

Greeley Drought Emergency Plan

FINAL REPORT

Final Report

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Greeley Drought Emergency Plan

Prepared for

Greeley Water and Sewer Department

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EXECUTIVE SUMMARY

Greeley's water system includes a diversified portfolio of water rights and storage facilities and has a high degree of reliability. However, Greeley is located in a semi-arid climate where severe droughts occasionally occur. No water supply system is completely drought proof, but being able to provide adequate water supplies to Greeley's residents and businesses under any future climatic and hydrologic conditions is critical to the continued growth and prosperity of the City.

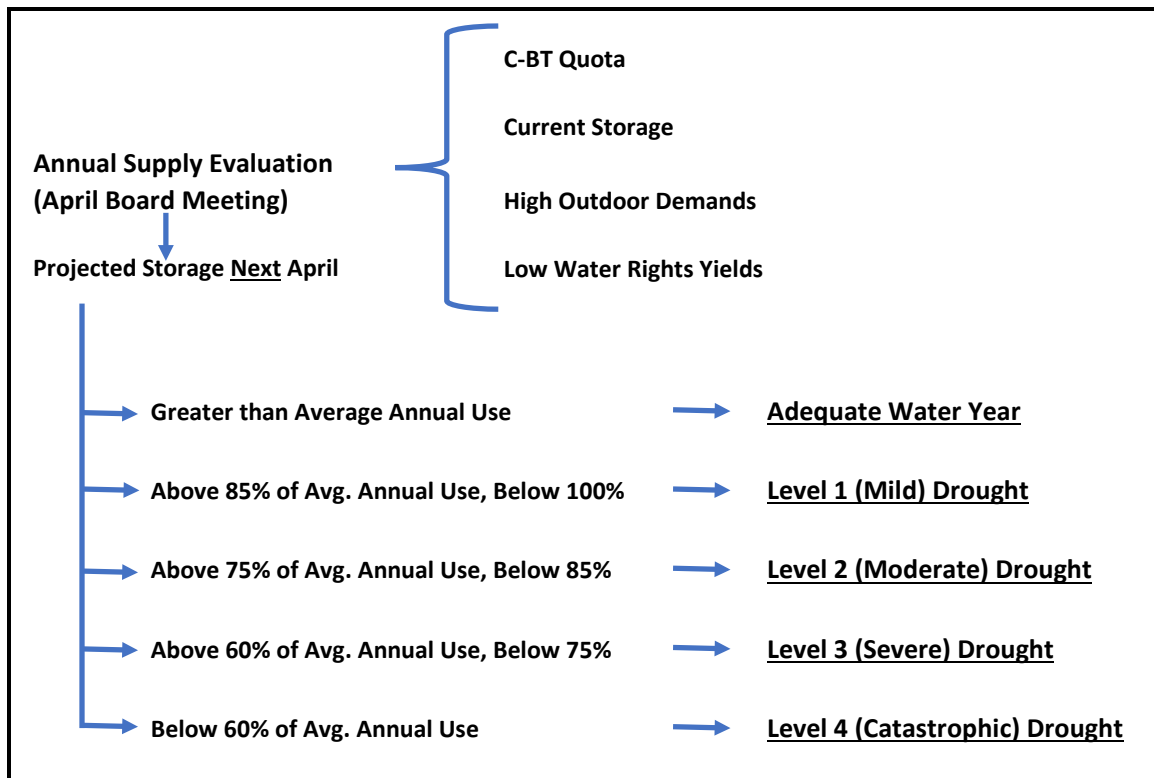
Greeley has successfully navigated previous droughts, including the most severe drought during the past few decades which was experienced in 2001-2003. However, Greeley needs an updated drought emergency plan for several reasons:

- Greeley's current drought emergency plan is more than 15 years old, with portions of the plan described in documents from 2003 and other portions dating back to 1997.
- During the past 15 years, Greeley's total annual water use has remained relatively consistent – despite substantial growth in the number of customers – but water use per account has declined substantially as Greeley's customers have become more efficient.
- Greeley's billing practices and rate structure have also changed, providing new opportunities for managing water use under drought conditions.

Drought Response Trigger and Declaration Process. Each April, shortly after the C-BT quota for the year has been established, Greeley's Water Resources staff will project the storage volume that will be available on April 1st of the following year under "conservative" assumptions of high outdoor irrigation demands from Greeley's customers (as has been typical under hot and dry conditions during years such as 2002 and 2012) and low yields from Greeley's water supplies. Based on that projection, Greeley will declare an adequate water year, or a drought under one of four potential levels. This process is summarized in Figure ES-1, on the following page. Water savings goals for each potential drought level are:

- **Level 1 (Mild) Drought:** reduce outdoor water use by up to 15 % (currently about 1,530 acre-feet) per year
- **Level 2 (Moderate) Drought:** to reduce outdoor water use by up to 25 % (currently about 2,560 acre-feet) per year
- **Level 3 (Severe) Drought:** reduce outdoor water use by up to 50 % (currently about 5,130) per year.
- **Level 4 (Catastrophic) Drought:** reduce outdoor water use by up to 70 % (currently about 7,170 acre-feet) per year.

Figure ES-1. Annual Greeley Water Supply Evaluation and Drought Declaration Process



Greeley may also decide to declare a mild drought and invoke the drought response measures discussed later in this plan if other adverse events that affect Greeley’s water supplies (for example if wildfires affect the watersheds that Greeley relies on), or in times when a regional drought response in Northern Colorado is deemed appropriate by the Board.

Important considerations in developing Greeley’s drought response strategies.

During the development of Greeley’s new drought emergency plan, the Water & Sewer Board and the members of the City’s Executive Leadership Team emphasized several objectives for the plan. These important objectives included:

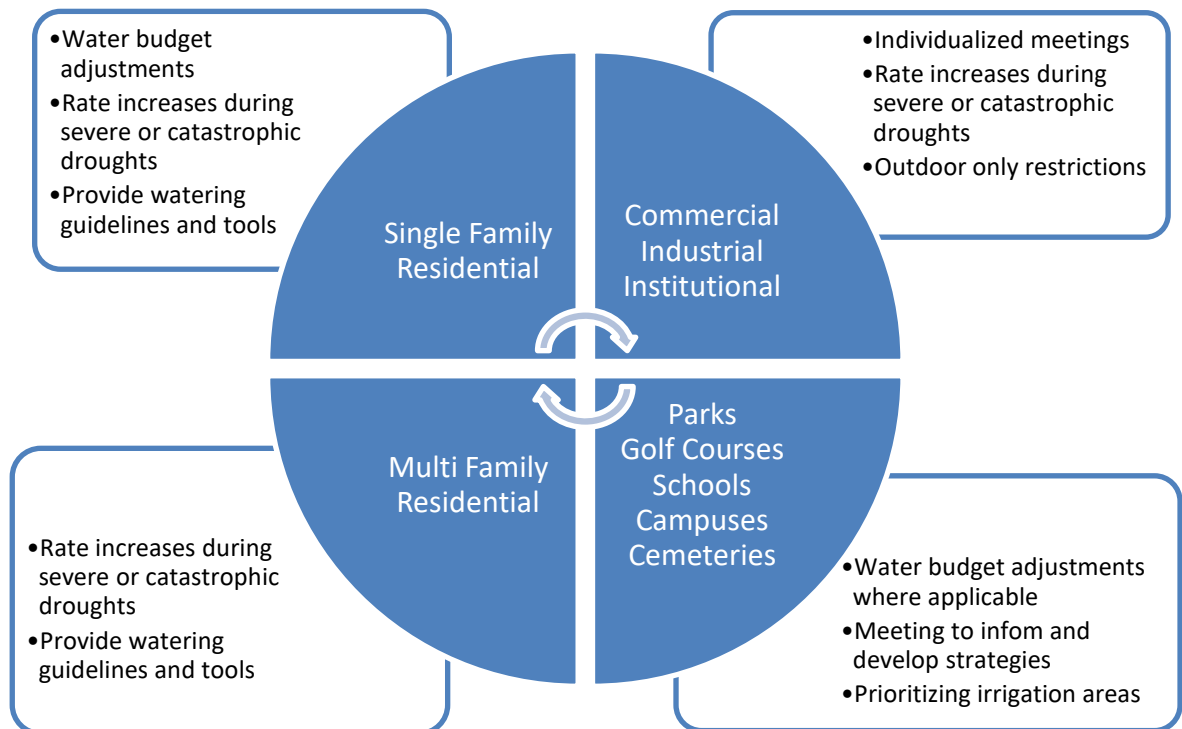
- **Equity among Greeley’s customers.** While outdoor water use by single family customers must be a focus for drought emergency water use reductions, other customer classes need to contribute their share to the City’s water savings.
- **Minimize impacts to landscapes.** Although drought-related water use reductions are likely to stress lawns in Greeley, modifications to water budgets and watering restrictions should be designed to avoid long-term damage to trees and other non-turf vegetation as much as possible.

- Minimize financial impacts to customers and the water utility.** Greeley examined potential financial impacts on different customer classes under drought conditions. In general, if customers meet the water savings goals, they will pay less than normal during drought conditions. If customers do not reduce their use, they will pay more – particularly under Level 3 (Severe) and Level 4 (Catastrophic) drought conditions.

Response Strategy for Each Drought Level. Greeley has identified a set of measures that can be used in response to each different level of drought emergency. As noted at the beginning of this section, every drought is different and the water savings from emergency drought measures can be difficult to predict – so Greeley will maintain the flexibility to modify the measures it puts in place based on evolving drought conditions and the degree of success achieved in reducing water use by its customers. Section III of the report provides detailed drought response measures for each potential drought level.

Public Awareness and Messaging. One of the most important elements of any drought response plan is timely and effective communication with customers to explain the situation and motivate the necessary changes in water use behavior. Improved technology, social media and other recent changes provide additional avenues for reaching and educating customers. Figure ES-2 summarizes key messages for each of Greeley’s customer groups. More detailed messaging strategies are discussed in Section III.

Figure ES-2. Summary of overall messaging strategies for Greeley’s different customer groups



Monitoring. After a drought has been declared, Greeley’s staff will provide regular updates to the Board. Those updates will include:

- Updated information regarding Greeley’s water supplies and storage;
- Identification of all drought response measures that have been invoked during the past month;
- Description of steps taken to communicate with Greeley’s customers, and a summary of public comments to date;
- Estimated reductions in water use as a result of the drought management effort; and
- Recommendations regarding any change in the drought status based on the preceding information.

Plan review and updates. The study team recommends Greeley review and consider updating this plan at least once in every five years. As indicated in Section III, the next few years are likely to see the implementation of new technology, such as AMI, that will make additional tools available to Greeley and its customers to help manage their water use. Greeley will also have more customers on water-budget based billing as all new dedicated irrigation accounts migrate to that type of rate structure. Opportunities to communicate with customers are also constantly evolving.

Apart from regular reviews and potential updates, the drought emergency plan should be particularly closely scrutinized following any period during which Greeley has to declare a drought emergency. Actual experience with the measures described in this plan will undoubtedly help inform refinements and revisions that can improve the plan’s effectiveness.

SECTION I.

Introduction and Background

Greeley Water and Sewer (Greeley or Greeley Water) currently supplies about 21,300 acre-feet (6.9 billion gallons) of water per year to more than 110,000 people, along with many commercial and industrial operations. Greeley continues to grow each year, and its population is projected to more than double by 2065. Under average weather conditions, about one-half of the total annual water use by Greeley's customers is for outdoor irrigation (including non-potable deliveries for irrigating parks, schools and other large outdoor areas). Absent intentional measures to reduce demand, outdoor water use increases to about 55 % of annual use under hot and dry conditions.¹ During the peak irrigation season from June through September, outdoor water use typically makes up about 70% of total use. That percentage increases under hot and dry conditions.

Greeley's water system includes a diversified portfolio of water rights and storage facilities and has a high degree of reliability. However, Greeley is located in a semi-arid climate where severe droughts occasionally occur. No water supply system is completely drought proof. The cost of acquiring water rights and developing water supply facilities that would only be used once in many decades would not be a prudent use of public funds. But, being able to provide adequate water supplies to Greeley's residents and businesses under any future climatic and hydrologic conditions is critical to the continued growth and prosperity of the City.

Need for a New Drought Emergency Plan

Greeley has successfully navigated previous droughts, including the most severe drought during the past few decades which was experienced in 2001-2003. However, Greeley needs an updated drought emergency plan for several reasons:

- Greeley's current drought emergency plan is more than 15 years old, with portions of the plan described in documents from 2003 and other portions dating back to 1997.
- During the past 15 years, Greeley's total annual water use has remained relatively consistent – despite substantial growth in the number of customers – but water use per account has declined substantially as Greeley's customers have become more efficient.
- Greeley's billing practices and rate structure have also changed:
 - Greeley converted from bi-monthly to monthly billing in April 2003, which means that financial signals to Greeley's customers are now more timely than they were during previous droughts.

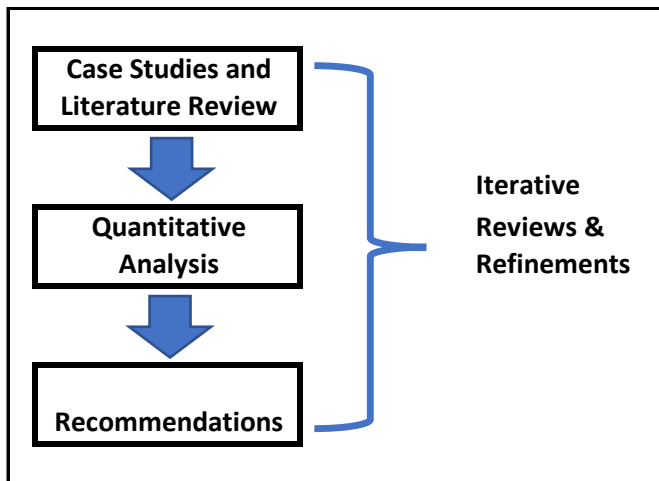
¹ City of Greeley Water Demand and Population Projections. BBC Research & Consulting. 2018.

- Greeley moved its single-family residential customers to water budget-based billing in 2017. Customer-specific water budgets provide Greeley’s residential water users with more information regarding optimal water use and financial disincentives for over-consumption.

Process of Developing the New Plan

Greeley’s new drought emergency plan was developed during a 12-month period, beginning in the Fall of 2019. The basic process of developing the new plan is illustrated in Figure I-1.

Figure I-1. New Drought Emergency Plan Development



Case studies and literature review. Greeley’s recent transition to water budget-based billing for single-family residential customers raised important questions for the development of this updated drought emergency plan. The study team reviewed the current drought plans of 17 water providers using water budget-based rates (13 in California and 4 in Colorado). We also conducted telephone interviews with eight of those providers (5 in California and 3 in Colorado) to gather insight on how water budget-based rates were incorporated into their drought plans and how those plans had performed under actual drought conditions (where applicable). Insights from these case studies are summarized in Section III of this report (Drought Response Strategies) and a more complete report on this research is provided in Appendix A.

The study team also conducted research regarding the potential impacts of drought response measures on the landscaping industry in and around Greeley by contacting and interviewing four landscaping businesses serving Northern Colorado.² Results from those interviews are also discussed in Appendix A.

Finally, the study team conducted a literature review of studies concerning the price elasticity of water demand, or the extent to which water use can be expected to decline if prices (e.g. rates) are increased during drought conditions. While that literature review did not uncover any

² The Lawn Barber, LLC; Northern Colorado Lawn; The Family Lawn and Highlands Landscaping and Fencing.

studies specific to utilities with water budget-based rates, it did provide information from studies which compared the elasticity of water demand under different types of rate structures, including inclining block rate (sometimes called conservation rate) structures. This information indicates that customers appear to be more responsive to changes in rates under these types of structures, and that heightened responsiveness likely applies to water budget-based rates as well. This research is also summarized in Appendix A.

Quantitative analysis. Potential financial impacts of drought response measures on Greeley's customers, as well as financial impacts on the utility itself, were important considerations in developing the updated drought response plan. The study team examined the potential financial effects from temporary changes to customers' outdoor water budgets under the various drought emergency levels, as well as the potential financial impacts from temporary changes in water rates (or drought surcharges) under drought conditions. We also examined the potential effects on Greeley's revenues when the emergency drought plan is implemented. Key results from these analyses are discussed in Section III.

Iterative reviews and refinements. The study team, including both the consultants and Greeley Water & Sewer Department staff, met in person and virtually (due to the Coronavirus pandemic) on numerous occasions during the 12-month period while the new drought emergency plan was being developed. Preliminary results and recommendations were discussed with the City's Executive Leadership Team in June 2020 and with the Greeley Water & Sewer Board (the Board) during August and October 2020 to receive feedback on the proposed drought plan recommendations.

SECTION II.

Identifying and Classifying Drought

Determining the need to implement emergency drought response measures, and which measures should be implemented, depends on both the projected availability of water supplies for Greeley's customers and the anticipated level of water use by those customers.

Greeley's Water Supplies

As one of the oldest cities in Northern Colorado, Greeley has a relatively robust water supply portfolio and continues to acquire new supplies to meet forecasted growth within its service area. The "firm yield"³ of Greeley's water supply portfolio is currently estimated to be about 40,000 acre-feet (AF) per year, substantially more than the current annual demand from Greeley's customers which has averaged about 21,300 AF per year since 2010.⁴ However, like other water providers, Greeley needs to maintain sufficient water supplies in storage to guard against the potential for severe and prolonged droughts.

The single largest component of Greeley's treatable water supplies is the more than 22,800 units Greeley owns in the Colorado-Big Thompson Project (C-BT units). The amount of water that these units will yield is determined annually by the quota set by the Northern Colorado Water Conservancy District which manages the C-BT project.

Drought Response Trigger and Declaration Process

Each April, shortly after the C-BT quota for the year has been established, Greeley's Water Resources staff will project the storage volume that will be available on April 1st of the following year under "conservative" assumptions of high outdoor irrigation demands from Greeley's customers (as has been typical under hot and dry conditions during years such as 2002 and 2012) and low yields from Greeley's water supplies.

If the storage volume on the following April 1st is projected to be greater than or equal to Greeley's average annual water demands (currently estimated to be 21,300 AF), Greeley's staff will recommend that the Board declare an "adequate water year" and allow water rentals at volumes that continue to maintain a projected target volume at or above 21,300 AF.

If the storage volume on the following April 1st is projected to be less than Greeley's average annual water demands (21,300 AF), staff will recommend that the Board declare a drought and implement the drought emergency plan.

³ Firm-yield is an estimate of the maximum amount of annual demand that can be served by the city's water supplies under a repeat of historic drought of record hydrologic conditions. However, long-term historical climate analyses indicate that more severe droughts than the drought of record have occurred in the past and will likely occur again in the future.

⁴ Based on annual water use by customer class tables produced by Greeley, excluding wholesale deliveries to Evans, Johnstown, Milliken and Windsor.

Drought Levels and Drought Response Goals

The severity of the drought, and the water savings goals from the drought response measures, will generally be based on the projected volume of water in storage on the following April 1st. For each drought level, the drought response goals will be to 1) avoid the drought condition worsening and Greeley's water supplies falling to a more severe drought level, and 2) strive to recover to adequate water conditions within a two-year period.

Level 1 – Mild Drought

Generally, Greeley will declare a mild drought when the projected volume of water in storage on the following April 1st is ***less than 100%, but greater than 85%*** of average annual water demands.

The goals of the drought response effort will be to **reduce outdoor water use by up to 15 % (currently about 1,530 acre-feet⁵) per year.**

Greeley may also decide to declare a mild drought and invoke the drought response measures discussed later in this plan for other reasons – such as other adverse events that affect Greeley's water supplies (for example if wildfires affect the watersheds that Greeley relies on), or in times when a regional drought response in Northern Colorado is deemed appropriate by the Board.

Level 2 – Moderate Drought

The projected volume of water in storage on the following April 1st is ***between 75% and 85%*** of average annual water demands

The goals of the drought response effort will be to **reduce outdoor water use by up to 25 % (currently about 2,560 acre-feet) per year.**

Level 3 – Severe Drought

The projected volume of water in storage on the following April 1st is ***between 60% and 75%*** of average annual water demands

The goals of the drought response effort will be to **reduce outdoor water use by up to 50 % (currently about 5,130 acre-feet) per year.**

Level 4 – Catastrophic Drought

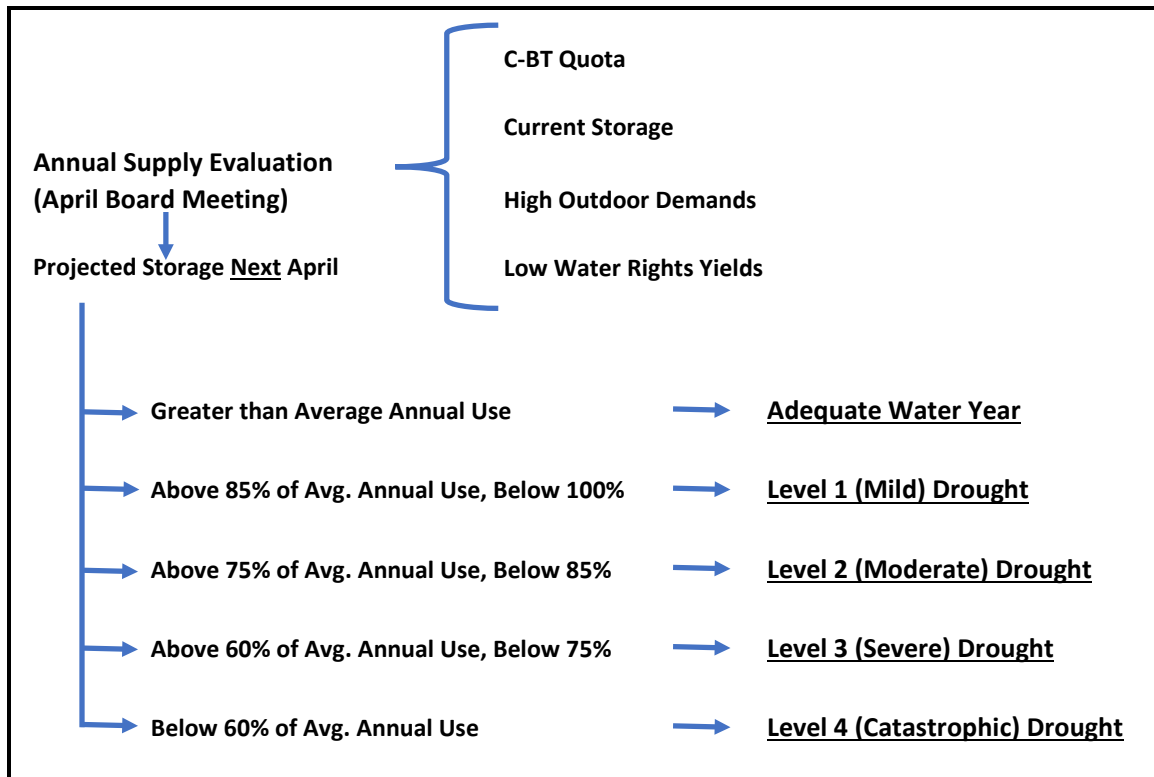
The projected volume of water in storage on the following April 1st is ***less than 60%*** of average annual water demands

⁵ All potential savings estimates are based on projected outdoor demands under hot and dry conditions – estimated to be 17 percent greater than outdoor demands under average conditions.

The goals of the drought response effort will be to **reduce outdoor water use by up to 70 % (currently about 7,170 acre-feet) per year.**

The annual water supply evaluation and drought declaration process is summarized in Figure II-1.

Figure II-1. Annual Greeley Water Supply Evaluation and Drought Declaration Process



SECTION III.

Drought Response Strategies

Uncertainty is one of the defining characteristics of drought. When a city enters a drought, it is impossible to accurately predict how long the drought may last, or how severe it may become. It is also difficult to project exactly how much water will be saved by individual drought response measures, such as outreach to customers, voluntary or mandatory restrictions on outdoor irrigation, reductions in water budgets, increases in rates or other policies and practices. Consequently, it is prudent to have an array of measures available for each drought level and flexibility to adapt as conditions change.

Fundamentally, Greeley can respond to drought in two overall ways – by seeking to increase its available water supplies and by encouraging customers to reduce their water usage.

Water Supply-related Measures

Historically, several of the water districts and rural communities within the region that do not have water supply portfolios as robust as Greeley’s have leased water from Greeley during periods of water shortage. Greeley also typically leases available water to provide a supplemental supply for local agricultural operations.

Consistent with Greeley’s long-standing policies dating back to its 1998 drought plan, leases of water supplies to other entities during a mild or moderate drought will require approval of the Board. No water will be leased to other entities during a severe or catastrophic drought.⁶

Water Demand-related Measures

In order to identify and recommend potential measures for reducing water demand during drought, the study team reviewed Greeley’s previous drought experience. We also gathered information from other water suppliers using water budget-based rates similar to those Greeley adopted in 2017. Finally, we considered a number of other priorities important to Greeley and its customers, including:

- Flexibility and adaptability to changing conditions;
- Avoiding or minimizing long-term damage to landscaping;
- Sharing the burden between customer classes;
- Minimizing financial impacts on customers; and
- Minimizing financial impacts on the water utility

⁶ City of Greeley Drought Emergency Plan. Tuttle Applegate, Inc. June 1998.

Greeley’s previous drought experience. Greeley’s most severe extended drought on record occurred during the 1950s. Given the tremendous changes over the past 60 years in Greeley’s development, and its water supply portfolio, the more relevant experience for current drought response planning is the 2000-2003 drought. The year 2002, in particular, was the worst year for water supply in Greeley’s region during the past 300 years, according to tree ring studies, and included the lowest snowpack ever recorded.⁷

The primary tools that Greeley used to reduce demand during the drought of the early 2000s were an extensive public awareness and education effort, time-of-day and number of days-per-week watering restrictions. Greeley also considered implementing “conservation rates” in 2003 which included a 20 % increase for outdoor use up to normal irrigation volumes and another 20 % increase for usage above normal irrigation volumes⁸, but appears to have been able to avoid taking this step – likely due to the major snowstorm in the Spring of 2003.

Figure III-1 provides a summary of the history of watering restrictions in Greeley from 2000 through 2019. As shown in the figure, Greeley began increasing its restrictions in 2002, and then further restricted use during 2003 before beginning to ease restrictions from 2004 forward. It is notable that Greeley has a much longer history of restricting outdoor water use, having invoked a policy limiting watering to every other day that dates back to 1907.

⁷ Greeley’s 2003 Drought Plan. PowerPoint Presentation.

⁸ Ibid.

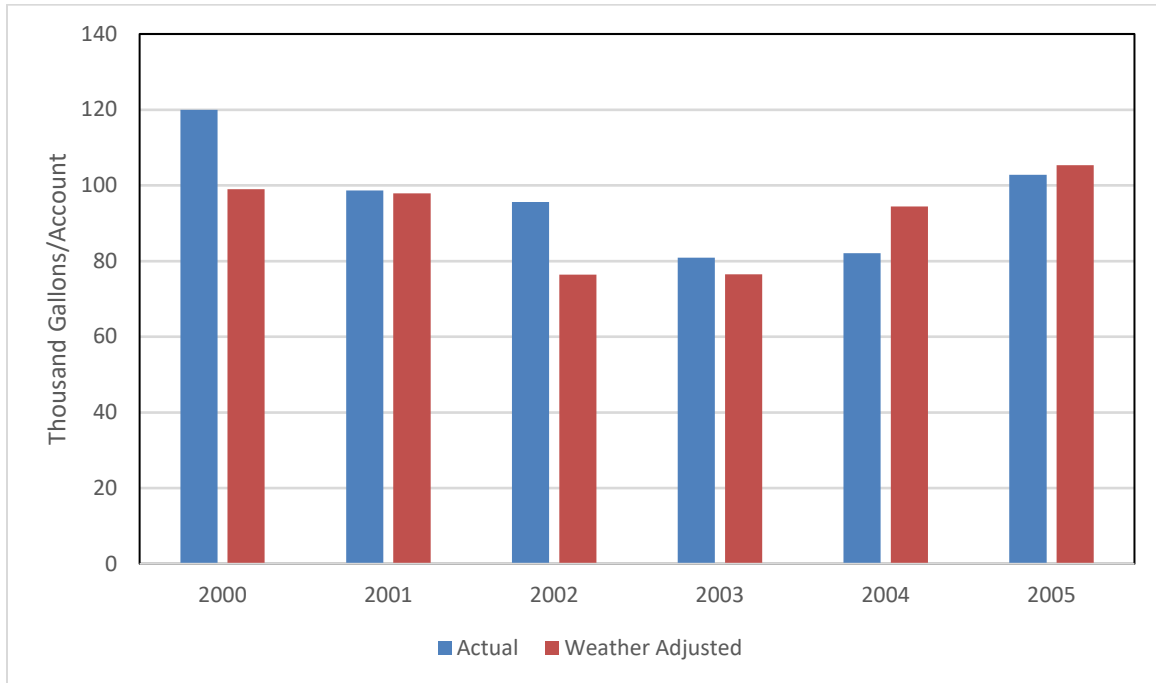
Figure III-1. Summary History of Watering Restrictions in Greeley, 2000-2019

Time Period	Watering Limitations (Changes shown in Bold)
2000-2001	All Customers: Every other day All Customers: No watering 1 PM to 5 PM
2002	All Customers: Voluntary, once every three days, July 13 to end of season All Customers: No watering 1 PM to 5 PM
2003	All Customers: No watering Jan 1. to April 15 All Customers: 1 day per week April 16 through May 15 All Customers: 2 days per week May 16 through September 15 All Customers: 1 day per week September 16 through October 15 All Customers: No watering after Oct. 15 All Customers: No watering 10 AM to 6 PM
2004	All Customers: No watering Jan 1. to April 15 All Customers: 1 day per week April 16 through May 15 All Customers: 2 days per week May 16 through June 14 All Customers: 3 days per week June 15 to end of season All Customers: No watering 10 AM to 6 PM
2005-2017	All Customers: 3 days per week, No watering Noon to 5 PM
2017-2019	Single Family Residential: Water Budgets Other Classes: 3 days per week, No watering Noon to 5 PM
2020	Single Family Residential: Water Budgets Other Classes: 3 days per week All Customers: No watering 10 AM to 6 PM

Source: Greeley Water & Sewer Department, 2020.

The combination of outreach, restrictions and rate increases during the early 2000s was effective in reducing water use. As shown in Figure III-2, when adjusted for year-to-year weather variation, outdoor water use by Greeley’s single-family residential customers declined from an average of nearly 100,000 gallons per household per year in 2001 to less than 80,000 gallons per year during 2002-2003. After the drought ended and restrictions were eased, Greeley’s average outdoor residential water use gradually returned to about 100,000 gallons per year by 2005. (Note that average outdoor use has declined substantially since 2005 due to Greeley’s water conservation program and other factors).

Figure III-2. Average Outdoor Annual Single-Family Residential Water Use per Account, 2000-2005



Source: BBC Research & Consulting based on data from 2018 Greeley Water Demand Model files.

While Greeley was able to reduce demand during the early 2000's drought, the region was also fortunate that the drought was substantially mitigated by a large snowstorm in the Spring of 2003 which helped replenish reservoirs and increase stream flows. The earlier 1950s drought-of-record demonstrates that droughts can be much more persistent than the early 2000s experience.

Other water providers with water budget-based rates. As noted in Section I, the study team collected and analyzed drought plans from other utilities with water-budget rate structures. The objective of the review was to examine how the drought plans of other municipal utilities use their water-budget rate structures, along with other measures, to reduce water use during times of drought.

In total, drought plans for 17 utilities with water budget-based rates were reviewed including four utilities in Colorado and 13 utilities in California (Figure III-3). More in-depth interviews were conducted with eight utilities to explore drought management topics in further detail.

Figure III-3. Utilities with Drought Plans and Water-Budget Rate Structures

Utility	Drought Plan Reviewed	Interview Conducted
Colorado Utilities		
City of Boulder	Yes	Yes
Castle Pines N. Metro District	Yes	
Town of Castle Rock	Yes	Yes
Centennial WSD	Yes	Yes
California Utilities		
Western Municipal WD	Yes	Yes
Santa Margarita WD	Yes	
City of Santa Cruz	Yes	
Rancho WD	Yes	Yes
Palmdale WD	Yes	
Moulton Niguel WD	Yes	
Las Virgenes WD	Yes	
Irvine Ranch WD	Yes	
Elsinore Valley MWD	Yes	Yes
El Toro WD	Yes	
Eastern Municipal WD	Yes	Yes
City of Corona	Yes	
Coachella Valley WD	Yes	Yes

The California utilities we interviewed have experienced drought since adopting their water-budget rate structures. They consistently cited reductions in their customers' water budgets as important factors in reducing their overall water use during drought conditions.

While most utilities decrease the water budgets of their customers during droughts, our interviews also indicated that the selection of water use reduction measures are influenced by a number of other considerations. In particular, utilities emphasized the importance of including a variety of water use reduction measures in each drought stage to provide water managers with the flexibility they need to achieve pre-defined water use reduction targets.

During droughts, utilities need to achieve rapid reductions in municipal water use. This creates a trade-off between the effectiveness and timeliness of measures. Measures like offering rebates for the installation of efficient fixtures or drought-tolerant landscaping are effective at reducing water use over the medium and long terms, but are less effective at reducing water use in the short term, which is why utilities do not use these types of measures in their drought plans.

Many utilities consider public awareness to be the most timely and effective measure to reduce water use. Changes to water budgets – and the corresponding water rates – are also considered to be effective in reducing water use. Initially, reductions in the water budgets can reinforce the utility's public awareness effort by communicating the specific reduction in water use needed from each individual single-family household. The financial signal from changes in water budgets is less timely since there is generally a lag of at least a month between the time the water budget is reduced and the time when the customer sees the impact in an increased water bill. As a

result, many utilities use a combination of public awareness and changes to water budgets to reduce the lag.

When utilities reduce water budgets, they typically begin by reducing the outdoor portion in an effort to limit impacts on their customers. Like Greeley, outdoor water use is generally the largest and most discretionary component of municipal water use for the other utilities we examined. Outdoor irrigation is the easiest water use to curtail without having large impacts on customers lifestyles and their perceptions of utility performance. Generally, utilities will fully curtail outdoor use before reducing indoor water budgets.

In addition to reducing customers’ water budgets, many utilities also use non water-budget measures to reduce water use during droughts. Figure III-4 shows a sample of the water use reducing measures we noted from the drought plans of other utilities under increasingly severe drought stages. Notably, the severity of the measures increases with the severity of the drought stage. As noted above, preserving flexibility by including multiple measures at each drought stage was important to each of the utilities we contacted.

Figure III-4. Examples of Non-Water-Budget Measures to Reduce Water Use During Drought

Stage 1	Stage 2	Stage 3	Stage 4-5
Public information campaign	Public information campaign	Public information campaign	Public information campaign
Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code
Outdoor conservation efforts	Drought surcharges on rates	Drought surcharges on rates	Drought surcharges on rates
Leak audits	Voluntary restriction of certain outdoor uses	Mandatory restrictions of certain outdoor uses	No new potable water connections
Outdoor watering time restrictions	Irrigation audits	Eliminate municipal uses like street cleaning	No new landscape
Postpone landscape changes	No proactive water service by restaurants	No personal car washing	No irrigation for municipal facilities

Source: Drought plans and interviews with other providers using water budget-based rates.

Important considerations in developing Greeley’s drought response strategies.

During the development of Greeley’s new drought emergency plan, the Board and the members of the City’s Executive Leadership Team emphasized several objectives for the plan. These important objectives included:

- **Focus on education, particularly during level one and level two drought emergencies.**
Greeley believes that its customers will respond appropriately to drought emergencies if they are provided with the information to understand the situation and how they can contribute to the solution. As discussed later in this report, that type of response was demonstrated during the drought of the early 2000s..
- **Equity among Greeley’s customers.** While outdoor water use by single family customers must be a focus for drought emergency water use reductions, other customer classes need to contribute their share to the City’s water savings.

- **Minimize impacts to landscapes.** Although drought-related water use reductions are likely to stress lawns in Greeley, modifications to water budgets and watering restrictions should be designed to avoid long-term damage to trees and other non-turf vegetation as much as possible.
- **Minimize financial impacts to customers and the water utility.** Potential financial impacts are discussed further at the end of this section.

Response Strategy for Each Drought Level

Greeley has identified a set of measures that can be used in response to each different level of drought emergency. As noted at the beginning of this section, every drought is different and the water savings from emergency drought measures can be difficult to predict – so Greeley will maintain the flexibility to modify the measures it puts in place based on evolving drought conditions and the degree of success achieved in reducing water use by its customers.

At present, only single-family residential customers, and newer dedicated irrigation accounts, are on water-budget based billing. Those customers will be notified of specific changes to their individual outdoor water budgets, and provided with recommendations about how to reduce their outdoor water use to remain within their budget. Examples include changes in the number of days per week and/or changes in the duration of irrigation for lawns, trees and other landscape.

Eventually, Greeley may extend customer-specific water budget-based billing to its other customer classes. Until that occurs, Greeley will rely on the same types of restrictions on outdoor irrigation and other outdoor water uses that it has successfully used in the past for these other customer groups.

Figures III-5, on the following page, identifies Greeley’s recommended response measures for water budgets and landscape irrigation restrictions for each of the potential drought levels. Greeley’s philosophy in developing these response measures was to build on what has worked in the past (including the use of watering restrictions similar to those implemented during the drought of the early 2000s), while taking advantage of the new opportunities presented by its water budget-based billing for single family residential customers. The objectives described previously also helped define the selection of appropriate measures.

Figure III-5. Greeley Drought Response Measures – Water Budgets and Landscape Restrictions

GREELEY DROUGHT RESPONSE PROGRAM 2020					
With a two year recovery period	Adequate Yr	Mild	Moderate	Severe	Catastrophic
LEVEL OF RESPONSE	no drought	1	2	3	4
Target Storage	100%	85% to 99%	75% to 84%	60% to 74%	Less than 60%
Target Reduction (outdoor)	0%	15%	25%	50%	70%
Target Storage (in AF)	21,300	18,100	16,000	12,800	10,700
Annual Outdoor Reduction Goal	normal conservation	1,530	2,560	5,130	7,170
MEASURES					
Water Budget and Restrictions					
Single Family Residential on Water Budget		15%	25%	50%	70%
Proposed Water Budget Reduction	0%	15%	25%	50%	70%
Recommended Schedule Suggested Days		max 3 days/week	2 days/week	1 day/week	
Multi Family & HOA Not on Water Budget	mand. 3/wk	max 3 days/week	2 days/week	1 day/week	no watering
Reductions in Use	0%	15%	25%	50%	70%
Commercial Industrial Institutional (ICI)	mand. 3/wk	3 days/week	2 days/week	1 day/week	no watering
Reduction on Landscape Water Same as SFR	Normal conservation	15%	25%	50%	70%
Restrictions Landscape (Non Water Budget)					
Lawns/Turf	set day /week 3 days/week	no irrigation until May1 or after Sept. 30	irrigation May-Oct; 1"/week	no watering in July; let go dormant	no watering June 15-Aug 15
Non-watering Hours	10am-6pm	10am-6pm	10am-6pm	8am-8pm	8am-8pm
Installing New Lawns & Watering Permits	yes w/soil prep	yes w/soil prep	not June-Aug	not June-Aug	none
Multi Family	3 days/week	3 days/week	2 days/week	1 day/week	no watering
Large Properties with > 4 acres of Turf Need to Submit a Water Budget to Get a Watering Variance	3 days/week	1.5"/week WB	1.0"/week WB	only enough to keep it alive	not allowed
Trees and Shrubs				on days or drip or by hand	
Vegetable Gardens				on days or drip or by hand	
Flower Gardens				on days or drip or by hand	
Non Potable Ditch Water (city system)				follow restrictions or restrictions due to delivery	
Non Potable Ditch Water (private)				cannot regulate	
Well Water				cannot regulate	

Figure III-6, on the following page, highlights Greeley’s recommended response measures for other outdoor uses.

Figure III-6. Greeley Drought Response Measures – Other Outdoor Water Uses

GREELEY DROUGHT RESPONSE PROGRAM 2020					
With a Two Year Recovery Period	Adequate Yr	Mild	Moderate	Severe	Catastrophic
LEVEL OF RESPONSE	No drought	1	2	3	4
Other outdoor Uses (hosing and washing)					
Home Car Washing	with BMPs and no runoff	bucket & shut off	bucket & shut off	commercial car wash	commercial car wash
Frequency		1x/week	1x/month	not allowed	not allowed
Washing Sidewalks, Driveways, Garages or Other Pavement		prohibited except for health or safety			not allowed
Siding on Houses, Patios, Decks		only in prep. for painting/staining 1 x per year with power washer			not allowed
Fleet Washing at Auto Dealerships/Mobile		1x/week	1x/month	not allowed	not allowed
Car Washes -Fundraising		prohibited except at commercial carwashes			
Commercial/restaurant/fast food					
Drive Thru/Sidewalk		prohibited except for health or safety			only with a bucket & broom
Parking Lot		prohibited			
Fountains/Ponds/Spas					
Water Fountains (w/o fish)		unrestricted	no topping off	no water	no water
Public		unrestricted	no topping off	no water	no water
Private		unrestricted	unrestricted	no topping off	no topping off
Ponds with Fish or Plants		unrestricted	unrestricted	unrestricted	topping only to preserve fish
Swimming Pools and Spa's Private		unrestricted	Unrestricted	not allowed	not allowed
Semi-Private Neighborhoods		unrestricted	Unrestricted	not allowed	not allowed
City Pools		unrestricted	Unrestricted	no topping off	no topping off
City Uses					
City Parks /Athletic Fields		water budget	water budget cut	prioritize athletic fields only	
Golf Courses		10-20% cut back	10-20% cut back no watering roughs	max 1"/wk for tees and greens only	max 1"/wk for tees and greens only
City Facilities & Around Buildings		3 days/wk	2 days/week	1 day/week	no watering
Street Cleaning/Parking Lots with Trucks		unrestricted	unrestricted	restricted to essential situations	
Hydrant Flushing & Testing		unrestricted	limited to critical situations		
Washing Fleet Vehicles & Mobile Washers		1 x /week	every other week	1 x /month	none

Financial Impact Analysis

Apart from concerns about maintaining adequate water supplies, reducing water use during drought conditions can also adversely affect the financial condition of municipal water providers. Absent modifications to water rates or drought surcharges, utility revenues typically decline much more during drought emergencies than is offset by any reductions in operating costs from providing less water.

Temporary increases in water rates or drought surcharges can serve two purposes. These measures help reduce the water provider’s financial vulnerability during droughts. They also can send important financial signals to customers that reinforce the need to conserve water. A recent study of the drought experience of California and Texas water providers recommended: “Adopt surcharges early. Increasing rates is often the most effective tool for achieving water savings.”⁹

As noted earlier, Greeley’s leadership is concerned about the financial impacts of droughts on the water system, but also is concerned about the financial impacts on Greeley’s customers. In order to balance these concerns, Greeley plans to only increase water rates during severe or catastrophic droughts (Levels 3 and 4). Under Level 3 drought conditions, Greeley may increase its rates for the outdoor irrigation water budgets of its single-family customers by 25%, as well

⁹ Use and Effectiveness of Municipal Irrigation Restrictions During Drought. Alliance for Water Efficiency. January 2020.

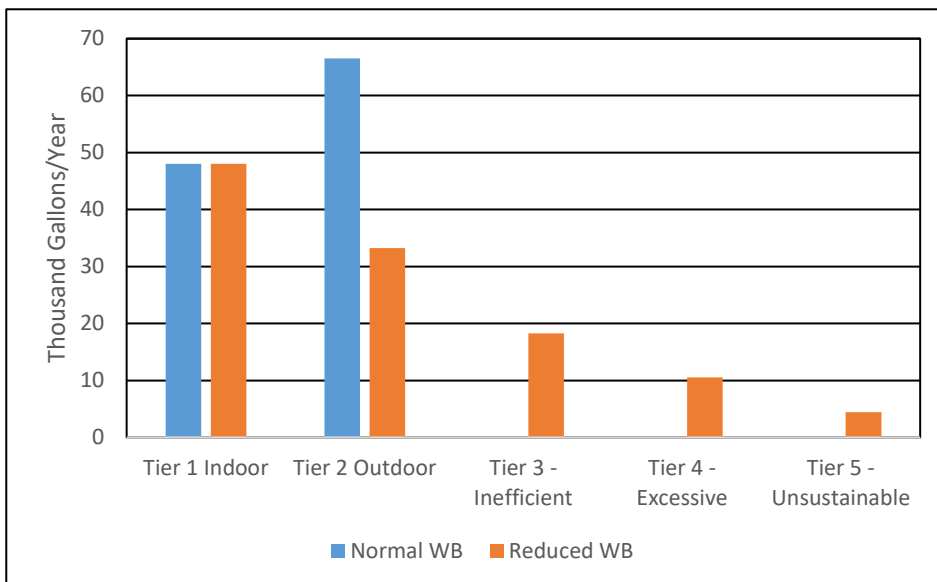
as the rates for its other customer classes. Under Level 4 drought conditions, Greeley may increase its rates for both customer groups by 35%.

Financial effects on Greeley’s customers. Due to differences in Greeley’s rate structure, and differences in the proportion of water that is used outdoors by different customer classes, drought response measures would have different degrees of financial impact on different types of customers. In general, however, under the new drought emergency plan all customers would pay less than normal if they reduce their outdoor use to meet the water savings objectives described previously. Under the more severe drought levels (Level 3 and Level 4) customers would pay considerably more than normal if they do not reduce their water use.

Single-family residential customers. The combination of reducing single-family residential outdoor water budgets and increasing rates for outdoor use during drought conditions can send a particularly strong financial signal to the single-family residential customers who make up the majority of Greeley’s outdoor water use. Because of the water budget-based rate structure, single-family customers will have the strongest financial incentives to meet the target reductions in outdoor water use.

Figure III-7 depicts the potential effects of a Level 3, 50% reduction in the outdoor water use budget for a typical single-family customer in Greeley if that customer does not reduce their water use. With the reduced water budget, half of the customer’s water use that would have normally been billed under Tier 2 (Normal outdoor use) would now be billed under Tiers 3, 4 and 5 which have substantially higher rates. (Note that this analysis is based on the five-tier water budget structure that Greeley plans to implement once its new Customer Information System is in place, rather than the four-tier system that was in place as of 2020.)

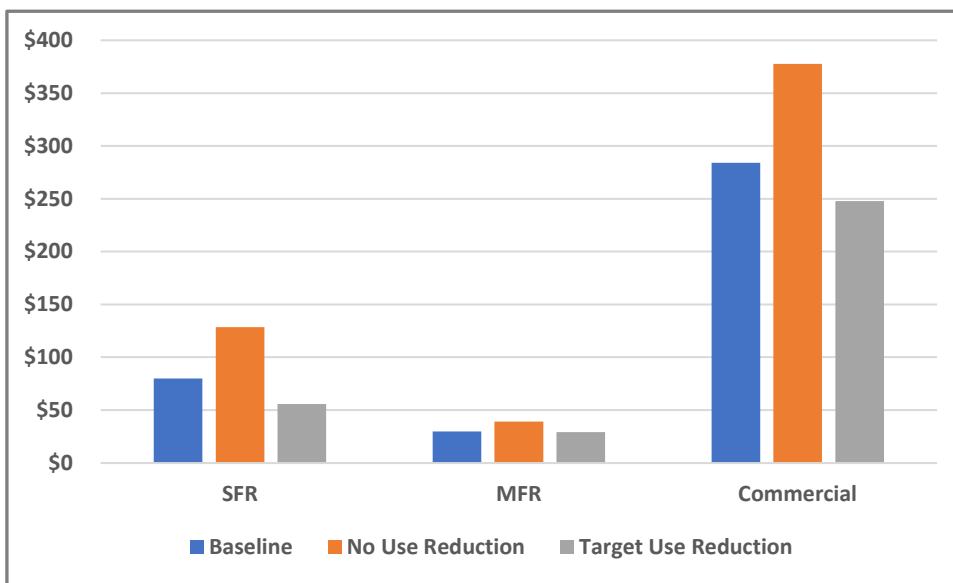
Figure III-7. Illustration of Effects of Level 3 Reduction in Water Budget if the Customer Does Not Reduce Their Water Use



Other customers. Greeley’s other customer classes do not have separate rates for indoor and outdoor use. Consequently, the potential rate increases under Level 3 (Severe) drought conditions and Level 4 (Catastrophic) drought conditions would not send as strong a financial signal for these customers. However, like the single-family residential customers, commercial and multi-family residential customers would generally pay less than normal if they reduce their water use to meet the drought savings objectives, and would pay more than normal under Level 3 and Level 4 droughts if they do not. The potential rate increases for these customers under the more adverse drought levels would also help offset some of the loss in revenue that Greeley Water could experience under these drought conditions.

Figure III-8 depicts the potential effects on average monthly water bills during the irrigation season for different types of customers under a Level 4 drought. As shown previously, under this catastrophic drought condition, single-family residential outdoor water budgets would be reduced by 70 % and the rates for outdoor water use (by single-family customers) and all water use (for other customer classes) would be increased by 35 %.

Figure III-8. Average Monthly Bill During Irrigation Season Under Level 4 Drought for Different Types of Customers – With and Without Reduction in Outdoor Water Use



If customers do not reduce their water use under Level 4 (Catastrophic) conditions, the prototypical single-family customer would see a 60% increase (\$48) in their monthly bill during the irrigation season. If they do reduce their water use to meet the drought response goals, they would see a 30% decrease (-\$24) relative to their normal bill during the irrigation season.

The average irrigation season monthly bill per multi-family residence would increase by about 30% (\$9) if they did not reduce their water use, but would decrease slightly (-\$1) if they do reduce their use to meet the drought response objectives. The financial signals are a little stronger for commercial customers – a 33% increase (\$94) per month if they do not reduce their use compared to a 13% reduction (-\$36) if they do reduce their use to meet the drought response goals.

Financial Effects on Greeley Water. Meeting the water use reduction objectives in Greeley's drought emergency plan will reduce Greeley Water's revenues, even with the anticipated rate increases under Level 3 or Level 4 drought conditions. Overall:

- Greeley Water's revenues are projected to be reduced by between \$240,000 and \$630,000 per month during the irrigation season under the varied levels of drought conditions
- Annual revenues are projected to be reduced by \$1.6 to \$3.0 million per year (4 to 8 % of normal revenue) during drought response
- Greeley plans to implement and gradually accrue a drought reserve fund for future use in mitigating reductions in revenues due to decreased water sales during drought emergencies

The anticipated rate increases under Level 3 or Level 4 droughts substantially reduce the potential financial impacts on Greeley Water. Absent those rate increases, annual revenues could decline by as much as 21 % under a Level 4 drought. Although Greeley Water would experience some reduction in variable costs (such as electricity and chemical costs) due to providing less water, those financial savings would be very small compared to the projected reductions in revenues.

Public Awareness and Messaging

One of the most important elements of any drought response plan is timely and effective communication with customers to explain the situation and motivate the necessary changes in water use behavior. Improved technology, social media and other recent changes provide additional avenues for reaching and educating customers.

Communication during the 2002 drought. During Greeley's last significant drought, Greeley Water successfully used a number of techniques to reach its customers, including:

- Bill stuffers to educate customers and provide updates
- Direct mail to every household
- Regular updates to the Greeley Water website
- Media outreach including the local newspaper, radio spots and Greeley TV
- Photos to tell the story of the drought
- Public meetings, and
- Participation in existing community events

New opportunities. Greeley now has, or soon will have, a number of additional tools and means to educate customers and encourage water savings during droughts. These include:

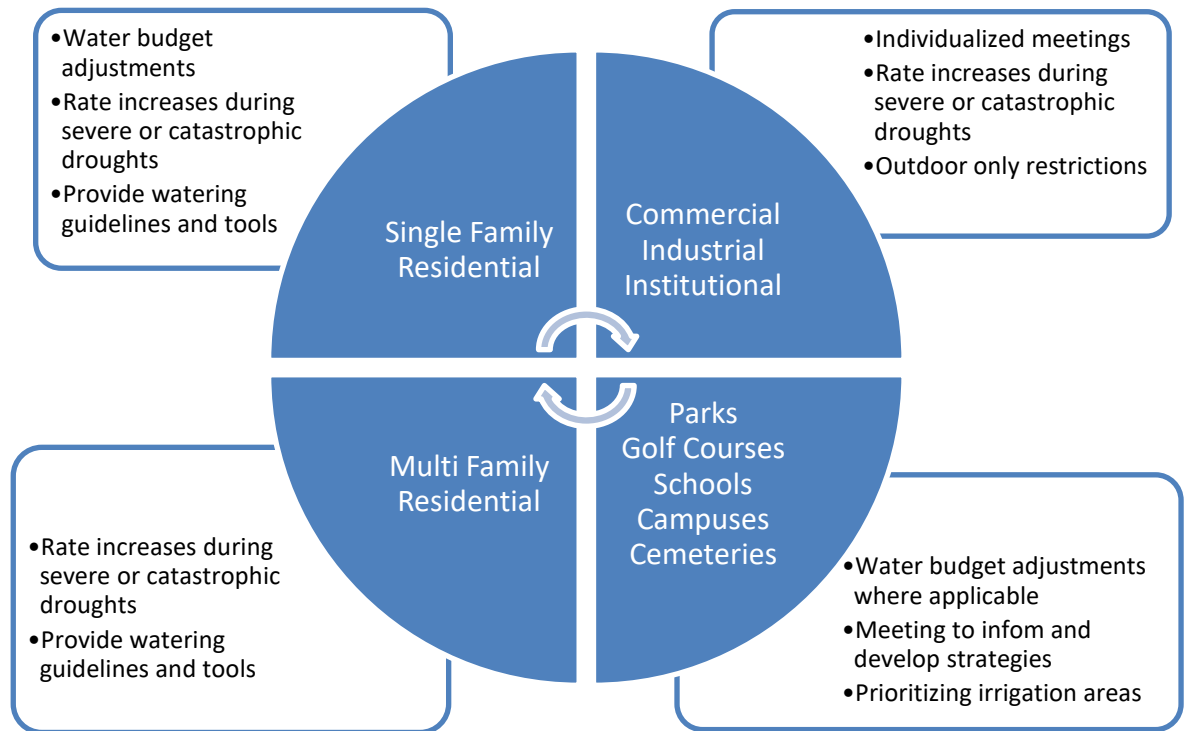
- A new and improved billing system
- Single-family residential water budget-based billing which will provide more specific and frequent updates on progress in reducing water use
- Advanced Metering Infrastructure (AMI) which will make real time water use information available to Greeley's customers
- Greeley's WaterSmart customer portal
- Social media presence on outlets such as Facebook, Twitter and NextDoor
- An improved website with E Newsletters and blogs
- A simplified and accessible executive summary of Greeley's new drought emergency plan

Messaging. Tailored messaging to different types of customers is at least as important as the vehicles for communication. All customers will receive:

- Clear and timely communication
- Updates as situation progresses or doesn't
- Watering restrictions and/or guidelines
- Rebates on water efficient products
- Audits-indoor and out
- Leak Detection
- AMI metering information

The following graphic summarizes the messaging strategies for different customer groups.

Figure III-9. Summary of overall messaging strategies for Greeley’s different customer groups



Specific messaging to Single Family Residential Customers. Greeley’s key messages for single family water users will include:

- Water budgets will be used as a tool by giving each customer a consumption target to aim for:
 - Indoor budget will not be affected
 - Reduced outdoor water use will save the customer money if they stay within their outdoor budget
- Guidance regarding the number of days per week/hours per day to water and stay within the outdoor water budget
 - These will be similar to the recommendations for non-water budget customers
- Explanation of effects on outdoor landscaping that can be expected

- Other tools to achieve reduction goals:
 - Adjusting sprinkler controllers
 - Alternative landscaping
 - Audits/rebates

Messaging to Multi-family Residential and Commercial Customers. Key messages for these customers will include:

- Days of the week watering restrictions
- Solutions to help businesses cut back on water use where possible
- Availability of audits and leak detection programs
- Potential rate increases only under level 3 and level 4 droughts to incentivize savings
- Future commercial customers will receive an outdoor tap and a water budget

Communication with Large Industrial Customers. Greeley will work with its large industrial customers, including:

- Scheduling meetings to understand water use processes and find ways to conserve use
- Providing incentives
- Offering audits, and
- Outdoor watering restrictions, if applicable

Communication with Parks, Golf Courses, Schools and Campuses. Greeley will also communicate with these large outdoor water users, including:

- Providing reduced water budgets for parks and golf courses
- Describing potable and non-potable watering restrictions for each of these customer groups
- Messaging that watering restrictions will become progressively more restrictive for more severe drought levels
- Holding meetings to develop solutions for adjusting watering practices, such as prioritizing irrigation areas

SECTION IV.

Implementation, Monitoring, Plan Review and Updates

Greeley’s new drought emergency plan will be implemented when necessary based on current and anticipated water supply conditions. When droughts occur, ongoing monitoring of water supply and demand conditions will be critical for managing Greeley’s drought response.

Implementation. Greeley has traditionally evaluated its water supply each April by making a forward-looking assessment of future water storage volumes for the following April. This assessment is based on conservative assumptions of low yields from its water supply portfolio and high demands associated with potential hot and dry conditions during the oncoming irrigation season. This process of declaring an “adequate water year” if future supplies appear sufficient – as indicated by a projected storage volume greater than average annual water use – will continue under this new drought plan. However, if future water supplies do not appear to be sufficient based on the projected future storage criteria, Greeley will declare a drought emergency and identify the appropriate drought level as described in Section II.

Monitoring. During a drought emergency, Greeley’s staff will provide monthly updates to the Executive Leadership Team and the Board. Those updates will include:

- Updated information regarding Greeley’s water supplies and storage;
- Identification of all drought response measures that have been invoked during the past month;
- Description of steps taken to communicate with Greeley’s customers, and a summary of public comments to date;
- Estimated reductions in water use as a result of the drought management effort; and
- Recommendations regarding any change in the drought status based on the preceding information.

Quantifying reductions in water use during drought can be challenging. Often, as during the 2002 drought, low snowpack and streamflow due to dry winter conditions are followed by hot and dry weather conditions during the following irrigation season. Absent drought management efforts such as those described in this drought plan, those weather conditions would typically result in larger than normal outdoor water use.

The effects of the drought emergency plan should be measured against baseline water use estimates that account for increased outdoor demand under hot and dry conditions. Because Greeley already calculates weather-specific daily irrigation water requirements to modify its single-family residential customers' outdoor water budgets based on weather conditions, it has the tools necessary to estimate what outdoor water use would have been had the drought management measures not been in place.

Plan review and updates. Historically, Greeley has not updated its drought emergency plan on a regular basis because it has not needed to do so. Although Greeley has experienced hot and dry years, such as 2012, since the previous drought plan was developed, there has not been a significant drought since the early 2000s.

The study team recommends Greeley review and consider updating this plan more frequently, at least once in every five years. As indicated in the Section III, the next few years are likely to see the implementation of new technology, such as AMI, that will make additional tools available to Greeley and its customers to help manage their water use. Greeley will also have more customers on water-budget based billing as all new dedicated irrigation accounts migrate to that type of rate structure. Opportunities to communicate with customers are also constantly evolving.

Apart from regular reviews and potential updates, the drought emergency plan should be particularly closely scrutinized following any period during which Greeley has to declare a drought emergency. Actual experience with the measures described in this plan will undoubtedly help inform refinements and revisions that can improve the plan's effectiveness.

Appendix A.

Supplemental Research

MEMORANDUM

To: City of Greeley Water and Sewer Board
From: BBC Research & Consulting
Re: Review of Municipal Drought Plans Under Water-Budget Rate Structures
Date: May 1, 2020

Background

As part of BBC's work for Greeley to develop an updated drought plan, we collected and analyzed drought plans from other utilities with water-budget rate structures (Figure 1). The objective of the review was to examine how the drought plans of other municipal utilities use their water-budget rate structures, along with other measures, to reduce water use during times of drought.

Figure 1. Utilities with Drought Plans and Water-Budget Rate Structures

Utility	Drought Plan Reviewed	Interview Conducted
Colorado Utilities		
City of Boulder	Yes	Yes
Castle Pines N. Metro District	Yes	
Town of Castle Rock	Yes	Yes
Centennial WSD	Yes	Yes
California Utilities		
Western Municipal WD	Yes	Yes
Santa Margarita WD	Yes	
City of Santa Cruz	Yes	
Rancho WD	Yes	Yes
Palmdale WD	Yes	
Moulton Niguel WD	Yes	
Las Virgenes WD	Yes	
Irvine Ranch WD	Yes	
Elsinore Valley MWD	Yes	Yes
El Toro WD	Yes	
Eastern Municipal WD	Yes	Yes
City of Corona	Yes	
Coachella Valley WD	Yes	Yes

In total, BBC reviewed drought plans for 17 utilities, including four utilities in Colorado and 13 utilities in California (Figure 1). In addition to reviewing the drought plans for each utility, BBC developed a structured questionnaire and conducted interviews with eight utilities to explore some topics in more detail.

Many of the utilities we interviewed have experienced droughts since adopting water-budget rate structures and cite reductions in their customers' water budgets as important factors for reducing their overall water use during these times.

For example, the Coachella Valley Water District in California experienced a drought in 2014 and had to reduce water use by 36 percent by mandate. The district increased water rates in its inefficient tiers (Tier 3 and higher) and introduced a \$25 drought penalty in its fifth tier to reduce water use. Both measures were successful according to the utility. The Elsinore Valley Municipal Water District also experienced a drought in 2014 and had to achieve the same 36 percent mandated reduction. The district adjusted its customers' water budgets – but kept water rates the same – and believed the adjustments were responsible for about 90 percent of the utility's reduction in water use.

During our review of the drought plans several other pertinent themes emerged that are relevant to Greeley's efforts:

- Baseline water budgets;
- Short vs. long run effects;
- Indoor vs. outdoor water use reduction;
- Equity of using water budgets to reduce water use;
- Revenue considerations;
- Non water-budget water use reduction measures; and
- Elasticity of water demand and relationship to water budgets.

The remainder of this memorandum summarizes our review and discusses our findings for each of the above topics as they relate to the development of Greeley's Drought Plan.

Overview of Utility Drought Plans and Measures

Most utilities with water-budget rate structures are found in California, but there are at least four other utilities in Colorado that also utilize water-budget rate structures (Figure 1). By law, all water utilities in California are required to develop plans to reduce water use during times of drought. Colorado has no such law, though the Colorado Water Conservation Board provides drought management planning grants to assist water providers in developing drought management plans. Three of the four Colorado utilities we examined have developed drought plans to incorporate their water-budget rate structures.

While most utilities decrease the water budgets of their customers during droughts, our interviews with several utilities also indicated that the selection of water use reduction measures are influenced by a number of other considerations. In particular, utilities expressed how important it is to include a variety of water use reduction measures in each drought stage to provide water managers with the flexibility they need to achieve pre-defined water use reduction targets. These primary considerations are discussed in more detail below.

Baseline Water Budgets. The outdoor water budgets of Greeley's residential customers are calculated using real-time climate variables. This means during droughts – when it is typically hot and dry – Greeley's outdoor water budgets will be higher than they would be under average conditions. If water use reductions are calculated from water budgets under drought conditions, overall water use may still be higher than it would be under average conditions.

We spoke to several utilities to understand how they handle this potential complication. Like Greeley, most utilities use real-time E/T to calculate outdoor water budgets. The utilities we spoke to indicated that their water use reduction targets are therefore calculated from water budgets under drought conditions. The City of Boulder is the only exception. The City calculates outdoor water budgets using a 10-year moving average E/T and calculates water use reductions during drought based on the long-run average.

Short Run vs. Long Run Water Use Response. During droughts, utilities need to achieve rapid reductions in municipal water use. This creates a trade-off between the effectiveness and timeliness of measures. Measures like offering rebates for the installation of efficient fixtures or drought-tolerant landscaping are effective at reducing water use over the medium and long runs, but are less effective at reducing water use in the short run, which is why utilities do not use these types of measures in their drought plans.

Many utilities consider public awareness to be the most timely and effective measure to reduce water use. Changes to water budgets – and the corresponding water rates – are considered to be effective for reducing water use. Initially, reductions in the water budgets can reinforce the utility's public awareness effort communicating the specific reduction in water use need from each individual single-family household. The financial signal from changes in water budgets is less timely since there is generally a lag of at least a month between the time the water budget is reduced and when the customer sees the impact in an increased water bill. As a result, many utilities use a combination of public awareness and changes to water budgets to reduce the lag.

Indoor vs. Outdoor Reductions. When utilities reduce water budgets, they typically begin by reducing the outdoor portion in an effort to reduce impacts on their customers. Like Greeley, outdoor water use is generally the largest and most discretionary component of municipal water use for the utilities we spoke to. As a result, it is the easiest water use to curtail without having large impacts on customers lifestyles and perceptions of utility performance. Generally, utilities will fully curtail outdoor use before reducing indoor water budgets.

Equity Considerations. Most utilities recognized the potential equity concerns arising from reducing the water budgets for single-family residential users without seeking comparable

water use reductions from other customer classes, but they generally prioritized economic health over seeking water use reductions from each customer class in equal proportions. In other words, most utilities preferred to reduce the water budgets of residential customers to greater and greater degrees before curtailing the use of commercial and industrial customers. The City of Boulder and Coachella Valley Water District - which both reduce the water budgets of all of their customers classes equally - were the only exceptions we noted.

Impacts on Landscaping Industry. We are aware the City of Greeley is sensitive to the impact that water use reductions can have on local businesses in general, and landscaping businesses in particular. BBC contacted four landscaping businesses in Northern Colorado to investigate their views on how reductions in outdoor water use would impact their business. The businesses we spoke with all believed their financial performance would be supported by population growth and rising incomes in the future and were not particularly concerned about potential impacts from reductions in outdoor water use during drought conditions. These businesses said outdoor watering restrictions only impact their businesses when droughts become severe (i.e. watering is limited to only one to two times per week).

Water Budgets for Non-Residential Customer Classes. Some of the utilities we researched applied water budget rate structures to all of their customer classes. The City of Boulder has a five-tier water budget rate structure that it applies to all of its customer classes. As noted above, the City's drought plan calls for reducing the water budgets of all of its customers equally during times of drought. The Coachella Valley Water District also uses a five-tier water budget rate structure that it applies to all of its customer classes, including commercial and irrigation customers. The District calculates indoor use for commercial customers by estimating each commercial customer's water use in terms of equivalent dwelling units. Irrigation customers do not have an indoor water budget due to the nature of their water use.

Non-Water-Budget Water Use Reduction Measures. In addition to reducing customer's water budgets, many utilities use non water-budget measures to reduce water use during droughts. Figure 2 shows a sample of the water use reducing measures we noted from the drought plans of other utilities under increasingly severe drought stages. Notably, the severity of the measures increases with the severity of the drought stage. As noted above, preserving flexibility by including multiple measures at each drought stage was important to each of the utilities we contacted.

Figure 2. Examples of Non-water-budget Measures to Reduce Water Use During Drought

Stage 1	Stage 2	Stage 3	Stage 4-5
Public information campaign	Public information campaign	Public information campaign	Public information campaign
Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code	Charges, fees, and fines for violating water use code
Outdoor conservation efforts	Drought surcharges on rates	Drought surcharges on rates	Drought surcharges on rates
Leak audits	Voluntary restriction of certain outdoor uses	Mandatory restrictions of certain outdoor uses	No new potable water connections
Outdoor watering time restrictions	Irrigation audits	Eliminate municipal uses like street cleaning	No new landscape
Postpone landscape changes	No proactive water service by restaurants	No personal car washing	No irrigation for municipal facilities

Revenue Considerations. Other utilities were concerned about the revenue impacts from reducing water budgets during droughts, but to different degrees. Many of the utilities we spoke with set aside a portion of their revenues during normal years to offset future revenue shortfalls during periods of drought. Many utilities we spoke with also use rate increases, special surcharges, and/or drought penalties to help preserve revenues and maintain financial reserves.

For example, the Town of Castle Rock and Centennial Water District both maintain reserve funds to compensate for reduced revenue during droughts. The City of Boulder has considered using a base fee to stabilize revenue during droughts. In California, utilities use drought penalty charges to offset reductions in revenue where possible, but this can be difficult in California because of strict legal interpretations in that state concerning the required nexus between operational costs and water rates.

Elasticity of Water Demand. During BBC's previous work to develop the new water demand model for Greeley, we found that Greeley's residential water customers had historically reduced their water use by 0.3 percent for every 1 percent increase in the average price of water. This means that to achieve a 20 percent reduction in overall use, prices would have to be increased by more than 50 percent. However, this elasticity estimate was derived under the City's previous uniform volumetric charges for both indoor and outdoor use. Other studies have found that customers are more sensitive to changes in the price of water used for outdoor uses than indoor uses, and that more complex rate structures such as increasing block rates or water budgets can increase the price elasticity of demand for water.

BBC reviewed the economic literature on price elasticities for outdoor water use of residential customers under increasing block rate structures – the closest approximation to water-budget rate structures – and found that the price elasticities varied from a low of -0.74 to a high of -1.18. This means the average response of residential customers to a 1 percent increase in price is to reduce outdoor water use by between 0.74 percent and 1.18 percent. Based on these elasticity estimates, a 33 percent increase in the average price of residential water would decrease water use by between 24 and 39 percent.