Alternative approaches to meet GMD3 Q-Stable targets

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1. Introduction

K.S.A. 82a-1044, the statute resulting from Kansas House Bill 2279, contains two requirements for Kansas Groundwater Management Districts (GMDs). First, all GMDs must have identified priority areas of concern by July 1, 2024. Second, GMDs are required to create plans to adequately address the identified concerns by July 1, 2026. Since the law was enacted, a series of stakeholder meetings have been held to discuss proposed curtailments in groundwater withdrawals within the Southwest Kansas GMD (GMD3). The meetings presented reductions in groundwater withdrawals, produced by the Kansas Geological Survey (KGS) and displayed in figure 1, estimated to stabilize groundwater levels for each Irrigation Climate and Resource Evaluation (I-CARE) region in GMD3. The reduction targets were estimated using the Q-Stable methodology, a statistical approach for determining the relationship between total groundwater withdrawals and declining aquifer levels. The values for each I-CARE region displayed in figure 1 represent the percent reduction in withdrawals, relative to a ten-year average of historical pumping, estimated to keep the aquifer level stable.

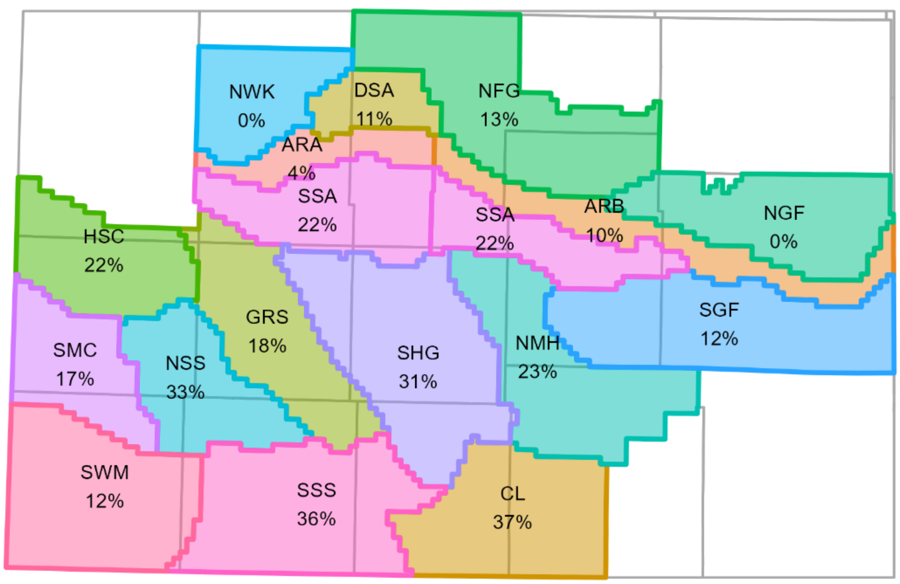

Figure 1. Percent reduction in groundwater withdrawals relative to a ten-year average (1994-2023) estimated to keep the aquifer level stable in each I-CARE region. The percent reductions are estimated using the Q-Stable methodology.

Prior research demonstrates the choice of policy mechanism to reach reduction targets can create large differences in the resulting net social benefits. Smaller, incremental reductions in withdrawals are generally less costly than retiring water rights completely (Rouhi Rad et al., 2025). Retirement programs are costly because the units of groundwater retired are some of the most valuable to producers—reducing pumping an additional inch becomes increasingly costly as the limit approaches crop-specific thresholds. In contrast, producers can adjust to a small reduction in water use allocation by improving irrigation efficiency, reducing irrigated acres, or changing crop rotations (Cameron-Harp & Hendricks, 2025; Drysdale & Hendricks, 2018).

In this brief, I present three policy mechanisms for reducing withdrawals and the impact each would have on the distribution of water rights across the I-CARE regions in GMD3. The results depicted in this report are generated such that all three policy options reduce withdrawals to the KGS Q-Stable level in each I-CARE region. While the plan GMD3 proposes to fulfil the K.S.A. 82a-1044 requirements will likely differ from this objective, the goal of this exercise is to illustrate how the choice of curtailment policy affects the reductions imposed on individual water right holders. The data I use are drawn from the Water Information Management and Analysis System (Wilson et al., 2005) and are aggregated to the water right group level at which authorized quantities and acreage are recorded. Water right groups represent unique networks of overlapping points of diversion, water rights, and places of use.

2. Uniform depth-applied limit

As a reference point, I first present results for a policy limiting depth-applied (inches of groundwater per acre). The changes in limits to total withdrawals and the maximum potential depth-applied values are displayed in figure 2. The two graphs in the top row of figure 2 display the changes in total withdrawals and maximum potential depth applied from before and after the policy is enacted. The second row of graphs shows how the distributions of total withdrawals and maximum depth-applied values change from before the policy to after it. Blue bars represent the number of water-right groups at each water-use level before the policy, and red bars represent the number after the policy. The maroon segments indicate the number of groups that fall into the same water-use level in both policy environments. To determine how the curtailments will affect water use, I assume water rights whose 10-year historical average is above the threshold will irrigate at the new limit and those below will continue irrigating at their historical average value. I also assume irrigated acreage will remain at the 10-year historical average value. Notice in figure 2 the number of water rights for whom the new limit will reduce the maximum potential depth-applied value by 5 inches or more.

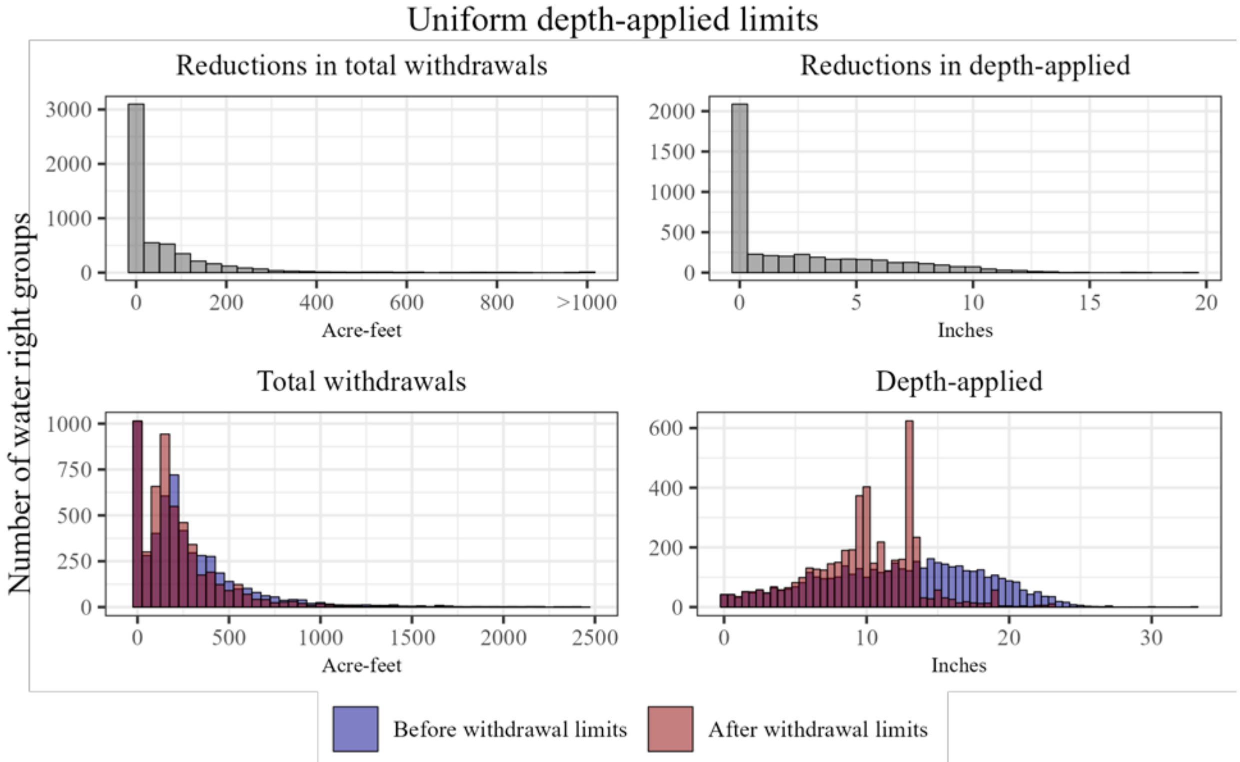

Figure 2. Total water use and depth-applied for water rights following implementation of a policy limiting depth-applied, or acre-feet applied per irrigated acre.

3. Percent reduction relative to historical use

A second means of meeting the reduction targets in GMD3 would be to require a percent reduction in groundwater use relative to each user's ten-year historical average. I present how this policy option would affect the distribution of total withdrawals and depth-applied values in figure 3. In contrast to the results for uniform depth-applied limits in figure 2, the results in the top right graph in figure 3 include fewer reductions of 9 inches or more. Instead, a greater number of irrigators using smaller quantities of groundwater bear a larger portion of the total reductions.

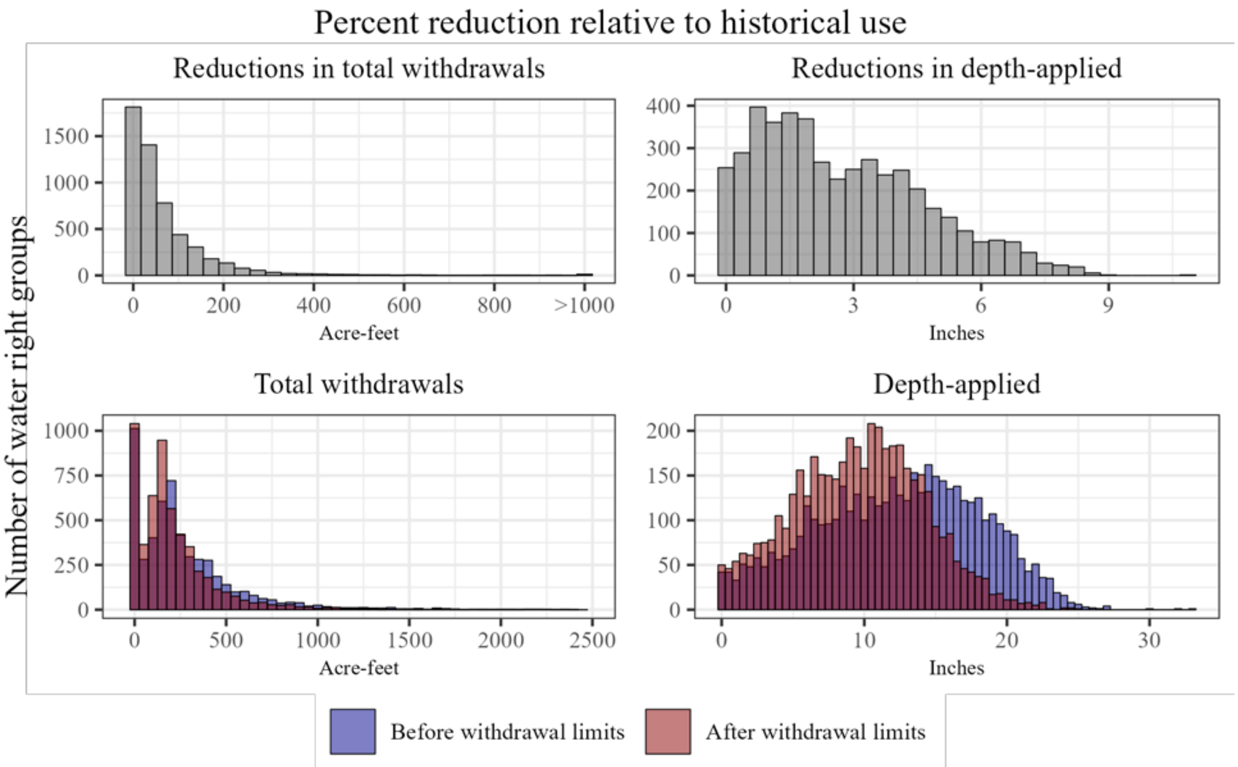

Figure 3. Total water use and depth-applied following implementation of a policy that requires a uniform percent reduction in total water use for I-CARE regions.

One disadvantage of setting reduction targets as a percent of historical use is that it may inadvertently incentivize irrigators to refrain from conserving groundwater. If irrigators anticipate future curtailments will be made using the same mechanism, they may strategically pump their maximum allowable quantities each year. One way to mitigate this possibility is to scale the reduction based on the difference between irrigators' historical use and their authorized quantities. Irrigators who pumped less than their authorized quantities receive a smaller fraction of the percent reduction and those who consistently pump the entire authorized quantity receive the majority of the percent reduction. Alternatively, the reductions relative to historical use can be combined with maximum and minimum bounds. For example, an I-CARE region could impose a 10% reduction relative to historical use, but stipulate irrigators do not have to reduce depth applied below the minimum of 9 inches. In addition, they could require all irrigators to keep depth-applied below a maximum value of 15 inches. Both modifications are methods of controlling the portion of the reduction burden born by irrigators with historically high or low groundwater use.

4. Retire junior water rights

The final option I present achieves the target reductions by retiring water rights in order of seniority. I present this policy option as means of simultaneously addressing the mandated reductions and over-appropriation of water rights (Edwards et al., 2025). The results presented in Figure 4 are generated assuming the most junior water rights are retired first and withdrawals for the remaining senior water rights are limited to their 10-year historical average values.

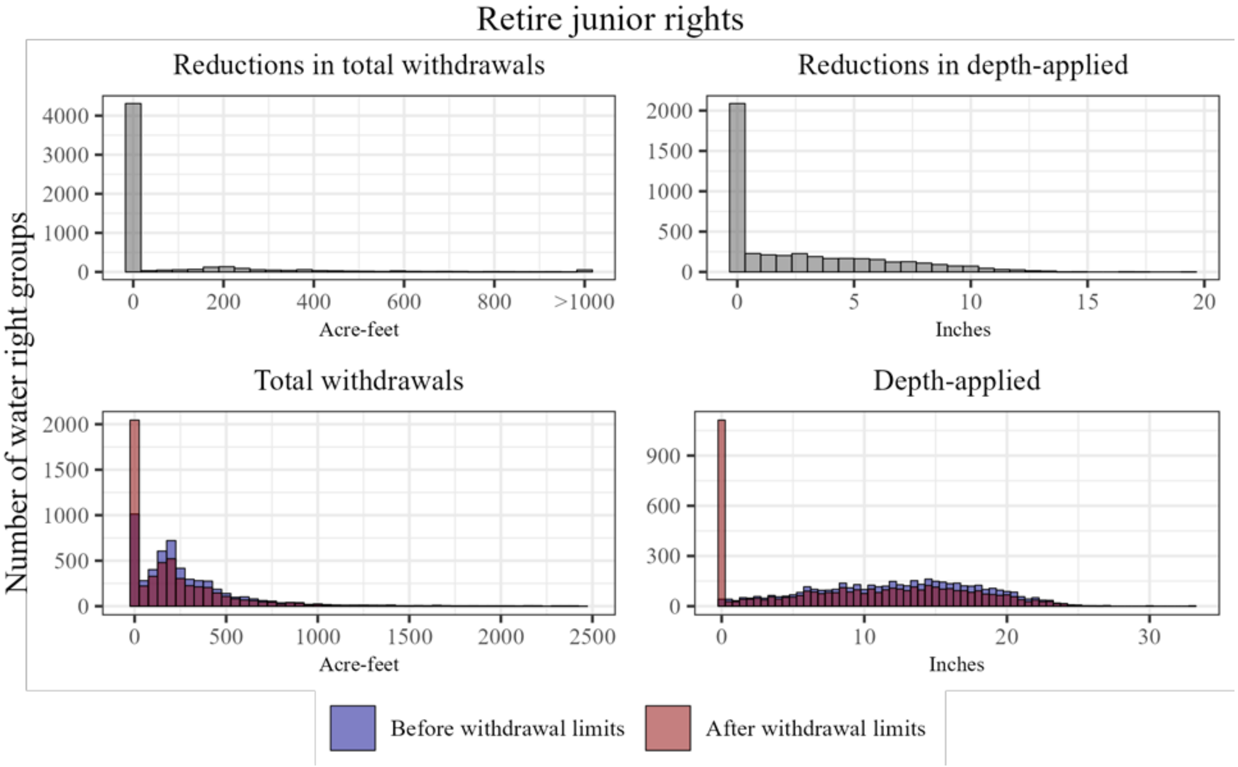

Figure 4. Total water use and depth-applied following implementation of a policy that retires junior water rights until the target reduction in total water use is achieved.

While the results in figure 4 illustrate the impacts of a policy that completely retires junior water rights, this policy option could be modified such that junior water rights receive greater curtailments than more senior water rights. Doing so may mitigate some of the high costs involved with complete retirement of a water right. One difficulty of this approach is administrative burden involved in navigating the complex web of interconnected water rights, points of diversion, and places of use.

5. Other considerations

Each of the options presented here will involve different private costs of adaptation for irrigators in GMD3. The goal in presenting these alternatives is to encourage discussion of the option which achieves the desired distribution of costs. One means of allowing irrigators to determine the cost-efficient means of achieving reductions is to couple water right trading with the mandated reductions (Bruno & Sexton, 2020). For example, after setting limits to total annual withdrawals as in the unform depth-applied limits option, irrigators could then be allowed to trade quantities of water within I-CARE regions on an annual basis. This option may benefit irrigators regardless of the quantity they are limited to. For example, an irrigator limited to a small quantity insufficient for growing irrigated corn could sell the right to this water to irrigators with a quantity barely sufficient to grow irrigated corn. In doing so, the irrigator with the low water right receives payment for a resource with few benefits at the price that the buyer is willing to pay to greatly improve yields and reduce production risk. In practice, there are several key considerations which must be considered for such a market to function properly. First, trades in groundwater allocations would need to be limited to nearby areas sharing the same hydrological context. Second, there would need to be a mechanism to validate whether the remaining quantity in a water right is based on groundwater that is available. Requiring pump tests prior to trades could ensure trades are based on available water, but this would entail an additional administrative burden on the GMD. Finally, tracking the trades would require accounting which may prove to be a costly endeavor.

6. References

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