



## TECHNICAL MEMORANDUM

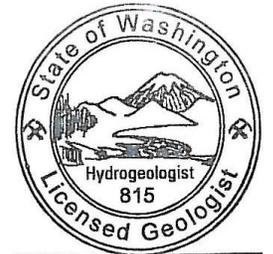
# Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System

**To:** Jeremy Jenkins, President/Spokane Aquifer Joint Board

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**Attachments:** Figures 1 and 2



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Attachment A: Development of Climate-Change Factors for Groundwater Modeling Analyses of Future Conditions at SAJB Production Wells

Attachment B: Time-Series Plots Showing Estimated Seasonal and Monthly Changes in Groundwater Levels During the Latter Part of the 21<sup>st</sup> Century

Attachment C: Bar Charts Showing Range of Potential Climate Influences on Spring and Summer Groundwater Levels During the Latter Part of the 21<sup>st</sup> Century

Attachments D, E, and F: Maps Showing the Spatial Distribution of the Largest Changes in Groundwater Levels During May, July, and August During the Latter Part of the 21<sup>st</sup> Century

**Date:** December 15, 2025

## Introduction

On behalf of the Spokane Aquifer Joint Board (SAJB), GSI Water Solutions, Inc. (GSI), has conducted a groundwater modeling analysis of the potential effects of future changes in climate and hydrology on groundwater levels at water supply wells belonging to SAJB members, who collectively provide all municipal drinking water supplies for the communities overlying the Washington portion of the SVRP Aquifer. Based on a similar study for the City of Spokane (GSI, 2024), the SAJB commissioned this study for its members with the recognition that climate-driven changes in the timing and amounts of recharge to the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer could affect groundwater levels in the aquifer and hence at the many wells belonging to SAJB members.

The study evaluates how changes in precipitation, temperatures, and other hydrologic variables (e.g., streamflows, inflows to the aquifer from lakes and tributary watersheds) can affect conditions in the SVRP Aquifer, and hence at SAJB member wells during the latter three decades of the 21<sup>st</sup> century (the years 2070 through 2099). The analysis examines a range of future climate conditions and provides a quantitative, numerical modeling-based assessment of the general amounts of groundwater level changes at SAJB member

wells that might arise in the future compared with recent historical conditions. Figure 1 shows the locations of the SAJB member wells and the geographic extent of the SVRP Aquifer in Washington and Idaho.

This technical memorandum is organized into the following sections:

- **Section 1:** A description of the methodology for conducting the modeling analysis
- **Section 2:** The simulated changes in groundwater levels for each SAJB member
- **Section 3:** Conclusions from this study
- **Section 4:** Limitations of the analysis
- **Section 5:** A list of references cited in this technical memorandum

## 1. Methodology

The study used a numerical three-dimensional groundwater flow model of the SVRP Aquifer and overlying and adjacent surface water bodies to simulate (1) recent historical conditions in the aquifer and (2) multiple scenarios of future changes in surface and subsurface hydrologic variables that affect recharge to the aquifer. The analysis used the newest version of SAJB’s three-dimensional numerical groundwater flow model of the SVRP Aquifer, which was developed in 2025 and is documented by GSI (2025). The model simulates groundwater elevations, groundwater flow directions, and groundwater budgets (including the rates of groundwater/surface water exchanges) using the U.S. Geological Survey (USGS) groundwater modeling software program MODFLOW-USG (Panday et al., 2013; Panday, 2025).

Four variables affect groundwater recharge to the aquifer: (1) inflows to the Spokane River from Coeur d’Alene Lake, (2) subsurface inflows to the SVRP Aquifer from lakes that bound the aquifer, (3) surface inflows from tributary streams/watersheds that bound the aquifer and infiltrate water into the SVRP Aquifer at the mouth of each tributary watershed, and (4) recharge from precipitation and human uses of water (for irrigation and septic systems) directly over the footprint of the SVRP Aquifer. The first step in this study consisted of developing the climate-change factors to apply to each of these four variables. The study evaluated six sets of climate scenarios for the latter three decades of the 21<sup>st</sup> century, (calendar years 2070 through 2099). The six climate scenarios were based on (1) two different scenarios for greenhouse gas (GHG) emissions and (2) low, median, and high degrees of climate change under each of these future emissions scenarios during the last three decades of the 21<sup>st</sup> century. The two GHG emissions scenarios are called Representative Concentration Pathways (RCPs) and are as follows:

- **RCP 4.5:** This scenario assumes that GHG emissions stabilize by the year 2050 and then decline steadily. This can be thought of as a somewhat optimistic scenario for future GHG emissions.
- **RCP 8.5:** This scenario assumes that GHG emissions do not decline and continue at their historical rates, resulting in continued accumulation of GHGs in the atmosphere through the remainder of the 21<sup>st</sup> century. This can be thought of as a “business as usual” scenario for future GHG emissions.

All six of the climate-change scenarios were evaluated using the numerical groundwater flow model, including a seventh “baseline” scenario with no climate change that was simulated for comparative analysis with each climate-change scenario. For each of the six future conditions, the method for deriving future water demands and the climate-change-based changes in hydrologic conditions of the SVRP Aquifer and the Spokane River was as follows:

- **Surface Water Inflows to the Spokane River from Coeur d’Alene Lake.** Climate-model projections of changes in future flows of the Spokane River at Post Falls, Idaho (at the headwaters of the Spokane River) were obtained from an online data portal called The Climate Toolbox.<sup>1</sup> This data portal contains climate and streamflow projections that have been locally downscaled from multiple global-scale climate models by the research community and compiled into a geospatial viewer to facilitate data retrieval and analysis at specific locations of interest. Table 1 summarizes the average daily flow rates at Post Falls under average historical conditions (as available from The Climate Toolbox) and the future streamflow projections. Figure 2 compares the historical average values of monthly flows (as obtained from The Climate Toolbox) with future flow projections for each month under both GHG emissions scenarios and the range of climate-change possibilities for those emissions scenarios. Table 2 provides the same information but expressed as a percentage change in flows. As shown in Table 2, climate change is expected to increase streamflows during the winter and early spring (December through March) and decrease streamflows during the remaining 8 months of the year (April through November). These values for flows at the headwaters of the Spokane River were programmed directly into MODFLOW-USG’s Streamflow-Routing Package, serving as inputs that were used by the model to evaluate how seepage rates through the bed of the Spokane River (i.e., recharge to the underlying aquifer from the river) might vary in the future throughout the reach of the river extending downstream of Post Falls.
- **Inflows to the SVRP Aquifer as Lake Underflow.** Future changes to SVRP Aquifer inflow originating from the major lakes along the aquifer boundary were estimated using a modified version of the same Climate Toolbox dataset that was used for estimating tributary inflow. Groundwater flowing into the SVRP Aquifer as underflow through the saturated zone from lake boundaries represents a significant source of inflow. The volume of flow is anticipated to be somewhat dependent on the stage of the lake; specifically, higher hydraulic head caused by higher lake levels theoretically increases the rate of underflow into the SVRP Aquifer, though the variations in underflow rates also depend on the hydraulic conductivity of the lakebed sediments. GSI assumed that although future lake levels could be affected by future climate-induced changes in the timing and rates of surface inflows to each lake, the actual volumetric changes to underflow occurring into the SVRP Aquifer on a monthly basis will be significantly less than changes in surface water inflows to the lakes. Historical inflow rates were normalized to a +/- 5 percent scale for the climate-change simulations, meaning the subsurface inflow rates from lakes were (1) increased by up to 5 percent for the wettest months (December and January) when surface inflows to lakes are anticipated to increase under future climates and (2) decreased by up to 5 percent during the driest months (June through September) reflecting reduced summer-season surface inflows to each lake. Table 3 lists the percentage adjustments for each month to the historical average subsurface inflow rates. These adjustments were made to all lakes except Lake Coeur d’Alene and Pend Oreille Lake, as lake levels in these two large lakes are highly regulated. These adjustments to tributary inflow rates were programmed into the WELL Package of MODFLOW-USG, which is used to specify tributary inflow rates under historical and projected future conditions.

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<sup>1</sup> The Climate Toolbox is available at <https://climatetoolbox.org/>.

**Table 1. Future Estimates of Spokane River Streamflows (cfs) at Post Falls, Idaho**

Month	Average Historical Streamflow (1950–2005)	Low Streamflow Under 2070–2099 Climate Change	Average Streamflow Under 2070–2099 Climate Change	High Streamflow Under 2070–2099 Climate Change
January	5,236	4,869 (RCP 4.5) 6,530 (RCP 8.5)	6,884 (RCP 4.5) 7,874 (RCP 8.5)	8,690 (RCP 4.5) 8,731 (RCP 8.5)
February	7,463	7,819 (RCP 4.5) 12,044 (RCP 8.5)	12,274 (RCP 4.5) 14,007 (RCP 8.5)	16,039 (RCP 4.5) 17,239 (RCP 8.5)
March	8,941	9,166 (RCP 4.5) 8,290 (RCP 8.5)	11,558 (RCP 4.5) 11,640 (RCP 8.5)	14,068 (RCP 4.5) 15,357 (RCP 8.5)
April	15,394	11,086 (RCP 4.5) 7,742 (RCP 8.5)	14,714 (RCP 4.5) 12,974 (RCP 8.5)	17,831 (RCP 4.5) 17,121 (RCP 8.5)
May	17,408	7,236 (RCP 4.5) 3,152 (RCP 8.5)	10,278 (RCP 4.5) 6,420 (RCP 8.5)	13,064 (RCP 4.5) 9,846 (RCP 8.5)
June	9,118	1,675 (RCP 4.5) 931 (RCP 8.5)	2,436 (RCP 4.5) 1,410 (RCP 8.5)	3,484 (RCP 4.5) 2,181 (RCP 8.5)
July	2,381	595 (RCP 4.5) 396 (RCP 8.5)	741 (RCP 4.5) 543 (RCP 8.5)	971 (RCP 4.5) 754 (RCP 8.5)
August	877	195 (RCP 4.5) 132 (RCP 8.5)	297 (RCP 4.5) 207 (RCP 8.5)	388 (RCP 4.5) 348 (RCP 8.5)
September	798	236 (RCP 4.5) 160 (RCP 8.5)	318 (RCP 4.5) 233 (RCP 8.5)	411 (RCP 4.5) 344 (RCP 8.5)
October	1,368	632 (RCP 4.5) 494 (RCP 8.5)	740 (RCP 4.5) 600 (RCP 8.5)	886 (RCP 4.5) 793 (RCP 8.5)
November	2,903	1,999 (RCP 4.5) 1,953 (RCP 8.5)	2,824 (RCP 4.5) 2,529 (RCP 8.5)	3,642 (RCP 4.5) 3,600 (RCP 8.5)
December	4,646	4,869 (RCP 4.5) 5,327 (RCP 8.5)	6,414 (RCP 4.5) 7,194 (RCP 8.5)	9,570 (RCP 4.5) 9,984 (RCP 8.5)
Annual Average	6,361	4,173 (RCP 4.5) 3,876 (RCP 8.5)	5,744 (RCP 4.5) 5,412 (RCP 8.5)	7,361 (RCP 4.5) 7,124 (RCP 8.5)

**Notes**

All values are in units of cubic feet per second (cfs).

RCP = Representative Concentration Pathway for future global greenhouse gas emissions

**Table 2. Future Estimates of Percentage Changes in Spokane River Streamflows at Post Falls, Idaho**

Month	Percentage Change (Low Streamflows in 2070–2099 versus Average Historical Streamflows)	Percentage Change (Average Streamflows in 2070–2099 versus Average Historical Streamflows)	Percentage Change (High Streamflows in 2070–2099 versus Average Historical Streamflows)
January	-7.0% (RCP 4.5) +24.7% (RCP 8.5)	+31.5% (RCP 4.5) +50.4% (RCP 8.5)	+66.0% (RCP 4.5) +66.8% (RCP 8.5)
February	+4.8% (RCP 4.5) +61.4% (RCP 8.5)	+64.5% (RCP 4.5) +87.7% (RCP 8.5)	+114.9% (RCP 4.5) +131.0% (RCP 8.5)
March	+2.5% (RCP 4.5) -7.3% (RCP 8.5)	+29.3% (RCP 4.5) +30.2% (RCP 8.5)	+57.3% (RCP 4.5) +71.8% (RCP 8.5)
April	-28.0% (RCP 4.5) -49.7% (RCP 8.5)	-4.4% (RCP 4.5) -15.7% (RCP 8.5)	+15.8% (RCP 4.5) +11.2% (RCP 8.5)
May	-58.4% (RCP 4.5) -81.9% (RCP 8.5)	-41.0% (RCP 4.5) -63.1% (RCP 8.5)	-25.0% (RCP 4.5) -43.4% (RCP 8.5)
June	-81.6% (RCP 4.5) -89.8% (RCP 8.5)	-73.3% (RCP 4.5) -84.5% (RCP 8.5)	-61.8% (RCP 4.5) -76.1% (RCP 8.5)
July	-75.0% (RCP 4.5) -83.4% (RCP 8.5)	-68.9% (RCP 4.5) -77.2% (RCP 8.5)	-59.2% (RCP 4.5) -68.4% (RCP 8.5)
August	-77.8% (RCP 4.5) -84.9% (RCP 8.5)	-66.1% (RCP 4.5) -76.4% (RCP 8.5)	-55.7% (RCP 4.5) -60.3% (RCP 8.5)
September	-70.4% (RCP 4.5) -80.0% (RCP 8.5)	-60.1% (RCP 4.5) -70.9% (RCP 8.5)	-48.5% (RCP 4.5) -56.9% (RCP 8.5)
October	-53.8% (RCP 4.5) -63.9% (RCP 8.5)	-45.9% (RCP 4.5) -56.1% (RCP 8.5)	-35.2% (RCP 4.5) -42.0% (RCP 8.5)
November	-31.2% (RCP 4.5) -32.7% (RCP 8.5)	-2.7% (RCP 4.5) -12.9% (RCP 8.5)	+25.5% (RCP 4.5) +24.0% (RCP 8.5)
December	+4.8% (RCP 4.5) 14.7% (RCP 8.5)	+38.1% (RCP 4.5) +54.8% (RCP 8.5)	+106.0% (RCP 4.5) +114.9% (RCP 8.5)
Annual Average	-34.4% (RCP 4.5) -39.1% (RCP 8.5)	-9.7% (RCP 4.5) -14.9% (RCP 8.5)	+15.7% (RCP 4.5) +12.0% (RCP 8.5)

**Note**

RCP = Representative Concentration Pathway for future global greenhouse gas emissions

**Table 3. Percentage Adjustments for Monthly Variations in Subsurface Lake Inflow Rates**

Month	Percentage Adjustment in Subsurface Lake Inflow Rates
January	+4.4%
February	+1.2%
March	-1.9%
April	-3.0%
May	-4.0%
June	-4.5%
July	-5.0%
August	-5.0%
September	-4.0%
October	-2.1%
November	+2.8%
December	+5.0%

- Inflows to the SVRP Aquifer from Adjoining Tributaries.** Historical and future projections of precipitation and runoff were used to define the inflows to the SVRP Aquifer from 71 tributaries that drain to the outer boundary of the aquifer and infiltrate this runoff into the aquifer along its outer margins. The Climate Toolbox was used as the source of the future projections, providing future runoff estimates on a seasonal (rather than monthly) basis and for Spokane County as a whole. As shown in Table 4, these seasonal inflows into the aquifer are estimated to be higher than current flows during the fall and winter months (from approximately September or October through February or March) and lower during the remaining months of the year. (See Table A-2 and Figure A-2 in Attachment A for the equivalent runoff depths in inches.) These adjustments to tributary inflow rates were programmed into the WELL Package of MODFLOW-USG, which is used to specify tributary inflow rates under historical and projected future conditions.

**Table 4. Future Estimates of Percentage Changes in Runoff (Tributaries Draining into the SVRP Aquifer)**

Season	Percentage Change (Low Runoff in 2070–2099 versus Average Historical Runoff)	(Median Runoff in 2070–2099 versus Average Historical Runoff)	(High Runoff in 2070–2099 versus Average Historical Runoff)
December–February	+19.5% (RCP 4.5) +23.5% (RCP 8.5)	+23.9% (RCP 4.5) +29.6% (RCP 8.5)	+28.2% (RCP 4.5) +35.5% (RCP 8.5)
March–May	-11.9% (RCP 4.5) -15.1% (RCP 8.5)	-6.3% (RCP 4.5) -9.1% (RCP 8.5)	-1.2% (RCP 4.5) -3.6% (RCP 8.5)
June–August	-9.6% (RCP 4.5) -12.2% (RCP 8.5)	-6.5% (RCP 4.5) -8.6% (RCP 8.5)	-3.3% (RCP 4.5) -5.6% (RCP 8.5)
September–November	+10.6% (RCP 4.5) +15.6% (RCP 8.5)	+16.1% (RCP 4.5) +19.8% (RCP 8.5)	+22.6% (RCP 4.5) +22.2% (RCP 8.5)
Annual Average	+1.6% (RCP 4.5) +2.2% (RCP 8.5)	+6.4% (RCP 4.5) +7.4% (RCP 8.5)	+11.2% (RCP 4.5) +11.8% (RCP 8.5)

**Notes**

RCP = Representative Concentration Pathway for future global greenhouse gas emissions

SVRP = Spokane Valley-Rathdrum Prairie

- Areal Recharge of Precipitation.** The percentage changes in runoff that were applied to tributary recharge (as listed in Table 4) were also applied to precipitation infiltration rates over the footprint of the SVRP Aquifer. These adjustments to areal recharge rates were programmed into the Recharge Package of MODFLOW-USG, which is used to simulate surface infiltration arising from precipitation, irrigation, and septic systems. The SAJB model uses a spatially variable recharge array derived from an earlier model developed by the USGS (Hsieh et al., 2007). At any given location, the recharge value is the sum of these three sources of recharge, and the model uses multipliers to vary the summed recharge value on a month-by-month basis in its representation of historical recharge rates to the aquifer. Because the climate simulations seek to vary only precipitation recharge (and not recharge from irrigation or septic systems), the multipliers for the combined recharge from all three sources of water required different adjustment factors than those listed above in Table 4 for tributary recharge. Table 5 summarizes the monthly multipliers, which were developed from a series of complex calculations and are used in the Recharge Package for historical conditions and each of the six climate scenarios evaluated with the model.

Attachment A provides further details regarding the technical methodology for developing the climate-change scenarios and climate-change factors used in the groundwater model.

**Table 5. Recharge Multipliers (for Total Recharge from Precipitation, Irrigation, and Septic Systems)**

Month	Multiplier for Average Historical Recharge	Multiplier for Low Recharge in 2070–2099	Multiplier for Median Recharge in 2070–2099	Multiplier for High Recharge in 2070–2099
January	1.418	1.681 (RCP 4.5) 1.734 (RCP 8.5)	1.740 (RCP 4.5) 1.817 (RCP 8.5)	1.798 (RCP 4.5) 1.896 (RCP 8.5)
February	0.955	1.128 (RCP 4.5) 1.163 (RCP 8.5)	1.167 (RCP 4.5) 1.217 (RCP 8.5)	1.205 (RCP 4.5) 1.269 (RCP 8.5)
March	0.683	0.676 (RCP 4.5) 0.664 (RCP 8.5)	0.650 (RCP 4.5) 0.635 (RCP 8.5)	0.620 (RCP 4.5) 0.603 (RCP 8.5)
April	0.568	0.563 (RCP 4.5) 0.555 (RCP 8.5)	0.544 (RCP 4.5) 0.534 (RCP 8.5)	0.523 (RCP 4.5) 0.511 (RCP 8.5)
May	0.434	0.431 (RCP 4.5) 0.425 (RCP 8.5)	0.419 (RCP 4.5) 0.412 (RCP 8.5)	0.405 (RCP 4.5) 0.398 (RCP 8.5)
June	0.397	0.391 (RCP 4.5) 0.386 (RCP 8.5)	0.384 (RCP 4.5) 0.380 (RCP 8.5)	0.379 (RCP 4.5) 0.374 (RCP 8.5)
July	0.404	0.398 (RCP 4.5) 0.393 (RCP 8.5)	0.391 (RCP 4.5) 0.387 (RCP 8.5)	0.385 (RCP 4.5) 0.380 (RCP 8.5)
August	0.309	0.305 (RCP 4.5) 0.302 (RCP 8.5)	0.301 (RCP 4.5) 0.298 (RCP 8.5)	0.297 (RCP 4.5) 0.293 (RCP 8.5)
September	0.267	0.279 (RCP 4.5) 0.284 (RCP 8.5)	0.285 (RCP 4.5) 0.289 (RCP 8.5)	0.292 (RCP 4.5) 0.292 (RCP 8.5)
October	0.644	0.692 (RCP 4.5) 0.715 (RCP 8.5)	0.718 (RCP 4.5) 0.735 (RCP 8.5)	0.747 (RCP 4.5) 0.746 (RCP 8.5)
November	1.273	1.400 (RCP 4.5) 1.460 (RCP 8.5)	1.467 (RCP 4.5) 1.511 (RCP 8.5)	1.544 (RCP 4.5) 1.540 (RCP 8.5)
December	1.508	1.788 (RCP 4.5) 1.845 (RCP 8.5)	1.852 (RCP 4.5) 1.933 (RCP 8.5)	1.913 (RCP 4.5) 2.018 (RCP 8.5)

**Note**

RCP = Representative Concentration Pathway for future global greenhouse gas emissions

## 2. Climate-Change Simulation Results

The results of the modeling analyses are described below and are presented in terms of three different degrees of climate change. As discussed in Attachment A, the correlation of low, average, and high streamflow rates and tributary valley inflow rates to the three degrees of climate change are as follows:<sup>2</sup>

- The low degree of climate change involves the smallest reductions in projected dry-season Spokane River streamflows, the highest projected wet-season streamflows in the Spokane River, the smallest projected increases in wet-season tributary inflows, and the smallest projected reductions in dry-season tributary inflows.
- The median degree of climate change involves the median projected changes in Spokane River streamflows and tributary inflows in all months.
- The high degree of climate change involves the largest reductions in projected dry-season Spokane River streamflows, the lowest projected wet-season streamflows in the Spokane River, the largest projected increases in wet-season tributary inflows, and the largest projected reductions in dry-season tributary inflows.

Following are discussions of:

- Seasonal patterns in future groundwater level changes
- Groundwater level changes during the late spring and summer seasons
- The spatial distribution of groundwater level changes during the late spring and summer seasons

### 2.1 Seasonal Patterns in Future Groundwater Level Changes

Attachment B shows time-series plots of the model-simulated range of seasonal and monthly changes in groundwater levels that could occur each month during the latter three decades of the 21<sup>st</sup> century. The plots show the changes for each of the six climate scenarios that were evaluated using the groundwater model. In most cases, the plot for an individual SAJB member shows conditions at a well that is representative of all wells owned by that SAJB member, with very little difference occurring from well to well. Multiple plots are shown in Attachment B for four SAJB members (Consolidated Irrigation District No. 19, the City of Spokane, Spokane County Water District No. 3, and Whitworth Water District No. 2), for whom wells in different parts of the SVRP Aquifer show notable differences in the magnitudes of the groundwater level changes that could occur in the future.

Key observations from the time-series plots are as follows:

- In the easternmost portion of Spokane Valley, the range in potential future groundwater level changes is significant. Low degrees of climate change (RCP 4.5 Low and RCP 8.5 Low) result in little to no decrease in groundwater levels throughout the year, but the remaining climate scenarios (representing average and high degrees of climate change) result in groundwater level decreases throughout much (if not all) of the year. See, for example, the plots for Consolidated Irrigation District No. 19, Liberty Lake Sewer & Water District No. 1, and Moab Irrigation District No. 20. In Washington, this portion of the SVRP Aquifer is estimated to experience the greatest declines in future groundwater levels during the late spring and summer.

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<sup>2</sup> During all months, rates of precipitation recharge over the footprint of the aquifer behave similar to tributary valley inflows in terms of their relationship to the three degrees of climate change. Similarly, rates of total recharge over the aquifer's footprint (precipitation plus irrigation plus septic systems) follow the same relationships as tributary inflows from September through February. However, total recharge over the aquifer from March through August does not follow the same pattern as tributary inflows because of the importance of irrigation recharge during these months.

- Other wells in Spokane Valley (east of the City of Spokane) also show noteworthy seasonal fluctuations in the degree of future changes in groundwater levels. Compared with the easternmost portion of Spokane Valley, this area experiences smaller declines during the late spring and summer and a greater tendency to not experience declines during the rest of the year. See, for example, the plots for Carnhope Irrigation District No. 7 and East Spokane Water District No. 1 (the furthest west in this area) and Trentwood Irrigation District No. 3 and Spokane Business & Industrial Park (the furthest east in this area, and closest to Consolidated Irrigation District No. 19).
- Inside the City of Spokane, the range in potential future groundwater level changes shows considerable variability, with wells closest to the Spokane River (such as the Well Electric Well Station) showing the greatest changes, wells a modest distance from the river (such as the Grace Well Station) showing more modest changes, and wells furthest from the river (such as the Hoffman Well Station) showing the least amount of change.
- North of the City of Spokane, the distance from the Spokane River also governs the amount of potential future changes in groundwater levels. Wells closest to the river (such as Spokane County Water District No. 3's Lyons & Normandie well) show notable fluctuations which are smaller than observed in Spokane Valley but are notably greater than those observed further north of the Spokane River (such as at wells owned by Whitworth Water District No. 2).

## 2.2 Groundwater Level Changes During the Late Spring and Summer

For each SAJB member, Attachment C presents a single bar chart showing the model-simulated range of potential changes in groundwater levels during the late spring and early summer months during the latter part of the 21<sup>st</sup> century. Each bar chart shows the groundwater level declines starting in either May or June and continuing through August. Each bar chart focuses on the late spring and early summer because this is the time period when groundwater level declines are estimated to be greatest in magnitude during the latter part of the 21<sup>st</sup> century. For each SAJB member, the bar chart shows the groundwater level changes for the well that is estimated by the model to experience the greatest magnitude of water level declines under the high degree of future potential climate change.

Key observations from the bar charts are as follows:

- Nearly all of the bar charts show reductions in late-century groundwater levels from May or June through August for all six of the climate scenarios that were evaluated. The only exceptions are in the easternmost portion of Spokane Valley, near the Washington-Idaho state line, where wells owned by Liberty Lake Sewer & Water District No. 1 and Moab Irrigation District No. 20 show possibly higher groundwater levels for the two climate models having low degrees of future change (RCP 4.5 Low and RCP 8.5 Low). Wells near the state line that are owned by Consolidated Irrigation District No. 19 may also experience higher groundwater levels from May/June through August under these two climate models, as shown for Well 11 in Attachment B; however, other wells are estimated to experience slightly lower July and August groundwater levels late this century, as shown by the time-series plots in Attachment B for Wells 1 and 5 and in the bar chart in Attachment C for the well (Well 11) that is most affected under a high degree of climate change.
- The bar charts show that the greatest declines in groundwater levels occur during the late spring and early summer, with somewhat less groundwater level decline during the latter portion of the summer (August). This occurs because the greatest changes in climate and in watershed/aquifer hydrology occur during the spring, which is the season experiencing the greatest changes in watershed snowmelt, precipitation, and runoff (streamflows). The onset of earlier snowmelt and peak-season runoff causes the latter portion of the spring season (i.e., May and June) to be drier, resulting in these months experiencing the greatest changes in hydrology compared with historical conditions. With summer-like conditions anticipated to

begin in May and early June during the latter part of the century, these months experience the greatest changes in groundwater levels, whereas the continuation of summer conditions in August is similar to historical conditions and results in less change in groundwater levels during August than in May and June.

## 2.3 Spatial Distribution of Groundwater Level Changes During the Late Spring and Summer

Attachments D, E, and F present maps for May, July, and August, respectively, that show the spatial distribution of the largest groundwater level changes that are estimated to occur in the latter part of the 21<sup>st</sup> century for the three degrees of climate change under the RCP 8.5 climate scenarios. The maps show three noteworthy observations:

- During a given month, the largest changes in groundwater levels vary considerably when considering the low versus average versus high degrees of climate change.
- Groundwater level changes are greatest in eastern Spokane Valley and smallest in the northwest corner of the aquifer (in Hillyard Trough, north of the City of Spokane). In between these areas, the changes can vary considerably between these two extremes from month to month and from one climate scenario to the next.
- Groundwater level declines during the late spring and summer are expected to be less than 10 feet in most locations and under most of the climate scenarios. The maps show that the only exceptions to this occur for the high degree of climate change and are limited to wells in the easternmost part of Spokane Valley, close to the Washington-Idaho state line and a few of the City of Spokane wells closest to the Spokane River. Under the average and low degrees of climate change, most wells show no more than 5 to 6 feet of groundwater level reductions in the late spring and summer months of the late 21<sup>st</sup> century.

## 3. Conclusions

The primary conclusion from the study is that future changes in groundwater levels at SAJB member wells are expected to be less than 10 feet during the latter part of the 21<sup>st</sup> century in many of the future scenarios evaluated with the model. Only one climate scenario (a high degree of climate change under RCP 8.5) estimates that groundwater level declines of more than 10 feet could occur, which is limited to the easternmost portion of Spokane Valley and a few of the City of Spokane wells closest to the Spokane River. Elsewhere, particularly for low and medium degrees of climate change, most wells are expected to show no more than 5 to 6 feet of groundwater level reductions in the late spring and summer months of the late 21<sup>st</sup> century. For each SAJB member well, the depth of the well and the depth of the pump intake will control whether these changes might pose any operational difficulties in the future.

A second primary conclusion from this analysis is that future groundwater levels are likely to be most influenced by future changes that might occur in Spokane River flows at Post Falls (the most important factor) and by inflows of surface water runoff from tributary valleys that flow to the margins of the SVRP Aquifer and provide groundwater recharge. This interpretation is not only suggested for future conditions by this analysis, but is consistent with recent historical observations of conditions during the past few decades in the Spokane River and its contributing watershed. Specifically, a phased study conducted by the SAJB from 2014 through 2016 (Porcello et al., 2017) examined the historical decreases in the seasonal low flows of the Spokane River since the early 1900s, with particular focus on evaluating why the seasonal low flows at the stream gage in downtown Spokane were continuing to decrease in recent decades. The study found that an approximately 40 percent reduction in summer-season water use in the Spokane/Coeur d'Alene metropolitan region had occurred by the late 1980s compared with summer-season water uses during the 1940s and 1950s. The reduction in peak-season regional water uses began when surface water diversions for agricultural water use ended in the 1960s. The SAJB study found that river flows were still declining despite reductions in water use,

and that other changes over the footprint of the SVRP Aquifer (e.g., changes in stormwater management, wastewater discharges, and irrigation water use) have had little influence on the continued declines in the river's seasonal low flows during the rest of the 20<sup>th</sup> century and the first 15 years of the 21<sup>st</sup> century. The last phase of the SAJB study examined data on snowpack conditions in the watersheds that contribute flow into Coeur d'Alene Lake and found that notable shifts in the magnitudes and timing of snow accumulation and snowmelt occurred during the first 15 years of the 21<sup>st</sup> century compared with conditions during the last two decades of the 20<sup>th</sup> century. The SAJB study found a correlation between recent historical changes in April snowpack conditions and the continuation of historical decreases in August low flows in the Spokane River in downtown Spokane. The projections from climate models of future climate-driven changes in Spokane River flows are consistent with the findings of SAJB's historical study of the changes in Spokane River flows.

#### 4. Limitations of this Study

The study described in this technical memorandum used a detailed process for (1) identifying and studying a range of climate-change scenarios that are projected to affect the SVRP Aquifer and the surrounding watershed in which it resides; and (2) evaluating the influences of changing climate and changing demands on SAJB member wells (using a three-dimensional numerical groundwater flow model of the SVRP Aquifer). Nonetheless, despite the detail and the in-depth nature of this study, the supporting data and analyses provide a simplification of a complex climatic and hydrogeologic system and also contain certain built-in assumptions pertaining to these systems and the nature of future water demands. Accordingly, the interpretations and conclusions presented in this study should not be viewed as absolute results and could change in the future as new climate projections become available and as the groundwater model is refined in the future (which will occur in 2026 in the Idaho portion of the SVRP Aquifer).

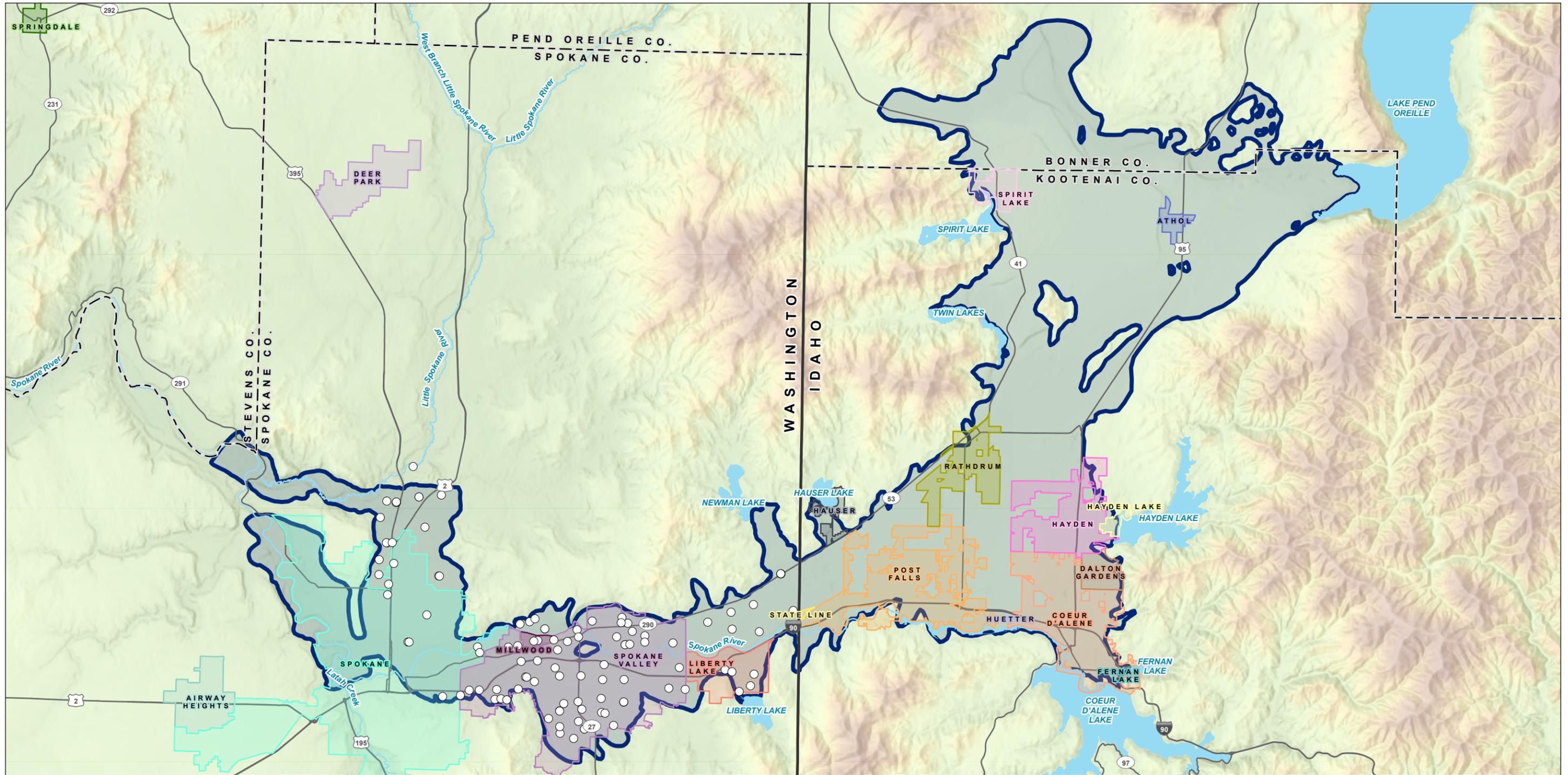
In addition to the general limitations described above, the study presented in this memorandum has two specific limitations:

- The study did not account for changes in future water demands (and hence increases in future pumping from the SVRP Aquifer) that would occur in the region, except for the City of Spokane (City) where the pumping volumes are those used in a similar study recently completed for the City (GSI, 2024). Increased future pumping by municipal water suppliers elsewhere in the SVRP Aquifer could further lower groundwater levels in the aquifer. However, based on simulations conducted for the City study (GSI, 2024), additional decreases in groundwater levels at other SAJB member wells would likely be only a small percentage beyond the water level decreases described in this study.
- The groundwater model's representation of the spatial distribution of recharge over the footprint of the SVRP Aquifer (recharge which arises from precipitation, agricultural irrigation, urban irrigation, and septic systems) is based on land use information that is on the order of 20 years old (or older). As a result, these rates do not fully reflect current or projected future land and water uses.

## 5. References

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**LEGEND**

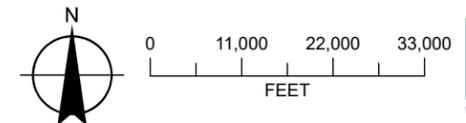
- Spokane Aquifer Joint Board Well
- ▭ Major Road
- ▭ Spokane Valley-Rathdrum Prairie Aquifer
- ▭ Watercourse
- All Other Features**
- ▭ Waterbody
- ▭ County Boundary
- ▭ State Boundary

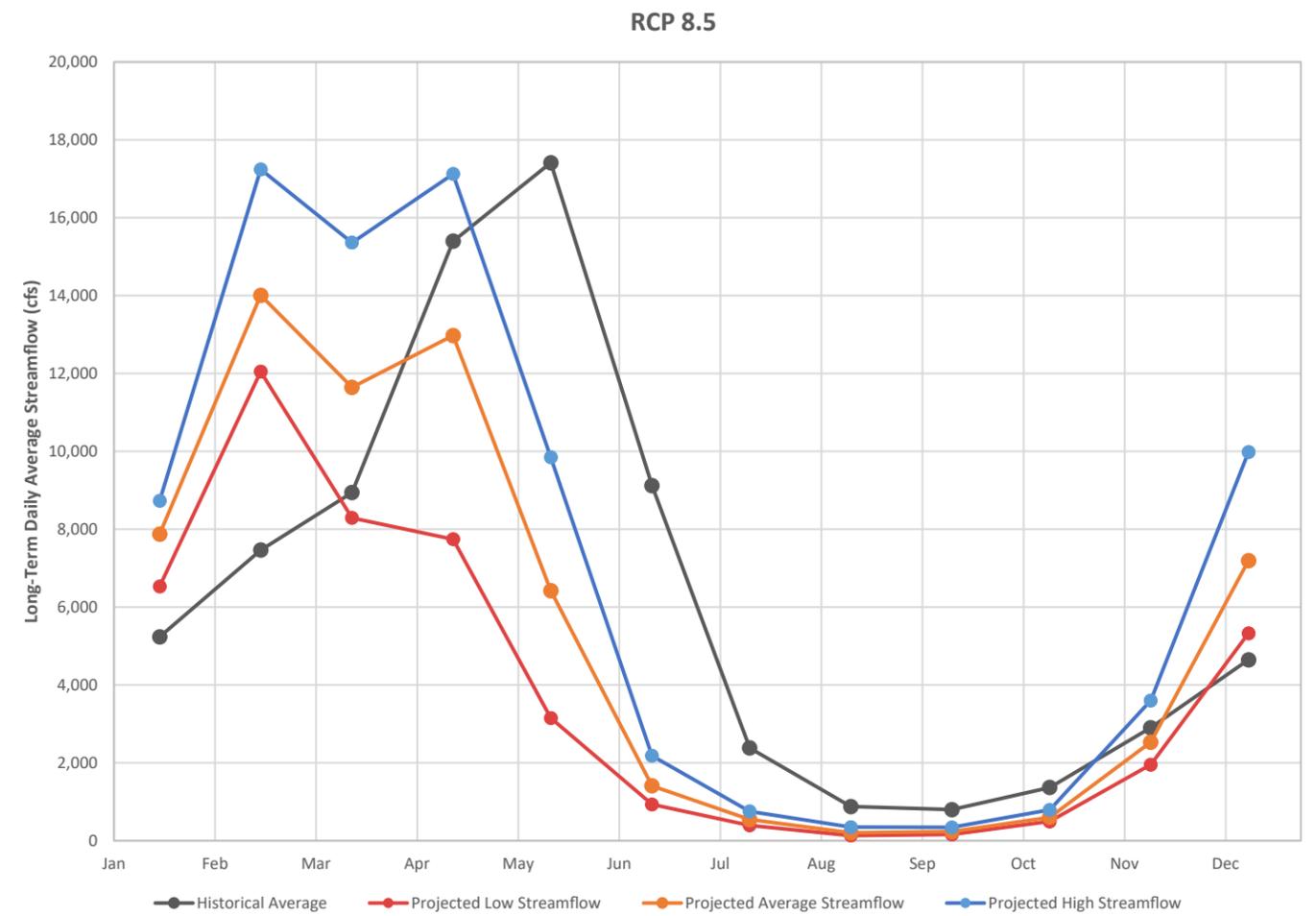
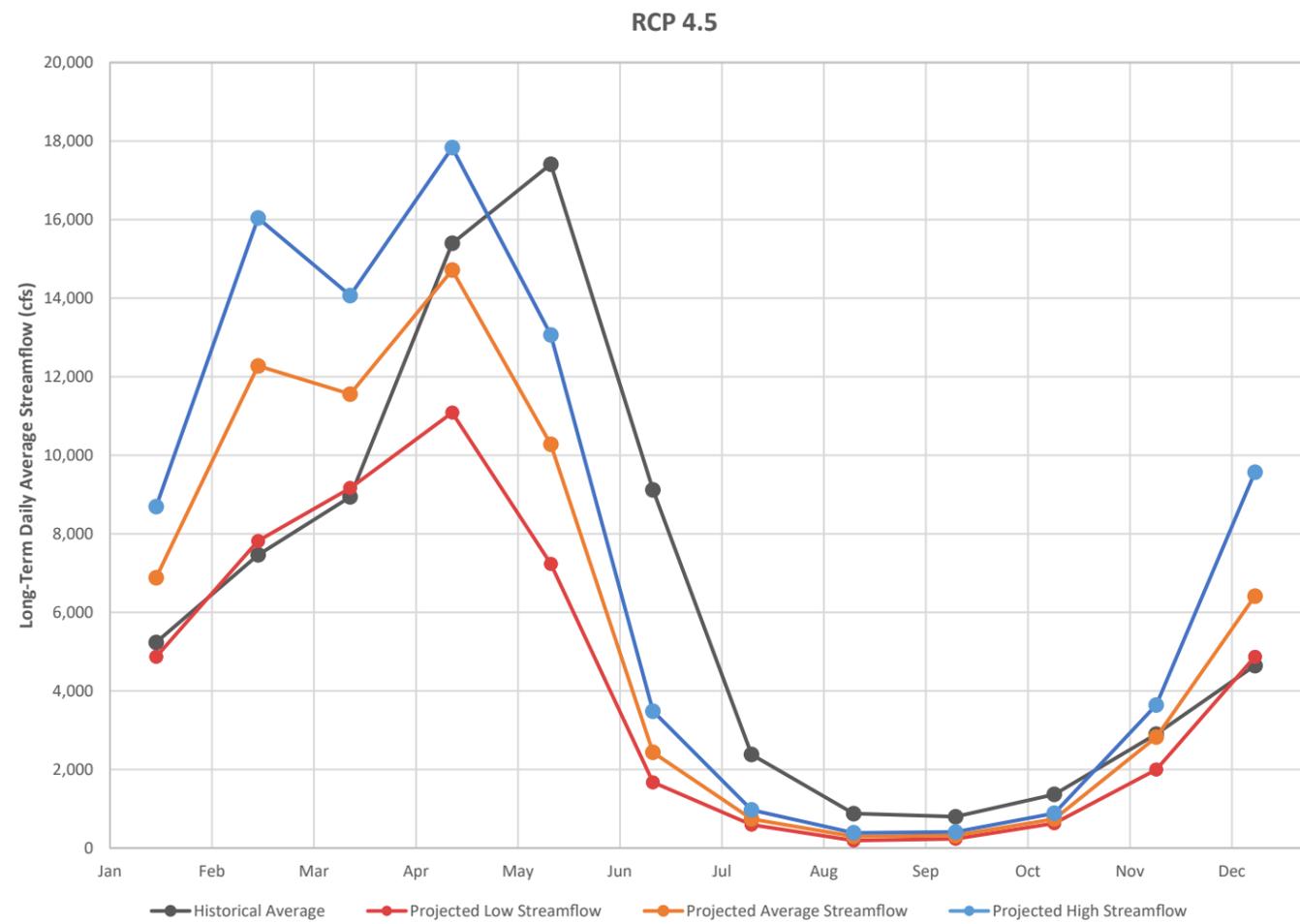
Date: October 29, 2025  
 Data Sources: BLM, ESRI, ODOT, USGS, Imagery (2022)

**FIGURE 1**

**Location and Areal Extent of the Spokane Valley-Rathdrum Prairie Aquifer**

Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System





**NOTE**  
RCP = Representative Concentration Pathway for global greenhouse gas emissions

**FIGURE 2**  
**Projected Monthly Streamflows in 2070–2099**  
**for the Spokane River at Post Falls, Idaho**  
Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells  
Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System



## **Attachment A**

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# **Development of Climate-Change Factors for Groundwater Modeling Analyses of Future Conditions at SAJB Production Wells**



## Development of Climate-Change Factors for Groundwater Modeling Analyses of Future Conditions at SAJB Production Wells

December 2025

### Introduction

This attachment describes the methodology that was used by GSI Water Solutions, Inc. (GSI), to obtain, process, and simulate climate-change influences on future natural hydrologic processes occurring in the Spokane River and the Spokane Valley-Rathdrum Prairie (SVRP) Aquifer. The climate-change projections described in this appendix were used in groundwater modeling analyses of future groundwater conditions at each municipal water supply well owned and operated by members of the Spokane Aquifer Joint Board (SAJB).

The groundwater model simulated multiple scenarios of future potential changes in recharge arising from climate-driven changes in (1) future surface water flows at the headwaters of the Spokane River at Post Falls, Idaho, (2) inflows (runoff) from tributaries adjoining the SVRP Aquifer, and (3) precipitation recharge over the footprint of the aquifer. The climate projections were obtained from an online data portal called The Climate Toolbox.<sup>1</sup> The Climate Toolbox provides climate-change projections for two future global greenhouse gas (GHG) emissions pathways, which are called Representative Concentration Pathway (RCP) 4.5 and RCP 8.5. Projections are available for a range of future climates under each GHG emissions pathway and for multiple time frames (including the 3-decade periods of 2010–2039, 2040–2069, and 2070–2099). For streamflows and runoff, the projections on The Climate Toolbox website are projections from 10 individual spatially downscaled global climate models,<sup>2</sup> as well as a projection that is the average condition simulated by the full suite of global climate models. The projections available on The Climate Toolbox website were processed and downscaled by the National Atmospheric and Oceanic Administration's Climate Impacts Research Consortium at Oregon State University (Mote et al., 2014) and made available to the public on The Climate Toolbox website by Hegewisch and Abatzoglou (2022).

GSI downloaded climate projections for each hydrologic variable (Spokane River flows, runoff from adjoining tributaries, and precipitation over the aquifer) in October 2022 and focused on the period 2070–2099 for this study, to help SAJB members plan for water infrastructure improvements over the next 50 years or longer. Following are discussions of the projections for Spokane River flows, runoff from adjoining tributaries, and precipitation recharge over the footprint of the aquifer.

### Projections of Spokane River Flows at Post Falls, Idaho

Historical and future streamflow projections are available for two gages on the Spokane River: at Coeur d'Alene, Idaho (representing inflow to Coeur d'Alene Lake) and at Post Falls, Idaho (representing

<sup>1</sup> The Climate Toolbox is accessible at <https://climatetoolbox.org/>.

<sup>2</sup> These 10 global climate models are listed in the downloaded runoff data sets as the bcc-csm1-1m, CanESM2, CCSM4, CNRM-CM5, CSIRO-Mk3-6-0, HadGEM2-CC365, HadGEM2-ES365, IPSL-CM5A-MR, MICOR5, and NorESM1-M models. The output from these large-scale global climate-models has been downscaled to a 1/16<sup>th</sup>-degree grid resolution for publication on the Climate Toolbox website.

outflow from Coeur d'Alene Lake that provides inflow into the first portion of the river to enter the SVRP Aquifer area). The projections were developed by Mote et al. (2014) using a streamflow routing model developed by Lohmann et al. (1996). GSI downloaded streamflow projections for the Spokane River at Post Falls to provide direct input to the groundwater flow model where the river first crosses over the SVRP Aquifer.<sup>3</sup>

These streamflow projections are available from the “Future Streamflows” tool in the “Water” application menu on The Climate Toolbox website. The Climate Toolbox contains two sets of streamflow projections: bias-corrected and non-bias-corrected. The non-bias-corrected data route gridded data from hydrologic rainfall-runoff models into stream channels, with less regard for historical streamflow observations than are applied to the bias-corrected data sets. Therefore, GSI used the bias-corrected projections for the Spokane River at Post Falls in the groundwater model simulations.

Table A-1 and Figure A-1 show the projected changes in Spokane River flows at Post Falls on a monthly basis. The highest percentage increases in flow (compared with historical average conditions for the period 1950–2005) are projected to occur from December through March, potentially doubling (exceeding a 100 percent increase) under the highest-flow scenarios but showing small changes under the lowest-flow scenarios. Percentage decreases dominate the period of April through November, with the greatest percentage decreases occurring during the transitional month of June (following the spring freshet) and also during the seasonal-low flow months of July through September.

### Runoff Projections (Recharge from Tributary Valley Inflows)

Historical and future projections of total runoff by quarter were used to calculate monthly changes in inflows from tributaries that drain into the SVRP Aquifer at its margins. GSI used the 10-model-mean projected runoff values for Spokane County in 2070–2099 (as obtained from The Climate Toolbox) in the groundwater modeling analyses.

The spatially downloaded data consisted of projected amounts of rainfall that become runoff, expressed in measurement units of depths in inches. For the 3-decade period 2070–2099, these runoff projections are available as 3-month averages for the time periods December through February, March through May, June through August, and September through November (Hegewisch and Abatzoglou, 2022). The data were obtained from the “Future Boxplots” tool in the “Water” application menu on The Climate Toolbox website. For a given 3-month period and a given GHG emissions pathway, this tool provides the runoff depths as the minimum, 5<sup>th</sup> percentile, median (50<sup>th</sup> percentile), 95<sup>th</sup> percentile, and maximum values simulated by the 10 global climate models as a group. As shown in Table A-2, GSI converted these quarterly runoff depths into (1) percentage changes by month and (2) monthly multipliers that GSI applied to historical tributary inflows already programmed into the groundwater flow model.

For both RCP 4.5 and RCP 8.5, the runoff depths for each quarter are shown in Figure A-2, and the percentage changes in runoff are shown in Figure A-3. The figures show that 2070–2099 runoff is expected to be greater than historical runoff during the fall and winter seasons and lower than historical runoff during the spring and summer seasons. During the latter part of the 21<sup>st</sup> century, runoff during the December–February quarter is projected to be (approximately) 20 to 30 percent higher under RCP 4.5 and 25 to 35 percent higher under RCP 8.5. Spring runoff during the latter part of the 21<sup>st</sup> century is projected to be (approximately) 1 to 12 percent lower under RCP 4.5 and 3 to 15 percent lower under RCP 8.5.

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<sup>3</sup> The Climate Toolbox refers to this location as Spokane River at Post Falls, Washington. This is in contrast with stream gaging measurements, which are collected at a dedicated stream gaging station identified by the U.S. Geological Survey (USGS) as Spokane River at Post Falls, Idaho (USGS gage number 12419000).

## Degrees of Climate Change

For modeling and presentation purposes, the future projections of Spokane River streamflows and runoff entering the aquifer from tributary valleys were combined in a specific manner as to create analyses that reflect differing degrees of climate change influences on the regional aquifer system during the latter part of the 21<sup>st</sup> century (the years 2070 through 2099). Specifically:

- **Spokane River Streamflows.** Changes in Spokane River streamflows during the late spring through early fall seasons were used to define the degree of climate change, given that the concerns about future water levels at SAJB member wells are focused on the summer season. Each climate-change model projects that for the months of May through October, the 2070–2099 streamflows will be lower than historical average flows. The least degree of reduction in May through October streamflows is classified in the model as a “low” degree of climate change, while the greatest degree of reduction is classified as a “high” degree of climate change. The median projected streamflows in all months comprise the “median” degree of climate change.
  - Because of the significant influence of snowpack in the Spokane River’s watershed, the months of November through April are simulated with the highest projected streamflows for the “low” degree of climate change and the lowest projected streamflows for the “high” degree of climate change.
- **Recharge from Tributary Valley Inflows and from Precipitation Recharge Over the Aquifer.** The late fall and winter seasons were used for classifying the degree of climate change related to recharge from tributary valley inflows and precipitation recharge over the aquifer. Each climate-change model projects that for the months of September through February, the 2070–2099 runoff from tributary valleys (which also serves as a surrogate for precipitation recharge over the aquifer) will be higher than historical average runoff, because of rising temperatures and the subsequent increase in the influence of rainfall rather than snowmelt on the magnitudes and timing of runoff from tributary valleys. The smallest increase in September through February tributary inflows is classified in the model as a “low” degree of climate change, while the greatest increase in September through February tributary inflows is classified as a “high” degree of climate change. The median projected tributary inflows in all months comprise the “median” degree of climate change.
  - The months of March through August are projected to have reduced tributary inflows because of rising temperatures and increased evaporative demands. Accordingly, these months are simulated with smaller reductions in tributary inflows for the “low” degree of climate change and larger reductions in tributary inflows for the “high” degree of climate change.

In summary:

- The low degree of climate change involves the smallest reductions in projected dry-season Spokane River streamflows, the highest projected wet-season streamflows in the Spokane River, the smallest projected increases in September through February tributary inflows and precipitation recharge, and the smallest projected reductions in March through August tributary inflows and precipitation recharge.
- The median degree of climate change involves the median projected changes in Spokane River streamflows, tributary inflows, and precipitation recharge in all months.
- The high degree of climate change involves the largest reductions in projected dry-season Spokane River streamflows, the lowest projected wet-season streamflows in the Spokane River, the largest projected increases in September through February tributary inflows and precipitation recharge, and the largest projected reductions in March through August tributary inflows and precipitation recharge.

## References

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## Tables

**Table A-1. Spokane River Streamflows at Post Falls, Idaho**

		<b>RCP 4.5</b>					
Month	Historical Streamflow	2070-2099 Streamflow			2070-2099 % Change in Streamflow		
		Low Streamflow	Average Streamflow	High Streamflow	Low Streamflow	Average Streamflow	High Streamflow
Jan	5,236	4,869	6,884	8,690	-7.02%	31.47%	65.96%
Feb	7,463	7,819	12,274	16,039	4.77%	64.46%	114.91%
Mar	8,941	9,166	11,558	14,068	2.52%	29.26%	57.34%
Apr	15,394	11,086	14,714	17,831	-27.99%	-4.42%	15.83%
May	17,408	7,236	10,278	13,064	-58.43%	-40.96%	-24.95%
Jun	9,118	1,675	2,436	3,484	-81.63%	-73.29%	-61.79%
Jul	2,381	595	741	971	-75.03%	-68.88%	-59.21%
Aug	877	195	297	388	-77.81%	-66.10%	-55.70%
Sep	798	236	318	411	-70.43%	-60.10%	-48.53%
Oct	1,368	632	740	886	-53.80%	-45.94%	-35.23%
Nov	2,903	1,999	2,824	3,642	-31.15%	-2.72%	25.47%
Dec	4,646	4,869	6,414	9,570	4.81%	38.05%	105.99%
Annual Average	6,361	4,173	5,744	7,361	-34.40%	-9.70%	15.72%

		<b>RCP 8.5</b>					
Month	Historical Streamflow	2070-2099 Streamflow			2070-2099 % Change in Streamflow		
		Low Streamflow	Average Streamflow	High Streamflow	Low Streamflow	Average Streamflow	High Streamflow
Jan	5,236	6,530	7,874	8,731	24.72%	50.38%	66.76%
Feb	7,463	12,044	14,007	17,239	61.39%	87.69%	130.99%
Mar	8,941	8,290	11,640	15,357	-7.28%	30.19%	71.76%
Apr	15,394	7,742	12,974	17,121	-49.71%	-15.72%	11.22%
May	17,408	3,152	6,420	9,846	-81.89%	-63.12%	-43.44%
Jun	9,118	931	1,410	2,181	-89.78%	-84.54%	-76.08%
Jul	2,381	396	543	754	-83.39%	-77.21%	-68.35%
Aug	877	132	207	348	-84.89%	-76.39%	-60.30%
Sep	798	160	233	344	-79.99%	-70.85%	-56.90%
Oct	1,368	494	600	793	-63.92%	-56.13%	-42.01%
Nov	2,903	1,953	2,529	3,600	-32.72%	-12.87%	24.00%
Dec	4,646	5,327	7,194	9,984	14.66%	54.84%	114.88%
Annual Average	6,361	3,876	5,412	7,124	-39.07%	-14.92%	11.99%

**Note**

The streamflow value for any given month is the average rate of flow, in cubic feet per second (cfs).

Table A-2. Translation of Runoff Depth Projections into Recharge Multipliers for Tributary Valley Inflows

Runoff Depths (inches) Downloaded from The Climate Toolbox

RCP 4.5				
Quarter	2070-2099 Projected Depth of Runoff (inches)			
	Historical Avg.	Low	Median	High
Dec-Feb	1.779	2.126	2.205	2.281
Mar-May	2.213	1.950	2.074	2.185
Jun-Aug	1.360	1.230	1.271	1.315
Sept-Nov	1.471	1.627	1.708	1.803
Annual Average	1.706	1.733	1.815	1.896

RCP 4.5			
Quarter	2070-2099 Projected % Change in Runoff		
	Low	Median	High
Dec-Feb	19.51%	23.93%	28.22%
Mar-May	-11.89%	-6.27%	-1.25%
Jun-Aug	-9.56%	-6.53%	-3.32%
Sept-Nov	10.59%	16.14%	22.58%
Annual Average	1.61%	6.38%	11.16%

RCP 8.5				
Quarter	2070-2099 Projected Depth of Runoff (inches)			
	Historical Avg.	Low	Median	High
Dec-Feb	1.779	2.197	2.306	2.411
Mar-May	2.213	1.880	2.012	2.134
Jun-Aug	1.360	1.194	1.243	1.284
Sept-Nov	1.471	1.700	1.763	1.798
Annual Average	1.706	1.743	1.831	1.907

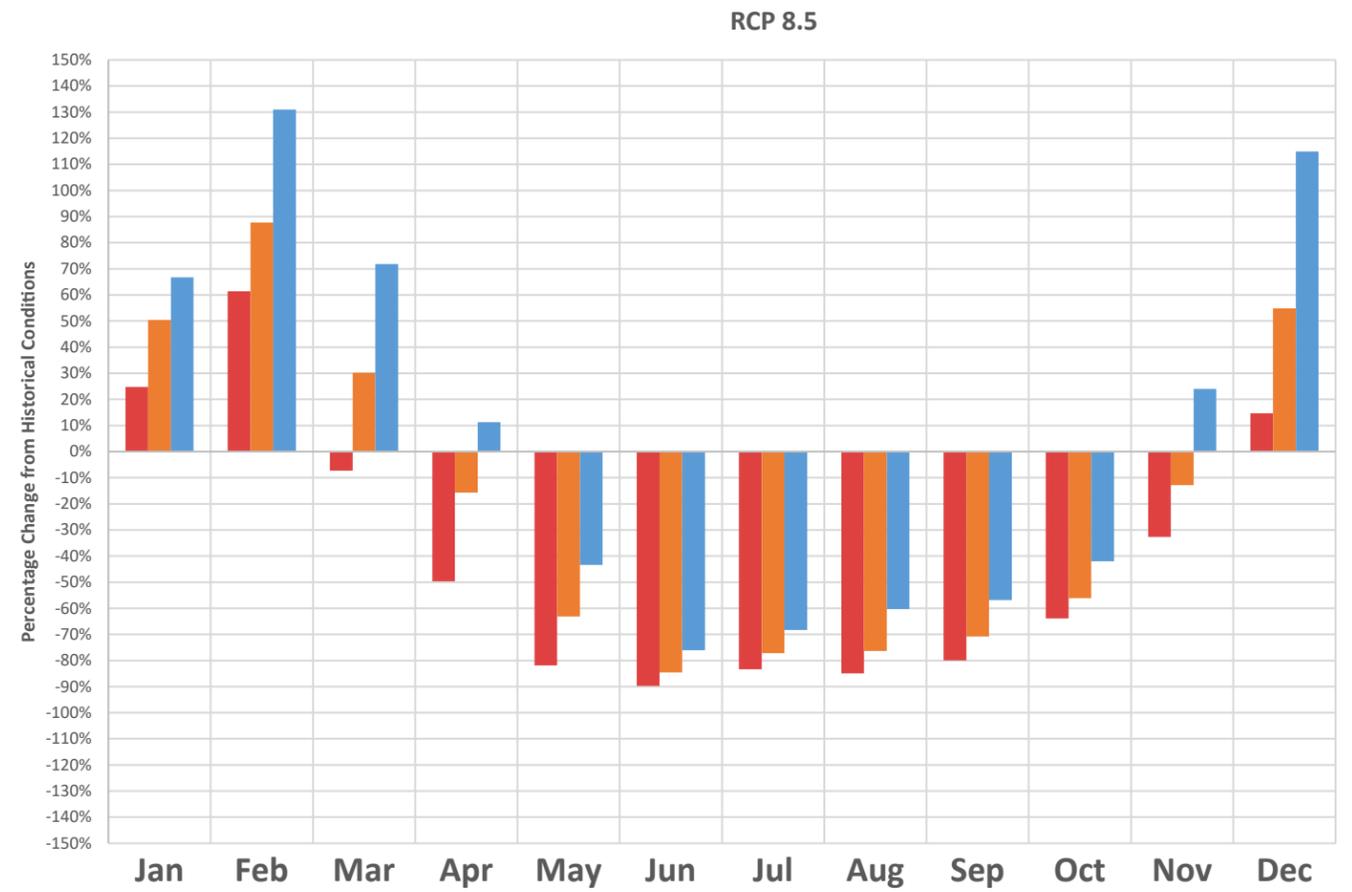
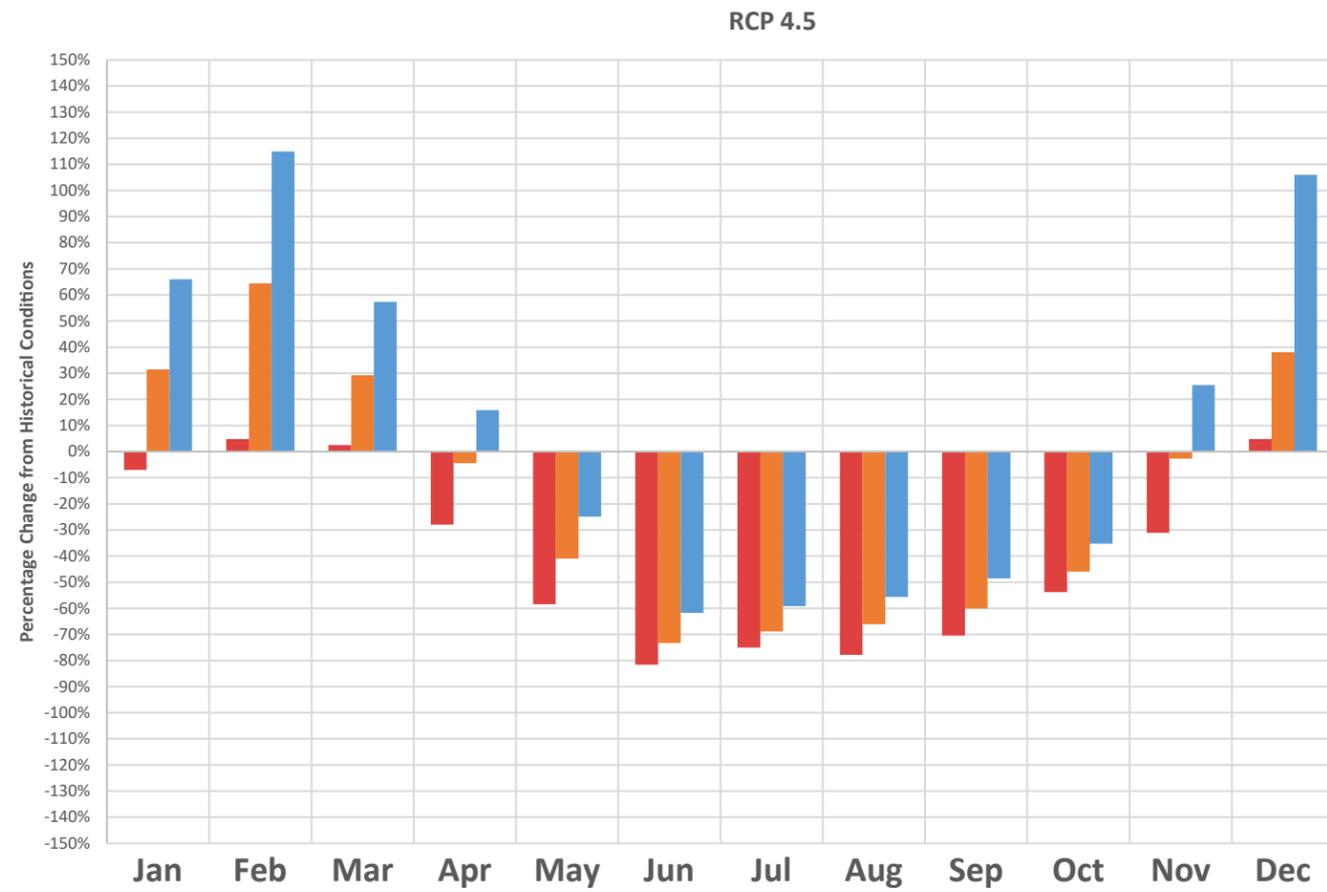
RCP 8.5			
Quarter	2070-2099 Projected % Change in Runoff		
	Low	Median	High
Dec-Feb	23.49%	29.62%	35.53%
Mar-May	-15.05%	-9.05%	-3.57%
Jun-Aug	-12.20%	-8.60%	-5.62%
Sept-Nov	15.56%	19.83%	22.22%
Annual Average	2.17%	7.35%	11.78%

Calculated Recharge Multipliers

Month	Historical Multiplier	RCP 4.5					
		2070-2099 Projected % Change in Runoff			2070-2099 Multiplier		
		Low	Median	High	Low	Median	High
January	2.523	19.51%	23.93%	28.22%	3.015	3.127	3.235
February	1.676	19.51%	23.93%	28.22%	2.003	2.077	2.149
March	1.009	-11.89%	-6.27%	-1.25%	0.889	0.946	0.996
April	0.174	-11.89%	-6.27%	-1.25%	0.153	0.163	0.172
May	0.336	-11.89%	-6.27%	-1.25%	0.296	0.315	0.332
June	0.174	-9.56%	-6.53%	-3.32%	0.157	0.163	0.168
July	0.336	-9.56%	-6.53%	-3.32%	0.304	0.314	0.325
August	0	-9.56%	-6.53%	-3.32%	0	0	0
September	0	10.59%	16.14%	22.58%	0	0	0
October	0.841	10.59%	16.14%	22.58%	0.93	0.977	1.031
November	2.26	10.59%	16.14%	22.58%	2.499	2.625	2.77
December	2.691	19.51%	23.93%	28.22%	3.216	3.335	3.45

Month	Historical Multiplier	RCP 8.5					
		2070-2099 Projected % Change in Runoff			2070-2099 Multiplier		
		Low	Median	High	Low	Median	High
January	2.523	23.49%	29.62%	35.53%	3.116	3.27	3.419
February	1.676	23.49%	29.62%	35.53%	2.07	2.172	2.271
March	1.009	-15.05%	-9.05%	-3.57%	0.857	0.918	0.973
April	0.174	-15.05%	-9.05%	-3.57%	0.148	0.158	0.168
May	0.336	-15.05%	-9.05%	-3.57%	0.285	0.306	0.324
June	0.174	-12.20%	-8.60%	-5.62%	0.153	0.159	0.164
July	0.336	-12.20%	-8.60%	-5.62%	0.295	0.307	0.317
August	0	-12.20%	-8.60%	-5.62%	0	0	0
September	0	15.56%	19.83%	22.22%	0	0	0
October	0.841	15.56%	19.83%	22.22%	0.972	1.008	1.028
November	2.26	15.56%	19.83%	22.22%	2.612	2.708	2.762
December	2.691	23.49%	29.62%	35.53%	3.323	3.488	3.647





**LEGEND**

- Low Streamflow
- Average Streamflow
- High Streamflow

**NOTE**

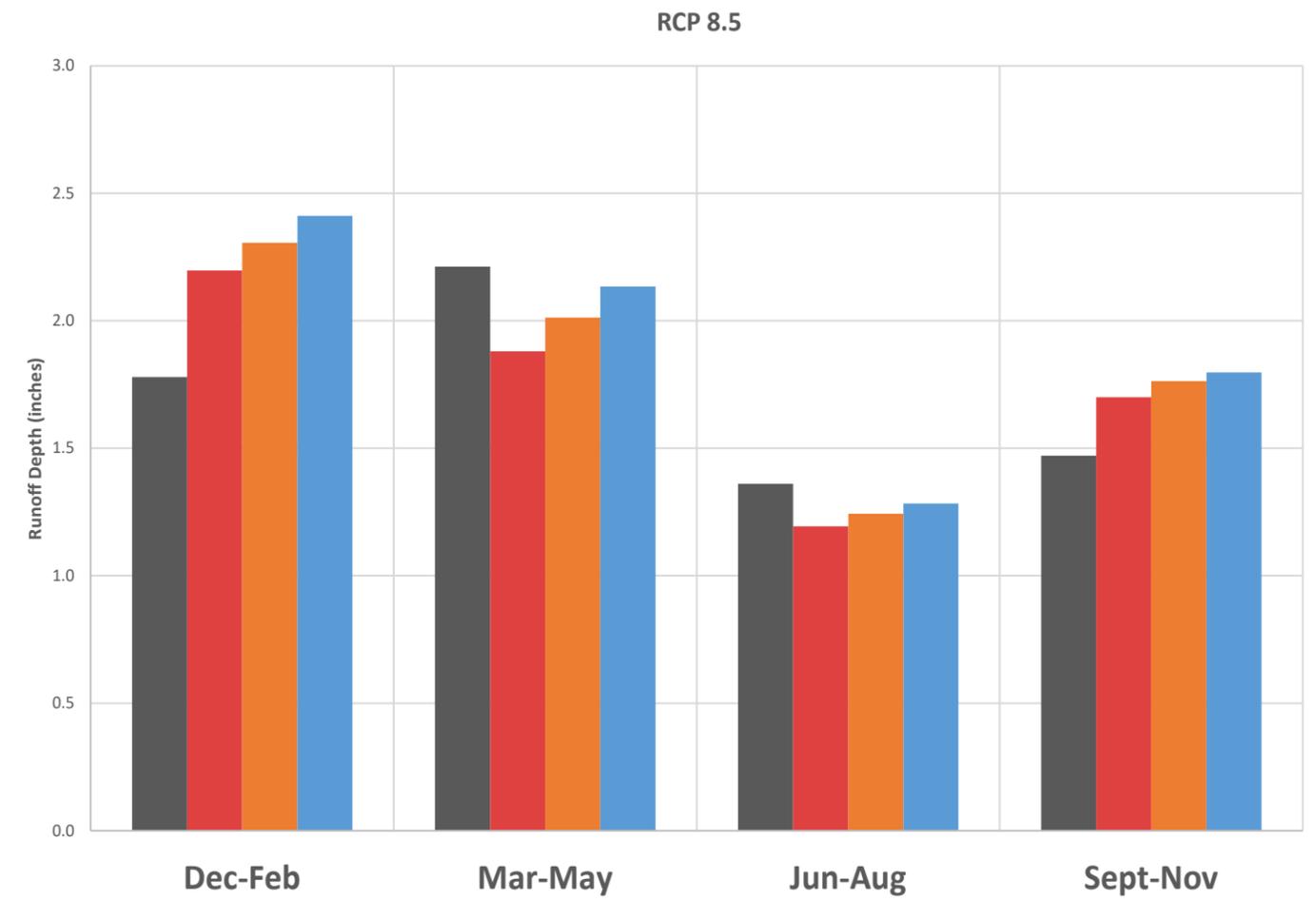
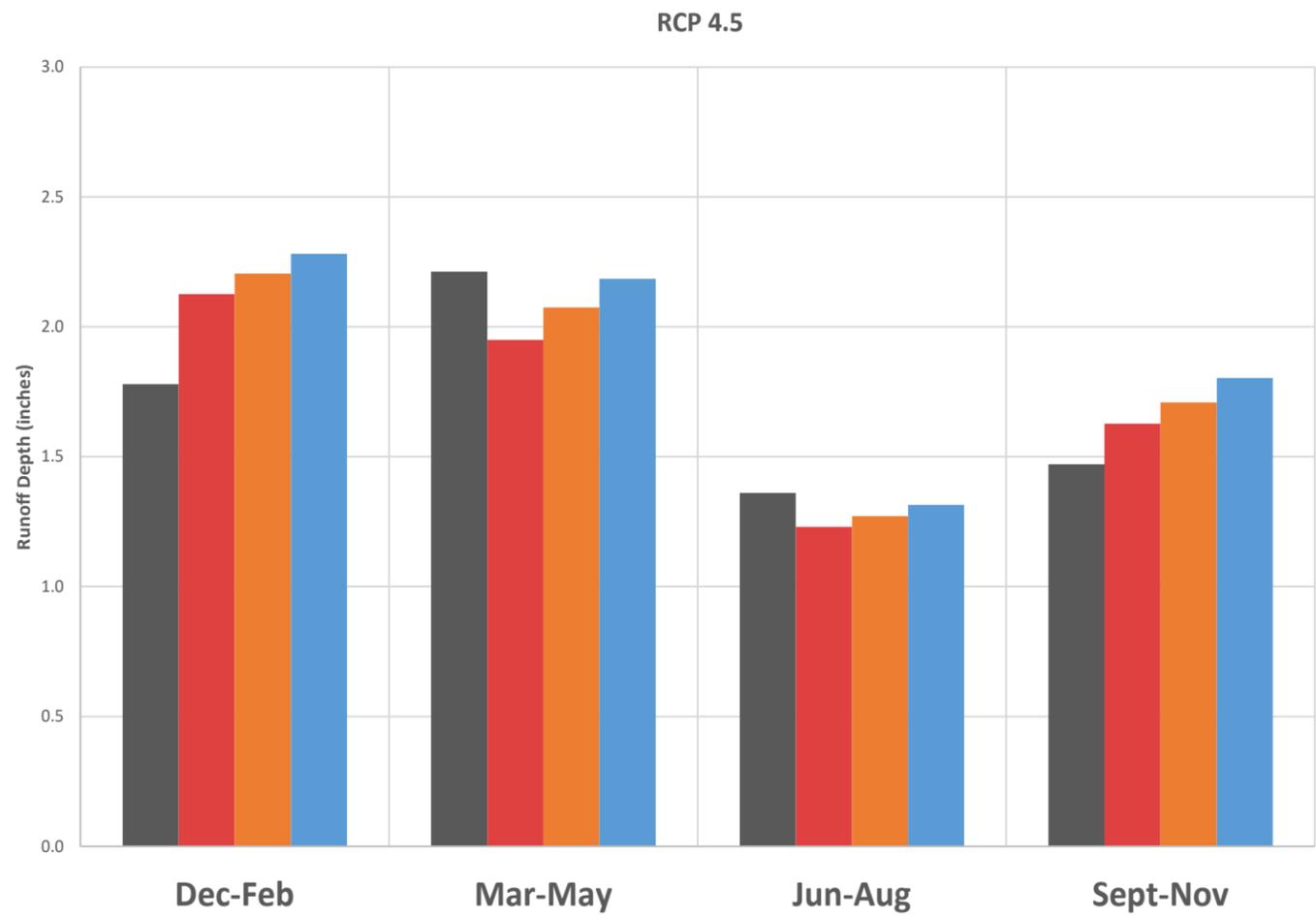
RCP stands for Representative Concentration Pathway for future global greenhouse gas emissions.

**FIGURE A-1**

**Projected Monthly Percentage Changes in 2070–2099  
Spokane River Streamflows at Post Falls, Idaho**

Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells  
Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System





**LEGEND**

- High 2070-2099 Recharge
- Median 2070-2099 Recharge
- Low 2070-2099 Recharge
- Historical Average Recharge (1950-2005)

**NOTE**

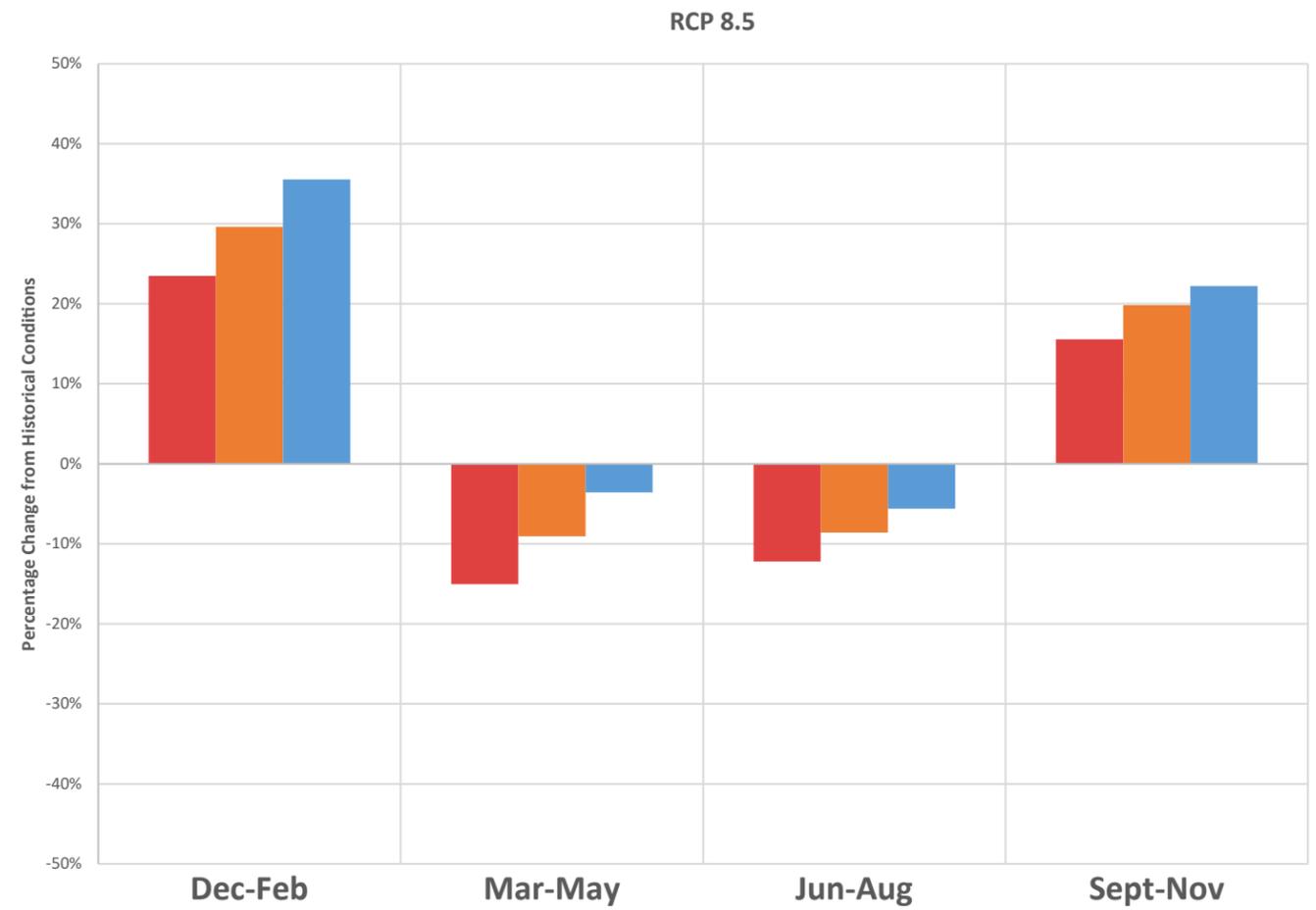
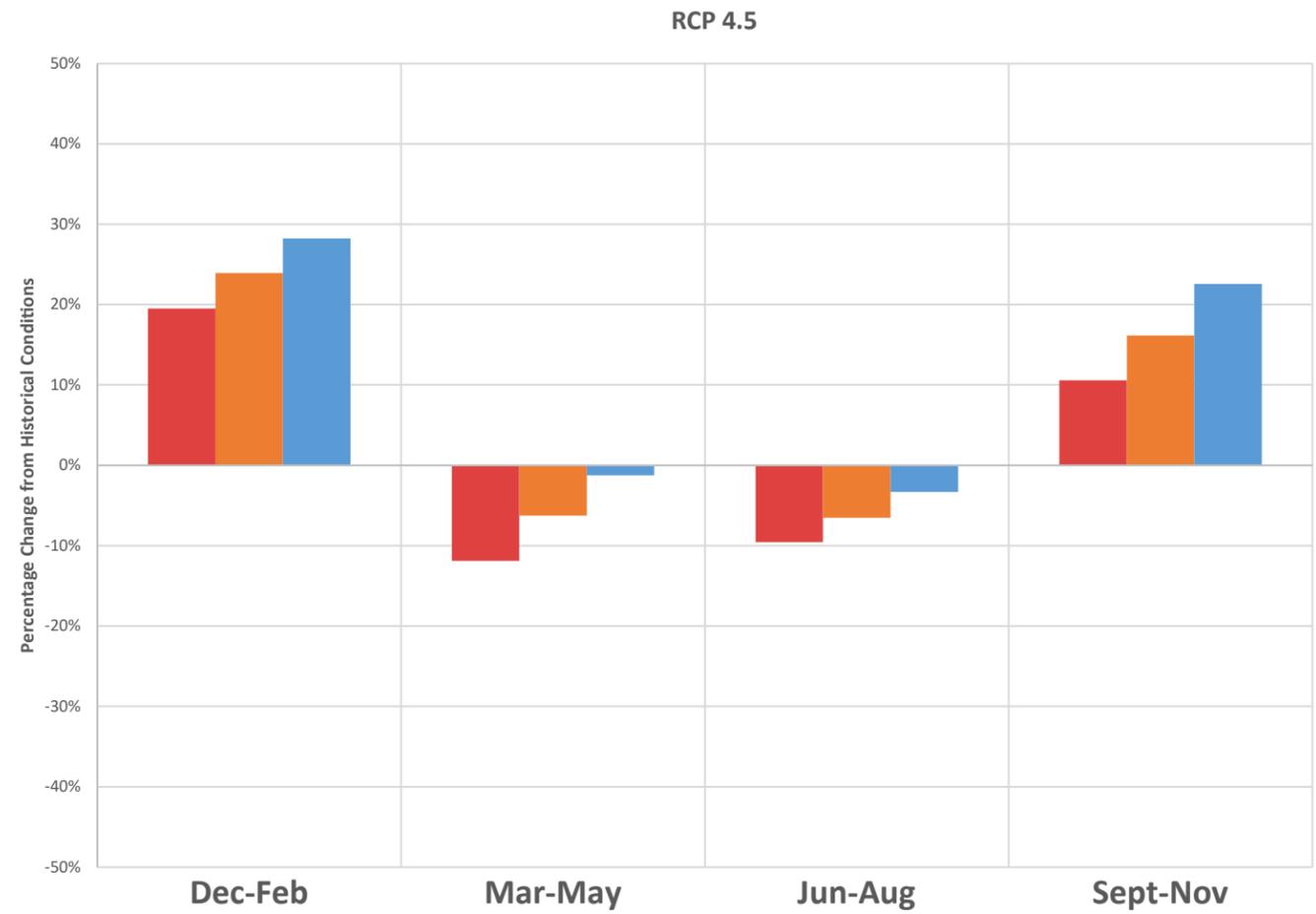
RCP stands for Representative Concentration Pathway for future global greenhouse gas emissions.

**FIGURE A-2**

**Recharge from Tributary Inflows in 2070–2099  
(Expressed as Runoff in Inches)**

Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System





**LEGEND**

- High 2070-2099 Recharge
- Median 2070-2099 Recharge
- Low 2070-2099 Recharge

**NOTE**

RCP stands for Representative Concentration Pathway for future global greenhouse gas emissions.

**FIGURE A-3**

**Projected Monthly Percentage Changes in 2070–2099 Recharge from Tributary Inflows**

Modeling Study of Future Potential Changes to Groundwater Levels in SAJB Member Wells Arising from Future Changes in Climate and Hydrology for the SVRP Aquifer System



## **Attachment B**

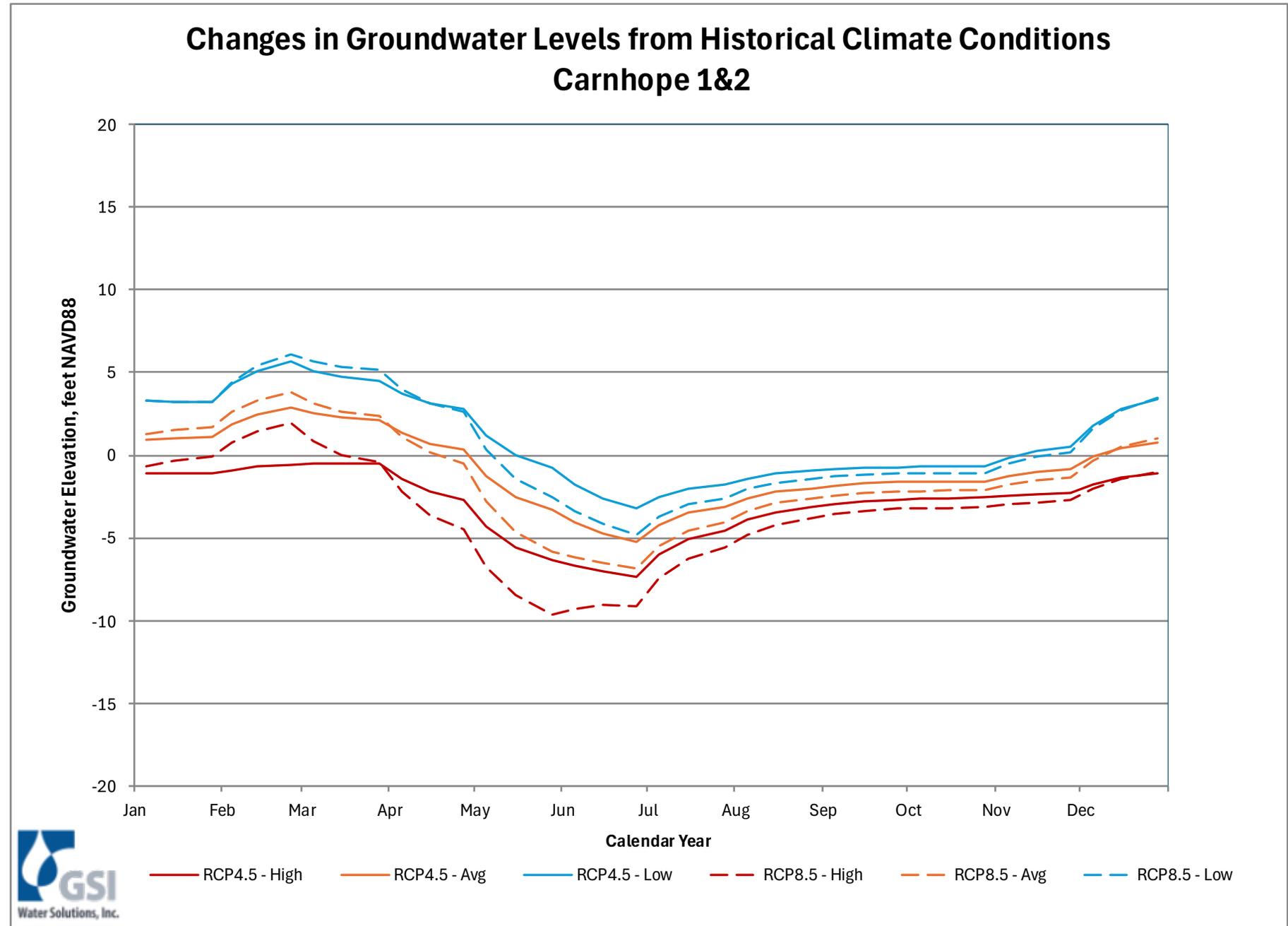
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# **Time-Series Plots Showing Estimated Seasonal and Monthly Changes in Groundwater Levels During the Latter Part of the 21<sup>st</sup> Century**

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Carnhope Irrigation  
District No. 7**

**Carnhope Well**



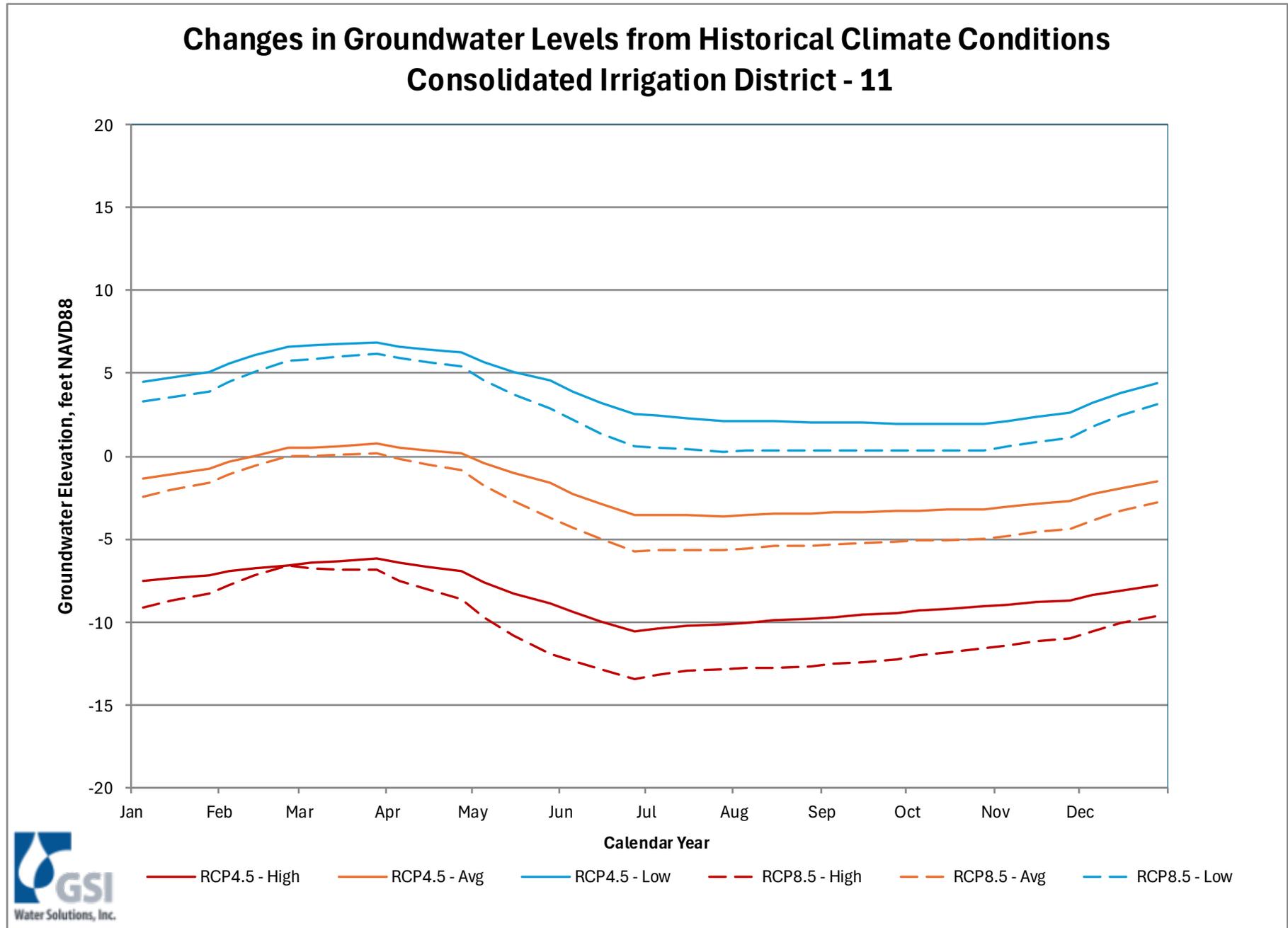
— RCP4.5 - High    — RCP4.5 - Avg    — RCP4.5 - Low    - - RCP8.5 - High    - - RCP8.5 - Avg    - - RCP8.5 - Low

Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

Consolidated Irrigation District No. 19

Well 11



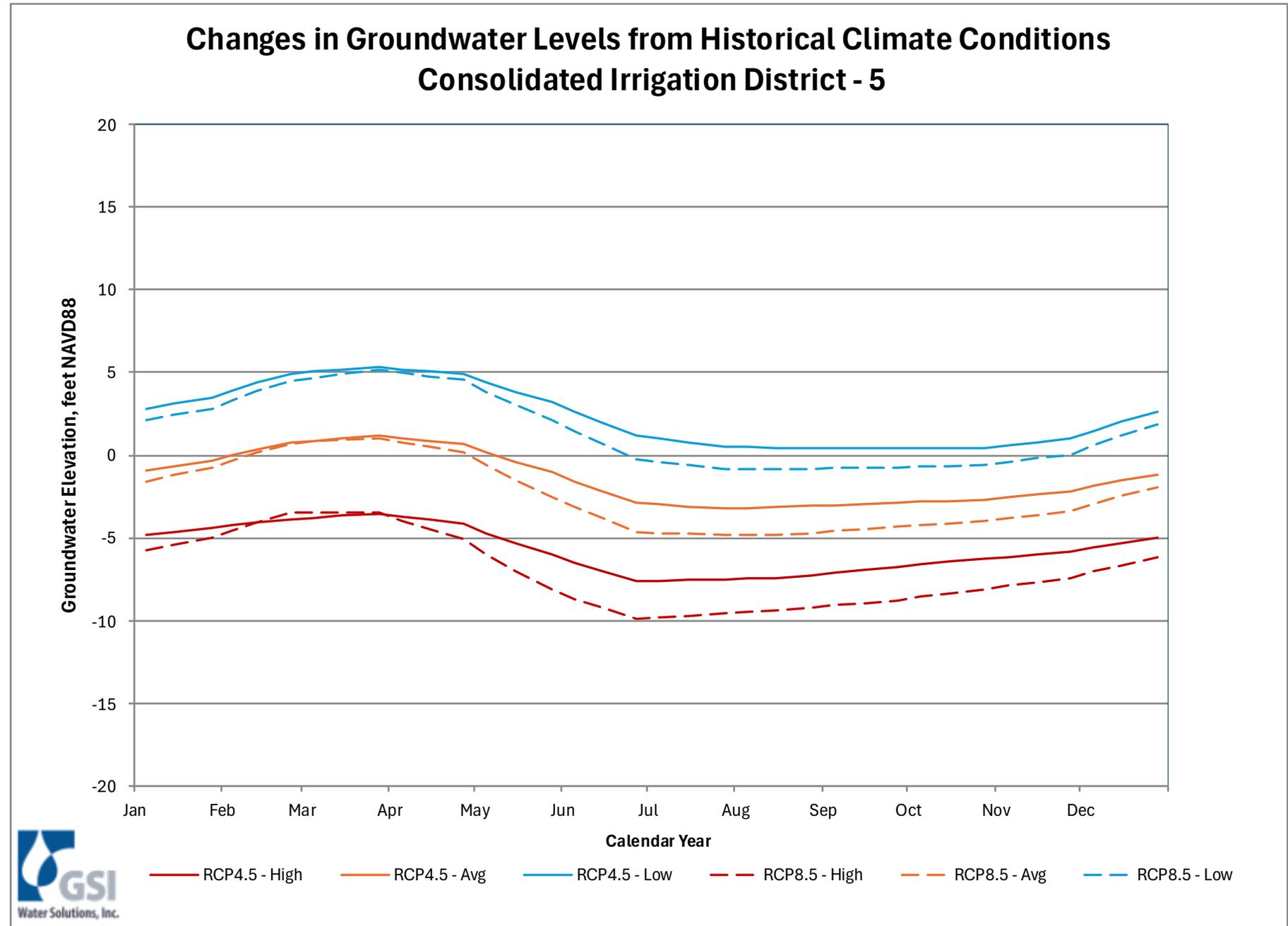
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Consolidated  
Irrigation District  
No. 19**

**Well 5**



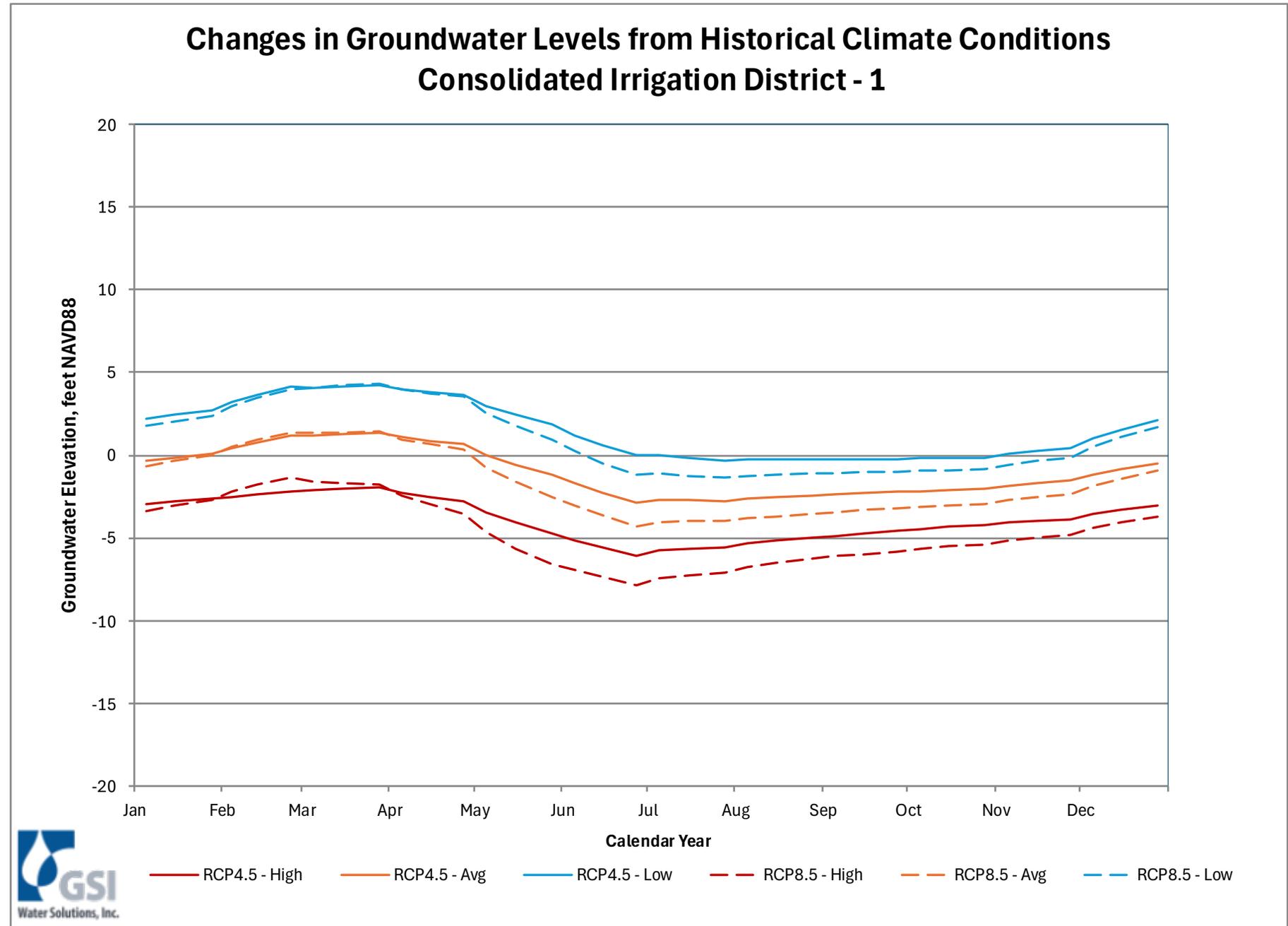
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Consolidated  
Irrigation District  
No. 19**

**Well 1**



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



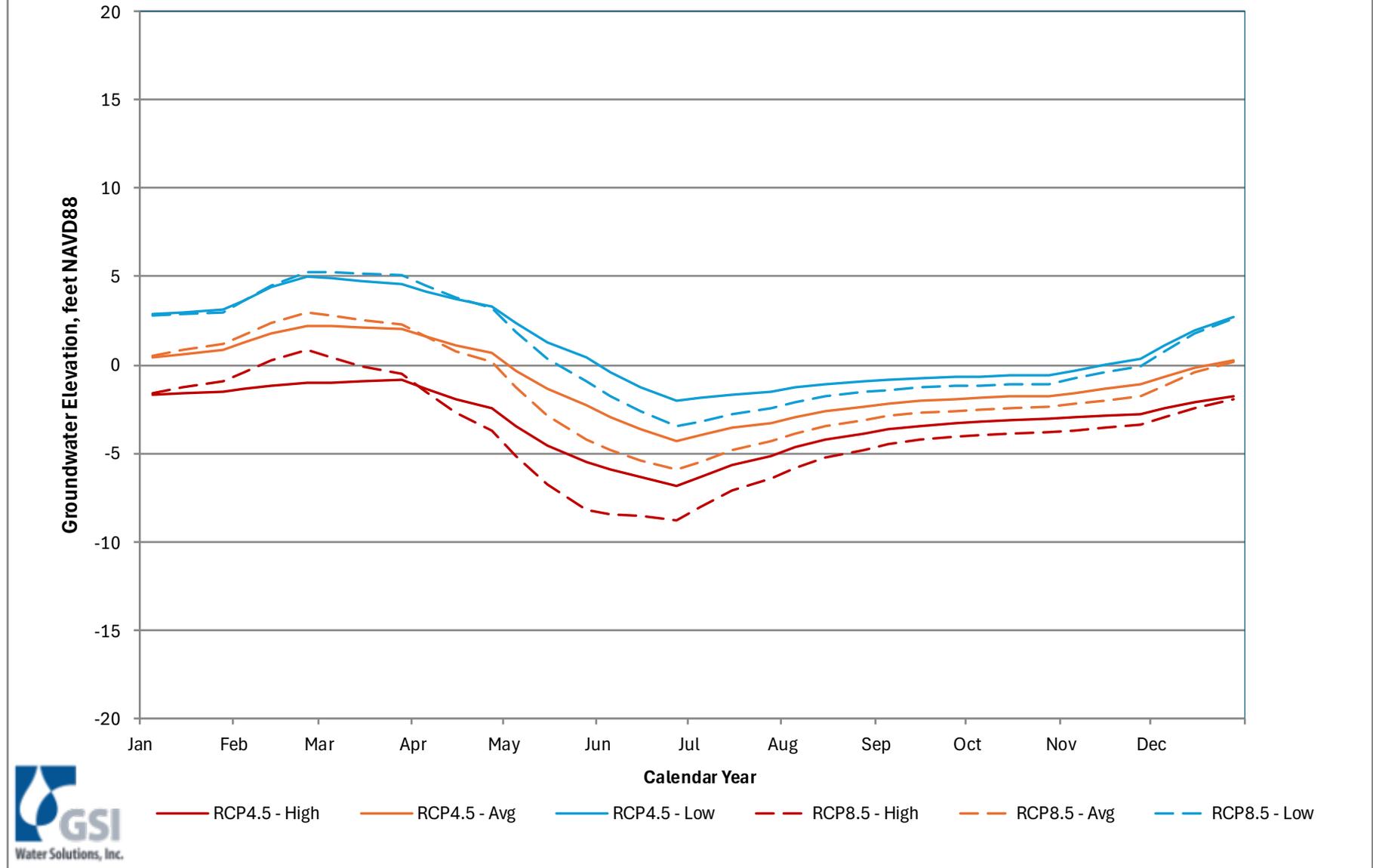
# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**East Spokane Water District No. 1**

**Wells 1 & 2**



## Changes in Groundwater Levels from Historical Climate Conditions East Spokane Water District - 1&2



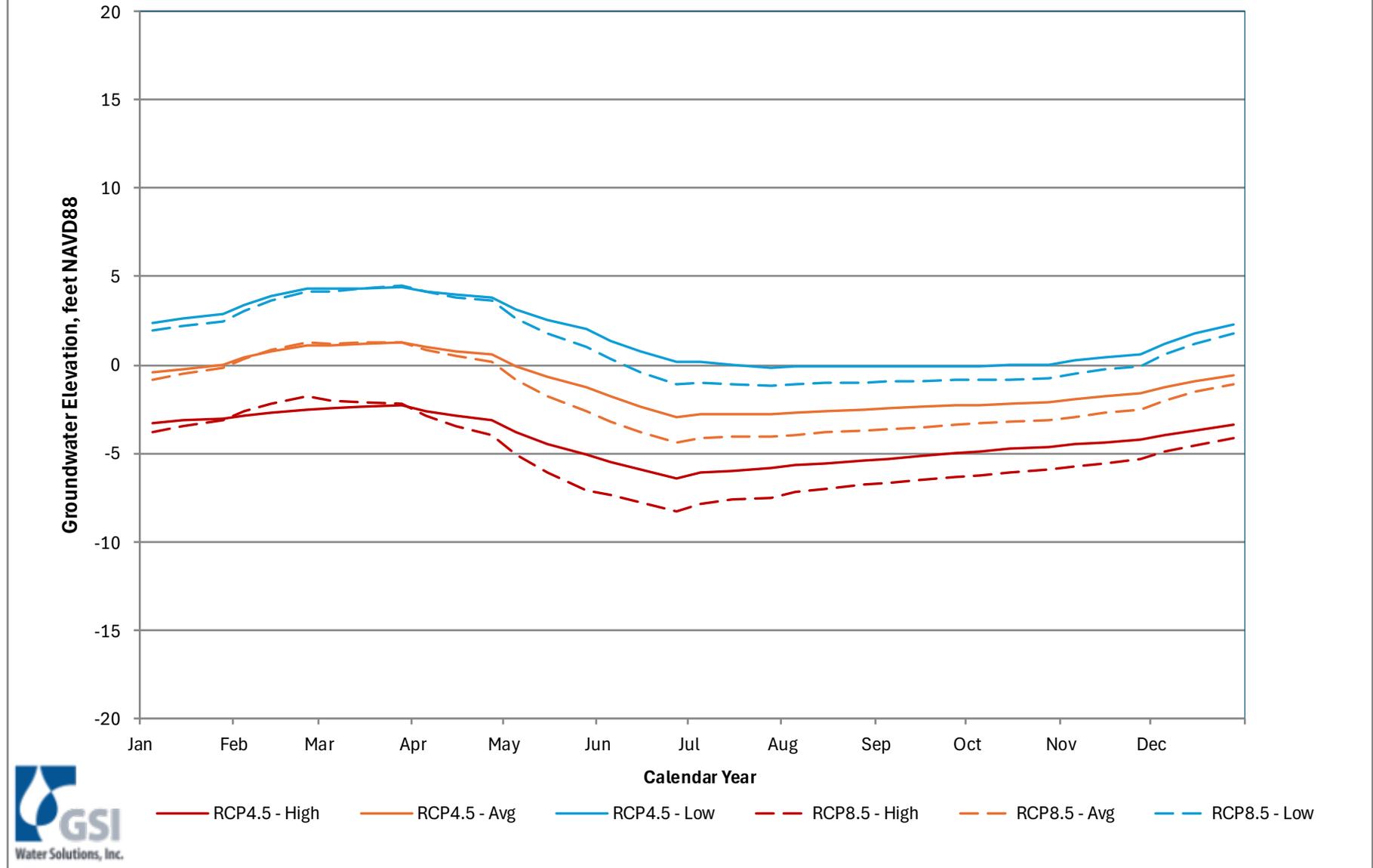
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Honeywell  
Electronic  
Materials**

**Well 1**

## Changes in Groundwater Levels from Historical Climate Conditions Honeywell 1



— RCP4.5 - High    — RCP4.5 - Avg    — RCP4.5 - Low    - - - RCP8.5 - High    - - - RCP8.5 - Avg    - - - RCP8.5 - Low

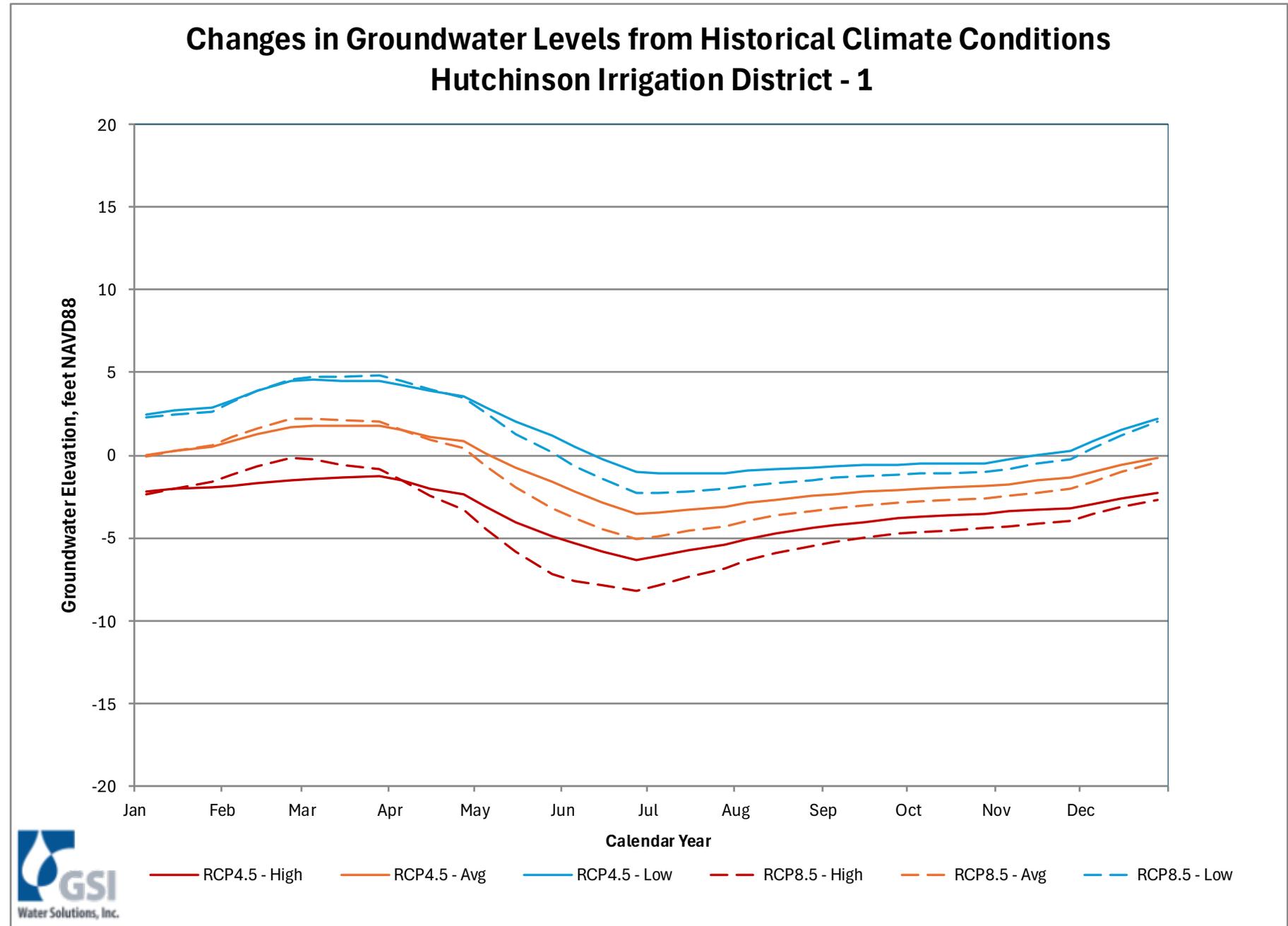
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Hutchinson  
Irrigation District  
No. 16**

**Well 1**



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

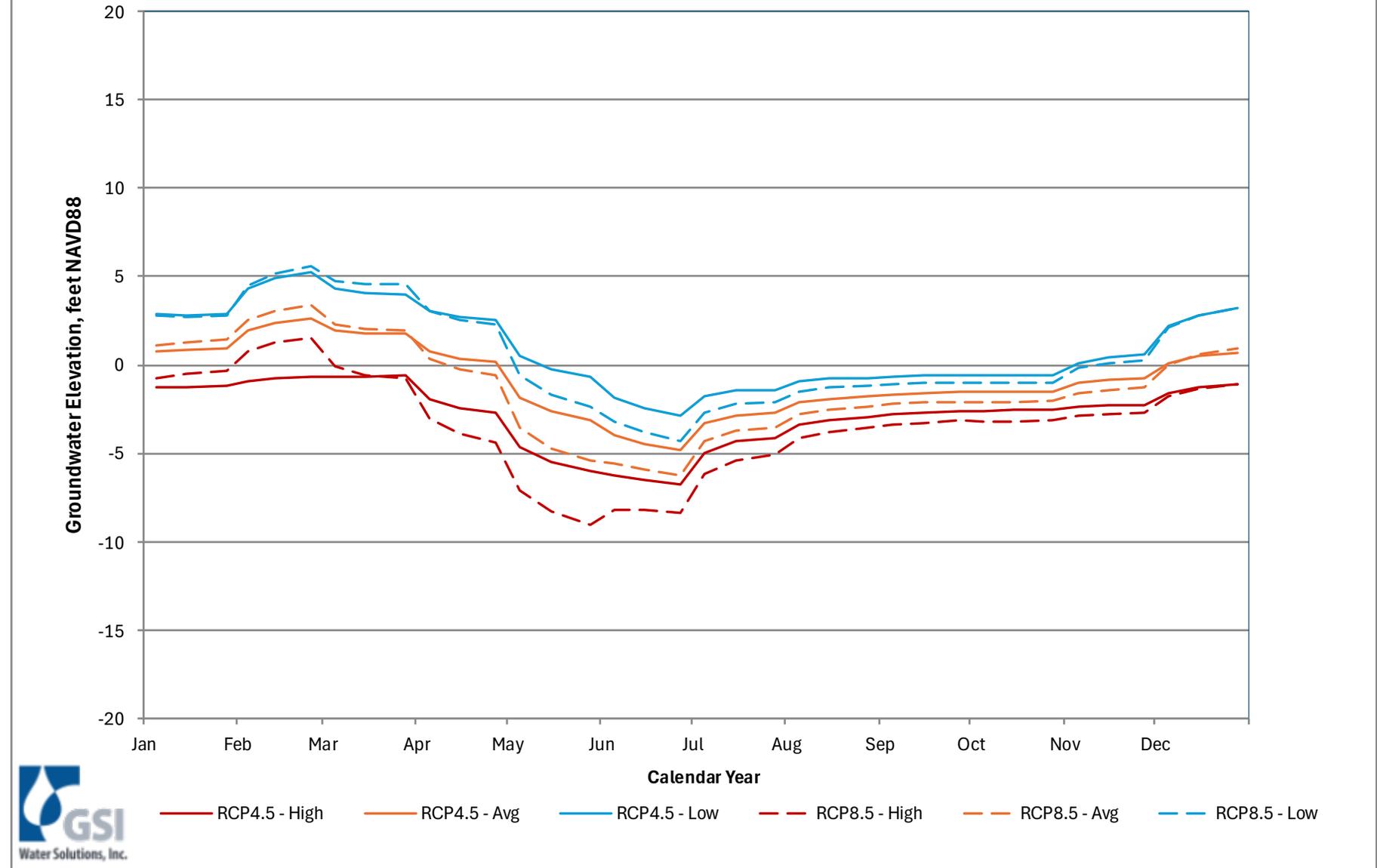


# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

Irvin Water District No. 6

Well 5

## Changes in Groundwater Levels from Historical Climate Conditions Irvin Water District - 5



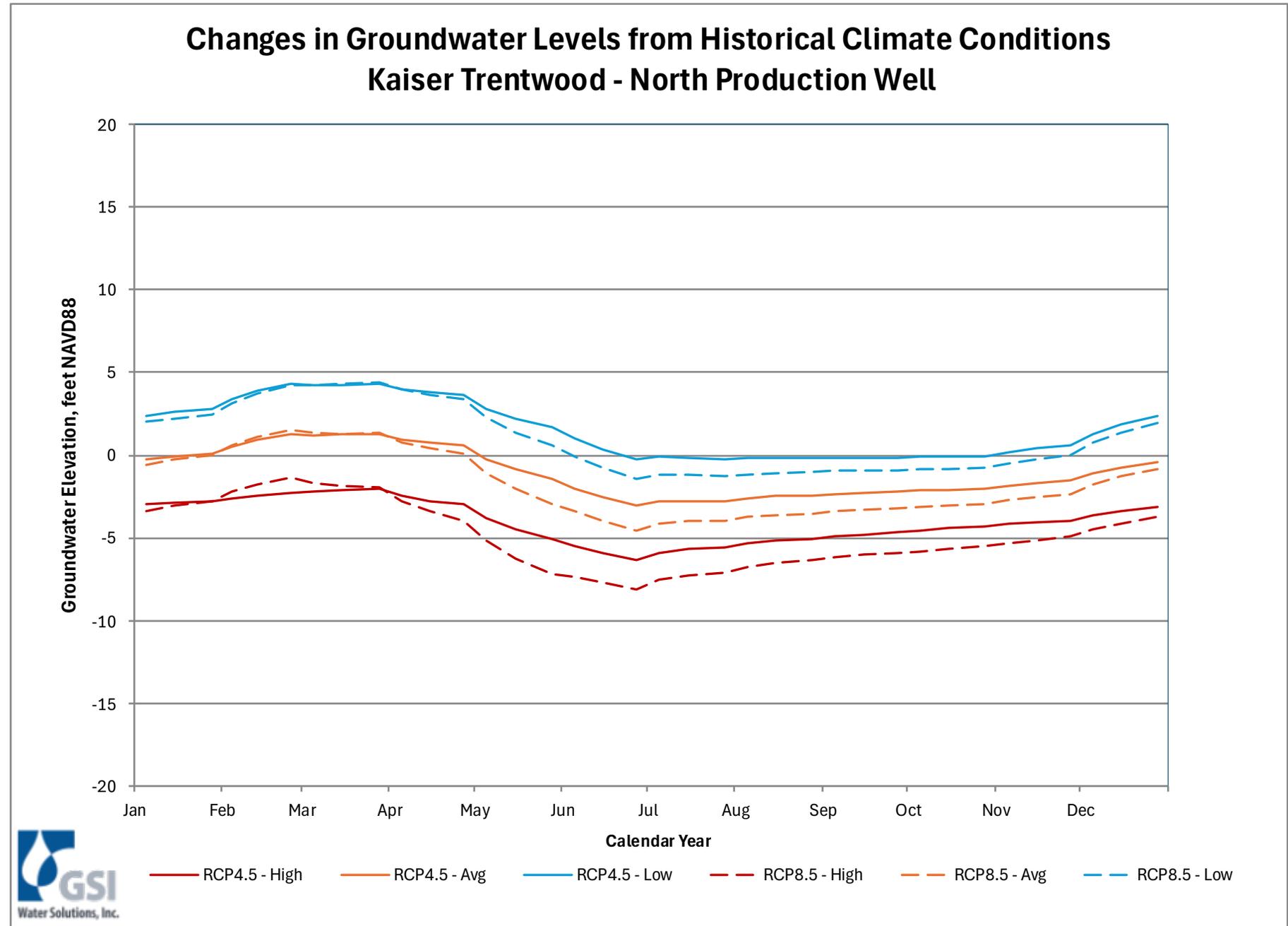
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

*Kaiser Aluminum  
Trentwood Works*

*North Production  
Well*



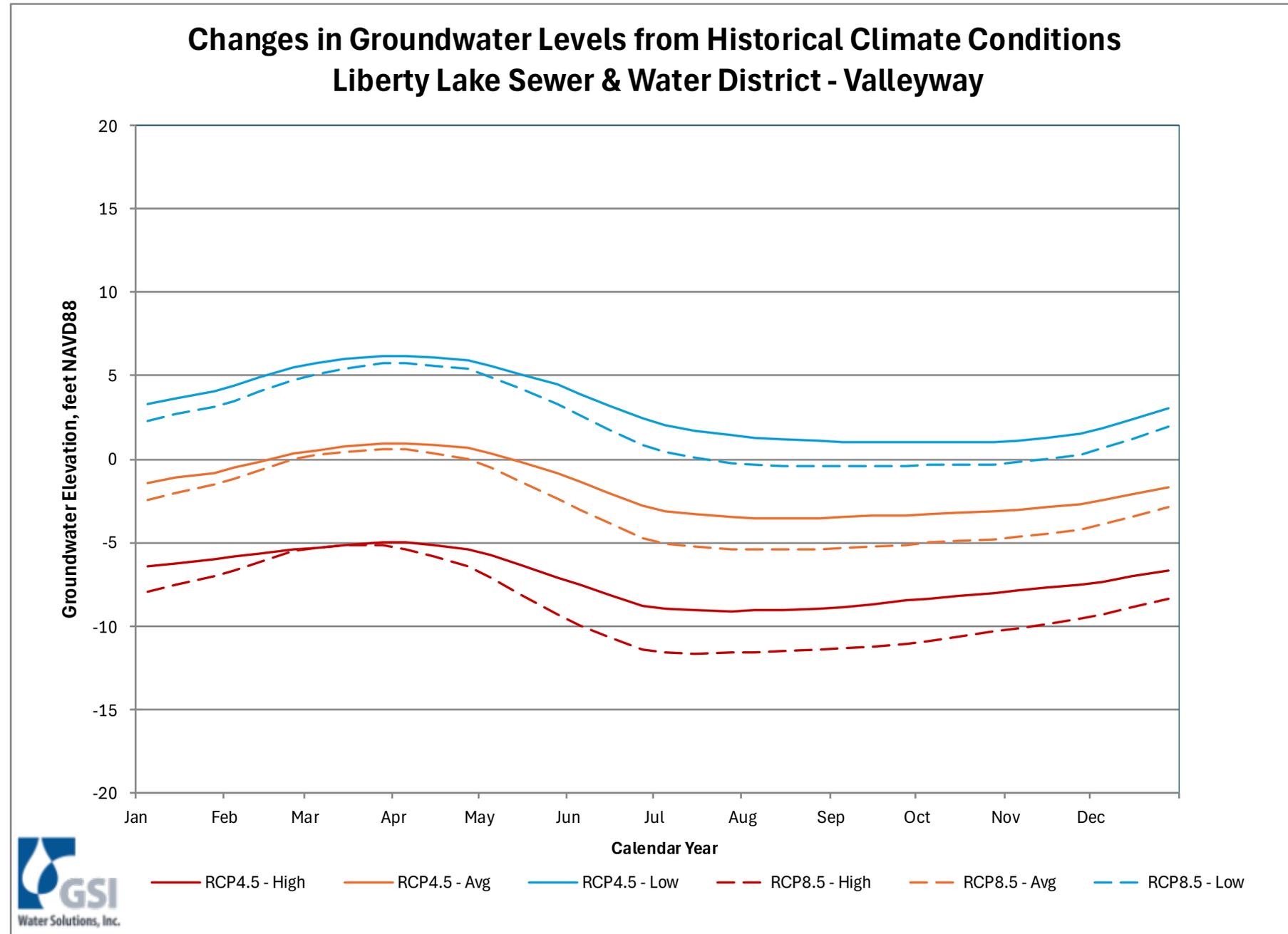
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Liberty Lake Sewer  
& Water District  
No. 1**

**Valleyway Well**

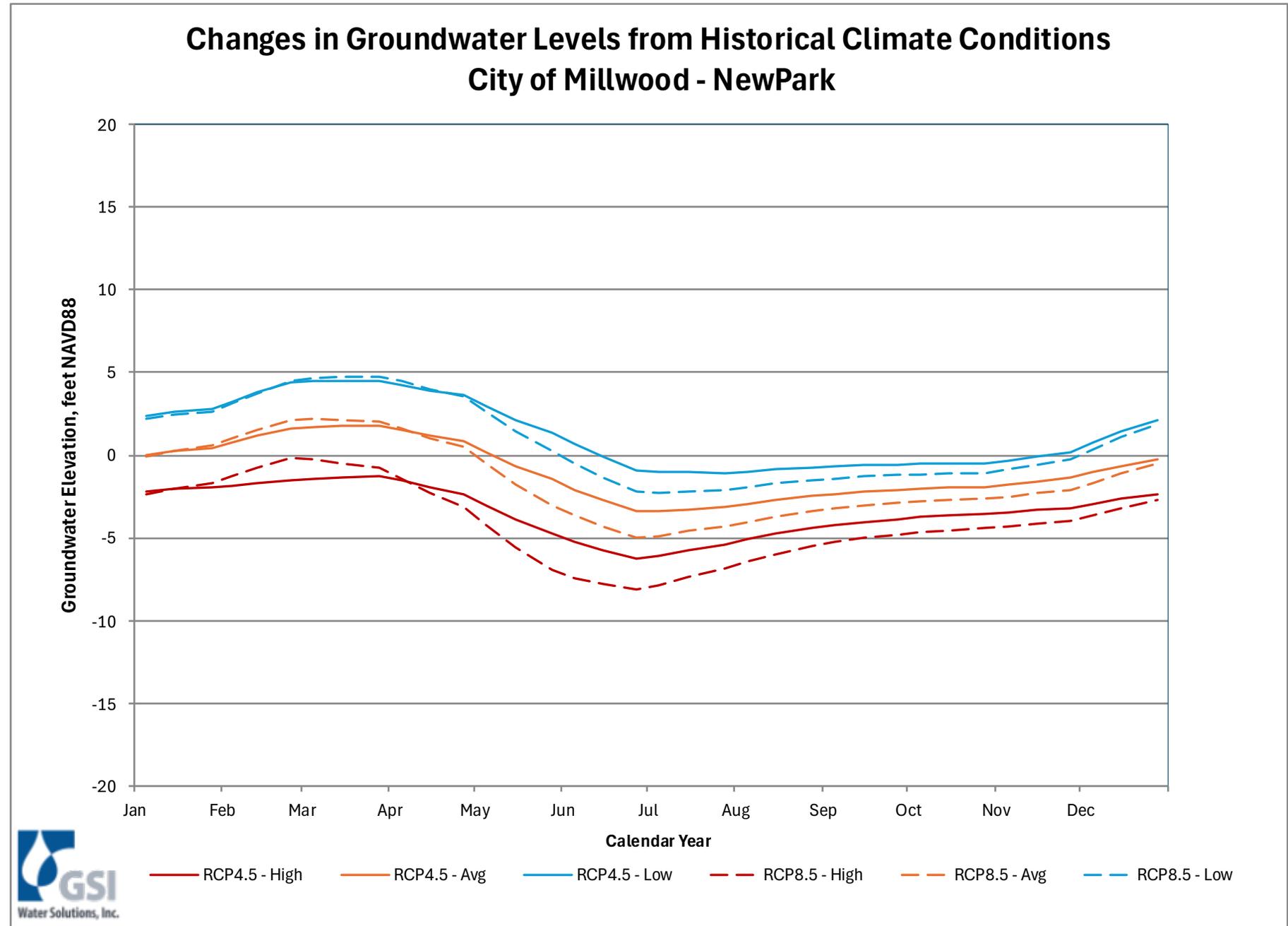


Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

*City of Millwood*

*New Park Well*



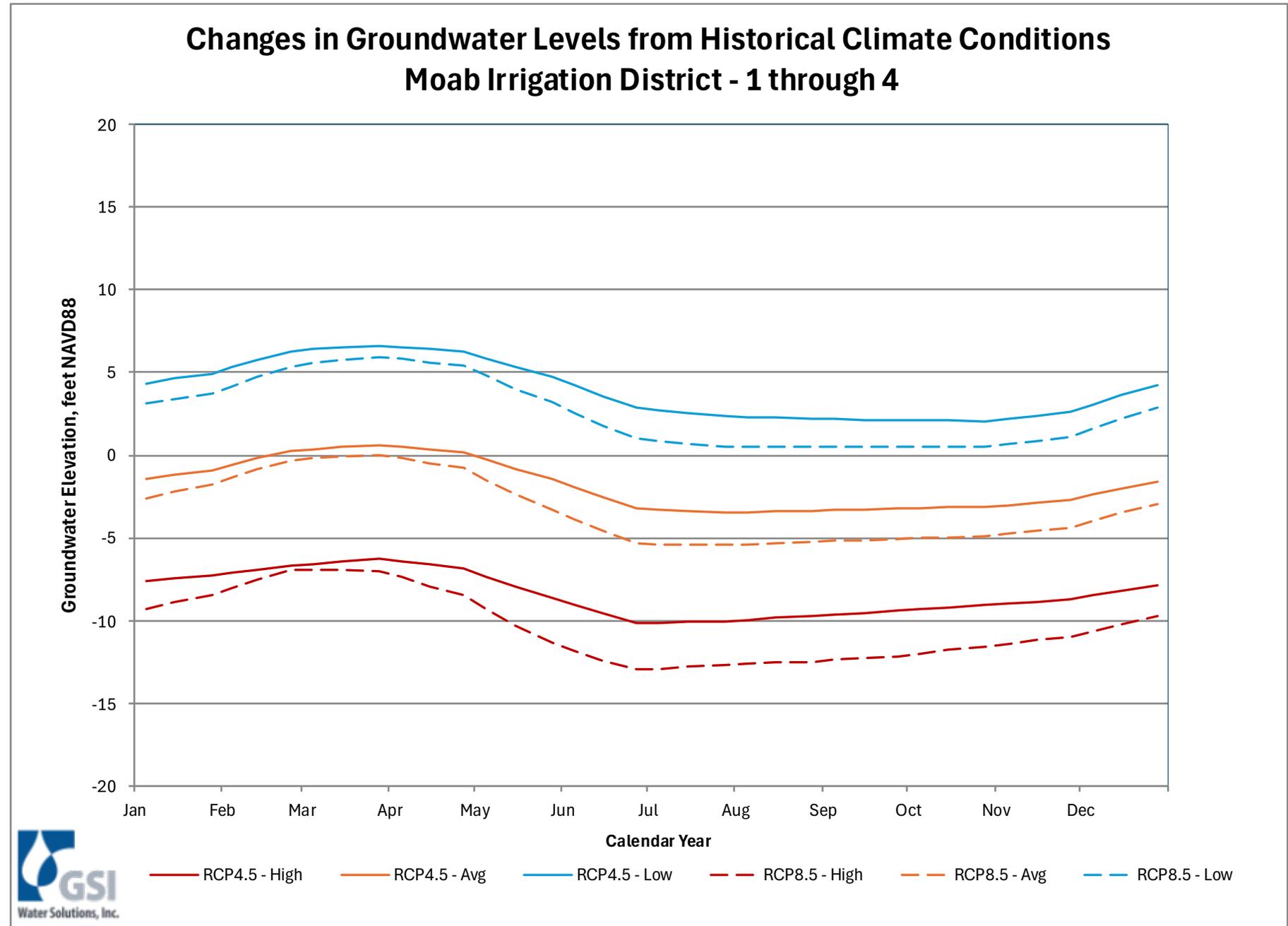
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

Moab Irrigation District No. 20

Wells 1-4



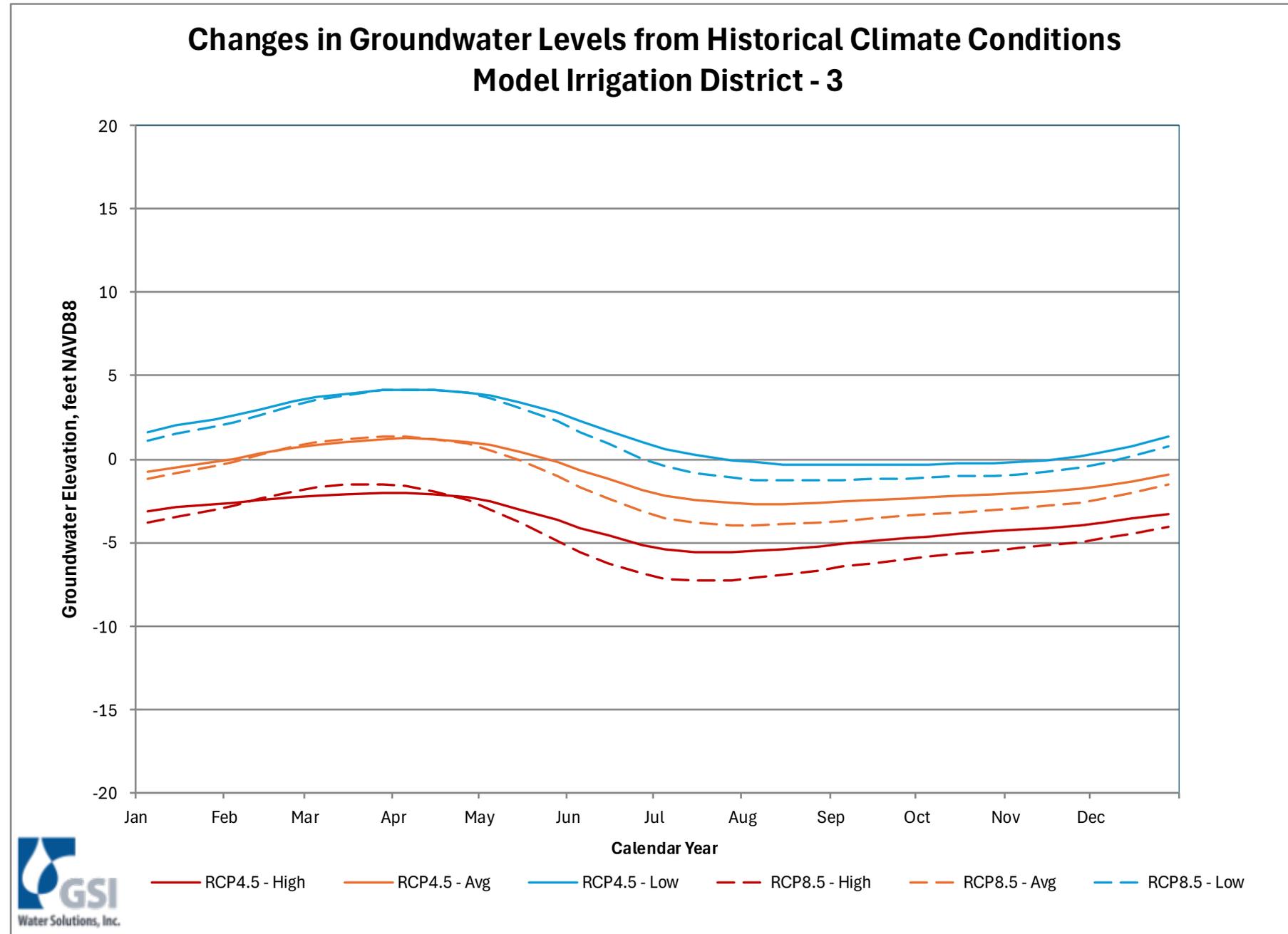
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

Model Irrigation District No. 18

Well 3



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

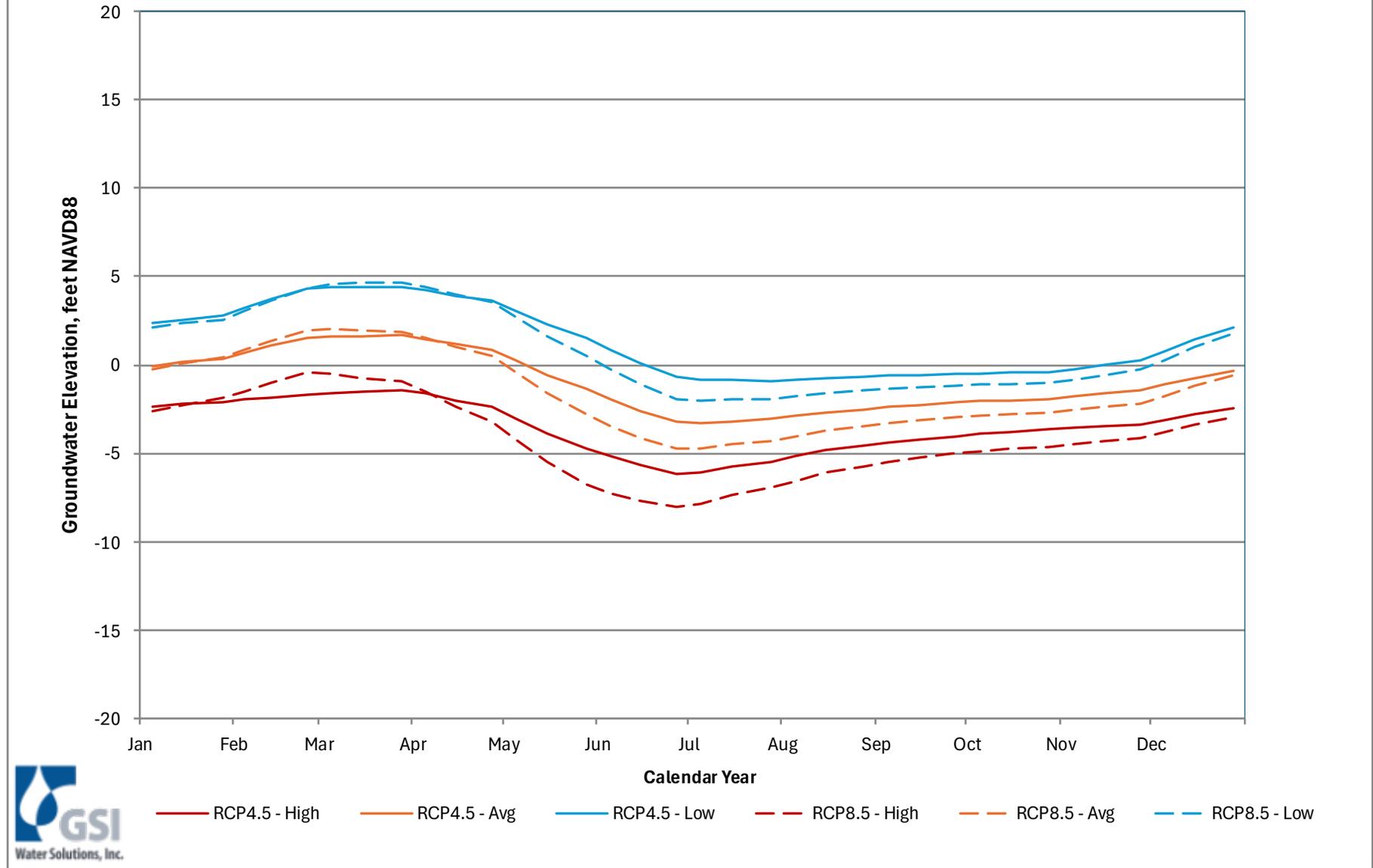


# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Modern Electric Water Company**

**Well 4**

## Changes in Groundwater Levels from Historical Climate Conditions Modern Electric Water Company - 4



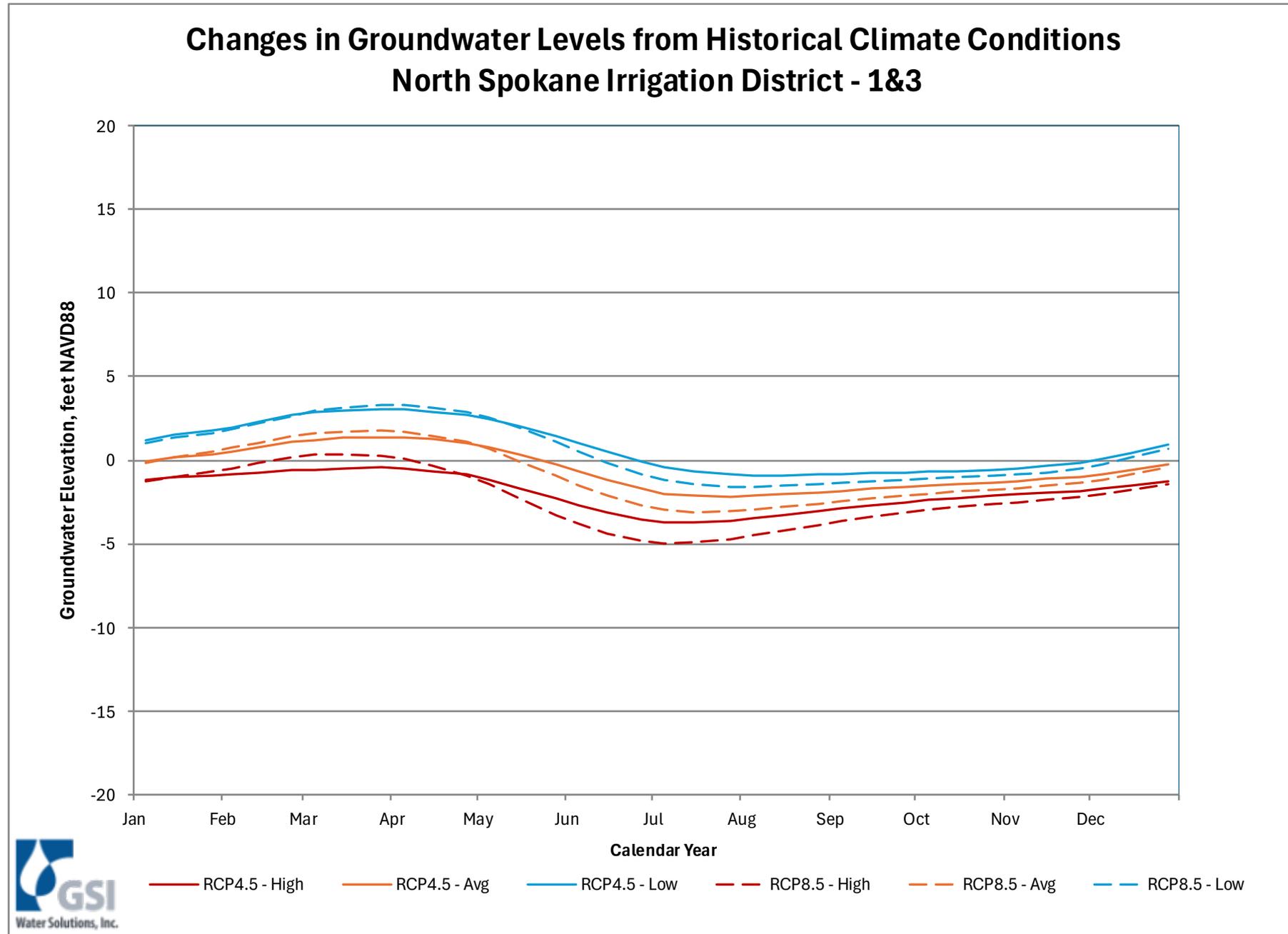
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

North Spokane Irrigation District No. 8

Wells 1 & 3



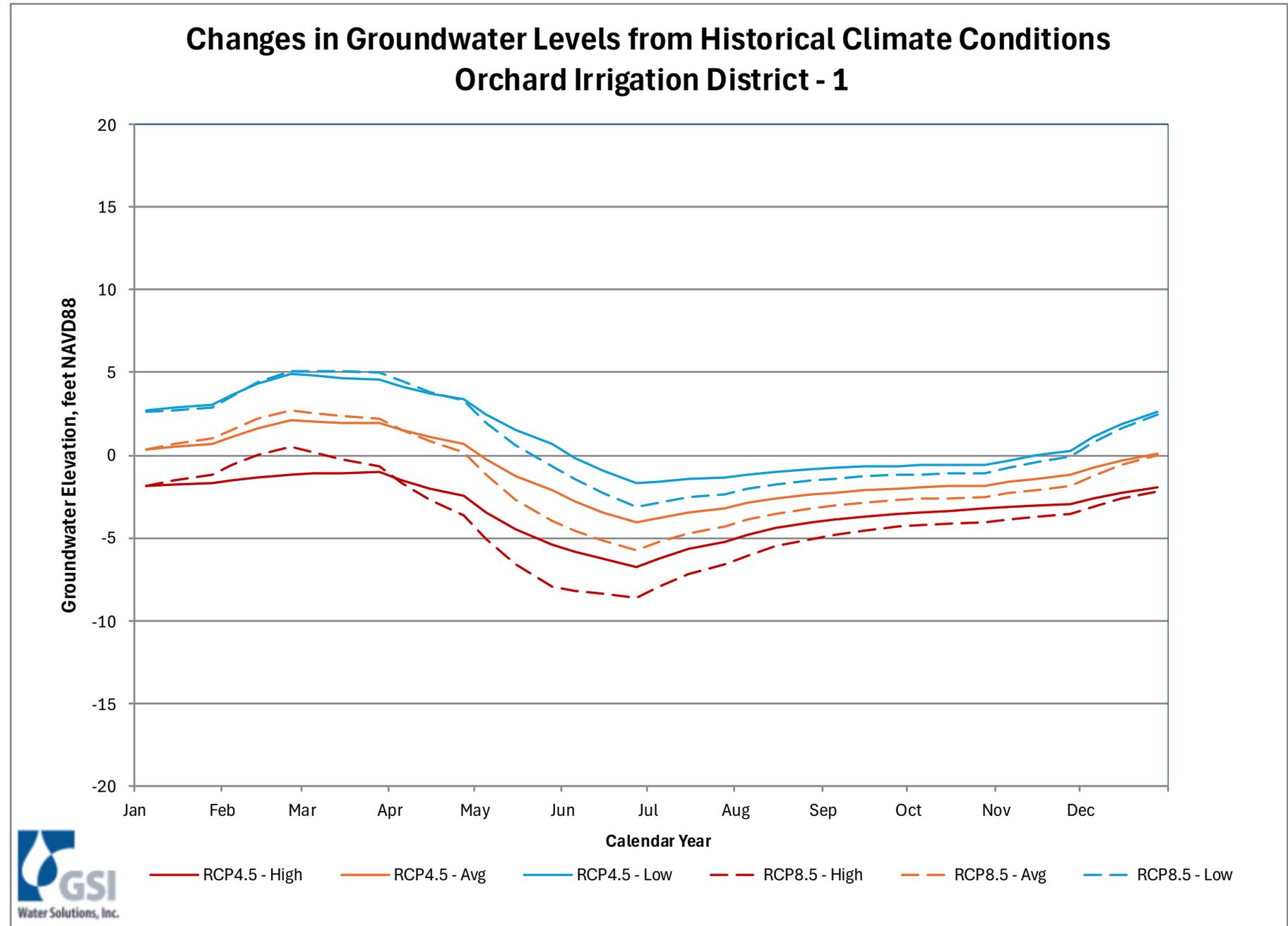
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Orchard  
Irrigation District  
No. 6**

**Well 1**



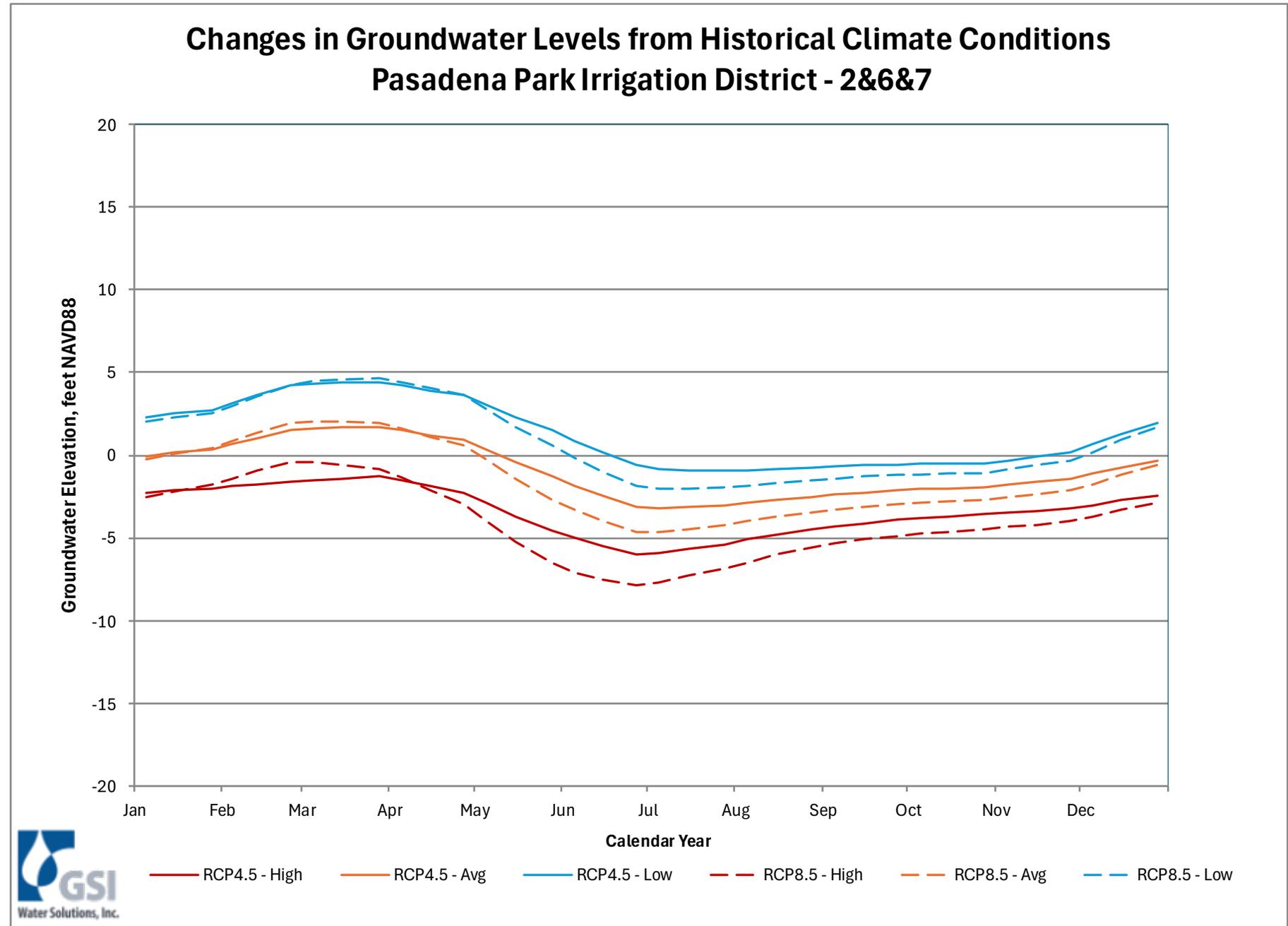
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Pasadena Park  
Irrigation District  
No. 17**

**Wells 2, 6, 7**



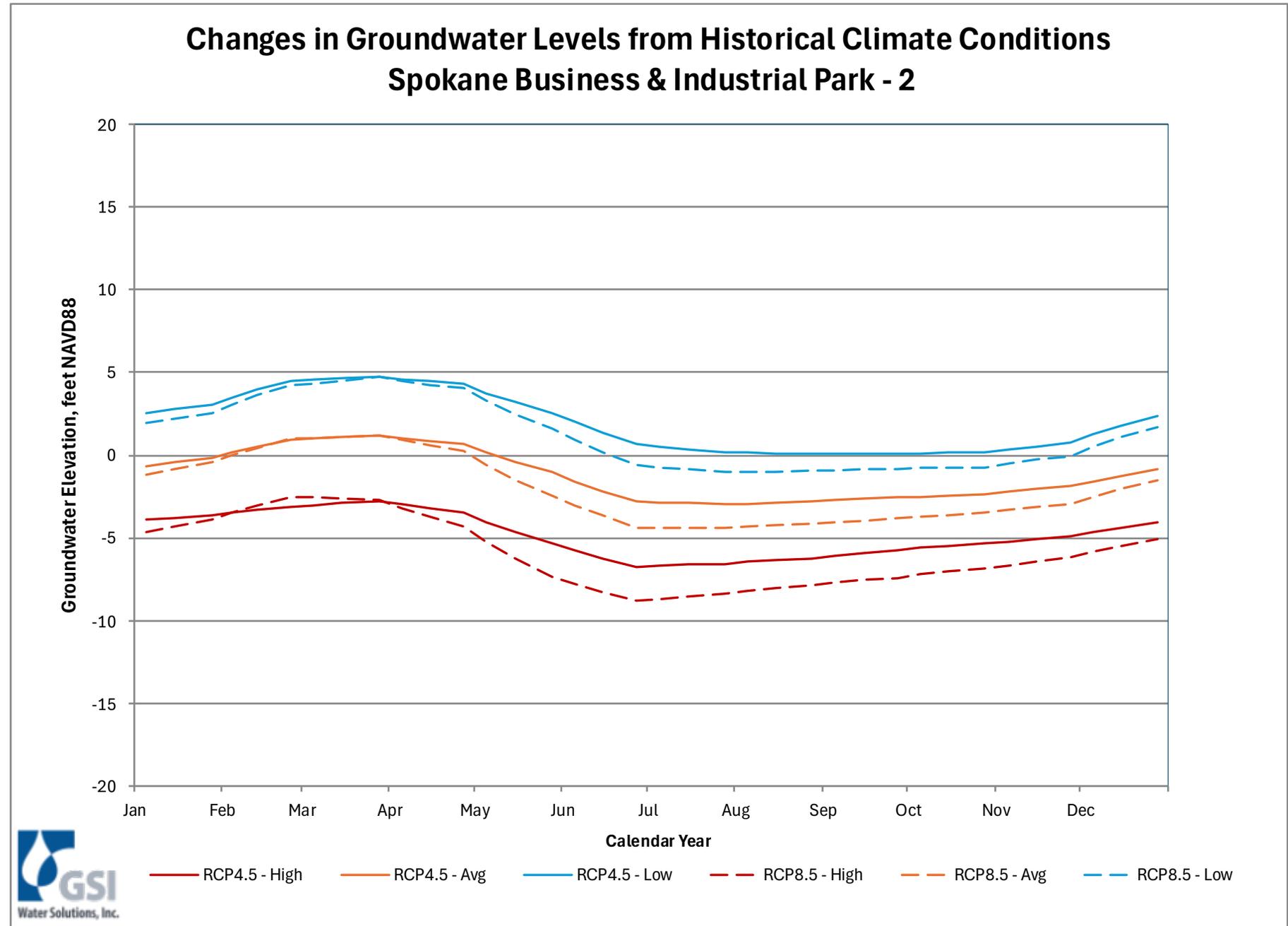
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

## Spokane Business & Industrial Park

### Well 2



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

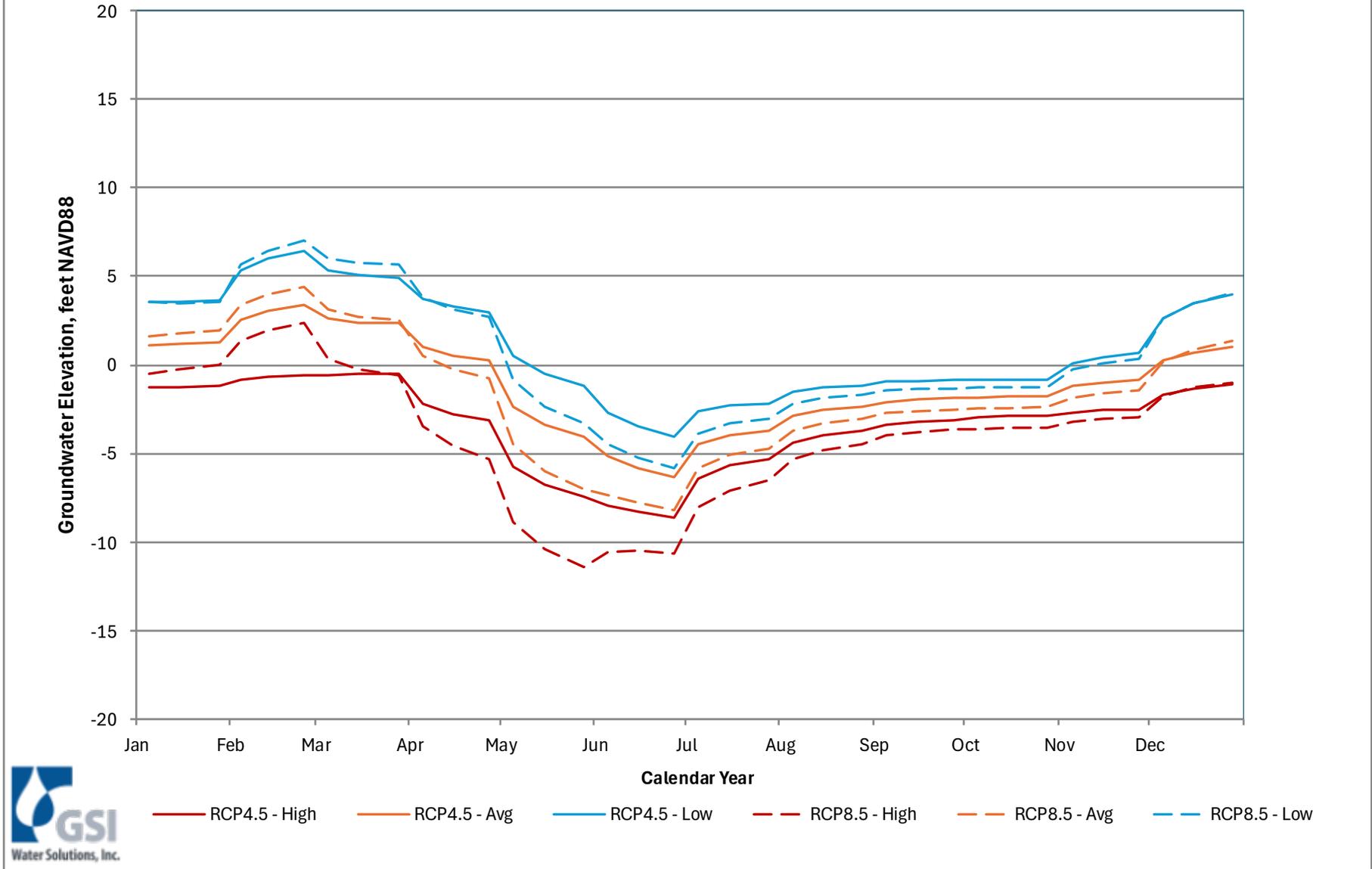


# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

City of Spokane

Well Electric Well Station

## Changes in Groundwater Levels from Historical Climate Conditions City of Spokane - Well Electric



— RCP4.5 - High    — RCP4.5 - Avg    — RCP4.5 - Low    - - RCP8.5 - High    - - RCP8.5 - Avg    - - RCP8.5 - Low

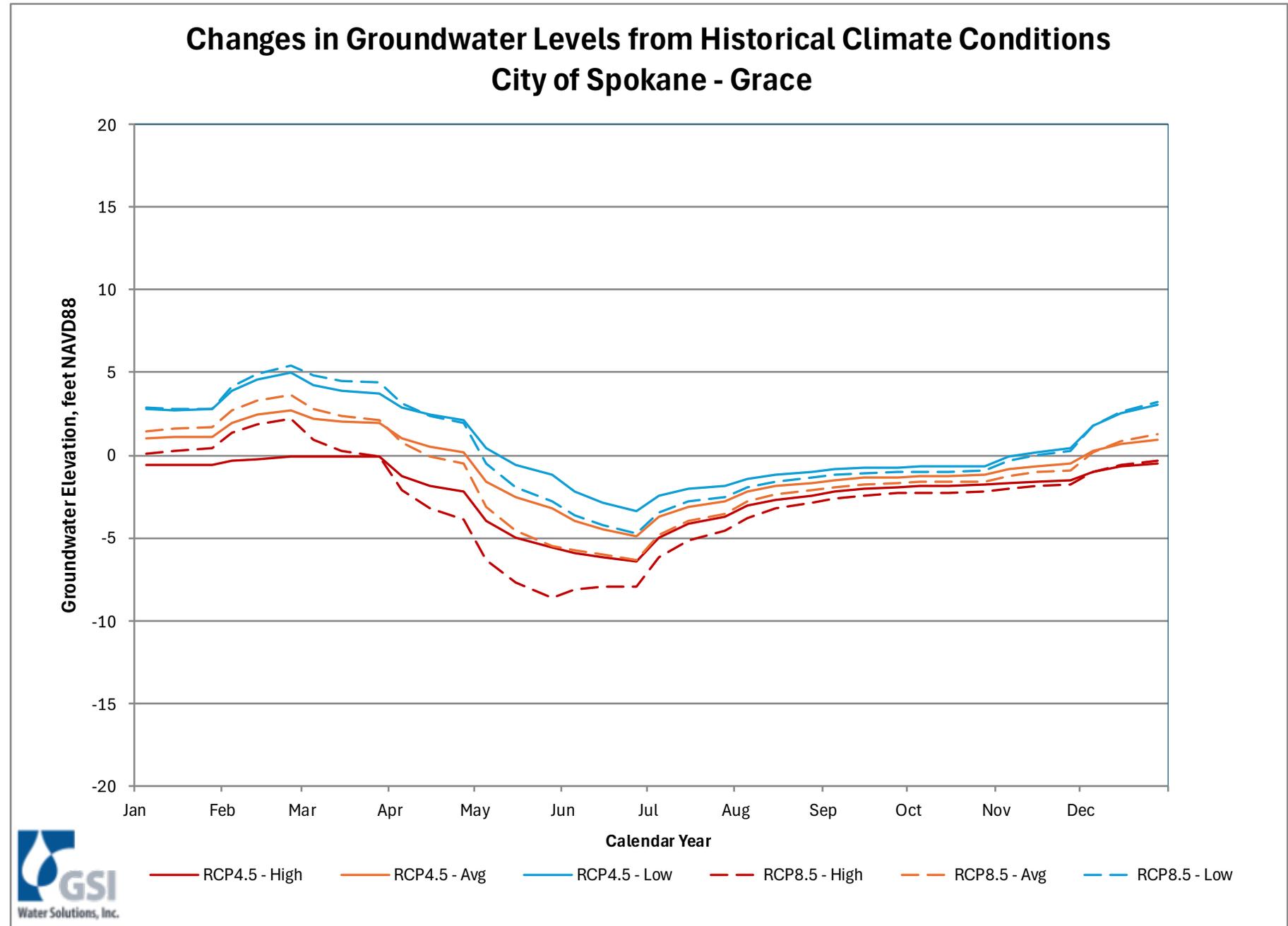
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

City of Spokane

Grace Well Station



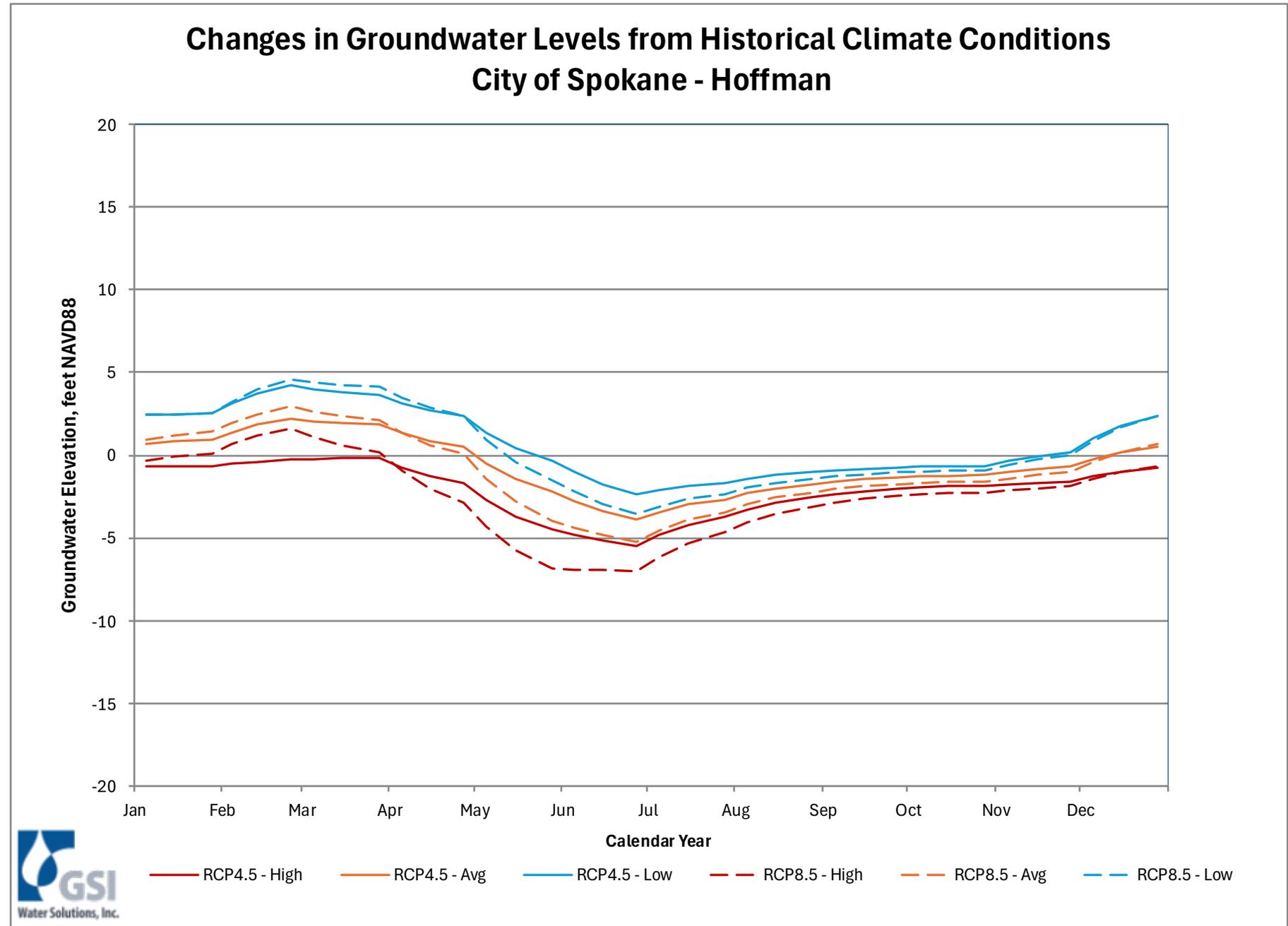
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

City of Spokane

Hoffman Well Station



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



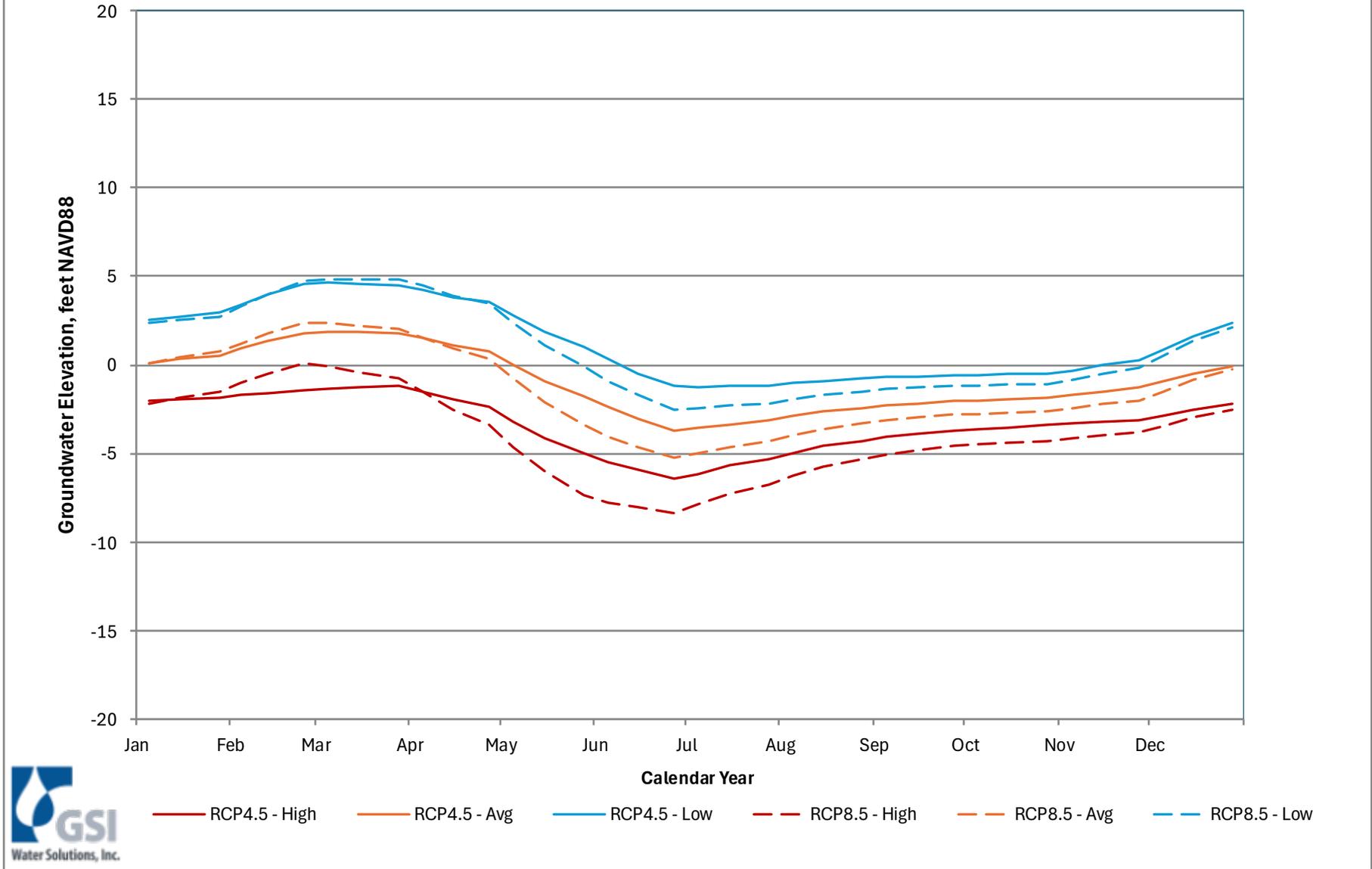
# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

Spokane County Water District No. 3 (East Wellfield)

Freeway & Vista Well



## Changes in Groundwater Levels from Historical Climate Conditions East Spokane Water District - Freeway & Vista



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

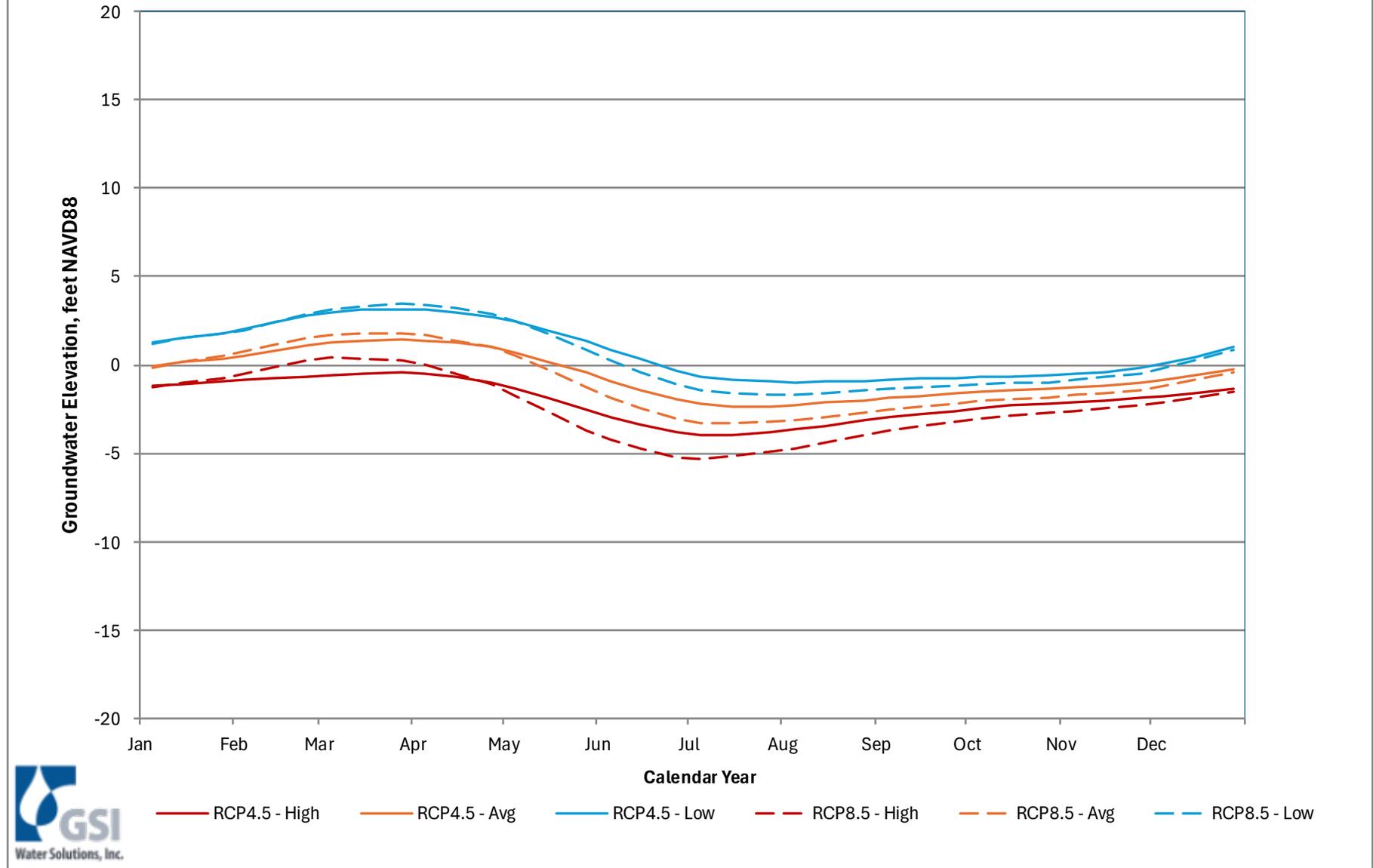
# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Spokane County  
Water District No. 3  
(North Wellfield)**

**Lyons & Normandie  
Well**



## Changes in Groundwater Levels from Historical Climate Conditions North Spokane Water District - Lyons & Normandie

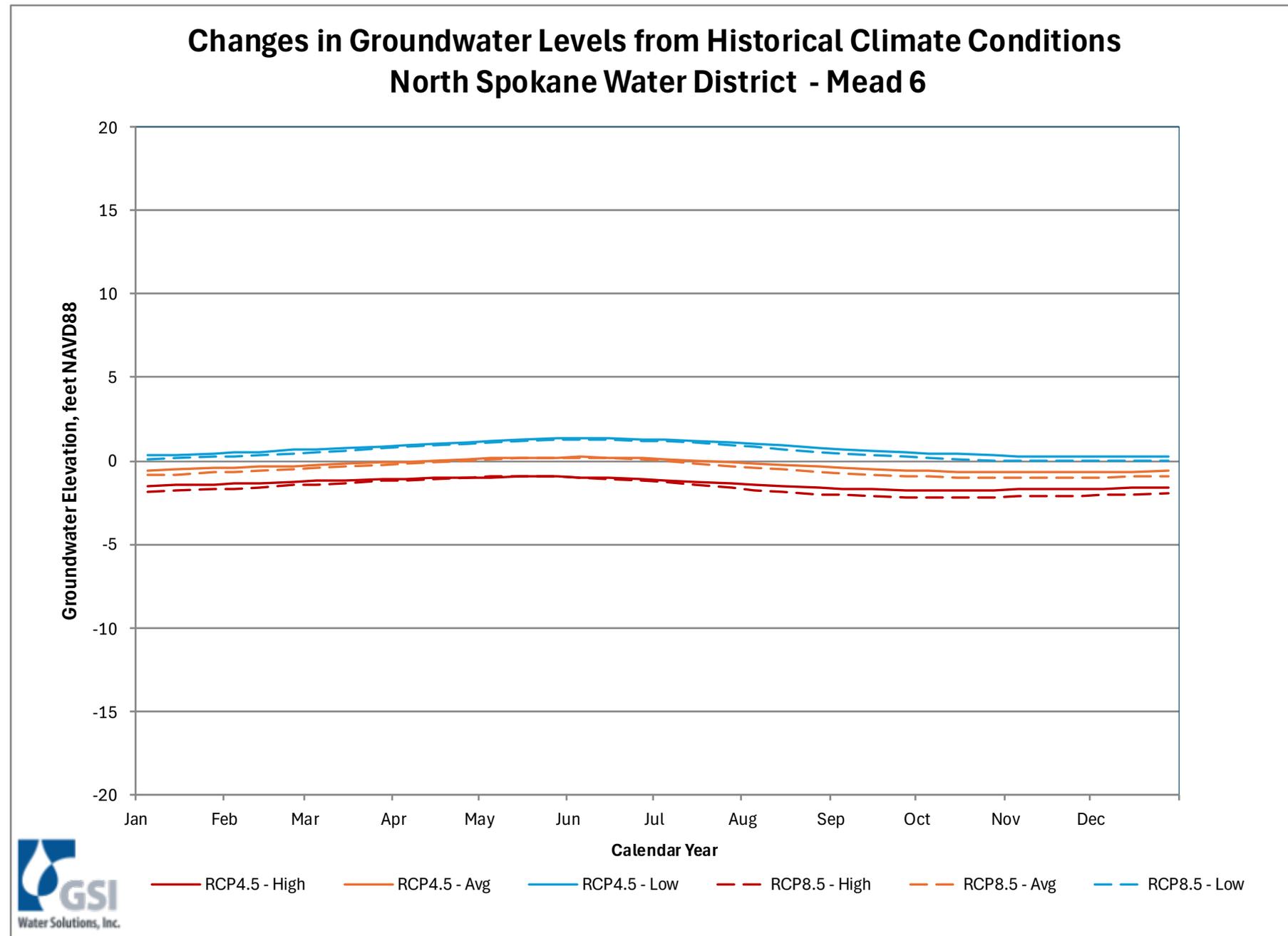


Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Spokane County  
Water District No. 3  
(North Wellfield)**

**Mead 6 Well**



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

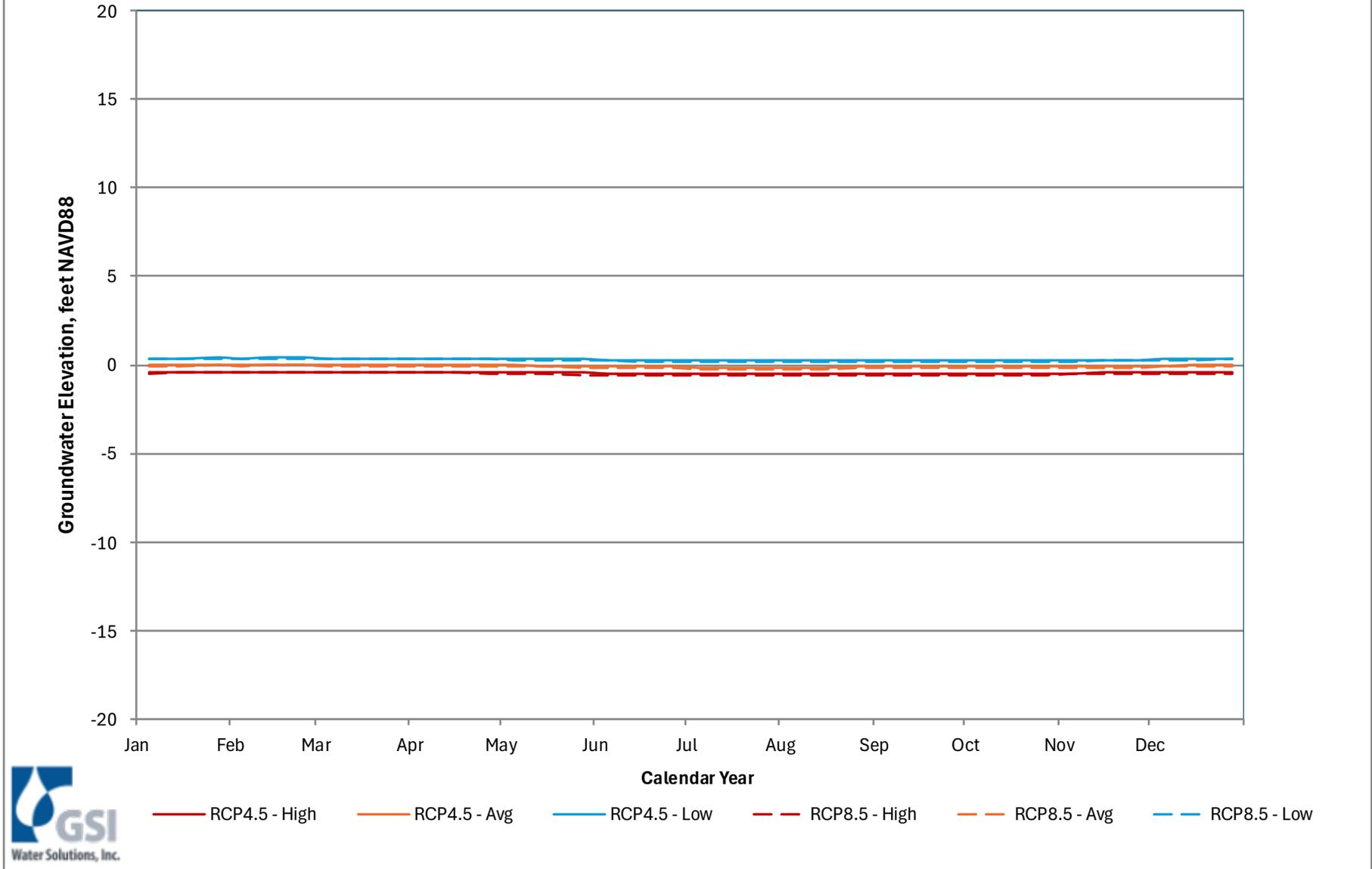
*Spokane County  
Water District No. 3  
(North Wellfield)*

*Pineriver Park 1&2  
Wells*



GSI Water Solutions, Inc.

## Changes in Groundwater Levels from Historical Climate Conditions North Spokane Water District - Pineriver Park - 1&2

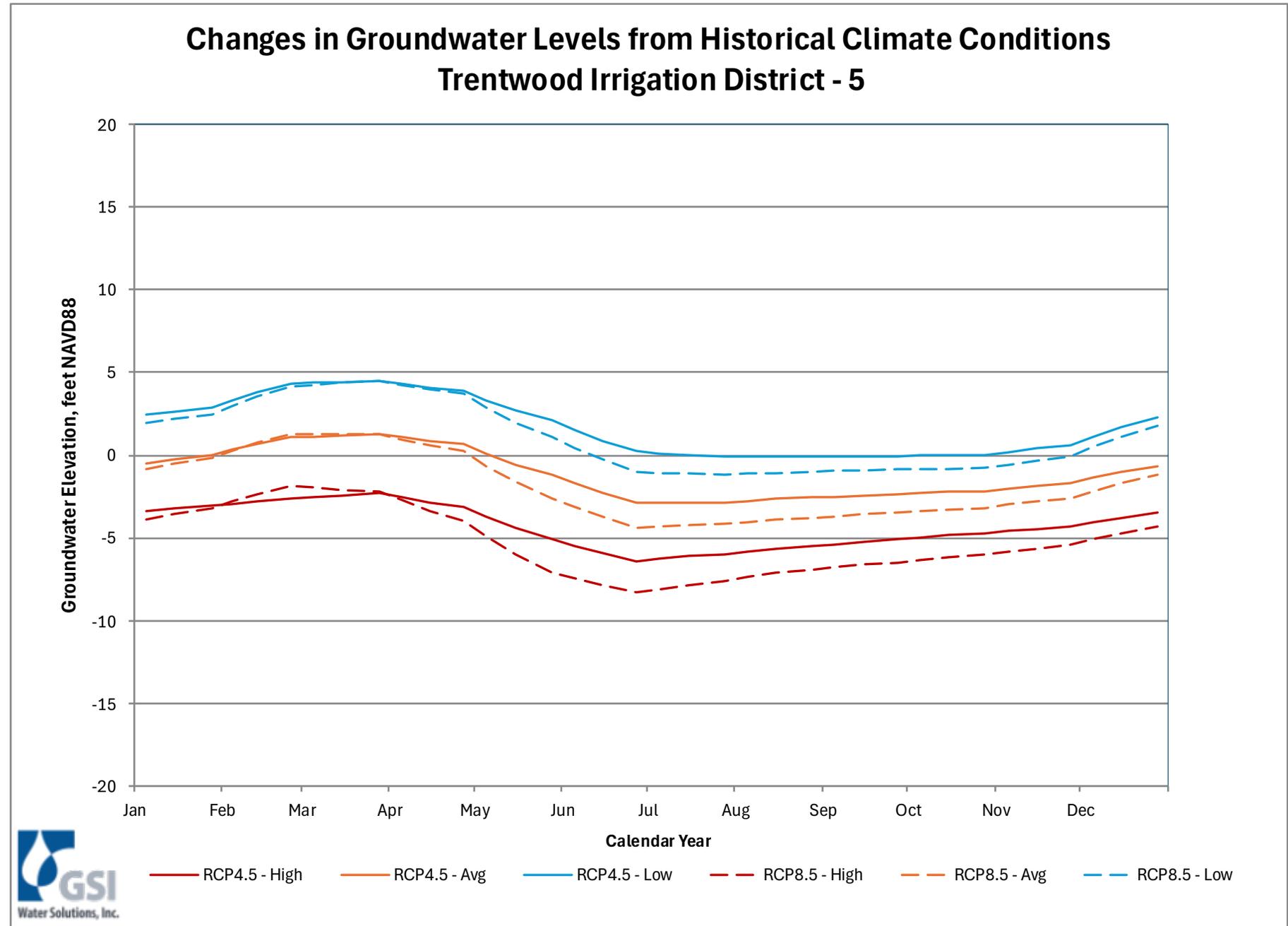


Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Trentwood  
Irrigation District  
No. 3**

**Well 5**



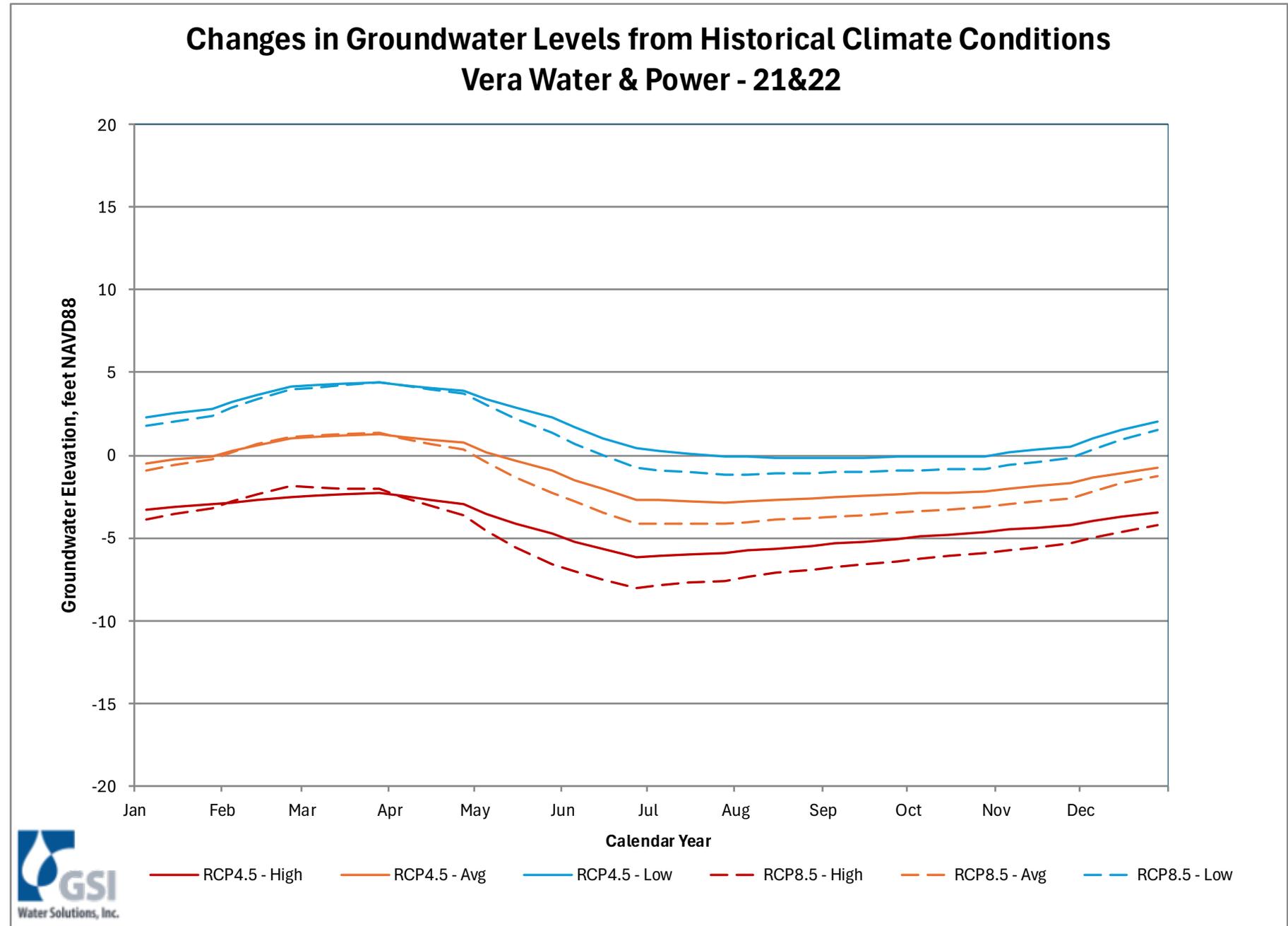
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

*Vera Water & Power*

*Wells 21 & 22*



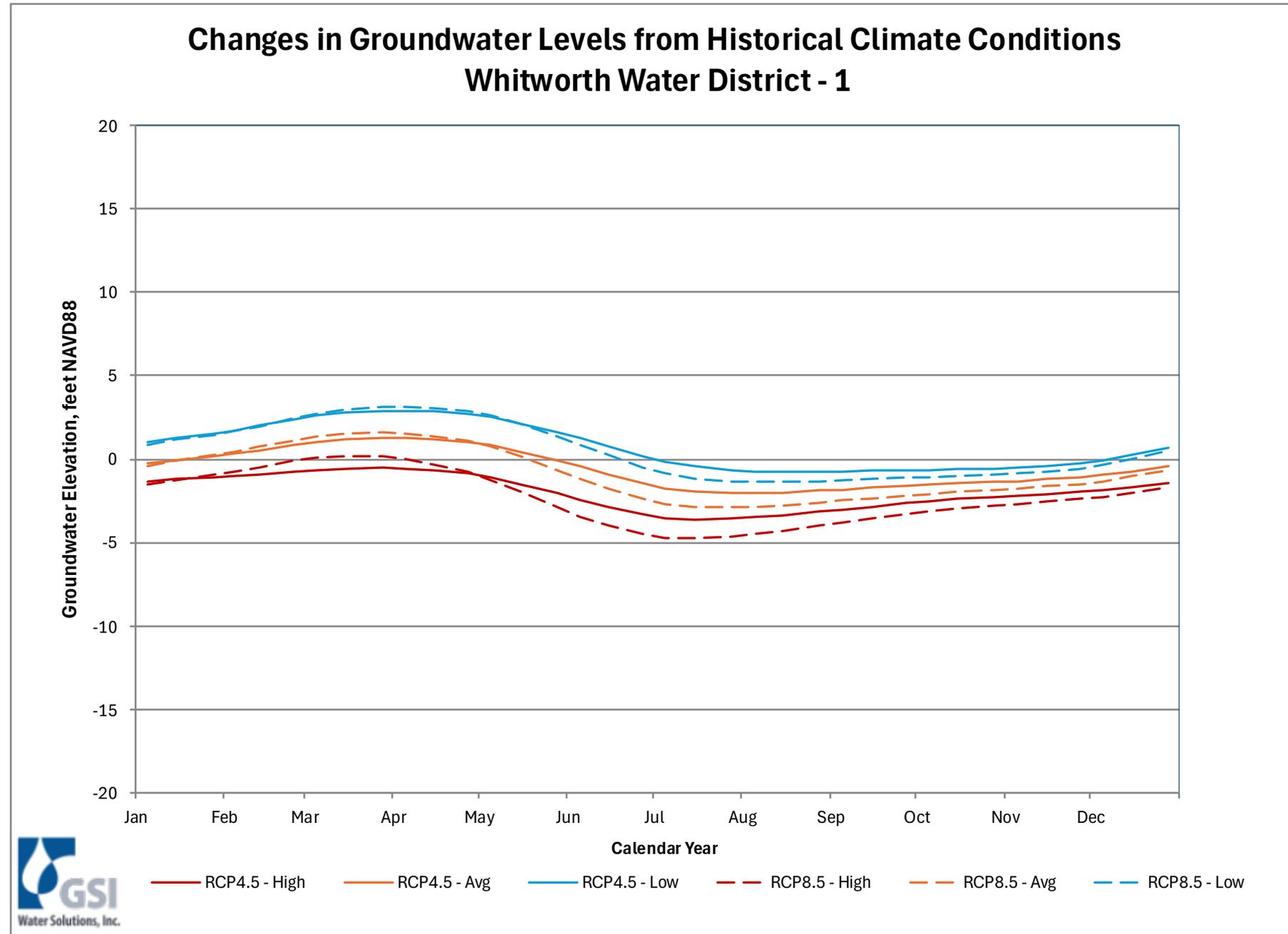
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

**Whitworth Water District No. 2**

**Well 1**

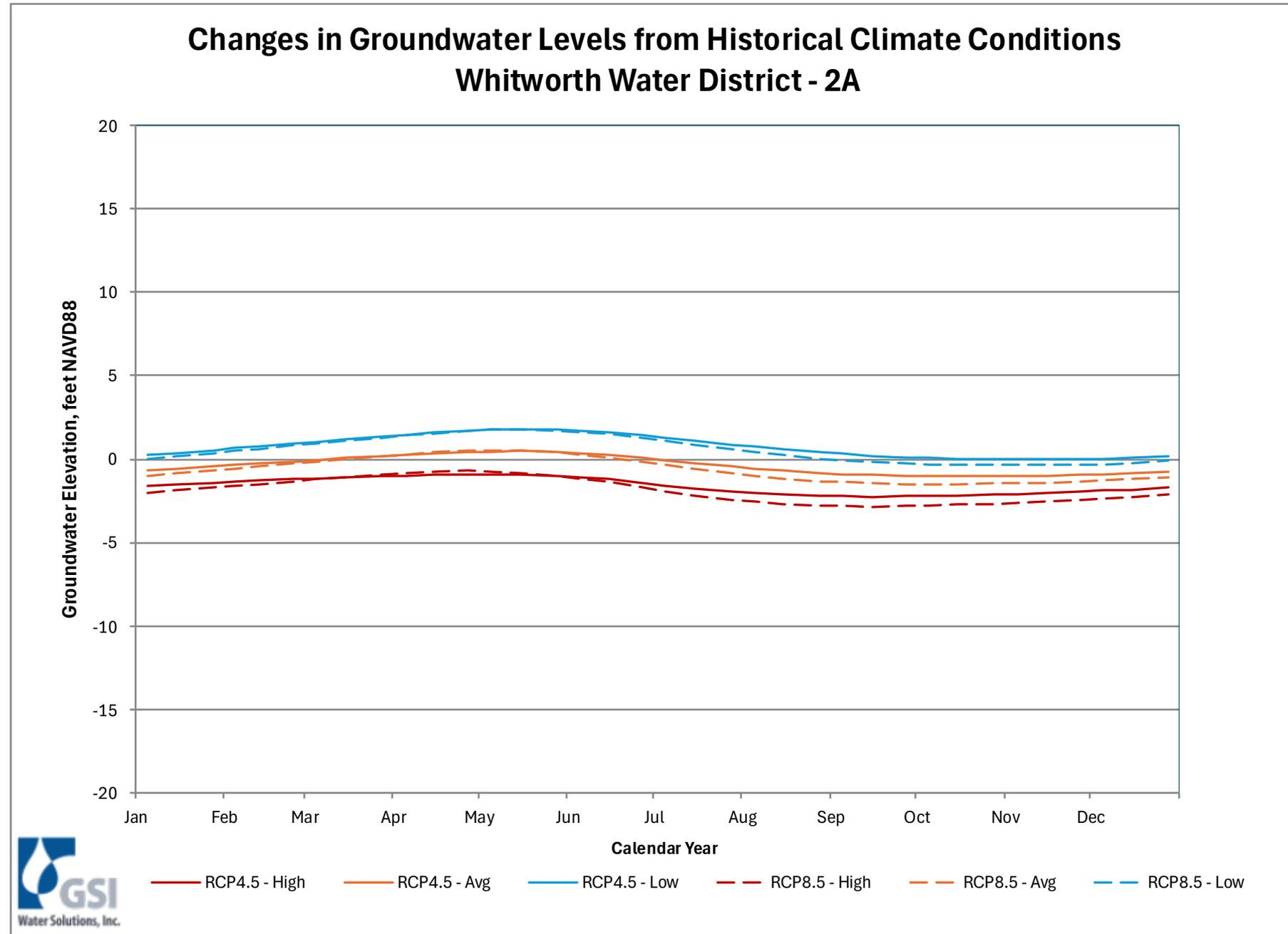


Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

*Whitworth Water District No. 2*

*Well 2A*



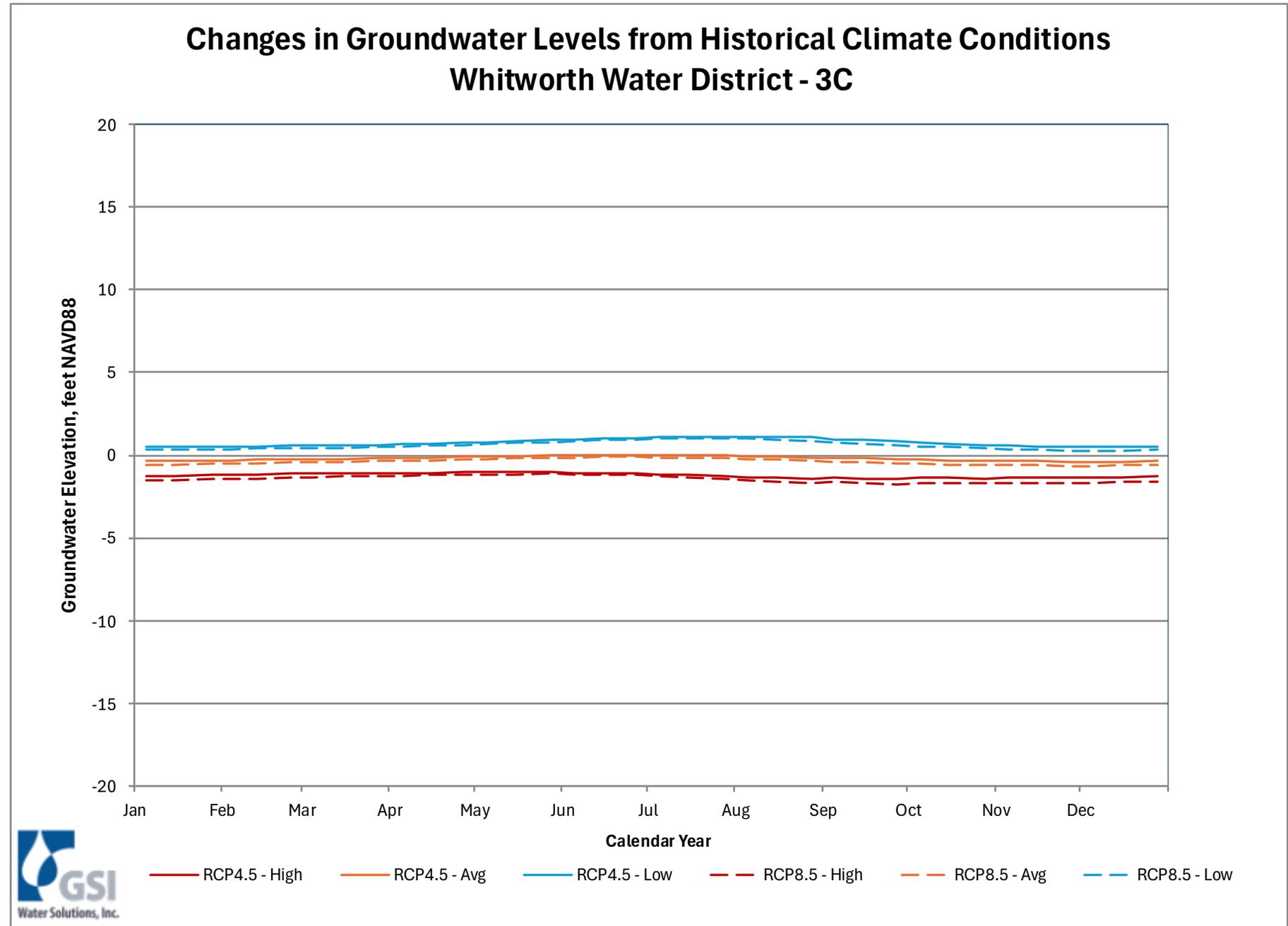
Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



# Estimated Seasonal and Monthly Changes in Groundwater Levels (2070-2099)

*Whitworth Water District No. 2*

*Well 3C*



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow



## **Attachment C**

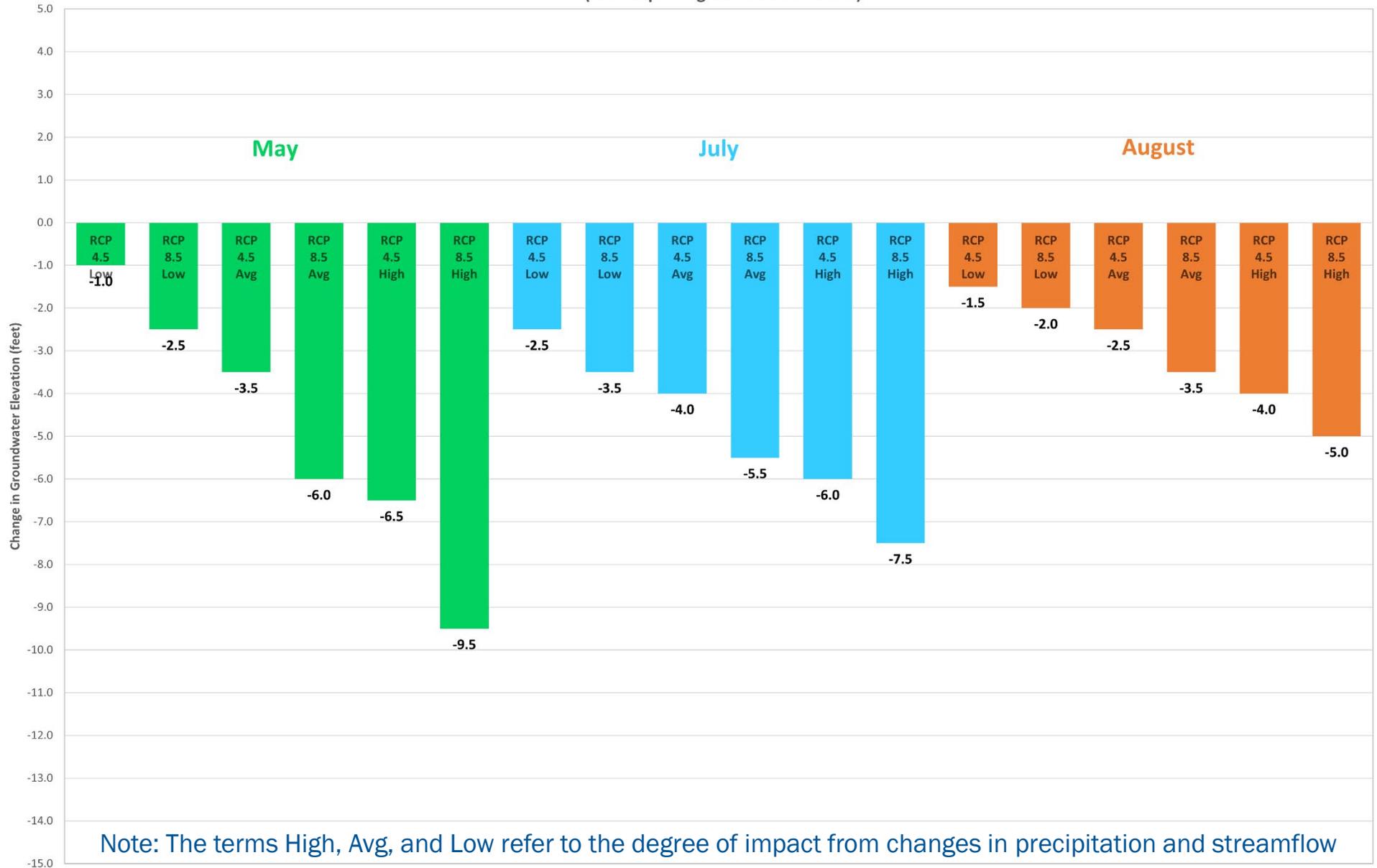
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# **Bar Charts Showing Range of Potential Climate Influences on Spring and Summer Groundwater Levels During the Latter Part of the 21<sup>st</sup> Century**

# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Carnhope Irrigation District No. 7

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Carnhope Irrigation District No. 7)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

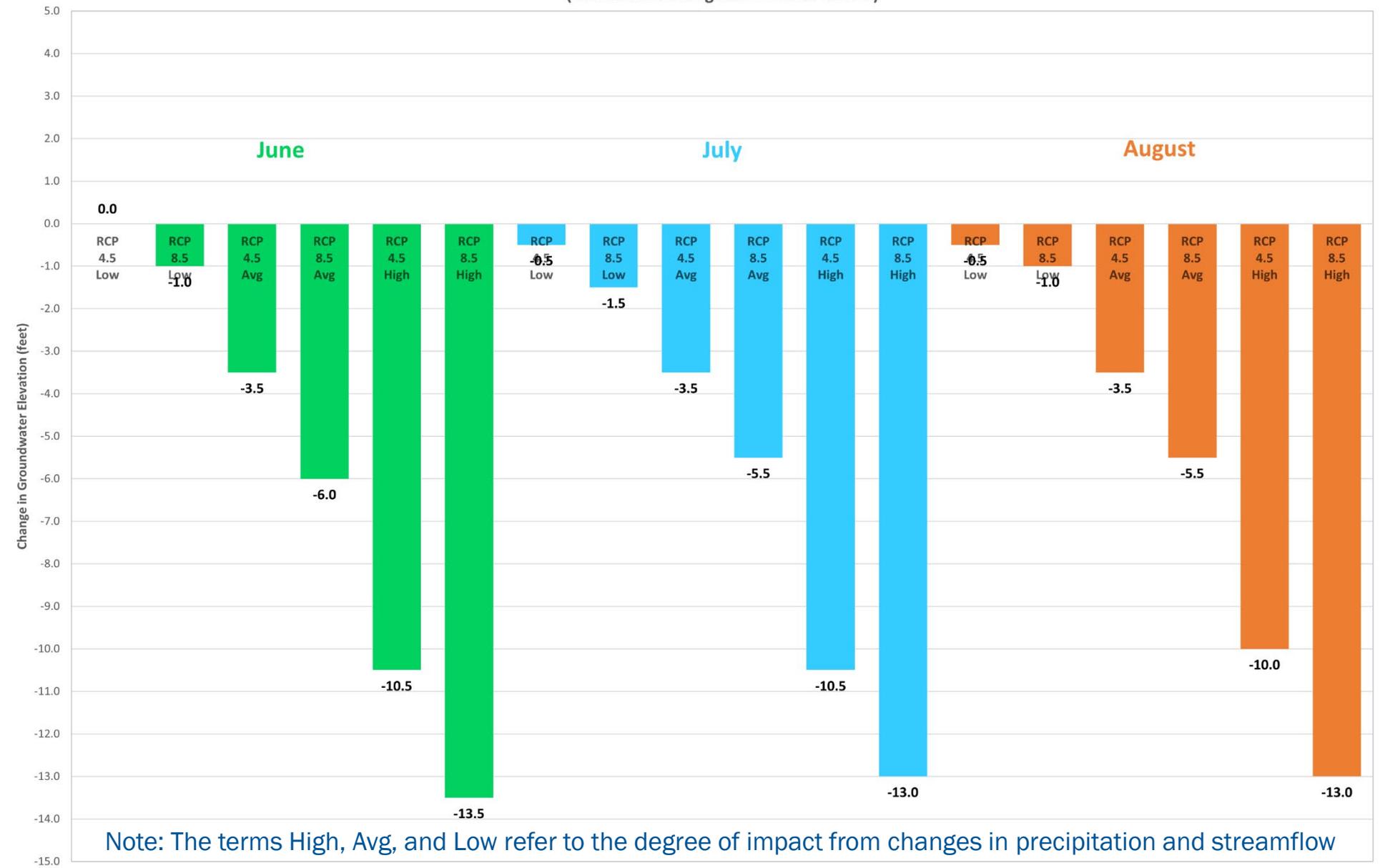
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Consolidated Irrigation District No. 19

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Consolidated Irrigation District No. 19)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

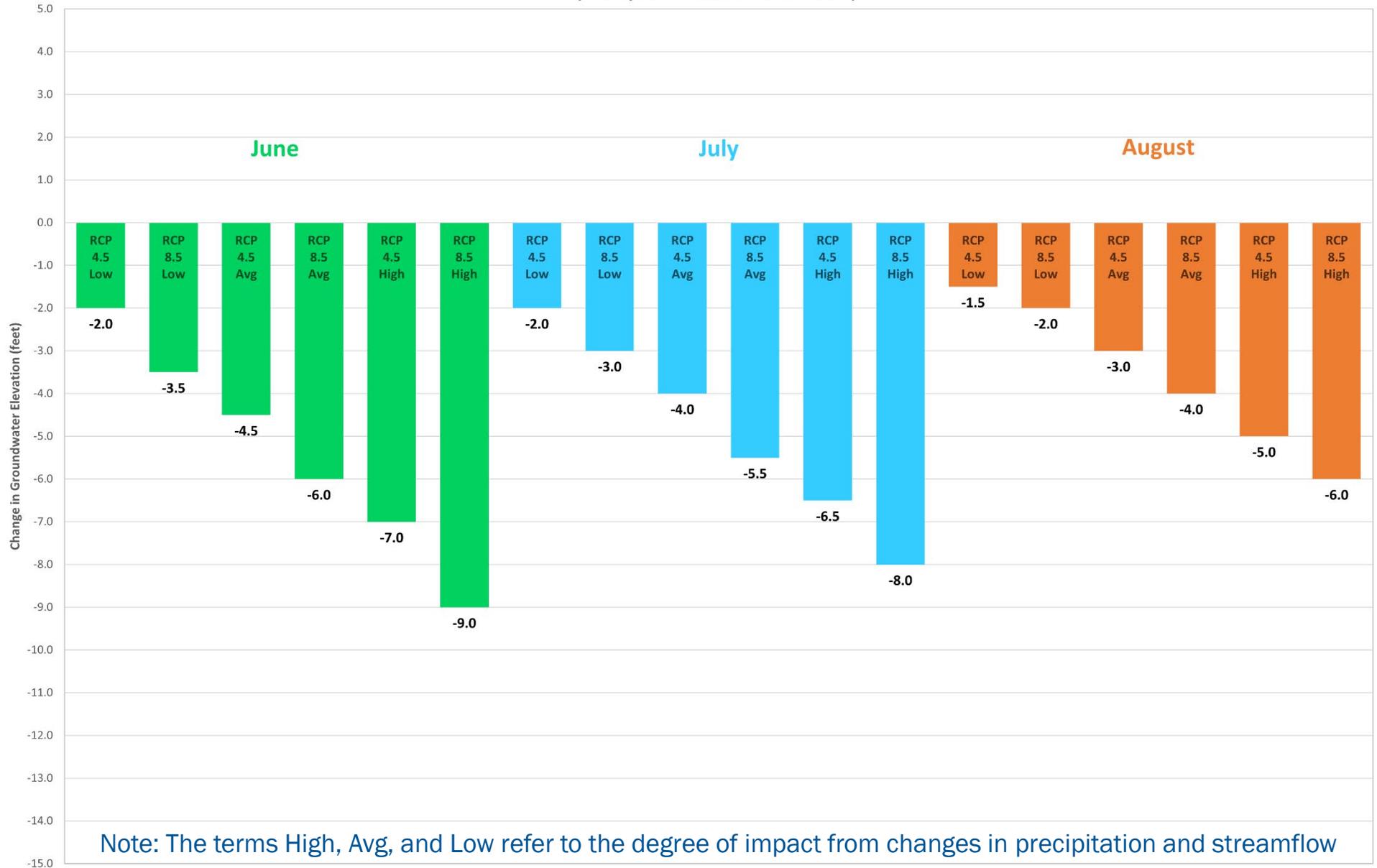
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## East Spokane Water District No. 1

Largest Modeled Changes in Groundwater Levels Amongst All Wells (East Spokane Water District No. 1)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

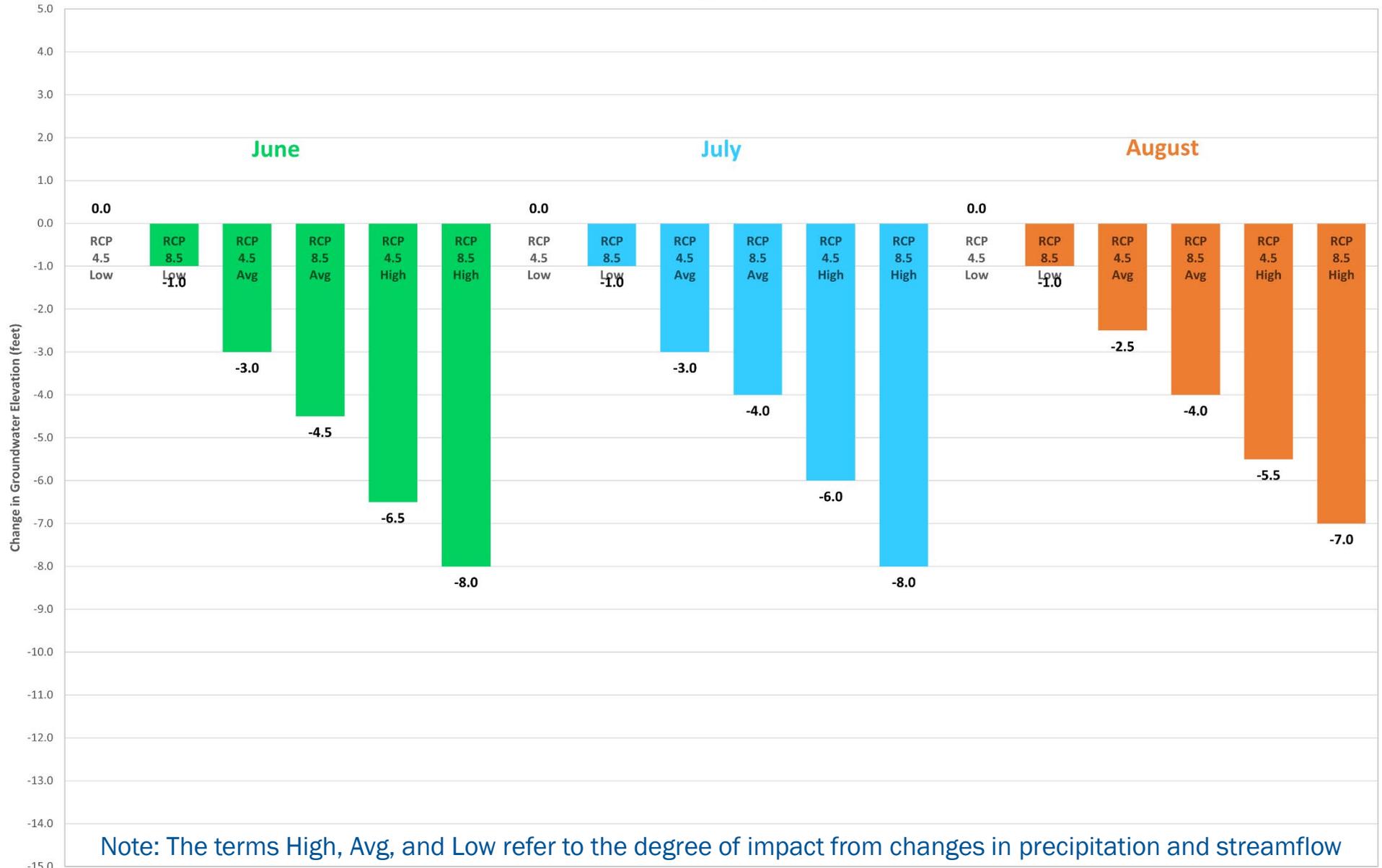
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

*Honeywell Electronic Materials*

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Honeywell)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

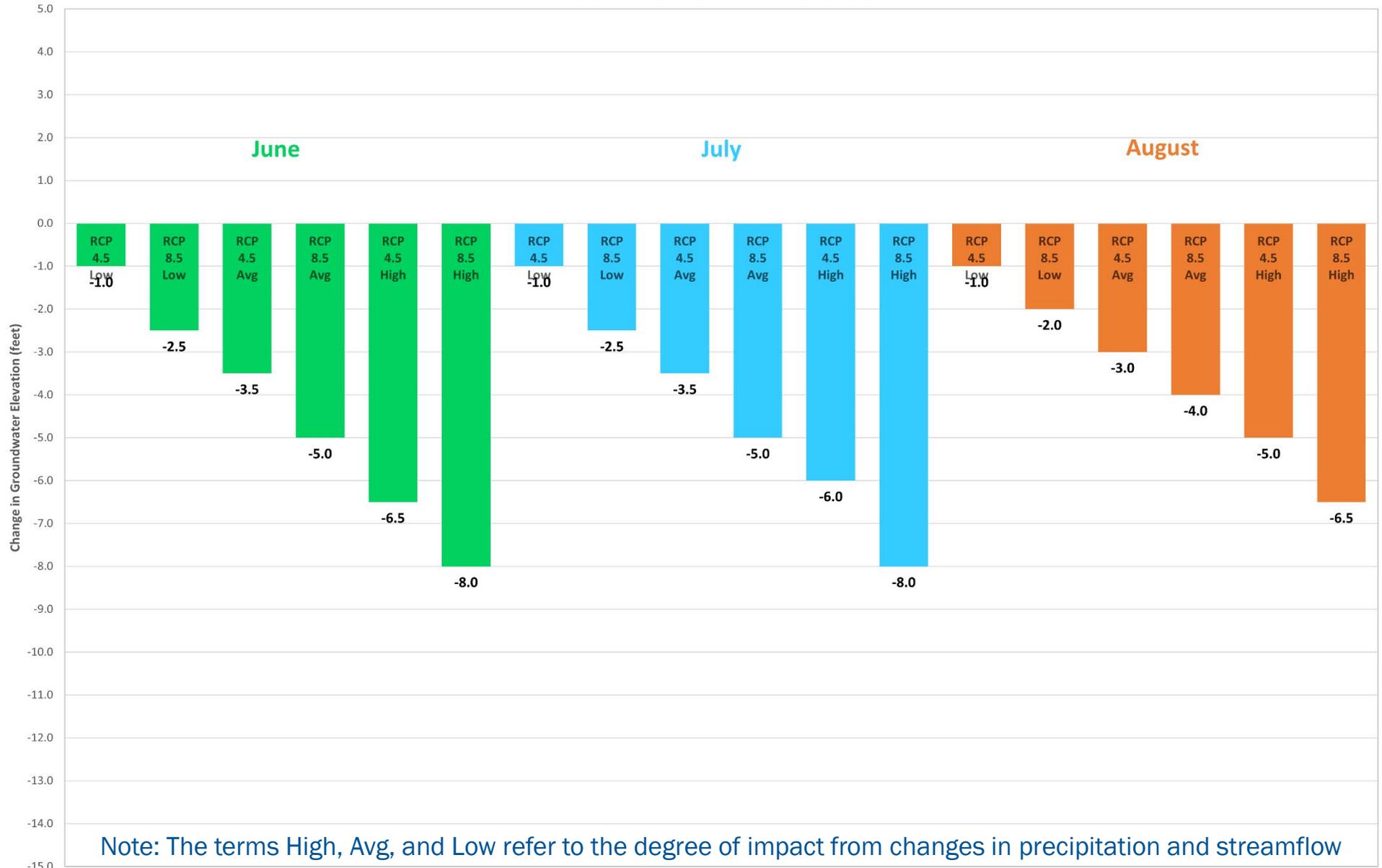
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Hutchinson Irrigation District No. 16

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Hutchinson Irrigation District No. 16)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

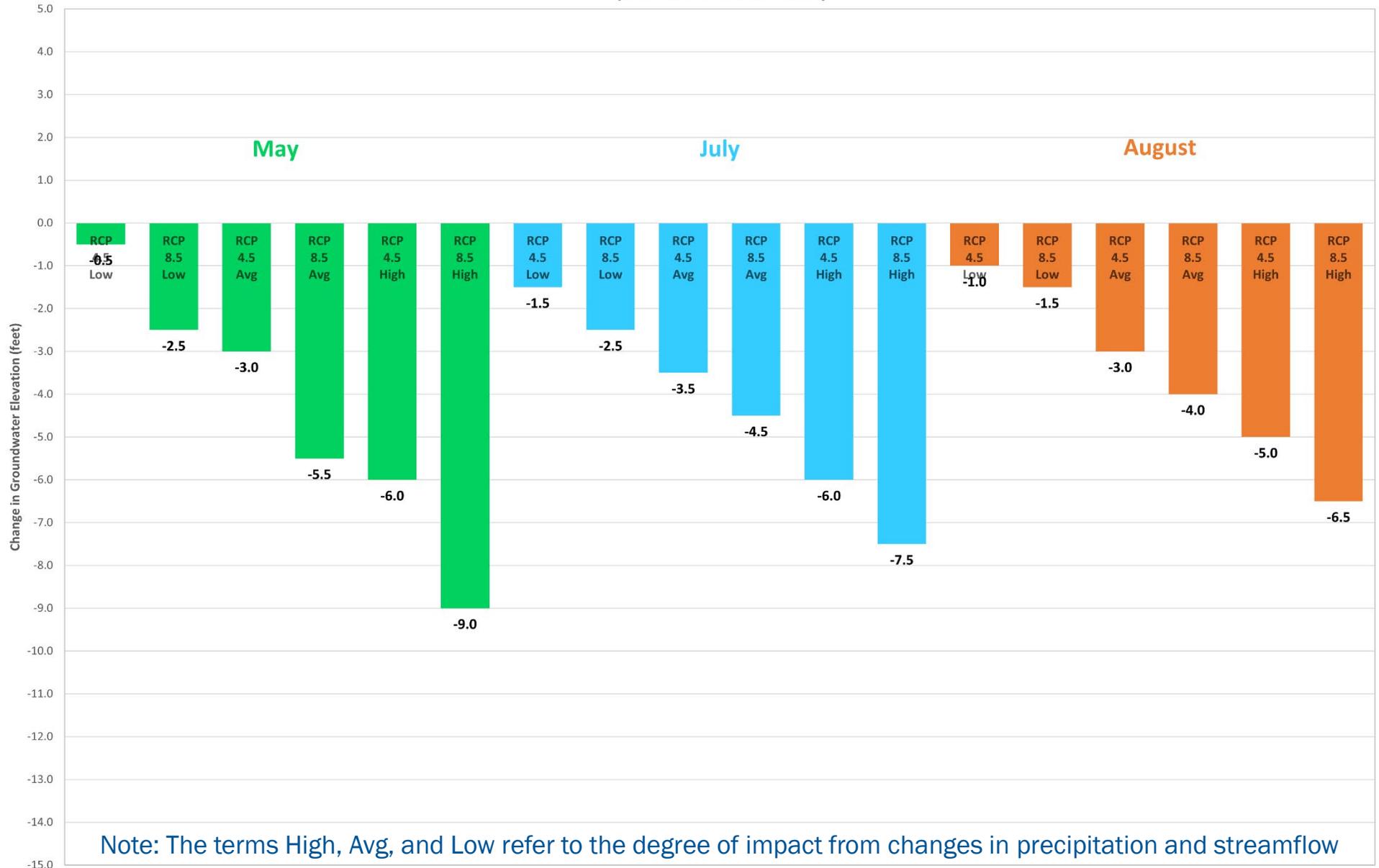
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Irvin Water District No. 6

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Irvin Water District No. 6)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

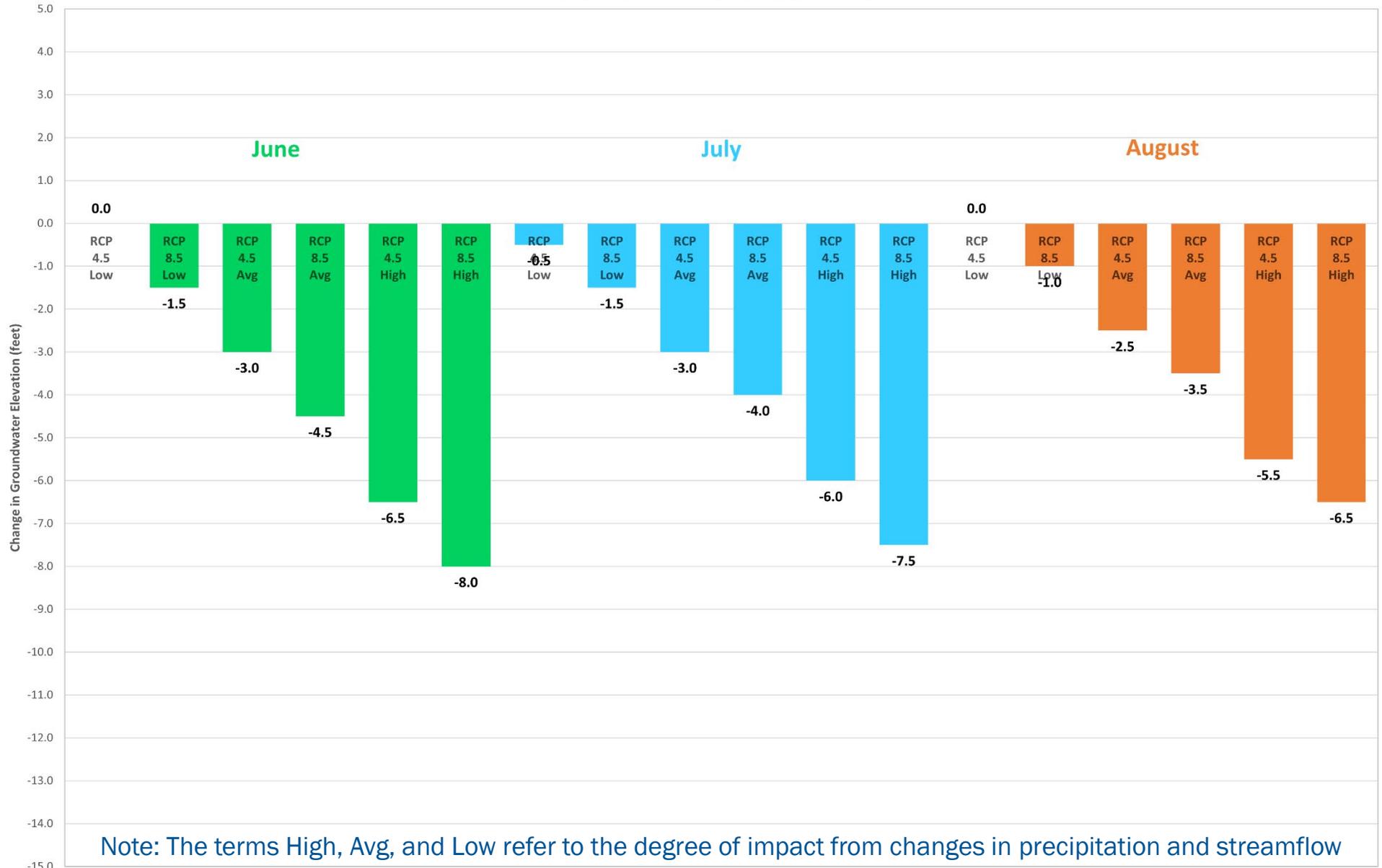
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

**Kaiser Aluminum Trentwood Works**

Largest Modeled Changes in Groundwater Levels  
(Kaiser Trentwood North Production Well)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Liberty Lake Sewer & Water District No. 1

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Liberty Lake Sewer and Water District)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

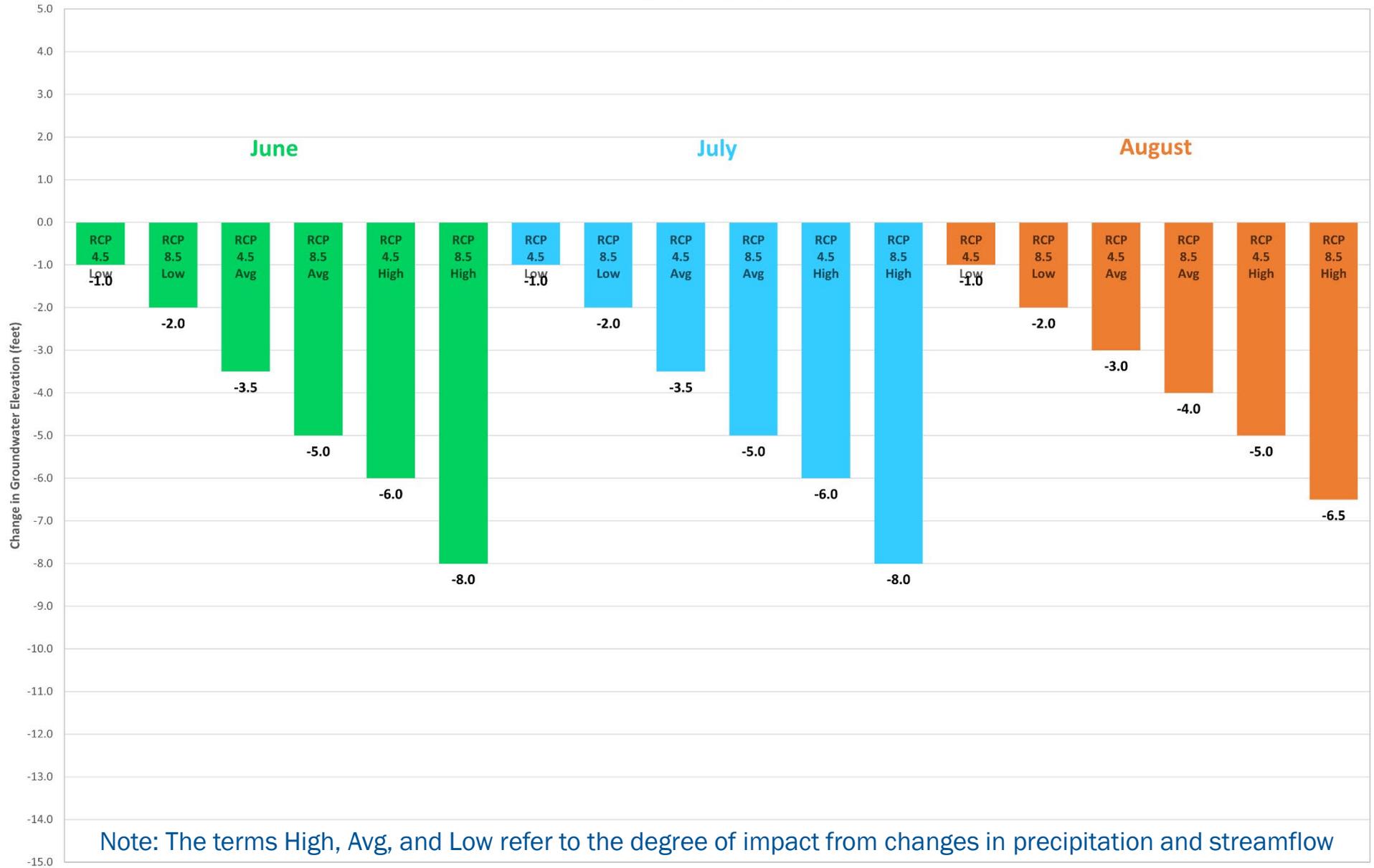
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

City of Millwood

Largest Modeled Changes in Groundwater Levels Amongst All Wells (City of Millwood)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Moab Irrigation District No. 20

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Moab Irrigation District No. 20)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

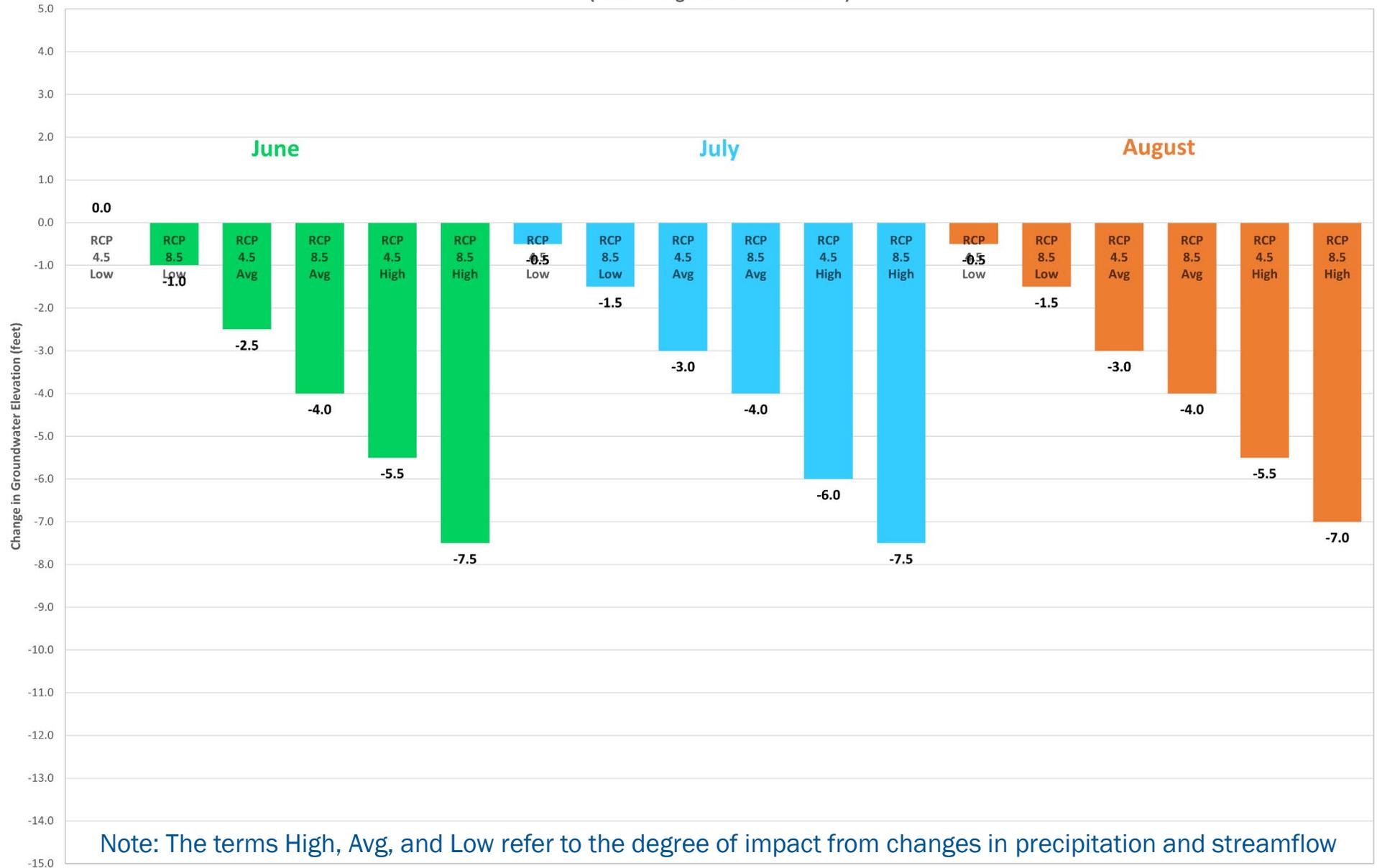
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Model Irrigation District No. 18

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Model Irrigation District No. 18)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

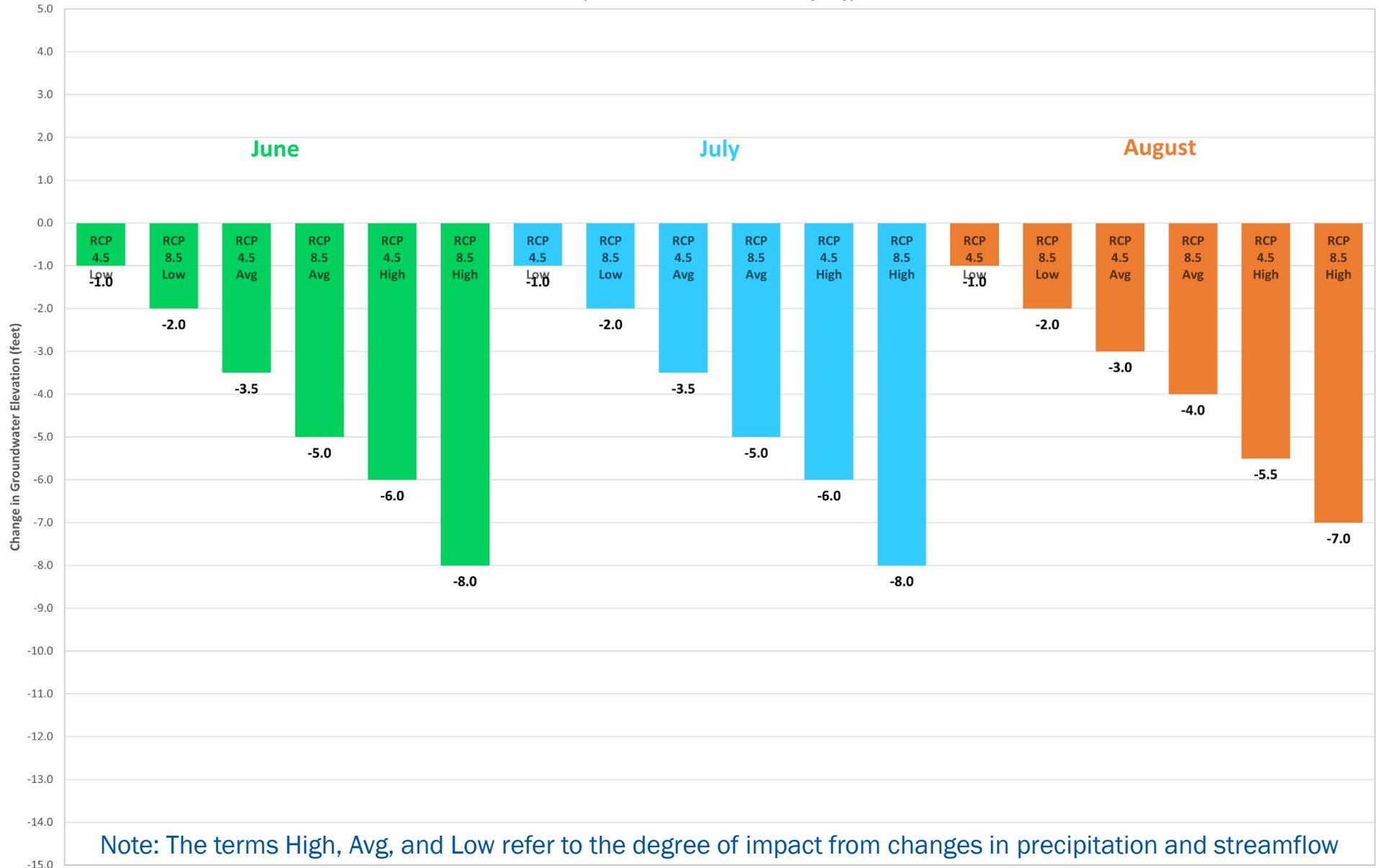
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

**Modern Electric Water Company**

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Modern Electric Water Company)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

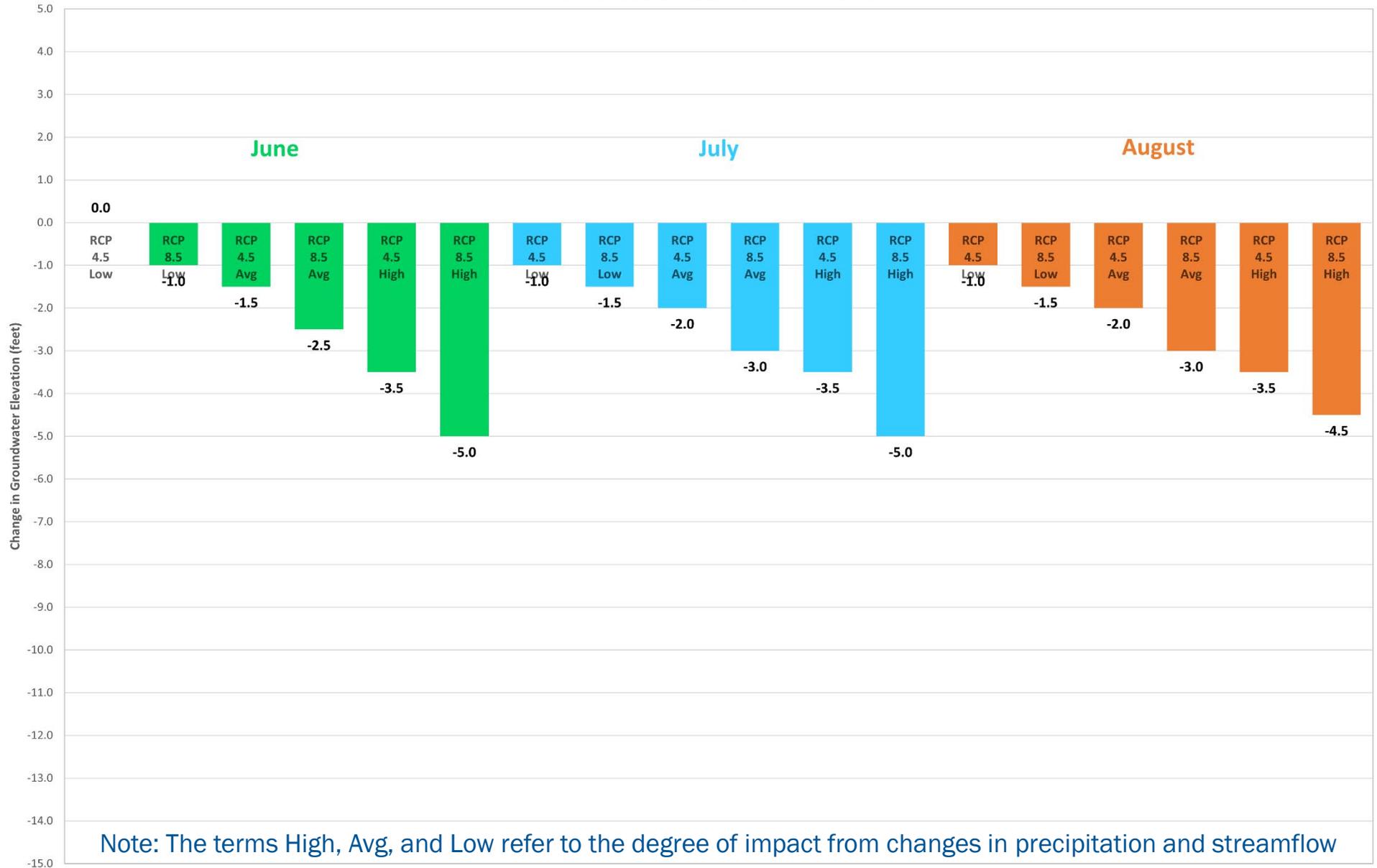
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## North Spokane Irrigation District No. 8

Largest Modeled Changes in Groundwater Levels Amongst All Wells (North Spokane Irrigation District No. 8)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

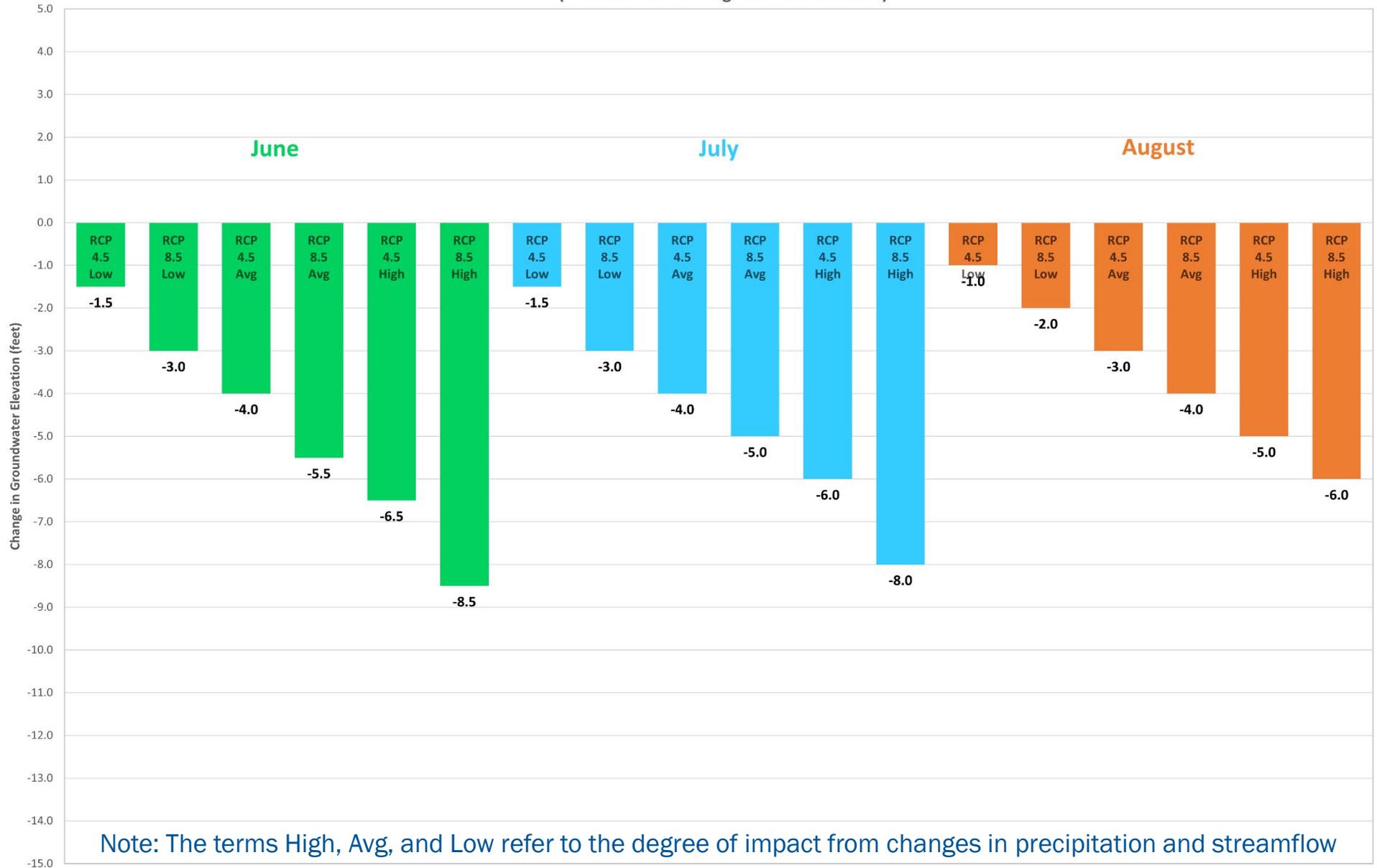
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Orchard Irrigation District No. 6

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Orchard Avenue Irrigation District No. 6)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

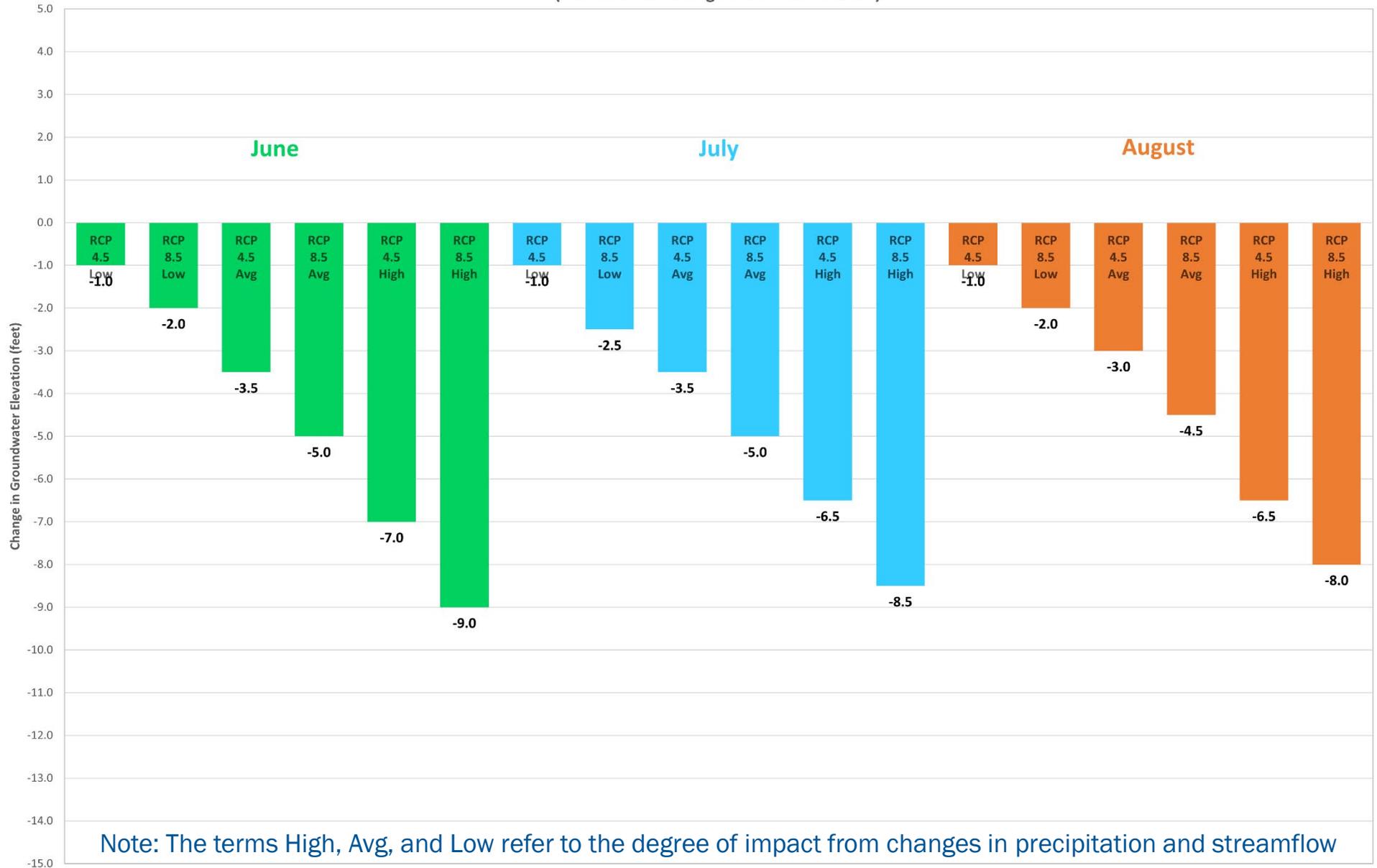
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Pasadena Park Irrigation District No. 17

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Pasadena Park Irrigation District No. 17)



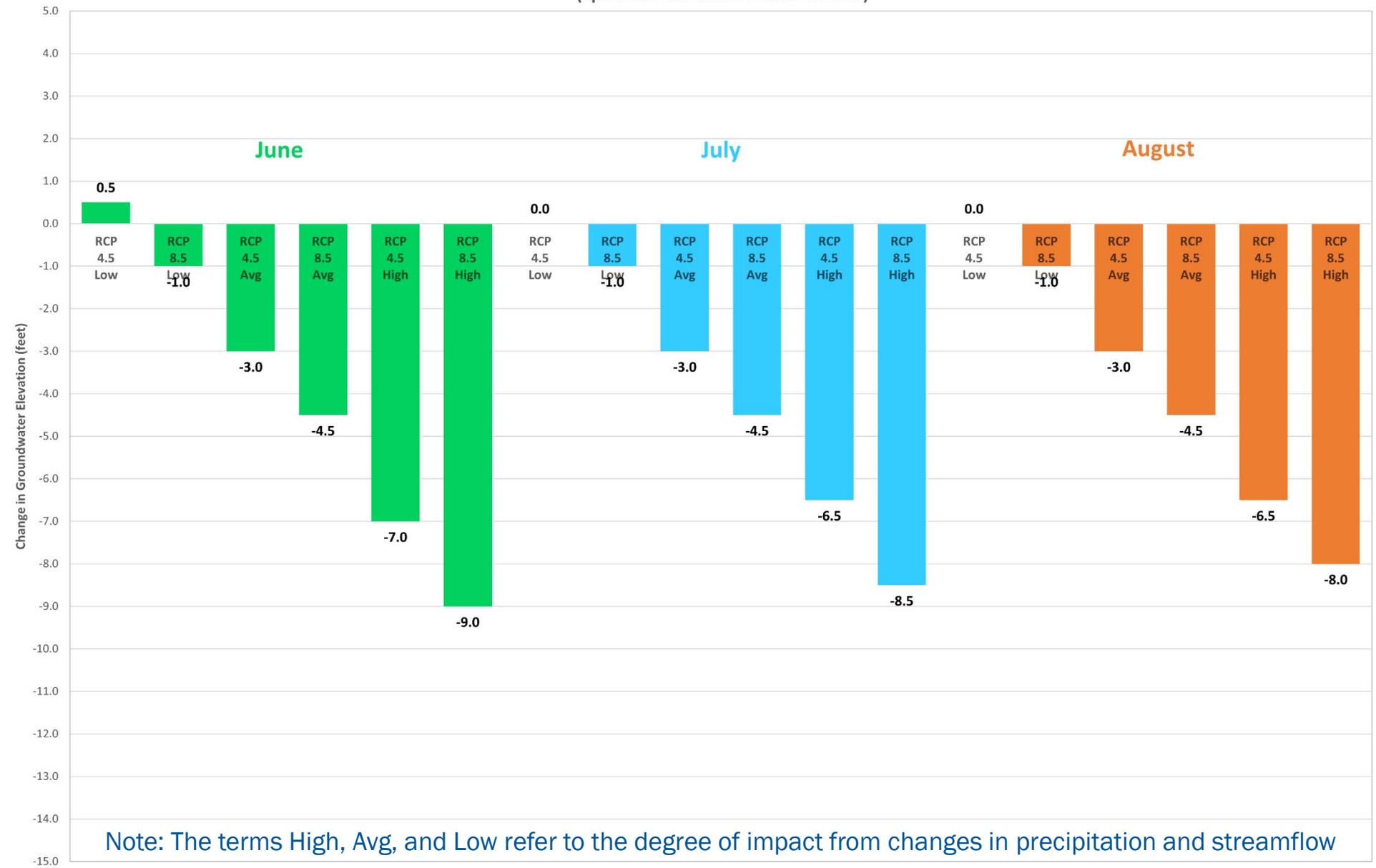
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Spokane Business & Industrial Park

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Spokane Business & Industrial Park)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

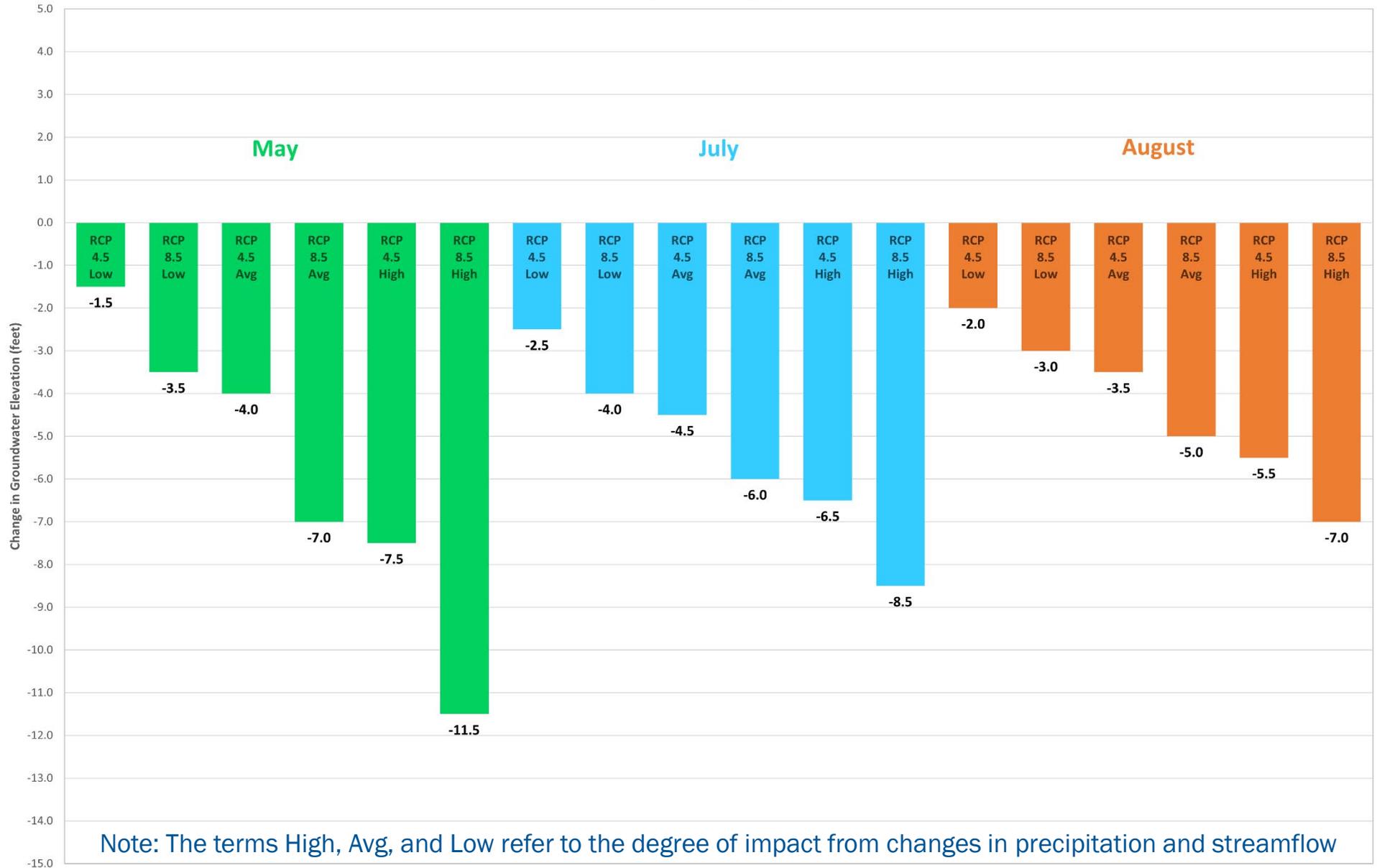
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

City of Spokane

Largest Modeled Changes in Groundwater Levels Amongst All Wells (City of Spokane)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

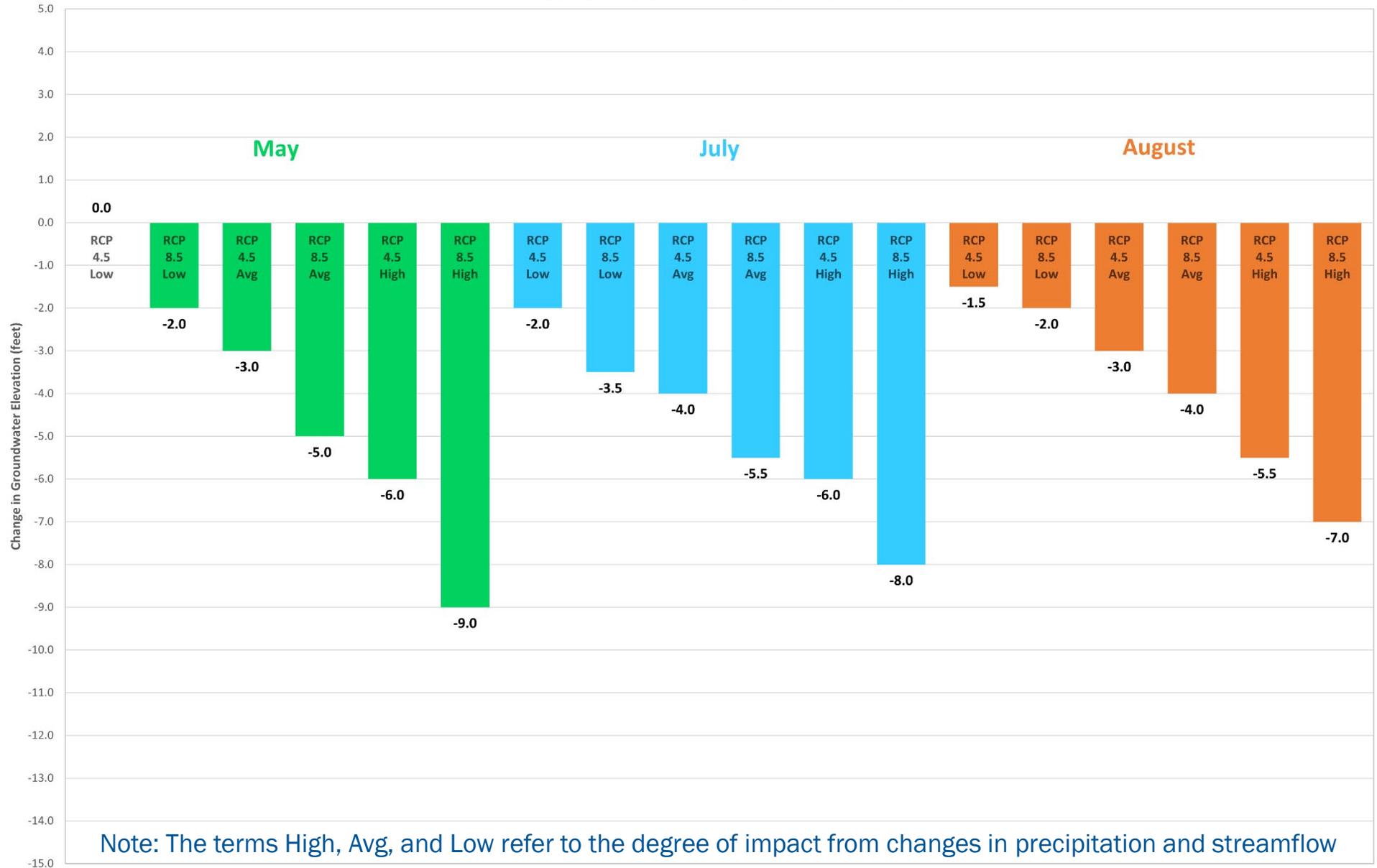
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Spokane County Water District 3 (East Wellfield)

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Spokane County Water District 3 - System 1)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Spokane County Water District 3 (North Wellfield)

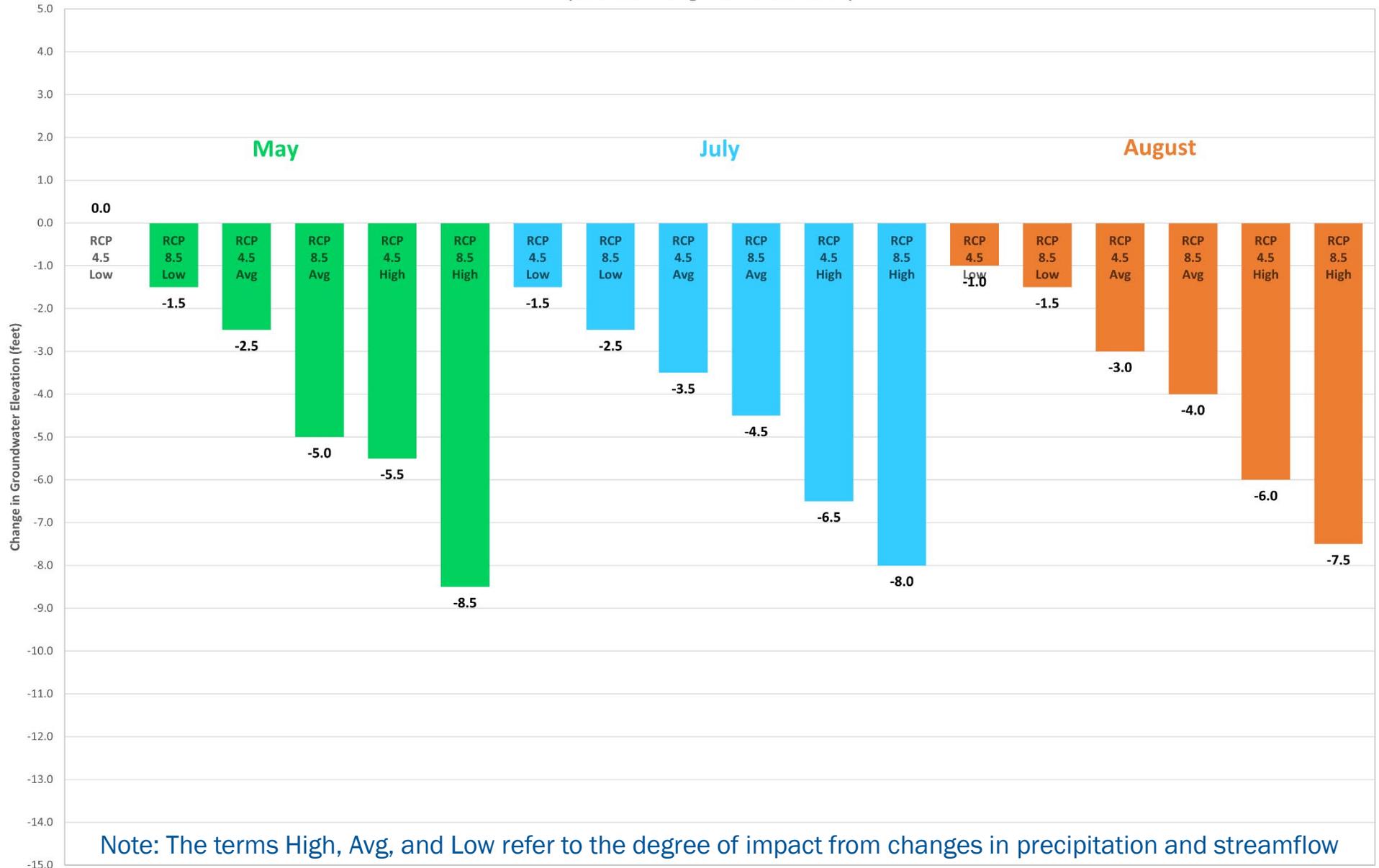
Largest Modeled Changes in Groundwater Levels Amongst All Wells (Spokane County Water District 3 - Systems 3&4)



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Trentwood Irrigation District No. 3

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Trentwood Irrigation District No. 3)



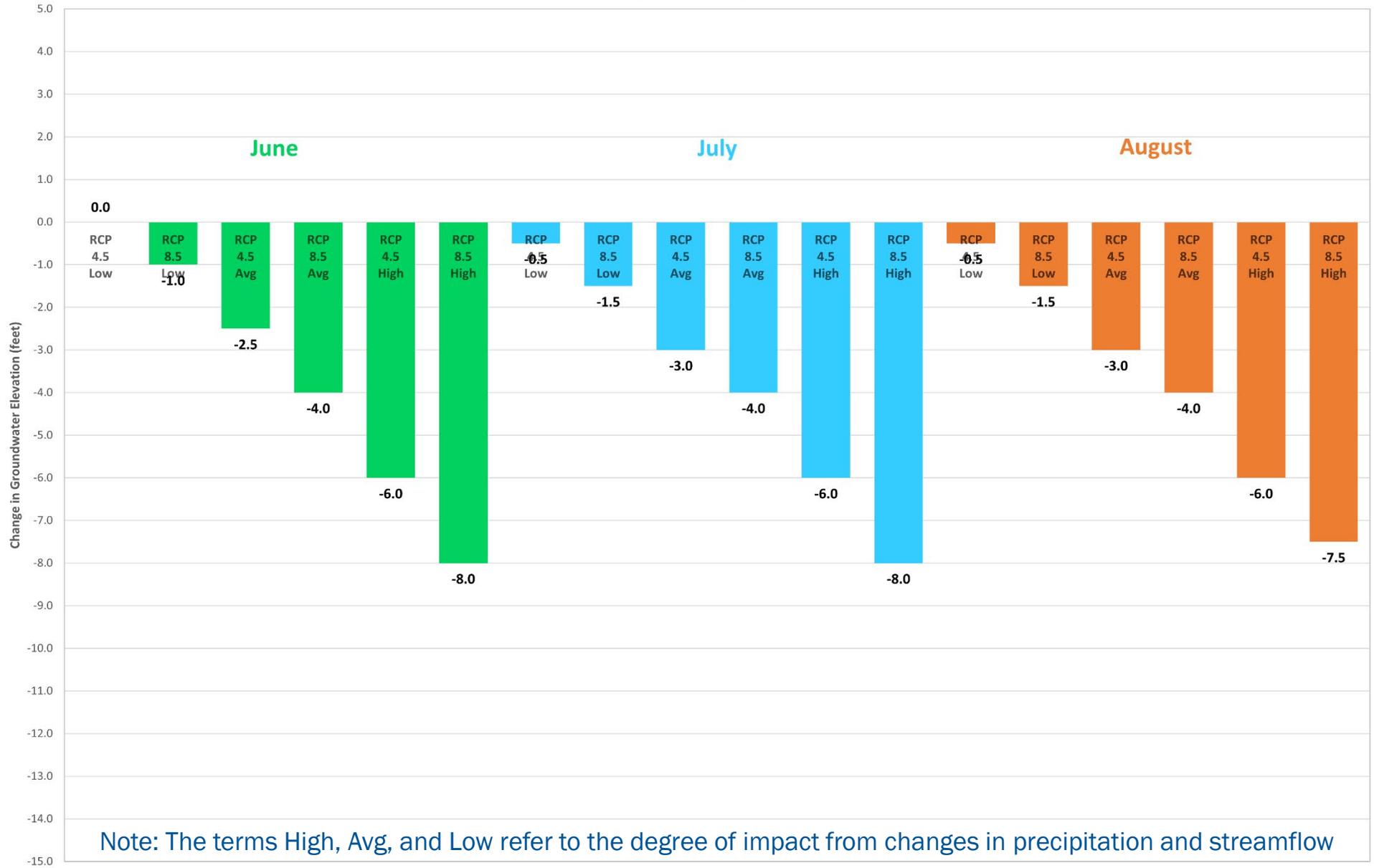
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

Vera Water & Power

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Vera Water & Power)



Note: The terms High, Avg, and Low refer to the degree of impact from changes in precipitation and streamflow

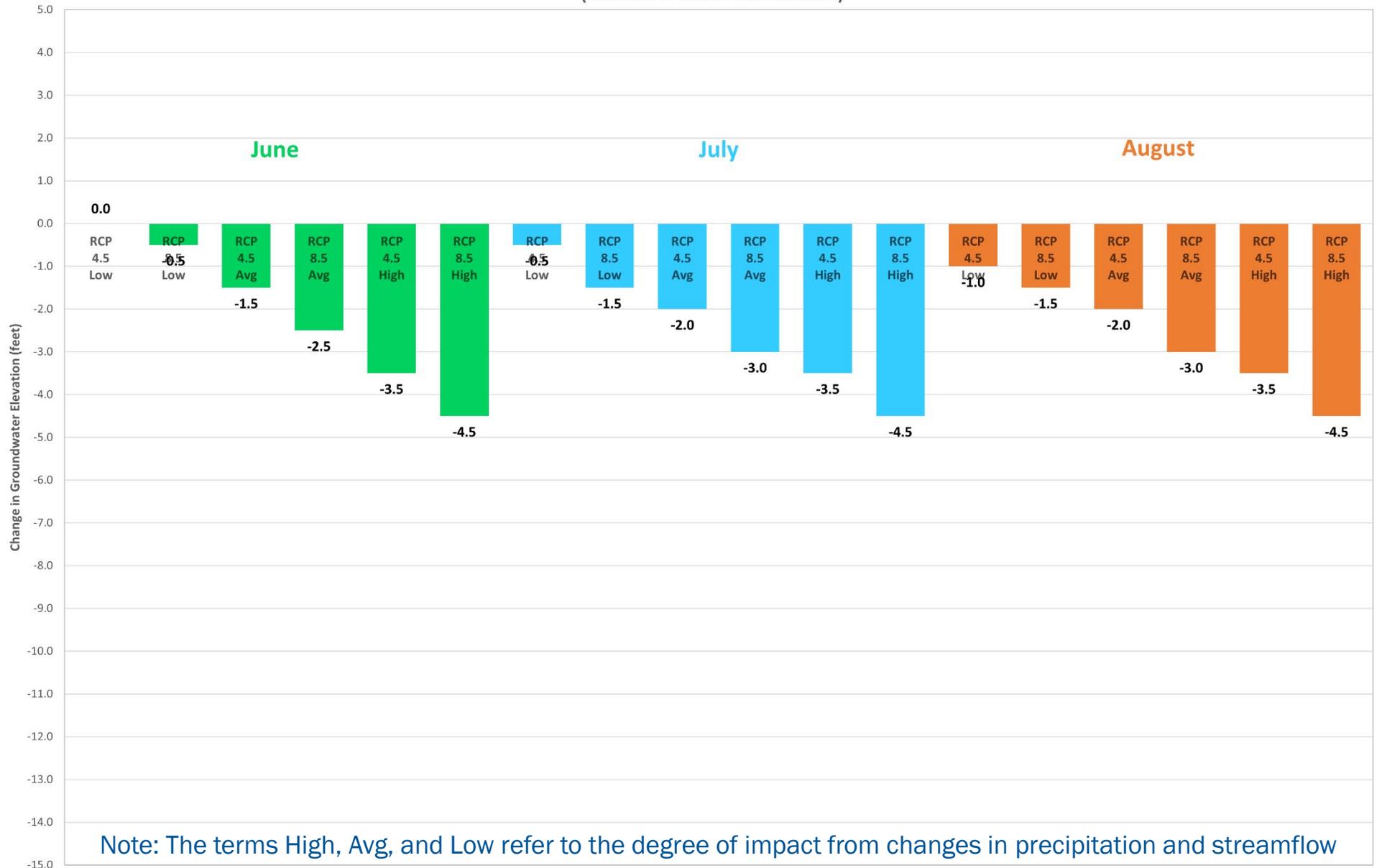
Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



# Range of Potential Climate Influences on Spring and Summer Groundwater Levels

## Whitworth Water District No. 2

Largest Modeled Changes in Groundwater Levels Amongst All Wells (Whitworth Water District No. 2)



Note: RCP = Representative Concentration Pathway for future greenhouse gas emissions



## **Attachment D**

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# **Maps Showing the Spatial Distribution of the Largest Changes in Groundwater Levels During May During the Latter Part of the 21<sup>st</sup> Century**

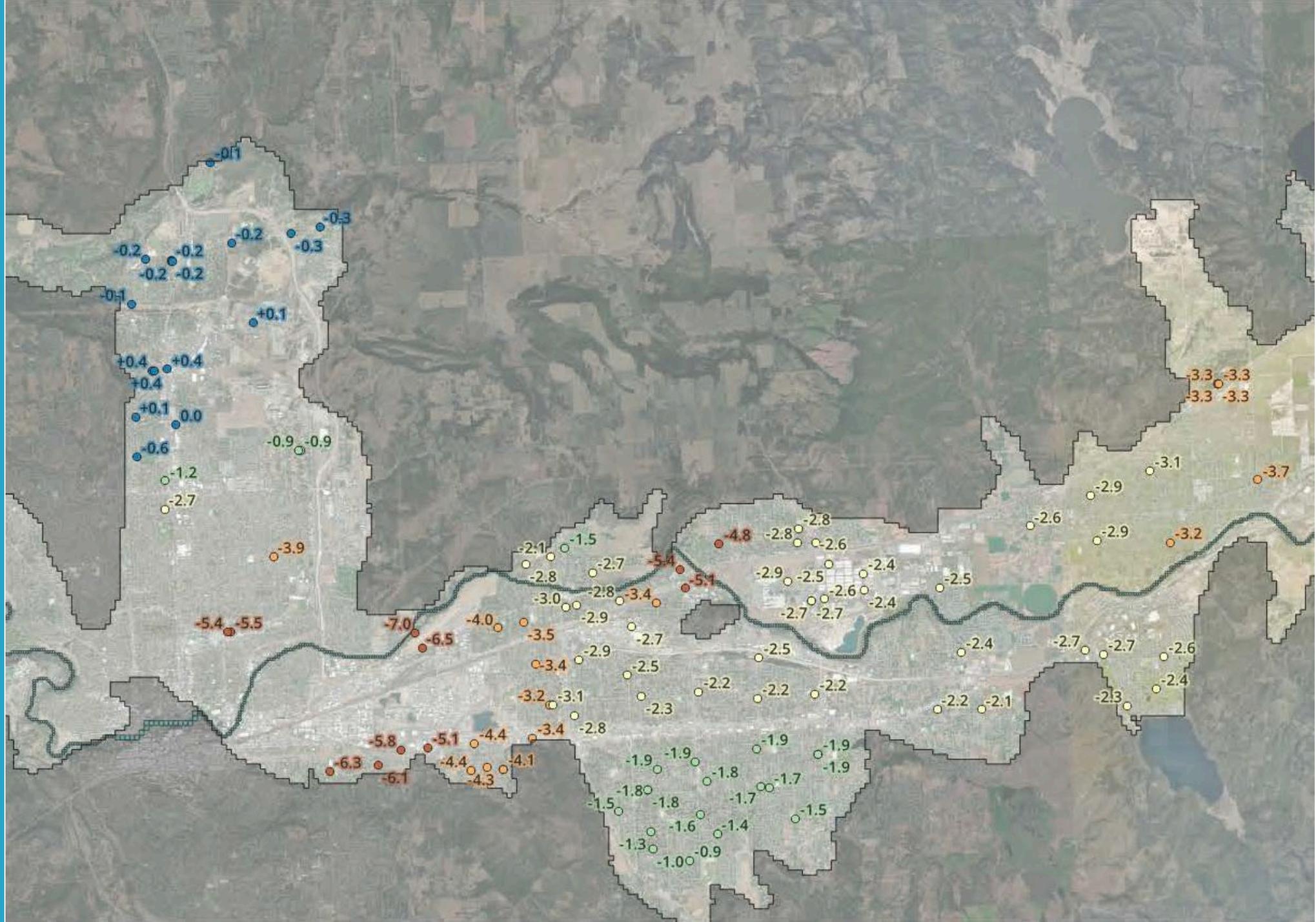
# Largest Change in Groundwater Levels in May (2070-2099)

RCP 8.5 Low  
(Low Degree of  
Climate Change)



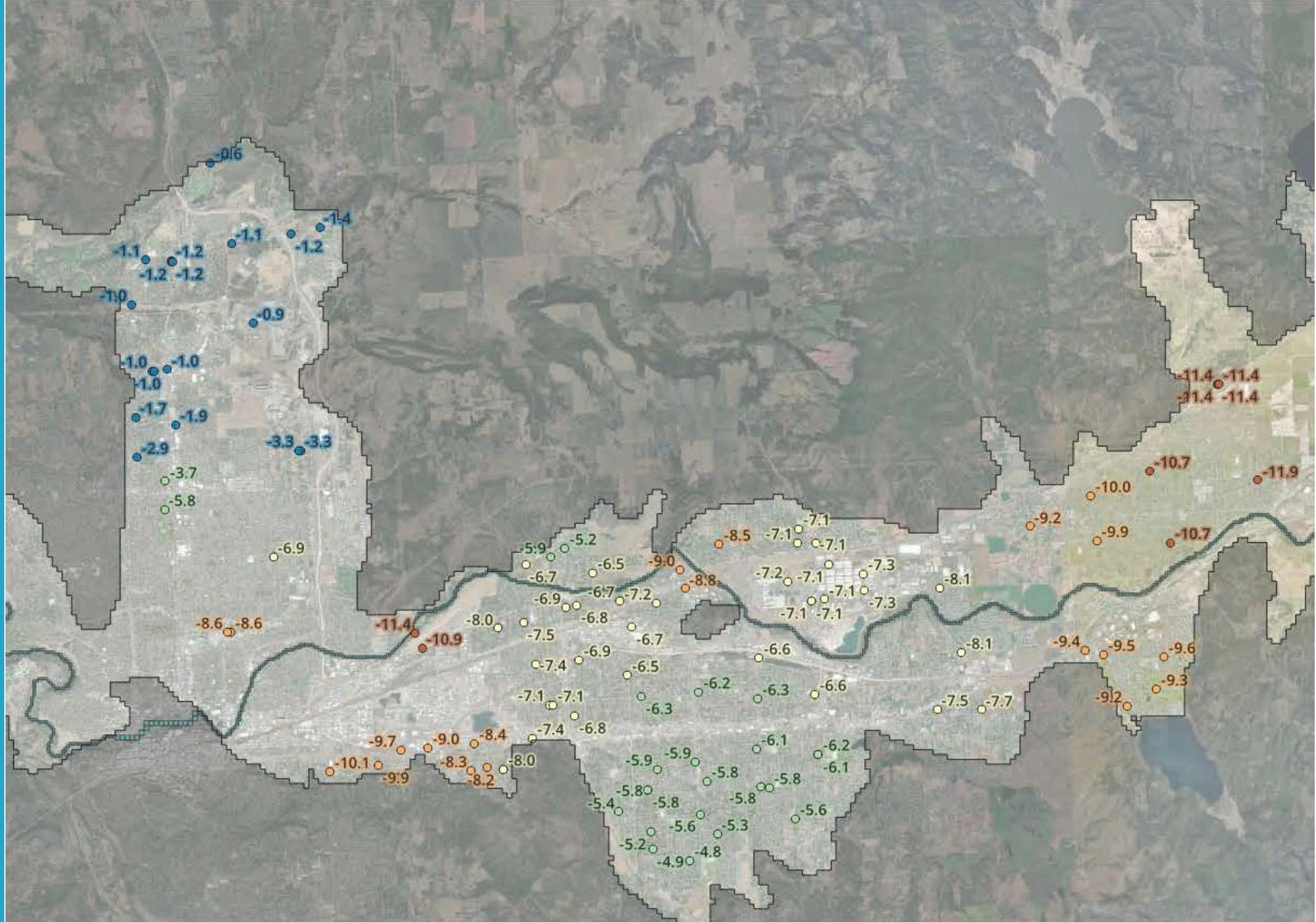
# Largest Change in Groundwater Levels in May (2070-2099)

RCP 8.5 Avg.  
(Average Degree of  
Climate Change)



# Largest Change in Groundwater Levels in May (2070-2099)

RCP 8.5 High  
(High Degree of  
Climate Change)



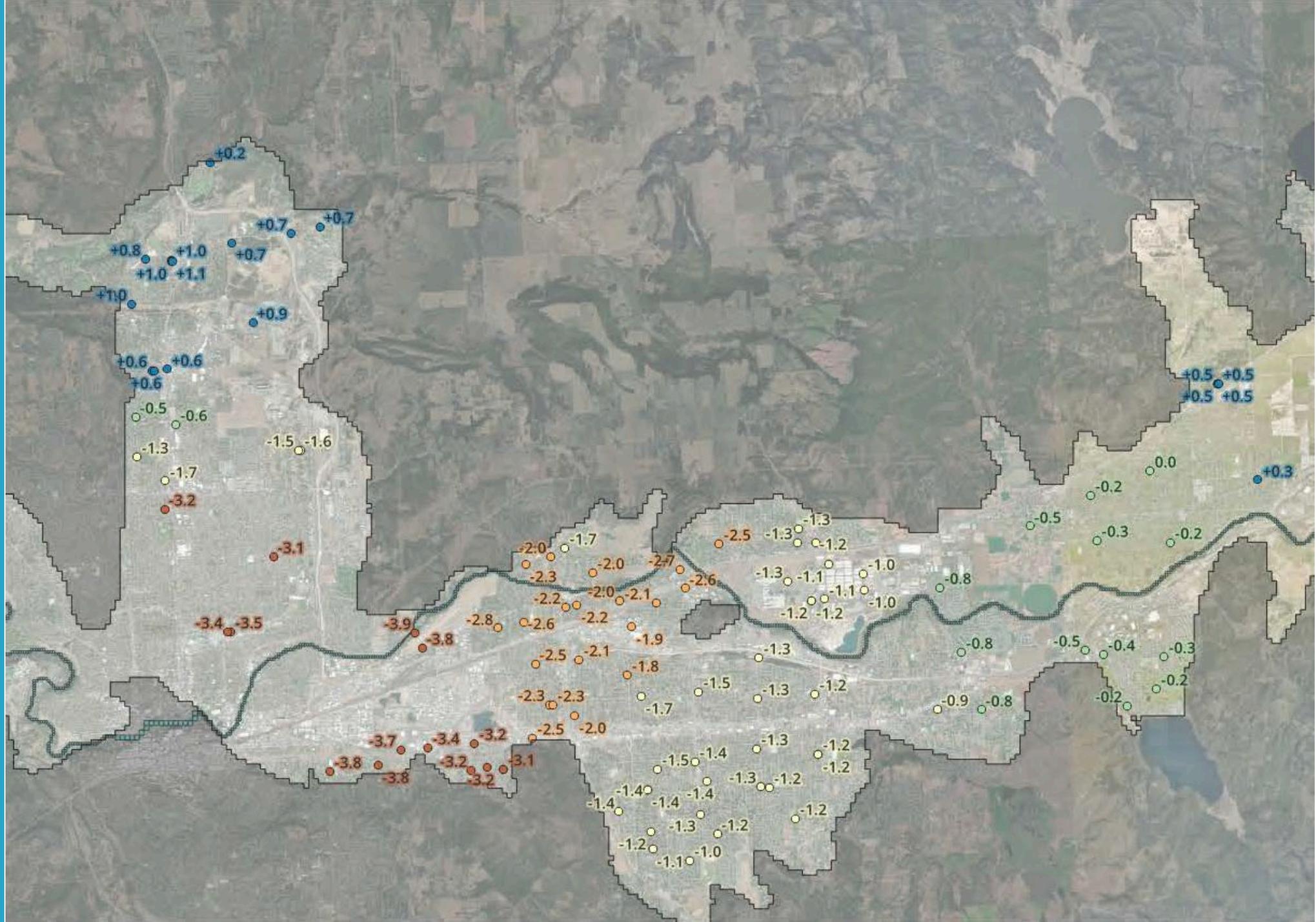
## **Attachment E**

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**Maps Showing the Spatial Distribution of the Largest  
Changes in Groundwater Levels During July During the  
Latter Part of the 21<sup>st</sup> Century**

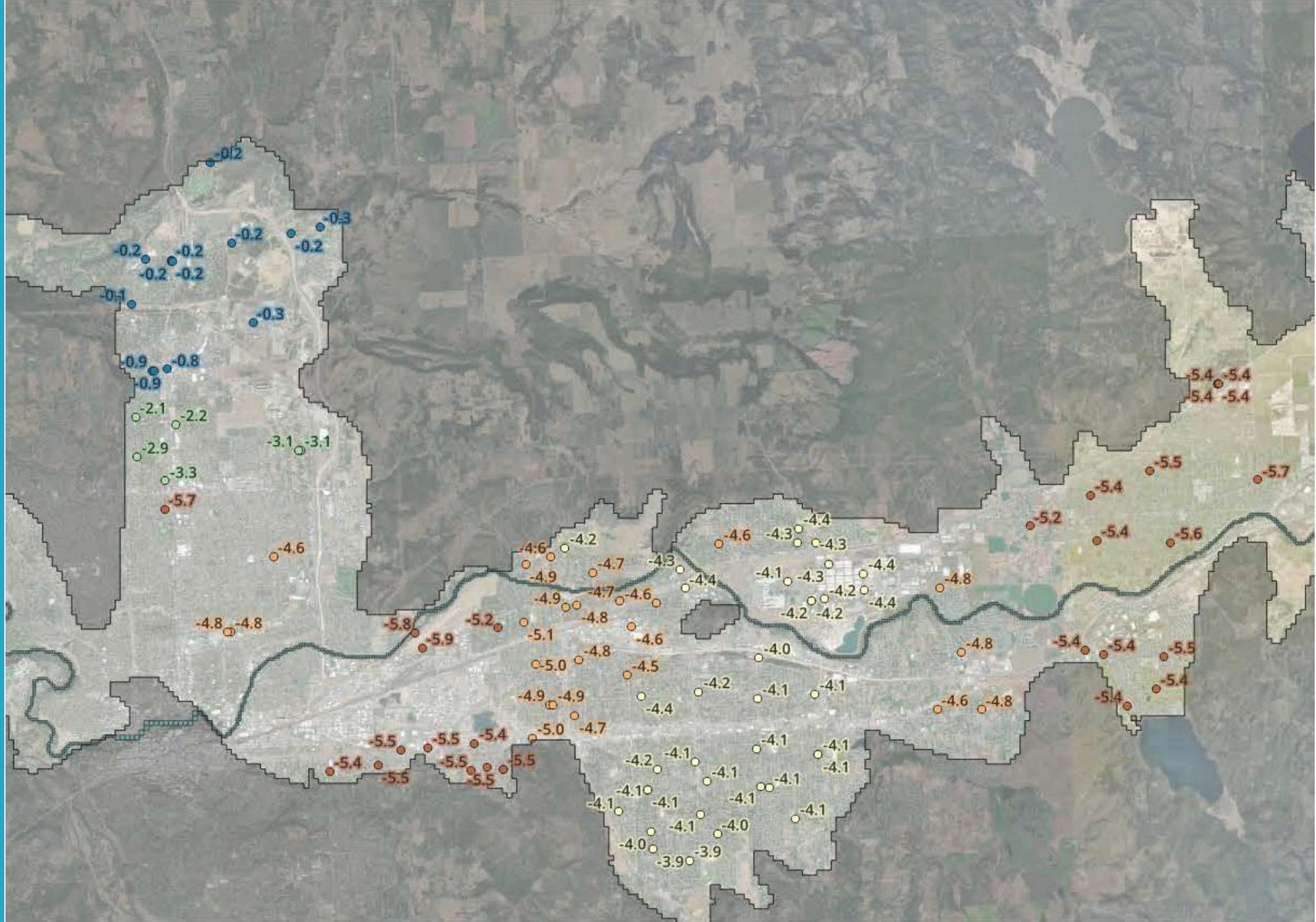
# Largest Monthly Change in Groundwater Levels in July (2070-2099)

RCP 8.5 Low  
(Low Degree of Climate Change)



# Largest Monthly Change in Groundwater Levels in July (2070-2099)

RCP 8.5 Avg.  
(Average Degree of Climate Change)





## **Attachment F**

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**Maps Showing the Spatial Distribution of the Largest Changes in Groundwater Levels During August During the Latter Part of the 21<sup>st</sup> Century**





