Draft: Groundwater Assistance Program Annual Needs Assessment 2021

Prepared for:

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December 9, 2021

Version 2.0

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EXECUTIVE SUMMARY

This report comprises the Post Oak Savannah Groundwater Conservation District (POSGCD) Groundwater Assistance Program (GWAP) Annual Needs Assessment for 2021, hereafter referred to in this document as GANA. The objective of the GANA is to identify eligible wells where water levels are likely to decline below the elevation of the pump setting as a result of regional groundwater production in GMA 12 within the next 10 years. To be eligible for funding under the GWAP, a well must be: (1) either a low-capacity permitted well or an exempt well used for domestic and/or livestock use, and, (2) completed in any aquifer in the District other than the Trinity Aquifer, Yegua-Jackson Aquifer and river alluvial or terraced formations.

A well is designated as a high-priority well if its model predicted well water level in 2030 is less than 15 feet above the elevation of its pump setting recorded in the POSGCD database. The simulated predictive water levels were generated using a recently updated Groundwater Management Area (GMA) 12 groundwater availability model (GAM) and a modified GMA 12 pumping scenario based upon Pumping Scenario 19 (PS-19).

A total of 24 wells were identified as high-priority wells. Of the 24 wells, 17 are completed in the Carrizo Aquifer with the remaining 7 in the Sparta (n=3), Calvert Bluff (n=3), Queen City (n=1), and Simsboro (n=0), and Hooper (n=0). Most high-priority wells are a result of pumping from the Vista Ridge well field. Forty percent of the Carrizo wells that would become high-priority wells by 2030 will have already met the criteria by 2023. Because most eligible wells do not have pump elevation data in the POSGCD well database, we also used inference and the statistics underlying the high priority wells to identify wells that are likely to have been classified as been high priority wells if pump elevation data were available. These wells are termed moderate priority wells. A total of 38 moderate priority wells were identified. All 38 wells pump from the Carrizo Aquifer. Out of these 38 wells, 25 wells are likely to require corrective action because of low water levels by 2030 and 2023, respectively.

The assessment of high priority and moderate priority wells is necessarily based on predictive groundwater modeling, which assumes that the modeling has low predictive uncertainty. The modeling relies on assumptions regarding well data, future pumping scenarios and the accuracy of historical pumping values. Since these assumptions may not always be valid, some wells that are designated priority wells may not require assistance within the next 10 years or may not actually require assistance at all. Therefore, POSGCD's Water Resource Specialist should verify the eligibility and review the well construction of the 62 high-priority wells and moderate-priority wells. For all these wells, it would be useful have measured water levels in the wells that can be used to help calibrate an updated version of the GAM in the near future.

Since last year, POSGCD has assisted 53 eligible wells in the Carrizo Aquifer by setting the pump lower in high priority and mid priority wells identified in the 2020 GWAP report (Young and Kushnereit, 2020). Of the 51 assisted eligible wells with known pump depths, 45 would have been identified as high priority wells in this study based on their pump depths prior to assistance from POSGCD Staff. After lowering of their pump depths, none of the 51 assisted wells are identified as high priority wells in 2030. All 45 of the assisted wells are screened in the Carrizo formation.

Study Limitations

The findings contained in this report represent INTERA's professional opinion arrived at in accordance with applicable professional standards and based upon analysis of information available at the time the report was produced. The report was prepared at the request of the Post Oak Savannah Groundwater Conservation District (POSGCD) to support on-going assessment of the District's aquifers, groundwater resources, and management policies. This report is a technical analysis and may or may not be partially or wholly consistent with the POSGCD Board's policies or current thinking. Because groundwater management is an adaptive process, updates and changes to the report findings may be appropriate as conditions change and new information becomes available.

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ACRONYMS AND ABBREVIATIONS

%	percent
AFY	acre-feet per year
BVGCD	Brazos Valley Groundwater Conservation District
DEM	Digital Elevation Model
DFCs	Desired Future Conditions
ft	feet
GAM	groundwater availability models
GANA	Groundwater Assistance Program Annual Needs Assessment for 2020
GMA	Groundwater Management Area
gpm	gallons per minute
GWAP	Groundwater Assistance Program
ID	identification
NED	National Elevation Dataset
LPGCD	Lost Pines Groundwater Conservation District
POSGCD	Post Oak Savannah Groundwater Conservation District
PS	Pumping Scenario
TWDB	Texas Water Development Board

1.0 INTRODUCTION

This report comprises the Post Oak Savannah Groundwater Conservation District (POSGCD, or "District") Groundwater Assistance Program (GWAP) Annual Needs Assessment for 2020, referred to herein as the GANA. According to the POSGCD GWAP documentation (POSGCD, 2020), the GANA:

> *"Shall identify high-priority wells that are projected to experience water level declines below the pump within the next 10 years. The projections will be based on an integration of two sources of information. One source will be water level predictions from the GAM. The other source will be adjustments to GAM model predictions based on potential biases in the GAM simulations."*

This report documents the process used to identify high priority wells and provides a discussion of the tools and assumptions used to make this assessment as well as prioritize the wells based upon their need for assistance over the next 10 years. Finally, the report reviews GANA findings and makes recommendations for improving both the GWAP and the GANA to achieve District goals.

1.1 GWAP Background

The GWAP was created to assist owners of exempted and low-capacity permitted wells (typically domestic & livestock) whose water levels are projected to decline below the pump from regional groundwater production in Groundwater Management Area (GMA) 12 over the course of the next decade. The GWAP is a proactive program meant to identify high-priority wells in the District projected to experience water level declines below their pump during typical operations from groundwater production in the District and GMA 12. A second objective is to provide technical and/or financial assistance to well owners to help prevent the loss of water supply in high-priority wells. While meant to be proactive, assistance under GWAP may include temporarily restoring a water supply to those well owners should a situation arise where the water level in a well has dropped below the pump before corrective action has taken place.

The following sections describe the methodology used to identify priority wells that should be investigated by POSGCD. The District Water Resource Management Specialist has the primary responsibility of recommending appropriate actions to be taken.

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2.0 DATA SOURCES SUPPORTING THE ASSESSMENT

There are several types of data required to perform the GANA. These data include information regarding exempt and permitted POSGCD wells, monitoring well data from the POSGCD Monitoring Well Network, and future predicted aquifer water levels using the groundwater availability models (GAMs) used by the POSGCD to simulate Desired Future Conditions (DFCs) in the relevant POSGCD aquifers. Each of these data sources will be described in the following subsections of this report.

2.1 Eligible Wells

According to the POSGCD GWAP documentation (POSGCD, 2020), to be eligible for assistance in the GWAP, a well must meet the following criteria:

1. Located in Milam or Burleson counties
2. Functional and registered with the District
3. Accessible for monitoring water levels by POSGCD
4. Owner must agree to allow monitoring by POSGCD
5. Either a low-capacity permitted well that produces less than 50 gallons per minute (gpm) OR an exempt well used for domestic and/or livestock use as defined in the District's Rules
6. Completed in any aquifer in the District other than the Trinity Aquifer, Yegua-Jackson Aquifer and river alluvial or terraced formations
7. May not be covered by a mitigation agreement included in a permit issued by the District or required by the State of Texas

POSGCD maintains an online database of all wells registered in the District (https://posgcd.halff.com). The HALFF database was used to help identify wells eligible for assistance. Well information needed to determine wells potentially eligible includes whether they are exempt or non-exempt (permitted) status and, if they are permitted, whether they are incapable of producing greater than 50 gpm. Other important well attributes required are what aquifer the well is completed in and well completion details, in particular the pump depth. **Table 1** provides the total number of exempt wells in the POSGCD HALFF database completed in GWAP-eligible aquifers, along with an accounting of how many of those wells have pump depth in the HALFF database. **Appendix A** provides maps of the locations of the exempt wells that are currently registered by POSGCD in the aquifers relevant to this analysis. **Figure 1** shows the map of exempt well locations for the Carrizo Aquifer provided in Appendix A.

Table 1 All Exempt Wells in POSGCD in Eligible Aquifers

Aquifer	Has Pump Depth Information	No Pump Information	Total Eligible Exempt Wells
Sparta	133	1029	1162
Queen City	157	1018	1175
Carrizo	123	258	381
Calvert Bluff	177	568	745
Simsboro	63	376	439
Hooper	170	533	703
TOTAL	823	3782	4605

For this report, a well is considered a low-capacity, permitted well (eligibility requirement #5) if the maximum production pumping capacity of the permitted well in the HALFF database is 50 gpm or less and the well is completed in an eligible aquifer (requirement #6). If the maximum production capacity of the well is not listed in the database, a well would also be included if the average annual permitted production is less than 81 acre-feet, which is equivalent to pumping continuously at a rate of 50 gpm for an entire year. **Table 2** provides the total number of permitted wells that meet requirements #5 and #6, along with an accounting of how many of those wells have pump depth in the HALFF database. **Table 3** provides the total number of exempt and permitted wells eligible for the GWAP and summarized by aquifer. **Appendix B** shows the locations of the low-capacity permitted wells that are currently registered by POSGCD. **Figure 2** shows the map of low-capacity permitted well locations for the Carrizo Aquifer provided in Appendix B.

Table 2 Permitted wells in POSGCD with an average annual permitted production of 50 gallons per minute or less in eligible aquifers

Aquifer	Has Pump Depth Information	No Pump Information	Total Eligible Permitted (Low Capacity) Wells
Sparta	6	16	22
Queen City	6	10	16
Carrizo	8	2	10
Calvert Bluff	22	12	34
Simsboro	7	6	13
Hooper	6	4	10
TOTAL	55	50	105

Table 3 Number of exempt and permitted wells eligible for the GWAP by aquifer

Aquifer	Total Eligible Exempt Wells	Total Eligible Permitted Wells	Total Eligible Wells
Sparta	1162	22	1184
Queen City	1175	16	1191
Carrizo	381	10	391
Calvert Bluff	745	34	779
Simsboro	439	13	452
Hooper	703	10	713
TOTAL	4605	105	4710

There are a total of 4,710 eligible wells in the POSGCD HALFF database. Of those, 4,605 are exempt wells and 105 are permitted wells meeting the capacity requirement for eligibility. The depth to the well pump is only known for 18 percent (%) of the exempt wells. The depth to the well pump is known for 52% of the low-capacity permitted wells.

As will be discussed, if an eligible well is found to be a high priority well, the POSGCD will attempt to characterize the well completion details through cooperation with the well owner to make it eligible for corrective action. Throughout the analysis, individual wells will be referenced by their POSGCD

identification (ID). Any well owner can obtain the POSGCD ID for a well by contacting the POSGCD office in Milano, Texas.

2.2 Monitoring Network

One of the eligibility requirements for well owners to receive assistance from the GWAP is to agree to allow POSGCD to monitor the water level and or water quality in their well. Depending on its location, the POSGCD may decide to incorporate the well into the POSGCD network of groundwater monitoring wells. **Figure 3** shows the locations and aquifer assignments for 308 wells currently in the POSGCD network. The POSGCD uses measured water levels from the POSGCD monitoring wells to evaluate the aquifer conditions and to improve its understanding of the groundwater system. One of the evaluations performed by POSGCD is to determine whether or not the aquifer water levels are in compliance with the DFCs that POSGCD has for its aquifers. Currently, the DFCs are expressed as a maximum amount of water level change that can occur over a 60-year period. The POSGCD also uses the measure water levels to update and improve the capability of groundwater models to predict the impact of future pumping on water level change.

POSGCD Monitoring Well network consists of the 308 wells shown in **Figure 3**

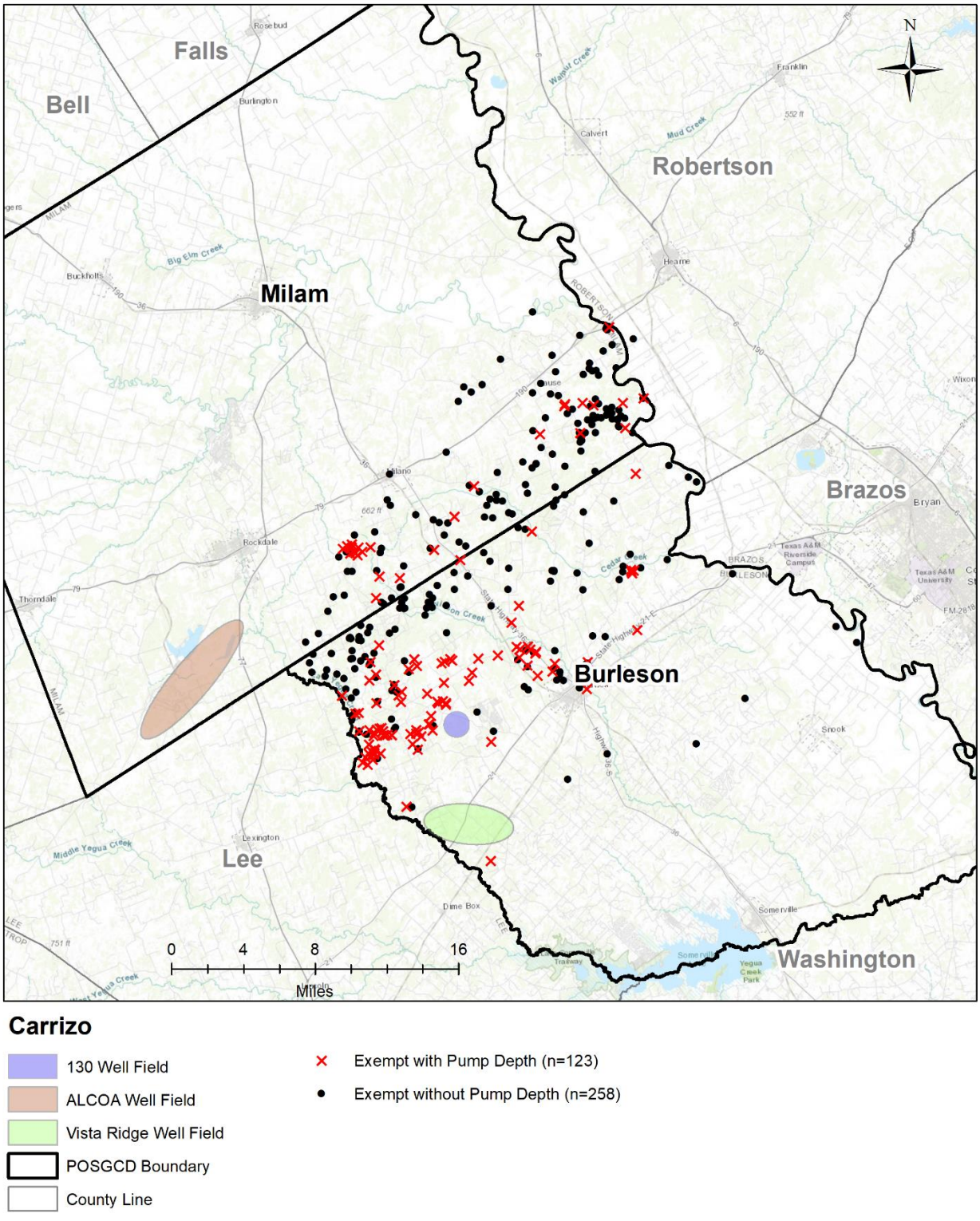


Figure 1 Locations of eligible exempt wells completed in the Carrizo Aquifer

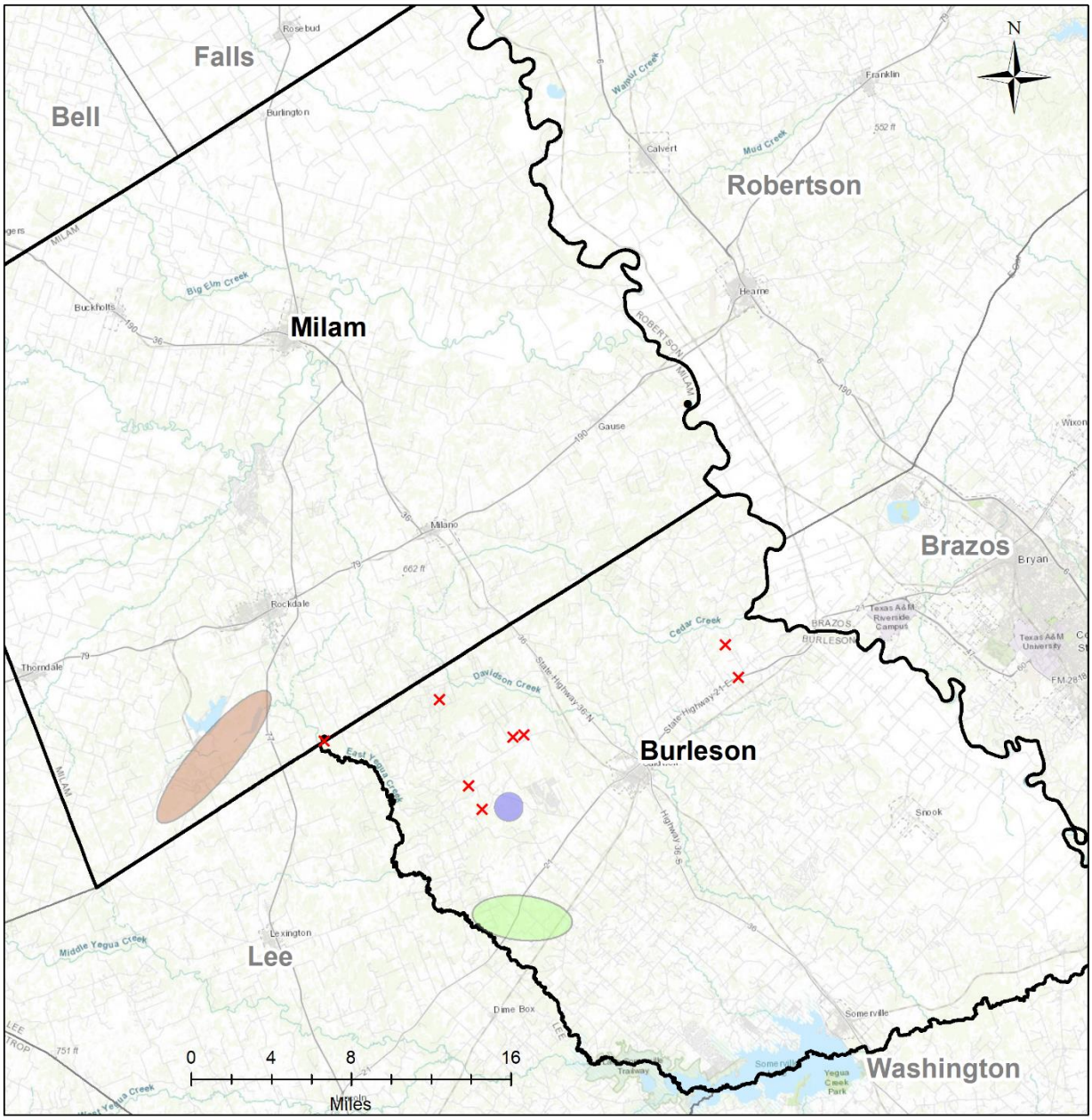
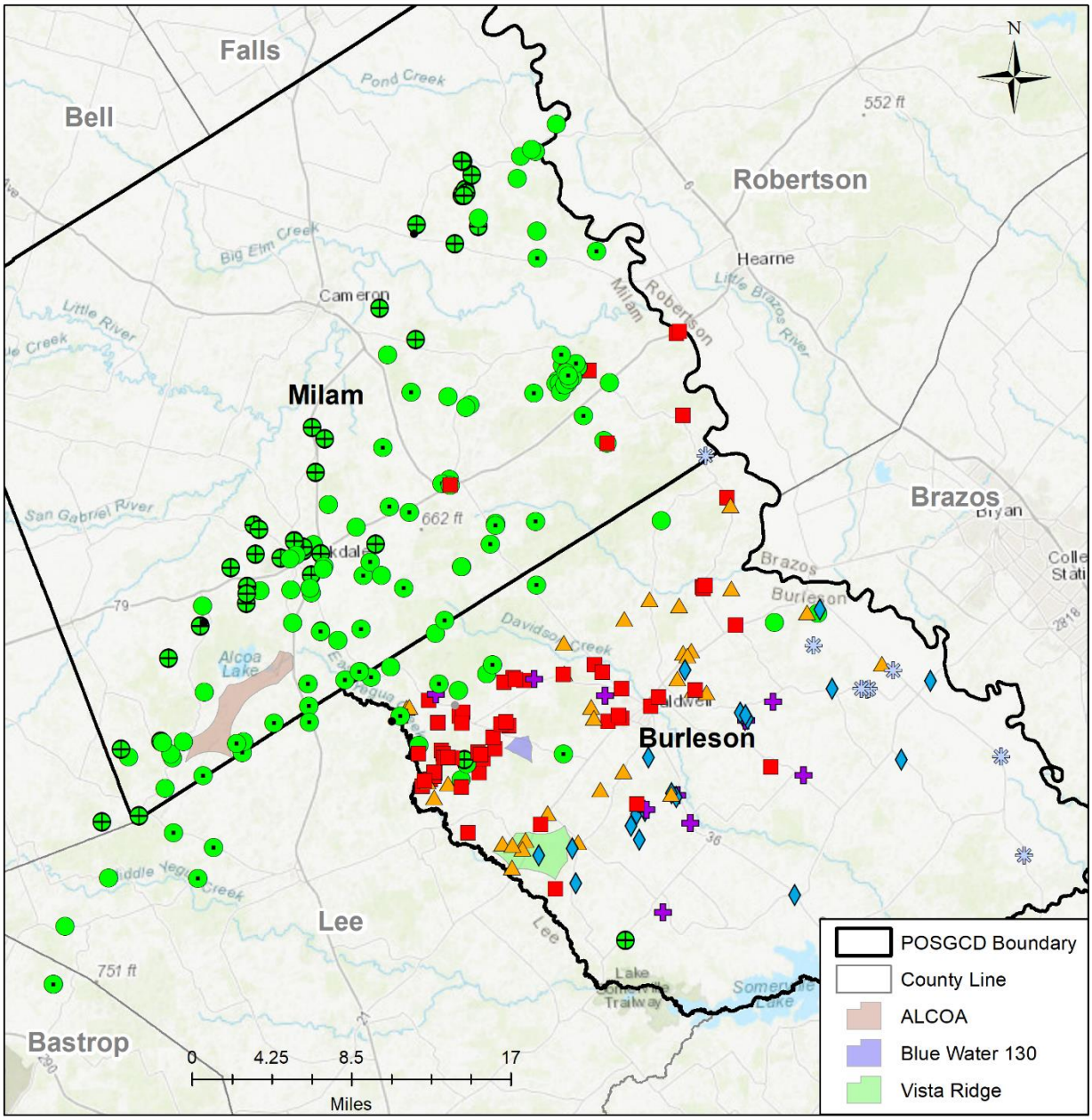


Figure 2 Locations of eligible low-capacity permitted wells completed in the Carrizo Aquifer



Wells

- BRAA
- Sparta
- Cook Mountain
- Queen City
- Carrizo
- Calvert Bluff
- Simsboro
- Hooper
- Below Hooper
- Not Yet Assigned

Figure 3 Monitoring wells in POSGCD Groundwater Monitoring Network

2.3 Modeled Groundwater Water Levels

The POSGCD has registered wells in all the GWAP-eligible aquifers: Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and the Hooper. The Carrizo, Calvert Bluff, Simsboro and Hooper aquifers are collectively referred to as the Carrizo-Wilcox Aquifer in Texas, but the individual members are physically distinct and have different hydrogeologic properties and are managed separately in GMA 12.

As part of the regional planning process in GMA 12, POSGCD uses the updated Texas Water Development Board (TWDB) Central Queen City, Sparta and Carrizo-Wilcox GAM to simulate changes in water levels in response to future pumping. The updated Central Queen City, Sparta and Carrizo-Wilcox GAM is accepted by the TWDB as the best available science for the region (Young and others, 2018). In 2020, the GMA 12 consultants agreed to incorporate new aquifer test data in the Simsboro in the vicinity of the Vista Ridge Project to improve model parameters in that area. The revised GAM was documented (Young and others, 2020), reviewed by the TWDB, and has been developed with stakeholder review and comment.

In 2021, POSGCD had collected measured water levels for the first year of pumping from the Vista Ridge monitoring project. Monitoring wells are shown in Figure 3. The additional data warranted another update to the Central Queen City, Sparta and Carrizo-Wilcox GAM which used the monitoring well data from December 2019 through July 2021. The parameter estimation code PEST++ ies (iterative ensemble smoother) (White and others, 2020) was used to improve the GAM so that it would be a better predictor of water level change caused by pumping from the Vista Ridge wells and other wells in POSGCD.

Table 4 Groundwater Availability Models used by POSGCD to simulate impacts of pumping on water levels as part of the regional planning process

Groundwater Availability Model	Aquifers	Reference
Central Sparta, Queen City, and Carrizo-Wilcox Aquifers	Sparta, Queen City, Calvert Bluff, Simsboro, Hooper	Young and others (2018)
GMA-12 Update to the Central Sparta, Queen City, and Carrizo-Wilcox Aquifers	Sparta, Queen City, Calvert Bluff, Simsboro, Hooper	Young and others (2020)
GMA-12 Update to the update of Central Sparta, Queen City, and Carrizo-Wilcox Aquifers	Sparta, Queen City, Calvert Bluff, Simsboro, Hooper	Young and others (2021)

The POSGCD GWAP documentation (POSGCD, 2020) states that GAMs will be used to perform GANA annual assessments and that the GAM simulations will include the most recent information on projected pumping in GMA 12. For this study, the projected pumping is represented by a modified version of GMA 12 pumping scenario nineteen (PS-19). The well file for PS-19 was developed by the GMA 12 consultants in Fall 2021 to represent a future pumping scenario where the amount of permitted pumping in GMA 12 was fully utilized in 2070. **Figure 4** shows a time series of the GAM pumping rates by aquifer in PS-19 in the POSGCD. Because water levels in POSGCD are also affected by pumping in adjoining counties, **Figure 5** and **Figure 6** provide a similar time series plots of GAM pumping rates by aquifer in PS-19 in Lost Pines Groundwater Conservation District (LPGCD) and Brazos Valley Groundwater Conservation District (BVGCD), respectively.

For this study, the pumping rates in PS-19 were used except that the pumping rates in the Vista Ridge wells were modified to represent the measured pumping in 2020. Previously Vista Ridge wells had estimated 9,160 acre-ft of pumping in the Carrizo and 25,203 acre-ft in the Simsboro but has since been updated in PS-19 to 8,880 acre-ft and 24,543 acre-ft in the Carrizo and Simsboro aquifers respectively.

Table 5 lists the pumping rates in POSCD by aquifer included in PS-19.

The water levels for wells in the Sparta, Queen City, and Carrizo-Wilcox aquifers were simulated using the recently revised Central Sparta, Queen City and Carrizo-Wilcox Aquifer GAM (Young and others, 2021) and the GMA 12 well file for PS-19.

Table 5 Pumping rates in POSGCD aquifers for PS-19

Aquifer	Pumping Rate (acre-feet per year) for PS-19						
	2020	2021	2023	2027	2030	2040	2070
Sparta	1,237	2,251	2,644	2,755	2,840	3,131	4,105
Queen City	513	3,905	4,018	4,253	4,438	5,110	7,838
Carrizo	11,209	17,070	17,112	17,199	17,264	17,486	18,206
Calvert Bluff	2,180	2,210	2,272	2,400	2,940	3,304	4,761
Simsboro	29,953	40,773	36,751	39,562	65,539	74,832	79,433
Hooper	1,806	1,828	1,871	1,959	2,027	2,264	3,126
Total	46,899	68,037	64,668	68,128	95,047	106,127	117,470

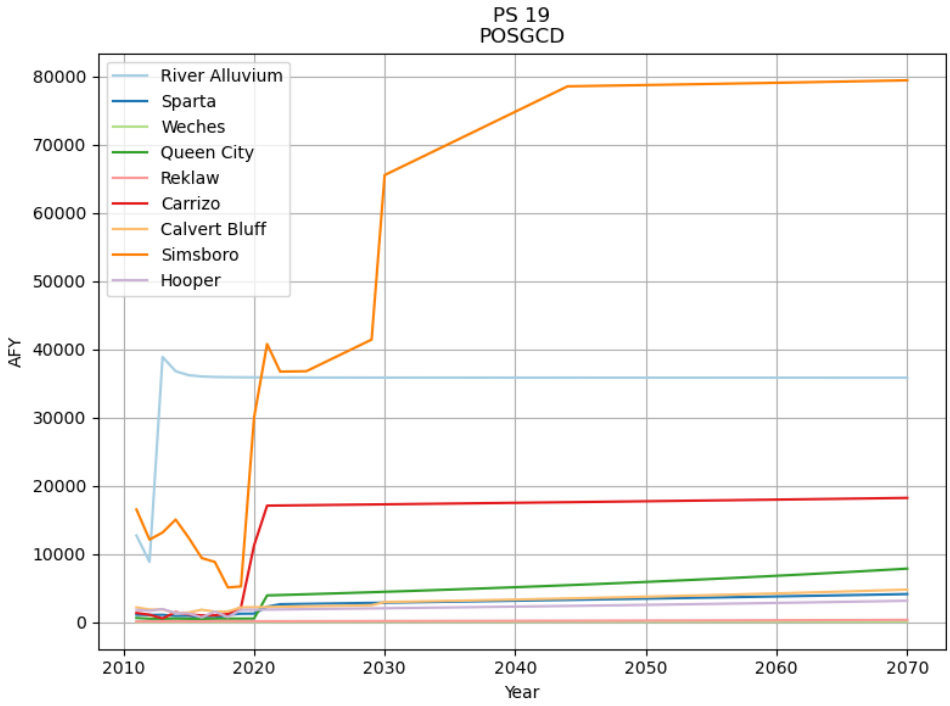


Figure 4 POSGCD pumping rates from the year 2011 to 2070 used in GMA-12 Pumping Scenario 19

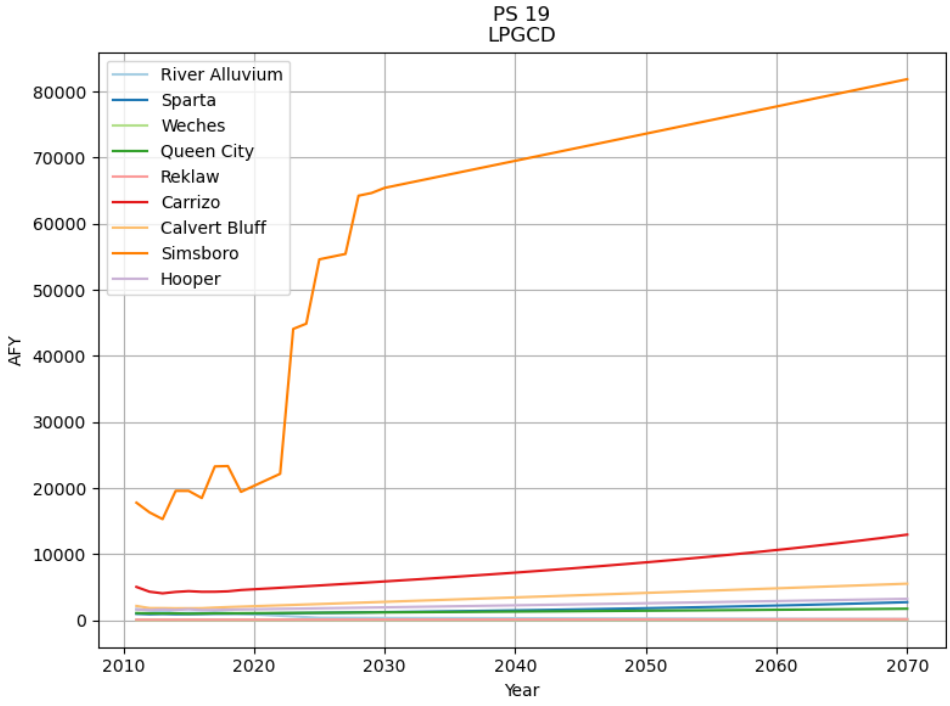


Figure 5 LPGCD pumping rates from the year 2011 to 2070 used in GMA-12 Pumping Scenario 19

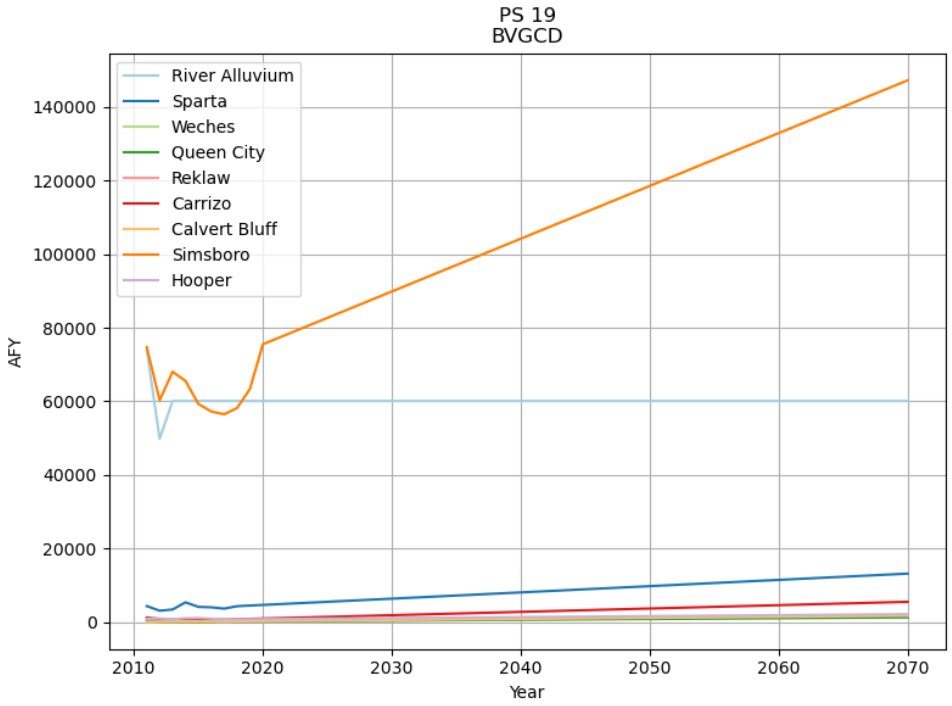


Figure 6 BVGCD pumping rates from the year 2011 to 2070 used in GMA-12 Pumping Scenario 19

3.0 GWAP ASSESSMENT

3.1 Priority Assessment Methodology

The primary issue of concern for the GWAP assessment is whether the water level at an eligible groundwater well will drop below the elevation of that well's pump setting. Specifically, the GWAP defines high-priority wells as wells where the water level is projected to fall below the pump elevation within 10 years. The relevant time frame of interest in this year's assessment for high-priority wells is a 10-year period from December 2020 to December 2030. The purpose of this document is to define those high-priority wells so that POSGCD staff can perform the necessary due diligence required to investigate whether corrective actions are needed.

This assessment uses the predicted water levels from the PS-19 GAM simulation introduced in Section 2.3. PS-19 is considered the best current estimate of future pumping in GMA 12 for assessing regional water level declines and their local impacts on the operation of wells. In addition to predicted water levels, the GANA must either know, or assume, the elevation of a well's pump. The pump elevation for each well is determined by subtracting the reported pump depth from the surface elevation, which is established from the 10-meter resolution National Elevation Dataset (NED) Digital Elevation Model (DEM). Because wells require some available drawdown to produce water and because of inaccuracies in estimating ground surface elevation at the well, we have assumed that, if the projected water level in an eligible well is within 15 feet of the elevation of the pump, that pump is considered dry and that well classifies as a high priority well.

Because the majority eligible wells do not have pump depth information on record in the POSGCD database, a second analysis was performed to identify wells that are of interest even though pump elevation is unknown. One reason for conducting the second analysis is to estimate how many of the wells with no pump depth may potentially need corrective action. This information can inform program budgets considered by the district in the future.

3.2 Results

3.2.1 Simulated Drawdown in Relevant Aquifers

To help identify high-priority wells and the time frame these wells may need corrective action, we have analyzed drawdown over two different time periods. The first is a three-year period from 2020 through 2023. The second is a ten-year period from 2020 through 2030. The ten-year period is the time frame recognized in the GWAP for identifying high-priority wells. The reason we also looked at a three-year period is because we noticed that the drawdown cones propagated quickly and that it may be important to prioritize the sequence in which the well investigations are conducted.

Figure 8 through **Figure 13** show the drawdown that occurs between 2020 and 2023 and 2020 and 2030 as simulated by the Central Sparta/Queen City/Carrizo-Wilcox GAM based on pumping in Run PS-19 for all qualifying aquifers. These figures identify which wells have pump information in the POSGCD database and which ones do not. For those eligible wells that have pump information, the figures identify if the predicted water level at the well is greater than or less than 15 feet above the pump at the

period of interest (2023 or 2030). The figures also identify wells where the simulated water level in 2020 is less than 15 feet above the pump elevation. Wells that have water levels below the pump in 2020 are not necessarily considered as high-priority wells because, if both the pump data and the simulated water levels were correct, the well would have stopped operating properly in 2020 and the well owner would have reported the problem to POSGCD or have lowered the pump. For this report, wells with water wells less than 15 feet above the pump elevation in 2020 are considered wells of concern.

Several key observations are organized by aquifer below.

- Sparta Aquifer - Figure 7 shows the drawdown contours for Sparta Aquifer from 2020 through 2023 and for 2020 through 2030. Drawdowns are relatively around 10 feet with some 30-foot drawdown near the outcrop and are isolated in Burleson county as the Sparta Aquifer outcrops in only Burleson county. Three wells have water levels below the pump elevation in 2020. Three high-priority wells are identified in either 2023 or 2030.
- Queen City Aquifer - Figure 8 shows the drawdown contours for Queen City Aquifer from 2020 through 2023 and for 2020 through 2030. Again, because the Queen City Aquifer outcrops in southernmost Milam and northernmost Burleson County, drawdown is limited primarily to Burleson county. Drawdowns are minimal (between 0 and 40 feet) a large drawdown cone is present in Burleson county close to Washington county and is likely caused by public water use for the city of Deanville. Six wells have predicted water levels below the pump elevation in 2020. One well in 2023 and 2030 has a simulated water level below the pump elevation. That well is in an area where the predicted drawdown from 2020 to 2030 is less than 10 feet.
- Carrizo Aquifer - Figure 9 shows the drawdown contours for Carrizo Aquifer from 2020 through 2023 and for 2020 through 2030. From a review of the drawdown contours in 2023 and in 2030, one can see that the impact of Vista Ridge pumping on regional water levels is predicted to occur relatively quickly. It is expected that the drawdown cones associated with Vista Ridge will come into a quasi-equilibrium by 2030, and the identification of new high priority wells should fall off after 2030 barring additional projects not modeled in PS-19. The largest drawdown occurs in the vicinity of the Vista Ridge well field and the drawdown values decrease radially outward from there towards Robertson and Brazos counties. By 2030 the drawdowns are between 400 and 230 feet (ft) in the Vista Ridge wellfield, are generally less than 10 ft in northeast Milam County, and are generally less than 60 ft along the county line with Brazos County. Eight wells have well levels below the pump elevation in 2020. Six and 15 high-priority wells are identified in 2023 and in 2030, respectively. The majority of high-priority wells are located within a radial distance of 8 miles from the Vista Ridge well field within 120 feet of drawdown. The area that includes the high-priority wells also includes most of the 53 wells that POSGCD assisted well owners with lowering the elevation of their pump to account for large decreases in water levels in the well.
- Calvert Bluff Aquifer - Figure 10 shows drawdown contours for the Calvert Bluff Aquifer from 2020 through 2023 and for 2020 through 2030. The drawdown contours exhibit a similar pattern to those for the Carrizo Aquifer, but the drawdowns are less. The drawdowns are about 130 ft or less near the Vista Ridge wellfield, are generally less than 10 feet in northeast Milam County, and are generally from 50 to 70 ft along the county line with Brazos County. Three wells have predicted water levels below the pump elevation in 2020. Two high-priority wells are identified in 2023 and three high-priority wells are identified in 2030.
- Simsboro Aquifer - Figure 11 shows drawdown contours for Simsboro Aquifer from 2020 through 2023 and for 2020 through 2030. The drawdowns contours are about 290 ft or less in the Vista Ridge wellfield, are less than 30 ft across the outcrop in Milam County and are about

140 ft or less along the county line with Brazos County. Twelve wells have well levels below the pump elevation in 2020. No high-priority wells are identified in 2023 or 2030.

- Hooper Aquifer - Figure 12 shows drawdown contours for the Hooper Aquifer from 2020 through 2023 and for 2020 through 2030. In the Hooper Aquifer, the drawdowns are greatest several miles north of the Vista Ridge well field, where they are about 120 ft. Across most of the outcrop for the Hooper Aquifer in Milam County, the drawdowns are less than 10 ft and, along the county line with Brazos County, the drawdowns range between 80 ft to less than 10 ft in the outcrop in Milam County. Nine wells have well levels below the pump elevation in 2020. No high-priority wells are identified in either 2023 or 2030.

Appendix C lists the 24 wells identified as high-priority wells and the 41 wells of concern that have simulated water levels in 2020 that are less than 15 feet above the pump elevation.

Appendix D shows the hydrographs of the simulated water levels for high-priority wells. **Appendix E** shows the hydrographs of the simulated water levels for the wells of concern. Each figure shows the simulated water level in the well from 2000 to 2032 and includes markers for the land surface, measured water levels, the pump location, the top of well screen, and the bottom of the well. The title of the figure indicates the aquifer intersected by the well screen, whether it is an exempt or permitted low capacity well, and if the well is in the POSGCD monitoring well network.

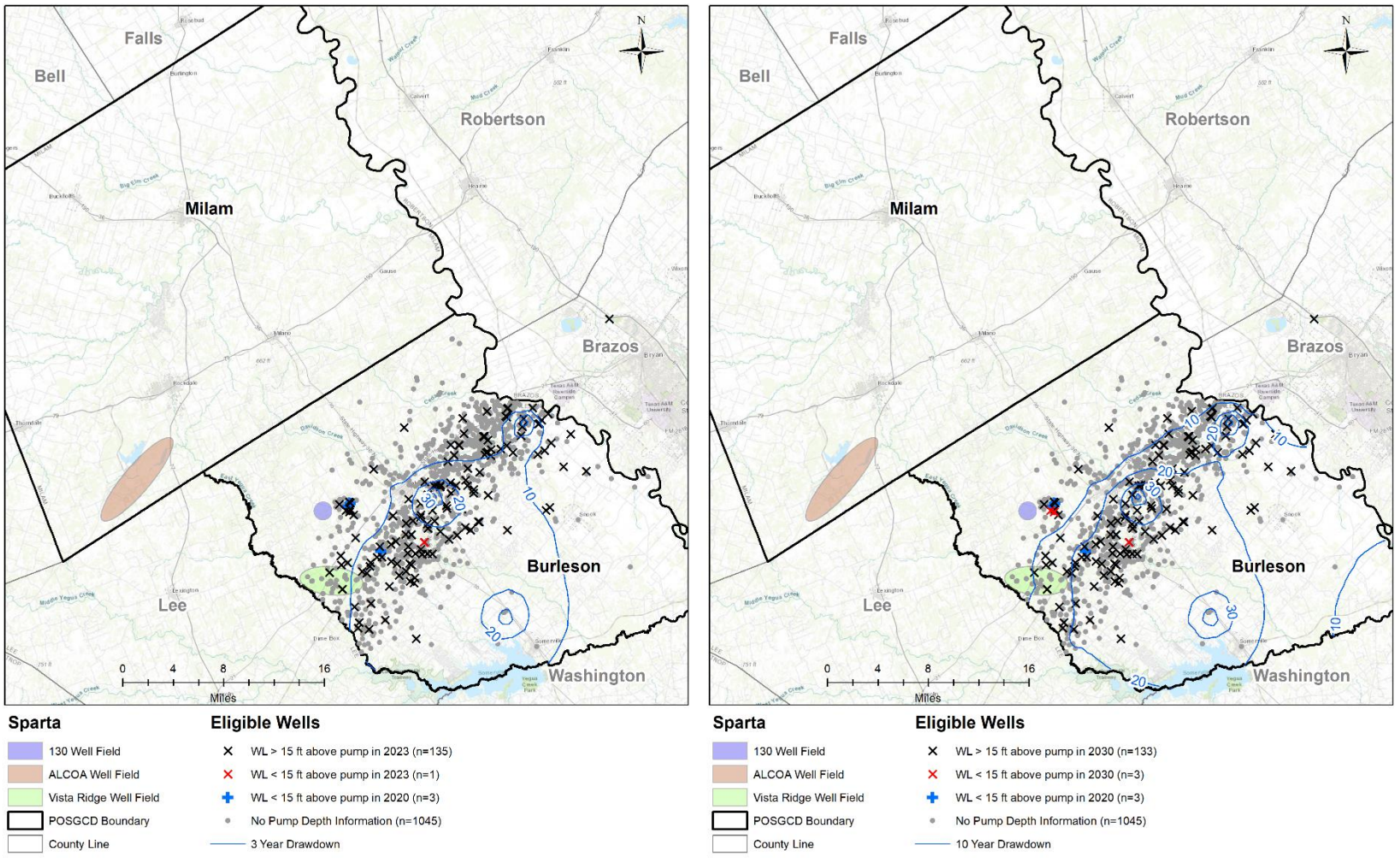


Figure 7 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Sparta Aquifer

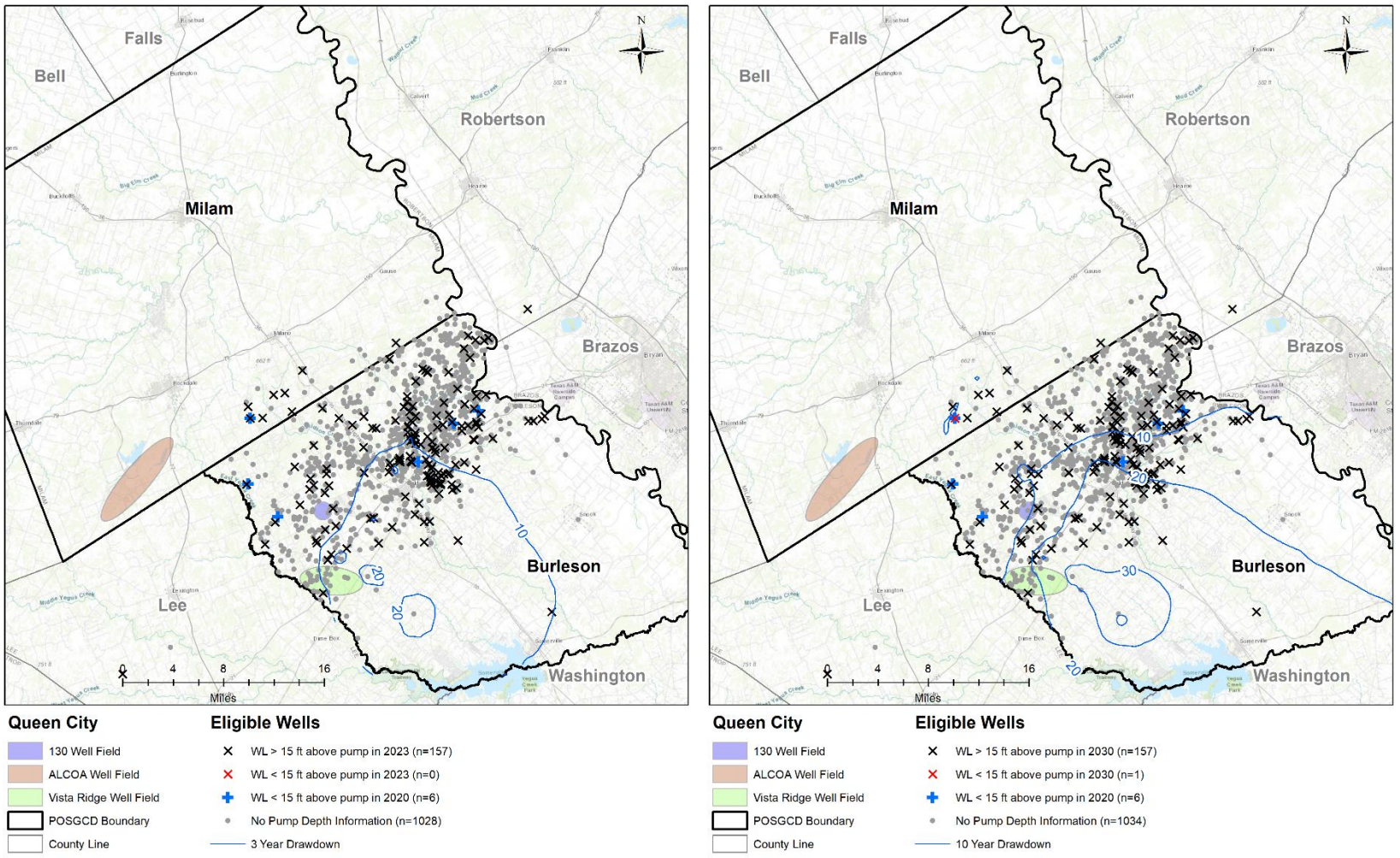


Figure 8 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Queen City Aquifer

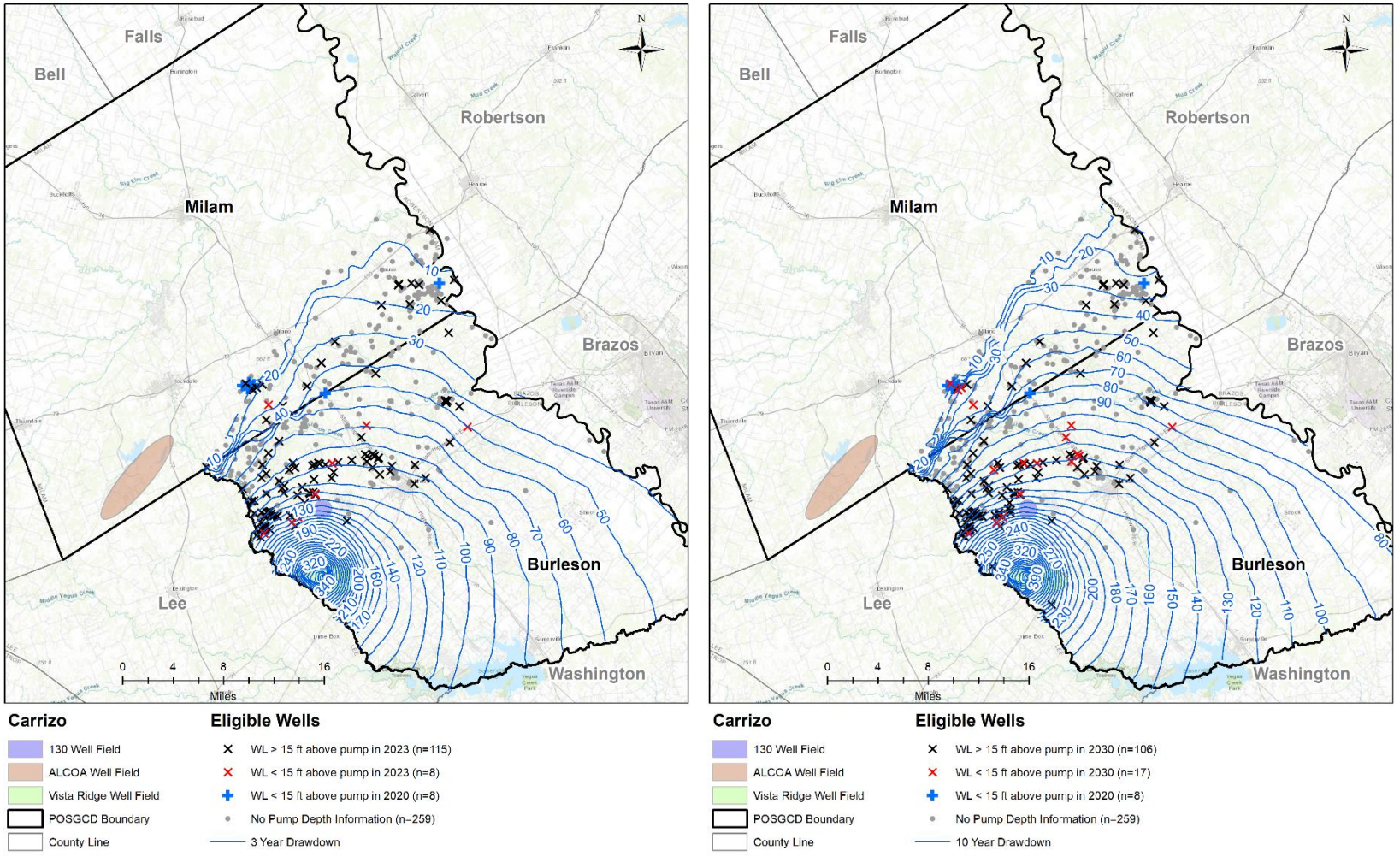


Figure 9 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Carrizo Aquifer

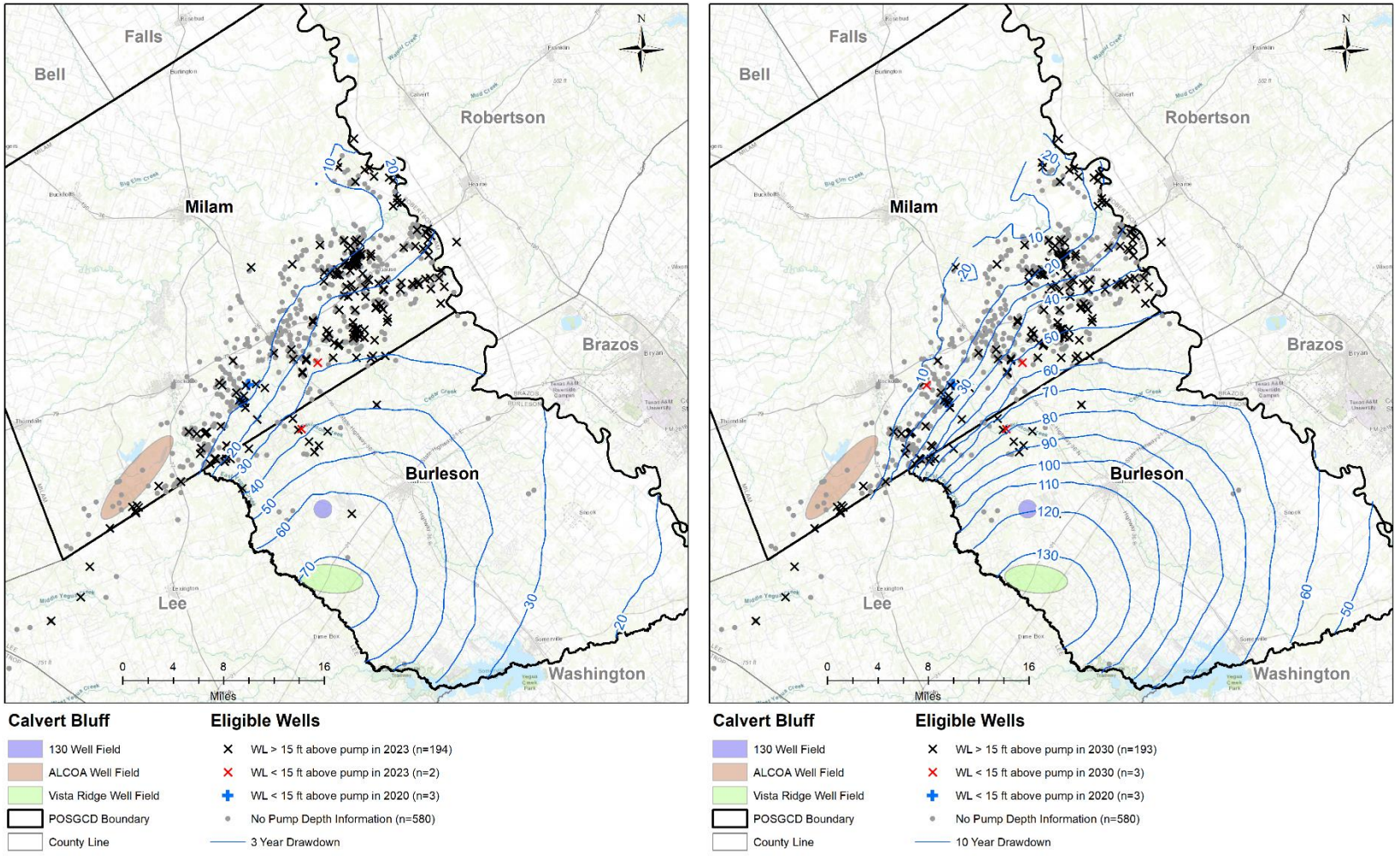


Figure 10 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Calvert Bluff Aquifer

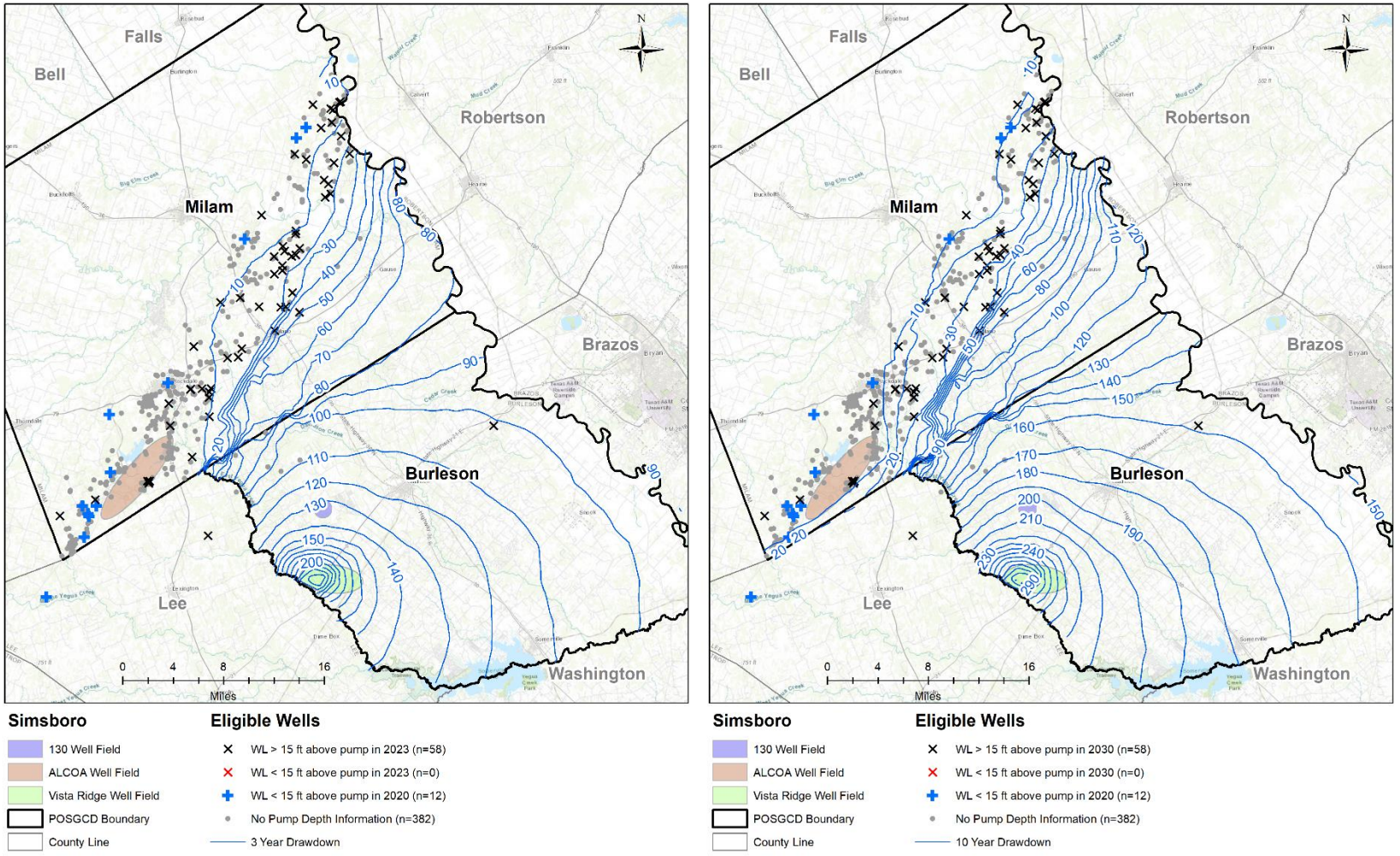


Figure 11 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Simsboro Aquifer

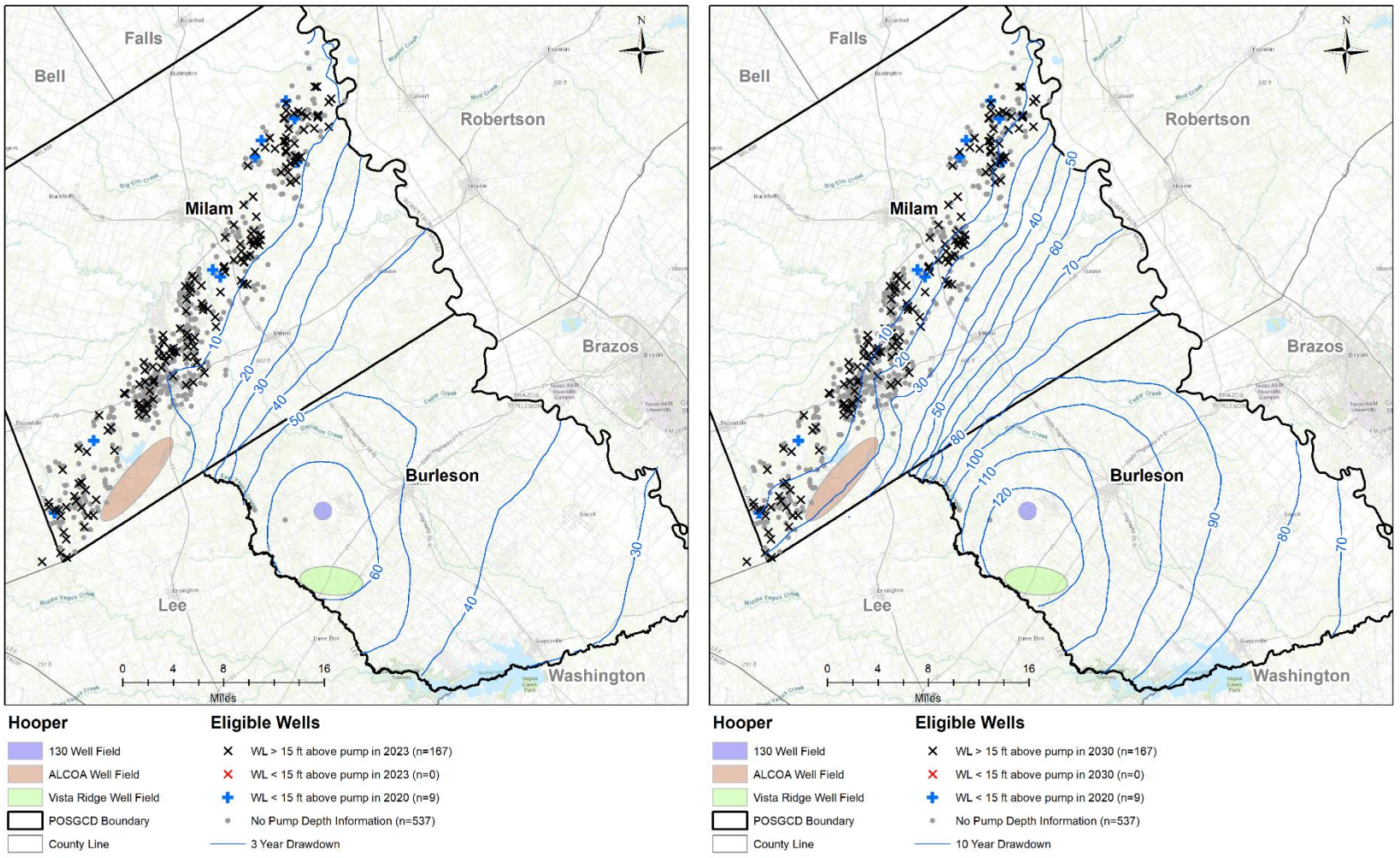


Figure 12 Contours of simulated drawdown from 2020 to 2023 and 2020 to 2030 in the Hooper Aquifer

3.2.2 High Priority Wells Based Upon Known Pump Elevations

Changes in water levels from 2020 to 2023 and from 2020 to 2030 were simulated for 878 eligible wells; either exempt wells (n =823) or low-capacity permitted wells (n=55) that have pump information in the POSGCD well database. A well is considered a high-priority well if the following two conditions are met: (1) the simulated water level is greater than 15 ft above the pump elevation in 2020, and (2) the simulated water level is less than 15 ft above the pump elevation in 2030. The information provided in Figures 9 through 14 shows the location of 24 eligible wells that are classified as high-priority.

Table 6 provides the statistics for the elevation difference between the simulated water level and the pump elevation for 2023 and 2030. What is significant regarding the two sets of statistics is that 47% of the Carrizo wells that would become high-priority wells by 2030 have already met the criteria by 2023.

Table 6 Simulated water level elevation relative to pump elevation in eligible wells for the administrative period (2020 through 2030) and for the time period from 2020 through 2023.

Aquifer	Eligible Wells w/Pump Info	Year	Simulated Water Level Elevation Relative to Pump Elevation									
			<15 ft above pump	<10 ft above pump	<5 ft above pump	< 2 ft above pump	> 2 ft below pump	> 5 ft below pump	>10 ft below pump	>25 ft below pump	>50 ft below pump	> 100 ft below pump
Sparta	140	2023	1	1	0	0	0	0	0	0	0	0
		2030	3	1	1	1	0	0	0	0	0	0
Queen City	163	2023	0	0	0	0	0	0	0	0	0	0
		2030	1	1	0	0	0	0	0	0	0	0
Carrizo	131	2023	8	7	7	7	6	6	6	4	1	1
		2030	17	15	12	12	12	11	9	7	6	1
Calvert Bluff	199	2023	2	2	1	1	0	0	0	0	0	0
		2030	3	3	3	2	2	2	2	1	0	0
Simsboro	71	2023	0	0	0	0	0	0	0	0	0	0
		2030	0	0	0	0	0	0	0	0	0	0
Hooper	176	2023	0	0	0	0	0	0	0	0	0	0
		2030	0	0	0	0	0	0	0	0	0	0

3.2.3 Treatment of Wells without Pump Information in the Carrizo

Based on the review of the well data in Figures 8 through 13, there are a significant number of Carrizo wells located near the high-priority wells that may have been identified as high-priority wells if their pump elevation were known. To provide an estimate of how many wells could fall in this category, we develop a three-step process that consists of the following:

Step 1 - Select the drawdown value that encompasses most of the high-priority wells in the Carrizo aquifer. From a review of **Figure 9** we determined that the 120 ft drawdown contour encompasses most high-priority wells in the Carrizo aquifer (n=9) that are located near the Vista Ridge well field. However, many wells have had their pump settings lowered by POSGCD staff

since 2020 (see **section 3.3**) so it was decided to use the number of high-priority wells with over 120 ft of drawdown before the pump setting adjustments in the Carrizo aquifer (n=52) (see **Figure 14**).

Step 2 - Calculate the percentage of the wells with pump information (n=80) that have drawdowns greater than 120 ft that are high-priority wells (n=52). This percentage is 65%, which is determined using the information in **Table 7**.

Step 3 - Identify the number of Carrizo wells without pumping information in Figure 10 (or Figure 14) that have greater than 120 feet of drawdown. This number is 38 wells (see Table 7). To estimate the number of additional potential high-priority wells could have been identified if all the Carrizo wells had pump elevation data, we multiply 38 wells by 56% to get 25 wells (see Table 7).

These additional 38 wells estimated in Step 3 above are designated as moderate-priority wells. Twenty-five (25) out of the 38 wells are estimated to potentially have problems with low water levels before 2030. **Appendix F** lists the 38 moderate-priority wells, and **Appendix G** provides hydrographs for these moderate-priority wells. The number 25 was estimated by applying the three-step process to the information in **Table 8** and depicted in **Figure 15** below. For 2023 the drawdown contour that encompassed the majority of the high priority wells with pump elevations was 90 feet of drawdown.

Table 7 Estimate of Number of Moderate-Priority Wells in 2030 based on an Analysis of the Location of High-Priority Wells

Number of Wells Encircled by the 120 ft Drawdown Contour in 2030*				
(a) Wells with Pump Information	(b) Number of High Priority Wells Before Assistance	(c) Percent of Wells with Pump Information that are High-Priority Wells	(d) Number of Eligible Wells with No Pump Information	(e) Number of wells in Column (d) that are moderate-risk wells based on the percentage in Column (c)
80	52	65%	38	25

*tabulated values are based on information shown in Figure 16

Table 8 Estimate of Number of Moderate-Priority Wells in 2023 based on an Analysis of the Location of High-Priority Wells

Number of Wells Encircled by the 90 ft Drawdown Contour in 2023*				
(a) Wells with Pump Information	(b) Number of High Priority Well Before Assistance	(c) Percent of Wells with Pump Information that are High-Priority Wells	(d) Number of Eligible Wells with No Pump Information	(e) Number of wells in Column (d) that are moderate-risk wells based on the percentage in Column (c)
62	35	56%	28	16

*tabulated values are based on information shown in Figure 17

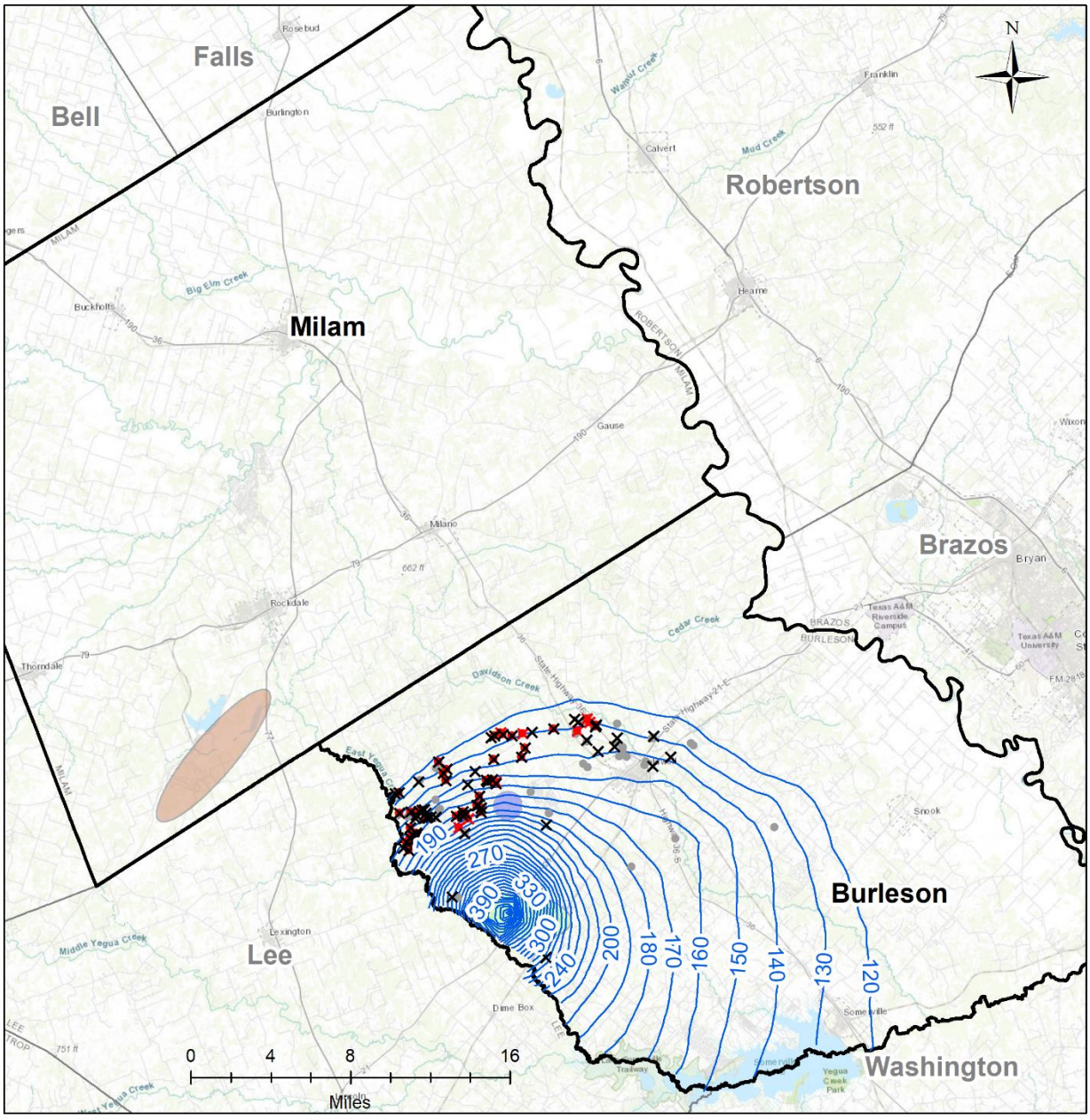


Figure 14 Drawdown in the Carrizo Aquifer greater than 120 feet from 2020 to 2030 and predicted water level relative to known pump settings based on information in the POSGCD well database

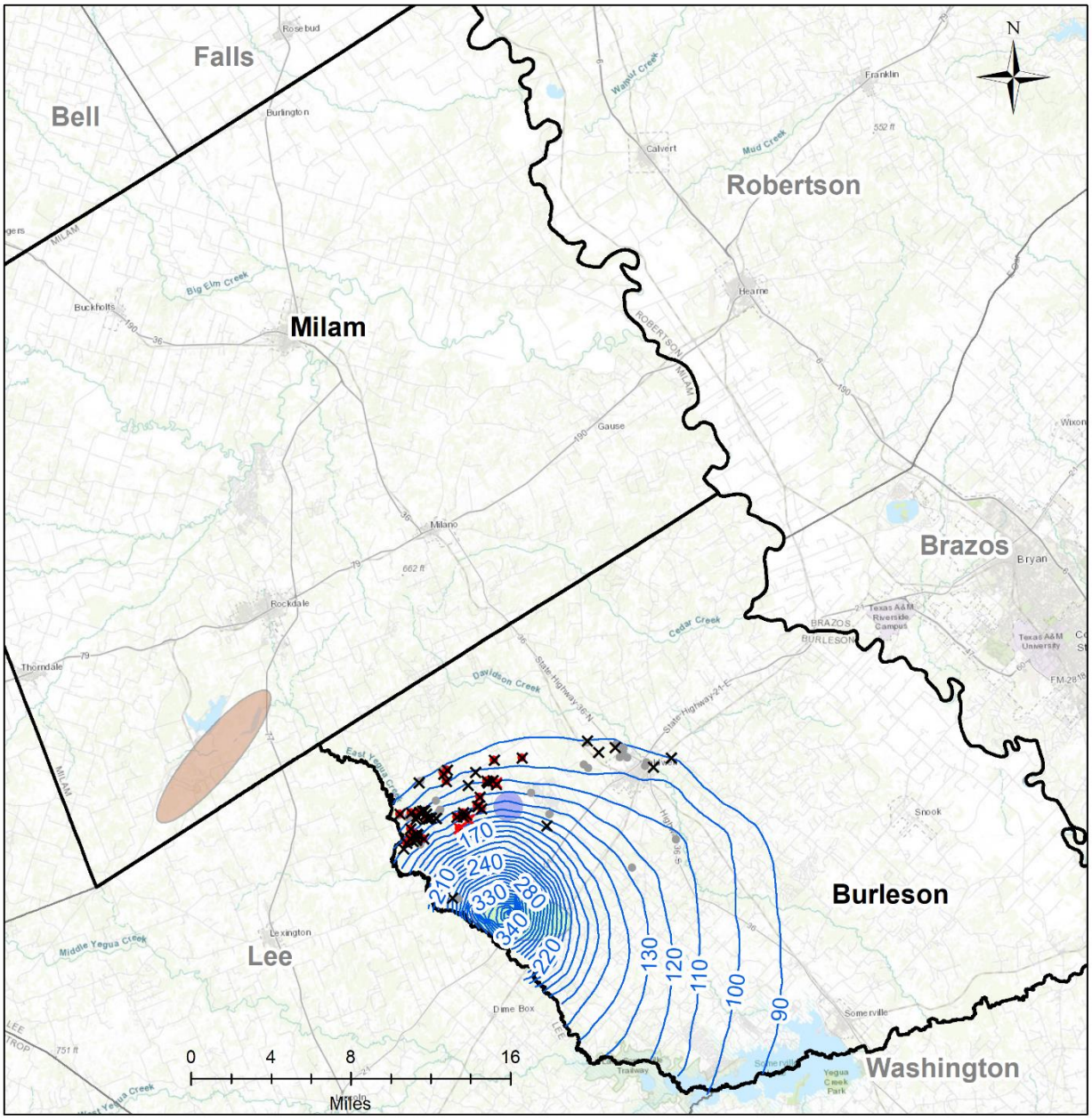


Figure 15 Drawdown in the Carrizo Aquifer greater than 90 feet from 2020 to 2023 and predicted water level relative to known pump settings based on information in the POSGCD well database

3.3 Assisted Wells

Since 2020, multiple wells that were identified as high priority, mid priority or a well of concern have been helped by POSGCD as a part of the GWAP program. POSGCD has assisted at least 53 eligible wells by dropping their pump setting by up to 260 ft and, on average, 155 ft, which is shown in **Table 9.** Table 9 provides the height of the simulated 2030 water level elevation above the reset pump elevation and the top of the Carrizo Aquifer. Of the 51 assisted eligible wells with known pump depths, 45 would have been identified as high priority wells prior to assistance from POSGCD Staff. After lowering of their pump depths, none of the assisted 51 wells are identified as high priority wells in 2030. All eligible assisted wells were screened in the Carrizo formation were Carrizo wells. Sixteen (16) more wells are slated to have their pump setting lowered in the near future by POSGCD shown in **Figure 16.**

Table 10 lists sixteen wells that are planned for GWAP assistance sometime in the near future. All sixteen of the wells are identified as a high priority well. **Appendix H** lists the 53 assisted wells, and **Appendix I** provides hydrographs for these assisted wells.

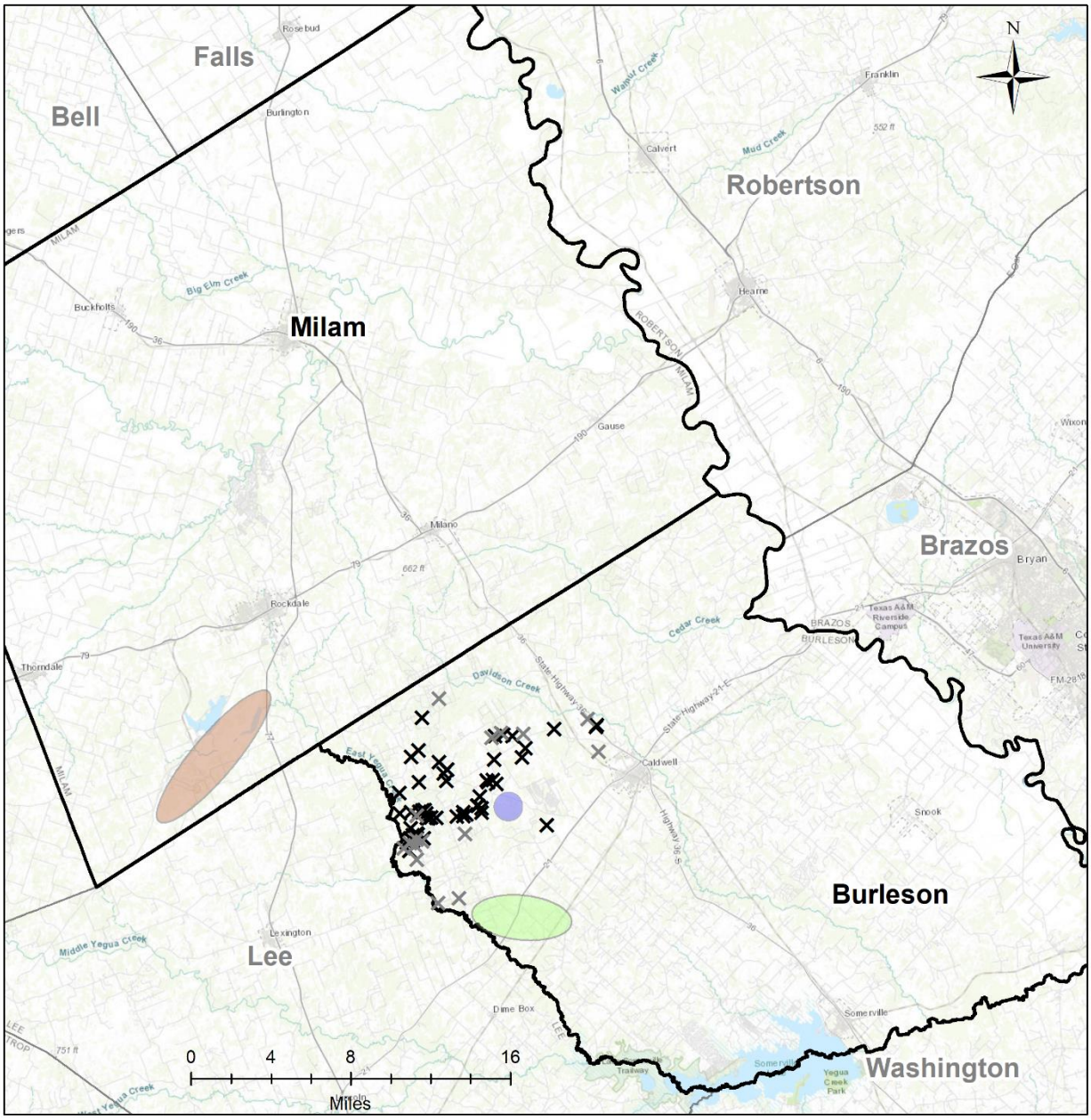


Figure 16 Wells that POSGCD staff has lowered the pump setting in and wells that POSGCD plans to assist in the near future.

Table 9 POSGCD wells that have had their pump settings lowered Simulated water level elevation relative to pump elevation in eligible wells for the administrative period (2020 through 2030) and for the time period from 2020 through 2023.

POSGCD Well ID	Previous Pump Elevation (ft-amsl)	Current Pump Elevation (ft-amsl)	Change in Pump Elevation (ft)	Simulated Water above Current Pump (ft) in 2030	Simulated Available Drawdown above formation (ft) in 2030
PO-000475	244	144	100	16	279
PO-001327	244	124	120	37	145
PO-001328	235	115	120	66	155
PO-001331	201	-11	212	193	155
PO-001342	234	54	180	146	475
PO-003440	259	79	180	131	133
PO-003444	190	-30	220	206	176
PO-004459	97	35	62	147	155
PO-004976	252	52	200	124	604
PO-005228	265	165	100	81	127
PO-005231	234	54	180	124	426
PO-005767	ND	49	ND	221	243
PO-005816	223	51	172	255	187
PO-005817	211	91	120	180	243
PO-005821	149	9	140	151	279
PO-006405	197	137	60	26	185
PO-006551	222	52	170	124	604
PO-006658	159	-1	160	160	279
PO-006815	201	61	140	137	177
PO-006816	230	41	189	175	140
PO-007393	252	112	140	150	127
PO-007765	259	39	220	160	118
PO-008053	213	33	180	139	160
PO-008054	176	46	130	126	160
PO-008271	241	81	160	117	177
PO-008326	242	62	180	123	411
PO-008794	190	30	160	145	384
PO-008805	193	73	120	132	455
PO-008923	227	67	160	108	384
PO-008956	92	-68	160	193	453
PO-008964	174	94	80	88	155

POSGCD Well ID	Previous Pump Elevation (ft-amsl)	Current Pump Elevation (ft-amsl)	Change in Pump Elevation (ft)	Simulated Water above Current Pump (ft) in 2030	Simulated Available Drawdown above formation (ft) in 2030
PO-008965	219	39	180	159	177
PO-009032	233	55	178	136	439
PO-009067	251	-9	260	201	417
PO-009125	169	-11	180	151	264
PO-009135	221	101	120	75	176
PO-009242	213	33	180	139	160
PO-009332	217	37	180	122	279
PO-009434	219	119	100	21	264
PO-009570	183	23	160	134	190
PO-009572	184	24	160	151	384
PO-009609	233	93	140	132	82
PO-009787	159	19	140	121	264
PO-010952	190	50	140	132	155
PO-010967	203	43	160	129	160
PO-010979	149	49	100	132	155
PO-011170	216	56	160	149	455
PO-011370	238	78	160	94	160
PO-011373	211	31	180	141	160
PO-011380	137	32	105	150	155
PO-011383	233	33	200	142	384
PO-011385	190	95	95	64	160
PO-011435	ND	79	ND	140	156

Note: ND = no data

Table 10 POSGCD wells that are slated to have their pump settings lowered before the end of 2022.

District ID	Formation	Current Pump Elevation	Simulated Water above Current Pump (ft) in 2030	Simulated Available Drawdown above formation (ft) in 2030
PO-000943	Carrizo	19.4	-99.4	247.6
PO-006560	Queen City	259.0	-77.5	54.1
PO-008073	Carrizo	171.0	-65.7	763.2
PO-008147	Carrizo	141.7	-31.7	174.2
PO-008219	Carrizo	127.1	-78.0	455.5
PO-008338	Carrizo	108.1	-63.8	159.8
PO-008668	Carrizo	172.8	-19.5	416.6
PO-008773	Carrizo	236.0	-102.9	72.5
PO-008826	Carrizo	198.3	-6.7	455.5
PO-009239	Queen City	ND	ND	48.9
PO-009386	Carrizo	ND	ND	374.5
PO-009431	Carrizo	182.7	3.1	521.5
PO-011024	Carrizo	157.8	-23.8	154.8
PO-011376	Queen City	262.9	-73.4	58.6
PO-011382	Queen City	ND	ND	92.2
PO-011384	Carrizo	245.9	85.1	144.8

Note: ND = no data

4.0 SUMMARY OF ANALYSES AND RECOMMENDATIONS

The GWAP assists well-owners with exempt and permitted low-capacity wells whose water levels are predicted to decline to less than 15 feet about the pump setting prior to 2030 as a result of regional groundwater production in GMA 12. The report identifies high priority wells based as simulations of a modified GAM using a future estimated pumping from a DFC simulation created by GMA 12. The high-priority classification for a well requires that the pump elevation of the well is known. For a well to be classified as a high-priority well, the following two conditions need to be met: (1) its simulated water level in 2020 is greater than 15 ft above the pump elevation, and (2) its simulated water level in 2030 is less than 15 ft above the elevation of its pump elevation. For wells without pump information, the well is designated as a moderate-priority well if there is sufficient cause to believe that the well would be classified as a high-priority well if the pump information were available.

The future water levels are generated from GAM simulations and estimates of a future pumping. The incorporation of multiple sources of data and multiple analysis includes several assumptions that introduces error and uncertainty into each well evaluation. Because our analyses are predictive and therefore not certain, some wells that are designated as priority wells that may not require assistance within the next 10 years or may not actually require assistance at all in the future.

4.1 Summary of Analyses

This section summarizes the key analysis performed and documented in this report.

- A modified version of the Central Sparta/Queen City/Carrizo-Wilcox Aquifer GAM (Young and others, 2021) was used to simulate water levels in POSGCD and surrounding counties using a future pumping scenario called PS-19. From 2021 to 2028, PS-19 presumes that the Vista Ridge well field is pumping at its full permitted amount of 15,000 acre-feet per year (AFY) in the Carrizo Aquifer and 30,992 AFY in the Simsboro Aquifer from fall 2020 to 2070. Based on PS-19, the following general trends in drawdown were simulated for the period 2020 to 2030:
  - Across most of the Sparta and Queen City aquifers, the drawdown is less than 30 ft
  - In the Carrizo Aquifer, drawdown in the vicinity of the Vista Ridge well field is greater than 250 ft and decreases radially outward from the well field to about 70 ft at the Brazos County line and to 20 ft in the outcrop in Milam County
  - In the Calvert Bluff Aquifer, drawdown in the vicinity of the Vista Ridge well field is greater than 130 ft and decreases radially outward from the well field to about 50 ft at the Brazos County line and to 20 ft in the outcrop in Milam County
  - In the Simsboro Aquifer, drawdown in the vicinity of the Vista Ridge well field is greater than 200 ft and decreases radially outward from the well field to about 150 ft at the Brazos County line and to 10 ft in the outcrop in Milam County
  - In the Hooper Aquifer, maximum drawdown is centered approximately five miles north of the Vista Ridge well field and is as high as 120 ft. Across most of the outcrop for the Hooper Aquifer in Milam County, the drawdowns are less than 30 ft and, along the county line with Brazos County, the drawdowns range between 60 ft to less than 10 ft in the outcrop in Milam County.
- For all eligible wells in the with information about the pump settings, a comparison was made between the simulated water level in the well and the elevation of the pump to determine the

likelihood of whether there would be sufficient water for pumping the well for the next ten years. A well was classified as a high priority well if the following two conditions are met: (1) its simulated water level in 2020 is greater than 15 ft above the pump elevation, and (2) its simulated water level in 2020 is less than 15 ft above the elevation of its pump elevation. A total of 24 wells were identified as high-priority wells. Of the 24 wells, 17 are completed in the Carrizo Aquifer with the remaining 7 in the Sparta (n=3), Calvert Bluff (n=3), Queen City (n=1), and Simsboro (n=0), and Hooper (n=0). Forty-seven percent of the Carrizo wells that would become high-priority wells by 2030 will have already met the criteria by 2023 (n=8).

- For eligible wells without information about the pump settings, wells were classified as moderate-priority well if there is sufficient cause to believe that the well would be classified as a high-priority well if the pump information were available. The identification of moderate-priority wells was based on estimated drawdown at the well in 2030. Thirty-eight (38) wells were classified as potential candidates for moderate-priority wells. Twenty-two (25) out of the 38 candidate wells are estimated to have problems with low water levels before the end of 2030. Of those thirty-eight, sixteen (16) wells may need corrective actions before 2023.
- Hydrographs of simulated water levels from 2000 to 2032 were created for the 24 high-priority wells, 38 candidate moderate-priority wells, and 41 wells of concern. Wells are classified as wells of concern if their simulated water levels in 2020 is less than 15 ft above their pump setting.
- The number of high priority wells has decreased from last year's GWAP investigation from 56 to 24.
- Fifty-three (53) wells have had their pump setting lowered by POSGCD staff, forty-five (45) of fifty-one (51) wells with a known pump setting would have been considered high-priority in 2030 but are now not expected to have water level below 15 ft above the new pump setting.
- Sixteen (16) wells are planned to have their pump setting lowered in the near future.

4.2 Recommendations

Based on the data, data analysis, and findings presented in the report, the following actions are recommended:

- POSGCD's Water Resource Specialist should verify the eligibility and review the well construction, the 24 high-priority wells, 38 moderate-priority wells, and 41 wells of concern and then consider measuring water levels at these wells to check the accuracy of the simulated water levels.
- Water levels should be measured at each high priority Carrizo well (or at nearby wells) at least once every four months and the elevation of the pump setting should be verified
- The Sparta/Queen City/Carrizo-Wilcox GAM should be continually updated using monitoring data so that it will be better suited for predicting the drawdown impacts that will be caused by the pumping of more than 50,000 AFY associated with the Vista Ridge Project and the planned pumping of over 25,000 AFY from the SLR well field for the Samsung Plant in Taylor.
- A methodology should be developed for using measured water level data to help adjust for biases and error in the simulated water levels.
- POSGCD should develop a practice for checking and quantifying the accuracy of reported pumping for non-exempt permits.

5.0 REFERENCES

Post Oak Savannah Groundwater Conservation District (POSGCD), 2020. Draft; Post Oak Savannah Groundwater Conservation District Groundwater Well Assistance Program (GWAP).

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APPENDIX A

LOCATION OF EXEMPT WELLS BY AQUIFER

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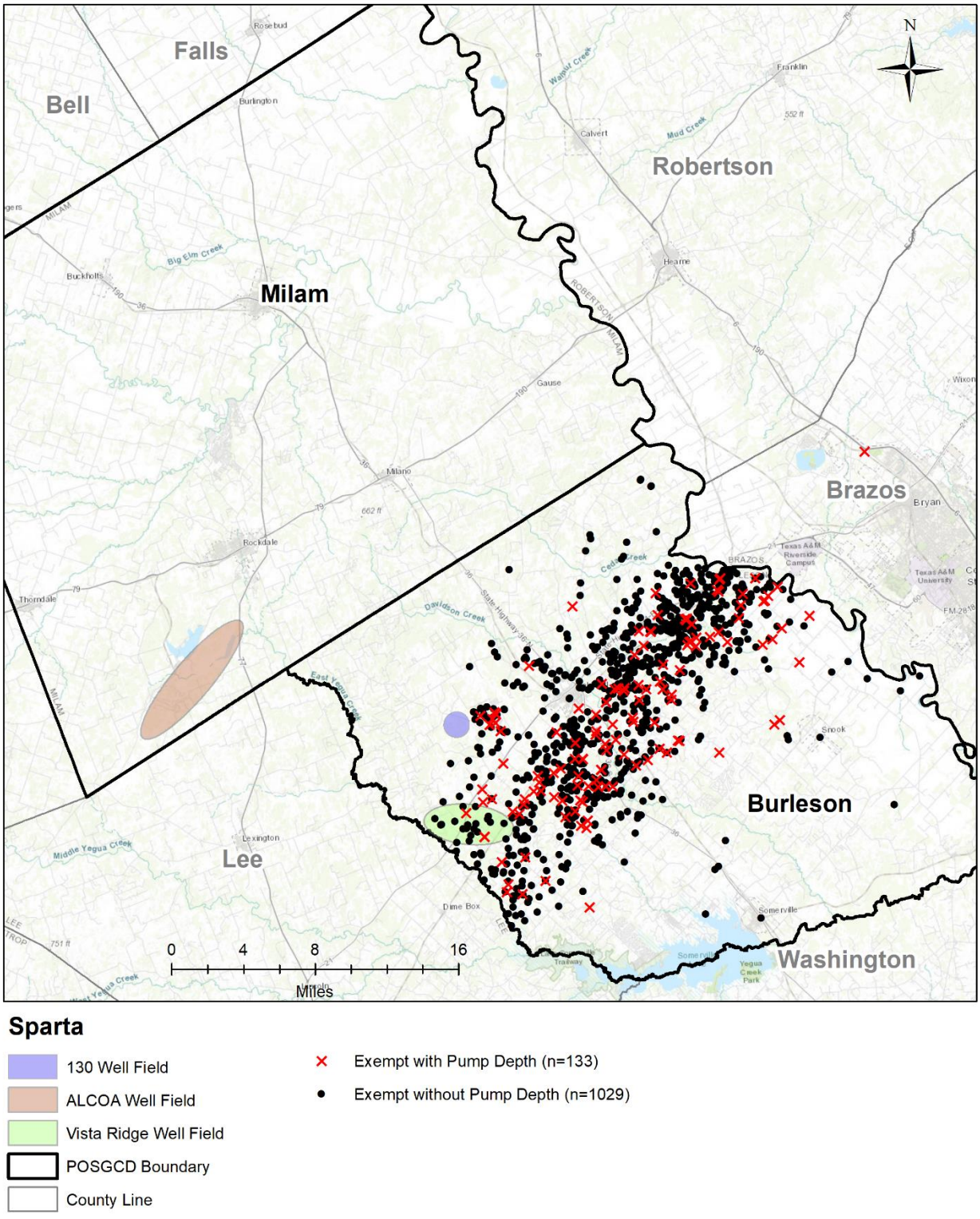

Figure A-1 Location of eligible exempt wells in the Sparta Aquifer

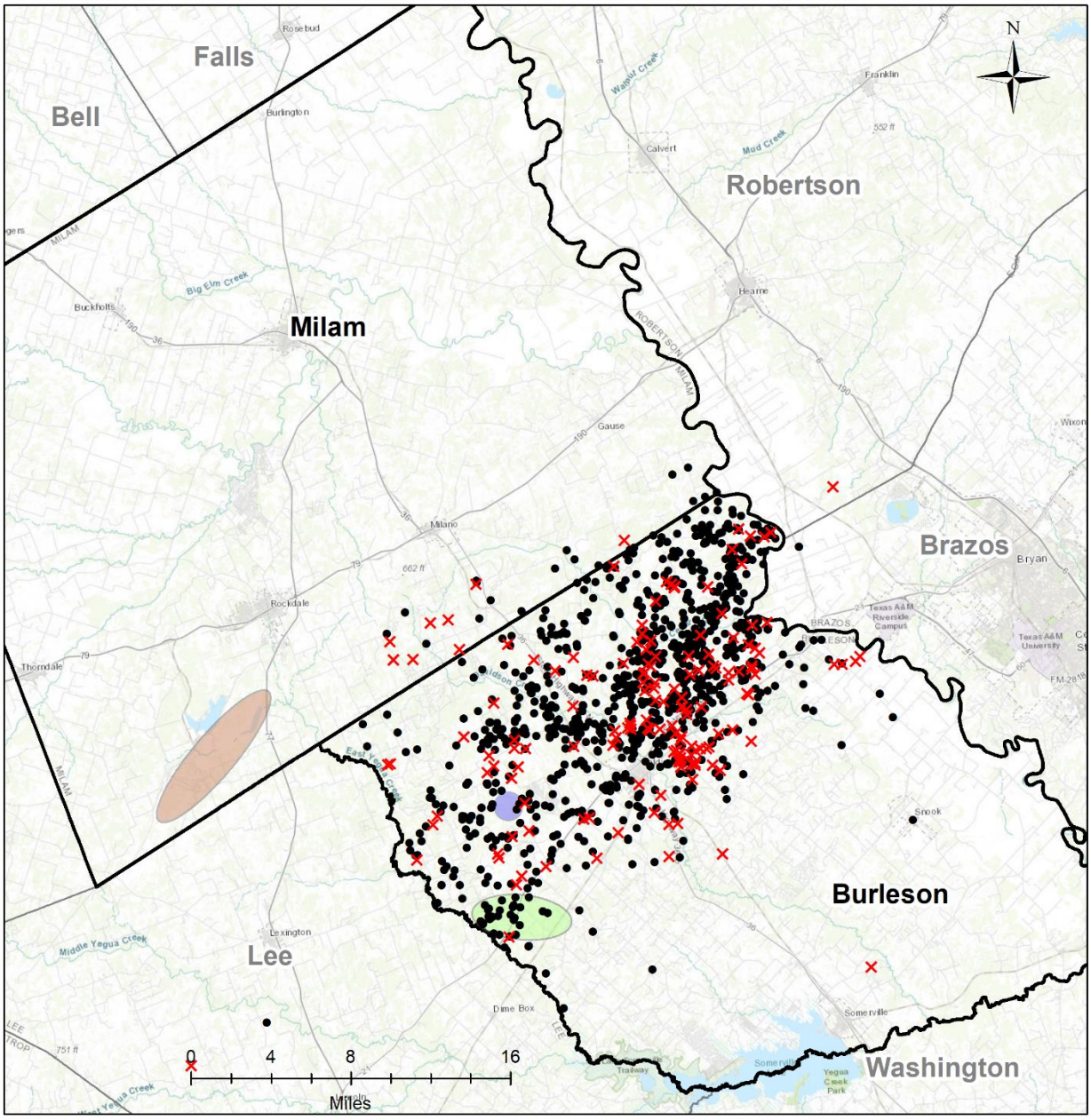

Figure A-2 Location of eligible exempt wells in the Queen City Aquifer

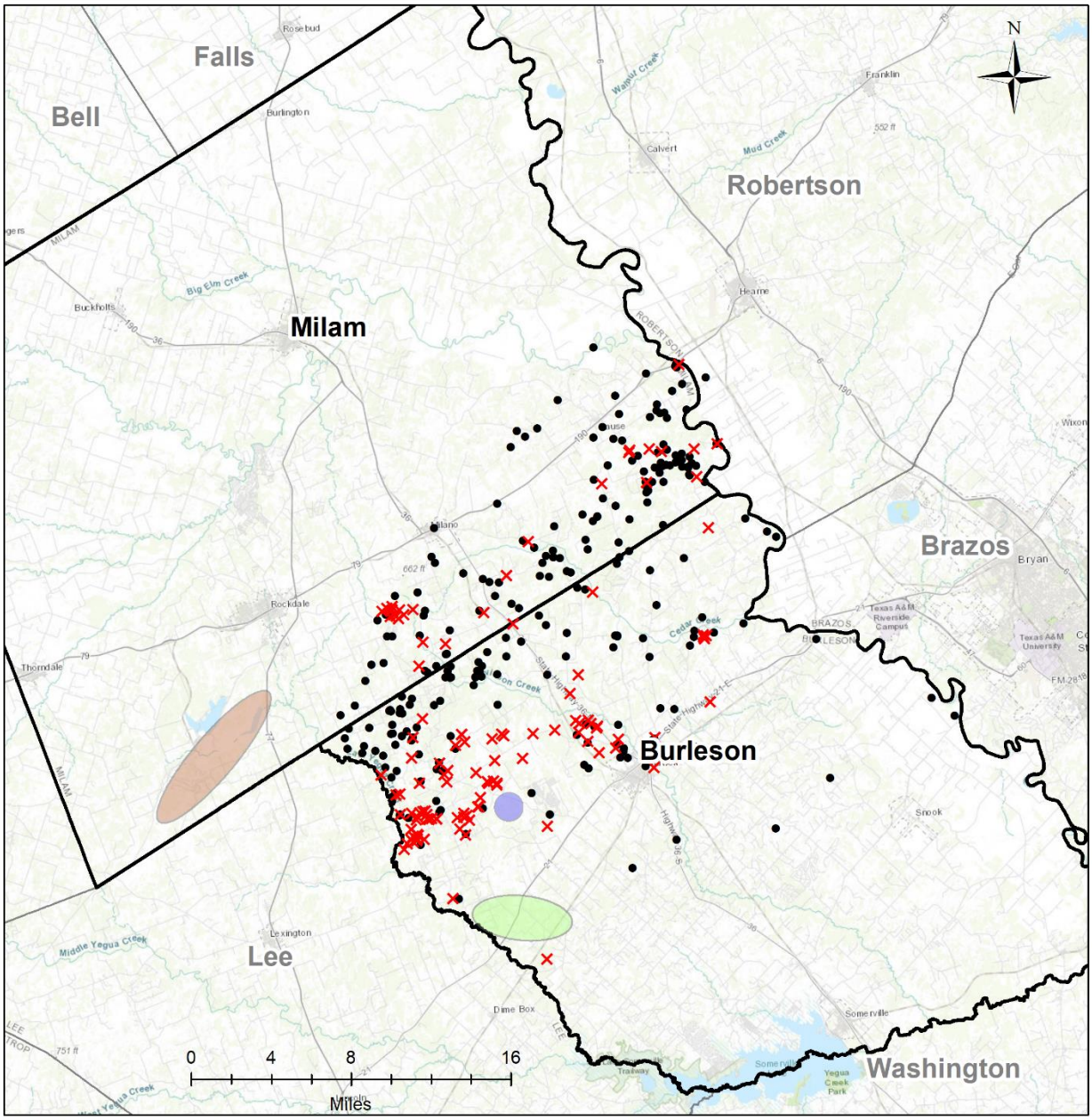

Figure A-3 Location of eligible exempt wells in the Carrizo Aquifer

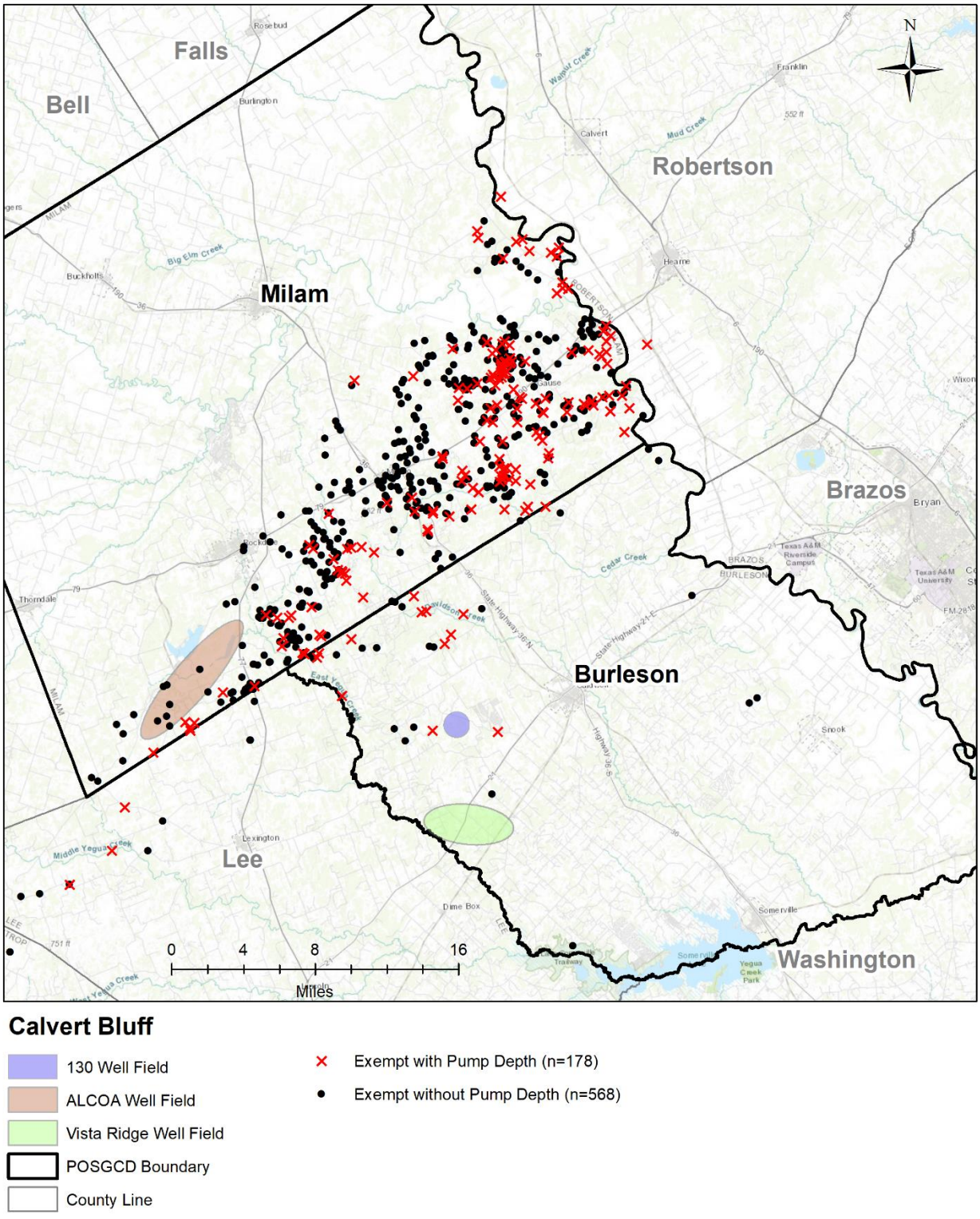

Figure A-4 Location of eligible exempt wells in the Calvert Bluff Aquifer

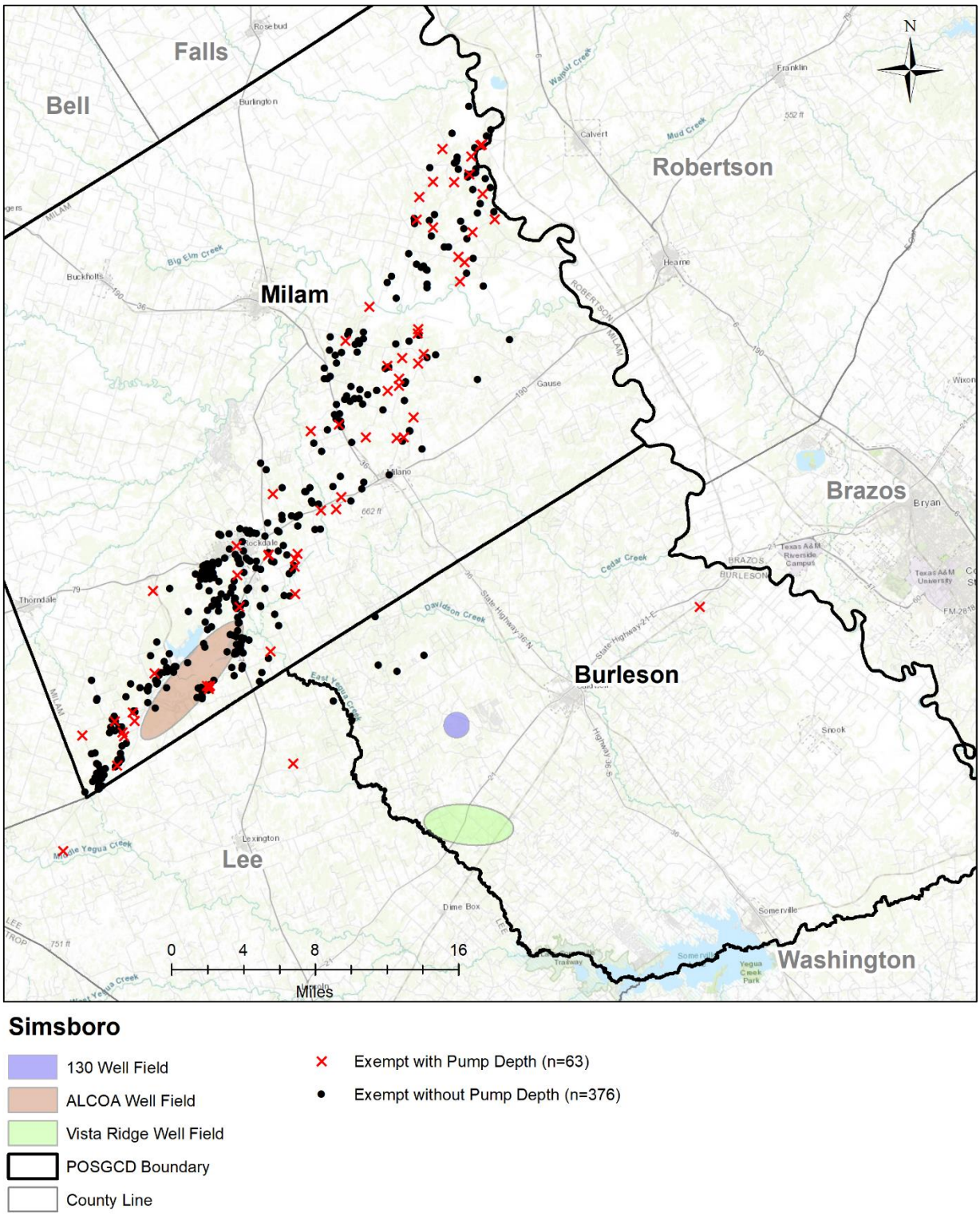

Figure A-5 Location of eligible exempt wells in the Simsboro Aquifer

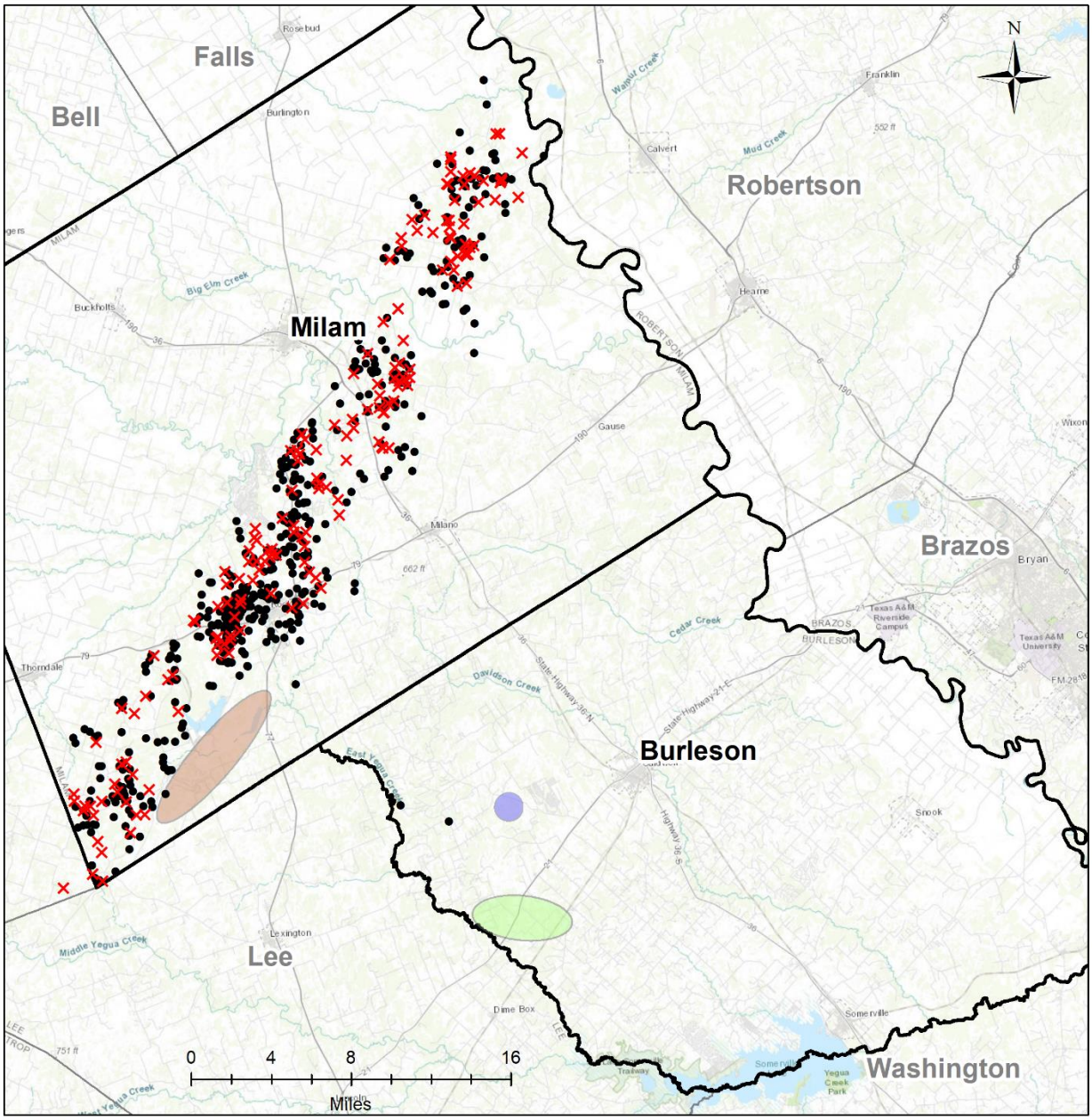

Figure A-6 Location of eligible exempt wells in the Hooper Aquifer

APPENDIX B

LOCATION OF LOW-CAPACITY PERMITTED WELLS BY AQUIFER

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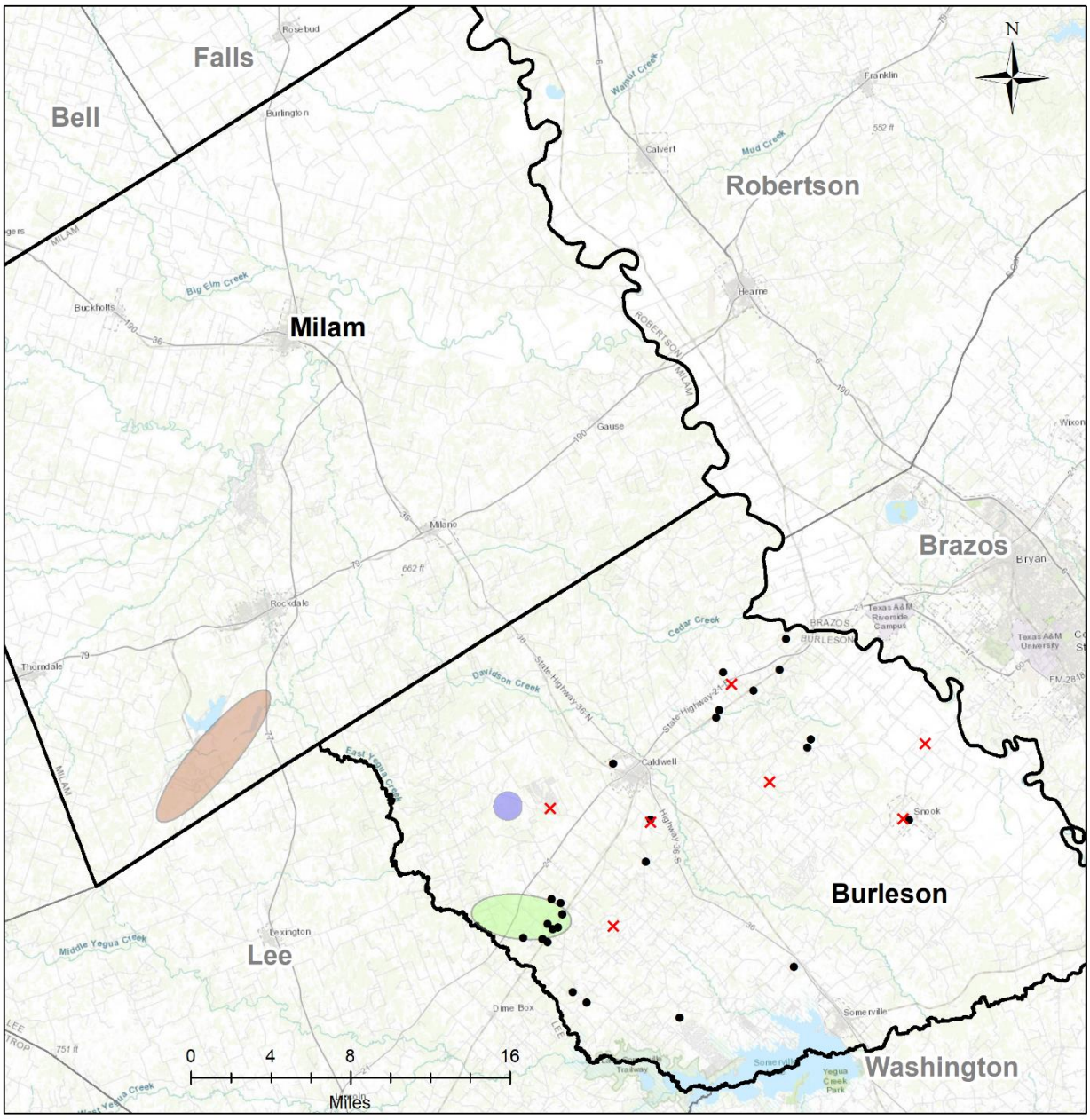

Figure B-1 Location of eligible low-capacity permitted wells in the Sparta Aquifer

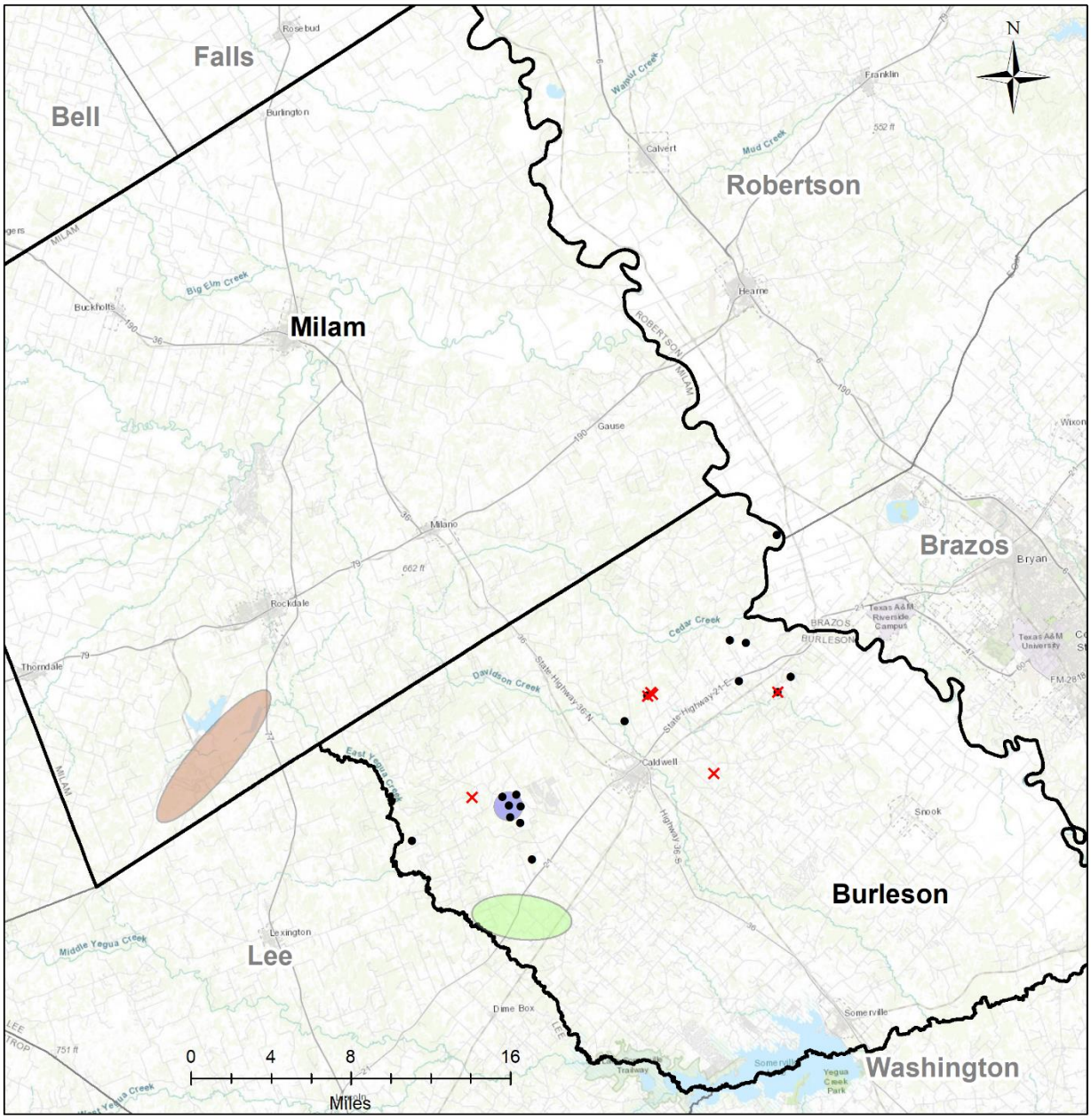

Figure B-2 Location of eligible low-capacity permitted wells in the Queen City Aquifer

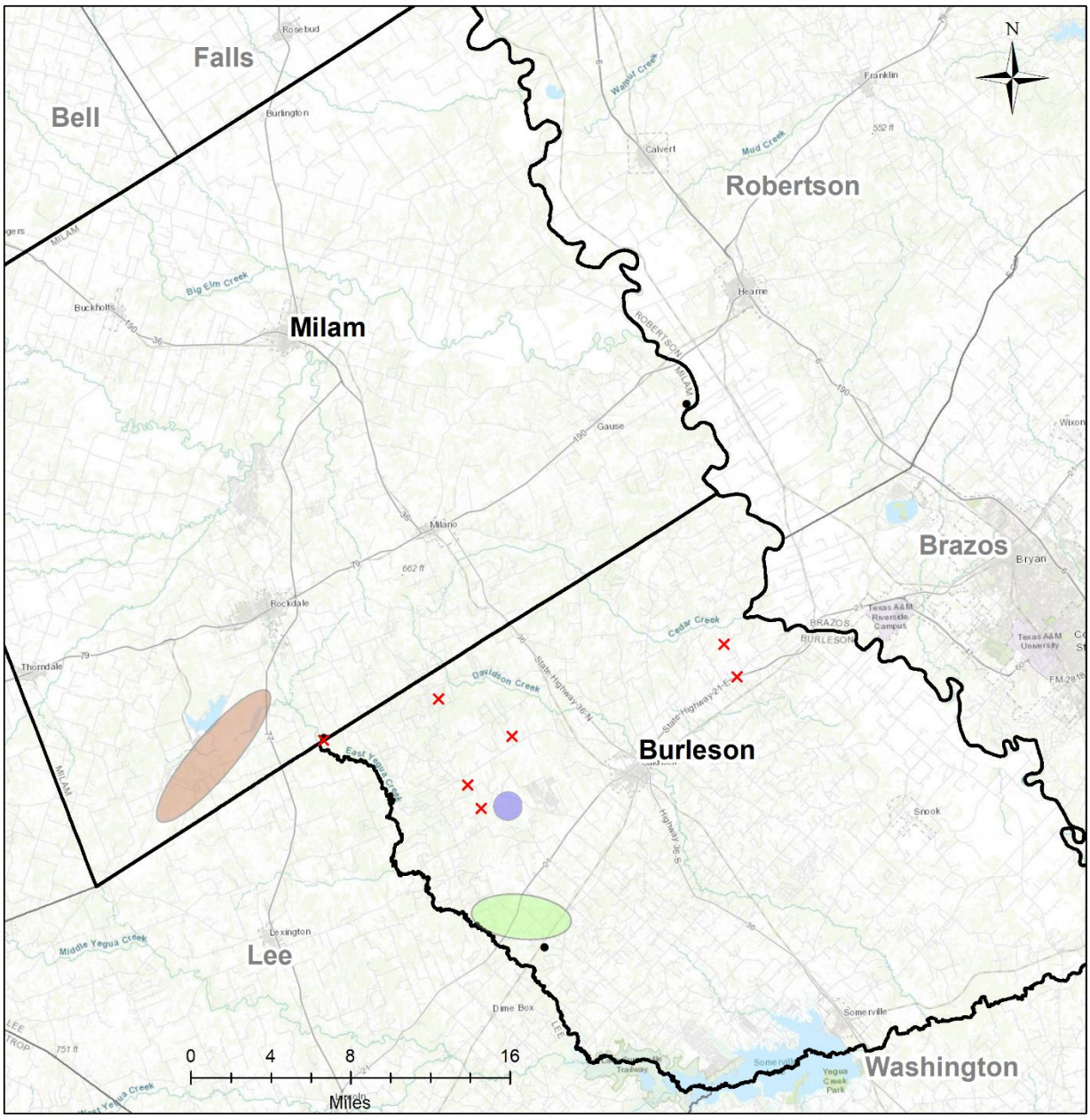

Figure B-3 Location of eligible low-capacity permitted wells in the Carrizo Aquifer

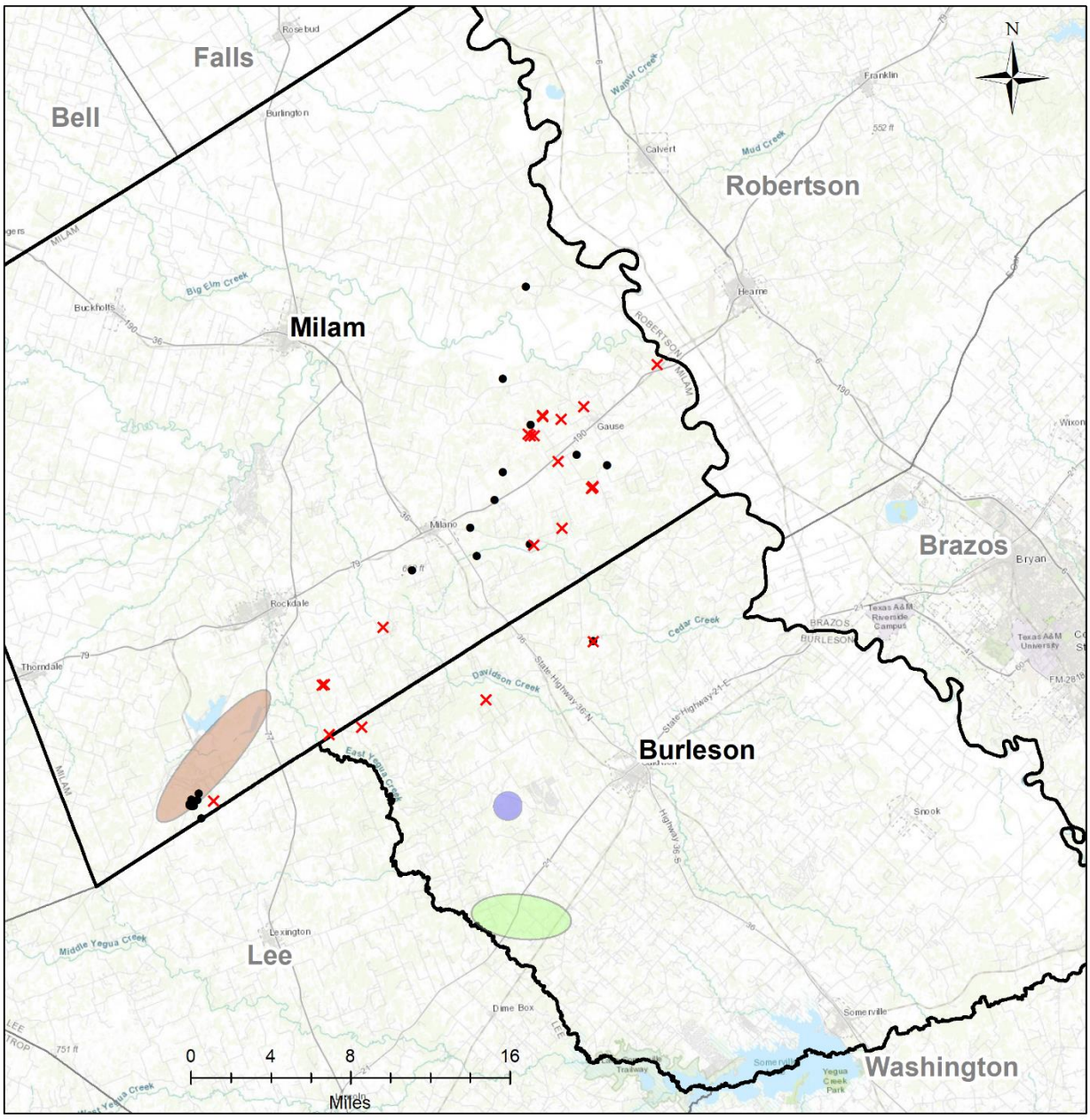

Figure B-4 Location of eligible low-capacity permitted wells in the Calvert Bluff Aquifer

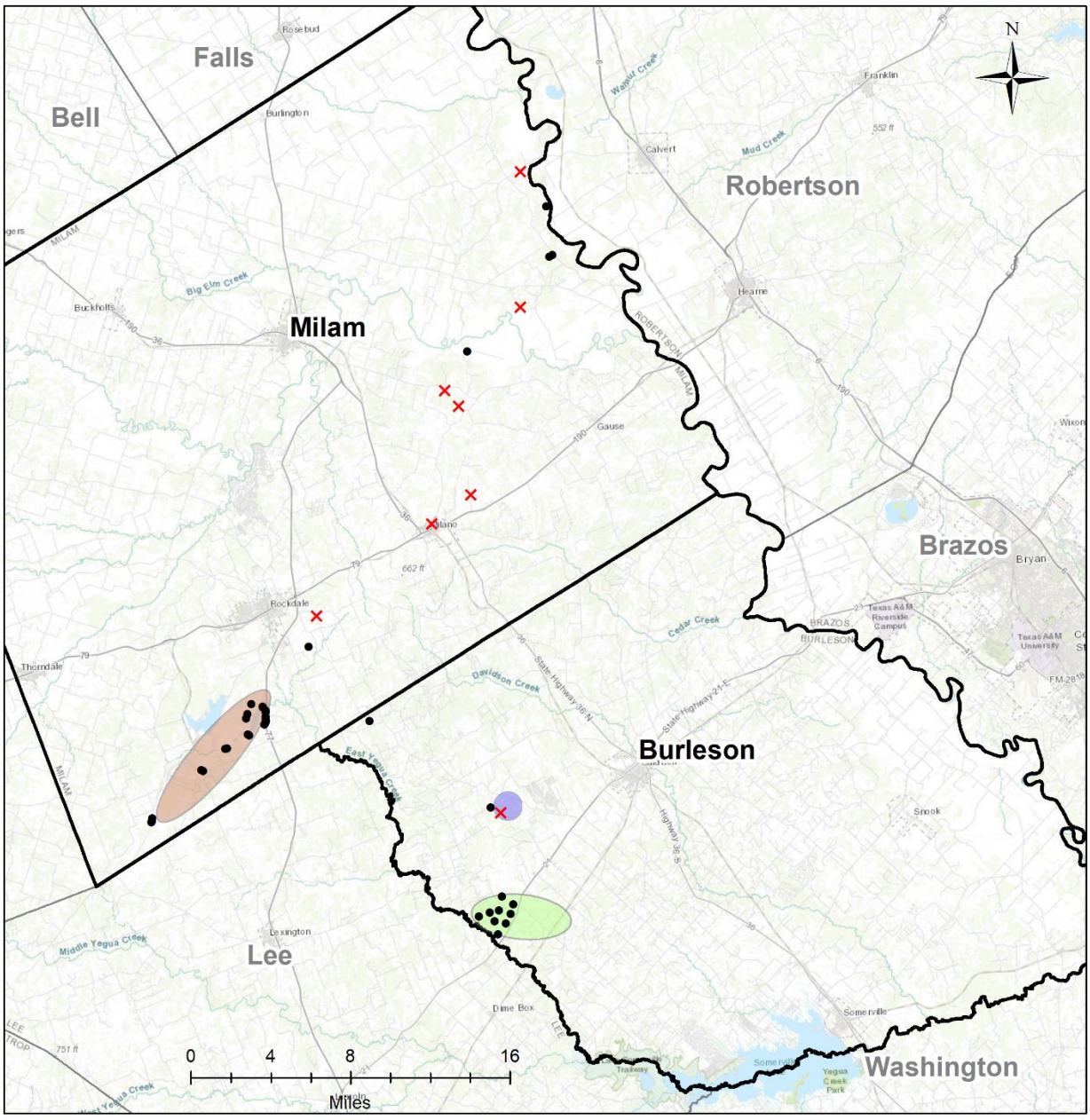

Figure B-5 Location of eligible low-capacity permitted wells in the Simsboro Aquifer

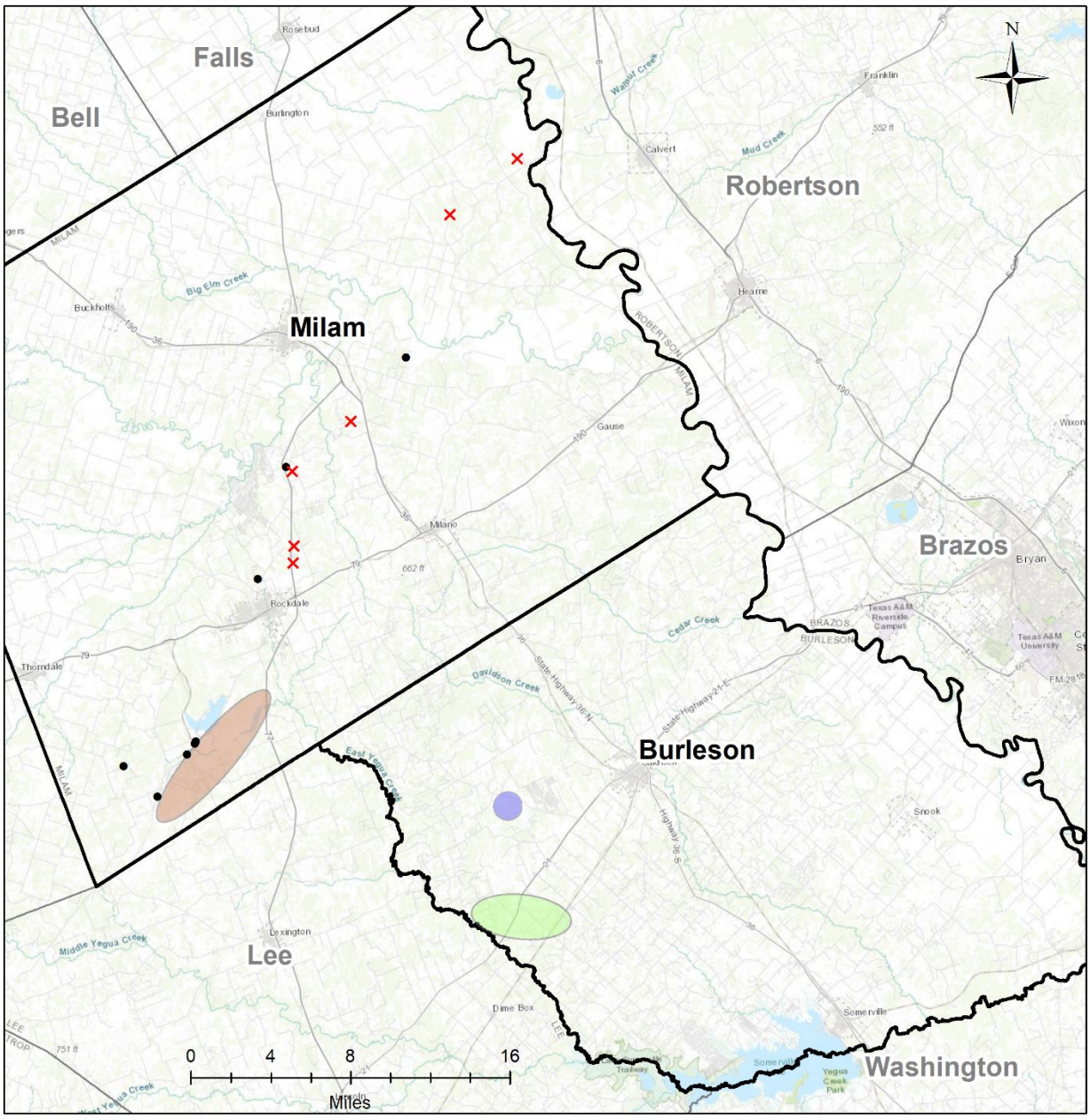

Figure B-6 Location of eligible low-capacity permitted wells in the Hooper Aquifer

APPENDIX C

Listing of high-priority wells and wells of concern

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Well ID	Aquifer	Water Level is less than 15 feet above Pump in Year			High-Priority Well	Well of Concern
		2020	2023	2030		
PO-000268	Simsboro	1	1	1	no	yes
PO-001120	Carrizo	0	0	1	yes	no
PO-001883	Simsboro	1	1	1	no	yes
PO-002014	Simsboro	1	1	1	no	yes
PO-002205	Simsboro	1	1	1	no	yes
PO-005754	Carrizo	0	0	1	yes	no
PO-006058	Carrizo	0	0	1	yes	no
PO-006277	Queen City	0	0	0	yes	no
PO-006282	Carrizo	0	0	1	yes	no
PO-006350	Carrizo	0	0	0	yes	no
PO-007242	Calvert Bluff	0	0	0	yes	no
PO-007363	Simsboro	1	1	1	no	yes
PO-007378	Simsboro	1	1	1	no	yes
PO-007390	Sparta	0	0	1	yes	no
PO-007641	Simsboro	1	1	1	no	yes
PO-008172	Hooper	1	1	1	no	yes
PO-008207	Hooper	1	1	1	no	yes
PO-008208	Hooper	1	1	1	no	yes
PO-008246	Carrizo	0	0	1	yes	no
PO-008322	Carrizo	0	0	1	yes	no
PO-008659	Calvert Bluff	1	1	1	no	yes
PO-008668	Carrizo	0	0	1	yes	no
PO-008700	Queen City	1	1	1	no	yes
PO-008793	Carrizo	1	1	1	no	yes
PO-008799	Queen City	1	1	1	no	yes
PO-008826	Carrizo	0	0	0	yes	no
PO-008884	Carrizo	0	0	0	yes	no
PO-008908	Carrizo	1	1	1	no	yes
PO-009005	Sparta	1	1	1	no	yes
PO-009033	Queen City	1	1	1	no	yes
PO-009084	Carrizo	1	1	1	no	yes
PO-009241	Hooper	1	1	1	no	yes
PO-009288	Sparta	1	1	1	no	yes
PO-009372	Queen City	1	1	1	no	yes
PO-009377	Hooper	1	1	1	no	yes
PO-009431	Carrizo	0	0	0	yes	no
PO-009474	Sparta	0	0	0	yes	no
PO-009526	Carrizo	0	0	0	yes	no

Well ID	Aquifer	Water Level is less than 15 feet above Pump in Year			High-Priority Well	Well of Concern
		2020	2023	2030		
PO-009527	Hooper	1	1	1	no	yes
PO-009597	Simsboro	1	1	1	no	yes
PO-009607	Calvert Bluff	0	0	1	yes	no
PO-009658	Hooper	1	1	1	no	yes
PO-009741	Hooper	1	1	1	no	yes
PO-009753	Simsboro	1	1	1	no	yes
PO-009754	Simsboro	1	1	1	no	yes
PO-010918	Carrizo	1	1	1	no	yes
PO-011076	Hooper	1	1	1	no	yes
PO-011129	Queen City	1	1	1	no	yes
PO-011143	Simsboro	1	1	1	no	yes
PO-011146	Reklaw	1	1	1	no	yes
PO-011280	Carrizo	0	0	0	yes	no
PO-011288	Calvert Bluff	1	1	1	no	yes
PO-011317	Carrizo	0	0	0	yes	no
PO-011329	Carrizo	0	0	0	yes	no
PO-011384	Carrizo	0	0	1	yes	no
PO-011403	Carrizo	1	1	1	no	yes
PO-011410	Carrizo	0	0	0	yes	no
PO-011411	Calvert Bluff	1	1	1	no	yes
PO-011432	Sparta	1	1	1	no	yes
PO-011485	Queen City	1	1	1	no	yes
PO-011490	Carrizo	1	1	1	no	yes
PO-011494	Calvert Bluff	0	0	1	yes	no
PO-011514	Carrizo	1	1	1	no	yes
PO-011526	Carrizo	1	1	1	no	yes
PO-011554	Weches	1	1	1	no	yes
PO-011558	Simsboro	1	1	1	no	yes
PO-011609	Sparta	0	0	0	yes	no

APPENDIX D

Hydrographs for High-Priority Wells

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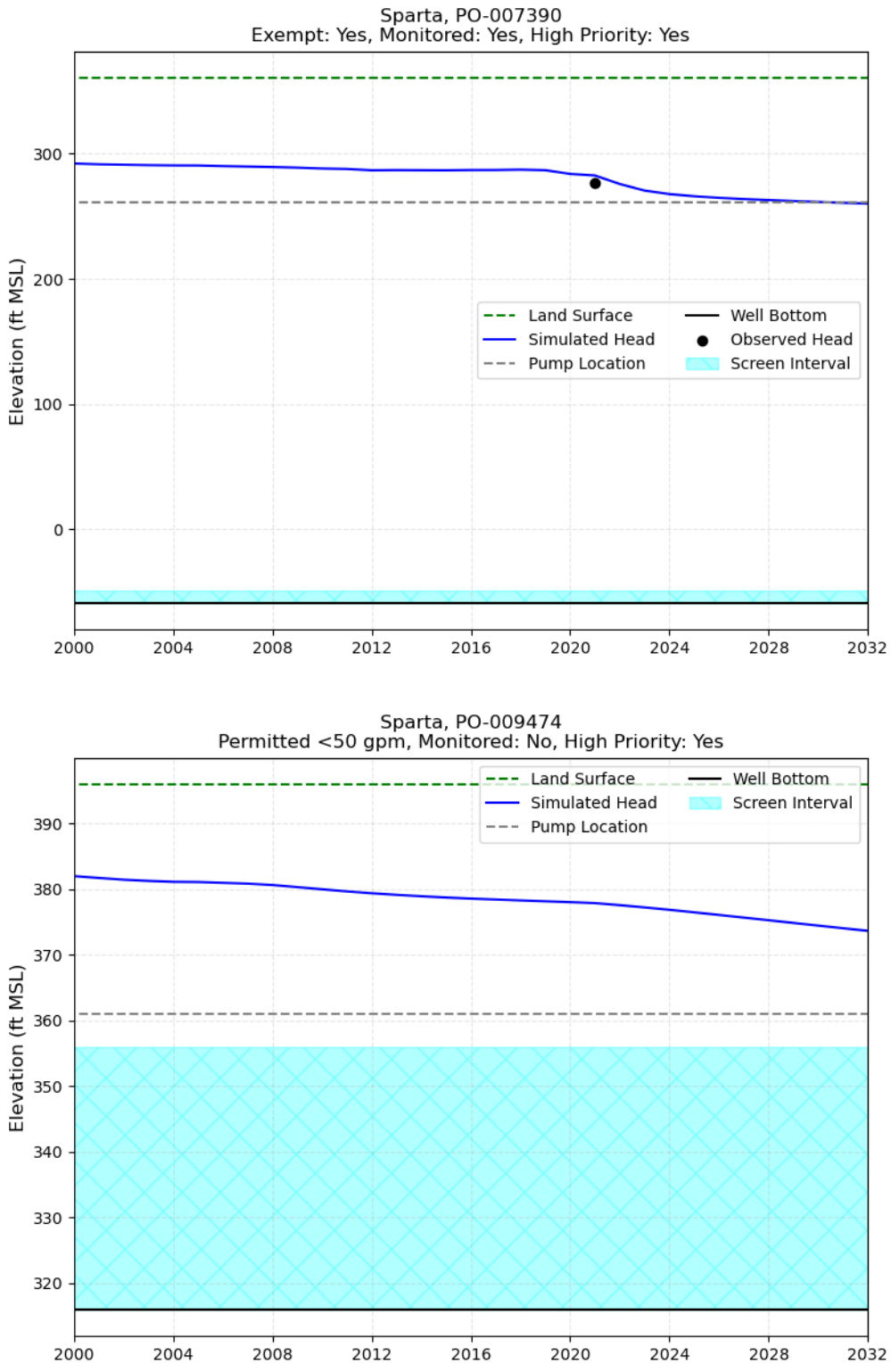

Figure D-1 Simulated water levels for high-priority wells PO-007390 and PO-009474 located in the Sparta Aquifer

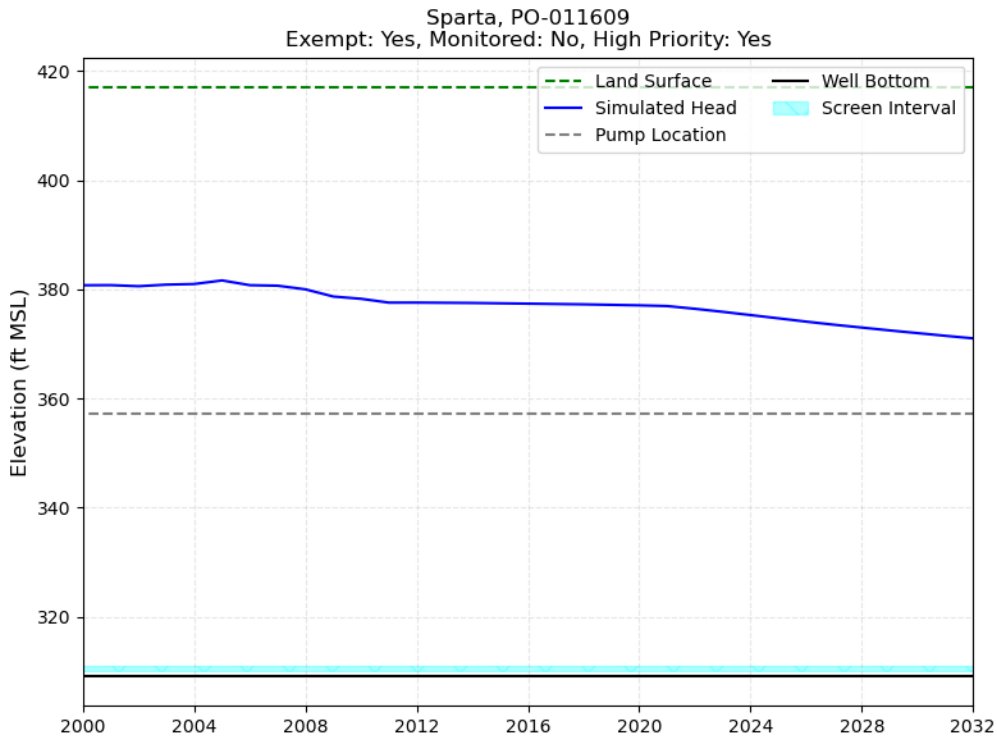

Figure D-2 Simulated water levels for high-priority well PO-011609 located in the Sparta Aquifer

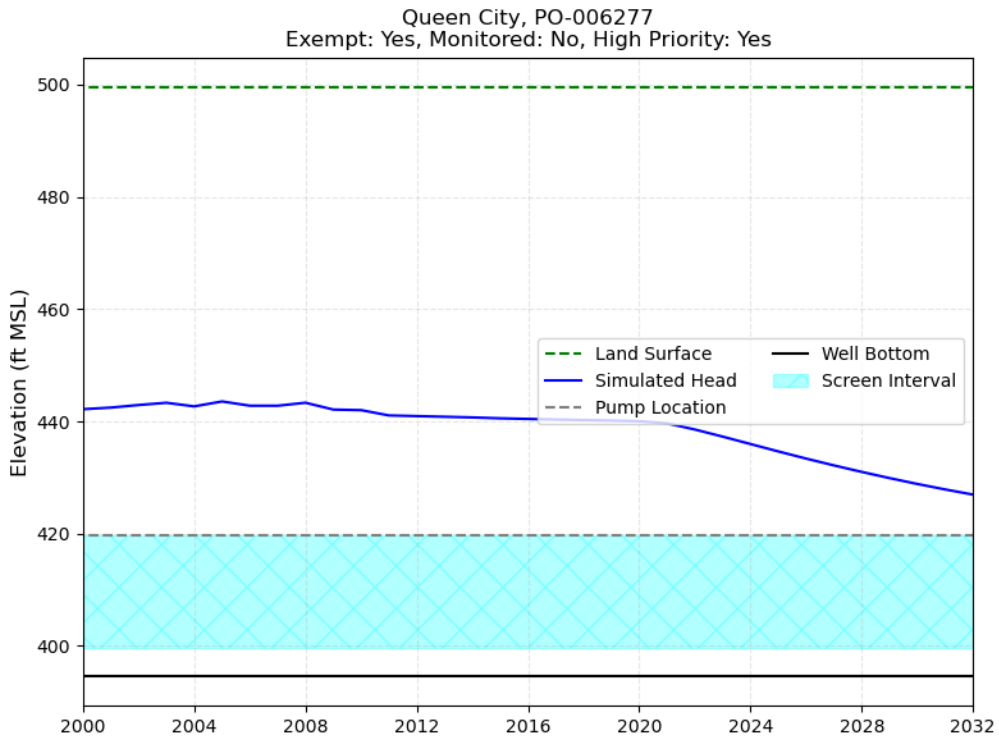

Figure D-3 Simulated water levels for high-priority well PO-006277 located in the Queen City Aquifer

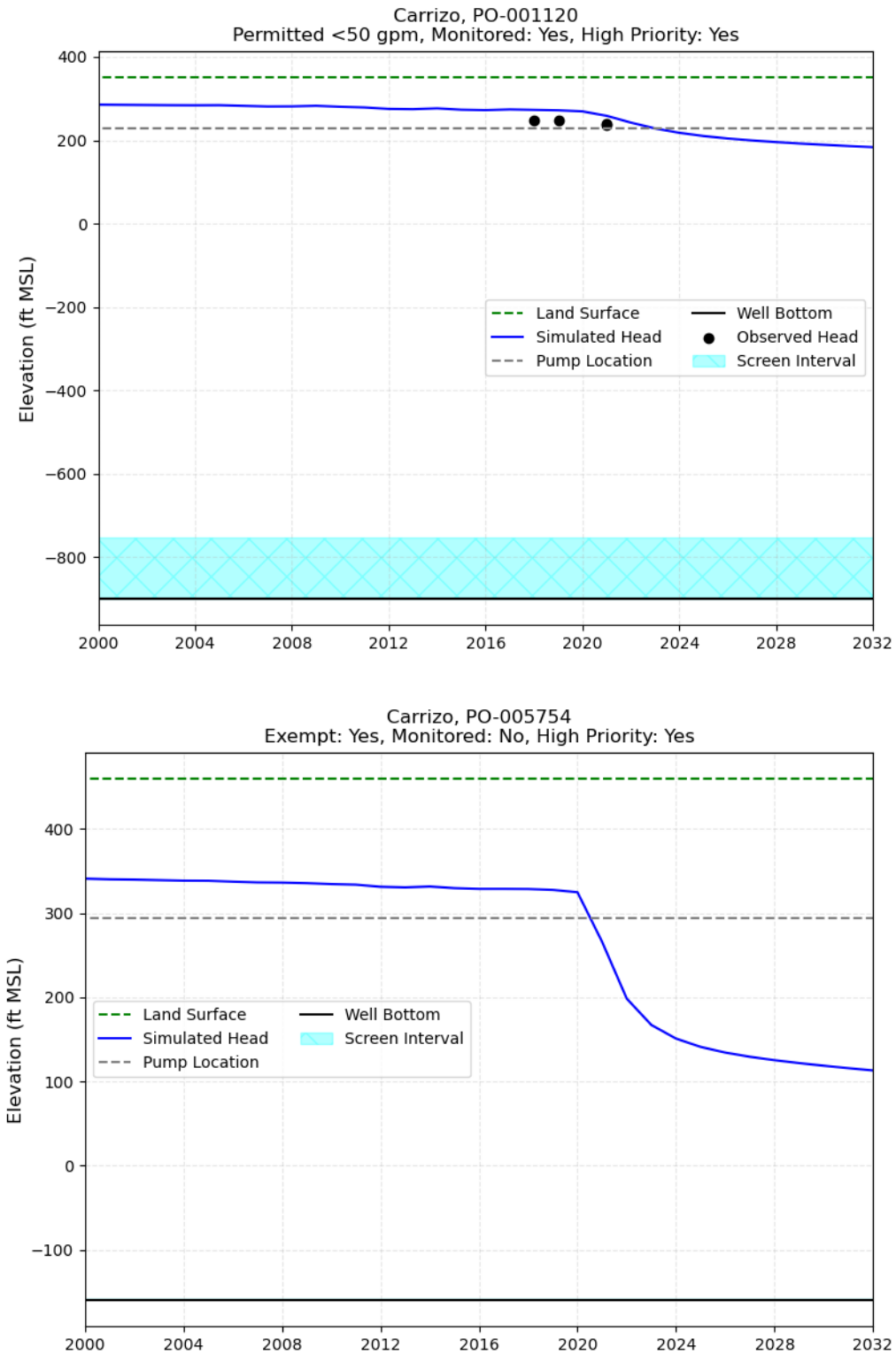

Figure D-4 Simulated water levels for high-priority wells PO-001120 and PO-005754 located in the Carrizo Aquifer

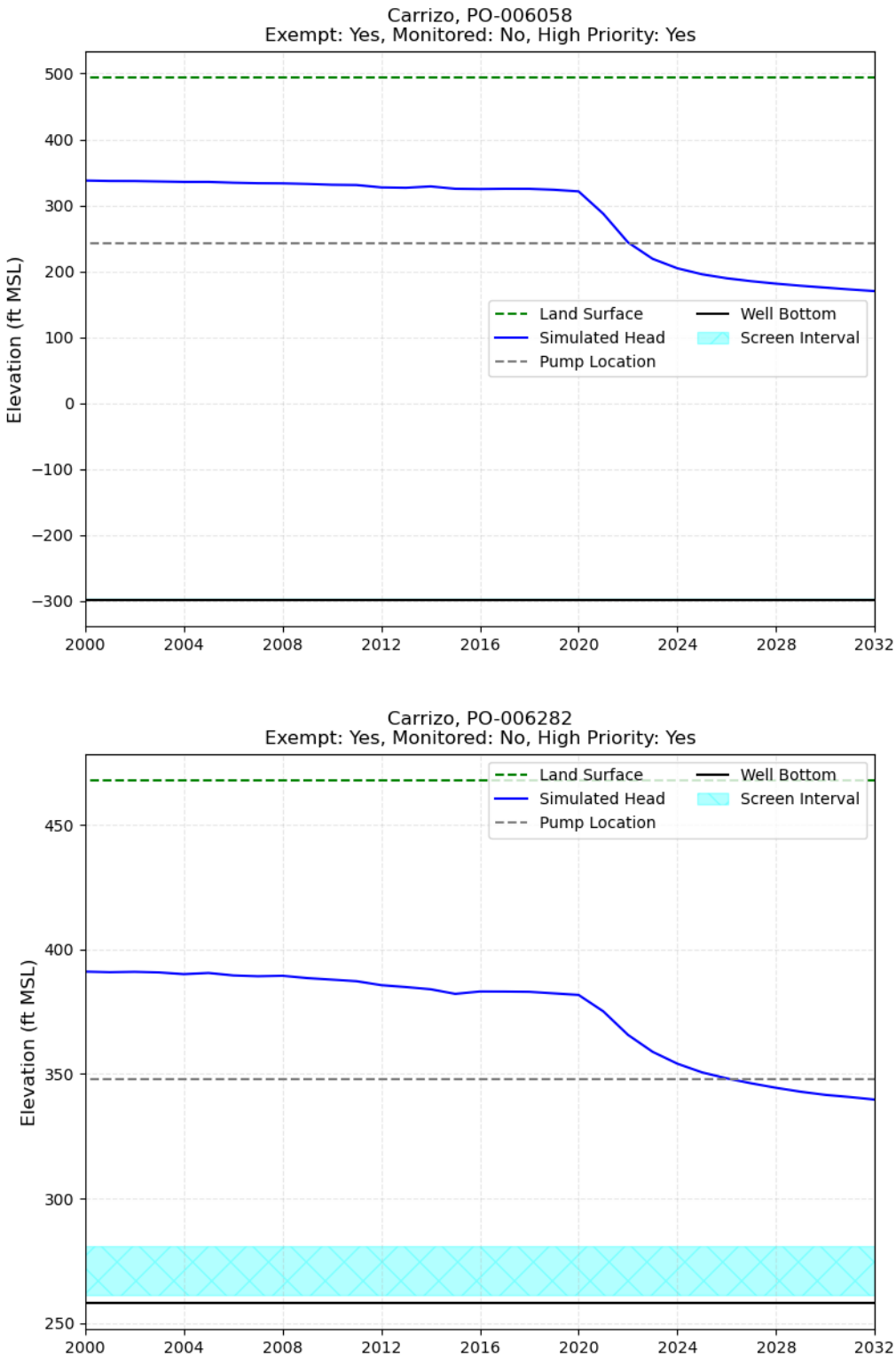

Figure D-5 Simulated water levels for high-priority wells PO-006058 and PO-006282 located in the Carrizo Aquifer

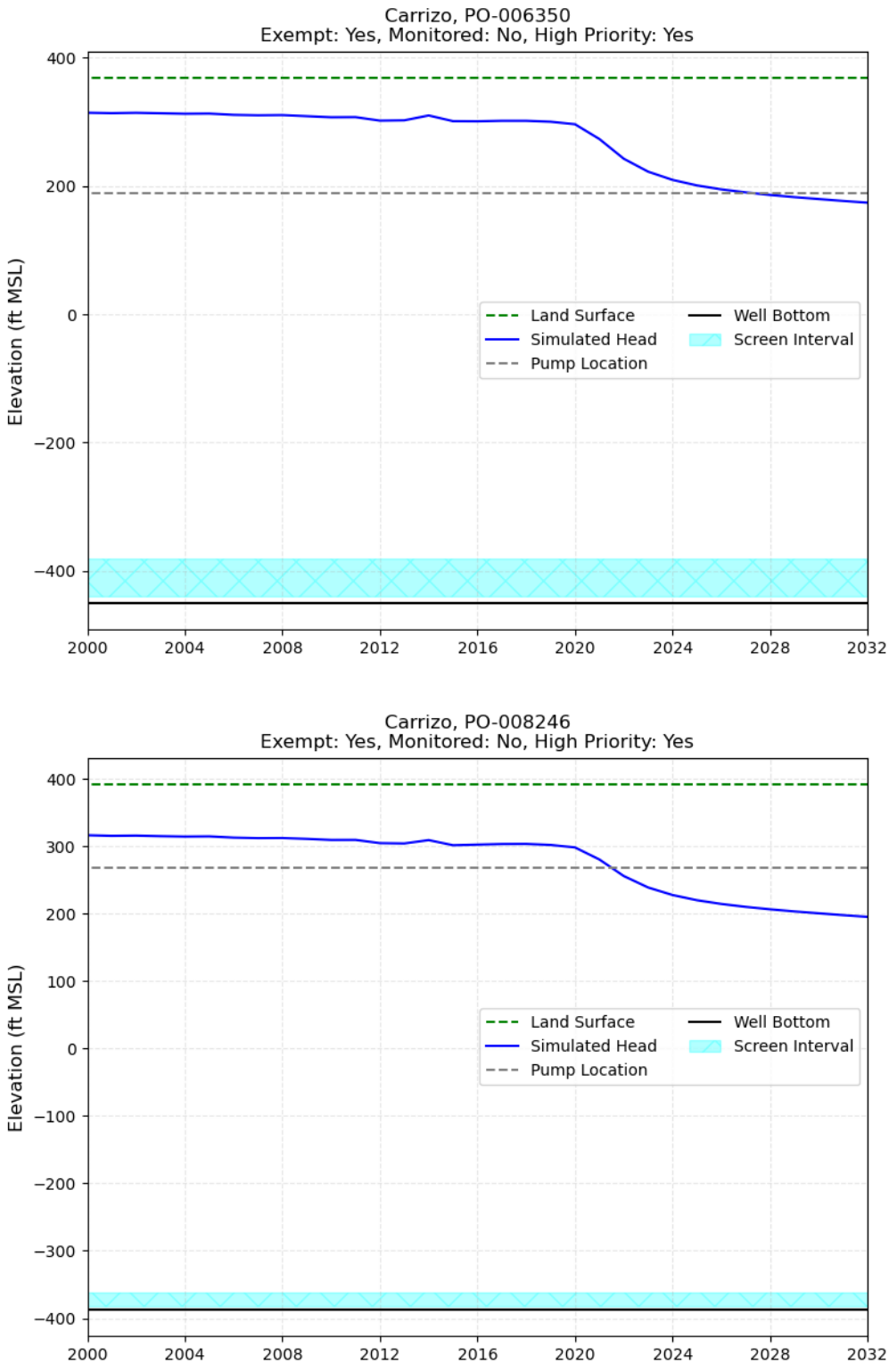

Figure D-6 Simulated water levels for high-priority wells PO-006350 and PO-008246 located in the Carrizo Aquifer

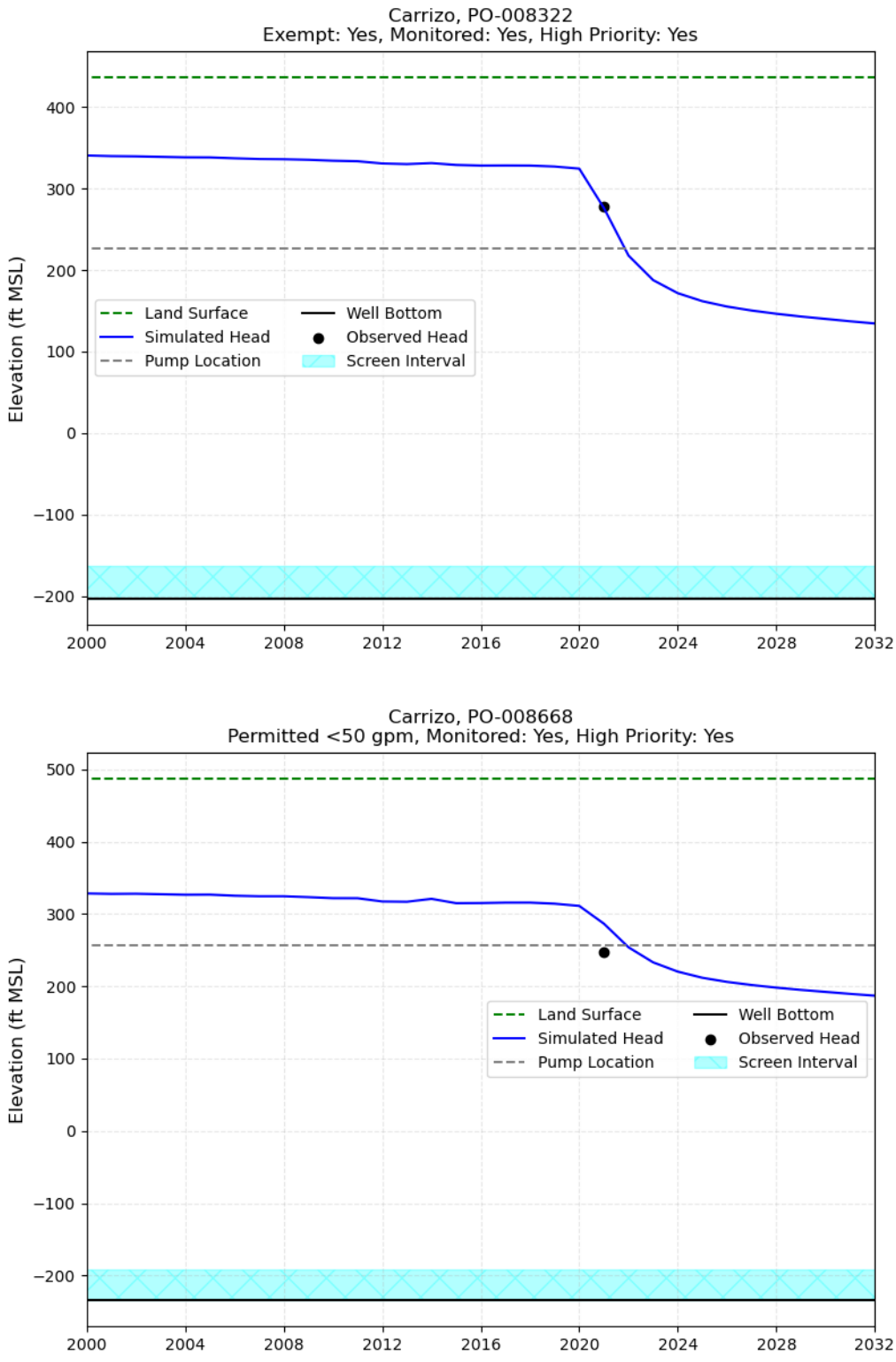

Figure D-7 Simulated water levels for high-priority wells PO-008322 and PO-008668 located in the Carrizo Aquifer

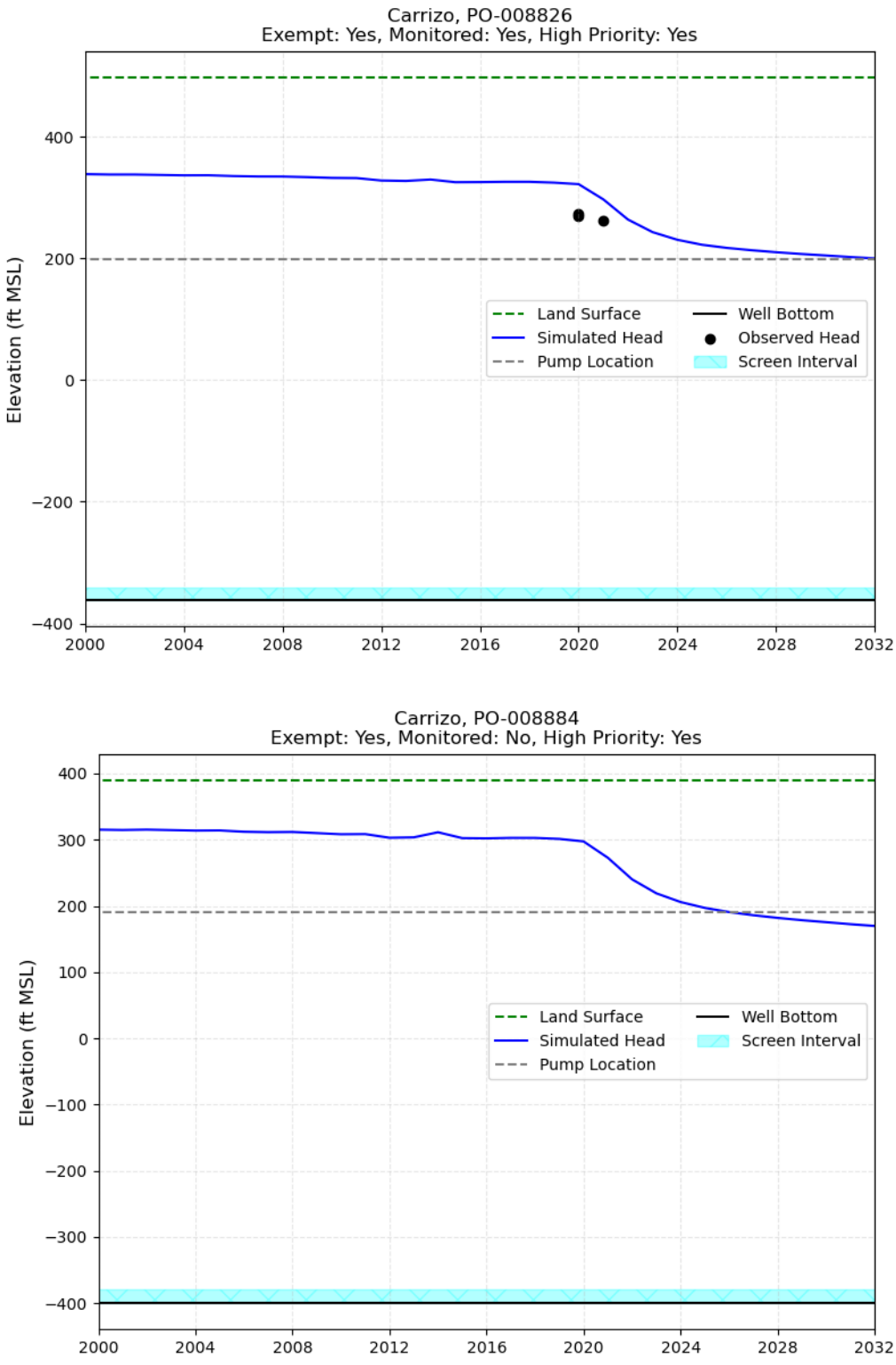

Figure D-8 Simulated water levels for high-priority wells PO-008826 and PO-008884 located in the Carrizo Aquifer

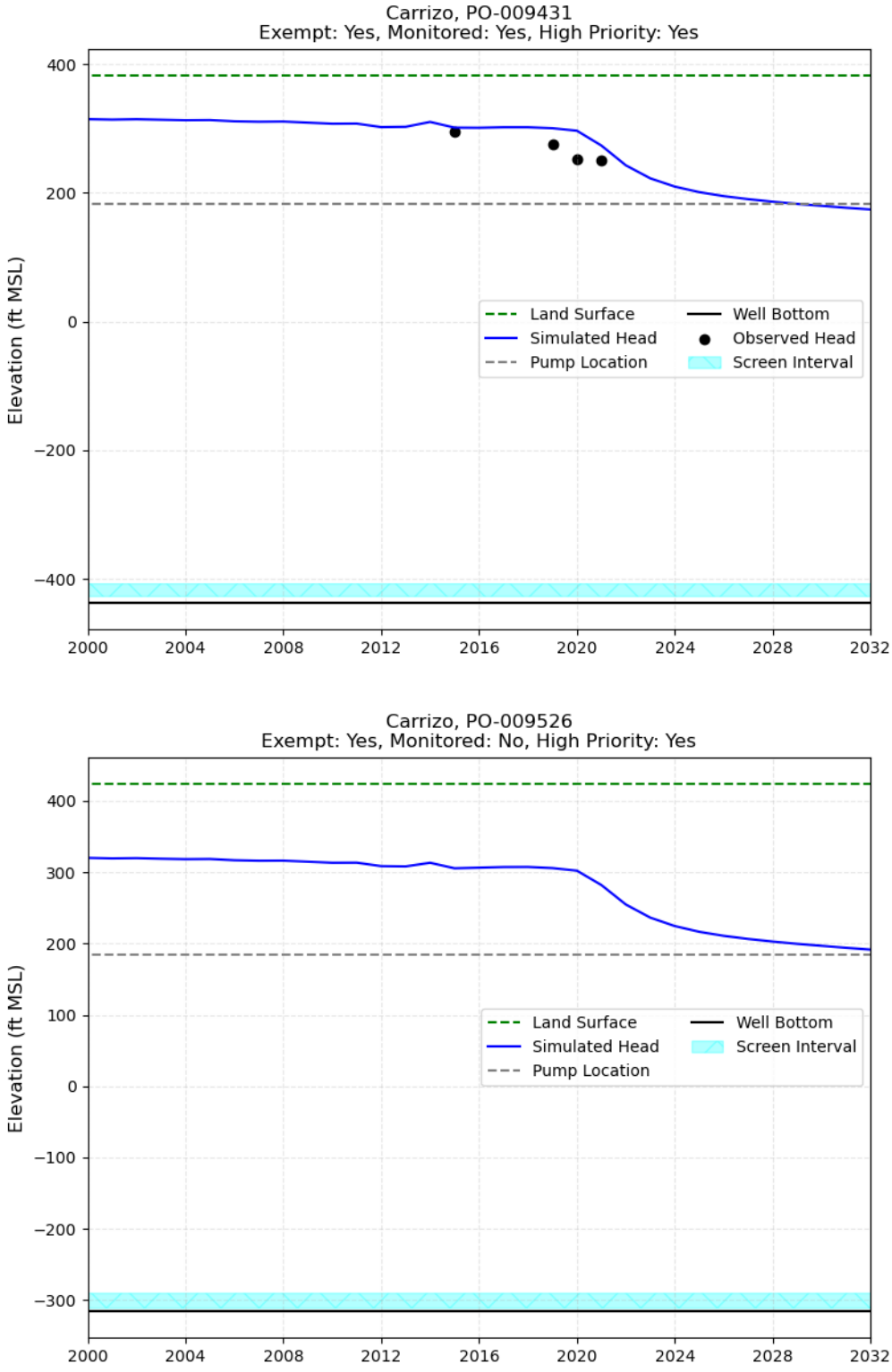

Figure D-9 Simulated water levels for high-priority wells PO-009431 and PO-009526 located in the Carrizo Aquifer

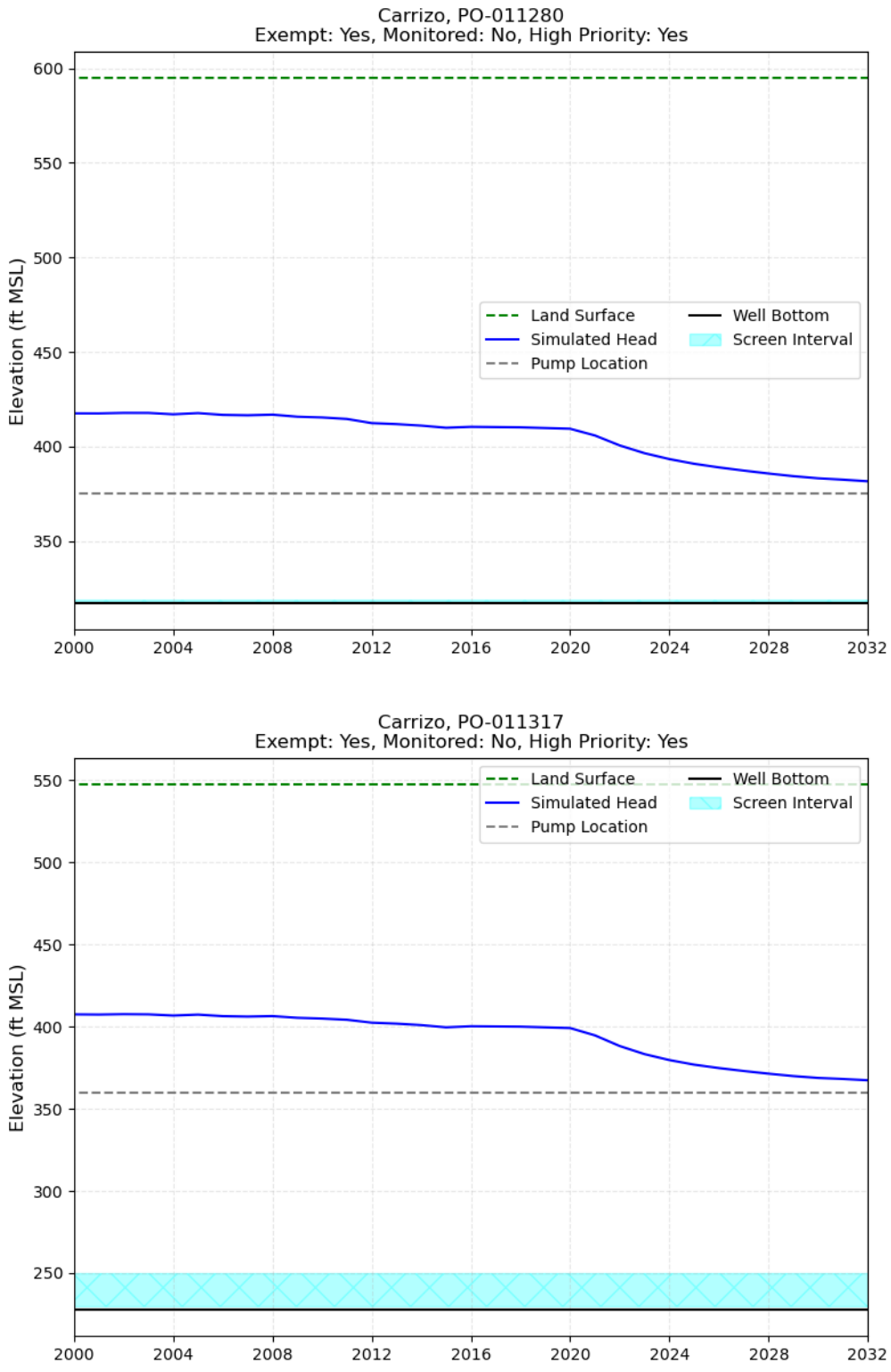

Figure D-10 Simulated water levels for high-priority wells PO-011280 and PO-011317 located in the Carrizo Aquifer

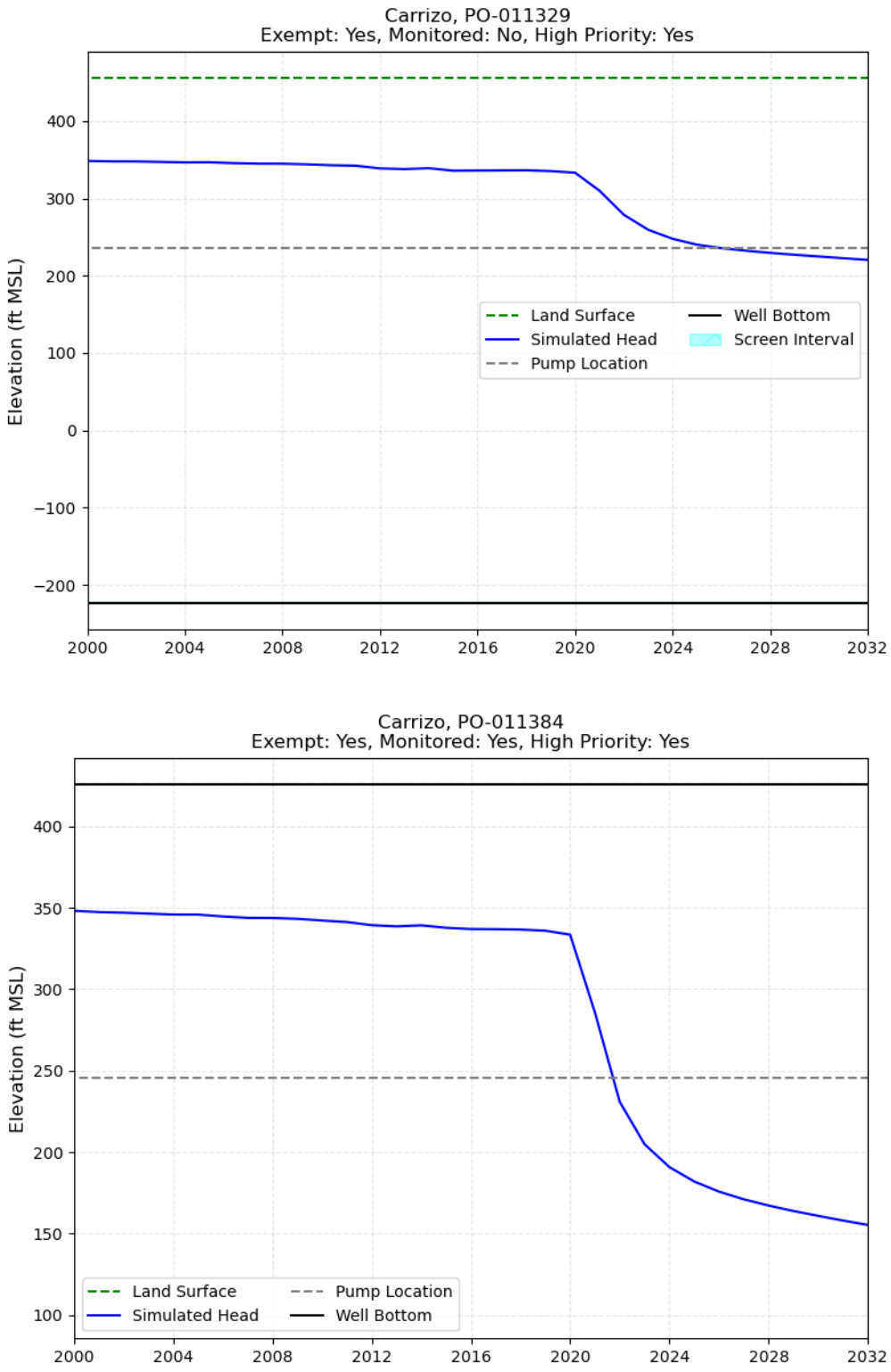

Figure D-11 Simulated water levels for high-priority wells PO-011329 and PO-011384 located in the Carrizo Aquifer

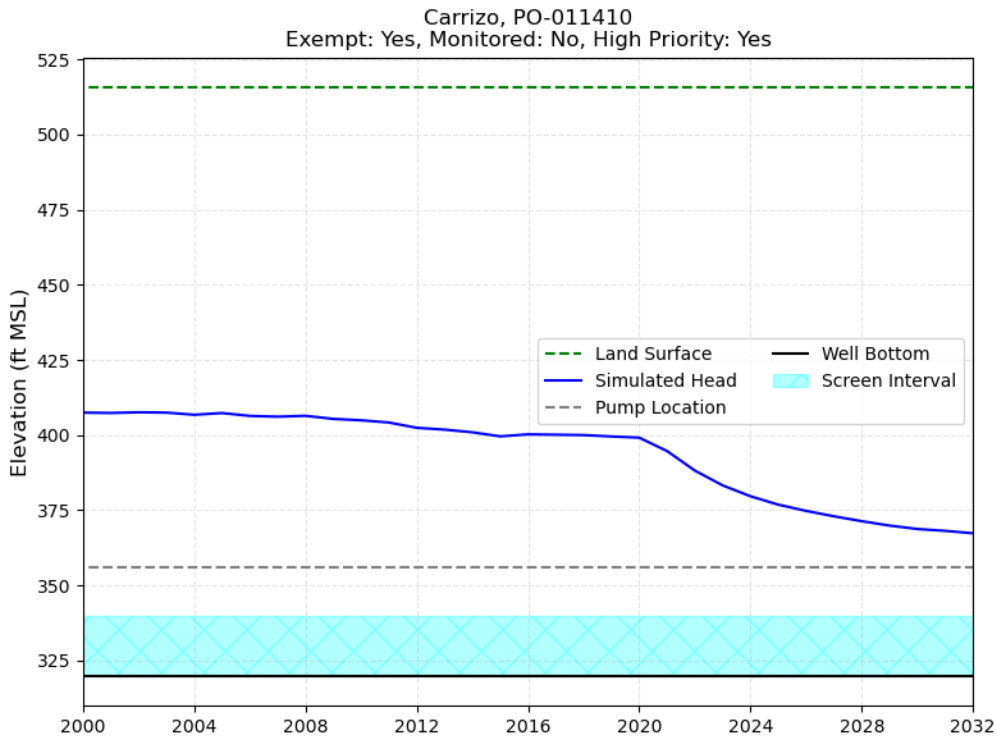

Figure D-12 Simulated water levels for high-priority well PO-011410 located in the Carrizo Aquifer

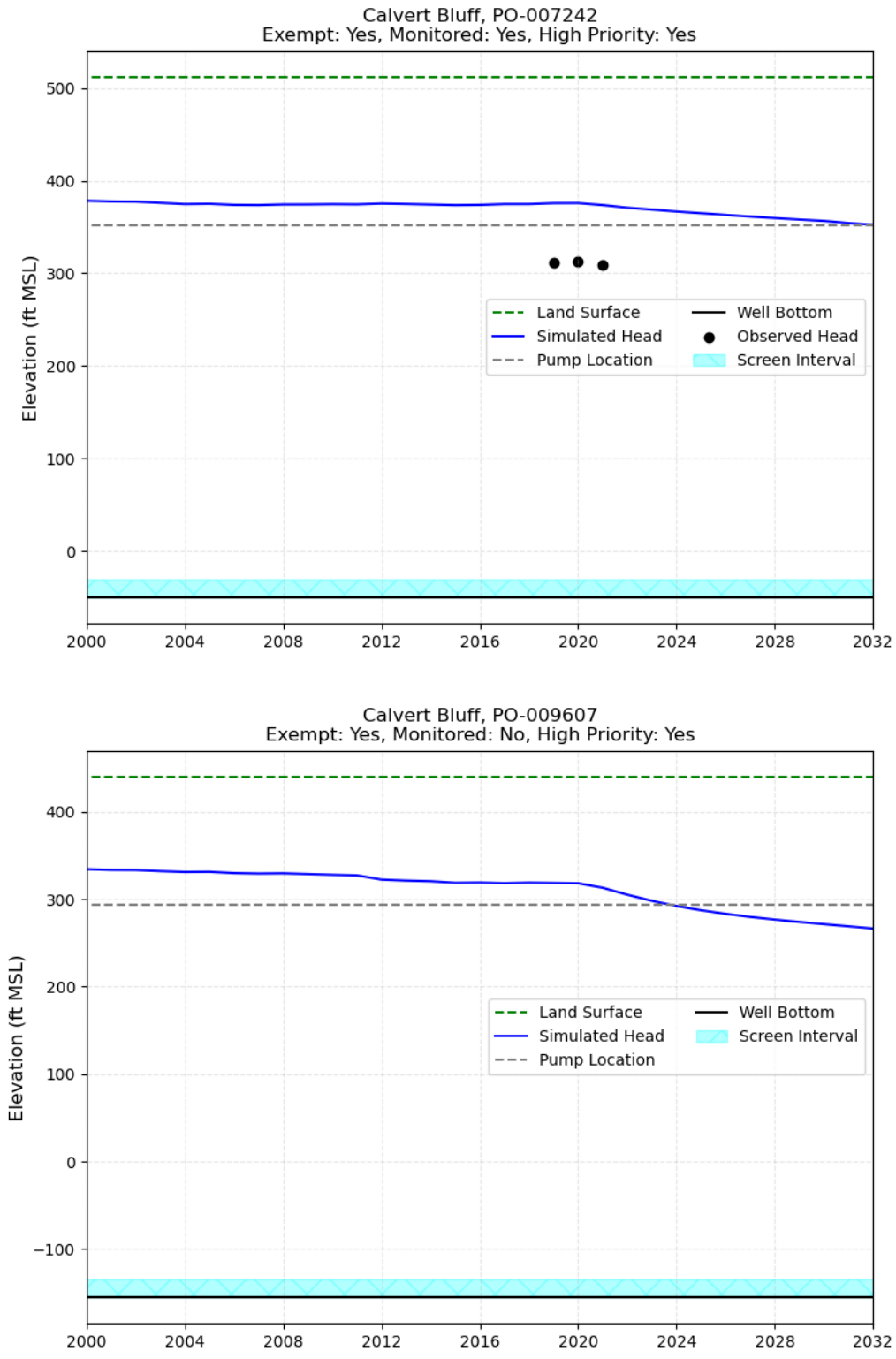

Figure D-13 Simulated water levels for high-priority wells PO-007242 and 009607 located in the Calvert Bluff Aquifer

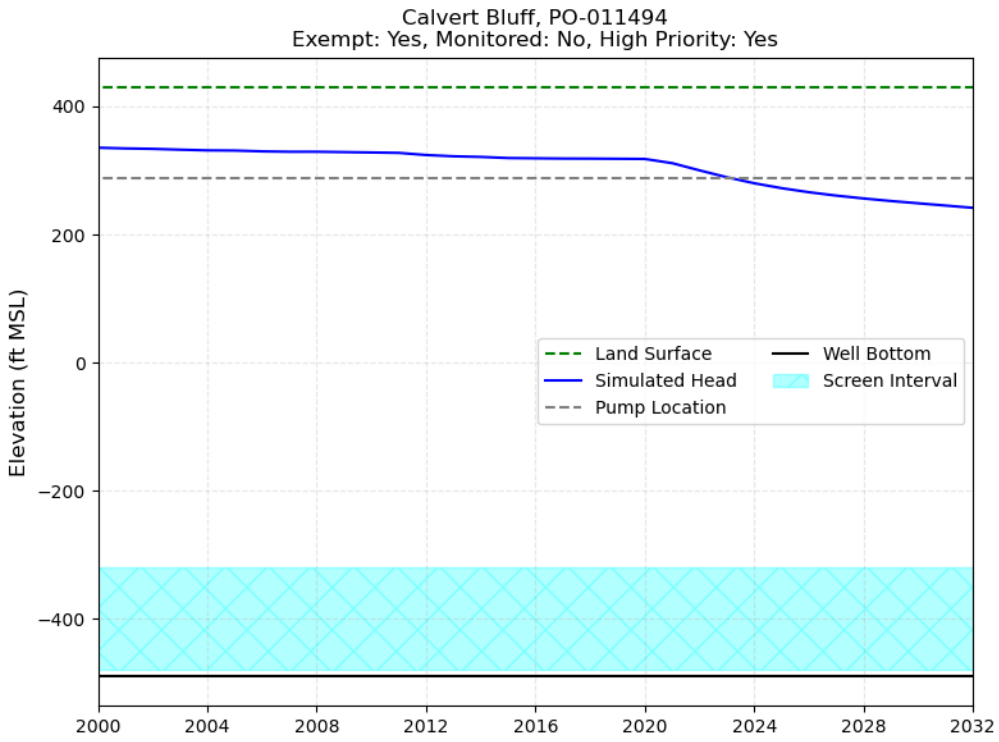

Figure D-14 Simulated water levels for high-priority well PO-011494 located in the Calvert Bluff Aquifer

APPENDIX E

Hydrographs for Wells of Concern

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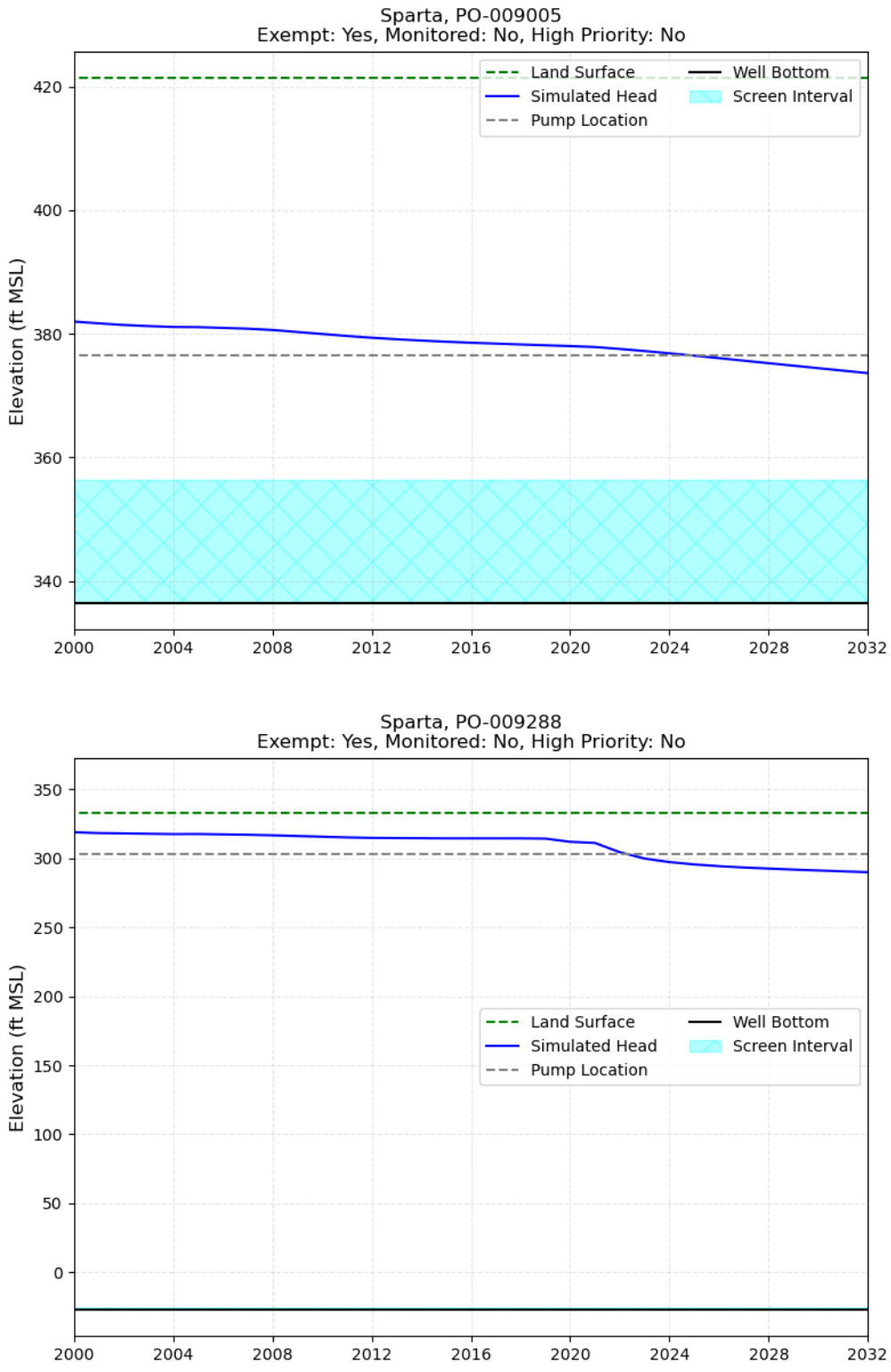

Figure E-1 Simulated water levels for wells of concern PO-009005 and PO-009288 located in the Sparta Aquifer

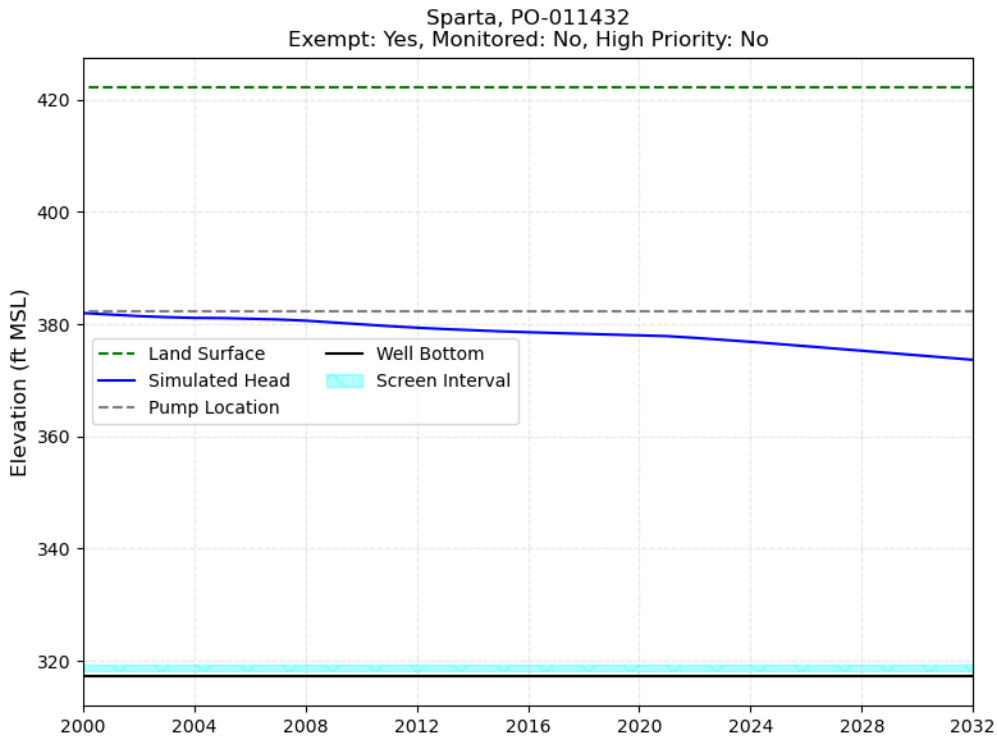

Figure E-2 Simulated water levels for wells of concern PO-011432 located in the Sparta Aquifer

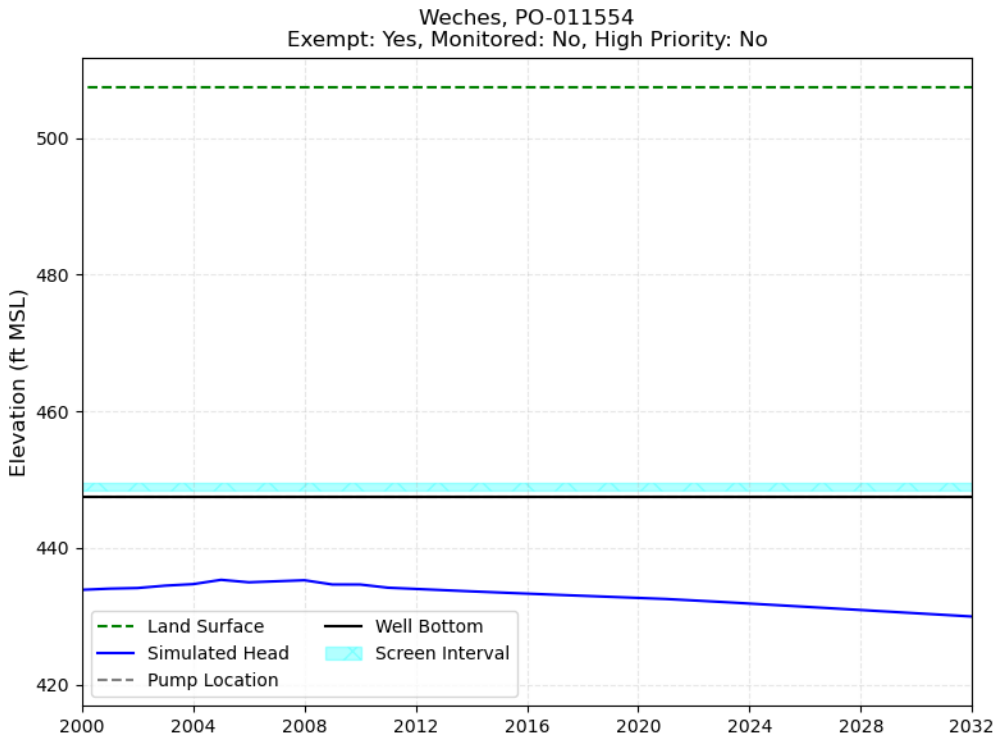

Figure E-3 Simulated water levels for well of concern PO-011554 located in the Weches Aquifer

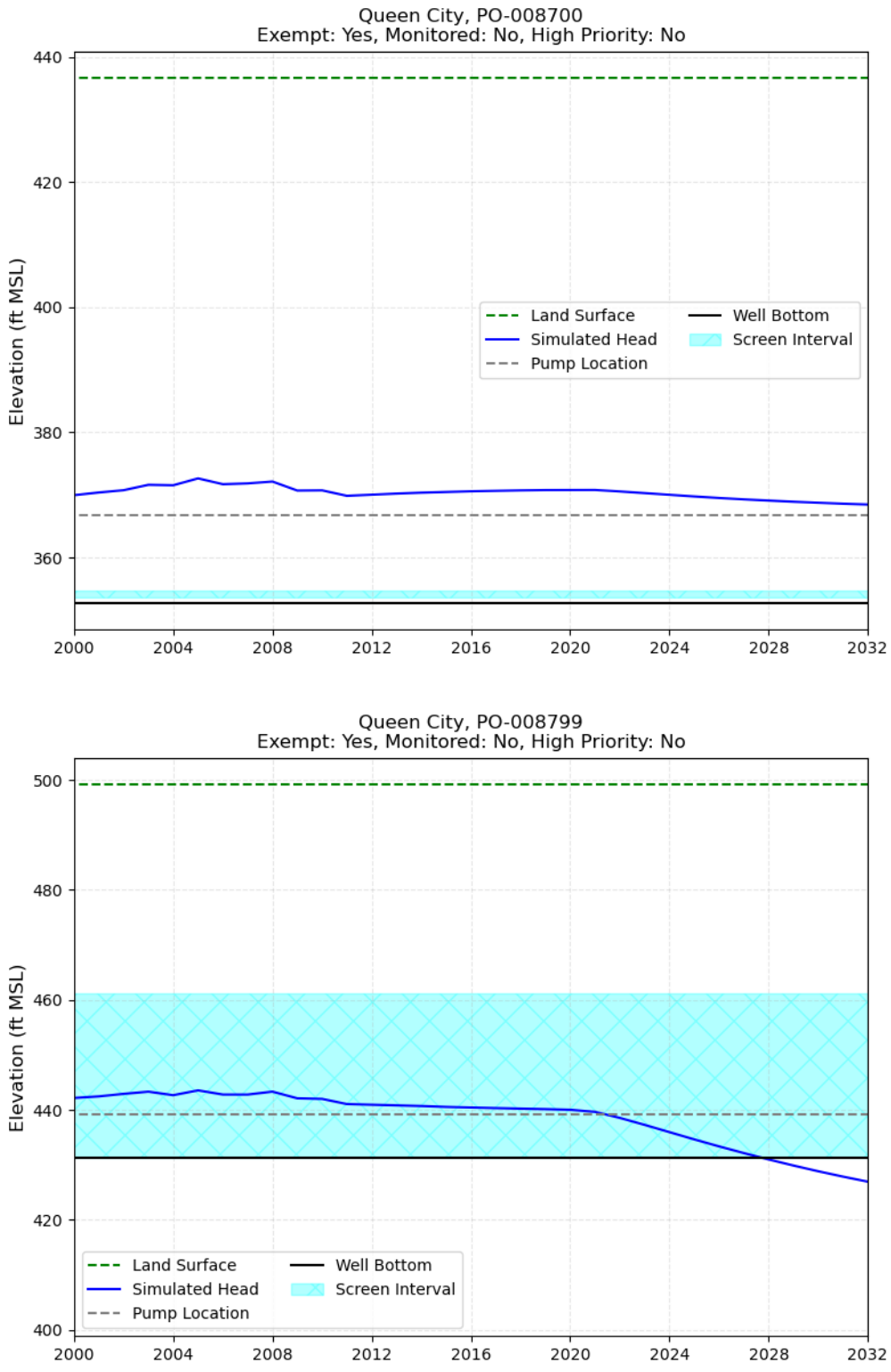

Figure E-4 Simulated water levels for wells of concern PO-008700 and PO-008799 located in the Queen City Aquifer

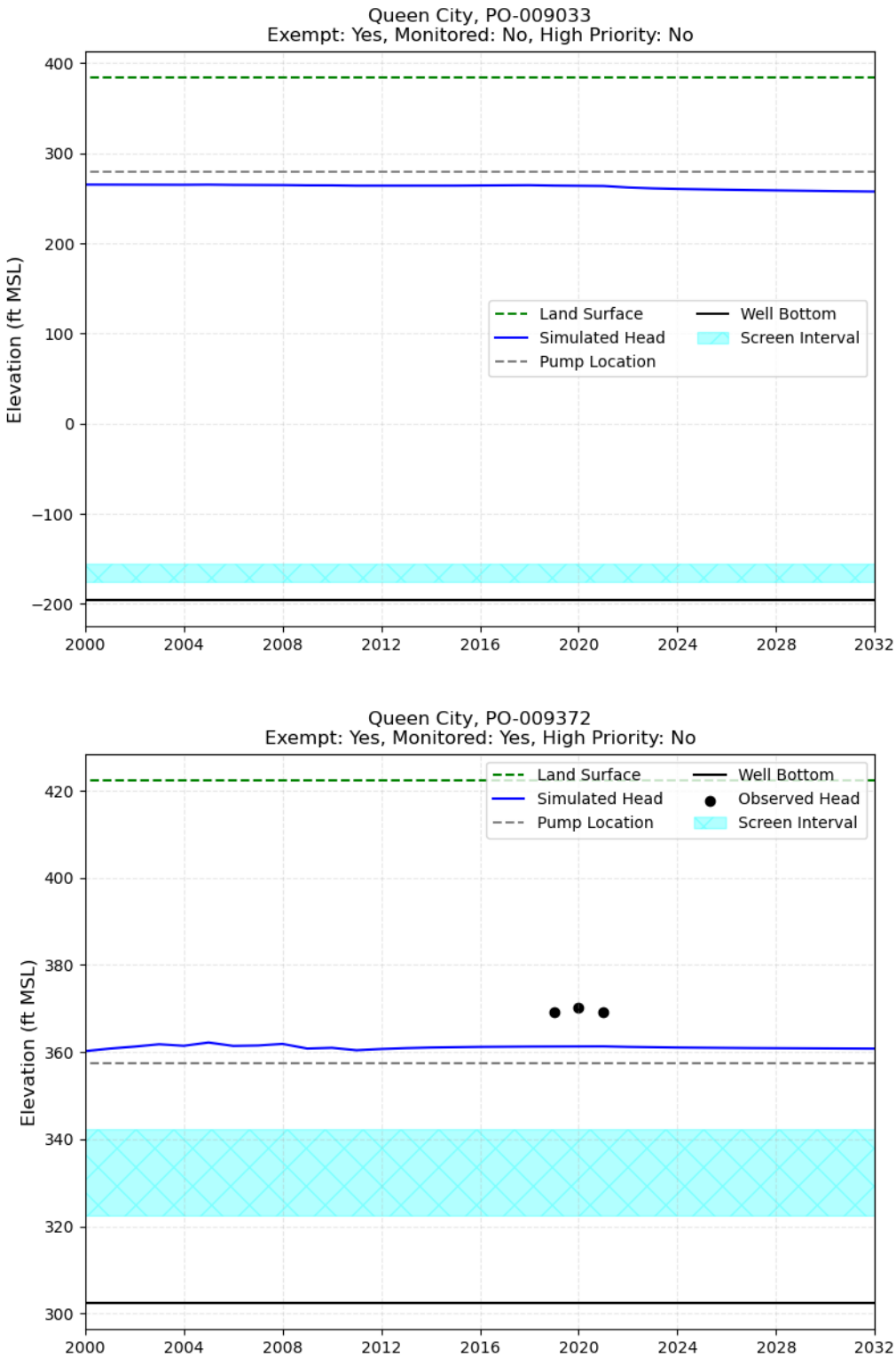

Figure E-5 Simulated water levels for wells of concern PO-009033 and PO-009372 located in the Queen City Aquifer

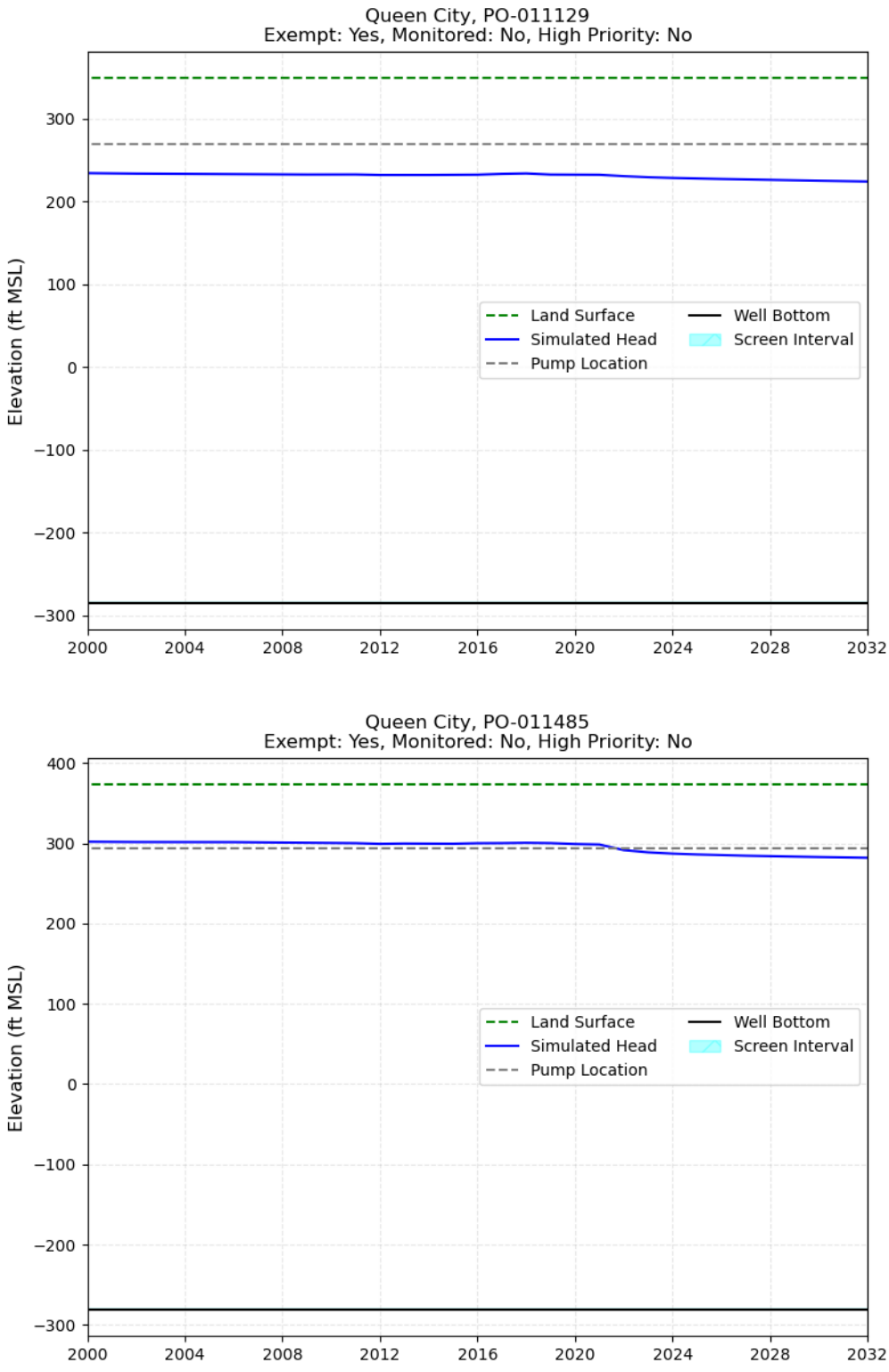

Figure E-6 Simulated water levels for wells of concern PO-011129 and PO-011485 located in the Queen City Aquifer

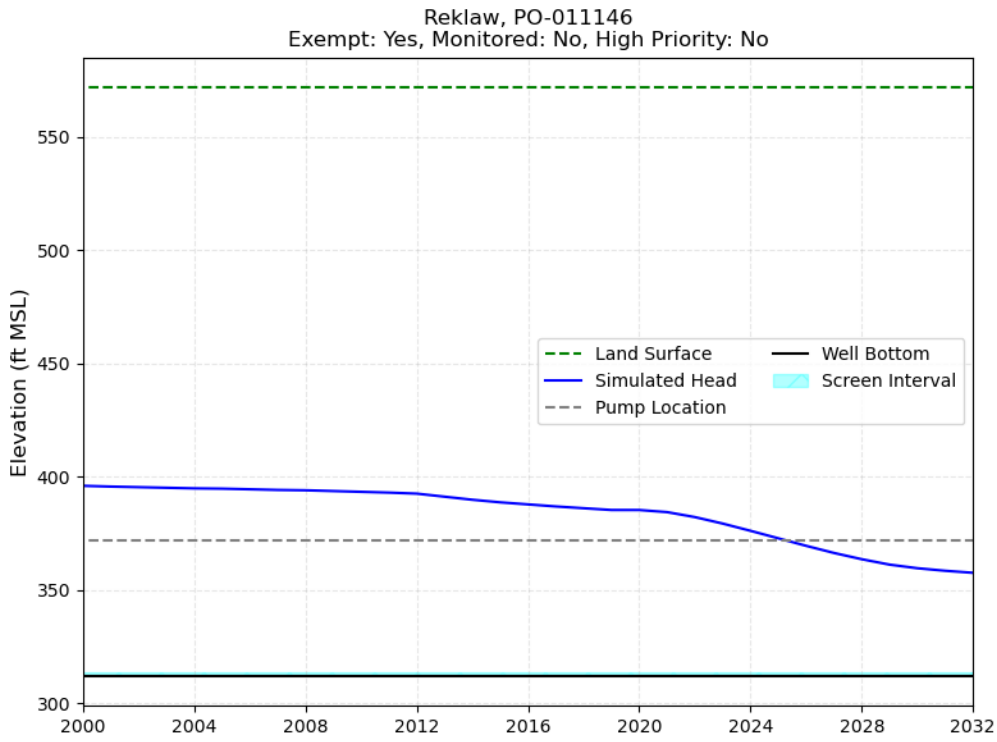

Figure E-7 Simulated water levels for well of concern PO-11146 located in the Reklaw Aquifer

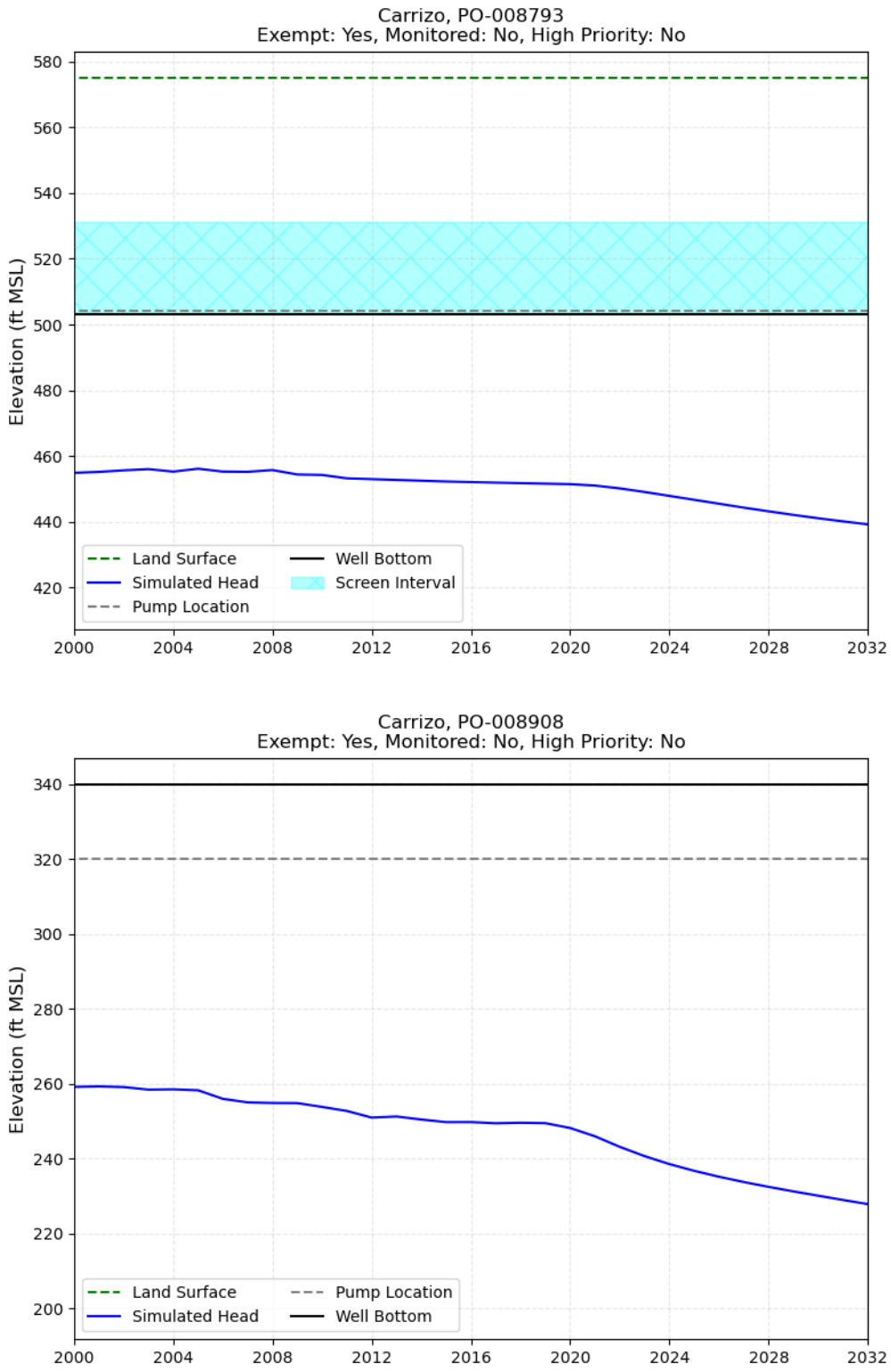

Figure E-8 Simulated water levels for wells of concern PO-008793 and PO-008098 located in the Carrizo Aquifer

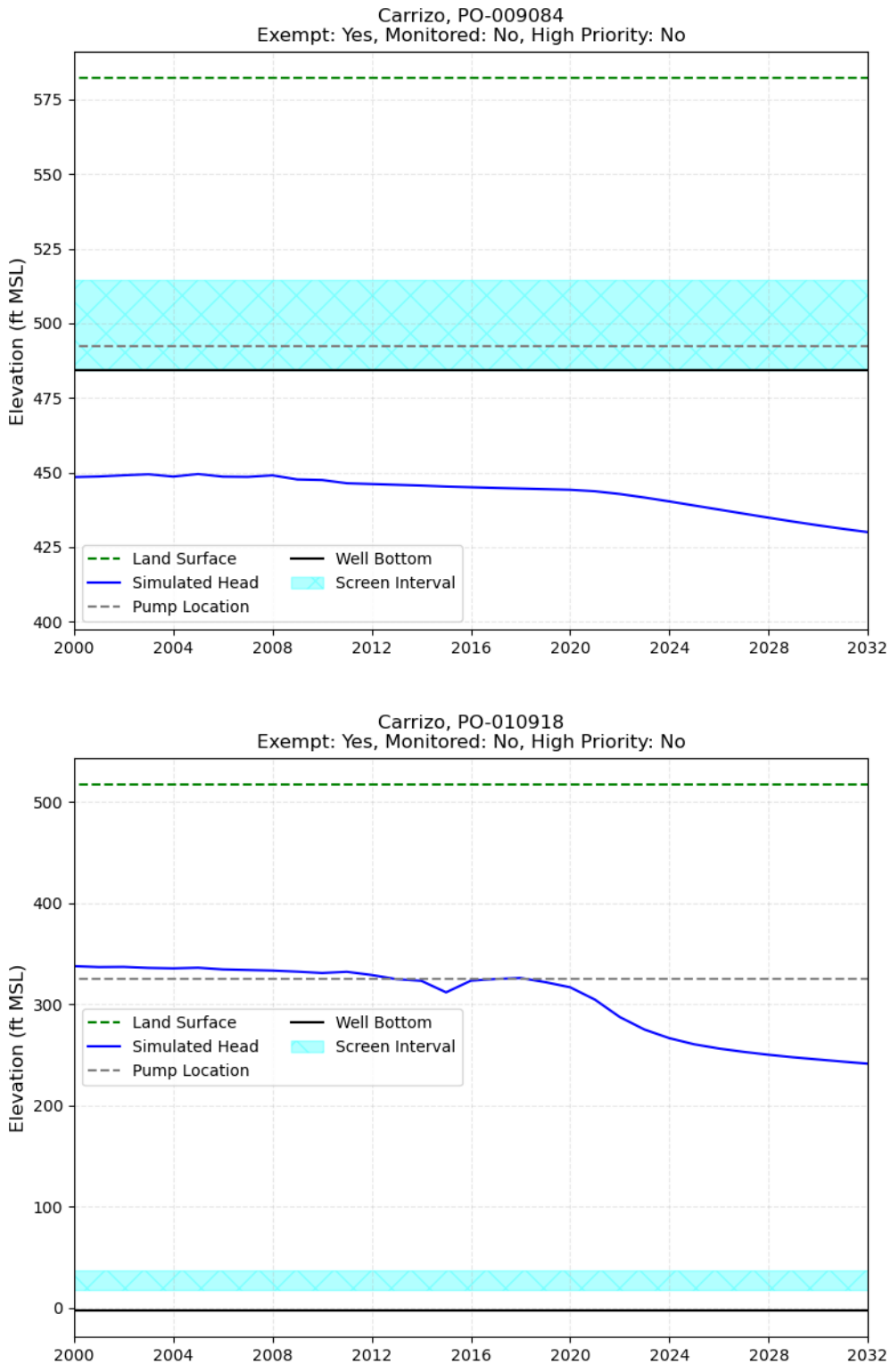

Figure E-9 Simulated water levels for wells of concern PO-009084 and PO-010918 located in the Carrizo Aquifer

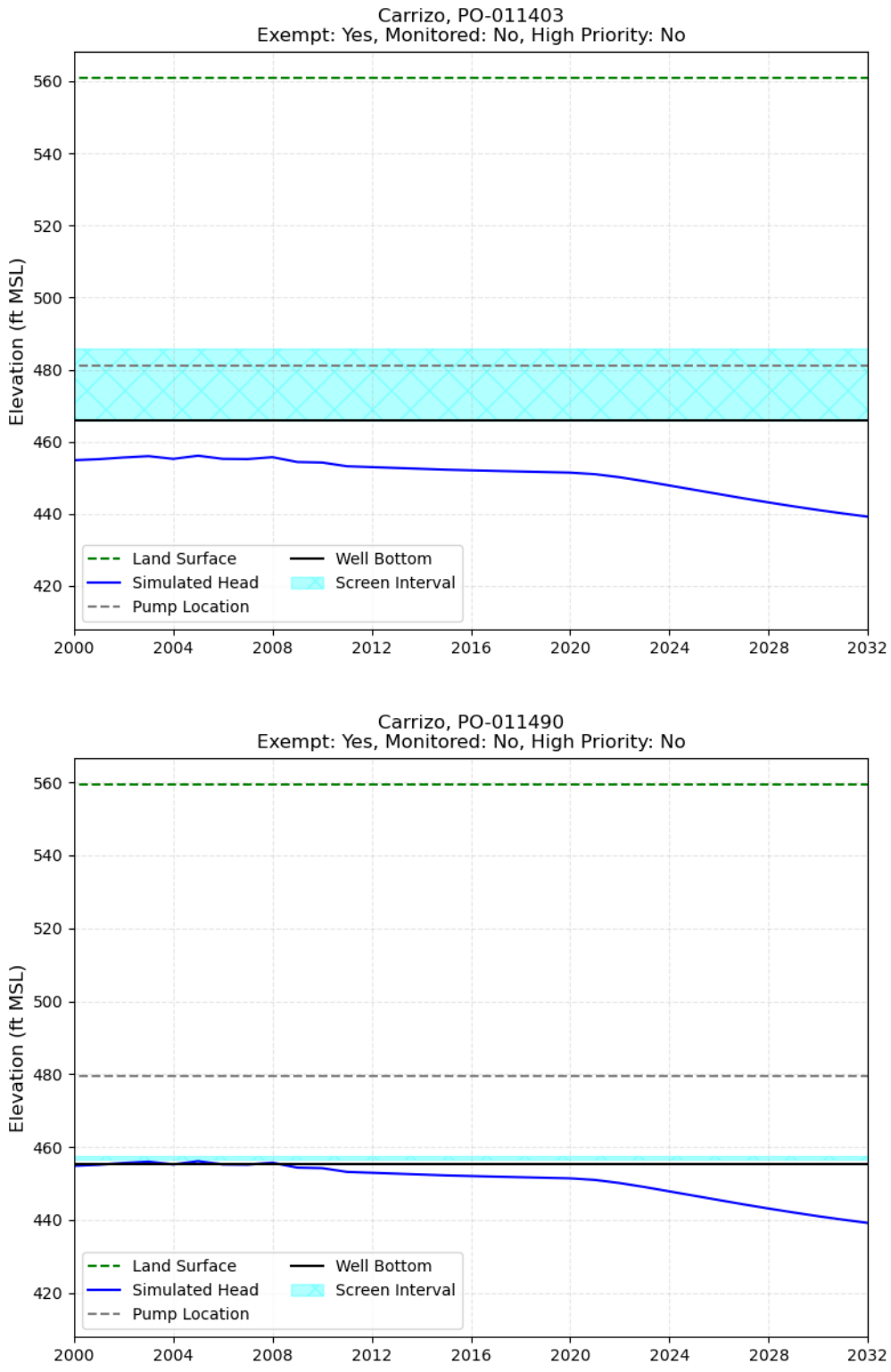

Figure E-10 Simulated water levels for wells of concern PO-011403 and PO-011490 located in the Carrizo Aquifer

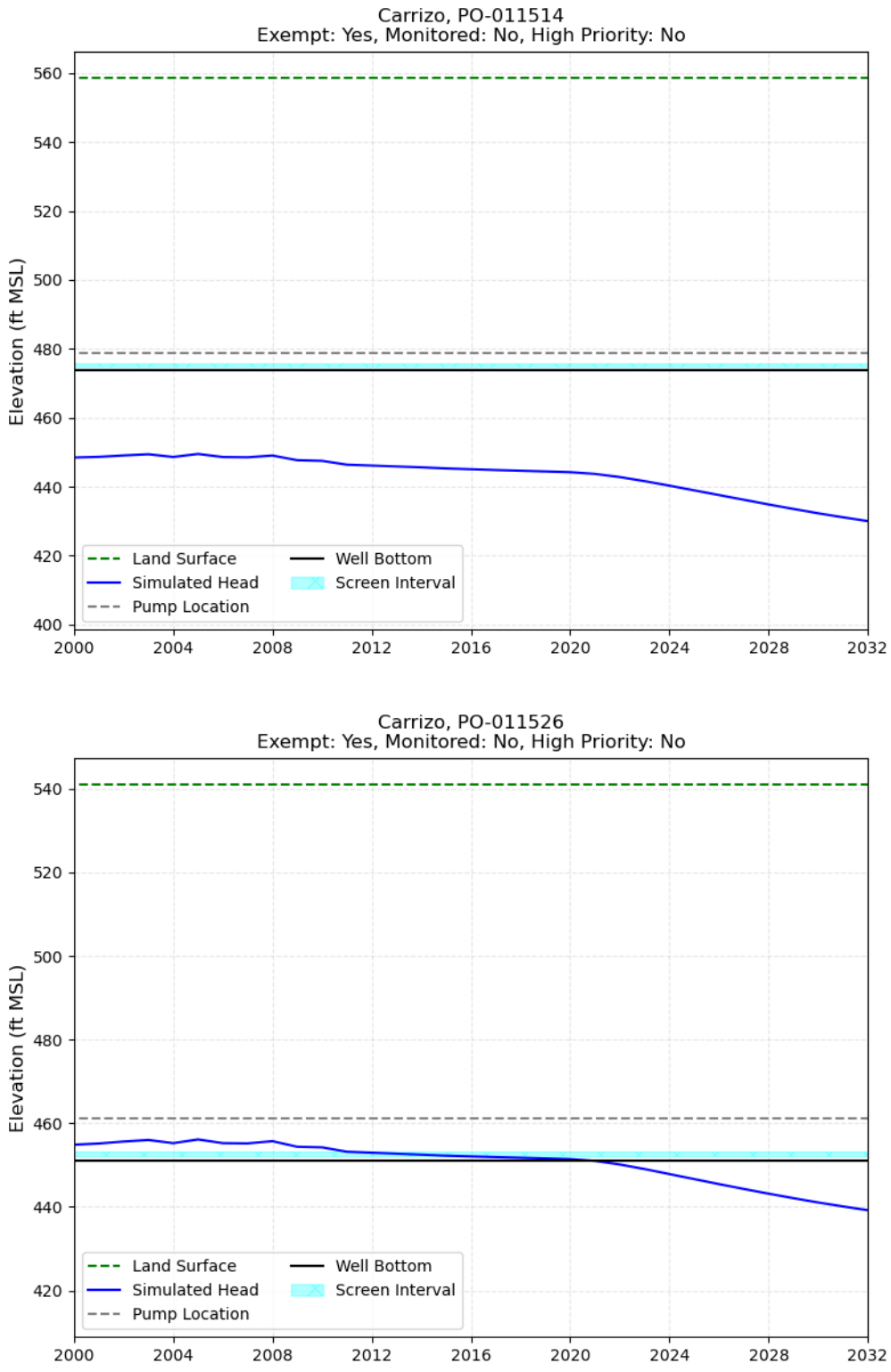

Figure E-11 Simulated water levels for wells of concern PO-011514 and PO-011526 located in the Carrizo Aquifer

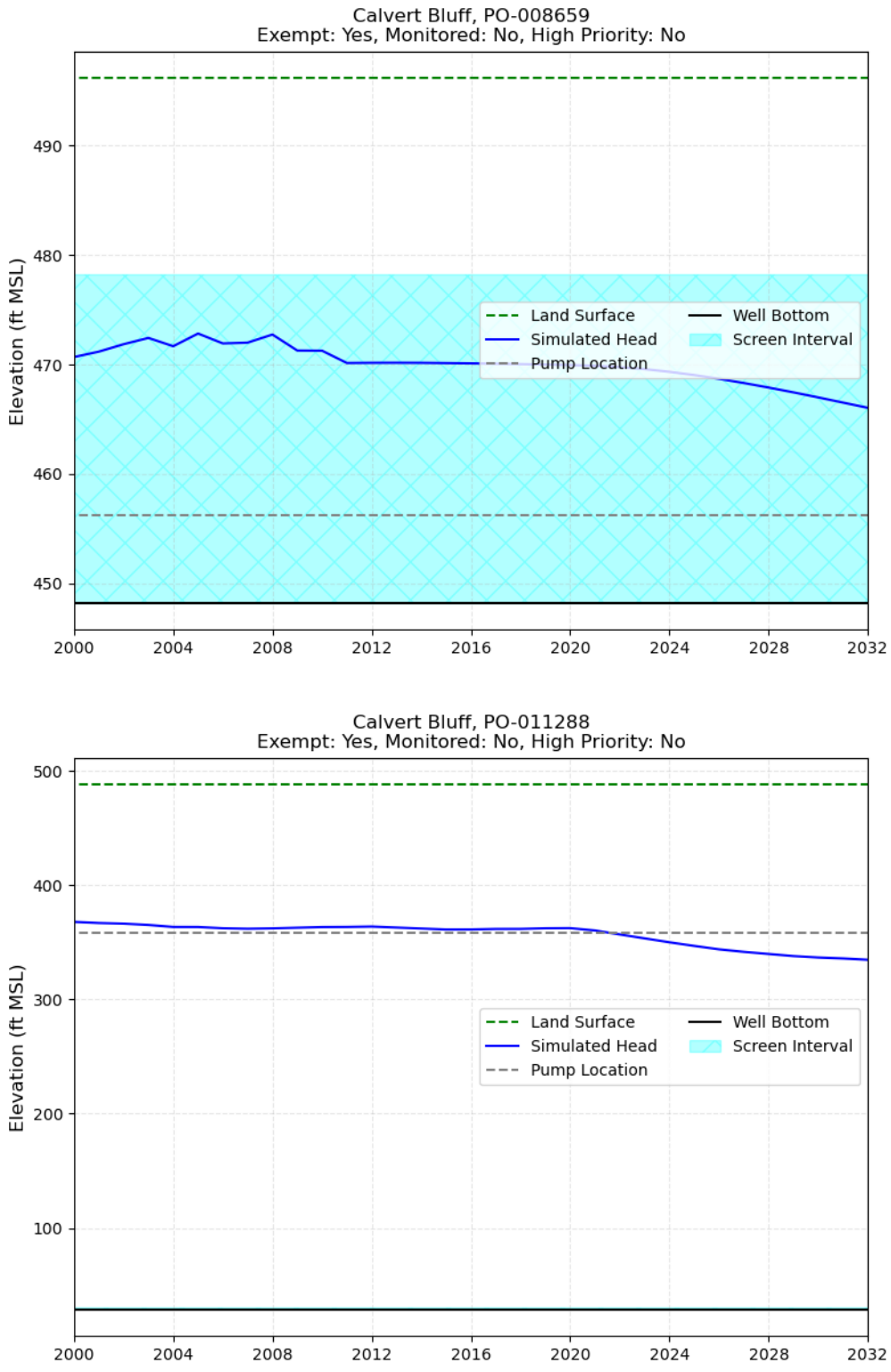

Figure E-12 Simulated water levels for wells of concern PO-008659 and PO-011288 located in the Calvert Bluff Aquifer

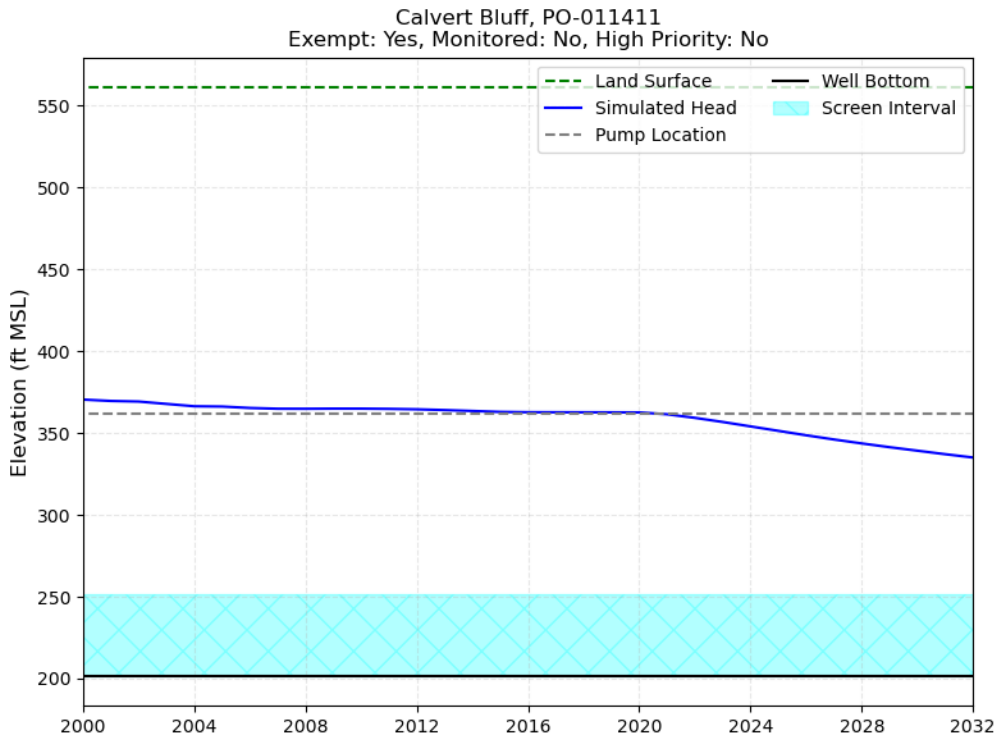

Figure E-13 Simulated water levels for well of concern PO-011411 located in the Calvert Bluff Aquifer

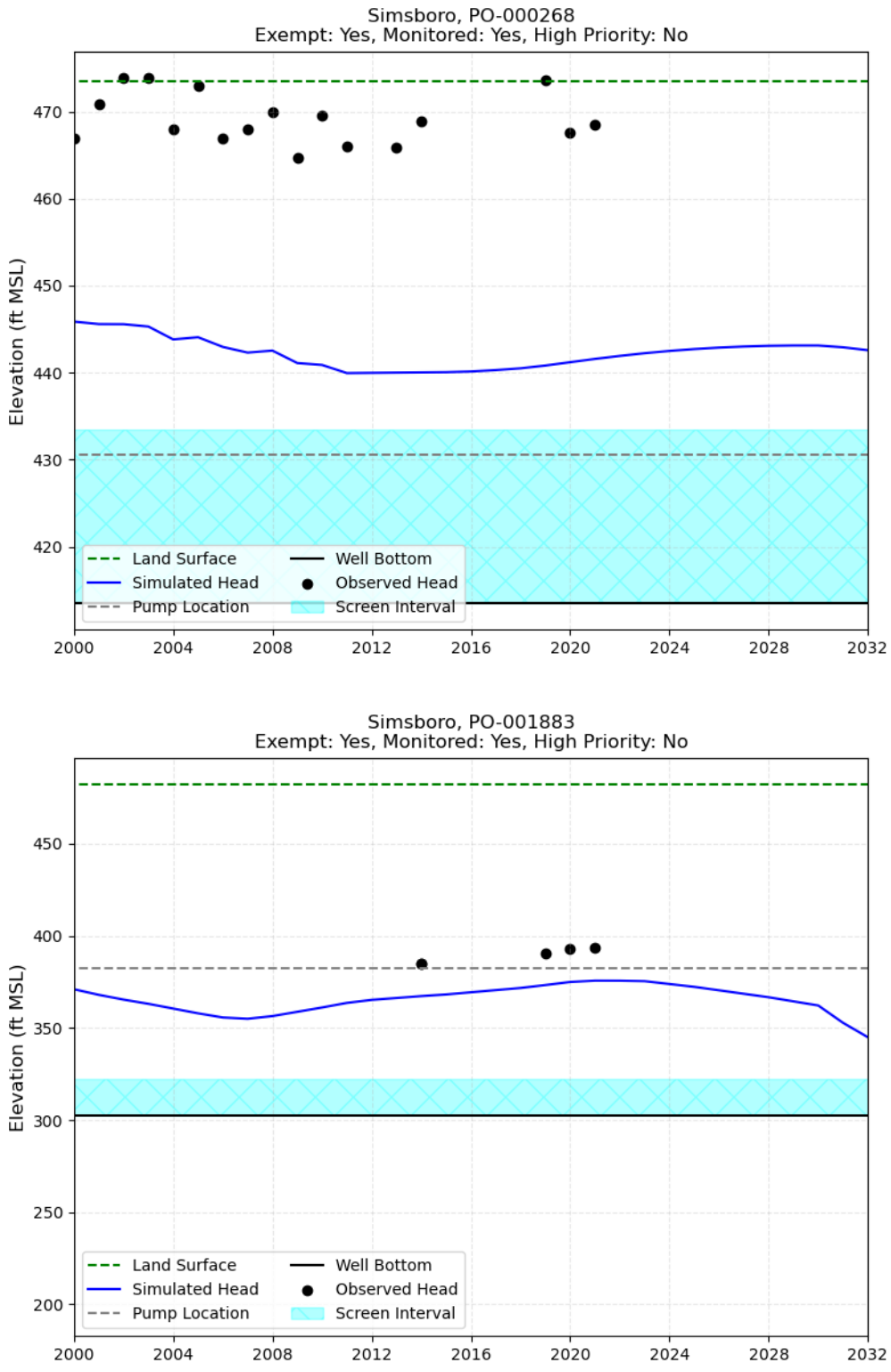

Figure E-14 Simulated water levels for wells of concern PO-000268 and PO-001883 located in the Simsboro Aquifer

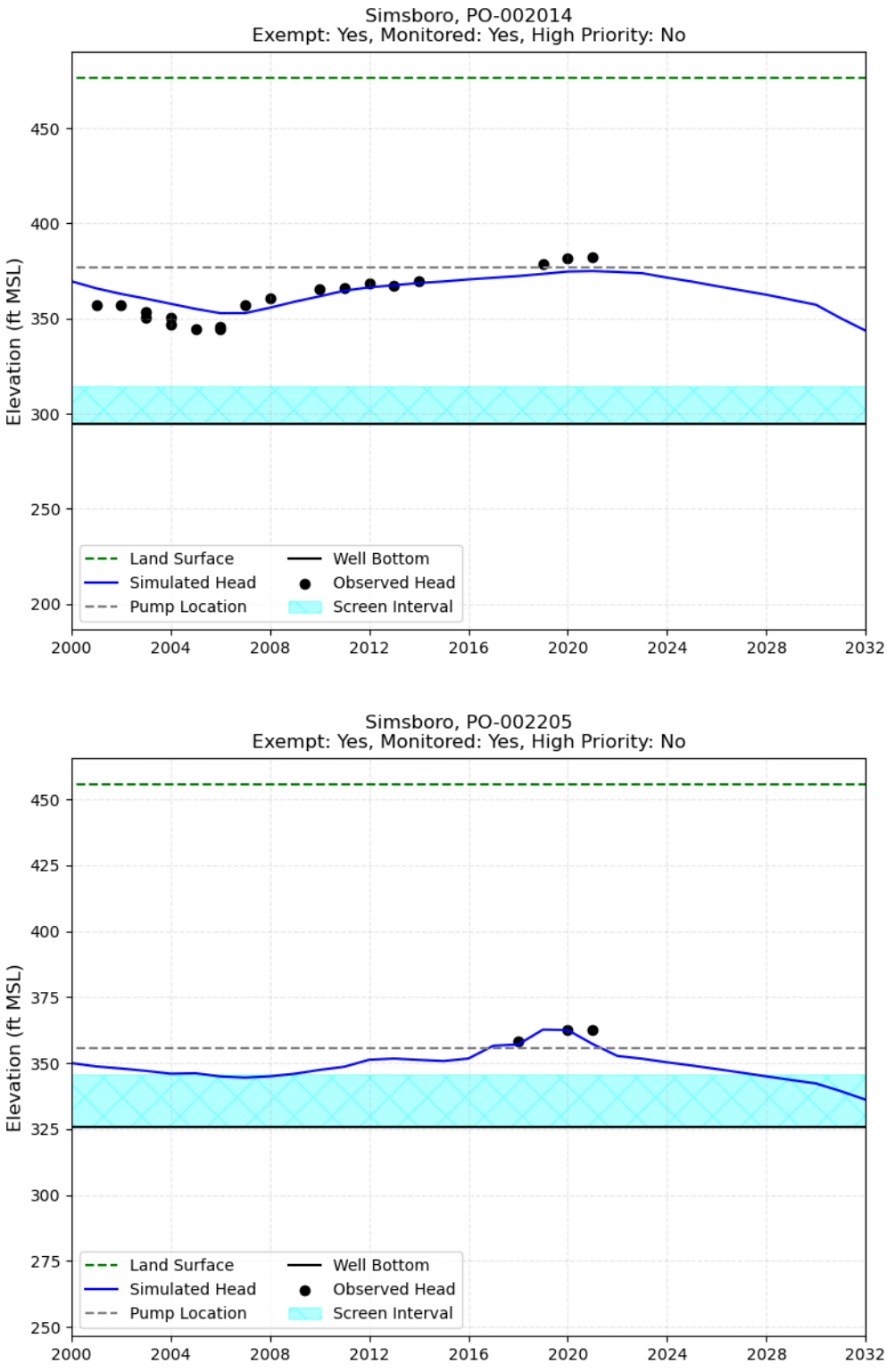

Figure E-15 Simulated water levels for wells of concern PO-002014 and PO-002205 located in the Simsboro Aquifer

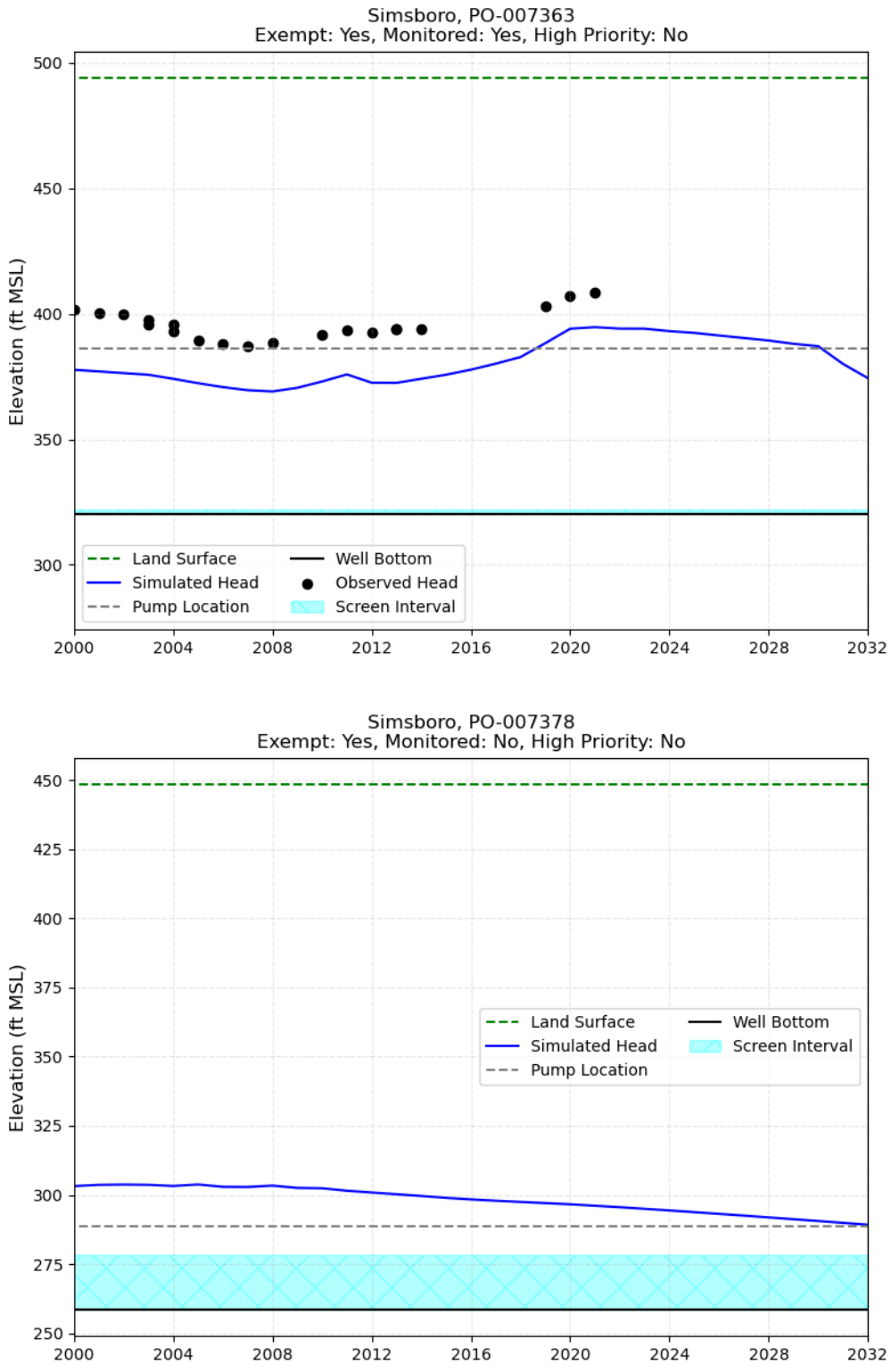

Figure E-16 Simulated water levels for wells of concern PO-007363 and PO-007378 located in the Simsboro Aquifer

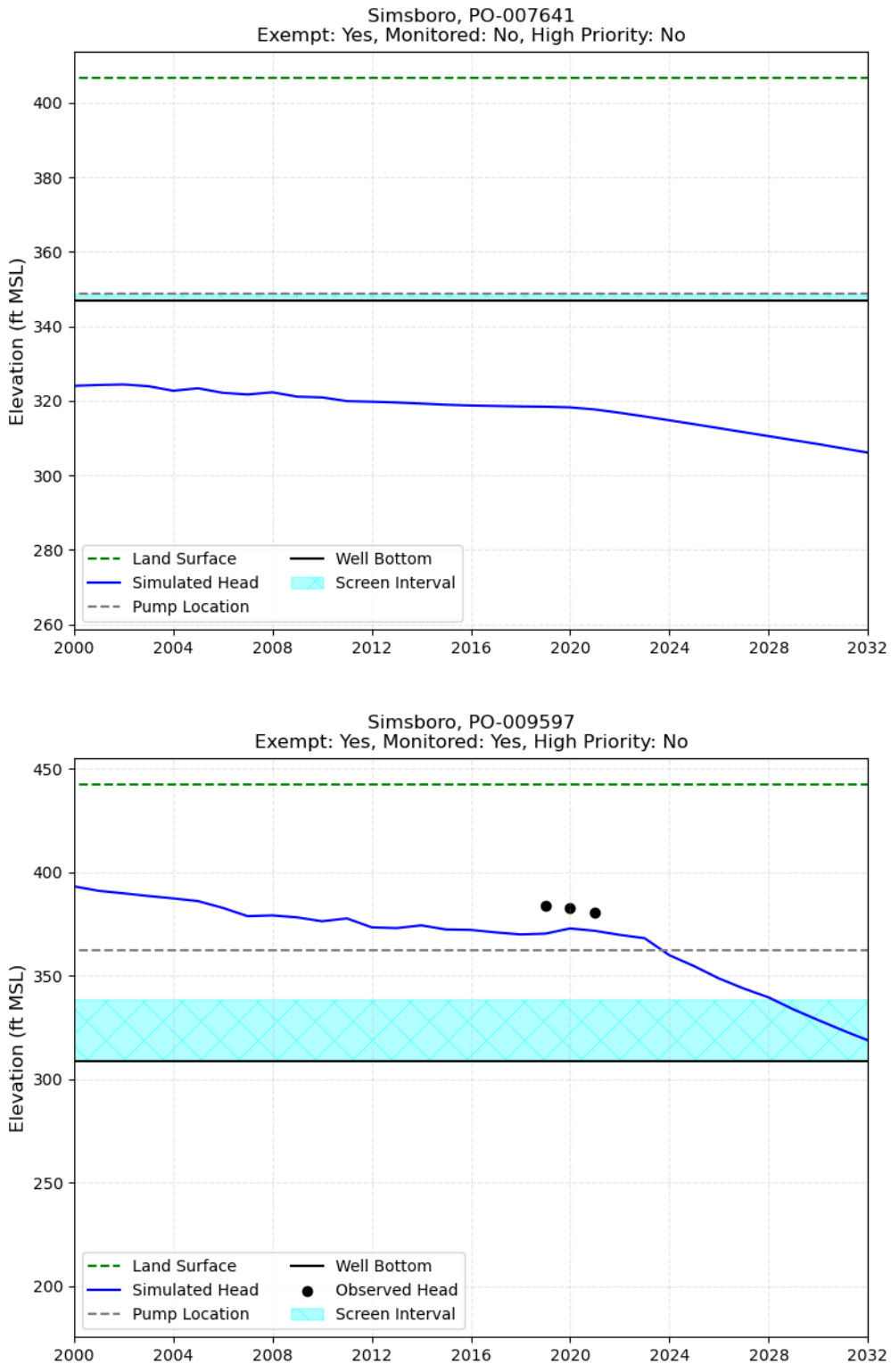

Figure E-17 Simulated water levels for wells of concern PO-007641 and PO-009597 located in the Simsboro Aquifer

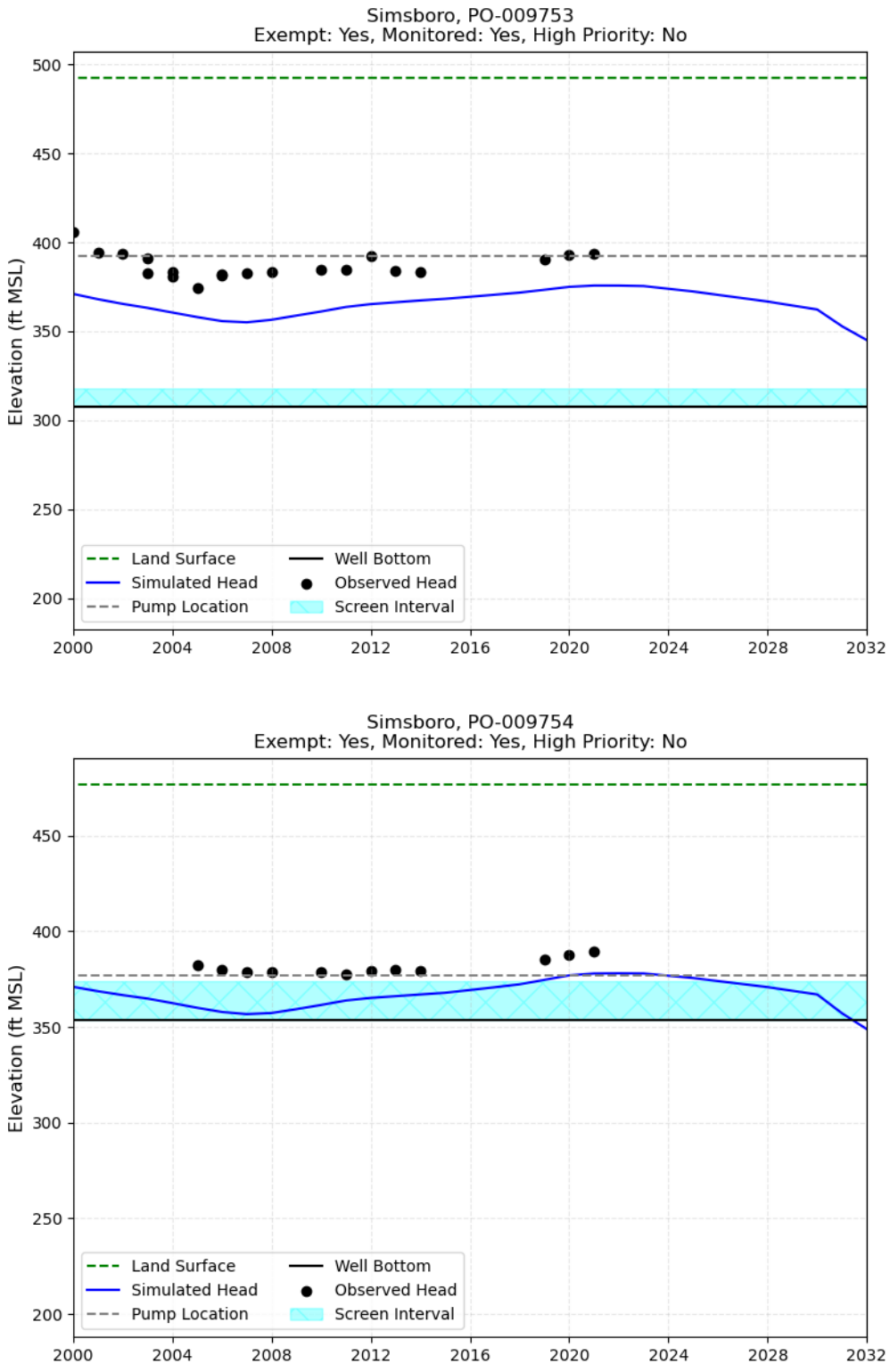

Figure E-18 Simulated water levels for wells of concern PO-009753 and PO-009754 located in the Simsboro Aquifer

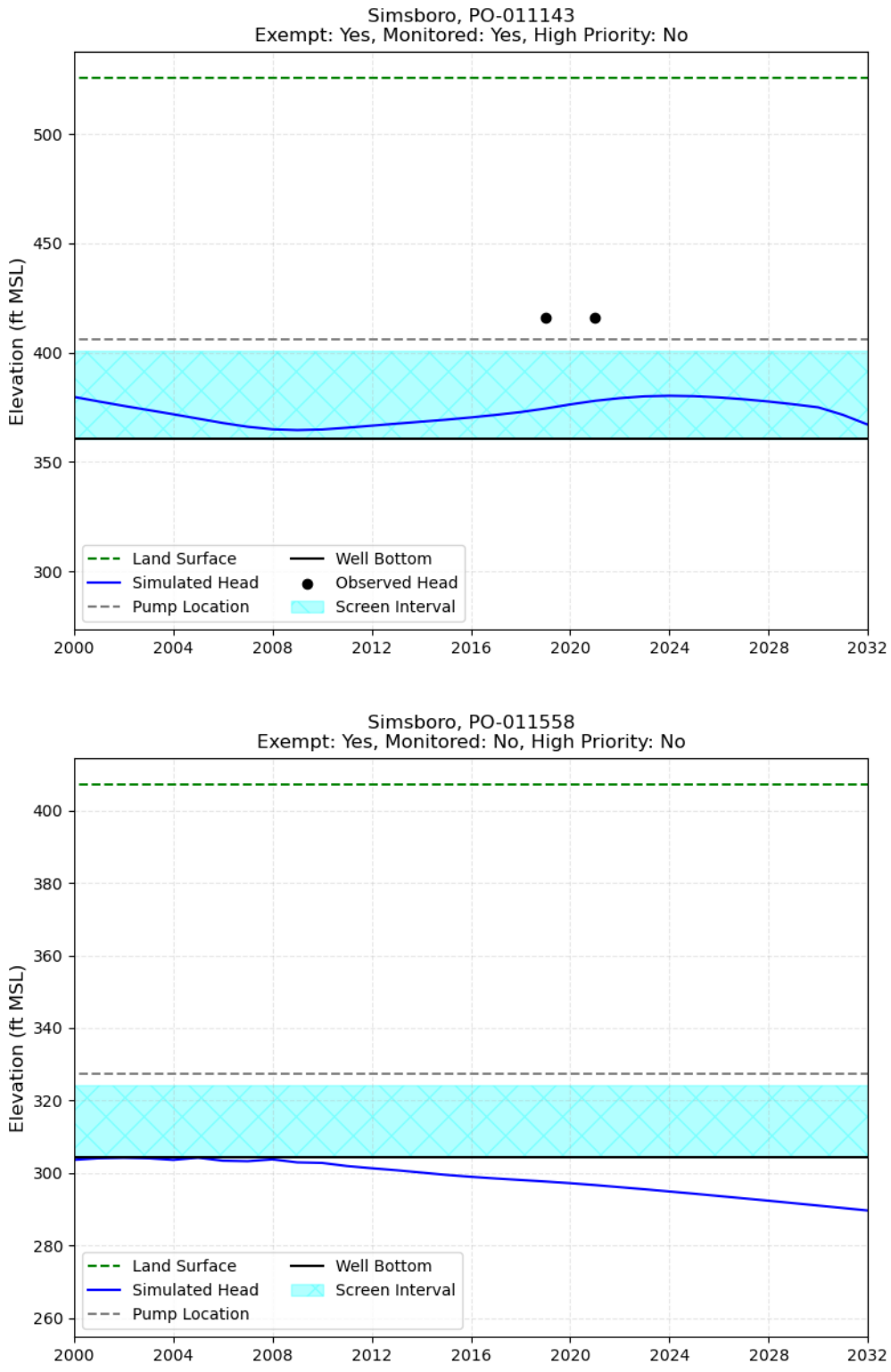

Figure E-19 Simulated water levels for wells of concern PO-11143 and PO-11558 located in the Simsboro Aquifer

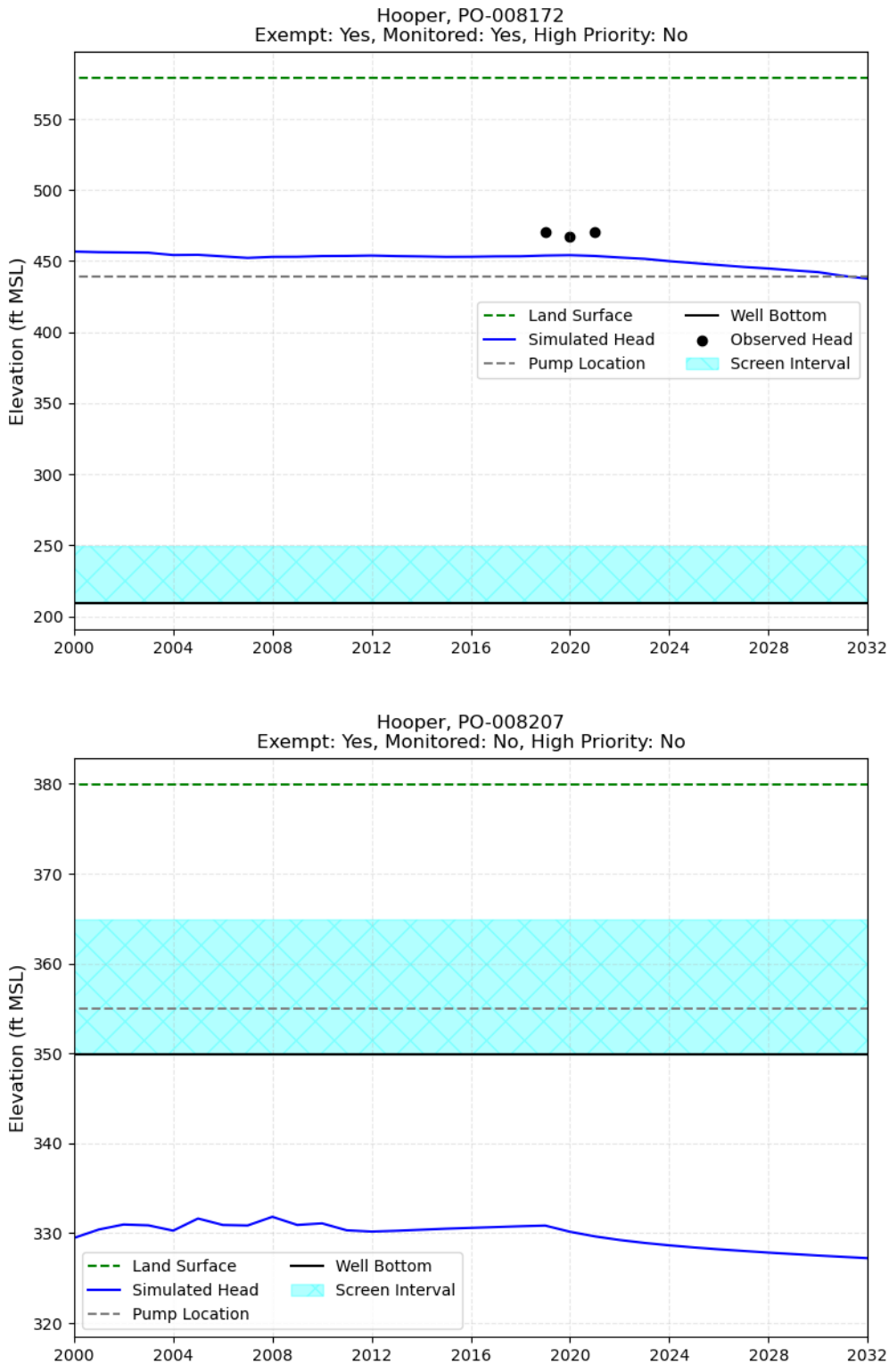

Figure E-20 Simulated water levels for wells of concern PO-008172 and PO-008207 located in the Hooper Aquifer

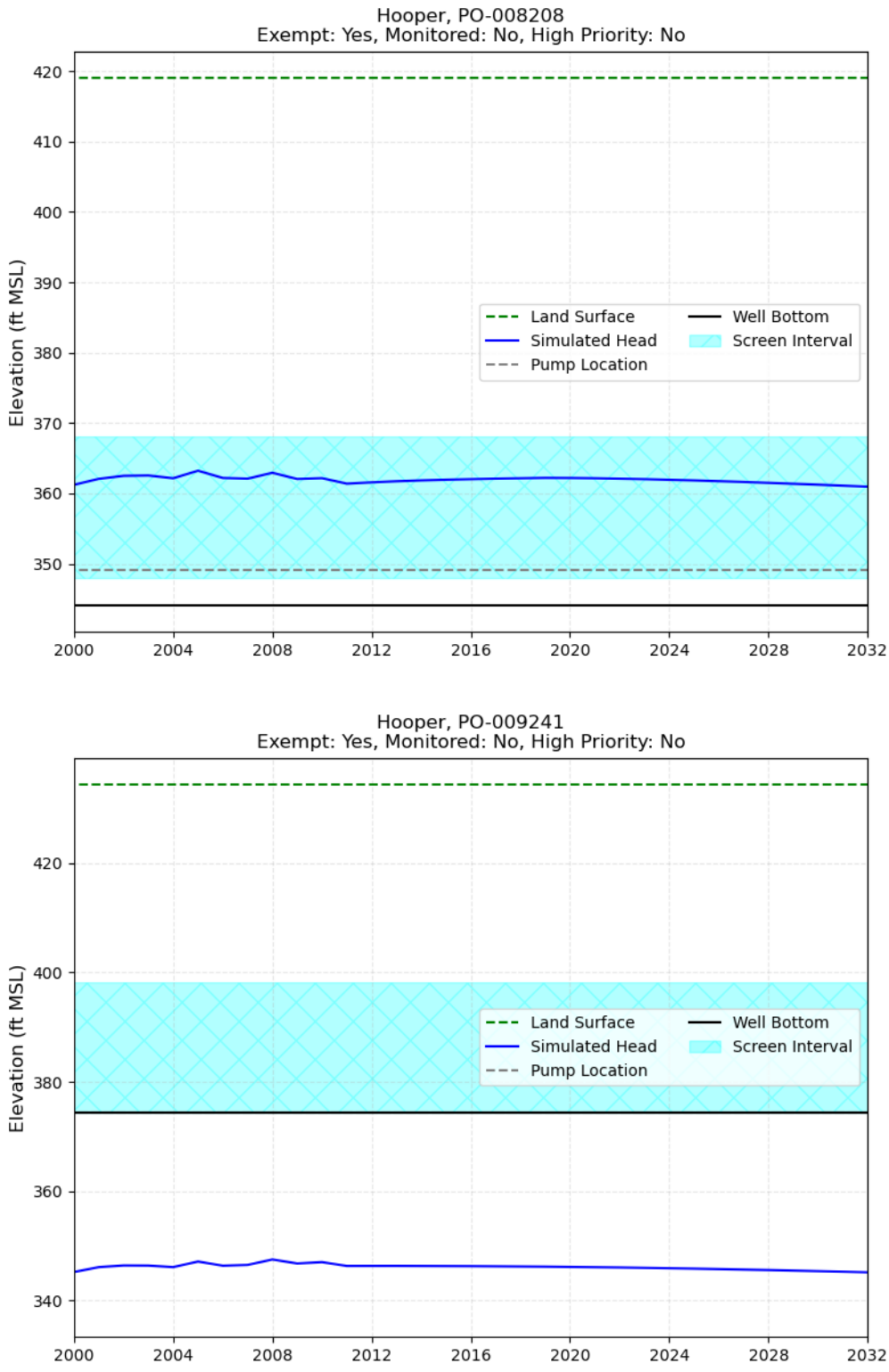

Figure E-21 Simulated water levels for wells of concern PO-008208 and PO-009241 located in the Hooper Aquifer

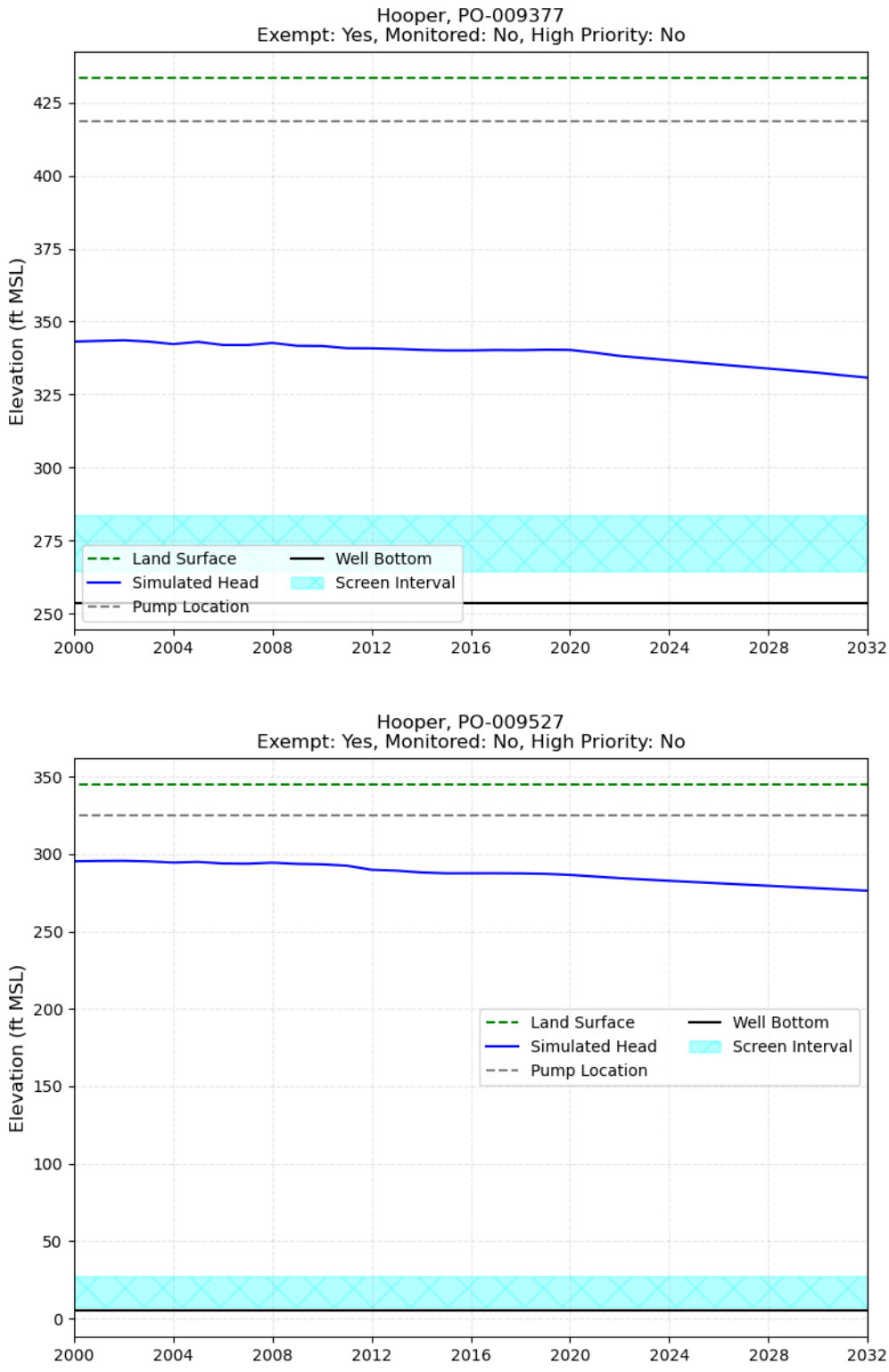

Figure E-22 Simulated water levels for wells of concern PO-009377 and PO-009527 located in the Hooper Aquifer

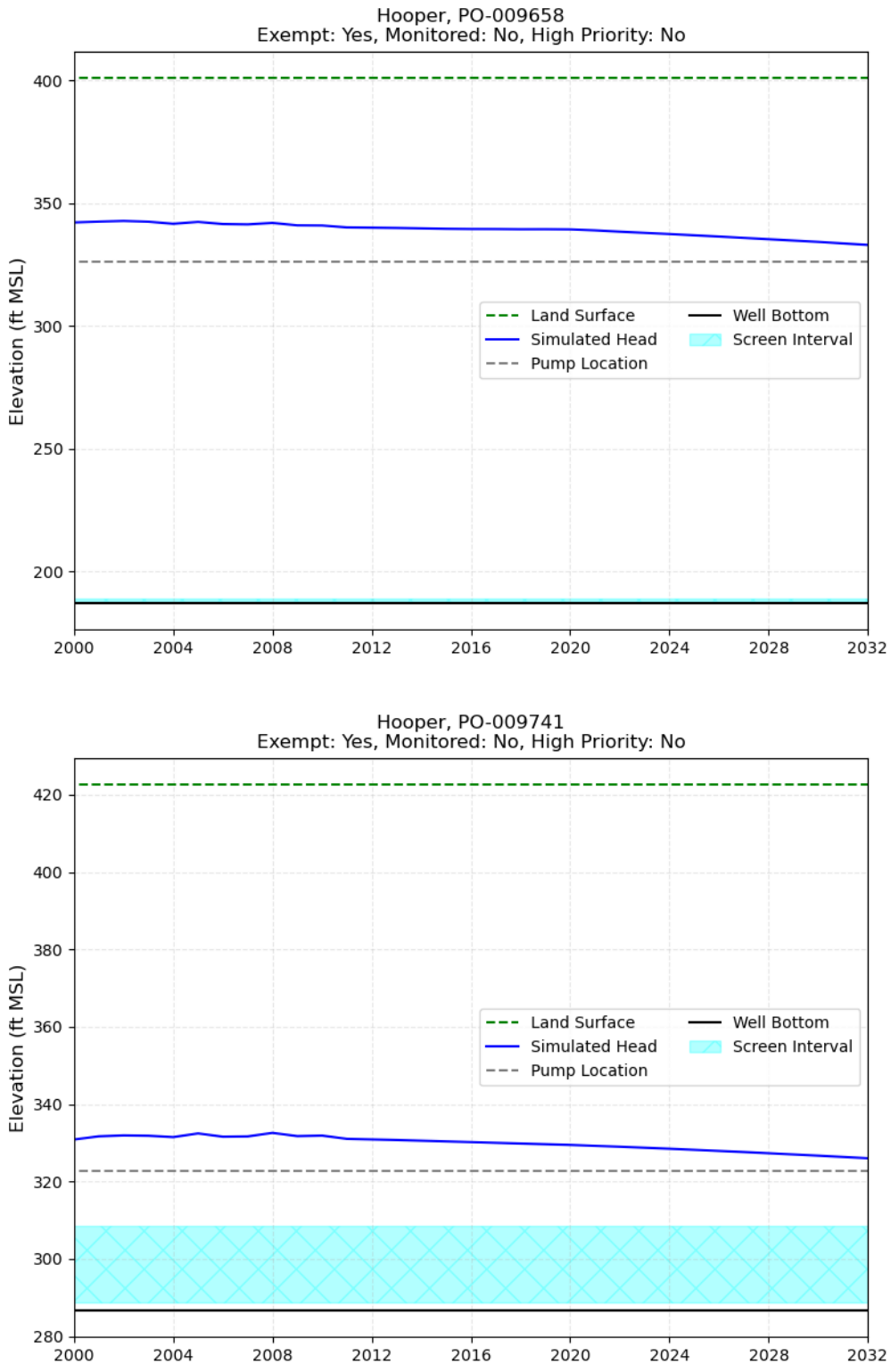

Figure E-23 Simulated water levels for wells of concern PO-009658 and PO-009741 located in the Hooper Aquifer

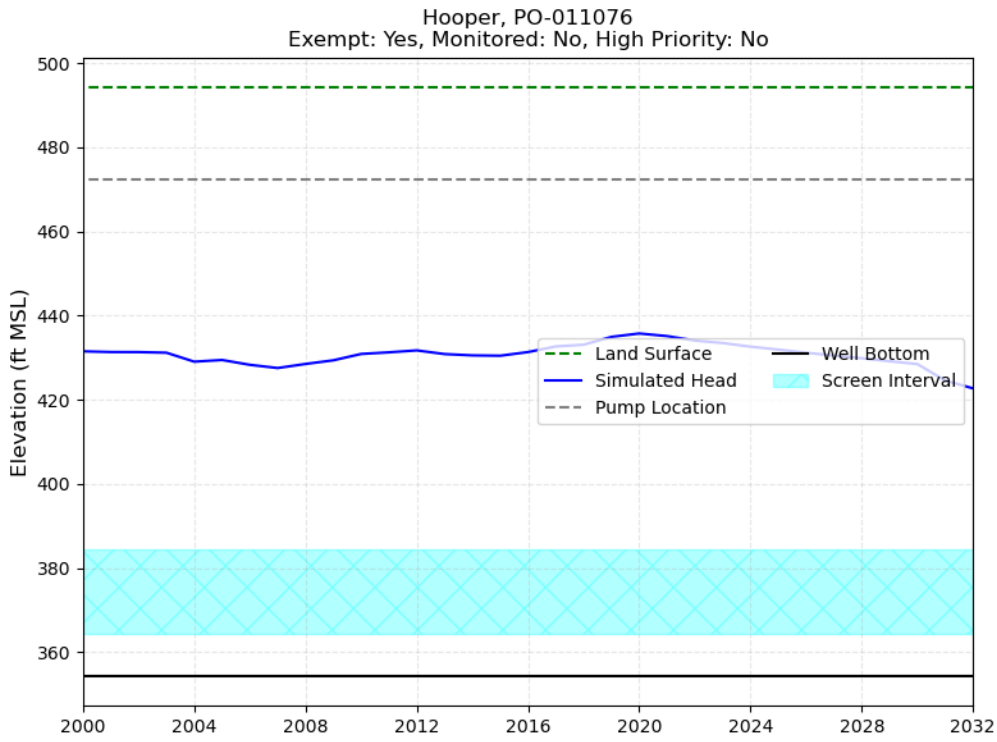

Figure E-24 Simulated water levels for wells of concern PO-009741 and PO-011076 located in the Hooper Aquifer

APPENDIX F

Listing of moderate-priority wells in the Carrizo Aquifer

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WellId
PO-000302
PO-000315
PO-000325
PO-000393
PO-000488
PO-000493
PO-000496
PO-000497
PO-000506
PO-000510
PO-000525
PO-000625
PO-003430
PO-003437
PO-004965
PO-004971
PO-004998
PO-005098
PO-005102
PO-005109
PO-005113
PO-005214
PO-005218
PO-005244
PO-005246
PO-005249
PO-005728
PO-005729
PO-005759
PO-005763
PO-005810
PO-006817
PO-007246
PO-007332
PO-009386

WellId
PO-010970
PO-011387
PO-011519

APPENDIX G

Hydrographs for Moderate-Priority Wells in the Carrizo Aquifer

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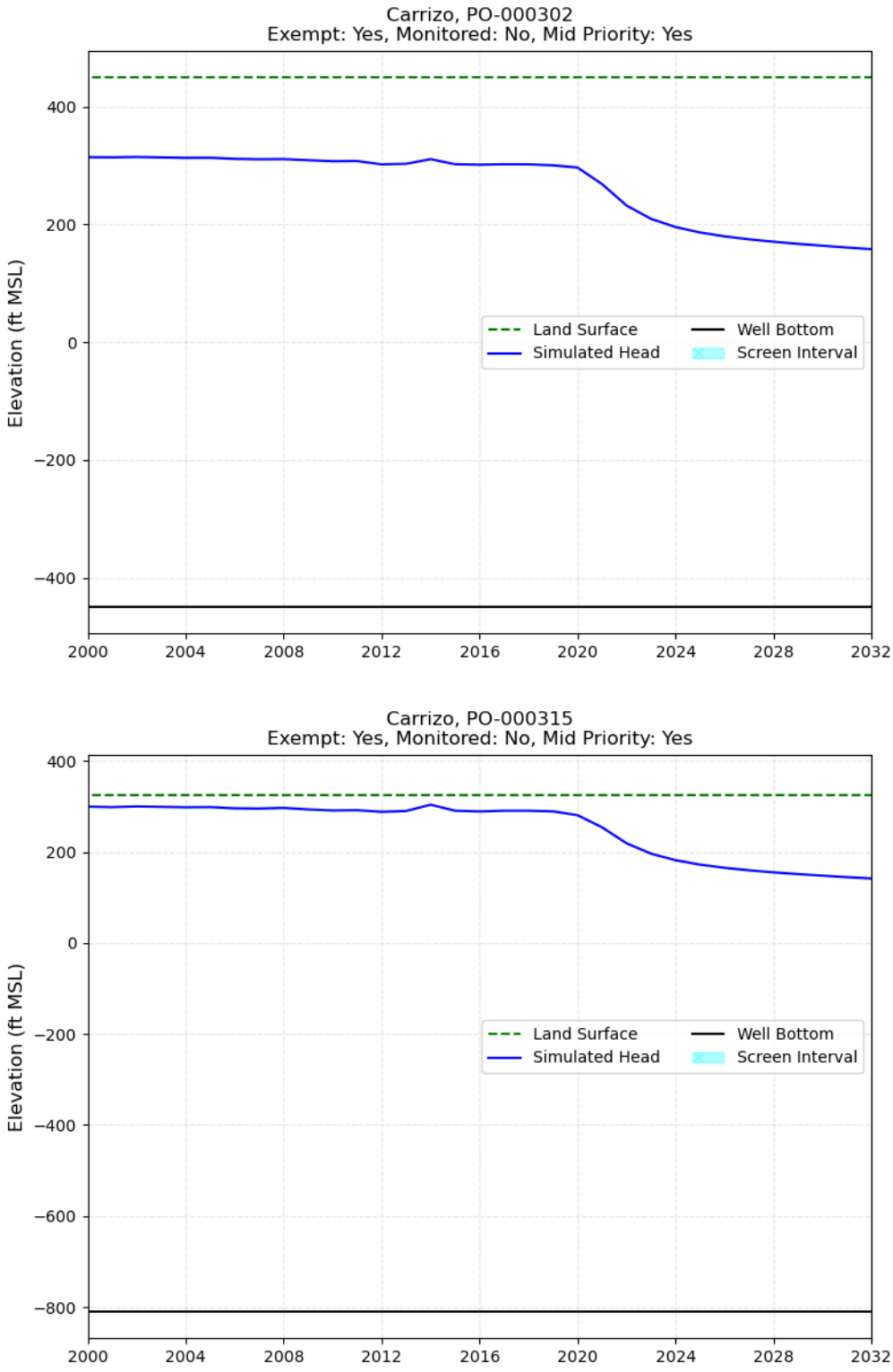

Figure G-1 Simulated water levels for moderate-priority wells PO-000302 and PO-000315 located in the Carrizo Aquifer

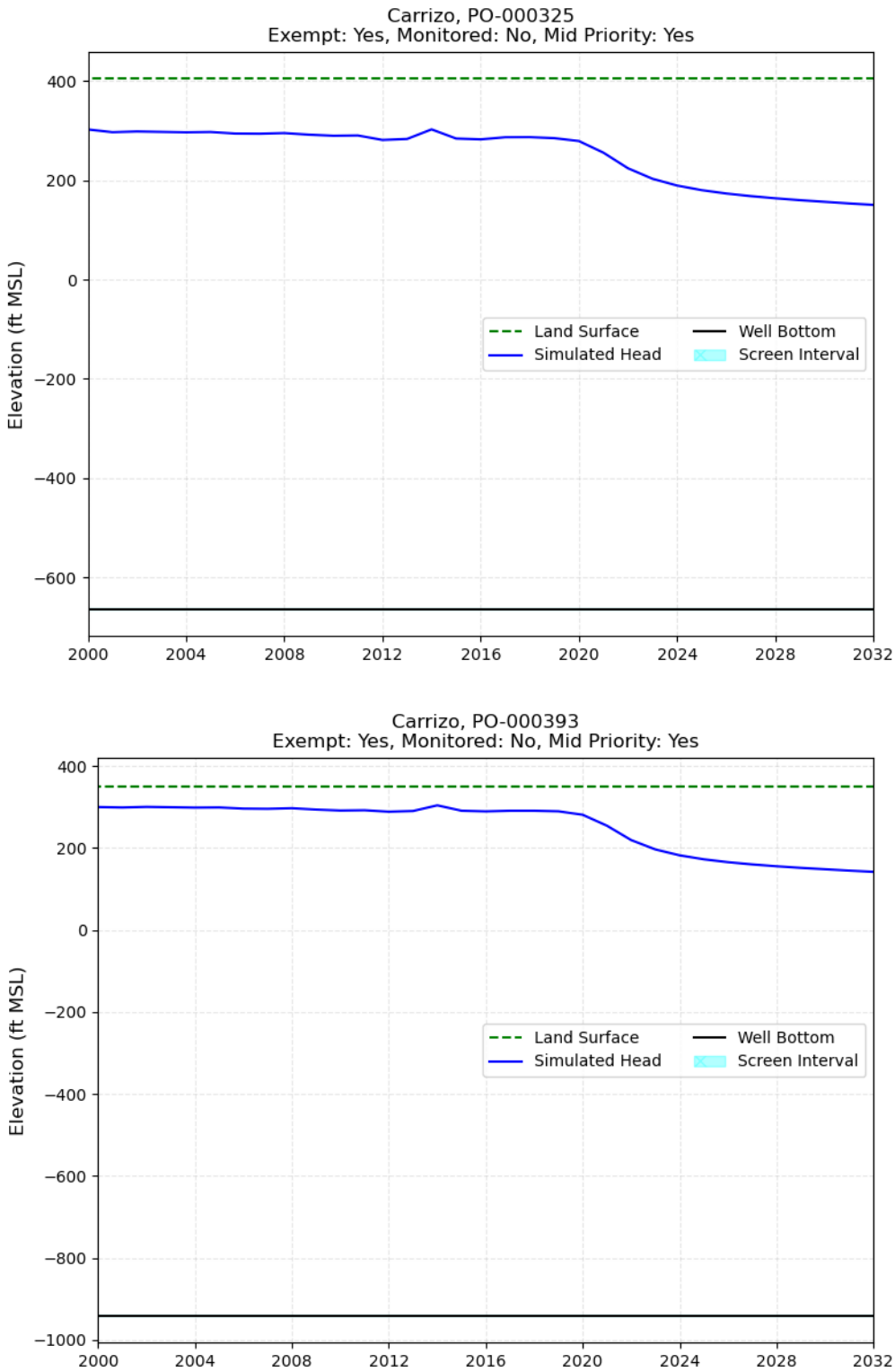

Figure G-2 Simulated water levels for moderate-priority wells PO-000325 and PO-000393 located in the Carrizo Aquifer

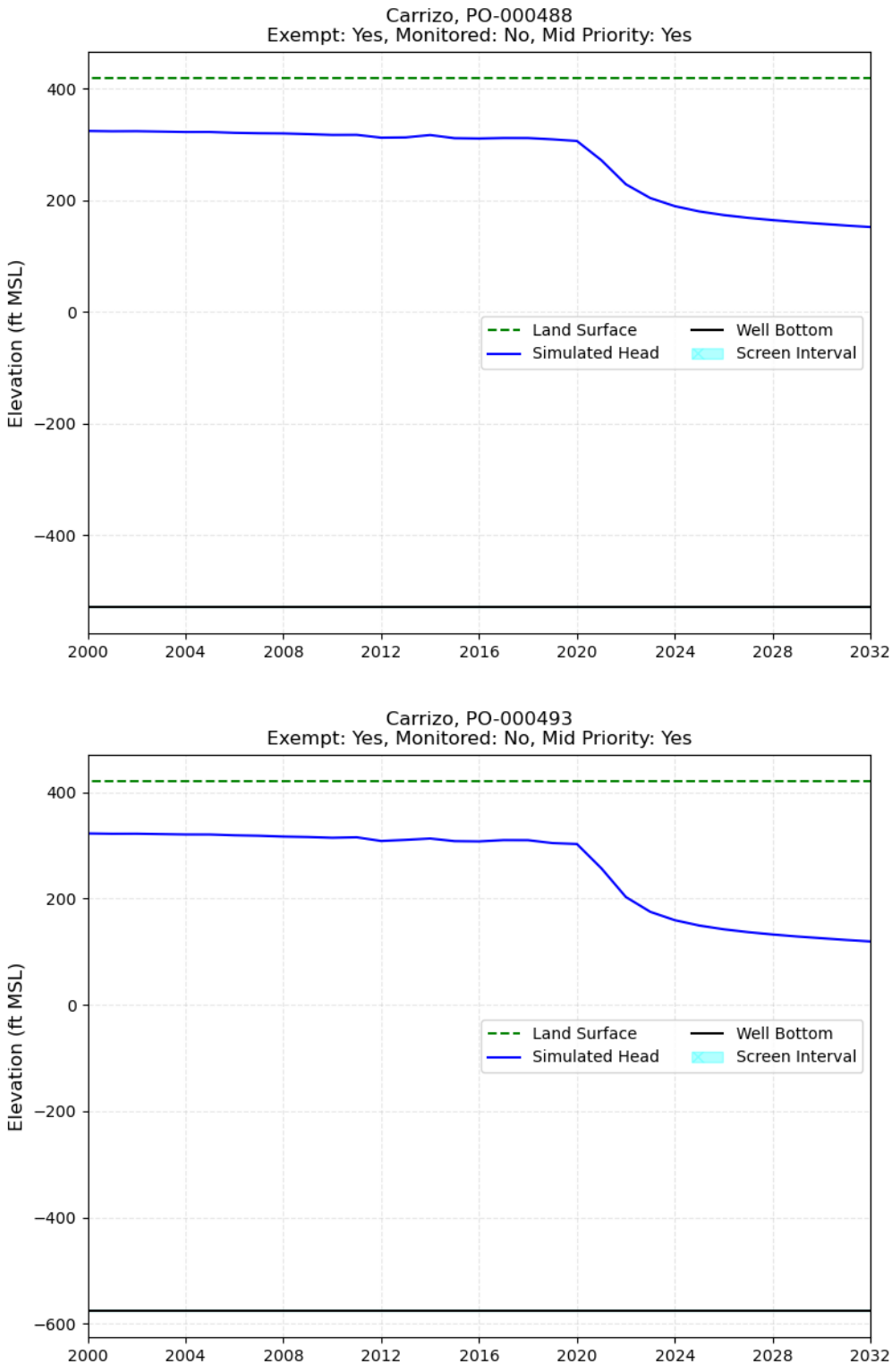

Figure G-3 Simulated water levels for moderate-priority wells PO-000488 and PO-000493 located in the Carrizo Aquifer

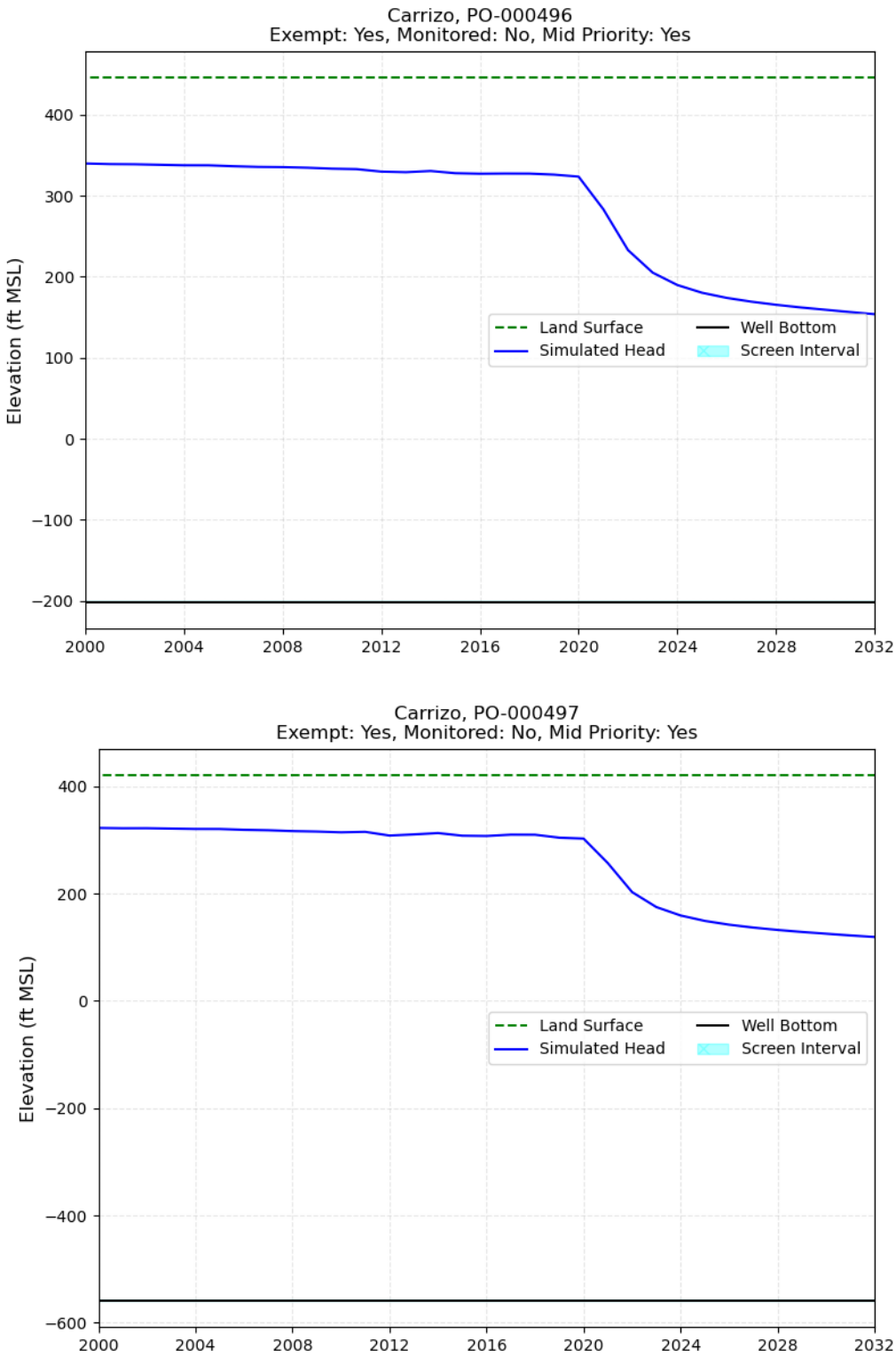

Figure G-4 Simulated water levels for moderate-priority wells PO-000496 and PO-000497 located in the Carrizo Aquifer

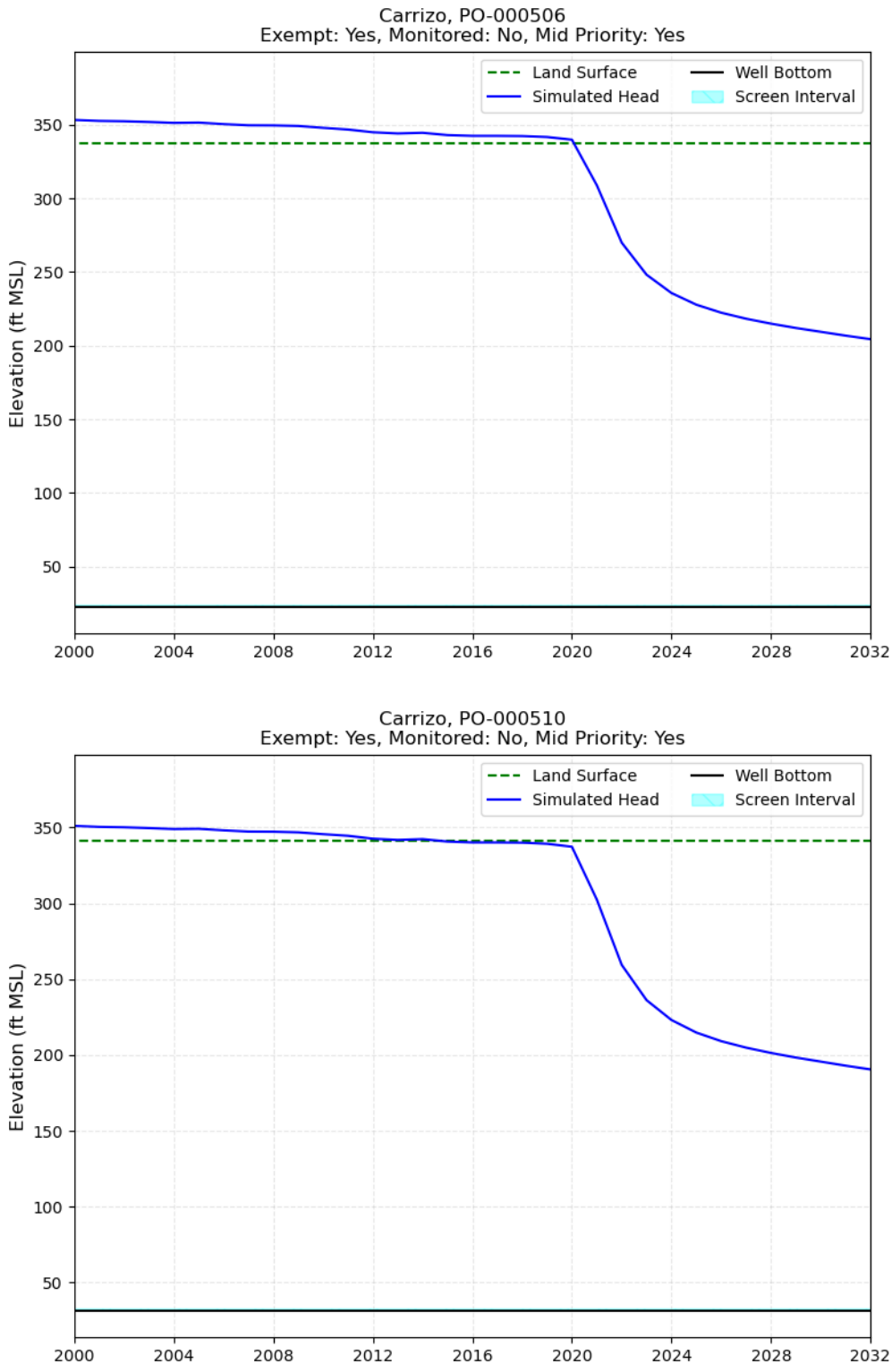

Figure G-5 Simulated water levels for moderate-priority wells PO-000506 and PO-000510 located in the Carrizo Aquifer

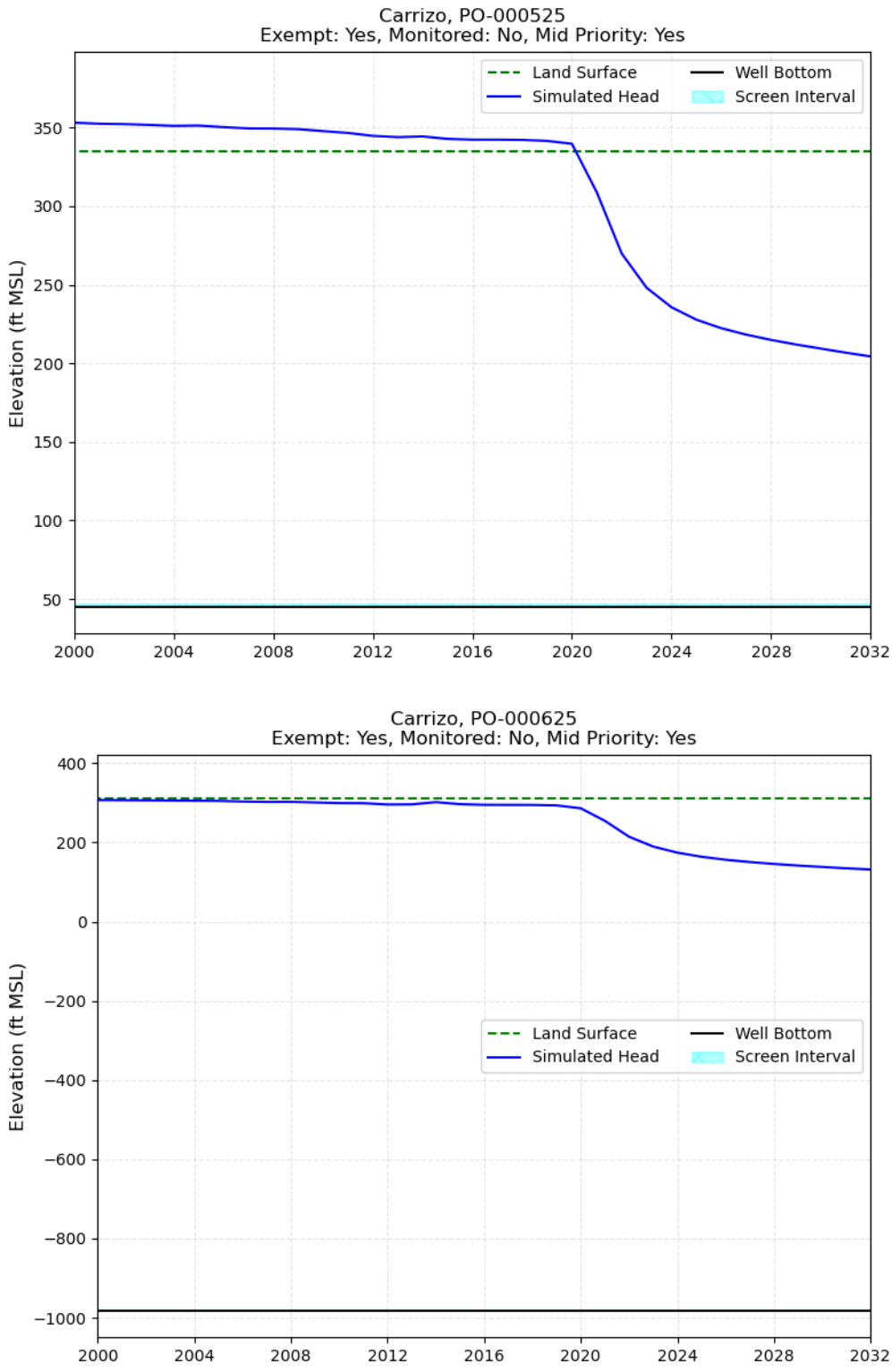

Figure G-6 Simulated water levels for moderate-priority wells PO-000525 and PO-000625 located in the Carrizo Aquifer

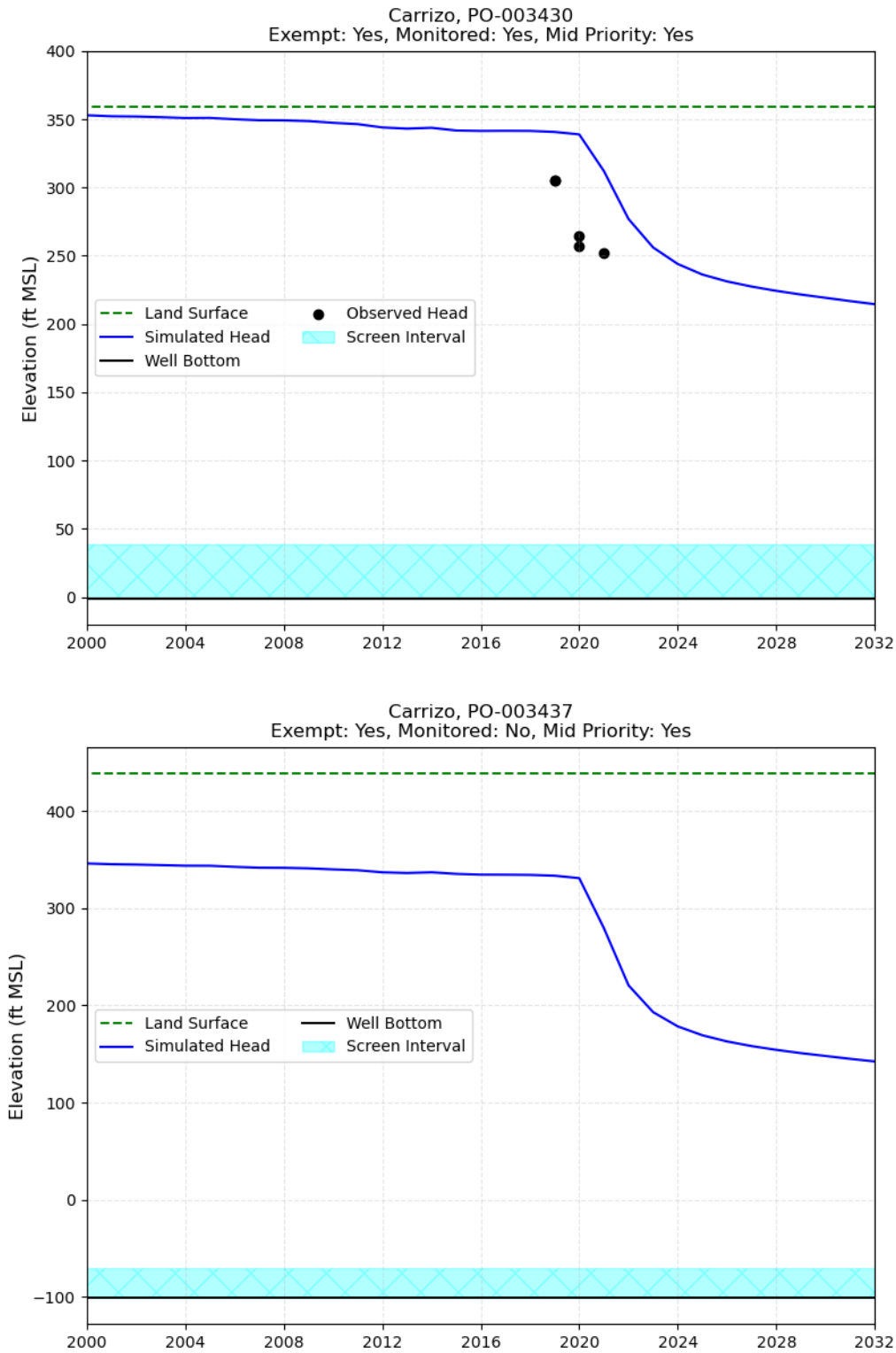

Figure G-7 Simulated water levels for moderate-priority wells PO-003430 and PO-003437 located in the Carrizo Aquifer

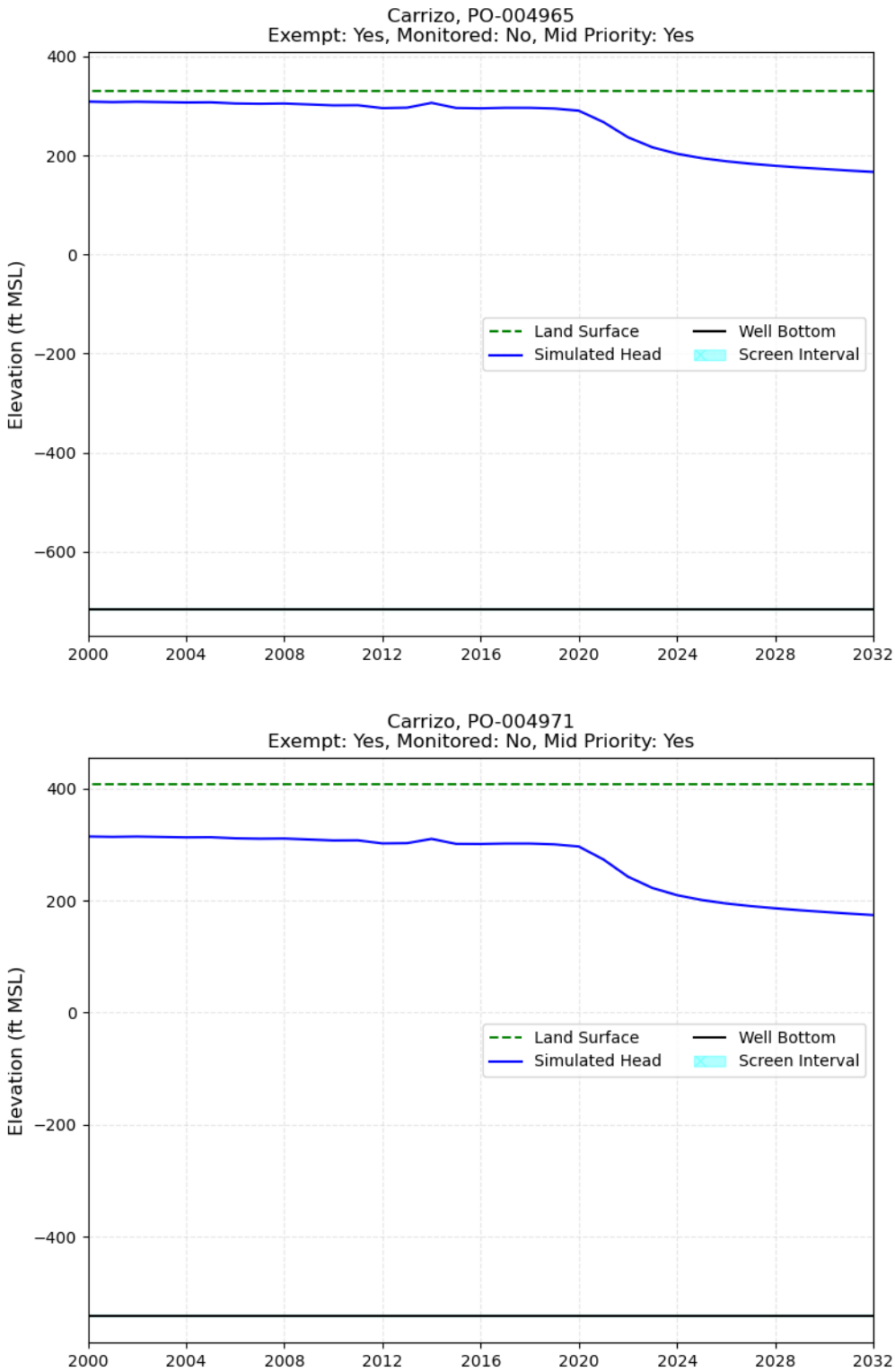

Figure G-8 Simulated water levels for moderate-priority wells PO-04965 and PO-004971 located in the Carrizo Aquifer

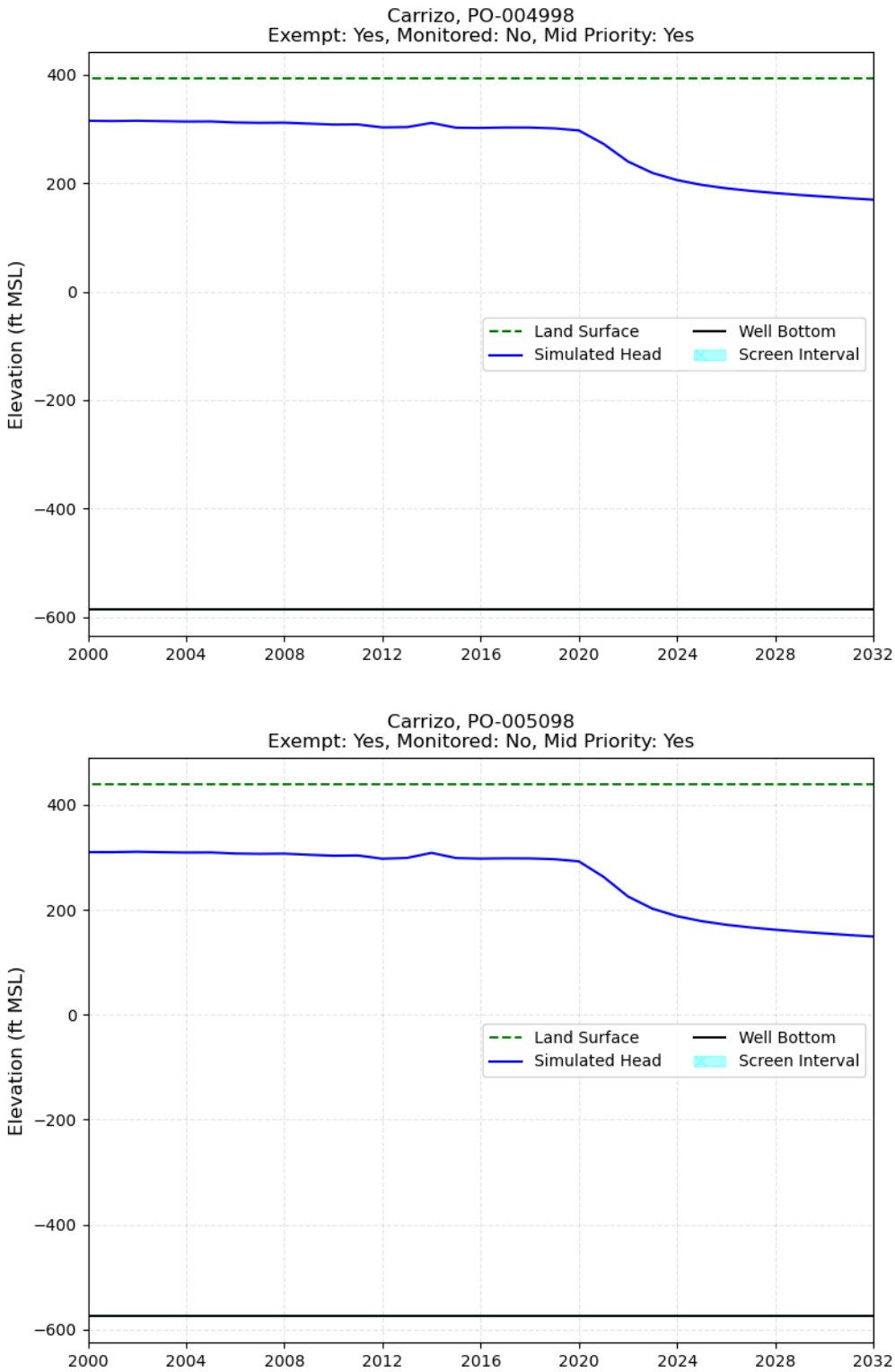

Figure G-9 Simulated water levels for moderate-priority wells PO-004998 and PO-005098 located in the Carrizo Aquifer

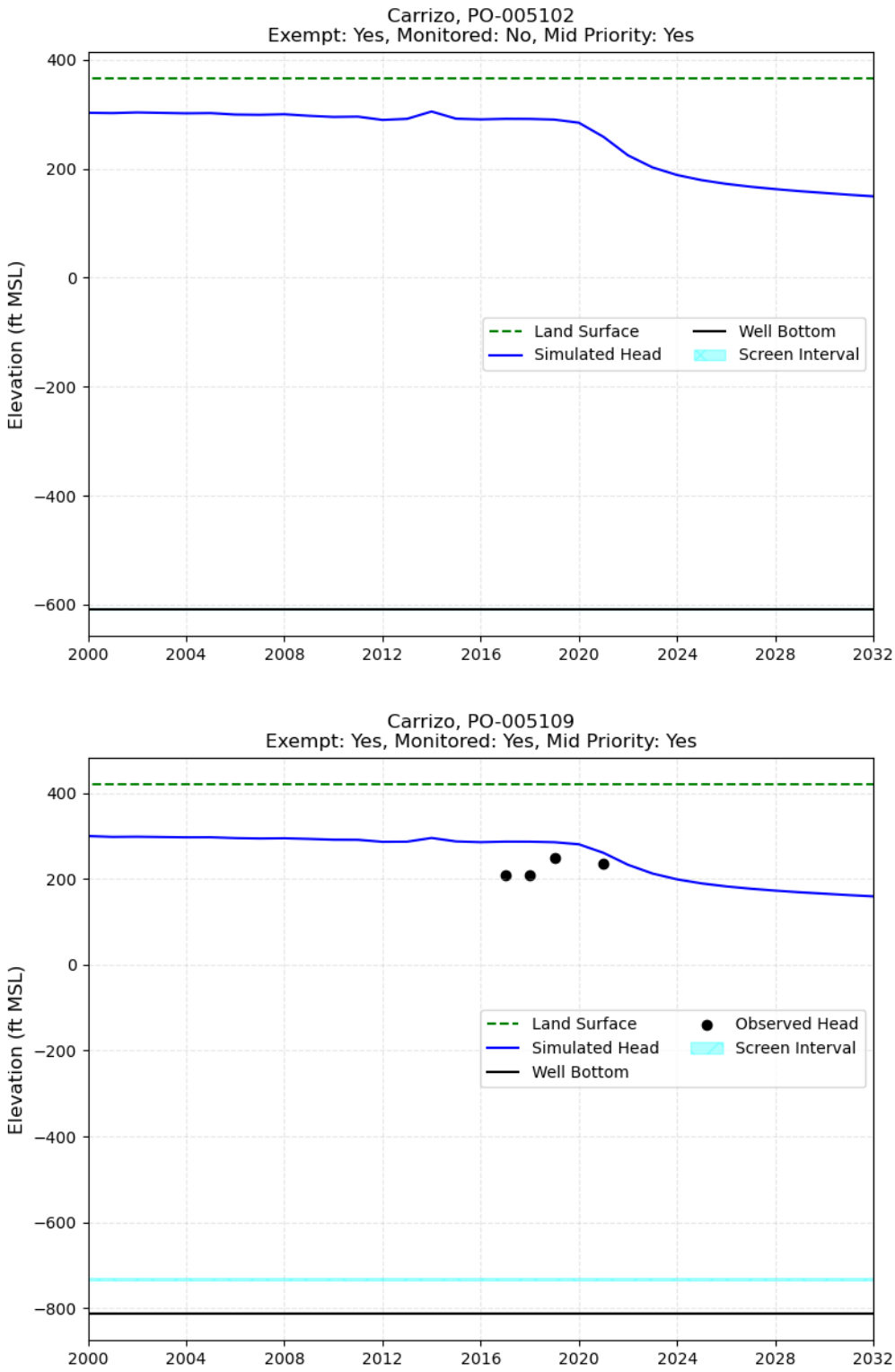

Figure G-10 Simulated water levels for moderate-priority wells PO-005102 and PO-005109 located in the Carrizo Aquifer

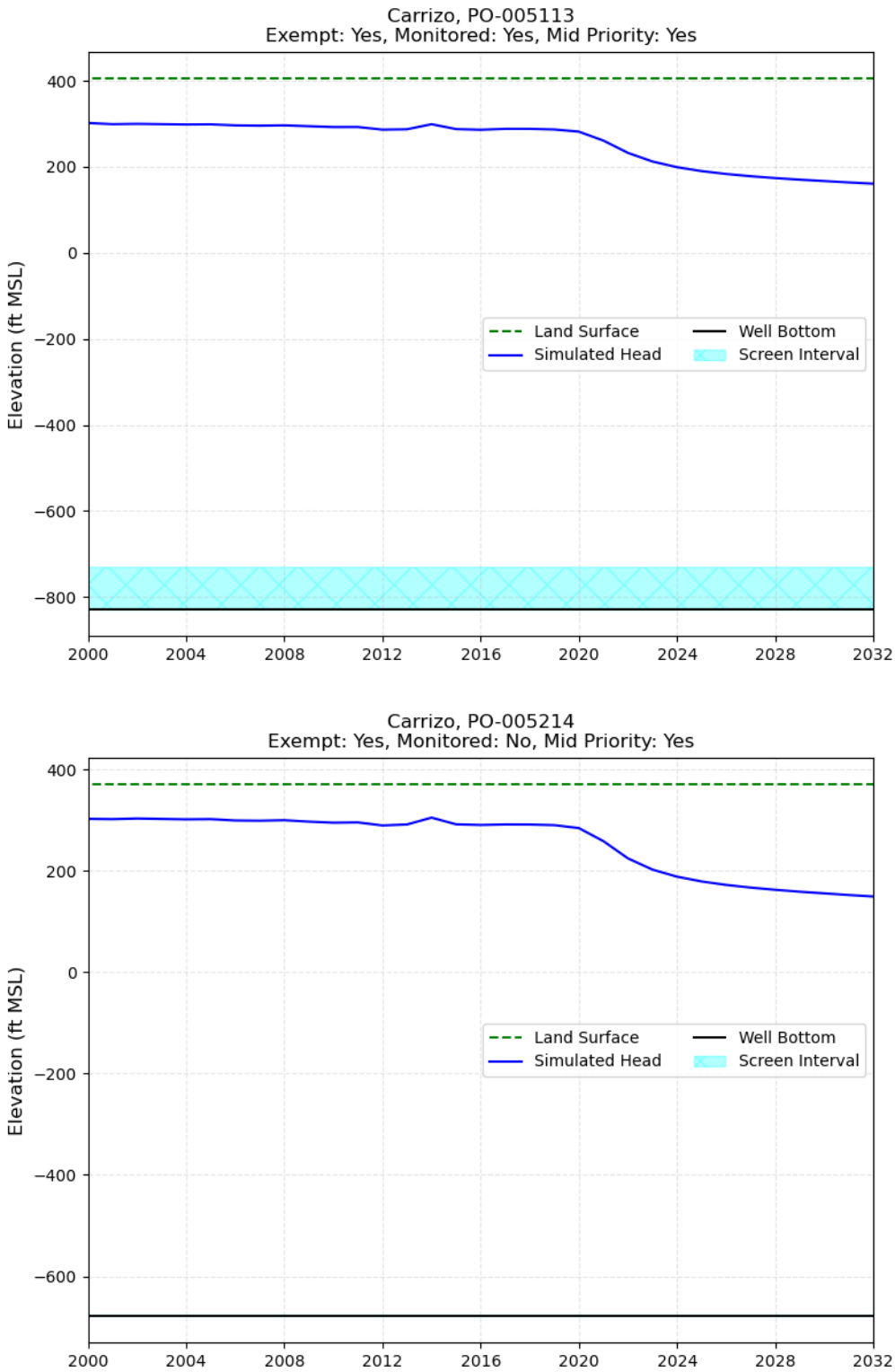

Figure G-11 Simulated water levels for moderate-priority wells PO-005113 and PO-005214 located in the Carrizo Aquifer

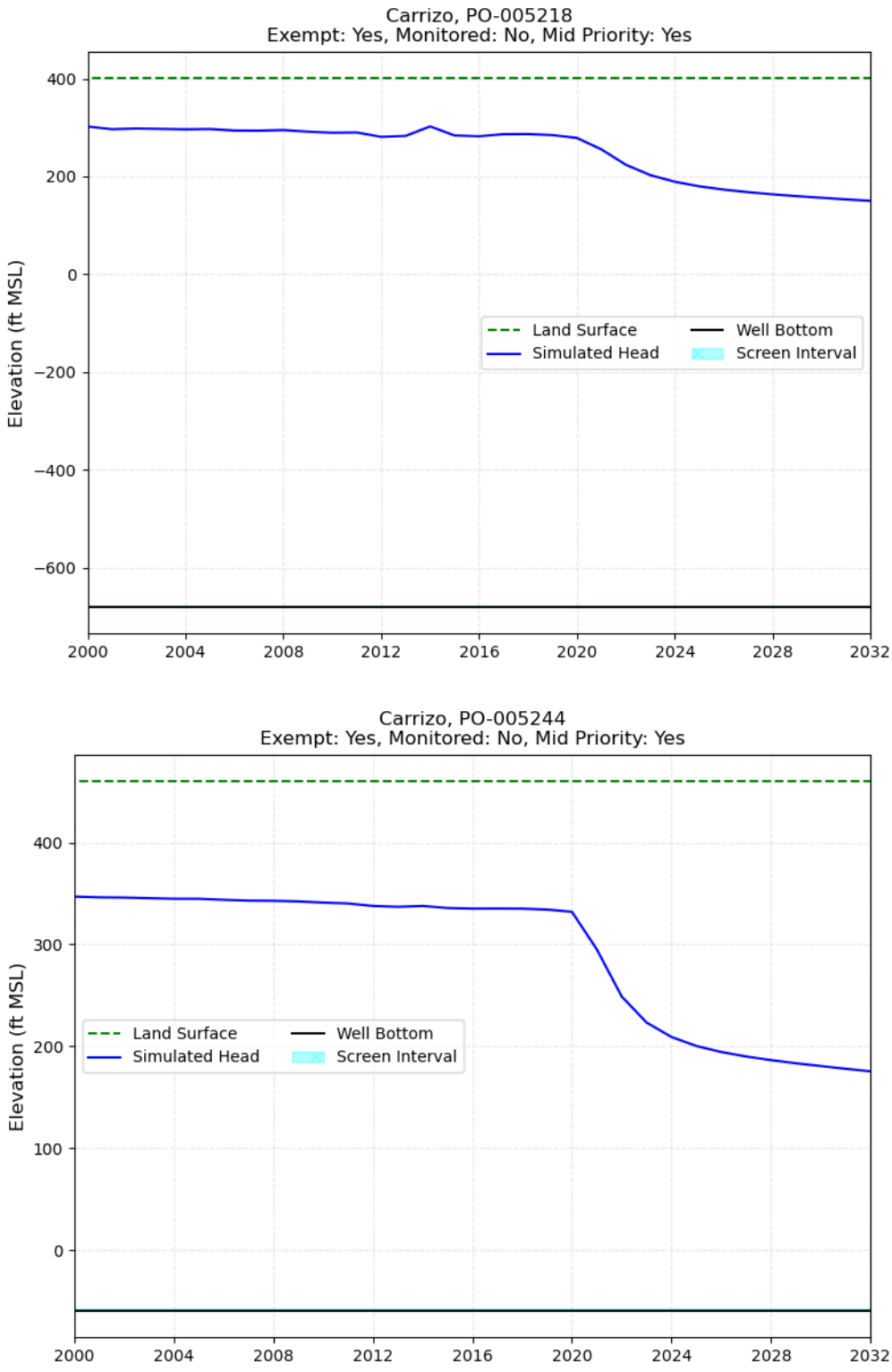

Figure G-12 Simulated water levels for moderate-priority wells PO-005218 and PO-005244 located in the Carrizo Aquifer

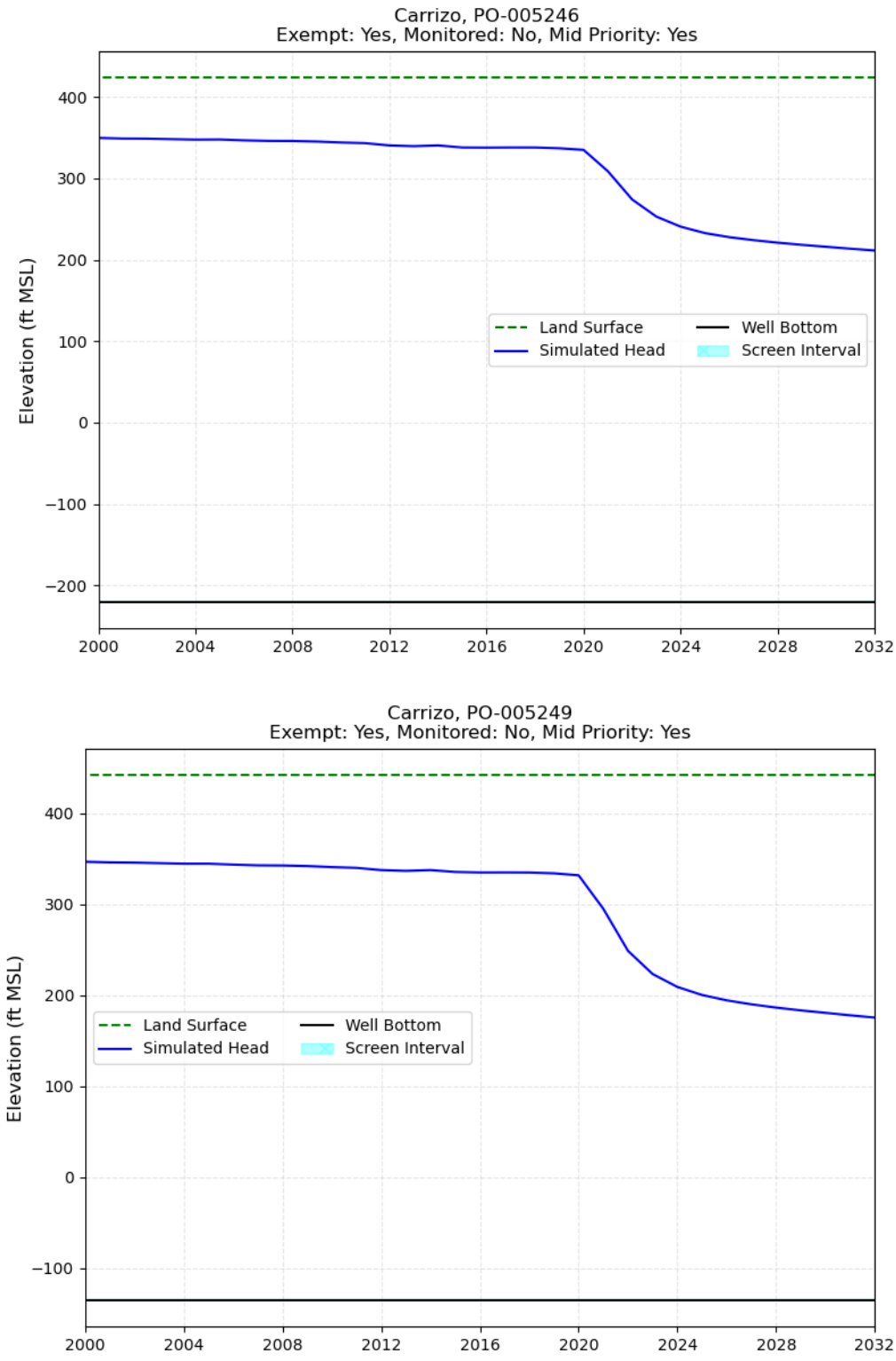

Figure G-13 Simulated water levels for moderate-priority wells PO-005246 and PO-005249 located in the Carrizo Aquifer

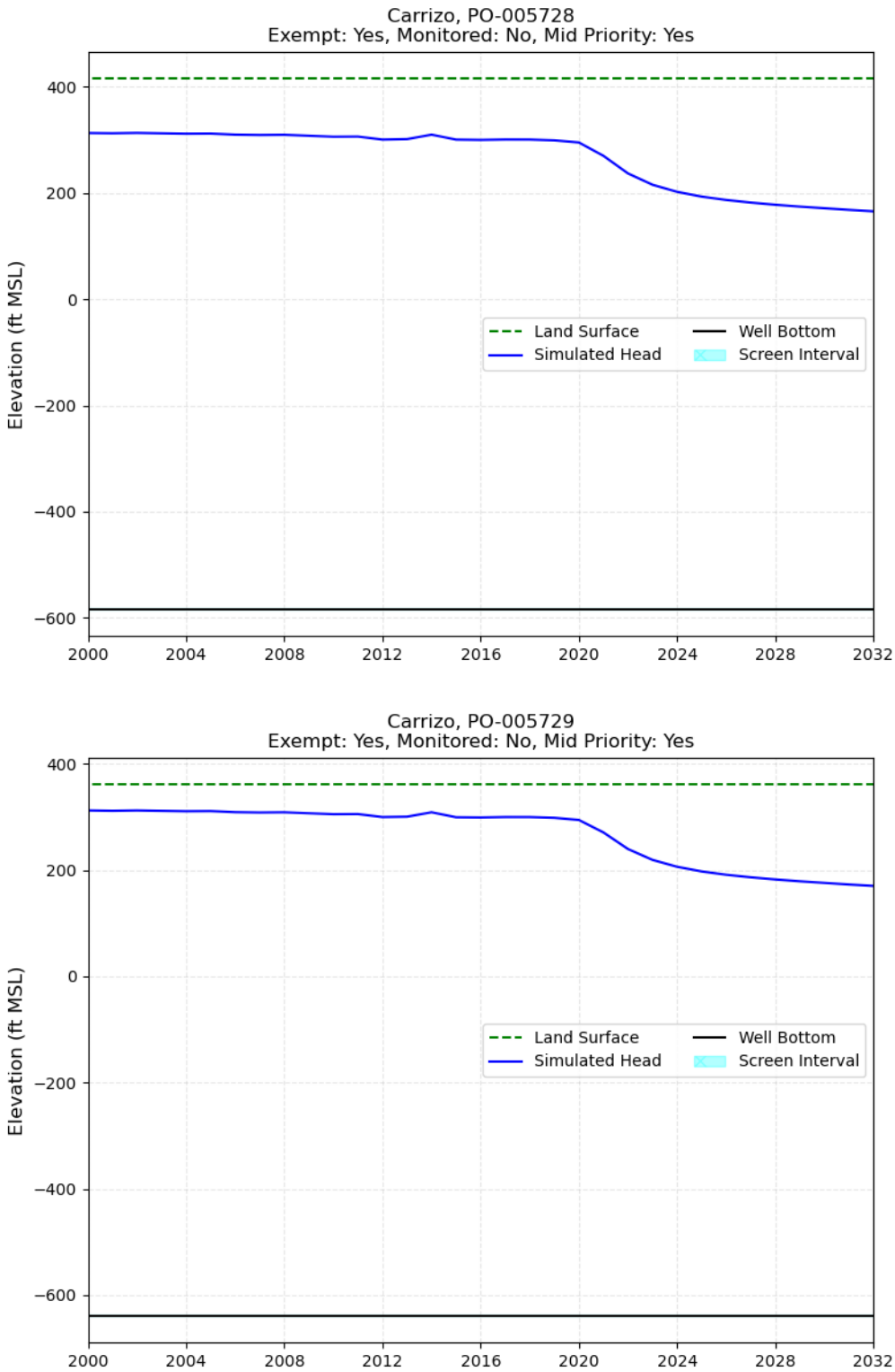

Figure G-14 Simulated water levels for moderate-priority wells PO-005728 and PO-005729 located in the Carrizo Aquifer

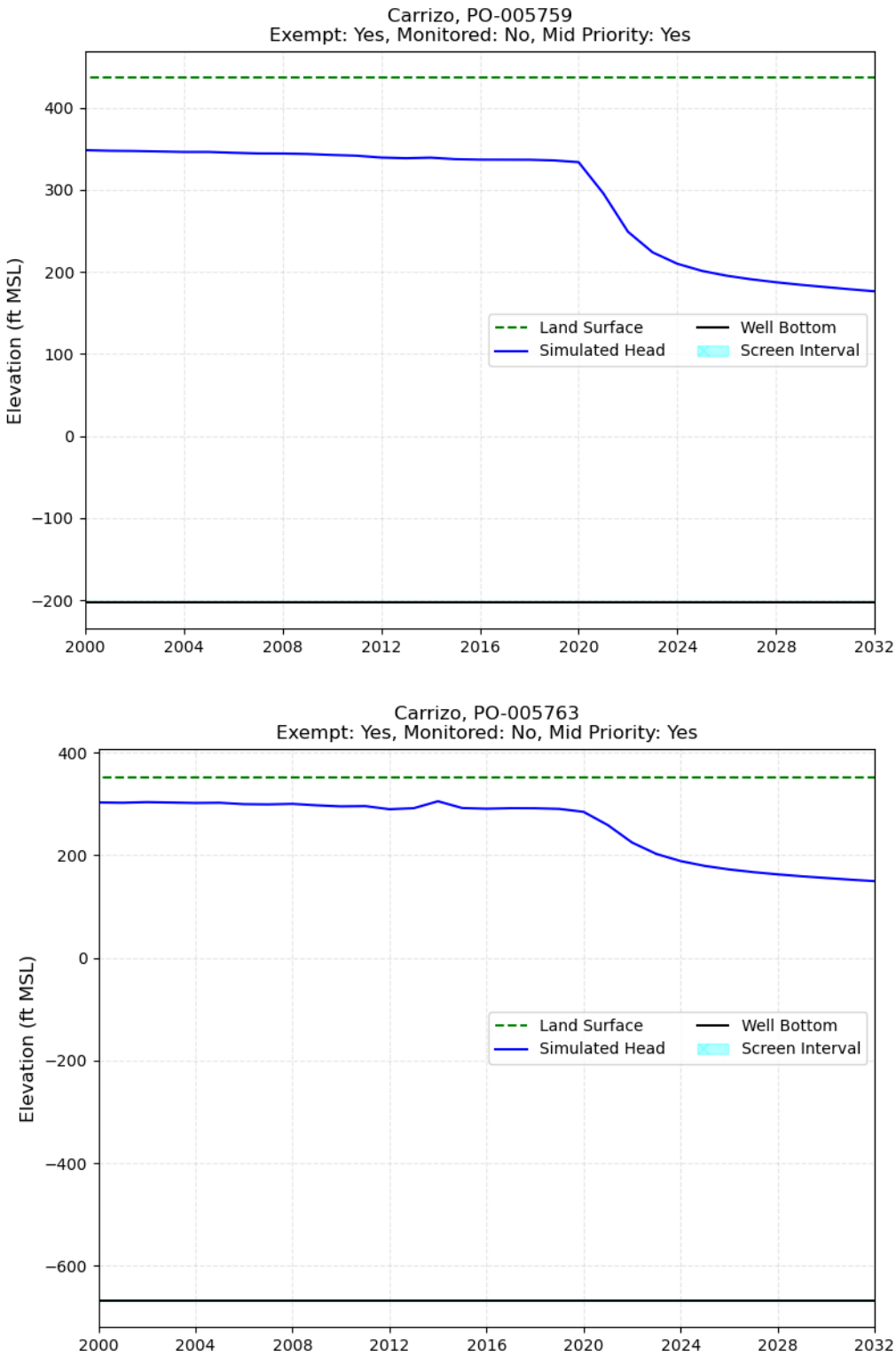

Figure G-15 Simulated water levels for moderate-priority wells PO-005759 and PO-005763 located in the Carrizo Aquifer

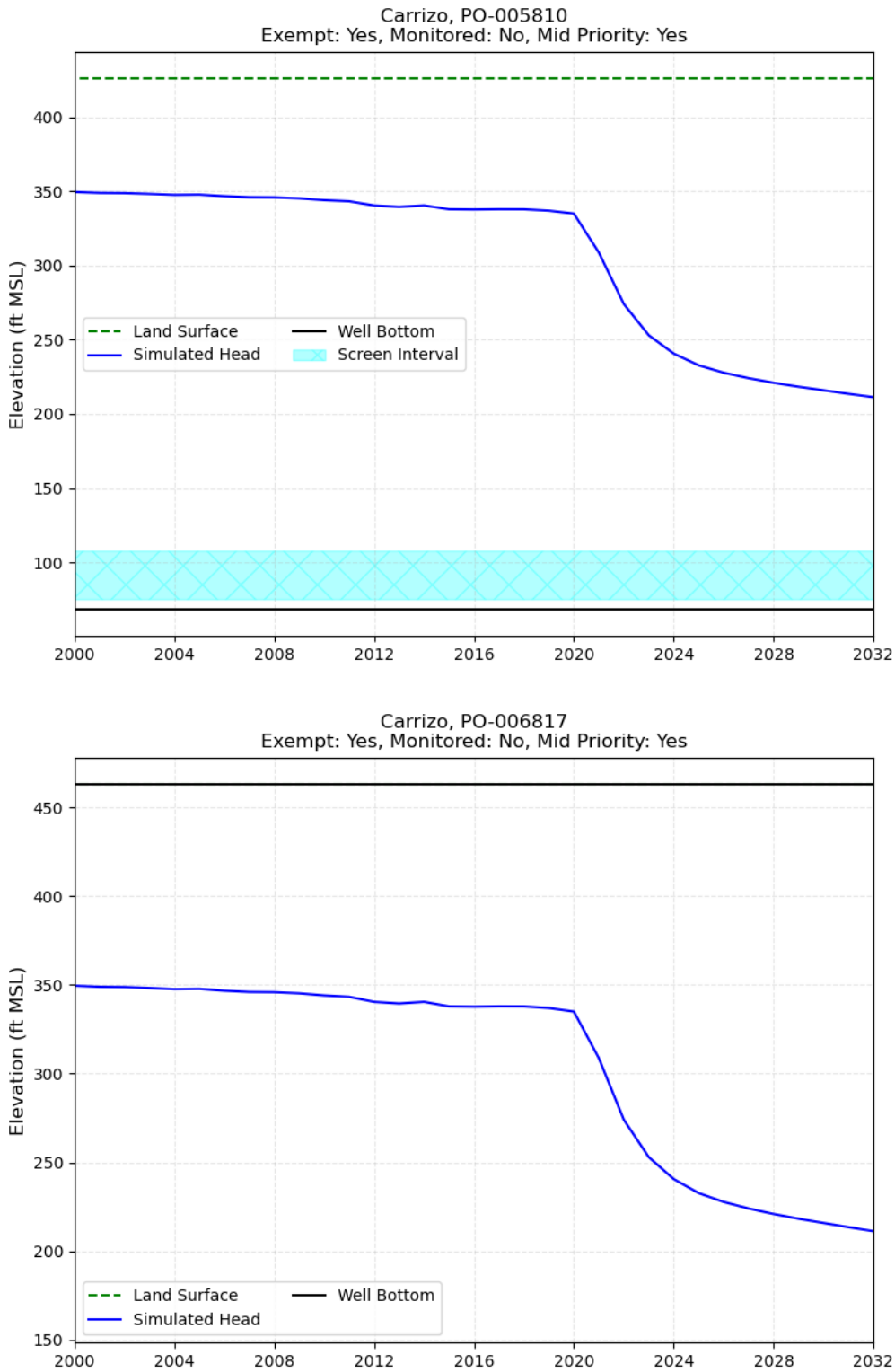

Figure G-16 Simulated water levels for moderate-priority wells PO-005810 and PO-006817 located in the Carrizo Aquifer

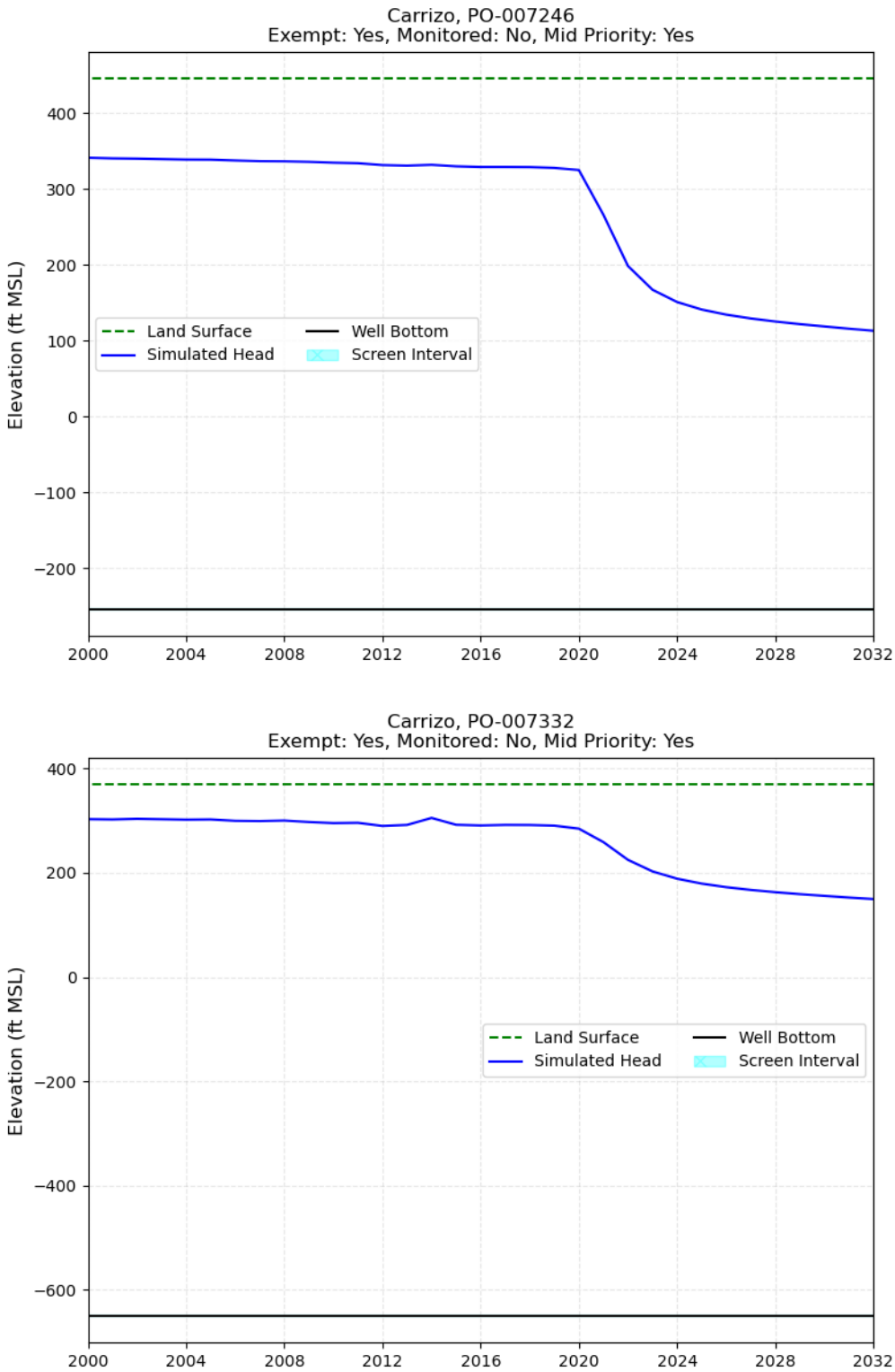

Figure G-17 Simulated water levels for moderate-priority wells PO-007246 and PO-007332 located in the Carrizo Aquifer

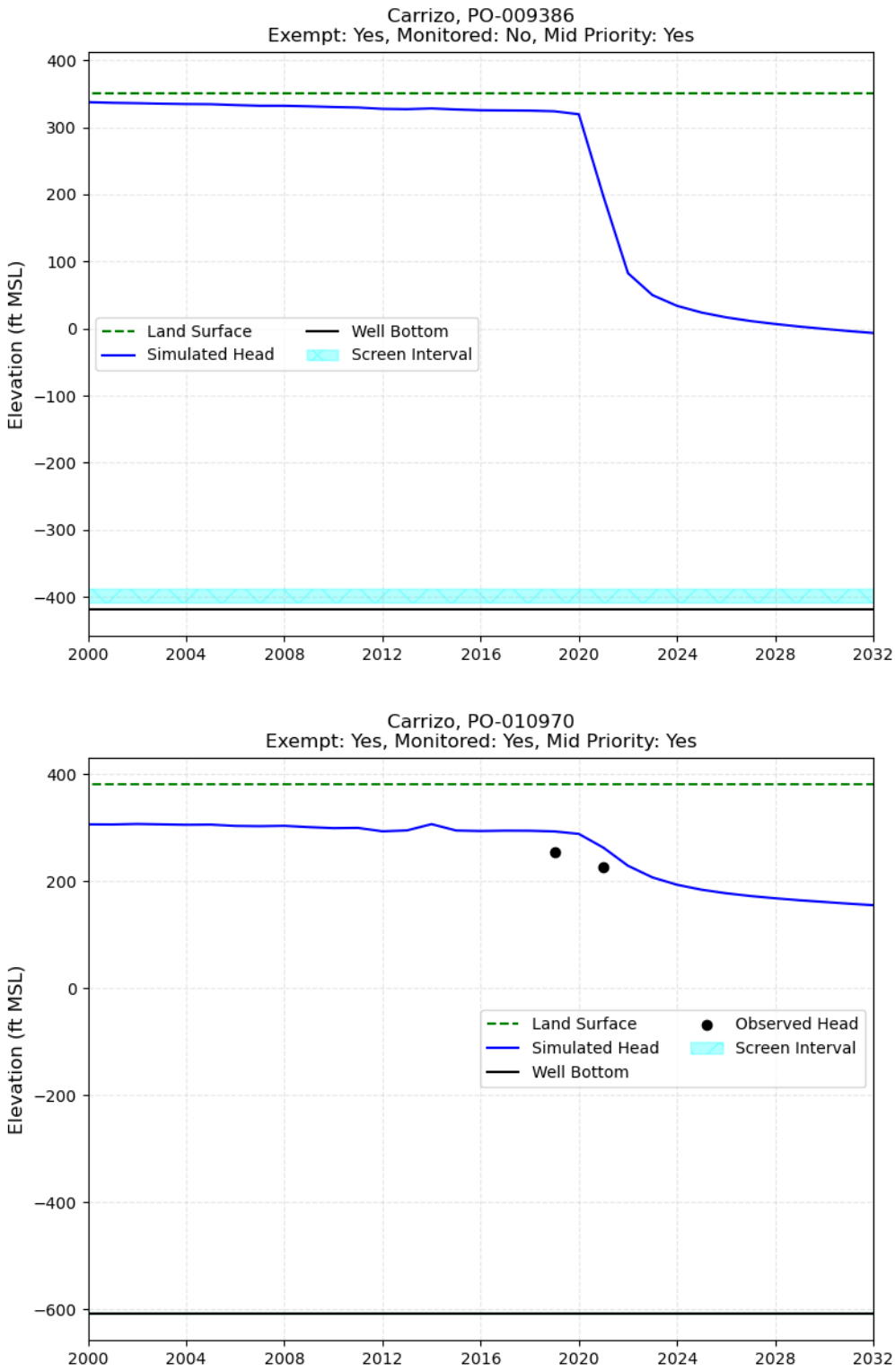

Figure G-18 Simulated water levels for moderate-priority wells PO-009386 and PO-010970 located in the Carrizo Aquifer

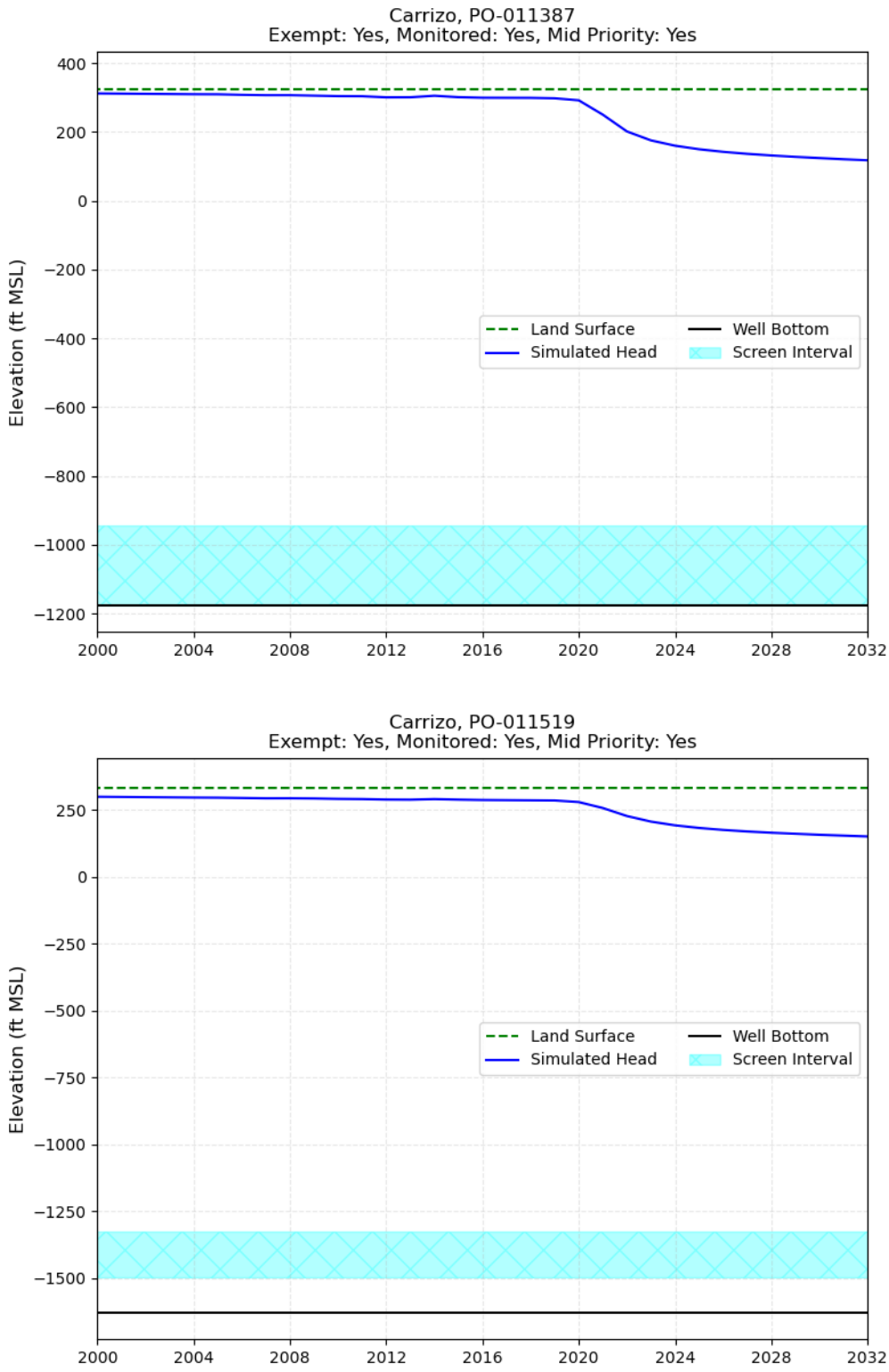

Figure G-19 Simulated water levels for moderate-priority wells PO-011387 and PO-011519 located in the Carrizo Aquifer

APPENDIX H

Hydrographs for Assisted Wells in the Carrizo Aquifer

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WellId	Before/After Assistance	2020	2023	2030
PO-000475	After	above pump setting	above pump setting	dry
	Before	above pump setting	dry	dry
PO-001327	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-001328	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-001331	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-001342	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-003440	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-003444	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-004459	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-004976	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-005228	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-005231	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-005767	After	above pump setting	above pump setting	above pump setting
	Before	N/D	N/D	N/D
PO-005816	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-005817	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-005821	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-006405	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-006551	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-006658	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-006815	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-006816	After	above pump setting	above pump setting	above pump setting

WellId	Before/After Assistance	2020	2023	2030
	Before	above pump setting	dry	dry
PO-007393	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-007765	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008053	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008054	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-008271	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008326	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008794	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008805	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-008923	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-008956	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-008964	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-008965	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009032	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-009067	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009125	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-009135	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009242	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009332	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009434	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry

WellId	Before/After Assistance	2020	2023	2030
PO-009570	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-009572	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-009609	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-009787	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-010952	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	dry
PO-010967	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-010979	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-011170	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-011370	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-011373	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-011380	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	above pump setting	above pump setting
PO-011383	After	above pump setting	above pump setting	above pump setting
	Before	above pump setting	dry	dry
PO-011385	After	above pump setting	above pump setting	above pump setting
	Before	N/D	N/D	N/D
PO-011435	After	above pump setting	above pump setting	above pump setting
	Before	N/D	N/D	N/D

APPENDIX I

Hydrographs for Assisted Wells in the Carrizo Aquifer

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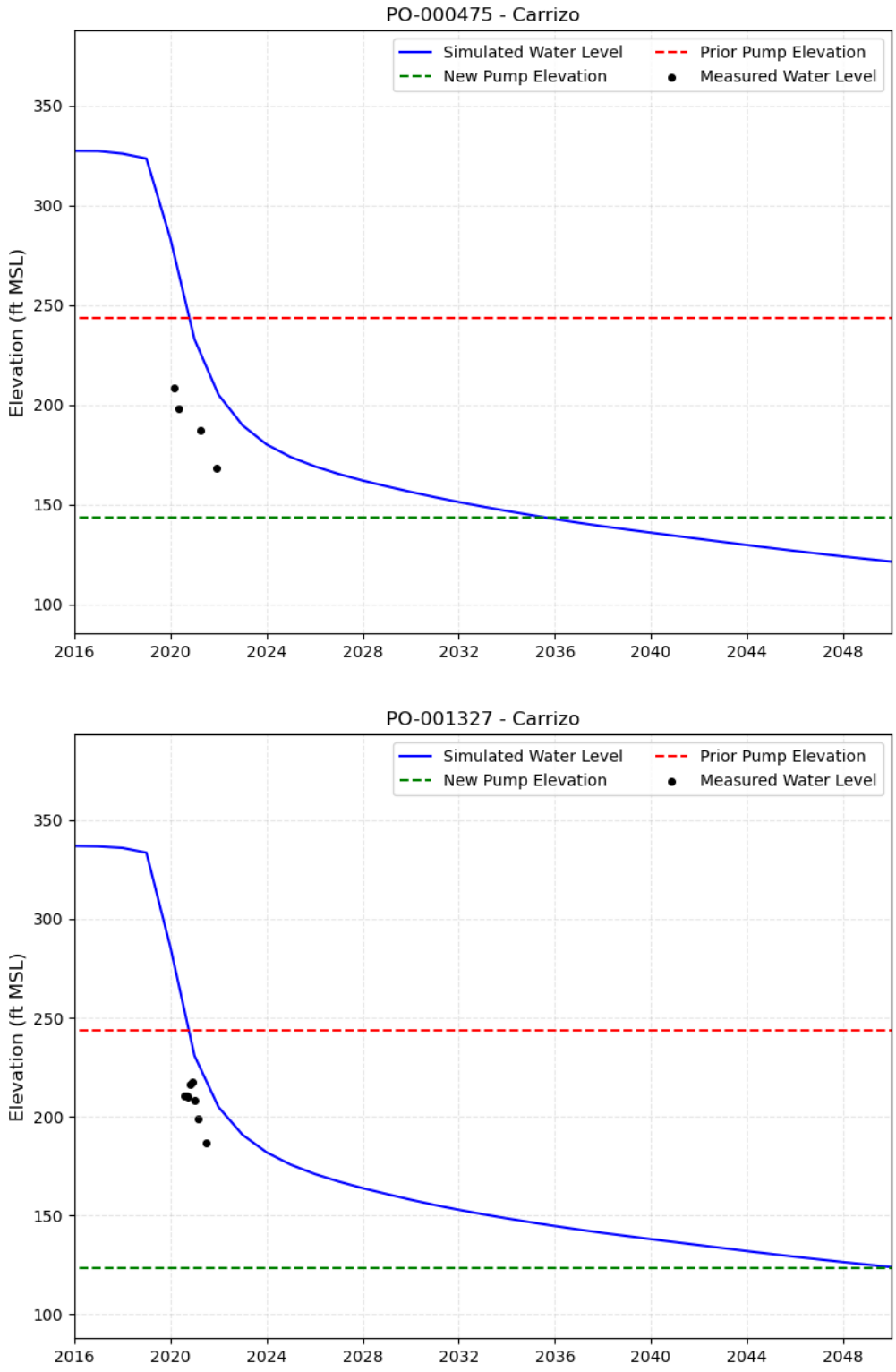

Figure I-1 Simulated water levels for moderate-priority wells PO-000475 and PO-001327 located in the Carrizo Aquifer

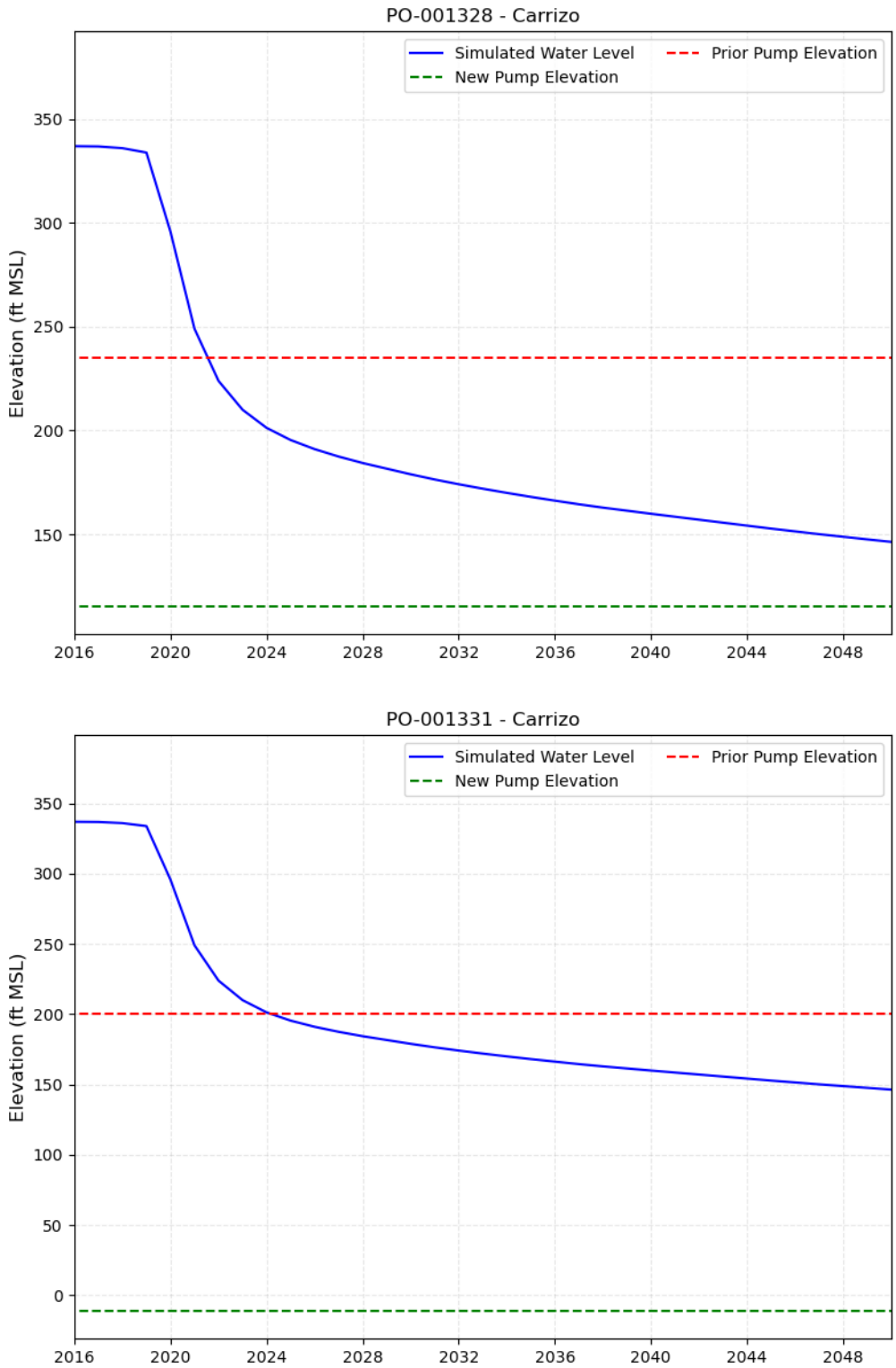

Figure I-2 Simulated water levels for moderate-priority wells PO-001328 and PO-001331 located in the Carrizo Aquifer

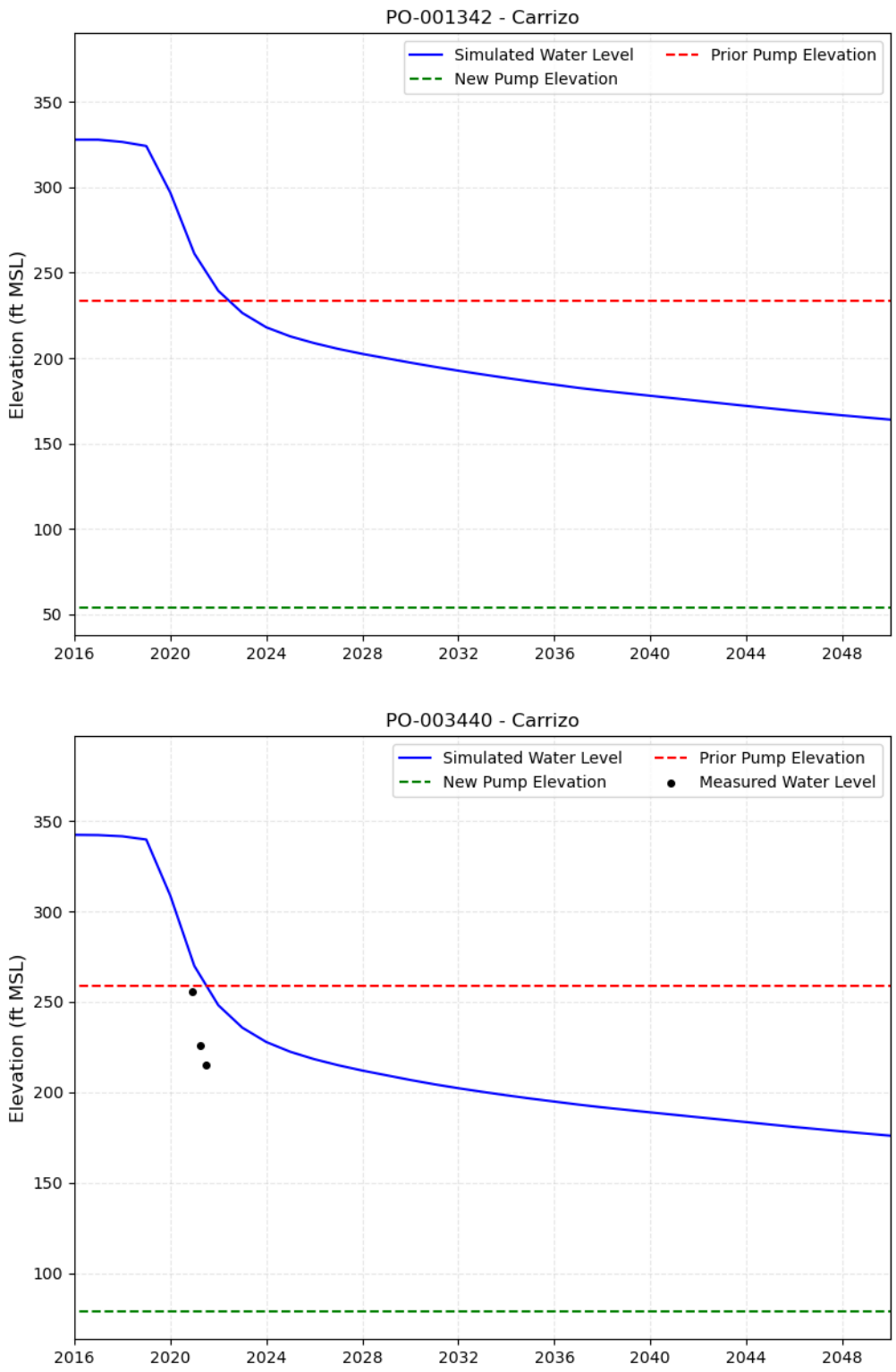

Figure I-3 Simulated water levels for moderate-priority wells PO-001342 and PO-003440 located in the Carrizo Aquifer

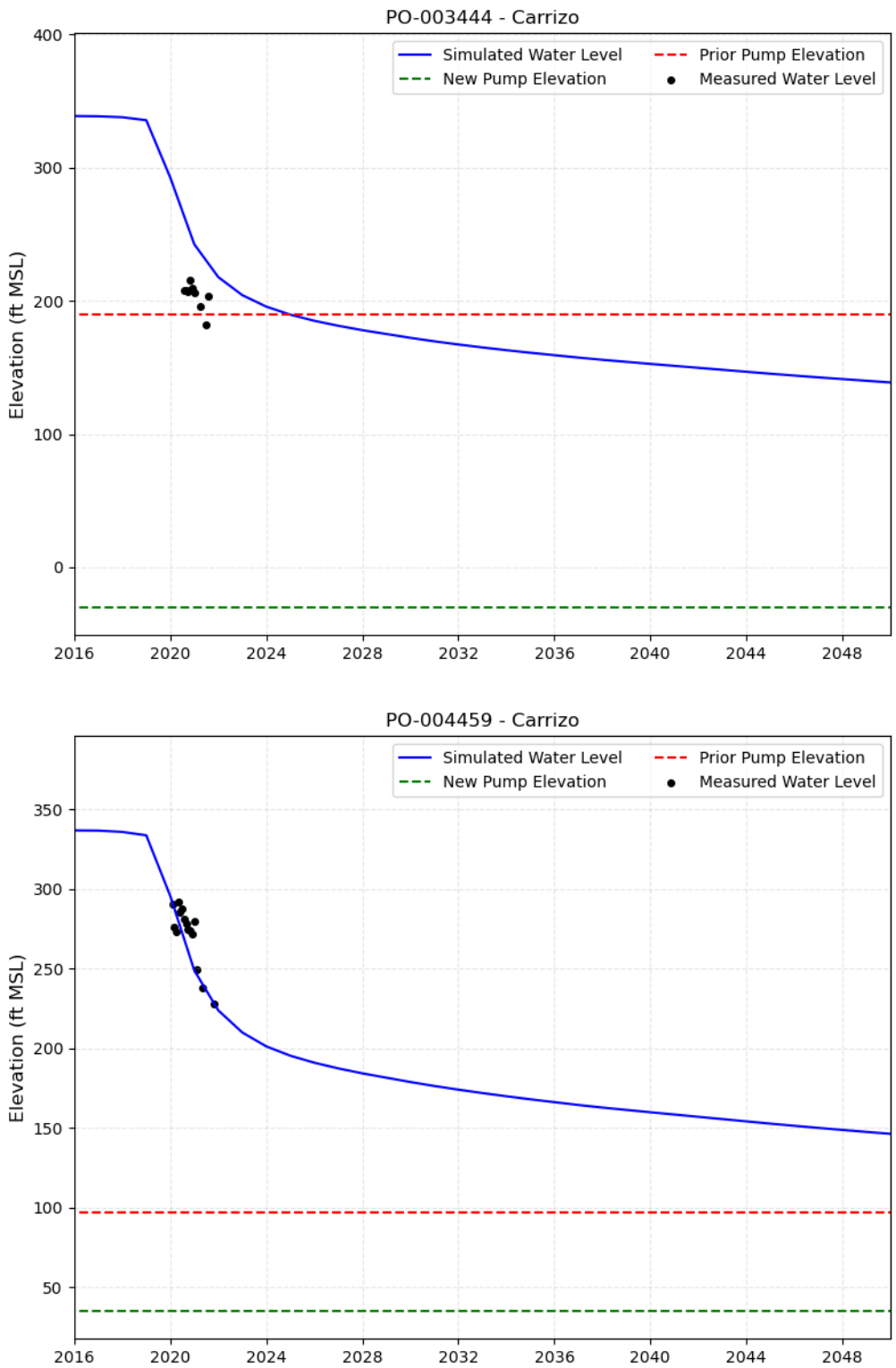

Figure I-4 Simulated water levels for moderate-priority wells PO-03444 and PO-004459 located in the Carrizo Aquifer

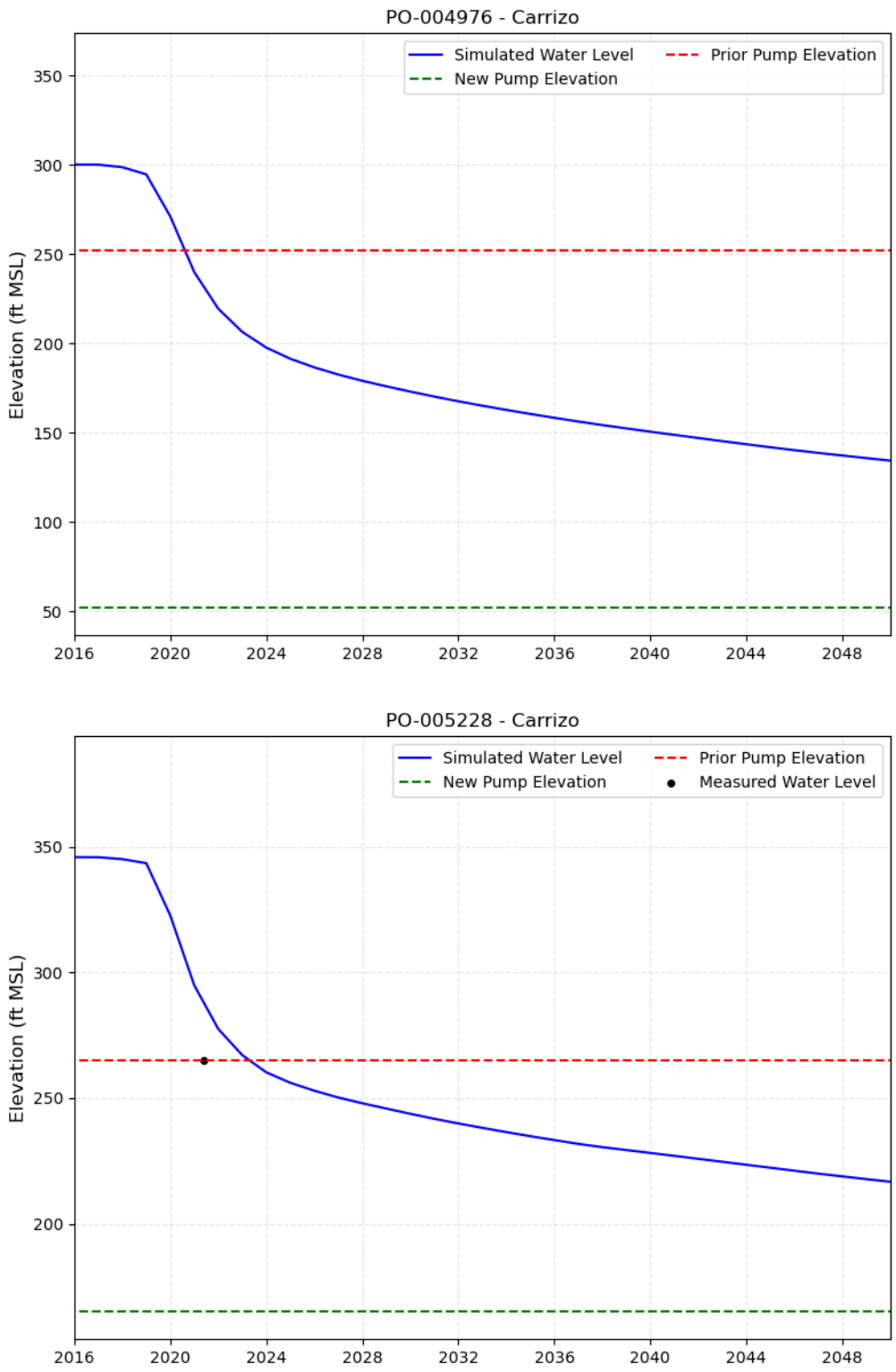

Figure I-5 Simulated water levels for moderate-priority wells PO-004976 and PO-005228 located in the Carrizo Aquifer

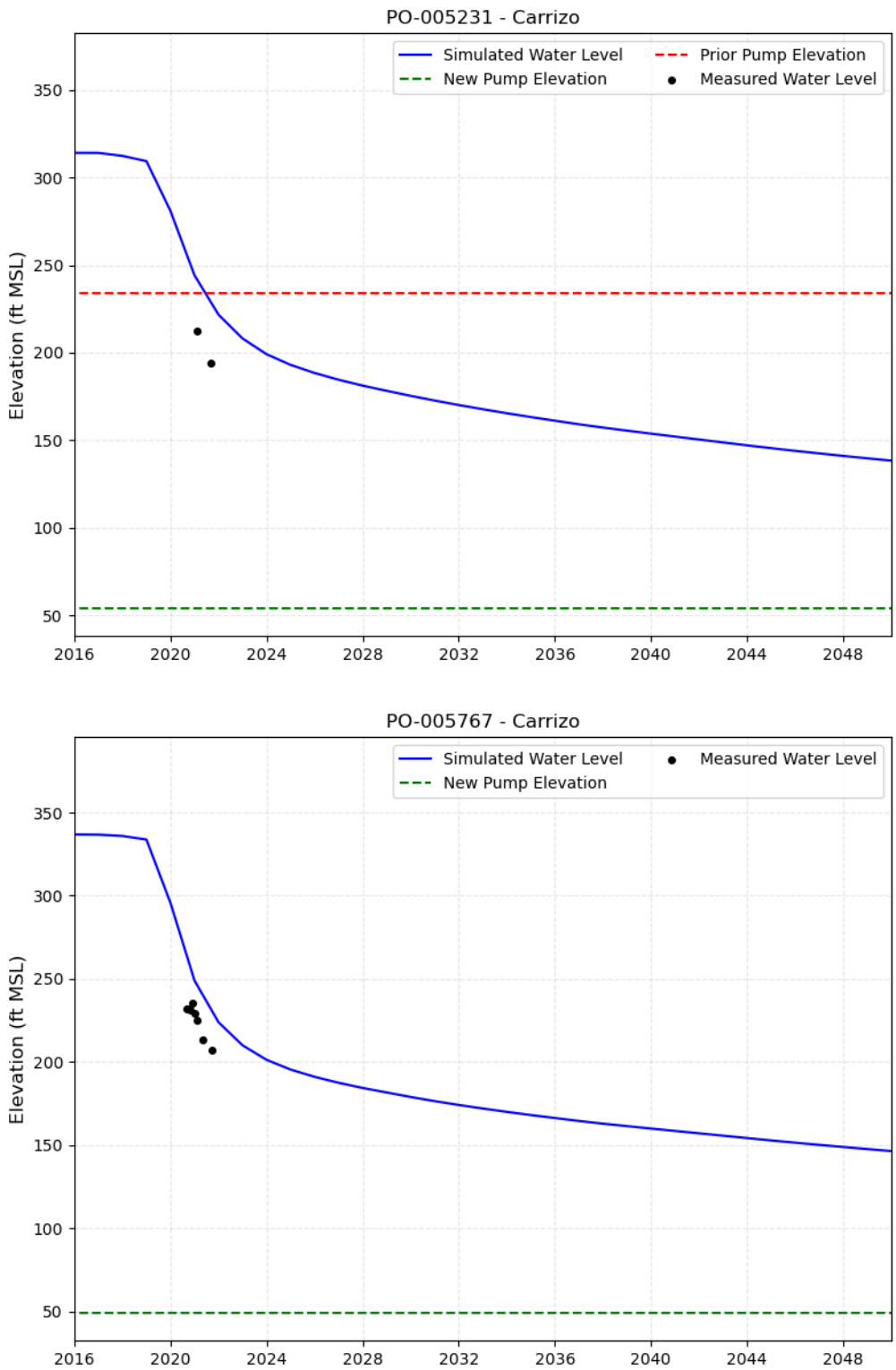

Figure I-6 Simulated water levels for moderate-priority wells PO-005231 and PO-005767 located in the Carrizo Aquifer

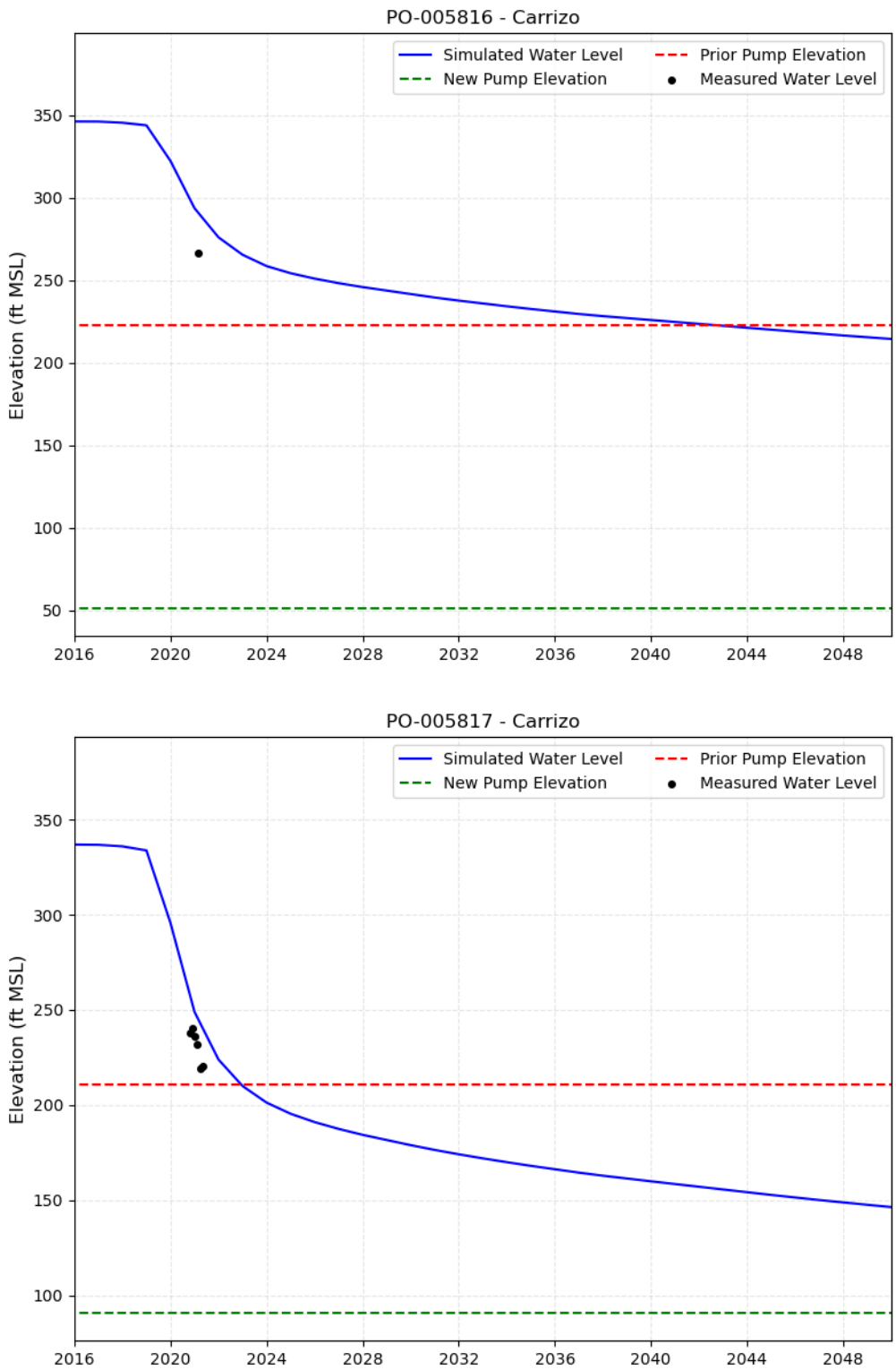

Figure I-7 Simulated water levels for moderate-priority wells PO-005816 and PO-005817 located in the Carrizo Aquifer

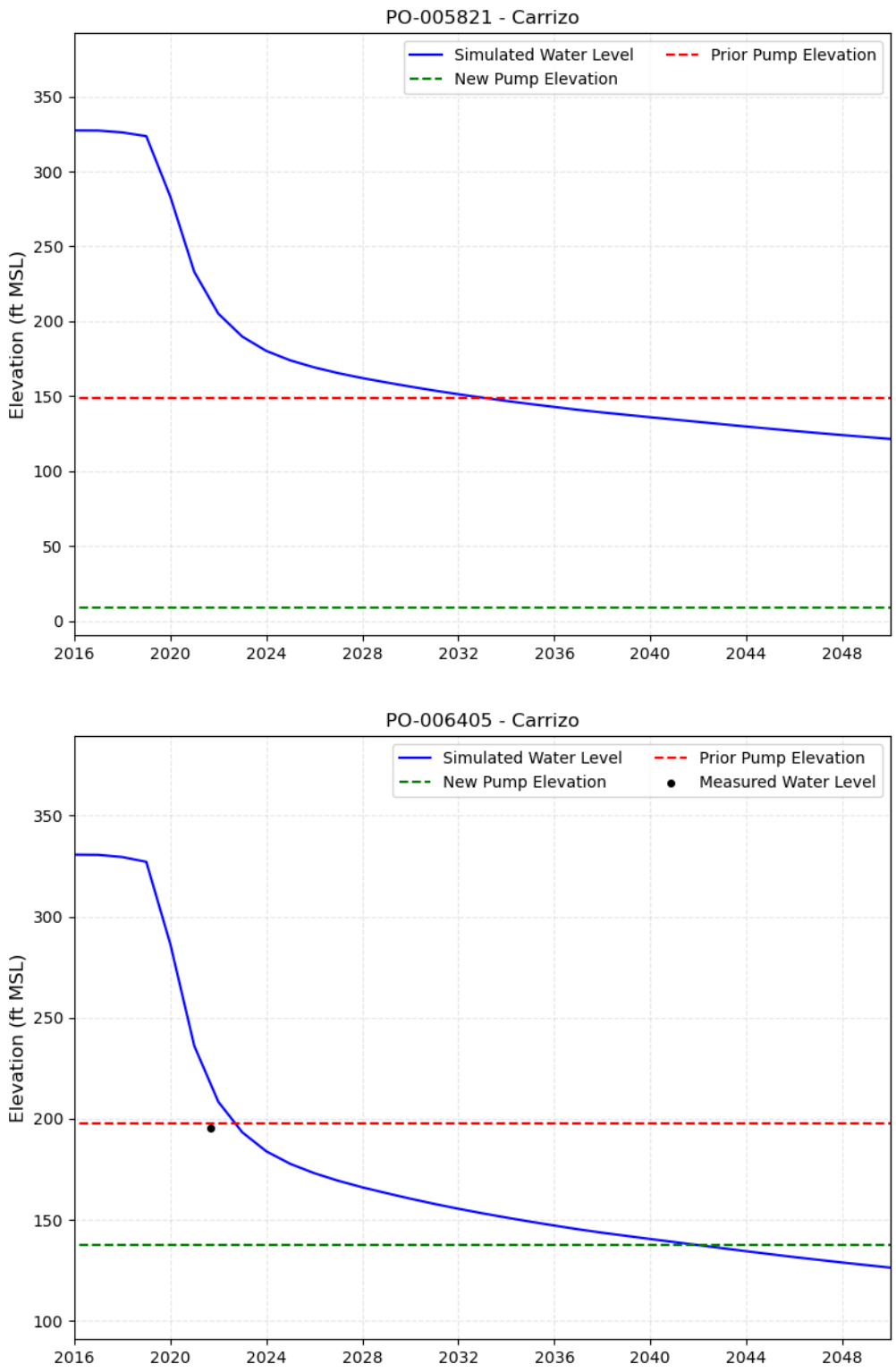

Figure I-8 Simulated water levels for moderate-priority wells PO-005821 and PO-006405 located in the Carrizo Aquifer

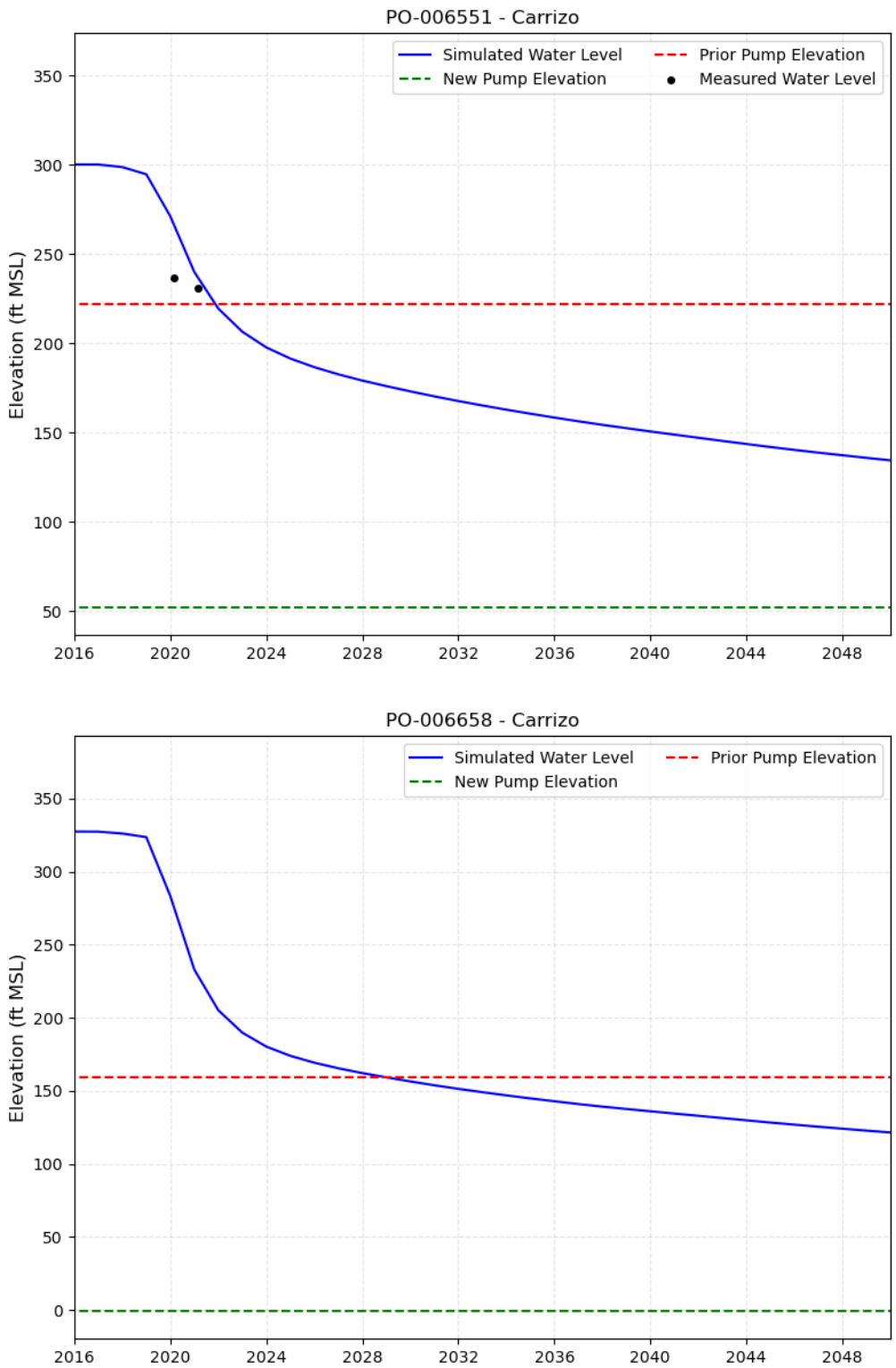

Figure I-9 Simulated water levels for moderate-priority wells PO-006551 and PO-006658 located in the Carrizo Aquifer

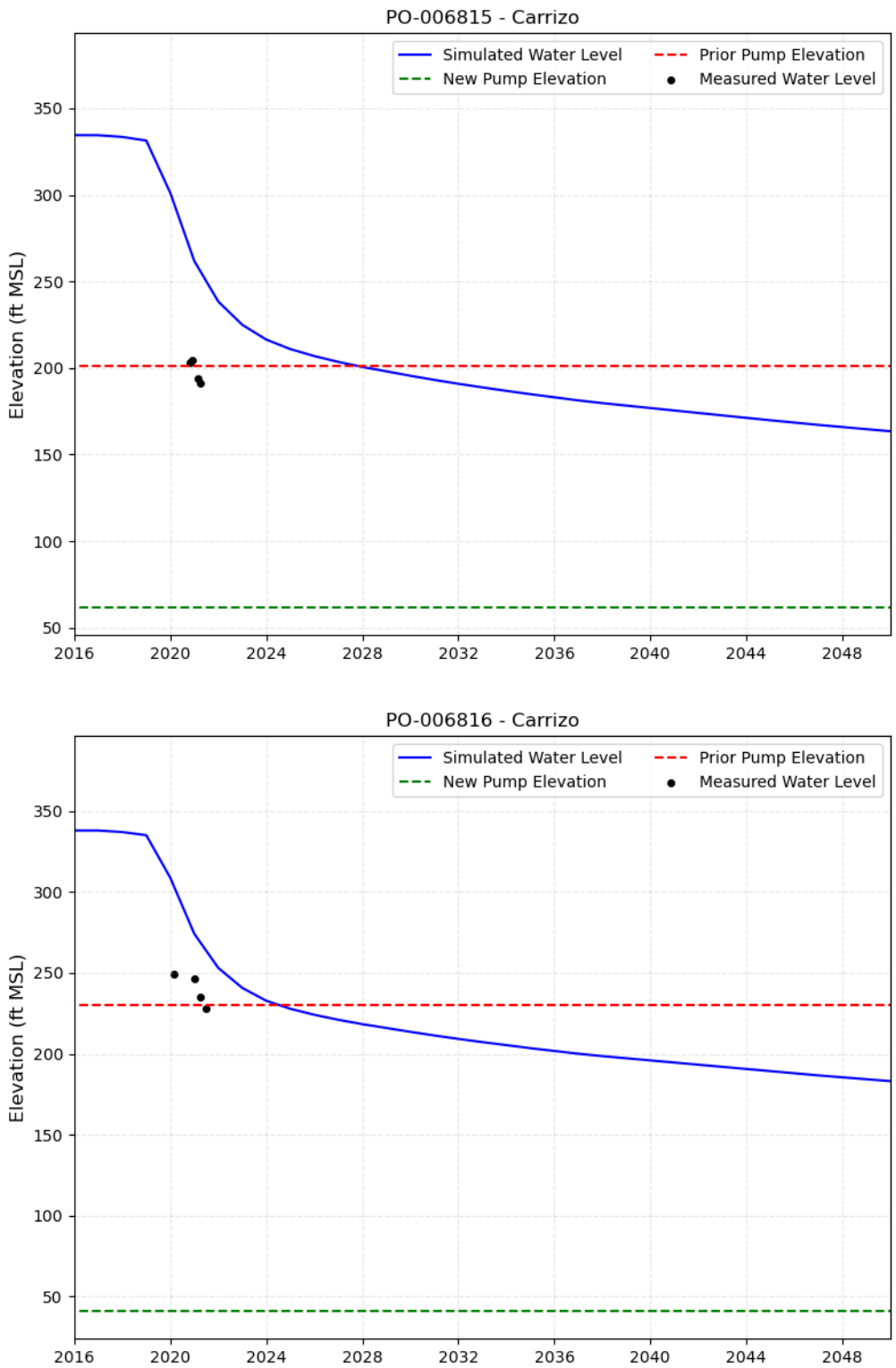

Figure I-10 Simulated water levels for moderate-priority wells PO-006815 and PO-006816 located in the Carrizo Aquifer

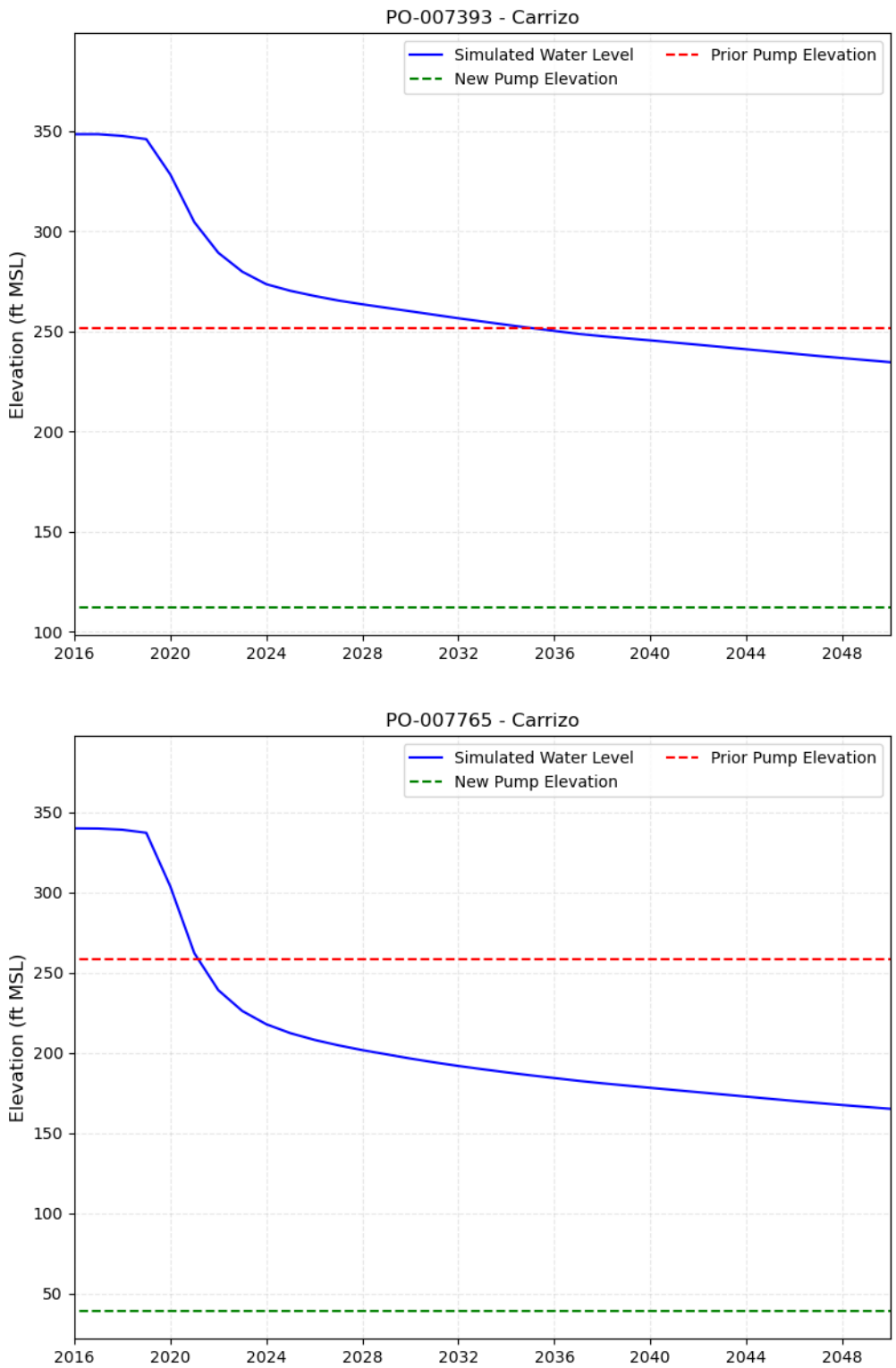

Figure I-11 Simulated water levels for moderate-priority wells PO-007393 PO-007765 located in the Carrizo Aquifer

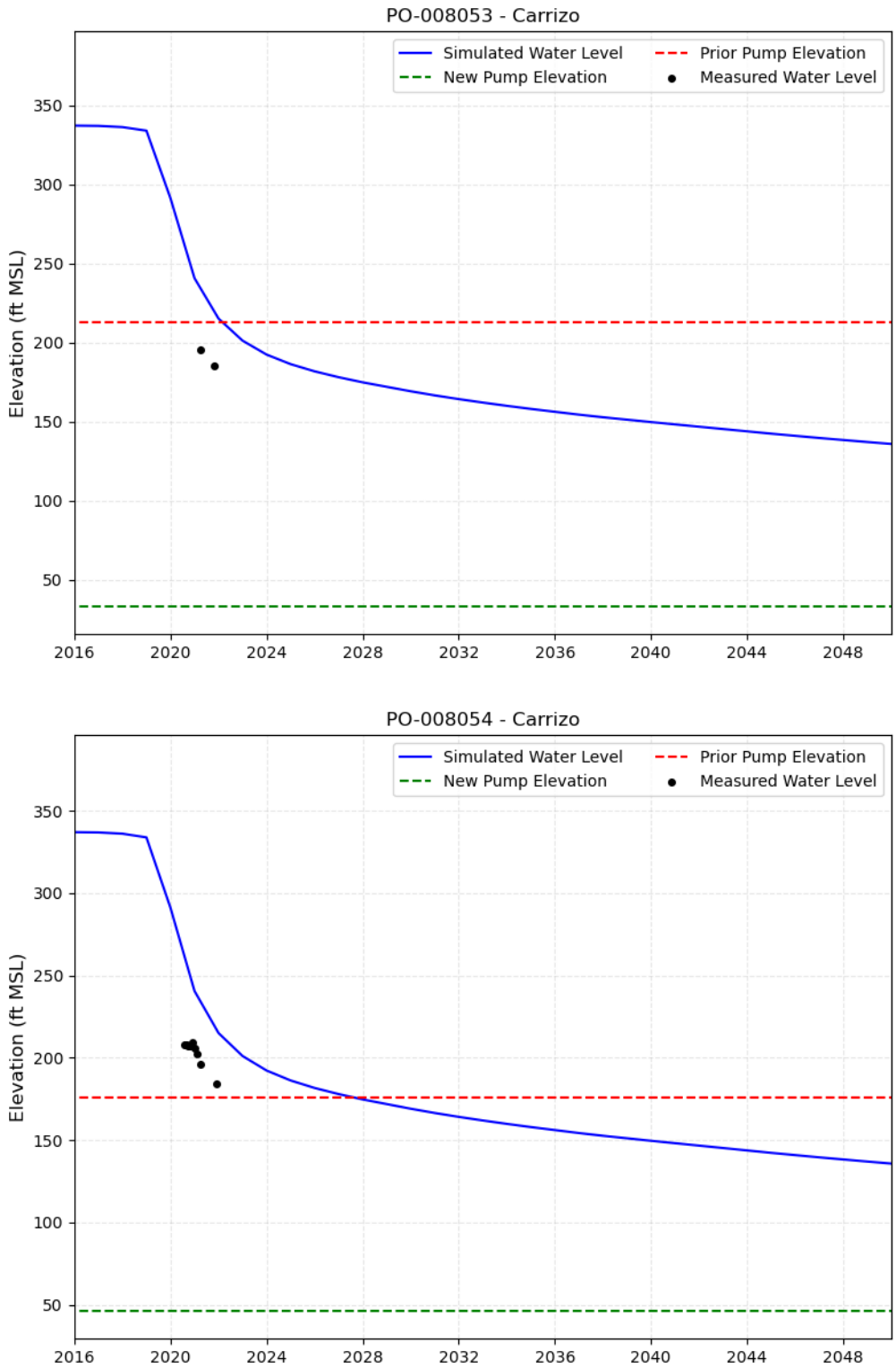

Figure I-12 Simulated water levels for moderate-priority wells PO-008053 and PO-008054 located in the Carrizo Aquifer

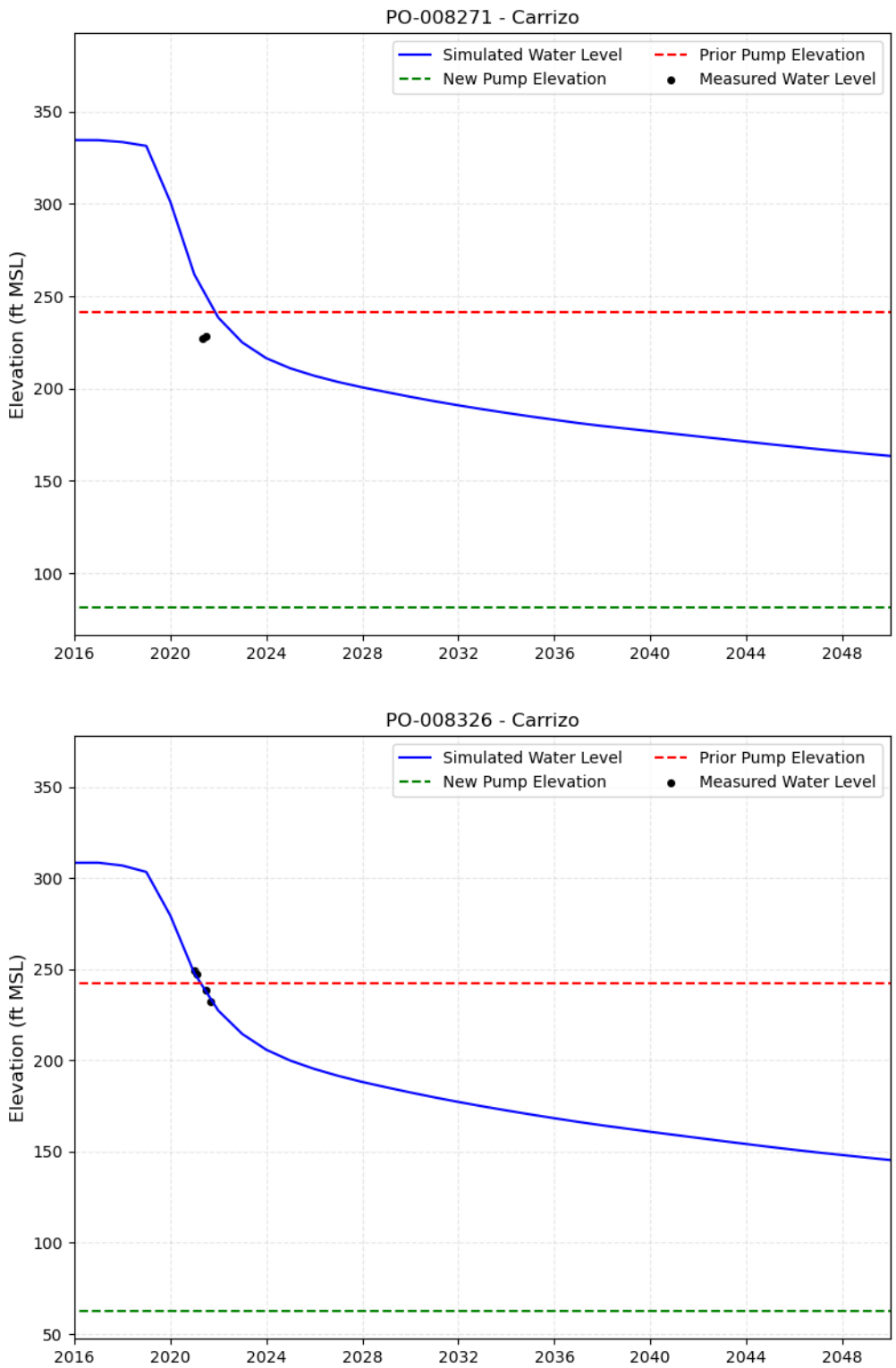

Figure I-13 Simulated water levels for moderate-priority wells PO-008271 and PO-008326 located in the Carrizo Aquifer

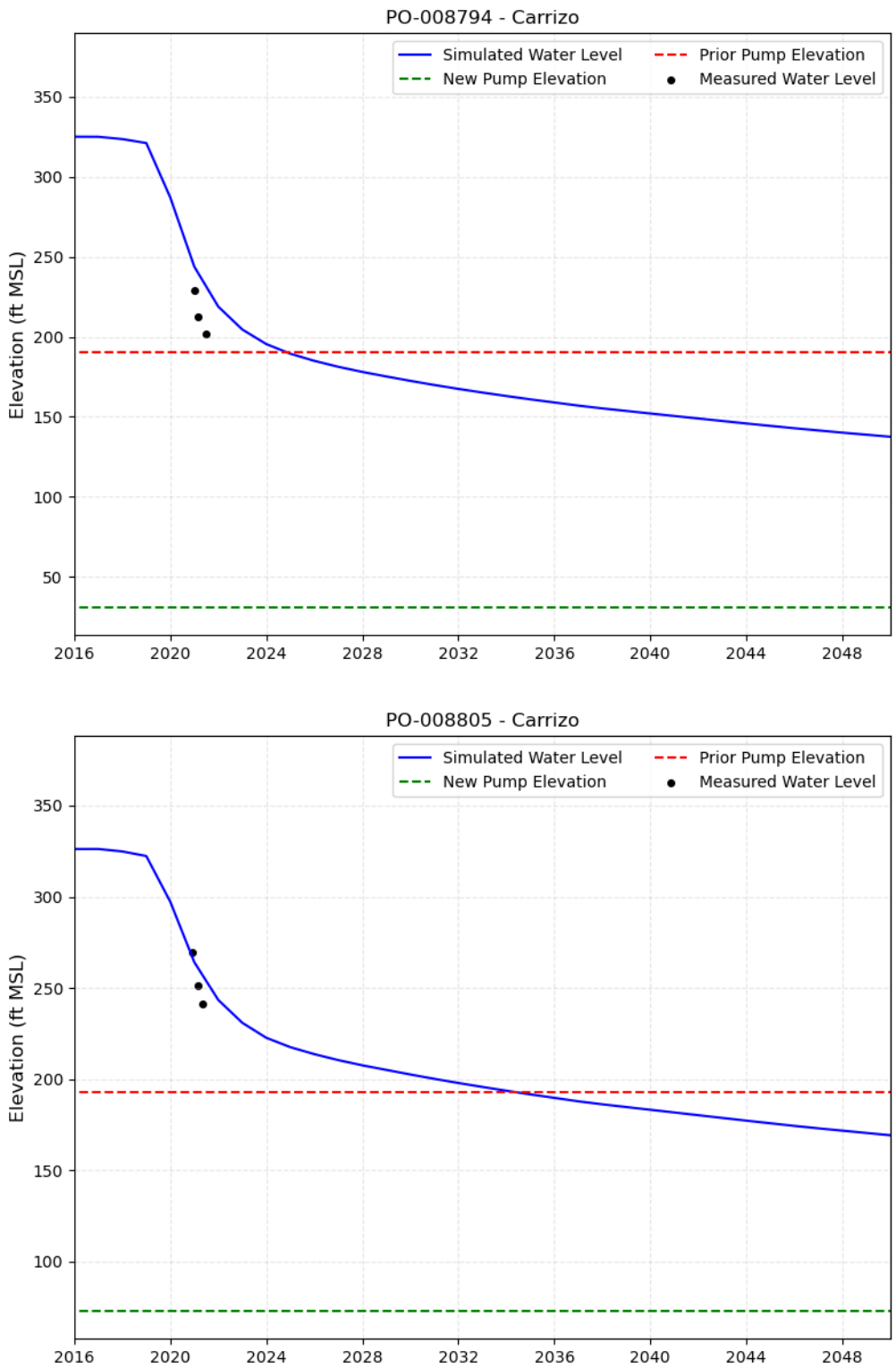

Figure I-14 Simulated water levels for moderate-priority wells PO-008794 and PO-008805 located in the Carrizo Aquifer

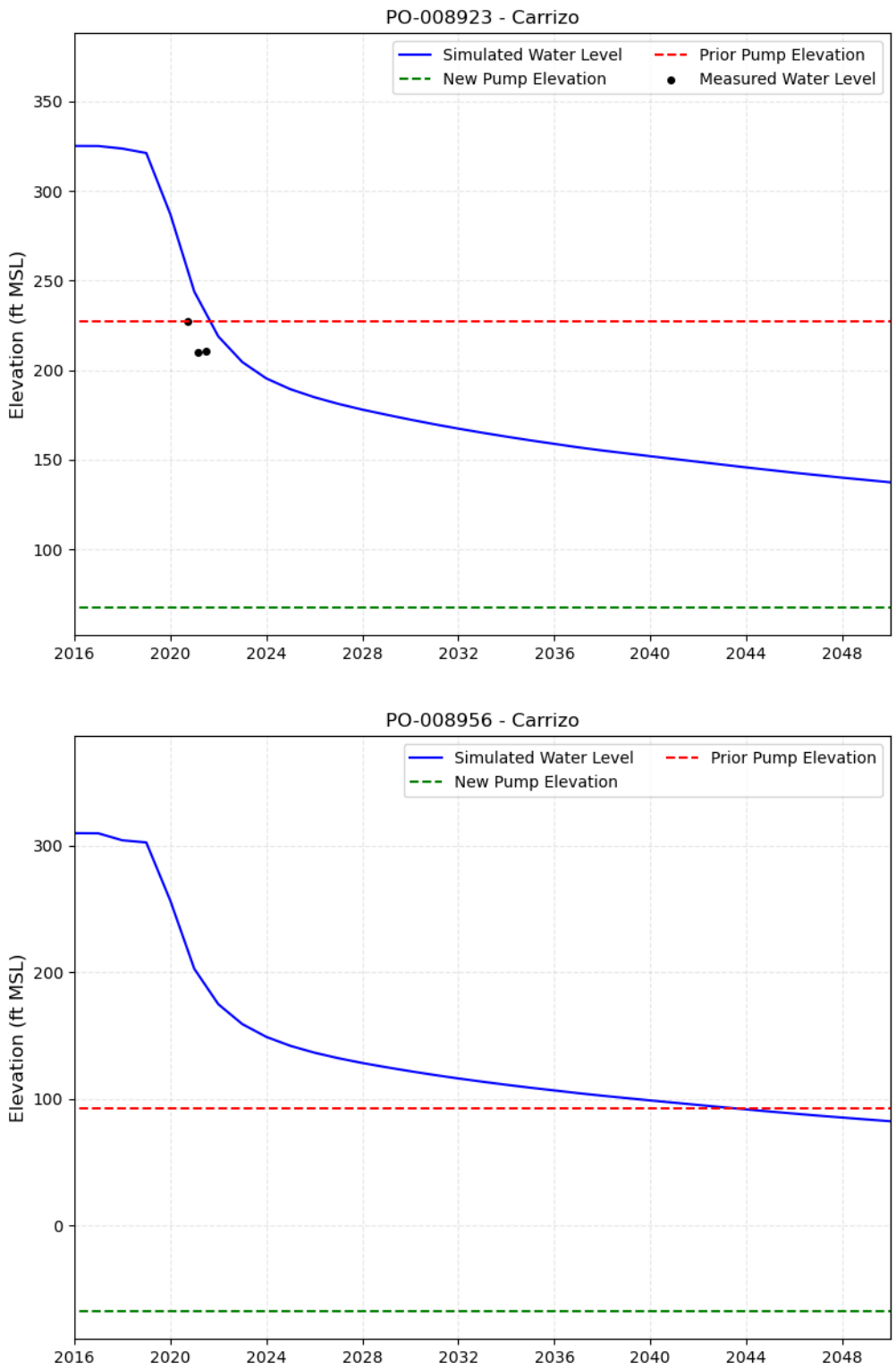

Figure I-15 Simulated water levels for moderate-priority wells PO-008923 and PO-008956 located in the Carrizo Aquifer

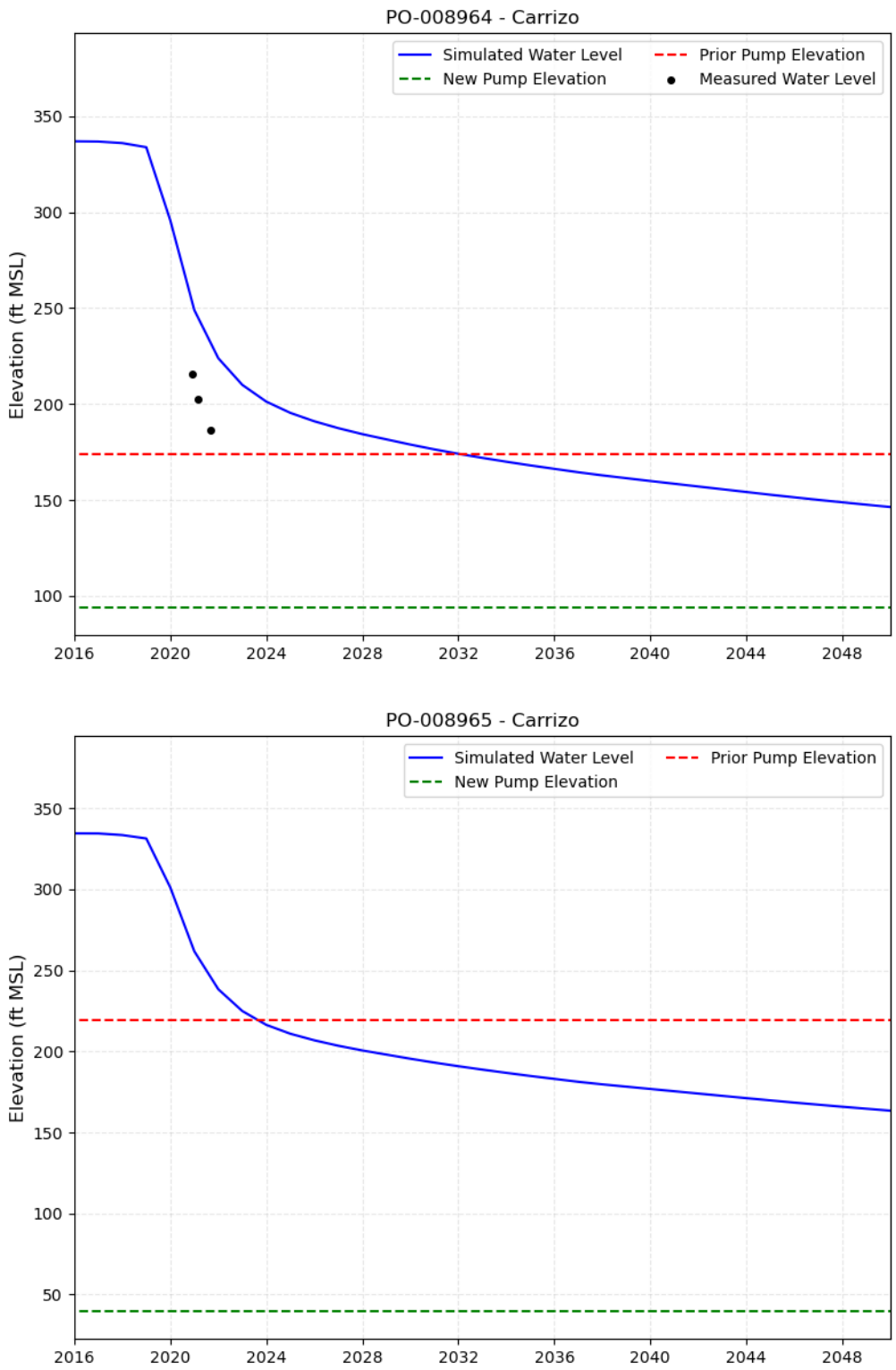

Figure I-16 Simulated water levels for moderate-priority wells PO-008964 and PO-009965 located in the Carrizo Aquifer

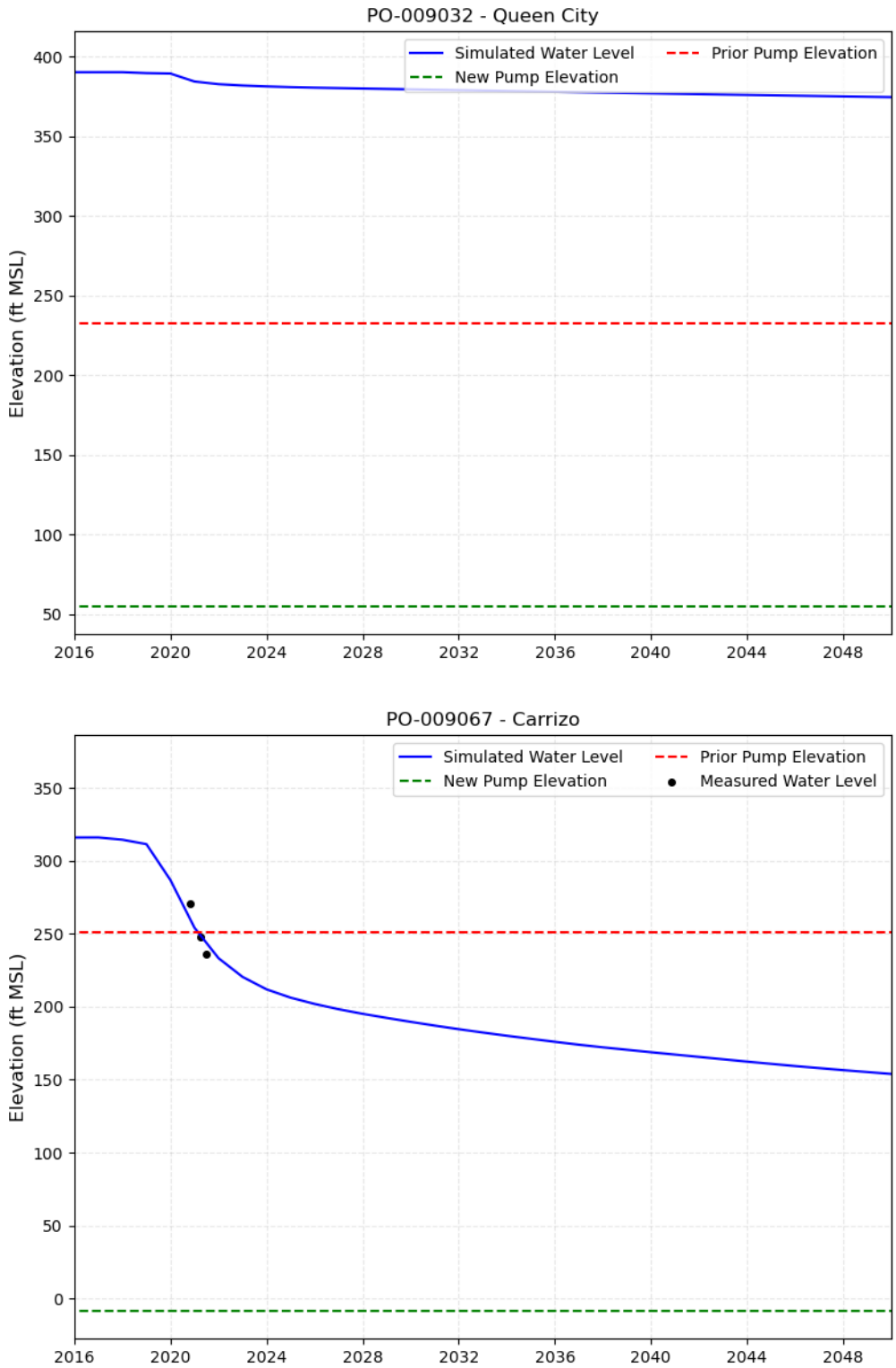

Figure I-17 Simulated water levels for moderate-priority wells PO-009032 and PO-009067 located in the Carrizo Aquifer

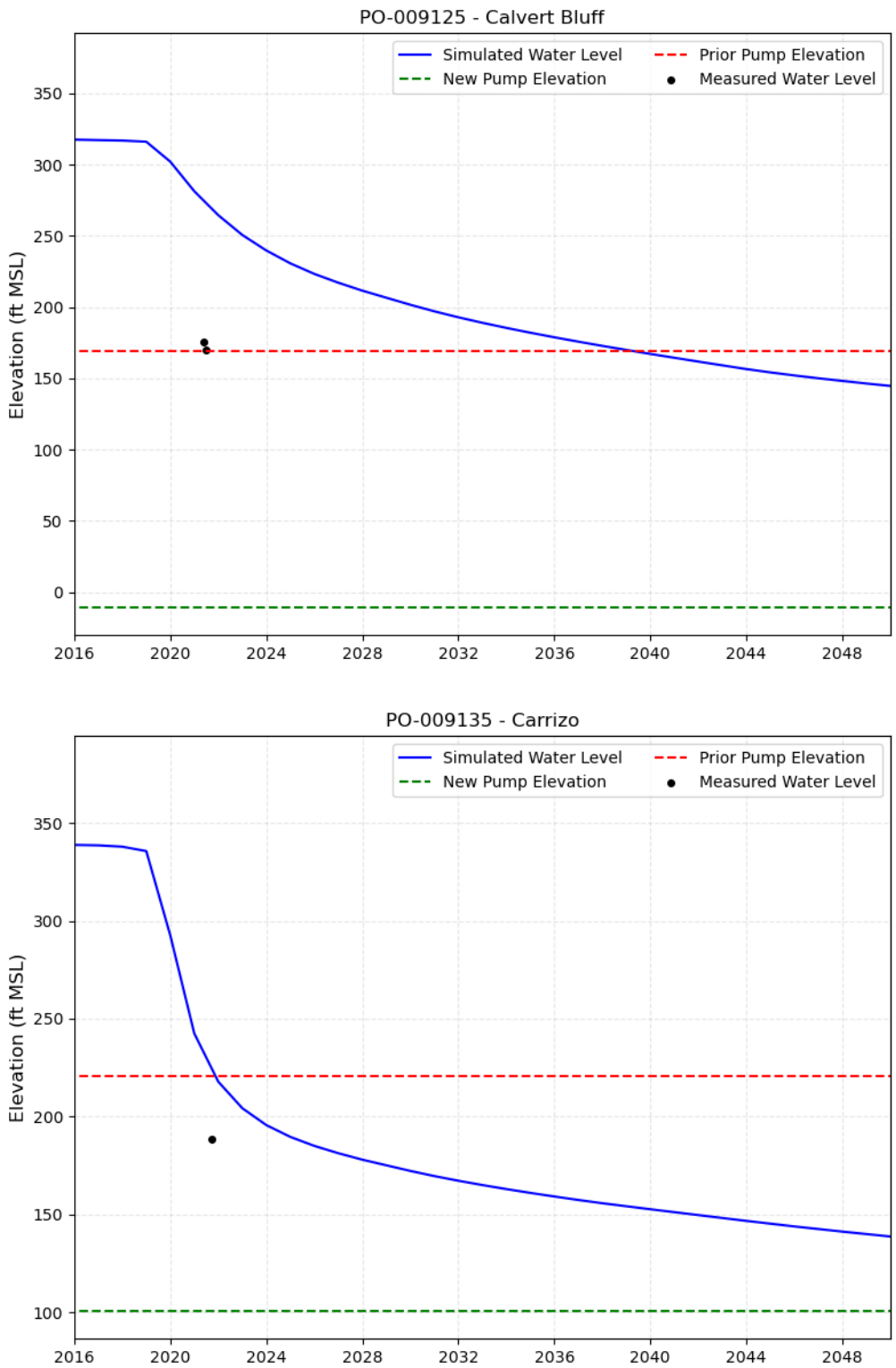

Figure I-18 Simulated water levels for moderate-priority wells PO-009125 and PO-009135 located in the Carrizo Aquifer

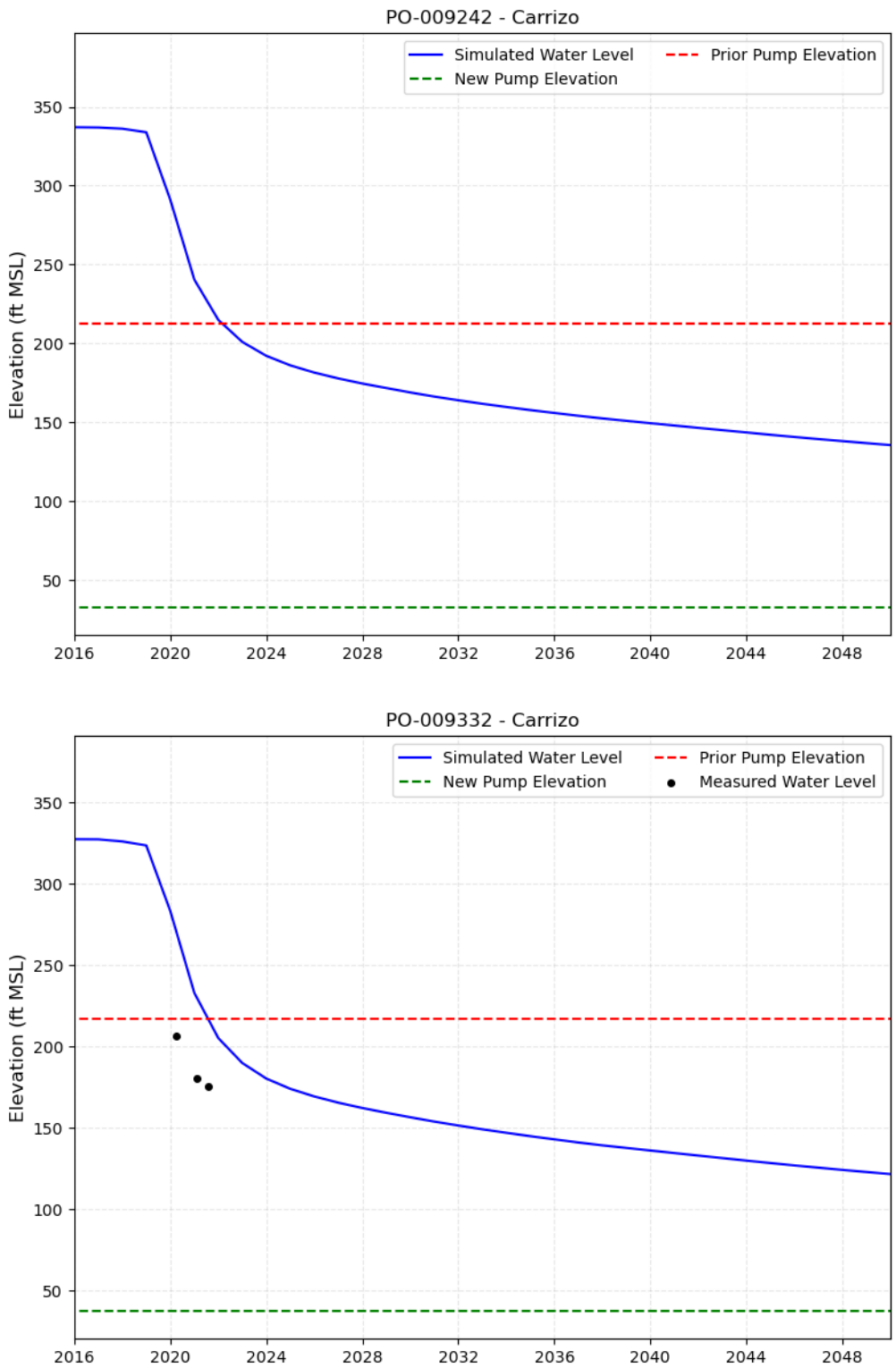

Figure I-19 Simulated water levels for moderate-priority wells PO-009242 and PO-009332 located in the Carrizo Aquifer

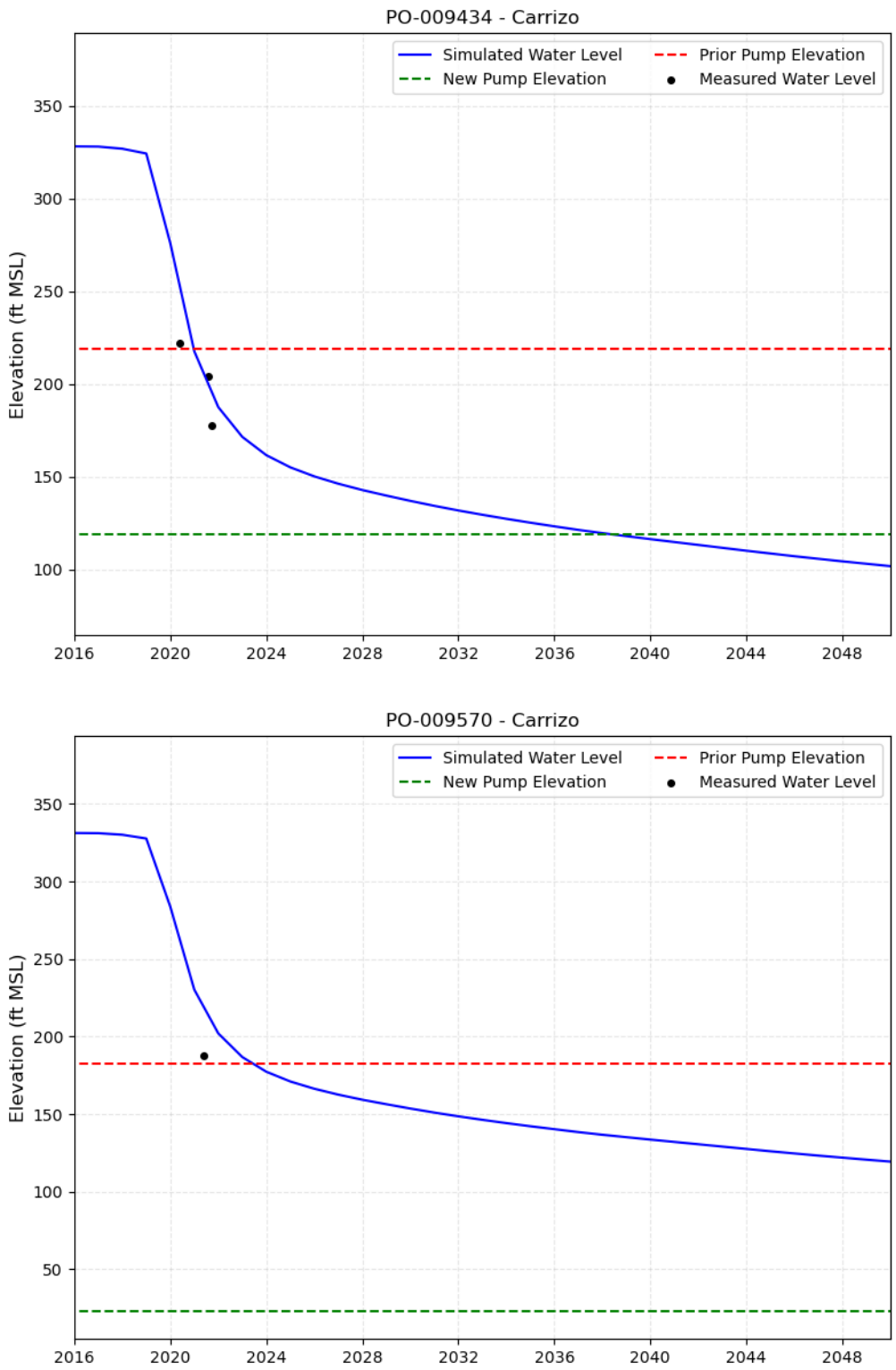

Figure I-20 Simulated water levels for moderate-priority wells PO-009434 and PO-009570 located in the Carrizo Aquifer

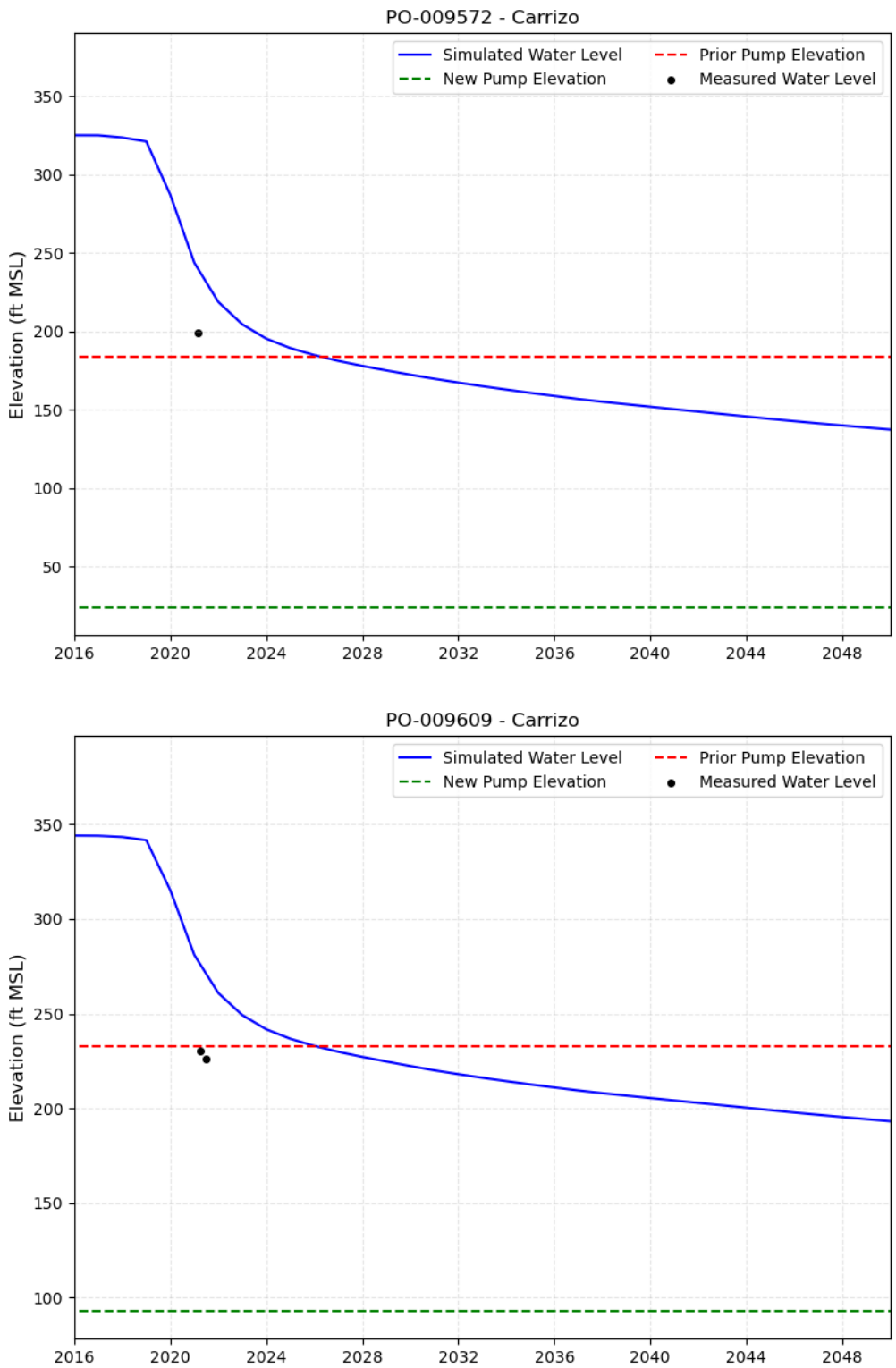

Figure I-21 Simulated water levels for moderate-priority wells PO-009572 and PO-009609 located in the Carrizo Aquifer

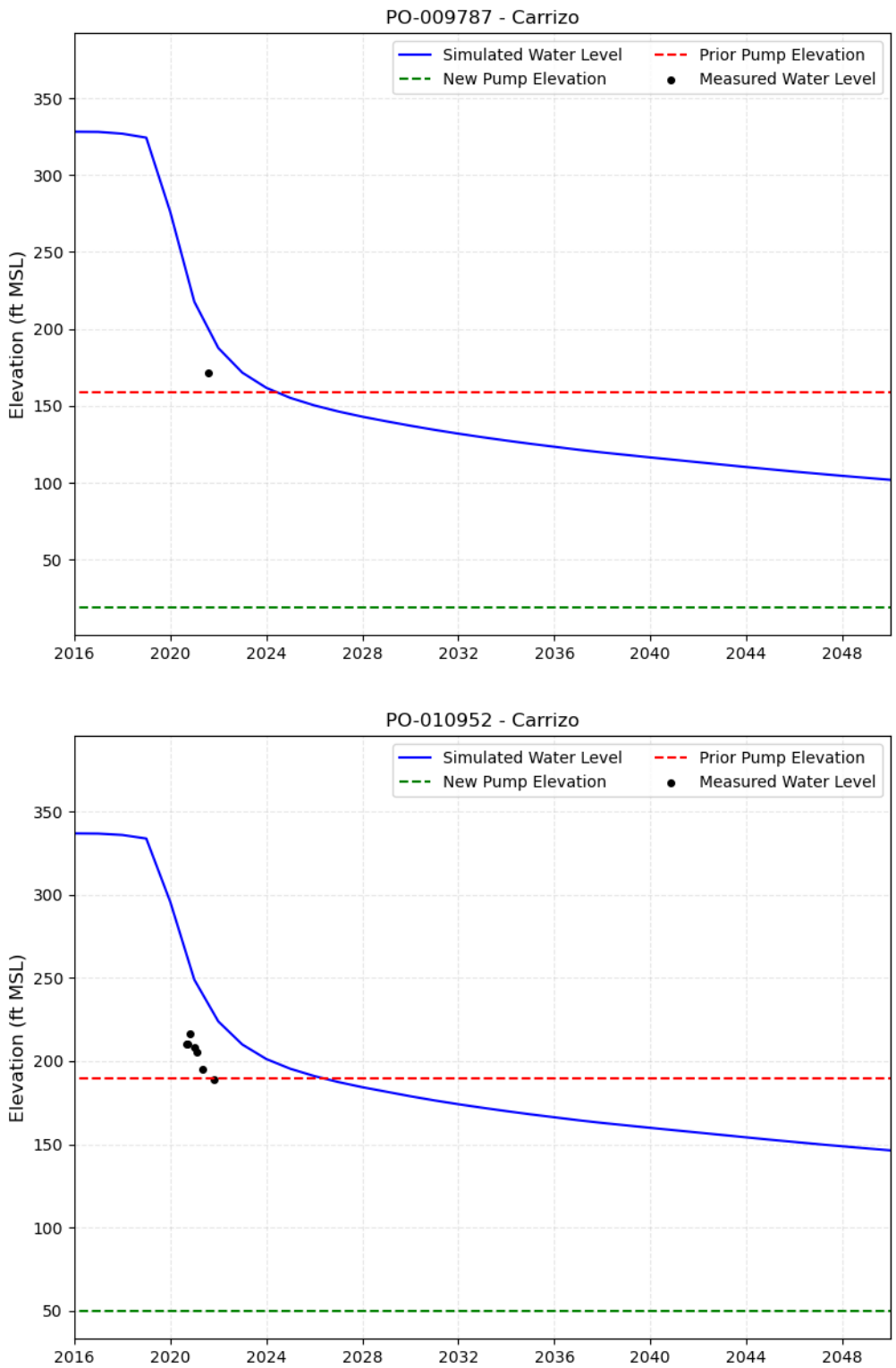

Figure I-22 Simulated water levels for moderate-priority wells PO-009787 and PO-010952 located in the Carrizo Aquifer

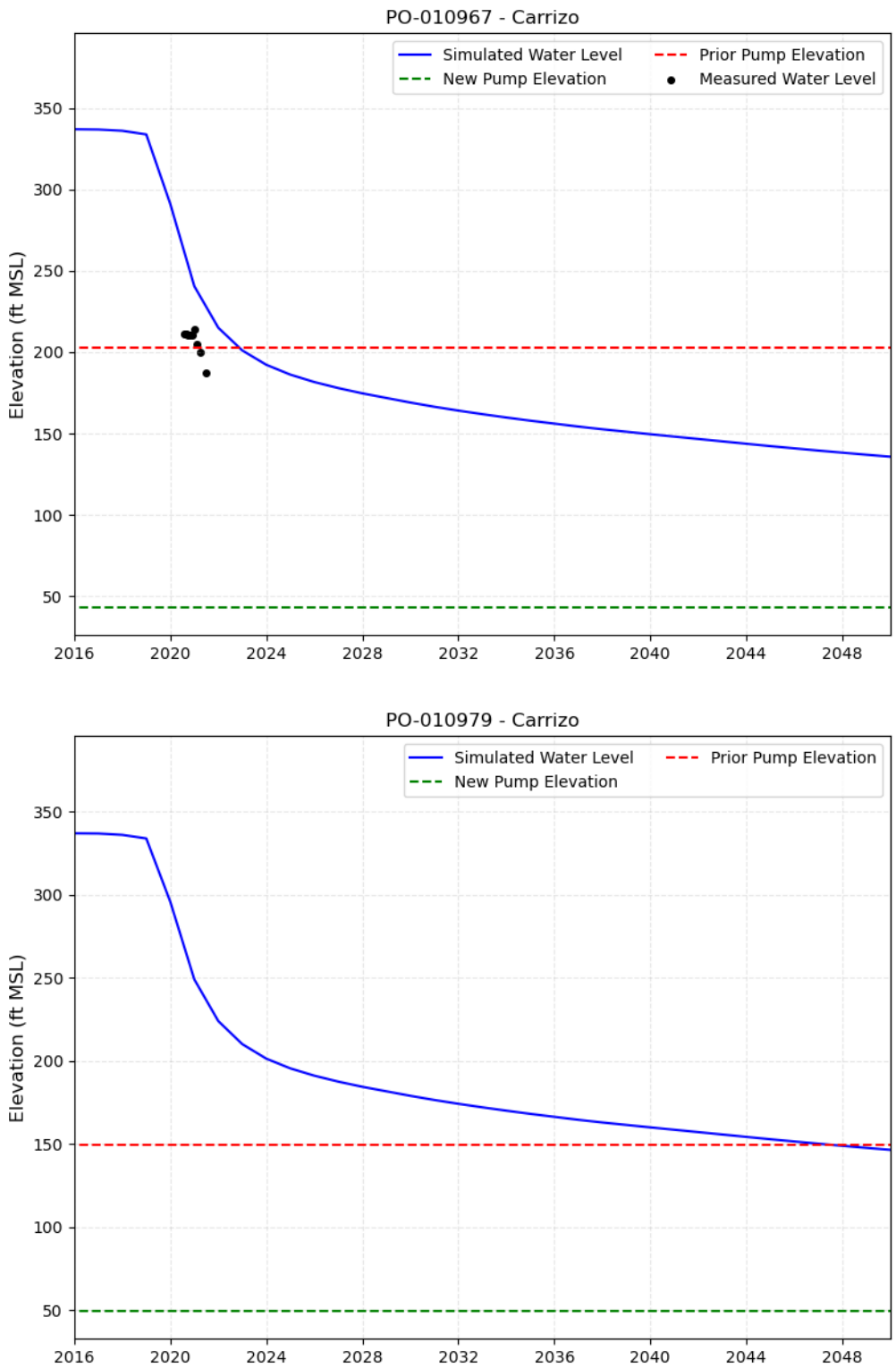

Figure I-23 Simulated water levels for moderate-priority wells PO-010967 and PO-010979 located in the Carrizo Aquifer

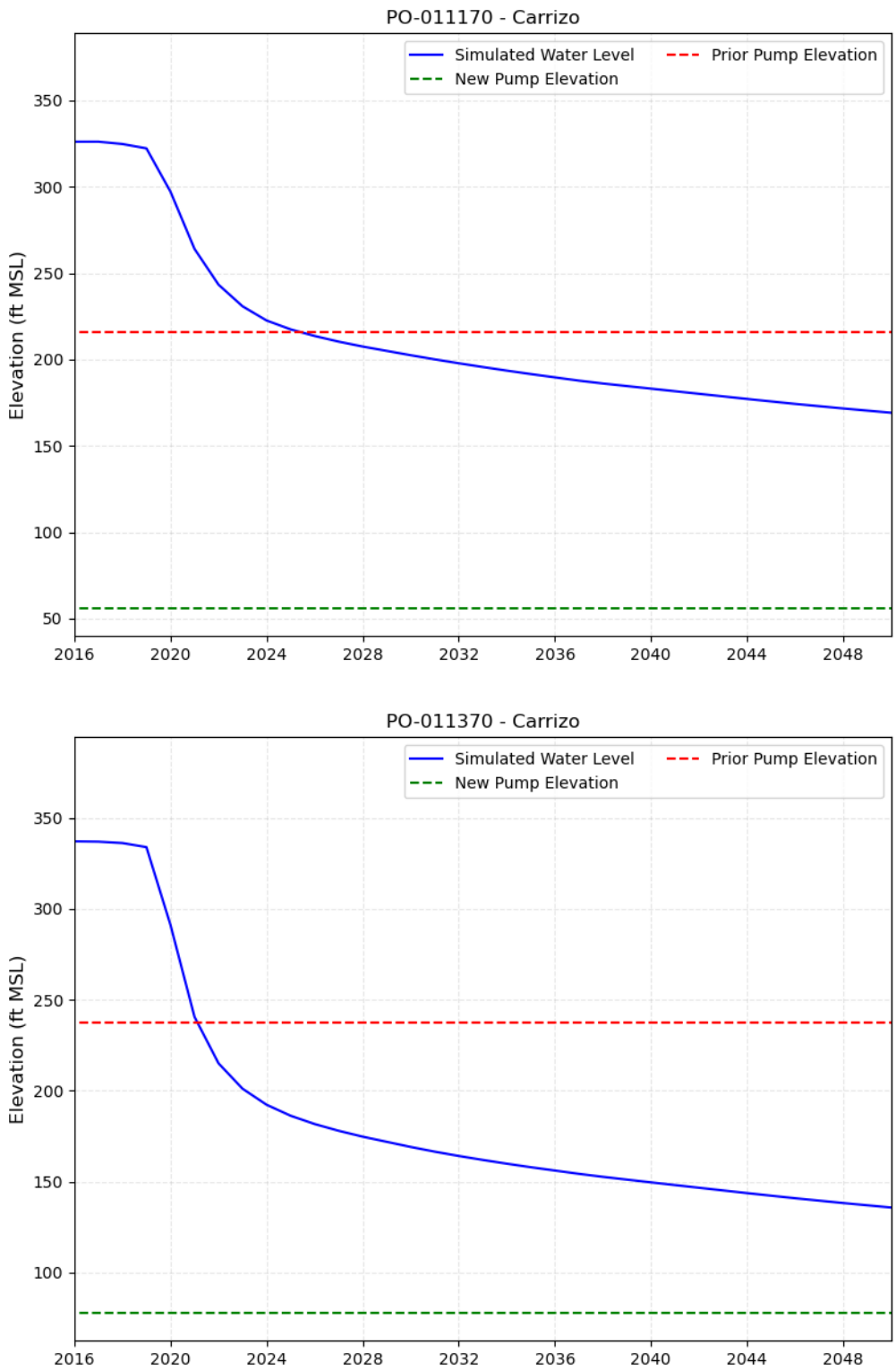

Figure I-24 Simulated water levels for moderate-priority wells PO-011170 and PO-011370 located in the Carrizo Aquifer

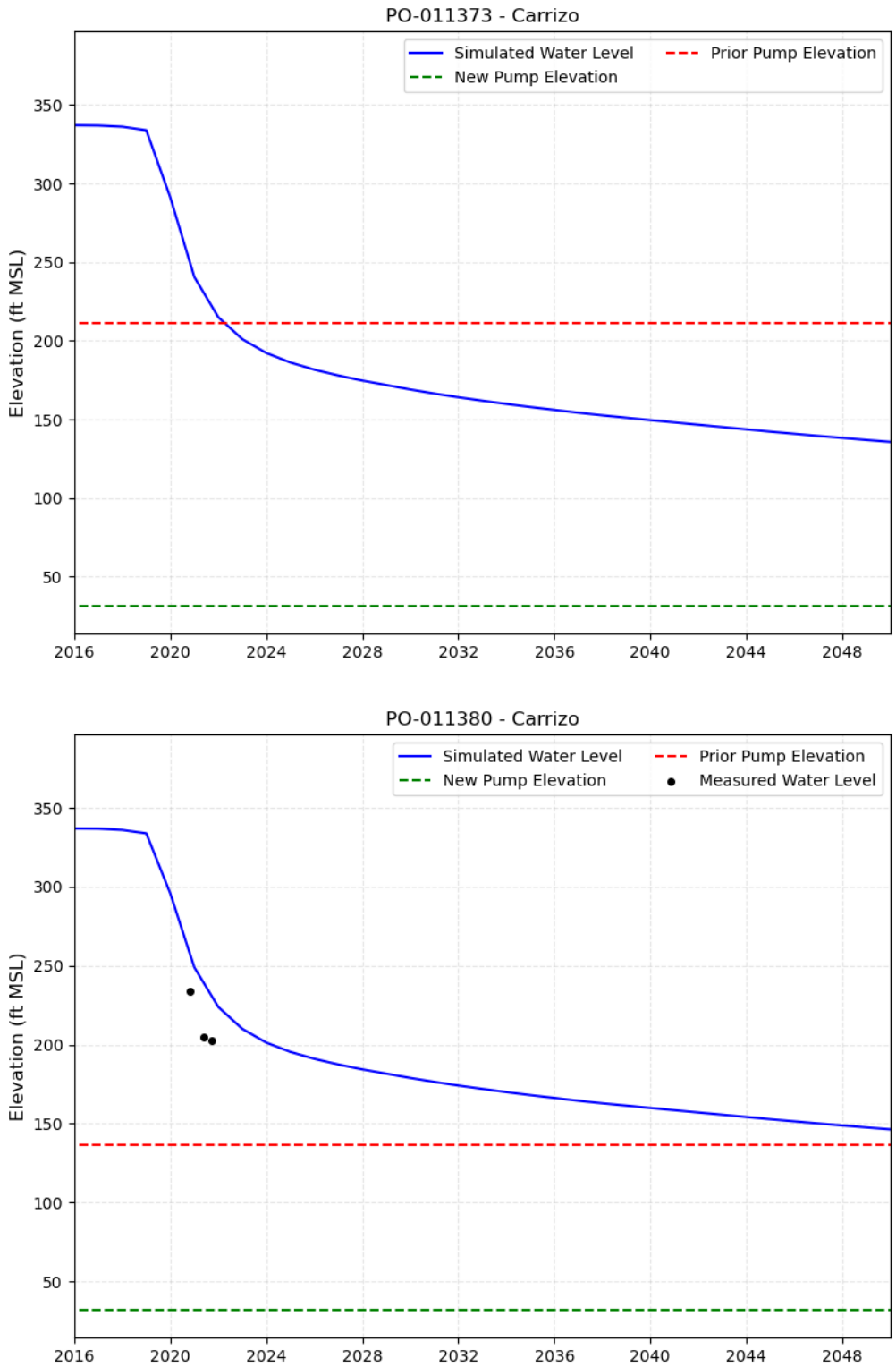

Figure I-25 Simulated water levels for moderate-priority wells PO-011373 and PO-011380 located in the Carrizo Aquifer

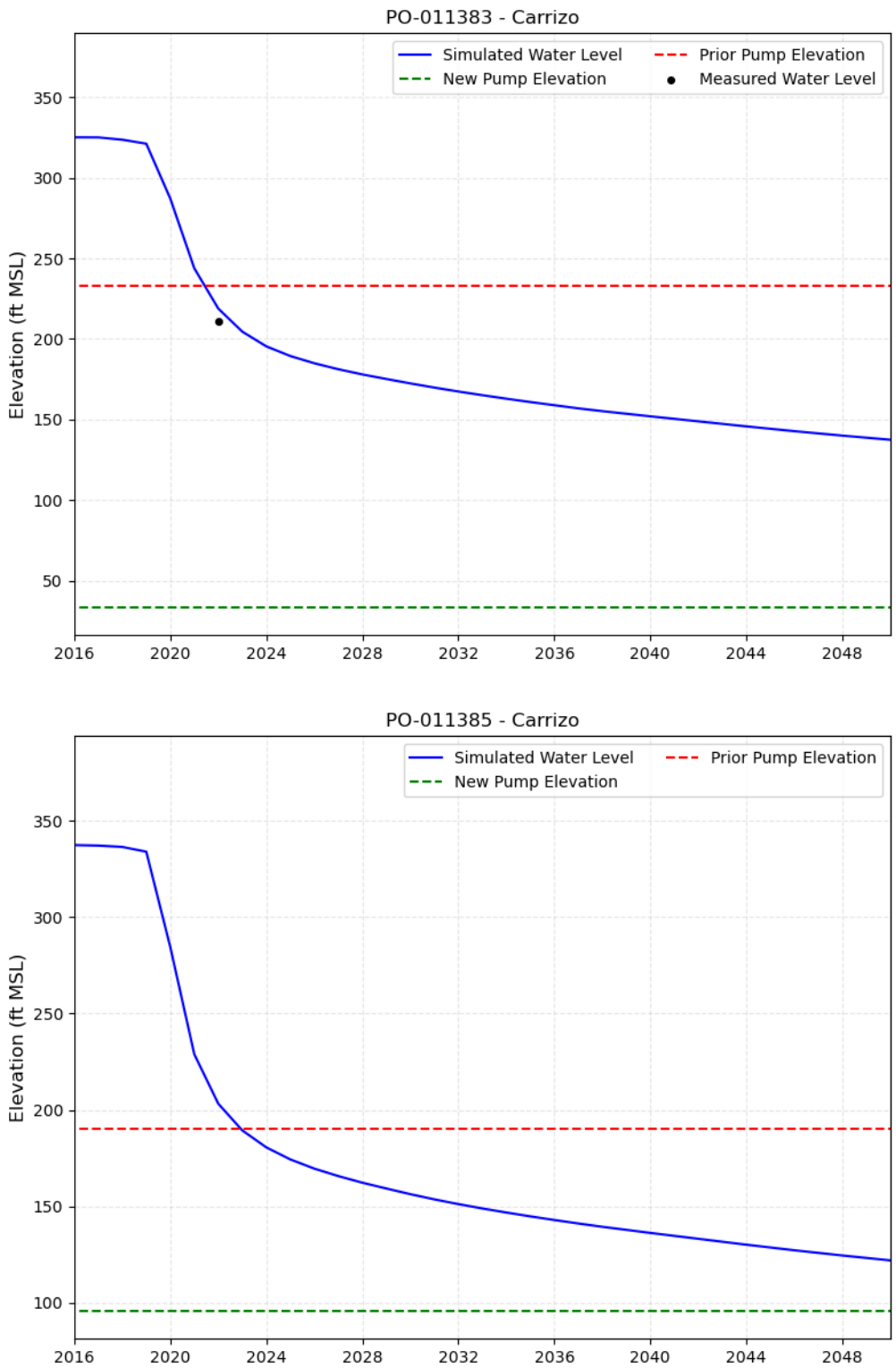

Figure I-26 Simulated water levels for moderate-priority wells PO-011383 and PO-0111385 located in the Carrizo Aquifer

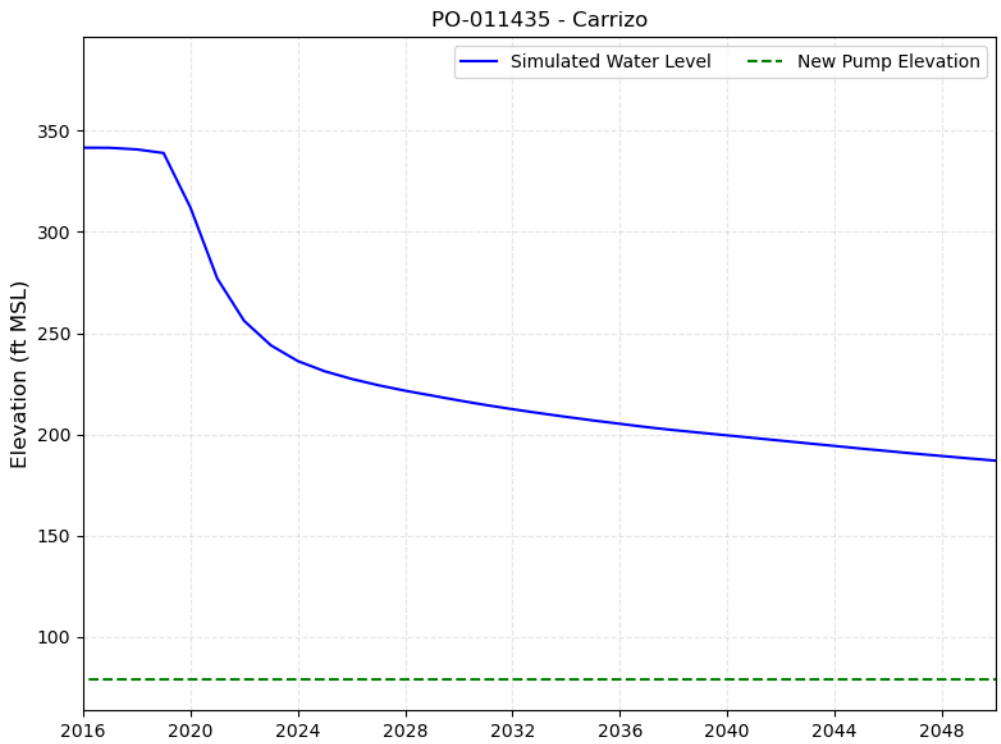

Figure I-27 Simulated water levels for moderate-priority well PO-0111435 located in the Carrizo Aquifer