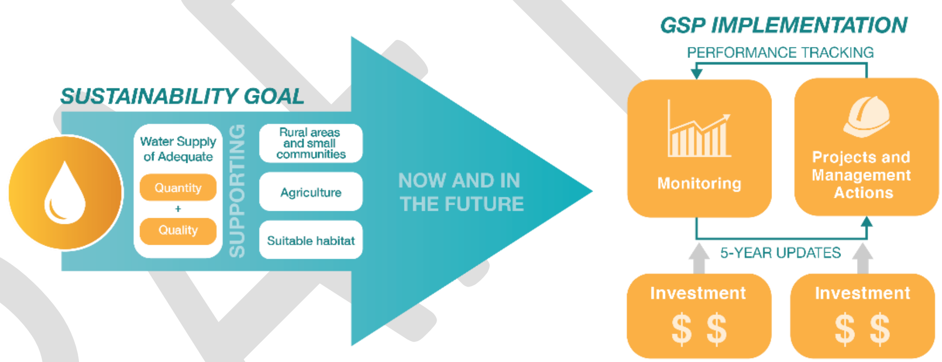
3. SUSTAINABLE MANAGEMENT CRITERIA

Sustainable management criteria (SMC) offer guideposts and guardrails for groundwater managers seeking to achieve sustainable groundwater management. 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*," where the planning and implementation horizon is 50 years with the first 20 years spent working toward achieving sustainable groundwater management and the following 30 years (and beyond) spent maintaining it (California Water Code §10721). For the Vina Subbasin (Subbasin), SMC were formulated by working with the Vina Groundwater Sustainability Agency (GSA) and the Rock Creek Reclamation District GSA Boards of Directors, the Stakeholder Advisory Committee (SHAC), and members of the public. This stakeholder outreach process was facilitated by CBI with sessions documented on the Vina Subbasin GSAs website. Outreach included a robust discussion and broad agreement on the Vina Subbasin sustainability goal as well as what constitutes locally defined undesirable results. The sustainability goal is meant to reflect the GSAs desired condition, maintained over time, for the groundwater basin.



Undesirable results are associated with up to six sustainability indicators (SI), including groundwater levels, groundwater storage, water quality, seawater intrusion, land subsidence, and interconnected surface water. SGMA defines undesirable results as those having significant and unreasonable negative impacts. Failure to avoid undesirable results on the part of the GSAs may lead to intervention by the State. Once the sustainability goal and undesirable results have been locally identified, projects and management actions are formulated to achieve the sustainability goal and avoid undesirable results.

The Vina Subbasin is divided into three management areas: North, Chico, and South. The associated undesirable results for each SI have been defined similarly across the three management areas within the Vina Subbasin. In turn, the rationale and approach for determining minimum thresholds (MT) and measurable objectives (MO) for each SI are the same across all management areas in the Vina Subbasin.

The terminology for describing SMC are defined as follows:

- **Undesirable Results** – Significant and unreasonable negative impacts associated with each SI**.**
- **Minimum Thresholds (MT)** – Quantitative threshold for each SI used to define the point at which undesirable results may begin to occur.
- **Measurable Objectives (MO)** – Quantitative target that establishes a point above the MT that allows for a range of active management to prevent undesirable results.
- **Margin of Operational Flexibility** – The range of active management between the MT and the MO.
- **Interim Milestones (IM)** – Targets set in increments of 5 years over the implementation period of the GSP offering a path to sustainability.

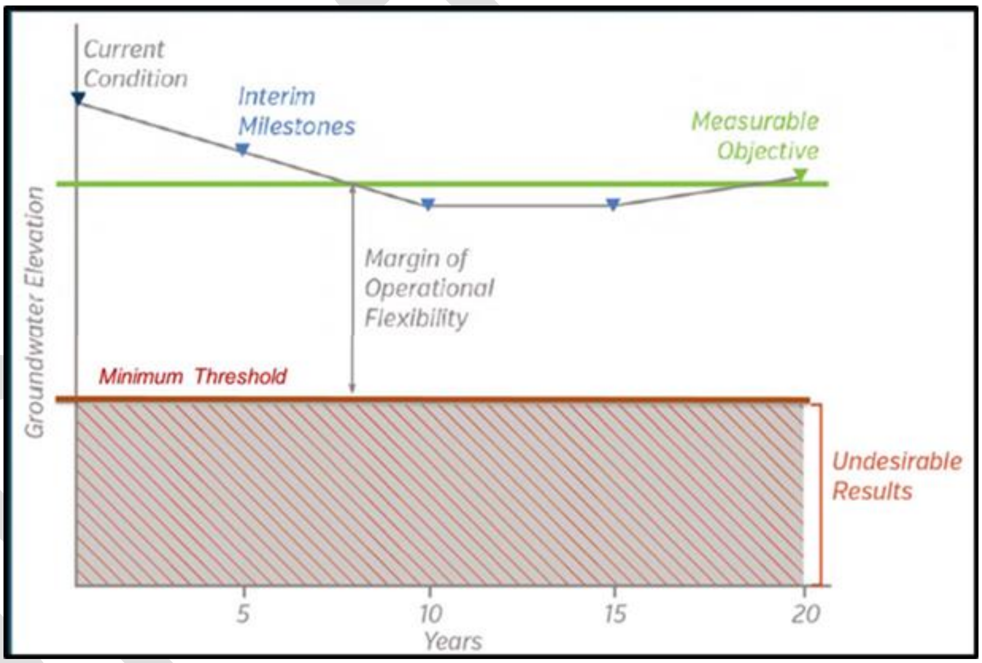


Illustration of terms used for describing SMC using the groundwater level SI.

Sustainability indicators are intended to be measured and compared against quantifiable sustainable management criteria throughout a monitoring framework of representative monitoring sites (RMS; see **Chapter 4.10**). Ongoing monitoring of SI can

- determine compliance with the adopted GSP,
- offer a means to evaluate the effectiveness of projects and management actions over time,

- allow for course correction and adaptation in 5-year updates,
- facilitate understanding among diverse stakeholders, and
- support decision-making on the part of the GSAs into the future.

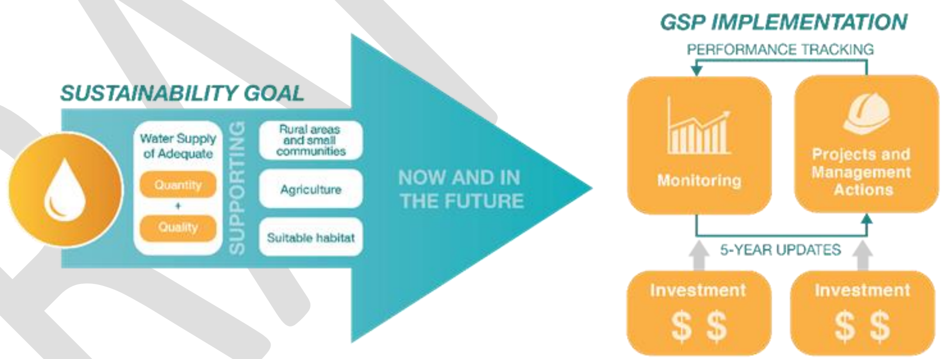
To quantify SMC for the Vina Subbasin, information from the Hydrogeologic Conceptual Model (HCM, see Chapter 2), descriptions of current and historical groundwater conditions, and input from stakeholders have been considered.

3.1 Sustainability Goal

The sustainability goal for the Vina Subbasin is:

> *to ensure that groundwater is managed to provide a water supply of adequate quantity and quality to support rural areas and small communities, the agricultural economic base of the region, and environmental uses now and in the future.*

Implementation of the Vina GSP may achieve sustainability before 2042; however, groundwater levels in the Vina Subbasin may continue to decline during the implementation period. As projects and management actions are implemented, sustainable groundwater management will be achieved. The Subbasin will be managed to prevent undesirable results throughout the implementation period, despite the possible decline of groundwater levels. This sustainability goal is supported by locally defined MT that will avoid undesirable results. Demonstration of stable groundwater levels on a long-term average basis combined with the absence of undesirable results will ensure the Vina Subbasin is operating within its sustainable yield and the sustainability goal will be achieved.



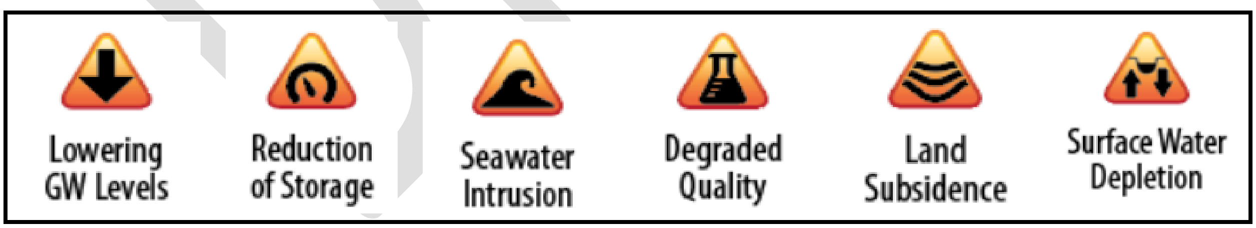
Sustainable management criteria within the Vina Subbasin emphasize management objectives related to domestic, municipal, and agricultural wells as well as suitable habitat. Groundwater management has already been occurring throughout Butte County, and the Vina Subbasin will be managed within its sustainable yield by adapting existing management objectives and strategies to address current and future conditions, or by developing new ones. Sustainable yield means the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result. The Vina Subbasin intends to achieve its sustainability goal by implementing GSP projects and management actions that both augment water supply and increase efficiency of water application (see **Chapter 6** for proposed projects and management actions and **Chapter 7** for the implementation plan to achieve sustainability).

The Butte County Department of Water and Resource Conservation (Department) has been participating in groundwater management activities for many years, including within the Vina Subbasin. In the last several years, the Department has increased groundwater level and water quality monitoring and has worked with other entities to collect and disseminate water data. In addition, the Department assists with other locally driven groundwater management activities. The Vina Subbasin intends to build on this ongoing county-wide process and broadly shares the objective of long-term maintenance of high-quality groundwater resources within the region for domestic, agricultural, and environmental uses.

3.2 Sustainability Indicators (SI), Minimum Thresholds (MT), and Measurable Objectives (MO)

Sustainability Indicators

Six SI are defined by SGMA and are used to characterize groundwater conditions throughout a basin or subbasin. SGMA requires development of locally defined sustainable management criteria for each SI and allows for identification of SI that are not applicable. For example, sea water intrusion is not applicable in the Vina Subbasin due to its distance from the Pacific Ocean.



SI and associated undesirable results, if significant and unreasonable

Minimum Thresholds (MT)

As noted earlier, MT are those quantitative thresholds for each SI used to define the point at which undesirable results may begin to occur. Undesirable results are those having significant and unreasonable negative impacts, avoidance of which is required by SGMA. Potential impacts and the extent to which they are considered “significant and unreasonable” were determined by the GSAs Boards of Directors with input from the SHAC and members of the public. The GSAs established minimum thresholds intended to prevent such significant and unreasonable negative impacts from occurring. If observed data trend toward the locally defined MT, this will trigger action on part of the GSAs to reverse this trend before reaching the MT. For this reason, MT are like guardrails. Actions to reverse a trend toward a MT could be taken at any time during GSP implementation.

Measurable Objectives (MO)

MO are those quantitative targets that establish a point above the MT that allows for a range of active management to achieve the sustainability goal and prevent undesirable results. This range of active management between the MT and the MO is referred to as the margin of operational flexibility.

MO were determined by the GSAs Boards of Directors with input from the SHAC and members of the public. The GSAs established MO intended to preserve the desired condition throughout the Vina Subbasin while offering flexibility in GSP implementation. IM are targets set in increments of 5 years over the implementation period of the GSP offering a path to sustainability. For this reason, the MO and IM are like guideposts.

3.3 Groundwater Levels SMC

Groundwater Levels SMC are those meant to address the chronic lowering of groundwater levels and avoid the depletion of supply at a given location that may lead to undesirable results caused by groundwater pumping. The locally defined undesirable result, MT, and MO are discussed in the next sections.

Undesirable Result

An undesirable result caused by the chronic lowering of groundwater levels is experienced if

> *sustained groundwater levels are too low to provide a water supply of adequate quantity and quality to support rural areas and small communities, and the agricultural economic base of the region, or if significant and unreasonable impacts to environmental uses of groundwater occur.*

Minimum Thresholds (MT)

The Groundwater Levels MT represent quantitative thresholds used to define the point at which undesirable results may begin to occur, avoidance of which is required under SGMA. To establish locally defined MT, the GSAs Boards of Directors, SHAC, and members of the public explored potential impacts of declining groundwater levels.

Potential impacts identified by stakeholders from declining groundwater levels included:

- Wells going dry
- Reduced pumping capacity of existing wells
- Need for deeper well installations and/or lowering of pumps
- Increased pumping costs due to greater lift
- Reduced flows in rivers and streams supporting aquatic ecosystems
- Water table depth dropping below the maximum rooting depth of Valley Oak (*Quercus lobata*) or other deep-rooted tree species

Issues related to reduced flows in rivers and streams and/or water tables that support deep-rooted tree species are addressed in the Interconnected Surface Water SMC (see **Chapter 3.8**).

In recent years, Butte County has documented a number of domestic wells that have "gone dry," meaning groundwater levels have fallen below the depth of the well installation and/or pump. This occurred during summer months of recent drought years and heightened concern among some stakeholders. As a result, domestic well reliability and protection are the focus of the Groundwater Levels MT. From a policy perspective, sustainably constructed domestic wells going dry during non-dry year conditions would be a "significant and unreasonable" undesirable result of groundwater management. The quantitative Vina subbasin Undesirable Result for the Chronic Lowering of Groundwater Levels occurs when:

> *Two RMS wells within a management area reach their MT for two consecutive non-dry year-types.*

Domestic wells are generally shallower than other wells throughout the Vina Subbasin. Protection of domestic wells was therefore deemed to be additionally protective of other well types, such as agricultural wells. In addition, the lowering of groundwater levels during two or more consecutive dry and/or critically dry year types is not considered significant and unreasonable and therefore not considered an undesirable result, as long as the groundwater levels rebound to levels greater than the MT following those consecutive dry and/or critically dry years.

The Vina subbasin SMC for Chronic Lowering of Groundwater Levels is based on groundwater levels throughout the subbasin that would support sustainably constructed domestic wells. Exceeding the MT may lead to significant and unreasonable effects during drought years, impacts to domestic wells and other groundwater uses may occur and would not constitute an Undesirable Result. Local and state drought response play a role in addressing dry year impacts. However, once a drought period ends, it is anticipated that groundwater conditions should return to the MO levels. Year-type is defined according to the Sacramento Valley Water Year Hydrologic Classification and groundwater level is defined based on groundwater elevation above mean sea level.

In order to establish appropriate MT levels protective of sustainably constructed domestic wells, a representative zone is established for each RMS well. The Department of Water Resources domestic well database provides information on all submitted well completion reports when a well is drilled. This database contains information on characteristics of the wells, including well location, groundwater surface elevation of the well, and total well depth. These well characteristics, however, are not always accurate or precise, and, unfortunately, it is not known which of the wells in the database are in use or have been abandoned or replaced.

To refine the dataset, wells installed before 1980 were removed. This removes the oldest wells and wells likely to have been replaced as a result of historically low groundwater conditions that occurred during the 1976-1977 drought. Wells that remain are more likely to be consistent with current well standards and currently serving domestic water needs. Still, there is much information that remains to be gathered to further refine the dataset given the unknowns previously identified, as well as relationships to changes in surface elevation. Therefore, a data gap has been identified that will be further investigated.

Using this refined dataset removing domestic wells installed before 1980, two different methods were used to establish an MT: one in the South Vina and Chico management areas and the other in the North Vina management area.

South Vina and Chico Management Area Approach

For each RMS well, a circle with a 3-mile radius from each well has been drawn identifying all domestic wells within this circle (see figures in Appendix 3-1). While this methodology creates a uniform approach for each well, it also results in multiple overlap scenarios where a single domestic well is associated with two or more RMS well zones. Further, the MT established for each RMS well is intended to be set at the level that is protective of 85 percent of domestic wells within the RMS zone.

An illustration of this is as follows: a MT of 50 feet above mean sea level at an RMS having 100 domestic wells within a three-mile radius means that 15 wells within that radius have a total well depth such that the bottom of the well is at or above 50 feet above mean sea level (and are therefore potentially vulnerable to going dry) and 85 wells have a total well depth at an elevation below 50 feet above mean sea level (and are therefore not vulnerable to going dry). Note that the fifteenth-percentile MT assigned to each RMS is protective of at least 85 percent of all domestic wells within its three-mile radius. It should be noted that some wells that fall above the MT may not "go dry" even if the MT is reached due to differences in groundwater elevation conditions within the RMS zone. Setting the MT to be protective of 85% of the wells recognizes some outlier wells remain in the dataset (unreasonably shallow, not sustainably constructed wells) and changing groundwater level conditions and ground surface elevations within the RMS zone means the RMS well will not be fully representative of conditions for all domestic wells within the RMS zone.

Appendix 3-1 contains the box and whisker plots for each RMS.

North Vina Management Area Approach

For the North Vina management area, in order to determine which wells should be represented by each RMS well and to avoid double or triple counting domestic wells, the Vina North management area was divided into polygons that represent proximate areas to each RMS well (see figure in Appendix 3-1). Each point (or represented well) within each area is closer to its respective RMS well than any other RMS well. The size of each polygon depends on the density of the RMS network. For example, the higher the density of RMS wells in a management area, the smaller the polygons. Each polygon is a different shape and size, determined by the distribution of the RMS wells in the management area. Ground surface elevation was also considered. The result is a more refined dataset that more proximately reflects the relationship of domestic wells with each RMS well. In addition, rather than just looking at a percentage of domestic wells to protect, the elevation levels were examined in comparison to what would be considered sustainable domestic wells for the area. The result is setting an MT for each RMS well that better corresponds with elevation changes and provides operational flexibility between the MO and the MT.

[Editor's note: the intent is to use a consistent approach in establishing the MT throughout the Vina Subbasin. The public is encouraged to provide input on which approach is preferred.]

Measurable Objectives (MO)

The Groundwater Levels MO represent quantitative targets that establish a point above the MT allowing for a range of active management to prevent undesirable results and reflect the desired state for groundwater levels at the year 2042. To establish the MO, the water-level hydrograph of observed groundwater levels at each RMS was evaluated. The historical record at these locations shows cyclical fluctuations of groundwater level over a four- to seven-year cycle consistent with variations in water year type according to the Sacramento Valley Water Year Hydrologic Classification. Groundwater levels are typically lower during dry years and higher during wet years. Superimposed on this four- to seven-year short-term cycle is a long-term decline in groundwater levels. In other words, groundwater levels during more recent dry-year cycles are lower than groundwater levels in earlier dry-year cycles.

The wet-dry cycles are climatically induced, and the GSAs has no ability to change this cyclical behavior; there will always be short-term cyclical fluctuations in groundwater levels. The MO are therefore intended to address the long-term trend of the "peaks and valleys" of the short-term cycles and stop the long-term decline in groundwater levels during dry years. Because the GSAs cannot immediately augment water supply and/or increase efficiency of water application, some continuation of the long-term decline in groundwater levels is possible in the near future. Currently (in 2021), the Vina Subbasin appears to be coming out of a wet period of a short-term cycle (2017 and 2019 being wet years) and beginning the next dry period of a short-term cycle starting in 2020. The MO was therefore based on the trend line of observed historical data extended to the year 2030. The year 2030 was chosen as a reasonable time frame in which the GSAs could implement projects and management actions to address long-term groundwater level decline while recognizing that groundwater levels may experience another dry period of the short-term cycle in the intervening years. The MO for the Groundwater Levels SMC is

> *the groundwater level based on the groundwater trend line for the dry periods (since 2000) of observed short-term climatic cycles extended to 2030.*

The projection of groundwater levels for each RMS was based on a simple non-statistical linear projection of the observed data. Generally, the lowest groundwater levels of a given cycle were used for the projection, unless they appeared to be outliers relative to the general long-term trend of the non-dry years in the cycle.

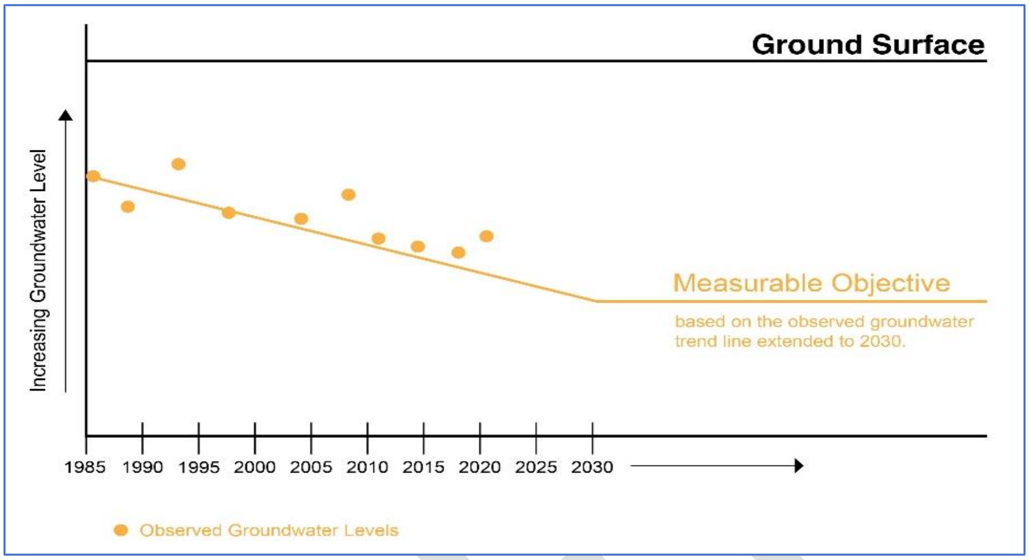


Illustration of long-term trend using historical water levels extended to 2030 for development of MO

IM for groundwater levels between 2022 and 2042 were interpolated based on the linear projection of groundwater level at each RMS. By projecting based on the dry years in the cycle, the observed groundwater levels may be higher than the IM. This will be addressed in the annual reports and interim GSP updates based on what occurs with respect to the short-term cycles in the future. **Appendix 3-2** contains the hydrographs for each RMS.

Summary

To achieve the sustainability goal and therefore preserve the desired condition for the groundwater basin over time, the GSAs, in setting Groundwater Levels SMC, will implement appropriate projects and/or management actions as necessary to maintain groundwater levels within operational flexibility to limit the decline in groundwater levels to certain values and manage groundwater levels within certain ranges at each RMS shown on **Table 3-1**. (See **Chapter 4**, **Figure 4-5**, and **Table 4-6** for relevant information on the RMS for groundwater levels.)

3.4 Groundwater Storage SMC

Groundwater Storage SMC are those meant to address the reduction of groundwater storage caused by groundwater pumping. The locally defined undesirable result, MT, and MO are discussed in the next sections.

Undesirable Result

An undesirable result coming from the reduction of groundwater storage is experienced if

> *sustained groundwater storage volumes are insufficient to support rural areas and small communities, the agricultural economic base of the region, and environmental uses for suitable habitat.*

This undesirable result is closely related to that associated with groundwater levels. Because groundwater levels and groundwater storage are closely related, measured changes in groundwater levels can serve as a proxy for changes in groundwater storage. For this reason, the SMC developed for groundwater levels are used for groundwater storage to ensure avoidance of the undesirable result.

Minimum Thresholds (MT)

As Groundwater Levels SMC are used by proxy, the MT for groundwater storage is the same as for groundwater levels:

> *Two RMS wells reach their MT for two consecutive non-dry year-types.*

In the historical record, there are isolated incidences of shallow wells going dry during summer months of recent critically dry years. This was noted in the earlier section addressing the development of Groundwater Levels SMC. MT intended to prevent significant and unreasonable negative impacts related to the chronic lowering of groundwater levels are assumed adequate to protect against significant and unreasonable reductions of groundwater storage.

Measurable Objectives (MO)

As Groundwater Levels SMC are used by proxy, the MO for groundwater storage is the same as for groundwater levels:

> *the groundwater level based on the groundwater trend line for the dry periods (since 2000) of observed short-term climatic cycles extended to 2030.*

The aquifer system in the Vina Subbasin generally has sufficient groundwater storage capacity to take additional groundwater recharge during wet periods and remain saturated during dry periods, allowing for a range of active management reflecting the desired state for groundwater storage at the year 2042.

3.5 **Water Quality SMC**

Water Quality SMC are those meant to address degraded water quality caused by groundwater pumping. The locally defined undesirable result, MT, and MO are discussed in the next sections.

Undesirable Result

An undesirable result coming from degraded water quality is experienced if

> *groundwater pumping compromises the long-term viability of rural areas and small communities, the agricultural economic base of the region, and environmental uses for suitable habitat. This occurs in the Vina subbasin when two RMS wells exceed their MT for two consecutive non-dry years.*

Minimum Threshold (MT)

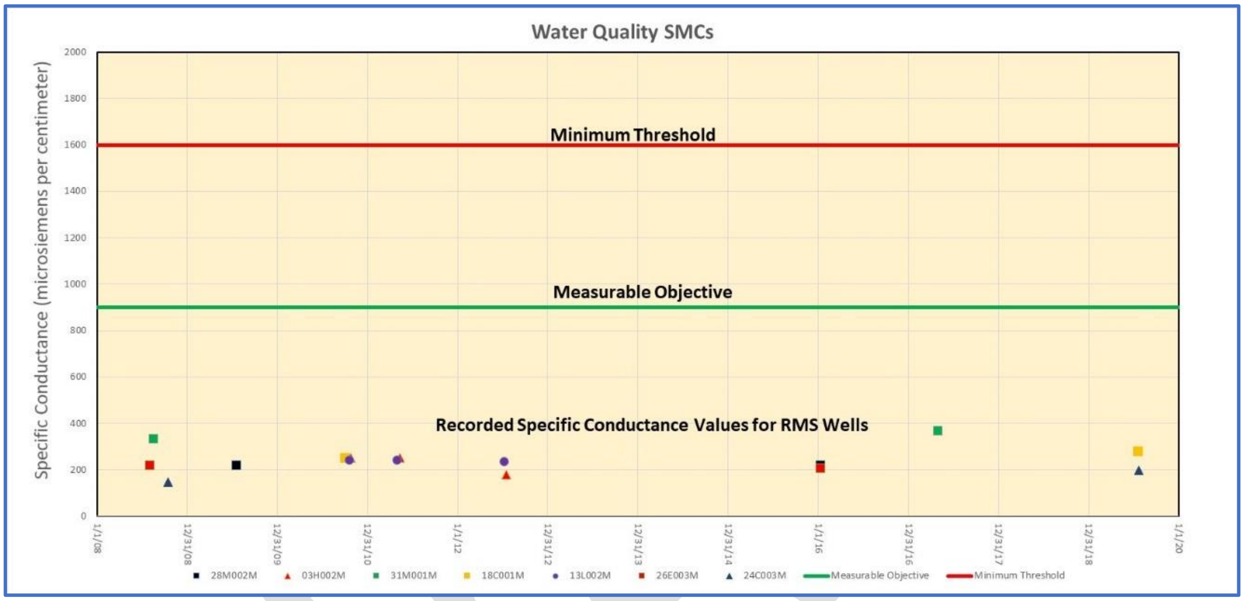
The Water Quality MT represents a quantitative threshold used to define the point at which undesirable results may begin to occur, avoidance of which is required under SGMA. The MT is established based on the potential for movement of underlying brackish water from greater depths into the freshwater pool where groundwater pumping for beneficial uses occurs. To establish a locally defined MT, the GSAs Boards of Directors, SHAC, and members of the public explored potential impacts of degraded water quality.

Potential impacts identified by stakeholders were:

- Aesthetic concerns for drinking water
- Reduced crop yield and quality
- Increased reliance on surface water for “blending”

To address the potential impacts of concern related to degraded water quality, the GSAs, in setting a minimum threshold, commits to avoiding a decline in water quality as it relates to specific conductance, a measure of the water’s saltiness, which can impact the suitability of the water as a source for drinking water, agricultural irrigation, and other uses. _An undesirable result is considered “significant and unreasonable” if groundwater quality degrades such that the specific conductance exceeds the upper limit of the Secondary Maximum Contaminant Level (SMCL) of 1,600 microsiemens per centimeter (µS/cm) based on State Secondary Drinking Water Standards. Values of specific conductance exceeding this number are typically unacceptable for drinking water. Secondary Drinking Water Standards are set on the basis of aesthetic concerns. For that reason, there is no public health goal or maximum contaminant level goal associated with specific conductance.) The MT for the Water Quality SMCL is *the upper limit of the SMCL for specific conductance based on the State Secondary Drinking Water Standards.*

Undesirable results related to water quality as a result of groundwater pumping in the Vina Subbasin have not occurred historically, are not currently occurring, and are not likely to occur in the future. Observations of specific conductance at RMS from 2008 through 2019 ranged between 148 and 364 µS/cm and demonstrated no trend.



Water Quality Measurable Objectives and Minimum Thresholds in relationship to reported historical specific conductance for RMS Wells.

Measurable Objective (MO)

The Water Quality MO represents a quantitative target that establishes a point above the MT allowing for a range of active management to prevent undesirable results and reflect the desired state for groundwater quality at the year 2042. To address the potential impacts of concern related to degraded water quality, the MO was established for specific conductance at the recommended SMCL of 900 µS/cm based on State Secondary Drinking Water Standards. The MO for the Water Quality SMC is

the recommended SMCL for specific conductance based on the State Secondary Drinking Water Standards.

Water quality monitoring implemented for compliance with SGMA will build upon Butte County's existing groundwater quality monitoring program. Additional monitoring by

DWR and other agencies will continue to track constituents not managed by the GSAs, including minerals, metals, pesticides, and herbicides.

Summary

To achieve the sustainability goal and therefore preserve the desired condition for the groundwater basin over time, the GSAs, in setting the Water Quality SMC, commits to managing groundwater quality in line with the State Secondary Drinking Water Standards at each RMS shown on **Table 3-2**. (See **Chapter 4**, **Figure 4-6**, and **Table 4-8** for relevant information on the RMS for water quality.)

3.6 Seawater Intrusion SMC

Seawater intrusion is not applicable to the Vina Subbasin due to its distance from the Pacific Ocean.

3.7 Land Subsidence SMC

Land Subsidence SMC are those meant to address land subsidence that substantially interferes with surface land uses caused by groundwater pumping. The locally defined undesirable result, MT, and MO are discussed in the next sections.

Undesirable Result and Minimum Thresholds (MT)

An undesirable result coming from land subsidence is experienced if

> *groundwater pumping leads to changes in the ground surface elevation severe enough to disrupt critical infrastructure, development of projects that enhance the viability of rural areas, small communities, and the agricultural economic base of the region.*

Land subsidence typically occurs concurrently or shortly after significant declines in groundwater levels, therefore measured changes in groundwater levels can serve as a proxy for potential land subsidence. For this reason, the SMC developed for groundwater levels are used for land subsidence to ensure avoidance of the undesirable result.

As Groundwater Levels SMC are used by proxy, the quantitative Undesirable Result for land subsidence is the same as for groundwater levels:

> *Occurs when two RMS wells reach their MT for two consecutive non-dry year-types.*

Undesirable results related to land subsidence in the Vina Subbasin have not occurred historically, are not currently occurring, and are not likely to occur in the future. To assess land subsidence in the Sacramento Valley, a subsidence monitoring network was established consisting of observation stations and extensometers managed jointly by the US Bureau of Reclamation (USBR) and DWR. This subsidence monitoring network includes 19 GPS monuments located within the Vina Subbasin, on the boundary between Butte and Tehama counties, or on the boundary between the Vina and Butte subbasins. The subsidence monitoring network also includes three extensometers in Butte County with a period of record beginning in 2005. (There are no extensometers in the Vina Subbasin.) By 2019, a review of the data showed that changes in ground surface elevations were slight and remained at or above baseline levels, indicating that inelastic land subsidence has not been an observed in the Vina Subbasin. This is likely due to historically relatively stable groundwater levels and subsurface materials that are not conducive to compaction. For this reason, inelastic land subsidence due to groundwater pumping is unlikely to produce an undesirable result in the Vina Subbasin.

Measurable Objectives (MO)

As Groundwater Levels SMC are used by proxy, the MO for land subsidence is the same as for groundwater levels:

> *the groundwater level based on the groundwater trend line for the dry periods (since 2000) of observed short-term climatic cycles extended to 2030.*

3.8 Interconnected Surface Water SMC

Interconnected Surface Water SMC are those meant to address depletions of interconnected surface water caused by groundwater pumping. Relevant context, the Interconnected Surface Water SMC framework, and the locally defined undesirable result, MT and MO are presented in the next sections.

Relevant Context

The objective of the Interconnected Surface Water SMC is to avoid significant and unreasonable adverse impacts on beneficial uses of the surface water. To address this SMC, DWR has provided various forms of guidance, including mapping of potential Groundwater Dependent Ecosystems (GDE). GDE are a sub-class of aquatic and riparian habitat that depend on groundwater for optimum ecological function. The distinction between an ecosystem's dependence on groundwater versus its dependence on surface water and the associated riparian zone or floodplain is important. In addition, the distinction between the shallow aquifer zone and the deep aquifer zone, or principal aquifer, is also important. The principal aquifer only influences surface water to the extent that it affects water levels in the shallow aquifer zone which then influences the shallow aquifer zone's connection to the stream. The Vina Subbasin includes upland streams (e.g., Big Chico Creek) and their associated riparian zones and the mainstem floodplain of the Sacramento River (Figure 3-1). The scales of the ecosystems and associated hydrologic dependencies in these two landscapes are quite different. Streamflow and adjacent narrow riparian areas in the upland stream systems are very sensitive to watershed and climatic conditions outside of the Vina Subbasin in the foothills of the Cascades and Sierra Nevada. The Sacramento River and its floodplain are affected by much larger and cumulative hydrologic processes, including operation of multiple reservoirs and the cumulative hydrology of multiple watersheds extending to the headwaters of the Cascades.

Potential impacts of the depletion of interconnected surface water were discussed by stakeholders during technical discussions covering the fundamentals of groundwater-surface water interactions and mapping analysis of GDE prepared by Butte County Department of Water Resources. The GDE mapping analysis is presented in Appendix 3-3. Potential impacts identified by stakeholders were:

- Disruption to GDEs
- Reduced flows in rivers and streams supporting aquatic ecosystems and water right holders
- Degradation of "Urban Forest" habitat in the City of Chico
- Streamflow changes in upper watershed areas outside of the Vina GSAs boundary
- Water table depth dropping below the maximum rooting depth of Valley Oak (*Quercus lobata*) or other deep-rooted tree species
- Cumulative groundwater flow moving toward the Sacramento River from both the Vina Subbasin and surrounding GSAs on both the east and west side of the river

The Vina Subbasin acknowledges that overall function of the riparian zone and floodplain is dependent on multiple components of the hydrologic cycle that may or may not have relationships to groundwater levels in the principal aquifer. For example, hydrologic impacts outside of the Vina Subbasin, such as upper watershed development or fire-related changes in run-off, could result in impacts to streamflow, riparian areas, or GDE that are completely independent of any connection to groundwater use or conditions within the Vina Subbasin.

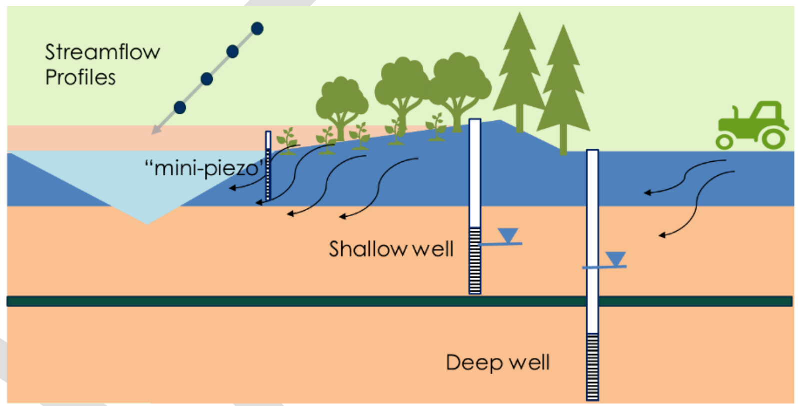
Data needed to develop this SMC includes: definition of stream reaches and associated priority habitat, streamflow measurements to develop profiles at multiple time periods, and measurements of groundwater levels directly adjacent to stream channels, first water bearing aquifer zone, and deeper aquifer zones. These data are not available and are a data gap for the GSP. The GSAs in the Vina Subbasin intend to further evaluate this SMC to avoid undesirable results to aquatic ecosystems and GDEs. To that end, an Interconnected Surface Water SMC framework has been developed for the GSP as described below. This framework will guide future data collection efforts to fill data gaps, either as part of GSP projects and management actions or plan implementation. As additional data are collected and evaluated, the Vina Subbasin GSAs will evaluate the development of additional SMC, as appropriate, for specific stream reaches and associated habitat where there is a clear connection to groundwater pumping in the principal aquifer.

Interconnected Surface Water SMC Framework

To evaluate the potential for depletion of interconnected streams, an integrated assessment of both surface water and groundwater is required that includes:

- **Definition of stream reaches and associated priority habitat.** This is typically developed using a combination of geomorphic classification of the stream channel and ecological classification of the associated habitat.
- **Multiple streamflow measurements in each stream reach to develop a profile of streamflow at multiple time periods over at least one year.** Comparison of flow rates in each reach defines whether the reach is gaining (water moving from the groundwater system to the stream/river) or losing (water moving from the stream/river to the groundwater system). A reach can be both gaining and losing, depending on the time of year (i.e., losing during high flow periods and gaining during low flow periods).
- **Measurement of groundwater levels directly adjacent to the stream channel in the adjacent riparian zone or floodplain.** Groundwater measurement of this type is typically done with piezometers, or "mini-piezos," which may be very shallow (less than 15 feet deep) and hand-driven (i.e., not requiring a drill rig). Groundwater levels are collected simultaneous to streamflow profiles.
- **Measurement of groundwater levels in the first water bearing aquifer zone.** This is the first regional or sub-regional aquifer that interacts with the stream by either discharging water to the stream or gaining water from the stream. These wells are typically between 20 and 100 feet deep and require a drill rig for installation. It is important for the screen interval of these wells to cross the water table. Groundwater levels are collected simultaneous to stage measurements along the streamflow profile. Water level differences between the shallow aquifer and the water surface elevation of the nearest stream reach are evaluated.

- **Measurement of groundwater levels in deeper aquifer zones.** These are typically regional or sub-regional aquifers that are used for regional supply. Water levels in these aquifers can be higher or lower than water levels in the overlying aquifer. The degree of connectivity to the nearest stream reach depends on how stratigraphically isolated the deeper zone is from the shallow zone. These wells are typically greater than 100 feet deep and require a drill rig for installation. It is important to conduct a pumping test of the deeper aquifer and measure water levels in the overlying aquifer to determine how hydraulically connected it is to the overlying aquifer. It is important to complete wells in the shallow aquifer across the water table. Groundwater levels are collected simultaneous to streamflow profiles. Additional Airborne Electromagnetic (geophysical) data would be valuable in further understanding the structure and potential interconnection of the aquifers in different zones.



This information is then integrated to define which surface water reaches are connected to the shallow aquifer zones and where those shallow aquifer zones are influenced by pumping of the deeper aquifer zones.

Undesirable Result

The undesirable result for this SMC is focused on connectivity where there is a measurable connection between groundwater levels in the principal aquifer and streamflow or associated aquatic habitat viability. The Vina Subbasin specifically recognizes deep-rooted tree species, such as Valley Oak (*Quercus lobata*), that are common along riparian corridors in both upland streams and the Sacramento River. This connectivity is not well measured or understood in the Vina Subbasin at this time. For now, an undesirable result coming from the depletion of interconnected surface water is simply defined as

> *Avoiding significant and unreasonable depletion of surface water flows caused by groundwater pumping that significantly impacts beneficial uses*

For this reason, the SMC developed for groundwater levels are used as a proxy for interconnected surface water in an interim manner until data gaps are addressed.

Minimum Thresholds (MT)

The potential impact of groundwater levels on aquatic habitat or GDE is typically specific to a certain stream reach or geographic area. Groundwater modeling conducted in association with the HCM (see **Chapter 2**) incorporates the interaction of surface water and groundwater at a regional scale, including all the GSAs in Butte County. While the model is a useful tool for evaluating regional behavior of the groundwater system overall, there are significant data gaps that limit calibration of the groundwater response in the uppermost layer of the model, where the dynamics and "interconnectedness" between surface water and groundwater actually occur. Therefore, at this time, Groundwater Levels SMC are used by proxy and the MT for interconnected surface water is the same as for groundwater levels:

> *Two RMS wells reach their MT for two consecutive non-dry year-types.*

Measurable Objectives (MO)

As Groundwater Levels SMC are used by proxy, the MO for interconnected surface water is the same as for groundwater levels:

> *the groundwater level based on the groundwater trend line for the dry periods (since 2000) of observed short-term climatic cycles extended to 2030.*

As described previously, the historical record of groundwater levels shows fluctuations over a four- to seven-year cycle consistent with variations in water year type according to the Sacramento Valley Water Year Hydrologic Classification. It is not known whether streamflow and associated aquatic habitat and GDE that are connected to groundwater have also experienced a long-term decline. In the upland streams, it is likely that similar long-term declines have occurred, since the recharge that produces the groundwater level fluctuations likely correlates with streamflow in the upper watershed areas. However, long-term declines in Sacramento River streamflow may have been avoided by reservoir releases aimed at maintaining streamflow levels. As described previously, the wet-dry cycles are climatically induced, and the GSAs has no ability to change this cyclical behavior; there will always be short-term cyclical fluctuations in surface water availability, particularly in the upland streams. The MO are therefore intended to address the long-term trend of the "peaks and valleys" of the short-term cycles. A focus on long-term trends will be maintained as more data are collected to inform future MOs for the shallowest zone of the aquifer system.

3.9 SMC Summary Tables

Groundwater Levels SMC and Water Quality SMC for each RMS are shown on **Table 3-1** and **Table 3-2**, respectively.

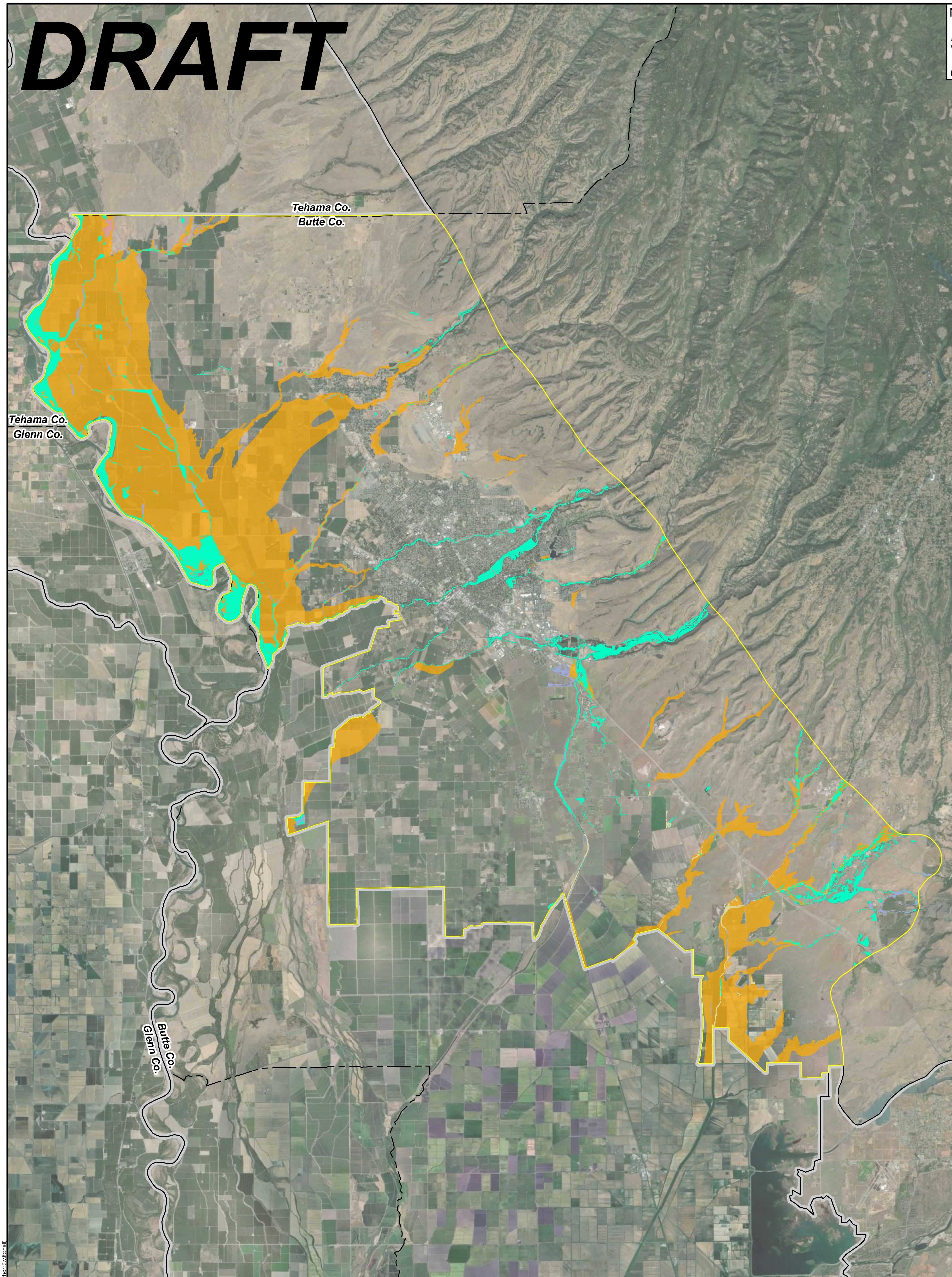
Table 3-1. Groundwater Levels SMC by RMS in feet above mean sea level

RMS Well ID	MT	MO	IM		
			2027	2032	2037
Vina Subbasin – North Management Area					
25C001M	50	130	131	130	130
10E001M	80	136	139	136	136
07H001M[a]	72	136	145	136	136
05M001M	31	115	116	115	115
36P001M	45	108	110	108	108
33A001M	72	125	126	125	125
Vina Subbasin – Chico Management Area					
CWSCH01b	85	106	108	106	106
28J001M	85	110	111	110	110
CWSCH03	85	108	110	108	108
CWSCH02	85	105	108	105	105
CWSCH07	85	108	109	108	108
Vina Subbasin – South Management Area					
21C001M	44	64	66	64	64
18C003M	65	130	134	130	130
10C002M	20	92	95	92	92
24C001M	33	77	82	77	77
09L001M	43	91	94	91	91
26E005M	57	95	96	95	95

[a] MT is associated with GSP Well ID 18A001M.

Table 3-2. Water Quality SMC by RMS in µS/cm

GSP Well ID	MT	MO	IM		
			2027	2032	2037
Vina Subbasin – North Management Area					
28M002M	1,600	900	900	900	900
03H002M					
31M001M					
Vina Subbasin – Chico Management Area					
28J005M	1,600	900	900	900	900
Vina Subbasin – South Management Area					
18C001M	1,600	900	900	900	900
13L002M					
26E003M					
24C003M					



Legend

Groundwater-Dependend Ecosystems (GDEs)[1]

- Likely a GDE
- Not likely a GDE
- Not likely a GDE near rice
- Not likely a GDE within 50' of Irrigated Ag
- FEMA Flood Zone A[2]
- Vina Subbasin
- Other subbasins
- County boundaries

Notes:
1) More detailed descriptions of GDEs are available in Appendix "X".
2) Federal Emergency Management Agency (FEMA), 2019, National Flood Hazard Layer https://www.fema.gov/flood-maps/products-tools/national-flood-hazard-layer

4 2 0 4 Miles

Groundwater-Dependent Ecosystems
Vina GSA

Geosyntec consultants

Project No.: SAC282 | May 2021

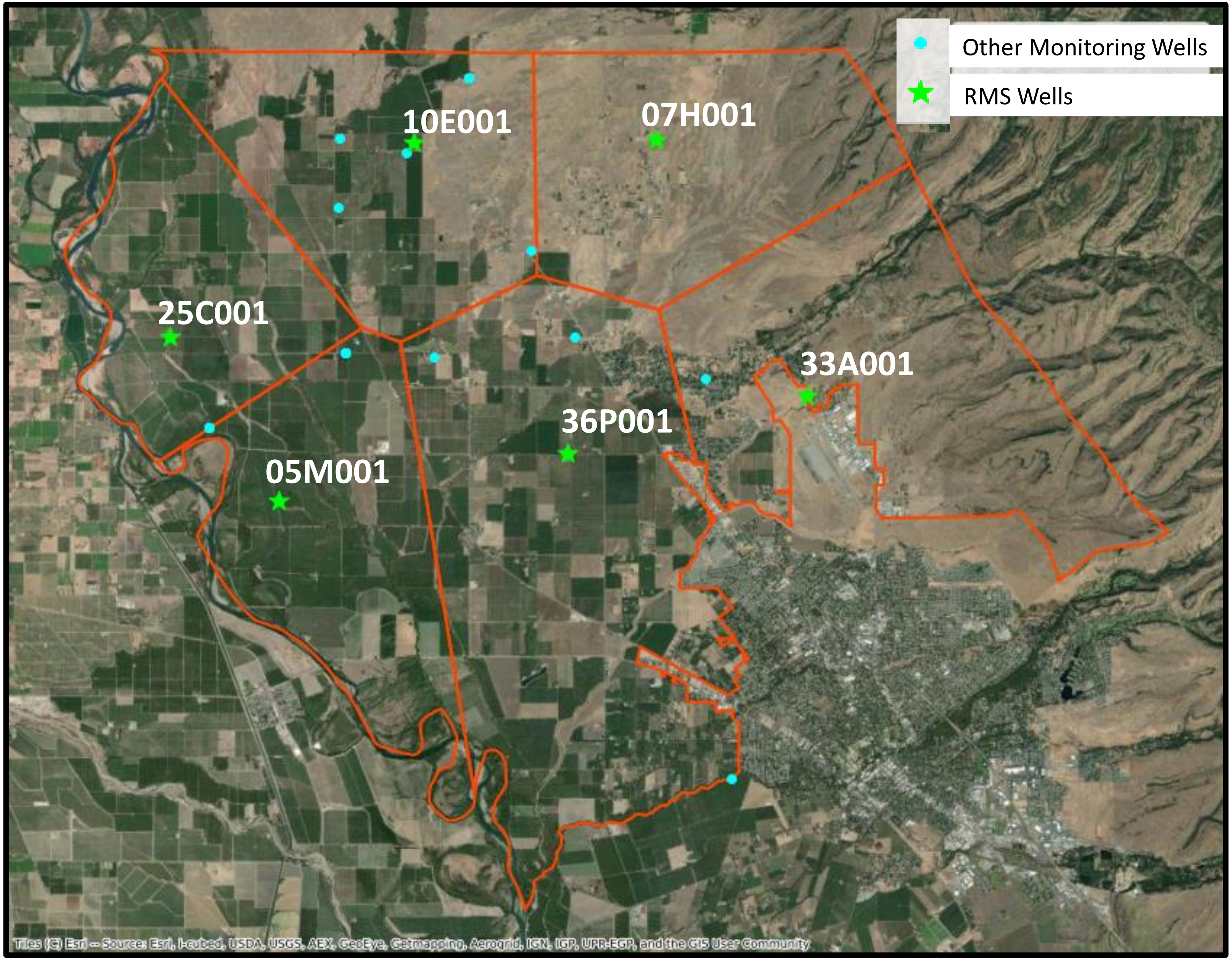
Figure 3-1

P:\GIS\SAC282 - Butte County\Project\202010_GSP_Maps\GDE_Vina.mxd 5/6/2021 4:38:53 PM (Author: SMitchell)

Appendix 3-1

Figures of RMS Well Polygons (Vina North) and Box and Whisker Plots (Vina Chico and South)

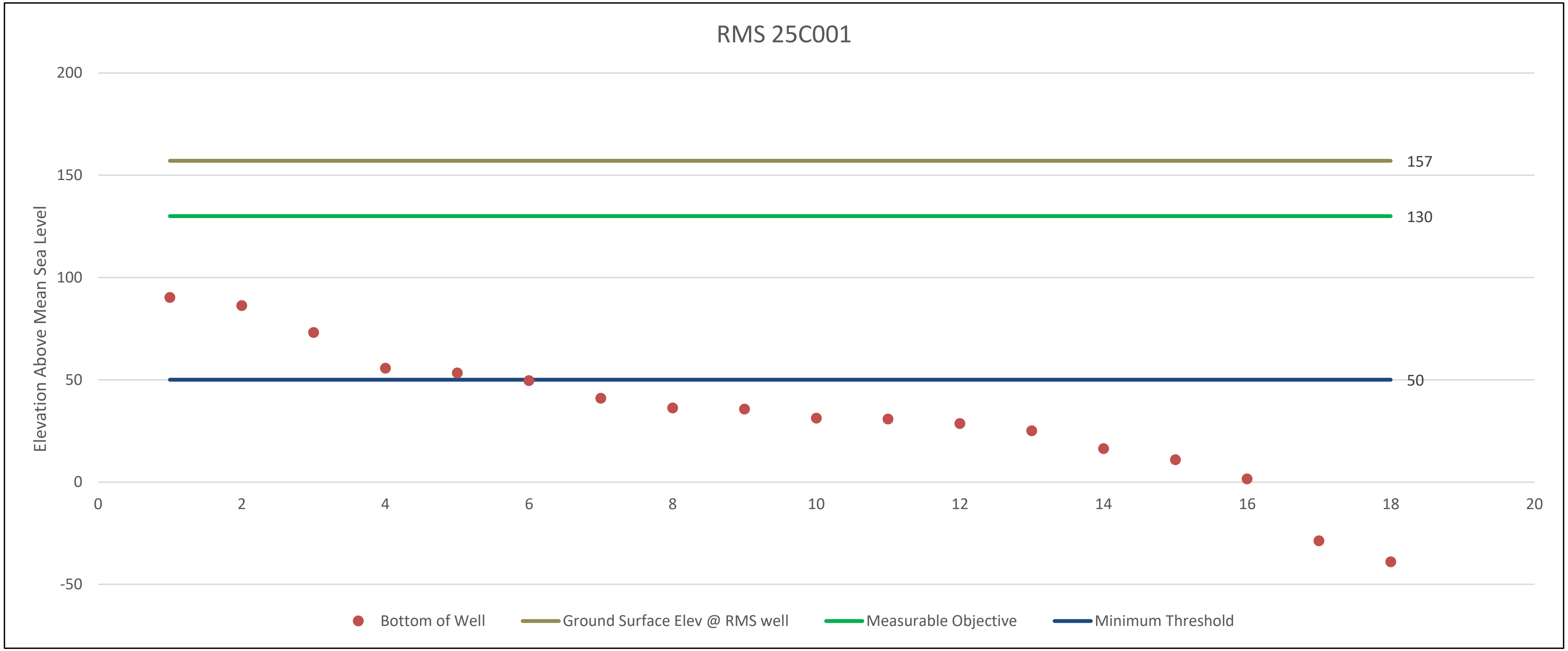
Vina North Management Area
RMS Wells and Polygons

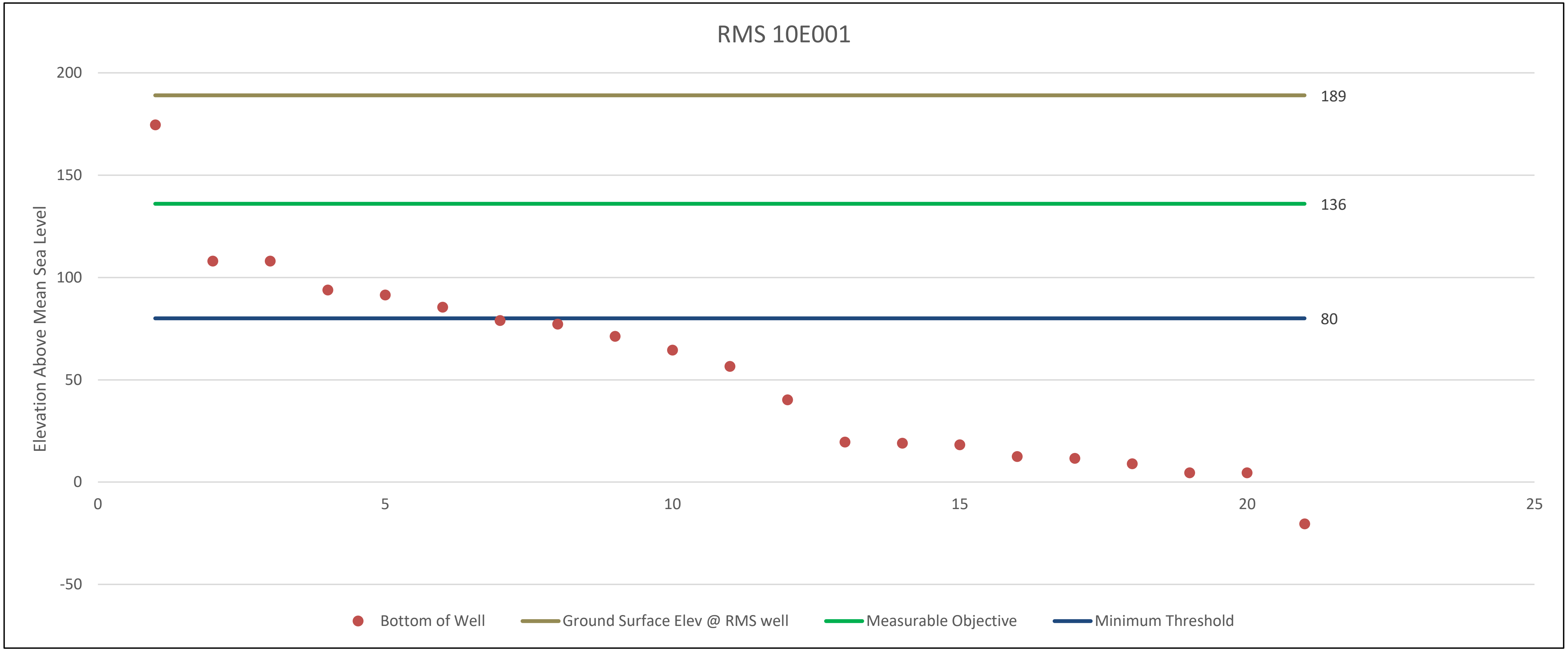


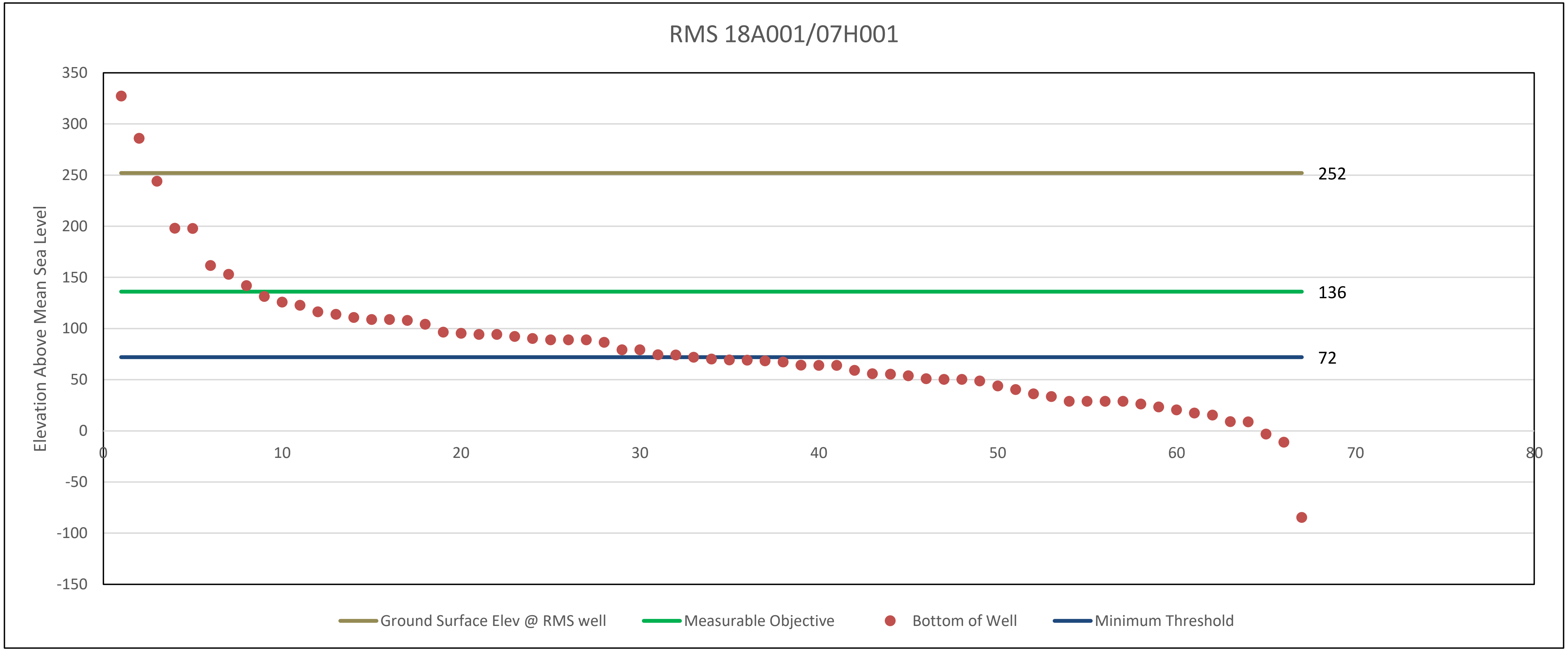
Graphs show the Elevation of the Bottom of domestic wells in the RMS Zone relative to the RMS well's ground surface elevation. Each point on the graph represents a domestic well in the RMS zone. Everything is converted to elevation above mean sea level in feet. The elevation of the Measurable Objective and Minimum Threshold established at the RMS well is shown relative to the elevation of the bottom of all domestic wells (post 1980 from the well database) within the zone.

The graphs were used to identify the Minimum Threshold that would be protective of the majority of the domestic wells in the RMS zone while recognizing the RMS well is not fully representative of wells within the zone due to changes in groundwater surface and water surface elevation throughout the area. Wells above the Minimum Threshold elevation tend to be especially shallow (less than 100 feet deep) or have a significantly different (higher) ground surface elevation than the RMS well.

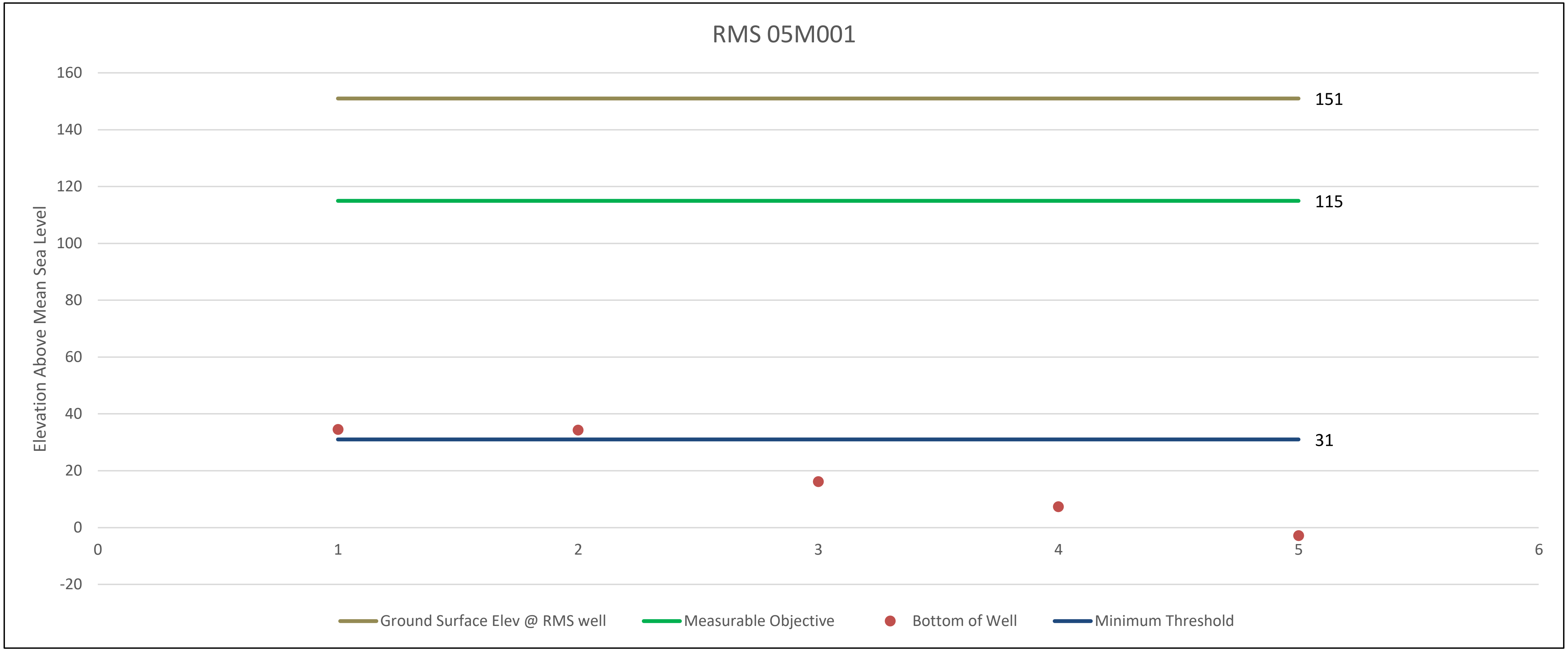
RMS Well	25C001	10E001	18A001/ 07H001	05M001	36P001	33A001
Ground Surface Elevation @ RMS well	157	189	252	151	163	252
Measurable Objective	130	136	136	115	108	125
Minimum Threshold	50	80	72	31	45	72
# Wells in RMS Zone	18	21	67	5	329	307
Number of wells above the MO	0	1	8	0	0	40
Number of wells above the MT	5	6	32	2	69	116


RMS 25C001
Elevation Above Mean Sea Level
200
150
100
50
0
-50
0
2
4
6
8
10
12
14
16
18
20
157
130
50
Bottom of Well
Ground Surface Elev @ RMS well
Measurable Objective
Minimum Threshold

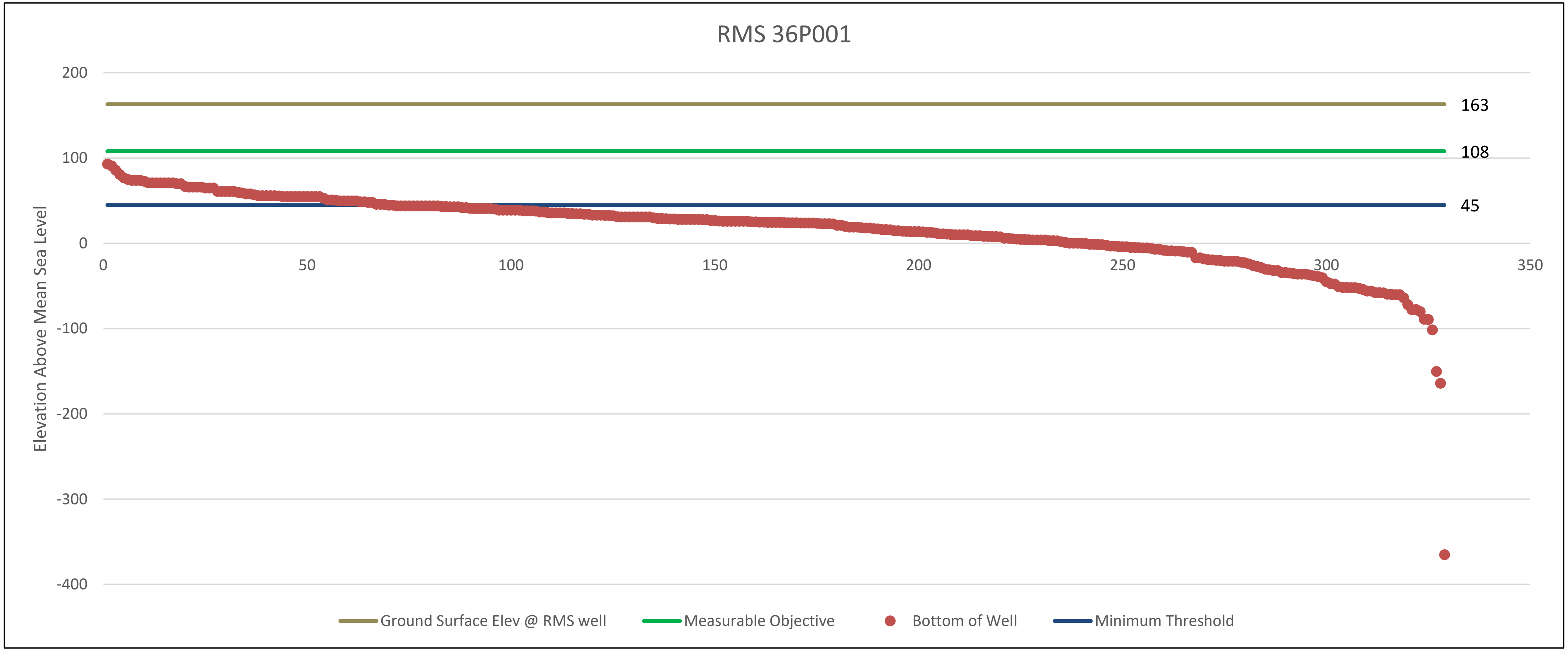

RMS 10E001
200
150
100
50
0
-50
Elevation Above Mean Sea Level
0
5
10
15
20
25
189
136
80
Bottom of Well
Ground Surface Elev @ RMS well
Measurable Objective
Minimum Threshold



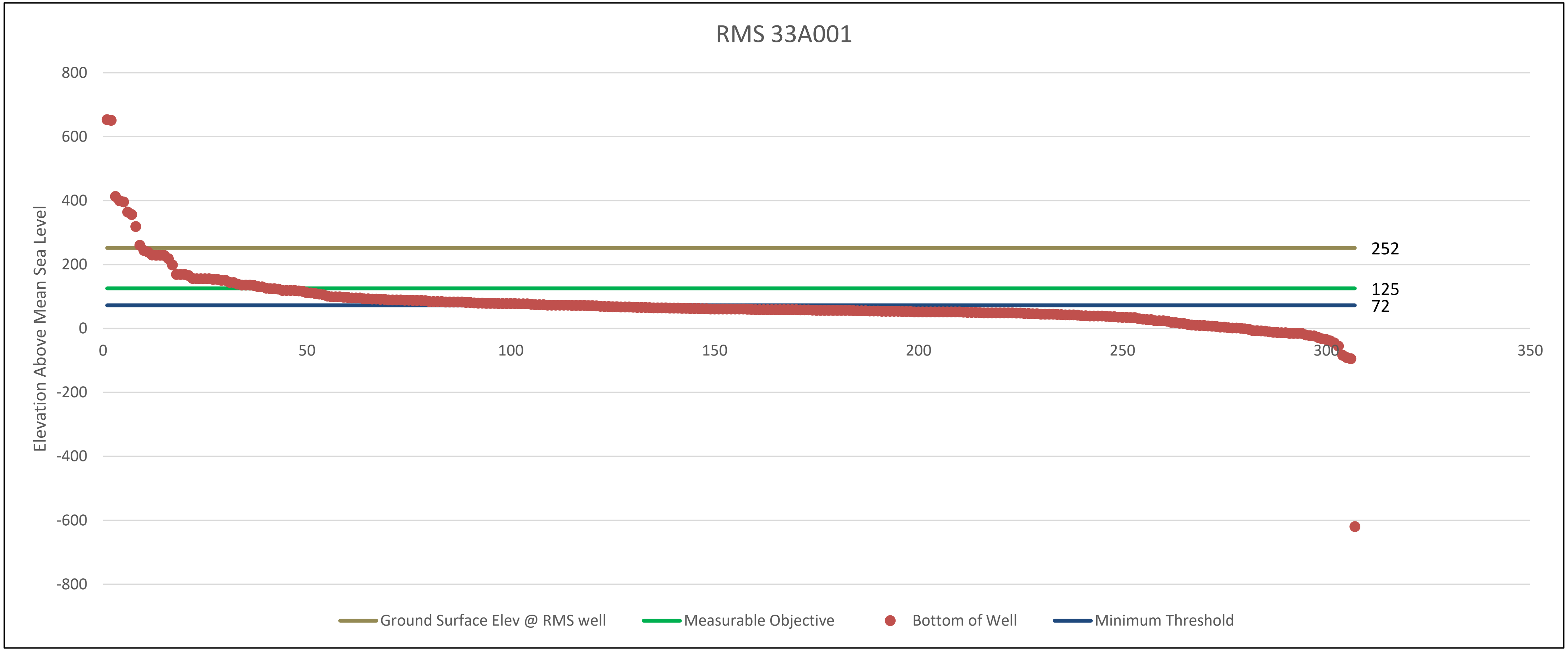
RMS 18A001/07H001
Elevation Above Mean Sea Level
350
300
250
200
150
100
50
0
-50
-100
-150
0
10
20
30
40
50
60
70
80
252
136
72
Ground Surface Elev @ RMS well
Measurable Objective
Bottom of Well
Minimum Threshold



RMS 05M001
Elevation Above Mean Sea Level
160
140
120
100
80
60
40
20
0
-20
0
1
2
3
4
5
6
151
115
31
Ground Surface Elev @ RMS well
Measurable Objective
Bottom of Well
Minimum Threshold



RMS 36P001
Elevation Above Mean Sea Level
200
100
0
-100
-200
-300
-400
0
50
100
150
200
250
300
350
163
108
45
Ground Surface Elev @ RMS well
Measurable Objective
Bottom of Well
Minimum Threshold

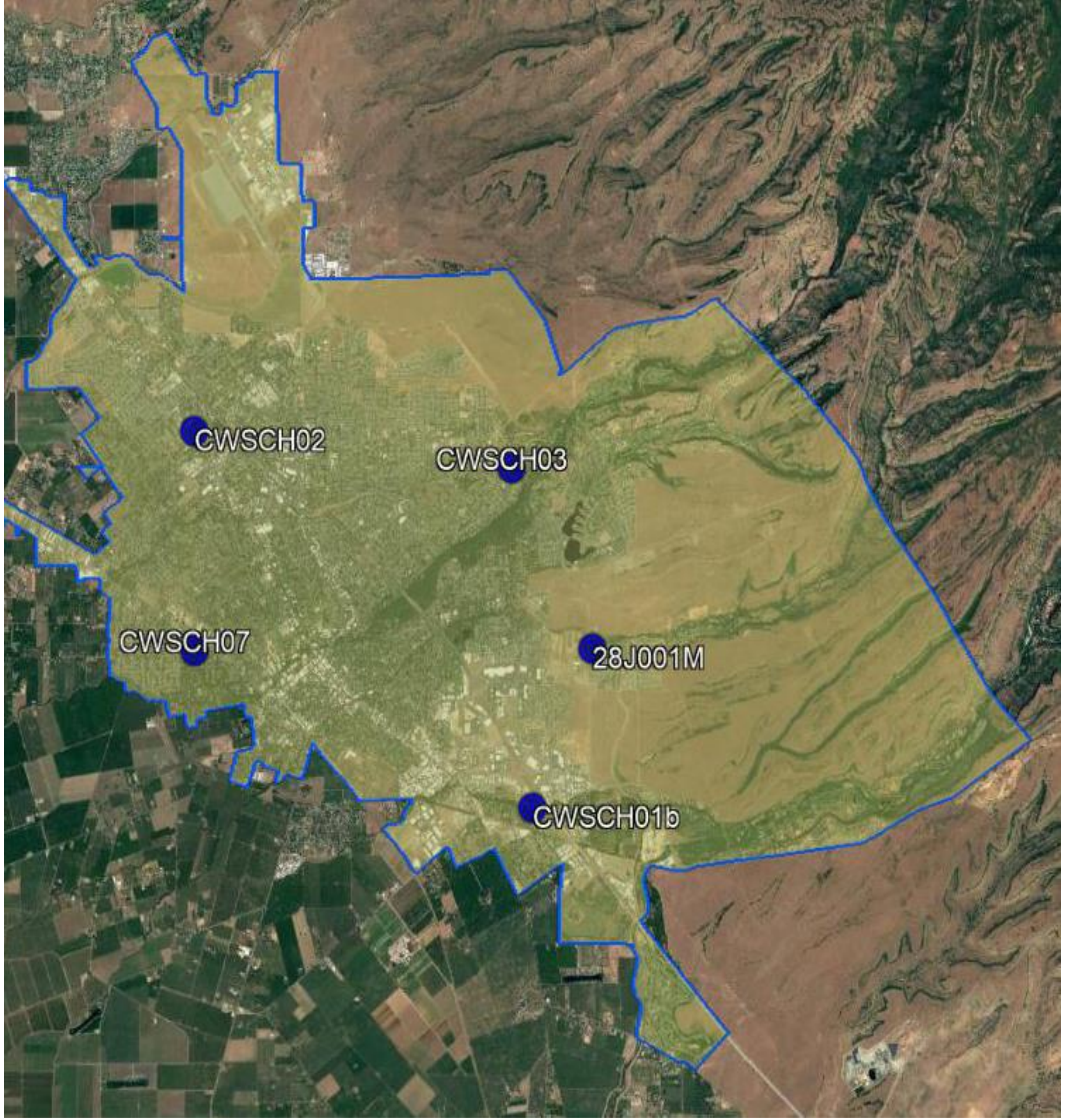


RMS 33A001
Elevation Above Mean Sea Level
800
600
400
200
0
-200
-400
-600
-800
0
50
100
150
200
250
300
350
252
125
72
Ground Surface Elev @ RMS well
Measurable Objective
Bottom of Well
Minimum Threshold

Vina Chico Management Area

RMS Wells

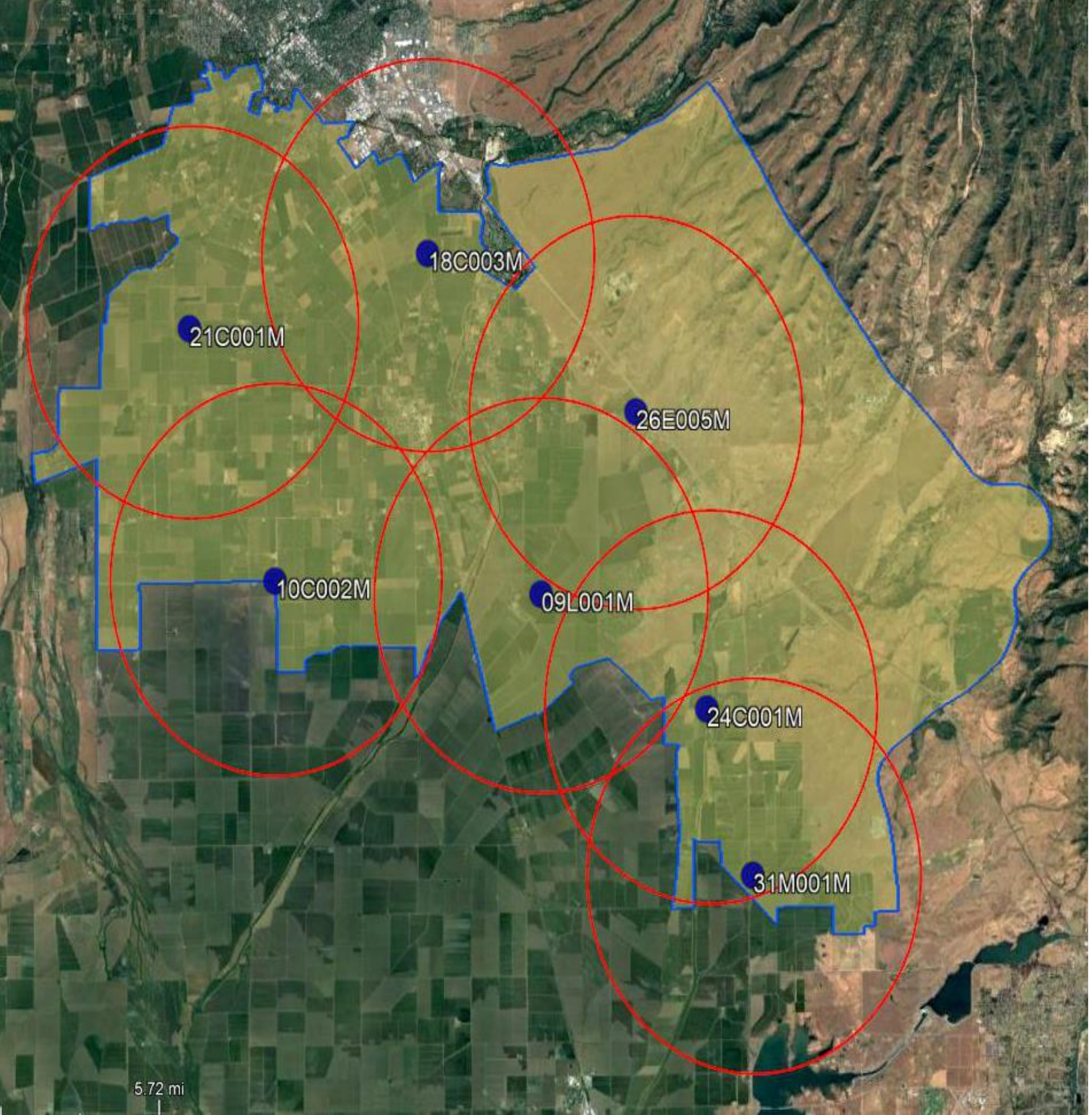
The MT was calculated using all domestic wells completed after 1980 within the management area and applied to all RMS Wells.



RMS Well Location

Vina South Management Area

RMS Wells and 3-Mile Radius

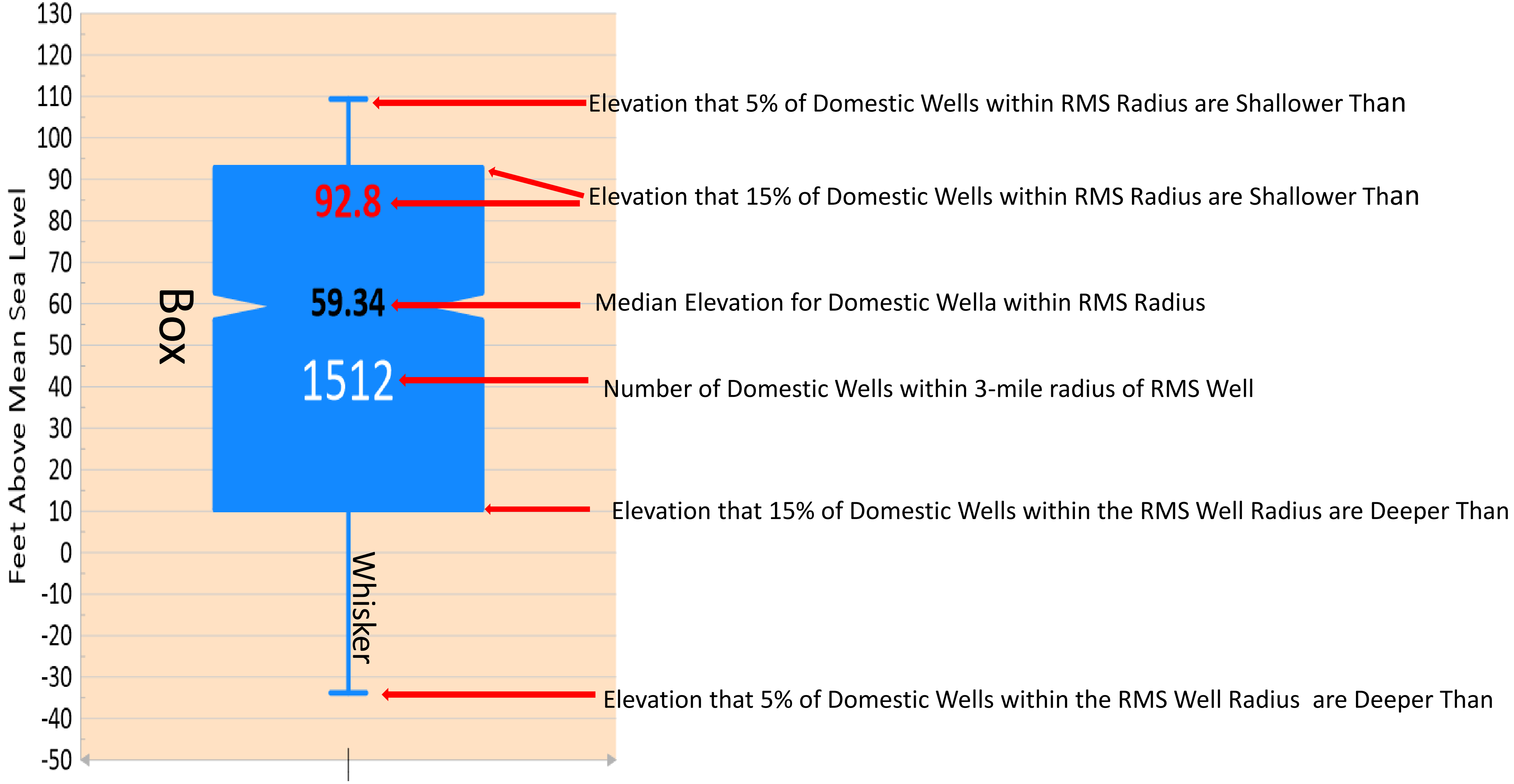


Note: Domestic wells within radius areas that do not fall within the boundaries of the management area are not included in the assessment for developing the MT.

RMS Well Location

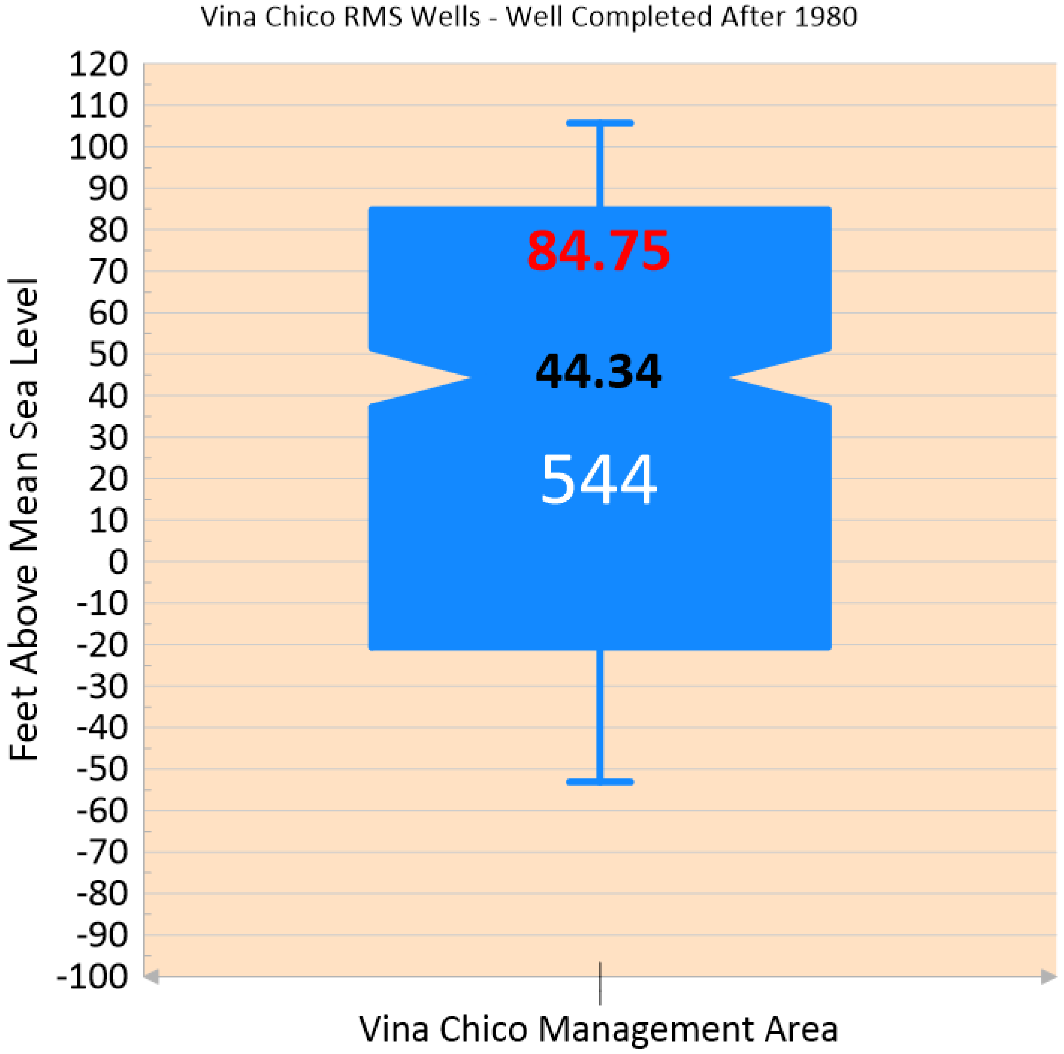
3-Mile Radius

Figure describing portions of a box and whisker plot.

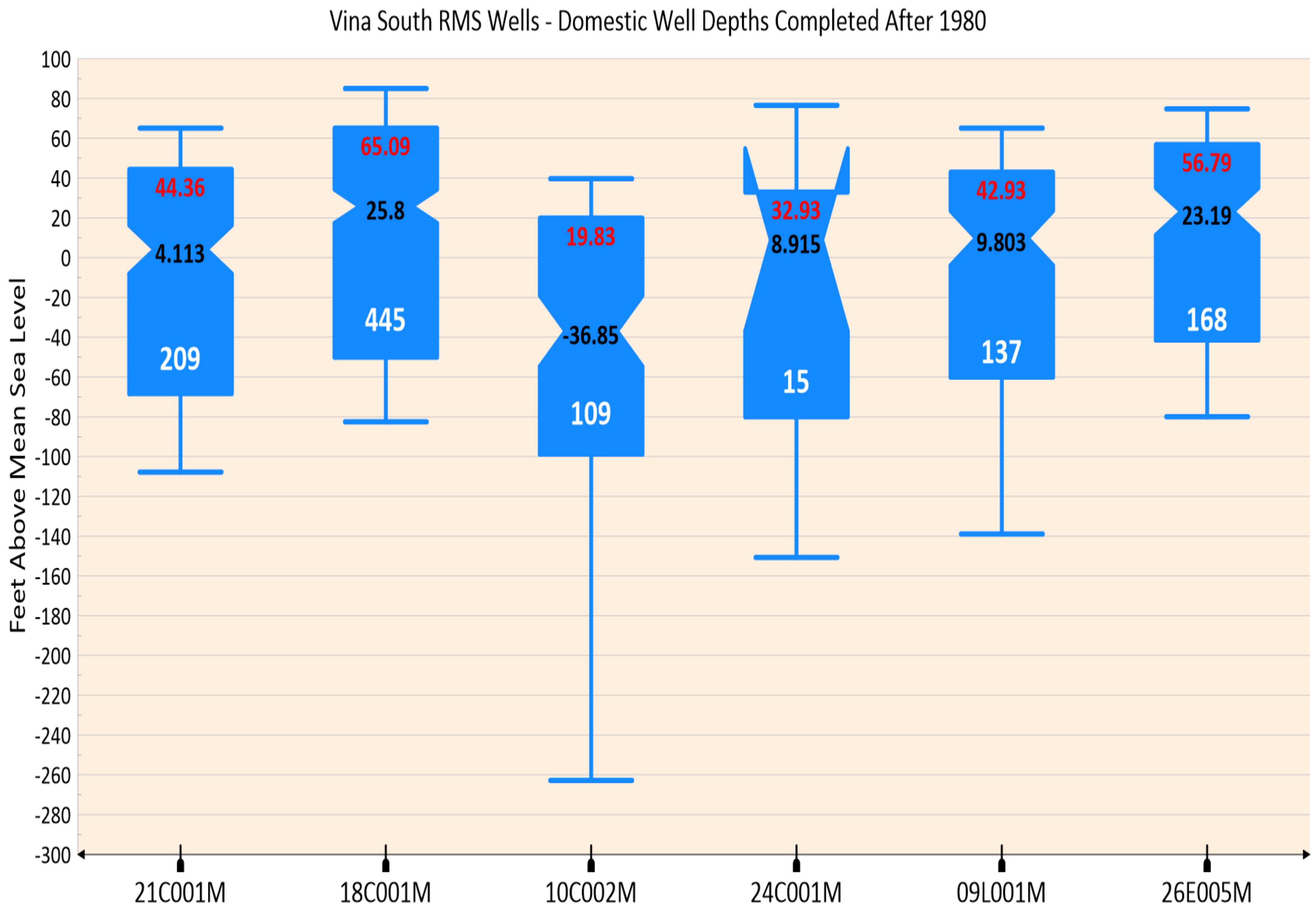


Notes

1. Only includes wells completed after 1980
2. Elevations are for total depth of the domestic well
3. Wells within 3-mile radius not within the management area are not included



71.22	Elevation where the total depth of 15 Percent of Domestic wells within Chico Management Area are Shallower Than
32.74	Elevation of the mean total depth of Domestic wells within the Chico Management Area
32.74	Total number of domestic wells completed after 1980 located within Chico Management Area.



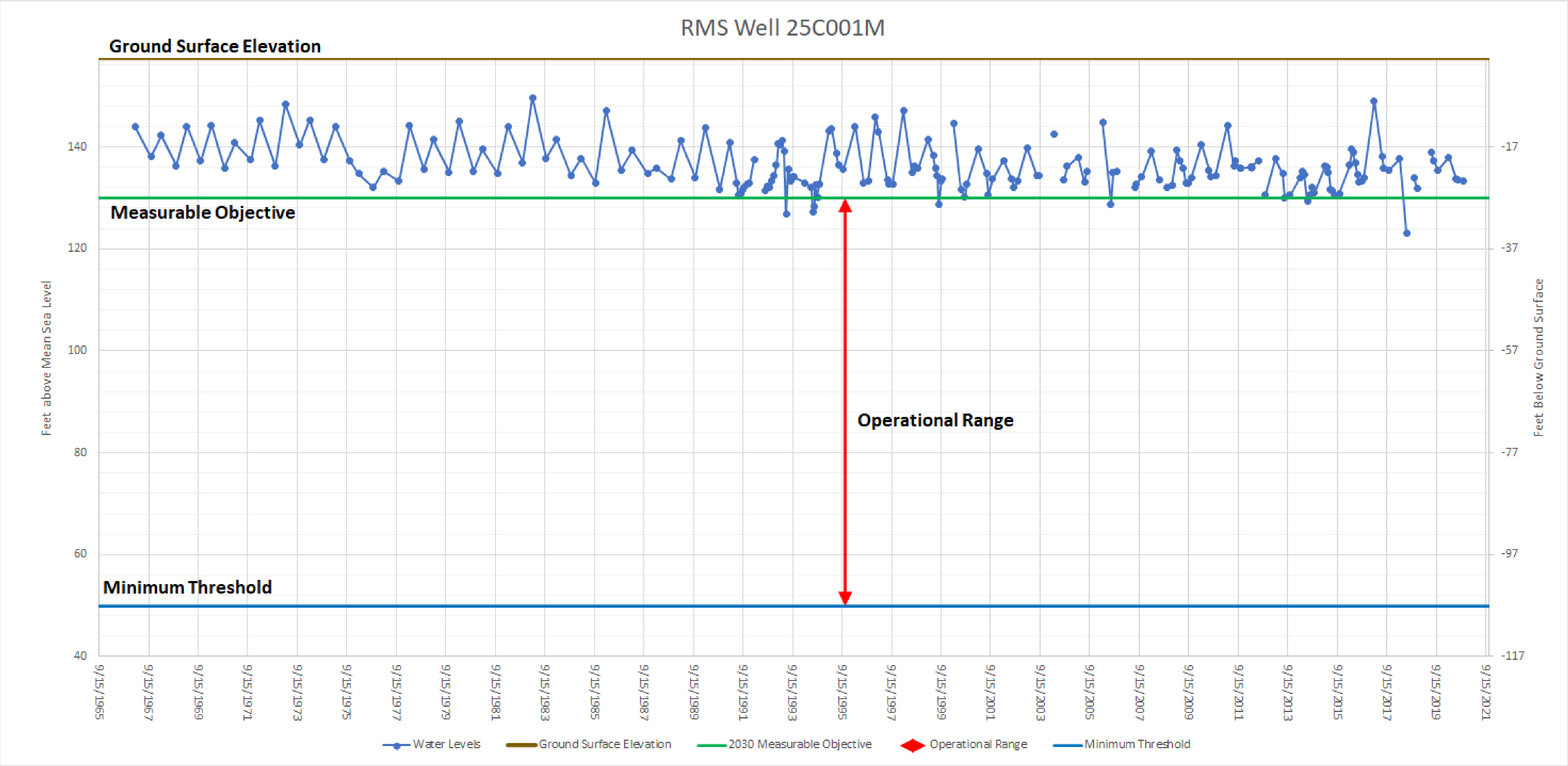
71.22	Elevation where the total depth of 15 Percent of Domestic wells within RMS Well Radius are Shallower Than
32.74	Elevation of the mean total depth of Domestic wells within RMS Well Radius
32.74	Total number of domestic wells completed after 1980 located within RMS Well Radius. Does not include wells located outside of the management area.

Appendix 3-2

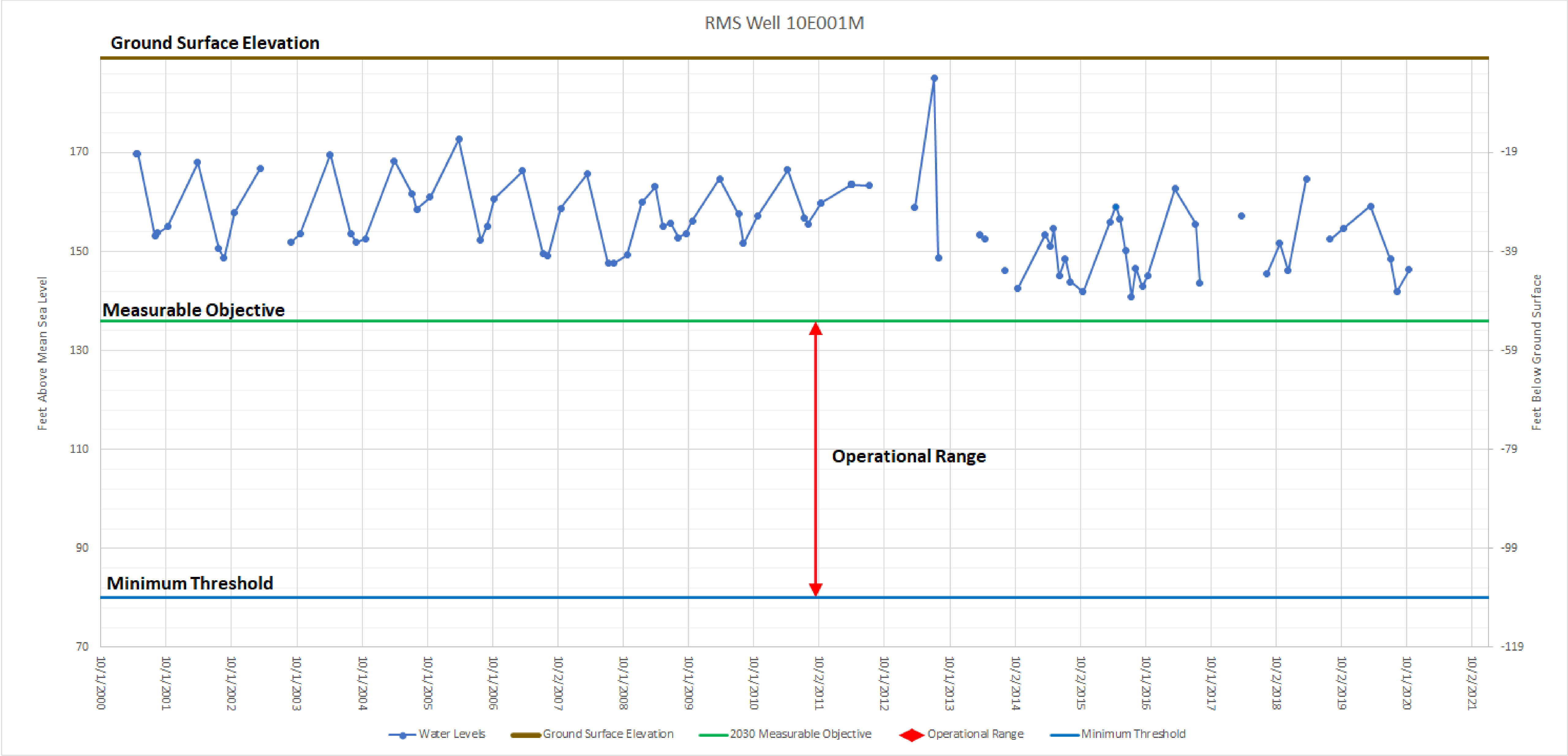
RMS Well Hydrographs

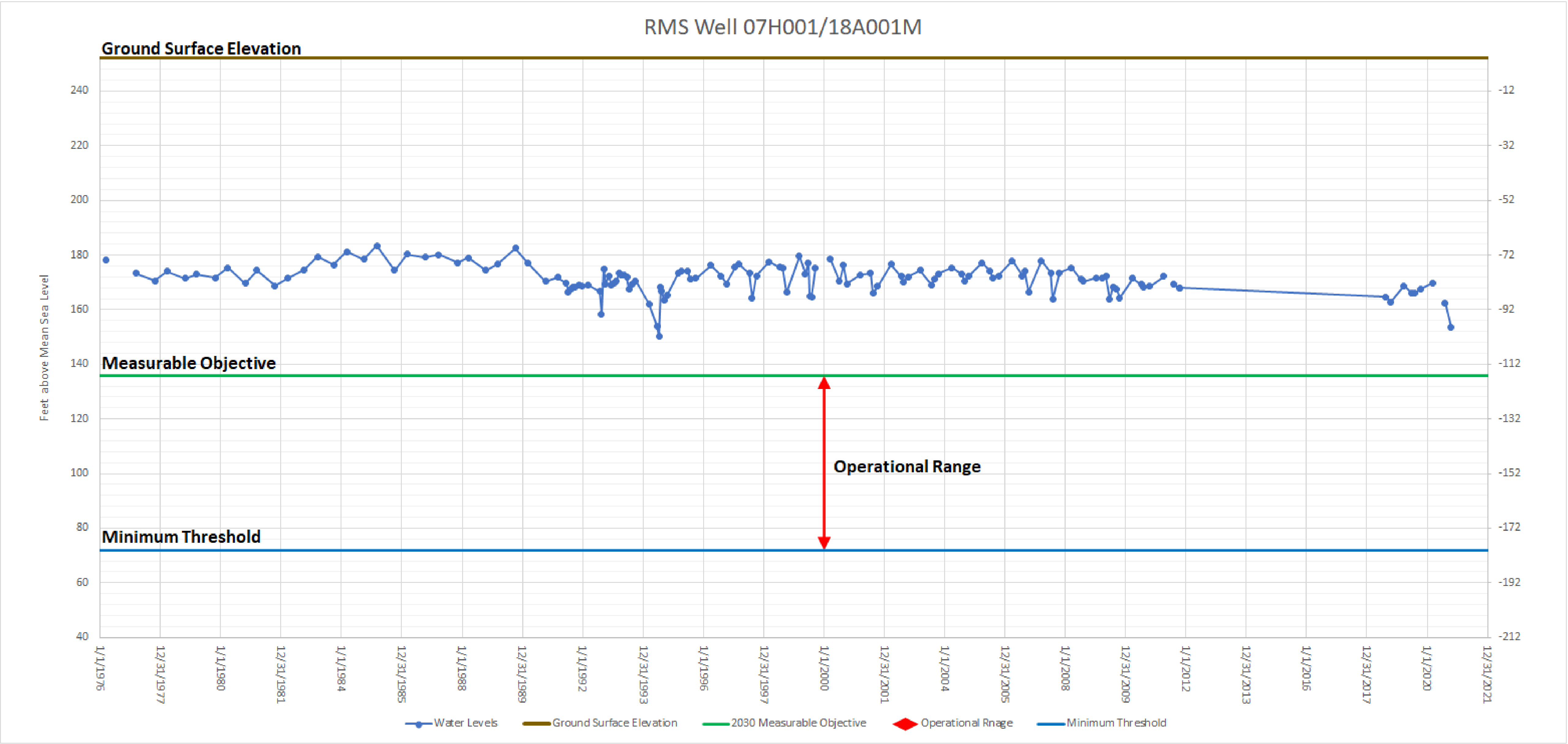
Vina Subbasin

North Management Area

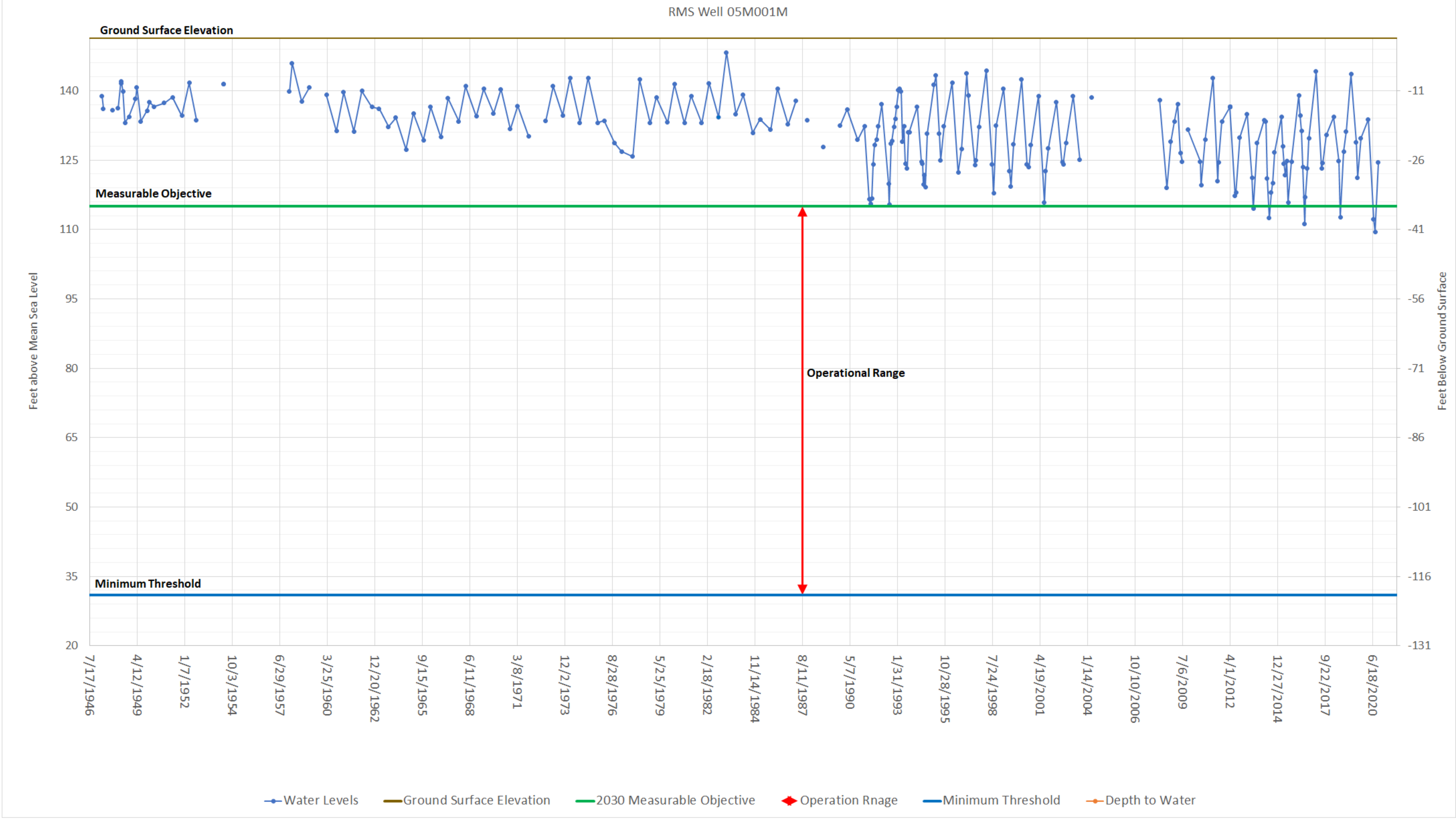


RMS Well 25C001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
140
120
100
80
60
40
-17
-37
-57
-77
-97
-117
9/15/1965
9/15/1967
9/15/1969
9/15/1971
9/15/1973
9/15/1975
9/15/1977
9/15/1979
9/15/1981
9/15/1983
9/15/1985
9/15/1987
9/15/1989
9/15/1991
9/15/1993
9/15/1995
9/15/1997
9/15/1999
9/15/2001
9/15/2003
9/15/2005
9/15/2007
9/15/2009
9/15/2011
9/15/2013
9/15/2015
9/15/2017
9/15/2019
9/15/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Range
Minimum Threshold

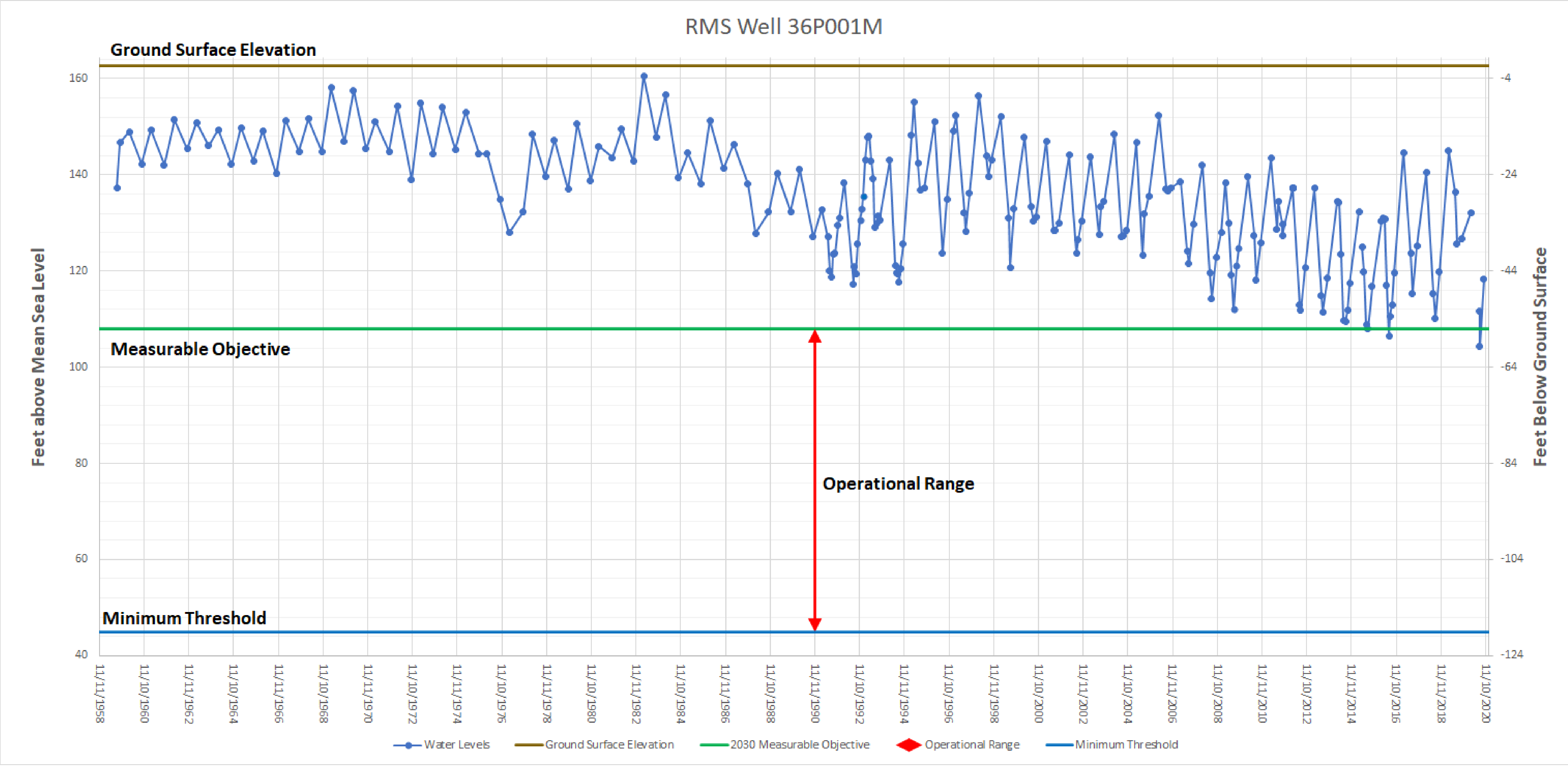

RMS Well 10E001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet Above Mean Sea Level
Feet Below Ground Surface
170
150
130
110
90
70
-19
-39
-59
-79
-99
-119
10/1/2000
10/1/2001
10/1/2002
10/1/2003
10/1/2004
10/1/2005
10/1/2006
10/2/2007
10/1/2008
10/1/2009
10/1/2010
10/2/2011
10/1/2012
10/1/2013
10/2/2014
10/2/2015
10/1/2016
10/1/2017
10/2/2018
10/2/2019
10/1/2020
10/2/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Range
Minimum Threshold



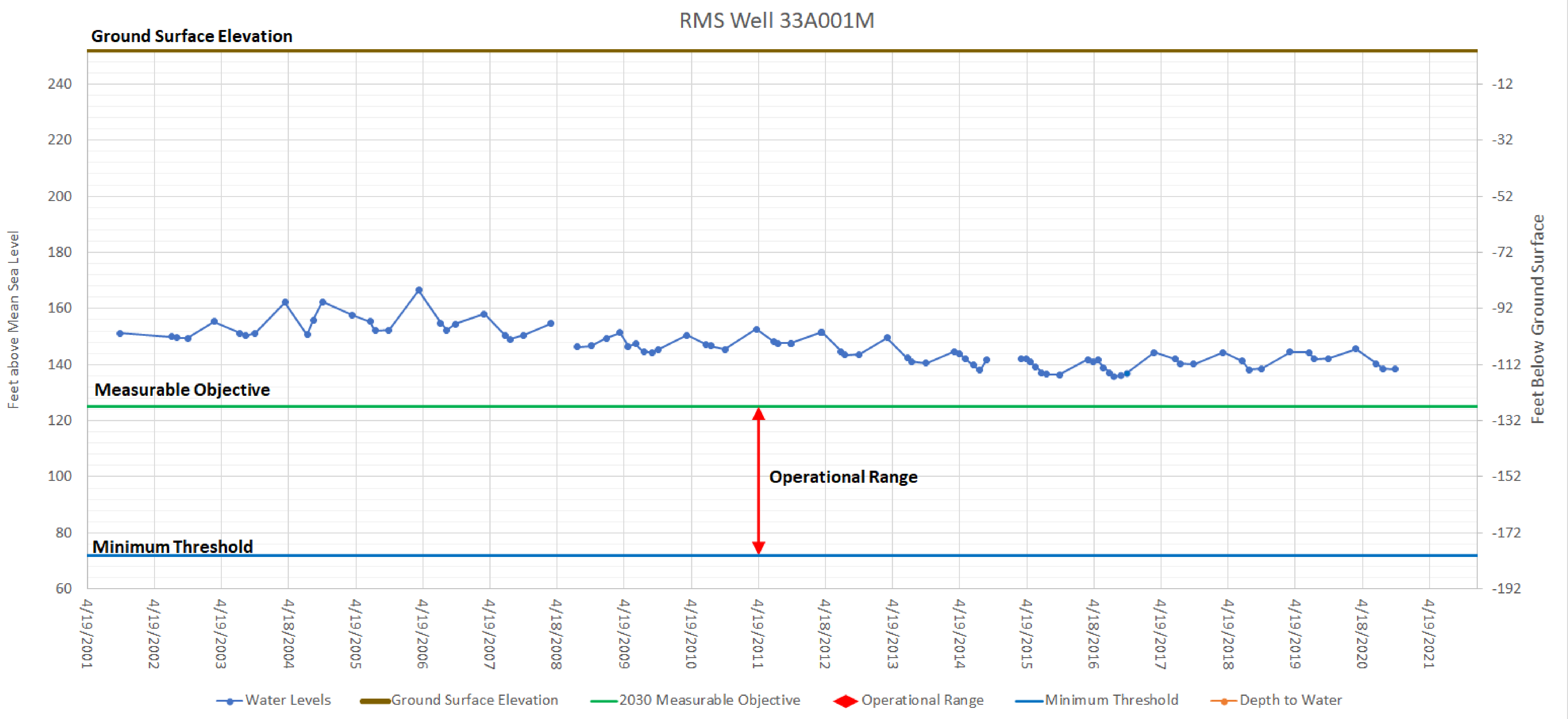
RMS Well 07H001/18A001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
240
220
200
180
160
140
120
100
80
60
40
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
-212
1/1/1976
12/31/1977
1/1/1980
12/31/1981
1/1/1984
12/31/1985
1/1/1988
12/31/1989
1/1/1992
12/31/1993
1/1/1996
12/31/1997
1/1/2000
12/31/2001
1/1/2004
12/31/2005
1/1/2008
12/31/2009
1/1/2012
12/31/2013
1/1/2016
12/31/2017
1/1/2020
12/31/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold



RMS Well 05M001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
140
125
110
95
80
65
50
35
20
-11
-26
-41
-56
-71
-86
-101
-116
-131
7/17/1946
4/12/1949
1/7/1952
10/3/1954
6/29/1957
3/25/1960
12/20/1962
9/15/1965
6/11/1968
3/8/1971
12/2/1973
8/28/1976
5/25/1979
2/18/1982
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
4/1/2012
12/27/2014
9/22/2017
6/18/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operation Rnage
Minimum Threshold
Depth to Water



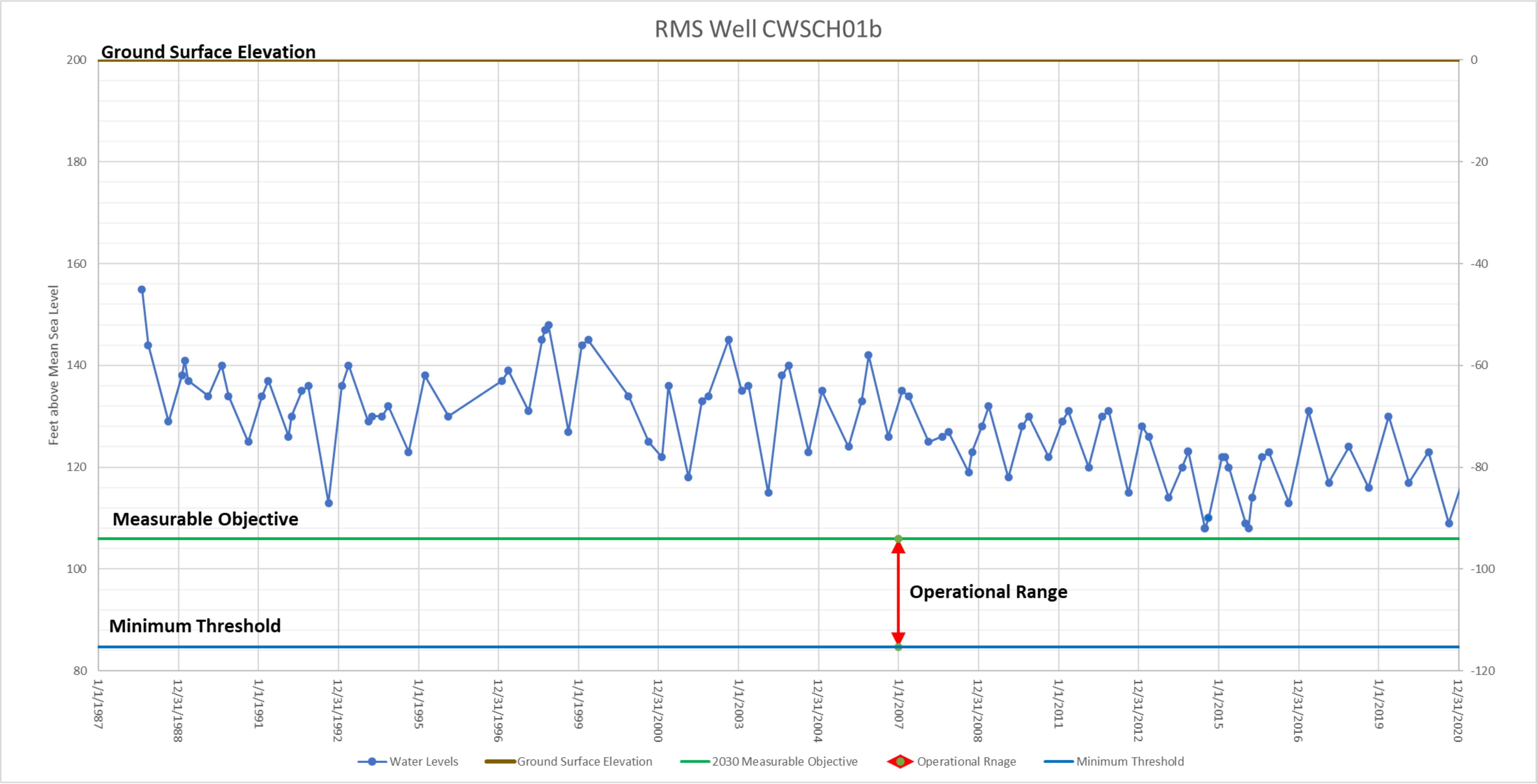
RMS Well 36P001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
160
140
120
100
80
60
40
-4
-24
-44
-64
-84
-104
-124
11/11/1958
11/10/1960
11/11/1962
11/10/1964
11/11/1966
11/10/1968
11/11/1970
11/10/1972
11/11/1974
11/10/1976
11/11/1978
11/10/1980
11/11/1982
11/10/1984
11/11/1986
11/10/1988
11/11/1990
11/10/1992
11/11/1994
11/10/1996
11/11/1998
11/10/2000
11/11/2002
11/10/2004
11/11/2006
11/10/2008
11/11/2010
11/10/2012
11/11/2014
11/10/2016
11/11/2018
11/10/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Range
Minimum Threshold



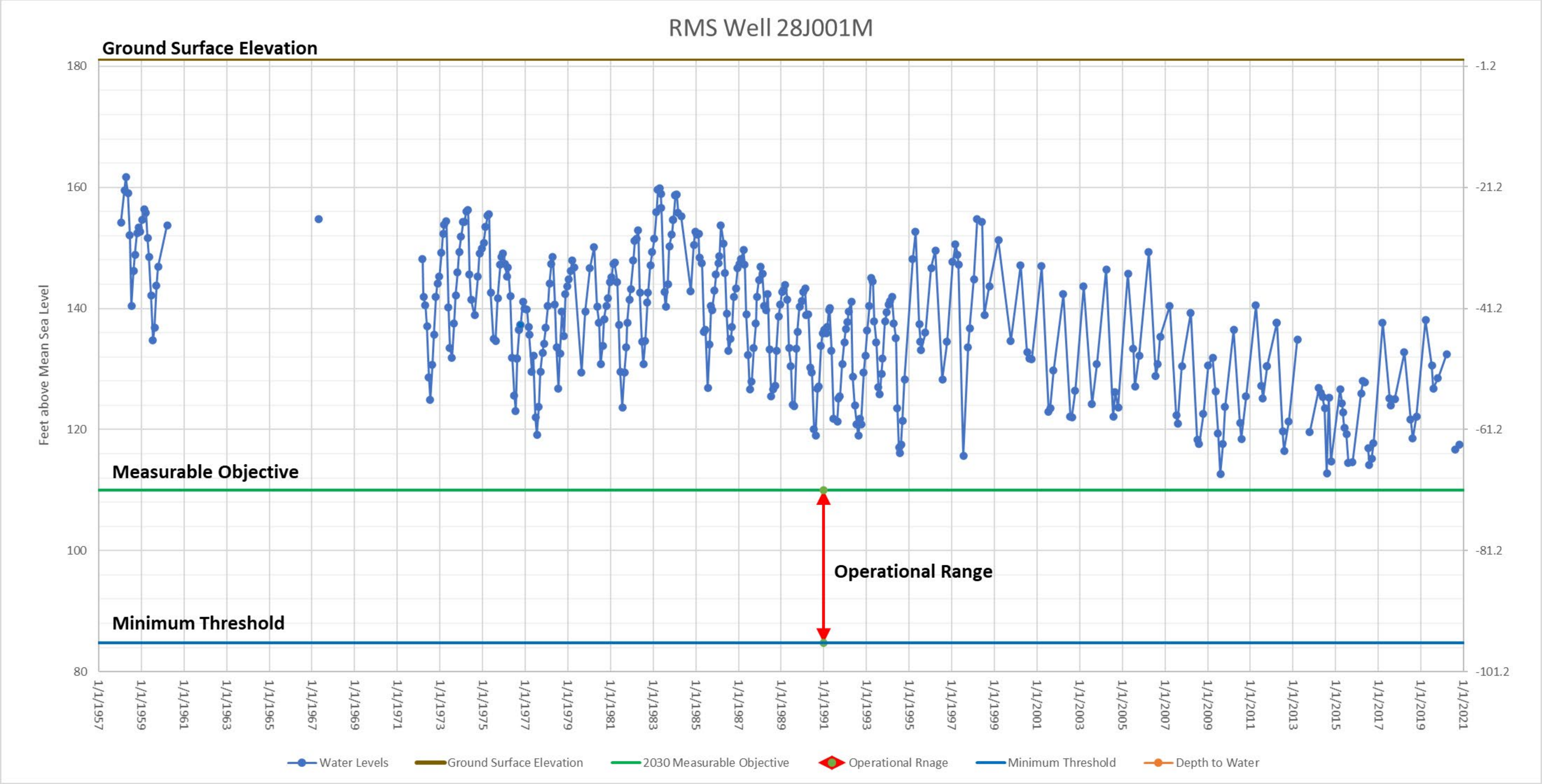
RMS Well 33A001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
240
220
200
180
160
140
120
100
80
60
-12
-32
-52
-72
-92
-112
-132
-152
-172
-192
4/19/2001
4/19/2002
4/19/2003
4/18/2004
4/19/2005
4/19/2006
4/19/2007
4/18/2008
4/19/2009
4/19/2010
4/19/2011
4/18/2012
4/19/2013
4/19/2014
4/19/2015
4/18/2016
4/19/2017
4/19/2018
4/19/2019
4/18/2020
4/19/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Range
Minimum Threshold
Depth to Water

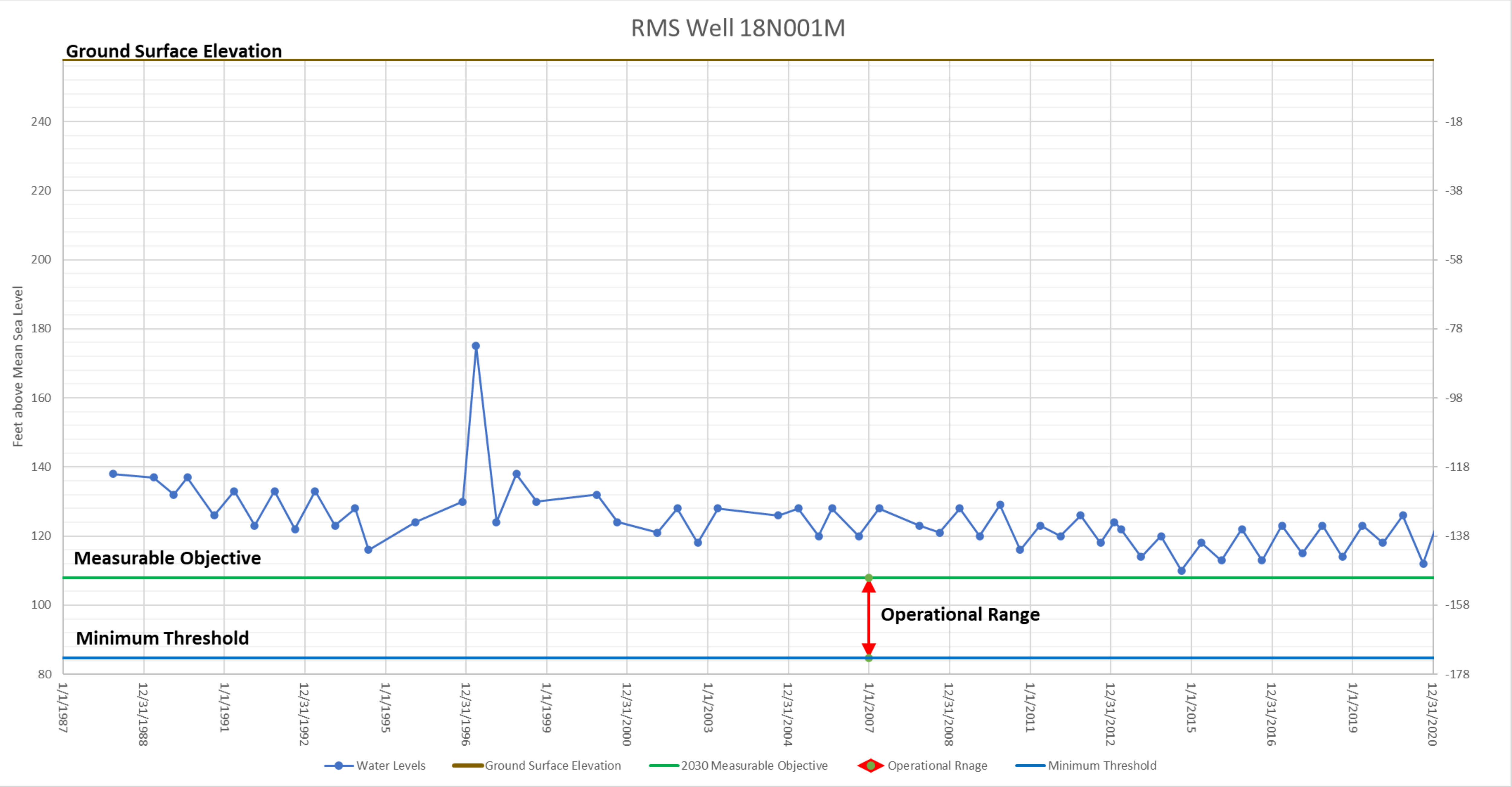
Vina Subbasin

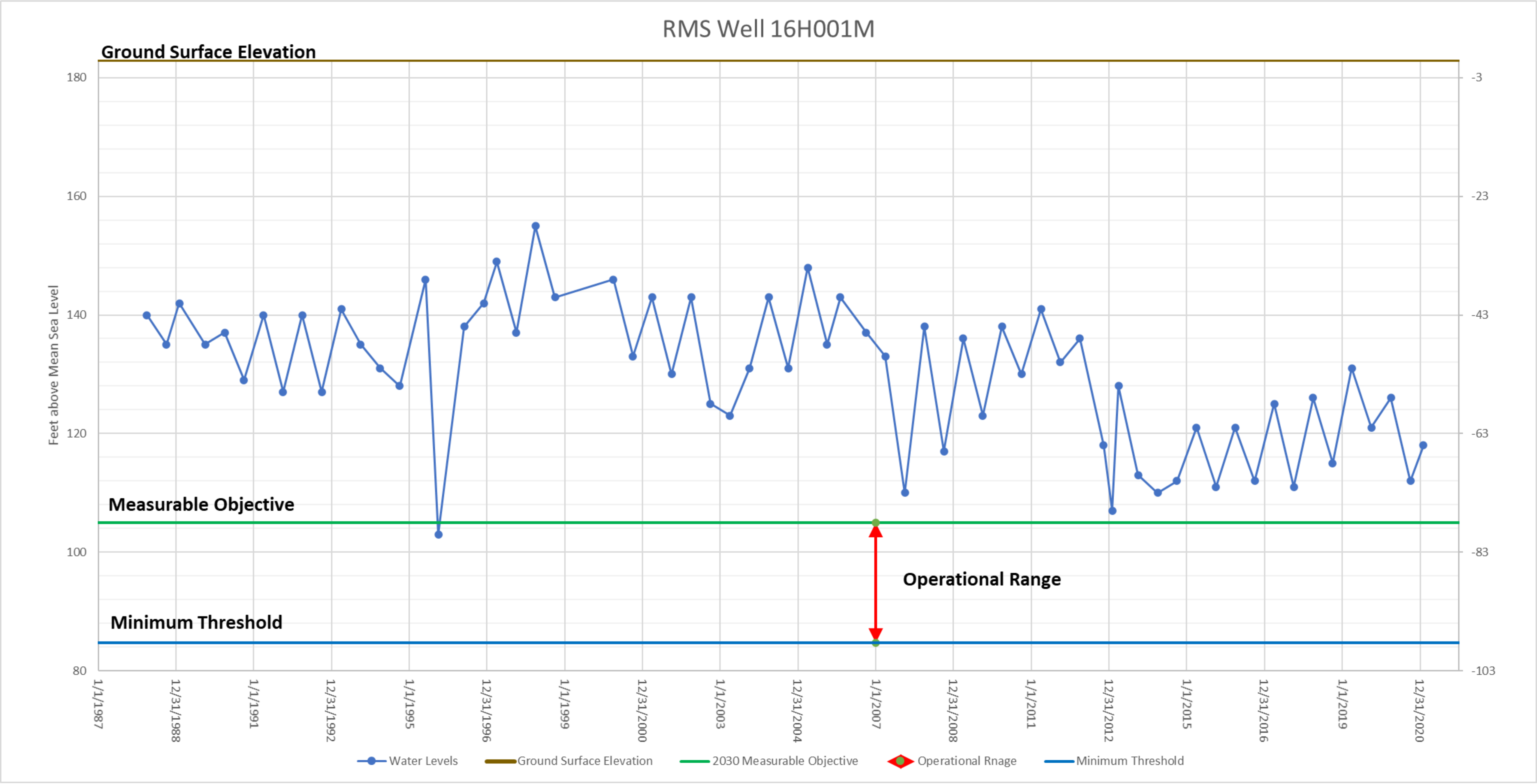
Chico Management Area

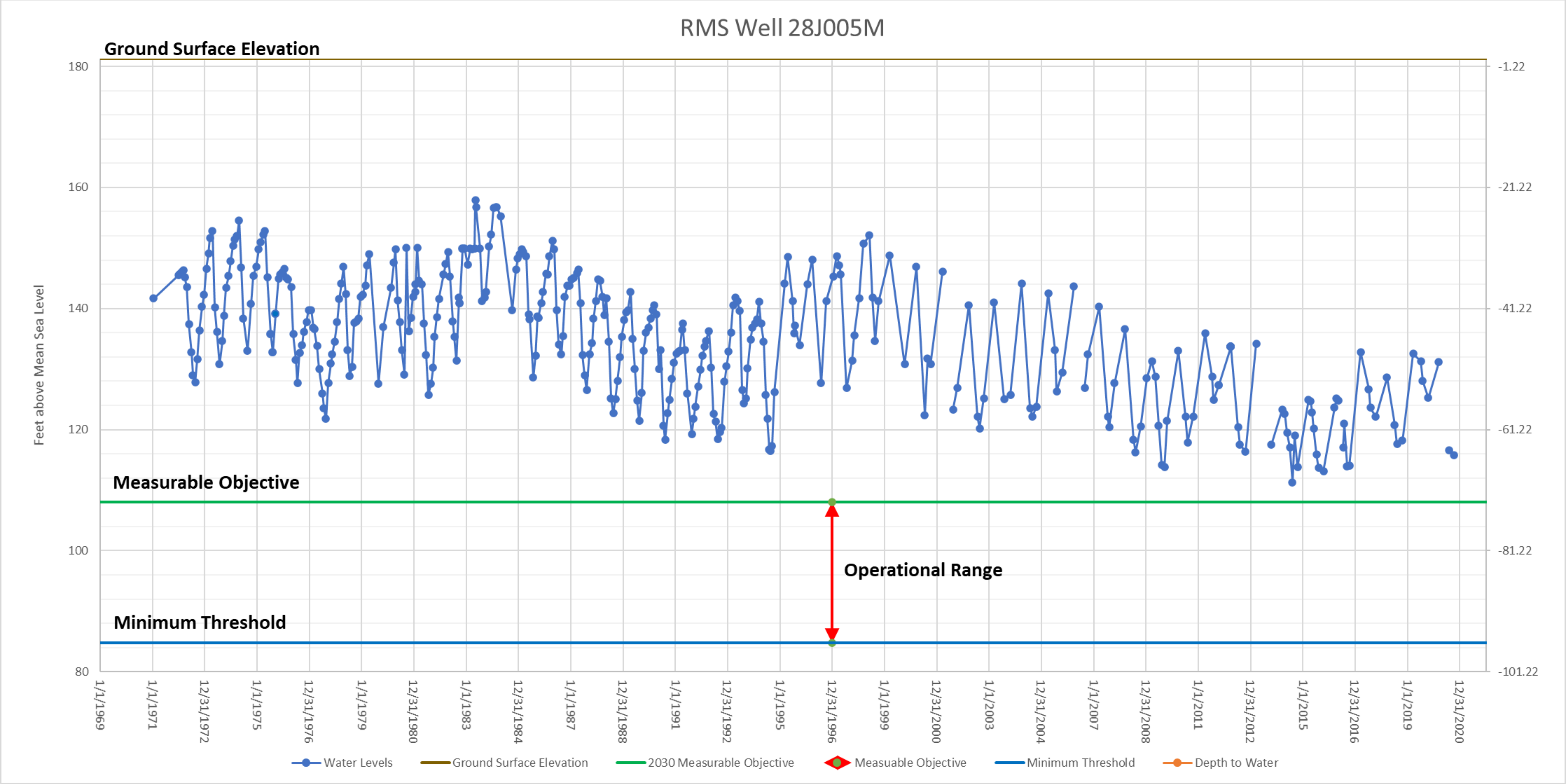


RMS Well CWSCH01b
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
200
180
160
140
120
100
80
0
-20
-40
-60
-80
-100
-120
1/1/1987
12/31/1988
1/1/1991
12/31/1992
1/1/1995
12/31/1996
1/1/1999
12/31/2000
1/1/2003
12/31/2004
1/1/2007
12/31/2008
1/1/2011
12/31/2012
1/1/2015
12/31/2016
1/1/2019
12/31/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold


RMS Well 28J001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
180
160
140
120
100
80
-1.2
-21.2
-41.2
-61.2
-81.2
-101.2
1/1/1957
1/1/1959
1/1/1961
1/1/1963
1/1/1965
1/1/1967
1/1/1969
1/1/1971
1/1/1973
1/1/1975
1/1/1977
1/1/1979
1/1/1981
1/1/1983
1/1/1985
1/1/1987
1/1/1989
1/1/1991
1/1/1993
1/1/1995
1/1/1997
1/1/1999
1/1/2001
1/1/2003
1/1/2005
1/1/2007
1/1/2009
1/1/2011
1/1/2013
1/1/2015
1/1/2017
1/1/2019
1/1/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold
Depth to Water


RMS Well 18N001M
Ground Surface Elevation
Feet above Mean Sea Level
240
220
200
180
160
140
120
100
80
-18
-38
-58
-78
-98
-118
-138
-158
-178
Measurable Objective
Operational Range
Minimum Threshold
1/1/1987
12/31/1988
1/1/1991
12/31/1992
1/1/1995
12/31/1996
1/1/1999
12/31/2000
1/1/2003
12/31/2004
1/1/2007
12/31/2008
1/1/2011
12/31/2012
1/1/2015
12/31/2016
1/1/2019
12/31/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold

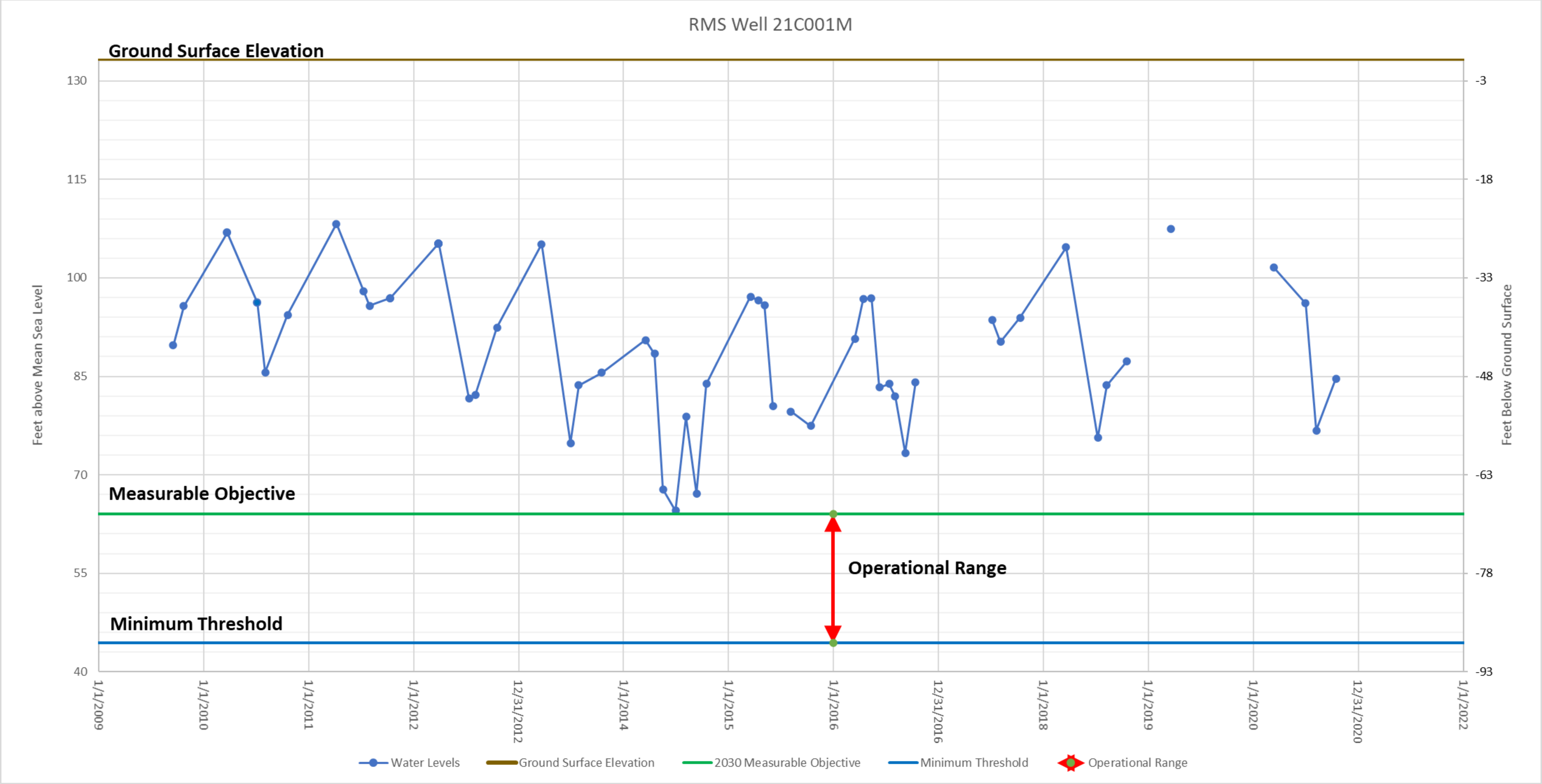

RMS Well 16H001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
180
160
140
120
100
80
-3
-23
-43
-63
-83
-103
1/1/1987
12/31/1988
1/1/1991
12/31/1992
1/1/1995
12/31/1996
1/1/1999
12/31/2000
1/1/2003
12/31/2004
1/1/2007
12/31/2008
1/1/2011
12/31/2012
1/1/2015
12/31/2016
1/1/2019
12/31/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold



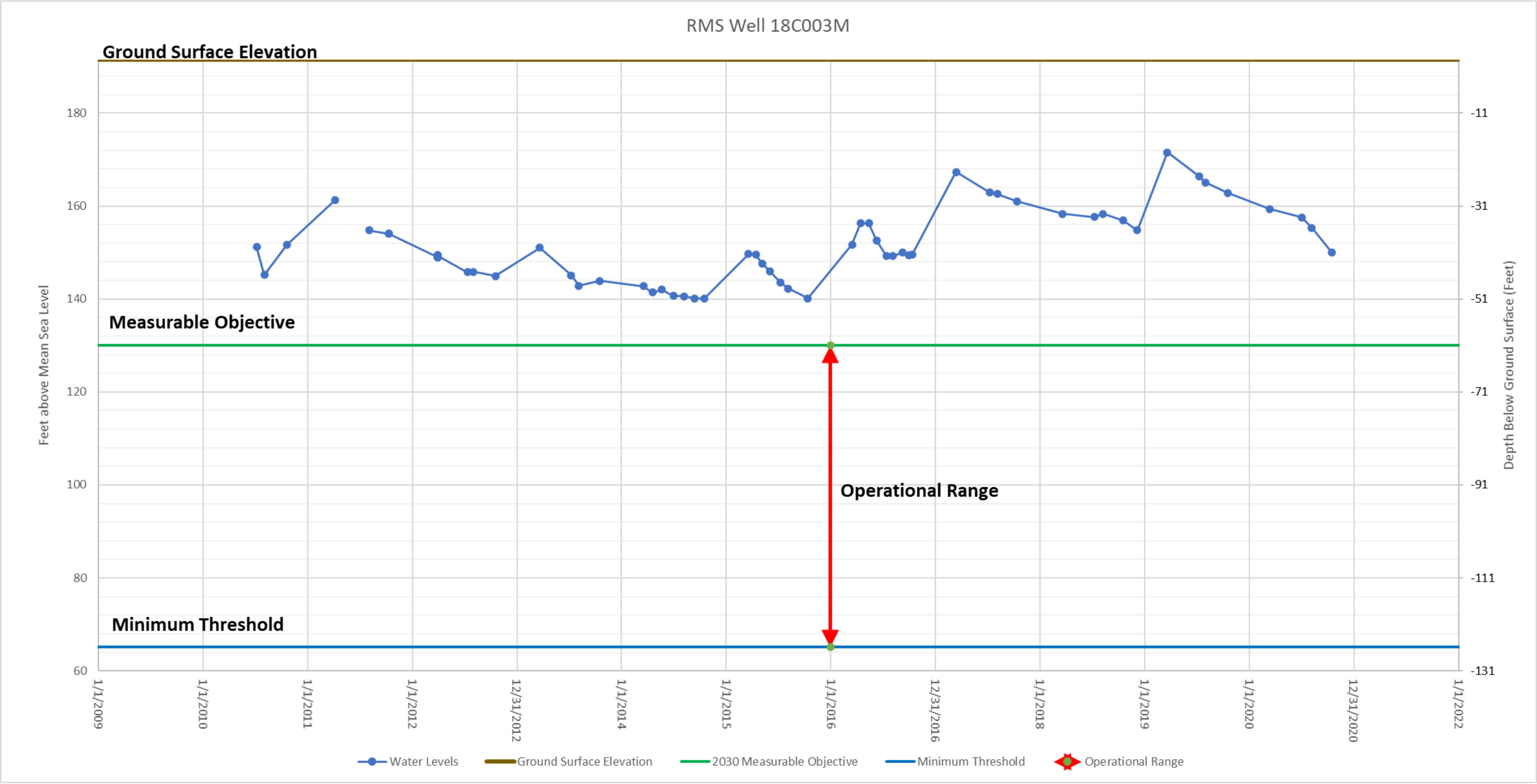
RMS Well 28J005M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
180
160
140
120
100
80
-1.22
-21.22
-41.22
-61.22
-81.22
-101.22
1/1/1969
1/1/1971
12/31/1972
1/1/1975
12/31/1976
1/1/1979
12/31/1980
1/1/1983
12/31/1984
1/1/1987
12/31/1988
1/1/1991
12/31/1992
1/1/1995
12/31/1996
1/1/1999
12/31/2000
1/1/2003
12/31/2004
1/1/2007
12/31/2008
1/1/2011
12/31/2012
1/1/2015
12/31/2016
1/1/2019
12/31/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Measuable Objective
Minimum Threshold
Depth to Water

Vina Subbasin

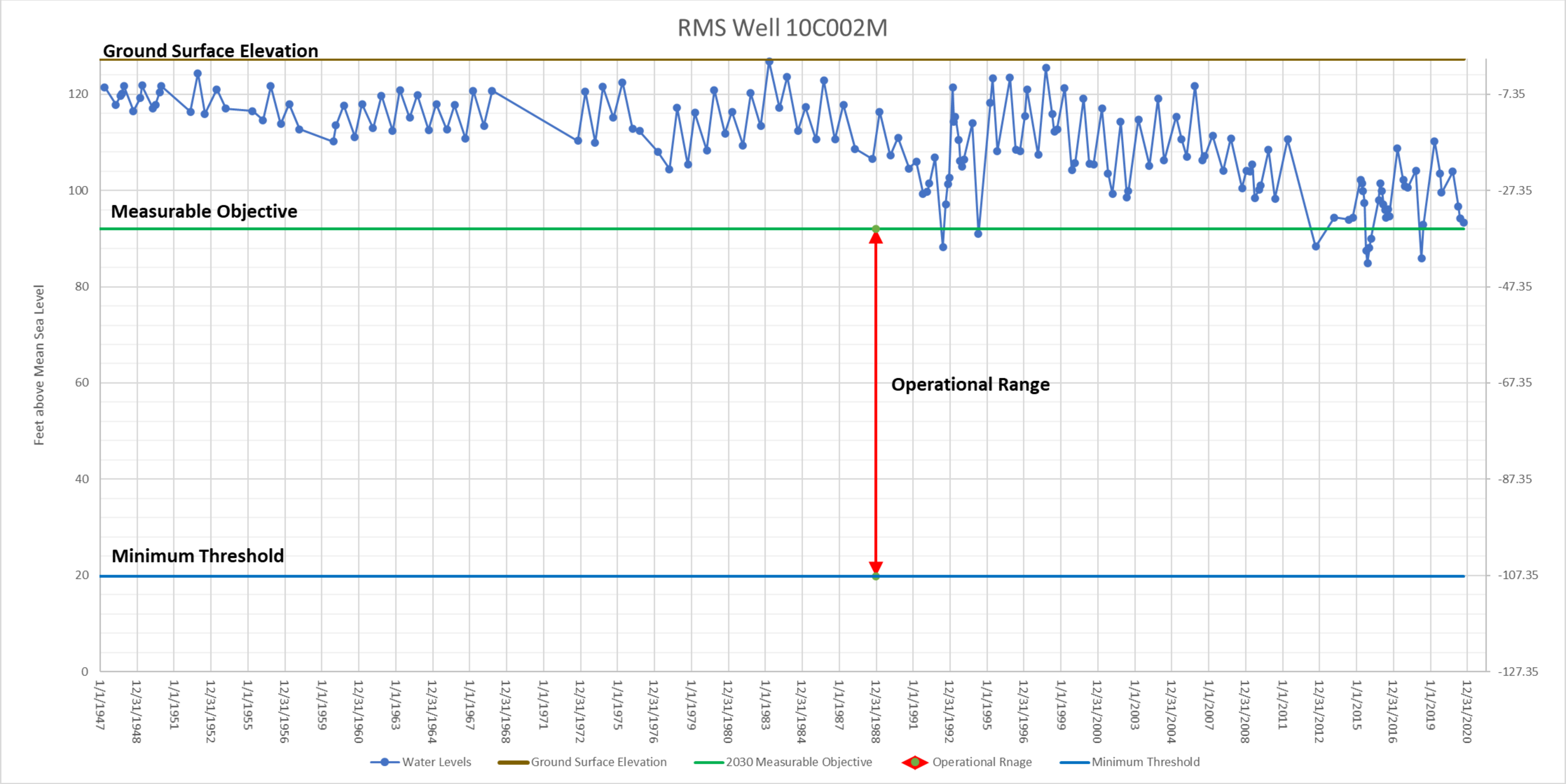
South Management Area



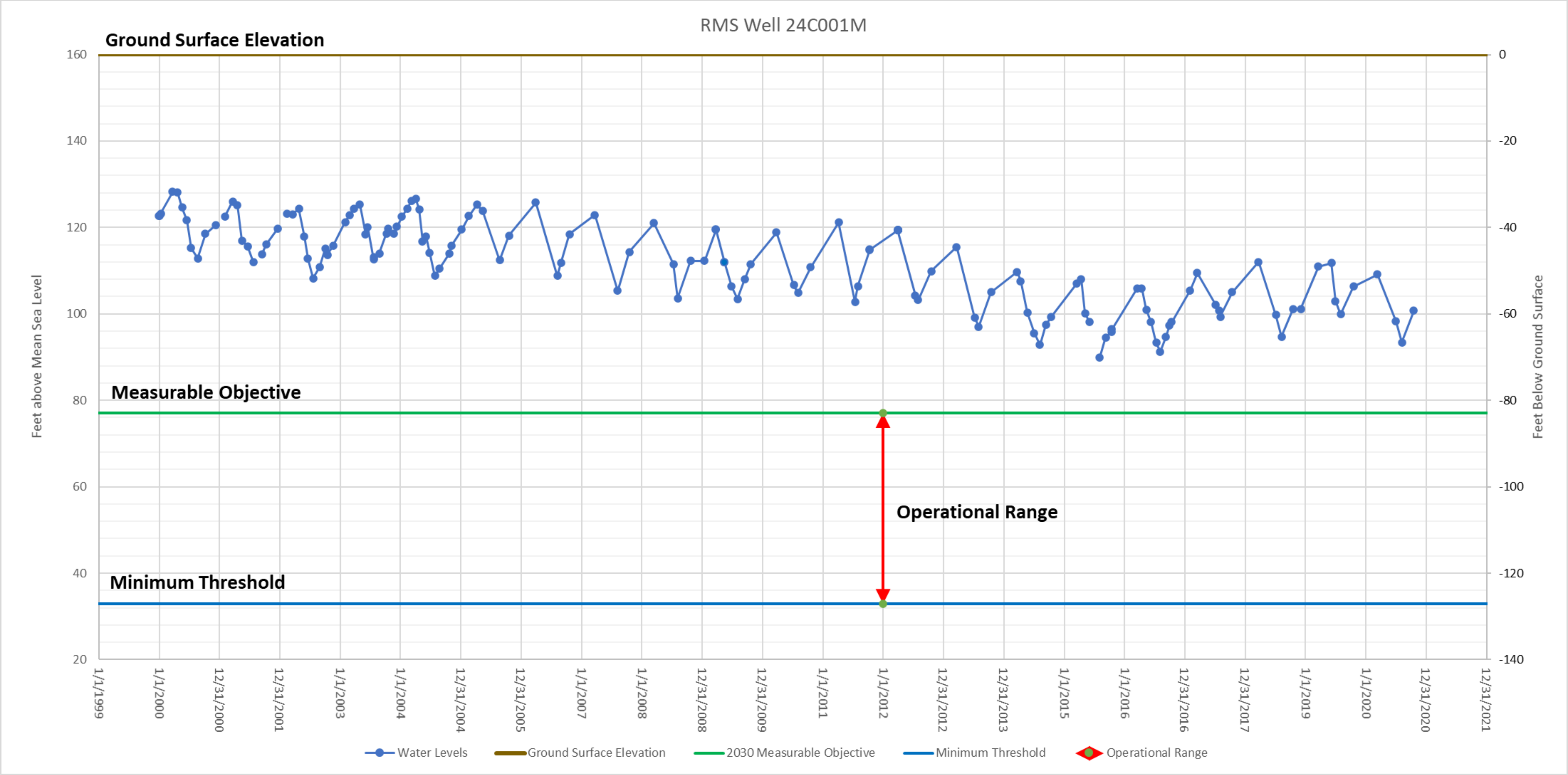
RMS Well 21C001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
130
115
100
85
70
55
40
-3
-18
-33
-48
-63
-78
-93
1/1/2009
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
1/1/2016
12/31/2016
1/1/2018
1/1/2019
1/1/2020
12/31/2020
1/1/2022
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Minimum Threshold
Operational Range



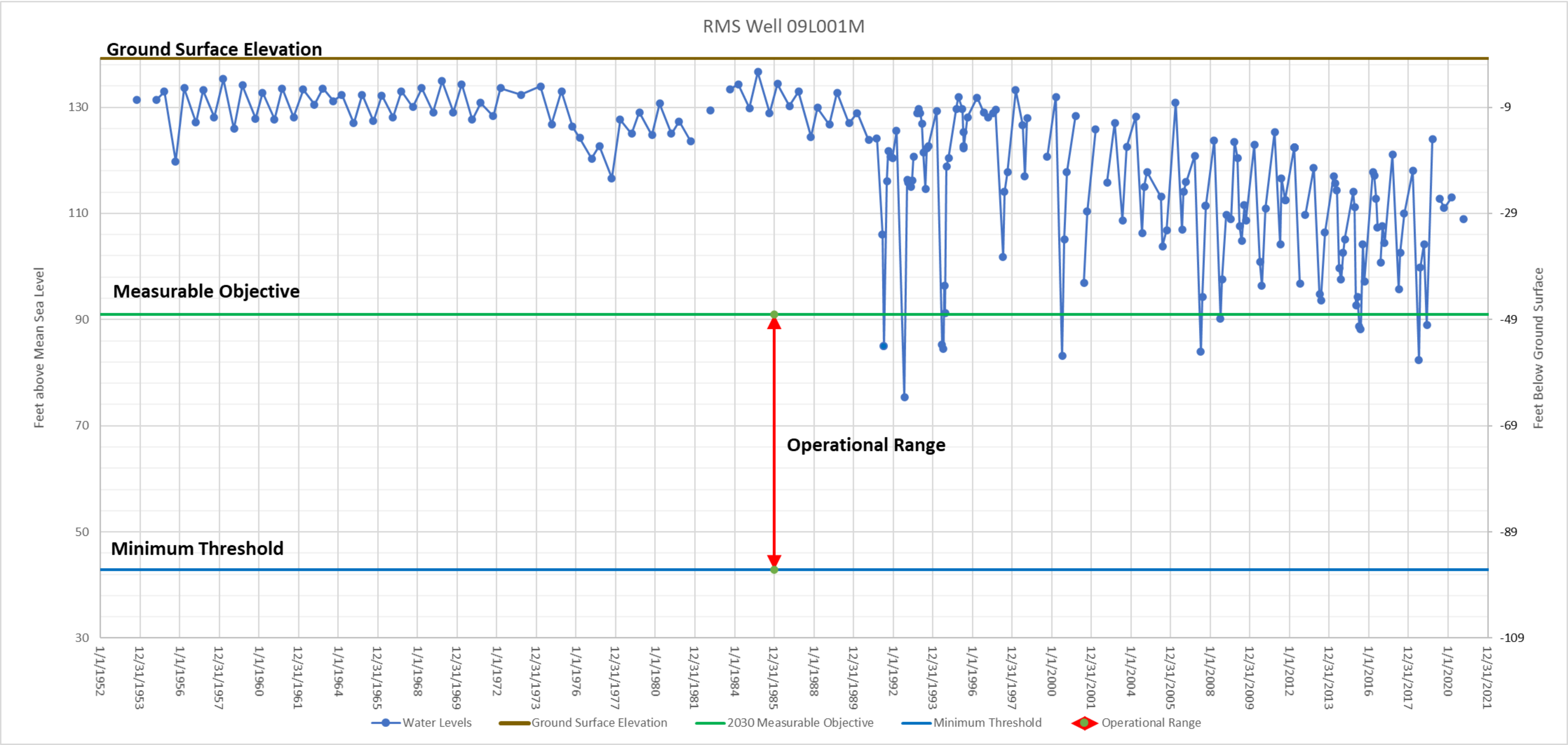
RMS Well 18C003M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Depth Below Ground Surface (Feet)
180
160
140
120
100
80
60
-11
-31
-51
-71
-91
-111
-131
1/1/2009
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
1/1/2016
12/31/2016
1/1/2018
1/1/2019
1/1/2020
12/31/2020
1/1/2022
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Minimum Threshold
Operational Range



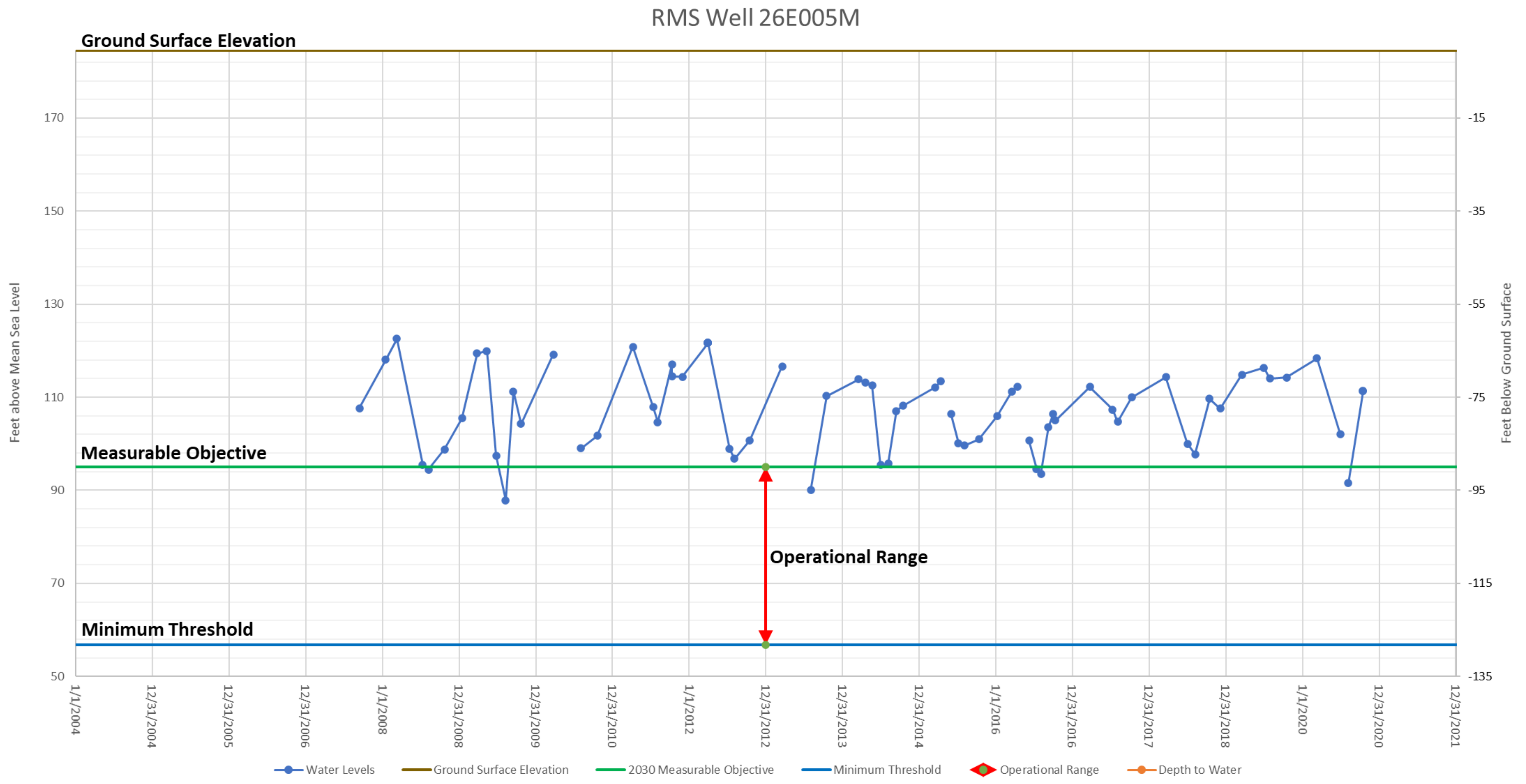
RMS Well 10C002M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
120
100
80
60
40
20
0
-7.35
-27.35
-47.35
-67.35
-87.35
-107.35
-127.35
1/1/1947
12/31/1948
1/1/1951
12/31/1952
1/1/1955
12/31/1956
1/1/1959
12/31/1960
1/1/1963
12/31/1964
1/1/1967
12/31/1968
1/1/1971
12/31/1972
1/1/1975
12/31/1976
1/1/1979
12/31/1980
1/1/1983
12/31/1984
1/1/1987
12/31/1988
1/1/1991
12/31/1992
1/1/1995
12/31/1996
1/1/1999
12/31/2000
1/1/2003
12/31/2004
1/1/2007
12/31/2008
1/1/2011
12/31/2012
1/1/2015
12/31/2016
1/1/2019
12/31/2020
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Operational Rnage
Minimum Threshold



RMS Well 24C001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
1/1/1999
1/1/2000
12/31/2000
12/31/2001
1/1/2003
1/1/2004
12/31/2004
12/31/2005
1/1/2007
1/1/2008
12/31/2008
12/31/2009
1/1/2011
1/1/2012
12/31/2012
12/31/2013
1/1/2015
1/1/2016
12/31/2016
12/31/2017
1/1/2019
1/1/2020
12/31/2020
12/31/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Minimum Threshold
Operational Range



RMS Well 09L001M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
130
110
90
70
50
30
-9
-29
-49
-69
-89
-109
1/1/1952
12/31/1953
1/1/1956
12/31/1957
1/1/1960
12/31/1961
1/1/1964
12/31/1965
1/1/1968
12/31/1969
1/1/1972
12/31/1973
1/1/1976
12/31/1977
1/1/1980
12/31/1981
1/1/1984
12/31/1985
1/1/1988
12/31/1989
1/1/1992
12/31/1993
1/1/1996
12/31/1997
1/1/2000
12/31/2001
1/1/2004
12/31/2005
1/1/2008
12/31/2009
1/1/2012
12/31/2013
1/1/2016
12/31/2017
1/1/2020
12/31/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Minimum Threshold
Operational Range



RMS Well 26E005M
Ground Surface Elevation
Measurable Objective
Operational Range
Minimum Threshold
Feet above Mean Sea Level
Feet Below Ground Surface
170
150
130
110
90
70
50
-15
-35
-55
-75
-95
-115
-135
1/1/2004
12/31/2004
12/31/2005
12/31/2006
1/1/2008
12/31/2008
12/31/2009
12/31/2010
1/1/2012
12/31/2012
12/31/2013
12/31/2014
1/1/2016
12/31/2016
12/31/2017
12/31/2018
1/1/2020
12/31/2020
12/31/2021
Water Levels
Ground Surface Elevation
2030 Measurable Objective
Minimum Threshold
Operational Range
Depth to Water

Appendix 3-3

Groundwater Dependent Ecosystems

Appendix 3-3: Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined in the SGMA regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [Cal. Code of Regs, title 23, § 351(m)]. Groundwater Dependent Ecosystems exist within the Vina subbasin largely where vegetation accesses shallow groundwater for survival; and in areas with streams and creeks where a connection to groundwater exists. Without access to shallow groundwater, these plants and the ecosystems supported by the hydrology would die.

<u>NCCAG Database</u>

The initial identification of GDEs for this GSP was performed by using the Natural Communities Commonly Associated with Groundwater (NCCAG) database to identify and map potential GDEs (iGDEs) in the Vina subbasin. The NCCAG database was developed by a working group comprised of DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) by reviewing publicly available state and federal agency datasets that have mapped California vegetation, wetlands, springs and seeps and by conducting a screening process to retain types and locations of these commonly associated with groundwater. The results were compiled into the NCCAG database with two habitat classes defined. The first class includes wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions. The second class includes vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes). Figures 1 and 2 show the locations of all iGDEs identified by the NCCAG database within the Vina subbasin.

Figure 1. Potential Groundwater Dependent Ecosystems (iGDEs) in the northern portion of the Vina subbasin as identified in the Natural Communities Commonly Associated with Groundwater (NCCAG) database developed by The Nature Conservancy.

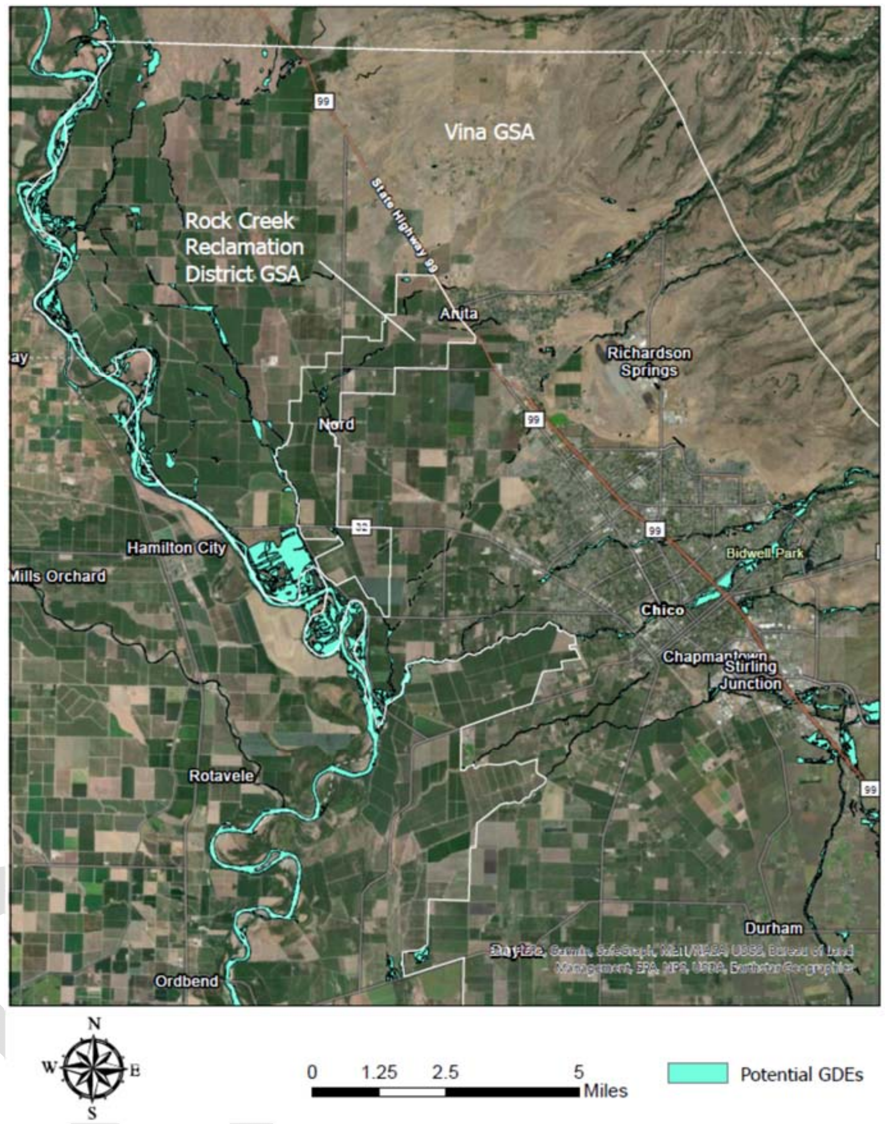
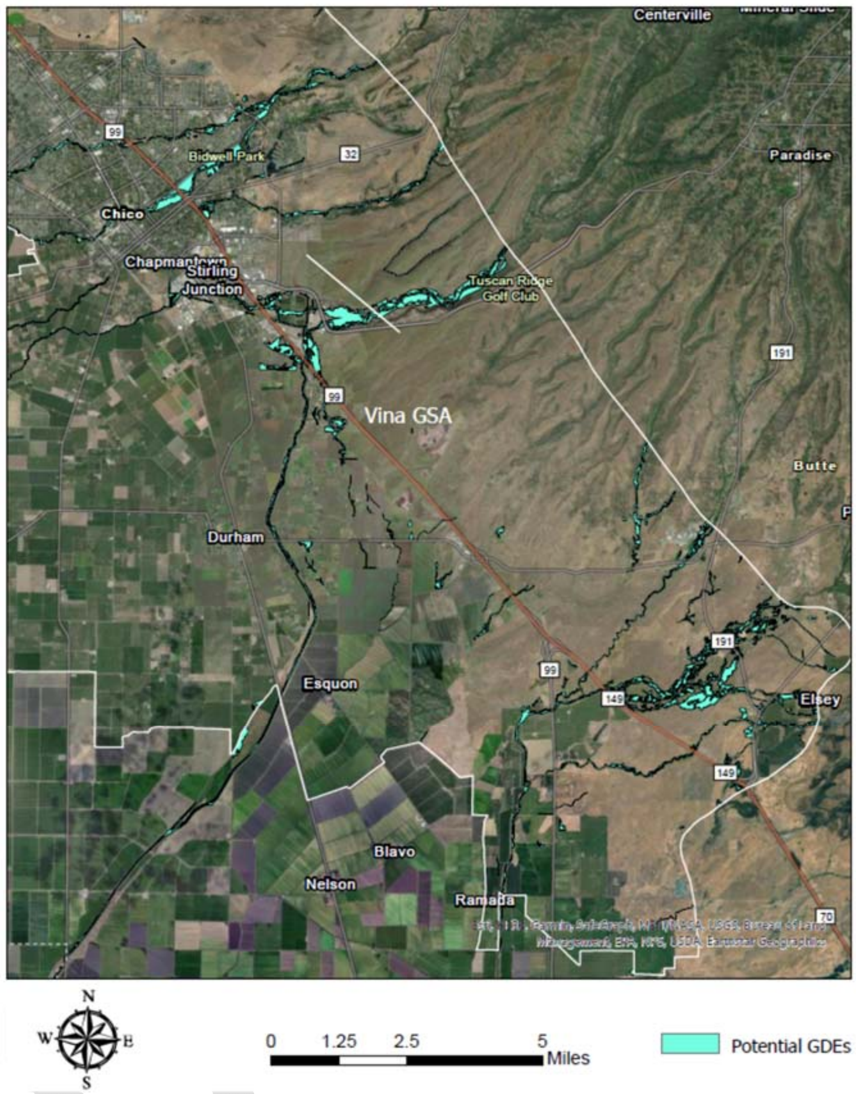


Figure 2. Potential Groundwater Dependent Ecosystems (iGDEs) in the southern portion of the Vina subbasin as identified in the Natural Communities Commonly Associated with Groundwater (NCCAG) database developed by The Nature Conservancy.



The NCCAG dataset is based on 48 layers of publicly available data developed by state or federal agencies that map vegetation, wetlands, springs, and seeps in California (DWR, 2019). A NCCAG technical working group with representatives from DWR, CDFW, and TNC reviewed the datasets compiled to assemble the NCCAG dataset. The NCCAG dataset attempts to extract mapped vegetation and wetland features that have indicators suggesting dependence on groundwater. The data presented in NCCAG dataset display vegetation polygons that have indicators of GDEs based on published and/or field observations of phreatophytic vegetation defined as a “deep-rooted plant that obtains water that it needs from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone” (Rhoade et.al., 2018). The dominance of phreatophytic plant species in a mapped vegetation type is a primary indicator of GDEs. A list of plant species considered to be phreatophytes based on peer-reviewed scientific literature on rooting depths, published lists of phreatophytes, expert field observations, and vegetation alliance descriptions is publicly available (Klausmeyer et al., 2018; DWR, 2018).

While developing the NCCAG dataset of areas with indicators of GDEs, the technical working group attempted to exclude vegetation and wetland types and polygons that are less likely to be associated with groundwater (Klausmeyer et al., 2018). The NCCAG working group attempted to remove any polygons that are not likely to be GDEs where they occurred in areas where they are likely to be supported by alternate artificial water sources (e.g. local seepage from agricultural irrigation canals), or where appropriate available data indicated the shallow groundwater depth is located well below the rooting zone, (Klausmeyer et al., 2018).

The vegetation data presented in the NCCAG dataset is a latest available starting point for the identification of GDEs as the dataset includes the best available public datasets and has been screened to include only areas that have indicators of groundwater dependent vegetation. DWR has stated that use of the NCCAG dataset is not mandatory and does not represent DWR's determination of a GDE (DWR, 2018). Rather, the NCCAG dataset can provide a starting point for the identification of GDEs within a groundwater basin.

Additional information, such as near surface groundwater depth obtained from piezometers, information about subsurface stratigraphy and geology on confining layers, and information on local land use and hydrology can be used to confirm whether vegetation in areas identified by the NCCAG as iGDEs is, in fact, reliant on groundwater.

<u>Initial iGDE Analysis</u>
GSA Managers from the subbasin used this database as a starting point to analyze a portion of the total iGDEs in the NCCAG database to evaluate local groundwater dependence. The GSA Managers applied specific criteria to each polygon under analysis to answer a series of questions that led to an eventual characterization for each iGDE. These iGDEs were designated as either "Likely a GDEs", "Not likely a GDEs" or "Uncertain" based on their evaluations. The criteria aimed at understanding each iGDE's dependence on groundwater including questions about land use changes, proximity to perennial surface water supplies, irrigated agriculture and agricultural dependent surface water, condition of vegetation during drought years and water applications to the iGDEs.

The first phase of the analysis was conducted by thorough review of aerial photographs from Google Earth across multiple years specifically focusing on the 2007, 2009, 2013 and 2015 drought years as well as use of the Managers' local knowledge of these areas.

<u>iGDE Designations</u>
While there were some areas identified as "Not likely a GDE" during this effort, Managers were also able to add any iGDEs into the map that were not captured in the original

NCCAG database. NCCAG areas identified as "Not likely a GDE" from the initial analysis by Managers can be categorized as follows.

Not Likely a GDE Due to Significant Land Use Change

Some areas in the NCCAG database may have changed in land use since the database was published. Developed areas where there have been significant land use changes to the iGDE i.e. land transitioned to cultivated irrigated agricultural lands, industrial or residential development occurred or lands had undergone man-made changes such as golf courses or other obvious anthropogenic changes were labeled as "Not likely a GDE".

Not Likely a GDE Due to Perennial Surface Water Supplies

Areas with perennial water supplies such as those subject to historical hydraulic gold mining runoff and dredging activities or those near reservoirs were labeled as "Not likely a GDE". In some areas historic mining activities have left tailings of cobbles and coarse gravel which rapidly transmit water. To some extent, it is assumed that pooled water in this area is tied to river stage through direct connections with the river with surface water bodies. Likewise, the reservoirs provide water year-round for adjacent ecosystems. If any iGDEs were located within 150 feet of reservoirs or mine tailings, they were assumed to be able to access the nearby surface water bodies and were labeled as "Not likely a GDE".

Not Likely a GDE Due to Supplemental Water Supplies

Irrigated agriculture, irrigated refuge / managed wetlands or irrigated urban areas with supplemental water deliveries were identified by Managers during the initial GDE analysis effort. These areas are assumed to be accessing supplemental water supplies and not reliant on groundwater and were labeled as "Not likely a GDE".

Not Likely a GDE Due to Adjacency to Irrigated Agricultural Fields

Agricultural lands are dependent on reliable water supplies to ensure a successful harvest. Surface water and / or groundwater pumped from the aquifer is used to irrigate crops in the Vina subbasin. Such irrigation benefits not only the crops, but also surrounding vegetation. Potential GDEs further than 150 feet from irrigated rice fields and areas further than 50 feet from all other irrigated agriculture were assumed to be unable to access irrigation water. These distances are based on professional judgment, including past experience in the region and consideration of the physical characteristics of the Vina subbasin, such as hydraulic conductivity. Rice fields, along with other irrigated agriculture, are known to have percolation and lateral seepage, supplying water to the aquifer and into adjacent areas. Lateral seepage in Sacramento Valley rice areas has been estimated at between 1.0% and 1.9% of the total irrigation volume (LaHue & Lindquist, 2019). A larger distance was used for rice due to the long-term ponding of water and due to restrictive layers in the subsurface that result in the horizontal spreading of irrigation water. Refinement of these distances is included as a project and is discussed in Section xx. Potential GDEs near these irrigated areas are assumed to be accessing irrigation water through lateral movement through the soils, thus, they were labeled as "Not likely a GDE".

Not Likely a GDE Due to Dependence on Agricultural-dependent Surface Water
Similar to areas adjacent to reservoirs, iGDEs adjacent to surface water bodies that are perennial due to agricultural practices and those near drainage canals, are able to access surface water throughout the year. Agricultural water conveyance features i.e. the Cherokee Canal is included in this definition however, this does not include the Sacramento River, Butte Creek, or Honcut Creek because these natural waterways also convey non-agricultural water. Potential GDEs within 150 feet of these agricultural-dependent surface water bodies were assumed to be accessing water from them thus, they were labeled as "Not likely a GDE".

Not Likely a GDE Due to Non-Survival during Drought Conditions
To assess if the iGDE was groundwater dependent, Managers reviewed the condition of the iGDE over multiple dry drought years using aerial photographs from Google Earth. Specifically the group focused on the drought years of 2007, 2009, 2013 and 2015 in addition to the Managers' local knowledge of these areas. Green vegetation over multiple drought years during summer months indicated survival of the iGDE as well as an assumed connection to groundwater. Potential GDEs which did not indicate any surviving conditions over multiple drought years were assumed to not be connected to groundwater and were labeled as "Not likely a GDE".

Uncertain – All Other Areas
The iGDEs analyzed by the Managers in this initial effort, which did not receive a designation as either "Not likely a GDE" or "Likely a GDE" based on the conclusions from the analysis above, were labeled as "Uncertain" and were analyzed in additional analyses as described below.

Additional GIS Analysis
Irrigated Agricultural Land Use
After the initial analysis was completed for a selection of the total iGDEs in the NCCAG database as described above, a Geographical Information Systems (GIS) analysis was performed for all remaining iGDEs in this subbasin by Butte County staff to determine each iGDE's proximity to rice and other irrigated agriculture as described below. The DWR / Land IQ land use and crop mapping data for 2016 (California Department of Water Resources, 2019) was used to determine the dominant crop type throughout the subbasin.

Land classified as "Rice" for the "Crop Type 2016" in the dataset was identified. Then all polygons in the TNC iGDEs dataset within 150 feet of land classified as rice were identified and designated as "Not likely a GDE near irrigated rice" for the same reasons as described above in the *"Not Likely a GDE Due to Adjacency to Irrigated Agricultural Fields"* section of this document above.

Land with "Crop Type 2016" classifications other than "Managed Wetland", "Urban", "Rice" and "Mixed Pasture" in the dataset were identified and for this purpose referenced as "Other Irrigated Agriculture" for this GIS analysis, as all other remaining irrigated crop types. All polygons in the NCCAG dataset within 50 feet of land classified as "Other Irrigated Agriculture" were designated as "Not likely a GDE near irrigated agriculture

(Non-Rice)" for the same reasons as described above in the "Not Likely a GDE Due to Adjacency to Irrigated Agricultural Fields" section of this document.

Valley Oak Dominated Areas

The dataset provided by TNC indicates the dominant species of vegetation for each polygon. There are 275 polygons representing 1,998 acres of iGDEs dominated by Valley oak (*Quercus lobata*) in the Vina subbasin. Those polygons were classified as "Likely a GDE" due to feedback from TNC staff that this species can access groundwater over a wide range of depths (M. Rohde personal communication March 2, 2021).

Sacramento River Corridor Areas

Using GIS analysis tools polygons located within the active floodplain of the Sacramento River manually were selected. There are a total of 351 polygons near the Sacramento River Corridor representing 3,277 acres in the Vina subbasin. These polygons were classified as "Likely a GDE" due to their proximity to the Sacramento River, which is classified as a gaining river throughout most, if not all of its length throughout the subbasin.

Draft Mapping

The draft maps in Appendix A shown as Figures 3 and 4 show iGDEs classified as "Likely a GDE" or "Not Likely a GDE" for one of the reasons described above. The draft maps in Figures 4 and 5 in Appendix A show iGDEs classified as "Not Likely a GDE" along with the reason for the classification. The iGDEs classified as "Not Likely a GDE" in the Vina subbasin were designated this way due to either their proximity to irrigated agriculture as rice, proximity to irrigated agriculture other than rice, or because they did not survive dry conditions as determined during the initial analyses performed by the GSA Managers.

References:

California Department of Water Resources. 2019. 2016 Statewide Land Use Mapping. https://data.cnra.ca.gov/dataset/statewide-crop-mapping.

California Department of Water Resources Sustainable Groundwater Management Program. 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer.

LaHue, G. T., & Lindquist, B. A. 2019. The Magnitude and Variability of Lateral Seepage in California Rice Fields. Journal of Hydrology, 574, 202-210.

Klausmeyer, K., Howard J., Keeler-Wolf T., Davis-Fadtke K., Hull R., and Lyons A. 2018. Mapping Indicators of Groundwater dependent ecosystems in California.

Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson. 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management

Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy, San Francisco, California.

Figure 3 - Potential Groundwater Dependent Ecosystems in the Vina Subbasin

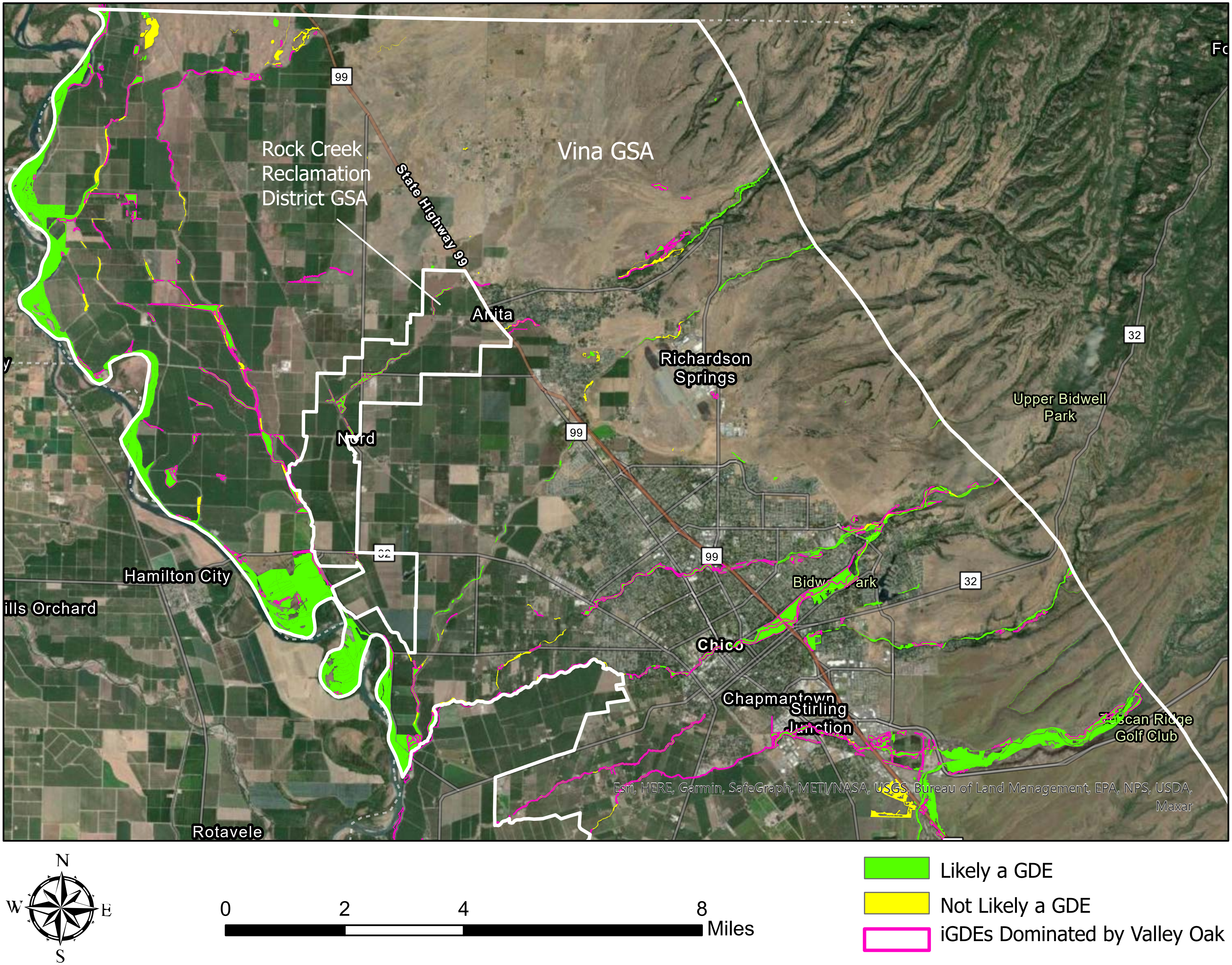


Figure 4 - Potential Groundwater Dependent Ecosystems in the Vina Subbasin

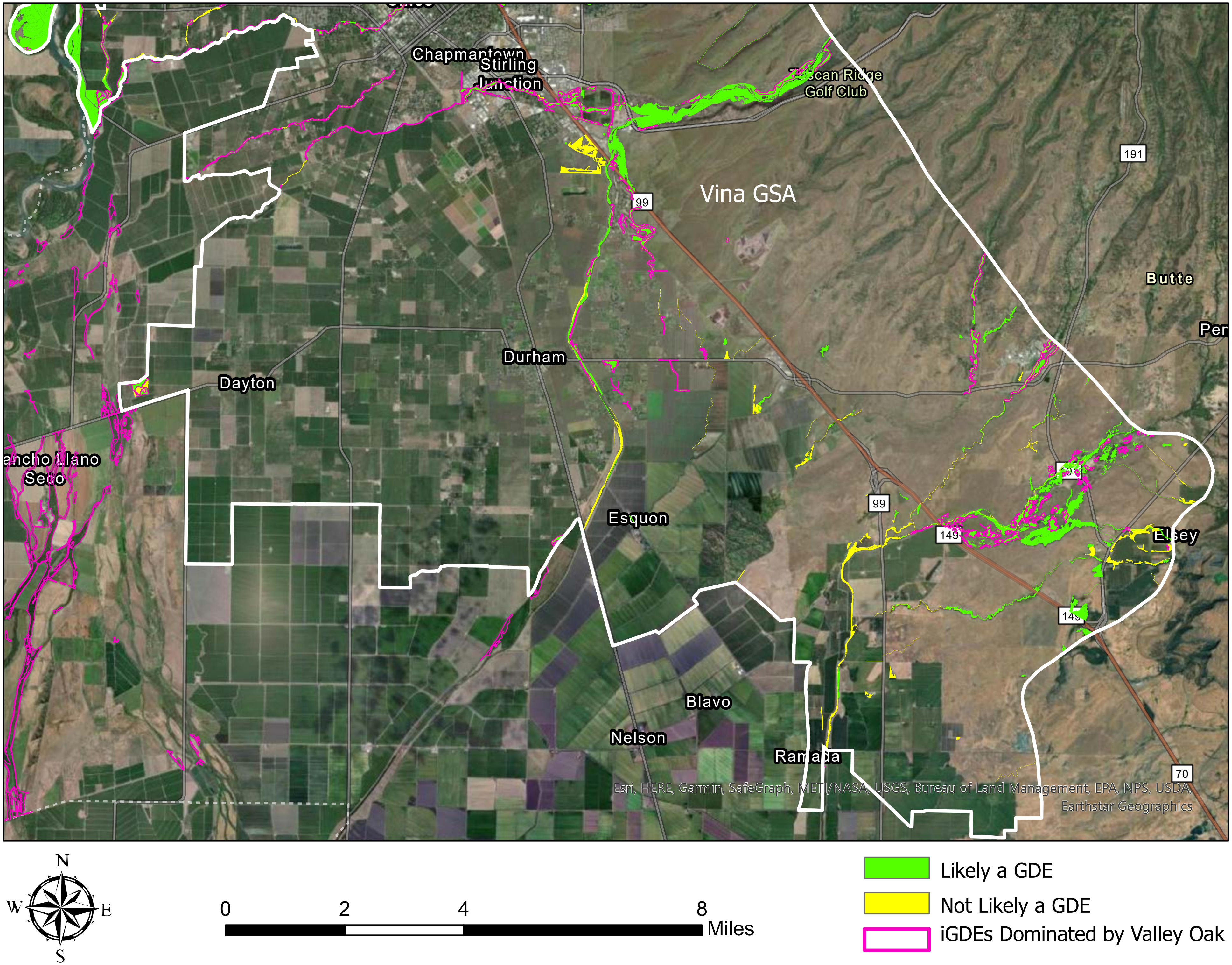


Figure 5 - Not Likely Groundwater Dependent Ecosystems in the Vina Subbasin

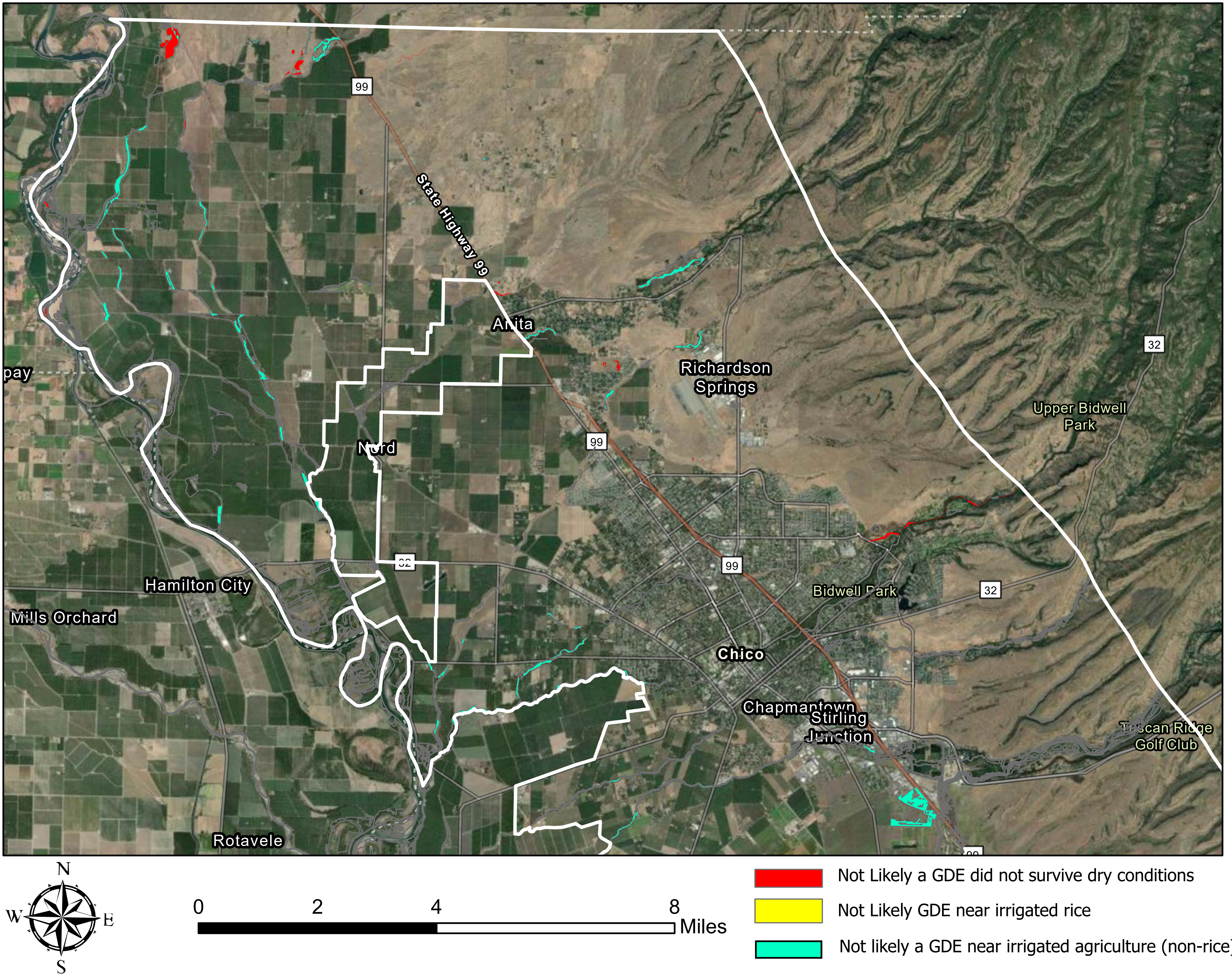


Figure 6 - Not Likely Groundwater Dependent Ecosystems in the Vina Subbasin