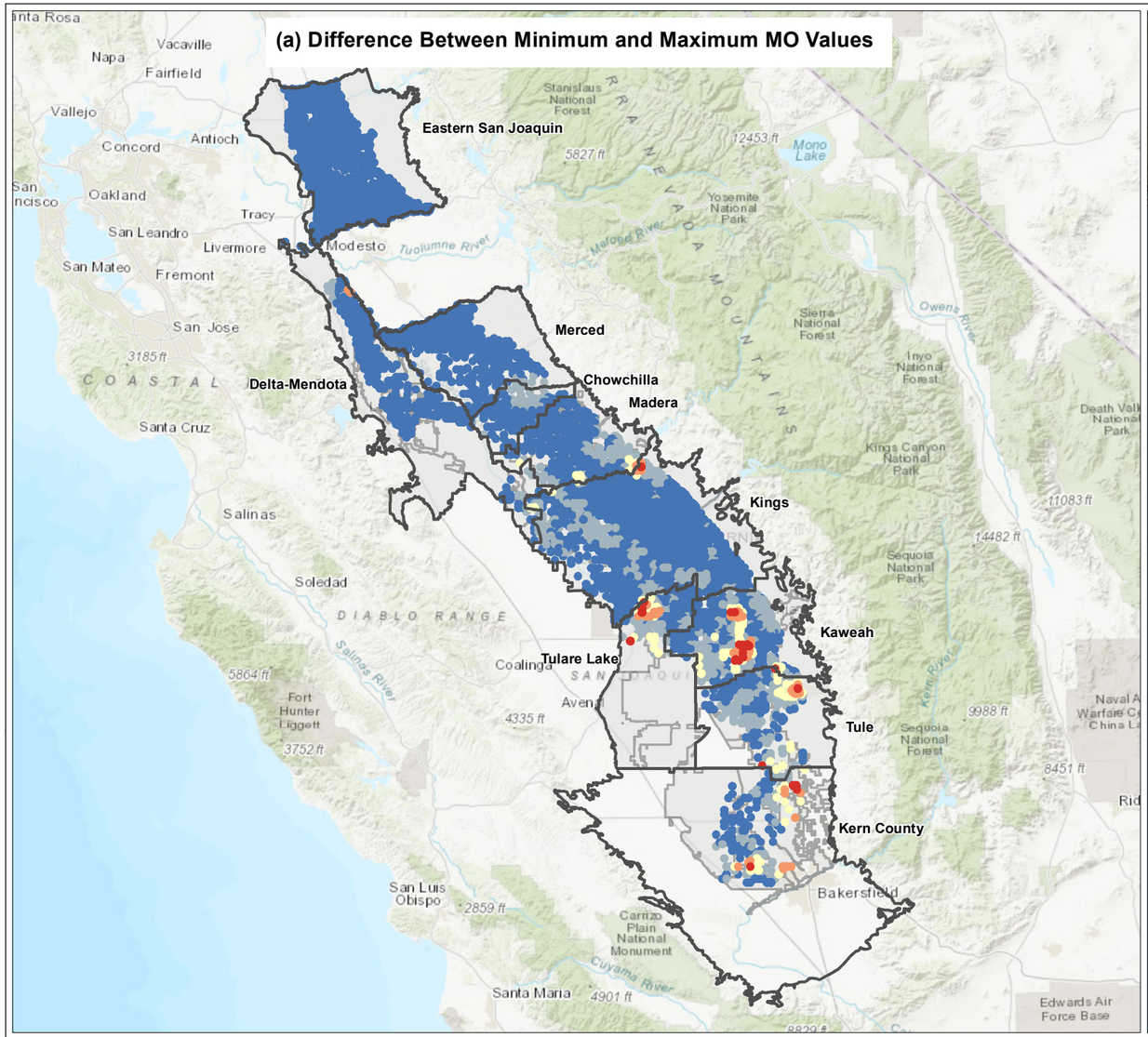
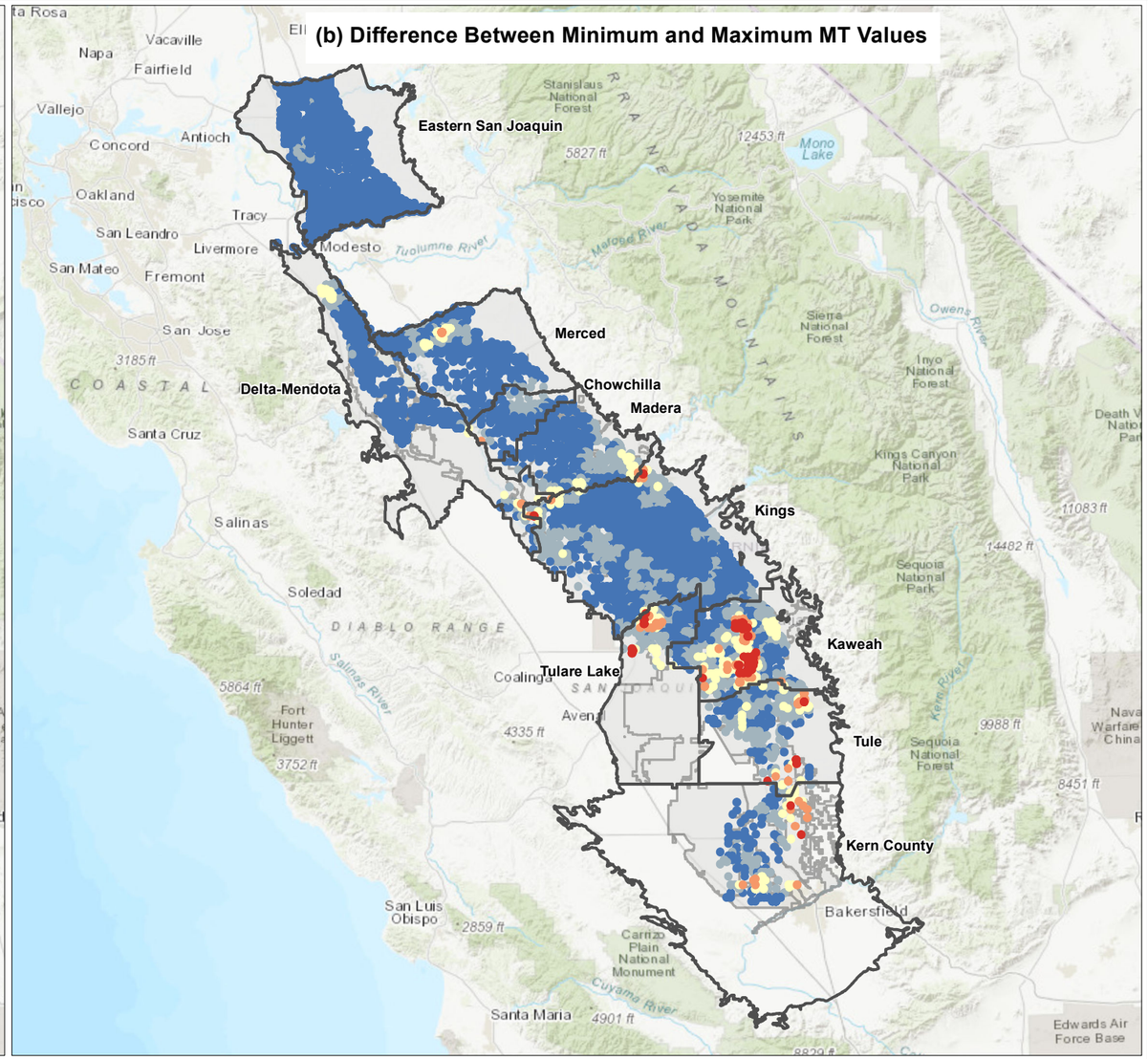
April 2020
EKI B90087.01
**Figure 6**

Path: X:\B90087.02\Maps\2020\03\Fig5_WellDataset.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Difference in Depth to Groundwater (feet)**

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- >80

## Abbreviations

MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System

## Notes

1. All locations are approximate.
2. This map reflects the difference between estimated MO and MT values within each PLSS section containing domestic wells within the study area.

## Sources

1. Domestic wells as mapped in Figure 5.
2. Estimated depth to groundwater at MOs and MTs (Figure 3).
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

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(Scale in Miles)

**Difference in Estimated MOs and MTs within PLSS Section**

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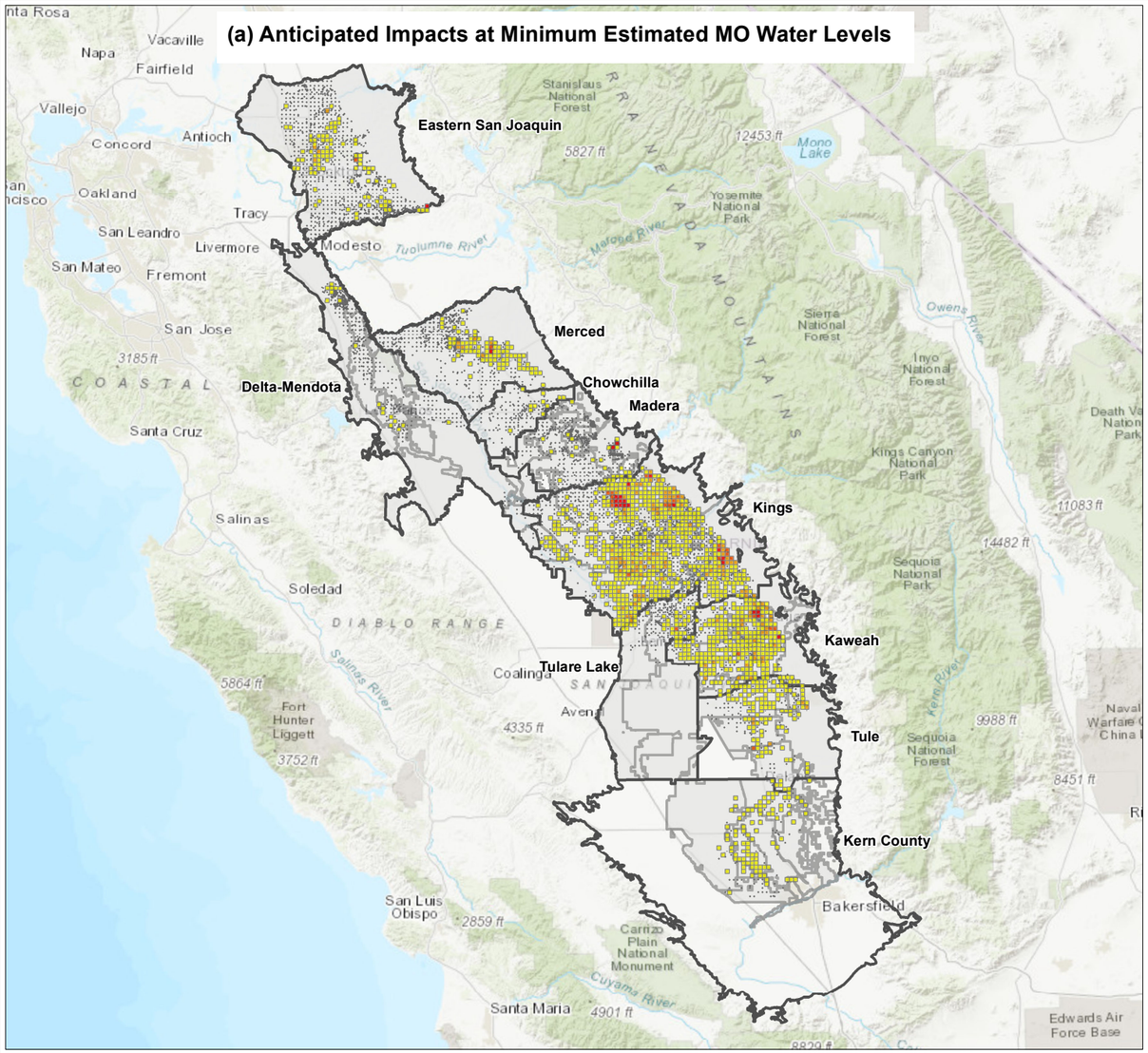
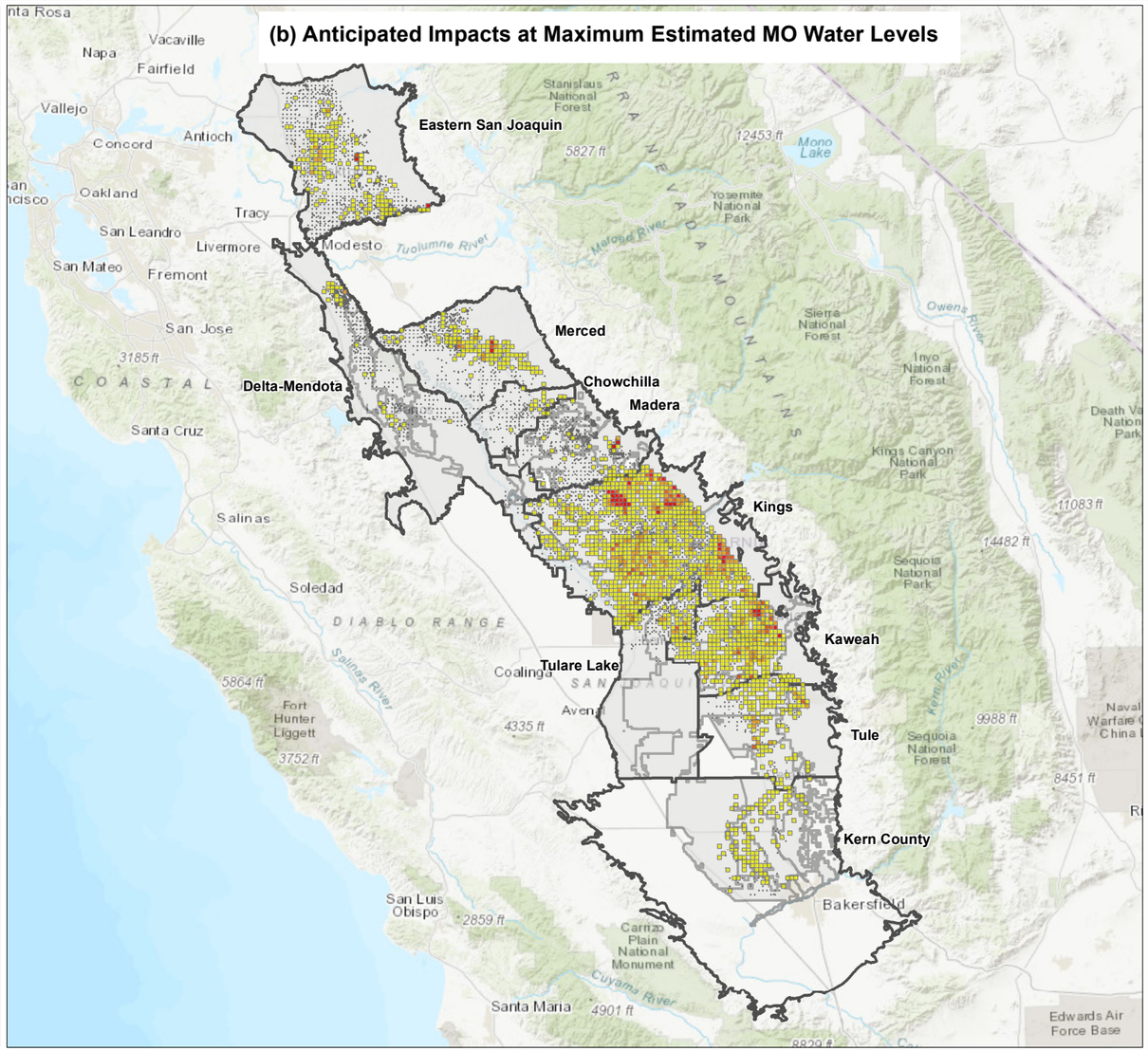
April 2020
EKI B90087.01

**Figure 7**

Path: X:\B90087.02\Maps\2020\03\Fig7_MOMT_MinMax_PLSS.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Impacted Domestic Well Counts by PLSS Section**

- 1 - 5
- 6 - 10
- 11 - 15
- >15
- Domestic Wells Included in Study

## Abbreviations

GSP = Groundwater Sustainability Plan
MO = Measurable Objective
PLSS = Public Land Survey System

## Notes

1. All locations are approximate.
2. Using the domestic wells included in the study (Figure 5), impacts to domestic wells at minimum and maximum MO values (Figure 3) were assessed whereby a well is fully dewatered if the depth to groundwater is greater than or equal to the minimum separation distance from the bottom of the screened interval and is partially dewatered if the depth to groundwater is greater than or equal to the top of the screen.
3. Impacted domestic well statistics are limited to those with sufficient data for evaluation (Figure 5).

## Sources

1. Domestic wells as mapped in Figure 5.
2. Depth to groundwater at MO values as mapped in Figure 3.
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

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0 35 70

(Scale in Miles)

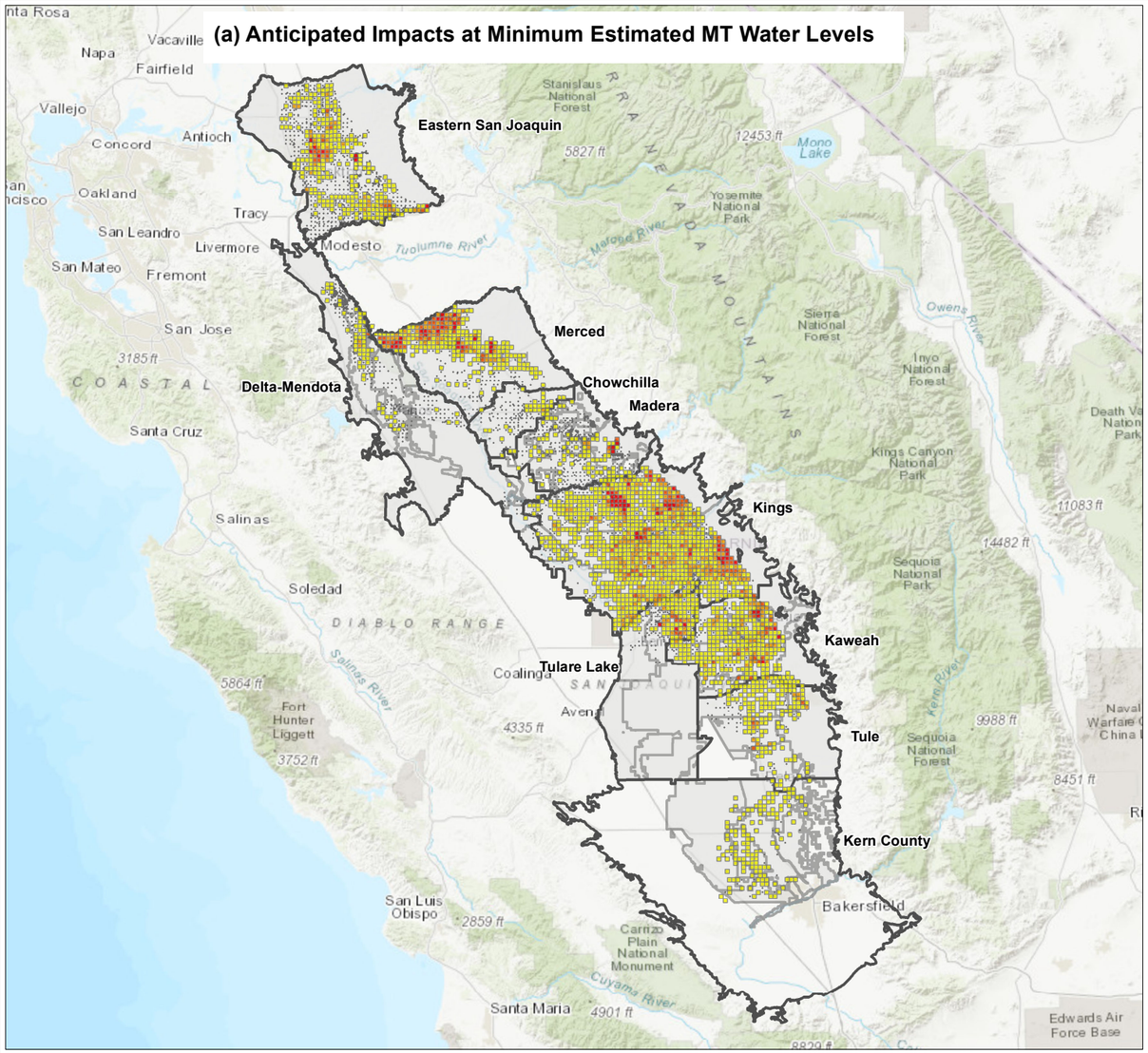
**Estimated Domestic Well Dewatering Impacts at MO Water Levels**

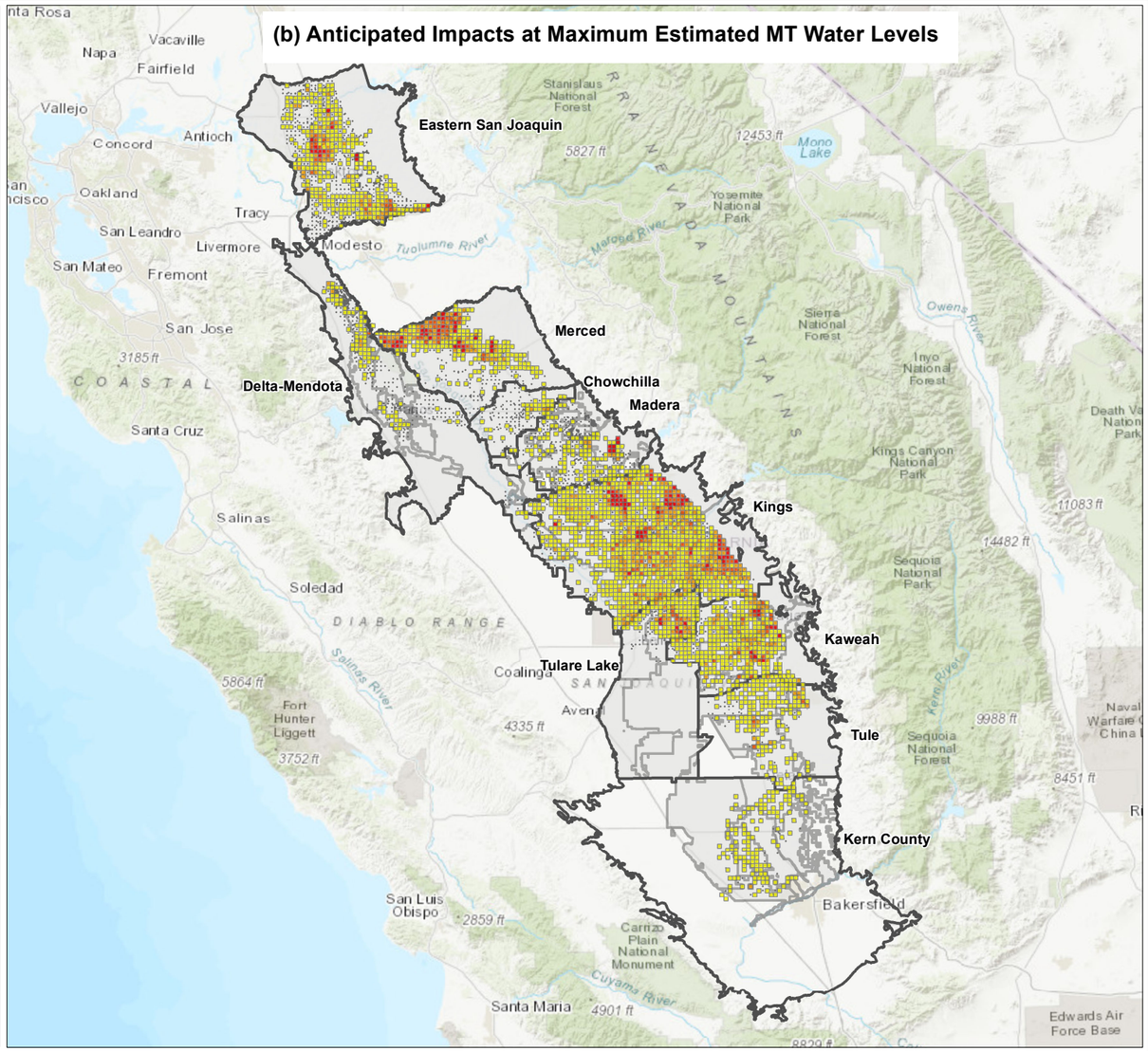
Water Foundation
April 2020
EKI B90087.01

**Figure 8**

eki environment & water

Path: X:\B90087.02\Maps\2020\03\Fig8_ImpactedCounts_MO.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Impacted Domestic Well Counts by PLSS Section**

- 1 - 5
- 6 - 10
- 11 - 15
- >15
- Domestic Wells Included in Study

## Abbreviations

GSP = Groundwater Sustainability Plan
MT = Minimum Threshold
PLSS = Public Land Survey System

## Notes

1. All locations are approximate.
2. Using the domestic wells included in the study (Figure 5), impacts to domestic wells at minimum and maximum MT values (Figure 3) were assessed whereby a well is fully dewatered if the depth to groundwater is greater than or equal to the minimum separation distance from the bottom of the screened interval and is partially dewatered if the depth to groundwater is greater than or equal to the top of the screen.
3. Impacted domestic well statistics are limited to those with sufficient data for evaluation (Figure 5).

## Sources

1. Domestic wells as mapped in Figure 5.
2. Depth to groundwater at MT values as mapped in Figure 3.
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 35 70

(Scale in Miles)

**Estimated Domestic Well Dewatering Impacts at MT Water Levels**

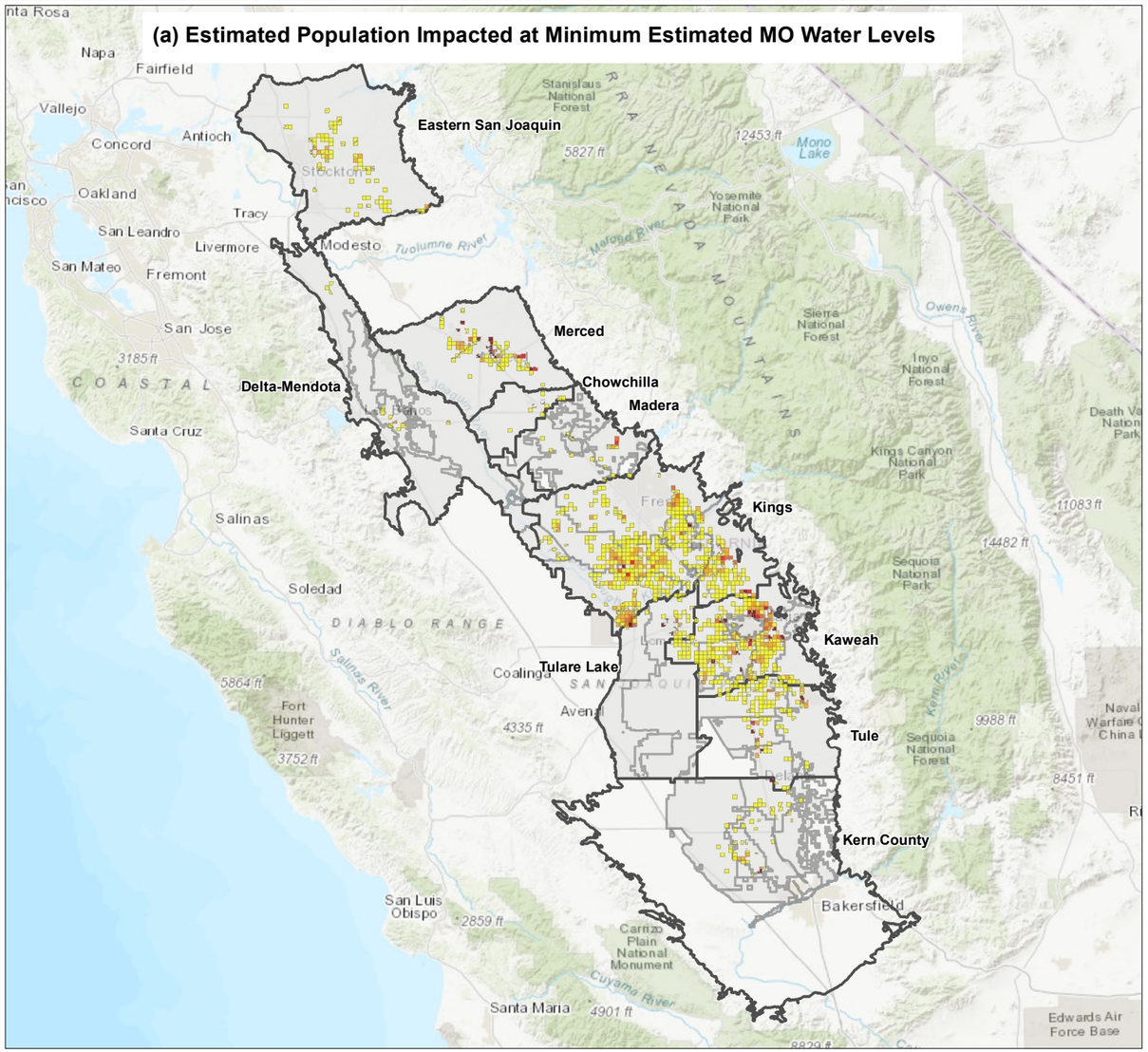
Water Foundation
April 2020
EKI B90087.01

**Figure 9**

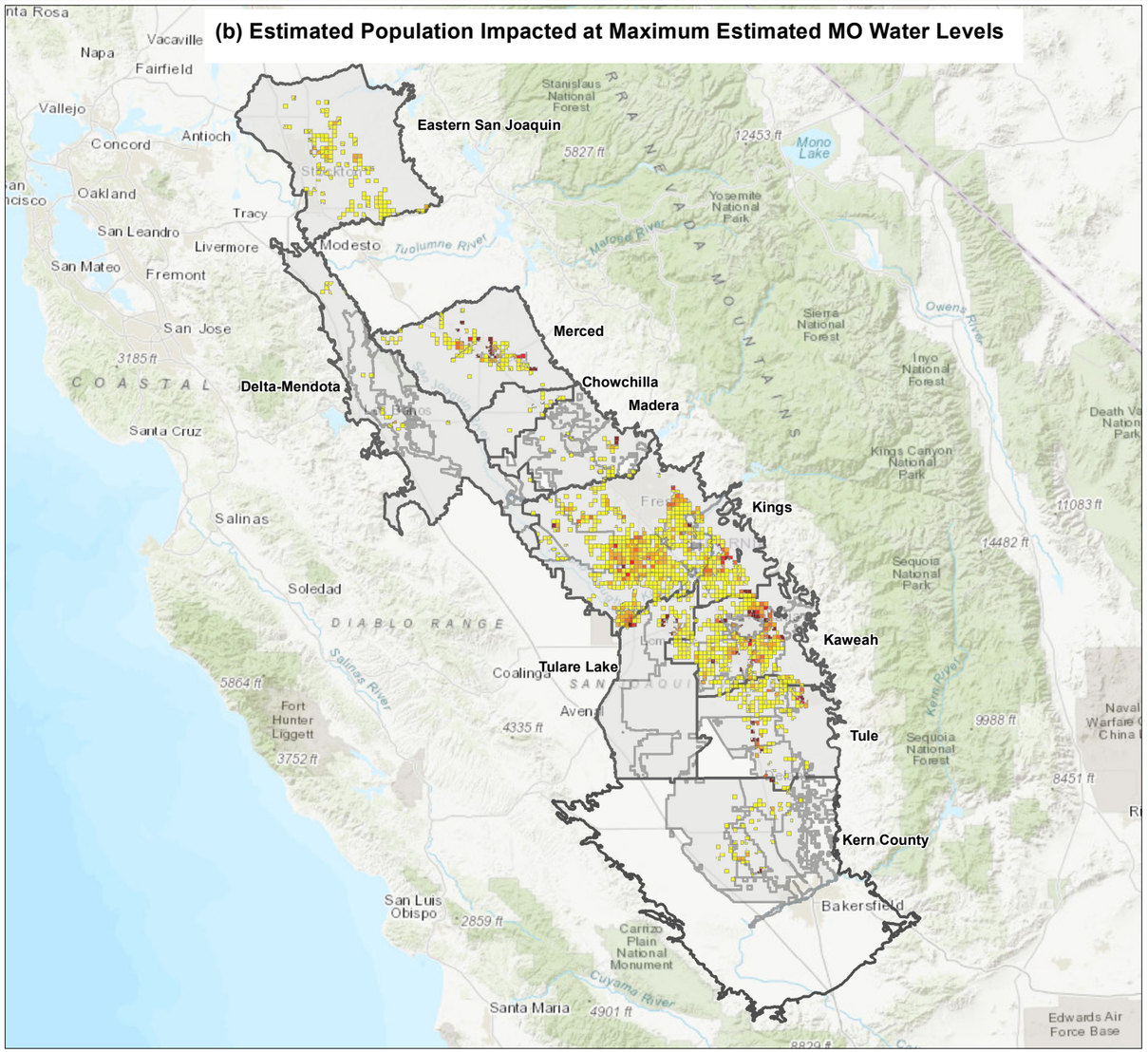
eki environment & water

Path: X:\B90087.02\Maps\2020\03\Fig9_ImpactedCounts_MT.mxd

## (a) Estimated Population Impacted at Minimum Estimated MO Water Levels




## (b) Estimated Population Impacted at Maximum Estimated MO Water Levels




### Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Estimated Population Impacted by PLSS Section**

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- >200

### Abbreviations

GSP = Groundwater Sustainability Plan
MO = Measurable Objective
PLSS = Public Land Survey System

### Notes

1. All locations are approximate.
2. Estimated population reliant upon groundwater is scaled by the impacted domestic well counts (Figure 5) by PLSS Section to estimate the population anticipated to be impacted by domestic well dewatering.

### Sources

1. Impacted domestic wells as mapped in Figure 5.
2. Estimated population reliant upon groundwater from UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well locations version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 35 70

(Scale in Miles)

**Estimated Population Anticipated to be Impacted by Domestic Wells Dewatering at MO Water Levels**

eki environment & water

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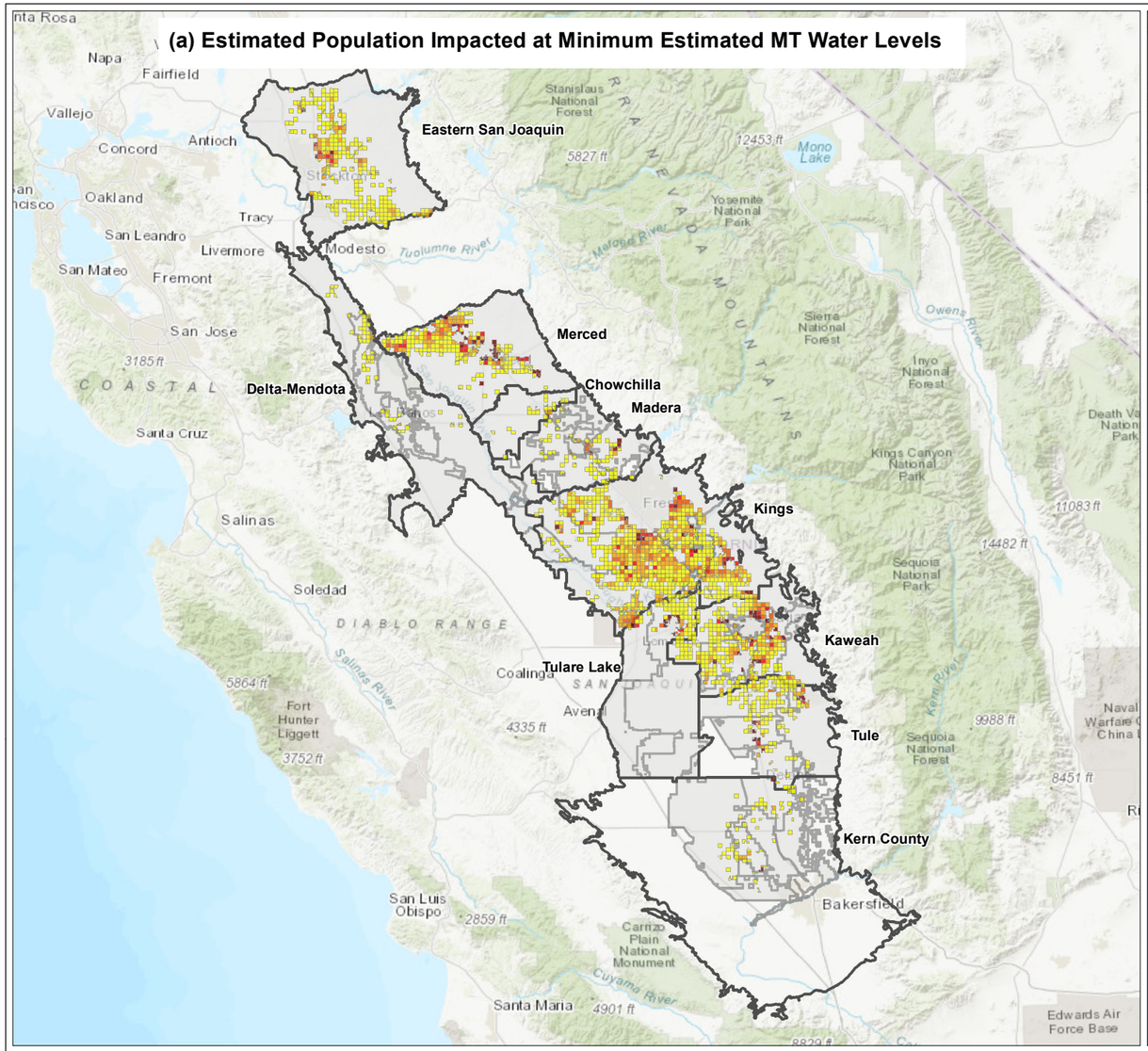
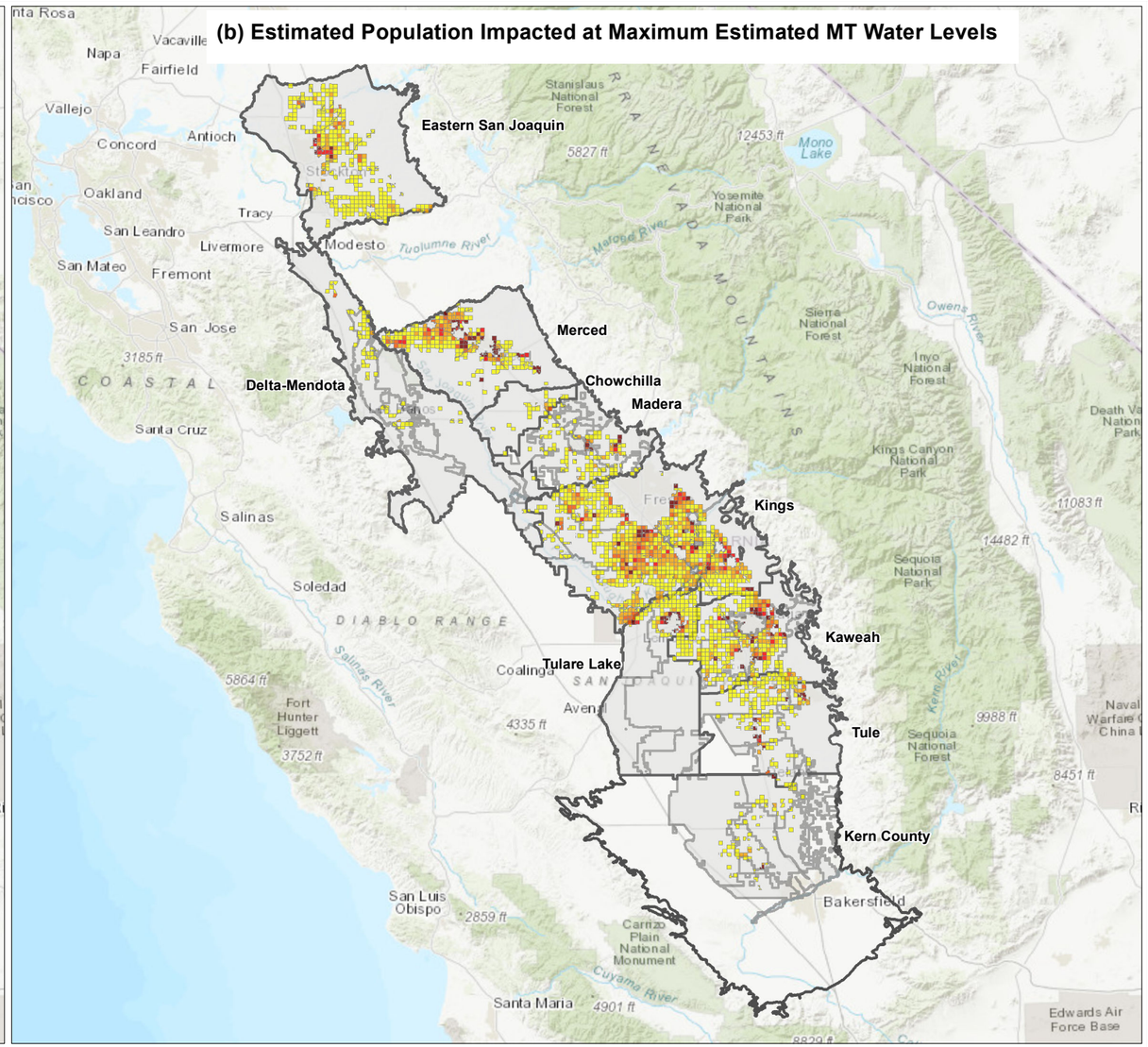
April 2020
EKI B90087.01
**Figure 10**

Path: X:\B90087.02\Maps\2020\03\Fig10_ImpactedPopulation_MO.mxd




## Legend

- Groundwater Subbasins
- Study Area GSP Areas

**Estimated Population Impacted by PLSS Section**

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- >200

## Abbreviations

GSP = Groundwater Sustainability Plan
MT = Minimum Threshold
PLSS = Public Land Survey System

## Notes

1. All locations are approximate.
2. Estimated population reliant upon groundwater is scaled by the impacted domestic well counts (Figure 5) by PLSS Section to estimate the population anticipated to be impacted by domestic well dewatering.

## Sources

1. Impacted domestic wells as mapped in Figure 5.
2. Estimated population reliant upon groundwater from UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well locations version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
3. GSP areas as mapped in their respective GSPs (see references section for list).
4. Basemap provided by ESRI.
5. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 35 70

(Scale in Miles)

**Estimated Population Anticipated to be Impacted by Domestic Wells Dewatering at MT Water Levels**

Water Foundation
April 2020
EKI B90087.01
**Figure 11**

eki environment & water

Path: X:\B90087.02\Maps\2020\03\Fig11_ImpactedPopulation_MT.mxd

**Table 1. Summary of Available Domestic Well Data**

| Subbasin | Total Wells | Included in Study | | Not Included in Study | | |
|---|---|---|---|---|---|---|
| | | Not Expected to be Impacted at Current DTW | Partially Dewatered at Current DTW | Fully Dewatered at Current DTW | Insufficient Construction Information Available | Outside Fall 2018 DTW Contour Extent |
| Chowchilla | 505 | 179 | 114 | 135 | 73 | 4 |
| Delta-Mendota | 2,240 | 1,338 | 8 | 61 | 10 | 823 |
| Eastern San Joaquin | 9,738 | 7,034 | 113 | 465 | 90 | 2,036 |
| Kaweah | 3,492 | 1,224 | 280 | 695 | 144 | 1,149 |
| Kern County | 1,994 | 193 | 95 | 64 | 25 | 1,617 |
| Kings | 15,272 | 6,524 | 826 | 3,040 | 704 | 4,178 |
| Madera | 4,745 | 1,545 | 745 | 1,317 | 187 | 951 |
| Merced | 3,673 | 2,825 | 24 | 472 | 54 | 298 |
| Tulare Lake | 1,780 | 794 | 87 | 672 | 71 | 156 |
| Tule | 1,300 | 410 | 89 | 75 | 24 | 702 |
| **Total** | **44,739** | **22,066** | **2,381** | **6,996** | **1,382** | **11,914** |
| *Percentage of Total Wells* | | *49%* | *5%* | *16%* | *3%* | *27%* |

**Abbreviations:**

DTW = depth to groundwater

DWR = California Department of Water Resources

GICIMA = Groundwater Information Center Interactive Map Application

WESS = Water Equity Science Shop

**Notes:**

1. Current DTW is defined as Fall 2018 DTW for the purposes of this study.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
4. Wells with missing or implausible screened interval depths were eliminated if screened interval depths could not be reasonably estimated. See White Paper for details.

**Sources:**


1. DWR (2019). Fall 2018 depth to groundwater contours, GICIMA https://gis.water.ca.gov/app/gicima/ accessed 5 December 2019.
2. UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well locations version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.

**Table 2a. Estimated Domestic Wells Impacted at MOs by GSP Area**

| GSP Area | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| Aliso WD GSA | 4 | 0 - 1 | 0 - 25% | 0 - 0 | 0 - 0% | 0 - 1 | 0 - 25% |
| Central Kings GSA | 1,884 | 139 - 143 | 7 - 8% | 249 - 455 | 13 - 24% | 388 - 598 | 21 - 32% |
| Chowchilla Subbasin GSAs | 293 | 11 - 16 | 4 - 5% | 0 - 0 | 0 - 0% | 11 - 16 | 4 - 5% |
| County of Fresno GSA | 23 | 0 - 0 | 0 - 0% | 0 - 1 | 0 - 4% | 0 - 1 | 0 - 4% |
| Delano-Earlimart ID GSA | 47 | 15 - 17 | 32 - 36% | 8 - 15 | 17 - 32% | 23 - 32 | 49 - 68% |
| East Kaweah GSA | 86 | 30 - 18 | 35 - 21% | 9 - 31 | 10 - 36% | 39 - 49 | 45 - 57% |
| Eastern San Joaquin Groundwater Authority | 7,147 | 96 - 131 | 1 - 2% | 109 - 221 | 2 - 3% | 205 - 352 | 3 - 5% |
| Eastern Tule GSA | 136 | 28 - 39 | 21 - 29% | 20 - 43 | 15 - 32% | 48 - 82 | 35 - 60% |
| Farmers WD GSA | 2 | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% |
| Grassland GSA | 82 | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% |
| Greater Kaweah GSA | 998 | 171 - 151 | 17 - 15% | 408 - 519 | 41 - 52% | 579 - 670 | 58 - 67% |
| James GSA | 95 | 5 - 4 | 5 - 4% | 17 - 29 | 18 - 31% | 22 - 33 | 23 - 35% |
| Kern Groundwater Authority | 288 | 86 - 82 | 30 - 28% | 43 - 65 | 15 - 23% | 129 - 147 | 45 - 51% |
| Kings River East GSA | 1,113 | 117 - 133 | 11 - 12% | 290 - 400 | 26 - 36% | 407 - 533 | 37 - 48% |
| Lower Tule River ID GSA | 183 | 51 - 44 | 28 - 24% | 44 - 64 | 24 - 35% | 95 - 108 | 52 - 59% |
| Madera Subbasin Joint GSP | 2,290 | 86 - 122 | 4 - 5% | 12 - 34 | 1 - 1% | 98 - 156 | 4 - 7% |
| McMullin Area GSA | 337 | 84 - 89 | 25 - 26% | 39 - 99 | 12 - 29% | 123 - 188 | 36 - 56% |
| Merced Subbasin GSAs | 2,849 | 36 - 40 | 1 - 1% | 177 - 242 | 6 - 8% | 213 - 282 | 7 - 10% |
| Mid-Kaweah GSA | 421 | 98 - 85 | 23 - 20% | 199 - 265 | 47 - 63% | 297 - 350 | 71 - 83% |
| North Fork Kings GSA | 538 | 110 - 108 | 20 - 20% | 200 - 255 | 37 - 47% | 310 - 363 | 58 - 67% |
| North Kings GSA | 3,290 | 462 - 504 | 14 - 15% | 465 - 840 | 14 - 26% | 927 - 1,344 | 28 - 41% |
| Northern and Central Delta-Mendota Region GSAs | 543 | 2 - 2 | 0 - 0% | 6 - 25 | 1 - 5% | 8 - 27 | 1 - 5% |
| Pixley ID GSA | 132 | 33 - 37 | 25 - 28% | 27 - 42 | 20 - 32% | 60 - 79 | 45 - 60% |
| San Joaquin River Exchange Contractors GSP Group | 692 | 3 - 3 | 0 - 0% | 9 - 14 | 1 - 2% | 12 - 17 | 2 - 2% |
| South Kings GSA | 93 | 6 - 6 | 6 - 6% | 2 - 10 | 2 - 11% | 8 - 16 | 9 - 17% |
| Tulare Lake Subbasin GSAs | 881 | 42 - 91 | 5 - 10% | 38 - 74 | 4 - 8% | 80 - 165 | 9 - 19% |
| **Total** | **24,447** | **1,711 - 1,866** | **7 - 8%** | **2,371 - 3,743** | **10 - 15%** | **4,082 - 5,609** | **17 - 23%** |

**Abbreviations:**

DTW = depth to groundwater

DWR = California Department of Water Resources

GICIMA = Groundwater Information Center Interactive Map Application

GSA = Groundwater Sustainability Agency

GSP = Groundwater Sustainability Plan

## Table 2a. Estimated Domestic Wells Impacted at MOs by GSP Area

ID = Irrigation District
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act
WD = Water District

**Notes:**

1. GSA Groups represent those GSAs who developed and adopted a joint GSP.
2. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
3. Well is considered partially dewatered if the DTW is less than the top of the screen.
4. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
5. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
6. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 2b. Estimated Domestic Wells Impacted at MOs by Subbasin**

| Subbasin | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| Chowchilla | 293 | 11 - 16 | 4 - 5% | 0 - 0 | 0 - 0% | 11 - 16 | 4 - 5% |
| Delta-Mendota | 1,346 | 5 - 6 | 0 - 0% | 15 - 40 | 1 - 3% | 20 - 46 | 1 - 3% |
| Eastern San Joaquin | 7,147 | 96 - 131 | 1 - 2% | 109 - 221 | 2 - 3% | 205 - 352 | 3 - 5% |
| Kaweah | 1,504 | 299 - 254 | 20 - 17% | 615 - 814 | 41 - 54% | 914 - 1,068 | 61 - 71% |
| Kern County | 288 | 86 - 82 | 30 - 28% | 43 - 65 | 15 - 23% | 129 - 147 | 45 - 51% |
| Kings | 7,350 | 923 - 987 | 13 - 13% | 1,262 - 2,088 | 17 - 28% | 2,185 - 3,075 | 30 - 42% |
| Madera | 2,290 | 86 - 122 | 4 - 5% | 12 - 34 | 1 - 1% | 98 - 156 | 4 - 7% |
| Merced | 2,849 | 36 - 40 | 1 - 1% | 177 - 242 | 6 - 8% | 213 - 282 | 7 - 10% |
| Tulare Lake | 881 | 42 - 91 | 5 - 10% | 38 - 74 | 4 - 8% | 80 - 165 | 9 - 19% |
| Tule | 499 | 127 - 137 | 25 - 27% | 100 - 165 | 20 - 33% | 227 - 302 | 45 - 61% |
| **Total** | **24,447** | **1,711 - 1,866** | **7 - 8%** | **2,371 - 3,743** | **10 - 15%** | **4,082 - 5,609** | **17 - 23%** |

**Abbreviations:**

DTW = depth to groundwater
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
4. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 2c. Estimated Domestic Wells Impacted at MOs by California Senate District**

| California Senate District | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| 5 | 6,457 | 87 - 118 | 1 - 2% | 80 - 177 | 1 - 3% | 167 - 295 | 3 - 5% |
| 8 | 2,749 | 387 - 363 | 14 - 13% | 429 - 757 | 16 - 28% | 816 - 1,120 | 30 - 41% |
| 12 | 9,643 | 476 - 571 | 5 - 6% | 579 - 1,012 | 6 - 10% | 1,055 - 1,583 | 11 - 16% |
| 14 | 4,578 | 556 - 634 | 12 - 14% | 826 - 1,202 | 18 - 26% | 1,382 - 1,836 | 30 - 40% |
| 16 | 1,020 | 205 - 180 | 20 - 18% | 457 - 595 | 45 - 58% | 662 - 775 | 65 - 76% |
| **Total** | **24,447** | **1,711 - 1,866** | **7 - 8%** | **2,371 - 3,743** | **10 - 15%** | **4,082 - 5,609** | **17 - 23%** |

**Abbreviations:**

DTW = depth to groundwater

MO = Measurable Objective

PLSS = Public Land Survey System

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Table 2d. Estimated Domestic Wells Impacted at MOs by California Assembly District**

| California Assembly District | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| 5 | 2,578 | 96 - 138 | 4 - 5% | 12 - 34 | 0 - 1% | 108 - 172 | 4 - 7% |
| 9 | 572 | 0 - 0 | 0 - 0% | 0 - 1 | 0 - 0% | 0 - 1 | 0 - 0% |
| 12 | 5,117 | 91 - 119 | 2 - 2% | 73 - 151 | 1 - 3% | 164 - 270 | 3 - 5% |
| 13 | 1,468 | 5 - 12 | 0 - 1% | 36 - 69 | 2 - 5% | 41 - 81 | 3 - 6% |
| 21 | 4,148 | 42 - 46 | 1 - 1% | 192 - 281 | 5 - 7% | 234 - 327 | 6 - 8% |
| 23 | 1,999 | 366 - 342 | 18 - 17% | 385 - 690 | 19 - 35% | 751 - 1,032 | 38 - 52% |
| 26 | 2,637 | 489 - 477 | 19 - 18% | 897 - 1,223 | 34 - 46% | 1,386 - 1,700 | 53 - 64% |
| 31 | 4,401 | 446 - 513 | 10 - 12% | 596 - 1,029 | 14 - 23% | 1,042 - 1,542 | 24 - 35% |
| 32 | 1,483 | 170 - 216 | 11 - 15% | 180 - 261 | 12 - 18% | 350 - 477 | 24 - 32% |
| 34 | 44 | 6 - 3 | 14 - 7% | 0 - 4 | 0 - 9% | 6 - 7 | 14 - 16% |
| **Total** | **24,447** | **1,711 - 1,866** | **7 - 8%** | **2,371 - 3,743** | **10 - 15%** | **4,082 - 5,609** | **17 - 23%** |

**Abbreviations:**

DTW = depth to groundwater

MO = Measurable Objective

PLSS = Public Land Survey System

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Table 3a. Estimated Domestic Wells Impacted at MTs by GSP Area**

| GSP Area | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| Aliso WD GSA | 4 | 2 - 1 | 50 - 25% | 0 - 2 | 0 - 50% | 2 - 3 | 50 - 75% |
| Central Kings GSA | 1,884 | 184 - 195 | 10 - 10% | 847 - 1,009 | 45 - 54% | 1,031 - 1,204 | 55 - 64% |
| Chowchilla Subbasin GSAs | 293 | 38 - 53 | 13 - 18% | 2 - 5 | 1 - 2% | 40 - 58 | 14 - 20% |
| County of Fresno GSA | 23 | 1 - 3 | 4 - 13% | 0 - 1 | 0 - 4% | 1 - 4 | 4 - 17% |
| Delano-Earlimart ID GSA | 47 | 12 - 8 | 26 - 17% | 22 - 30 | 47 - 64% | 34 - 38 | 72 - 81% |
| East Kaweah GSA | 86 | 20 - 13 | 23 - 15% | 44 - 55 | 51 - 64% | 64 - 68 | 74 - 79% |
| Eastern San Joaquin Groundwater Authority | 7,147 | 369 - 470 | 5 - 7% | 728 - 1,062 | 10 - 15% | 1,097 - 1,532 | 15 - 21% |
| Eastern Tule GSA | 136 | 21 - 19 | 15 - 14% | 79 - 94 | 58 - 69% | 100 - 113 | 74 - 83% |
| Farmers WD GSA | 2 | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% | 0 - 0 | 0 - 0% |
| Grassland GSA | 82 | 0 - 0 | 0 - 0% | 2 - 4 | 2 - 5% | 2 - 4 | 2 - 5% |
| Greater Kaweah GSA | 998 | 153 - 145 | 15 - 15% | 627 - 711 | 63 - 71% | 780 - 856 | 78 - 86% |
| James GSA | 95 | 5 - 9 | 5 - 9% | 30 - 41 | 32 - 43% | 35 - 50 | 37 - 53% |
| Kern Groundwater Authority | 288 | 105 - 109 | 36 - 38% | 90 - 105 | 31 - 36% | 195 - 214 | 68 - 74% |
| Kings River East GSA | 1,113 | 136 - 115 | 12 - 10% | 626 - 755 | 56 - 68% | 762 - 870 | 68 - 78% |
| Lower Tule River ID GSA | 183 | 41 - 40 | 22 - 22% | 80 - 92 | 44 - 50% | 121 - 132 | 66 - 72% |
| Madera Subbasin Joint GSP | 2,290 | 239 - 340 | 10 - 15% | 142 - 229 | 6 - 10% | 381 - 569 | 17 - 25% |
| McMullin Area GSA | 337 | 77 - 68 | 23 - 20% | 134 - 197 | 40 - 58% | 211 - 265 | 63 - 79% |
| Merced Subbasin GSAs | 2,849 | 138 - 151 | 5 - 5% | 1,404 - 1,646 | 49 - 58% | 1,542 - 1,797 | 54 - 63% |
| Mid-Kaweah GSA | 421 | 61 - 52 | 14 - 12% | 295 - 352 | 70 - 84% | 356 - 404 | 85 - 96% |
| North Fork Kings GSA | 538 | 105 - 96 | 20 - 18% | 353 - 386 | 66 - 72% | 458 - 482 | 85 - 90% |
| North Kings GSA | 3,290 | 527 - 518 | 16 - 16% | 1,444 - 1,802 | 44 - 55% | 1,971 - 2,320 | 60 - 71% |
| Northern and Central Delta-Mendota Region GSAs | 543 | 2 - 6 | 0 - 1% | 30 - 59 | 6 - 11% | 32 - 65 | 6 - 12% |
| Pixley ID GSA | 132 | 39 - 38 | 30 - 29% | 57 - 68 | 43 - 52% | 96 - 106 | 73 - 80% |
| San Joaquin River Exchange Contractors GSP Group | 692 | 7 - 10 | 1 - 1% | 82 - 97 | 12 - 14% | 89 - 107 | 13 - 15% |
| South Kings GSA | 93 | 6 - 8 | 6 - 9% | 40 - 49 | 43 - 53% | 46 - 57 | 49 - 61% |
| Tulare Lake Subbasin GSAs | 881 | 134 - 155 | 15 - 18% | 259 - 407 | 29 - 46% | 393 - 562 | 45 - 64% |
| **Total** | **24,447** | **2,422 - 2,622** | **10 - 11%** | **7,417 - 9,258** | **30 - 38%** | **9,839 - 11,880** | **40 - 49%** |

**Abbreviations:**

DTW = depth to groundwater

DWR = California Department of Water Resources

GICIMA = Groundwater Information Center Interactive Map Application

GSA = Groundwater Sustainability Agency

GSP = Groundwater Sustainability Plan

## Table 3a. Estimated Domestic Wells Impacted at MTs by GSP Area

ID = Irrigation District
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act
WD = Water District

**Notes:**

1. GSA Groups represent those GSAs who developed and adopted a joint GSP.
2. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
3. Well is considered partially dewatered if the DTW is less than the top of the screen.
4. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
5. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
6. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 3b. Estimated Domestic Wells Impacted at MTs by Subbasin**

| Subbasin | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| Chowchilla | 293 | 38 - 53 | 13 - 18% | 2 - 5 | 1 - 2% | 40 - 58 | 14 - 20% |
| Delta-Mendota | 1,346 | 12 - 20 | 1 - 1% | 114 - 163 | 8 - 12% | 126 - 183 | 9 - 14% |
| Eastern San Joaquin | 7,147 | 369 - 470 | 5 - 7% | 728 - 1,062 | 10 - 15% | 1,097 - 1,532 | 15 - 21% |
| Kaweah | 1,504 | 234 - 210 | 16 - 14% | 965 - 1,117 | 64 - 74% | 1,199 - 1,327 | 80 - 88% |
| Kern County | 288 | 105 - 109 | 36 - 38% | 90 - 105 | 31 - 36% | 195 - 214 | 68 - 74% |
| Kings | 7,350 | 1,040 - 1,009 | 14 - 14% | 3,474 - 4,239 | 47 - 58% | 4,514 - 5,248 | 61 - 71% |
| Madera | 2,290 | 239 - 340 | 10 - 15% | 142 - 229 | 6 - 10% | 381 - 569 | 17 - 25% |
| Merced | 2,849 | 138 - 151 | 5 - 5% | 1,404 - 1,646 | 49 - 58% | 1,542 - 1,797 | 54 - 63% |
| Tulare Lake | 881 | 134 - 155 | 15 - 18% | 259 - 407 | 29 - 46% | 393 - 562 | 45 - 64% |
| Tule | 499 | 113 - 105 | 23 - 21% | 239 - 285 | 48 - 57% | 352 - 390 | 71 - 78% |
| **Total** | **24,447** | **2,422 - 2,622** | **10 - 11%** | **7,417 - 9,258** | **30 - 38%** | **9,839 - 11,880** | **40 - 49%** |

**Abbreviations:**

DTW = depth to groundwater
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
4. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 3c. Estimated Domestic Wells Impacted at MTs by California Senate District**

| California Senate District | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| 5 | 6,457 | 349 - 446 | 5 - 7% | 590 - 894 | 9 - 14% | 939 - 1,340 | 15 - 21% |
| 8 | 2,749 | 350 - 347 | 13 - 13% | 1,133 - 1,385 | 41 - 50% | 1,483 - 1,732 | 54 - 63% |
| 12 | 9,643 | 867 - 979 | 9 - 10% | 2,915 - 3,615 | 30 - 37% | 3,782 - 4,594 | 39 - 48% |
| 14 | 4,578 | 692 - 700 | 15 - 15% | 2,097 - 2,571 | 46 - 56% | 2,789 - 3,271 | 61 - 71% |
| 16 | 1,020 | 164 - 150 | 16 - 15% | 682 - 793 | 67 - 78% | 846 - 943 | 83 - 92% |
| **Total** | **24,447** | **2,422 - 2,622** | **10 - 11%** | **7,417 - 9,258** | **30 - 38%** | **9,839 - 11,880** | **40 - 49%** |

**Abbreviations:**

DTW = depth to groundwater

MT = Minimum Threshold

PLSS = Public Land Survey System

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Table 3d. Estimated Domestic Wells Impacted at MTs by California Assembly District**

| California Assembly District | Domestic Wells Included in Study | Partially Dewatered | | Fully Dewatered | | Partially or Fully Dewatered | |
|---|---|---|---|---|---|---|---|
| | | Count | Percentage | Count | Percentage | Count | Percentage |
| 5 | 2,578 | 277 - 392 | 11 - 15% | 145 - 237 | 6 - 9% | 422 - 629 | 16 - 24% |
| 9 | 572 | 3 - 8 | 1 - 1% | 33 - 50 | 6 - 9% | 36 - 58 | 6 - 10% |
| 12 | 5,117 | 311 - 362 | 6 - 7% | 536 - 749 | 10 - 15% | 847 - 1,111 | 17 - 22% |
| 13 | 1,468 | 55 - 100 | 4 - 7% | 159 - 263 | 11 - 18% | 214 - 363 | 15 - 25% |
| 21 | 4,148 | 149 - 169 | 4 - 4% | 1,517 - 1,805 | 37 - 44% | 1,666 - 1,974 | 40 - 48% |
| 23 | 1,999 | 320 - 313 | 16 - 16% | 963 - 1,178 | 48 - 59% | 1,283 - 1,491 | 64 - 75% |
| 26 | 2,637 | 428 - 382 | 16 - 14% | 1,614 - 1,899 | 61 - 72% | 2,042 - 2,281 | 77 - 86% |
| 31 | 4,401 | 590 - 582 | 13 - 13% | 1,917 - 2,355 | 44 - 54% | 2,507 - 2,937 | 57 - 67% |
| 32 | 1,483 | 274 - 298 | 18 - 20% | 528 - 715 | 36 - 48% | 802 - 1,013 | 54 - 68% |
| 34 | 44 | 15 - 16 | 34 - 36% | 5 - 7 | 11 - 16% | 20 - 23 | 45 - 52% |
| **Total** | **24,447** | **2,422 - 2,622** | **10 - 11%** | **7,417 - 9,258** | **30 - 38%** | **9,839 - 11,880** | **40 - 49%** |

**Abbreviations:**

DTW = depth to groundwater

MT = Minimum Threshold

PLSS = Public Land Survey System

**Notes:**

1. Range of domestic wells impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Table 4a. Estimated Population Anticipated to be Impacted by Domestic Well Dewatering by GSP Area**

| GSP Area | Estimated Total Population | Estimated Population Impacted | | | | | |
|---|---|---|---|---|---|---|---|
| | | MO Value | | | MT Value | | |
| | | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered |
| Aliso WD GSA | 52 | 0 - 5 | 0 - 0 | 0 - 5 | 5 - 5 | 0 - 0 | 5 - 5 |
| Central Kings GSA | 23,514 | 1,731 - 1,822 | 2,768 - 5,222 | 4,505 - 7,050 | 2,335 - 2,778 | 9,723 - 11,932 | 12,055 - 14,713 |
| Chowchilla Subbasin GSAs | 3,792 | 103 - 114 | 0 - 0 | 103 - 114 | 305 - 442 | 6 - 6 | 311 - 448 |
| County of Fresno GSA | 191 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 22 | 0 - 0 | 0 - 22 |
| Delano-Earlimart ID GSA | 2,374 | 884 - 1,102 | 45 - 61 | 929 - 1,163 | 897 - 888 | 133 - 303 | 1,031 - 1,191 |
| East Kaweah GSA | 12,675 | 437 - 296 | 158 - 420 | 595 - 713 | 337 - 259 | 604 - 764 | 942 - 1,023 |
| Eastern San Joaquin Groundwater Authority | 70,157 | 684 - 842 | 477 - 1,264 | 1,165 - 2,109 | 3,067 - 3,944 | 5,459 - 7,759 | 8,535 - 11,710 |
| Eastern Tule GSA | 23,551 | 274 - 459 | 654 - 1,173 | 927 - 1,632 | 115 - 172 | 1,710 - 1,850 | 1,825 - 2,019 |
| Farmers WD GSA | 1 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 |
| Grassland GSA | 521 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 | 3 - 7 | 3 - 7 |
| Greater Kaweah GSA | 20,510 | 1,916 - 1,694 | 7,321 - 8,412 | 9,232 - 10,106 | 1,934 - 1,584 | 10,239 - 11,341 | 12,176 - 12,924 |
| James GSA | 588 | 23 - 11 | 60 - 99 | 82 - 110 | 8 - 24 | 104 - 133 | 112 - 157 |
| Kern Groundwater Authority | 10,831 | 823 - 510 | 1,572 - 2,008 | 2,393 - 2,517 | 500 - 429 | 2,202 - 2,308 | 2,702 - 2,736 |
| Kings River East GSA | 21,341 | 972 - 1,202 | 2,526 - 3,616 | 3,501 - 4,821 | 1,192 - 1,027 | 5,498 - 6,521 | 6,689 - 7,550 |
| Lower Tule River ID GSA | 3,695 | 567 - 483 | 467 - 730 | 1,037 - 1,214 | 459 - 731 | 887 - 1,001 | 1,345 - 1,731 |
| Madera Subbasin Joint GSP | 29,399 | 453 - 749 | 24 - 96 | 477 - 845 | 1,874 - 2,782 | 811 - 1,603 | 2,683 - 4,384 |
| McMullin Area GSA | 4,535 | 904 - 924 | 478 - 1,179 | 1,383 - 2,104 | 853 - 760 | 1,474 - 2,238 | 2,329 - 2,997 |
| Merced Subbasin GSAs | 50,078 | 783 - 1,202 | 6,216 - 7,117 | 7,000 - 8,321 | 2,882 - 2,233 | 19,190 - 22,889 | 22,077 - 25,120 |
| Mid-Kaweah GSA | 12,917 | 1,615 - 1,418 | 2,234 - 3,052 | 3,848 - 4,470 | 1,219 - 721 | 3,659 - 5,422 | 4,882 - 6,145 |
| North Fork Kings GSA | 5,614 | 928 - 810 | 2,008 - 2,444 | 2,939 - 3,257 | 906 - 792 | 3,169 - 3,415 | 4,073 - 4,205 |
| North Kings GSA | 33,069 | 1,369 - 2,344 | 823 - 1,790 | 2,193 - 4,132 | 3,367 - 3,368 | 6,377 - 8,632 | 9,738 - 12,001 |
| Northern and Central Delta-Mendota Region GSAs | 23,609 | 0 - 0 | 14 - 49 | 14 - 49 | 15 - 100 | 110 - 224 | 125 - 323 |
| Pixley ID GSA | 3,128 | 601 - 975 | 252 - 528 | 853 - 1,503 | 771 - 679 | 905 - 1,076 | 1,675 - 1,754 |
| San Joaquin River Exchange Contractors GSP Group | 9,491 | 19 - 19 | 105 - 132 | 124 - 151 | 40 - 38 | 431 - 497 | 471 - 535 |
| South Kings GSA | 429 | 0 - 0 | 12 - 82 | 12 - 82 | 22 - 22 | 204 - 228 | 226 - 250 |
| Tulare Lake Subbasin GSAs | 35,320 | 1,479 - 2,486 | 918 - 3,515 | 2,395 - 6,005 | 2,745 - 2,438 | 7,232 - 10,194 | 9,978 - 12,639 |
| **TOTAL** | **401,383** | **16,565 - 19,467** | **29,132 - 42,989** | **45,707 - 62,473** | **25,848 - 26,238** | **80,130 - 100,343** | **105,988 - 126,589** |
| *Percentage of Total* | | *4 - 5%* | *7 - 11%* | *11 - 16%* | *6 - 7%* | *20 - 25%* | *26 - 32%* |

**Abbreviations:**

DTW = depth to groundwater
DWR = California Department of Water Resources
GICIMA = Groundwater Information Center Interactive Map Application
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
ID = Irrigation District
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System

SGMA = Sustainable Groundwater Management Act
WD = Water District
WESS = Water Equity Science Shop

**Notes:**

1. GSA groups represent those GSAs who developed and adopted a joint GSP.
1. Range of population impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
3. Well is considered partially dewatered if the DTW is less than the top of the screen.
4. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
5. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
6. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Sources:**

1. UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well communities version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
2. Estimated domestic wells impacted at MOs and MTs, see Tables 2a and 3a, respectively.

**Table 4b. Estimated Population Anticipated to be Impacted by Domestic Well Dewatering by Subbasin**

| Subbasin | Estimated Total Population | Estimated Population Impacted | | | | | |
|---|---|---|---|---|---|---|---|
| | | MO Value | | | MT Value | | |
| | | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered |
| Chowchilla | 3,888 | 103 - 114 | 0 - 0 | 103 - 114 | 305 - 442 | 6 - 6 | 311 - 448 |
| Delta-Mendota | 33,769 | 19 - 24 | 119 - 181 | 138 - 205 | 60 - 165 | 544 - 728 | 604 - 892 |
| Eastern San Joaquin | 70,157 | 684 - 842 | 477 - 1,264 | 1,165 - 2,109 | 3,067 - 3,944 | 5,459 - 7,759 | 8,535 - 11,710 |
| Kaweah | 46,085 | 3,968 - 3,408 | 9,696 - 11,867 | 13,658 - 15,272 | 3,490 - 2,564 | 14,485 - 17,510 | 17,983 - 20,075 |
| Kern County | 10,831 | 823 - 510 | 1,572 - 2,008 | 2,393 - 2,517 | 500 - 429 | 2,202 - 2,308 | 2,702 - 2,736 |
| Kings | 89,091 | 5,927 - 7,113 | 8,675 - 14,432 | 14,615 - 21,556 | 8,683 - 8,771 | 26,549 - 33,099 | 35,222 - 41,873 |
| Madera | 29,399 | 453 - 749 | 24 - 96 | 477 - 845 | 1,874 - 2,782 | 811 - 1,603 | 2,683 - 4,384 |
| Merced | 50,078 | 783 - 1,202 | 6,216 - 7,117 | 7,000 - 8,321 | 2,882 - 2,233 | 19,190 - 22,889 | 22,077 - 25,120 |
| Tulare Lake | 35,320 | 1,479 - 2,486 | 918 - 3,515 | 2,395 - 6,005 | 2,745 - 2,438 | 7,232 - 10,194 | 9,978 - 12,639 |
| Tule | 32,765 | 2,326 - 3,019 | 1,435 - 2,509 | 3,763 - 5,529 | 2,242 - 2,470 | 3,652 - 4,247 | 5,893 - 6,712 |
| **TOTAL** | **401,383** | **16,565 - 19,467** | **29,132 - 42,989** | **45,707 - 62,473** | **25,848 - 26,238** | **80,130 - 100,343** | **105,988 - 126,589** |
| *Percentage of Total* | | *4 - 5%* | *7 - 11%* | *11 - 16%* | *6 - 7%* | *20 - 25%* | *26 - 32%* |

**Abbreviations:**

DTW = depth to groundwater
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
WESS = Water Equity Science Shop

**Notes:**

1. Range of population impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Sources:**

1. UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well communities version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
2. Estimated domestic wells impacted at MOs and MTs, see Tables 2b and 3b, respectively.

**Table 4c. Estimated Population Anticipated to be Impacted by Domestic Well Dewatering by California Senate District**

| California Senate District | Estimated Total Population | Estimated Population Impacted | | | | | |
|---|---|---|---|---|---|---|---|
| | | MO Value | | | MT Value | | |
| | | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered |
| 5 | 61,146 | 651 - 778 | 382 - 1,069 | 1,036 - 1,850 | 2,954 - 3,786 | 4,804 - 6,958 | 7,764 - 10,750 |
| 8 | 29,960 | 762 - 951 | 752 - 1,278 | 1,516 - 2,226 | 1,317 - 1,512 | 2,833 - 3,553 | 4,154 - 5,063 |
| 12 | 152,265 | 4,804 - 6,160 | 9,968 - 14,593 | 14,778 - 20,759 | 10,230 - 10,194 | 34,032 - 42,638 | 44,260 - 52,832 |
| 14 | 129,827 | 7,630 - 9,096 | 12,354 - 18,804 | 19,989 - 27,914 | 8,904 - 8,992 | 29,939 - 36,265 | 38,842 - 45,262 |
| 16 | 28,184 | 2,718 - 2,482 | 5,676 - 7,245 | 8,388 - 9,724 | 2,443 - 1,754 | 8,522 - 10,929 | 10,968 - 12,682 |
| **TOTAL** | **401,383** | **16,565 - 19,467** | **29,132 - 42,989** | **45,707 - 62,473** | **25,848 - 26,238** | **80,130 - 100,343** | **105,988 - 126,589** |
| *Percentage of Total* | | *4 - 5%* | *7 - 11%* | *11 - 16%* | *6 - 7%* | *20 - 25%* | *26 - 32%* |

**Abbreviations:**

DTW = depth to groundwater
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
WESS = Water Equity Science Shop

**Notes:**

1. Range of population impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.

**Sources:**

1. UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well communities version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
2. Estimated domestic wells impacted at MOs and MTs, see Tables 2c and 3c, respectively.

**Table 4d. Estimated Population Anticipated to be Impacted by Domestic Well Dewatering by California Assembly District**

| California Assembly District | Estimated Total Population | Estimated Population Impacted | | | | | |
|---|---|---|---|---|---|---|---|
| | | MO Value | | | MT Value | | |
| | | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered | Partially Dewatered | Fully Dewatered | Partially or Fully Dewatered |
| 5 | 37,691 | 556 - 868 | 24 - 96 | 580 - 964 | 2,184 - 3,229 | 817 - 1,609 | 2,999 - 4,837 |
| 9 | 8,380 | 0 - 0 | 0 - 12 | 0 - 12 | 32 - 314 | 1,213 - 1,582 | 1,245 - 1,898 |
| 12 | 42,016 | 673 - 772 | 413 - 1,052 | 1,089 - 1,827 | 2,590 - 3,020 | 3,522 - 4,884 | 6,122 - 7,908 |
| 13 | 15,843 | 11 - 70 | 64 - 200 | 76 - 270 | 445 - 610 | 724 - 1,293 | 1,168 - 1,904 |
| 21 | 81,743 | 802 - 1,221 | 6,335 - 7,298 | 7,138 - 8,521 | 2,937 - 2,371 | 19,734 - 23,617 | 22,676 - 25,985 |
| 23 | 24,248 | 729 - 887 | 657 - 1,083 | 1,387 - 1,967 | 1,204 - 1,354 | 2,178 - 2,752 | 3,383 - 4,103 |
| 26 | 89,047 | 6,910 - 7,282 | 13,102 - 17,175 | 20,010 - 24,460 | 6,585 - 5,710 | 22,507 - 27,080 | 29,100 - 32,788 |
| 31 | 52,570 | 4,162 - 4,938 | 4,726 - 9,031 | 8,894 - 13,975 | 6,150 - 6,241 | 18,048 - 22,870 | 24,188 - 29,116 |
| 32 | 49,427 | 2,722 - 3,429 | 3,811 - 7,042 | 6,533 - 10,477 | 3,721 - 3,389 | 11,387 - 14,656 | 15,107 - 18,050 |
| 34 | 417 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 | 0 - 0 |
| **TOTAL** | **401,383** | **16,565 - 19,467** | **29,132 - 42,989** | **45,707 - 62,473** | **25,848 - 26,238** | **80,130 - 100,343** | **105,988 - 126,589** |
| *Percentage of Total* | | *4 - 5%* | *7 - 11%* | *11 - 16%* | *6 - 7%* | *20 - 25%* | *26 - 32%* |

**Abbreviations:**

DTW = depth to groundwater
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
WESS = Water Equity Science Shop

**Notes:**

1. Range of population impacted reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Well is considered partially dewatered if the DTW is less than the top of the screen.
3. Well is considered fully dewatered if the DTW is less than 25 feet above the bottom of the screened interval.
4. Based on the available data and methodology used in this assessment, no impacted population is identified within Assembly District 34. This is due to generalizations of the locations of the population and domestic well datasets, and the minimal overlap of Assembly District 34 with the study area.

**Sources:**

1. UC Berkeley WESS (2019). UC Berkeley Water Equity Science Shop Domestic well communities version 1.0, 2019, Authors: Clare Pace, Carolina Balazs, Lara Cushing, Rachel Morello-Frosch.
2. Estimated domestic wells impacted at MOs and MTs, see Tables 2d and 3d, respectively.

**Table 6a. Estimated Mitigation Costs Anticipated for Domestic Wells at MOs by GSP Area**

| GSP Area | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| Aliso WD GSA | $ 61 - $ 269 | $ - - $ 10,000 | $ - - $ - | $ - - $ - | $ 61 - $ 10,269 | $ 1 - $ 198 | $ 15 - $ 2,567 |
| Central Kings GSA | $ 72,425 - $ 121,366 | $ 1,500,000 - $ 1,760,000 | $ 28,000 - $ 468,000 | $ 5,390,395 - $ 10,962,605 | $ 6,990,820 - $ 13,311,971 | $ 297 - $ 566 | $ 3,711 - $ 7,066 |
| Chowchilla Subbasin GSAs | $ - - $ 45 | $ - - $ 10,000 | $ - - $ - | $ - - $ - | $ - - $ 10,045 | $ - - $ 3 | $ - - $ 34 |
| County of Fresno GSA | $ 380 - $ 739 | $ - - $ 10,000 | $ - - $ - | $ - - $ - | $ 380 - $ 10,739 | $ 2 - $ 56 | $ 17 - $ 467 |
| Delano-Earlimart ID GSA | $ 7,202 - $ 10,613 | $ 150,000 - $ 160,000 | $ 82,000 - $ 134,000 | $ 390,310 - $ 698,855 | $ 629,512 - $ 1,003,468 | $ 265 - $ 423 | $ 13,394 - $ 21,350 |
| East Kaweah GSA | $ 4,568 - $ 10,547 | $ 270,000 - $ 220,000 | $ 4,000 - $ 64,000 | $ 225,975 - $ 820,870 | $ 504,543 - $ 1,115,417 | $ 40 - $ 88 | $ 5,867 - $ 12,970 |
| Eastern San Joaquin Groundwater Authority | $ 171,198 - $ 280,994 | $ 930,000 - $ 1,650,000 | $ 296,000 - $ 1,136,000 | $ 2,102,545 - $ 4,058,810 | $ 3,499,743 - $ 7,125,804 | $ 50 - $ 102 | $ 490 - $ 997 |
| Eastern Tule GSA | $ 7,190 - $ 18,701 | $ 170,000 - $ 330,000 | $ 44,000 - $ 120,000 | $ 539,695 - $ 1,218,080 | $ 760,885 - $ 1,686,781 | $ 32 - $ 72 | $ 5,595 - $ 12,403 |
| Farmers WD GSA | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - |
| Grassland GSA | $ 835 - $ 1,868 | $ - - $ - | $ - - $ - | $ - - $ - | $ 835 - $ 1,868 | $ 2 - $ 4 | $ 10 - $ 23 |
| Greater Kaweah GSA | $ 153,757 - $ 209,885 | $ 1,920,000 - $ 1,680,000 | $ 1,256,000 - $ 1,982,000 | $ 12,005,885 - $ 16,224,206 | $ 15,335,642 - $ 20,096,091 | $ 748 - $ 980 | $ 15,366 - $ 20,136 |
| James GSA | $ 6,933 - $ 12,488 | $ 90,000 - $ 40,000 | $ - - $ 72,000 | $ 431,595 - $ 969,450 | $ 528,528 - $ 1,093,938 | $ 899 - $ 1,861 | $ 5,563 - $ 11,515 |
| Kern Groundwater Authority | $ 42,166 - $ 55,075 | $ 750,000 - $ 720,000 | $ 764,000 - $ 962,000 | $ 2,406,381 - $ 4,014,366 | $ 3,962,548 - $ 5,751,440 | $ 366 - $ 531 | $ 13,759 - $ 19,970 |
| Kings River East GSA | $ 92,200 - $ 124,373 | $ 1,450,000 - $ 1,830,000 | $ 308,000 - $ 658,000 | $ 5,772,425 - $ 8,355,670 | $ 7,622,625 - $ 10,968,043 | $ 357 - $ 514 | $ 6,849 - $ 9,854 |
| Lower Tule River ID GSA | $ 40,140 - $ 49,673 | $ 500,000 - $ 460,000 | $ 654,000 - $ 752,000 | $ 1,610,119 - $ 2,344,566 | $ 2,804,259 - $ 3,606,239 | $ 759 - $ 976 | $ 15,324 - $ 19,706 |
| Madera Subbasin Joint GSP | $ 10,752 - $ 25,978 | $ 510,000 - $ 660,000 | $ 78,000 - $ 146,000 | $ 582,245 - $ 1,736,500 | $ 1,180,997 - $ 2,568,478 | $ 40 - $ 87 | $ 516 - $ 1,122 |
| McMullin Area GSA | $ 19,348 - $ 37,341 | $ 830,000 - $ 950,000 | $ 36,000 - $ 206,000 | $ 1,224,520 - $ 3,263,700 | $ 2,109,868 - $ 4,457,041 | $ 465 - $ 983 | $ 6,261 - $ 13,226 |
| Merced Subbasin GSAs | $ 124,964 - $ 172,453 | $ 340,000 - $ 350,000 | $ 692,000 - $ 1,326,000 | $ 4,989,160 - $ 6,802,825 | $ 6,146,124 - $ 8,651,278 | $ 123 - $ 173 | $ 2,157 - $ 3,037 |
| Mid-Kaweah GSA | $ 81,392 - $ 124,828 | $ 980,000 - $ 860,000 | $ 812,000 - $ 1,138,000 | $ 6,830,915 - $ 9,753,145 | $ 8,704,308 - $ 11,875,973 | $ 674 - $ 919 | $ 20,675 - $ 28,209 |
| North Fork Kings GSA | $ 60,280 - $ 81,029 | $ 1,140,000 - $ 1,140,000 | $ 260,000 - $ 588,000 | $ 6,941,285 - $ 8,965,055 | $ 8,401,565 - $ 10,774,084 | $ 1,496 - $ 1,919 | $ 15,616 - $ 20,026 |
| North Kings GSA | $ 110,711 - $ 196,190 | $ 4,580,000 - $ 5,550,000 | $ 284,000 - $ 348,000 | $ 9,784,660 - $ 20,326,825 | $ 14,759,371 - $ 26,421,015 | $ 446 - $ 799 | $ 4,486 - $ 8,031 |
| Northern and Central Delta-Mendota Region GSAs | $ 11,539 - $ 29,936 | $ 20,000 - $ 20,000 | $ 4,000 - $ 12,000 | $ 152,605 - $ 552,920 | $ 188,144 - $ 614,856 | $ 8 - $ 26 | $ 346 - $ 1,132 |
| Pixley ID GSA | $ 22,680 - $ 28,798 | $ 330,000 - $ 390,000 | $ 422,000 - $ 516,000 | $ 987,160 - $ 1,600,593 | $ 1,761,840 - $ 2,535,391 | $ 563 - $ 811 | $ 13,347 - $ 19,208 |
| San Joaquin River Exchange Contractors GSP Group | $ 16,254 - $ 24,673 | $ 10,000 - $ 10,000 | $ 4,000 - $ 4,000 | $ 147,200 - $ 242,880 | $ 177,454 - $ 281,553 | $ 19 - $ 30 | $ 256 - $ 407 |
| South Kings GSA | $ 803 - $ 1,997 | $ 40,000 - $ 90,000 | $ - - $ - | $ - - $ 85,560 | $ 40,803 - $ 177,557 | $ 95 - $ 413 | $ 439 - $ 1,909 |
| Tulare Lake Subbasin GSAs | $ 21,506 - $ 41,897 | $ 400,000 - $ 820,000 | $ 8,000 - $ 28,000 | $ 998,660 - $ 2,135,780 | $ 1,428,166 - $ 3,025,677 | $ 40 - $ 86 | $ 1,621 - $ 3,434 |
| **Total** | **$ 1,079,285 - $ 1,661,754** | **$ 16,910,000 - $ 19,720,000** | **$ 6,036,000 - $ 10,660,000** | **$ 63,513,736 - $ 105,133,260** | **$ 87,539,021 - $ 137,175,014** | **$ 218 - $ 342** | **$ 3,581 - $ 5,611** |

**Abbreviations:**

DWR = California Department of Water Resources
GICIMA = Groundwater Information Center Interactive Map Application
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
ID = Irrigation District
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act
WD = Water District

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by GSP Area (Table 4a).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.8 - $2.7 million) are assumed to already be incurred by domestic well owners.
4. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
5. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 6b. Estimated Mitigation Costs Anticipated for Domestic Wells at MOs by Subbasin**

| Subbasin | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| Chowchilla | $ - - $ 45 | $ - - $ 10,000 | $ - - $ - | $ - - $ - | $ - - $ 10,045 | $ - - $ 3 | $ - - $ 34 |
| Delta-Mendota | $ 29,069 - $ 57,484 | $ 30,000 - $ 50,000 | $ 8,000 - $ 16,000 | $ 299,805 - $ 795,800 | $ 366,874 - $ 919,284 | $ 11 - $ 27 | $ 273 - $ 683 |
| Eastern San Joaquin | $ 171,198 - $ 280,994 | $ 930,000 - $ 1,650,000 | $ 296,000 - $ 1,136,000 | $ 2,102,545 - $ 4,058,810 | $ 3,499,743 - $ 7,125,804 | $ 50 - $ 102 | $ 490 - $ 997 |
| Kaweah | $ 239,661 - $ 344,961 | $ 3,170,000 - $ 2,760,000 | $ 2,072,000 - $ 3,184,000 | $ 19,028,045 - $ 26,763,491 | $ 24,509,706 - $ 33,052,451 | $ 532 - $ 717 | $ 16,296 - $ 21,976 |
| Kern County | $ 42,166 - $ 55,075 | $ 750,000 - $ 720,000 | $ 764,000 - $ 962,000 | $ 2,406,381 - $ 4,014,366 | $ 3,962,548 - $ 5,751,440 | $ 366 - $ 531 | $ 13,759 - $ 19,970 |
| Kings | $ 362,700 - $ 574,783 | $ 9,630,000 - $ 11,360,000 | $ 916,000 - $ 2,340,000 | $ 29,544,880 - $ 52,928,865 | $ 40,453,580 - $ 67,203,648 | $ 454 - $ 754 | $ 5,504 - $ 9,143 |
| Madera | $ 10,752 - $ 25,978 | $ 510,000 - $ 660,000 | $ 78,000 - $ 146,000 | $ 582,245 - $ 1,736,500 | $ 1,180,997 - $ 2,568,478 | $ 40 - $ 87 | $ 516 - $ 1,122 |
| Merced | $ 124,964 - $ 172,453 | $ 340,000 - $ 350,000 | $ 692,000 - $ 1,326,000 | $ 4,989,160 - $ 6,802,825 | $ 6,146,124 - $ 8,651,278 | $ 123 - $ 173 | $ 2,157 - $ 3,037 |
| Tulare Lake | $ 21,506 - $ 41,897 | $ 400,000 - $ 820,000 | $ 8,000 - $ 28,000 | $ 998,660 - $ 2,135,780 | $ 1,428,166 - $ 3,025,677 | $ 40 - $ 86 | $ 1,621 - $ 3,434 |
| Tule | $ 77,269 - $ 108,085 | $ 1,150,000 - $ 1,340,000 | $ 1,202,000 - $ 1,522,000 | $ 3,562,014 - $ 5,896,824 | $ 5,991,283 - $ 8,866,909 | $ 183 - $ 271 | $ 12,007 - $ 17,769 |
| **Total** | **$ 1,079,285 - $ 1,661,754** | **$ 16,910,000 - $ 19,720,000** | **$ 6,036,000 - $ 10,660,000** | **$ 63,513,736 - $ 105,133,260** | **$ 87,539,021 - $ 137,175,014** | **$ 218 - $ 342** | **$ 3,581 - $ 5,611** |

**Abbreviations:**

DWR = California Department of Water Resources
GICIMA = Groundwater Information Center Interactive Map Application
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by subbasin (Table 4b).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.8 - $2.7 million) are assumed to already be incurred by domestic well owners.
4. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
5. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 6c. Estimated Mitigation Costs Anticipated for Domestic Wells at MOs by California Senate District**

| California Senate District | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| 5 | $ 163,950 - $ 267,735 | $ 870,000 - $ 1,500,000 | $ 292,000 - $ 1,136,000 | $ 1,470,735 - $ 3,125,355 | $ 2,796,685 - $ 6,029,090 | $ 46 - $ 99 | $ 433 - $ 934 |
| 8 | $ 102,688 - $ 174,055 | $ 4,080,000 - $ 4,200,000 | $ 268,000 - $ 294,000 | $ 9,080,285 - $ 18,463,480 | $ 13,530,973 - $ 23,131,535 | $ 452 - $ 772 | $ 4,922 - $ 8,415 |
| 12 | $ 302,995 - $ 486,439 | $ 4,060,000 - $ 5,200,000 | $ 1,090,000 - $ 2,808,000 | $ 16,607,610 - $ 29,817,775 | $ 22,060,605 - $ 38,312,214 | $ 145 - $ 252 | $ 2,288 - $ 3,973 |
| 14 | $ 325,493 - $ 469,244 | $ 5,790,000 - $ 6,980,000 | $ 2,536,000 - $ 3,886,000 | $ 21,751,106 - $ 33,186,377 | $ 30,402,599 - $ 44,521,621 | $ 234 - $ 343 | $ 6,641 - $ 9,725 |
| 16 | $ 184,159 - $ 264,282 | $ 2,110,000 - $ 1,840,000 | $ 1,850,000 - $ 2,536,000 | $ 14,603,999 - $ 20,540,273 | $ 18,748,158 - $ 25,180,555 | $ 665 - $ 893 | $ 18,381 - $ 24,687 |
| **Total** | **$ 1,079,285 - $ 1,661,754** | **$ 16,910,000 - $ 19,720,000** | **$ 6,036,000 - $ 10,660,000** | **$ 63,513,736 - $ 105,133,260** | **$ 87,539,021 - $ 137,175,014** | **$ 218 - $ 342** | **$ 3,581 - $ 5,611** |

**Abbreviations:**

GSP = Groundwater Sustainability Plan

MO = Measurable Objective

PLSS = Public Land Survey System

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by California Senate District (Table 4c).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.8 - $2.7 million) are assumed to already be incurred by domestic well owners.

**Table 6d. Estimated Mitigation Costs Anticipated for Domestic Wells at MOs by California Assembly District**

| California Assembly District | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| 5 | $ 10,813 - $ 26,292 | $ 510,000 - $ 680,000 | $ 78,000 - $ 146,000 | $ 582,245 - $ 1,736,500 | $ 1,181,058 - $ 2,588,792 | $ 31 - $ 69 | $ 458 - $ 1,004 |
| 9 | $ 1,338 - $ 3,243 | $ - - $ - | $ - - $ - | $ - - $ - | $ 1,338 - $ 3,243 | $ 0 - $ 0 | $ 2 - $ 6 |
| 12 | $ 95,692 - $ 165,414 | $ 840,000 - $ 1,410,000 | $ 240,000 - $ 608,000 | $ 1,520,645 - $ 2,815,890 | $ 2,696,337 - $ 4,999,304 | $ 64 - $ 119 | $ 527 - $ 977 |
| 13 | $ 74,168 - $ 112,337 | $ 90,000 - $ 240,000 | $ 56,000 - $ 528,000 | $ 581,900 - $ 1,242,920 | $ 802,068 - $ 2,123,257 | $ 51 - $ 134 | $ 546 - $ 1,446 |
| 21 | $ 153,521 - $ 228,559 | $ 370,000 - $ 380,000 | $ 700,000 - $ 1,342,000 | $ 5,288,965 - $ 7,598,625 | $ 6,512,486 - $ 9,549,184 | $ 80 - $ 117 | $ 1,570 - $ 2,302 |
| 23 | $ 92,341 - $ 155,128 | $ 3,860,000 - $ 3,970,000 | $ 260,000 - $ 286,000 | $ 8,128,430 - $ 16,872,340 | $ 12,340,771 - $ 21,283,468 | $ 509 - $ 878 | $ 6,173 - $ 10,647 |
| 26 | $ 355,508 - $ 510,534 | $ 5,180,000 - $ 5,330,000 | $ 3,114,000 - $ 4,678,000 | $ 25,681,949 - $ 37,210,404 | $ 34,331,458 - $ 47,728,939 | $ 386 - $ 536 | $ 13,019 - $ 18,100 |
| 31 | $ 198,102 - $ 317,767 | $ 4,410,000 - $ 5,610,000 | $ 588,000 - $ 1,732,000 | $ 14,845,120 - $ 27,359,995 | $ 20,041,222 - $ 35,019,762 | $ 381 - $ 666 | $ 4,554 - $ 7,957 |
| 32 | $ 97,696 - $ 141,510 | $ 1,630,000 - $ 2,090,000 | $ 1,000,000 - $ 1,336,000 | $ 6,884,481 - $ 10,082,456 | $ 9,612,177 - $ 13,649,966 | $ 194 - $ 276 | $ 6,482 - $ 9,204 |
| 34 | $ 106 - $ 970 | $ 20,000 - $ 10,000 | $ - - $ 4,000 | $ - - $ 214,130 | $ 20,106 - $ 229,100 | $ 48 - $ 549 | $ 457 - $ 5,207 |
| **Total** | **$ 1,079,285 - $ 1,661,754** | **$ 16,910,000 - $ 19,720,000** | **$ 6,036,000 - $ 10,660,000** | **$ 63,513,736 - $ 105,133,260** | **$ 87,539,021 - $ 137,175,014** | **$ 218 - $ 342** | **$ 3,581 - $ 5,611** |

**Abbreviations:**

GSP = Groundwater Sustainability Plan

MO = Measurable Objective

PLSS = Public Land Survey System

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by California Assembly District (Table 4d).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.8 - $2.7 million) are assumed to already be incurred by domestic well owners.

**Table 7a. Estimated Mitigation Costs Anticipated for Domestic Wells at MTs by GSP Area**

| GSP Area | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| Aliso WD GSA | $ 697 - $ 1,043 | $ 20,000 - $ 10,000 | $ 14,000 - $ 12,000 | $ - - $ 77,970 | $ 34,697 - $ 101,013 | $ 669 - $ 1,947 | $ 8,674 - $ 25,253 |
| Central Kings GSA | $ 232,572 - $ 296,546 | $ 2,330,000 - $ 2,440,000 | $ 836,000 - $ 1,410,000 | $ 21,809,520 - $ 26,615,025 | $ 25,208,092 - $ 30,761,571 | $ 1,072 - $ 1,308 | $ 13,380 - $ 16,328 |
| Chowchilla Subbasin GSAs | $ 1,977 - $ 3,855 | $ 60,000 - $ 70,000 | $ 12,000 - $ 18,000 | $ 28,865 - $ 123,625 | $ 102,842 - $ 215,480 | $ 27 - $ 57 | $ 351 - $ 735 |
| County of Fresno GSA | $ 714 - $ 1,414 | $ 10,000 - $ 30,000 | $ 8,000 - $ 22,000 | $ - - $ 25,300 | $ 18,714 - $ 78,714 | $ 98 - $ 412 | $ 814 - $ 3,422 |
| Delano-Earlimart ID GSA | $ 16,075 - $ 20,635 | $ 130,000 - $ 80,000 | $ 196,000 - $ 176,000 | $ 1,147,754 - $ 1,658,858 | $ 1,489,829 - $ 1,935,493 | $ 627 - $ 815 | $ 31,698 - $ 41,181 |
| East Kaweah GSA | $ 19,129 - $ 25,542 | $ 210,000 - $ 130,000 | $ 246,000 - $ 250,000 | $ 1,356,425 - $ 1,876,354 | $ 1,831,554 - $ 2,281,896 | $ 145 - $ 180 | $ 21,297 - $ 26,534 |
| Eastern San Joaquin Groundwater Authority | $ 658,405 - $ 849,086 | $ 4,580,000 - $ 5,600,000 | $ 5,966,000 - $ 8,178,000 | $ 17,108,090 - $ 26,863,310 | $ 28,312,495 - $ 41,490,396 | $ 404 - $ 591 | $ 3,961 - $ 5,805 |
| Eastern Tule GSA | $ 35,234 - $ 50,274 | $ 220,000 - $ 210,000 | $ 264,000 - $ 336,000 | $ 2,614,923 - $ 3,363,535 | $ 3,134,157 - $ 3,959,809 | $ 133 - $ 168 | $ 23,045 - $ 29,116 |
| Farmers WD GSA | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - | $ - - $ - |
| Grassland GSA | $ 5,670 - $ 7,671 | $ - - $ - | $ 12,000 - $ 18,000 | $ 43,930 - $ 88,205 | $ 61,600 - $ 113,876 | $ 118 - $ 219 | $ 751 - $ 1,389 |
| Greater Kaweah GSA | $ 278,678 - $ 353,124 | $ 1,740,000 - $ 1,560,000 | $ 2,460,000 - $ 2,548,000 | $ 20,609,245 - $ 25,099,061 | $ 25,087,923 - $ 29,560,185 | $ 1,223 - $ 1,441 | $ 25,138 - $ 29,619 |
| James GSA | $ 13,530 - $ 21,011 | $ 70,000 - $ 90,000 | $ 106,000 - $ 248,000 | $ 911,950 - $ 1,431,290 | $ 1,101,480 - $ 1,790,301 | $ 1,873 - $ 3,045 | $ 11,595 - $ 18,845 |
| Kern Groundwater Authority | $ 88,356 - $ 107,752 | $ 1,010,000 - $ 1,100,000 | $ 1,390,000 - $ 1,582,000 | $ 5,698,896 - $ 6,910,237 | $ 8,187,252 - $ 9,699,988 | $ 756 - $ 896 | $ 28,428 - $ 33,681 |
| Kings River East GSA | $ 214,201 - $ 256,388 | $ 1,540,000 - $ 1,510,000 | $ 1,740,000 - $ 1,940,000 | $ 15,586,672 - $ 19,097,869 | $ 19,080,873 - $ 22,804,256 | $ 894 - $ 1,069 | $ 17,144 - $ 20,489 |
| Lower Tule River ID GSA | $ 57,974 - $ 69,522 | $ 400,000 - $ 380,000 | $ 662,000 - $ 728,000 | $ 3,190,563 - $ 3,806,931 | $ 4,310,537 - $ 4,984,453 | $ 1,166 - $ 1,349 | $ 23,555 - $ 27,237 |
| Madera Subbasin Joint GSP | $ 59,408 - $ 102,919 | $ 1,330,000 - $ 2,380,000 | $ 626,000 - $ 738,000 | $ 6,397,910 - $ 10,715,585 | $ 8,413,318 - $ 13,936,504 | $ 286 - $ 474 | $ 3,674 - $ 6,086 |
| McMullin Area GSA | $ 49,226 - $ 70,380 | $ 870,000 - $ 790,000 | $ 434,000 - $ 682,000 | $ 4,742,025 - $ 7,299,740 | $ 6,095,251 - $ 8,842,120 | $ 1,344 - $ 1,950 | $ 18,087 - $ 26,238 |
| Merced Subbasin GSAs | $ 699,271 - $ 818,680 | $ 1,490,000 - $ 1,630,000 | $ 6,894,000 - $ 7,202,000 | $ 41,291,178 - $ 49,821,973 | $ 50,374,449 - $ 59,472,653 | $ 1,006 - $ 1,188 | $ 17,681 - $ 20,875 |
| Mid-Kaweah GSA | $ 141,912 - $ 202,497 | $ 700,000 - $ 550,000 | $ 920,000 - $ 828,000 | $ 11,256,691 - $ 15,378,783 | $ 13,018,603 - $ 16,959,280 | $ 1,008 - $ 1,313 | $ 30,923 - $ 40,283 |
| North Fork Kings GSA | $ 129,591 - $ 153,181 | $ 1,110,000 - $ 980,000 | $ 1,092,000 - $ 1,132,000 | $ 12,898,745 - $ 14,598,879 | $ 15,230,336 - $ 16,864,060 | $ 2,713 - $ 3,004 | $ 28,309 - $ 31,346 |
| North Kings GSA | $ 340,158 - $ 445,928 | $ 6,710,000 - $ 6,110,000 | $ 562,000 - $ 1,872,000 | $ 35,164,470 - $ 47,556,297 | $ 42,776,628 - $ 55,984,225 | $ 1,294 - $ 1,693 | $ 13,002 - $ 17,016 |
| Northern and Central Delta-Mendota Region GSAs | $ 20,801 - $ 50,802 | $ 30,000 - $ 60,000 | $ 44,000 - $ 186,000 | $ 594,205 - $ 1,448,655 | $ 689,006 - $ 1,745,457 | $ 29 - $ 74 | $ 1,269 - $ 3,214 |
| Pixley ID GSA | $ 38,520 - $ 45,450 | $ 390,000 - $ 380,000 | $ 604,000 - $ 640,000 | $ 2,361,211 - $ 2,867,826 | $ 3,393,731 - $ 3,933,276 | $ 1,085 - $ 1,257 | $ 25,710 - $ 29,798 |
| San Joaquin River Exchange Contractors GSP Group | $ 78,357 - $ 95,708 | $ 90,000 - $ 110,000 | $ 432,000 - $ 1,044,000 | $ 1,678,195 - $ 2,135,205 | $ 2,278,552 - $ 3,384,913 | $ 240 - $ 357 | $ 3,293 - $ 4,891 |
| South Kings GSA | $ 7,642 - $ 10,500 | $ 80,000 - $ 100,000 | $ 12,000 - $ 16,000 | $ 797,985 - $ 1,083,990 | $ 897,627 - $ 1,210,490 | $ 2,090 - $ 2,819 | $ 9,652 - $ 13,016 |
| Tulare Lake Subbasin GSAs | $ 97,768 - $ 139,789 | $ 1,420,000 - $ 1,720,000 | $ 984,000 - $ 1,356,000 | $ 8,429,615 - $ 13,224,080 | $ 10,931,383 - $ 16,439,869 | $ 309 - $ 465 | $ 12,408 - $ 18,660 |
| **Total** | **$ 3,285,866 - $ 4,199,695** | **$ 26,540,000 - $ 28,020,000** | **$ 26,516,000 - $ 33,162,000** | **$ 215,719,062 - $ 283,168,583** | **$ 272,060,928 - $ 348,550,278** | **$ 678 - $ 868** | **$ 11,129 - $ 14,257** |

**Abbreviations:**

DWR = California Department of Water Resources
GICIMA = Groundwater Information Center Interactive Map Application
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
ID = Irrigation District
MO = Measurable Objective
MT = Minimum Threshold
PLSS = Public Land Survey System
SGMA = Sustainable Groundwater Management Act
WD = Water District

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by GSP Area (Table 4a).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.7 - $1.8 million) are assumed to already be incurred by domestic well owners.
4. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
5. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 7b. Estimated Mitigation Costs Anticipated for Domestic Wells at MTs by Subbasin**

| Subbasin | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| Chowchilla | $ 1,977 - $ 3,855 | $ 60,000 - $ 70,000 | $ 12,000 - $ 18,000 | $ 28,865 - $ 123,625 | $ 102,842 - $ 215,480 | $ 26 - $ 55 | $ 351 - $ 735 |
| Delta-Mendota | $ 106,239 - $ 156,637 | $ 150,000 - $ 210,000 | $ 510,000 - $ 1,282,000 | $ 2,316,330 - $ 3,775,335 | $ 3,082,569 - $ 5,423,972 | $ 91 - $ 161 | $ 2,290 - $ 4,030 |
| Eastern San Joaquin | $ 658,405 - $ 849,086 | $ 4,580,000 - $ 5,600,000 | $ 5,966,000 - $ 8,178,000 | $ 17,108,090 - $ 26,863,310 | $ 28,312,495 - $ 41,490,396 | $ 404 - $ 591 | $ 3,961 - $ 5,805 |
| Kaweah | $ 439,433 - $ 580,701 | $ 2,650,000 - $ 2,240,000 | $ 3,626,000 - $ 3,626,000 | $ 33,187,631 - $ 42,309,679 | $ 39,903,064 - $ 48,756,380 | $ 866 - $ 1,058 | $ 26,531 - $ 32,418 |
| Kern County | $ 88,356 - $ 107,752 | $ 1,010,000 - $ 1,100,000 | $ 1,390,000 - $ 1,582,000 | $ 5,698,896 - $ 6,910,237 | $ 8,187,252 - $ 9,699,988 | $ 756 - $ 896 | $ 28,428 - $ 33,681 |
| Kings | $ 986,920 - $ 1,253,932 | $ 12,710,000 - $ 12,020,000 | $ 4,782,000 - $ 7,300,000 | $ 91,911,367 - $ 117,683,090 | $ 110,390,287 - $ 138,257,022 | $ 1,239 - $ 1,552 | $ 15,019 - $ 18,810 |
| Madera | $ 59,408 - $ 102,919 | $ 1,330,000 - $ 2,380,000 | $ 626,000 - $ 738,000 | $ 6,397,910 - $ 10,715,585 | $ 8,413,318 - $ 13,936,504 | $ 286 - $ 474 | $ 3,674 - $ 6,086 |
| Merced | $ 699,271 - $ 818,680 | $ 1,490,000 - $ 1,630,000 | $ 6,894,000 - $ 7,202,000 | $ 41,291,178 - $ 49,821,973 | $ 50,374,449 - $ 59,472,653 | $ 1,006 - $ 1,188 | $ 17,681 - $ 20,875 |
| Tulare Lake | $ 97,768 - $ 139,789 | $ 1,420,000 - $ 1,720,000 | $ 984,000 - $ 1,356,000 | $ 8,429,615 - $ 13,224,080 | $ 10,931,383 - $ 16,439,869 | $ 309 - $ 465 | $ 12,408 - $ 18,660 |
| Tule | $ 148,088 - $ 186,343 | $ 1,140,000 - $ 1,050,000 | $ 1,726,000 - $ 1,880,000 | $ 9,349,181 - $ 11,741,669 | $ 12,363,269 - $ 14,858,012 | $ 377 - $ 453 | $ 24,776 - $ 29,776 |
| **Total** | **$ 3,285,866 - $ 4,199,695** | **$ 26,540,000 - $ 28,020,000** | **$ 26,516,000 - $ 33,162,000** | **$ 215,719,062 - $ 283,168,583** | **$ 272,060,928 - $ 348,550,278** | **$ 678 - $ 868** | **$ 11,129 - $ 14,257** |

**Abbreviations:**

DWR = California Department of Water Resources
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GSA = Groundwater Sustainability Agency
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**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by subbasin (Table 4b).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.7 - $1.8 million) are assumed to already be incurred by domestic well owners.
4. Of the five GSPs prepared within the Kern County subbasin, only the GSP prepared by the Kern County Groundwater Authority ("KGA") GSA overlaps the study area. The KGA GSA GSP is structured such that monitoring network and MO and MT information are included in separate Management Area Plan documents for each Management Area within the GSA. Given this, only Management Areas with significant coverage of the DWR GICIMA dataset are included in the study area.
5. Four GSPs have been prepared within the Madera subbasin, but because the subbasin Coordination Agreement has not yet been signed, DWR has not released the GSPs via the DWR SGMA Portal website. The Madera Subbasin Joint GSP comprises 94% of the subbasin by area. For purposes of this study, the Madera Subbasin Joint GSP as posted on the Madera County Water & Natural Resources website was used to represent the entirety of the Madera subbasin.

**Table 7c. Estimated Mitigation Costs Anticipated for Domestic Wells at MTs by California Senate District**

| California Senate District | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| 5 | $ 609,502 - $ 786,295 | $ 4,280,000 - $ 5,310,000 | $ 5,796,000 - $ 7,890,000 | $ 13,721,915 - $ 22,241,805 | $ 24,407,417 - $ 36,228,100 | $ 399 - $ 592 | $ 3,780 - $ 5,611 |
| 8 | $ 278,840 - $ 360,140 | $ 4,520,000 - $ 4,100,000 | $ 486,000 - $ 1,550,000 | $ 27,453,950 - $ 36,498,700 | $ 32,738,790 - $ 42,508,840 | $ 1,093 - $ 1,419 | $ 11,909 - $ 15,463 |
| 12 | $ 1,270,110 - $ 1,607,818 | $ 8,230,000 - $ 9,160,000 | $ 10,572,000 - $ 12,960,000 | $ 87,242,418 - $ 113,339,509 | $ 107,314,528 - $ 137,067,328 | $ 705 - $ 900 | $ 11,129 - $ 14,214 |
| 14 | $ 804,672 - $ 1,010,311 | $ 7,730,000 - $ 7,890,000 | $ 7,306,000 - $ 8,478,000 | $ 62,614,213 - $ 79,317,894 | $ 78,454,885 - $ 96,696,205 | $ 604 - $ 745 | $ 17,137 - $ 21,122 |
| 16 | $ 322,743 - $ 435,130 | $ 1,780,000 - $ 1,560,000 | $ 2,356,000 - $ 2,284,000 | $ 24,686,566 - $ 31,770,675 | $ 29,145,308 - $ 36,049,805 | $ 1,034 - $ 1,279 | $ 28,574 - $ 35,343 |
| **Total** | **$ 3,285,866 - $ 4,199,695** | **$ 26,540,000 - $ 28,020,000** | **$ 26,516,000 - $ 33,162,000** | **$ 215,719,062 - $ 283,168,583** | **$ 272,060,928 - $ 348,550,278** | **$ 678 - $ 868** | **$ 11,129 - $ 14,257** |

**Abbreviations:**

GSP = Groundwater Sustainability Plan

MT = Minimum Threshold

PLSS = Public Land Survey System

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by California Senate District (Table 4c).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.7 - $1.8 million) are assumed to already be incurred by domestic well owners.

**Table 7d. Estimated Mitigation Costs Anticipated for Domestic Wells at MTs by California Assembly District**

| California Assembly District | Increased Lift Over 20 Years | Screen Cleaning | Pump Lowering | Well Replacement | Total Costs | Total Cost per Capita Reliant on Groundwater | Total Cost per Well |
|---|---|---|---|---|---|---|---|
| 5 | $ 62,040 - $ 107,783 | $ 1,410,000 - $ 2,460,000 | $ 652,000 - $ 768,000 | $ 6,458,975 - $ 10,949,380 | $ 8,583,015 - $ 14,285,163 | $ 228 - $ 379 | $ 3,329 - $ 5,541 |
| 9 | $ 27,719 - $ 40,895 | $ 90,000 - $ 130,000 | $ 12,000 - $ 4,000 | $ 435,505 - $ 930,120 | $ 565,224 - $ 1,105,015 | $ 67 - $ 132 | $ 988 - $ 1,932 |
| 12 | $ 449,697 - $ 570,028 | $ 3,720,000 - $ 4,270,000 | $ 3,720,000 - $ 4,750,000 | $ 13,470,525 - $ 19,854,175 | $ 21,360,222 - $ 29,444,203 | $ 508 - $ 701 | $ 4,174 - $ 5,754 |
| 13 | $ 180,989 - $ 238,163 | $ 770,000 - $ 1,200,000 | $ 2,234,000 - $ 3,424,000 | $ 3,202,060 - $ 6,079,015 | $ 6,387,049 - $ 10,941,178 | $ 403 - $ 691 | $ 4,351 - $ 7,453 |
| 21 | $ 803,522 - $ 971,572 | $ 1,610,000 - $ 1,800,000 | $ 7,382,000 - $ 8,436,000 | $ 43,575,308 - $ 53,461,838 | $ 53,370,830 - $ 64,669,411 | $ 653 - $ 791 | $ 12,867 - $ 15,591 |
| 23 | $ 222,219 - $ 286,836 | $ 4,080,000 - $ 3,700,000 | $ 296,000 - $ 1,224,000 | $ 23,274,735 - $ 30,786,420 | $ 27,872,954 - $ 35,997,256 | $ 1,149 - $ 1,485 | $ 13,943 - $ 18,008 |
| 26 | $ 712,231 - $ 914,713 | $ 4,720,000 - $ 4,200,000 | $ 6,166,000 - $ 6,422,000 | $ 52,254,371 - $ 65,879,100 | $ 63,852,602 - $ 77,415,813 | $ 717 - $ 869 | $ 24,214 - $ 29,358 |
| 31 | $ 568,069 - $ 731,934 | $ 7,140,000 - $ 6,910,000 | $ 3,000,000 - $ 4,428,000 | $ 52,351,680 - $ 67,432,941 | $ 63,059,749 - $ 79,502,875 | $ 1,200 - $ 1,512 | $ 14,329 - $ 18,065 |
| 32 | $ 255,733 - $ 331,255 | $ 2,850,000 - $ 3,200,000 | $ 3,048,000 - $ 3,662,000 | $ 20,432,898 - $ 27,377,454 | $ 26,586,630 - $ 34,570,709 | $ 538 - $ 699 | $ 17,928 - $ 23,311 |
| 34 | $ 3,648 - $ 6,516 | $ 150,000 - $ 150,000 | $ 6,000 - $ 44,000 | $ 263,005 - $ 418,140 | $ 422,653 - $ 618,656 | $ 1,013 - $ 1,482 | $ 9,606 - $ 14,060 |
| **Total** | **$ 3,285,866 - $ 4,199,695** | **$ 26,540,000 - $ 28,020,000** | **$ 26,516,000 - $ 33,162,000** | **$ 215,719,062 - $ 283,168,583** | **$ 272,060,928 - $ 348,550,278** | **$ 678 - $ 868** | **$ 11,129 - $ 14,257** |

**Abbreviations:**

GSP = Groundwater Sustainability Plan

MT = Minimum Threshold

PLSS = Public Land Survey System

**Notes:**

1. Increased lift is assumed to occur over 20 years. Screen cleaning, pump lowering, and well replacement are assumed to be a one-time cost. Range of costs reflects the uncertainty of the location of domestic wells within a given PLSS section.
2. Total cost per capita is based on estimated total population reliant upon groundwater by California Assembly District (Table 4d).
3. Estimated costs do not include wells anticipated to have MTs above current (Fall 2018) depth to groundwater. Costs due to dewatering at current water levels (approximately $1.7 - $1.8 million) are assumed to already be incurred by domestic well owners.

# Appendix A
# Raster Interpolation Methodology for Fall 2018 Depth to Groundwater

This Attachment describes the methodology used to process Fall 2018 depth to water ("DTW") geospatial data used in the study to represent the current groundwater conditions, prior to implementation of Groundwater Sustainability Plans ("GSPs").

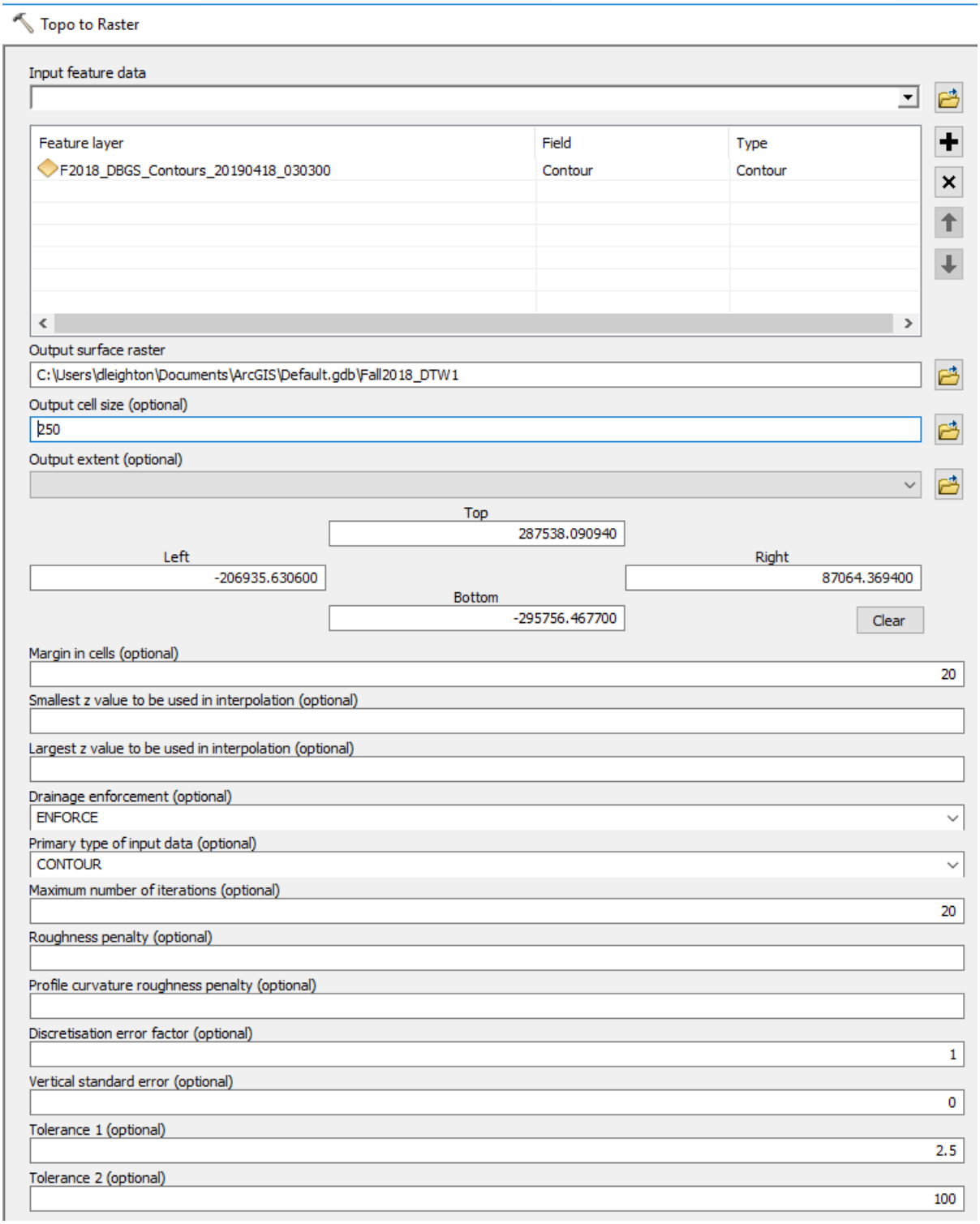
Fall 2018 depth to water contours were obtained from the DWR Groundwater Information Center Interactive Map Application ("GICIMA") https://gis.water.ca.gov/app/gicima/ on 5 December 2019. A polygon shapefile was created to represent the extent of the Fall 2018 DTW contours.

The Fall 2018 DTW contour layer was then used as input to the ArcGIS Spatial Analyst 'Topo to Raster' tool[1] with the settings shown in the screen shots provided on the following pages. Any settings not shown were left as the default settings.

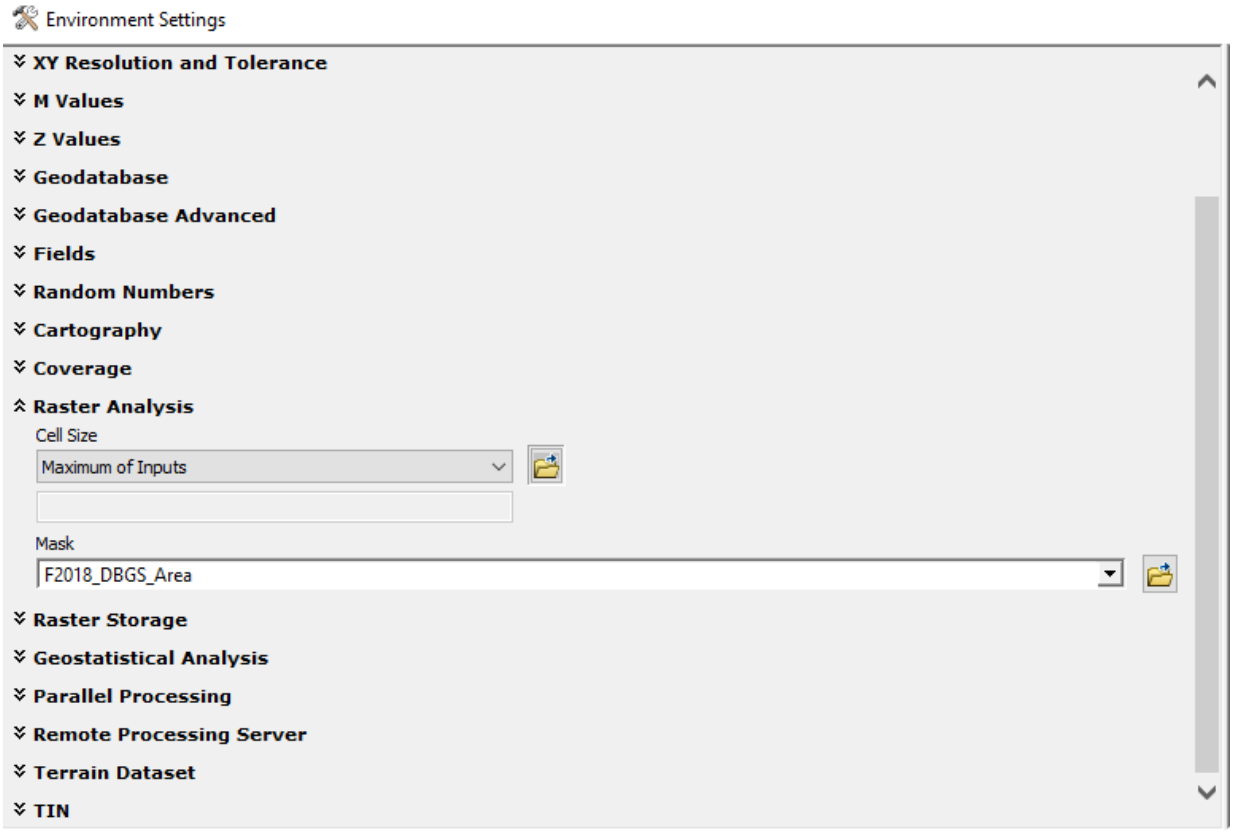
The 'Topo to Raster' tool is typically used to create topographically correct rasters of terrain from various data sets including elevation contours, stream networks, and other elevation data. The ArcGIS documentation states that this tool "is the only ArcGIS interpolator specifically designed to work intelligently with contour inputs." Therefore, this tool was used to create the raster from the depth to water contours. In this case, only the contours of Fall 2018 DTW were used; no other elevation input was provided. Spot-checking of raster values along contours indicates that the results are representative of the original data source.

[1] ArcGIS Desktop version 10.6 was used for this analysis.

***Main Tool Window:***



***Environment Settings - Raster Analysis:***



# Appendix B
# Raster Interpolation Methodology for Depth to Groundwater at MOs and MTs

Numerous different statistical methods and algorithms are available for creating contoured surfaces from point data. Some methods are very "true" to the data and interpolate values strictly between points, and other methods apply various weighting techniques to "smooth" the data and minimize what, in some contexts, could be considered to be outlier or insignificant points.

In order to ensure that the contouring method selected for this purposes was appropriate and "true" to the data, a methodology sensitivity analysis was performed. Various contouring methods available within Surfer 11[1] were evaluated using a subset of data within the Study area. Specifically, this sensitivity analysis used Measurable Objective ("MO") values from the Merced and Tule Subbasins, which appear to have a high degree of variability between Representative Monitoring Wells ("RMWs") within relatively small geographic areas. Contouring methods evaluated included: Inverse Distance to a Power, Kriging, Minimum Curvature, Modified Shepard's Method, Natural Neighbor, Nearest Neighbor, Radial Basis Function, Triangulation with Linear Interpolation, and Local Polynomial.

Based on this analysis, the Kriging method was selected as the most appropriate method for purposes of this study. Groundwater elevation contours of MO and MTs values were therefore created using the following steps: (1) MOs and MTs were compiled from twenty-six Groundwater Sustainability Plans ("GSPs"), (2) default settings were applied to the Kriging grid creation with a grid spacing of 250 meters, and (3) contour intervals were set to 10 feet and smoothed using the Spline Smooth command in Surfer 11 with default settings applied. The resultant raster datasets were used for purposes of comparing domestic well construction data to MO and MT water level conditions.

[1] Surfer 2D and 3D mapping software by Golden Software: https://www.goldensoftware.com/products/surfer.

# Appendix C
# Sensitivity Analysis Regarding Inclusion of Deep Aquifer Wells in MO and MT Water Level Surface Contours

In areas where multiple aquifers are present due to a significant confining layer, domestic wells tend to be shallow, and constructed within the uppermost aquifer. However, even when a confining layer is present, the degree to which aquifers are hydraulically separated into discrete upper and lower aquifer units can be spatially variable due to differing thickness and permeability of the confining layer, the prevalence of wells screened across the aquifers, and other factors, and is often the subject of differing professional opinions. In order evaluate the effect of including lower aquifer representative monitoring wells ("RMWs") in the estimation of water levels at measurable objectives ("MOs") and minimum thresholds ("MTs"), a sensitivity analysis was conducted.

Figure C-1 shows the distribution of RMWs across the study area GSAs. The left panel includes all RMWs, regardless of aquifer designation, and the right panel excludes RMWs identified in their respective GSPs as being from a "lower" or "confined" aquifer. Figures C-2 and C-3 show contours of MO and Mt water levels both with and without the inclusion of lower and confined aquifer RMWs.

Figure C-4 shows the changes in contoured water levels that would result if the lower/confined RMWs are included, for both MOs and MTs. The areas shown in red would result in lower water levels (likely reflecting more impacted domestic wells), yellow areas are approximately the same water levels, and blue areas result in higher water levels (likely reflecting fewer impacted domestic wells).

Figures C-5 and C-6 are histograms summarizing the distribution of known depths of domestic wells and the depths of lower and confined aquifer RMWs in the three subbasins included in the sensitivity analysis.

Based on the results of this sensitivity analysis and for the reasons identified below, RMWs identified in Groundwater Sustainability Plans ("GSPs") as being from a lower or confined aquifer were excluded from the calculation of MO and MT water levels:

- The California Department of Water Resources ("DWR") Groundwater Information Center Interactive Map Application ("GICIMA") dataset used for comparison to current groundwater conditions, is intended to represent the uppermost aquifers - "water level measurements are selected based on measurement date and well construction information (where available) and approximate groundwater levels in the unconfined to uppermost semi-confined aquifers" per https://gis.water.ca.gov/app/gicima/). While DWR does not present detailed methodologies for how the GICIMA water levels are

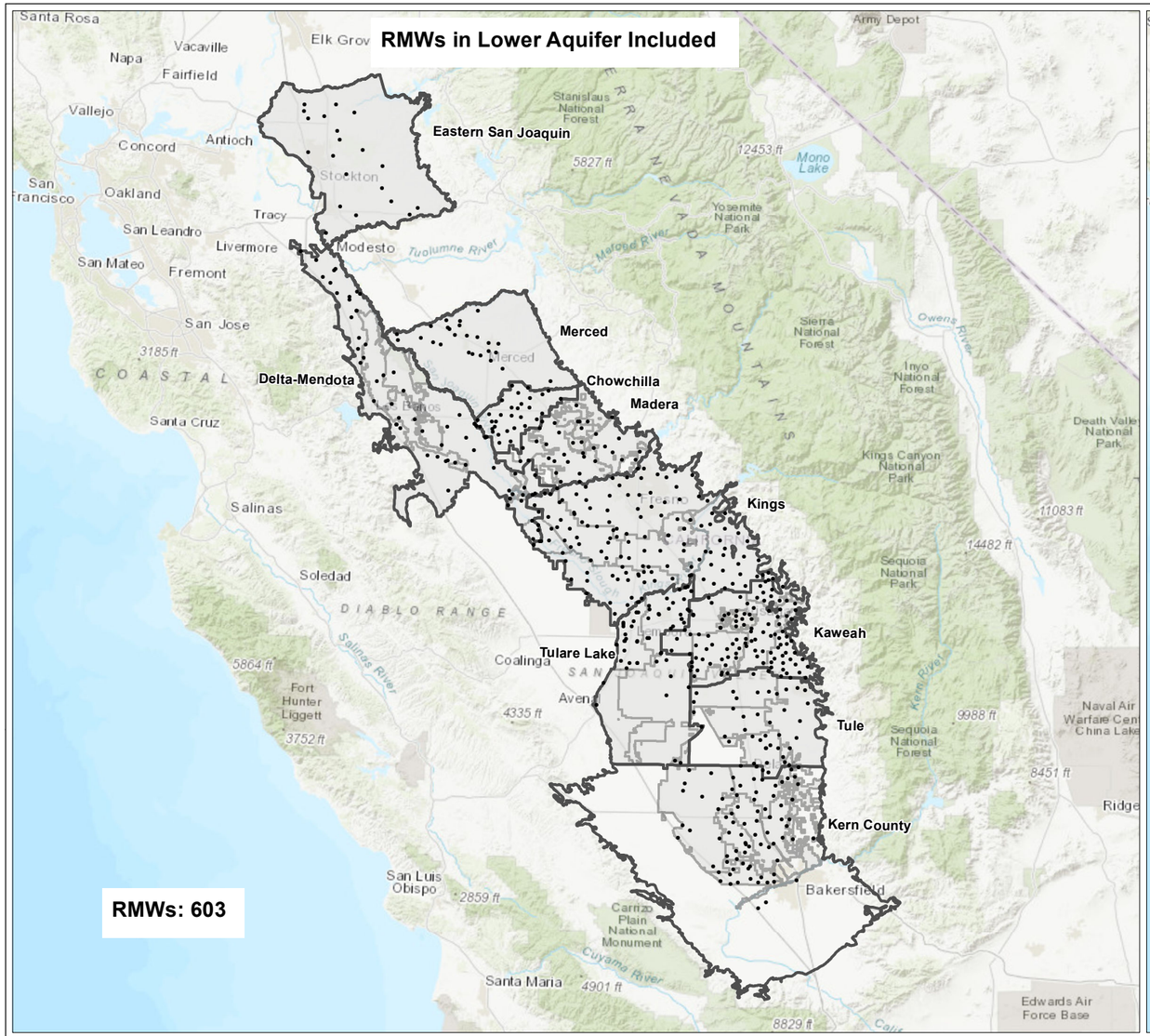
developed, given the way the dataset is described, it may not be appropriate to compare MOs/MTs from lower aquifer RMWs to the GICIMA dataset.

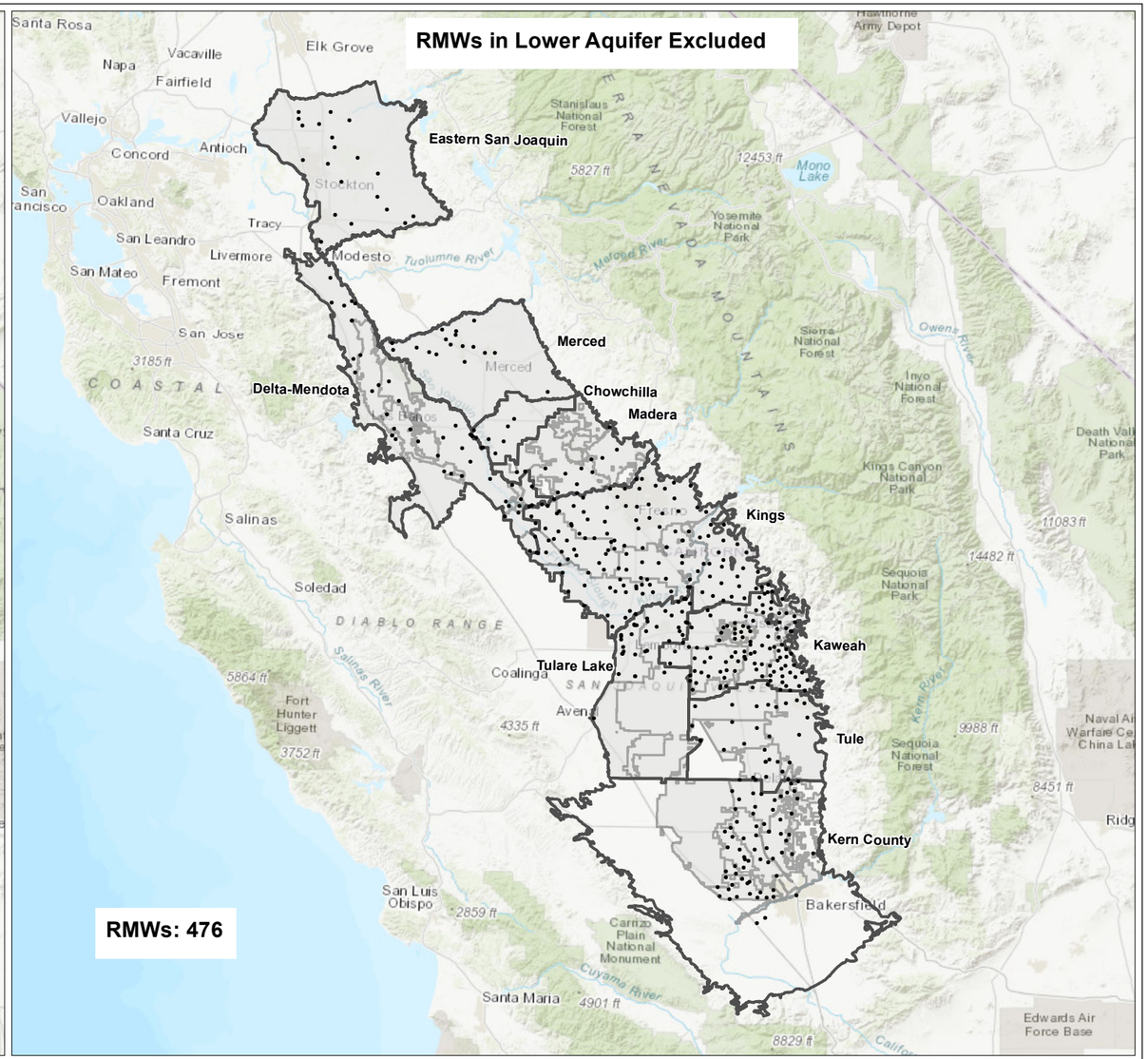
- As illustrated in Figures C-5 and C-6, domestic wells appear to be distinctly and significantly more shallow than lower aquifer RMWs. Within the area evaluated for this analysis, 90% of domestic wells are shallower than 500 feet, and 78% of RWMs are deeper than 500 feet. These data are consistent with the assumption that domestic wells tend to be shallow, and represent first encountered groundwater. The grouping of the lower aquifer RMW depths is also consistent with there being a relatively consistent designation of a confined aquifer across these subbasins.

- It is noted that in one area (the Madera Subbasin) a closer review of the GSP suggests that some of the RMWs identified as lower aquifer wells may actually be located in unconfined areas. That is, the GSP appears to be internally inconsistent, and designates RMWs as upper, lower, and composite aquifer in areas where the GSP indicates that the Corcoran clay is not present. However, due to the scale of this study, it is not feasible or appropriate to thoroughly review the hydrogeological conceptual models, aquifer delineations, and RMW designations presented in the GSPs for accuracy.

While the details and data are imperfect, relying on the DWR GICIMA dataset and the GSP aquifer designations is a robust and consistent method to apply the available data, but likely underestimates the potential risk to domestic wells. If deep aquifer RMWs were included in the MO and MT contours, the impacts to domestic well users would be estimated to be more significant. It is acknowledged that water level changes in lower aquifer RMWs may have an influence on upper aquifer water levels that is not captured in by this assessment.

**Figures**




## Legend

- Groundwater Subbasins
- Study Area GSP Areas
- Representative Monitoring Wells

## Abbreviations

GSP = Groundwater Sustainability Plan
RMW = representative monitoring well

## Notes

1. All locations are approximate.
2. This map reflects all RMWs with and without inclusion of those clearly defined by GSPs as being located in "lower", "confined", "below corcoran" etc. aquifers.

## Sources

1. RMWs as identified in their respective GSPs.
2. GSP areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 35 70

(Scale in Miles)

**Representative Monitoring Wells**

Water Foundation
April 2020
EKI B90087.01
**Figure C-1**

Path: X:\B90087.02\Maps\2020\03\FigC-1_RMW_Map.mxd

**Estimated Depth to Groundwater at MOs with Lower Aquifer RMWs Included**

**Estimated Depth to Groundwater at MOs with Lower Aquifer RMWs Excluded**

Turlock
Merced
Madera
Delta-Mendota
Chowchilla
Kings
Westside

## Legend

- Groundwater Subbasins
- Selected GSAs

**Depth to Groundwater at MO levels (ft bgs)**

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- >300
- Representative Monitoring Wells

## Abbreviations

ft bgs = feet below ground surface
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
RMW = representative monitoring well

## Notes

1. All locations are approximate.
2. This map reflects depth to groundwater if water levels at all RMWs reached their respective MOs, as presented in the selected GSPs, with and without inclusion of RMWs clearly defined by GSPs as being located in "lower", "confined", "below corcoran" etc. aquifers.

## Sources

1. RMWs and associated MO values as identified in each selected GSP.
2. GSA areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 10 20

(Scale in Miles)

**Estimated Depth to Groundwater at Measurable Objectives**

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April 2020
EKI B90087.01
**Figure C-2**

Path: X:\B90087.02\Maps\2020\03\FigC-2_DeepAquiferSensitivityAnalysis_MO.mxd

Estimated Depth to Groundwater at MTs with Lower Aquifer RMWs Included

Estimated Depth to Groundwater at MTs with Lower Aquifer RMWs Excluded

Turlock
Merced
Madera
Delta-Mendota
Chowchilla
Kings
Westside

## Legend

- Groundwater Subbasins
- Selected GSAs

**Depth to Groundwater at MT levels (ft bgs)**

- 1 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 300
- 301 - 350
- 351 - 400
- >400
- Representative Monitoring Wells

## Abbreviations

ft bgs = feet below ground surface
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MT = Minimum Threshold
RMW = representative monitoring well

## Notes

1. All locations are approximate.
2. This map reflects depth to groundwater if water levels at all RMWs reached their respective MTs, as presented in the selected GSPs, with and without inclusion of RMWs clearly defined by GSPs as being located in "lower", "confined", "below corcoran" etc. aquifers.

## Sources

1. RMWs and associated MT values as identified in each selected GSP.
2. GSA areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 10 20

(Scale in Miles)

**Estimated Depth to Groundwater at Minimum Thresholds**

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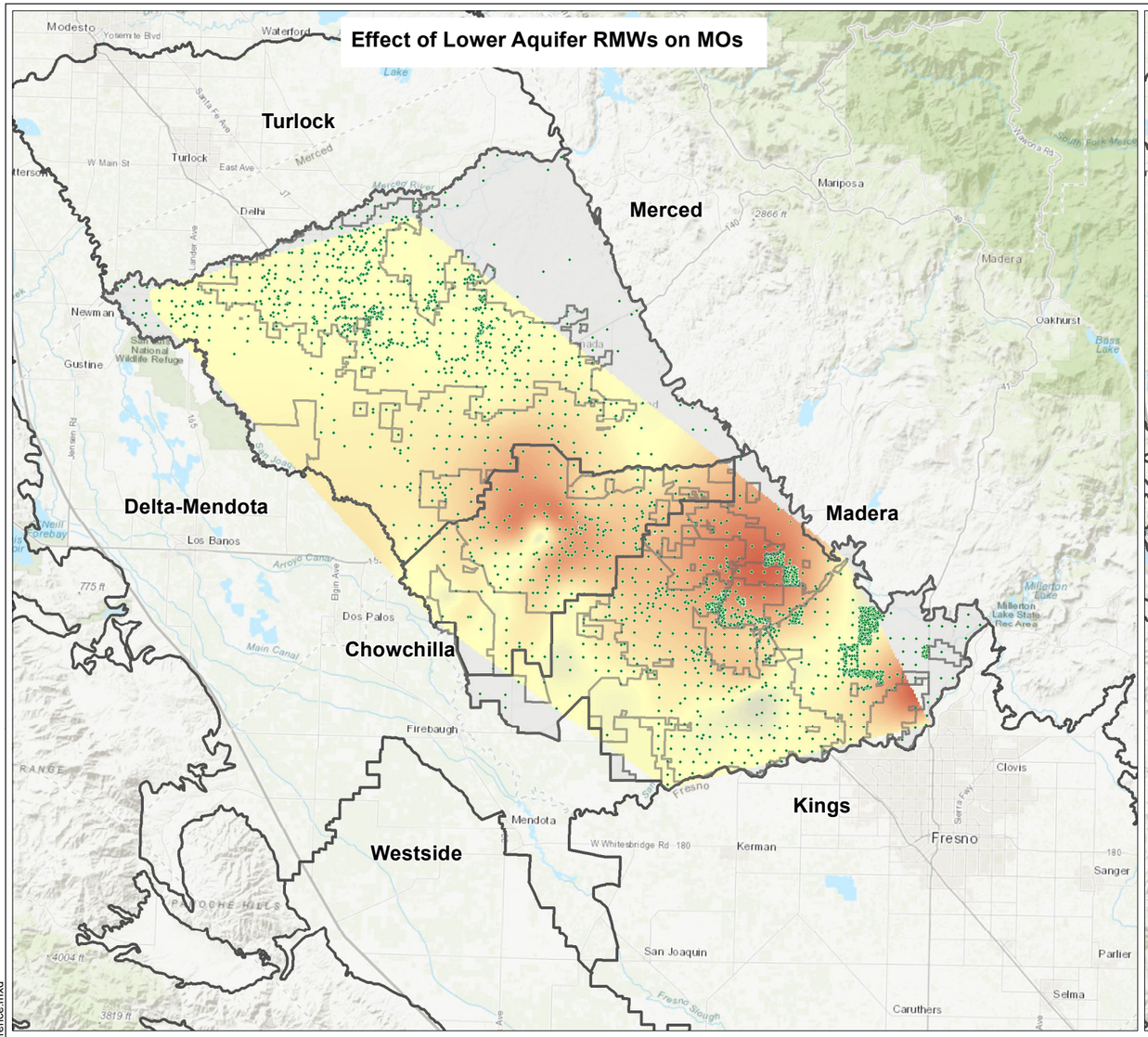
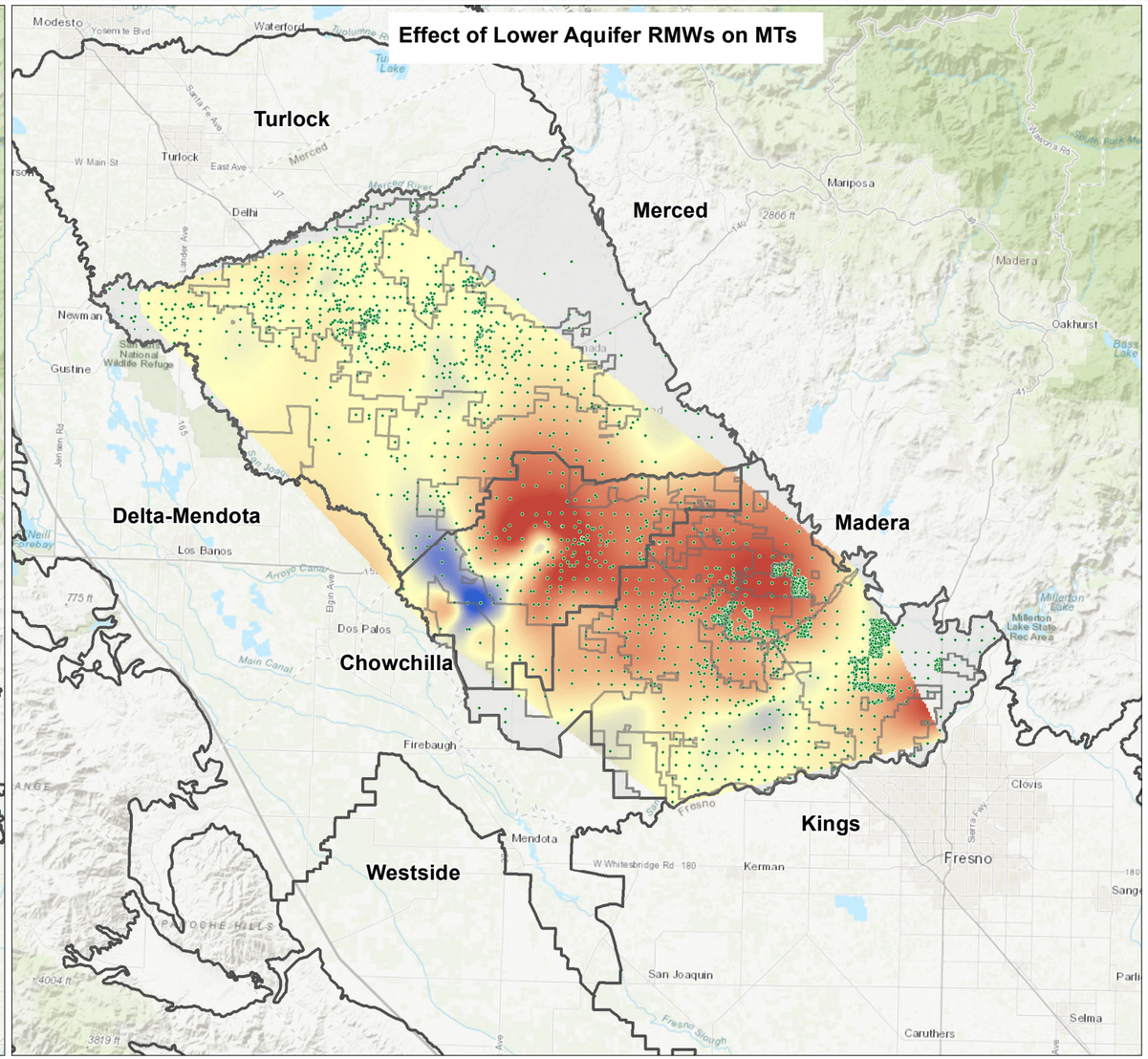
EKI B90087.01
**Figure C-3**

Path: X:\B90087.02\Maps\2020\03\FigC-3_DeepAquiferSensitivityAnalysis_MT.mxd




## Legend

- Groundwater Subbasins
- Selected GSAs

**Difference in Estimated Groundwater Levels with Inclusion of Lower Aquifer RMWs**

- 152 ft Higher
- No Difference
- 286 ft Lower
- Domestic Wells

## Abbreviations

ft bgs = feet below ground surface
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
MO = Measurable Objective
MT = Minimum Threshold
RMW = representative monitoring well

## Notes

1. All locations are approximate.
2. This map reflects the effect of including lower aquifer RMWs in contours of MO and MT water levels.

## Sources

1. RMWs and associated MO and MT values as identified in each selected GSP.
2. GSA areas as mapped in their respective GSPs (see references section for list).
3. Basemap provided by ESRI.
4. Groundwater subbasin extents as defined by DWR's Bulletin 118 Final Basin Prioritization, February 2019.

N

0 10 20

(Scale in Miles)

**Effect of Lower Aquifer RMWs on Contoured Groundwater Levels**

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EKI B90087.01
**Figure C-4**

Path: X:\B90087.02\Maps\2020\03\FigD-4_DeepAquiferSensitivityAnalysis_Difference.mxd

**Figure C-5**
**Frequency of Lower/Confined Aquifer RMWs by Well Depth**

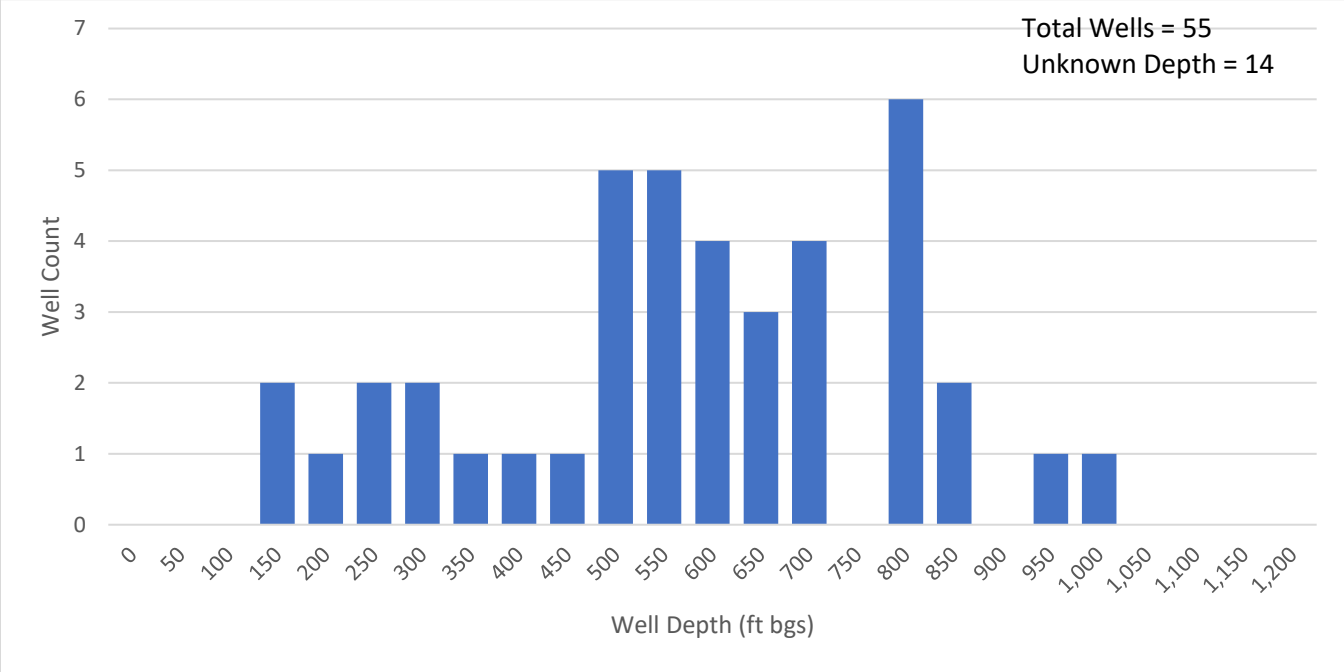


**Figure C-6**
**Frequency of Domestic Wells by Well Depth**