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TECHNICAL MEMORANDUM

DATE: January 28, 2022 **PROJECT #:** 9150.0504

TO: Bob Jaques, Technical Program Manager, Seaside Basin Watermaster

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PROJECT: Seaside Basin Watermaster

SUBJECT: Updated Modeling of Seaside Basin Replenishment Options

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INTRODUCTION

Background

In April 2013, HydroMetrics Water Resources Inc. (now acquired by Montgomery & Associates) completed a groundwater modeling study that evaluated 3 potential future scenarios:

- **Scenario 1**: A 25-year groundwater overpumping replenishment program proposed by California American Water (Cal-Am) which replenishes their overpumping by in-lieu recharge through reducing pumping from their Seaside Basin wells production wells
- **Scenario 2**: A set of pumping reductions by Standard and Alternative Producers to achieve protective groundwater levels over a 25-year period
- **Scenario 3**: Cal-Am's replenishment plan coupled with additional injection into the Santa Margarita aquifer to achieve protective elevations in 25 years

Scenario 1 did not achieve protective elevations as 700 acre-feet per year (AFY) is not enough replenishment to raise groundwater levels to protective elevations at coastal wells, therefore this option was not included as part of this updated modeling of replenishment options.

Under Scenario 2, a pumping reduction by Standard and Alternative Producers of just over 2,000 AFY (including Cal Am's 700 AFY reduction) was needed to achieve protective groundwater levels at the coast. Since Scenario 2 is not a practical solution because Standard and Alternative producers do not have access to supplemental sources of water, it was not included as part of this updated modeling of replenishment options.

The results of Scenario 3 showed that when combined with Cal-Am's 25-year repayment schedule of 700 AFY, protective groundwater elevations can be achieved by injecting an additional 1,000 AFY of water into existing Aquifer Storage & Recovery (ASR) wells.

Recharged water is left in the basin to replenish the over drafted aquifers and is not pumped by Standard or Alternative producers. This approach requires less supplemental water to implement than the pumping reduction approach for Scenario 2.

The predictive simulation for the 2013 scenarios only considered historical Carmel River ASR by Monterey Peninsula Water Management District (MPWMD) and not Pure Water Monterey (PWM), since in early 2013 PWM was only in the beginning planning stages.

UPDATED BASELINE MODEL

Baseline Project

In this Technical Memorandum the term “baseline simulation” refers to the simulation of future conditions assuming only operation of currently planned projects with no additional replenishment added. The baseline simulation includes:

- Using the new hydrology described in the section below
- ASR injection - tied to the new hydrology
- Cal-Am's 25 year 700 AFY in-lieu replenishment
- PWM Expansion project (tied to the new hydrology)
- All the other planned projects described in the section below titled “Existing and Planned Projects” (e.g., Seaside Golf Courses shift to recycled water, Security National Guaranty (SNG) and Campus Town developments, etc.)
- No other sources of replenishment water

In other words, the baseline represents the "do nothing" scenario without the addition of any replenishment water.

Extend and Update Baseline Period and Hydrology

Previous predictive model simulations have been based on repeating the historical hydrology from the original 22-year model calibration period of 1987–2008 (referred to hereafter as “the historical model”). Previous predictive simulations run from 2009 through 2042. While maintaining this approach allows for direct comparison between new and previous simulations, it does not take advantage of the additional 9 years of hydrologic and climatic data that have been incorporated into the historical model. The historical model was updated in 2014 and 2018, and now includes a continuous 31-year hydrologic record from January 1987 through December 2017 (HydroMetrics WRI, 2014, 2018). Significantly, this 31-year hydrologic record includes both the 1987–1991 drought and the recent 2012–2015 drought. Climate change models predict increasing variability in temperature and precipitation, and using this extended historical hydrology and climate dataset as the basis for all predictive modeling incorporates a broader range of potential climate variability into the simulations. While previous predictive groundwater models used a calendar year basis, the updated predictive model is now based on water year (WY).

The updated baseline model simulates a 33-year period from October 2017 through the end of September 2050 (WY 2018–2050). The hydrology (rainfall, recharge, and streamflow) for WY 2018–2021 is based on measured values, while the hydrology for WY 2022–2050 is simulated by repeating the hydrology record from WY 1988–2016, as illustrated on Figure 1 and detailed in Table 3.

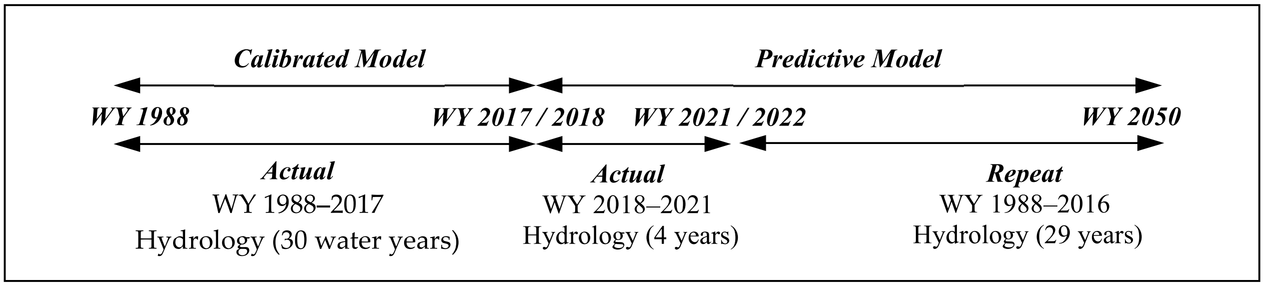


Figure 1: Repetition of Hydrology for Predictive Model

The 2013 replenishment modeling effort assumed protective groundwater elevations must be reached within 25 years from the time supplemental water is available to offset pumping (assumed at that time to begin in 2016) thereby resulting in protective elevations being reached in 2041. Per the TAC's direction for this model update of replenishment options, the model is used to determine how much replenishment water is needed to achieve protective coastal groundwater elevations in 20 years. Extending the hydrology to WY 2050 covers the 20-year target to be used for evaluating replenishment volumes that achieve protective elevations and also covers the entire 25-year Cal-Am repayment period.

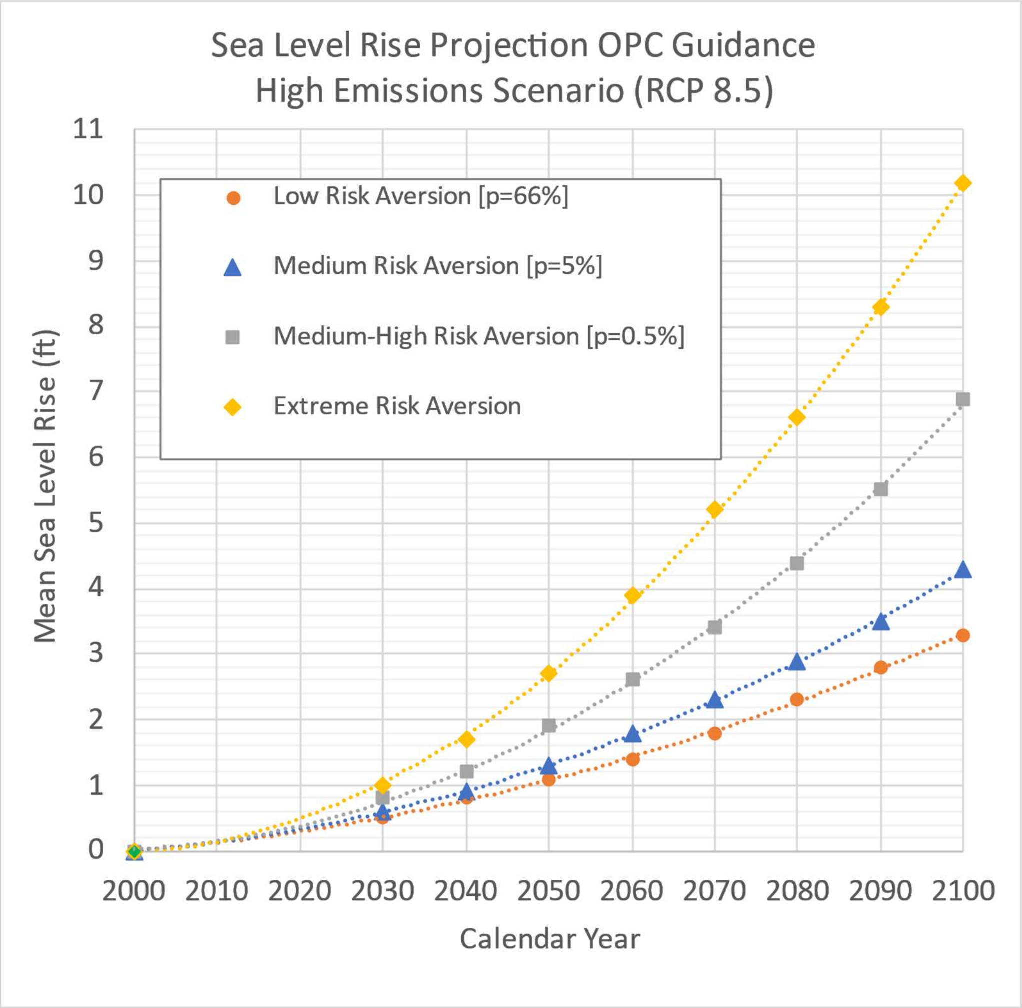
Actual hydrology and measured pumping and injection rates are used for WY 2018–2021, with the following WY 2022–2050 period using projected production and injection rates as described in the sections below.

The update of hydrology also included an update of the estimated shallow groundwater recharge from percolation of precipitation based on the new updated hydrology cycle, while the irrigation return flow, ponds, system losses, and septic systems are based on the previously modeled estimates.

Incorporating of Sea Level Rise at Ocean Boundaries

Estimates of projected sea level rise (SLR) through WY 2050 are incorporated into the predictive model simulation by adjusting the freshwater equivalent head boundary conditions specified along the ocean boundary. The mean sea level rise (MSLR) estimate is based on one of the scenarios of the projected MSLR for Monterey Bay from the 2018 update of the State of California Sea-Level Rise Guidance document recently released by the California Ocean Protection Council (OPC, 2018), shown on Figure 2. The State of California considers the SLR projections in the OPC guidance document to represent the current best available science. The OPC guidance presents projections for 2 different possible future greenhouse gas emissions scenarios: a low emissions scenario, RCP 6.2, which would result in lower future MSLR, and a high emissions scenario, RCP 8.5, which would generally result in higher future SLR. The term "RCP" is short for Representative Concentration Pathway, and in combination with the number, 6.2 or 8.5, refers to a specific carbon emissions scenario included in the Intergovernmental Panel on Climate Change 5th Assessment Report (IPCC, 2014). RCP 8.5 is considered the high-end "business-as-usual" fossil fuel intensive scenario and is chosen for incorporation in the updated baseline groundwater model simulation to represent a conservative emissions scenario that will maximize potential future SLR.

The SLR projections from the OPC guidance document are developed by running many simulations (an ensemble) of global climate models based on a specific assumption on the global response to climate change (e.g., how quickly we cut emissions). Each individual simulation results in a specific SLR prediction, and when the results from this ensemble of predictions are looked at statistically, a probability of SLR exceeding a certain level can be defined. For a given emissions scenario, the probability value, *p*, shown in the legend entries of Figure 2 represents the likelihood that SLR will meet or exceed the sea level value shown on the chart. So for example, looking at the curve for the medium risk (*p*=5%) projection this can be understood as saying that for the RCP 8.5 emissions scenario there is a 1-in-20 chance that SLR will be equal to or greater than the values shown on the chart each year. In contrast, the *p* = 0.5% curve represents that there is a 1-in-500 chance that seal level rise will meet or exceed the values on that curve. In consultation with the TAC, the High Emissions, Medium Risk [PB1][PB2]Aversion scenario (blue trianlges on Figure 2) was selected, which projects a mean SLR of at least 1.3 feet by 2050. As the protective head elevations are tied to mean sea level, a simple equivalent adjustment to the protective head elevations is made by increasing the protective elevations by the projected SLR over time. For WY 2018–2021 measured values of actual MSLR for the Monterey Bay (NOAA, 2021) are used, while projected MSLR is used for WY 2022–2050.



[PB3]

Figure 2. Projections of Rise in Mean Sea Level[PB4][PB5][PB6]

Projected Groundwater Pumping

The assumptions used for projected groundwater pumping are:

1. Actual reported pumping within the Seaside basin is used for WY 2017–2021. Projected Standard and Alternative Producer pumping are set at the 5-year average of measured WY 2017–2021 pumping shown in Table 1 from WY 2022 and onward, with a few specific exceptions described in the next section. This assumption means that some of the producers are assumed to pump less than their allocations. Projected pumping for all Standard Producer and Alternative Producers stays within their safe yield allocations of native Seaside basin groundwater from WY 2022 onward, except for City of Seaside, whose 5-year WY 2017–2021 average of 182 AFY exceeds their current municipal allocation of 120 AFY.

Table 1. Five-Year Average (WY 2017-2021) Standard and Alternative Producer Pumping [PB7][PB8][PB9]

Sub-Area and Producer	WY2017-2021 Average (AFY)	Natural Safe Yield Allocation (AFY)
Coastal and Northern Inland	**2,741***	**2,367**
Calabrese	0	12
Cal-Am	2,048*	1,474
Mission Memorial Park	22	31
City of Seaside (golf course)	487	540
City of Seaside (municipal)	182	120
SNG	1	149
Sand City	1	9
Granite Rock Company	0	11
DBO Development No. 30	0	21
Laguna Seca	**575**	**644**
Cal-Am**	153	0
LS County Park	19	41
LS Golf Resort (Bishop)	206	320
The Club at Pasadera	181	251
York School	16	32

*Includes non-native PWM & ASR recovery
** Set to 0 AFY in WY2022 and onward

2. Cal-Am ceases pumping from the Ryan Ranch and Bishop Units in the Laguna Seca subarea starting in WY 2021. Pumping continues from the Hidden Hills Unit which is located just outside the Laguna Seca subarea.

3. Cal-Am's projected demand and pumping schedule for WY 2022–2050 is based on an updated version of the spreadsheet supply-demand forecast model originally developed by MPWMD for use in the 2019 PWM Expansion Supplemental Environmental Impact Report (SEIR) modeling (MPWMD, 2019). This is described in more detail below.

4. Private pumping within the Seaside Basin was based on repeating the estimated WY2017 rates for private produces from the calibrated Seaside historical model. [PB10][PB11][PB12][PB13]

5. Pumping rates for adjacent subbasins remain as they currently are and do not assume that[BG14][PB15][PB16] any projects included in their respective GSPs are implemented.

6. Pumping outside the Seaside basin in the Corral de Tierra and Toro Creek areas of the Monterey Subbasin is based on repeating the most recently estimated pumping rates from the

calibrated Seaside historical model period, with the exception of Cal-Am Hidden Hills pumping which is based on the 5-year average of reported pumping for WY 2017–2021 of 128 AFY[PB17][PB18].

7. Pumping by the Marina Coast Water District (MCWD) is not explicitly simulated in the model but is represented by proxy via the prescribed constant head boundary along the model boundary in the Marina/Ord area. These are assumed to remain the same as in the calibrated historical model, and do not reflect any impacts from GSP projects.

8. Golf course irrigation pumping both within and outside the Seaside basin matches the historical pumping aligned with the cycled historical hydrology. In a few cases where the historical pumping record was not consistent or complete, an average rate is used. Another exception is the change in the City of Seaside golf course water supply described in the next section.

Existing and Planned Projects

Assumptions regarding existing and planned projects are:

1. Carmel River ASR injection quantities are assumed to be the same as current operations based on cycled historical Carmel River hydrology. Projected Carmel River diversion and ASR injection schedule is described in more detail in a subsequent section.

2. The Pure Water Monterey (PWM) base injection averages 3,500 AFY beginning in WY 2020 with the PWM Expansion project increasing to an annual average of 5,750 AFY assumed to start in WY 2024. Actual measured monthly injection rates for WY 2020–2021 are used followed by a projected injection schedule for the remainder of the simulation, using the injection delivery spreadsheet previously developed for the PWM project modeling and updated for the simulated future hydrology. The PWM recharge assumptions are described in more detail in a subsequent section of this technical memorandum.

3. Cal-Am's 700 AFY reduction in pumping of native groundwater as part of its 25-year groundwater over-pumping replenishment program is assumed to start in WY 2024, following completion of the PWM Expansion Project. The repayment period stops at the end of WY 2048. Note that Cal Am's agreement with the Watermaster requires it to repay all of its overpumping since the date of issuance of the Adjudication Decision. The amount that must be repaid may require the pumping reduction to extend beyond 25 years.

4. The SNG development is supplied water from Cal-Am wells under an agreement with Cal-Am. As part of the agreement, Cal-Am uses SNG's native groundwater water right of

149.7 AFY to meet the project demand. The SNG development is assumed to be completed in 2025 with usage starting at 25 AFY in 2025 and ramping up to 30 AFY in 2026, 50 AFY in 2027, and 70 AFY from 2028 onward. Annual usage is allocated monthly based on the historical monthly demand percentages the Cal-Am Monterey District used in the MPWMD Cal-Am Demand-Supply model developed for the PWM Expansion SEIR.

5. The City of Seaside replaces its golf course irrigation with PWM recycled water starting in WY 2023 and through its agreement with the Watermaster uses its 540 AFY golf course irrigation allocation to augment their municipal water system's allocation to meet demand of the Campus Town development project. The groundwater model assumes that this pumping will be produced by their municipal Well #4. This results in a decrease in pumping of approximately 480 AFY from the 2 irrigation wells screened in the shallow Paso Robles aquifer but will result in an increase in pumping in the deeper Santa Margarita aquifer[1]. Based on information provided by the City of Seaside on projected total water use and construction timeline, the Campus Town project is assumed to begin in WY 2023 with usage starting at 100 AFY in 2023, 130 AFY in 2024, 215 AFY in 2025, and reaching a maximum of 301.1 AFY in 2026. The annual usage was allocated monthly based on the historical monthly demand percentages for the Cal-Am Monterey District used in the MPWMD Cal-Am Demand-Supply model developed for the PWM Expansion SEIR and was added to the projected existing City of Seaside municipal pumping demand projections.

Predicted Carmel River Flow Diversions and ASR Injection Assumptions

The amount of Carmel River water available for diversion for ASR injection and for Cal-Am's Table 13[2] diversions [PB19][PB20]used to meet Cal-Am system demand for the predictive simulation period is based on historical streamflow records. Because the future simulated hydrology is based on the historical hydrology of WY 1988–2016, the projected streamflow is taken as being the same as the historical streamflow and used as the basis for determining when and if diversions can occur. As part of the PWM Expansion SEIR modeling (MPWMD, 2019a), MPWMD staff compared historical daily streamflow between WY 1987 and WY 2008 with daily minimum streamflow requirements. This allowed MPWMD to identify how many days in each month ASR water could be diverted from the Carmel River. Using an assumed daily

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[1] In the Seaside model, the Muni #4 is represented as being screened in both the Paso Robles and the Santa Margarita formations, although there is some uncertainty as to whether Seaside Muni #4 is in fact screened in both aquifers, or only one of them (J. Lear, personal communication., September 2021).

[2] Table 13 diversions refers to a streamflow-dependent water right that Cal-Am can use in its Carmel River well fields as identified in Table 13 of SWRCB Decision 1632 (1995). It is in addition to Cal-Am's entitled 3,376 AFY water right from the Carmel Valley basin with no streamflow restrictions.

diversion rate of 20 AF per day[3], MPWMD estimated the volume of Carmel River water that could be injected into the ASR system each month. The analysis has been updated as part of this study and extended to include Carmel River streamflow data through WY 2021 and used to develop a revised projected monthly Carmel River diversion schedule for the baseline model. The Carmel River water available for injection was divided between the ASR 1&2 Well Site and the ASR 3&4 Well Site according to the historic division of injection. The projected annual ASR injection and Cal Am Table 13 diversions are shown below on Figure 3. The projected period starts off during a multi-year drought[4], such that there are almost no diversions in the first 4 projected water years, followed by a period that includes multiple years of Above Normal and Extremely Wet conditions which allow for very high amounts of diversion. Table 1 lists the average number of projected annual diversion days, total ASR diversions, and Table 13 diversions for each Carmel River water year type, based on the analysis of historical daily stream flows from WY 1987–2021. Note that the allowable diversion for ASR injection can easily drop by half even in just in going from a Normal water year to a Below Normal water year.

Note that the approach of tying the ASR injection volumes directly to the cycled hydrology period differs from the previous 2013 replenishment modeling where a constant average annual ASR injection volume of 1,445 AFY, characteristic of Normal water year conditions was assumed.

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[3] Historically, the diversion rate has been between 10–15 AF per day. The 20 AF diversion capacity assumes that planned improvements to increase the capacity of the Cal-Am Carmel River well field are implemented (Jon Lear, personal communication, January 21, 2022).

[4] Corresponding to the historical 1987–1991 drought

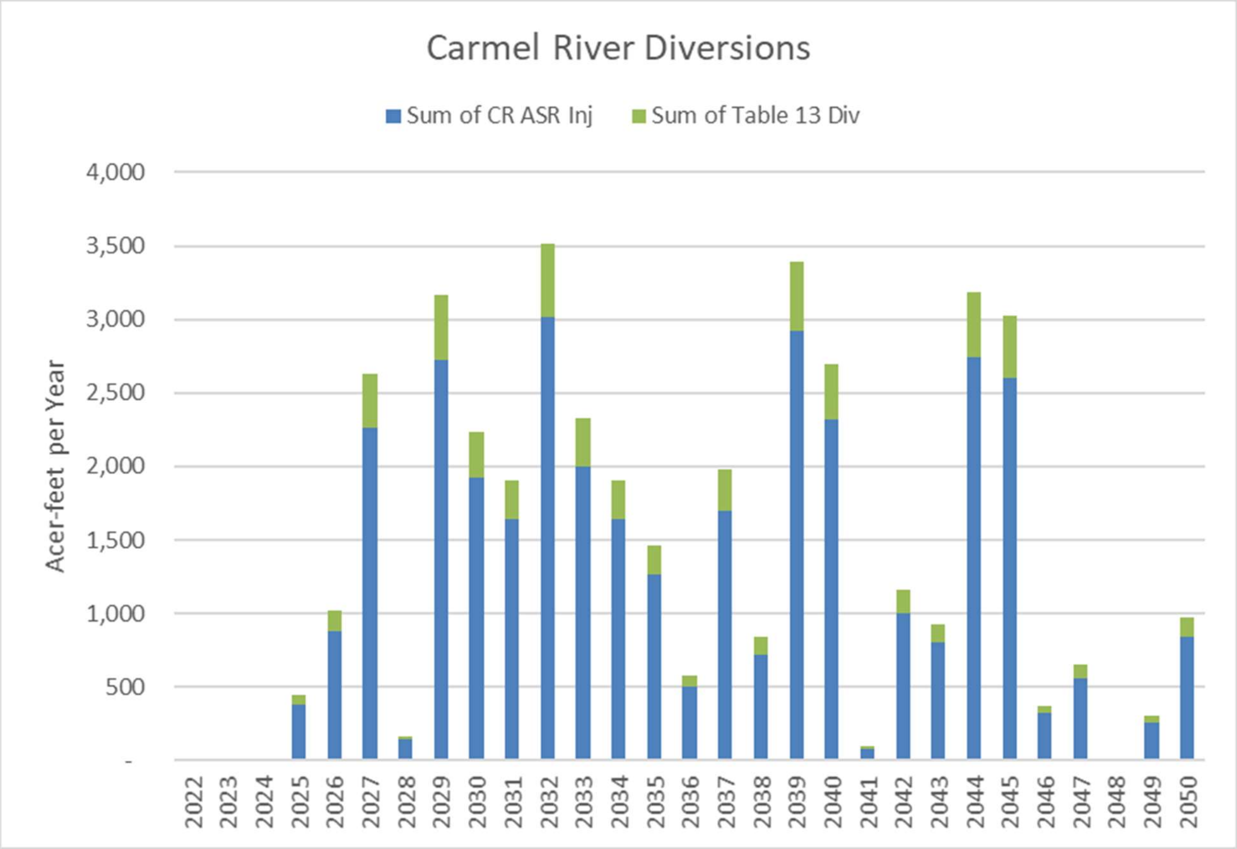

Figure 3. Projected Annual Carmel River Diversion for ASR Injection and Cal-Am Table 13 Diversions (CR = Carmel River)

Table 2. Projected Average Annual Carmel River Diversions by Water Year Type

Carmel River Water Year Type	Average Number Diversion Days	Average ASR Diversions (AFY)	Average Table 13 Diversions (AFY)	Average Total Diversions (AFY)
Extremely Wet	142	2,847	463	3,309
Wet	125	2,500	406	2,906
Above Normal	105	2,108	343	2,451
Normal	64	1,274	207	1,481
Below Normal	33	655	106	761
Dry	19	380	62	442
Critically Dry	3	51	8	60

Table 3. Annual Summary of Updated Baseline Simulation Water Year Types, Data Sources, and Major Project Events

Water Year	Carmel River Water Year Type	Hydrology Source Water Year	Pumping & Injection	Cal-Am Repayment Year	Project Timelines
2018	Below Normal	Actual	Actual		
2019	Extremely Wet	Actual	Actual		
2020	Normal	Actual	Actual		**PWM Base Project Begins (3,500 AFY)**
2021	Critically Dry	Actual	Actual		Cal-Am ceases pumping in Laguna Seca subbarea
2022	Critically Dry	1988	Projected		PWM ramps up to 4,100 AFY
2023	Critically Dry	1989	Projected		**Seaside GC's shift to PWM water**, Campus Town begins (100 AFY)
2024	Critically Dry	1990	Projected	**1**	**PWM Expansion Begins (5,750 AFY)**, Campus Town ramp up (130 AFY)
2025	Dry	1991	Projected	**2**	SNG begins (25 AFY), Campus Town ramp up (215 AFY)
2026	Normal	1992	Projected	**3**	SNG ramp up (30 AFY), Campus Town full capacity (301 AFY)
2027	Wet	1993	Projected	**4**	SNG ramp up (50 AFY)
2028	Critically Dry	1994	Projected	**5**	SNG full Capacity (70 AFY)
2029	Extremely Wet	1995	Projected	**6**	
2030	Above Normal	1996	Projected	**7**	
2031	Above Normal	1997	Projected	**8**	
2032	Extremely Wet	1998	Projected	**9**	
2033	Normal	1999	Projected	**10**	
2034	Above Normal	2000	Projected	**11**	
2035	Normal	2001	Projected	**12**	
2036	Below Normal	2002	Projected	**13**	
2037	Normal	2003	Projected	**14**	
2038	Below Normal	2004	Projected	**15**	
2039	Wet	2005	Projected	**16**	
2040	Wet	2006	Projected	**17**	
2041	Critically Dry	2007	Projected	**18**	
2042	Normal	2008	Projected	**19**	
2043	Normal	2009	Projected	**20**	
2044	Above Normal	2010	Projected	**21**	
2045	Above Normal	2011	Projected	**22**	
2046	Dry	2012	Projected	**23**	
2047	Dry	2013	Projected	**24**	
2048	Critically Dry	2014	Projected	**25**	**Final Year of Cal-Am Repayment Period**
2049	Dry	2015	Projected		
2050	Below Normal	2016	Projected		

Pure Water Monterey Project Recharge Assumptions

Pure Water Monterey Base Project WY 2020–2023

The PWM project is a recycled water supply project that became operational in March 2020. It injects and stores purified recycled water in the Seaside basin temporarily for use as source of municipal water supply. Once injected into the Seaside Basin, the purified water mixes with native groundwater in the aquifers and is stored for future extraction and use. PWM currently provides 3,500 AFY of supply for Cal-Am to deliver to its customers in the Monterey Service district, allowing Cal-Am to reduce its diversions from the Carmel River system by that same amount.

The PWM Project also includes a drought reserve component to support the use of recycled water for agricultural irrigation during dry years. The project provides an additional 200 AFY of purified water that will be injected in the Seaside Basin in wet and normal years for up to 5 consecutive years. This will result in a banked drought reserve totaling up to 1,000 AF. During dry years, the project will inject less than 3,500 AF of water in the Basin; however Cal-Am will be able to extract the banked water to make up the difference in supply. Recycled water that would have otherwise been purified and injected during these dry years when the drought reserve is in use will be sent to augment the Castroville Seawater Intrusion Project's (CSIP) agricultural irrigation supply in the Salinas Valley. Because the drought reserve component has not yet been agreed to by the CSIP growers, it is not currently active. However, it is assumed in the model to start in WY 2024 when the Expansion Project is projected to come online.

PWM purified water is recharged through 4 deep injection wells (DIW) screened in the Santa Margarita Formation (deep aquifer), and 2 vadose zone wells (VZW) screened in the Aromas Sands that recharge the Paso Robles Formation (shallow aquifer). PWM water from back-flushing of the DIW wells as part of weekly maintenance operations is discharged to percolation ponds also recharging the shallow aquifer. In the model, recharge to the shallow aquifer from the VZW wells and the percolation ponds is simulated by applying it as additional percolation at the water table beneath the recharge locations.

The PWM base project is simulated from WY 2020 through WY 2023. For WY 2020–2021 the simulation uses the actual monthly recharge volumes to the 4 currently operational recharge wells, DIW-1; DIW-2; VZW-1; and VZW-2, and to the percolation ponds used for discharging backflush water. It should be noted that as originally planned, 70% of the recharged water (~2,450 AFY) would recharge the Santa Margarita Formation and 30% (~1,050 AFY) would recharge the Paso Robles Formation. However, once injection operations began in spring of 2020 it was found that the VZW wells had a much lower capacity than originally planned for, and the recharge distribution is currently closer to 95% to the Santa Margarita aquifer and only 5% to the Paso Robles aquifer. The updated model takes this new distribution into account.

For WY 2022–2023, the model uses projected recharge rates developed for recent modeling of the PWM project included in the recently submitted Addendum to the PWM Title 22 Engineering Report (M&A, 2021). This period includes a planned ramp up from an annual recharge rate of 3,500 AFY to include an additional 600 AFY of recharge for total of 4,100 AFY[PB21][PB22] [5]. The modeling also includes bringing online the 2 additional recently constructed deep injection wells, DIW-3 and DIW-4, assumed to become operational in WY 2022. The actual and projected injection rates to the DIW wells and to the VZW wells backflush percolation ponds are shown below on Figure 4. Recharge at the VZW wells is assumed to remain at the same monthly rates as in WY 2021. Additional backflush water for each additional DIW well is also added to percolation pond recharge volumes in the simulation.

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[5] A brief description of the proposed ramp up is found in the recent request to Water Board to amend the PWM operating permit: "Submittal of Report of Waste Discharge, Amendment of Pure Water Monterey WDRs–WRRs," October 2021: https://documents.geotracker.waterboards.ca.gov/regulators/deliverable_documents/2069074332/M1W%20PWM%20cover%20letter%20ROWD%2029Oct2021_.pdf

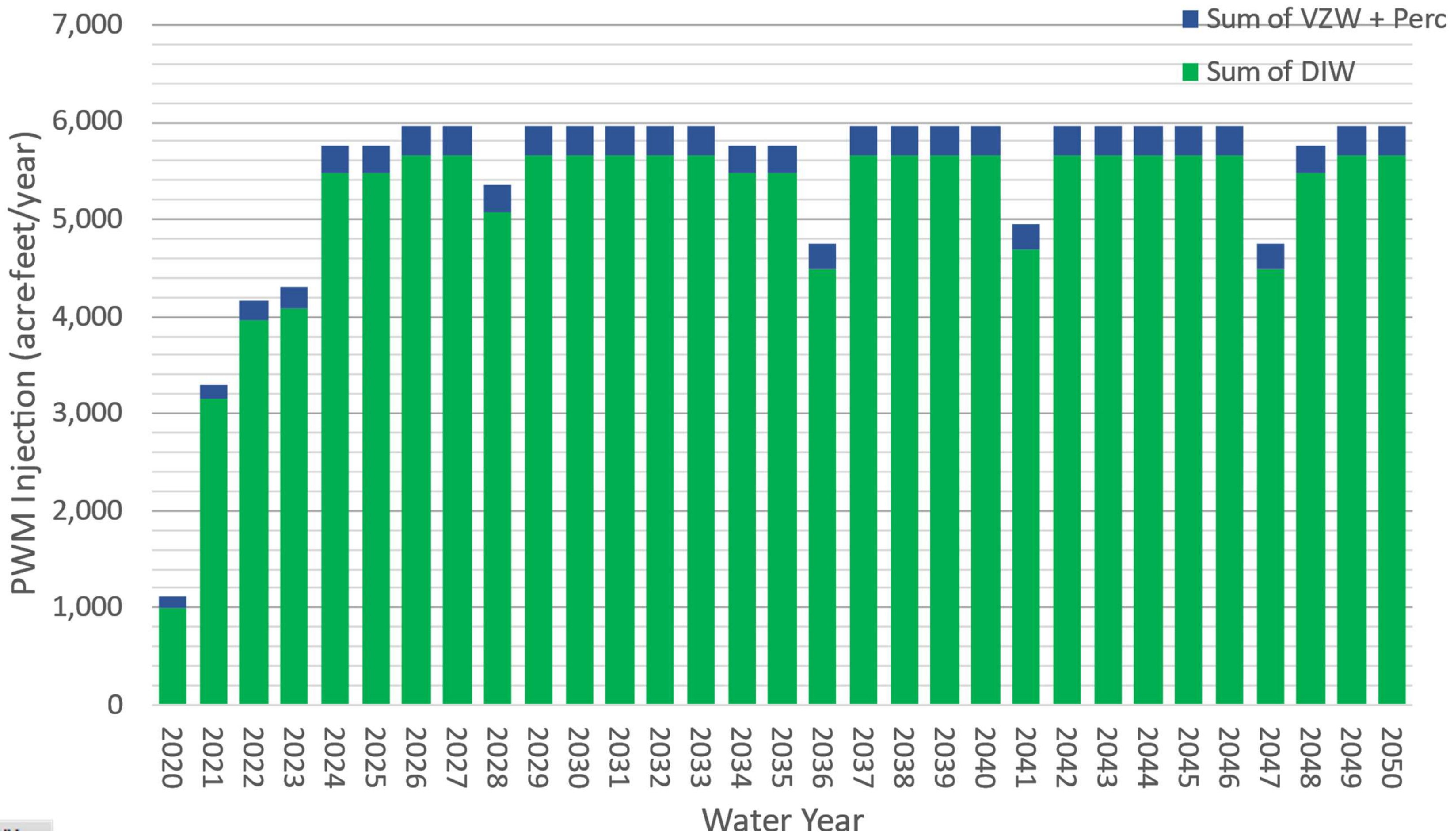

Figure 4. Actual and Projected Annual PWM Recharge to the Deep Aquifer (DIW wells) and the Shallow Aquifer (VZW & Percolation Ponds)

Pure Water Monterey Expansion Project (WY 2024-2050)

The proposed PWM Expansion project is assumed to come online in WY 2024 and includes an expanded capacity of the advanced water purification facility and an increase of recharge to the Seaside Basin by an additional 2,250 AFY for a total average yield of 5,750 AFY. Up to 3 additional deep injection wells and an additional backflush basin are proposed for the expansion project.

For Cal-Am to extract additional injected groundwater, deliver it to meet its system demands at all times, and also provide system redundancy, 4 new extraction wells and associated infrastructure would be constructed. These include 2 new extraction wells located at Seaside Middle School (EW-1 and EW-2), and 2 new extraction wells located off General Jim Moore Boulevard (EW-3 and EW-4). The location of these additional wells and pond are shown on Figure 5.

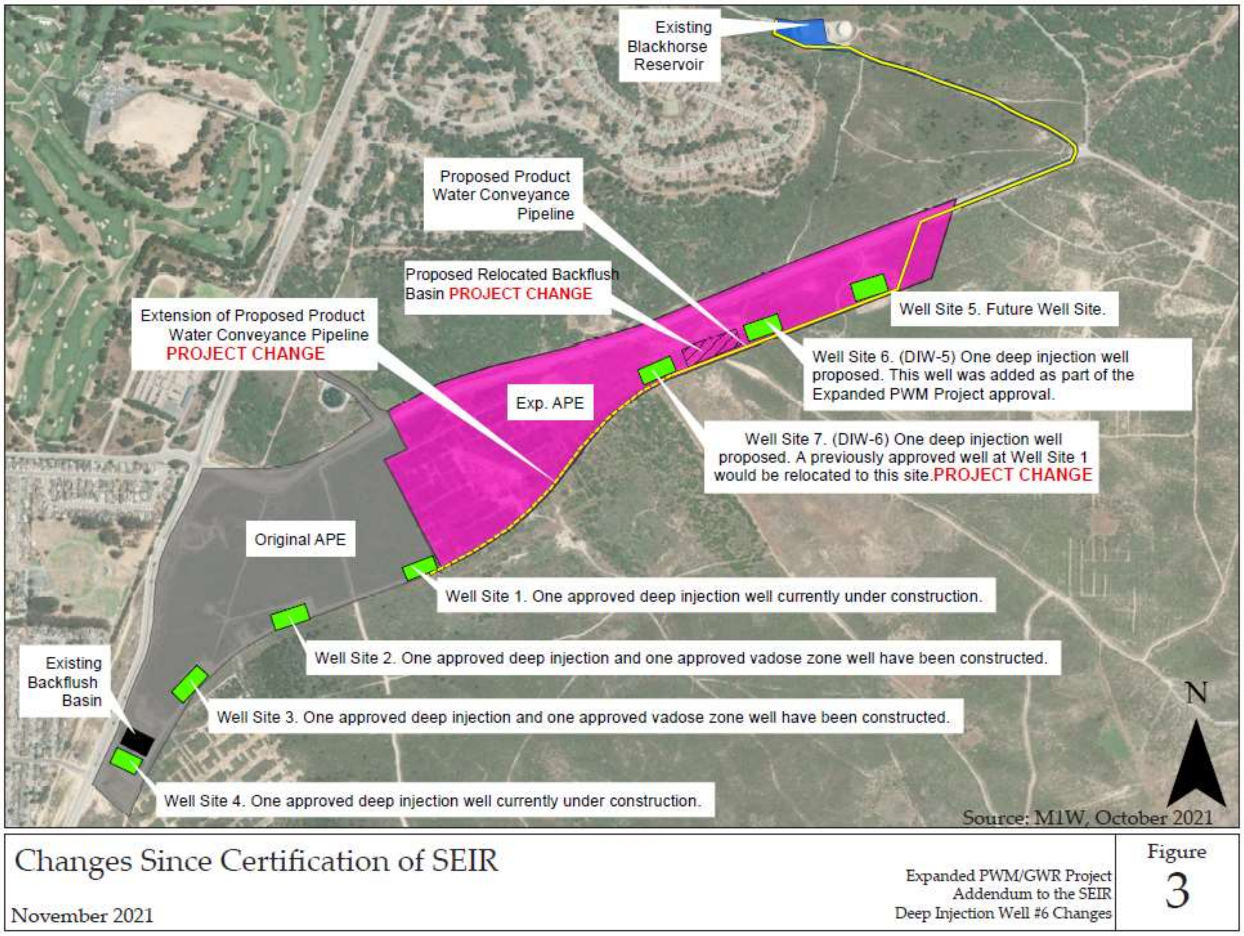

Figure 5. Pure Water Monterey Expansion Injection Facilities (source: M1W, 2021)

The PWM Expansion project recharges varying volumes of water each year, with an average of 5,750 AF recharged per year. The amount of water recharged annually depends on whether the projected hydrology is in a drought or non-drought year, and on the rules for banking and delivering water to the CSIP for irrigation use in the Salinas Valley. The drought year classification is based on percent deviation from long term average total annual precipitation data in the CSIP area. A monthly recharge schedule that includes an accounting and description of the CSIP banking and delivery program is shown in Table 10. The recharge schedule and the water year classification are updated and extended to align with the new baseline model hydrology period, and so for this reason, it differs from the delivery schedule used for the PWM Expansion SEIR modeling (M&A, 2019b). Locations of the planned wells have also been changed since the 2019 SEIR modeling so the expansion DIW well locations in the baseline model were updated to align with the latest planned locations (M1W, 2021). Injection well DIW-7 is assumed to not be constructed. Additionally, it was found during the 2019 PWM Expansion SEIR modeling that injected water was being lost to the neighboring Monterey Subbasin, and that M1W is planning on allocating less injection volumes to the northernmost DIW wells to try to minimize how much injected water is lost out of the basin. Because this could impact the evaluation of the protective elevations, this revised plan is incorporated in the updated baseline model by adjusting the percentage of recharge water that each well receives. The recharge at the VZW wells was kept at WY 2021 rates. Of the total recharge water injected, 98.5% is injected into the Santa Margarita aquifer through the deep injection wells, and the remaining 1.5% is injected into the Paso Robles aquifer through the vadose zone wells[6]. Monthly recharge via backflush basins was also simulated based on estimated backflush rates reported in the recent addendum to the PWM Expansion Project SEIR (M1W, 2021).

The assumed PWM Expansion Project Scenario allocation of recharge between different well sites is shown below in Table 4, and the annual injection volumes for the WY 2024–2050 period are shown on Figure 4. Significant reductions in recharge of up to 1,000 AFY occur during drought years when recycled water is delivered to CSIP (e.g., WY 2027; 2036; 2042; and 2047).

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[6] Note that this differs substantially from the assumptions used in the PWM Expansion SEIR modeling, where the split was 90% (~5,1750 AFY) Santa Margarita and 10% Paso Robles (~575 AFY).

Table 4. Allocation of Recharge to Deep Injection Wells and Vadose Zone Wells for Expanded PWM Expansion Project

Percent of Total Recharge	Deep Injection Wells						Vadose Zone Wells	
	98.5%						1.5%	
Well Site	**DIW-1**	**DIW-2**	**DIW-3**	**DIW-4**	**DIW-5**	**DIW-6**	**VZW-1**	**VZW-2**
Percent of Deep Recharge	30%	20%	20%	5%	10%	15%	-	-
Percent of Vadose Zone Recharge	-	-	-	-	-	-	63%	37%
Percent of Total Recharge	29.6%	19.7%	19.7%	4.9%	9.9%	14.8%	0.9%	0.6%

Cal-Am Supply and Demand Projections

Projected Cal-Am pumping in the Seaside basin for WY 2022–2050 is estimated using an updated version of the supply-demand forecast spreadsheet model developed by MPWMD for the 2019 PWM Expansion SEIR modeling (MPWMD, 2019a). The demand model was updated for the revised and expanded hydrologic period, and to incorporate the Cal-Am wells supplying the water demand of the SNG project when it is completed. The demand forecast has a uniform increase in demand over time, is tied to the hydrology cycle, and accounts for all of Cal-Am’s water rights and allocations and demand/supply sources (Carmel River Table 13 diversion, Sand City Desal, native groundwater, ASR, and PWM) to determine the projected monthly Seaside Basin pumping demand which is then distributed to Cal-Am extraction wells. The demand model also accounts for the reduction of Cal-Am’s wellfield pumping capacity that occurs during the 2 months following ASR injection operations when ASR wells cannot be used for extraction, and during which extraction shifts to other wells. The demand model incorporates Cal-Am’s 700 AF replenishment payment and the Cease-and-Desist Order (CDO) restricting Cal-Am’s diversion of Carmel River water. It is assumed that the 25-year 700 AFY replenishment begins in WY 2024 and finishes at the end of WY 2048, unless it needs to be extended as mentioned earlier.

Cal-Am’s projected total annual water demand in WY 2022 is assumed to be 9,300 AF and to increase linearly to 11,700 AF through the end of WY 2050. The assumed starting volume is based on the 5-year average of Cal-Am’s historical demand for WY 2016–2020 as reported in Cal-Am’s 2020 Urban Water Management Plan (WSC, 2021). The 2050 demand is based on the upper demand projection from Figure 4 of the 2019 MPWMD supply and demand memo (MPMWD, 2019b). The monthly distribution of Cal-Am’s annual deliveries, provided by

MPWMD, is used to estimate future monthly demand, and is based on monthly averages of Cal-Am deliveries from 2007 to 2017. The demand model estimates that roughly two-thirds of the total Cal-Am demand can be satisfied by extraction of native groundwater, injected Carmel River water, and injected PWM water from the Seaside Basin. Extraction from Carmel Valley[7], Cal-Am's Carmel River Table 13 diversion[PB23][PB24], and the Sand City Desalination plant. The demand model assumes that Cal-Am will first exhaust available water from its native groundwater right (which drops from 1,474 AFY to 774 AFY during the repayment period), followed by recovery of Pure Water Monterey water, and then finally recovery of ASR water from storage.

Total projected Cal-Am annual demand is shown on Figure 6, broken out by water source. It includes the very small additional 70 AFY to supply SNG. Projected total annual Cal-Am Seaside Basin groundwater extracted is shown in Figure 7. Most of the pumping demand is supplied by recovery of PWM water (red), while ASR recovery (green) is primarily used during drought years. Cal-Am's 25-year 700 AFY over-production repayment is visible in the drop in Native groundwater right (blue) from WY 2024 to 2048.

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[7] Cal-Am has a total entitled right of 3,376 AFY from the Carmel River Aquifer that is not reliant on seasonal diversion minimum flow requirements as is the case with the Table 13 water rights diversions.

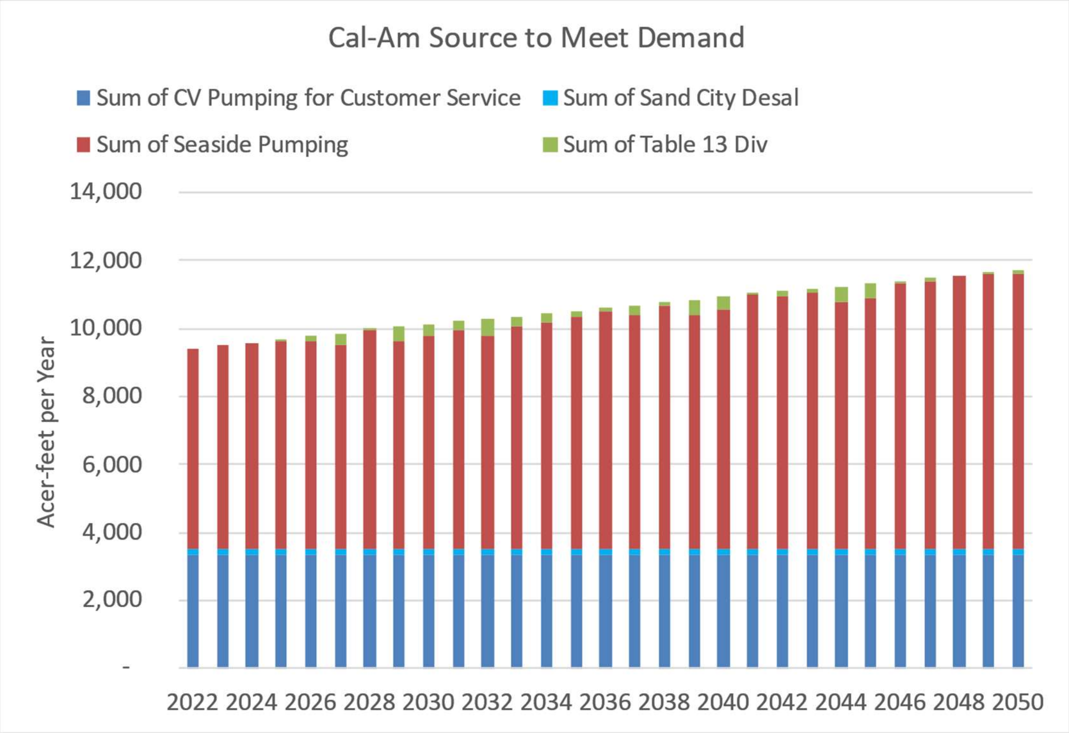

Figure 6. Total Cal-Am Annual Demand and Source to Meet Demand (CV = Carmel Valley)

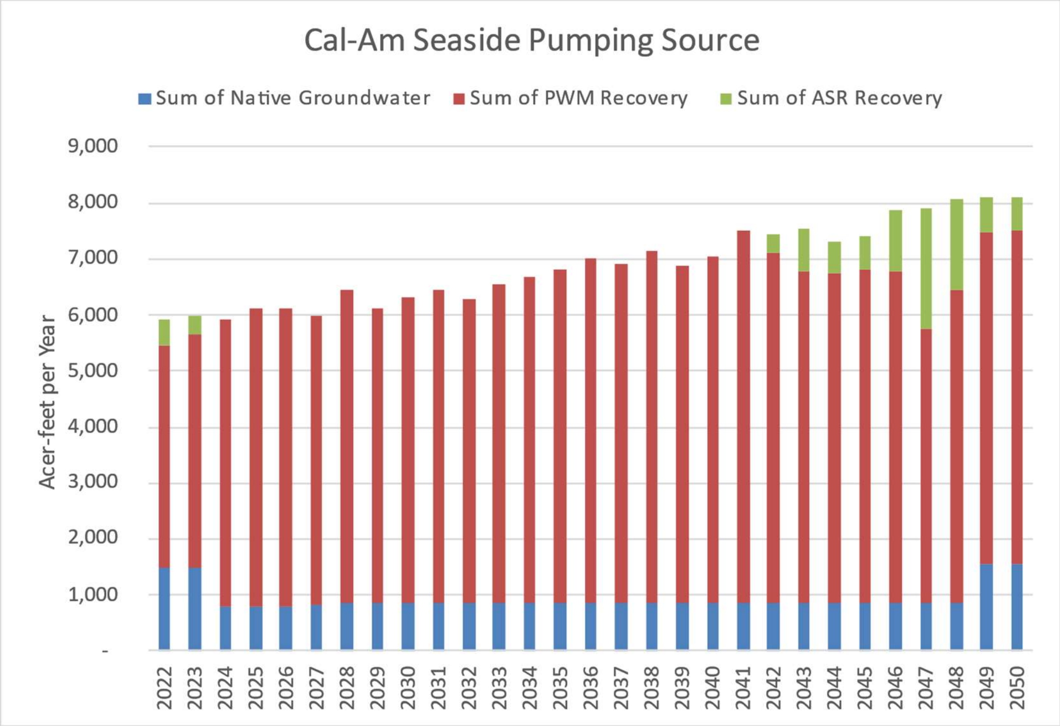

Figure 7. Projected Cal-Am Seaside Basin Pumping by Water Right

Updated Aquifer Parameters in the Vicinity of PWM Project Wells

The updated baseline model incorporates modifications made in 2019 to the model's hydrogeologic parameters in the region of the PWM project wells to incorporate data from aquifer tests conducted in the 2 existing deep injection wells DIW-1 and DIW-2, 4 MPMWD ASR wells, and the Paralta well. Data from those tests were used to adjust horizontal hydraulic conductivity, aquifer storativity, and aquifer thickness (M&A, 2019a). These updates are also now incorporated into the historical model.

Initial Conditions

Simulated groundwater levels for September 2017 from the historical model are used as the initial conditions for groundwater levels in the baseline model.

REPLENISHMENT SCENARIOS

In addition to the baseline scenario detailed above, which includes the 25-year Cal-Am 700 AFY in-lieu replenishment and the PWM Expansion project both starting in WY 2024, 4 additional scenarios were run to evaluate the impact on achieving protective elevations:

1. Providing 500 acre-feet of replenishment water per year starting in WY 2024
2. Providing 1,000 acre-feet of replenishment water per year starting in WY 2024
3. Providing 1,500 acre-feet of replenishment water per year starting in WY 2024
4. Providing 1,500 acre-feet of replenishment water per year starting in WY 2024 while also reducing pumping in the shallow Paso Robles aquifer starting that same year by assuming that Mission Memorial Park switches to irrigating with recycled water instead of groundwater, and that the City of Seaside shifts all municipal pumping from Muni #4 to a new deeper well screened only in the Santa Margarita Formation

For the additional replenishment scenarios, the water is assumed to be injected into the Santa Margarita Formation at the 6 PWM DIW wells. The total annual additional replenishment volume is assumed to be distributed throughout the year in the same monthly proportions as the PWM injection rates at each DIW well. The additional replenishment injections do not affect the projected recovery of PWM water by Cal-Am.

MODEL RESULTS

Model assumptions for the scenarios discussed above are integrated into the Seaside Basin groundwater flow model and the model is run separately for each scenario. Results of the model runs are presented in the subsections below. The first subsection discusses the ability of each simulated scenario to reach protective elevations at coastal monitoring wells. The second subsection discusses changes in simulated net inflow of water to the basin from offshore.

Groundwater Levels at Coastal Monitoring Wells

- The simulated groundwater elevations for the updated baseline and for each scenario are evaluated in the 6 monitoring wells used for establishing protective elevations against seawater intrusion (HydroMetrics LLC, 2009). These monitoring wells are: MSC Deep, MSC Shallow, PCA-West Deep, PCA-West Shallow, Sentinel Well 3 (also referred to as SBMW-3), and CDM MW-4 (Figure 11).

- Simulated water levels for the updated baseline simulation in the 3 monitoring wells screened in the deep aquifer (Santa Margarita or Purisima Formation), along with the simulated change in mean sea level are shown in Figure 8, and the same data for the 3 monitoring wells screened in the shallow aquifer (Paso Robles Formation) are shown in Figure 9.

The groundwater levels in both the deep and shallow wells rise and fall seasonally with changes in seasonal demand and climatic conditions. These seasonal fluctuations are superimposed on the longer-term water level trends related both to dry and wet cycles and to changes in pumping and aquifer recharge. The protective water level elevations were established based on modeling that assumes steady-state conditions that have no time component to them. This steady-state assumption can be thought of as considering long-term averages of water levels, rather than considering shorter-term seasonal fluctuations. For this reason, for the purposes of comparing the changes in simulated groundwater levels to the protective elevations and to compare between scenarios more easily, annually averaged simulated groundwater levels are used in the following figures and analysis rather than the highest or lowest groundwater level within a given year.

- Hydrographs of the annually averaged simulated groundwater levels at the 6 monitoring wells where protective elevations are established are shown on Figure 12 through Figure 17 for the updated baseline simulation and replenishment scenarios 1 through 3, along with the protective elevation adjusted for SLR for each well. For comparison with actual current conditions the hydrographs also show the most recent groundwater levels measured at each well from WY 2018–2021.

For all 3 replenishment scenarios, and at all the protective elevation monitoring wells, except for CDM MW-4[8], the annual average groundwater levels rise steadily starting in WY 2024 (when both the PWM Expansion and the Cal-AM replenishment repayment period begin) through WY 2033. After WY 2033 mean annual groundwater levels begin to either level off and/or drop to varying degrees in response to periods of drought. During years when the Carmel River water year is classified as Below Normal, Dry, or Critically Dry, the volumes of both ASR injection and Table 13 Carmel River diversions to meet Cal-Am Monterey District demand are greatly reduced, as previously shown on Figure 3. Similarly, drought conditions in the CSIP service area result in a marked reduction in injected PWM water (shown on Figure 4), as source water is diverted to augment the CSIP irrigation supply and also as Cal-Am recovers credited water from the "banked" drought reserve. In all the scenarios, groundwater levels drop markedly in the last several years of the simulation period (WY 2046–2050) because of the impacts of a simulated

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[8] As has been observed in previous modeling, because of its very shallow depth and position in the basin, the groundwater levels at CDM MW-4 are largely insensitive to injection in the Santa Margarita Formation.

multi-year drought period[9] during which both ASR and PWM injection are greatly reduced, Table 13 diversions are reduced and Cal-Am begins recovering banked ASR water credits to meet their system demand. The last 2 years of this period also coincides with the end of Cal-Am's repayment period, such that Cal-Am can exercise their full native groundwater rights during WY 2049–2050.

The direct correlation of decreased Carmel River diversions for ASR and decreased PWM injection during these dry years and the sharp drops in groundwater level can be clearly seen in Figure 10 which shows the annually averaged groundwater levels in each of the wells, overlain with the total replenishment from ASR injection and PWM injection during the baseline scenario, as well as the periods and annual volumes when Cal-Am is projected to recover stored ASR water.

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[9] The WY 2046–2050 drought is based on the repeated hydrology of the recent 2012–2015 drought

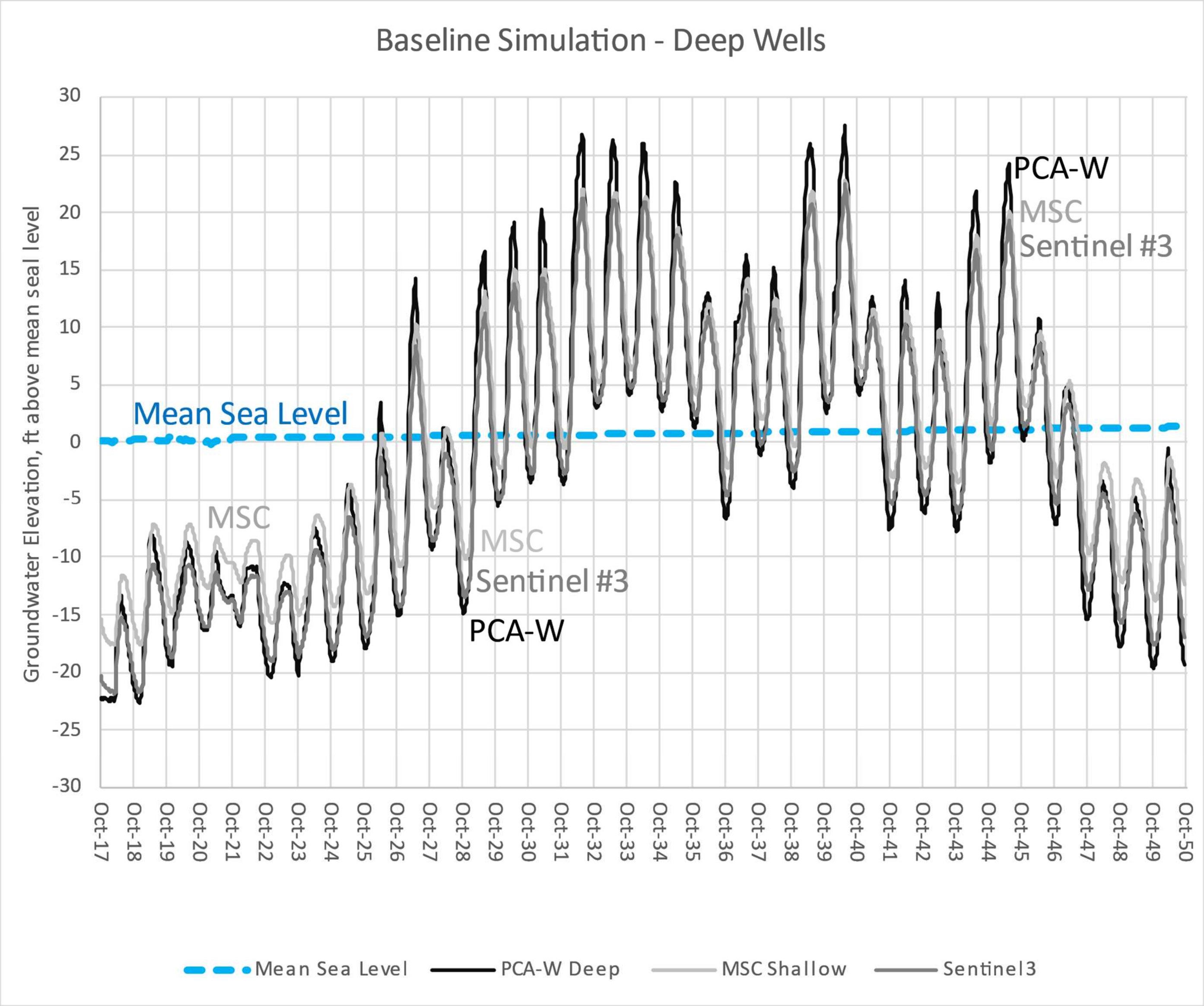

Figure 8. Simulated Groundwater Elevation in Deep Monitoring Wells for Updated Baseline Simulation

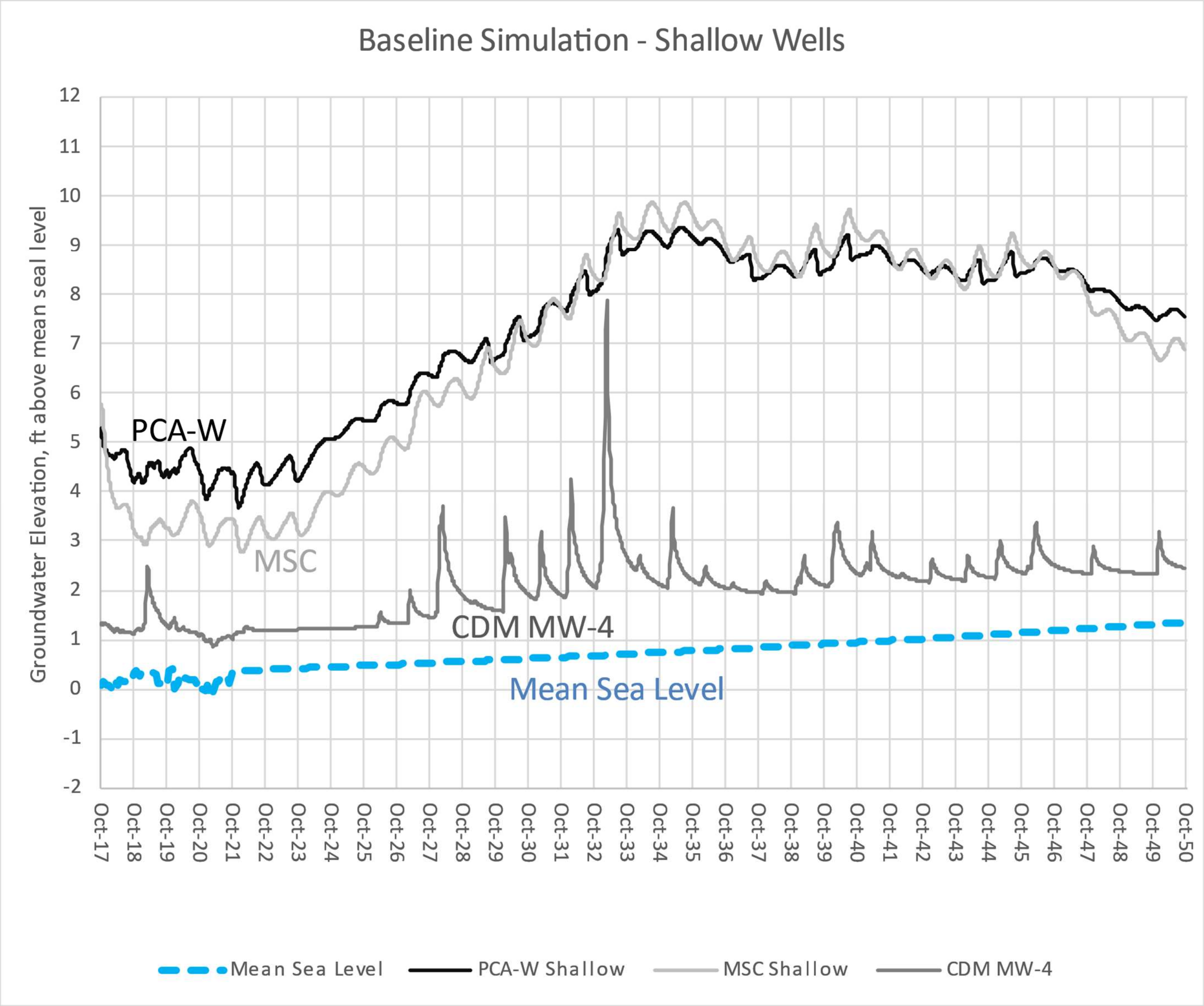

Figure 9. Simulated Groundwater Elevation in Shallow Protective Elevation Monitoring Wells for Updated Baseline Simulation

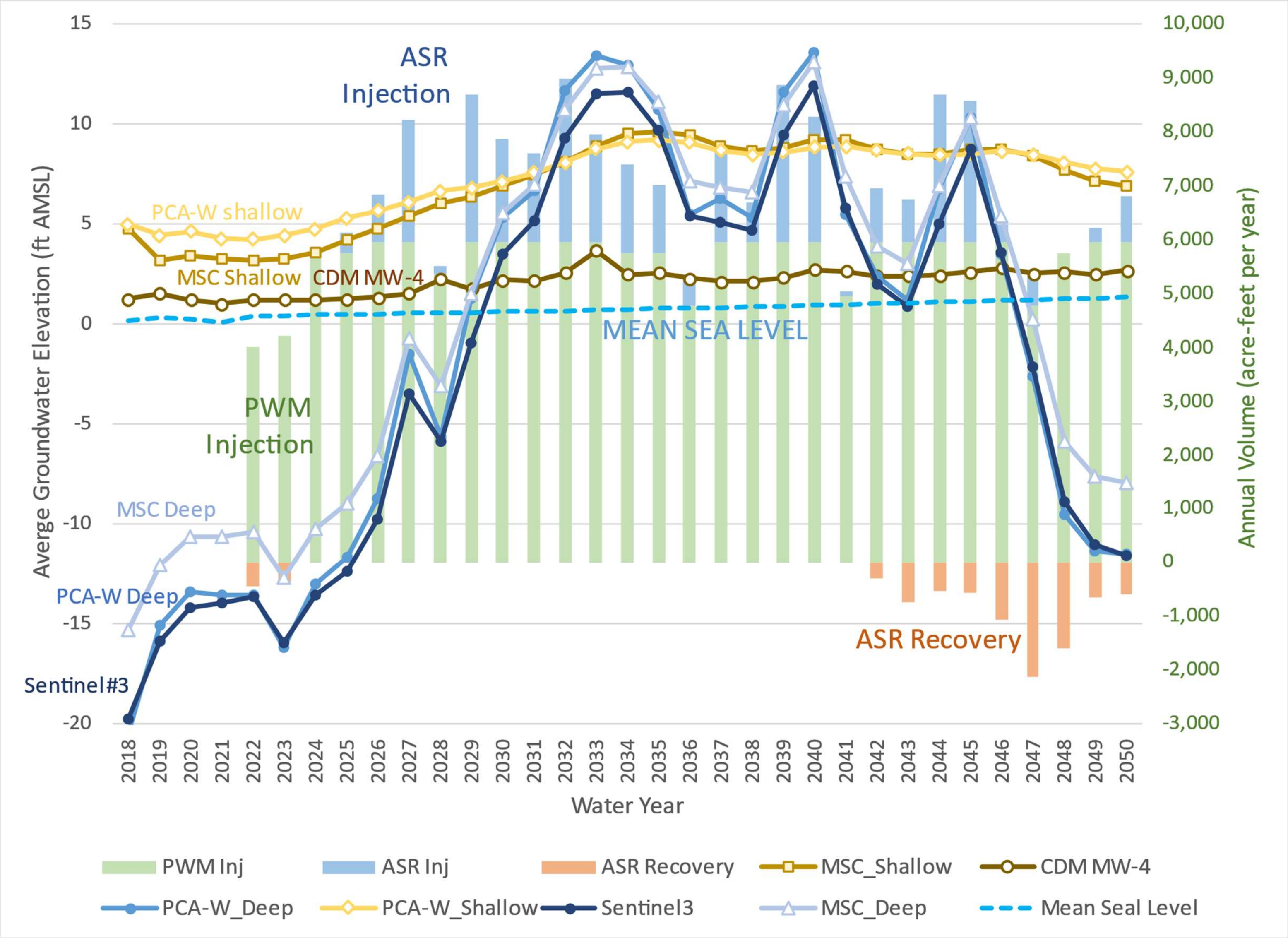

Figure 10. Annually Averaged Groundwater Elevations in Protective Elevation Wells Compared to PWM and ASR Injection and ASR Recovery (right axis) for the Baseline Scenario

Table 5 through Table 9 present summary values for a range of metrics for comparing the success of different replenishment amounts in achieving protective elevations at each of the monitoring wells. The metrics are calculated for the 25-year Cal-Am repayment period from WY 2024–2048. For each scenario, the tables identify:

- during which water year the protective elevation is first reached at the well
- the number of years it takes to reach the protective elevation
- the number of water years during which the annually averaged groundwater level is at or above the protective elevation (within ± 3/4 foot)
- the percentage of years during the 25-year period that the protective elevation is achieved or exceeded
- the maximum head difference between the initial average groundwater level at the start of the 25-year period and the groundwater levels during the replenishment period
- the increase in the maximum head difference for the scenario relative to the head difference during the baseline simulation
- the incremental change in max head difference per each additional 500 AF increase in the annual replenishment amount

The sections below will focus primarily on the results of the first 3 replenishment scenarios. The results of Scenario 4, which expands Scenario 3 by also including some redistribution of pumping away from the Paso Robles aquifer, will be addressed primarily in the context of evaluating if water levels at MSC Shallow, screened in the Paso Robles, could be further or more efficiently raised without additional injection in the Santa Margarita.

Sentinel 3 (Deep aquifer)

Groundwater levels in Sentinel 3 start off below its protective elevation but quickly rise above it in all the scenarios, as well as the baseline. The protective elevation is reached within 7 years from the start the PWM Expansion project for the baseline scenario, and incrementally sooner with each additional increase in annual replenishment volume, to as short as within 3 years for the 1,500 AFY replenishment scenario. As described above, however, the average annual groundwater levels plateau and then start fluctuating in response to periodic drought conditions and the protective elevation is not maintained for the entire 25-year period. However, even in the baseline scenario, the protective elevation is achieved during 52% (13 years) of the 25-year period, and 88% of the time for both the 1,000 AFY and 1,500 AFY replenishment scenarios. The biggest incremental increase in groundwater levels occurs between the 500 AFY scenario and the 1,000 AFY scenario.

PCA-West (Deep) and MSC (Deep)

The groundwater level response in PCA-West (Deep) and MSC (Deep) is very similar to that of Sentinel 3, with similar ranges of average groundwater level increases of between 26 and 48 feet relative to the initial levels at start of the repayment period. However, because of the higher protective elevations designated for these wells, the protective elevation is never reached in the baseline scenario, though the protective elevation is achieved in all the replenishment scenarios, albeit less frequently than in Sentinel 3. Protective elevations in both wells are achieved within 9 years for the 500 AFY scenario but are only achieved for 8%-12% of the 25-year period. Protective elevations are achieved at both wells 52%-56% of the years during the 1,000 AFY scenario, and between 68%-72% of the years for the 1,500 AFY scenario. As in the case of Sentinel 3, the biggest incremental increase in groundwater levels and in frequency of maintaining protective elevations occurs in the 1,000 AFY replenishment scenario.

PCA-West (Shallow)

The general pattern of the groundwater level response in PCA-West (Shallow) is similar to that in the deep wells, but at a lesser scale. Maximum annual average head differences are only on the order of 5–6 feet. The groundwater levels start off already above the protective elevation and remain so for the entire 25-year period, for all the scenarios including the baseline.

MSC (Shallow)

MSC Shallow also follows the same general pattern as the other wells, though with slightly greater increases in groundwater levels of between 6 and 8.5 feet. However, because of the higher protective elevation for this well, the average annual groundwater level never reaches the protective elevation for either the baseline or the 500 AFY scenario. During the 1,000 AFY scenario, the protective elevations are achieved in WY 2035 after 11 years of replenishment, but the protective elevation is only maintained for 1 year. With the 1,500 AFY scenario, the protective elevation is reached within 10 years and is achieved for 5 of the 25 years (20% of the simulation period). Scenario 4 was developed primarily to evaluate if water levels at MSC Shallow could be further raised without the need for injecting additional replenishment water into the Santa Margarita. Like Scenario 3 it consists of 1,500 AFY of replenishment to the Santa Margarita but also includes a reduction in pumping in the Paso Robles by means of assuming the conversion of landscape irrigation water at Mission Memorial Park from the current shallow groundwater source (22 AFY) to recycled water and moving City of Seaside municipal pumping (~580 AFY) from well Muni #4, which is screened across both the Lower Paso Robles and the Santa Margarita, to a new well screened only in the deeper Santa Margarita. The results of Scenario 4 show that the in-lieu replenishment resulting from reducing pumping in the Paso

Robles was able to increase the percent of years that protective elevations are achieved in MSC Shallow to 40% as compared to only 20% for Scenario 3.

CDM MW-4 (Shallow Aquifer)

The groundwater level response in CDM MW-4 is very different from all the other wells. As described in previous modeling studies the sharp spikes in groundwater level in the well are responses to shallow recharge events at the land surface. The large spike in 2032 for example, corresponds to response to a very wet year. Because of its very shallow depth and position in the Southern Coastal subarea of the basin the groundwater levels are insensitive to changes in recharge activities in the Northern Inland and Northern Coastal Santa Margarita aquifer. The groundwater levels in the well also appear to be heavily influenced by SLR, as the base groundwater level follows the SLR trend visible in the adjusted protective elevation curve. Although the simulated groundwater levels at CDM MW-4 are slightly below the protective elevation, comparison with measured groundwater levels in the well indicates that the model generally underpredicts the groundwater levels at the well by about a foot, and that the simulated groundwater levels in the well would be at or above the protective elevation for the entire 25-year period.

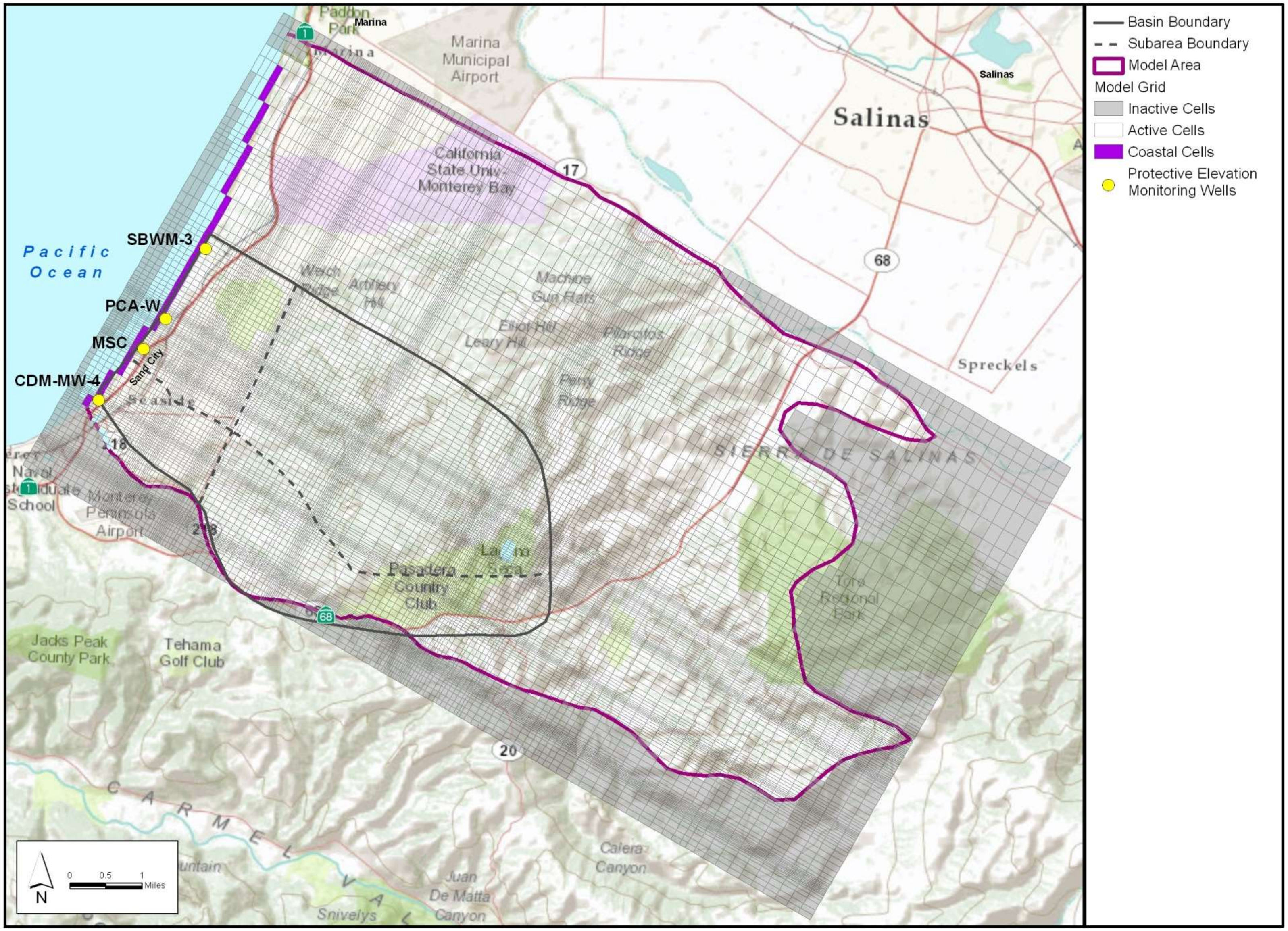

Figure 11. Location of Protective Elevation Monitoring Wells

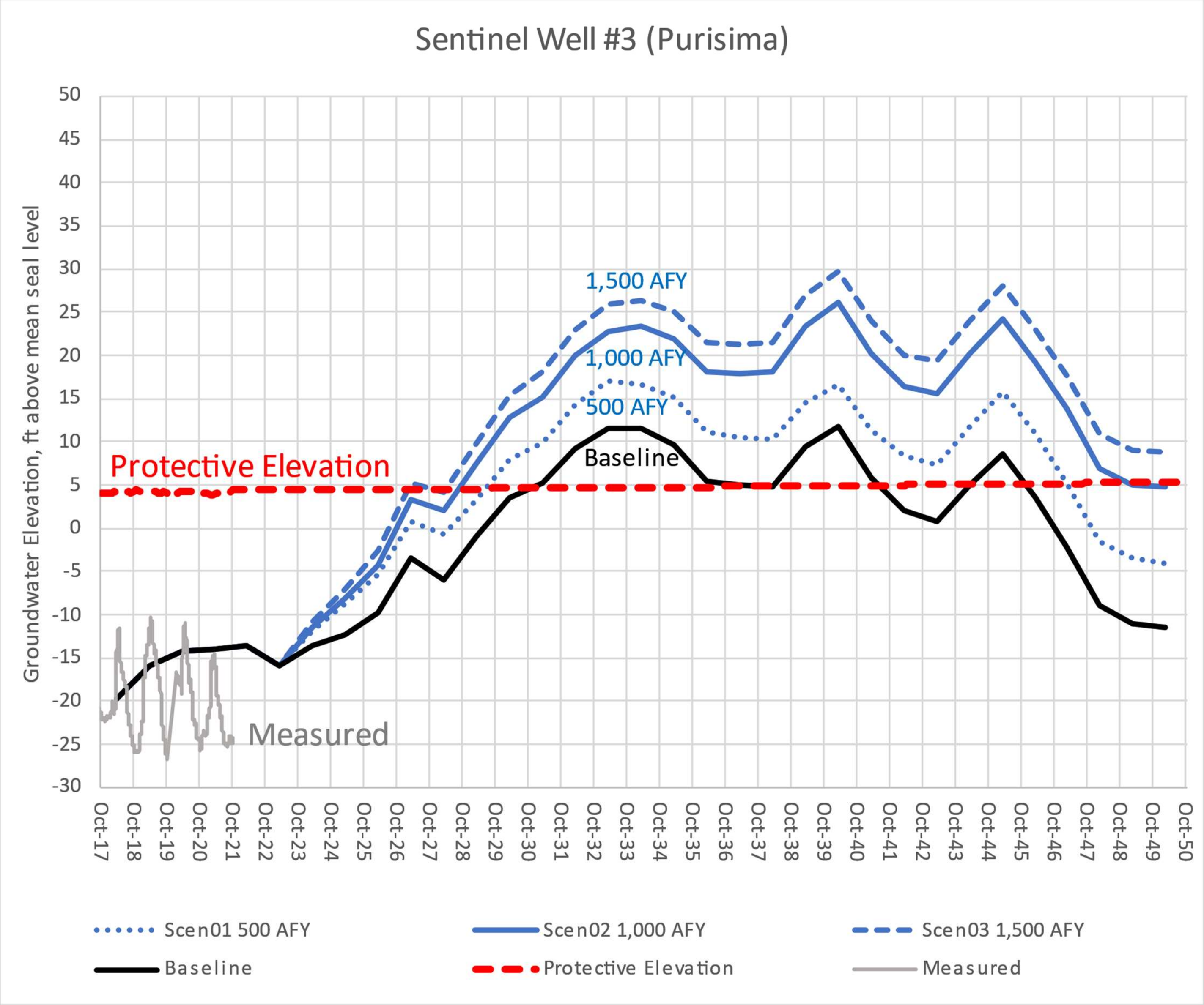

Figure 12. Simulated Groundwater Elevations and Protective Elevation at Sentinel Well #3

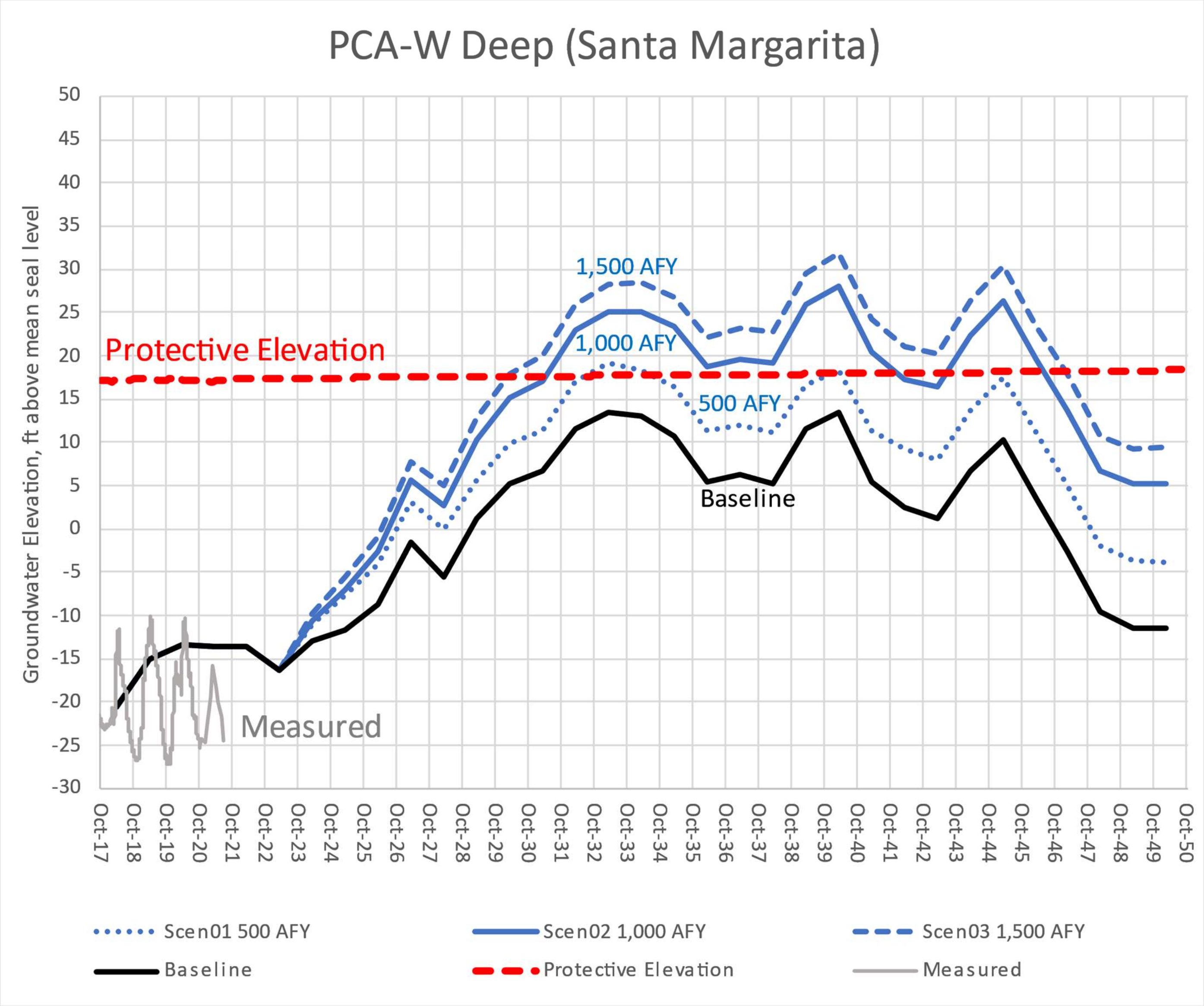

Figure 13. Annualy Averaged Simulated Groundwater Elevations and Protective Elevation at PCA-West Deep

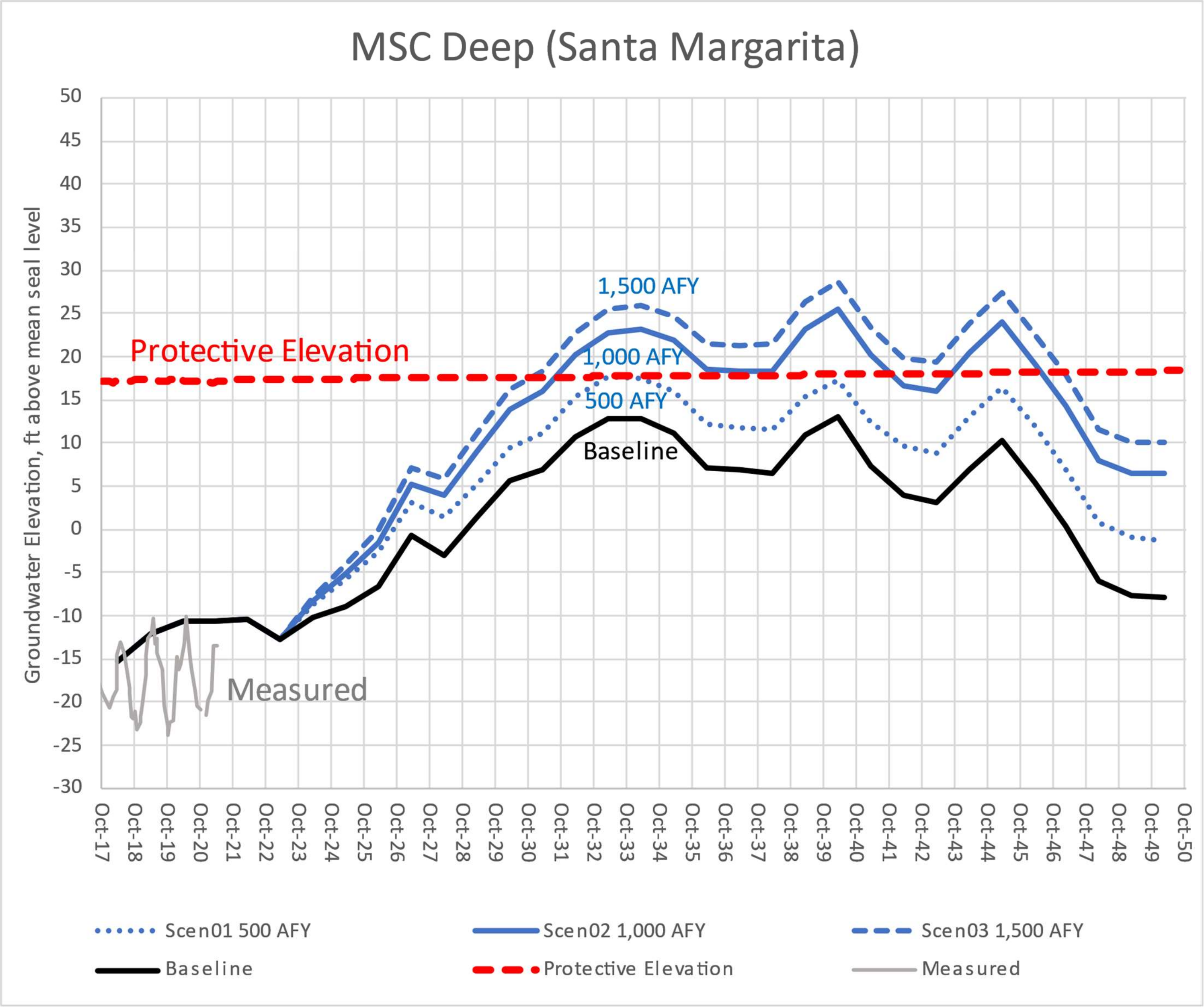

Figure 14. Annualy Averaged Simulated Groundwater Elevations and Protective Elevation at MSC Deep

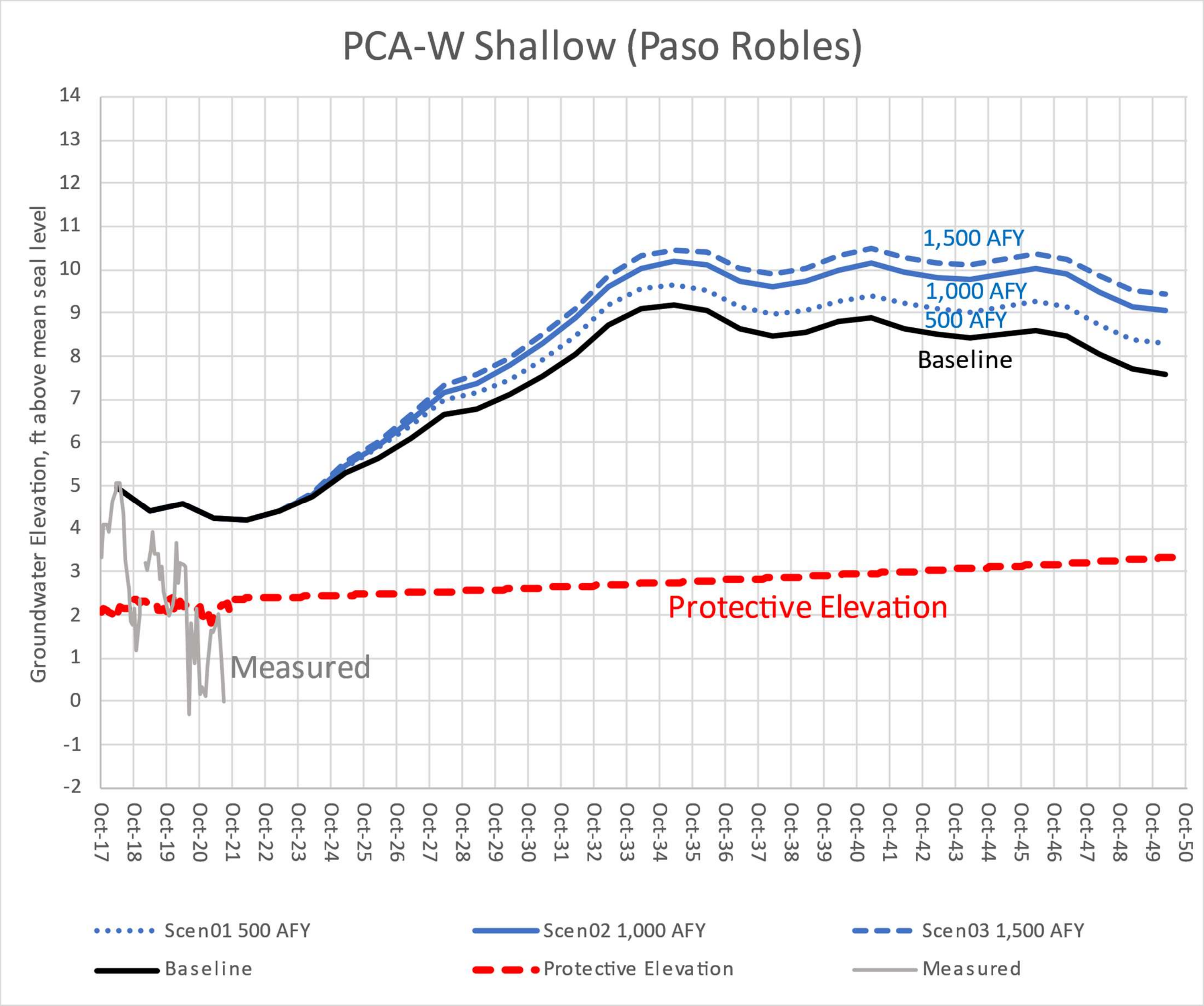

Figure 15. Annualy Averaged Simulated Groundwater Elevations and Protective Elevation at PCA-West Shallow

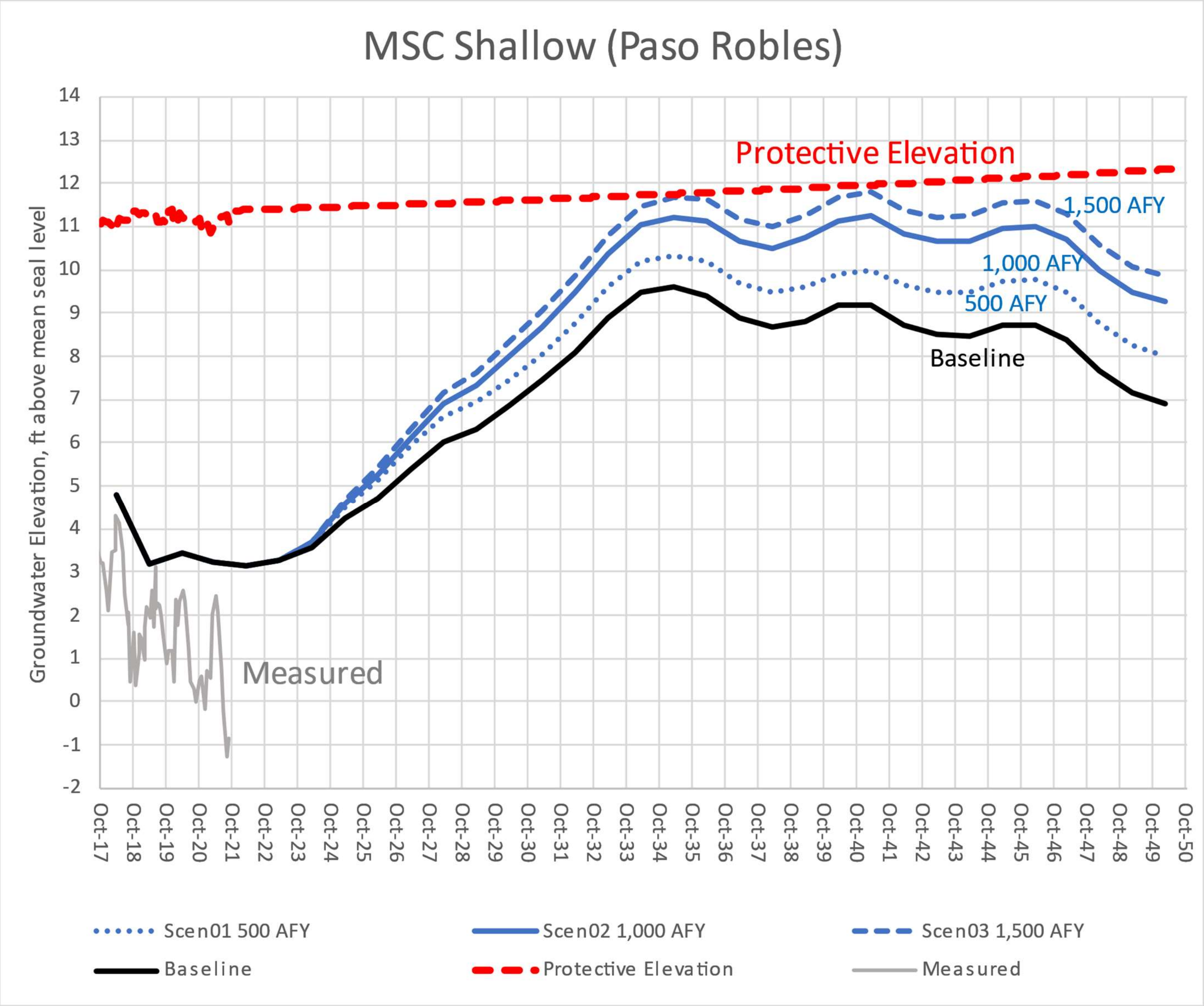

Figure 16. Annualy Averaged Simulated Groundwater Elevations and Protective Elevation at MSC Shallow

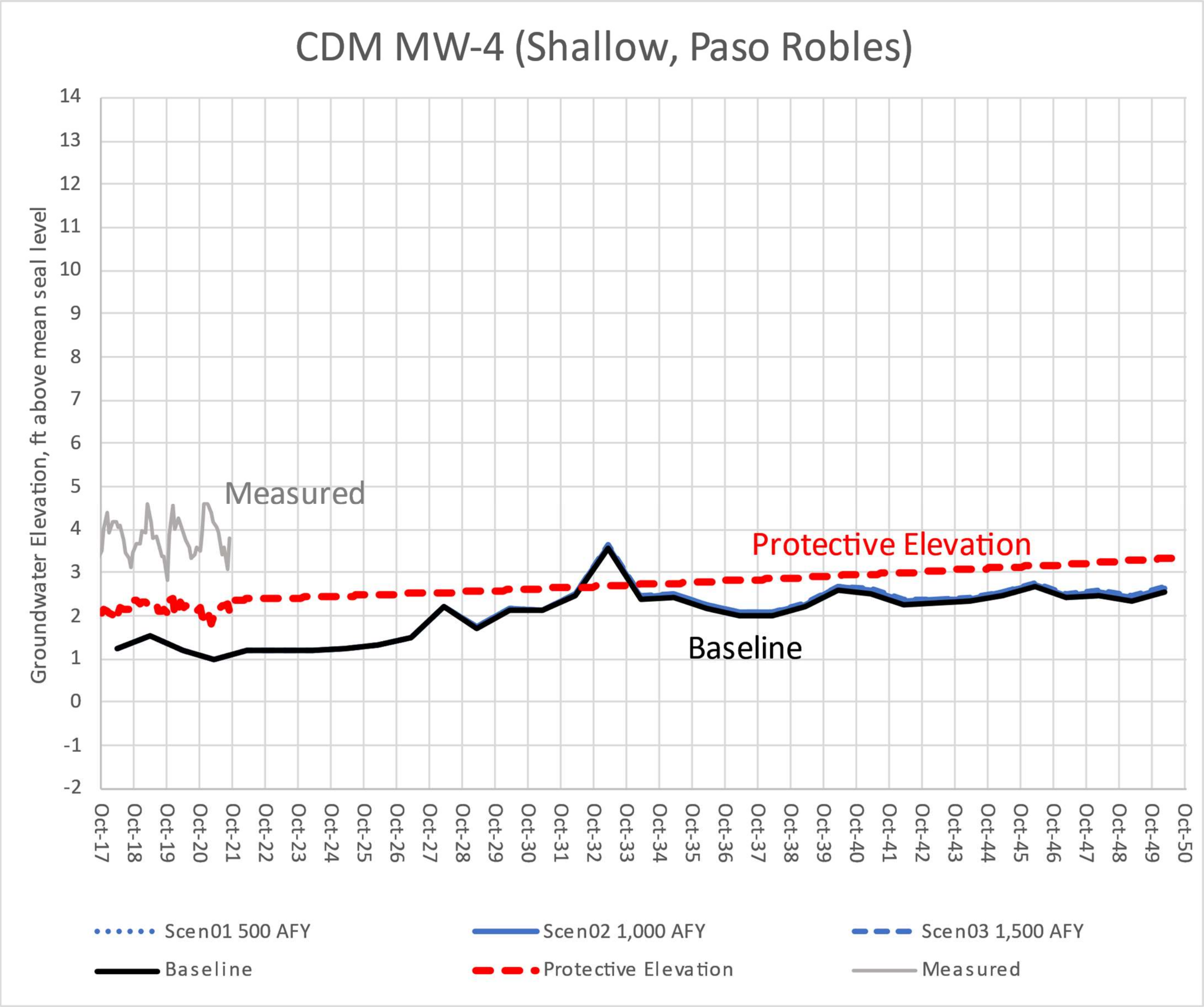

Figure 17. Annualy Averaged Simulated Groundwater Elevations and Protective Elevation at CDM MW-4

Table 5. Number of Years from WY2024 for Average Groundwater Level to Reach Protective Elevation and Year Reached

Scenario	Sentinel 3 (Deep)	PCA-W (Deep)	MSC (Deep)	PCA-W (Shallow)	MSC (Shallow)	CDM MW-4 (Shallow)
Baseline	7 (2031)	not reached	not reached	already reached	not reached	already reached
1) 500 AFY	6 (2030)	9 (2033)	9 (2033)	already reached	not reached	already reached
2) 1,000 AFY	5 (2029)	7 (2031)	8 (2032)	already reached	11* (2035)	already reached
3) 1,500 AFY	3 (2027)	6 (2030)	6 (2030)	already reached	10 (2034)	already reached
4) 1,500 AFY + Q Redist.	3 (2027)	7 (2031)	7 (2031)	already reached	9 (2033)	already reached

*within 0.75 foot

Table 6. Percent and Number of Years from WY2024-2048 that Average Groundwater Level Achieves Protective Elevation

Scenario	Sentinel 3 (Deep)	PCA-W (Deep)	MSC (Deep)	PCA-W (Shallow)	MSC (Shallow)	CDM MW-4 (Shallow)
Baseline	52% (13)	not reached	not reached	100% (25)	not reached	100% (25)
1) 500 AFY	72% (18)	12% (3)	8% (2)	100% (25)	not reached	100% (25)
2) 1,000 AFY	88% (22)	56% (14)	52% (13)	100% (25)	4%* (1)	100% (25)
3) 1,500 AFY	88% (22)	72% (18)	68% (17)	100% (25)	20% (5)	100% (25)
4) 1,500 AFY + Q Redist.	84% (21)	64% (16)	64% (16)	100% (25)	40% (10)	100% (25)

*within 0.75 foot

Table 7. Maximum Average Groundwater Level Increase from WY2024 to WY2048 in Feet

Scenario	Sentinel 3 (Deep)	PCA-W (Deep)	MSC (Deep)	PCA-W (Shallow)	MSC (Shallow)	CDM MW-4 (Shallow)
	Maximum Average Groundwater Elevation Increase, Feet					
Baseline	28	30	26	4.8	6.3	2.4
1) 500 AFY	33	35	30	5.2	7.1	2.4
2) 1,000 AFY	42	44	38	5.8	8.0	2.4
3) 1,500 AFY	46	48	41	6.0	8.5	2.4
4) 1,500 AFY + Q Redist.	44	46	40	6.3	8.7	2.5

Table 8. Maximum Average Groundwater Level Increase over Baseline Scenario

Scenario	Sentinel 3 (Deep)	PCA-W (Deep)	MSC (Deep)	PCA-W (Shallow)	MSC (Shallow)	CDM MW-4 (Shallow)
	Maximum Average Groundwater Elevation Increase, Feet					
Baseline	-	-	-	-	-	-
1) 500 AFY	5	6	5	0.4	0.8	0
2) 1,000 AFY	14	15	13	1.0	1.7	0
3) 1,500 AFY	18	18	16	1.2	2.2	0
4) 1,500 AFY + Q Redist.	16	16	14	1.5	2.4	0.1

Table 9. Increase in Average Groundwater Level per Each Additional 500 AFY of Replenishment

Scenario	Sentinel 3 (Deep)	PCA-W (Deep)	MSC (Deep)	PCA-W (Shallow)	MSC (Shallow)	CDM MW-4 (Shallow)
	Average Groundwater Elevation Increase, Feet					
Baseline	-	-	-	-	-	-
1) 500 AFY	5	6	5	0.4	0.8	0
2) 1,000 AFY	9	9	8	0.6	0.9	0
3) 1,500 AFY	4	4	3	0.2	0.5	0
4) 1,500 AFY + Q Redist.*	2	2	2	0.5	0.7	0.1

*For Scenario 4, values are compared to Scenario 2

Change in Net Inflow to the Basin from Offshore

In addition to evaluating how the replenishment scenarios succeed in raising groundwater levels to protective elevations, the water budget analysis of the model results in Figure 18 shows the net annual inflow of groundwater into the Seaside Basin from the offshore portions of the aquifer for the updated baseline simulation and Scenario 2 (1,000 AFY replenishment). Positive values represent net inflow of groundwater moving from offshore across the coastline into the basin. Negative values represent net outflow of water from the onshore aquifers into the offshore region. The solid dark blue line represents the net inflow into the Northern Coastal subarea of the basin for the baseline scenario, and it shows that prior to the start of the repayment period in WY2024 there is a net inflow of water from the offshore areas into the basin along the coastal boundary associated with the multi-year drought period. While not necessarily implying seawater intrusion, because there may be freshwater stored offshore in the aquifer, this represents a condition that would increase the potential for sea water intrusion. In WY2024 when both the PWM Expansion and the Cal-Am repayment period begins, groundwater levels in the basin begin to rise and simulated flows change to reflect a net outflow of groundwater from the basin in the offshore direction. The net outflow reaches a peak in WY2033 following a series of wet and extremely wet years (identified by dates with blue shading), and then begins to decrease in magnitude and hovers around a constant level before starting to move back in the direction decreased flow to the offshore areas as the simulation passes through the final multi-year drought. This trend is maintained in Scenario 2 as shown by the dashed blue line, but with the injection of the additional 1,000 AFY of replenishment water creates an additional buffer of offshore outflow. Increased offshore groundwater flow minimizes the potential for seawater intrusion. The orange line represents the Southern Coastal subarea, which as would be expected appears to be largely insensitive to the replenishment projects in the Northern subareas. This analysis suggests that even if protective elevations are not maintained 100% of the time because of periods of drought, the basin would still maintain a net outflow to the ocean during the 1,000 AFY replenishment scenario. This analysis considers the total net flow over the entire coastal boundary of each coastal subarea and for all the layers combined, however, and so may not show differences in trends that could be spatially localized along the coast or at different depths. The model results could be further broken out in the future to look at potential variability by depth and location along the coastline.

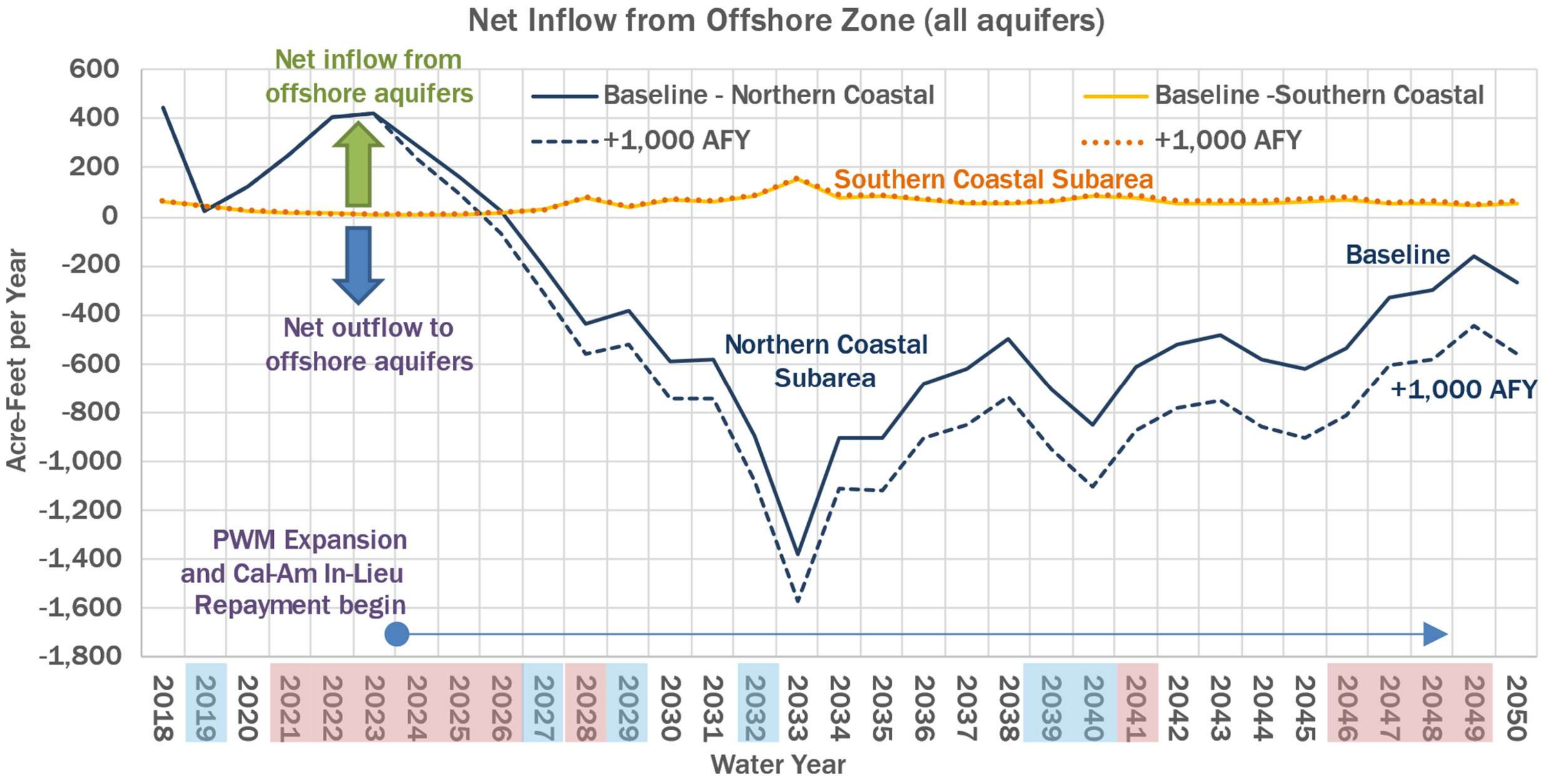

Figure 18. Net Groundwater Inflow to the Seaside Basin from Offshore for the Baseline and 1,000 AFY of Replenishment Water Scenario)

Conclusions & Considerations

1. Under the 1,000 AFY replenishment scenario, protective groundwater elevations are reached, at least initially, in all protective elevation wells within 11 years. Average annual groundwater levels remain above protective elevations for over 50% of the water years during the 25-year replenishment period, except at MSC Shallow, at which the protective elevation is reached only once, in WY 2035. After this year, groundwater levels stop increasing and slowly decline due to the drought years in the projected hydrologic cycles that reduces the availability of water for ASR and PWM injection and increases recovery of ASR and PWM water in storage. [PB25][PB26]

2. A water budget analysis of the net inflow of water from offshore areas into the basin indicates the 1,000 AFY scenario maintains and enhances the reversal of flow from a net inflow of water from offshore to a net outflow of water to offshore, even when protective elevations are not being met at all the wells. The additional replenishment water adds an additional buffer to maintain strong net offshore outflows even in drought years.

3. Increasing replenishment to 1,500 AFY results in only slight improvement at MSC Shallow, and only marginal increases in protective elevation metrics at the other protective elevation wells. Because both the other shallow aquifer protective elevation monitoring wells, (PCA-W Shallow and CDM MW-4), start off already meeting protective elevations, this suggests that there is limited benefit in trying to continue to raise the groundwater levels at MSC Shallow by increasing injection in the deeper Santa Margarita Formation. Rather, as illustrated by the results of Scenario 4, other alternatives could be considered and evaluated such as redistributing pumping from wells screened completely or partially in the Paso Robles, increased use of recycled water for irrigation purposes, such as at Mission Memorial Park, and simulating additional recharge directly to the Paso Robles aquifer.

4. The original 2013 replenishment modeling (Hydrometrics WRI, 2013) did not explicitly account for impacts of drought on the availability of Carmel River water for ASR injection and other Cal-Am use. Instead, it used a constant average injection and recovery rate each year rather having it fluctuate with hydrologic cycles. The results of the updated model scenarios that couple ASR and PWM operations to the hydrology illustrate the significant impact that multi-year droughts, and even just below normal periods, can have on the availability of water for ASR and PWM recharge and on the timing of reaching and maintaining protective elevations.

5. Simulated groundwater levels rose quickly in response to replenishment during periods of Normal and Above Normal water years following the prolonged drought at the start of the

simulated replenishment period, suggesting that levels would rebound again after the drought at the end of the simulation period. However, this rapid rebound is also a function of the assumption that Cal-Am will extract ASR water as its last source of supply, after exhausting available water from their native groundwater rights and PWM water. This assumption has the consequence that a very large portion of the injected ASR water is left in storage in the Basin.

6. The 2009 modeling that established the protective elevations assumed steady-state conditions that have no time component to them, and essentially assumes that sufficient time has passed that conditions have equilibrated to fixed state. That modeling did not directly consider and does not inform or suggest for how long a period groundwater levels can stay below protective elevations without greatly increasing the risk of sea water intrusion. This is something that could be evaluated with additional modeling.
7. In addition to the constant 1,000 AFY replenishment, additional “booster” injections could be considered following protracted drought periods to make up the lost water.
8. The modeling simulation period ends just as Cal-Am’s 25-year repayment period ends. It is not clear what impact the end of the repayment period will have on water levels.
9. It is also not clear how climate change and the potential increased frequency and duration of extreme weather events will impact the ability to maintain protective elevations. Additional modeling of projected future climate scenarios could be used to evaluate this.

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Table 10. Projected PWM Expansion Project Water Injection Schedule and CSIP Storage and Delivery Operation

Water Year	Simulated Historical Climate Water Year	Salinas Station Precipitation (% of Average)	Drought Year Criteria (<75% of Average)	Injection Delivery Schedule	Injection Volume (acre-feet)	Annual Recycled Water to CSIP (acre-feet)	Drought Reserve Change (acre-feet)	Cumulative Drought Reserve (acre-feet)	Injection Delivery Schedule (acre-feet)												
									Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
2023	1989	69%	Drought		4,100	-	-	0													
2024	1990	64%	Drought	G	5,750	200	-	0	607	610	641	625	569	621	348	349	337	348	353	343	5,750
2025	1991	73%	Drought	G	5,750	200	-	0	607	610	641	625	569	621	348	349	337	348	353	343	5,750
2026	1992	83%		A	5,950	-	200	200	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2027	1993	125%		A	5,950	-	200	400	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2028	1994	66%	Drought	E	5,350	600	(400)	0	607	610	641	625	569	621	282	281	271	280	285	278	5,350
2029	1995	130%		A	5,950	-	200	200	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2030	1996	103%		A	5,950	-	200	400	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2031	1997	131%		A	5,950	-	200	600	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2032	1998	247%		A	5,950	-	200	800	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2033	1999	104%		A	5,950	-	200	1000	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2034	2000	116%		B	5,750	-	-	1000	573	577	607	591	538	587	381	383	369	382	387	376	5,750
2035	2001	102%		B	5,750	-	-	1000	573	577	607	591	538	587	381	383	369	382	387	376	5,750
2036	2002	55%	Drought	H	4,750	1,000	(1,000)	0	573	577	607	591	538	587	217	214	205	213	218	212	4,750
2037	2003	80%		A	5,950	-	200	200	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2038	2004	84%		A	5,950	-	200	400	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2039	2005	159%		A	5,950	-	200	600	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2040	2006	125%		A	5,950	-	200	800	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2041	2007	74%	Drought	C	4,950	1,000	(800)	0	607	610	641	625	569	621	217	214	205	213	218	212	4,950
2042	2008	79%		A	5,950	-	200	200	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2043	2009	89%		A	5,950	-	200	400	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2044	2010	141%		A	5,950	-	200	600	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2045	2011	125%		A	5,950	-	200	800	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2046	2012	81%		A	5,950	-	200	1000	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2047	2013	74%	Drought	H	4,750	1,000	(1,000)	0	573	577	607	591	538	587	217	214	205	213	218	212	4,750
2048	2014	54%	Drought	G	5,750	200	-	0	607	610	641	625	569	621	348	349	337	348	353	343	5,750
2049	2015	89%		A	5,950	-	200	200	607	610	641	625	569	621	381	383	369	382	387	376	5,950
2050	2016	117%		A	5,950	-	200	400	607	610	641	625	569	621	381	383	369	382	387	376	5,950

Prior Water Year Drought Reserve (acre-feet)	Purified Water Delivery Schedule for Injection (acre-feet[AF])			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
NA	Normal/Wet Building Reserve	wet/normal year	A	607	610	641	625	569	621	381	383	369	382	387	376	5,950
1000	Normal/Wet Full Reserve	wet/normal year	B	573	577	607	591	538	587	381	383	369	382	387	376	5,750
800	before drought reserve complete	drought year (1,000 AF to CSIP)	C	607	610	641	625	569	621	217	214	205	213	218	212	4,950
600	before drought reserve complete	drought year (800 AF to CSIP)	D	607	610	641	625	569	621	250	248	238	247	251	245	5,150
400	before drought reserve complete	drought year (600 AF to CSIP)	E	607	610	641	625	569	621	282	281	271	280	285	278	5,350
200	before drought reserve complete	drought year (400 AF to CSIP)	F	607	610	641	625	569	621	315	315	304	314	319	310	5,550
0	before drought reserve complete	drought year (200 AF to CSIP)	G	607	610	641	625	569	621	348	349	337	348	353	343	5,750
1000	Drought Full Reserve	drought year (1,000 AF to CSIP)	H	573	577	607	591	538	587	217	214	205	213	218	212	4,750