6-16-2022 Draft of revised GSP
Chapter 4 only

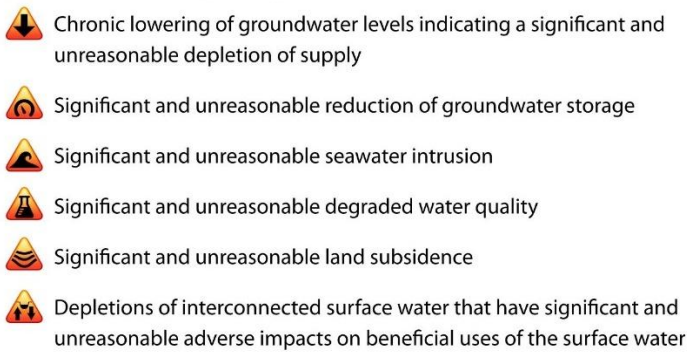
4 Sustainable Management Criteria

Regulation Requirements:

§354.22 This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

SGMA defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. The avoidance of undesirable results is important to the success of the GSP. Several requirements from GSP regulations have been grouped together under the heading of Sustainable Management Criteria, including a Sustainability Goal, Undesirable Results, Minimum Thresholds, and Measurable Objectives for various indicators of groundwater conditions. Development of these Sustainable Management Criteria is dependent on basin information developed and presented in the hydrogeologic conceptual model, groundwater conditions, and water budget chapters of the North Kings GSA plan (DWR, 2017).

Indicators for the sustainable management of groundwater were determined by SGMA based on that are important to the health and general well-being of the public. There are six indicators that must be monitored throughout the planning and implementation period of the GSP including:



This chapter will describe the indicators and why they are significant and will define the applicable management thresholds.

The Sustainable Management Criteria described herein were prepared following the requirements set forth in the California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2, Article 5, Subarticle 3 (§354.22 through §354.30).

4.1 Sustainability Goal

Regulation Requirements:

§354.24 Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

The sustainability goal of the Kings Basin and this GSA is to ensure that by 2040 the basin is being managed to maintain a reliable water supply for current and future beneficial uses without experiencing undesirable results. This goal will be met by balancing water demand with available water supply to stabilize declining groundwater levels without significantly and unreasonably impacting water quality, land subsidence, or interconnected surface water. The goal of the Basin is to correct and end the long-term trend of a declining water table understanding that water levels will fluctuate based on the season, hydrologic cycle and changing groundwater demands within the basin and its proximity.

The conditions with the basin and this GSA will be considered sustainable when:

- The basin is managed within its sustainable yield.
- The current rate of decline of the groundwater table within the basin monitoring network indicator wells has been corrected and the multi-year trend of water elevations in these wells has been stabilized.
- Groundwater management activities prevent undesirable results to groundwater levels, groundwater storage, groundwater quality, land subsidence and interconnected surface water.

The seven GSAs within the Kings Subbasin have been coordinating for several years on how to reach and maintain sustainability. As described in the Chapter 3 – Basin Setting, the Kings Subbasin includes significantly varied geologic conditions, water supplies, and land uses that lead to different conditions and obligations within each GSA. The Kings Subbasin setting describes the trend of declining groundwater levels within the Kings Subbasin and this GSA. The degree of decline varies by location based primarily on land use and available surface water supplies. The basin setting information, including historic groundwater conditions, surface water supplies, groundwater flows, land use, and other information were used to establish the water budgets, estimates of storage change within each GSA, and sustainable yield. Coordination efforts between the GSAs have resulted in concurrence of the initial quantities of storage change responsibility for each GSA to correct in order to achieve sustainability as shown below.

GSA	Proposed Initial Responsibility (AF)
Central/South	-7,100
James	16,700
Kings River East	-11,000
McMullin	-91,100
North Fork	-50,300
North Kings	20,800
Total	-122,000

These quantities and each GSAs respective obligation will continue to be monitored and evaluated as additional information is gathered.

Each GSA in the Kings Subbasin is responsible for implementing the projects and management actions necessary to reach sustainability and meet their initial mitigation requirements for storage change. Each GSA has identified measures that will be implemented to ensure the Kings Subbasin will be managed within the sustainable yield, as identified in Chapter 6 of each GSP – Projects and Management Actions to Achieve Sustainability. Collectively, these projects and programs have been

identified to ensure the Kings Subbasin reaches sustainability by 2040. The projects and programs include technical data and estimates of project benefit; the total of these benefits meet the initial estimates for reaching sustainability within the Kings Subbasin.

The Kings Subbasin has agreed to a phased approach of increasing mitigation to achieve sustainability. The proposed mitigation schedule for correcting the groundwater overdraft is shown below:

Period	Percent of Overdraft Mitigated	Cumulative Mitigation
2020-2025	10%	10%
2025-2030	20%	30%
2030-2035	30%	60%
2035-2040	40%	100%

Note that these are minimum goals and progress may be faster than described. A phased approach with gradually increasing progress was selected since time will be necessary to secure funding, plan, design and build projects, and develop water management programs. Furthermore, if recharge or banking projects are developed, a wet period will be needed before project benefits are realized. Consequently, efforts will be consistent throughout the 20-year period, but many benefits will likely not be seen until the latter years of implementation. Each GSA in the Kings Subbasin is planning to implement projects and management actions in accordance with the agreed mitigation targets. The GSAs will continue to meet regularly to review data to ensure all GSAs are meeting their milestones and progress is being made toward sustainability.

4.2 Groundwater Levels

4.2.1 Undesirable Results

4.2.1.1 Criteria to Define Undesirable Results

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

The SGMA regulations define Undesirable Results for groundwater levels as:

> *"Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods."* [CWC §10721(x)(1)]

The undesirable result for chronic lowering of groundwater levels is a result that would cause significant and undesirable reduction in the long-term viability of domestic, agricultural, municipal or environmental uses over the planning and implementation period of this GSP. The terms "significant and unreasonable" are not defined by regulations, rather the conditions leading to this

classification are determined by the GSA, beneficial users, and the basin they are a part of. The process used to develop criteria for determining undesirable results began with discussions with stakeholders and landowners. Primary concerns related to Undesirable Results for groundwater levels were:

- Groundwater levels declining in dry periods to a point that they will not likely recover during normal/wet periods
- A significant and unreasonable number of shallow domestic wells going dry

Identification of Undesirable Results is based on the monitoring network of Indicator Wells described in Section 5. The GSAs in the Kings Basin have defined the Undesirable Result as occurring when 15% of the Indicator Wells have exceeded the Minimum Threshold during a single monitoring event. This value was chosen to provide a balance between unanticipated hydrology, potentially erroneous data, and coverage of a significant area within the GSA. Exceedance of a Minimum Threshold at a single Indicator Well is not necessarily sufficient to indicate GSA-wide conditions are causing undesirable results.

The sustainability goal and the undesirable results provide the qualitative basis for the quantitative sustainable management criteria described below:

- Measurable Objective is the quantitative goal that will allow the basin to achieve its sustainability goal within the 20-year planning period. More specifically, the measurable objective is the elevation at an Indicator Well that will be stabilized and maintained over time. The measurable objective has been set such that there is a reasonable margin of operational flexibility that will accommodate droughts, climate change, and conjunctive use operations. The GSAs in the basin will manage the basin to the measurable objectives using adaptive management and implementing the projects and management actions described in Section 6 when needed to ensure sustainability will be achieved.

  The basin is currently not in a sustainable condition, and GSAs recognize that it will take several years to reach sustainability. The measurable objective was set based on the decline in each Indicator Well within the monitoring network during a recent period of average surface water deliveries within the basin from 1997 to 2012, and an incremental mitigation correction planned to reach sustainable water levels during the planning period. Hence, the Measurable Objective is based on what is considered a reasonable level of continued decline, since halting the overdraft before 2040 would not be practical or even feasible given the current and anticipated future water supply conditions. A more detailed description of the measurable objective is included later in this section.

- Interim Milestones are 5-year target groundwater levels at each Indicator Well that have been set for the basin to reach sustainability over the 20-year planning period. The interim milestones have been set based on the long-term average hydrologic conditions and the planned projects and management actions the GSAs will use to make incremental improvement toward sustainability over the 20-year planning period. The GSAs will manage the basin to these Interim Milestones during the planning period by comparing hydrologic conditions to historic average conditions and implementing management actions if needed to maintain a path to sustainability.

- Minimum Threshold is the groundwater elevation at an Indicator Well that when exceeded in combination with minimum thresholds at other Indicator Wells, may cause an undesirable result in the basin. More specifically for groundwater levels, the minimum threshold is the groundwater elevation below which significant and unreasonable impacts to beneficial users occurs. As noted previously, the primary concerns for groundwater users and uses were groundwater levels declining to a point that would not recover to sustainable levels, or declining to levels that would cause a significant and unreasonable number of shallow wells to go dry. Although the undesirable result (as defined) may not occur until water levels are below the minimum threshold, the basin will use the 5-year milestones and minimum threshold levels as trigger for operational change.

  The Kings Basin GSAs recognize that some wells will go dry, and the GSAs have indicated that it is not significant and unreasonable impacts if less than 15% of the shallow wells in the basin go dry. However, DWR has indicated through public comment and direct consultation with the basin that GSAs need to demonstrate how an impact to even just one single well is not significant and unreasonable. The shallowest wells in the basin are typically private domestic wells. Using the shallowest wells within the basin as a control to maintain water levels is impractical considering well construction has varied significantly and many wells may have been constructed too shallow, not considering or having been approved for sustainable or planned groundwater elevations.

  Agricultural uses are the largest groundwater user within the basin and agriculture production is the primary economic driver for the region. Setting minimum thresholds to maintain water levels to the shallowest well in an area would cause a significant and unreasonable economic impact to the basin' s varied groundwater users, including agriculture users and the many communities that are solely groundwater dependent because of the significant demand reduction it would require for all users. This is especially true when considering that suitable wells can be constructed deeper within the basin. The Kings Basin has a very large aquifer with existing water levels well above the base of the unconfined aquifer, and as shown in Chapter 2 – Basin Setting, recent water levels are several hundred feet above the base of the aquifer in much of the basin. Because the aquifer is so significant and of such good quality in most of the basin, a productive well of suitable quality can still be constructed as water levels continue to decline until sustainability is reached.

  Considering the economic, social and environmental impacts to domestic, agricultural, municipal and other groundwater users as well as the correlation to other sustainable management criteria, the basin plans to have groundwater levels continue to decline until sustainability can be reached within the planning period, but develop a program to address shallow well impacts. The Minimum Thresholds have been set below the measurable objective based on the needed operational flexibility to accommodate dry hydrologic conditions. Operational flexibility is the elevation difference between the Measurable Objective and the Minimum Threshold. During dry periods, more groundwater pumping will occur causing groundwater levels to decline below measurable objective levels. This Operational Flexibility is based on a five-year drought period. This amount of Operational Flexibility is consistent with other GSPs in the State that were approved. A more detailed description of the minimum threshold is included later in this chapter.

The GSAs in the basin acknowledge that some shallow wells will go dry, so the GSAs will develop a domestic well mitigation program to help address the impacts to domestic wells that are shallower than the minimum thresholds within the basin. A more detailed description of the proposed domestic well mitigation program is included in Chapter 6. At the time of the initial GSP submittal in January of 2020, not all of the GSPs in the Kings Basin included an analysis of the potential shallow well impacts. Each GSA now includes an analysis of the potential number of domestic wells impacted by the Minimum Thresholds.

These terms are illustrated in Figure 4-1.

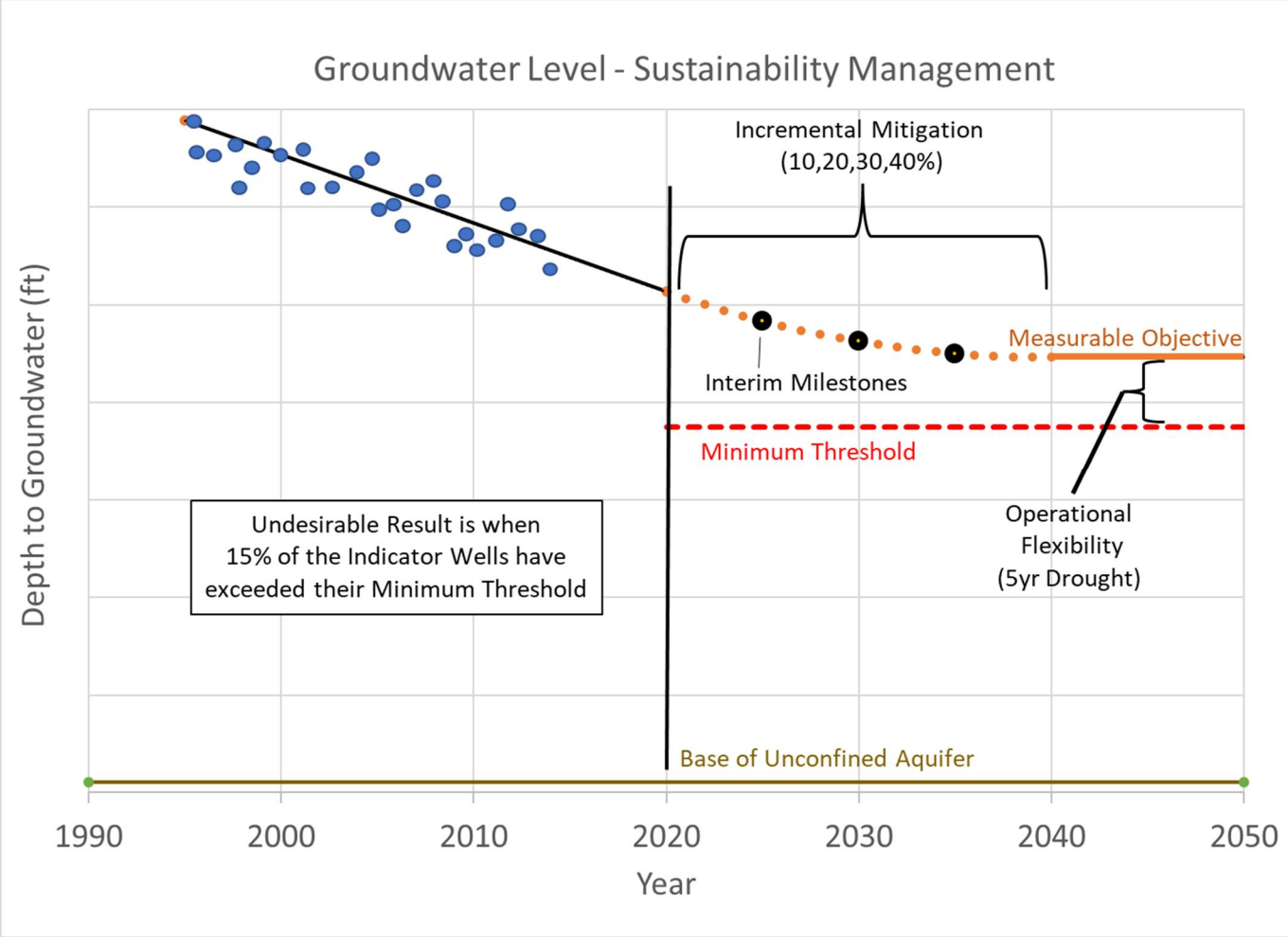


Figure 4-1 Groundwater Level - Sustainability Management

~~The GSAs within the Kings Subbasin have defined the Undesirable Result for groundwater levels to be significant and unreasonable when either the water level has declined to a depth that a new productive well cannot be constructed, or when the water level has declined to a depth that water quality cannot be treated for beneficial use.~~

~~As defined by the Kings Subbasin, the Undesirable Result in much of the subbasin is actually below the elevation of the Minimum Threshold. Because the aquifer is so significant and of such good~~

~~quality in most of the basin, the requirement to stabilize water levels by 2040 becomes the controlling condition for setting target water levels. The water level elevation at the point of stabilization is the Measurable Objective. The measurable objective was set based on the historic 1997-2012 decline in each Indicator Well within the monitoring network, and an incremental mitigation used to determine the future water levels. The selected Indicator Wells are wells that have a consistent history of water level measurements and that have known construction information to allow development of measurable objectives. A more detailed description of the measurable objective is included later in this section.~~

~~The minimum threshold was set at an elevation to allow operational flexibility of the anticipated water level decline during a 5-year drought. A more detailed description is provided later in this section.~~

~~So for much of the basin there will still be a significant aquifer of suitable quality below the levels set as the minimum threshold. Meaning a productive well of suitable water quality could still be constructed if the water level drops below the minimum threshold. The figure below illustrates this idea that for much of the basin, the minimum threshold is actually set at a level above the level of the Undesirable Result.~~

~~Although the undesirable result (as defined) may not occur until water levels are well below the minimum threshold, the requirement to operate at the basin at the Measurable Objective will control and the basin will use the milestone and minimum threshold levels as the indicator level for the need for operational change. Therefore, unless otherwise defined for a portion of a GSA, the basin will use the Minimum Threshold level as the point at which the effects of the groundwater decline become significant and unreasonable.~~

~~Figure 4-1 Groundwater Level - Sustainability Management~~

~~The GSAs in the basin recognize that water levels will continue to decline until the overdraft within the basin, and the impact of pumping from neighboring basins has been corrected. The GSAs also recognize that during this time, the water level may decline below the depth of some wells within the basin. Well construction has varied over the years and wells have been constructed at varying depths, and the construction depth of all wells in the basin is not known at this time. Some wells, even recently constructed wells, may have been poorly constructed or constructed too shallow for long term operation. SGMA does not require the GSA to maintain current water levels or prevent any wells from going dry. Rather, the GSA is required to stabilize and correct groundwater decline. Until water levels have been stabilized and the basin has reached sustainability, the GSA does not view a well going dry as an undesirable result.~~

~~Within each GSA there may be exceptions or additional considerations for the groundwater level undesirable result described within each GSA's GSP. The NFKGSA has no exceptions or additions to this definition.~~

4.2.1.2 Causes of Groundwater Conditions That Could Lead to Undesirable Results

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

~~At present there are no conditions resulting in undesirable results of groundwater levels in the GSA. Going forward there are factors that have the potential to cause changes leading to undesirable effects.~~ Each Indicator Well has a unique Minimum Threshold elevation, so ~~T~~the elevation at which an undesirable result occurs varies throughout the basin and each GSA. The continued decline of water levels below the minimum threshold would be the undesirable result. The potential decline of the water table below minimum threshold levels could be caused by:

- GSAs not correcting the overdraft at the basin-agreed incremental mitigation rates described later in this section.
- Hydrologic cycle significantly drier than historic average conditions.
- Extended or worse drought conditions than the historic 2012-2016 drought.
- Neighboring GSAs and Basins not correcting boundary flow losses to the Kings Basin and its GSAs.
- Increased demand and pumping beyond what are planned for in the water budget.
- Reduction of long-standing surface water supplies as a result of State or Federal regulations leading to the need for increased groundwater pumping in the Kings Basin or neighboring basins.

As noted above, for much of the basin there will still be a significant amount of suitable water supply well below the minimum threshold and above the point at which a productive well of suitable water quality could no longer be constructed.

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

The GSAs in the Kings Basin have defined the Undesirable Result as occurring when 15% of the Indicator Wells in a GSA have exceeded the Minimum Threshold during a single monitoring event (spring or fall). For the North Fork Kings GSA, that is 3 of the 23 Indicator Wells listed in the monitoring network discussion. The 15% was chosen to provide a balance between unanticipated hydrology, potentially erroneous data, and coverage of a significant area within the GSA. ~~Water level declining below the minimum threshold in one of the GSA's Indicator Wells in the Monitoring Network will be considered significant. The regulations and DWR BMP for chronic lowering of groundwater levels recommend significant and unreasonable being considered when some percentage of wells have dropped below minimum thresholds. However, with the monitoring network having Indicator Wells cover large areas, the exceedance of the minimum threshold at just one Indicator Well location is significant based on how the basin has determined the minimum thresholds described later in this section. The water level decline to this point would potentially be significant to the stakeholders in the proximity of this Indicator Well and warrant further evaluation by the GSA and potential action. Therefore, the exceedance of one minimum threshold will trigger further action by the NFKGSA.~~

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

The primary effect of the chronic lowering of the groundwater table has caused wells to be drilled deeper to maintain productivity. Without correcting the basin to sustainability and stabilizing the water table, the decades long trend of drilling deeper and deeper wells would continue causing increased financial burden on stakeholders. In eastern areas of the Kings ~~Sub~~Bbasin, bedrock is shallow and the availability of supply above the bedrock could be diminished such that productive wells could not be constructed if water levels are not stabilized above these levels. In some portions of the basin, as water levels decline, the water quality changes can be significant enough to require additional treatment. Stabilizing the water table will reduce the changing conditions and provide for more sustainable long-term conditions within the basin. The development of the domestic well mitigation program described in Chapter 6 will help to address some of the potential effects to domestic well owners.

4.2.1.3 Evaluation of Multiple Minimum Thresholds

Regulation Requirements:

§354.26 (c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

The GSA, in coordination with the other GSAs in the basin will utilize multiple wells to monitor and manage the GSA and basin. Indicator Wells of approximately two per township (with more where necessary and available) have been identified, and Measurable Objectives and Minimum Thresholds will be set at each of these Indicator Wells. ~~Since Indicator Wells sometimes cover large areas,~~As described previously, the exceedance of the minimum threshold at 15% of the~~just one~~ Indicator Wells in the GSA ~~location~~ is significant and will trigger further investigation and action by the GSA. ~~based on how the basin has determined the minimum thresholds.~~ A detailed description of the GSA's monitoring network is included in Chapter 5 of this GSP.

4.2.2 Minimum Thresholds

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

The GSA, in coordination with the other GSAs in the Basin, has established a monitoring network with multiple Indicator Wells for the unconfined aquifer. Insufficient data is available from the confined aquifer to establish any sustainable management criteria for the confined aquifer. A Measurable Objective and Minimum Threshold for groundwater levels have been determined at each of these Indicator Wells for the unconfined aquifer. The minimum threshold was set at an elevation to allow operational flexibility of the anticipated water level decline during a 5-year drought. For most Indicator Wells in the network, ~~T~~the operational flexibility below the measurable objective was set based on the actual decline during the historic 2012-2016 drought ~~was determined~~and increased by 20% to estimate the impacts of a five-year drought. The Operational Flexibility was used because of changing hydrologic conditions and concerns for extended periods of drought in the future. This amount of Operational Flexibility is consistent with methods used in other GSPs approved by the State. ~~, and t~~The minimum thresholds were set by adding that distance

below the measurable objective for each Indicator Well in the network. As additional data and understanding is gained during the planning period, it is recognized that the Minimum Threshold elevations may be updated. A more detailed description is provided later in this section.

Regulation Requirements:

§354.28 (d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Groundwater elevation will be used as the indicator for the chronic lowering of groundwater levels. The minimum thresholds used for groundwater levels will set the overall groundwater storage volume desired to be maintained below the groundwater levels. Water levels will not be used as proxy for the other sustainability indicators and there are separate discussions on each indicator later in this section.

4.2.2.1 Criteria to Define Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:
(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.

As required by the regulation, the Minimum Thresholds for chronic lowering of groundwater levels were established based on the rate of groundwater elevation decline considering historic trends, water year types and projected water use in the basin. As mentioned previously, the minimum thresholds have been set below the shallowest wells in the basin in some areas, but the GSAs are planning a domestic well mitigation program to help address these impacts.

As shown in Figure 4-1, the minimum threshold is the elevation below the measurable objective that provides the operational flexibility to allow for periods of increased groundwater pumping during dry periods. As mentioned, the minimum threshold was set at an elevation to allow operational flexibility of the anticipated water level decline during a 5-year drought. For most Indicator Wells in the network, ~~T~~the actual decline during the historic 2012-2016 drought was determined at each Indicator Well in the monitoring network and increased by 20%. That~~e~~ amount of decline ~~during the historic drought~~ was then used to determine the Minimum Threshold by deducting that amount from the elevation set for the Measurable Objective at that Indicator Well. At some of the Indicator wells, there is incomplete or inconsistent water level readings during the drought period. For those wells, the greater of the average rate of decline multiplied by 15 (three times the standard rate of decline for 5 years) and the measured decline was used to determine the total depth of decline for operational flexibility. The rate of decline during the 2012-2016 drought was observed to be roughly three times the average rate of decline.

The establishment of the minimum threshold was based on actual water level readings at each of the wells chosen to be Indicator Wells in the Monitoring Network. A hydrograph was generated for each well and the historic rate of decline identified for each well individually. The trendline was developed using the recent water level reading from the 1990s to the end of the Basin base period (2012). This considers recent base period conditions for the basin which factors in recent land use changes, different water year types and the water use within the basin. The amount of decline during the recent drought (2012-2016) was also determined. A table listing the minimum threshold for each Indicator Well is included as Table 4-1 and a hydrograph for each Indicator Well showing the Minimum Threshold is included in Appendix 4-A In addition to the Minimum Thresholds, the hydrographs include the rate of decline of each specific well, and the Measurable Objective elevation based on the incremental rate of mitigation. As with all sustainable management criteria, it is recognized that future data may allow for refinement of these thresholds.

Table 4-1 Groundwater Level Minimum Thresholds

Well ID	Minimum Threshold (Elevation in feet)	Minimum Threshold (Depth in feet)
18S20E02A001M	-41.8	284.6
17S18E09R001M	-126.1	323.9
17S20E12Q001M	-40.3	283
17S21E09M001M	40.2	212.5
17S20E08L001M	-78.6	311.3
17S19E11H001M	-93	315.7
17S22E07A001M	81.2	191.5
17S19E03L001M	-96	316
17S20E02M001M	-23.4	261.1
16S18E33Q001M	-145.2	343.9
16S20E31P001M	-72.3	310.0
16S20E35J001M	16.9	232.8
16S21E31J001M	38.9	218.8
16S19E25B001M	-59.7	296.4
16S21E30C001M	38.3	219.4
B06	-61.8	244.5
B22	-49.6	248.8
B31	-81.4	289.4
~~CID51~~	~~2.5~~	~~241~~
LID14	-12.1	248
LID21	-20.5	256.4
LID25	-120.9	333.8
LID26	-74.3	288.2

Need to remove as Indicator Well - shallow monitor well is dry

4.2.2.2 Relationships Between Minimum Thresholds and Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following: (2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.
§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows: (1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following: (B) Potential effects on other sustainability indicators.

The following provides an explanation of the relationship between the water level minimum thresholds and the other sustainability indicators and how the GSA determined that the minimum thresholds will avoid undesirable results for each Indicator:

- Groundwater Storage. The minimum thresholds used for groundwater levels will set the overall groundwater storage volume desired to be maintained below the minimum threshold groundwater levels. In much of the NFKGSA and the basin, there will remain a very significant amount of groundwater below the minimum threshold elevations. Section 4.3 on Groundwater Storage describes this further.
- Sea Water Intrusion. This indicator is not applicable to this basin.
- Groundwater Quality. Changing groundwater levels can affect groundwater contaminant concentrations positively and negatively. There are no known contaminant plumes that are expected to migrate as a result of declining water levels. The minimum thresholds were compared with known contaminants of concern where data and quality information by elevation was available. Groundwater levels are not used as proxy for groundwater quality conditions. GSA has set separate groundwater quality sustainable management criteria and will monitor water quality as water levels change.
- Land Subsidence. Lowering of groundwater levels has a direct impact on land subsidence when it is caused by pumping water below a confining clay layer. Large portions of the NFKGSA have experienced significant subsidence, primarily attributed to confined aquifer pumping beneath the E-Clay outside of the GSA. The vast majority of groundwater pumping in the NFKGSA occurs within the unconfined aquifer or the semi-confined aquifer between the C-clay and the E-Clay layer. There is very little known pumping from the confined aquifer within the NFKGSA, but this is recognized as a data gap. Because water level minimum thresholds are set below the C-Clay and above E-Clay, there is a potential for water level minimum thresholds to cause some subsidence of the C-Clay, but not the E-Clay. Each of the sustainability indicators will be monitored and whichever is most sensitive to chronic lowering of groundwater levels will be the controlling factor in the surrounding area.
- Interconnected Surface Water. ~~In accordance with SGMA regulations defining ISWs as continuously saturated, there are no ISWs in the NFKGSA, therefore this indicator is not applicable to NFKGSA~~The GSAs of the basin have identified Interconnected Surface Water as a data gap and will be investigating this further over the next few years.

4.2.2.3 Minimum Thresholds in Relation to Adjacent Basins

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following: (3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The minimum thresholds established are based on implementation of incremental correction of the historic decline starting immediately and reaching stabilization by 2040. This approach is believed to be conservative and correct the trend of existing groundwater decline. The Kings Basin is primarily negatively impacted by surrounding basin pumping as adjacent basins with limited surface water supplies have caused declining groundwater conditions that negatively impact the Kings Basin by increasing groundwater flows across basin boundaries. As described in Section 2, these flows have increased over time. Groundwater pumping in the confined aquifer in adjacent basins has also impacted the Kings Basin as the confined aquifer is primarily fed by the groundwater upgradient in the Kings Basin.

As a basin, the various Kings GSAs have met with their neighboring GSAs outside of the Kings Basin to discuss how thresholds have been established and potential impacts. At the time of the preparation of this GSP, criteria from the neighboring basins was not available. However, it is understood that minimum threshold elevations along the boundaries will not match exactly as the basins and GSAs have likely taken different approaches to establishing thresholds. Basin representatives have met with other basin representatives to begin discussions on inter-basin concerns, but additional discussion and determinations are needed. Once the neighboring basin GSP revisions are completed, the NFKGSA will evaluate the potential differences between thresholds and work to coordinate needed resolutions and clarifications and consider an Inter-basin agreement.

4.2.2.4 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

~~The minimum thresholds have been established based on historic rate of decline, the proposed mitigation rate and enough operational flexibility to maintain delivery during a 5-yr drought. The minimum thresholds have been determined based on the plan to correct the existing overdraft with an incremental approach intended to result in stabilized groundwater levels by 2040.~~ Stabilizing the groundwater levels will provide more certainty of the long-term availability of groundwater supply for all beneficial uses and users. Property values have always been influenced by the presence and depth of a useable well. Minimum Thresholds may affect those property values with existing wells with depths shallower than the Minimum Threshold. The GSAs in the basin recognize that water levels will continue to decline until the overdraft within the basin, and the impact of pumping from neighboring basins, has been corrected.

Well construction has varied over the years and wells have been constructed at varying depths, and the construction depth of all wells in the basin is not known at this time. Some wells, even recently constructed wells, may have been poorly constructed or constructed too shallow for long term operation. SGMA does not require the GSA to maintain current water levels or prevent any wells from going dry. Rather, the GSA is required to stabilize and correct groundwater decline.

The Kings Basin has a very large aquifer with existing water levels well above the base of the unconfined aquifer. As shown in Chapter 2 – Basin Setting, recent water levels are several hundred feet above the base of the aquifer in much of the subbasin. Much of the subbasin has a significant

amount of water available below the Measurable Objective and even below the Minimum Threshold levels.

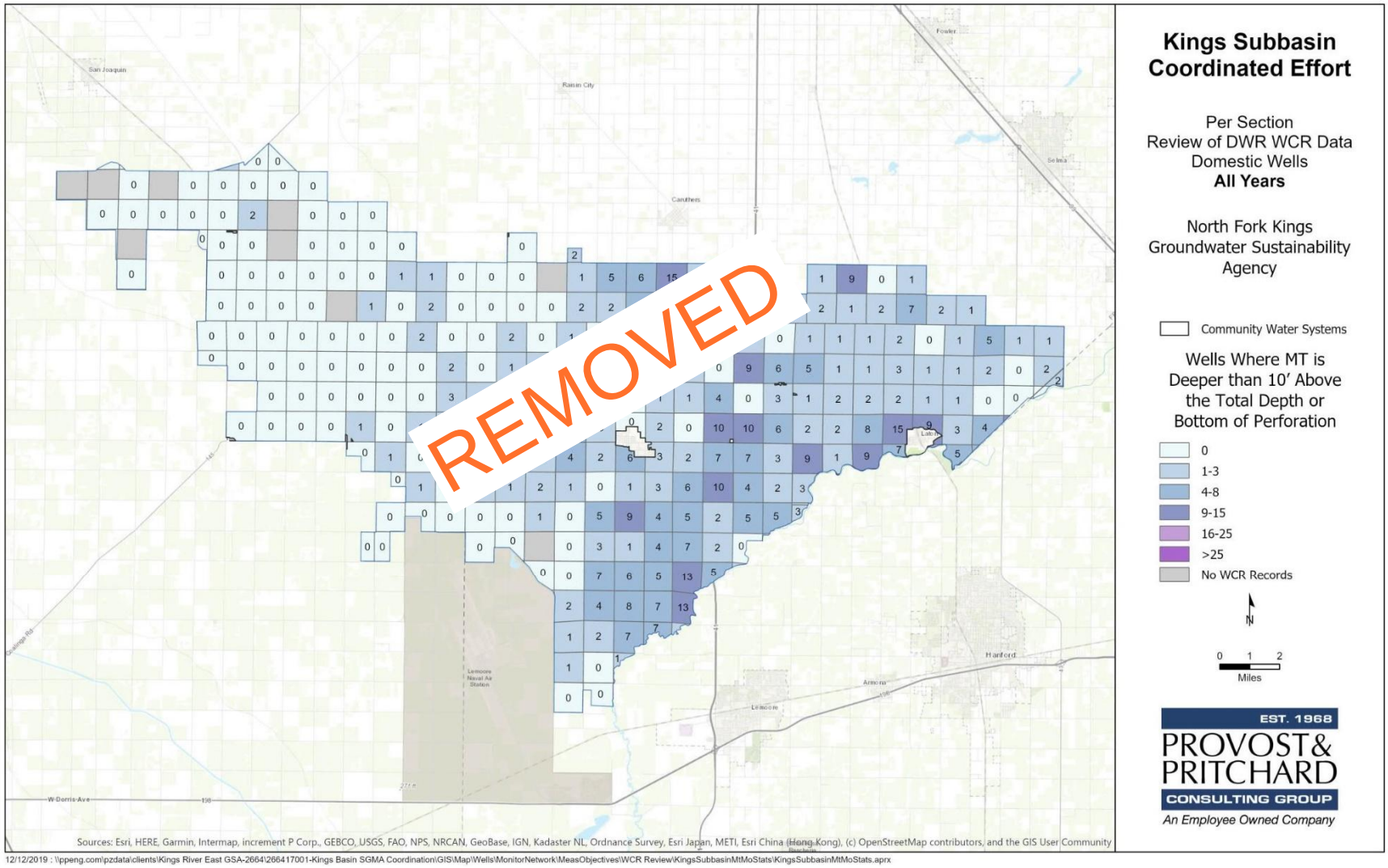
The GSA recognizes that some shallow wells will likely go dry until water levels have been stabilized. Without SGMA and the proposed incremental mitigation by the GSA, the shallow wells would have gone dry sooner, requiring the landowners to deepen these existing wells. However, the GSAs will develop a well mitigation program to help address impacts to domestic wells that may go dry above the minimum threshold. A more detailed description of the minimum threshold is included later in this chapter, and a description the proposed mitigation program is included in Chapter 6. ~~The minimum thresholds have been established to allow for continued beneficial use within the GSA and provide improved long-term certainty of groundwater levels within the GSA.~~

An analysis was performed to estimate the number of domestic wells that may potentially go dry at the minimum threshold elevations. Utilizing the minimum threshold elevation at each of the water level monitoring well sites shown in Table 4-1 (and included in Appendix 4-A, locations shown in Figure 5-1), a groundwater level contour surface was generated for the entire GSA utilizing GIS software. From this surface, the estimated average depth to groundwater in each Section (one-square mile) was obtained which provides an estimate of the depth to groundwater at the minimum threshold. The depth to water at the minimum threshold in each section was compared to the well completion report records available from DWR. DWR's well completion reports are grouped by section, but locations within each section are not known. It is important to note the inaccuracies of the well record data, including inaccurate locations and construction information, no consideration of abandoned or inactive wells, no consideration of well modifications, and may not include all recent well information. For this comparison, all domestic wells were selected from the DWR records. The perforation interval of the well was considered if included in the well completion report, otherwise the total depth of the well was considered. For every domestic well in each section in the GSA, the minimum threshold depth was compared to ten feet above the bottom of perforation interval (if known) or ten feet above the total depth of the well. Sections that are entirely contained within the boundaries of a community water system (City of Fresno, Clovis, etc.) were removed from the comparison, but if only a portion of the section was within the water system service area or within the GSA's exterior boundary, all of the wells in the section were included in the analysis since the exact location of the wells in a section is not included in the available data. In an effort to remove wells that have been abandoned or already gone dry, wells with depths or perforations shallower than the fall 2017 groundwater surface contours shown in Figure 3-28 were removed for this analysis. ~~The results of this analysis are shown in Figure 4-2 and showing the number of wells in each section that may be impacted.~~

Since the first comparison to minimum thresholds included all wells regardless of age, and many of those wells have likely been abandoned or failed, a second comparison was performed for wells constructed after 1990. 1990 was chosen as a comparison to provide a range of the estimated impact to wells that will be up to 50 years old in 2040. Using this period for the analysis is also consistent with SWRCB comments and studies performed by UCDavis. The results of this analysis are shown in Figure 4-2~~Figure 4-3~~ and showing the number of wells in each section that may be impacted.

~~For each comparison,~~ Tthe number of domestic wells shallower than the minimum threshold were totaled and compared to the total number of domestic well records. As mentioned previously, the total number of domestic wells used in these calculations is based on DWR records, and may include

abandoned, destroyed, or inactive wells. In addition, due to the unique geology within the NFKGSA there may be wells included that draw from shallow perched groundwater and will not go dry, or may only be dry for short periods of time. Utilizing all well data and all wells in a section that is only partially outside a community water system is very conservative considering the data includes many wells that are no longer active or are nearing the end of their usable life. For these reasons, it is anticipated that the number of impacted wells is lower than what is shown. These numbers may be refined as the GSP is implemented and more information becomes available.



~~Figure 4-2 Potential Impacts to Domestic Wells from All Years compared to Minimum Threshold~~

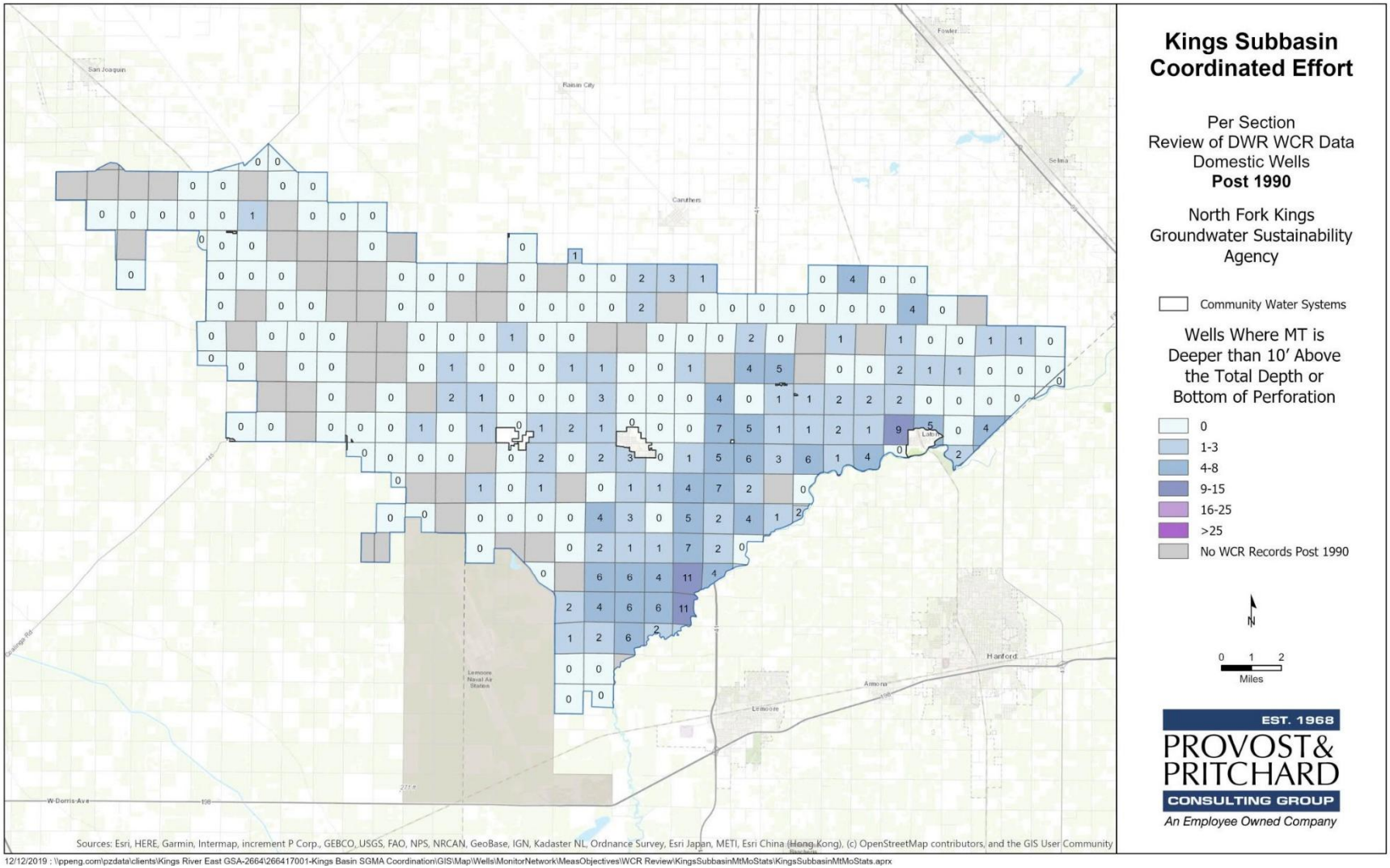


Figure 4-2 Potential Impacts to Post 1990 Domestic Wells compared to Minimum Threshold

4.2.2.5 Current Standards Relevant to Sustainability Indicator

Regulation Requirements

> §354.28 (b) The description of minimum thresholds shall include the following:
> (5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

There are currently no state, federal, or local regulatory standards applicable to groundwater levels. This GSP will become the basis for local regulatory standards.

4.2.2.6 Measurement of Minimum Thresholds

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater level readings will be made at Indicator Wells in accordance with water level measurement protocols described in Section 5 Monitoring Network of this GSP.

4.2.3 Measurable Objectives

4.2.3.1 Description of Measurable Objectives

Regulation Requirements:

> §354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
> (b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

The Measurable Objective is the quantitative goal that will allow the basin to achieve its sustainability goal within the 20-year planning period. More specifically, the measurable objective is the elevation at an Indicator Well that will be stabilized and maintained over time. The measurable objective has been set such that there is a reasonable margin of operational flexibility that will accommodate droughts, climate change, and conjunctive use operations. The GSAs in the basin will manage the basin to the measurable objectives using the projects and management actions described in Section 6.

The establishment of the Measurable Objective was based on actual water level readings at each of the wells chosen to be Indicator Wells in the Monitoring Network. The Monitoring Network is described in detail in Section 5 of this GSP. A hydrograph was generated for each well and the historic rate of decline identified for each well individually. The trendline was developed using the available water level readings from 1997 to 2012 which corresponds to the hydrologic base period for the basin. Use of this historic data considers recent base period conditions for the basin which factors in recent land use changes, different water year types and the water use within the basin. Outlying data points were omitted from the historic trend where applicable. The rate of decline was then projected from the more recently measured fall water level to year 2020 for each well. The basin wide agreed incremental mitigation rate for correction (shown in Table 4-2) was applied to each well's hydrograph. The incremental correction provides the calculation of the anticipated

water level at 2040. By 2040, there should no longer be a long-term average decline, therefore, the water level estimated for 2040 becomes the measurable objective. A table listing the Measurable Objective for each Indicator Well is included as Table 4-3 and a hydrograph for each Indicator Well showing the Measurable Objective is included in Appendix 4-A. In addition to the Measurable Objective, the hydrographs include the rate of decline of each specific well, and the Minimum Threshold elevation based on the necessary Operational Flexibility to maintain during a 5-year drought.

Table 4-2 Groundwater Level Incremental Correction

Year	Correction	Cumulative % Correction
2025	10%	10%
2030	20%	30%
2035	30%	60%
2040	40%	100%

The incremental mitigation for correction was selected based on the understanding that correcting decades of overdraft will take many years and implementation is dependent on many factors, including development of funding, project development, environmental and permit compliance, correction by neighboring GSAs and basins that impact the Kings Basin.

4.2.3.2 Operational Flexibility

Regulation Requirements:

> §354.30 (c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

A margin of operational flexibility, or margin of safety, allows for variation in groundwater levels due to historical water budgets, seasonal and yearly variations, and drought and also takes into consideration levels of uncertainty. Drought years may cause pumping to increase, but wet years may provide enough opportunity for surface water recharge to offset drought years. The operational flexibility for each well in the GSA will vary based on current groundwater levels and rate of decline. As shown in Figure 4-1 the operational flexibility is the difference in groundwater levels between the Measurable Objective and Minimum Threshold, and represents the amount of allowable decline in groundwater levels below the Measurable Objective. The measurable objective was established using the base period for the Kings basin which represents recent average hydrologic conditions and water uses with recent land uses and demands. As mentioned, the minimum threshold was set at an elevation to allow operational flexibility of the anticipated water level decline during a 5-year drought and was based on the recent historic drought of 2012-2016.

Table 4-3 Groundwater Level Operational Flexibility

Well ID	Operational Flexibility (feet)
18S20E02A001M	51.6
17S18E09R001M	38.7
17S20E12Q001M	54.3
17S21E09M001M	50.5
17S20E08L001M	54.2
17S19E11H001M	43.2
17S22E07A001M	48.2
17S19E03L001M	47.3
17S20E02M001M	42.2
16S18E33Q001M	45.0
16S20E31P001M	40.1
16S20E35J001M	35.0
16S21E31J001M	42.6
16S19E25B001M	51.2
16S21E30C001M	43.3
B06	32.0
B22	22.7
B31	51.5
CID51	41.7
LID14	35.1
LID21	47.1
LID25	83.4
LID26	46.0

4.2.3.3 Representative Monitoring

Regulation Requirements:

§354.30 (d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

The GSA is not proposing to use representative Measurable Objectives. Indicator wells are being used to establish measurable objectives and minimum thresholds.

4.2.3.4 Path to Achieve Measurable Objectives

Regulation Requirements:

§354.30 (e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The NFKGSA and the other GSAs in the basin will implement projects and programs to correct the declining groundwater levels and reach sustainability. The NFKGSA projects and programs are described in Section 6 of this GSP and implementation discussed in Section 7 of the GSP. The interim milestones for water level correction are unique to each Indicator Well, but follow the same basin wide agreed incremental mitigation rate for correction (shown in Table 4-2). The 5-year milestones to achieve measurement objectives are shown in Table 4-4. The Measurable Objective water levels have been used to determine the estimated volume of overdraft correction that is required within this GSA and the entire basin. The potential future groundwater gradients if water levels reach the Measurable Objectives are similar to those groundwater gradients existing today. There are no known contaminant plumes that are expected to migrate as a result of declining water levels; nevertheless, annual groundwater sampling at the single known plume site within the NFKGSA discussed in Section 3.2.5 will confirm the plume is not migrating.

Although the undesirable result (as defined) may not occur until water levels are below the minimum threshold, the basin will use the 5-year milestones and minimum threshold levels as trigger for operational change. The GSAs will manage the basin to these Interim Milestones during the planning period by comparing hydrologic conditions to historic average conditions and implementing management actions if needed to maintain a path to sustainability.

The NFKGSA has identified the schedule for implementation of each project and management action as well as that project's anticipated benefit or yield. The combined benefit of each project and management action at each milestone shows that the GSA has identified projects to correct the total overdraft by 2040. Other future projects and management actions ~~which are currently unknown and not specifically identified in Section 6~~ would be included in the anticipated reduction in demand and overdraft.

Table 4-4 Groundwater Level Measurable Objectives

Well ID	Measurable Objective (Elevation in feet)	Measurable Objective (Depth in feet)
18S20E02A001M	9.8	233
17S18E09R001M	-87.4	285.2
17S20E12Q001M	14	228.7
17S21E09M001M	90.7	162
17S20E08L001M	-24.4	257.1
17S19E11H001M	-49.8	272.5
17S22E07A001M	129.4	143.3
17S19E03L001M	-48.7	268.7
17S20E02M001M	18.8	218.9
16S18E33Q001M	-100.2	298.9
16S20E31P001M	-32.2	269.9
16S20E35J001M	51.9	197.8
16S21E31J001M	81.5	176.2
16S19E25B001M	-8.5	245.2
16S21E30C001M	81.6	176.1
B06	-29.8	212.5
B22	-26.9	226.1
B31	-29.9	237.9
CID51	44.2	199.3
LID14	23.0	212.9
LID21	26.6	209.3
LID25	-37.5	250.4
LID26	-28.3	242.2

Table 4-5 Groundwater Elevation Interim Milestones and Measurable Objectives

Well ID	Interim Milestones (Elevation in feet)				Measurable Objective
	2020	2025	2030	2035	2040
18S20E02A001M	63.1	42.2	24.9	13.4	9.8
17S18E09R001M	-44.4	-61.2	-75.2	-84.5	-87.4
17S20E12Q001M	57.8	40.6	26.5	17.0	14.0
17S21E09M001M	119.6	108.3	98.9	92.7	90.7
17S20E08L001M	19.1	2.1	-12.0	-21.4	-24.4
17S19E11H001M	-3.3	-21.5	-36.6	-46.7	-49.8
17S22E07A001M	158.5	147.1	137.7	131.4	129.4
17S19E03L001M	-10.9	-25.7	-38.0	-46.1	-48.7
17S20E02M001M	72.6	51.5	34.1	22.5	18.8
16S18E33Q001M	-52.2	-71.0	-86.6	-96.9	-100.2
16S20E31P001M	11.9	-5.4	-19.7	-29.2	-32.2
16S20E35J001M	92.0	76.3	63.3	54.6	51.9
16S21E31J001M	115.6	102.3	91.2	83.8	81.5
16S19E25B001M	32.4	16.4	3.1	-5.7	-8.5
16S21E30C001M	116.4	102.8	91.5	84.0	81.6
B06	-4.2	-14.3	-22.6	-28.1	-29.8
B22	-11.2	-17.4	-22.5	-25.9	-26.9
B31	11.3	-4.8	-18.2	-27.1	-29.9
~~CID51~~	~~89.5~~	~~71.7~~	~~57.0~~	~~47.2~~	~~44.2~~
LID14	50.8	39.9	30.9	24.9	23.0
LID21	59.0	46.3	35.8	28.8	26.6
LID25	29.2	3.1	-18.5	-33.0	-37.5
LID26	8.5	-5.9	-17.8	-25.8	-28.3

4.3 Groundwater Storage

Groundwater storage is directly linked to groundwater levels, and the Measurable Objective and Minimum Threshold for Groundwater Levels dictate the amount of groundwater in storage. The criteria used to determine water level Undesirable Results, Measurable Objectives and Minimum Thresholds dictate Groundwater Storage items. As described in Section 3.2.3, the estimation of the amount of groundwater in storage is dependent upon groundwater elevations from multiple wells and the depth of groundwater at the beginning and end of the period for which the storage change is estimated, multiplied by specific yields at various depths.. The amount of groundwater in storage (or change over time) is estimated from these contoured surfaces from the beginning and end of the period in question. Once the subbasin reaches sustainability, the estimated volume of groundwater between the Measurable Objective and the Minimum Threshold levels provides the Operational Flexibility. The calculations of this volume are included in Table 4-6.

No change to Groundwater Storage

described in Section 6 of this GSP and implementation discussed in Section 7 of the GSP. The groundwater storage interim milestones are calculated based on the basin wide agreed incremental mitigation rate to reach water level Measurable Objectives. The GSA has identified the schedule for implementation of each project and management action (when required) as well as that project's anticipated benefit or yield. The combined benefit of each project at each milestone shows that the GSA has identified projects to correct the total overdraft by 2040. Other future projects and management actions which are currently unknown and not specifically identified in Section 6 would be included in the anticipated reduction in demand and overdraft.

4.4 Seawater Intrusion

Regulation Requirements:

§354.26 (d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.
§354.28 (c) (3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion ... to undesirable results. Minimum thresholds for seawater intrusion shall be supported ... (A) Maps and Cross-sections of the chloride concentration ... that defines the minimum threshold and measurable objective for each principal ... (B) A description of how the ... minimum threshold considers the effects of current and projected sea levels.
§354.28 (e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

No change to Seawater Intrusion

By definition, seawater intrusion occurs when saline water from the ocean infiltrates the groundwater system and begins to flow into areas of freshwater due to pressure differentials, in many cases caused by groundwater pumping. The Kings Subbasin and NFKGSA do not need to account for seawater intrusion since they are not located adjacent to the coast.

4.5 Groundwater Quality

As discussed in these previous chapters, groundwater quality in the NFKGSA is generally well suited for irrigation and domestic use, although groundwater issues for drinking water exist in localized areas within the NFKGSA. While some of these chemical concerns are caused by humans, several are natural occurring. Groundwater quality concerns within the NFKGSA have been identified in Section 3.2.5 and corresponding water quality figures included in Appendix 3-D. Groundwater monitoring and reporting by community water systems and non-community public supply wells is a requirement of California Code of Regulations (CCR) Title 22. Community and other public supply wells within the NFKGSA monitoring network area already being routinely monitored for a wide range of contaminants, including the chemicals of concern, by the water purveyors under Title 22.

Groundwater pollution characterization and mitigation are typically enforced by local agencies and state level programs. The NFKGSA will only have authority related to groundwater pumping policies and recharge projects, however the NFKGSA will review and analyze publicly available routine groundwater monitoring data reported by the community and non-community public supply wells in order to monitor if groundwater pumping may be exacerbating groundwater quality concerns and where to enforce pumping restrictions or other mitigation measures should it become

necessary. The minimum thresholds will be set at the screening levels protective of human health as applicable for the respective chemicals of concern. Some of these are significant concerns while others are minor or geographically limited. The NFKGSA chemicals of concern and California MCLs are identified in Table 4-8 in Section 4.5.1.1.

4.5.1 Undesirable Results

Groundwater quality in the Kings Basin is generally suited for irrigation and domestic use, although groundwater issues for drinking water exist in some areas within the Kings Basin. An undesirable result would be the significant and unreasonable reduction in groundwater quality as it relates to groundwater pumping and recharge projects such that the groundwater is no longer generally suitable for agricultural irrigation and domestic use. The NFKGSA will only have authority related to groundwater pumping policies and recharge supply projects, however the NFKGSA will review and analyze publicly available routine groundwater monitoring data reported by the community and non-community public supply wells, as it becomes available, in order to monitor if groundwater pumping may be exacerbating groundwater quality concerns and where to enforce pumping restrictions should it become necessary.

4.5.1.1 Criteria to Define Undesirable Results

Regulation Requirements:

§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to this basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

Within the Kings Basin the criteria that will be relied upon to define water quality undesirable results will generally be based on Maximum Contaminant Levels (MCLs) set in California Title 22 Code of Regulations when related to groundwater pumping policies and recharge projects.

The intent of SGMA is for the GSAs to be responsible for groundwater aspects related to pumping and recharge supply projects only. Other existing agencies and programs are generally responsible for tracking and remediation of groundwater quality. As described in the Plan Area chapter, these other agencies and programs include ILRP, CV-SALTS, Fresno County Rural Domestic Well Program (Volunteer basis), Kings County Drinking Water Source Assessment and Protection Program (DWSAP), Dairy General Order, RWQCB, SWRCB, Division of Drinking Water, DTSC, and others.

While there are several existing groundwater monitoring programs, they do not monitor all contaminants of concern within the NFKGSA and may not provide depth-specific water quality data. Water quality of private domestic wells is largely unknown as testing of the wells is not required and the Fresno County Rural Domestic Well Program is voluntary and relies on well owners to have some knowledge of preexisting groundwater quality issues to opt in. Due to these limitations, the data from these programs will not be relied on to set sustainable management criteria at this time. The GSA will explore future partnerships with private domestic well owners and those entities with domestic drinking water quality test results, such as Self-Help Enterprises, to fill spatial and temporal data gaps.

Groundwater monitoring and reporting by community water systems is a requirement of California Title 22 Code of Regulations. Monitoring and reporting schedule requirements can vary based on

the service population size, geographic area and population type (i.e. transient vs. non-transient). Under California Domestic Water Quality and Monitoring Regulations, community water systems must distribute, to each customer, an annual water quality report on the water purveyed. This consumer confidence rule requires public water suppliers that serve the same customers throughout the year (community water systems) to provide consumer confidence reports to their customers. These reports are also known as annual water quality reports or drinking water quality reports. These reports are generally publicly available from the water suppliers or through an online data base such as the State Safe Drinking Water Information System (https://sdwis.waterboards.ca.gov/PDWW/). Generally speaking, California Domestic Water Quality and Monitoring Regulations do not require all chemicals and contaminants to be tested at public supply wells, rather the intent is to test for chemicals and contaminants that are known or likely to occur in the area. Therefore, not all chemicals of concern will be tested in every well and the monitoring frequency for individual chemicals can vary from once every 3 to 6 years to once every 3 to 12 months depending on well history and well location relative to known groundwater impacts. Groundwater monitoring results from the community and non-community wells within the NFKGSA monitoring network will be reviewed annually and the analytical results for the chemicals of concern specific to the individual well locations will be compared against the respective MCL values for the chemicals of concern. The State MCL values for the chemicals of concern that have been identified in the Section 3.2 will be relied upon heavily as the criteria for defining undesirable results when related to groundwater pumping policies and recharge projects. Chemical of concern within the NFKGSA along with their respective MCL values are listed below in Table 4-8 .

Undesirable results determinations will be based on the aggregated effect of: 1) the degradation of water quality to excess of MCLs (i.e. California potable water standards) where concentrations of chemicals of concern were recent historically below MCLs; and 2) for wells that have had recent historic concentrations of Chemicals of Concern above MCLs, the degradation of water quality to a level in excess of 20% greater than the recent historically high concentration of the Chemical of Concern in the well.~~a significant increase in groundwater degradation where concentrations of chemicals of concern were historically above MCLs in recent periods.~~ The occurrence of an undesirable result will be defined as 15% of the monitoring indicator wells having reached either of these two criteria for two consecutive samples when shown to be altered by groundwater pumping or recharge activities.

Table 4-8 Chemicals of Concern and California MCLs

Chemical of Concern	California Primary MCL	California Secondary MCL	Lifetime Health Advisory Level
Arsenic	10 µg/L	-	-
Chromium (Total)	50 µg/L	-	-
Fluoride	2,000 µg/L	-	-
Gross Alpha	15 pCi/L	-	
Lead *	15 µg/L	-	-
Nitrate	10 mg/L (as N)	-	-
1,2,3-Trichloropropane	0.005 µg/L	-	-
Uranium	20 pCi/L		
Aluminum	1,000 µg/L	200 µg/L	-
Iron	-	300 µg/L	-
Manganese	-	50 µg/L	-
Total Dissolved Solids	-	500 mg/L to 1,000 mg/L	

* The USEPA regulates the concentration of lead in drinking water by an Action Level, which is similar to an MCL but requires additional testing at customer services.

4.5.1.2 Causes of Groundwater Conditions that Could Lead to Undesirable Results

Regulation Requirements:

> §354.26 (b) The description of undesirable results shall include the following:
> (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

There are several potential causes of groundwater quality degradation that could lead to undesirable results. However, some of these causes are not the GSA's responsibility and include, but are not limited to:

- The accumulated effects of fertilizer nutrient application and other farming practices leading to accumulation of chemicals of concern in groundwater, such as nitrates;
- One-time releases from sources of chemical contamination such as from fuel storage tanks or cleaning solvent tanks leading to petroleum hydrocarbon, MTBE, or solvent contaminant plumes; and
- The accumulated effects of regulated and unregulated waste discharge streams from wastewater treatment facilities, septic systems, industry, and food processors.

The following are causes of groundwater quality degradation that could lead to undesirable results which fall under the GSA's management responsibility ~~include~~:

- Declining groundwater levels can cause pumped groundwater to have higher concentrations of some naturally occurring chemicals which may be either health concerns or aesthetic concerns, such as arsenic or uranium. An article by Smith, Knight, and Fendorf (2018) indicates there may be a correlation from overpumping and dewatering of aquitards as a potential source of elevated arsenic concentrations;
- Groundwater pumping mobilizing groundwater contaminant plumes; and

- Recharge projects that are improperly located, causing downward movement of contaminants in the vadose zone or mobilize groundwater contaminant plumes.

Potential effects of reaching undesirable results on beneficial users will vary by location and which constituent has been exceeded. Concerns for agricultural versus municipal or domestic beneficial users vary in concentrations and constituents. Impacts of significantly degraded water quality could include decreased crop productivity, cost of deepening wells, and expensive water treatment for municipal beneficial users.

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

The State MCL values for the chemicals of concern that have been identified in the Section 3.2 will be relied upon primarily as the criteria for defining undesirable results. Groundwater quality data from selected public supply wells within the GSA will be reviewed annually and compared against MCLs or historic groundwater quality data.

Undesirable results determinations will be based on the aggerated effect of: 1) the degradation of water quality to excess of MCLs (i.e. California potable water standards) where concentrations of chemicals of concern were historically below MCLs; and 2) for wells that have had recent historic concentrations of Chemicals of Concern above MCLs, the degradation of water quality to a level in excess of 20% greater than the recent historically high concentration of the Chemical of Concern in the well.~~a significant increase in groundwater degradation where concentrations of chemicals of concern were recent historically above MCLs.~~ The occurrence of an undesirable result will be defined as 15% of the representative monitoring wells having reached either of these two criteria for two consecutive years when shown to be altered by groundwater pumping or recharge activities.

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

Irrigation water quality is a critical factor in crop production and can be complicated as not all crops have the same sensitivity to water quality. Groundwater with high Total Dissolved Solid (TDS) or EC concentrations or general mineral concentrations can cause issues for plants and soil health, leading to crop yield impacts. High salinity content in irrigation water can detract from the amount of water and nutrient uptake in plant roots and leads to a crusty top layer in soil that makes sprouting difficult. In addition, Boron is an essential nutrient for plant growth, however, elevated concentrations of this element can cause crop boron toxicity leading to lower crop yields. The severity of impact to agriculture is plant type dependent. Some orchard trees such as almonds have been found to be quite sensitive to boron, while others remain indifferent. Water quality as it relates to agricultural production within the NFKGSA is generally such that groundwater degradation leading to impacts to crop is not considered significant but will be monitored nonetheless.

Under California law, agencies that provide drinking water are required to routinely sample groundwater from their wells and compare the results to potable water standards (MCL), as appropriate for the individual chemicals. These results are reported by the water purveyors in Consumer Confidence Reports and are publicly available. Degraded groundwater quality can make drinking water treatment more difficult and expensive. However, the three municipal agencies within the NFKGSA have recently drilled new deep wells in order to avoid known water quality issues within the intermediate formation. Therefore, Groundwater quality degradation has potential effects to rural residential drinking water quality.

Residential structures not located within the service areas of the 3 municipal water agencies will typically have private domestic groundwater wells. Such wells are not monitored routinely and groundwater quality from those wells is unknown unless the landowner has initiated testing and shared the data. Degraded water quality could potentially lead to rural residential use of groundwater not meeting potable water standards or the need for installation of new domestic wells to deeper depths to reach groundwater of better quality.

4.5.1.3 Evaluation of Multiple Minimum Thresholds

Regulation Requirements:

> §354.26 (c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

It is not practical for a single exceedance to lead to an undesirable result for the entire GSA; therefore an undesirable result determination will be based on multiple monitoring locations within the GSA over consecutive years when related to groundwater pumping policies and recharge projects.

4.5.2 Minimum Thresholds

Regulation Requirements:

> §354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

Groundwater quality in the NFKGSA is generally suited for irrigation and domestic use, although groundwater issues for drinking water exist in some areas within the NFKGSA. The minimum thresholds have been set consistent with State and local water quality standards to be protective of water uses and users and are intended to be protective of human health (Title 22 of the CCR).

Minimum Threshold values have been established by two different methods, as follows:

- Numeric values for MCLs (i.e. California potable water standards) as identified in Table 4-8, where concentrations of chemicals of concern were recently below MCLs; or
- For wells that have had recent concentrations of Chemicals of Concern above MCLs, the degradation of water quality to a level in excess of 20% greater than the recent historically high concentration of the Chemical of Concern in the well. The 20% increase was selected as a criterion to provide a reasonable balance between natural fluctuations and uncertainty in the data with the desire to minimize further degradation.

~~The publicly available groundwater quality data from the selected representative wells will be obtained annually and either compared against MCL values, if historical data has indicated chemicals of concern were initially below MCLs, or evaluated for groundwater quality trends with respect to the chemicals of concern if historical data has indicated chemicals of concern were initially above MCLs. MCLs for the chemicals of concern are listed in Table 4-8. If water quality sampling indicates an MCL exceedance or concerning trends, then an evaluation will need to occur to determine if the exceedance is a result of groundwater management activities.~~

Based on available data, Table 4-9 shows the historical maximum concentration of Chemicals of Concern and where MCL exceedances have occurred. Minimum Threshold numeric values in these instances will be set at a 20% increase to the indicated table values. Note that there are several wells within the monitoring network for which groundwater quality data was not available at the time of writing. This represents a data gap, however the NFKGSA will strive to remedy this data gap over the first years of GSP implementation. Water quality degradation will be evaluated against the appropriate standards as more data becomes available in these instances. If water quality sampling indicates an MT exceedance, then an evaluation will need to occur to determine if the exceedance is a result of groundwater management activities.

Table 4-9 Chemicals of Concern with Historic Exceedances of MCLs (2015 to 2021)

Well ID	Well Type	Latitude	Longitude	Map Label (Figure 5-3)	Arsenic (µg/L)	Chromium - Total (µg/L)	Fluoride (µg/L)	Gross Alpha (pCi/L)	Lead (µg/L)	Nitrate as N (mg/L)	1,2,3-Trichloropropane (µg/L)	Uranium (pCi/L)	Aluminum (µg/L)	Iron (mg/L)	Manganese (mg/L)	Total Dissolved Solids (mg/L)
SL205254275-MW-HS	Public Supply	36.53169	-120.097286	1	NA	NA	NA	NA	NA	NA	NA	261 (313)	NA	NA	NA	NA
1000053-001	Public Supply	36.43091	-119.930805	8	21 (25.2)	ND	1700	5.54	9.2	ND	ND	NA	ND	3900 (4680)	0.097	800
1000627-001	Public Supply	36.459661	-119.770622	10	22 (26.4)	ND	380	39.8 (47.8)	ND	21 (25.2)	ND	43 (51.6)	ND	ND	ND	280
1000369-002	Public Supply	36.455473	-119.762943	11	41 (49.2)	ND	940	5.03	ND	11 (13.2)	ND	NA	480	370 (444)	ND	180
1010020-005	Public Supply	36.434	-119.679681	14	ND	ND	ND	NA	ND	0.69	ND	NA	ND	160	ND	100
1000186-001	Public Supply	36.532595	-120.099756	19	7.9	ND	350	ND	ND	ND	ND	NA	150	340 (408)	0.16	530
1010028-005	Public Supply	36.436346	-119.865598	20	NA	NA	NA	NA	NA	ND	ND	NA	NA	NA	NA	NA
1010028-004	Public Supply	36.431568	-119.860623	21	15	ND	1800	1.45	31 (37.2)	ND	ND	NA	120	NA	NA	NA
1600017-002	Public Supply	36.361942	-119.831814	22	24 (28.8)	NA	NA	2.8	NA	ND	NA	NA	NA	NA	NA	NA
1000182-001	Public Supply	36.491179	-119.989206	23	ND	ND	530	ND	ND	0.59	ND	NA	ND	3600 (4320)	0.29	620
1000053-002	Public Supply	36.433522	-119.922874	24	22 (26.4)	ND	1300	7.3	ND	ND	ND	NA	ND	ND	ND	580
1010028-009	Public Supply	36.42395	-119.844838	28	8.7	ND	2500 (3000)	ND	ND	ND	ND	NA	ND	ND	ND	680
1010020-003	Public Supply	36.435384	-119.690523	29	ND	ND	ND	17.1 (20.5)	ND	4.2	ND	19	ND	610 (732)	ND	230
1000445-001	Public Supply	36.432922	-120.030749	31	ND	ND	ND	38.8 (46.6)	ND	0.82	ND	30 (36)	ND	ND	0.78	4300 (5160)
1010020-004	Public Supply	36.434561	-119.691941	32	ND	ND	ND	NA	ND	1.6	ND	NA	ND	ND	ND	150
1000189-001	Public Supply	36.434055	-119.682899	33	4.2	ND	ND	9.06	ND	1.3	ND	5.3	ND	NA	NA	NA
1000562-001	Dedicated Monitoring	36.49218	-119.789711	34	8.1	ND	140	ND	ND	9.1	0.1	NA	ND	NA	NA	NA
California MCLs					10	50	2,000	15	15	10	0.005	20	1,000	300*	50*	500-1,000*

Notes:
* = California Secondary MCLs
NA = Not analyzed
ND = Not detected
Cells highlighted when max concentration is greater than the MCL. Minimum Threshold numeric values set at a 20% increase to the indicated max concentration value. Minimum Threshold actual values in parenthesis.

Regulation Requirements:

§354.28 (d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Declining water levels can potentially lead to increased concentrations of some chemicals that reside in larger proportions in deeper aquifer zones, such as arsenic or uranium. Conversely rising water levels can also lead to increased concentrations of some chemicals of concern, for example nitrates, that may reside in unsaturated soils at shallower depths. Groundwater levels will not be used as a proxy for water quality due to a lack of clear correlation between groundwater levels and changes in water quality.

Water quality data will be monitored and sampled for analysis according to the monitoring network, as discussed in Section 5. This includes regularly recurring analysis of various water quality constituents depending on the monitoring program the monitoring site is a participant of.

4.5.2.1 Criteria to Define Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be used on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

The criteria to define minimum thresholds will be based on the MCL values of the chemicals of concern discussed in the Groundwater Conditions chapter, Section 3.2 of this GSP. The publicly available groundwater quality data from the selected representative wells will be obtained annually and ~~either~~ compared against MT~~CL~~ values as discussed above.~~, if recent historical data has indicated chemicals of concern were initially below MCLs, or evaluated for groundwater quality trends with respect to the chemicals of concern if recent historical data has indicated chemicals of concern were initially above MCLs.~~ New emerging contaminants of concern and MCLs will be addressed in subsequent GSP updates.

4.5.2.2 Relationships Between Minimum Thresholds and Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

Changes to groundwater quality can be related to significant changes in groundwater levels and groundwater storage sustainability indicators. Declining water levels, which relate directly with a reduction of groundwater storage, can potentially lead to increased concentrations of chemical of concern for those that reside in larger proportions in deeper aquifer zones, such as arsenic or uranium. Conversely, rising water levels, which relate directly with an increase in groundwater storage, can also lead to increased concentrations of some chemicals of concern, for example nitrates, that may reside in unsaturated soils at shallower depths. Groundwater quality cannot be used to predict responses of other sustainability indicators; however, groundwater quality can potentially be affected by changes in groundwater levels and reduction of groundwater storage indicators. Based on this relationship, groundwater quality minimum thresholds should be established separately from other indicators.

4.5.2.3 Minimum Thresholds in Relation to Adjacent Basins

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

Because the water quality issues in NFKGSA are primarily not migratory problems, the minimum threshold for groundwater quality is protective of water uses and users and will prevent causing undesirable results in adjacent basins and will not affect the ability of adjacent basins to achieve sustainability goals.

4.5.2.4 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The minimum thresholds for groundwater quality will be protective of water uses and users from degradation of groundwater quality by known chemicals of concern to concentrations detrimental to human health. The minimum threshold for degraded water quality maintains existing and potential future beneficial uses of land and property interests.

4.5.2.5 Current Standards Relevant to Sustainability Indicator

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

The minimum thresholds for water quality are protective of human health and intended beneficial use and are based around MCLs found in Title 22 of the California Code of Regulations. The intent of SGMA is for the GSAs to be responsible for groundwater aspects related to pumping and recharge efforts only. Other existing agencies and programs are generally responsible for groundwater quality remediation. Minimum thresholds may differ from MCLs in locations where recent historical groundwater quality data indicates that MCLs have already been exceeded.

4.5.2.6 Measurement of Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater monitoring and reporting by community water systems and non-community public supply wells is a requirement of California Code of Regulations (CCR) Title 22. Community and other public supply wells within the NFKGSA area are already being monitored for a wide range of contaminants, including the chemicals of concern, by the water purveyors under Title 22. The publicly available groundwater quality data from selected representative wells will be obtained annually and ~~either~~ compared against MT~~CL~~ values as discussed above.., ~~if recent historical data has indicated chemicals of concern were initially below MCLs, or evaluated for groundwater quality trends with respect to the chemicals of concern utilizing appropriate statistical methods, such as the Mann-Kendall trend test. The Mann-Kendall trend test is a nonparametric test used to identify a trend in a series, even if there is a seasonal component to the series.~~

Selected public supply wells that will form the basis of the representative monitoring network for groundwater quality are shown in Chapter 5. Water quality will be measured in accordance with the measurement protocols described in Chapter 5 – Monitoring Network of this GSP. The selected groundwater quality monitoring network will be evaluated and augmented in subsequent GSP 5-year revisions.

4.5.3 Measurable Objectives

Within the Kings Basin, the measurable objective shall be to maintain water quality at potable water standards, or in other words, below MCLs for the chemicals of concern. In areas where chemical concentrations are initially above MCLs, the measurable objective shall be to maintain stable or improving groundwater quality trends.

4.5.3.1 Description of Measurable Objectives

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

Groundwater within the NFKGSA is generally used beneficially for municipal/domestic consumption or agriculture. Groundwater quality standards are typically higher than those required for agriculture. The minimum threshold for degraded water quality has been set at values that are protective of human health and intended beneficial use and users of groundwater resources (i.e. CCR Title 22).

For wells within the monitoring network (either existing or future wells), where concentrations of the chemicals of concern are historically below MCLs in recent periods, the measurable objective is to maintain water quality at potable water standards, or in other words, below MCLs for the chemicals of concern. In situations where monitoring network wells (either existing or future wells)

have recent historical concentrations above MCLs for contaminants of concern, the measurable objective is for the wells to maintain stable or improving groundwater quality trends in regard to the identified chemicals of concern.

4.5.3.2 Operational Flexibility

Regulation Requirements:

> §354.30 (c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

For wells within the monitoring network (either existing or future wells), where concentrations of the chemicals of concern are historically below MCLs in recent periods, the operational flexibility is the difference between the MCL and recent historic concentration of the chemical of concern. No operation flexibility will be set at this time for situations where monitoring network wells (either existing or future wells) have historical concentrations above MCLs for contaminants of concern.

4.5.3.3 Representative Monitoring

Regulation Requirements:

> §354.30 (d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

Groundwater levels will not be used as a proxy for water quality due to a lack of clear correlation between groundwater levels and changes in water quality.

4.5.3.4 Path to Achieve Measurable Objectives

Regulation Requirements:

> §354.30 (e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

Groundwater pollution characterization and remediation are enforced by local agencies and state level programs. The GSA will only have authority related to groundwater pumping policies and recharge supply projects, however the GSA will review and analyze publicly available routine groundwater monitoring data reported by the community and non-community public supply wells in order to understand how and if groundwater pumping is exacerbating groundwater quality concerns and when and where to enforce pumping restrictions or other mitigation measures should it become necessary. Management of groundwater pumping will occur over the lifetime of the planning and implementation horizon. No interim milestones have been set for the water quality indicator.

If a Minimum Threshold exceedance occurs, a site-specific investigation will be conducted to try to determine if GSA actions have contributed to the groundwater quality degradation. The investigation may include, but will not be limited to the following:

- Verification of groundwater gradient and flow direction in the area in question;
- Changes in the historic cropping record in the area compared against historic groundwater quality data;
- Groundwater quality compared against groundwater level changes in the area;

- Available groundwater pumping records for wells in the area will be reviewed and compared against groundwater quality trends;
- Available groundwater recharge records for recharge sites in the area will be reviewed and compared against groundwater quality data;
- A Phase I Environmental Site Assessment (Phase I ESA) could potentially be performed in order to assess the possibility of degradation resulting form third party activities.

Should investigations indicate GSA actions have contributed to groundwater quality degradation, then management actions described in Chapter 6 will be implemented in the area where the water quality has changed.

~~If an undesirable result occurs with regards to groundwater quality, actions may include:~~

- ~~Increased frequency of monitoring well sampling;~~
- ~~Additional data analysis;~~
- ~~Increased groundwater recharge in the area(s) of concern if that recharge would improve water quality conditions;~~
- ~~Increased use of surface water in the area(s) of concern to reduce groundwater pumping; and~~
- ~~Working collaboratively with state and local groundwater quality protection agencies and programs.~~

4.6 Land Subsidence

As described in Section 3.2.6, land subsidence within the Kings Basin primarily occurs in the western and southern portion of the basin that overlies the Corcoran Clay. The eastern extent of the Corcoran Clay is shown in Figure 3-17. Some pumping below the Corcoran Clay does occur within the Kings subbasin, but a significant amount of the land subsidence within the Kings is believed to be attributable to pumping from below the Corcoran Clay that occurs outside of the Kings Subbasin and is beyond the control of the NFKGSA.

DWR staff has indicated that the intent of SGMA was that land subsidence be avoided or minimized based to the extent within the GSAs control. Once groundwater levels have stabilized within the basin, land subsidence should be minimized. Measurable objectives for land subsidence were set based on this requirement.

4.6.1 Undesirable Results

SGMA defines an ~~An~~ undesirable result for land subsidence ~~would~~ as that which causes ~~be the~~ significant and unreasonable interference with surface land uses. ~~loss of functionality of levees, canals, structures, and other critical infrastructure such as bridges, roads or highways, wells and pumps within the Kings Basin due to land subsidence.~~
~~If land subsidence occurs to significant and unreasonable levels, it will be considered an undesirable result.~~ The terms "significant and unreasonable" are not defined by regulations, rather the conditions leading to this classification are determined by the local GSA, beneficial users, and the basin they are a part of. ~~The process used to develop criteria for determining undesirable results began with discussions with stakeholders and landowners.~~ The primary concern related to interference with surface land uses in the Kings Basin is subsidence reducing the capacity of gravity

flow water conveyance facilities such as canals or river channels. Subsidence within a portion of a river channel or canal could prevent conveyance of flood water in river channels increasing the risk of flooding adjacent land, or the subsidence within sections of an irrigation canal could restrict or prevent delivery of irrigation water to agricultural land.

The GSAs within the basin have defined the Undesirable Result of land subsidence as significant and unreasonable if loss of conveyance capacity of the Kings River or existing irrigation canals has occurred as a result of land subsidence.

~~Land subsidence, as described in detail in Section 3.2.6, is greatest in the western three-quarters of the NFKGSA. Since the North Fork Kings River flows through this area, the river system and related infrastructure will be an important primary focus of future monitoring.~~

4.6.1.1 Criteria to Define Undesirable Results

Regulation Requirements:

> §354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

The process used to develop the criteria for undesirable results began with the review of KRCD, USGS, DWR, NASA INSAR, and USBR land subsidence data, and through discussions with stakeholders and landowners regarding locally observed conditions. ~~The KRCD and NASA INSAR data will be used to monitor land subsidence and check that the annual rate and cumulative subsidence stay less than the minimum threshold criteria. The criteria for an Undesirable Result will be the significant loss of functionality of a structure or a facility to the point that, due to subsidence, the feature cannot be operated as designed requiring either significant retrofitting or replacement~~. The conveyance capacity of the Kings River channel is critical for both the conveyance of flood water and delivery of surface water for irrigation supplies. During flood periods, the conveyance capacity of the Kings River is necessary to route water through portions of the basin without causing flooding of lands adjacent to the river. During the irrigation season, the conveyance of surface water for irrigation from the Kings River and through irrigation canals is needed to maintain agricultural practices within the basin. These conveyance facilities are gravity flow systems, relying on open channel hydraulic pressure to convey water through the existing channels. Subsidence that lowers the canal or channel at the headworks or within a section of channel may prevents the channel from maintaining the water levels needed to convey the needed capacity of the channel, thereby restricting deliveries unless mitigated. Defining the Undesirable Result was based on the criteria to maintain adequate channel capacity within the river system and irrigation canals to continue historic surface water deliveries.

~~Based on the~~From discussions with stakeholders, local agencies and landowners, there have been reports of irrigation canals and portions of the river requiring fill material to raise the banks to maintain needed conveyance~~original design~~ capacity and freeboard (the distance between the water surface and the top of bank). Although in most situations the canal or channel banks can be raised as needed to restore conveyance capacity, the GSAs have still defined the loss of conveyance capacity as the undesirable result. ~~However, no known significant and unreasonable undesirable results have been reported within NFKGSA.~~

4.6.1.2 Causes of Groundwater Conditions That Could Lead to Undesirable Results

Regulation Requirements:

> §354.26 (b) The description of undesirable results shall include the following:
> (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

As described in 3.2.6, there are five types of subsidence in California; but only deep subsidence from declining groundwater levels is found in NFKGSA. Excessive pumping below the Corcoran Clay that occurs within the basin and outside the basin could cause the Undesirable Result of subsiding portions of a gravity flow channel or canal that reduces the conveyance capacity of that facility.

Excessive groundwater pumping can contribute to deep subsidence across a broad area, resulting in aquifer compaction, loss of storage capacity, and adverse effects to surface features, such as bridges, canals, flood control systems, and water supply pipelines that rely on gravity flow.

SGMA only applies to land subsidence from groundwater pumping. There are two general types of subsidence: elastic and inelastic. Elastic subsidence is recoverable if water levels later rise while inelastic subsidence is permanent. Elastic subsidence generally occurs in the coarse- grained portions of the aquifer where the materials compact. Although there are several causes of inelastic land subsidence, the compression of clay as a result of groundwater extraction from confined aquifers is the cause of the vast majority of subsidence documented in the San Joaquin Valley. This results in compaction of fine-grained confining beds (clays) above and within the confined aquifer system as water is removed from pores between the sediment grains. Once water is squeezed out of the compressible clay, the clay compacts resulting in the lowering of the overlying land surface. The compressed clays, in which the clay particles have been re-arranged more compactly, can no longer re-absorb water, thus the subsidence in these areas cannot be reversed. This process is known as aquifer system compaction.

In the Central Valley, aquifer system compaction primarily occurs within the Corcoran Clay layer. Though the eastern extent of the Corcoran Clay layer is debated by scholars and local well drillers, the Corcoran Clay lies beneath at least two-thirds, if not more, of the NFKGSA. Since the Corcoran Clay is a confining layer, land subsidence would occur when too much water is pumped from the confined aquifer below the Corcoran Clay. In a~~A~~reas prone to subsidence, soil textures, clay mineralogy, and other geologic and geochemical properties were intensely studied by the USGS in a series of Professional Papers in the 1960s, 1970s and 1980s. Regionally, the areas prone to subsidence were underlain by deposits where the clayey deposits are dominated by the clay mineral montmorillonite (USGS 497-C, Meade 1967). Most of the permanent subsidence in the San Joaquin Valley has historically been correlated to overdraft in the confined aquifer below the Corcoran Clay. However, with increased reliance on groundwater to meet demands, land subsidence is currently occurring in some isolated areas outside of the Corcoran clay. However, in these areas, subsidence is typically lower than ~~typically lower than~~ in areas underlain by the Corcoran Clay.

Regulation Requirements:

> §354.26 (b) The description of undesirable results shall include the following:
> (2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

The criteria to define when and where the effects of subsidence ~~the~~cause an Undesirable Result is based on the combination of exceedances of the minimum thresholds. ~~related to land subsidence is the significant loss of functionality of a structure or facility to the point that the feature cannot be operated as designed, requiring either significant retrofitting or replacement.~~ The proposed subsidence monitoring network will measure the annual rate and cumulative subsidence to verify those variables have not exceeded the minimum threshold. The exceedance of the minimum threshold ~~at just one monitoring site~~within a 36 square-mile~~s~~ area (roughly a Township) is significant based on how the basin has determined the minimum thresholds described later in this section. The exceedance of the annual rate or cumulative subsidence minimum threshold would potentially be significant to the stakeholders in the proximity of the subsidence area, and potentially downstream ~~river~~. A~~ny~~ minimum threshold exceedance would warrant further evaluation by the GSA and potential action.

Regulation Requirements:

§354.26 (b) The description of undesirable results shall include the following:
(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

The potential effects of land subsidence include those on manmade structures and those on natural features. In the ~~San Joaquin Valley~~GSA, the main ~~problems~~ concerns related to land subsidence are the impacts to gravity driven water conveyance structures such as canals or river channels. ~~, where even minor changes in gradients can cause reductions in the designed capacity of the feature. Other facilities sensitive to subsidence include roads, railways, bridges, pipelines, buildings, levees, and wells also can occur.~~

~~While more focus has been placed on the highly visible infrastructure damage from subsidence, which generally can be repaired, compaction of the aquifer system may permanently decrease its capacity to store water. Most compaction that occurs as a result of historically low groundwater levels is irreversible.~~

Within the NFKGSA, the primary gravity flow systems are the Kings River and various irrigation canals. ~~t~~The beneficial uses and users could potentially be affected by:

- ~~the F~~flooding caused by overtopping the river levees ~~and various irrigation canals~~ if subsidence lowers a section of channel, ~~. D~~decreasing~~ed~~ ~~channel~~ capacity and~~could also~~ hinder~~ing~~ the ability of the either the North Fork or South Fork Kings River to convey flood flows or irrigation water.
- Reduced conveyance capacity in irrigation canals caused by subsidence in a section of irrigation canal preventing delivery of surface water needed for crop irrigation or groundwater recharge to ~~D~~downstream water users. ~~and neighboring GSAs could also be impacted if they were anticipating capture and recharge of said flows.~~
- Roadways or bridges needing to be reconstructed to accommodate the raising of canal/channel banks that have been impacted~~lowered~~ by subsidence. These improvements can require additional road right of way requirements to raise channel crossings as well as transportation impacts during construction.
- Gravity flow cast-in-place pipelines needing to be repaired if cracking occurs because of subsidence.

~~Beneficial users could also be impacted by failure of the critical transportation infrastructure in the area including the three major highways, bridges, roads, and railways.~~

An additional impact of subsidence to beneficial uses is that compaction of the aquifer system may permanently decrease its capacity to store water. Most compaction that occurs as a result of historically low groundwater levels is irreversible.

4.6.1.3 Evaluation of Multiple Minimum Thresholds

Regulation Requirements:

§354.26 (c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

Monitoring for land subsidence will be done by evaluating data released from ~~KRCD and~~ NASA InSAR and, as a cross-check, the GSA gathers subsidence data from sites historically monitored by KRCD.~~,~~ The Kings River levees are monitored annually for subsidence. T~~t~~herefore minimum thresholds ~~will~~ have been set GSA-wide based on loss of conveyance capacity~~using the historical data across the Kings Subbasin~~ and will be evaluated by mapping the subsidence over the area. Monitoring sites for these programs extend beyond the Kings Subbasin boundaries which is adequate for covering the GSA's using contouring and interpolation techniques. The determination that undesirable results are occurring shall depend upon measurements from multiple monitoring sites from within ~~KRCD~~ each GSA and InSAR mapping over the entire Kings Subbasin. The exceedance of the minimum threshold ~~at just one subsidence monitoring location is~~over a 36 square-mile area may be considered significant based on how the basin has determined the minimum thresholds.

4.6.2 Minimum Thresholds

Regulation Requirements:

§354.28 (a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

Even though some subsidence has occurred, NFKGSA is not currently experiencing any known significant subsidence ~~related~~ issues along ~~major highways or levee infrastructure~~ river channel or canal facilities. ~~that~~ Any subsidence impacts on the canal or river system have been easily mitigated by raising a portion of the canal or levee bank to restore~~reduced~~ overall conveyance capacity.~~even though some subsidence has occurred~~. While there are known locations ~~of~~ where some capacity restriction has occurred~~s issues~~ because of land subsidence, as described in 3.2.6~~3.6.2~~, there has been some minimal land subsidence in other ~~smaller~~ portions of the NFKGSA without any known impact. The minimum threshold has been set based on ~~historic subsidence trends~~the amount of subsidence critical river channel and canal infrastructure can typically tolerate. The most vulnerable facilities in the GSA are irrigation canals due to their reliance on gravity flow as well as pipelines that may be subject to cracking. Irrigation canals in the GSA generally have about 3 feet of freeboard, which is the distance from the top of water surface to top of canal bank. Freeboard allows for operational flexibility so the water does not overtop the canal or channel. Hence, subsidence causing an elevation change of up to three feet difference between the head of a canal and the canal terminus can be tolerated before there is a loss of operational capacity. However, uniform

subsidence along a canal reach would not impact the canal gradient or freeboard, so the spatial distribution of subsidence will be important in determining how specific facilities are impacted. The minimum threshold was set at 3 feet of subsidence. The Kings River Levees have more than three feet of freeboard and can therefore tolerate this amount of subsidence before capacity is impacted.

Although an exact correlation between the groundwater level minimum thresholds and the anticipated amount of subsidence cannot be made, it is important to understand that subsidence will likely continue to occur during the planning period (2020-2040) until water levels are stabilized at the water level measurable objective in the Kings Subbasin as well as neighboring subbasins. It is anticipated that some subsidence would continue when hydrologic conditions cause the operational flexibility to be used and water levels drop below the Measurable Objective (potentially all the way to the Minimum Threshold level during a 5-year drought), but subsidence would stop after the water level reaches its lowest point and then is raised back up to the sustainable Measurable Objective level. Once water levels are stabilized at the measurable objective level then the minimum threshold for subsidence allows for water levels to drop to the minimum threshold level.

~~This historical subsidence has not resulted in discernable damage being reported within the NFKGSA, so basing the minimum thresholds on subsidence rates experienced during the worst drought period of record seems conservative until groundwater levels are stabilized and subsidence from groundwater overpumping has stopped.~~

Regulation Requirements:

§354.28 (d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

The water level SMCs are for the unconfined aquifer and confined aquifer groundwater levels would be needed to represent land subsidence. At this time, groundwater levels will not be used as a proxy for land subsidence due to a lack of quality data on the confined aquifer potentiometric surface. To monitor land subsidence based on water level, the well would have to be perforated below the Corcoran clay, and not be composite (i.e. constructed across multiple aquifer zones). There are limited wells within NFKGSA that are drilled below the Corcoran Clay with well construction information that are not composite wells. ~~However, the NFKGSA may reevaluate this in the future if improved monitoring efforts and correlative data becomes available.~~ There are few wells that only tap the confined aquifer, and of those that do the GSA does not have long-term water level data. The GSA will eventually add more wells to the representative monitoring well network to include more confined aquifer wells.

The groundwater level and pumping from the confined aquifer are considered a data gap and the project to fill those data gaps are included in this GSP as described in Section 6.3. The data gap project will include estimating groundwater pumping from the confined aquifer and identifying more confined aquifer wells to be able to develop a potentiometric surface. The data gap study is a high priority and will be commenced as soon as possible.

4.6.2.1 Criteria to Define Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following: (1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.
§354.28 (c) Minimum thresholds for each sustainability indicator shall be defined as follows: (5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following: (A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including and explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects. (B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

~~The Minimum Threshold for land subsidence are shown in Table 4-9 below as an annual land subsidence rate and a maximum cumulative land subsidence amount.~~

~~Table 4-9 Minimum Threshold for Land Subsidence~~

~~Minimum Threshold Parameter~~	~~Minimum Threshold Quantity~~
~~Annual Land Subsidence Rate~~	~~12.5~~1.2 ~~inches/year~~
~~Maximum Cumulative Land Subsidence~~	~~100~~ 24 ~~inches over 20 years~~

Most subsidence in the San Joaquin Valley is over the axial trough of the Valley, in an area west and encroaching into the south and west sides of the Kings Subbasin. Refer to Section 3.2.6 of the Basin Setting for more information on land subsidence conditions. Areas prone to subsidence, soil textures, clay mineralogy, and other geologic and geochemical properties were intensely studied by the USGS in a series of Professional Papers in the 1960s, 1970s and 1980s. Regionally, the areas prone to subsidence were underlain by deposits where the clayey deposits are dominated by the clay mineral montmorillonite (USGS 497-C, Meade 1967). The historic subsidence map, Figure 3-47 and the recent subsidence map, Figure 3-49, both show that generally subsidence increases where groundwater is likely increasingly confined to the south and west, and there is likely a higher percentage of montmorillonite in the finer-grained sediments near the axis of the valley. The maps and summary table showing historic subsidence within the GSA that were considered~~used~~ in establishing the minimum threshold for land subsidence are included in this section. Error! Reference source not found. Table 4-10 shows the summary of total historical land subsidence in NFKGSA as estimated by different agencies over various time frames and Error! Reference source not found. Table 4-11 shows the summary of the historical land subsidence rates. The tables include a minimum and maximum value for each map to show the variation of land subsidence in the NFKGSA.

~~The Minimum Threshold for annual land subsidence rate has been established as 12.5 inches/year with a maximum cumulative land subsidence of 100 inches over 20 years. The maximum historical land subsidence rate in NFKGSA was about 10 inches/year as measured by KRCD from 2013-2016, Table 4-11. With this historical rate, local stakeholders, landowners and water agencies have not observed any undesirable results from the subsidence. The historical rate of 10 inches/year is used for the Measurable Objective in NFKGSA. The minimum threshold is 25% more than this number to allow for operational flexibility during periods of drought. Since there have been no undesirable results with the historical rate of subsidence, it is anticipated that the minimum threshold will not cause undesirable results.~~ The criteria for cumulative subsidence was based~~amount~~

~~of land subsidence was determined by reviewing the 2013-2016 KRCD map Figure 3-51~~ on the amount of subsidence that could be tolerated for critical infrastructure. Irrigation canals are considered the most vulnerable infrastructure due to their reliance on gravity flow; they they can tolerate up to 3 feet of subsidence based on the typical amount of freeboard found in most canals. Significant and unreasonable conditions would occur if the total freeboard was lost due to subsidence, causing canal overtopping and loss of capacity. It should be noted that 3 feet of subsidence in the GSA would not necessarily cause an undesirable result, since the subsidence would need to cause a difference of 3 feet along the canal reach (i.e. 3 feet of subsidence at the head of the canal and no subsidence at the canal terminus). The spatial distribution of subsidence could cause the impact to the freeboard to range anywhere from zero to three feet. Uniform subsidence along a canal reach would not necessarily cause a loss of any capacity or freeboard. However, three feet of subsidence is the minimum amount that could cause significant issues. To address subsidence before reaching the Minimum Threshold, subsidence of one feet within a 36 square mile area in the GSA would trigger the following actions:

1. Capacity analysis to evaluate the impact of subsidence on critical infrastructure. If no capacity issues are identified, then there is no undesirable result.
2. If there is a capacity issue, then the facility will be mitigated through modifications and retrofits.
3. Investigate what is causing the land subsidence, and whether actions to decrease or eliminate subsidence are within the GSAs control.
4. If the facility cannot be restored to its original functions, then significant actions may be needed, such as reductions in pumping or importation of additional surface water supplies, to minimize further subsidence.

Minimum threshold exceedances may occur due to subsidence that originates outside of the GSA. The minimum threshold is set based on what the GSAs believe they can directly control. If subsidence appears to be encroaching into NFKGSA from other regions as shown by InSAR data, then neighboring GSAs will be contacted to coordinate studies that would need to be performed to evaluate the sources of subsidence in the NFKGSA and in the neighboring GSAs, and to coordinate mitigation efforts.

~~This shows the minimum subsidence in NFKGSA over a period of 3 years was around 1.0 feet. The 1.0 feet of land subsidence over 3 years has an annual rate of 0.33 feet/year, or 4 inches/year. The annual rate of 4 inches/year was used to estimate the amount of subsidence that would occur over 20 years. The estimate of land subsidence over 20 years is 80 inches. The minimum threshold is 25% more than this number to allow for operational flexibility during periods of drought.~~

Table 4-8 Historical Total Land Subsidence in NFKGSA

Total Subsidence in NFKGSA				
Monitoring Agency	Date Range			
	Start	End	Min (in)	Max (in)
USGS	1926	1972	-12	-96
DWR	1949	2005	0	-150
USBR	2011	2016	-1.8	-5.4
KRCD	2013	2016	-12	-30
NASA	2015	2017	-1	-15

Table 4-9 Historical Land Subsidence Rate in NFKGSA

Subsidence Rate in NFKGSA				
Monitoring Agency	Date Range			
	Start	End	Min (in/yr)	Max (in/yr)
USGS	1926	1972	-0.3	-2.1
DWR	1949	2005	0	-2.7
USBR	2011	2016	-0.4	-1.1
KRCD	2013	2016	-4	-10
NASA	2015	2017	-0.5	-7.5

4.6.2.2 Relationships Between Minimum Thresholds and Sustainability Indicators

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(2) The relationship between the minimum thresholds for each sustainability indictor, including and explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The following provides an explanation of the relationship between the subsidence minimum thresholds and the other sustainability indicators and how the GSA determined that the minimum thresholds will avoid undesirable results for each Indicator:

- Groundwater Levels. Land subsidence does not impact water levels, rather the water levels impact land subsidence. Land subsidence occurs due to a decline in water levels from confined groundwater pumping. It is assumed that the neighboring GSA's will reduce pumping to some extent from the confined aquifer to become sustainable. The reduction in confined groundwater pumping would lead to water levels stabilizing because of the water level sustainable management criteria, that would lead to land subsidence stabilizing. Although an exact correlation between the groundwater level minimum thresholds and the anticipated amount of subsidence cannot be made, it is important to understand that subsidence will likely continue to occur during the planning period (2020-2040) until water levels are stabilized at the water level measurable objective. Once water levels are stabilized at the measurable objective level then the minimum threshold for subsidence allows for water levels to drop to the minimum threshold level.
- Groundwater Storage. Land subsidence impacts storage change when there is inelastic land subsidence. Once inelastic land subsidence occurs, the loss in storage cannot be reversed.
- Sea Water Intrusion. This indicator is not applicable to this basin.
- Groundwater Quality. Research conducted by Stanford University and Community Water Center supports the premise that arsenic can reside within pore water of clay strata within aquifers and is released due to overpumping. Though historic groundwater pumping shows no link to current groundwater arsenic concentrations, there is a potential for land subsidence to be related to water quality. Further investigation and research are required to know the vertical locations/extent of subsidence, the presence of arsenic within clay pores, and potential impacts to surrounding aquifer water quality.
- Interconnected Surface Water. Land subsidence is not directly related.

4.6.2.3 Minimum Thresholds in Relation to Adjacent Basins

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

The minimum thresholds have been selected to avoid causing undesirable results in adjacent basins. The minimum thresholds do not exceed historical subsidence observed in the Kings Basin. It is anticipated that as water levels stabilize in NFKGSA, so will land subsidence. Furthermore, historical subsidence in NFKGSA has been less than in adjacent areas in terms of magnitude, especially to the south and west, so it is reasonably assumed that NFKGSA will not cause detrimental land subsidence in adjacent areas.

Though NFKGSA experienced high levels of subsidence during the recent drought, undesirable results were not reported. Figure 3-49 from NASA InSAR data shows that areas of greater subsidence are located outside of NFKGSA to the south and west where the Corcoran clay layer is pervasive and confined pumping occurs. NFKGSA will continue to monitor the subsidence within the GSA and along the borders to determine if and where subsidence is spreading and whether the subsidence is caused from confined aquifer pumping outside of the GSA. NFKGSA cannot control land subsidence that originates outside of GSA boundaries and outside the Basin boundaries. When subsidence results from confined aquifer pumping outside the GSA and extends into the GSA, NFKGSA will coordinate with its neighboring GSAs to address the subsidence issue.

4.6.2.4 Impact of Minimum Thresholds on Beneficial Uses and Users

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Within the NFKGSA, the beneficial uses and users could potentially be affected by land subsidence that causes overtopping of~~the flooding over~~ the river levees or loss of conveyance capacity to delivery surface water through~~and~~ various irrigation canals for crop irrigation or groundwater recharge. Decreased channel capacity could also hinder the ability of the North Fork Kings River to convey flood flows. Downstream water users and neighboring GSAs could also be impacted if they were anticipating capture and recharge of said flows. ~~Beneficial users could also be impacted by failure of the critical transportation infrastructure in the area including the three major highways, bridges, roads, and railways.~~

4.6.2.5 Current Standards Relevant to Sustainability Indicator

Regulation Requirements:

> §354.28 (b) The description of minimum thresholds shall include the following:
> (5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

There are currently no standards for land subsidence. If state, federal, or local agencies implement a land subsidence standard, then it will be reviewed and considered in the GSP five-year update. If the minimum threshold differs from the regulatory standard, the nature and basis for the difference will be explained.

4.6.2.6 Measurement of Minimum Thresholds

Regulation Requirements:

§354.28 (b) The description of minimum thresholds shall include the following:
(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Measurement of land subsidence data within the basin is taken by the USBR, SJRRP, KRCD, and NASA. The monitoring density is considered of adequate density and frequency to measure annual subsidence. Subsidence measurements will be made in accordance with the subsidence measurement protocols described in Chapter 5 – Monitoring Network of this GSP.

4.6.3 Measurable Objectives

4.6.3.1 Description of Measurable Objectives

Regulation Requirements:

§354.30 (a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

DWR staff has indicated that the intent of SGMA was that land subsidence be avoided or minimized based to the extent within the GSAs control. Once groundwater levels have stabilized within the basin, land subsidence should be minimized as long as water levels have also stabilized in neighboring basins. Measurable objectives for land subsidence were set based ~~on historical rateswater levels stabilizing and minimizing impacts to critical infrastructure~~in accordance with this requirement. ~~The measurable objective land subsidence rate does not exceed the maximum historical land subsidence rate.~~ It is assumed that land subsidence would stabilize as the water levels stabilize as part of the water level measurable objectives and subsidence would stop after the water level reaches its lowest point and then is raised back up to the sustainable Measurable Objective level.

Measurable Objective Parameter	Measurable Objective Quantity
Annual Land Subsidence Rate	~~10~~ 1 inch~~es~~/year

The Measurable Objective for annual land subsidence once water levels are stabilized will be a rate of 1 inch/year, to allow for the error of the InSAR data. ~~The Measurable Objective for annual land subsidence rate will be 10 inches/year. The annual rate of land subsidence was determined by reviewing the 2013-2016 KRCD map, Figure 3-51 in Chapter 3. This shows the maximum subsidence in NFKGSA over a period of 3 years was 2.5 feet. The 2.5 feet of land subsidence over 3 years has an annual rate of 0.83 feet/year, or 10 inches/year.~~

~~The Measurable Objective annual land subsidence rate matches the maximum historical land subsidence rate in NFKGSA of about 2.5 feet/year as measured by KRCD from 2013-2016, Figure 3-51 in Chapter 3, which has not yielded any significant and undesirable results in the GSA.~~

~~Measurable Objective Parameter~~	~~Measurable Objective Quantity~~

~~Maximum Cumulative Land Subsidence~~	~~80 inches over 20 years~~

The sustainability goal for the basin with 20 years of plan implementation is to eliminate land subsidence that is caused by actions within the GSA's control. Though the measurable objective during the implementation may be exceeded due to the error in the InSAR data and water levels still stabilizing, the goal is to have no subsidence once the basin and neighboring basins reach sustainability in 2040. Even after water levels have stabilized there is the potential for residual subsidence. Residual subsidence, also called delayed subsidence, occurs when the land surface continues to decline for a period even after groundwater levels have been stabilized. This phenomenon likely occurs due to the delayed propagation of the piezometric decline in the fine-grained layers and viscous deformations typical of fine-grained materials. Also, in dry years when groundwater levels decline below the groundwater level measurable objective, it is anticipated there will be some land subsidence in areas with confined aquifer pumping that occurs with continued groundwater level declines. It is believed that once groundwater levels have declined to a certain level and rise back up, there will not be additional subsidence that occurs.
~~The Measurable Objective for maximum cumulative land subsidence will be 80 inches over 20 years. The cumulative amount of land subsidence was determined by reviewing the 2013-2016 KRCD map, Figure 3-51 in Section 3. This shows the minimum subsidence in NFKGSA over a period of 3 years was around 1.0 feet. The 1.0 feet of land subsidence over 3 years has an annual rate of 0.33 feet/year, or 4 inches/year. The annual rate of 4 inches/year was used to estimate the amount of subsidence that would occur over 20 years. The estimate of land subsidence over 20 years is 80 inches.~~

4.6.3.2 Operational Flexibility

Regulation Requirements:

> §354.30 (c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

The operational flexibility is the difference between the measurable objective and minimum threshold. ~~The minimum threshold is 25% more than the measurable objective to allow for operational flexibility during periods of drought.~~ For NFKGSA, the operational flexibility is ~~2.5 inches/year or 20~~ 36 inches of cumulative subsidence.

4.6.3.3 Representative Monitoring

Regulation Requirements:

> §354.30 (d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

The water level SMCs are for the unconfined aquifer and confined aquifer groundwater levels would be needed to represent land subsidence. At this time, groundwater levels will not be used as a proxy for land subsidence due to a lack of quality data on the confined aquifer potentiometric surface. To monitor land subsidence based on water level, the well would have to be perforated below the Corcoran clay, and not be composite (i.e. constructed across multiple aquifer zones). There are limited wells within NFKGSA that are drilled below the Corcoran Clay with well construction information that are not composite wells. ~~However, the NFKGSA may reevaluate this in the future if improved monitoring efforts and correlative data becomes available.~~ There are few wells that only

tap the confined aquifer, and of those that do the GSA does not have long-term water level data. The GSA will eventually add more wells to the representative monitoring well network to include more confined aquifer wells.

The groundwater level and pumping from the confined aquifer are considered a data gap and the project to fill those data gaps are included in this GSP as described in Section 6.3. The data gap project will include estimating groundwater pumping from the confined aquifer and identifying more confined aquifer wells to be able to develop a potentiometric surface. The data gap study is a high priority and will be commenced as soon as possible.

4.6.3.4 Path to Achieve Measurable Objectives

Regulation Requirements:

> §354.30 (e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

The interim milestones will be based on the cumulative amount of subsidence observed within a 36 square mile area over five year incremental periods. The interim milestones are 1 feet of subsidence over a 5 year period. ~~Table 4-12 presents values of land subsidence based on the historical rates discussed earlier for each of the interim milestone years. Following the interim objectives, the total subsidence experienced from 2020 to 2040 would be approximately -80 inches.~~
Subsidence of one feet within a 36 square mile area in the GSA over 5 years would trigger the following actions:

1. Capacity analysis to evaluate the impact of subsidence on critical infrastructure. If no capacity issues are identified, then there is no undesirable result.
2. If there is a capacity issue, then the facility will be mitigated through modifications and retrofits.
3. Investigate what is causing the land subsidence, and whether actions to decrease or eliminate subsidence are within the GSAs control.
4. If the facility cannot be restored to its original functions, then significant actions may be needed, such as reductions in pumping or importation of additional surface water supplies, to minimize further subsidence.

If land subsidence exceeds the ~~10-inch/year annual rate or exceeds the interim milestones~~interim milestone, then there will be ~~outreach and education to make the affected areas aware of the land subsidence. There will also be~~ increased monitoring of impacts to infrastructure and coordination with neighboring GSAs who may be causing the NFKGSA undesirable results. If the land subsidence exceeds the Minimum Threshold and causes an undesirable result, then NFKGSA will implement ~~projects and management actions discussed in Section 6.~~actions identified in Section 4.6.2.1.

~~Table 4-12 Land Subsidence Interim milestones~~

~~Year~~	~~Cumulative Subsidence Measurable Objective (inches)~~
~~2020~~	~~0~~
~~2025~~	~~-20~~

~~2030~~	~~-40~~
~~2035~~	~~-60~~
~~2040~~	~~-80~~

4.7 Interconnected Surface Water and Groundwater

Regulation Requirements:

> §354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

Interconnected surface water has been defined in the California Code of Regulations Title 23, Division 2, Chapter 1.5, Subchapter 2 as surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.

An undesirable result would occur if groundwater pumping directly caused significant and unreasonable depletions of surface water. This would require the following: 1) surface water and groundwater are hydraulically connected; 2) groundwater pumping is causing a significant reduction in surface water flows; 3) the surface water depletion is not being mitigated by the GSA or other agencies/river management programs; and 4) third parties are being adversely impacted by the surface water depletion.

Figure 4-3 is a map of the Kings Subbasin, the main waterways, and other features related to interconnected surface water-groundwater. The map shows that the Kings River passes through the southern portion of NFKGSA.

Interconnection Status

Riparian water users are located along much of the Kings River Reach in NFKGSA. No minimum flows are required for these water users, rather they divert water only when it is available. There are also no mandated or minimum environmental flows in the portion of the Kings River that flows through NFKGSA. The Kings River fish flows end about 20 miles upstream of the GSA. As a result, this portion of the river is often dry with water typically only flowing during certain months. In dry years the river may not flow at all within the GSA. Based on the infrequency of flows, it is believed that the surface water and groundwater and not likely to be hydraulically connected.

Data Gap Analysis

Overall, additional information is needed to better define the status of surface water-groundwater connection and the extent of surface water depletions, if any, in the GSA. As a result, the GSA has identified these as data gaps that must be researched before sustainable management criteria can be developed. Chapter 6 includes the description of a project called "Interconnected Surface Water-Groundwater Data Gap Analysis." This is a high priority project that will include the following primary tasks:

1. Determine interconnection status of river reaches in the GSA based on various reports, studies, models and data

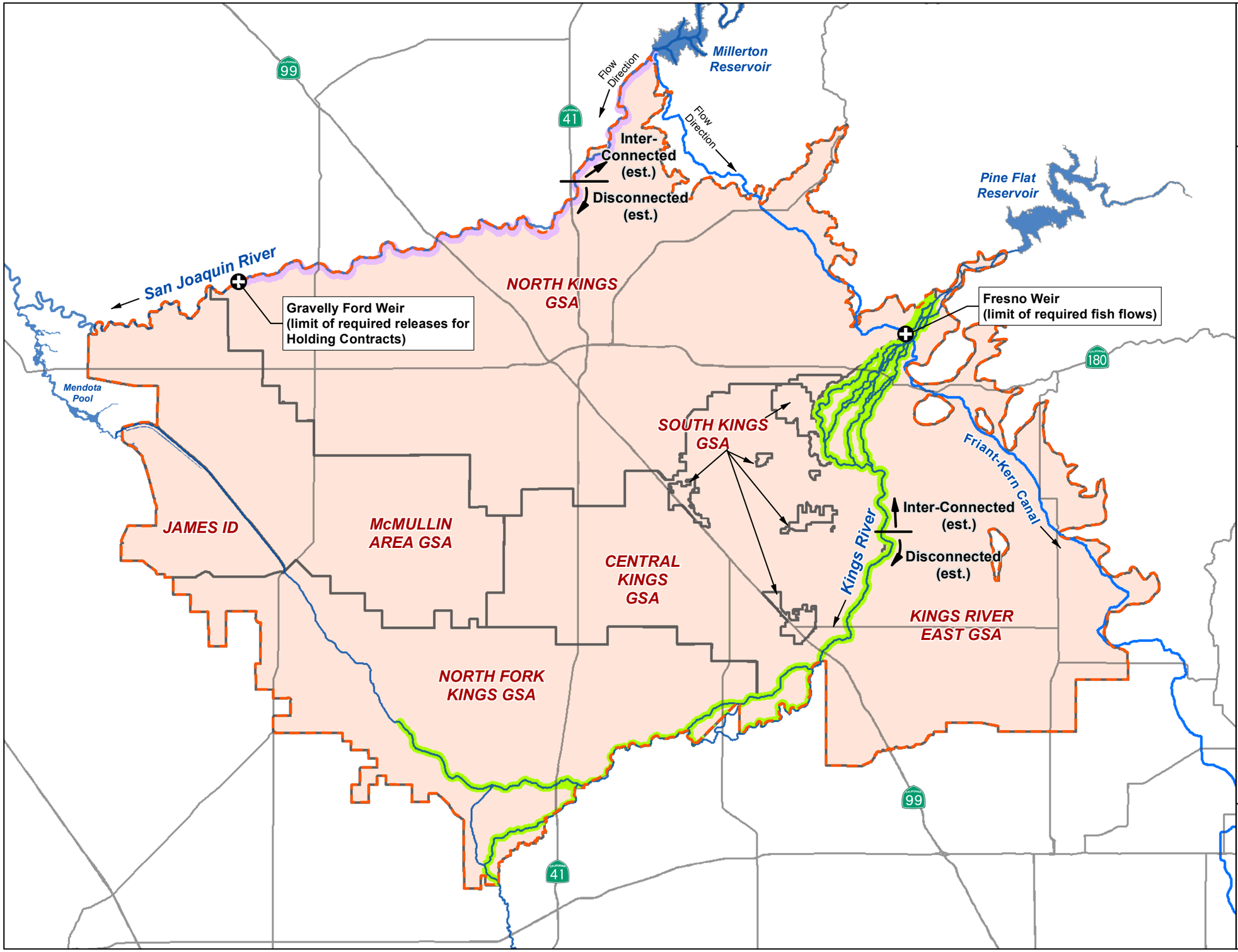
2. Coordinate with water rights holders and river management programs to determine how they impact and mitigate for surface water depletions, and if these efforts reduce or obviate the need for actions by the GSA
3. Evaluate impacts of groundwater pumping on surface water depletion using a model, analytical tool or other calculation method.

The study will provide the information needed to develop sustainable management criteria. Refer to Chapter 6 for more details on the project.

Kings Subbasin

Surface Water Features

Figure 4-3



Legend

- Weir
- Holding Contract Lands
- Riparian Water Right Users
- Kings Subbasin GSAs
- Kings Subbasin (2019)
- Highway

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company

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4/18/2022 : G:\Kings River East GSA-2664\266420002-KREGSA Ongoing Support\400 GIS\Map\kingssub_surface_water.mxd

~~4.7.1 Undesirable Results~~

~~An undesirable result would be the significant and unreasonable reduction of surface waters within the Kings Basin due to groundwater pumping. The major surface waters in the Kings Basin include the Kings River and the San Joaquin River.~~

~~4.7.1.1 Criteria to Define Undesirable Results~~

~~Regulation Requirements:~~

~~§354.26 (a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.~~
~~§354.26 (d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.~~

~~Due to existing river management programs and/or the lack of continuous interconnected surface water within the Kings Basin, undesirable results to surface water related to groundwater pumping are not likely to occur. The Kings River within the NFKGSA is dry during most of the year, and in accordance with SGMA regulations defining ISWs as continuously saturated, there are no ISWs in the NFKGSA. Within the NFKGSA, when the river runs during the coordinated run period, stream flow is measured by KRWA but there is no existing stream flow monitoring for the protection of ISWs since by definition ISWs do not exist in the area.~~

~~4.7.2 Measurable Objectives~~

~~Undesirable results to surface water related to groundwater pumping in the Kings Basin are not likely to occur and criteria, including measurable objectives has therefore not been set for the Kings Basin under regulation §354.26 (d).~~

4.8 Measurable Objectives for Additional Plan Elements

Regulation Requirements:

§354.30 (f) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.
§354.30 (g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for finding of inadequacy of the Plan.

NFKGSA will not be setting measurable objectives or interim milestones for additional plan elements described in Water Code Section 10727.4.