Oregon
Tina Kotek, Governor

Water Resources Department
725 Summer St NE, Suite A
Salem, OR 97301
(503) 986-0900
Fax (503) 986-0904
www.Oregon.gov/OWRD

Summary of Model Results Presented at RAC 11

I. Background

As part of the Harney Basin Groundwater Study, USGS and Department staff collaborated on the development of a numerical groundwater flow model which was published in early 2024. The Department is using the HBGM to simulate outcomes of different groundwater management proposals to inform the rulemaking process.

Over the last several Rules Advisory Committee (RAC) meetings, the Department has been working with the Division 512 RAC to develop different management scenarios to be simulated using the HBGM. A management scenario uses the HBGM to evaluate changes in groundwater use to simulate changes to groundwater levels, groundwater storage, natural discharge, dry wells, and other factors. The key inputs defined in a management scenario include:

1. **Where:** The scenario must define a management area or areas where changes in pumping can be applied.
2. **How much:** The scenario must specify the volume of groundwater pumpage allowed in each management area. Pumpage can be expressed in terms of an absolute value or as a percentage reduction from the model's baseline 2018 pumpage value.
3. **When:** The scenario must specify a timeline for implementing changes in pumpage including a start date and a phase-in period for reductions if desired.

The Department has participated in a robust public engagement process facilitated by Oregon Consensus in the form of discussion groups. Discussion groups are open to all members of the public and provide the opportunity for all participants to share their thoughts and local knowledge related to the rulemaking process. Input from the discussion groups related to management scenarios was brought to the October RAC meeting and was used to inform the three management scenarios proposed by the RAC. The Department has also proposed and received input from the RAC on two additional management scenarios for a total of five proposed management scenarios.

II. Discussion

The Department has run the HBGM for each management scenario defined by the department and the RAC. The scenarios were designed so that together they provide insight into the effects of each input (where, how much, when) on the Harney Basin's groundwater system. Table 1: Management scenarios as defined by OWRD and the RACTable 1 below provides basic details about the intent of the scenario and compares the inputs for each scenario. Further details for the three model inputs are discussed after Table 1.

Table 1: Management scenarios as defined by OWRD and the RAC

<table>
<tr><th>Scenario</th><th>A. Targeted reductions immediately using 15 subareas</th><th>B. Balanced reductions phased in over 30 years</th><th>C. Balanced reductions, minimize impacts to ecosystem and exempt uses phased in over 30 years</th><th>D. Balanced reductions, recover supply for ecosystem and exempt uses</th><th>E. Reduce basin to 1990 pumpage</th></tr>
<tr><td>Where – Management Areas</td><td>15 subareas; See Figure 1</td><td colspan="3">6 subareas; See Figure 2</td><td>One area; See Figure 3</td></tr>
<tr><td>How Much - Volume of pumping reductions</td><td>Pumpage reductions for 6 subareas; 9 subareas continue 2018 estimated pumpage
See Figure 4</td><td>Pumpage reductions focused in 3 subareas
See Figure 4</td><td>Pumpage reductions spread across all but 1 subarea
See Figure 4</td><td>Pumpage reductions spread across all but 1 subarea
See Figure 4</td><td>Reduce pumpage to 1990 estimated pumpage
See Figure 4</td></tr>
<tr><td>When - Start time and intervals of reduction</td><td>2030 start; no phasing</td><td colspan="2">2030 start; phased reductions over a 30-year period</td><td colspan="2">2030 start; no phasing</td></tr>
<tr><td>Proposed by</td><td>OWRD</td><td colspan="3">RAC with input from discussion groups</td><td>OWRD</td></tr>
</table>

<u>Where:</u>
Scenario A implements a targeted approach to reductions by breaking the proposed critical groundwater area into 15 subareas with reductions implemented in only 6 of the subareas. Figure 1 is a map depicting the 15 subareas used in Scenario A.

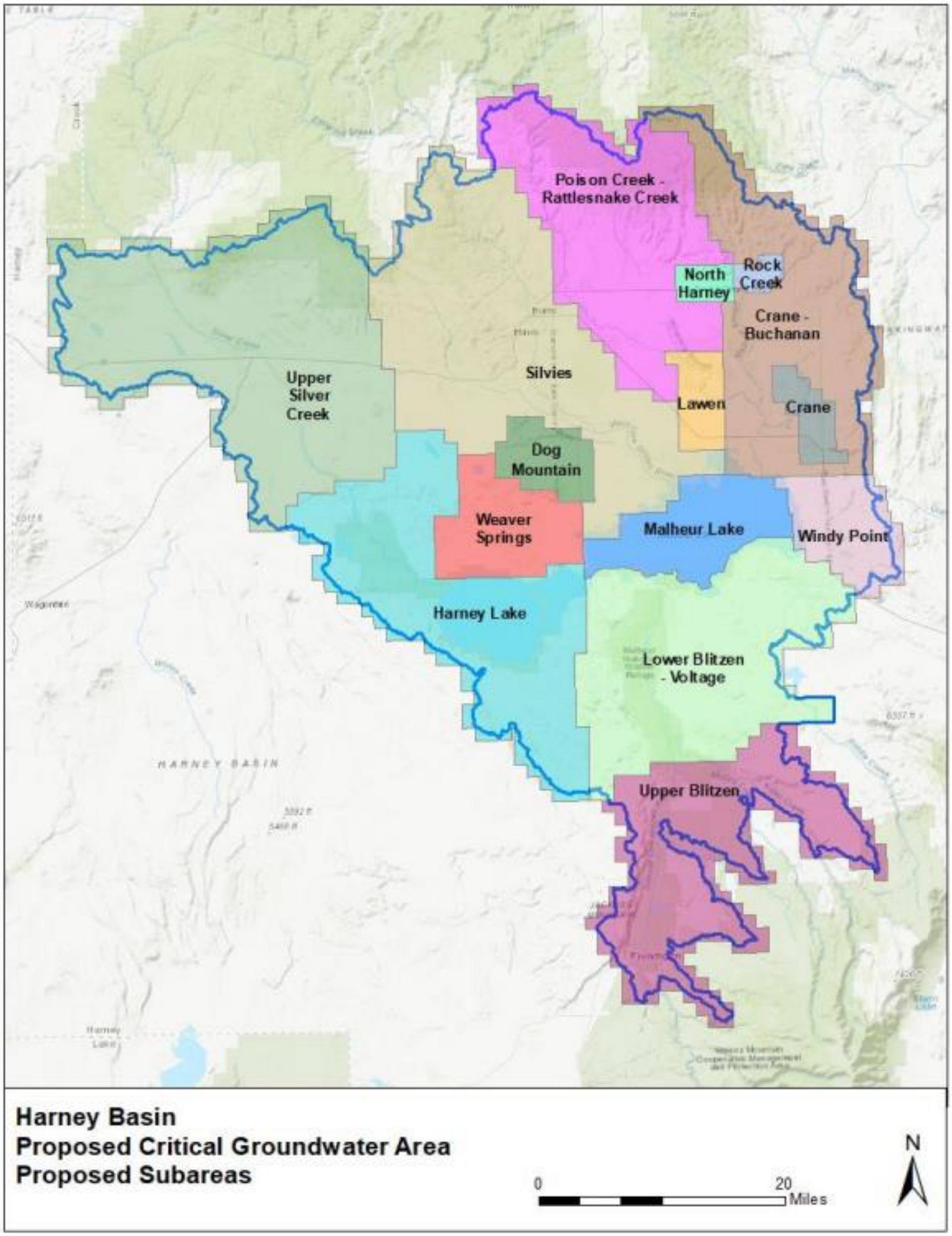


Figure 1: Map of 15 proposed subareas (Boschmann, 2024).

Scenarios B, C, and D split the proposed critical groundwater area into 6 subareas and implement different amounts of reductions across each subarea. Figure 2 is a map depicting the 6 subareas used in these three scenarios.

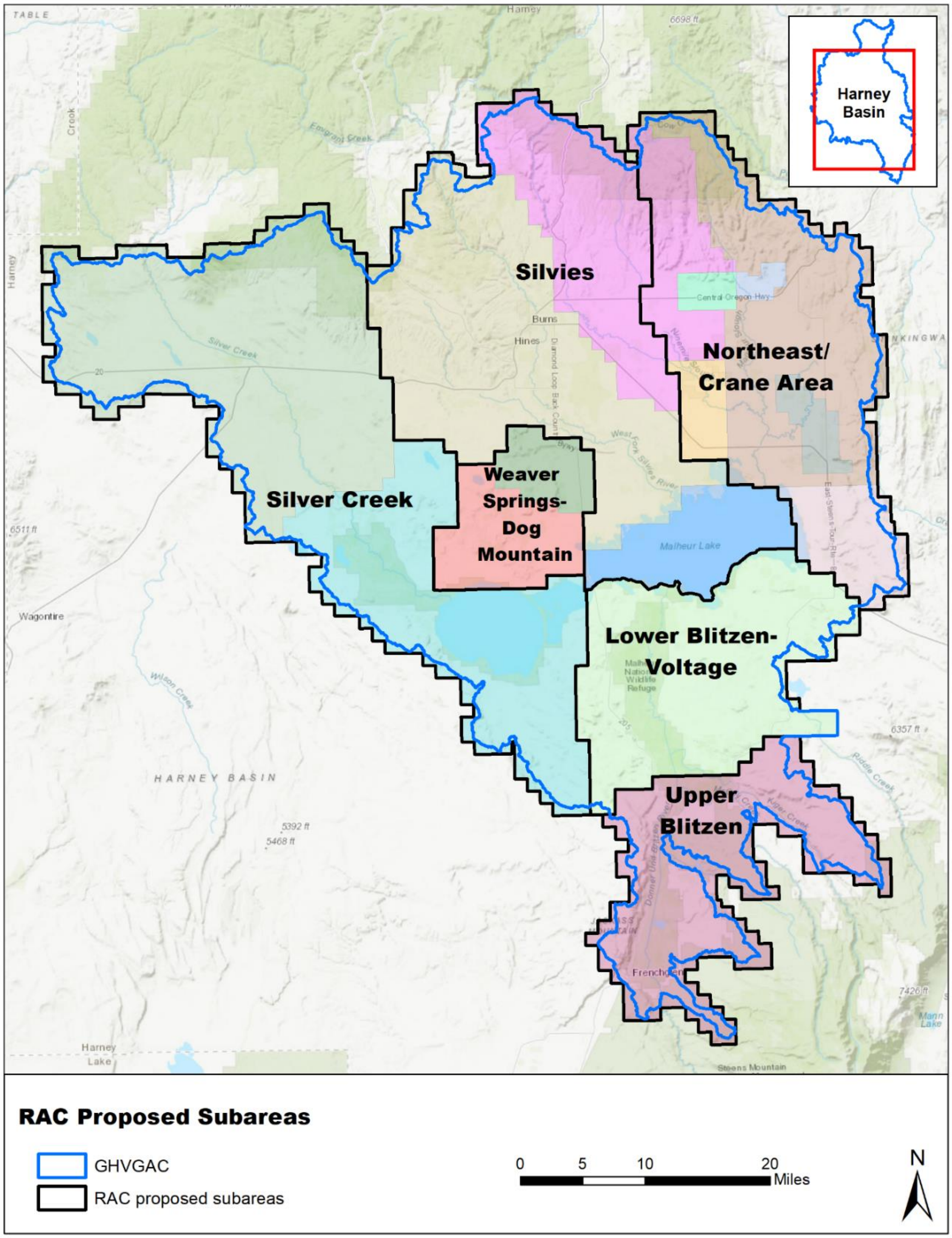


Figure 2: Scenarios B, C, and D subareas (bold black lines) overlain on OWRD 15 subareas. From Boschmann draft memo, 10/4/2024.

Scenario E establishes a single boundary for the proposed critical groundwater area and applies reductions broadly across the entire area. Figure 3 depicts the single proposed critical groundwater area used in scenario E.

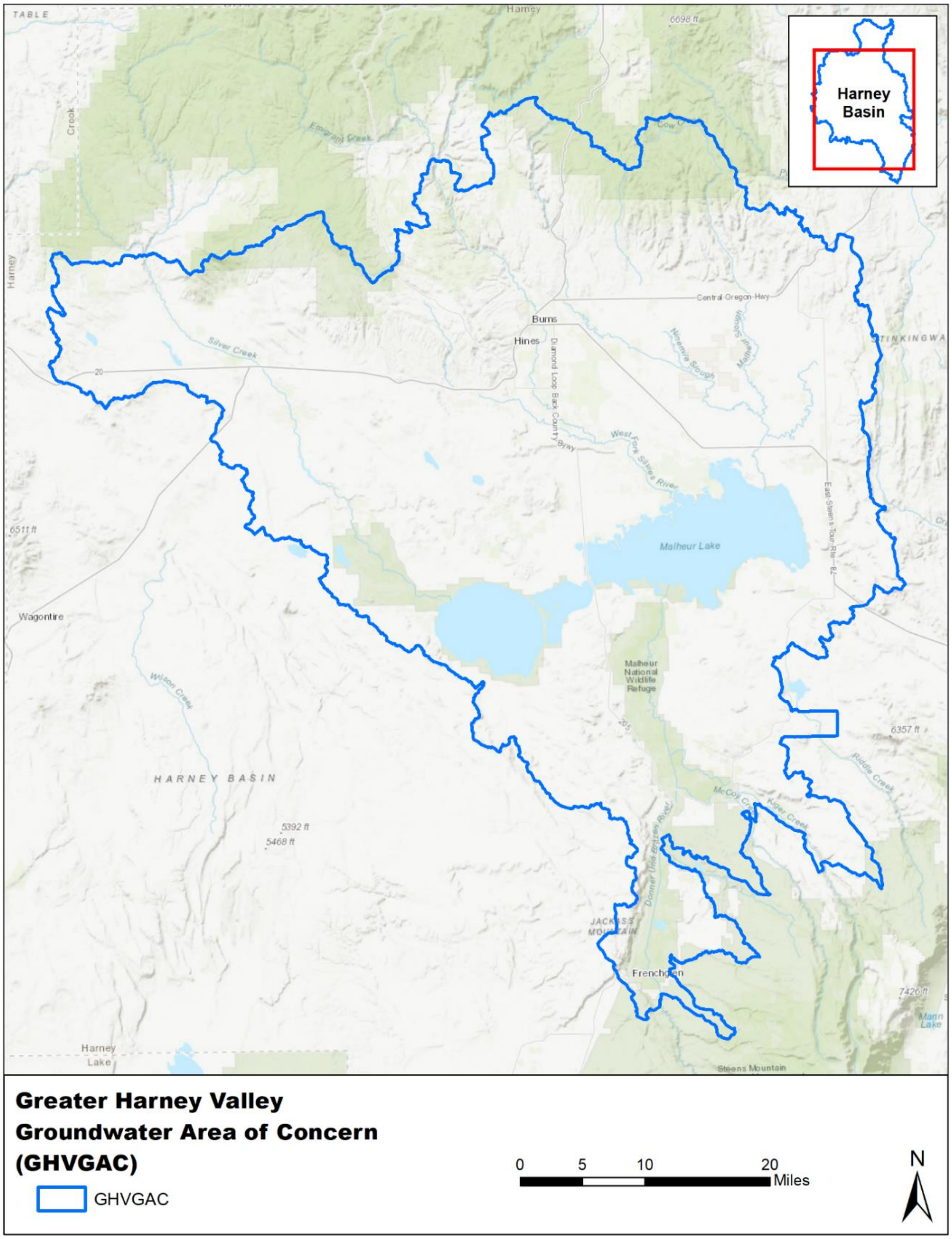


Figure 3: Greater Harney Valley Groundwater Area of Concern (Boschmann, 2024).

<u>How Much:</u>

For ease of comparison, each scenario begins reductions in 2030 and uses 2018 modeled pumpage as a baseline for reductions. Figure 4 shows a time series comparison of each scenario's pumpage input and percentage reduction from the 2018 pumpage baseline. Varying quantities of total reduction are implemented, with scenario A implementing the least amount of total pumpage reduction and scenario E implementing the most.

In each scenario, each subarea's modeled pumpage was allocated to water rights in order of increasing priority date. Pumpage allocated to each water right was limited to the estimated 2018 use published in OWRD Open-File Report 2023-01. For water rights with multiple modeled wells, additional pumpage was distributed equally among those wells. However, pumpage in any well was not allowed to exceed its 2018 modeled pumpage, and excess pumpage allocated to a right was distributed among other wells on that right up to their 2018 modeled pumpage.

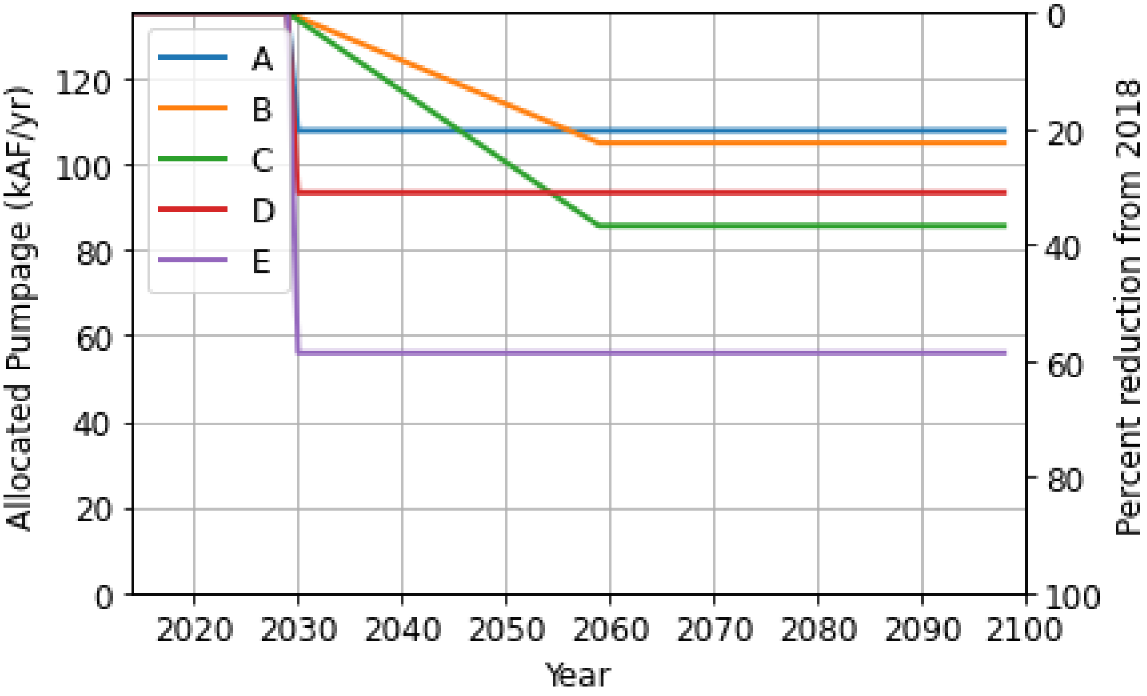


Figure 4: Time series comparison of pumpage input values for each of the 5 management scenarios over the modeled period.

<u>When:</u>
Two different timelines for reduction are tested in the scenarios. The timeline for implementation of reductions can be seen in Figure 4 above. Scenario A, D, and E implement all reductions in year 2030. Scenarios B and C implement phased reductions implemented linearly over a 30-year period.

Measures of Success
The Department has discussed measures of success with the RAC and discussion groups during September and October. Evaluating the relative effectiveness of each scenario requires defining objectives measures of success with which to make comparisons between the modeled outcomes of each scenario. The primary measure of success discussed with the RAC is a condition in which groundwater levels in the basin are stabilized over a specified timeline (Target Water Level Trend of zero feet per year). Additional measures of success discussed with the RAC include minimizing the number of additional exempt-use wells that become dry and minimizing

additional impacts to natural groundwater discharge (springs; stream baseflow; groundwater dependent ecosystems).

Evaluating modeled outcomes for these measures of success requires specifying parameters and statistical thresholds which determine the range of conditions that can be considered successful outcomes. For example, the timeline over which modeled groundwater levels are to stabilize must be defined to evaluate the success of the scenario. Longer timelines result in greater secondary impacts such as dry wells and reductions in natural groundwater discharge, while shorter timelines reduce those impacts but may cause greater economic impact in the short term.

The groundwater level trends at individual wells will be variable across any subarea. Given this variability, and the likelihood that some individual wells may continue declining at low rates for relatively long periods of time, some statistical threshold must be defined to determine whether success is achieved within that subarea. Examples of statistical thresholds discussed with the RAC include using the median decline rate or the 90th percentile amongst wells within a subarea. Discussions have also included the possibility of an additional threshold limiting the maximum allowable rate of decline for any individual well. Using the median decline rate value for a subarea, which is the midpoint in the set of values (50th percentile), would mean that half of the wells in the subarea could still be declining under a condition considered successful. Using the 90th percentile threshold would mean that 10% of the wells in the subarea could still be declining under a condition considered successful. Each of these defined thresholds has implications for what can be considered successful groundwater conditions, and we continue to discuss the pros and cons of these decisions with the RAC.

Results

Model results provide outputs related to groundwater levels, natural discharge, and groundwater storage over the length of the simulation. These outputs can be presented in various ways with this report focusing on:

- Maps depicting future groundwater level rates of change
- Figures comparing groundwater level rates of change between scenarios
- Water budget figures depicting the change in groundwater storage and natural discharge over time

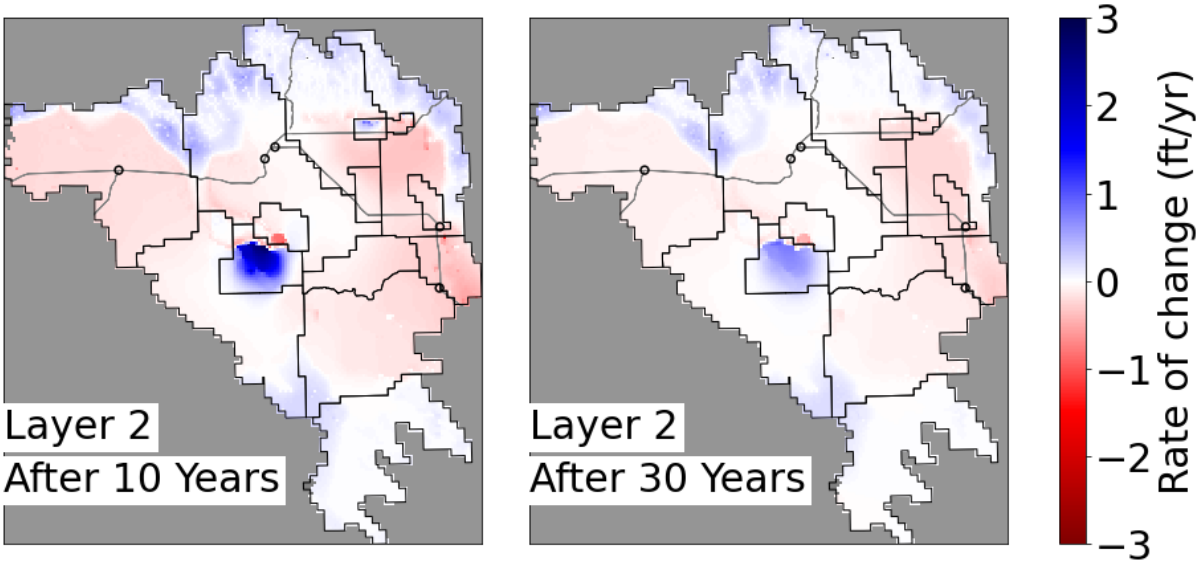
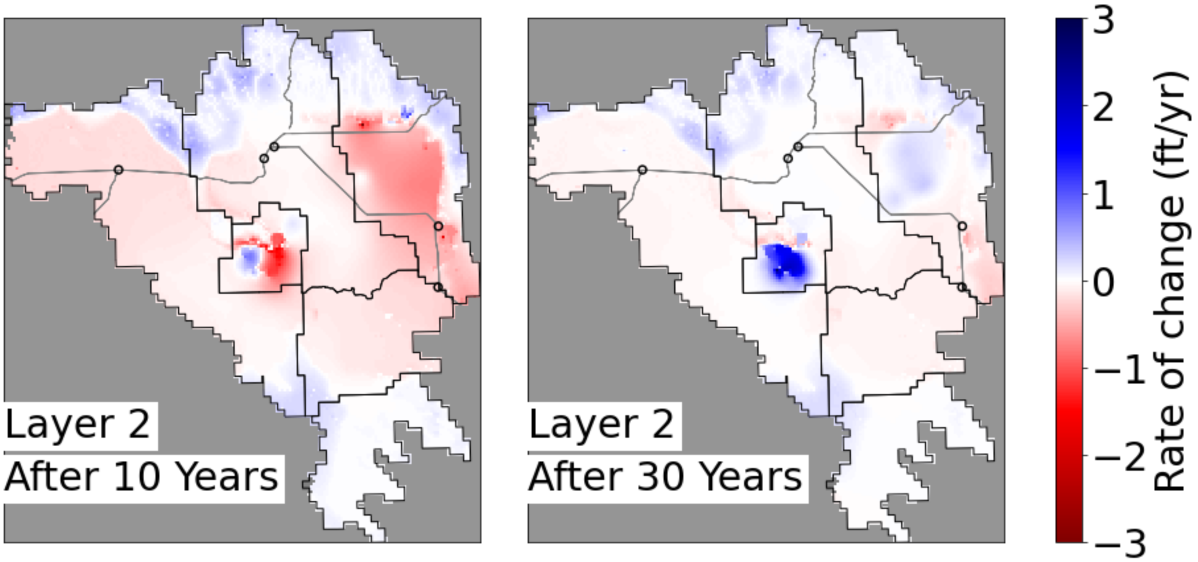
Groundwater level rates of change

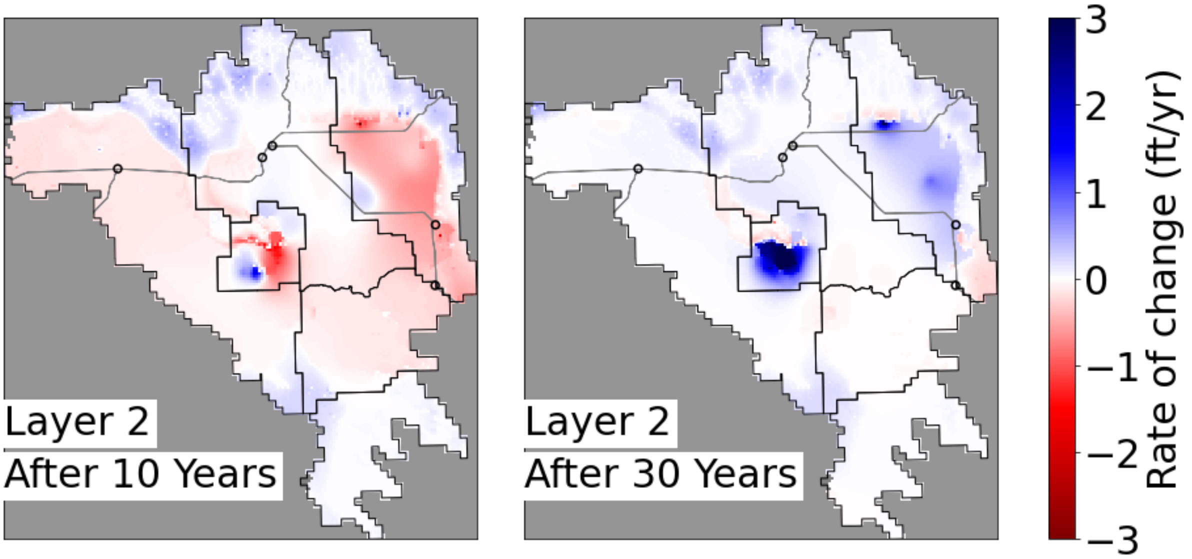
The stated goal for groundwater management in the proposed critical groundwater area is a target water level tend of zero decline. This means that the primary measure of success is stabilizing groundwater level rates of change across the area. As groundwater levels stabilize, an equilibrium will be reached in the groundwater system and additional impacts to groundwater storage, natural discharge, and domestic wells will be prevented. Model outputs were analyzed and synthesized into maps depicting groundwater level rates of change at different time intervals in the simulation. Table 2 provides a comparison of maps generated for 10 and 30 years after reductions in pumpage began and rates of change are displayed in a color gradated scale with shades of red showing negative rates of change (declines) and shades of blue showing positive rates of change (recovery). Key takeaways from these maps include:

- The deep cone of depression in the Weaver Springs/Dog Mountain area fills in (dark blue) rapidly in scenarios A, D, and E. Phased pumpage reductions in scenarios B and C result in the cone of depression continuing to worsen through the first 10 years of the simulation, and then beginning to recover by 30 years.

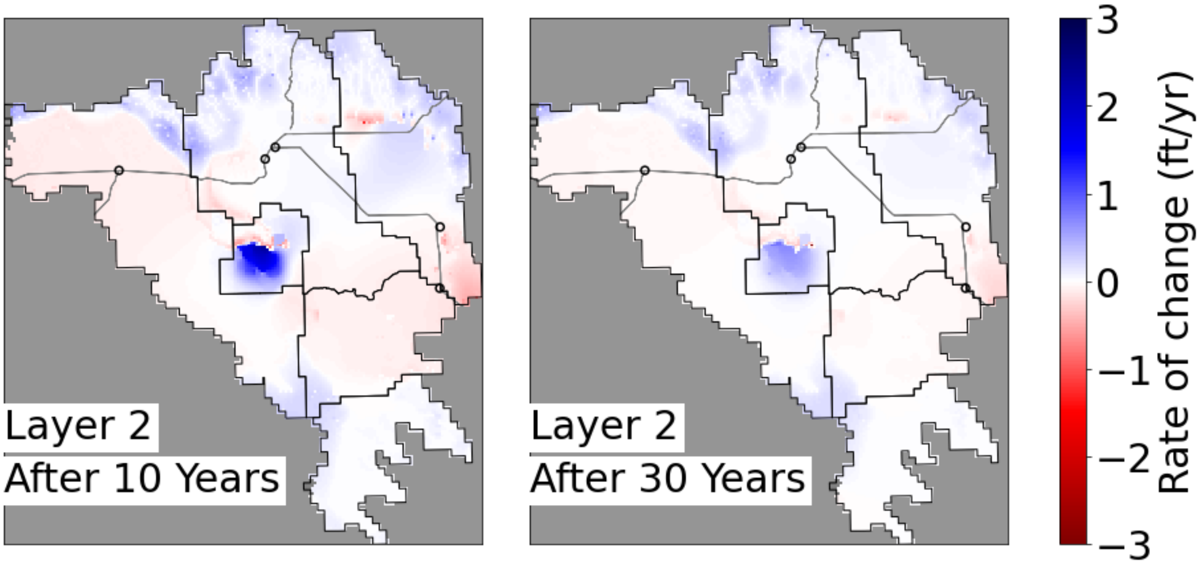
- Broad areas of decline continue through the first 10 years of simulation in all scenarios except E.
- Only scenario E achieves the target water level trend goal, and it does so within 10 years.

Table 2: comparison of the change in groundwater level rates of change in model layer 2 across the proposed critical groundwater area 10 and 30 years after reductions are implemented in each scenario. The basemap used in each map contains the subarea boundaries used in that scenario.

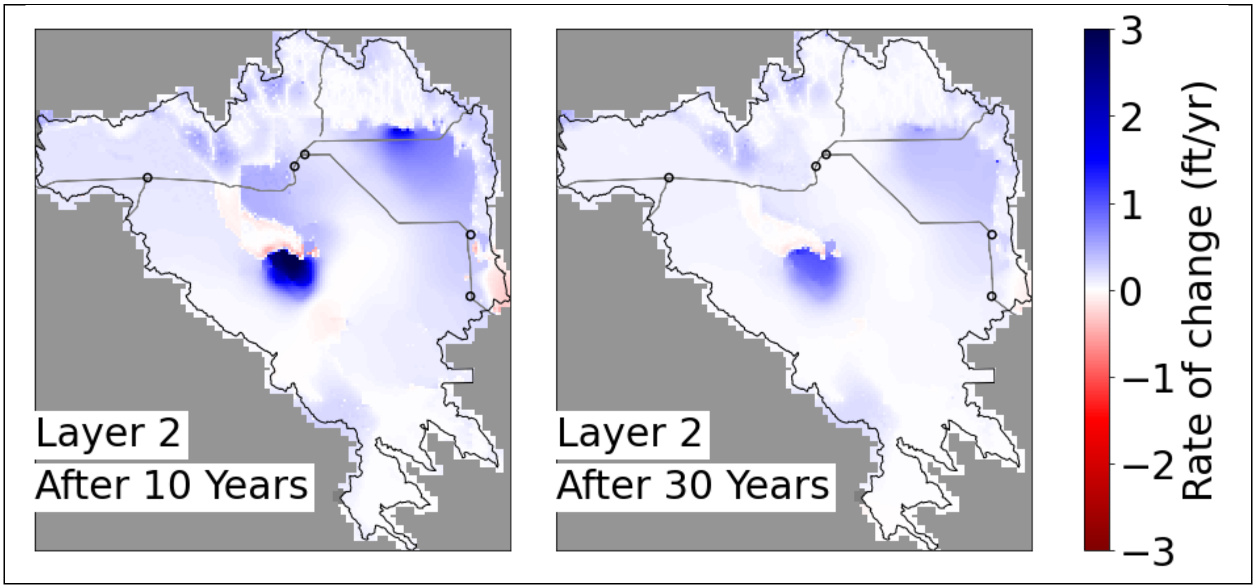
Scenario A - 10 and 30 years after reductions

Scenario B - 10 and 30 years after reductions

Scenario C – 10 and 30 years after reductions



Scenario D – 10 and 30 years after reductions



Scenario E – 10 and 30 years after reductions



One way of assessing the success of each scenario is to measure the median and 90th percentile groundwater level rates of change. **Error! Reference source not found.** contains six matrices comparing the calculated median (left three matrices) and 90th percentile (right three matrices) rates of change within each of the six RAC-defined subareas for each scenario after 10, 20, and 30 years. Comparison is made possible by calculating values using the six RAC-defined subareas regardless of the management areas used for implementing pumpage reductions. Values are depicted using a color gradated scale with red indicating a negative value (declining water levels), blue depicting positive values (recovering water levels), and white depicting a zero value (stable). Evaluating the scenarios for the goal of achieving a target water level trend of zero decline, we see that scenario E achieves both median and 90th percentile values greater than or equal to zero (blue or white) within 10 years and over 30 years those values become closer to 0 (lighter blue/white). All other scenarios achieve improved rates of change with their median and

90th percentile values becoming closer to zero over time, but do not achieve the target water level trend goal of zero decline.

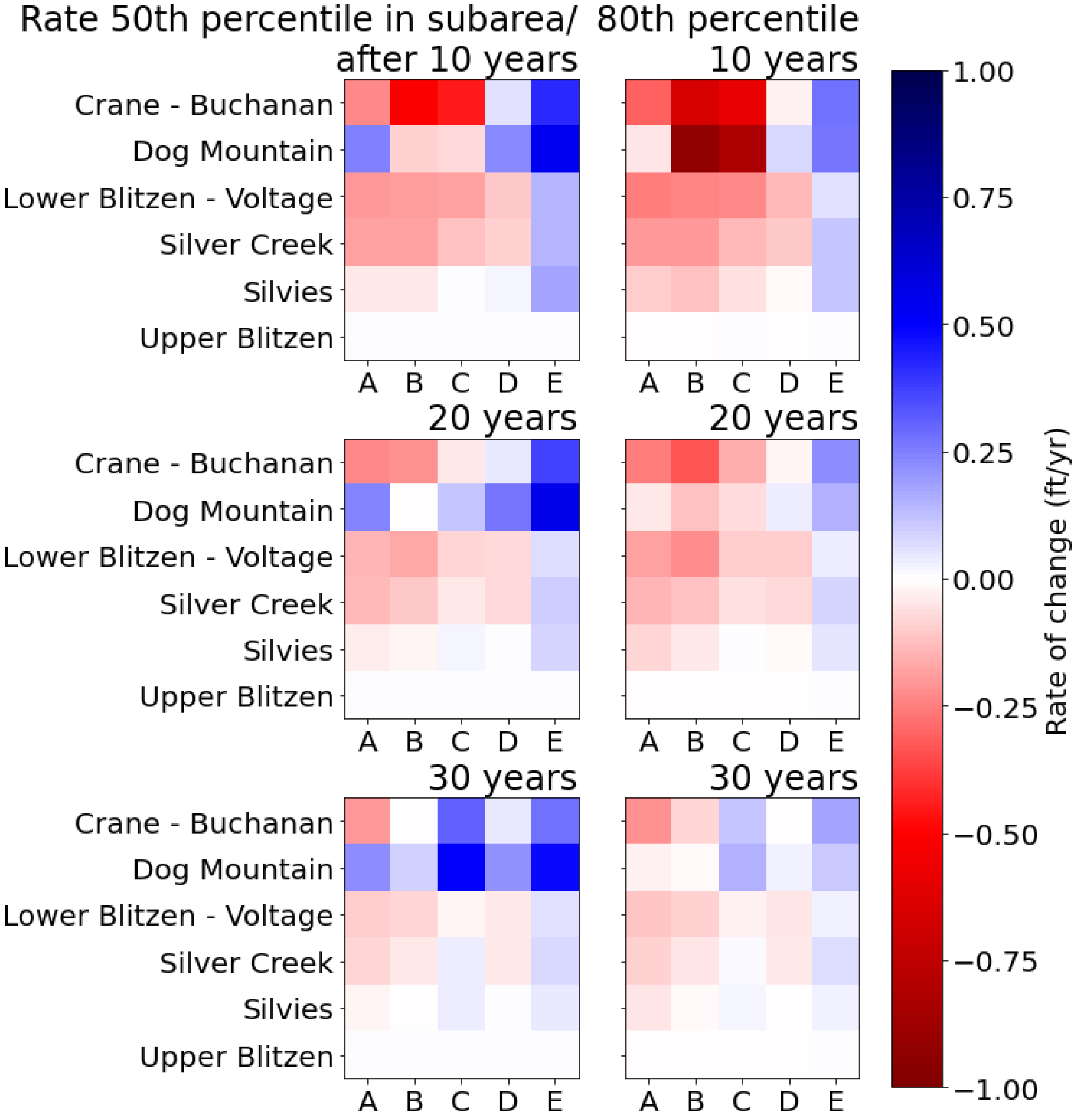


Figure 5: comparison of spatially aggregated rates of water level change for RAC scenarios A-E (x-axes), in each of the 6 subareas defined by the RAC in October 2024 (y-axes). Blue colors indicate rising water levels, and red colors indicate declines. Note the narrower color axis here (1 ft/yr) compared with maps (3 ft/yr). The left column of results shows the median rate of water-level change among well-cells in each subarea, and the right column shows the 90th percentile rate of decline (10th percentile rate of change) among those well-cells. The first row of boxes shows the rates 10 years after the initiation of pumpage reductions (year 2030 in all cases), while the middle row shows rates after 20 years, and the bottom row shows results after 30 years.

Other indicators of success recommended by the RAC focus on the basin-wide water budget, specifically changes in groundwater storage and discharge to surface water bodies. Both indicators of success have direct impacts on groundwater dependent ecosystems. Figure 6 depicts the change in groundwater storage over time for each scenario. All scenarios have positive impacts on groundwater storage as compared to taking no action in the basin, however only scenarios C and E result in substantial increases in groundwater storage.

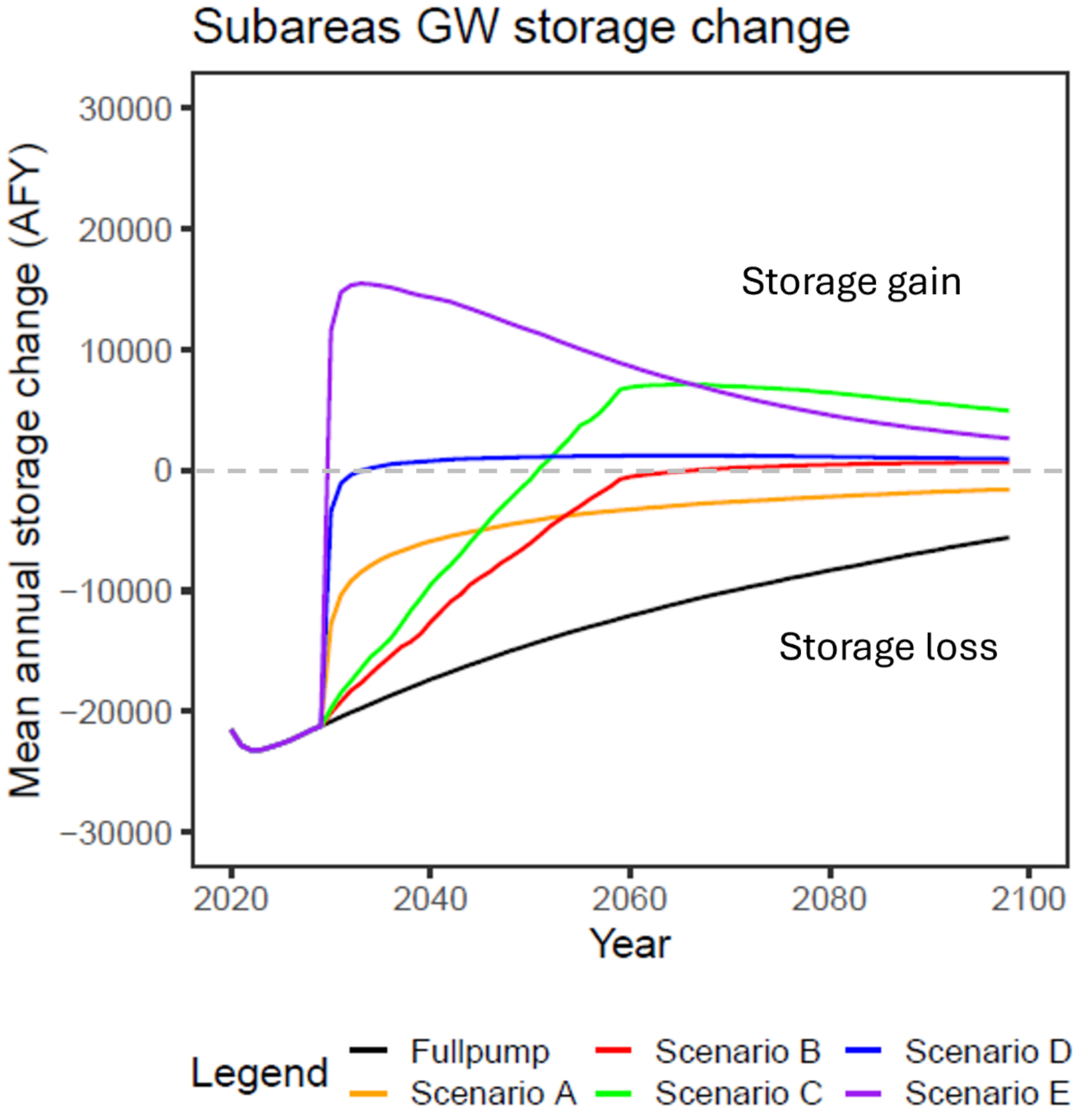


Figure 6: comparison of mean annual change in groundwater storage basin-wide for each scenario.

Figure 7**Error! Reference source not found.** depicts mean annual discharge of groundwater to surface water bodies for each scenario. Scenarios A and B result in stabilization of groundwater discharge to surface water bodies over the length of the simulation while scenarios C (after the 30-year phase in period), D, and E result in increases. Only scenario E results in immediate and substantial increases to groundwater discharge to surface water bodies recovering much of the historic losses in groundwater discharge.

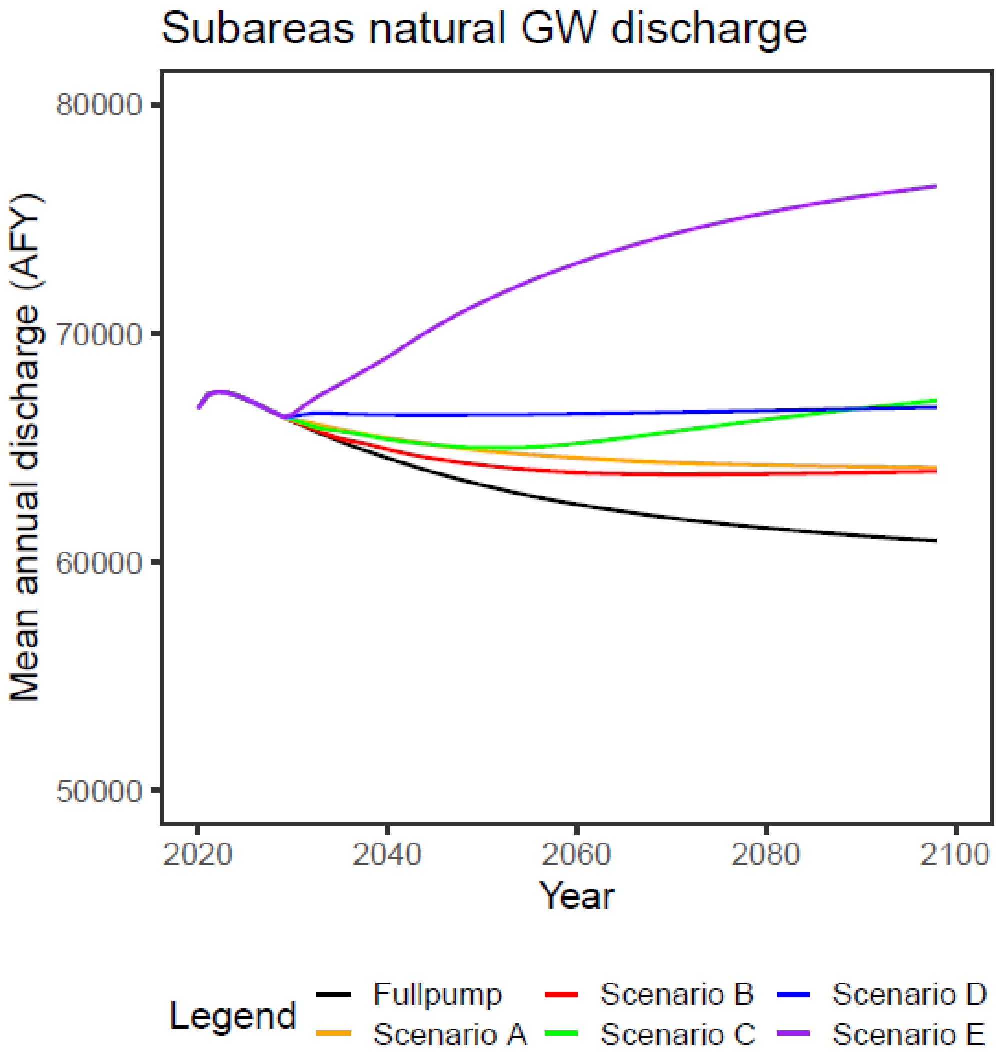


Figure 7: Mean annual groundwater discharge to surface water bodies

Summary of Scenario A Results

Results suggest that scenario A achieves substantial water level recovery quickly in areas like Weaver Springs and Noth Harney, while much of the rest of the basin experiences ongoing declines in response to continued 2018 pumpage rates. Median and 90th percentile rates of change never reach zero indicating further reductions are necessary to achieve the goal. Results also indicate that groundwater storage continues to decline under scenario A and groundwater discharge to surface water bodies decreases slightly or stays static. These results indicate that scenario A provides very little benefit to groundwater dependent ecosystems and risks additional dry wells.

Summary of Scenario B Results

Results for scenario B suggest that declines continue in the Weaver Springs area and broad slower rates of decline continue across much of the basin while pumpage reductions are phased in over 30 years. Once phased in completely, reductions begin to reverse the declines in Weaver Springs and slow the rates of decline across much of the basin. Results suggest median rates of change near zero in all subareas after 30 years, but 90th percentile rates of change indicate at least 10% of wells are still declining at 0.25 ft per year or greater in all subareas. Groundwater storage continues to decline under scenario B during the 30-year phase in period for reductions and then becomes near static for the final 40 years of the simulation. Groundwater discharge to surface water bodies also stays nearly static. These results indicate that the scenario provides very little benefit to groundwater dependent ecosystems and risks additional dry wells.

Summary of Scenario C Results

Like scenario B, results for scenario C suggest steep declines continue in the Weaver Springs area and broad slower rates of decline continue across much of the basin while pumpage reductions are phased in over 30 years. A primary difference between the scenarios is that after the phase in period, the larger reductions implemented in scenario C result in larger areas of stabilization or recovery. After 30 years, median water level rates of change do reach zero or greater and 90th percentile rate of change reaches zero or better in all but one subarea. Increases in groundwater storage and discharge to surface water bodies also occur. These results suggest that scenario C provides benefit to groundwater dependent ecosystems, though it takes decades for those improvements to be realized. Further analysis is needed to understand the risk of wells going dry.

Summary of Scenario D Results

Like scenario A, results for scenario D suggest that immediate implementation of reductions causes rapid recovery in Weaver Springs. However, unlike scenario A, the larger reductions implemented in scenario D result in broader recovery across the basin, though some areas continue to decline even after 30 years. After 30 years, median rates of change reach zero or higher in all but two subareas, while 90th percentile rates of change reach zero or higher in only three subareas. Scenario D has an immediate impact on groundwater storage, increasing storage immediately and then holding the rate of change of storage positive for the remainder of the simulation. Groundwater discharge to surface water bodies also increases over the duration of the simulation, with final amounts of discharge nearly equaling scenario C. These results indicate that scenario D does provide an immediate and long-term benefit to groundwater dependent ecosystems. Further analysis is needed to understand risk of wells going dry.

Summary of Scenario E Results

Results suggest that the immediate, large reductions in scenario E reverse groundwater level decline trends in nearly all portions of the basin within 10 years. Median and 90th percentile rates of change reach zero or better within 10 years and continue through 30 years. Changes in groundwater storage and discharge to surface water bodies is swift and indicates that impacts to groundwater dependent ecosystems would be positive and substantial. Risks of additional wells going dry are also minimized. While clearly achieving the target water level trend goal, these results required a 59% basin-wide reduction in pumpage. The scenario is helpful in that it shows reductions immediately implemented have positive effects on groundwater levels, storage, and discharge.

Optimization

Department staff have written a program that integrates with the HBGM to identify optimal pumpage based on a set of parameters. The program takes parameters such as the length of time for phasing in pumpage reductions, the number of years by which the goal must be met, and the statistical methods for measuring success. Using these guiding parameters the program runs the HBGM, evaluates the results, if needed changes the allowed pumpage, and then runs the HBGM again. The program repeats this process until the specified goal is met within the specified timeline. The optimization program has enabled Department staff to better understand the impacts of different sized subareas for management and the impacts of using different statistical thresholds for measuring success. As a starting point for optimization the Department set the parameters for the optimization program so that a 10-year phase in of reductions would occur and the goal of stabilizing water levels would be met at 30 years. **Error! Reference source not found.** below compares the optimized PTW for the three different subarea proposals (1, 6, or 15 subareas) with the amount of allowed pumpage when evaluating success using a median, 80th percentile, or 90th percentile.

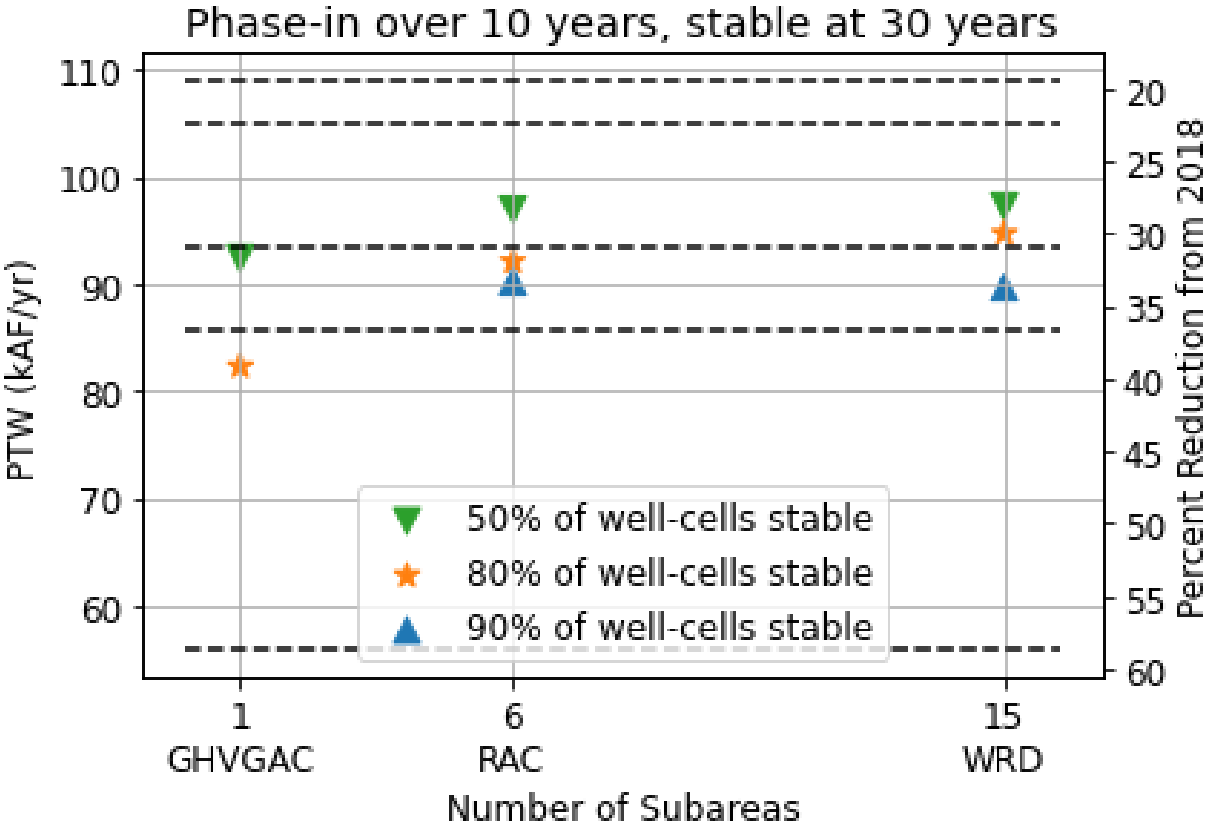


*Figure 8: Comparison of optimized total PTW over the entire GHVGAC for optimization runs that phased in PTW over 10 years and achieved stability after 30 years. The x-axis shows the number of subareas, with each set labeled by its origin (the GHVGAC is 1 area, the 6 subareas proposed by the RAC on 10/2/2024, and 15 subareas proposed by WRD). The color and shape of each marker represents the percent of well-cells within each subarea that are stable (rate of 0 ft/yr) or rising 30 years after the start of reductions. The dashed horizontal lines indicate the non-optimized PTWs from the 5 predefined pumpage scenarios, with increasing values in the order of E, C, D, B, and A (bottom to top). Of those 5 scenarios, only E achieved stability in all subareas at 30 years (**Error! Reference source not found.**). The right axis quantifies the PTW in terms of percent reduction from 2018 nonexempt pumpage.*

With a 10-year phase-in period for reductions and a 30-year target for groundwater stabilization, optimization results suggest that depending on the subarea boundaries and success metrics chosen basin-wide reductions of 28% to 40% from 2018 levels will achieve the goal. When only one management area is used (as in scenario E), pumpage reductions must be greater than with six or 15 subareas, regardless of the success metric used. More stringent success metrics result in more pumpage reductions being necessary to achieve the goal. However, when using median as the success metric, pumpage reductions are nearly equivalent between the six-subarea scenario and the 15-subarea scenario.

III. Conclusion

Out of the five management scenarios, only scenario E achieved the target water level trend goal of zero decline and it did so in 10 years. Scenario E simulated an immediate return to 1990 pumping levels which is a reduction of 59% from 2018 pumping levels. The remaining four scenarios would require more pumpage reductions to achieve the target water level trend goal.

Department staff built an optimization program for the model to gain insight into how different management choices impact groundwater levels and necessary pumpage reductions. Setting the success metric for a scenario at a larger percent of wells being stable (80th or 90th percentile rather than median) requires larger pumpage reductions to achieve the goal but also results in higher final water levels across the basin. Fewer subareas in a scenario lead to greater differences between the amounts of pumpage reductions needed for success when measured by the median, 80th percentile, and 90th percentile metrics. Initial evaluation shows that using the Department's proposed 15 subareas for management allows for strategic reductions in areas of severe decline, making the success metric less influential on required reductions. In some situations, this may allow for less pumpage reductions while still achieving the goal. Conversely, with fewer subareas, reductions are spread across larger areas creating larger variation across success measures.

Going forward in conversations with the RAC, the Department will be soliciting feedback on the following questions:

- What is a reasonable timeframe for achieving the goal of a target water level trend of zero decline?
- Should pumpage reductions be phased-in to allow time for economic adjustment? If so, how long should that phase-in period be?
- What size of subareas should be used to manage the basin? Considerations for this question include how subarea size affects the ability to form voluntary agreements and water right transfers and how important it is to strictly follow prior appropriation.
- What success metric (median, 90th, percentile, etc.) should be used to define success? Said another way, how many wells should be allowed to continue declining and still call the results success?
- How should impacts to natural discharge, groundwater storage, domestic wells, and the economy be considered when optimizing a management scenario?