Appendix 6-A
Simulation of Projects and Management Actions for the Petaluma Valley Groundwater Sustainability Plan

Introduction and Scenario Development

To inform groundwater sustainability planning in the Petaluma Valley Basin (Basin), projects and management actions (PMA) were simulated using the Petaluma Valley Integrated Hydrologic Model (PVIHM) and compared with future baseline scenario results (Petaluma Valley GSP Section 3.7) to identify potential changes to the Basin aquifer. Project benefits were evaluated by comparing projected groundwater elevations and water budget components with and without PMA.

A single PMA scenario was evaluated for the Basin. This scenario is referred to as the Group 1 Scenario, in case additional scenarios need to be evaluated in future planning. The Group 1 Scenario also parallels Group 1 Scenarios evaluated for the Sonoma Valley and Santa Rosa Plain basins in Sonoma County. The Group 1 Scenario for the Basin consists of two feasible water conservation efforts:

1. A 20% reduction in rural domestic pumping starting in water year (WY) 2025, and

2. A 10% reduction in vineyard irrigation starting in WY 2025.

The 20% reduction in rural domestic pumping is intended to reflect increasing outdoor water use efficiency by rural residences resulting from turf removal, rainwater harvesting, stormwater capture and reuse. This project does not include any potential future drought-related conservation requirements. The exact types of these projects and management actions are not specified for the purposes of evaluating potential project benefits.

The 10% reduction in vineyard irrigation is intended to reflect potential future changes such as delaying the start to the irrigation season, irrigation efficiency improvements, deficit irrigation, and grape varietals that require less water. The exact types of these changes are not specified for the purposes of evaluating potential project benefit.

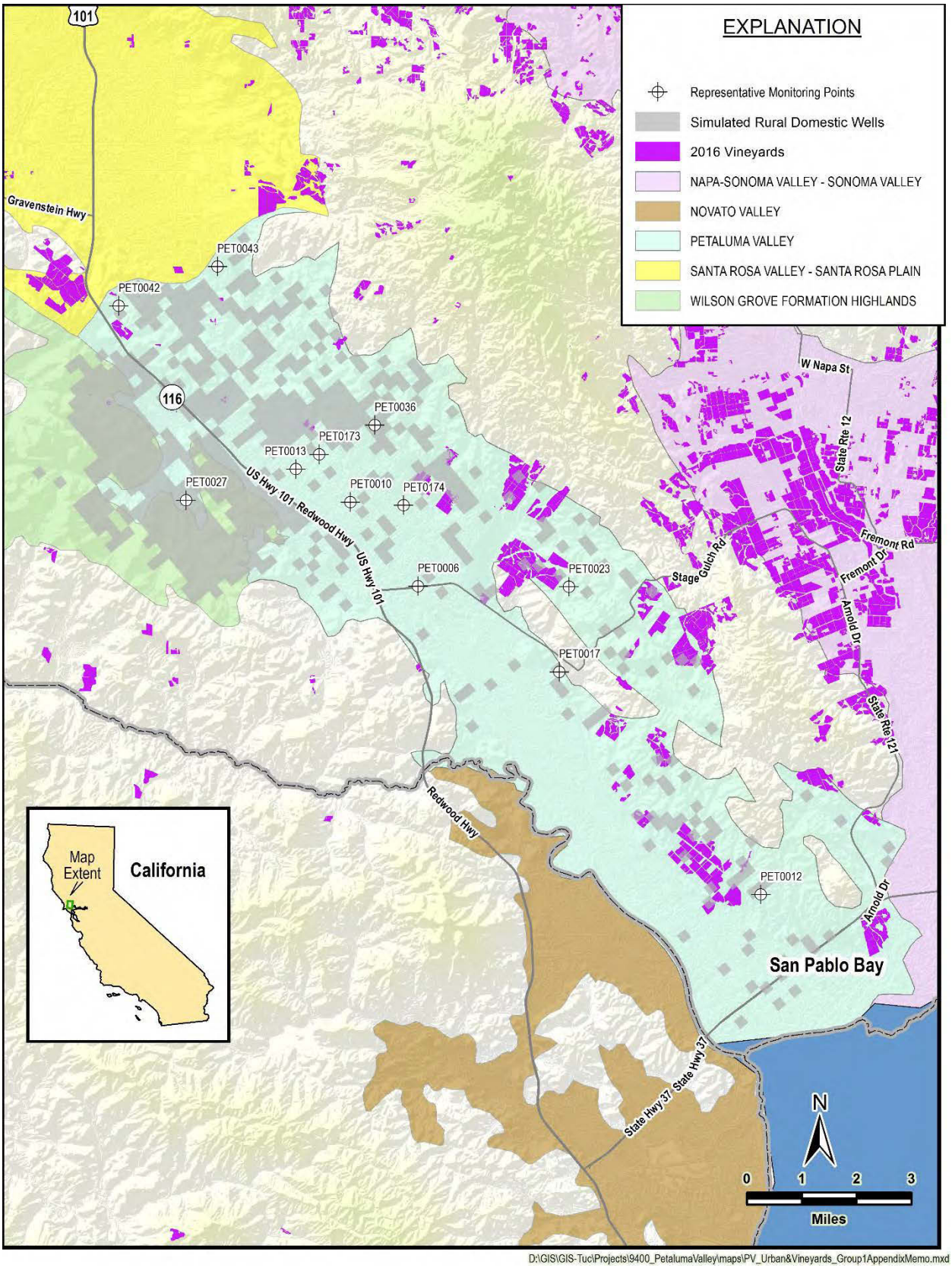

Figure 1: Modeled Urban and Vineyard Land use in the Petaluma Valley Basin

Implementation of Group 1 Projects in PVIHM

The Group 1 scenario was implemented by changing the following model inputs:

Rural Domestic Pumping: For Group 1, rural domestic pumping reductions were simulated by rescaling specified pumping rates for rural domestic wells in the MODFLOW WEL file. From WY 2025 until the end of the simulation, the rural domestic pumping rates were reduced by 20% from the baseline scenario.

Vineyard Consumptive Use: For Group 1, vineyard consumptive use reductions were simulated by reducing crop coefficients (K_c) by 10% during the growing season from what was used for the baseline scenario, beginning in water year 2025. Crop coefficients in the PVIHM were specified as part of the inputs to the MODFLOW-OWHM Farm Process (FMP).

Figure 2 below shows changes in projected agricultural and rural domestic pumping as part of the Group 1 scenario compared to the baseline scenario.

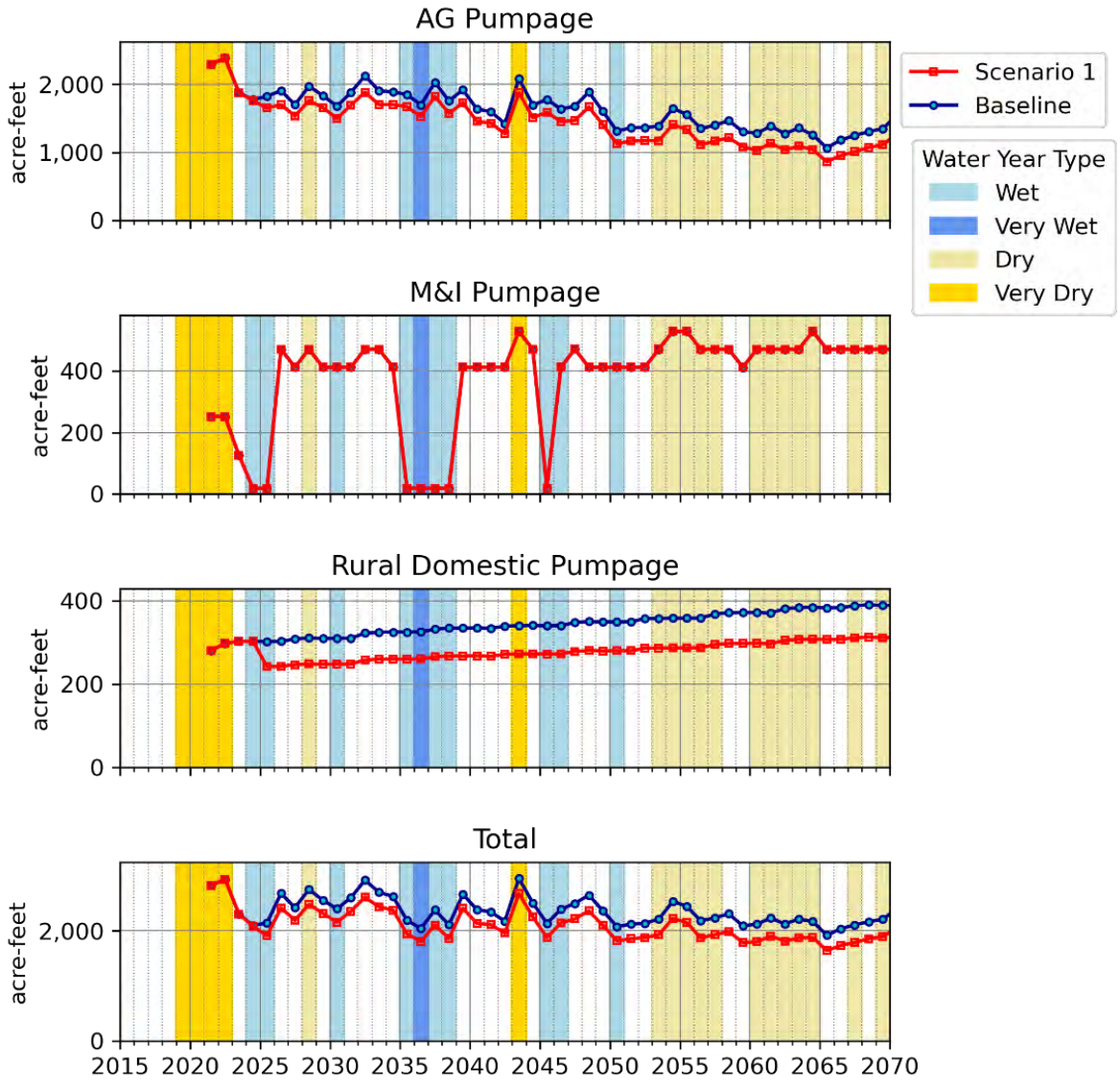

Figure 2: Baseline and Group 1 Scenario Projected Agricultural and Rural Domestic Groundwater Pumping

Table 1 compares average annual agricultural and rural domestic pumping between the baseline and Group 1 scenario. WY 2021 through WY 2070 projected pumping under the Group 1 scenario is approximately 250 AFY less than baseline projected pumping.

Table 1. Average Agricultural and Rural Domestic Pumping Rates

Mean Pumping (AFY)	Agricultural Baseline	Agricultural Group 1	Rural Domestic Baseline	Rural Domestic Group 1
WY 2021 – 2070	1,600	1,400	300	300
WY 2021 – 2040	1,900	1,700	300	300
WY 2041 – 2070	1,500	1,200	400	300

SCENARIO RESULTS

Project Benefits to Groundwater Levels

Figure 3 shows the difference in September 2070 projected groundwater levels between the Group 1 and baseline scenarios for PVIHM model layer 2, which represents the depth in the Petaluma Valley Basin Aquifer where most agricultural and domestic wells are screened (USGS, unpublished). Changes in groundwater elevation with Group 1 implementation are slight and impact small areas of the Basin, with less than 5 feet of increase from baseline expected by 2040, and less than 10 feet expected by 2070. As evidenced by the minimal amount of groundwater elevation change, the reduced pumping associated with Group 1 is not projected to significantly increase groundwater elevations. Instead, the primary projected benefit from Group 1 projects is to increase groundwater discharge to streams, as will be described in the Groundwater Budget section of this appendix.

The differences in projected groundwater elevation between the Group 1 and baseline scenarios for September 2040 were also reviewed, but found to be relatively minor. Differences between the two scenarios are more pronounced at the end of September 2070 due to the characteristics of the future climate scenario selected for the GSP, which consists of average to wet conditions through 2040, and then an extended drought from 2055 through 2070.

These simulation results indicate that the benefit from Group 1 projects in terms of increasing groundwater levels will be most significant during drought conditions, and least significant during wet periods when the water table is relatively shallow and there is minimal (unsaturated) storage capacity.

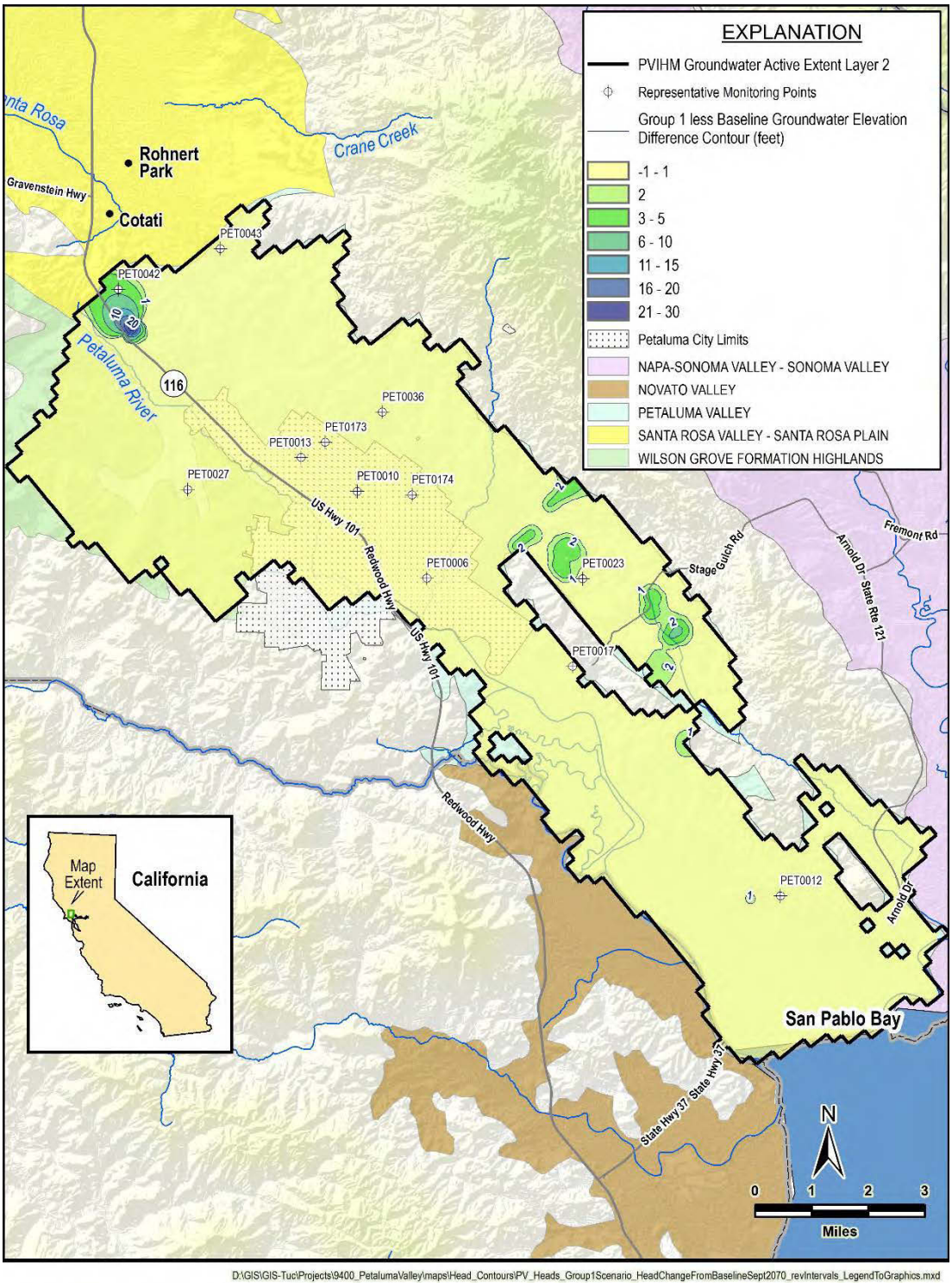

Figure 3: Group 1 Scenario Groundwater Elevation Changes from Baseline, September 2070, Model Layer 2

Appendix 6B compares projected groundwater level hydrographs between the baseline and Group 1 scenarios. As discussed above, projected groundwater level changes due to Group 1 are small. Table 2 shows the number of years for which projected groundwater levels are below the minimum thresholds (MT) set for representative monitoring point (RMP) wells in the Petaluma Valley Basin Aquifer. For all but one RMP well (PET0174), projected groundwater levels at each RMP well are above the corresponding MT. The MT exceedances at PET 0174 only are projected to occur after WY 2040 and the Group 1 scenario shows a reduction of MT exceedances.

Table 2. Number of Years with Water Levels Below Minmum Threshold for RMP Wells

RMP Well Name	Baseline		Group 1	
	WY 2021-2040	WY 2041-2070	WY 2021-2040	WY 2041-2070
PET0006	0	0	0	0
PET0010	0	0	0	0
PET0012	0	0	0	0
PET0013	0	0	0	0
PET0017	0	0	0	0
PET0023	0	0	0	0
PET0027	-	-	-	-
PET0036	0	0	0	0
PET0042	0	0	0	0
PET0043	0	0	0	0
PET0172	-	-	-	-
PET0173	0	0	0	0
PET0174	0	2	0	1

Groundwater Budget

Figure 4 shows cumulative change in storage for the future baseline and Group 1 scenarios. Table 3 shows the average annual change in storage for the Baseline and Group 1 scenarios. Both the Baseline and Group 1 scenarios project net depletion of groundwater storage over 2021-2070. On average, the Group 1 scenario projected groundwater storage depletion over WY 2021-2070 is about 20 AFY less than the Baseline groundwater storage depletion, when rounded to the nearest 10 AFY.

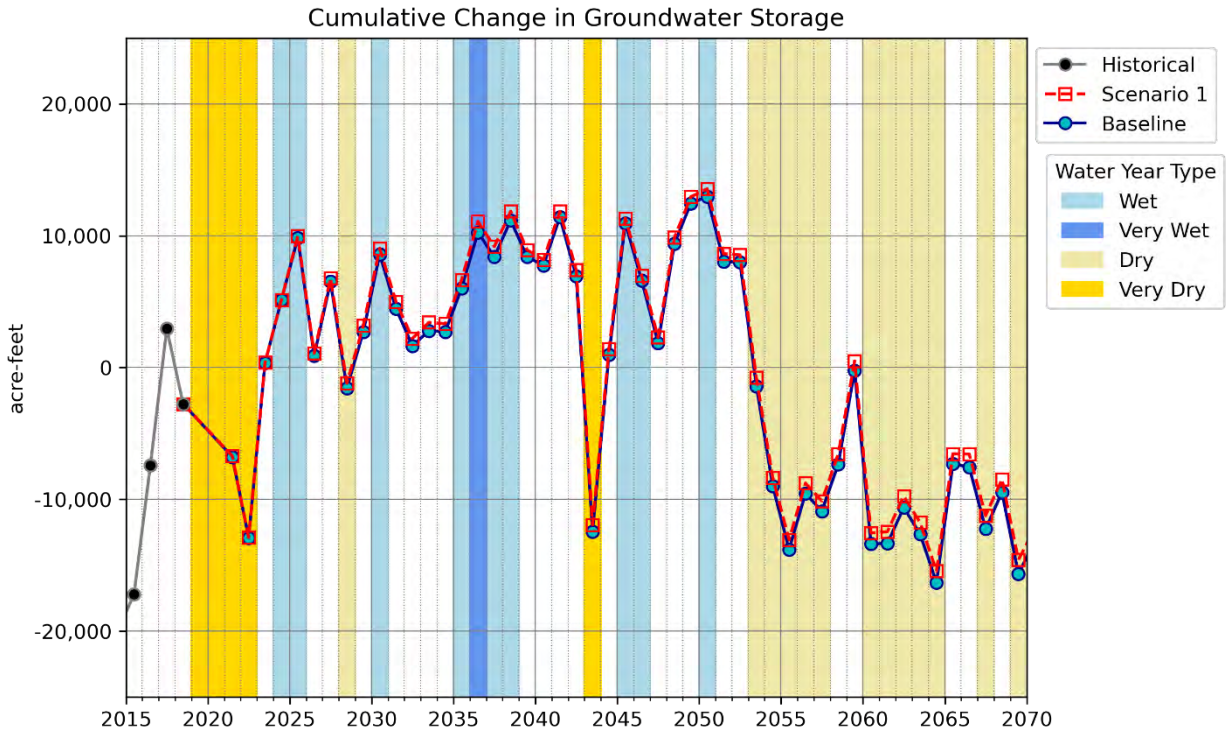

Figure 4 Projected Cumulative Change in Storage for Baseline and Group 1 Scenarios.

Table 3. Mean Annual Change in Storage (values in parentheses are unrounded values)

Average annual change in groundwater storage (AFY)	Baseline	Group 1
WY 2021 – 2040	500 (530)	600 (550)
WY 2041 – 2070	-700 (-700)	-700 (-680)
WY 2021 – 2070	-200 (-210)	-200 (-190)

Figure 5 shows the impact of the Group 1 scenario on net stream leakage, compared to the baseline. Table 4 shows the average annual mean net stream leakage for the Baseline and Group 1 scenario. Positive values indicate net leakage from surface water to groundwater, negative values indicate net discharge from groundwater to surface water. Results show that with Group 1, there is a projected increase in the magnitude of net groundwater discharge to surface water. This is due to diminished rates of stream leakage into the groundwater system rather than increased groundwater discharge to streams.

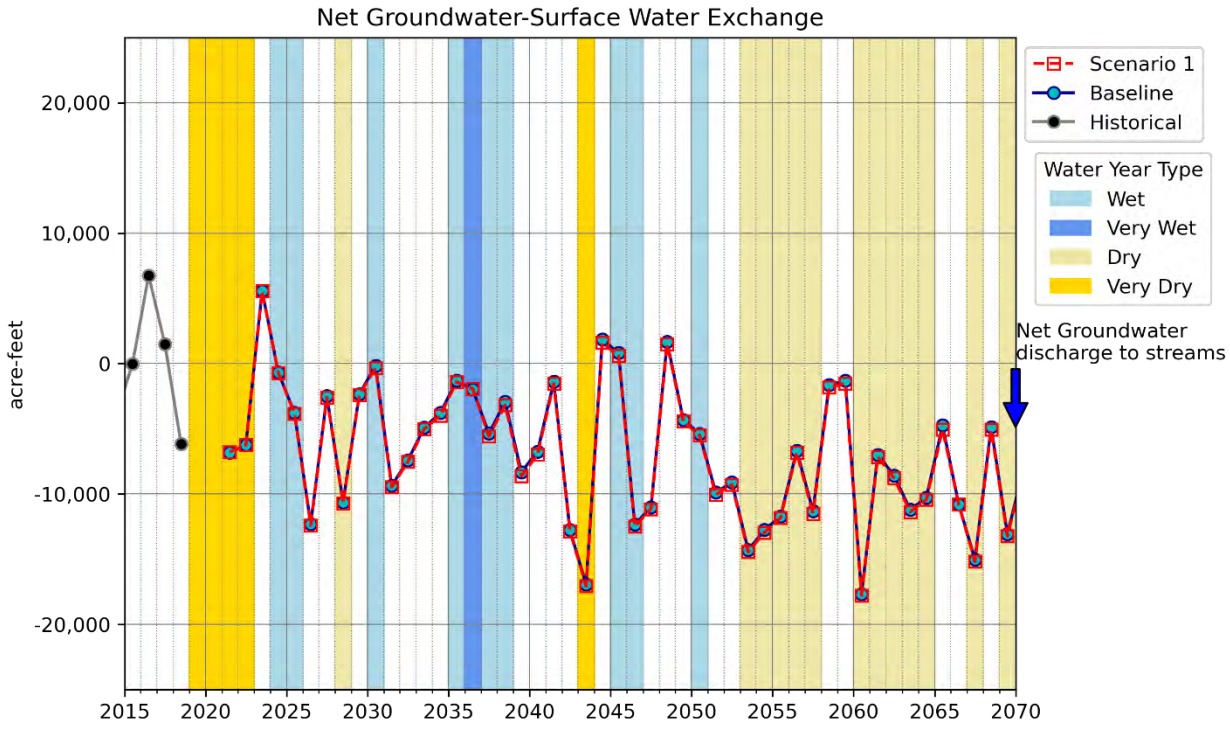

Figure 5. Projected Net Stream Leakage for Baseline and Group 1 Scenarios.

Table 4. Mean Net Stream Leakage.

Mean Net Stream Leakage (AFY)	Baseline	Group 1
WY 2021 – 2040	-4,600	-4,700
WY 2041 – 2070	-8,300	-8,500
WY 2021 – 2070	-6,800	-7,000

Figure 6 shows the impacts of the Group 1 scenario on net flow to the Baylands area and total inflow from the Petaluma River. Together, these inflows represent the potential inflow of brackish groundwater to the Basin. The trend of these inflows is notably upward throughout the 50-year simulation period as sealevels continue to rise. The response of surface leakage is also shown in Figure 6. This groundwater outflow continues to increase throughout the simulation period mirroring inflow from the Baylands, thus muting the effect of the sealevel rise on groundwater levels. Table 5 shows average annual net inflows from the Baylands. Table 6 shows average annual net inflow from the tidally-influenced Petaluma River. The Group 1 scenario has a negligible impact on flow from the Baylands. Projected inflow from the Petaluma River is about 30 AFY less in the Group 1 scenario, compared to the Baseline scenario (not shown in Table due to rounding).

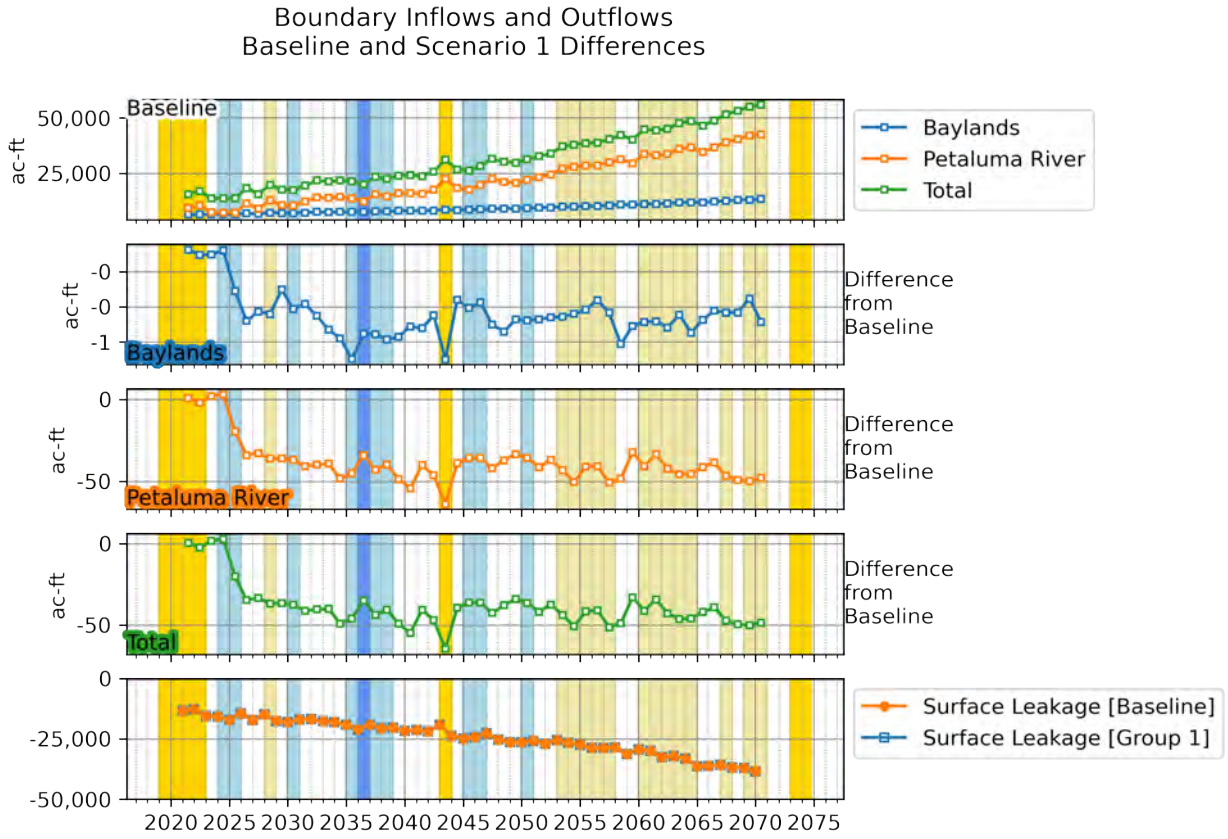

Figure 6. Projected Net Inflows from the Baylands and Tidally-Influenced Petaluma River for Baseline and Group 1 Scenarios.

Table 5. Mean Net Inflow From Baylands.

Mean Net Flow To/From Baylands (AFY)	**Baseline**	**Group 1**
WY 2021 – 2040	7,200	7,200
WY 2041 – 2070	10,400	10,400
WY2021 – 2070	9,100	9,100

Table 6. Mean Net Inflow in from Tidally-Influenced Petaluma River

Mean Inflow from Petaluma River (AFY)	Baseline	Group 1
WY 2021 – 2040	11,900	11,900
WY 2041 – 2070	28,700	28,600
WY2021 – 2070	22,000	21,900

REFERENCES CITED

USGS, unpublished, "Petaluma Valley Groundwater Resources and Model Development" [currently unpublished, will update when published]