Turf Replacement Program
Potential Water Savings and Consumptive Use Considerations

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Background

Colorado House Bill 22-1151 sought to incentivize water-wise landscapes by creating a state program and establishing funding to support the voluntary replacement of irrigated turf across Colorado. The bill, signed into law on June 8, 2022, established the Turf Replacement Program and allocated $2 million for use by the program by June 30, 2025. The Colorado Water Conservation Board (CWCB) manages Colorado's Turf Replacement Program and awards matching grants to municipal and industrial (M&I) water providers, Tribes, and 501(c)(3) non-profit agencies to support turf replacement. In the first year, the Turf Replacement Program awarded grants to 50 eligible entities, and requests to continue the program and allocate additional funding were approved by the Colorado legislature in 2024.

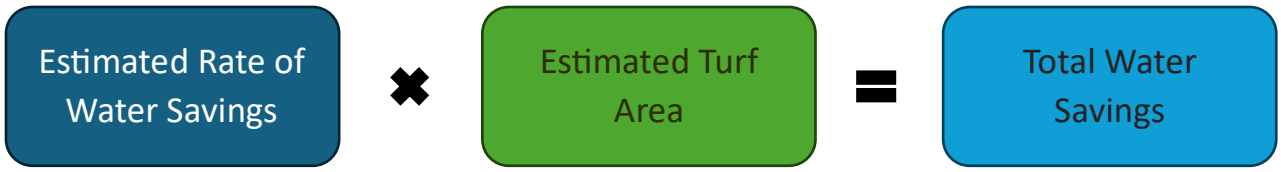
Shortly after House Bill 22-1151 was signed, two additional initiatives regarding water-wise landscaping were signed. First, water providers in the Colorado River basin signed a 2022 memorandum of understanding (MOU), committing the entities to take a series of actions that would reduce water consumption and increase the reuse and recycling of water within their service areas. One of those actions was to introduce programs to reduce the quantity of non-functional turf grass by 30% and replace it with drought and climate-resilient landscaping. Second, Governor Polis directed the development of water efficient landscaping policies for state facilities through Executive Order D 2023 018 (EO). Through this EO, a policy was developed that applies to water-wise landscaping for new construction and substantial renovation projects for state facilities.

These three efforts show that reducing the amount of turf and replacing it with water-wise landscaping is one of the many ways water providers can conserve water supplies and improve resiliency as the climate changes. Important questions remain, however, regarding the amount of non-functional turf in Colorado, the actual water savings resulting from reductions to turf, and costs to remove and replace turf. CWCB is working with several technical experts to gain a better understanding of the data that is available to answer these questions. CWCB began working with BBC Research & Consulting to conduct an analysis to identify potential water savings, benefits and costs from removing non-functional turf grass in Colorado. This effort resulted in two reports, an initial *Exploratory Analysis of Potential Water Savings, Costs and Benefits of Turf Replacement in Colorado* report in 2023 and the 2024 Update to the initial report (collectively referred to herein as BBC Reports).

The analyses and findings in this report build on these previous efforts while incorporating new data to further refine the potential water savings that could result from the Turf Replacement Program. This report also considers the consumptive use and return flow components of the water savings from turf replacement/removal. The report uses *total* and *net* water savings terminology to differentiate between the *total* reduction to the water delivered to the water user's meter and the *net* amount of water that was saved after accounting for the portion of the delivered water that returned to the river. Lastly, the report considers water savings maintained over the long term and compares the potential water savings to other water uses across the state.

Potential Total Water Savings Due to Turf Replacement Programs

One of the Turf Replacement Program's goals is to reduce the amount of water used to irrigate turf that is not frequently used or not used at all, referred to as non-functional turf, and either replace it with more water-wise landscaping, rockscape, or remove it completely. Potential water savings can be calculated as the product of the estimated rate of water saved per year due to the turf reduction/removal project multiplied by the potential acreage covered by the project. The total water savings reflects the amount of water delivered to the water user's meter that would be saved due to turf removal/replacement.



Estimated Rate of Water Savings

The BBC Reports estimated that, on average, most turf replacement/reduction projects could save approximately 12 gallons per square foot (GPSF) or 1.60 acre-feet per acre (AF/Acre) of water delivered at the water user's meter. According to the BCC Reports, this estimate aligns well with other estimates of water use savings provided by water providers' assessments and the first round of Turf Replacement Program projects.

Note, however, that some water providers expect significantly larger or smaller water use savings depending on conditions within the providers' service areas and contemplated projects. If the turf program projects include the complete removal of fully irrigated turf, water savings may be closer to 19 GPSF or 2.54 AF/Acre, which the BBC Reports estimated as a full irrigation supply for turf. Conversely, if turf program projects include replacing turf that was not receiving a full water supply (i.e. deficit irrigating) or reducing water deliveries through previous irrigation improvements, water savings will be lower than the average water use value. To provide a full range of potential water savings depending on the projects covered by turf removal/replacement programs, a value of 5 GPSF or 0.67 AF/Acre was used for a low water estimate.

Estimated Turf Area

The total amount of turf acreage that may feasibly be enrolled in a Turf Replacement Program is a difficult value to estimate. The BBC Reports indicate that a total of 167,800 acres may be irrigated statewide from municipal supplies, including functional and non-functional turf as well as trees and other landscaping features. A recent study on irrigated acreage in Denver County[1] provided a refined estimate of the amount of functional versus non-functional turf in developed areas. The study found that 88.5 percent of the irrigated turf is associated with residential areas, parks, educational facilities, cemeteries, and golf courses, and is considered functional[2]. The remaining 11 percent[3] of the irrigated acreage is associated with transportation, utilities, commercial and/or industrial facilities and is more likely to be non-functional. Using this estimate, a maximum of 18,500 acres of irrigated turf in Colorado may be considered non-functional turf (167,800 acres multiplied by 11 percent for non-functional turf). The Colorado River basin water providers MOU[4] sought to reduce the quantity of non-functional turf by 30 percent. Applying this factor to the statewide non-functional turf estimate results in 5,550 acres (18,500 acres multiplied by 30 percent) of non-functional turf that may be eligible for replacement or removal through the Turf Replacement Program.

Note that these calculations assume that the non-functional turf percentage in Denver County and the turf reduction actions in the MOU can be applied at a statewide level. Each community across the state, however, has different municipal landscape patterns, may use a different definition of non-functional turf, and may use

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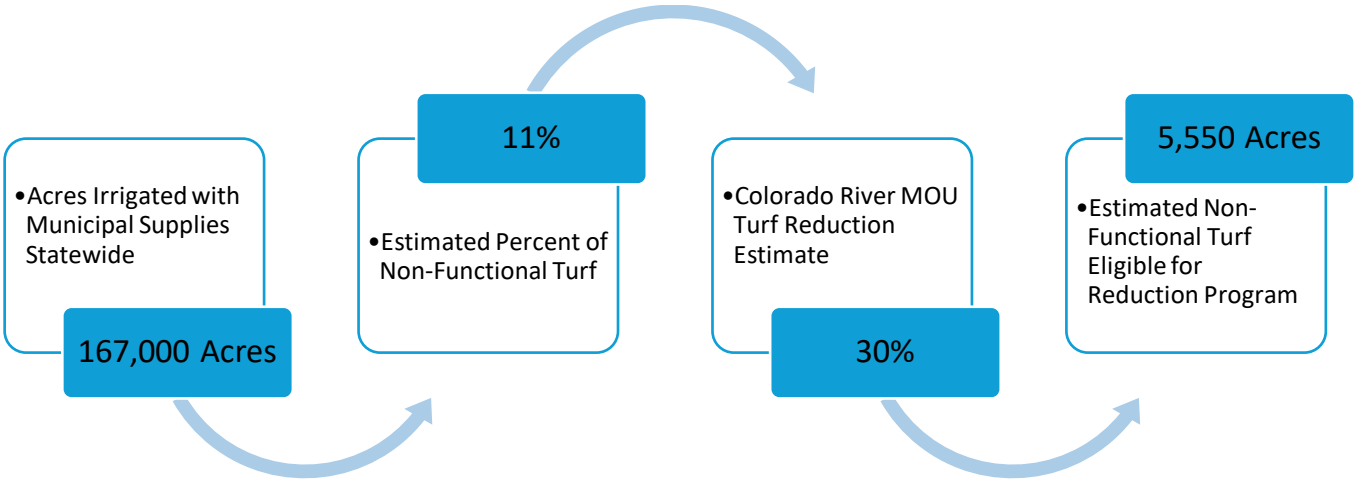
[1] Irrigated Land Cover by Land Use in Denver County, Colorado. Andrew Marx, PlanetScape Ai

[2] The definition for "functional" turf used in the analysis was supported by Colorado House Bill 22-1151 and Senate Bill 24-005

[3] Appendix C of Irrigated Land Cover by Land Use in Denver County report indicates 10.9 percent of non-functional turf and 88.5 percent of functional turf for Denver County. The remaining 0.6 percent of acreage was not categorized.

[4] Memorandum of Understanding by and among Colorado River Basin Municipal and Public Water Providers. August 2022

different actions or goals for their turf reduction planning purposes. As both the total amount of non-functional turf statewide and the total amount of acreage that could be enrolled in a Turf Replacement Program are unknown, these assumptions are used to develop a high-level estimate of these values for purposes of this report.



Additionally, note that this acreage estimate focuses on non-functional turf associated with municipal and industrial facilities and does not include turf that private entities or property owners may choose to replace. As individual water providers are scaling up their efforts to remove non-functional turf through the implementation of several rebate programs (many of which are being funded by the Turf Replacement Program), a portion of the turf that is being removed is considered "functional" based on the Denver County study. It is difficult to determine the amount of potentially functional turf that is being replaced because this determination is based on private water users' decisions on their landscaping needs. Additional data is needed to understand what portion of the total turf removal/replacement in these programs is considered to be non-functional compared to functional based on the Denver County study's definition and what the potential maximum of removal/replacement of functional turf may be.

Even with this consideration of including portions of functional turf, the publicly available acreage information for current programs reflect much lower turf reduction values.

- The BBC Reports indicate that annual turf replacement activity may exceed 69 acres per year based on trends reflected in water provider Water Efficiency Reports[5].
- The total area associated with 44 entities' [6] projects in the first round of the Turf Replacement Program is 58.4 acres.
- Northern Water's Collaborative Water-Efficient Landscape Grant Program has successfully converted 177 acres of landscapes since 2019, which is approximately 30 acres on average each year.

Adding together the acreage from these programs results in approximately 157 acres per year of turf removal or replacement. Even if the combined acreage from these programs is significantly underestimated, it is far less

[5] Note that some entities reporting turf replacement activity in Water Efficiency Reports (based on Colorado House Bill 10-1051 data) are the same entities enrolled in the Turf Replacement Program, resulting in an unknown amount of double-accounting of acreage between these two sources.
[6] Based on TRP Round 1 Data Breakdown for the July 2024 CWCB Board Meeting; two entities did not provide area information.

than the 5,550 acres estimate of non-functional turf that may be eligible for replacement or removal through a turf program.

Total Water Savings

Table 1 reflects the total amount of water delivered to the water user's meter that would be saved due to turf removal/replacement per year based on the range of potential water savings and acreage estimates. As reflected, the largest water savings are associated with full turf removal of 5,550 acres of non-functional turf statewide. Achieving both of these maximums is unlikely, however, as the acreage estimate far exceeds the combined acreage in current turf programs and the primary intent of the programs are to replace turf with more water-wise landscaping as opposed to rockscape, concrete, or asphalt. Water savings from CWCB's Turf Replacement Program may range from 39 AF to 148 AF; however, as many of the enrolled entities estimated the average water savings rate for their projects, this first round of the Turf Replacement Program may result in about 93 AF of total water savings (58.4 acres multiplied by 1.6 AF/Acre or 12 GPSF).

Table 1: Potential Water Savings of Turf Removal/Replacement

	Non-Functional Turf Acreage Estimate (5,550 Acres)	Combined Turf Program Acreage Estimate (157 Acres)	CWCB Turf Replacement Program Acreage Estimate (58.4 Acres)
Low Water Savings Rate (0.67 AF/Acre or 5 GPSF)	3,710 AF	105 AF	39 AF
Average Water Savings Rate (1.6 AF/Acre or 12 GPSF)	8,880 AF	252 AF	93 AF
Full Turf Removal Water Savings Rate (2.54 AF/Acre or 19 GPSF)	14,097 AF	400 AF	148 AF

Potential Net Water Savings and Impact on the River

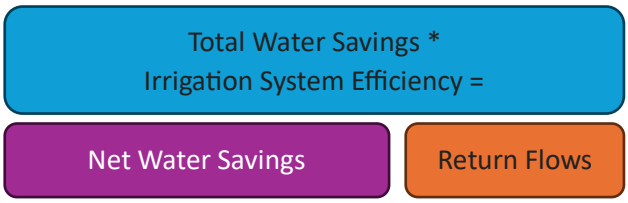
Not all of the water that is delivered to the water user's meter for outdoor irrigation purposes is used by the turf. A significant portion of the delivered water is used by the turf for plant growth (i.e. consumptively used); however, the remaining portion is not consumed and eventually returns back to the river. The proportion of the amount of water used by the turf compared to the total water delivered is the irrigation system efficiency. Irrigation efficiency varies based on the type and coverage of the irrigation system and the amount of water applied. With respect to irrigation systems, a drip irrigation system may be 90 percent efficient, whereas sprinkler systems may range from 50 to 70 percent efficient[7]. Regular maintenance, consistent coverage, and irrigation scheduling can all improve the efficiency of irrigation systems. Overwatering reduces the efficiency of the irrigation systems because there is a maximum amount of water that can be consumed by the turf; any irrigation beyond that amount is returned to the river. On cooler days early in the summer, the amount of water

[7] Efficient Landscape Irrigation during Drought and with Limited Water Availability in Colorado. Colorado State University Extension.

the turf may consume is much lower compared to the amount it can consume on hot days in the peak of the summer.

The irrigation return flows (Lawn Irrigation Return Flows or LIRFs) that eventually return to the river (typically weeks or months later than the water was originally diverted for irrigation) are then re-diverted by other water users. In some limited cases, the LIRFs have been quantified and taken through Colorado's Water Court process to allow the water provider to re-divert the return flows back into their own systems. The majority, however, return to the river and are available to other water users.

The only water savings from the river's perspective is the amount consumed by the turf, referred to as net water savings. The irrigation return flows are retimed, but they eventually accrue back to the river. To understand the amount of net water saved by turf removal/replacement projects from the river's perspective, the total water savings estimates from Table 1 can be reduced to reflect only the portion that is consumed by the turf. Although the irrigation systems and efficiencies are different for each project, an average irrigation efficiency value can provide perspective on the portion of the water savings measured at the water user's meter that would have been consumed by the turf compared to the portion that would have returned to the river as irrigation return flows.



The BBC Reports present irrigation efficiencies that range between 75 and 85 percent; the Technical Update to the Colorado Water Plan (Technical Update) generally uses 80 percent efficiency for outdoor irrigation. Table 2 reflects the net water savings associated with turf removal/replacement projects from the river's perspective, calculated as the values in Table 1 reduced by an 80 percent irrigation efficiency. The difference between Table 1 and Table 2 values reflects the portion of total water savings that would have just returned to the river. As reflected, the largest potential water savings has been reduced from 14,097 AF to 11,278 AF after adjusting for an 80 percent irrigation efficiency. Average water savings from the first round of CWCB's Turf Replacement Program is reduced from 93 AF to 75 AF after irrigation efficiency.

Table 2: Potential Net Water Savings of Turf Removal/Replacement Assuming 80% Irrigation Efficiency

	Non-Functional Turf Acreage Estimate	Combined Turf Program Acreage Estimate	CWCB Turf Replacement Program Acreage Estimate
Low Water Savings Rate	2,968 AF	84 AF	31 AF
Average Water Savings Rate	7,104 AF	201 AF	75 AF
Full Turf Removal Water Savings Rate	11,278 AF	320 AF	119 AF

Long-term Net Water Savings

The net water savings values presented above are annual averages and do not reflect the actual water savings realized by each Turf Replacement Program project each year. Additional data analysis by the water providers will

be needed to determine the actual net water savings. Net water savings will vary from one year to the next depending on irrigation season weather because the amount of water consumed by turf and outdoor landscaping changes based on weather conditions. Turf consumes less water in cooler years and more water in hotter years as long as sufficient irrigation supplies are available.

Figure 1 reflects how the net water savings from an average turf removal project (2.03 AF/Acre = 2.54 AF/Acre * 80% efficiency) would have varied annually had the project been in place over a recent ten-year period[8]. Assuming a sufficient water supply would have been available to the acreage, the net water savings would have varied by about +/- 20 percent between hotter and cooler years (2015 & 2020). Applying this same range to the net water savings from acreage converted through the Turf Replacement Program (Table 2), the net water savings may range from about 60 AF to 90 AF (75 AF * +/- 20 percent) between hotter and cooler years.

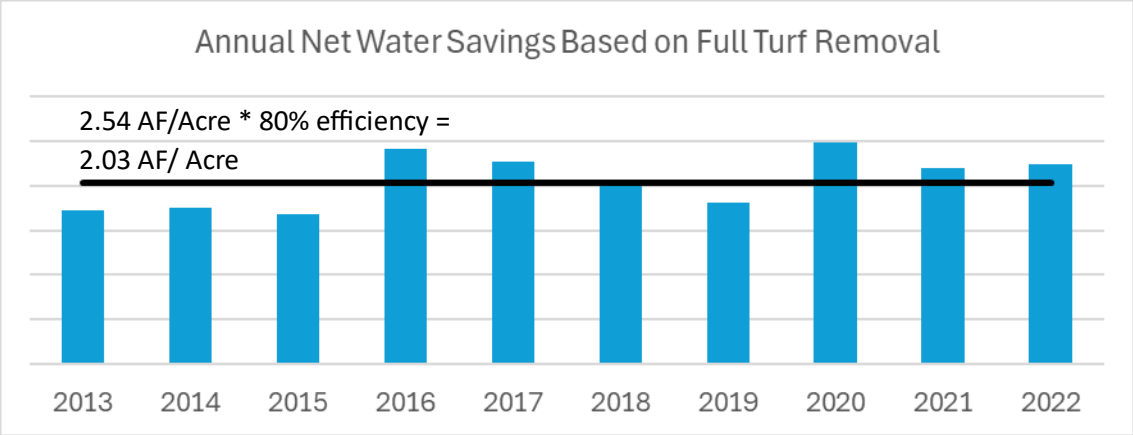


Figure 1: Range of Annual Net Water Savings for Full Turf Removal

In addition to the annual variation illustrated in Figure 1, net water savings are likely to vary based on location. Consumptive use is highly dependent on local climate factors like precipitation, temperature, and humidity, which are in turn influenced by elevation and other geographic factors. For example, turf at higher elevations is likely to have a shorter growing season and lower consumptive use, which will reduce the associated net water savings compared to turf replacement at lower elevations. Net water savings for any turf removal program will vary both annually and based on the location of the turf removed.

As the climate warms in Colorado, the amount of water consumed by turf will increase, again assuming sufficient irrigation supplies are available. The Technical Update to the Colorado Water Plan incorporated two potential 2050 climate conditions in their scenario planning, termed “In-Between” and “Hot and Dry”. The following table reflects the estimated percent increase in needed irrigation supplies relative to the increase in temperature in 2050 on average across Colorado. Net water savings from a full turf removal project (2.03 AF/Acre) may increase to 2.76 AF/Acre under In-Between climate conditions or 3.07 AF/Acre under Hot and Dry conditions by 2050.

[8] Colorado Division of Water Resources ET Data and StateCU Tool

Table 3: 2050 Projected Increases to Irrigation Needs and Temperature

	2050 In-Between Climate Conditions	2050 Hot and Dry Climate Conditions
Increase in Irrigation Supplies	136%	151%
Increase in Temperature[9]	2.28 °F	2.65 °F

The biggest factor, however, that impacts long-term water savings is how much acreage is enrolled in turf removal/replacement programs in the future and if that acreage remains at low or no water use levels (i.e. acreage is not converted back to turf or a higher water use landscape). The figure below illustrates the net water savings of the first round of the Turf Replacement Program (75 AF) and the Combined Turf Programs (201 AF) over the next 10 years[10] assuming 10 percent increase of acreage each year in the programs or steady or constant acreage in the programs each year. As reflected, the net water savings after 10 years from the Turf Replacement Program may range from about 1,088 AF assuming accelerated enrollment to about 750 AF assuming a steady enrollment. Similarly, the net water savings after 10 years from the Combined Turf Programs may range from about 2,915 AF assuming accelerated enrollment to about 2,010 AF assuming a steady enrollment.

[9] The Technical Update to the Colorado Water Plan projected temperature increases of 3.78 °F and 4.15 °F for the 2050 In-Between and Hot and Dry climate conditions, respectively, relative to 1970-1999 averages. The 2024 Climate Change in Colorado report noted that Colorado has already experienced warming of 1.5 °F since this time period, therefore the Colorado Water Plan values were reduced by 1.5 °F in this table.

[10] Funding for the current Turf Replacement Program expires on June 30, 2028; additional funding would be needed to support the estimates of long-term water savings.

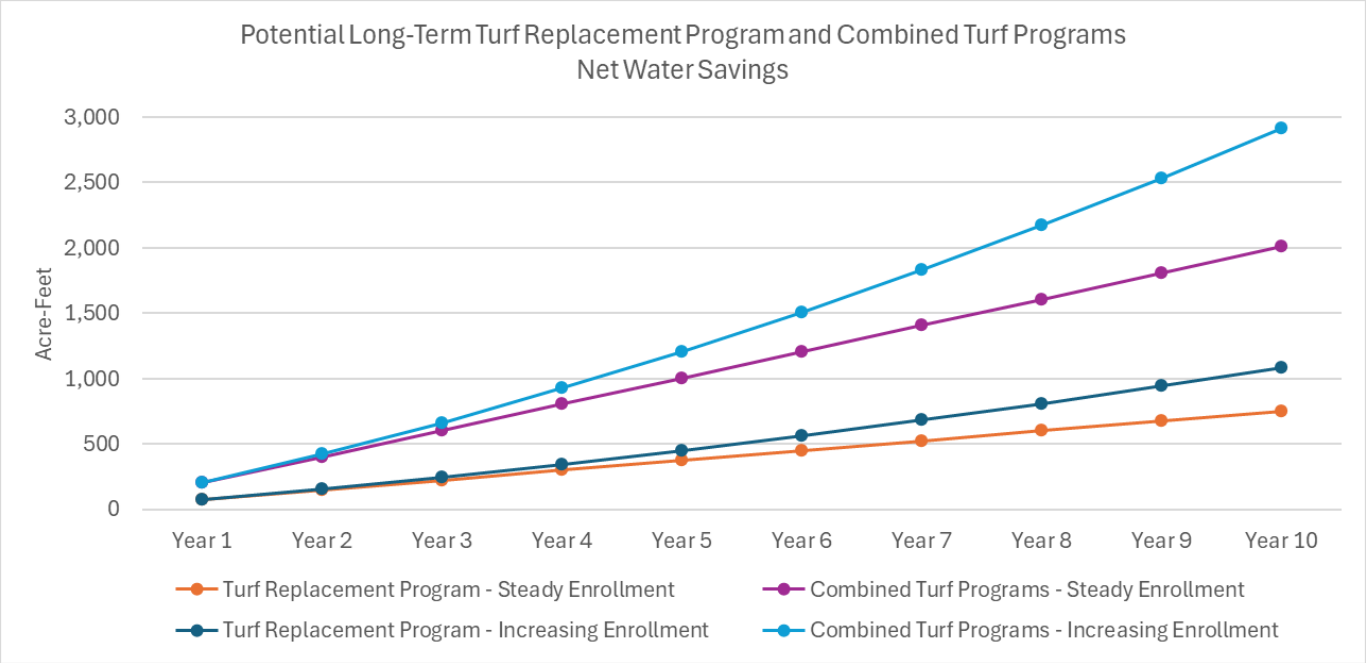


Figure 2: Potential 10-Year Net Water Savings

There is also the potential for reversion back to turf, however this is difficult to predict and may not be significant. A recent study on reversion within the Metropolitan Water District Turf Removal Program[11] indicated that between 1 to 1.5 percent of program participants perform a major reversion every two years (replanting turf on more than half of their project area) and only 0.6 percent of all program participants reverted all of their project area during the study period. More long-term studies of these types of programs will be needed to understand the driving factors for reversion and the impact on water savings.

Water Savings Comparisons

As outlined above, there is a range of potential water savings associated with turf removal/replacement programs. This section compares these values to other types of water uses in Colorado to provide context on the magnitude of these savings. Comparisons below are based on the potential average water savings from the non-functional turf removal and/or the Turf Replacement Program and use total water savings at the water user's meter or the net water savings (i.e. water savings reduced by efficiency) as noted.

- The Technical Update estimated that Coloradoans use about 397,000 AF of water per year for outdoor uses, including irrigation on an estimated 167,800 acres of land. The total water savings associated with non-functional turf removal and the Turf Replacement Program represent 2.2 percent and 0.02 percent, respectively, of this statewide water delivery to outdoor irrigation.

- The water savings from turf removal/replacement is a tiny fraction of the water used to irrigate crops on over 3 million acres in Colorado. A typical center pivot can irrigate approximately 130 acres of land[12]; the total acreage enrolled in the first round of the Turf Replacement Program would cover less than half of

[11] Estimating the Reversion Rate for the Turf Removal Rebate Program: 2020 Update
[12] USDA-Agricultural Research Service Center Pivot Irrigation

the center pivot. A typical ranch that irrigates 100 acres of native grasses on the Western Slope to feed their cattle consumes about 150 AF of water[13], about twice as much as the net water savings from the first round of the Turf Replacement Program.

- Storage is critical in Colorado, allowing water providers to store water when it becomes available and then release it to meet year-round demands. There are losses associated with storage, primarily evaporation from the surface of the reservoir. Annual evaporation from Colorado's largest reservoir, Blue Mesa Reservoir in the Gunnison River basin, is about 8,000 AF[14]. This is 900 AF greater than the net water savings from non-functional turf removal and over a hundred times larger than the net water savings from the first round of the Turf Replacement Program.

- Water is also delivered for recreational purposes across Colorado. Coors Field uses approximately 30 million gallons of water each year[15], or approximately 92 AF, which is nearly equal to the estimated average water savings from the first round of the Turf Replacement Program. During the winter, approximately 5,630 AF of water is diverted for snowmaking purposes statewide according to the Technical Update. The total water savings from the Turf Replacement Program represent 1.6 percent of this statewide delivery for snowmaking. Much of the water at a waterpark is recycled and reused, but approximately 3 percent of the water used each day is lost to evaporation and splashes out of rides. A 100,000 square foot (2 acre) waterpark may lose between 125,000 to 160,000 gallons[16] per day or between 35 to 44 AF over the summer season in Colorado. This is approximately half of the estimated net water savings from the first round of the Turf Replacement Program.

- The Cache La Poudre River carries about 126,000 AF of water on average each year[17] through the City of Fort Collins, with peak flows of about 52,000 AF occurring in June. The peak streamflow in this one month is over 7 times greater than the net water savings from non-functional turf removal and about 700 times larger than the net water savings from the first round of the Turf Replacement Program.

Conclusions

As noted above, additional multi-year data is needed to fully understand and quantify the actual water savings from the variety of turf removal/replacement programs in Colorado. These estimates do not account for water providers and/or individual water users who choose to convert turf to water-wise landscape without applying for a rebate or assistance program. Additionally, these estimates do not include water savings from acreage that may not ever have turf landscapes. Colorado Senate Bill 24-005, signed in March of 2024, prohibits the installation of non-functional turf in many commercial, industrial, and transportation areas. Land use planning codes are also evolving to reduce the amount of turf installed in new municipal and commercial areas. These

[13] Average annual consumptive use of pasture grass and hay in the Upper Colorado River basin, based on Colorado Decision Support System Consumptive Use modeling.
[14] Bureau of Reclamation Upper Colorado Region Water Operations: Historic Data
[15] "MLB, Rockies Pledge to Refill Colorado River Water Supply After Year-Long Drought" by Andrew Cohen, Sports Business Journal. September 23, 2021.
[16] "Is Water Conservation at Waterparks considered Oxymoronic?" by Eric B. Hansen, AIA, ISHC, Hotel & Leisure Advisors.
[17] Cache La Poudre River at Fort Collins, Colorado (USGS 06752260) Streamflow Records

efforts, in conjunction with turf removal/replacement programs discussed above, can lead to a reduction in the amount of water delivered by the water provider for outdoor uses.

Based on the information available to date, however, net water savings associated with non-functional turf estimates may be as much as 11,278 AF each year statewide assuming full turf removal. Net water savings associated with the first round of the Turf Replacement Program may be about 75 AF. Turf removal/replacement is an important tool for water providers to reduce the amount of water delivered for outdoor irrigation. The net water savings expected from these programs, however, are small relative to water providers' total deliveries, water used for other purposes across the state, and the amount of water that flows through Colorado's rivers.

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