25 Edelman
Suite 120
Irvine CA 92618

949.420.3030 phone
530.756.5991 fax
westyost.com

TECHNICAL MEMORANDUM
USE OF THE 2022 BVHM TO EVALUATE SUSTAINABILITY OF FUTURE PUMPING IN THE BORREGO SPRINGS SUBBASIN

DATE: March 31, 2025

TO: Technical Advisory Committee
Borrego Springs Watermaster

FROM: Andy Malone, PG; Eric Chiang, PhD; Lauren Salberg, PG (West Yost)

SUBJECT: Use of the *2022 BVHM* to Evaluate Sustainability of Future Pumping in the Borrego Spring Subbasin

BACKGROUND AND OBJECTIVES

Section II.E of the Judgment requires the Sustainable Yield of the Borrego Springs Subbasin (Basin) to be redetermined by January 1, 2025 through a process that includes: collecting additional data, refining the Borrego Valley Hydrologic Model (BVHM), and using model runs from the BVHM to update the Sustainable Yield. The Watermaster Board approved a redetermined Sustainable Yield of 7,952 acre-feet per year (afy) at its December 5, 2024 Board meeting (2025 Sustainable Yield).[1] The redetermined Sustainable Yield was based on the long-term, historical net recharge to the Basin as estimated by a recalibrated version of the BVHM[2], referred to herein as the *2022 BVHM* to distinguish it from prior calibrated versions.[3] The 2*022 BVHM* was developed with funding from the Department of Water Resource (DWR) Sustainable Groundwater Management (SGM) grant program.

[1] In redetermining the 2025 Sustainable Yield, the Board also considered the range in estimates of the Sustainable Yield produced from an uncertainty analysis of the model calibration. The uncertainty analysis considered results from the ten best model realizations, which produced a range of Sustainable Yields from 7,568 afy to 8,078 afy and averaged 7,803 afy.

[2] The BVHM is referred to throughout this document in various contexts. When referring to the model generally, such as its features and use as a tool for simulating groundwater conditions, the model is referred to as the BVHM. There are several versions of the BVHM that have been developed over time, but the *2022 BVHM* is the focus of this TM. This version of the BVHM is the *Calibrated BVHM* extended through WY 2070 and used to run projection scenarios and simulate future Basin conditions. Note that the term "2022 BVHM" was used during the performance of Tasks 1-3 of the scope of work to redetermine the 2025 Sustainable Yield. The methods and results of performing Tasks 1-3 are documented in TMs available on the Watermaster's website at: https://borregospringswatermaster.com/technical-advisory-committee-meetings/.

[3] Task 4 of the scope of work to redetermine the 2025 Sustainable Yield involved the calibration of the BVHM (referred to the *Calibrated BVHM*, which had a simulation period of WYs 1930 to 2023). The methods and results of model calibration are documented in a TM available on the Watermaster's website at: https://borregospringswatermaster.com/wp-content/uploads/2024/10/Task-4-TM_final.pdf

As part of the scope of work for the SGM grant, the *2022 BVHM* was to be used to predict future groundwater conditions in the Basin (i.e., future changes in groundwater-levels and groundwater storage), under future groundwater pumping plans and climatic conditions, to assess the sustainability of the pumping Rampdown to the 2025 Sustainable Yield by 2040 and through the planning and implementation horizon (to water year [WY] 2070).[4,5] The purpose of the evaluation is to identify if the Sustainability Goal for the Basin is met by 2040 and identify the potential for Undesirable Results that could occur for two of the applicable Sustainability Indicators defined in the Groundwater Management Plan (GMP) for the Borrego Springs Subbasin such as: Chronic Lowering of Groundwater Levels and Reductions in Groundwater in Storage. The GMP identifies groundwater-level and storage conditions that will occur when the Sustainability Goal for the Basin is met by 2040, which is planned to be compared to BVHM projections to determine if the following Sustainability Goals are expected to be met:

- Trends in groundwater levels are stable or increasing by 2040
- Groundwater levels are at sufficient elevations to not cause Undesirable Results

Additionally, the GMP defines that the Undesirable Result associated with chronic lowering of groundwater levels and reduction in groundwater storage is the loss of adequate water resources to support current and/or potential future beneficial uses and users. The evaluation for this potential Undesirable Result was to be accomplished by comparing the BVHM projections for groundwater levels and storage to the Sustainable Management Criteria (SMC) for chronic lowering of groundwater levels and reduction in groundwater storage (e.g., minimum thresholds at representative monitoring wells). Findings and conclusions from these evaluations would be used to demonstrate the likelihood of achieving sustainability by 2040 (and beyond), support adaptations to the GMP (if any), and would be documented in the 5-year Assessment of the GMP (GMP Assessment Report), which is due to the DWR on June 25, 2026.

As described later in this technical memorandum (TM), a discrepancy was discovered in the *2022 BVHM.* Wells in the multi-node well (MNW2) package were unable to pump their assigned rates in the future simulation (herein referred to as "under-pumping"). Because of this, the *2022 BVHM* simulation was unable to pump the projected groundwater volumes provided by some Pumpers.

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[4] The Sustainable Yield is allocated to parties with Baseline Pumping Allocation, or BPA. There are two named parties to the Judgment that do not have BPA rights but are afforded non-de minimis pumping rights. These rights are not subject to the Rampdown and do not have Carryover rights. The total non-BPA water rights of the two parties is 42 afy. The pumping of these parties is *in addition to* the Sustainable Yield amount and was considered in both the calibration of the *2022 BVHM* and in developing pumping projections. When referring to assessment of the "sustainability of the 2025 Sustainable Yield", we also are considering the pumping pursuant to these non-de minimis rights afforded by the Judgment. This will be evident later in this TM as presented in Table 1, which shows a total allowable pumping that is about 42 afy greater than 7,952 afy.

[5] The phrase "assess the sustainability of the 2025 Sustainable Yield" is used through the report. This refers to assessing both the Rampdown to the Sustainable Yield by 2040 and the long-term sustainability of pumping at the 2025 Sustainable Yield through 2070.

Following identification of the discrepancy, this issue was presented to the Technical Advisory Committee (TAC) at its March 18, 2025 Ad-Hoc meeting.[6] West Yost staff informed the TAC that the recommended action was to pause modeling of future projections, investigate the issue further, and develop options and cost estimates to complete the work to assess the sustainability of the 2025 Sustainable Yield. The revised objectives of this effort are to investigate and document the under-pumping issue and provide the Watermaster Board with recommendations on how the information produced from the efforts to date can be used and options to complete the evaluation of sustainability of the 2025 Sustainable Yield.

The objectives of this TM are:

- To document the results and interpretations from the work performed to-date to evaluate the sustainability of the 2025 Sustainable Yield, including the description of the model discrepancy that was identified.
- To describe recommendations to complete the effort to evaluate the sustainability of the 2025 Sustainable Yield, for consideration by the TAC and Watermaster Board.

Organization of this Technical Memorandum

This TM includes the following sections:

- **Methods to Characterize Future Groundwater Conditions.** This section describes the methods that were employed to define future cultural and climatic conditions (including future pumping, land use, and climate) and then perform BVHM simulations over the 47-year projection period of WY 2023 to 2070.
- **Preliminary Results and Interpretations**. This section describes the results and interpretations of the *2022 BVHM* projections of future groundwater levels and storage. During this work, a discrepancy was identified in the *2022 BVHM* that likely influences the model results. This section describes the model discrepancy and the limitations that the discrepancy causes for the interpretation of the model results. Hence, the results and interpretations described herein are considered "preliminary" at this time.
- **Recommendations and Next Steps**. This section describes the recommended next steps to resolve the discrepancy in the *2022 BVHM* and evaluate the sustainability of the 2025 Sustainable Yield.

METHODS TO CHARACTERIZE FUTURE GROUNDWATER CONDITIONS

The *2022 BVHM* can be used to simulate future cultural and climatic conditions (i.e., changes in pumping, land use, and hydrology) and the resultant Basin response (i.e., changes in groundwater levels and storage). The *2022 BVHM* has a historical simulation period of October 1, 1929 through September 30, 2022 (WY 1930 to 2022). To predict future groundwater conditions in the Basin from WY 2023 to 2070 and evaluate for groundwater sustainability, it was necessary to (i) characterize changes in pumping, land use, and hydrology for the 47-year projection period and (ii) modify how the *2022 BVHM* simulates future pumping and return flows, as compared to the historical simulation.

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[6] Meeting materials from March 18, 2025 Ad-Hoc TAC meeting are available on the Watermaster's website at: https://borregospringswatermaster.com/wp-content/uploads/2025/03/20250318-TAC-presentation.pdf

The following major tasks were planned and attempted to be executed:

1. Develop projections of future cultural and climatic conditions (pumping, land use, and hydrology)
2. Reconfigure the *2022 BVHM* to assign all future pumping to the MNW2 package (i.e., eliminate the use of the Farm Process (FMP) to estimate pumping for agricultural wells)
3. Extend all *2022 BVHM* input files through WY 2070
4. Run the *2022 BVHM* through WY 2070 under various future climate scenarios

Each task is described below in more detail, including any changes in methods caused by the evaluation of the model results.

Projections of Future Cultural and Climatic Conditions

Projections of future cultural and climatic conditions from WY 2023 to 2070 are necessary input data for BVHM simulations and evaluations for potential future groundwater conditions. Projections of future cultural and climatic conditions were developed for:

- Groundwater pumping
- Land use
- Hydrologic conditions (streamflow, precipitation, and evapotranspiration [ET]) under various future climates

Each of the future conditions are described below.

Future Groundwater Pumping

The primary stress to the Basin is groundwater pumping. Therefore, in order to reasonably assess for the potential for Undesirable Results to occur, it is important to simulate the most probable spatial distribution and temporal progression of future pumping under the Rampdown to the 2025 Sustainable Yield by 2040 and thereafter.

Two data sources were used to develop the pumping projections:

- Metered pumping data (WY 2023 and 2024)
- Party-specific pumping projections (WY 2025 to 2070)

To develop the pumping projections for WY 2025 to 2070, Watermaster staff interviewed all major Pumpers in the Basin to discuss and understand how each Pumper plans to Rampdown pumping to the 2025 Sustainable Yield by 2040 and thereafter (based on their knowledge at the time). The approach also considered the availability and use of Carryover, which allows Pumpers to address Overproduction if they pump above their Annual Allocation in any year.[7]

[7] Refer to the Watermaster's Annual Report for a detailed discussion of Water Rights accounting in accordance with the Judgment, including definition of all relevant terms. The Watermaster's most recent annual report for WY2024 is available on its website at: https://borregospringswatermaster.com/wp-content/uploads/2025/03/R-940-Water-Year-2024-Annual-Report.pdf

For each major Pumper, an annual pumping plan was developed, based on the following:

- If a Pumper intends to remain in the Basin, their pumping plan must include future pumping for WYs 2025 to 2070 and identify:
  - Rampdown strategy, including how the Pumper intends to avoid Overproduction if their projected demands exceed their Annual Allocation (i.e. fallow land to reduce demands or purchase Carryover and/or Baseline Pumping Allocation (BPA)).
  - Which well(s) will be pumped to meet demands.
  - If a Pumper intends to fallow land, the pumping plans must identify which parcels will be fallowed and when.
- If a Pumper intends to cease pumping, their pumping plan must identify when the Pumper is expected to stop pumping, which may occur abruptly or slowly over time.
- For all Pumpers who intend to utilize Carryover, the Pumping Projection assumes that they purchase the amount eligible for purchase every year.

Not all Parties were interviewed, including Small Pumpers (< 10 afy) and Inactive Pumpers (Parties who have never pumped). For Small Pumpers, it was assumed that these Pumpers will continue pumping in the future at a rate similar to their historical average (based on metered data) and purchase Carryover to address any Overproduction. For Inactive Pumpers, it was assumed that these Pumpers will not pump in the future and their BPA rights will be transferred to active Pumpers who have indicated they will purchase BPA to meet future demands.

The following are conclusions from conducting interviews with major Pumpers regarding future pumping in the Basin were:

- Most Pumpers plan to stay in the Basin and will implement strategies to Rampdown to the 2025 Sustainable Yield, such as: fallowing land to reduce demands, purchasing Carryover and/or BPA from other Pumpers, or changing land use to a more water-efficient crop.
- All wells planned to be operated in the future are existing wells; no new wells are currently planned to be drilled and operated.[8]
- Approximately 24 wells will (or have already) cease operation between WYs 2023 through 2070.
- Only two Parties expect to increase pumping over the projection period and will purchase additional BPA to enable increased pumping. Pumping from these Parties is for recreational and municipal uses. All other Parties who plan to remain in the Basin plan to reduce pumping in accordance with the Rampdown.

The individual pumping plans were then aggregated to develop a Basin-wide Pumping Plan that accounts for all Parties in the Basin and to determine if the aggregate plan adheres to the Judgment. Specifically, the Basin-wide Pumping Plan was assessed to ensure that the aggregate BPA (24,293 afy) and non-De Minimis Rights (42 afy) remained constant over time (24,335 afy total), that no Party accumulated more

[8] The Borrego Water District has informed the Watermaster that they are planning to perform a pumping optimization study and that they may plan for new wells based on the outcome of that study. This is their preliminary projection minus the optimization study.

Carryover than allowed by the Judgment (2x BPA), and that sufficient Carryover balance is available for those Pumpers who have indicated Carryover as a mechanism to address Overproduction.

A memo was prepared for the TAC documenting the methods and assumptions used to develop the projections, and also included a discussion of their input and feedback during their February 25, 2025 meeting.[9]

Table 1 presents the aggregate pumping plan for all Parties in the Basin for WYs 2025 through 2070, the table identifies:

- Total BPA and Non-De Minimis Rights (a). This is the sum of the BPA or Non-De Minimis Rights of all Parties and remains constant over time at 24,335 afy.
- Annual Allocation under Rampdown to the 2025 Sustainable Yield (b). This is sum of the Annual Allocation of all Parties per the revised Rampdown for the 2025 Sustainable Yield, plus allowed pumping by two Parties with non-de minimis rights of 42 afy. From 2040 on, this number will be 7,996 afy.[10]
- Projected groundwater pumping (c). This is the sum of planned pumping of all Parties.
- Annual Allocation Minus Planned Pumping [(d) = (b) – (c)]. This column shows the amount of pumping that is less than or greater than the Annual Allocation in each year. If the number is positive, planned pumping is less than the Annual Allocation. If the number is negative, planned pumping is greater than the Annual Allocation.
- Carryover Balance (e). This is the sum of all Carryover held by the Parties.
- Carryover Needed by Over-Pumpers (f). This is the amount of Carryover needed by Parties to cover any planned pumping that exceeds the sum of their Annual Allocation and available Carryover in any year.
- Carryover Rebalance [(g) = (e) – (f)]. This is the final annual Carryover Balance after subtracting the amount needed by over-pumpers.

Figure 1 is a time-history chart that plots the pumping projections for WYs 2025 through 2070 from Table 1, along with the metered pumping data for WYs 2023 and 2024. As shown in Table 1, planned pumping is generally less the Annual Allocation each year, except for WYs 2044 through 2049 and WYs 2057 through 2070 in which projected pumping is greater than the Annual Allocation (ranging from 16 to 195 acre-feet [af] above the Annual Allocation). However, as shown in column (e) of Table 1, there is sufficient Carryover available for Parties to purchase and offset any Overproduction that may occur in these years.

[9] For more detailed information, see Agenda Item IV. of the February 25, 2025 TAC meeting agenda package, available on the Watermaster's website at: https://borregospringswatermaster.com/wp-content/uploads/2025/02/20250225-TAC-Agenda-Package.pdf

[10] The Annual Allocation in each WY is determined by multiplying the Party's BPA by the Pumping Percentage in effect for that WY, based on the pumping Rampdown percentage to reach the 2025 Sustainable Yield of 7,952 afy by 2040. The Annual Allocation value for each Party is rounded to the nearest whole number. It also includes the addition of 42 af from two Non-BPA Parties who are not subject to the Rampdown. Thus, the total is 7,996 afy.

Table 1. Aggregate Basin-wide Pumping Plan for the Borrego Springs Subbasin (afy)
WY 2025 - 2070

Water Year	Total BPA + Non-De Minimis Rights (a)	Annual Allocation per Rampdown (b)	Planned Pumping (c)	Annual Allocation Minus Projected Pumping (d) = (b) - (c)	Carryover Balance (e)	Carryover Needed by Over-Pumpers (f)	Carryover Rebalance (g) = (e) - (f)
2025	**24,335**	**18,285**	**10,400**	**7,885**	**28,512**	**97**	**28,414**
2026	24,335	17,855	9,661	8,194	32,488	164	32,324
2027	24,335	17,439	8,984	8,455	36,353	171	36,182
2028	24,335	17,016	9,431	7,585	39,616	179	39,437
2029	24,335	16,599	9,366	7,233	41,780	198	41,582
2030	**24,335**	**16,161**	**8,805**	**7,356**	**42,398**	**124**	**42,274**
2031	24,335	15,350	8,842	6,509	44,804	130	44,674
2032	24,335	14,531	8,878	5,652	45,491	150	45,341
2033	24,335	13,715	8,915	4,800	45,978	165	45,813
2034	24,335	12,898	8,943	3,954	46,257	181	46,076
2035	**24,335**	**12,078**	**8,642**	**3,435**	**46,417**	**198**	**46,219**
2036	24,335	11,264	8,709	2,555	47,249	214	47,035
2037	24,335	10,445	8,738	1,708	47,284	231	47,052
2038	24,335	9,626	8,604	1,023	47,027	247	46,781
2039	24,335	8,812	8,633	180	46,681	263	46,418
2040	**24,335**	**7,996**	**7,896**	**100**	**46,018**	**121**	**45,897**
2041	24,335	7,996	7,925	71	45,600	121	45,479
2042	24,335	7,996	7,954	42	45,165	121	45,044
2043	24,335	7,996	7,983	13	44,710	121	44,589
2044	24,335	7,996	8,012	-16	44,234	121	44,113
2045	**24,335**	**7,996**	**8,040**	**-45**	**43,739**	**121**	**43,618**
2050	**24,335**	**7,996**	**7,812**	**183**	**40,962**	**121**	**40,841**
2051	24,335	7,996	7,841	154	40,720	121	40,599
2052	24,335	7,996	7,870	126	40,458	121	40,337
2053	24,335	7,996	7,899	97	40,175	121	40,054
2054	24,335	7,996	7,928	68	39,873	121	39,752
2055	**24,335**	**7,996**	**7,957**	**39**	**39,551**	**121**	**39,430**
2056	24,335	7,996	7,986	10	39,208	121	39,087
2057	24,335	7,996	8,015	-19	38,846	121	38,725
2058	24,335	7,996	8,044	-48	38,464	121	38,343
2059	24,335	7,996	8,072	-77	38,061	121	37,940
2060	**24,335**	**7,996**	**8,101**	**-106**	**37,639**	**121**	**37,518**
2061	24,335	7,996	8,110	-115	37,197	121	37,076
2062	24,335	7,996	8,119	-124	36,754	121	36,633
2063	24,335	7,996	8,128	-133	36,312	121	36,191
2064	24,335	7,996	8,137	-142	35,870	121	35,749
2065	**24,335**	**7,996**	**8,146**	**-151**	**35,427**	**121**	**35,306**
2066	24,335	7,996	8,155	-159	34,985	121	34,864
2067	24,335	7,996	8,164	-168	34,543	121	34,422
2068	24,335	7,996	8,173	-177	34,100	121	33,979
2069	24,335	7,996	8,182	-186	33,658	121	33,537
2070	**24,335**	**7,996**	**8,191**	**-195**	**33,216**	**121**	**33,095**

Notes

(a) The Judgment establishes separate, non-BPA pumping rights for two entities (Anza Borrego Desert State Park and the Borrego Springs Unified School District). These non-BPA rights are not subject to pumping Rampdown, Carryover, or transfer (to other Parties).

(b) The Annual Allocation in each WY is determined by multiplying the Party's BPA by the Pumping Percentage in effect for that WY, based on the pumping Rampdown percentage to reach the 2025 Sustainable Yield of 7,952 afy by 2040. The Annual Allocation value for each Party is rounded to the nearest whole number.

(c) Planned pumping is the sum of all Party plans based on conversations held with the major Pumpers in the Basin.

(d) This column shows the amount of pumping that is less than or greater than the Annual Allocation in each year. If the number is positive, planned pumping is less than the Annual Allocation. If the number is negative, planned pumping is greater than the Annual Allocation.

(e) The total Carryover account balance is the sum of all Carryover held by Parties based on their assumed elections.

(f) This is the amount of Carryover needed by Parties to cover any planned pumping that exceeds the sum of their Annual Allocation and available Carryover in any year

(g) The total amount of Carryover remaining after Carryover has been purchased and used by Parties who Overproduced during the water year.

Figure 1. Projections of Future Pumping in Borrego Springs, *WY 2023 - 2070*

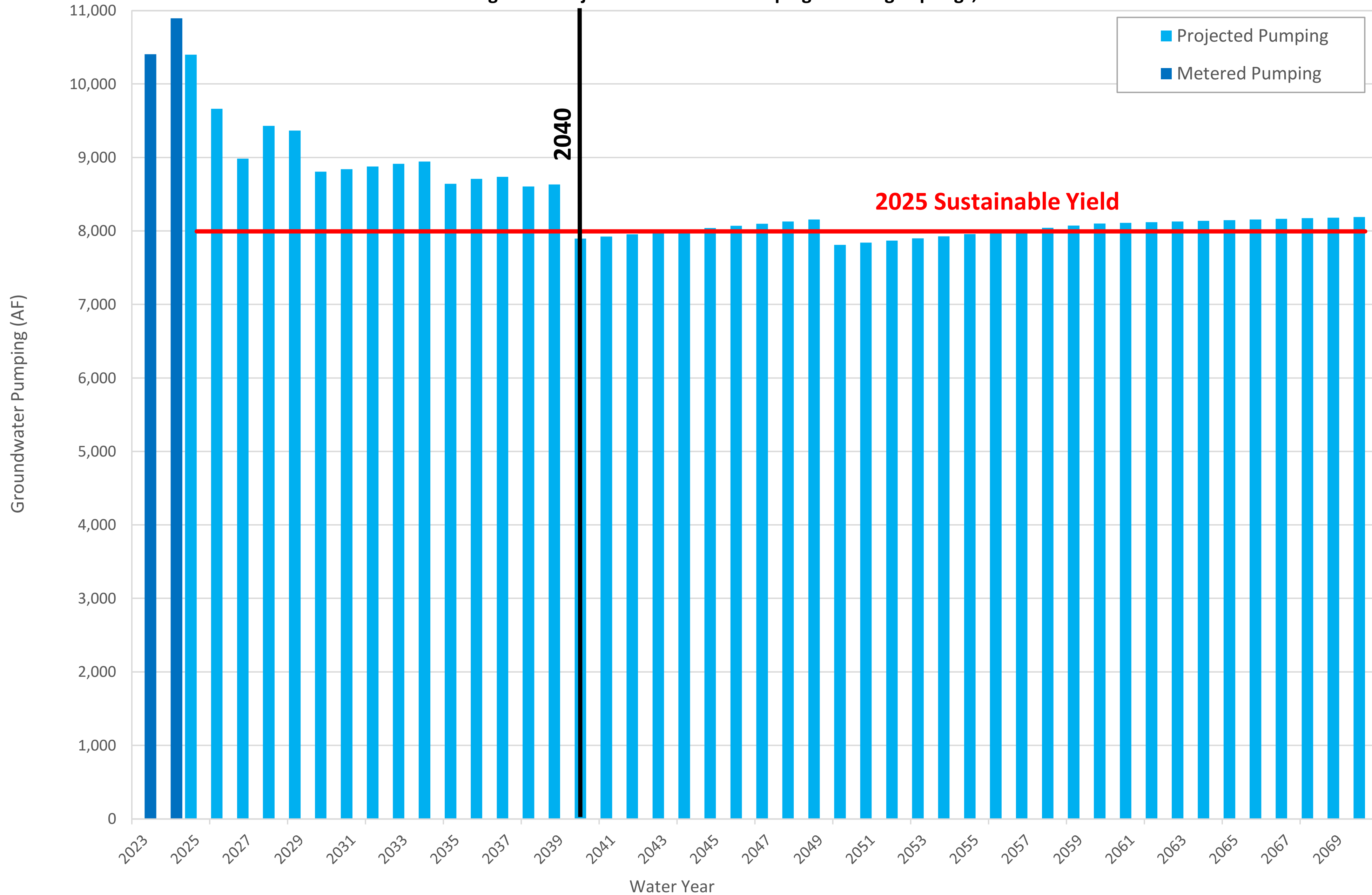

Figure 2 shows the time-history of pumping in the Basin for from WYs 1945 through 2070.[11] This figure identifies where pumping has and is expected to occur, relative to the three Management Areas defined in the GMP (North, Central, and South). The bottom bar chart shows the total pumping occurring in the Basin (i.e., the aggregate of pumping occurring in the North, Central, and South Management Areas). The pumping shown in this figure includes:

- Agricultural and recreational pumping estimated by the FMP during the historical model simulation period (WYs 1945 to 2022)
- Municipal and recreational pumping assigned in the MNW2 package during the historical model simulation period (WYs 1945 to 2022)
- All pumping (agricultural, recreational, and municipal) assigned in the MNW2 package during the projected model simulation period (WY 2030 through 2070)

The purpose of Figure 2 is to illustrate how pumping is changing over time in each Management Area. Historically, the majority of pumping occurred in the North Management Area, followed by the Central Management Area (areas of historical agricultural pumping). Pumping in these two management areas has always been significantly greater than pumping in the South Management Area. Pumping in the South Management Area was minimal and averaged 260 afy prior to WY 2015. In recent history, pumping in the Central Management Area has seen greater decreases in pumping volume relative to the North Management Area. Relative to current pumping levels as of WY 2023, the pumping projections show that:

- Pumping in the North Management Area is projected to decrease by approximately 4,100 afy from WYs 2023 to 2070.
- Pumping in the Central Management Area is projected to increase by approximately 2,000 afy from WYs 2023 to 2070. The increase in pumping in the Central Management Area is driven by a projected increase in municipal and recreational demands.
- Pumping in the South Management Area is projected to be constant at approximately 600 afy from WYs 2023 to 2070, which is higher than the historical average.

[11] The first 15 years of the BVHM (WYs 1930 to 1945) are considered a "spin-up" period; no groundwater pumping is simulated during this period. Figure 2 is a time-history chart from WYs 1945 to 2070, when pumping is simulated by the *2022 BVHM*.

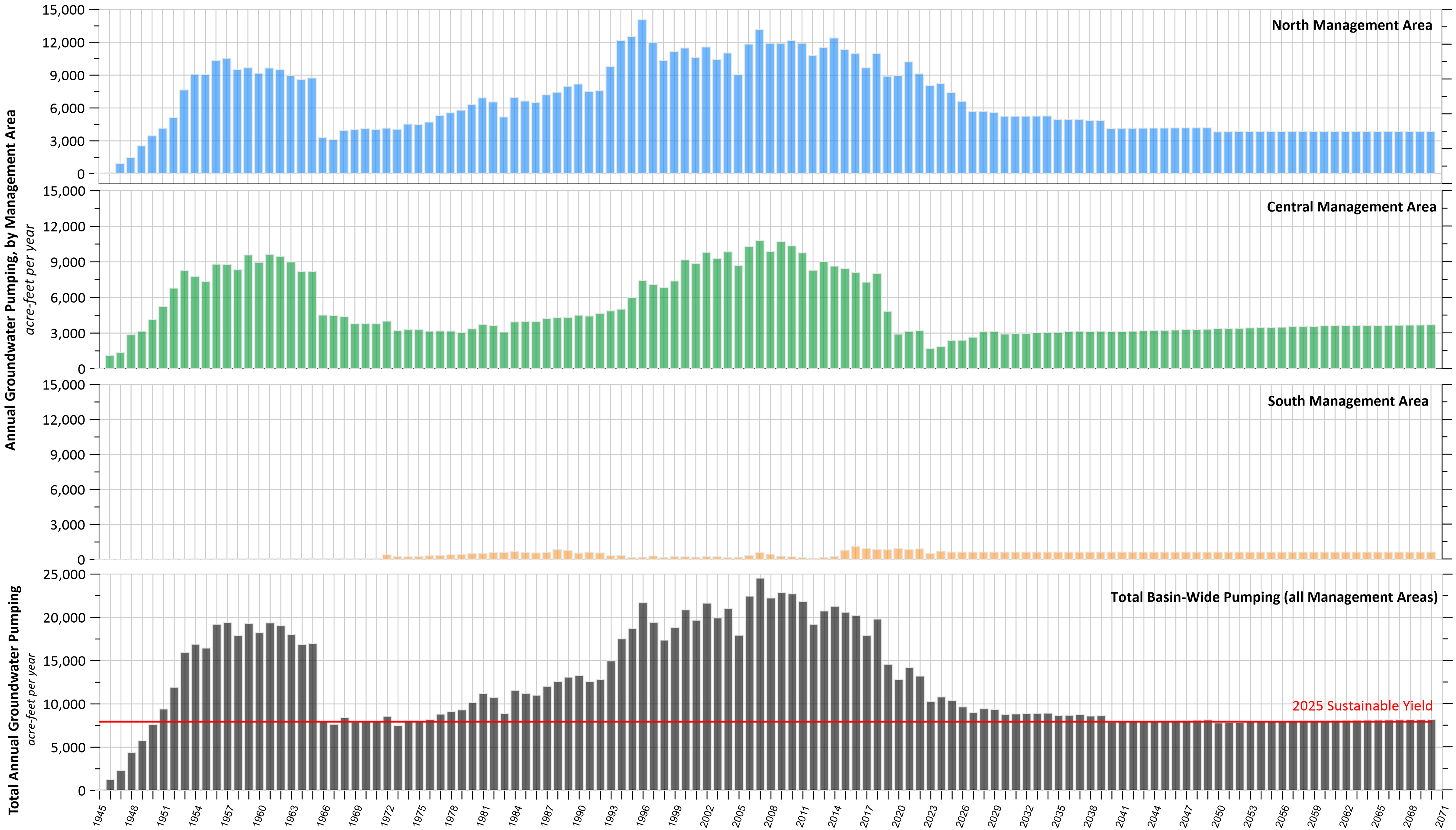

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Figure 2

Pumping by Management Area Simulated by the *2022 BVHM* (WY 1945 - 2070)

Future Land Use

Return flows from irrigation are an important source of recharge to the Basin and are a component of the water budget used to determine the Sustainable Yield. The BVHM estimates return flows from irrigation and precipitation using the FMP. Land use in the FMP is important because it determines where irrigation is occurring, and therefore, where return flows are being generated.

Land use classifications for the projection period were updated in the FMP based on Pumper plans (see the *Future Groundwater Pumping* section on how the information was gathered from the pumpers). Based on the Pumper interviews:

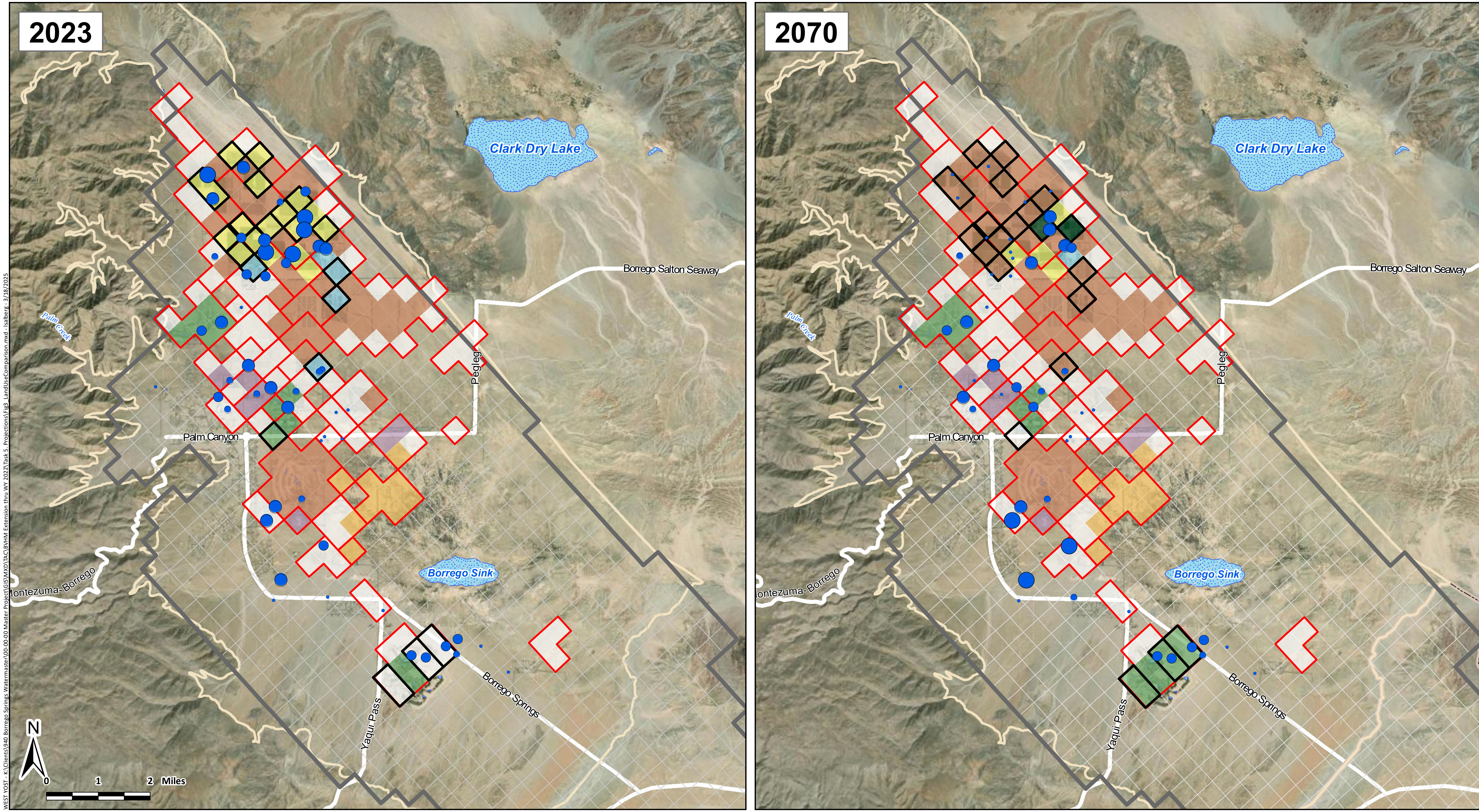
- The acreage of agricultural land uses will decrease as pumping is reduced to comply with the Rampdown. More than 1,200 acres of agricultural land is projected to be fallowed between WYs 2023 through 2070.
- The majority of agricultural Pumpers intend to reduce pumping to comply with the Rampdown and will do so through land fallowing, reducing the density of trees on farmed land, or replacing citrus trees with a more water-efficient crops (olives).
- Some agricultural Pumpers will end operations and cease pumping altogether before 2040.
- One recreational Pumper will expand the irrigated acreage of its golf course.

The delineation of farms (irrigated land areas for agriculture or recreation) in the FMP does not precisely align with the boundaries of the irrigated parcels in the Basin. This is due to the orientation and size of the grid cells in the BVHM (one grid cell is approximately 92 acres). Only one land use can be assigned to each grid cell in the FMP, so the goal is to have an approximation of the total irrigated area represented in the model, though it may be shifted slightly from the actual location. Best professional judgement was used to update the land use assigned to grid cells to reflect the change in irrigated area in the locations where changes are expected to occur.

In some cases, this approach required manually calculating return flows and directly assigning the return flow volume to the Unsaturated Zone Flow (UZF) package to ensure that all irrigation return flows were represented in the model. This adjustment accounts for return flows from grid cells that were fallowed in the FMP, but a portion of the grid contains land that will continue to be irrigated in the future. Return flows were estimated using an assumed irrigated efficiency (OFE) of 80 percent, meaning that approximately 20 percent of applied irrigation water was not used to meet crop demands and may become return flows. Return flows were estimated based on irrigation water supplied by nearby pumping wells, which pumped between 200 to 274 afy from WYs 2023 to 2070. Using these assumptions, total return flows assigned to the UZF package ranged from 40 to 55 afy. This process is functionally similar to how the FMP estimates return flows, where excess irrigation water percolates beyond the root zone and contributes to groundwater recharge. Note that the return flows assigned to the UZF package is water potentially available as recharge. Ultimately, it is dependent on the soil properties and UZF's assumptions about infiltration that determine the amount of return flows that will eventually become recharge (e.g., the fate of the return flows are dependent on the assumed aquifer properties in the location the water is applied).

Figure 3 shows a side-by-side comparison of the land use assigned in the FMP in WY 2023 and WY 2070, that reflects the land use changes planned by the Pumpers. Additionally, the figure identifies all wells that will pump in the projection scenarios. The wells are symbolized by the magnitude of annual pumping in each year. As shown in Figure 3:

- The majority of land fallowed in the Basin is in the North Management Area. In tandem, the well symbology illustrates that pumping in the North Management Area is reduced from WYs 2030 to 2070.
- The only expansion of irrigated acreage occurs in the South Management Area, where the Rams Hill golf course is projected to expand. It should be noted that pumping in the South Management Area remains constant over the projection period because the additional demands from the expanded golf course will be pumped from wells in the Central Management Area. The increased pumping by wells in the Central Management Area, specifically the south Central Management Area, is also illustrated by the well symbology.



Land Use Classification in BVHM Grid Cells

- Fallow
- Native
- Phreatophytes
- Palm
- Citrus
- Potatoes
- Golf Course
- Olives
- Urban
- Land Use Changed during Projection (WY 2023-2070)

Total Annual Pumping (AFY)

- 0 - 25
- 26 - 100
- 101 - 250
- 251 - 500
- 501 - 1,000

Other Features

- Boundary of Active Cells in the BVHM
- Water Balance Subregion in the FMP
- Borrego Springs Groundwater Subbasin

Prepared by:

WEST YOST

Borrego Springs Watermaster

Evaluation of Future Pumping in Borrego Springs

Figure 3

Land Use Changes in the *2022 BVHM*

October 2023 and September 2070

Future Hydrology and Climate

Hydrologic conditions, streamflow, precipitation, and ET are key components of the water budget that influence the availability of groundwater. Future estimates of these hydrologic conditions are necessary to simulate the Basin response to the future pumping and land use projections. Precipitation, ET, and streamflow are highly dependent upon climate conditions. Climate conditions are expected to change in the future, but when and how those changes will occur is uncertain. For this reason, multiple future hydrologies should be simulated to understand the range of potential Basin impacts under various climate conditions. Additionally, long-term climate change and shorter-term climatic variability have an important influence on the recharge to the Basin.

Considering the importance of climate, and the uncertainty around how it will change in the future and when, four climate scenarios were developed to simulate the potential range in Basin responses to projected changes in pumping and land use. The four scenarios are:

- ***Climate Scenario #1 - Repeat Hydrology*** (CS-1 RH). In this scenario, the past 47-years of historical climate data (WYs 1975 to 2022) are repeated to simulate the future 47-year period of WYs 2023 to 2070.
- ***Climate Scenario #2 - Repeated Hydrology with 2030 DWR Climate Change Factors*** (CS-2 RH30)**.** This scenario is similar to CS-1 RH, but the DWR's 2030 Climate Change factors are applied. The 2030 DWR Climate Change Factors are generated using the General Circulation Model (GCM) projections and are used to adjust the historical precipitation record to represent potential future conditions. The 2030 DWR Climate Change Factors are used to represent near-term climate change impacts (centered around the 2030s).
- ***Climate Scenario #3 - Repeated Hydrology with 2070 DWR Climate Change Factors*** (CS-3 RH70)**.** This scenario is similar to CS-1 RH, but the DWR's 2070 Climate Change factors are applied. Like the 2030 Climate Change Factors, the 2070 Climate Change Factors are generated using the GCM, but also are used to represent long-term climate change impacts (centered around the 2070s).
- ***Climate Scenario #4 - Drought Conditions through 2040*** (CS-4 D18)**.** This scenario represents a drought period through 2040 by repeating the driest 18-year period in the historical record starting in WY 2023. The "drought period" was determined through a statistical analysis of the 20th percentile of total precipitation over all 18-year periods in the historical climatic period.

For each of the four climate scenarios described above, input files of monthly precipitation, ET, and streamflow files were generated and used as inputs to the FMP.

Reconfigured Pumping Assignments in the BVHM and Assigned All Pumping

For the historical period WYs 1930 to 2022, the FMP was used to estimate groundwater pumping from agricultural and some recreational wells based on irrigation demands of the associated land use. Pumping was only prescribed in the MNW2 package for municipal and select recreational wells. For the projection period (WYs 2023 to 2070), pumping is prescribed for all wells, including agricultural wells, in the MNW2 package. A reconfiguration of the BVHM was performed to ensure that:

- The volume and spatial distribution of pumping were consistent with Pumper plans and the Rampdown schedule to the 2025 Sustainable Yield.

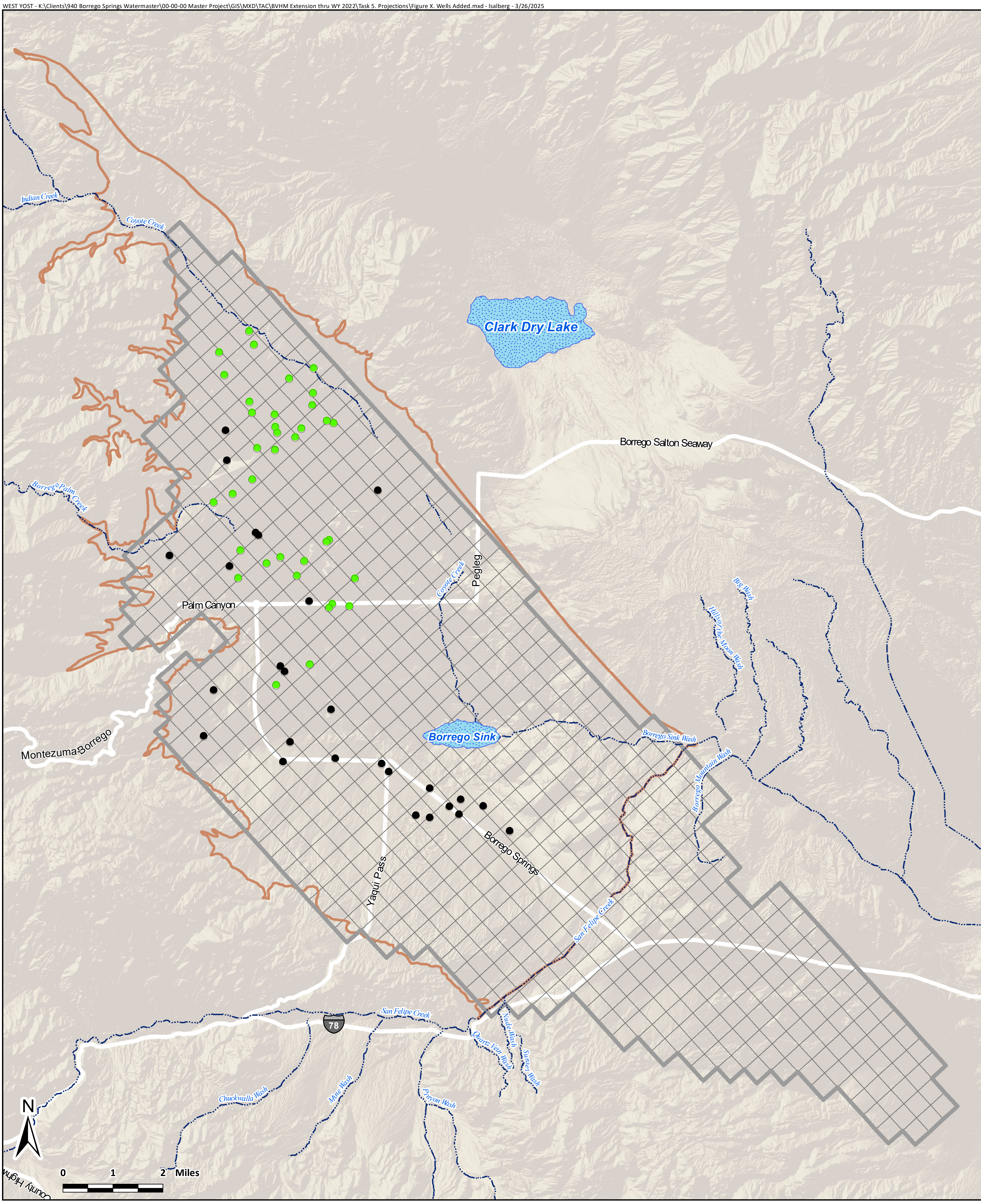
- Return flows from irrigation were estimated and generated using the FMP.
- Consistency was maintained between where pumping occurs in the MNW2 package and where it is applied to meet irrigation demands in the FMP.

The following steps were taken to reconfigure the *2022 BVHM*:

1. **Added new wells to the MNW2 package.** Pumpers identified which wells they plan to pump in the future (see *Future Groundwater Pumping* section). If a well that was planned to be operated in the future was not already defined in the MNW2 package (e.g.*,* pumping was historically estimated by the FMP), the well was added to the model. The wells added to the MNW2 package reflect the following:
    - A grid cell assignment reflective of the actual location of the well in the Basin.
    - The well screens and aquifer layer(s) from which the well pumps, where well construction information was available.
    - If no well construction information was available, the construction information from nearby wells was assigned.

    A total of 37 wells were added to the MNW2 package. The location of wells added to the MNW2 package are shown in Figure 4, which also shows the location of wells assigned pumping in the MNW2 package in the historical period (prior to WY 2023).
2. **Assigned future pumping to wells in the MNW2 package.** Input files of future pumping assigned directly to the MNW2 package wells were prepared as follows:
    - Pumping is based on the Pumper Plans such that the aggregate volumes match those presented in Table 1.
    - Pumper plans were used to input when wells are expected to pump during the year, if and when wells are expected to be taken offline, and/or which parcels the wells will serve for irrigation (if applicable). Monthly pumping rates were assigned based on the historical distribution pumping based on monthly meter data, which for most wells (with the exception of municipal wells and some recreational wells) is generally available for WYs 2021 through 2024. The monthly distribution and percent of total annual pumping for each well was shared with two major Pumpers, Rams Hill and BWD, to confirm the assumptions. Each of these Pumpers has multiple wells that will be pumped in the projection period.
    - Maximum pumping for FMP wells was set to zero so that pumping was not simulated by the FMP to meet crop demands.
3. **Assigned external deliveries to the FMP to meet irrigation demands.** While the FMP no longer estimates groundwater pumping, it continues to estimate return flows from irrigation. To ensure consistency between FMP-estimated irrigation demands and groundwater pumping from MNW2 wells, external deliveries were assigned to farms in the FMP to meet irrigation demands and generate return flows. The external deliveries supplied to each water-balance subregion (or “farm”) in the FMP match the groundwater pumped from wells in the MNW2 package. In summary, the workflow is: the FMP estimates irrigation demands, wells in the MNW2 package pump groundwater to meet the irrigation demands, and the groundwater pumped from the MNW2 package is delivered to the FMP via external deliveries. This approach maintains a connection between irrigation demands, groundwater pumping, and return flows in the BVHM despite removing the ability of the FMP to make estimates for groundwater pumping.

WEST YOST - K:\Clients\940 Borrego Springs Watermaster\00-00-00 Master Project\GIS\MXD\TAC\BVHM Extension thru WY 2022\Task 5. Projections\Figure X. Wells Added.mxd - Isalberg - 3/26/2025



Wells used in BVHM Projection Scenarios

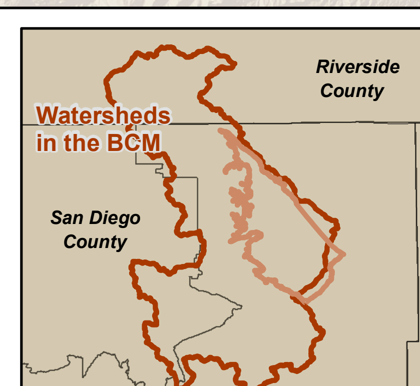
- Well added to MNW2 Package for Projection Scenarios
- Well simulated in MNW2 in Calibration and Projection Scenarios

Extent of Active Layers in the BVHM

- Boundary of Active Cells in the BVHM

Other Features

- Borrego Springs Groundwater Subbasin (7-024.01)



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WEST YOST

Figure 4

Wells used in BVHM Projection Scenarios

Extended Model Input Files through WY 2070

Model input files were generated for all relevant model packages to develop a complete time history of inputs for WYs 1930 to 2070 for the first climate scenario (CS-1 RH). The future pumping, land use changes, and climate conditions were used to extend the FMP and the MNW2, streamflow routing (SFR), and UZF packages as described above. These packages rely on dynamic inputs that change over time (e.g., pumping, land use, streamflow, precipitation, and ET).

All other model packages rely on steady state inputs (e.g., they are assumed not to change over time) and therefore only required an extension of model files through WY 2070. The inputs extended through WY 2070 are consistent with the *2022 BVHM* and include the following packages:

- Flow and Head Boundary Package (FHB) – this package is used for specified head cells and specified flow cells whose properties can vary within a stress period. In the BVHM, this package is used to simulate subsurface inflow from the mountain blocks that bound the Basin. These rates are assumed to be constant over time.
- Time-Varying Constant Head Package (CHD) – this package is used to simulate specified head boundaries that can change within or between stress periods. In the BVHM, this package is used to simulate subsurface outflow from the Basin. These rates are assumed to be constant over time.
- Discretization Package (DIS) – this package is used to define the spatial and temporal structure of the BVHM, including the number of layers, rows, and columns in the model, and the stress periods.
- Output Control (OC) – this package is used to define the frequency and type of information that should be saved from each model run, including groundwater elevation, drawdown, and water budget components.

Ran the BVHM through WY 2070

After all appropriate model packages were extended and reviewed for quality assurance, the *2022 BVHM* was used to simulate future Basin conditions under scenario CS-1 RH for the entire simulation period of WYs 1930 to 2070.

PRELIMINARY RESULTS AND INTERPRETATIONS

This section describes the preliminary results of the initial *2022 BVHM* projection from WYs 2023 to 2070 using CS-1 RH (referred to as the initial BVHM projection). This was the only projection scenario that was run because of a discrepancy that was identified in the MNW2 package of the BVHM which caused several wells in the South Management Area to “under-pump” their assigned pumping rates. We communicated the discrepancy to the TAC and Board with recommendations to pause the BVHM projections, investigate the discrepancy, and develop a recommended approach to fix the discrepancy, and complete the BVHM projections.

The subsections below describe the under-pumping discrepancy, the results of efforts to understand and fix the under-pumping discrepancy, and the preliminary interpretations that can be drawn from the results of the initial BVHM projection (despite the under-pumping discrepancy).

Under-Pumping in the MNW2 Package

When the simulation of CS-1 RH was completed, the pumping volumes that were assigned to all wells in the MNW2 package were compared against the pumping volumes that were simulated. This comparison revealed that seven (7) wells located in the in the South Management Area "under-pumped" their assigned rates during the BVHM projection.

Summary of Under-Pumping Discrepancy

Table 2 shows the total under-pumping that occurred over the projection period (WYs 2023 to 2070) in Scenario CS-1 RH. For each year, Table 2 shows: the pumping volume assigned in the MNW2 package, the pumping volume pumped by the MNW2 wells, the difference between the assigned and pumped volume, and the percent difference in pumped volume. About 3 percent of the total pumping assigned in the MNW2 package was not pumped during the projection (a total of about -10,657 af of "under-pumping" occurred over the 47-year projection period, or about -222 afy).

Figure 5 is a map of the wells that under-pumped in Scenario CS-1 RH. The figure shows the wells symbolized by the magnitude of the average annual under-pumping. The wells that under-pumped are all located in the South Management Area.

Table 3 summarizes the average annual under-pumping by well in Scenario CS-1 RH. Under-pumping by well ranged from about -2 afy to -84 afy (7 to 84 percent less than the assigned pumping volume). Total under-pumping across all seven wells was about -232 afy, or about -42 percent of the total assigned average annual pumping of 552 afy. The under-pumping discrepancy appears to be most pronounced in wells with deeper screens, primarily across model Layer 3 in the South Management Area.

Table 3 shows that the under-pumping discrepancy is relatively minor in the context of total assigned pumping in the BVHM projection (-3 percent of total assigned pumping), but Table 2 shows that it represents a significant percentage of pumping from wells screened across Layer 3 in the South Management Area, so the discrepancy should not be discounted.

Efforts to Understand and Resolve the Under-Pumping Discrepancy

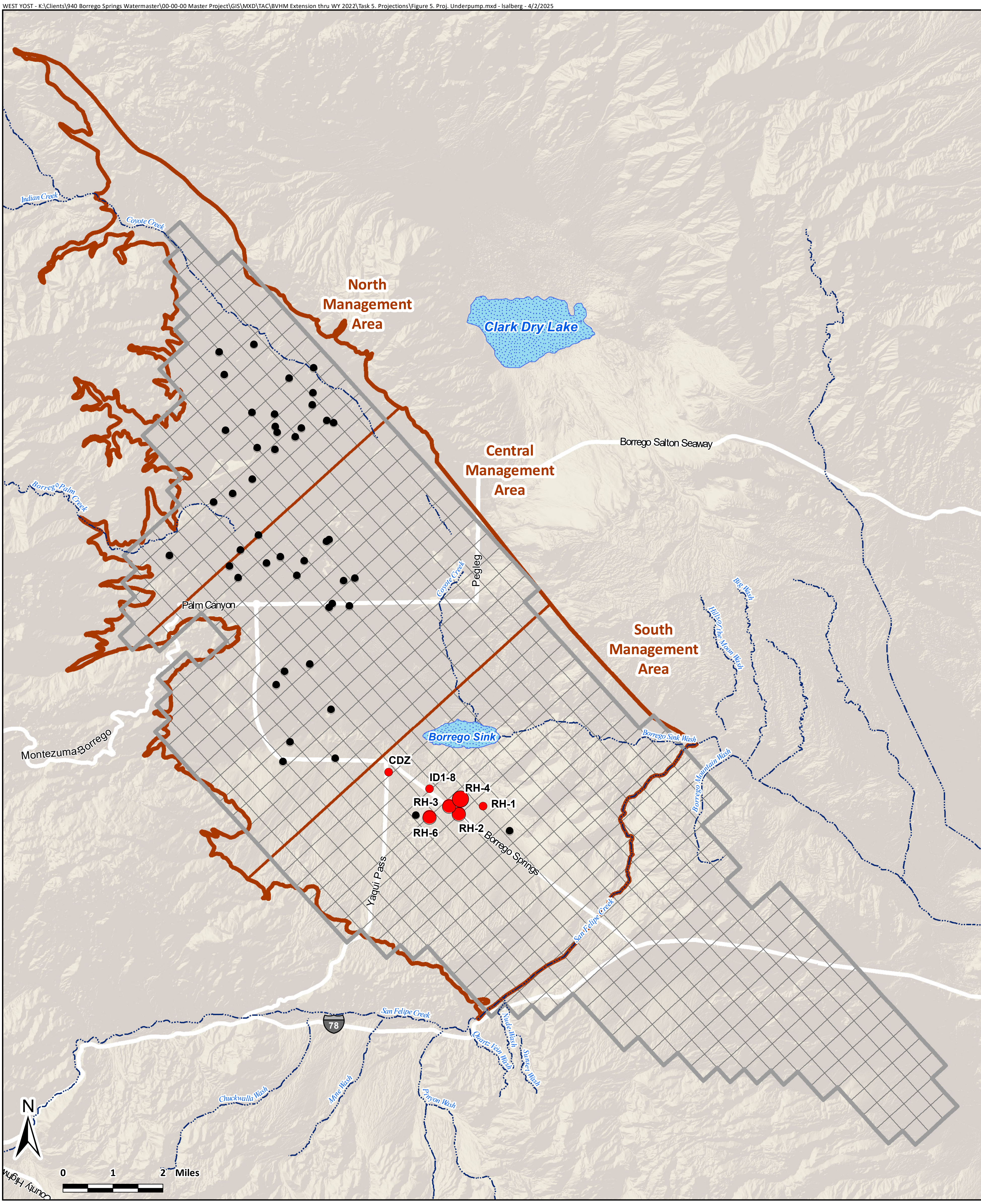
We inspected the model results and concluded that the under-pumping discrepancy at the seven wells in Table 3 was most likely related to excessive simulated drawdowns in the wells in the MNW2 package, primarily wells screened in model Layer 3. To better understand the under-pumping discrepancy, and potentially fix it, aquifer parameters were manually adjusted in BVHM Layer 3 near the wells that under-pumped, and then re-ran the BVHM over the entire historical and projection periods from WYs 1930 to 2070. The adjustments to the aquifer parameters greatly reduced the under-pumping discrepancy, but also caused significant changes in simulated groundwater levels in the Central and South Management Areas, which represents a "de-calibration" of the BVHM (i.e., simulated historical groundwater levels do not match the measured groundwater levels).

Table 2. Summary of Total Under-Pumping in the Initial BVHM Projection *(WY 2023 - 2070)*

Water Year	Pumping Assigned to MNW2 Wells *af* *(a)*	Volume Pumped by MNW2 Wells *af* *(b)*	Difference *af* *(c) = (b) - (a)*	Percent Difference *(d) = (c) / (a)*
2023	9,608	9,427	-181	-2%
2024	10,114	9,847	-267	-3%
2025	9,706	9,494	-212	-2%
2026	8,967	8,753	-214	-2%
2027	8,290	8,075	-215	-3%
2028	8,737	8,523	-214	-2%
2029	8,672	8,460	-212	-2%
2030	8,111	7,899	-213	-3%
2031	8,148	7,934	-214	-3%
2032	8,184	7,970	-214	-3%
2033	8,221	8,006	-215	-3%
2034	8,249	8,036	-213	-3%
2035	7,948	7,734	-214	-3%
2036	8,015	7,800	-215	-3%
2037	8,044	7,828	-215	-3%
2038	8,024	7,808	-216	-3%
2039	8,053	7,836	-216	-3%
2040	7,368	7,151	-217	-3%
2041	7,397	7,179	-218	-3%
2042	7,426	7,207	-218	-3%
2043	7,455	7,235	-219	-3%
2044	7,484	7,264	-220	-3%
2045	7,512	7,292	-221	-3%
2046	7,541	7,320	-221	-3%
2047	7,570	7,349	-222	-3%
2048	7,599	7,377	-222	-3%
2049	7,628	7,405	-223	-3%
2050	7,284	7,060	-224	-3%
2051	7,313	7,088	-225	-3%
2052	7,342	7,117	-225	-3%
2053	7,371	7,146	-225	-3%
2054	7,400	7,174	-225	-3%
2055	7,429	7,203	-226	-3%
2056	7,458	7,232	-226	-3%
2057	7,487	7,260	-227	-3%
2058	7,516	7,288	-227	-3%
2059	7,544	7,317	-228	-3%
2060	7,573	7,345	-228	-3%
2061	7,582	7,354	-228	-3%
2062	7,591	7,363	-229	-3%
2063	7,600	7,371	-229	-3%
2064	7,609	7,379	-230	-3%
2065	7,618	7,388	-231	-3%
2066	7,627	7,396	-231	-3%
2067	7,636	7,404	-232	-3%
2068	7,645	7,412	-233	-3%
2069	7,654	7,420	-233	-3%
2070	7,663	7,428	-234	-3%
Total	**378,011**	**367,353**	-10,657	**-3%**
Annual Average	**7,875**	**7,653**	**-222**	**-3%**

Table 3. Summary of Under-Pumping by Well, Initial BVHM Projection *(WY 2023 - 2070)*

Well Name	Depth of Well Screen (ft-bgs)	Model Layer(s) Penetrated by Well Screens	Average Annual Pumping Assigned to Well *afy*	Average Annual Volume Pumped by Well *afy*	Average Difference *afy*	Average Percent Difference
			(a)	*(b)*	*(c) = (b) - (a)*	*(d) = (c) / (a)*
ID1-8	72 - 830	Layers 1-3	26	24	-2	-9%
RH-1	180 - 580	Layers 2-3	16	8	-8	-50%
RH-2	120 - 720	Layers 1-3	90	39	-51	-57%
RH-3	295 - 885	Layers 1-3	121	61	-59	-49%
RH-4	280 - 670	Layers 2-3	101	16	-84	-84%
RH-6	238 - 938	Layers 2-3	173	148	-25	-15%
CDZ	125 - 445	Layers 1-3	25	23	-2	-7%
		Total	**552**	**320**	**-232**	**-42%**



Wells used in BVHM Projection Scenarios

- Other wells in MNW2 package

Wells that Under-Pumped in Scenario CS-1 RH

Average Annual Under-Pumping (afy)

- < 10
- 10 - 25
- 25 - 60
- 60 - 85

Extent of Active Layers in the BVHM

Boundary of Active Cells in the BVHM

Other Features

Borrego Springs Subbasin with Management Area Divisions

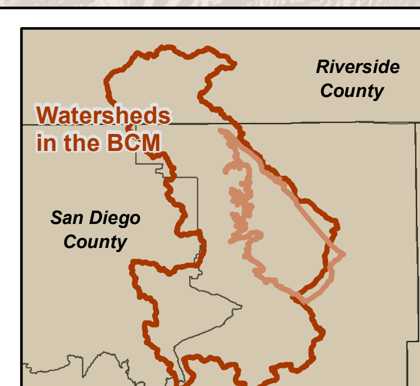


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Figure 5

Wells that Under-Pumped in the CS-1 RH Projection Scenario WY 2023 - 2070

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The results described above indicate that the under-pumping discrepancy cannot be "fixed" with minor adjustments to model parameters. The under-pumping discrepancy (and the efforts to fix it) are likely revealing that the complex geology in this area of the Basin is not well represented in the BVHM, nor is the BVHM well calibrated in this area. A review of the hydrogeologic conceptual model in the BVHM was not performed as part of the scope to develop the *2022 BVHM*. A model calibration issue was identified in this area during the *2022 BVHM* calibration efforts[12] but was not considered a significant issue during the calibration because increased pumping from Layer 3 in this area was relatively recent and likely had little influence on the historical water budget of the Basin. However, in the CS-1 RH projection, the pumping from wells in this area that are screened across the Layer 3 is greater compared to the long-term history of this area, and hence, has a greater influence on the BVHM projections.

In conclusion, the area of the Basin where the under-pumping discrepancy occurs has complicated geology that is not well understood and is likely not well characterized in the BVHM, which hinders BVHM calibration and the use of the tool for understanding the impacts of future changes in pumping, land use, and climate.

Actions Required to Resolve the Under-Pumping Discrepancy

The recommended actions to resolve the under-pumping discrepancy in the BVHM are to: (i) perform a hydrogeologic investigation to better characterize the geologic structure and aquifer properties of the area; (ii) update the BVHM using the investigation results; and (iii) recalibrate the BVHM (see the *Recommendations* section below for a more in-depth discussion of the potential options and associated costs to do this work).

Preliminary Interpretations of the BVHM Projection Results

Despite the under-pumping discrepancy, some preliminary interpretations can be drawn from the results of CS-1 RH (particularly in the North Management Area), while some interpretations cannot be made with confidence because of the under-pumping discrepancy in the Central and South Management Areas where BVHM improvements are needed.

The remainder of this subsection describes the results of the initial BVHM projection and the interpretations that can and cannot be made from the analysis of the projection results.

Projected Groundwater Levels

The following figures are time-series charts of simulated groundwater levels at selected wells from the initial BVHM projection (WYs 2023 to 2070). Each chart also includes the results from the BVHM historical period (WYs 1930 to 2022) and observed groundwater-level measurements for context:

- **Figure 6a** – *Viking Well*. This chart is representative of simulated groundwater levels in the North Management Area. Groundwater levels in this area are projected to stabilize by 2025, gradually increase by about 30 feet from 2025 to 2045, and then remain relatively stable through 2070.

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[12] See the section entitled *BVHM Calibration Results and Conclusions* of the TM documenting Task 4 to redetermine the 2025 Sustainable Yield for a description of the areas with complicated geology that are likely not well characterized in the model. This TM is available on the Watermaster's website at: https://borregospringswatermaster.com/wp-content/uploads/2024/10/Task-4-TM_final.pdf

- **Figure 6b** – *ID4-5*. This chart is representative of simulated groundwater levels in the northern portion of the Central Management Area. Groundwater levels in this area are projected to gradually decline by about 10 feet from 2023 to 2040, and then remain relatively stable through 2070.
- **Figure 6c** – *ID1-12*. This chart is representative of simulated groundwater levels in the southern portion of the Central Management Area. Groundwater levels in this area are projected to gradually decline by about 20 feet from 2023 to 2040 and continue to decline at a slower rate and by about an additional 10 feet through 2070. The groundwater elevations do not stabilize in the projection period.
- **Figure 6d** – *MW-3*. This chart is representative of simulated groundwater levels in the shallow aquifer (Layers 1 and 2) of the South Management Area. Groundwater levels in this area are projected to gradually decline by about 25 feet at a relatively constant rate from 2023 to 2070. The groundwater elevations do not stabilize in the projection period.
- **Figure 6e** – *RH-6*. This chart is representative of simulated groundwater levels in the deep aquifer (Layer 3) of the North Management Area. Groundwater levels in this area are projected to gradually decline by about 75 feet at a relatively constant rate from 2023 to 2070. The groundwater elevations do not stabilize in the projection period.

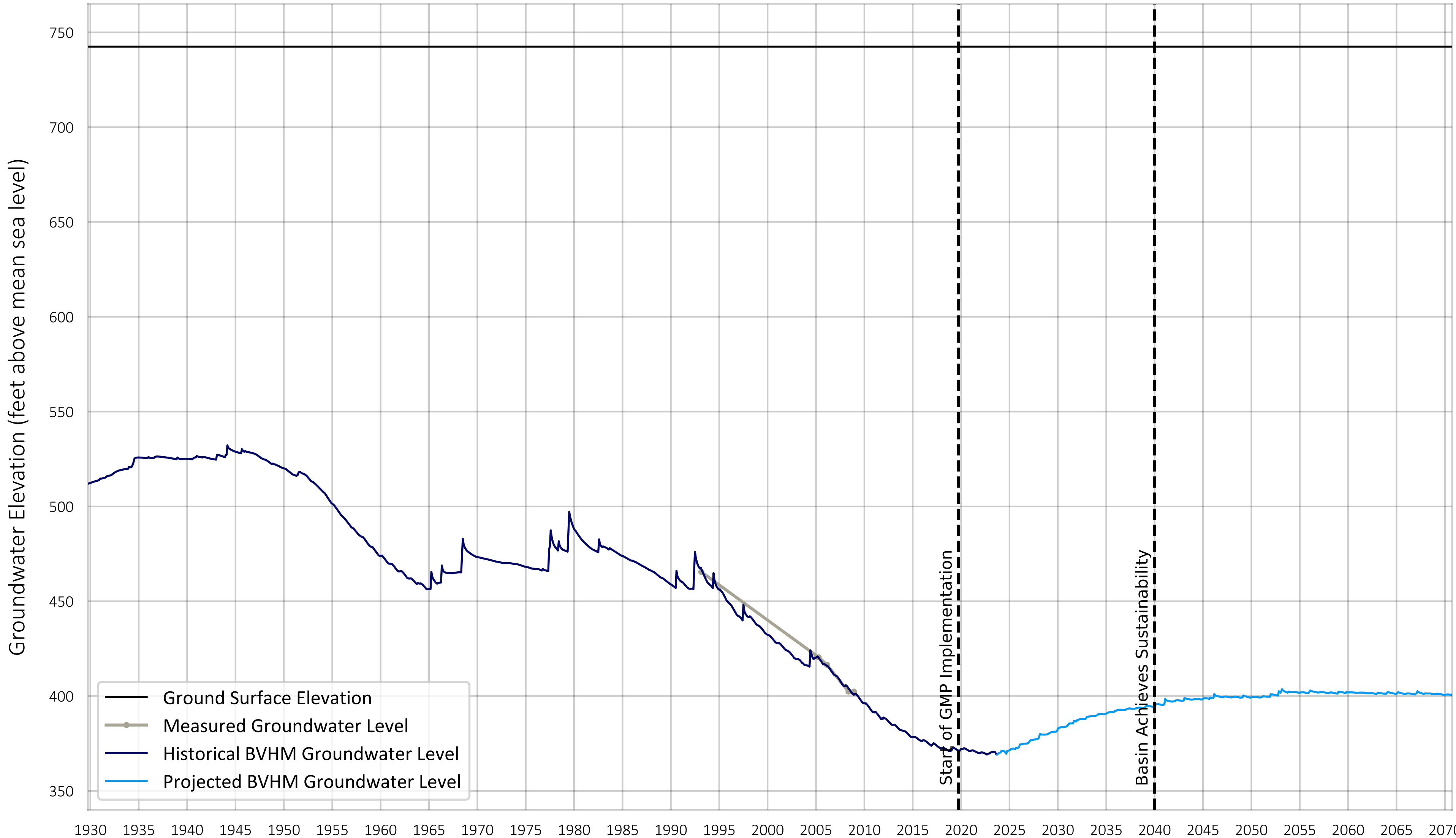
Preliminary Interpretations

The preliminary interpretations that can be made from scenario CS-1 RH are:

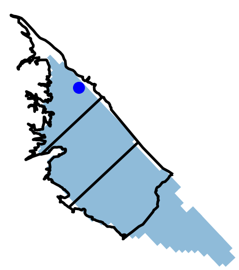
- **North Management Area**. The decades-long decline in historical groundwater levels in the North Management Area will likely cease in the near term. Then, groundwater levels will gradually increase through 2040 as the pumping in this area is projected to decline during the Rampdown period. Groundwater levels will likely be relatively stable after 2040. This outcome would be consistent with the Sustainability Goal for the Basin of stable or increasing groundwater levels by 2040 and thereafter.
- **Central and South Management Areas**. Groundwater levels in these areas may decline continuously through 2070, which would not be consistent with the Sustainability Goal for the Basin of stable or increasing groundwater levels by 2040 and thereafter. These groundwater-level declines may occur because of recent and planned increases in pumping from these areas.

Again, these interpretations are considered “preliminary” because of the recognized under-pumping discrepancy in the BVHM and the probability that the BVHM requires an update and recalibration to address the under-pumping discrepancy. That said, these interpretations could be used to inform future Watermaster policies, projects, and management actions to help achieve the Sustainability Goal for the Basin. For example, it would be reasonable to assume that there is a potential sustainability issue in the Central and South Management Areas in the future and policies could be developed to protect against long-term declining groundwater levels.

What should not be interpreted from the initial BVHM projection results are the magnitudes of the predicted changes in groundwater levels. This is particularly true in the South Management Area where the under-pumping discrepancy is located. This limits the ability of the Watermaster to (i) evaluate the sustainability of the 2025 Sustainable Yield (e.g., the results cannot be used to compare projected future groundwater levels to Minimum Thresholds, particularly in the Central and South Management Areas) and (ii) use BVHM projections to support the update of SMCs.



Well Location



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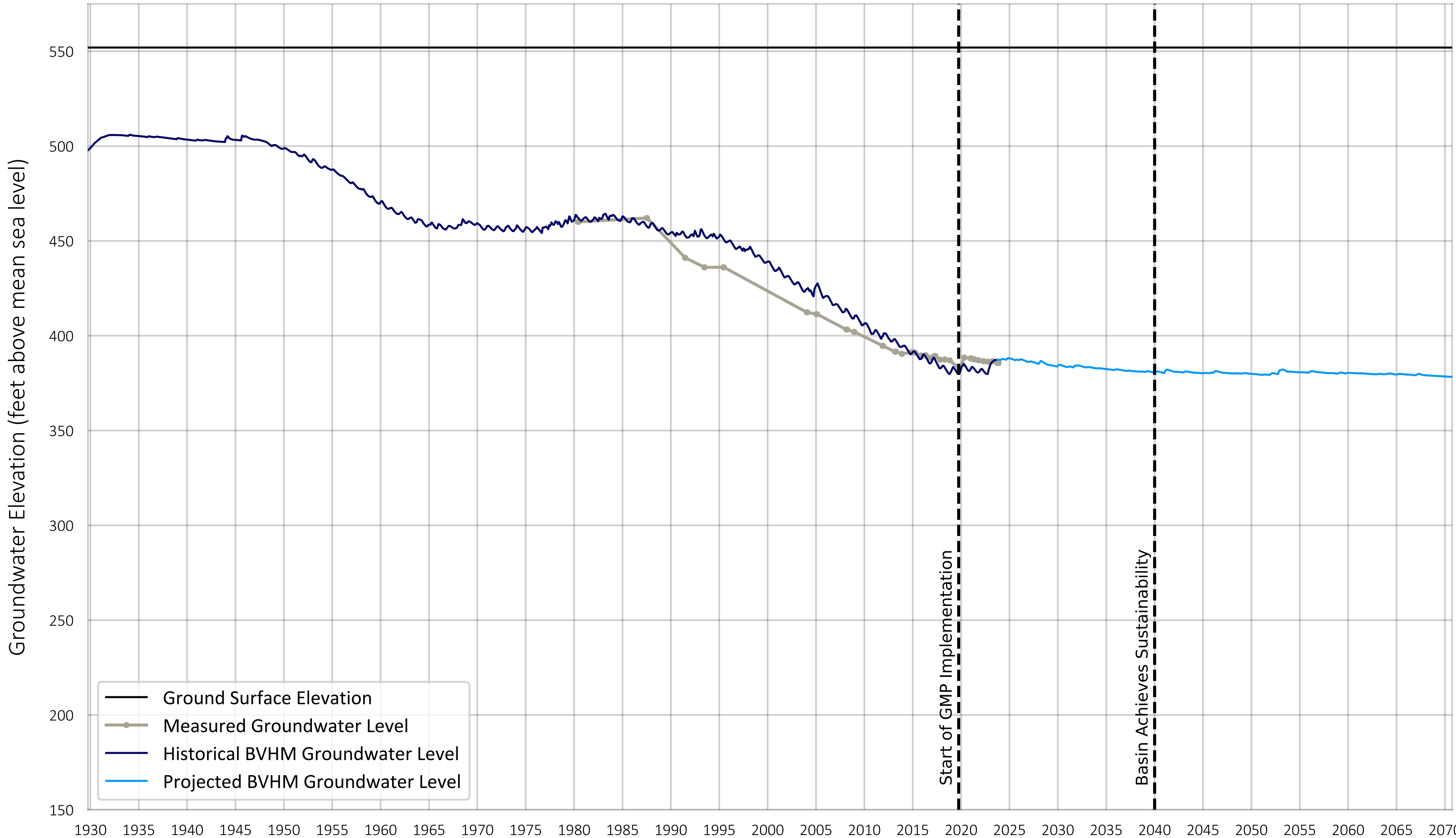
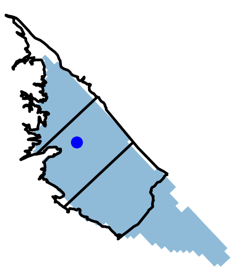
Water. Engineered.

Projected Groundwater Level
Well Name: Viking
Screen Interval (ft-bgs): 360 - 700

Figure 6a



Well Location



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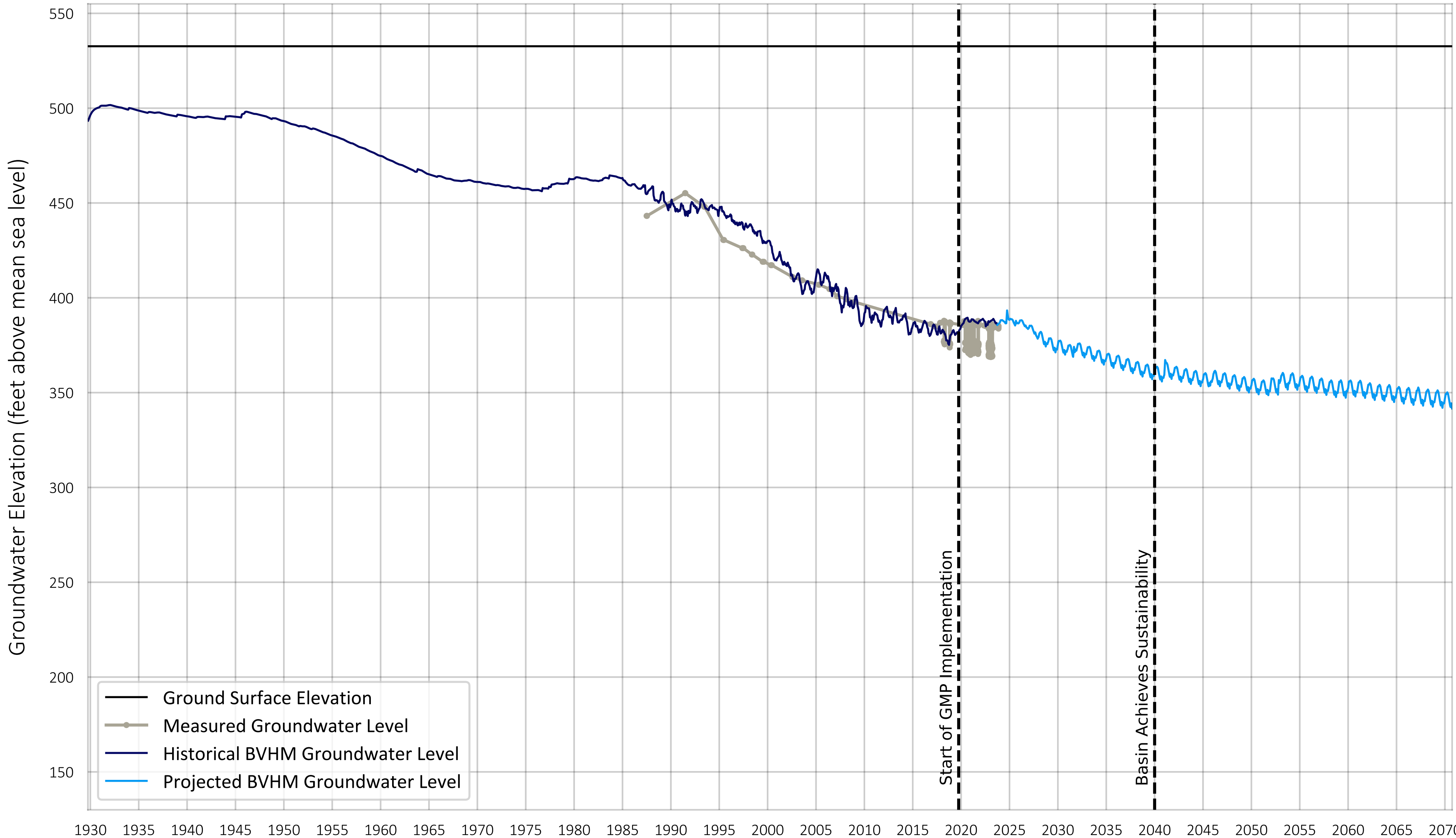
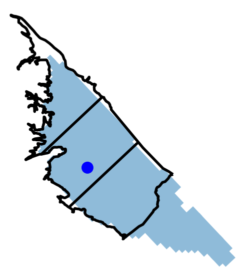
Projected Groundwater Level
Well Name: ID4-5
Screen Interval (ft-bgs): 520 - 640

Figure 6b



Well Location



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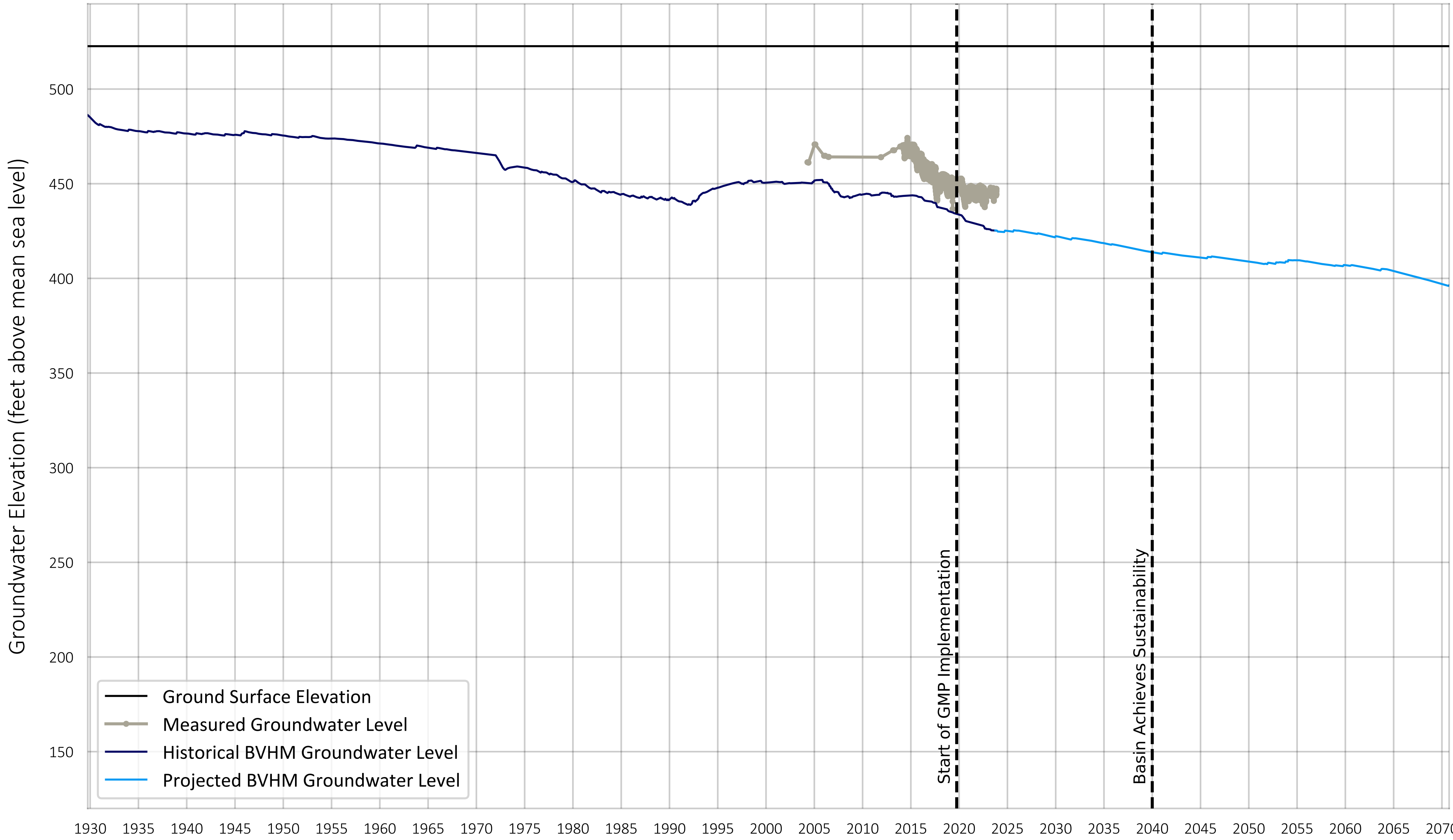
WEST YOST
Water. Engineered.

Projected Groundwater Level

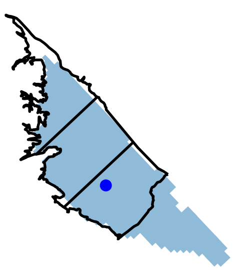
Well Name: ID1-12

Screen Interval (ft-bgs): 248 - 568

Figure 6c



Well Location



Prepared by:

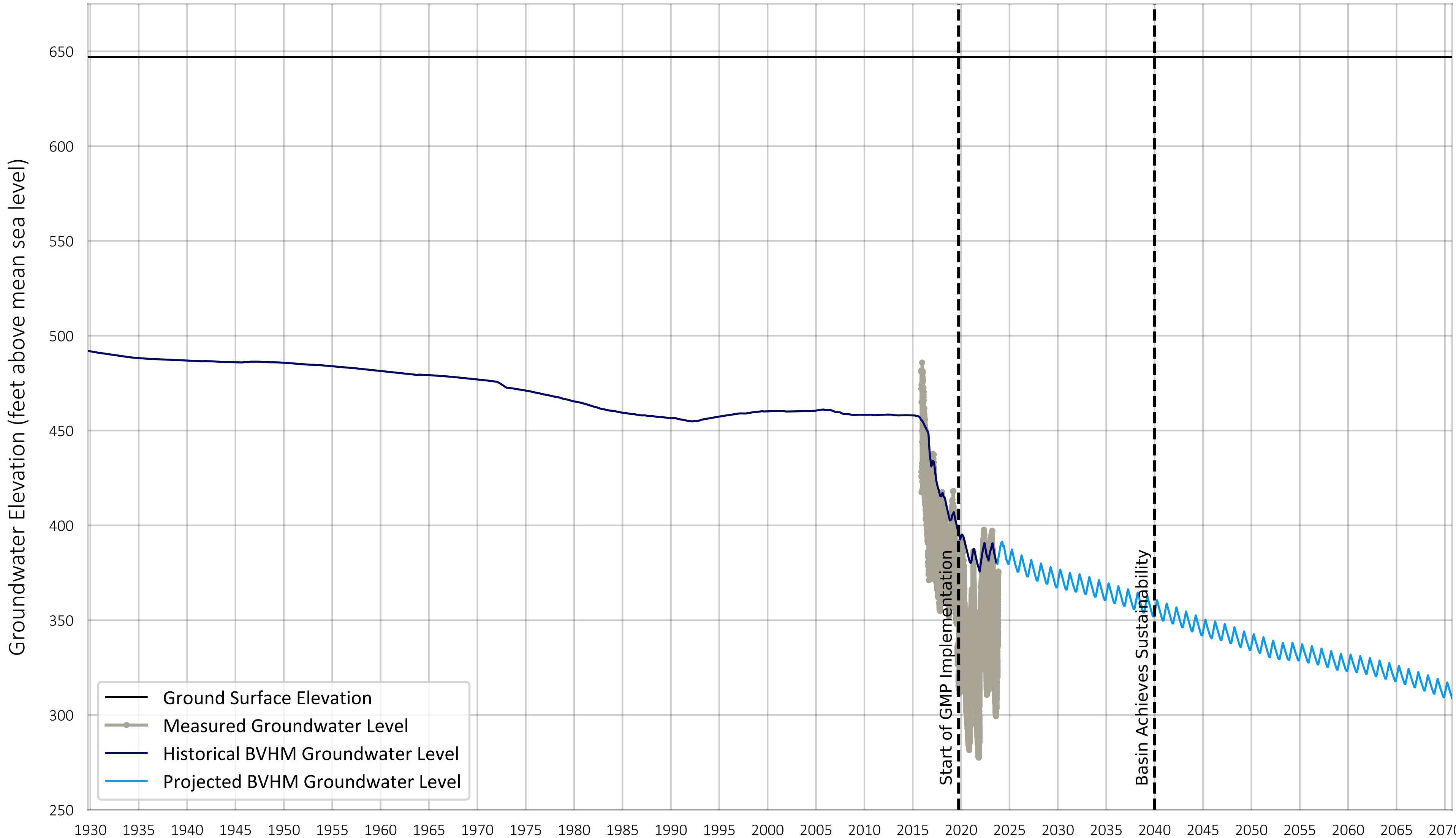
WEST YOST
Water. Engineered.

Projected Groundwater Level

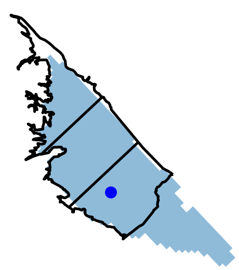
Well Name: MW-3

Screen Interval (ft-bgs): 175 - 331

Figure 6d



Well Location



Prepared by:

WEST YOST Water. Engineered.

Projected Groundwater Level
Well Name: RH-6
Screen Interval (ft-bgs): 238 - 938

Figure 6e

RECOMMENDATIONS AND NEXT STEPS

This section provides Watermaster with recommendations and options to fix the under-pumping discrepancy in the BVHM and use the BVHM projection results to evaluate the sustainability of the Sustainable Yield.

The recommended scope of work to address the under-pumping discrepancy is shown in Table 4 as a line-item scope-of-work and cost estimate, and includes four main tasks:

Task 1. Update the Hydrogeologic Conceptual Model (HCM)

The HCM is a description of the geometry, structure, layering, and hydraulic/storage properties of the aquifer system sediments of the Basin. There are new data/information available that could be used to update the HCM, particularly in the South Management Area where the under-pumping discrepancy is located (e.g*.,* Airborne Electromagnetic (AEM) surveys, new borehole/well information; pumping test results; high-frequency groundwater-level data recorded at wells, etc.). In addition, site-specific investigations and testing could be performed to better understand and characterize the hydrogeology of this portion of the Basin, if appropriate. These site-specific efforts are shown as an "optional" subtask in Table 4, and could include aquifer-system stress testing or analyses of existing pumping and high-frequency groundwater-level data that has been collected over the past several years in the South Management Area.

Once the new data/information is compiled, it could be compared against the current HCM in the BVHM and a proposal for BVHM updates could be prepared. The proposal would be run through the TAC/Board process for approval. With Board approval, the recommended updates to the BVHM would be made, and the BVHM would be used to re-run Scenario CS-1 RH to evaluate the effects of the updates on the projected groundwater levels and the under-pumping discrepancy. The BVHM results from this effort would be shared with the TAC and Board.

Task 2. Perform BVHM Recalibration

Model calibration is the process of adjusting model parameters during a historical model simulation to produce the best match between simulated and observed system responses, such as the time series of simulated and measured groundwater elevations at wells. The objective is to ensure that the model is an adequate simulator of the hydrology of the basin, including the water budget which is interpreted and used to estimate the Sustainable Yield.

To recalibrate the BVHM, input files would be prepared to perform calibration using manual adjustments and the parameter estimation code PESTPP-IES. Selected measured pumping and groundwater elevations would be used as calibration targets. During the model calibration, the values of aquifer parameters (such as hydraulic conductivity and storage coefficient) would be adjusted to minimize the differences between the model estimated and measured pumping and groundwater elevations. The calibration results would include a time series of simulated vs. measured values, along with calibration statistics and calculated residuals. The approach and results of the calibration would be documented in a TM and presented to the TAC. The TM would be finalized based on TAC comments.

Task 3. Use BVHM to Evaluate Future Basin Conditions under Variable Future Climate Conditions

After Task 2, the under-pumping discrepancy should be eliminated, and the BVHM could be used to simulate the pumping projections previously developed for WYs 2023 to 2070. The BVHM would be run through WY 2070 to predict future groundwater levels and storage in the Basin under the four future climate scenarios described in the *Future Hydrology and Climate* section (CS-1 RH, CS-2 RH30, CS-3 RH70, CS-4 D18).

Task 4. Evaluate BVHM Projection Results

In this task, the BVHM projection results from Task 3 would be evaluated to characterize the sustainability of pumping Rampdown to the Sustainable Yield. Specifically, the BVHM projection results would be analyzed for the following indications of sustainability:

a. *Trends in groundwater levels and storage are predominantly stable or increasing by 2040*. This analysis would be accomplished by preparing time-series charts of: (i) projected groundwater elevations for the Representative Monitoring Wells and (ii) projected total storage in the Basin. The time-series charts would be analyzed for stable or increasing trends by 2040 (and thereafter through 2070).
b. *Groundwater levels are at sufficient elevations to not cause Undesirable Results*. This analysis would be accomplished by comparing the 2040 projections for groundwater elevations and total storage against Minimum Thresholds.

These evaluations would be documented in a draft TM and presented to the TAC. The TM would be finalized based on TAC comments.

The potential outcomes of these evaluations are:

1. The BVHM projection results indicate that the pumping Rampdown to the **Sustainable Yield *is not sustainable***. This could be indicated by either BVHM projections of continuously declining groundwater levels after 2040 or the occurrence of undesirable results prior to or after 2040 (as defined above). In this case, the Watermaster would make policy and/or management decisions in efforts to achieve sustainability by 2040, and such decisions would likely need to be simulated and tested for sustainability with the BVHM (as a subsequent effort).
2. The BVHM projection results indicate that the pumping Rampdown to the **Sustainable Yield *is sustainable***. This would be indicated by BVHM projections of stable or increasing groundwater levels after 2040 and the absence of undesirable results prior to or after 2040 (i.e., no exceedances of Minimum Thresholds). In this case, no further BVHM simulations would be necessary.

The estimated cost to perform Tasks 1 through 4 (based on 2025 rates) ranges from about $240,000 to $260,000, depending on the inclusion of a $20,000 optional task to perform site-specific investigations in Task 1.[13]

[13] Note that this is a preliminary cost estimate that may be adjusted based on TAC input on the line-item scope of work.

Table 4. Cost Estimate for Tasks 1 through 4

Task No.	Task / Sub-Task	Labor Hours and Cost											
		Executive Director	Lead Technical Consultant	Principal Sci/Eng. II	Associate Sci/Goel/Eng. I	Staff Sci/Geo/Eng. II	Staff Sci/Geo/Eng. I	Field Technician	Administrative III/IV	Task Repetition Multiplier	Person Hours	Cost	
												Sub-Task	Total Cost
1	**Update the Hydrogeologic Conceptual Model (HCM)**	**8**	**80**	**34**	**220**	**74**	**74**	**48**	**5**	**10**	**543**		**$ 129,849**
1.1	***Evaluate new hydrogeologic information (pump test data, AEM survey data, well logs, etc.)***		***20***		***24***	***32***	***56***			***1***	***132***	***$29,634***	
1.1.1	Process and interpret AEM data		8		8	8	16			1	40	$9,226	
1.1.2	Collect and review new groundwater-level data, geologic data from well completion reports, pump test data, etc.		4		8	8				1	20	$4,945	
1.1.3	Prepare maps, charts, and hydrogeologic cross-sections		8		8	16	40			1	72	$15,463	
1.2	***Perform site-specific investigations to obtain new information (OPTIONAL)***		***12***	***2***	***16***	***24***		***48***		***1***	***102***	***$20,264***	
1.3	***Compare current HCM to new information***		***8***	***4***	***16***					***1***	***28***	***$7,691***	
1.3.1	Compare current aquifer parameters to new information		4	2	8					1	14	$3,845	
1.3.2	Compare current model structure to new information		4	2	8					1	14	$3,845	
1.4	***Propose recommended updates to HCM to the TAC***	***4***	***16***	***6***	***32***	***8***	***8***			***1***	***74***	***$19,491***	
1.4.1	Prepare draft TM	2	8	2	16	8	8			1	44	$11,044	
1.4.2	Conduct TAC meeting	1	4	2	8					1	15	$4,223	
1.4.3	Incorporate TAC comments into approach for revising HCM	1	4	2	8					1	15	$4,223	
1.5	***Update HCM in the BVHM***		***4***	***12***	***80***					***1***	***96***	***$24,332***	
1.6	***Run the BVHM with the updated HCM, compare water budgets, and check ability of wells to pump their assigned rates***		***4***	***4***	***20***					***1***	***28***	***$7,367***	
1.7	***Document results and present to the TAC***	***4***	***16***	***6***	***32***	***10***	***10***		***5***	***1***	***83***	***$21,070***	
1.7.1	Prepare draft TM and presentation	2	8	2	16	8	8		4	1	48	$11,660	
1.7.2	Conduct TAC meeting	1	4	2	8					1	15	$4,223	
1.7.3	Address TAC comments and finalize TM	1	4	2	8	2	2		1	1	20	$5,187	
2	**Perform BVHM Recalibration**	**4**	**26**	**20**	**152**	**10**	**0**	**0**	**5**	**9**	**302**		**$ 55,696**
2.1	***Prepare the input files for model calibration with PESTPP-IES***		***4***	***4***	***32***					***1***	***40***	***$10,247***	
2.2	***Calibrate the model***		***4***	***8***	***80***					***1***	***92***	***$23,049***	
2.3	***Prepare calibration results***		***2***	***2***	***8***					***1***	***12***	***$3,204***	
2.3.1	Develop time-series of simulated and measured values and other graphics		1	1	4					1	6	$1,602	
2.3.2	Generate calibration statistics and calculate residuals		1	1	4					1	6	$1,602	
2.4	***Document results***	***4***	***16***	***6***	***32***	***10***			***5***	***1***	***73***	***$19,197***	
2.4.1	Prepare a draft TM documenting the approach and results	2	8	2	16	8			4	1	40	$10,161	
2.4.2	Prepare for and conduct TAC meeting	1	4	2	8					1	15	$4,223	
2.4.3	Address TAC comments and finalize TM	1	4	2	8	2			1	1	18	$4,812	
3	**Use BVHM to Evaluate Future Basin Conditions under Variable Future Climate Conditions**	**0**	**2**	**4**	**24**	**0**	**0**	**0**	**0**	**12**	**120**		**$ 30,740**
3.1	***Create model input files for projection and climate scenarios***			***2***	***8***					***4***	***40***	***$10,247***	
3.2	***Run model through the projection period***				***8***					***4***	***32***	***$7,679***	
3.3	***QC model results***		***2***	***2***	***8***					***4***	***48***	***$12,814***	
4	**Evaluate BVHM Projection Results**	**5**	**29**	**6**	**42**	**0**	**24**	**0**	**5**	**17**	**165**		**$ 43,538**
4.1	***Generate time-series charts of groundwater-elevations at Rep. Monitoring Wells***		***1***		***2***					***4***	***12***	***$3,204***	
4.2	***Generate water budget***		***1***		***2***					***4***	***12***	***$3,204***	
4.3	***Calculate change in storage***		***1***		***2***					***4***	***12***	***$3,204***	
4.4	***Evaluate BVHM projection results for sustainability by 2040 and thereafter***	**1**	**4**		**4**					***4***	***36***	**$10,485**	
4.5	***Document results***	***4***	***22***	***6***	***32***		***24***		***5***	***1***	***93***	***$23,441***	
4.5.1	Prepare a draft TM documenting results and interpretations	2	12	2	16		16		4	1	52	$12,701	
4.5.2	Prepare for and conduct TAC meeting	1	4	2	8					1	15	$4,223	
4.5.3	Address TAC comments and finalize TM	1	6	2	8		8		1	1	26	$6,517	
	Total (without OPTIONAL task)	**17**	**125**	**62**	**422**	**60**	**98**	**0**	**15**		**1,028**		**$ 239,558**
	Total (with OPTIONAL task)	**17**	**137**	**64**	**438**	**84**	**98**	**48**	**15**		**1,130**		**$ 259,822**

Options for Implementation of Recommendations

There are two primary options for implementing the recommended tasks, and each option has advantages and disadvantages.

1. Perform all four tasks immediately in WYs 2025 and 2026.
   a. Advantages:
      i. Rapid improvements to the BVHM that the Watermaster could more confidently use to assess sustainability and test policies and management actions that are designed to achieve sustainability by 2040.
      ii. The ability to more confidently report on the likelihood of achieving sustainability by 2040 and thereafter (under the Rampdown to the 2025 Sustainable Yield) in the Five-Year Assessment Report due to the DWR by June 25, 2026.
      iii. Long-term costs will likely be lower because the work is being completed sooner and hence will avoid longer-term inflation.
   b. Disadvantages:
      i. Immediate costs will be higher due to the condensed schedule.
      ii. Identifying and acquiring grant funding to offset costs will take time and additional funding.
      iii. The BVHM may need an additional recalibration in WY 2029 for the 2030 redetermination of the Sustainable Yield, if results from the approved 2030 scope-of-work[14] indicate the need for BVHM recalibration following assessment of the Groundwater Dependent Ecosystem (GDE) study results and new monitoring data (pumping and water levels), which is due to be completed by the end of WY 2027.
2. Perform the four tasks incrementally as part of the scope to Redetermine the 2030 Sustainable Yield over WYs 2026 through 2029.
   a. Advantages:
      i. Immediate costs will be lower due to spreading the work out over four years.
      ii. More time is available to identify and solicit grant funding to support the work.
      iii. The work could be integrated into the planned Watermaster efforts to assess new data and information that may necessitate BVHM improvements and recalibration (e.g., GDE study results and new monitoring data), which may achieve efficiencies and avoid multiple recalibrations.

[14] At its December 19, 2024 Special Board meeting, the Watermaster Board approved a scope of work and budget to redetermine the 2030 Sustainable Yield. The approved scope included two tasks using: 1) GDE study results, and 2) Monitoring Program Data (groundwater-levels and metered pumping). The scope is described in more detail in the Item IV.A of the Board meeting agenda package, available here: https://borregospringswatermaster.com/wp-content/uploads/2024/12/20241219_Board-Agenda-Package.pdf

b. Disadvantages:

   i. BVHM updates would occur in later years, limiting its usefulness to the Watermaster in the meantime as a tool to perform assessments of sustainability and to test proposed policies and management actions that are designed to achieve sustainability.

   ii. More conservative and protective management strategies will likely be necessary given the higher uncertainty in future groundwater conditions, namely due to a concern that the future pumping plan may not be sustainable in the Central and South Management Areas.

   iii. Long-term costs may be greater due to inflation.

Next Steps

This TM and its recommendations will be presented to the TAC and Board for input and direction.