



CITY OF THORNTON

DROUGHT MANAGEMENT PLAN

JUNE 2019

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EXECUTIVE SUMMARY

BACKGROUND

Thornton's City Council adopted a Drought Management Plan in 2002, in response to the 2002 drought. The primary purpose of the 2002 Plan was to provide management and operational guidance for Thornton in times of drought. Drought response was divided into three stages according to drought severity. This Plan update draws from the lessons learned during the 2002, 2006 and 2012 droughts. The number of drought stages increased from three to four stages to improve guidance across a broader spectrum of water shortage intensities and durations.

OBJECTIVES, PRIORITIES AND OPERATING PRINCIPLES

This Drought Management Plan (Plan) prepares the city of Thornton (herein referred to as the city or Thornton) for drought and provides an action-based guidance framework to respond to a water shortage. The objectives of this Plan are:

- Proactively prepare for drought and determine the onset and severity of a drought by monitoring available climatic, hydrologic and other relevant information
- Reduce water demand and acquire additional water supplies to maintain the health and safety, community vitality and long-term resiliency of the community to the extent possible during a water shortage.

During droughts Thornton can experience a water shortage that requires the community to reduce water use. Table E-1 presents Thornton's prioritization of community water use during water shortages.

Table E-1: Water Use Priorities

Priority	Customer Use	Description
1	Health and safety	All indoor sanitary uses including indoor residential, health services, schools, businesses, etc. Firefighting and hydrant flushing.
2	Community vitality	Non-sanitary indoor uses and outdoor use for business and commercial purposes including construction water, commercial car washes, golf course(s) and indoor pools.
3	Established trees	Established trees throughout the city including trees in parks, residential neighborhoods, commercial centers, etc.
4	High priority outdoor use	Trees/shrubs, parks, sports fields, school fields, outdoor public pools, vegetable gardens.
5	Lower priority outdoor use	HOA common areas, established turf grass throughout community, private pools, water features.

The following operating principles were developed as means to assist with the development of this Plan and may also be used as a decision-making guidance tool when implementing the drought response program.

- The shortage response actions described in Sections 4 and 6, reflect the priorities designated by the Planning Team and community listed in the table above. These priorities were developed to maintain the health, safety and vitality of the community while also preserving overall quality of life and individual lifestyles to the maximum extent possible. They will be revisited upon declaration of a drought to best ensure that the response maintains these priorities.

- Drought protection that recognizes the importance of economic development and livelihoods along with environmental and recreational values is critical to sustaining healthy long-term communities within Thornton.
- Demographics play a role in how the community may be impacted by water restrictions. When possible, impacts resulting from drought response efforts (e.g., water restrictions) will be considered prior and during implementation to help ensure that they are distributed in as equitable manner as possible.
- Coordination and communication among Thornton staff are critical for implementing a successful drought mitigation and response program and in conveying consistent effective messages to the community. Deviations from this Plan will be communicated clearly among all relevant Thornton staff.

MITIGATION

Thornton is committed to drought preparedness and sustainable management of its water resources. The city carries out a variety of mitigation efforts to ensure water supply reliability and resiliency during water shortages. These are summarized in the bullets below.

- Planning efforts – Thornton routinely updates its water supply planning efforts, integrates drought planning with other city planning efforts and considers water shortages when scheduling maintenance activities and capital improvements.
- Water supplies – Thornton is in the process of developing new infrastructure to secure additional water supplies through the Thornton Water Project (TWP) and is also constructing a new water treatment plant (WTP). Thornton also maintains interconnections with other entities that can be used to deliver supplies during water shortages, while also seeking opportunities for temporary new supplies during shortages.
- Water efficiency – Thornton’s Water Efficiency Program provides long-term water savings. Thornton also manages its water supplies in a manner to optimize available storage capacity while minimizing losses, reuses backwash water from its WTPs and supports policy that promotes efficient wise water use.
- Water quality – Thornton remains up-to-date on water treatment best practices and innovative advancements that could provide water quality benefits during shortages. The city also engages with watershed programs that can equip stakeholders with resources to better address water quality challenges during drought.
- Funding - city annual fiscal planning ensures that Thornton can meet infrastructure needs while also allocating a reserve fund for water resources-related activities such as drought response.

DROUGHT STAGES, INDICATORS, RESPONSE TARGETS AND DROUGHT RESPONSE

Thornton’s response to water shortages is based on the four drought stages outlined in Table E-2 and shown in Figure E-1 on the following page. Each drought is unique and information from many indicators influence drought declaration and the designation of a specific stage. However, projected storage capacity on July 1 serves as the main indicator. The drought stages increase in severity as projected July 1 storage levels become less, calling for a higher demand reduction target (more water to be saved) with each elevating stage.

Each water shortage is unique and consequently may or may not “fit” within the exact parameters defined in Table E-2. The projected July 1 storage and other indicators serve as guidelines for a water shortage declaration rather than a “set of rules.” Professional expertise coupled with other factors may contribute to staff recommendations and City Council’s decision on drought declaration and targeted shortage response. Furthermore, while the indicators and drought stages primarily focus on drought-related shortages, these stages may be applied to water shortages that may not be drought-related. Such shortages could be induced by the destruction of significant infrastructure as a result of natural or human-induced events.

Priorities for Water Service During Shortages

- 1 – Health and safety
- 2 – Economic vitality
- 3 – Established trees
- 4 – High priority outdoor irrigation
- 5 – Lower priority outdoor irrigation

Table E-2 Summary of Drought Stages

Stage	Main Indicator - Projected July 1 Storage	Demand Reduction Targets	Summary of Drought Response
Stage 1: Moderate	75% to 65% of full capacity	Maintain baseline demand with allowance for demand increase as a result of elevated ET and lack of precipitation.	Voluntary Promote efficient water use and voluntary reductions for all five priorities.
Stage 2: Severe	70% to 45% of full capacity	Reduce baseline demands by 10% to 45%. The specific target percentage will depend on the severity of shortage.	Mandatory 10% to 24% reduction - Low priority irrigation (Priority 5) is limited. 25% to 45% reduction - Outdoor irrigation (Priorities 4 and 5) likely prohibited with exception to irrigation of established trees (Priority 3).
Stage 3: Extreme	50% to 35% of full capacity	Reduce baseline demands by more than 45%.	Mandatory Outdoor irrigation is prohibited (priorities 3 to 5) with limitations on uses associated with community vitality (Priority 2). A drought surcharge may be activated.
Stage 4: Exceptional	Storage levels are critically low, and the shortage is projected to continue	Ration water according to assigned water budgets that consider city storage levels.	Rationing Same as stage 3 with additional limitations on Priority 2 uses. Strict rationing may also be enforced. A drought surcharge may be activated.

Notes: 1) The demand reduction targets call for a percentage water savings using a “baseline demand.” The baseline demand is Thornton’s average gallons per capita water use (gpcd) over the most recent seven-year period. 2) The projected July 1 Storage indicator ranges overlap for Stage 2 and Stage 3 droughts, providing greater of flexibility when declaring a shortage.

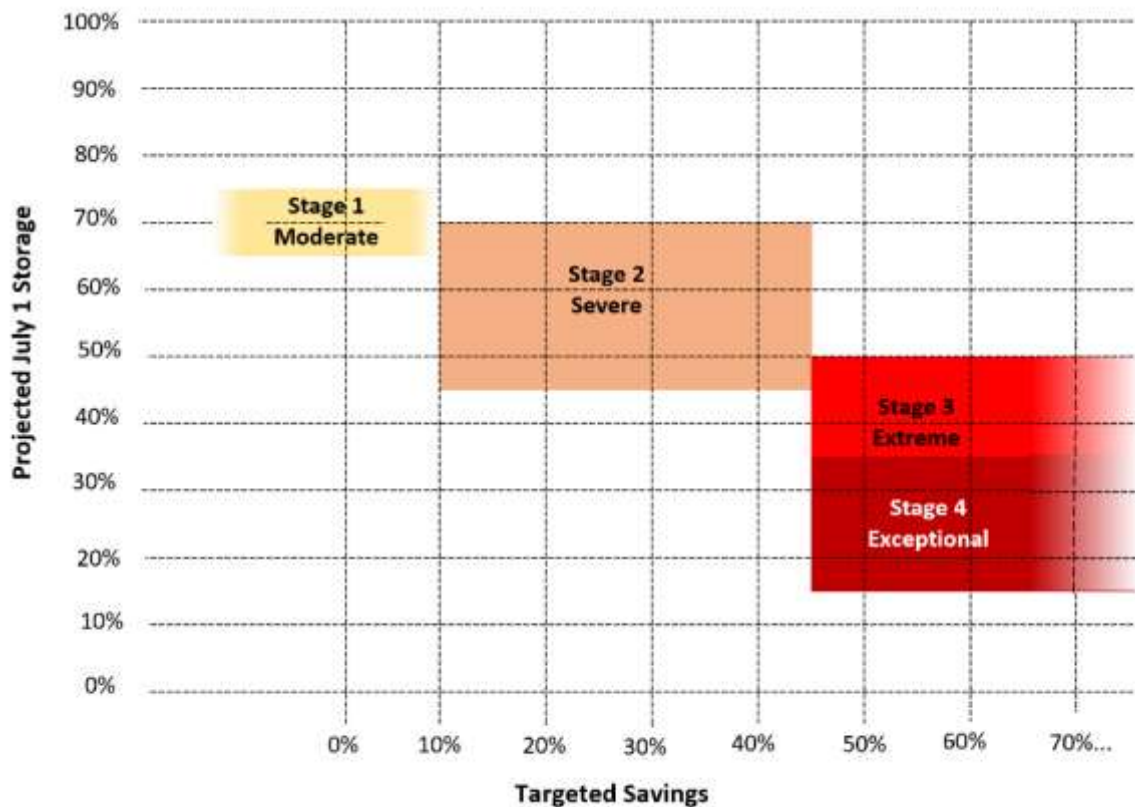


Figure E-1: Illustration of Thornton's Drought Stages

Stage 1 Moderate - The moderate drought stage is considered for declaration when projected July 1 storage levels are between 75% and 65% of full capacity. Thornton has historically observed increases in outdoor water demands during drought because of higher temperatures (higher evapotranspiration), longer growing seasons and less precipitation. Stage 1 moderate drought focuses on limiting this increase to no more than 10% of baseline demand. This stage focuses on incentives and a water use reduction campaign that promotes voluntarily reductions for all five priorities.

Stage 2 Severe - The severe drought stage is considered when projected storage levels are between 70% and 45% of full capacity and climate outlooks forecast continued drought. The demand reduction target in this stage ranges from a 10% to 45% reduction in demand, depending on conditions. This target is determined at the onset of the drought stage and may be adjusted to reflect conditions as the shortage persists. Mandatory water restrictions coupled with an intensive public water use reduction campaign will be enacted. This stage covers a broad spectrum of mandatory shortage response efforts. When demand reduction targets are set at 10% to 24%, mandatory restrictions may primarily focus on low priority irrigation (Priority 5). When the shortage is of warranted severity, demand reduction targets are set within the 25% to 45% range. Mandatory restrictions may limit all outdoor irrigation (Priorities 4 and 5) except for established trees (Priority 3). These restrictions are intended to preserve water for needs related to health and safety and economic livelihood (Priorities 1 and 2).

Stage 3 Extreme - The extreme drought stage is considered when projected July 1 storage levels are between 50% and 35% of capacity and other indicators show that the drought is anticipated to persist. The demand reduction target may exceed 45%. The target is determined at the onset of the stage and may be adjusted as the shortage persists. Outdoor irrigation (Priorities 4 and 5) is prohibited including the watering of outdoor trees (Priority 3). Additional measures are implemented to reduce non-sanitary indoor uses and outdoor use for business and commercial purposes (Priority 2). This may

lead to adverse economic impacts yet is necessary to conserve water for essential safety and health needs. A drought surcharge may be used to bolster revenue for operations and maintenance.

Stage 4 Exceptional - The exceptional drought stage is considered when July 1 projected storage levels are critically low (below 35% of full capacity) and other indicators show that the shortage is to persist. A shortage of this severity would likely only occur under a severe multi-year drought that exceeds historical records. Focus is placed on ensuring that the health and safety needs of the community can be met. All outdoor use is prohibited which may require the need for infrastructure capable of restricting total deliveries to customers (rationing). The reduction in water use could fail to generate enough revenue for normal operations and maintenance. This may require the collection of revenue outside the normal rate structure (drought surcharge), which would necessitate an amendment to Thornton's rate ordinance.

Table E-3 provides a summary of the drought response measures that may be implemented for each drought stage. This table will be used as guidance to develop the Rules and Regulations, detailing the drought response measures to implement when a drought stage is declared.

Table E-3 Summary of the Drought Response Program

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75%	Storage: 45% - 70%		Storage: 35% - 50%	Storage: Critically low
	Savings Target: Maintain	Savings Target: 10% - 24%	Savings Target: 25% - 45%	Savings Target: More than 45%	Rationing
Supply-Side Measures					
Water Supply Options					
Leasing water from other municipal water providers	Lease municipal water where available	Lease municipal water where available. Availability will become less with persistent severe shortage		Lease municipal water if available	Lease municipal water if available (although likely not available)
Leasing agricultural water rights	Consider leasing agricultural water where legally possible	Consider leasing agricultural water where legally possible		Lease agricultural water where legally possible	Lease agricultural water where legally possible
Temporarily use agricultural water rights owned by the city for municipal purposes	Consider filing substitute water supply plan (SWSP) to temporarily use city-owned agricultural water rights	Consider filing SWSP to temporarily use city-owned agricultural water rights		Consider filing SWSP to temporarily use city-owned agricultural water rights if water is available	Consider filing SWSP to temporarily use city-owned agricultural water rights if water is available
Negotiate modification of water lease with the city of Westminster	n/a	n/a	Consider negotiating modification of water lease with the city of Westminster	Negotiate modification of water lease with the city of Westminster	Negotiate modification of water lease with the city of Westminster
Engage in regional water supply options that could develop during drought	n/a	n/a	n/a	Consider new regional water supply options if they arise through course of shortage	Consider new regional water supply options if they arise through course of shortage
Pump tributary wells in accordance with the city's decrees for potable use	n/a	n/a	Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available	Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available	Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available
Curtail deliveries of water from the Standley Lake Pipeline and treat aesthetic and raw water irrigation water for potable purposes	n/a	Consider treating raw water from senior raw water irrigation rights for potable uses		Consider treating raw water obtained from senior raw water irrigation for potable use if available	Consider treating raw water for potable use if available

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75%	Storage: 45% - 70%		Storage: 35% - 50%	Storage: Critically low
	Savings Target: Maintain	Savings Target: 10% - 24%	Savings Target: 25% - 45%	Savings Target: More than 45%	Rationing
Use existing non-tributary groundwater wells as potable water	n/a	n/a	n/a	Consider developing infrastructure necessary to use the city's existing non-tributary groundwater for potable use (currently it may only be used for irrigation)	Consider developing infrastructure necessary to use the city's existing non-tributary groundwater for potable use (currently it may only be used for irrigation)
Explore new non-tributary groundwater options in the Denver Basin	n/a	n/a	n/a	Consider exploring non-tributary groundwater options in the Denver Basin	Consider exploring non-tributary groundwater options in the Denver Basin
Explore new storage opportunities that would provide additional yield during drought	n/a	n/a	n/a	Explore new storage opportunities (e.g. lower intake structures) that would provide additional yield during drought	Explore new storage opportunities (e.g. lower intake structures) that would provide additional yield during drought
Establish a water hauling program to provide water for drinking and other essential health and sanitary purposes	n/a	n/a	n/a	n/a	If needed, establish a water hauling program to provide water for drinking and other essential health and sanitary purposes
Operational Water Supply System Measures					
Divert poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards (e.g. runoff following a severe wildfire)	Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards	Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards	Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards	Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards	Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards
Reduce/prohibit using city water to fill ponds used for raw water irrigation and aesthetic purposes	n/a	Consider reducing use of city water to fill lakes for raw water irrigation and aesthetic purposes		Consider prohibiting use of city water to fill ponds used for raw water irrigation and aesthetic purposes	Prohibit use of city water to fill ponds used for raw water irrigation and aesthetic purposes

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75% Savings Target: Maintain	Storage: 45% - 70% Savings Target: 10% - 24%	Savings Target: 25% - 45%	Storage: 35% - 50% Savings Target: More than 45%	Storage: Critically low Rationing
Increase monitoring of inefficiencies in the distribution system and accelerate leak detection	Consider increasing monitoring of inefficiencies in the distribution system and accelerate leak detection	Increase monitoring of inefficiencies in the distribution system and accelerate leak detection		Increase monitoring of inefficiencies in the distribution system and accelerate leak detection	Increase monitoring of inefficiencies in the distribution system and accelerate leak detection
Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates	n/a	n/a	n/a	Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates	Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates
Reduce water supply system distribution pressure	n/a	n/a	n/a	Consider reducing water supply system distribution pressure	Consider reducing water supply system distribution pressure
Demand-Side Measures					
Outdoor Watering (residential, commercial, parks and city facilities)					
Established turf lawns Water restrictions	Voluntary Watering limited to no more than 3 times a week. No watering from 10:00 am to 6:00 pm.	Mandatory Watering limited to no more than 2 to 3 times a week. No watering from 10:00 am to 6:00 pm.	Mandatory Watering limited to no more than 1 to 2 times a week. No watering from 10:00 am to 6:00 pm.	Prohibited	Prohibited
Annual and perennial flowers, vegetable gardens, shrubs, established trees Water restrictions Also includes water-wise landscapes although they should require less water than the gardens mentioned above.	Voluntary May be watered by hand or by automatic system. No watering from 10:00 am to 6:00 pm.	Mandatory May be watered by hand or by automatic system every other day. No watering from 10:00 am to 6:00 pm.	Mandatory May be watered by hand, drip, deep root mechanical bubblers or subirrigated every other day. Established trees should only be watered twice a month. No hand watering between 10:00 am and 6:00 pm.	Mandatory All outdoor watering is prohibited with exception to watering of established trees twice a month by hand, or by deep root mechanical bubblers or <u>subirrigation</u> . No hand watering between 10:00 am and 6:00 pm.	Prohibited
City parks sports turf Water restrictions	Voluntary Savings target: Maintain Watering is reduced and closely monitored to ensure savings target is achieved. Watering may	Mandatory Savings target: 10-24%. Watering is reduced and closely monitored to ensure savings target is achieved. Watering may occur	Mandatory Savings target: 25-45%. Watering is reduced and closely monitored to ensure savings target is achieved. Watering may occur	Mandatory Savings target: More than 45%. Watering is reduced and closely monitored to ensure savings target is achieved. Watering may	Prohibited

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75%	Storage: 45% - 70%		Storage: 35% - 50%	Storage: Critically low
	Savings Target: Maintain	Savings Target: 10% - 24%	Savings Target: 25% - 45%	Savings Target: More than 45%	Rationing
	occur between 10:00 am to 6:00 pm.	between 10:00 am to 6:00 pm.	between 10:00 am to 6:00 pm.	occur between 10:00 am to 6:00 pm.	
City parks and right-of-way Water restrictions Turf grass and shrubs	Voluntary Savings target: Maintain Watering is reduced and closely monitored to ensure savings target is achieved. Watering may occur between 10:00 am to 6:00 pm.	Mandatory Savings target: 10-24% Watering is reduced and closely monitored to ensure savings target is achieved. Watering may occur between 10:00 am to 6:00 pm.	Mandatory Savings target: 25-45% Watering is reduced and closely monitored to ensure savings target is achieved. Watering may occur between 10:00 am to 6:00 pm.	All outdoor watering is prohibited with exception to watering of established trees twice a month by hand, or by deep root mechanical bubblers or <u>subirrigation</u> . Watering may occur between 10:00 am to 6:00 pm.	Prohibited
City golf course Water restrictions	Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly.	Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Convert watering of the greens, greens surrounds, driving range tee and clubhouse grounds to alternating sources every other irrigation event (potable vs non-potable). This would be a 50% reduction in potable use.	Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Convert watering of the greens, greens surrounds, driving range tee and clubhouse grounds to alternating sources every other irrigation event (potable vs non-potable). This would be a 50% reduction in potable use.	Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Discontinue the use of potable water. Convert all irrigation to 100% non-potable. Monitor the Big Dry Creek flows and consider limiting the use of non-potable water to lower priority areas (voluntarily).	Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Discontinue the use of potable water and convert all irrigation to 100% non-potable. Monitor the Big Dry Creek flows and reduce irrigation in the rough by 50%, reduce fairways and tees and clubhouse grounds by 25%. Carts to remain on paths at all times – no exceptions.

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75%	Storage: 45% - 70%		Storage: 35% - 50%	Storage: Critically low
	Savings Target: Maintain	Savings Target: 10% - 24%	Savings Target: 25% - 45%	Savings Target: More than 45%	Rationing
Irrigation system efficiency Outdoor irrigation consultations that include a water audit and recommendations on how to improve efficiency	Voluntary City increase promotion of outdoor irrigation consultations. Encourage conversion of sprinklers to high efficient irrigation.	Voluntary City increase promotion of outdoor irrigation consultations. Encourage conversion of sprinklers to high efficient irrigation.	Voluntary If watering allowed, city increase promotion of outdoor irrigation consultations. Encourage conversion of sprinklers to high efficient irrigation.	n/a	n/a
New landscape installations requiring water All landscapes must be installed to city code.	May be watered as needed for the first month. Recommend outdoor irrigation consultations and installation of efficient irrigation systems.	New installations may require a permit or be prohibited. If allowed, may be watered as needed for the first month. Irrigation consultations and installation of efficient irrigation systems are required. If prohibited, alternative non-irrigated groundcover (e.g. mulch) will be required.	Prohibited Alternative non-irrigated groundcover (e.g. mulch) will be required.	Prohibited Alternative non-irrigated groundcover (e.g. mulch) will be required.	Prohibited Alternative non-irrigated groundcover (e.g. mulch) will be required.
Residential (single-family attached, single-family detached and HOAs)					
Nonessential outdoor uses Water restrictions Misting devices, vehicle washing at residences, sidewalk and driveway washing and ornamental fountains	Voluntary Reduce or stop use	Prohibited With exception to ornamental fountains that are closed systems, recycling water.	Prohibited Ornamental fountains that are closed systems, recycling water may be allowed.	Prohibited	Prohibited
Private outdoor swimming pools and hot tubs	Voluntary Minimize filling and cover to reduce evaporation.	Mandatory Minimize filling and cover to reduce evaporation.	Mandatory Minimize filling and cover to reduce evaporation.	Mandatory May be prohibited. If allowed, minimize filling and cover to reduce evaporation.	Prohibited
Commercial (businesses, schools and churches)					
Restaurants Serve water only upon request	Voluntary	Mandatory	Mandatory	Mandatory	Mandatory

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Hotels/motels Implement policy where signs are posted asking customers to conserve water during their stay (e.g. not have linens washed every night)	Voluntary	Voluntary	Mandatory	Mandatory	Mandatory Guests likely subject to rationing.
Commercial car washes	City promote installation of water recycling technology and other water efficient technologies and practices.	City promote installation of water recycling technology and other water efficient technologies and practices.	Limitations may be placed on car washes that do not use recycled water and water efficient technologies. City promote installation of water recycling technology and other water efficient technologies and practices.	Water use limitations may be placed on daily water use for all car washes. City promote installation of water recycling technology and other water efficient technologies and practices.	Prohibited
Specific businesses Office/business water savings plan during drought.	n/a	n/a	City provide instructional resources to specific businesses on how to develop a water savings plan. Approved water savings plan may be required.	City provide instructional resources to businesses on how to develop a water savings plan. Approved water savings plan may be required.	City provide instructional resources to businesses on how to develop a water savings plan. Approved water savings plan will be required. Businesses will likely be subject to rationing.
City (city-wide water management decisions)					
Drought surcharge	n/a	n/a	Consider drought surcharge	Consider drought surcharge	Consider drought surcharge
Intensify water efficiency incentives on targeted users Many, if not all these incentives are implemented through Thornton's water efficiency program	Target incentives on high water users and other users where significant water savings may be achieved.	Target incentives on high water users and other users where significant water savings may be achieved.	Target incentives on high water users and other users where significant water savings may be achieved.	Target incentives on high water users, other users where significant savings may be achieved and on certain businesses.	Focus incentives on water efficiency needed to meet rationing requirements.

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
	Storage: 65%-75% Savings Target: Maintain	Storage: 45% - 70% Savings Target: 10% - 24%	Savings Target: 25% - 45%	Storage: 35% - 50% Savings Target: More than 45%	Storage: Critically low Rationing
New development New taps to city water distribution system	n/a	n/a	Consider changes to review process and limitations on number of taps allowed.	Consider changes to review process and limitations on number of taps allowed.	Consider changes to review process and limitations on number of taps allowed. Consider prohibiting additional taps.
Construction water Construction water for soil compaction, dust control, architectural uses, concrete mix, etc.	Allowed with BMPs implemented to use water efficiently.	Allowed with BMPs implemented to use water efficiently.	Allowed with BMPs implemented to use water efficiently.	Must obtain permit for use of construction water. The issuance and conditions of permit may depend on the stage a project is at in the city planning review process.	May be prohibited. If allowed, must obtain permit for use of construction water. The issuance and conditions of permit may depend on the stage a project is at in the city planning review process.
Washing of city-owned vehicles	Voluntary Reduce washing of city vehicles to once a month and take to commercial car wash that uses recycled water.	Mandatory Reduce washing of city vehicles to once a month and take to commercial car wash that uses recycled water.	Mandatory Limit washing of city vehicles to special circumstances and take to commercial car wash that uses recycled water.	Prohibited	Prohibited
Street cleaning	Allowed with BMPs in place for efficient water use.	Allowed with BMPs in place for efficient water use.	Closely monitor water use with BMPs in place for efficient water use. May limit street cleaning to areas in special need.	Closely monitor water use with BMPs in place for efficient water use. May limit street cleaning to areas in special need.	Consider prohibiting. If allowed, closely monitor water use with BMPs in place for efficient water use. Limit street cleaning to areas in special need.
Hydrant flushing	n/a	n/a	Recommend use of tanker trucks to reclaim water.	May be prohibited in certain circumstances. Recommend use of tanker trucks to reclaim water.	Only allowed for health and safety.
Commercial and City					
Public drinking fountains	n/a	n/a	Signs encouraged to promote efficient water use.	Signs encouraged to promote efficient water use.	Prohibited unless fountains are used for rationing purposes.

Possible Response Measures	Stage 1: Moderate	Stage 2: Severe		Stage 3: Extreme	Stage 4: Exceptional
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	Savings Target: Maintain	Savings Target: 10% - 24%	Savings Target: 25% - 45%	Savings Target: More than 45%	Rationing
Public outdoor swimming pools and hot tubs	Voluntary Minimize filling and cover to reduce evaporation.	Mandatory Minimize filling and cover to reduce evaporation.	Mandatory Minimize filling and cover to reduce evaporation.	Mandatory Minimize filling and cover to reduce evaporation. Use may be prohibited.	Prohibited
Public indoor swimming pools and hot tubs	Voluntary Use BMPs to limit spillage and evaporation.	Voluntary Use BMPs to limit spillage and evaporation.	Mandatory Use BMPs to limit spillage and evaporation.	Mandatory Use BMPs to limit spillage and evaporation.	Mandatory Use BMPs to limit spillage and evaporation. May be prohibited.

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INTRODUCTION

EXISTING WATER SYSTEM

Service Area

The city of Thornton's treated water service area is approximately 39 square miles and is generally bounded by U.S. 36 (south), 168th Avenue (north), Zuni Street (west), and Yosemite Street (east). The service area includes the area within the city boundary in addition to portions of unincorporated Adams County. Thornton also provides bulk treated water deliveries to the city of Westminster.

Thornton's water service area population was estimated to be 158,459 in 2018 which includes its corporate boundaries and areas served in unincorporated Adams County. As shown in Figure 1, the population increased by 41% from 2002 to 2018. Generally, population has annually increased by 1% to 3% since 2002.¹

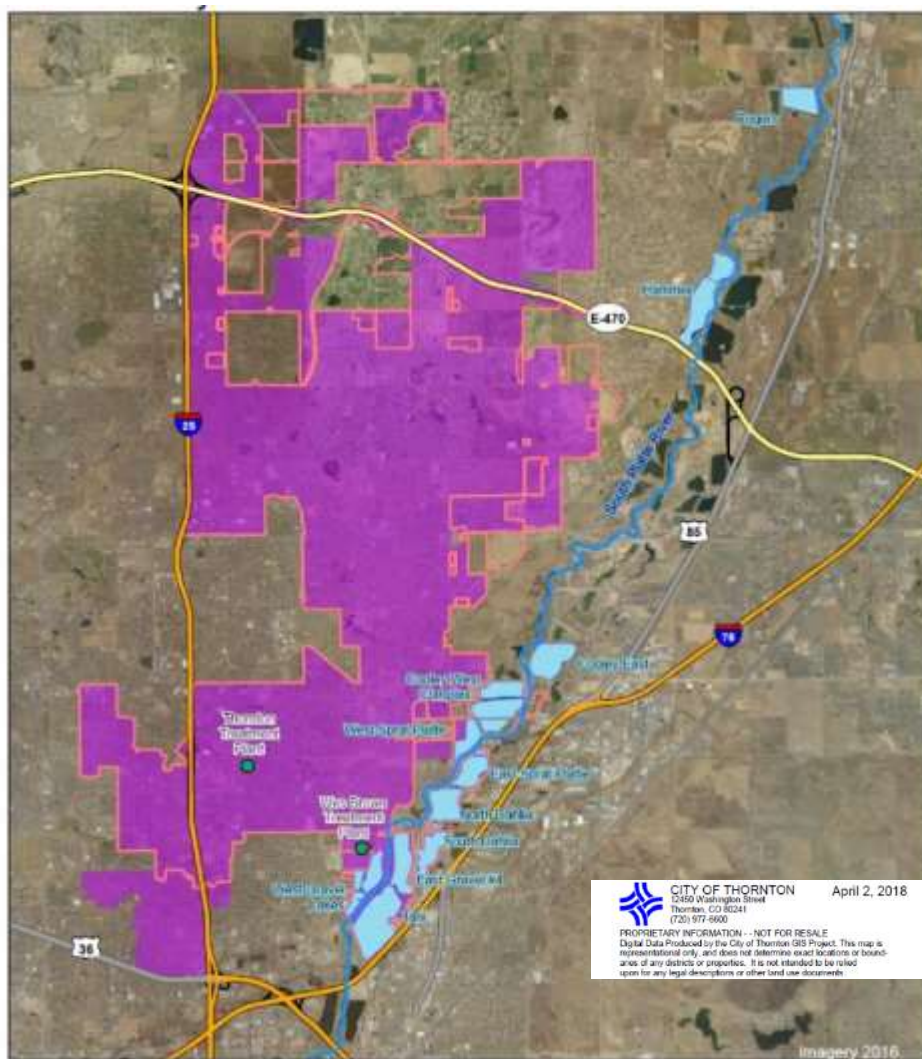


Figure 1: Location of Thornton

¹ These estimates were developed by the city and based on Thornton's water demand forecast. Note, the 6.56% growth rate in 2015 is attributed to improved economic conditions but is also artificially elevated some because in 2015 the city aligned their population estimates with third party population estimates produced by the U.S. Census and the Colorado State Demographers office.

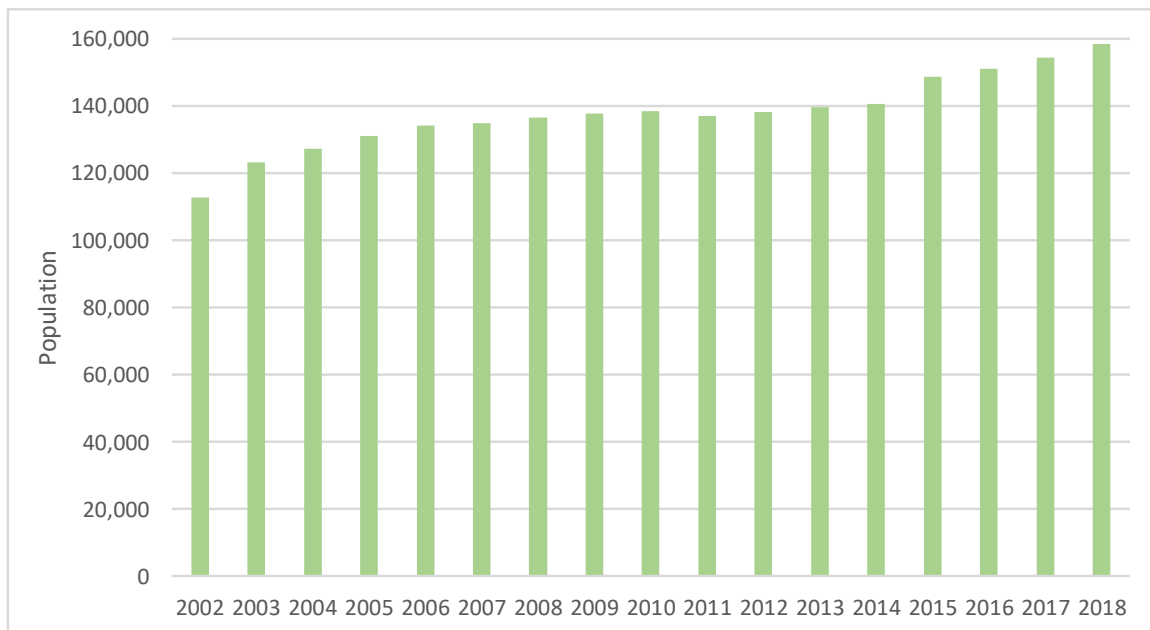


Figure 2: Historical Population

Water Supply System

Thornton's water supply originates primarily in the form of melting snow in the mountains of the South Platte River and Clear Creek basins. Supply is most plentiful during snowmelt runoff in spring and early summer. Because of the seasonal availability of streamflow, Thornton has developed reservoir storage facilities that allow the city to deliver water during low-flow periods when inflows to the city's reservoirs are less than outflows servicing community demand. Thornton typically fills its reservoir storage space in early to mid-June during the peak snowmelt runoff. As of spring 2019, Thornton has 36,537 AF of usable storage capacity. Thornton maintains a diverse portfolio of water rights through its ownership of stock in several ditch and reservoir companies, ranging in priority from the early 1860s to the 2000s. The water associated with these water rights is delivered to reservoirs owned by Thornton and into reservoirs in which the city shares ownership with other entities.

For purposes of describing Thornton's operations, the Clear Creek Basin may be divided into upper and lower systems. Water from the upper system is delivered into storage at Standley Lake from the Farmers' High Line Canal and the Croke Canal, as shown in Figure 3. The water stored in Standley Lake is conveyed to the Thornton Water Treatment Plant through an eleven-mile pipeline. Water from the lower system is delivered into storage at Brannan Lakes and at the West Gravel Lakes from the Lower Clear Creek Ditch and the Colorado Agricultural Canal. The water stored in Brannan Lakes can be pumped back into the Lower Clear Creek Ditch and conveyed to the West Gravel Lakes for storage. The water stored in the West Gravel Lakes is pumped to the Wes Brown Water Treatment Plant (WTP).

Thornton's South Platte River Basin system consists of a series of interconnected reservoirs located along the South Platte River which store water delivered primarily from the Burlington Canal. Thornton's reservoirs that take delivery of water conveyed through the Burlington Canal are South Tani Reservoir, East Gravel Lake No. 4, South Dahlia Reservoir, North Dahlia Reservoir, East Sprat Platte Reservoir, West Sprat Platte Reservoir, Cooley East, and the Cooley West Complex. These reservoirs are all connected through a series of pipes. The water stored in these reservoirs is pumped to the Wes Brown WTP from East Gravel Lake No. 4 and Cooley West.

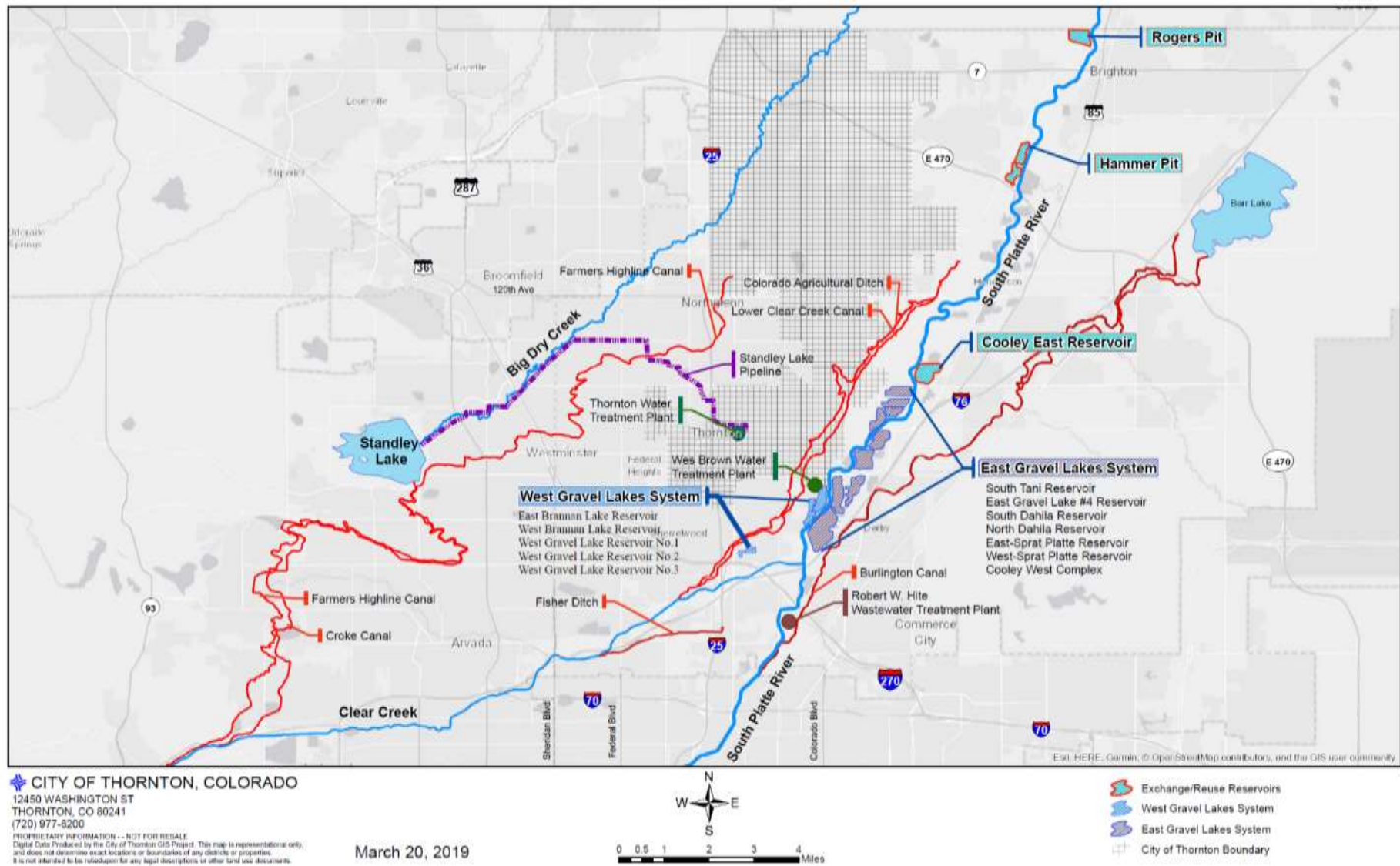


Figure 3: City of Thornton Clear Creek and South Platte Water Supplies

Thornton also developed a series of alluvial wells adjacent to the South Platte River. There are six wells that pump groundwater into the city’s reservoirs. Additionally, Thornton constructed six non-tributary groundwater wells that supply untreated raw water to parks for irrigation. Thornton also shares interconnections with the treated water systems of Denver Water and the city of Westminster. The city of Westminster is a wholesale treated water customer for the city and the interconnection serves as the delivery point to Westminster. An agreement with Denver Water would be needed to convey treated water through the Denver Water interconnect during a water shortage. Thornton also has a raw water interconnection with the city of Northglenn for emergency situations such as drought.

Water Demands

Thornton’s service area includes single and multi-family residences, businesses, schools, parks, and open spaces. Annual potable demands in 2017 were 28,024 AF. As shown in Figure 4, residential customers, including single- and multi-family, are the largest customer class making up 64% of 2017 potable water demands. Irrigation and commercial users comprise 11% and 10% respectively, while leases to Westminster account for 8%. On average, 45% of annual water use goes to meet outdoor demands such as lawn irrigation. Unaccounted for water including non-billable and system losses makes up 7%.² In addition to potable supplies, Thornton currently irrigates seven parks and one golf course (Thorncreek Golf Course) with non-potable water. Non-potable demands in 2017 were 291 AF.

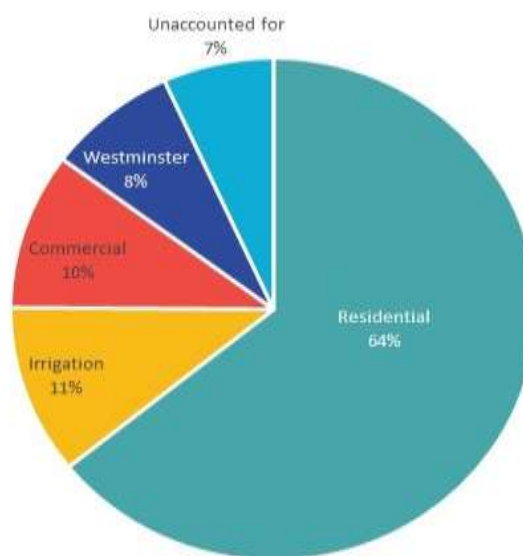


Figure 4 Potable Water Demand by Customer Type in 2017

DROUGHT MITIGATION AND RESPONSE PLANNING

What is a drought and water supply shortage?

A drought is a prolonged or chronic shortage of lack of water. Meteorologists describe drought as a span of time when the actual supply of moisture for a given location is consistently less than normally expected. The magnitude of an associated water shortage depends on the severity, geographic extent and duration of the drought. While droughts do not occur at regular, predictable intervals, they are inevitable and in Colorado, droughts are frequent events. According to the Colorado Water Conservation Board (CWCB), at least 5% of Colorado is in a 3-, 6-, 12-, or 24-month-long drought 93% of the time. Fortunately, most droughts do not affect the entire state at the same time. During the development of this Plan, the southwest portion of the state was in extreme to exceptional drought conditions, while the lower South Platte Basin conditions ranged from abnormally dry to no drought. This is depicted by the Drought Monitor in Figure 5.

Thornton defines drought within the context of its water supply system as follows: drought occurs when precipitation is less than normal resulting in a prolonged water supply shortage. In response,

² This percentage varies on an annual basis. For instance, in 2015, system losses were 9.5%.

important decisions are made to reduce water demands and utilize alternative water supplies to ensure priority water needs are met while addressing adverse impacts of the supply shortage.

Water supply shortages may occur during drought or could be caused by other factors such as the failure of a key water distribution pipeline or facility. During a shortage, Thornton is not able to maintain storage at adequate levels while also meeting community water demands. Strategies are needed to maintain supplies while also lowering community demands. This highlights the importance of proactive planning and maintaining infrastructure.

How does drought impact Thornton's water supply and demands?

During a drought, reduced precipitation and spring runoff from the mountains decreases the availability of water for storage in Thornton's reservoirs. Furthermore, warmer temperatures coupled with less precipitation results in higher evaporation rates and outdoor water demands, placing greater strain on Thornton's storage. The level of impact depends on the severity and duration of drought. While single-year droughts can impact storage for several subsequent years until ample precipitation is available for full recovery, multi-year droughts can place much greater stress on storage levels, since storage is compromised from previous dry-years. Multi-year droughts could require long-term water demand reductions to ensure enough supplies are maintained to meet priority needs. Thornton's ability to store and deliver treated water can further be comprised during drought if facilities are temporarily off line for maintenance or improvements.

Why plan for drought and water shortages?

Planning helps to preserve essential health and safety public services and to minimize the adverse effects of a water shortage on public health and safety, economic activity, environmental resources and individual lifestyles. Effective planning removes the "crisis" and reduces hardship. It also raises public confidence in the actions taken to address the shortage.

What is the difference between mitigation and response?

Mitigation consists of actions taken prior to a drought or water shortage to ensure optimum water supply reliability and that Thornton is prepared for addressing shortages. Responses are actions taken during a shortage to avoid and reduce impacts while best maintaining water storage for future community needs and essential services such as health and safety.

Coordination with Regional Planning Efforts

Drought planning is most effective when it is coordinated with other local and state drought planning efforts. Thornton worked with the CWCBC in securing State drought mitigation plan grant monies to

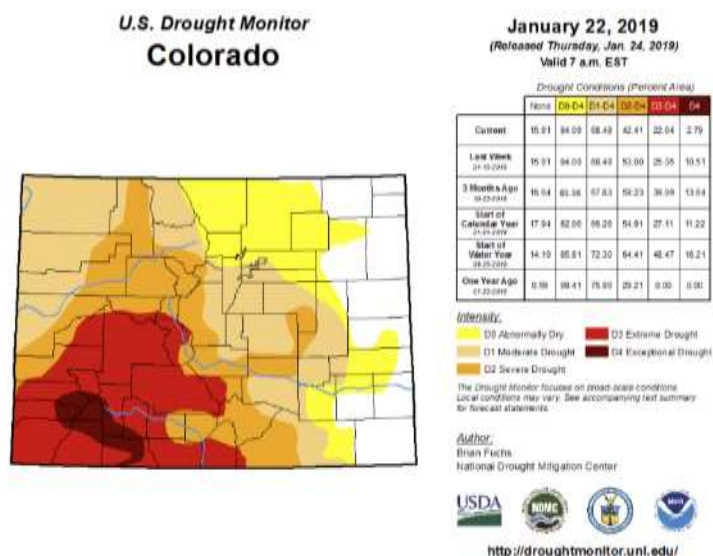


Figure 5: January 2018 Drought Status in Colorado

Drought - Water Shortages - Planning

During a water shortage, Thornton may not be able to maintain storage levels at adequate levels while also meeting community water demands. Shortages may be caused by drought or other factors. This Plan provides actions the city and community can take to respond water shortages to best preserve essential priorities such as health and safety.

develop this Plan. This Plan was developed in accordance to the CWCB's *Municipal Drought Management Plan Guidance Document*, taking advantage of the technical drought-related assistance that the State has to offer. In turn, this Plan helps inform the State's Drought Plan by providing feedback on local drought vulnerabilities, mitigation and response efforts.

This Drought Management Plan (Plan) is also developed in coordination with the *Thornton, Federal Heights, and Northglenn Hazard Mitigation Plan* developed in 2017. This local hazard mitigation plan addresses drought in addition to other natural hazards. The drought mitigation and response strategies spelled out in this Plan are consistent with Thornton's mitigation goals included in the Hazard Mitigation Plan. These include:

- Protect people, property, and natural resources
- Improve capability to prevent and reduce physical, economic, and social losses from disasters
- Ensure that functionality of local critical facilities is maintained in the event of a disaster
- Strengthen communication and coordination among public agencies, NGOs, businesses, and residents
- Increase public awareness of natural hazard risks and mitigation options
- Integrate hazard mitigation into other planning mechanisms
- Ensure that Hazard Mitigation will be acknowledged and supported by the Thornton Comprehensive Plan and other local plans

This Plan also works in close coordination with the city of Thornton's Emergency Operations Plan. Acute short-term water shortages attributed to non-drought related factors will primarily be addressed through the Emergency Plan. Prolonged shortages caused by drought and other factors are addressed in this Plan.

HISTORICAL DROUGHT PLANNING EFFORTS AND PLAN DEVELOPMENT

Thornton's City Council adopted a Drought Management Plan in 2002, in response to the 2002 drought. The primary purpose of the 2002 Plan was to provide management and operational guidance for Thornton in times of drought. Drought response was divided into three stages according to drought severity. This Plan draws from the lessons learned during the 2002, 2006 and 2012 droughts. city staff from multiple departments and divisions engaged in a variety of interactive activities to better integrate water efficiency, supply planning and climate change with drought and water shortage planning. This included a scenario planning exercise to encourage city staff to "think out of the box" about drought and how water supply shortages could impact Thornton.³ The number of drought stages increased from three (in the 2002 Plan) to four stages to improve guidance across a broader spectrum of water shortage intensities and durations. In addition, a community engagement effort was launched to ensure that the Plan incorporated community values and priorities.

DROUGHT PLANNING AND WATER EFFICIENCY

This Plan complements Thornton's Water Efficiency Plan to achieve overall efficient and prudent use of the city's water resources. Water efficiency activities that result in an ongoing reduction in water demand can provide drought resiliency benefits and therefore can be considered a component of water efficiency as well as drought mitigation. However, whereas the Water Efficiency Plan promotes long-term water savings, this Plan focuses on drought mitigation and short-term water reductions during shortages.

³ More information on the scenario planning exercise is provided in Appendix B.

Thornton recognizes water efficiency as an essential component to its long-term water supply planning strategy. As of 2016, Thornton achieved the water efficiency goal specified in the city’s 2009 Water Conservation Plan: residential water use was reduced from an average of 106 gpcd recorded in 2001 (before the 2002 drought and use of water restrictions) to 85 gpcd, based on a five-year rolling average. Thornton’s current water efficiency program aims to achieve 1,071 AF of savings annually by 2024 from both residential and commercial users. As of 2018, Thornton’s Water Efficiency Program consists of 19 programs focused on indoor and outdoor use and on water supply system losses. Each year new programs are designated to come online through 2024. These existing and future programs are listed in Table 15 of the 2018 Water Efficiency Plan.

Thornton and Water Efficiency

An integral part of the mission to secure a reliable and resilient water supply for the Thornton community is to serve as a model in water-efficient urban development.

STAKEHOLDERS, OBJECTIVES AND OPERATING PRINCIPLES

1.1 DROUGHT PLANNING TEAM

A diverse drought Planning Team was identified to guide the development of the Plan. The Planning Team, shown in Table 1, represents city staff from a cross section of departments that are directly affected by drought and responsible for carrying out portions of the Plan. This team provided background information and data to support the Plan development and community engagement, provided input on key Plan content, and provided assurances that the Plan is compatible with city operations and feasible to implement. During the update, the Planning Team participated in three workshops that focused on different sections of the Plan, represented the public based on their professional experience, participated in community engagement efforts and reviewed the draft Plan prior to distribution to the public for comment.

Table 1: Drought Planning Team

city Staff Member	Position	Role and Contribution
James Boswell	Water Policy Quality Manager	Provided input from a policy and water quality perspective
Ryan Doyle	Emergency and Safety Administrator	Provided input from an emergency response perspective
Brian Garner	Current Planning Manager	Provided input from a city planning and development perspective
Emily Hunt	Water Resources Manager	Provided input as the water resources manager
Mary Jensen	Water Resources Analyst II	Provided a rich history of experience and knowledge from a water resources planning and systems operations perspective
John Orr	Water Resources Administrator	Managed the project and provided input from a water resources planning and systems operations perspective
Richard Plautz	Park Maintenance Supervisor	Represented the Parks and Golf Division and provided input on the Plan
Rachel Walsh	Project Accountant	Provided input from a city finance perspective
Karen Widomski	Senior Policy Analyst	Provided input from a city planning and development perspective
Laura Wing	Water Resources Administrator	Provided input from a water resources and water conservation perspective

This Planning Team strengthened the robustness of the Plan by providing a broad spectrum of representation across city departments, ensuring that the Plan includes a diversity of perspectives and breadth of knowledge. When a drought occurs, the team will continue to be an asset by educating other city staff members on the Plan and ensuring that drought response is carried out in a coordinated, effective manner. Where relevant, members of the team will also be engaged in drought mitigation to proactively prepare for a drought.

1.2 OBJECTIVES OF THE DROUGHT MANAGEMENT PLAN

This Plan better prepares Thornton for drought and provides an action-based guidance framework to respond to a water shortage when it occurs. As discussed above, water shortages generally are attributed to drought, however, other circumstances such as planned infrastructure improvements or unplanned failures can contribute to a water shortage during drought or cause a water shortage. The mitigation and response mechanisms in this Plan are designed to address water shortages attributed to drought or other circumstances. The objectives of this Plan are the following:

- Proactively prepare for drought and determine the onset and severity of a drought by monitoring available climatic, hydrologic and other relevant information
- Reduce water demand and acquire additional water supplies to maintain the health and safety, community vitality and long-term resiliency of the community to the extent possible during a water shortage.

During droughts Thornton can experience a water shortage that requires the community to reduce water use. Table 2 presents Thornton’s prioritization of community water use during water shortages. These priorities were developed considering the severity of impact to the community. Water use restrictions to Priority 1 uses would impact the health and safety of the community and therefore during water shortages, Thornton will manage water services to ensure that these essential needs are met. Depending on the severity and duration of the water shortage, water uses in Priorities 2, 3, 4 and 5 may need to be reduced or in severe situations could be prohibited. Restrictions on Priority 2 uses could impact the business and commercial sector and would therefore likely not be implemented unless experiencing a very severe and long-term shortage. Restrictions on Priority 3, 4, and 5 uses could impact community lifestyle and while not desirable, are the first tier of restrictions implemented to maintain enough water for higher priority uses.

Table 2: Water Use Priorities

Priority	Type of Use	Description
1	Health and safety	All indoor sanitary uses including indoor residential, health services, schools, businesses, etc. Firefighting and hydrant flushing.
2	Community vitality	Non-sanitary indoor uses and outdoor use for business and commercial purposes including construction water, commercial car washes, golf course(s) and indoor pools
3	Established trees	Established trees throughout the city including trees in parks, residential neighborhoods, commercial centers, etc.
4	High priority outdoor use	Trees/shrubs, parks, sports fields, school fields, outdoor public pools, vegetable gardens
5	Lower priority outdoor use	HOA common areas, established turf grass throughout community, private pools, water features

Operating Principles

The following operating principles were developed as means to assist with the development of this Plan and may also be used as a decision-making guidance tool when implementing the drought response program.

- The shortage response actions described in Sections 4 and 6 reflect the priorities designated by the Planning Team and community listed in Table 2. These priorities were developed to maintain the health, safety, and vitality of the community while also preserving overall quality of life and individual lifestyles to the maximum extent possible. They will be revisited upon declaration of a drought to best ensure that the response maintains these priorities. If necessary, minor adjustments to these priorities may be made in response to community feedback and circumstantial water supply needs during water shortages.
- Drought protection that recognizes the importance of economic development and livelihoods along with environmental and recreational values is critical to sustaining healthy long-term communities within Thornton.
- Demographics play a role in how the community may be impacted by water restrictions. When possible, impacts resulting from drought response efforts (e.g., water restrictions) will be considered prior and during implementation to help ensure that they are distributed in as equitable manner as possible.

- Coordination and communication among Thornton staff are critical for implementing a successful drought mitigation and response program and in conveying consistent effective messages to the community. Deviations from this Plan will be communicated clearly among all relevant Thornton staff.

HISTORICAL DROUGHT AND IMPACT ASSESSMENT

2.1 HISTORICAL ASSESSMENT OF DROUGHT, AVAILABLE SUPPLIES, AND DEMANDS

Thornton was in its early stages of development and incorporation during the drought of the mid-1950s which affected both the lower and upper South Platte River basins with unusually hot summer weather. This was an exceptional state-wide drought and is still used by many water providers as the critical drought of record incorporated in their water supply modeling and planning projections. The next severe drought occurred in 1977. Precipitation on the West Slope was 48% of normal and spring runoff was 50% of normal. Snow accumulation was also low for the year. Natural Resources Conservation Service (NRCS) records for 1977 show that the South Platte Basin's snowpack was only 43% of average by the end of the snow accumulation season. That year, Thornton enacted an emergency ordinance that limited lawn watering to no more than three hours every third day. The next droughts of significance occurred in 2002, 2006 and 2012. The remainder of this Plan primarily focuses on these droughts because they are relatively recent with higher degrees of institutional memory among city staff and are more representative of Thornton's current conditions when considering population. The following discussion focuses on impacts experienced during these recent droughts based on input from city staff.

The onset of the 2002 drought was quick and unexpected. As shown in Figure 6, the entire State was in D3, extreme or D4, exceptional drought conditions at its peak in July 2002. As with many water providers on the Front Range, Thornton found itself unprepared and was slow to respond effectively. This was a pivotal drought for growing communities along the Front Range. City storage was at 45% (9,901 AF) in July of 2002. Thornton responded with new efforts to improve drought resiliency including the development of a Drought Management Plan and hiring a full-time water conservation specialist. In 2003, Thornton implemented a tiered rate structure.

In 2006, Thornton experienced a hot dry spring during which outdoor irrigation demands increased early in the season, snowpack melted quickly because of warm winds and there were more senior calls on the South Platte River. Also, three of Thornton's gravel pits were offline from June 2004 until April 2006 for construction of South Tani Reservoir. This compromised Thornton's ability to capture adequate runoff in the spring of 2006, leading to a water shortage and enactment of water restrictions. Neighboring water providers had not implemented restrictions and there was confusion among Thornton's community as to why water restrictions were enacted. This highlights the importance of considering climate projections prior to scheduling infrastructure modifications and maintenance and conveying consistent well-thought out message(s) when water restrictions are enacted.

The 2012 drought was like 2002 in terms of the severity and rapid onset of the drought. Figure 7 shows that Thornton's storage levels were below 75% from February 2012 to April 2013. However, Thornton was closely monitoring its storage and supply situation in 2012 and was better prepared

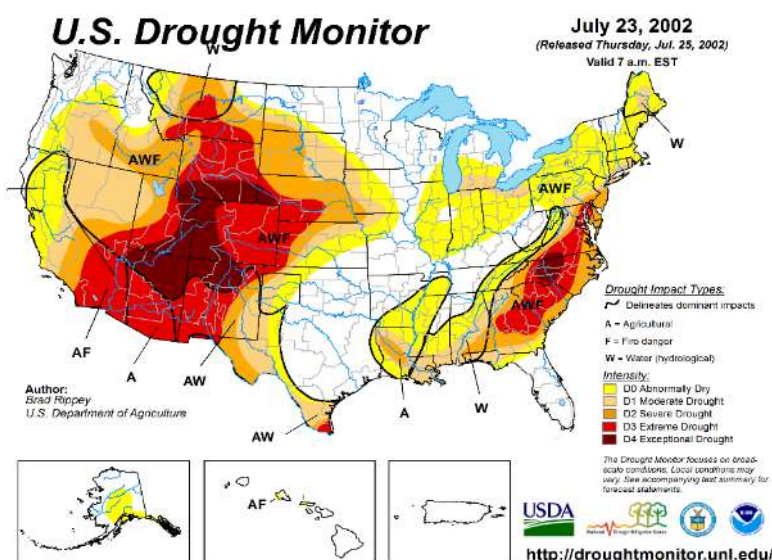


Figure 6: Drought Monitor Depiction of the 2002 Drought

than in 2002 and in 2006. City staff informed City Council early on regarding the drought conditions and promptly enacted drought response. Communication and messaging with the community was also improved based on lessons learned during the 2006 drought. Overall, city water resources staff felt better prepared than during the previous droughts.

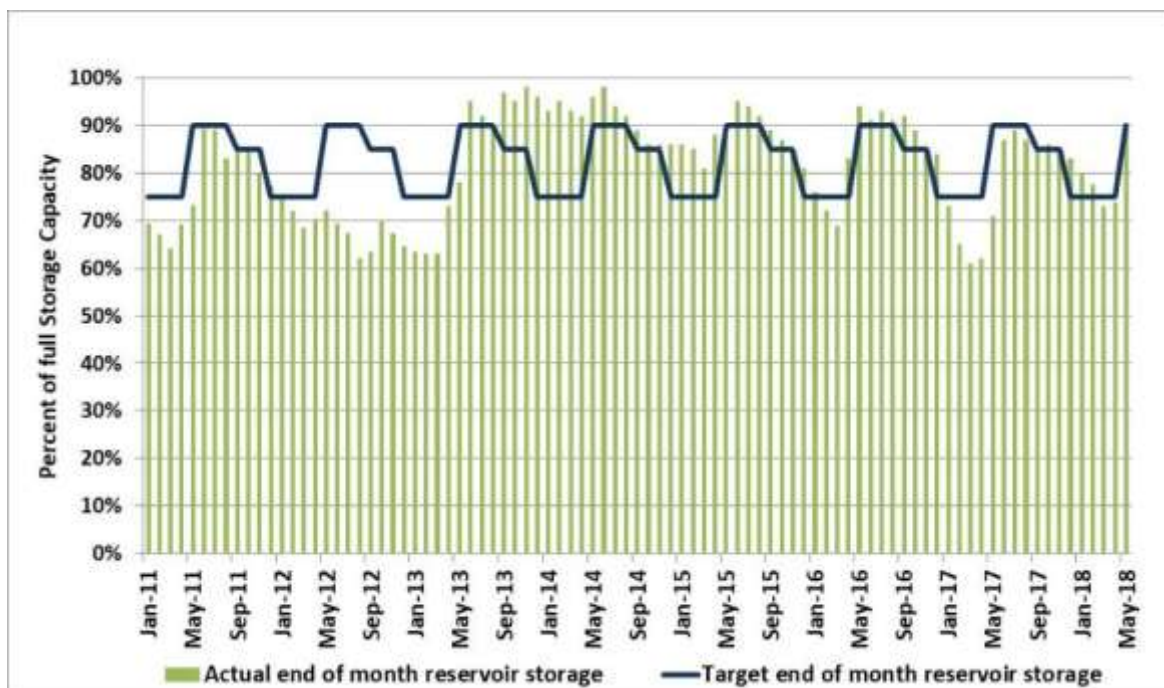


Figure 7: Storage in Thornton's Water Supply System during the 2012 Drought

Water Demands and Drought

Figure 8 shows Thornton's potable water demands and population from 2002 to 2017⁴. The demand fluctuations have generally followed weather patterns with drier years experiencing increases in water demand due to increased irrigation. However, from 2012 to 2013, Thornton experienced a 17% reduction in total water use. Water use has not yet returned to 2012 levels in the years since, even though the population has increased, and restrictions are no longer in place. This is attributed to water efficiency behaviors and the average climate conditions that have occurred following the 2012 drought, maintaining stable demands.

Weather plays a considerable role on outdoor water demands. Communities generally use less water during precipitation events and when the weather is cool. During a drought, water demand goes up as communities increase landscape watering to compensate for increases in temperature and evapotranspiration (ET) while precipitation decreases. In other words, without water restrictions, communities will often use more water at times when less water is available. Historical demand data has shown over a 10% increase in water demands in drought years. Table 3 shows the estimated increase in ET during the 2006 and 2012 droughts relative to the total per capita water use for Thornton's irrigation, commercial and residential accounts.⁵ Per capita demands increased by 12% for

⁴ This does not include unmetered demands and deliveries to Westminster which are 1.8 mgd.

⁵ The percentage increase was estimated by taking the difference between the 2006 and 2012 data (ET and per capita demand) with the average of the respective three previous years of data (2003 to 2005 and 2009 to 2011).

both droughts while the ET increased by 13% and 16% for the 2006 and 2012 droughts, respectively.⁶ These data suggest that watering restrictions were more effective in the 2012 drought than in 2006.

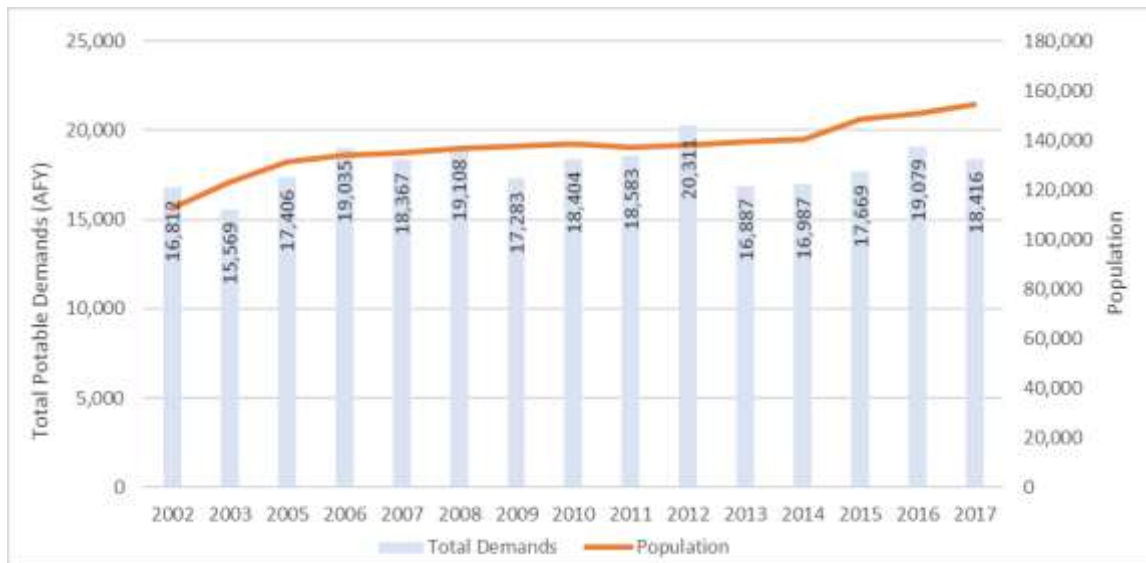


Figure 8: Potable Water Demand (2002 – 2017)

Table 3: Evapotranspiration and Demand Increase During Drought

Year	ET	Per Capita Demand Increase
2006 Drought	13%	12%
2012 Drought	16%	12%

Figures 9 and 10 show that total potable and residential per capita demands⁷ have decreased by 20% and 24%, respectively, from 2002 to 2017. The per capita demands tend to be higher during the 2002, 2006 and 2012 droughts followed by a period of significant reductions. As discussed above, this is attributed to weather patterns and improving water efficiency behaviors. Per capita demands have not returned to the levels observed during the 2002 drought.

Thornton has provided non-potable water to the city's Thorncreek Golf Course and select parks⁸ for more than a decade. Non-potable supply sources include raw untreated water from Standley Lake, Cooley West Reservoir and non-tributary groundwater wells. In recent years, the amount of irrigation with non-potable water has been increasing. The non-potable water is drawn from different sources including surface water from the South Platte River, Big Dry Creek and Clear Creek along with non-tributary groundwater. Total non-potable consumption has increased by approximately 12% from, 260 AF in 2005 to 291 AF in 2017.

⁶ The 12% increase in per capita demand shown in Table 3 is relative to an average of the previous 3 years per capita demand (gpcd). It was calculated using the potable per capita demand (from billed residential, commercial and irrigation accounts). For instance, the 2003-2005 average was compared to 2006 and the 2009-2011 average was compared to 2012. The same 3-year average was used for ET calculations.

⁷ The potable per capita water demands (gpcd) presented in Figures 9 and 10 are calculated as the annual potable demand (gallons per year) using billing data from commercial, residential and irrigation accounts divided by Thornton's service area population divided by 365 days. The total demands include billing data from commercial, residential and irrigation accounts. The residential only includes residential accounts. Master metered mobile home parks are not included in the residential number because they have a commercial rate code in the billing system.

⁸ Thornton currently irrigates seven parks with non-potable water.

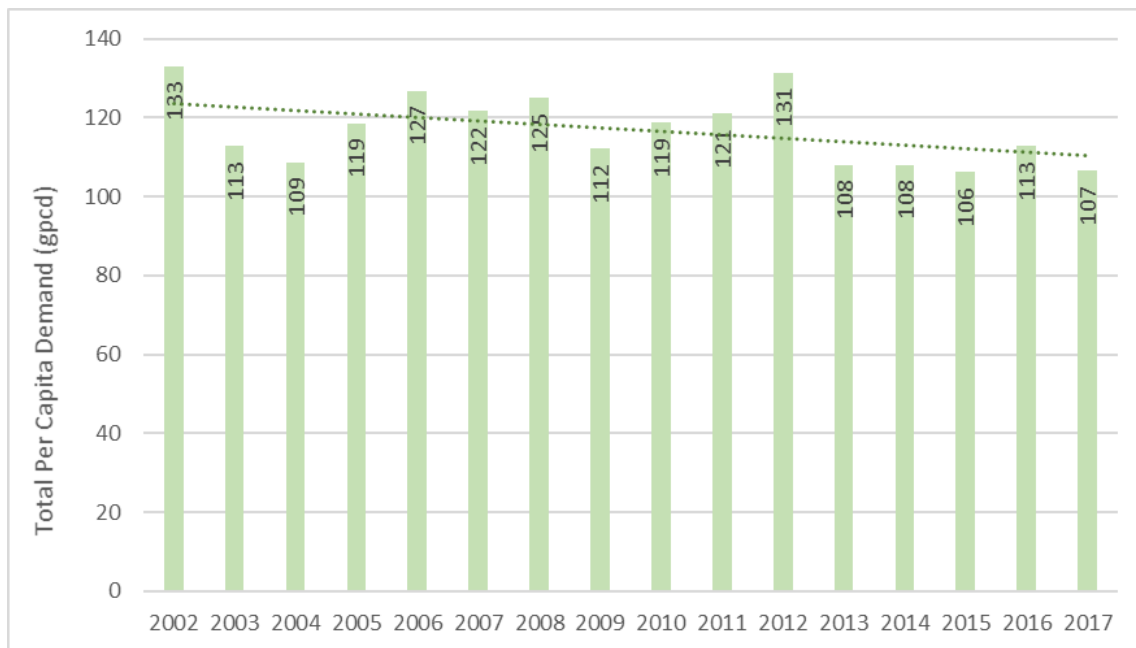


Figure 9: Total Potable Per Capita Demand (2002 -2017)

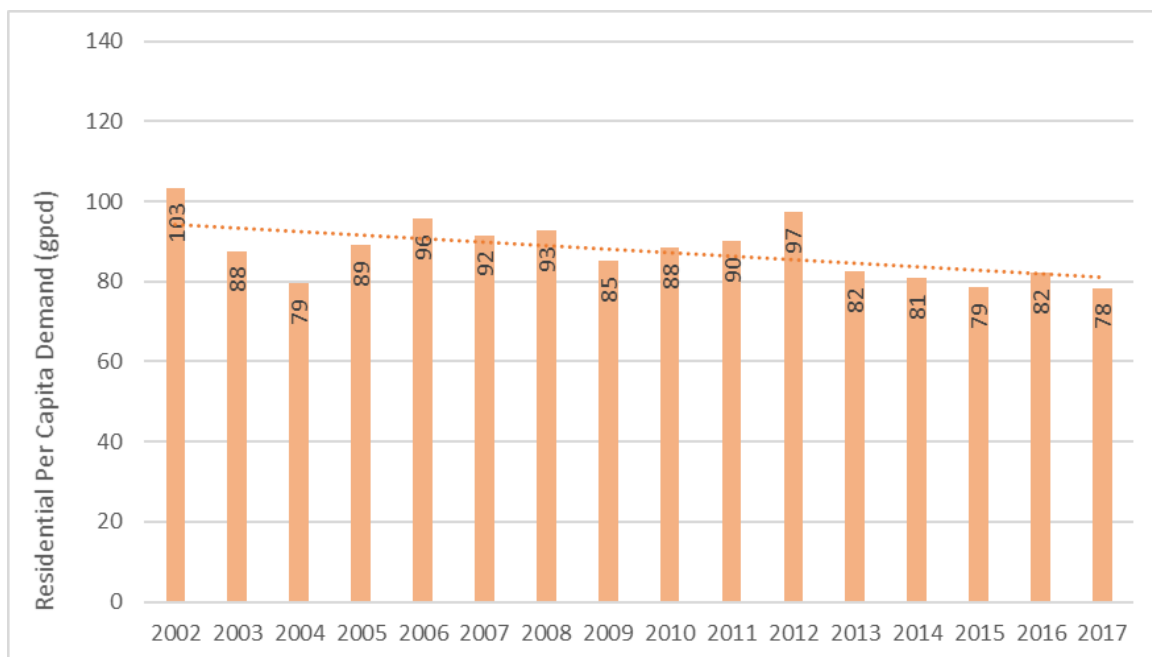


Figure 10: Residential Potable Per Capita Demand (2002-2017)

2.2 HISTORICAL DROUGHT IMPACT, MITIGATION AND RESPONSE ASSESSMENT

Historical Drought Impacts

Thornton experienced a variety of impacts during the 2002, 2006 and 2012 droughts. These impacts particularly affected storage reserves; drinking water quality; loss of landscaping; costs associated with acquiring additional supplies, addressing drinking water quality and replacement of landscaping; loss in revenue as a result of water restrictions; and complaints from the community related to water restrictions and taste and odor. Table 4 provides a comprehensive list of impacts based on input from city staff and the community.

Table 4: Historical Drought Impacts

Historical Impacts	Years	Severity Ranking
Reduction in storage reserves	2002, 2006, 2012	Significant (2012) Moderate (2006)
Higher water treatment costs (need for additional chemicals)	2002, 2006, 2012	Significant (2012) Moderate (2006)
Used Wes Brown WTP in winter to maintain storage in Standley Lake	2012	Significant
Costs to acquire/develop new water supplies/water rights transfers	2002, 2006, 2012 (leasing)	Moderate
Complaints about degraded drinking water quality (taste and odor)	2002, 2006, 2012	Moderate
HOA - loss of shrub and turf and expense to replace it	2012	Moderate
Increase in outdoor water demands	2002, 2006, 2012	Moderate
Loss of revenue from reduction in water sales	2006, 2012	Moderate
Parks - loss of shrub and turf, weeds invading, increased costs to replace landscape	2002, 2012	Moderate
Parks - loss of trees and other landscape	2002	Moderate
Public open space - landscaping stressed/killed	2002, 2006, 2012	Moderate
Heightened awareness about water conservation	2006, 2012	Moderate
Residential landscaping stressed or killed	2002, 2006, 2012	Minor
Complaints from residents and HOAs about water restrictions	2002	Minor
Confusion in community as to why Thornton was operating under drought conditions and other cities were not. The drought declaration was attributed dry conditions which were exacerbated by construction at one of Thornton's reservoirs.	2006	Minor
Complaints from landscapers about water restrictions	2012	Minor
Public perception concerns about not doing hydrant flushing	2012	Minor

Mitigation and Response to Historical Droughts

To meet demands of its service area during 2002, Thornton entered into short-term lease arrangements with Denver Water, Coors, and the Burlington Ditch Company. Thornton also adopted its first drought management plan, improved drought education, hired a full-time employee to initiate its current water efficiency (conservation) program, started to convert the irrigation of some of its parks from treated water to non-potable water, and implemented mandatory water restrictions. Table 5 provides further detail on the voluntary and mandatory restriction periods from 2002 through 2013.

Table 5: Periods of Drought Water Restrictions

Description	Restriction Periods
Voluntary restrictions	May 8, 2002 - August 31, 2002
Mandatory restrictions - 3 days/week, 15 min per spray zone, 45 min per rotor zone	Sept. 1, 2002 - October 31, 2002
No turf watering	November 1, 2002 - April 31, 2003
Mandatory restrictions - 2 days/week, 15 min per spray zone, 45 min per rotor zone	May 1, 2003 - May 14, 2003
New Tiered Rate Structure	May 15, 2003 – present

Description	Restriction Periods
Voluntary restrictions	May 15, 2003 - June 30, 2006
Mandatory restrictions - 3 days/week, 15 min per spray zone, 45 min per rotor zone	July 1, 2006 - Sept. 30, 2006
Voluntary restrictions	Oct. 1, 2006 - April 1, 2007
Voluntary restrictions	May 21, 2012 - August 31, 2012
Mandatory restrictions - 2 days/week	Sept. 1, 2012 - June 26, 2013

Note: Voluntary drought restrictions were implemented during a Stage 1 drought. Mandatory restrictions were implemented during a Stage 2 drought.

Since 2002, Thornton has followed the steps and options outlined in its 2002 Plan to efficiently and wisely manage its water supplies during dry periods. This includes demand management and the augmentation of supplies when needed. Public information strategies were also utilized to raise awareness and foster willingness to comply with water restrictions. Consequently, Thornton has been better prepared for drought. During the 2006 drought, Stage 1 and Stage 2 droughts were declared. Thornton entered several lease arrangements, although not nearly as many as in 2002. A mix of voluntary and mandatory water restrictions were enacted between 2003 and 2006 to ensure an adequate amount of water remained in storage to meet the critical needs in subsequent years.

Supply and Demand-Side Strategies

Supply-side management strategies aim to acquire additional water supplies during shortages while demand-side management strategies focus on reducing water use in the community.

During the 2012 drought Stage 1 and Stage 2 droughts were declared. Several lease arrangements and similar restrictions were put in place from May 2012 through June 2013. During the periods when water restrictions were in effect, Thornton water customers responded well and reduced their water usage, thereby avoiding the need to enact a stricter program.

DROUGHT VULNERABILITY ASSESSMENT

3.1 WATER SUPPLY RELIABILITY AND DROUGHT MANAGEMENT PLANNING

It is anticipated that Thornton's population will continue to grow. This represents an increase of over 63% from the 2018 population. Figure 11 provides population projections within the city's water service area through 2030 with an anticipated growth rate of 3% through 2020 followed by an annual growth rate of 1% through 2030. As Thornton continues to grow, development projections and planning are an integral part of meeting future needs of the community in both wet and dry periods.⁹

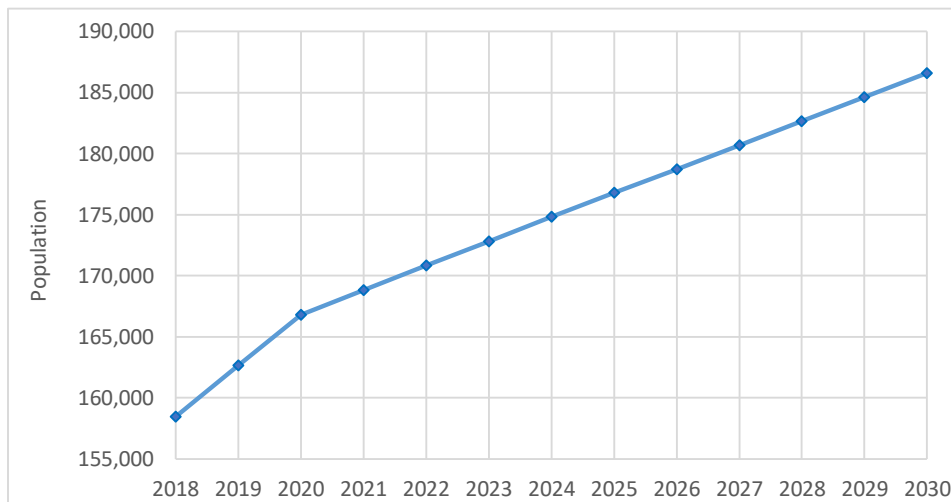


Figure 11: Projected Population

Thornton is engaged in many planning efforts to ensure that the community's water-related needs are best met in a reliable and sustainable manner. These efforts include:

- Water supply modeling - Thornton utilizes a customized computer model to estimate the firm yield of its water supplies and system. Firm yield is an estimate of the amount of demand Thornton's system can provide within a historical study period without experiencing a shortfall. The critical drought of record within the study period is the drought that occurred between 1954 to 1957. Information from this modeling effort informs the Utility Master Plan and raw water master planning.
- Water and Wastewater Systems Master Plan – Thornton will be completing an update in Fall 2019. This planning effort ties the city's raw water supply needs with infrastructure, ensuring that Thornton's water and wastewater systems sufficiently meet the community's future needs. Efforts are focusing on how to enhance the systems' flexibility, redundancy and reliability.
- Five-year Capital Improvement Plan (CIP) -Thornton annually updates its Five-year CIP which provides for cost-effective design and construction of capital projects. The CIP includes transportation, water, storm and sanitary sewer system projects that provide an enhancement to quality of life and in the reduction of costs for ongoing maintenance.

⁹ Projected growth spans as far south as 120th Avenue and north to State Highway 7, along Quebec Street. The focus of the growth will be single-family and multi-family housing located along the Quebec Street corridor and North Metro Rail Line. In terms of commercial development, it is projected to occur along the I-25 corridor and E-470 in the northwest portion of the service area.

- City Comprehensive Plan – Thornton’s population projections are updated annually, however, every ten years, Thornton conducts a thorough evaluation of how the city will grow and where the future development and redevelopment will occur. Population projections from this effort inform Thornton’s water supply planning efforts. The latest Comprehensive Plan is anticipated be completed Fall 2019.
- Water Efficiency Plan – Water conservation and efficiency is an important component of Thornton’s efforts in meeting future demands and can be critical in meeting higher priority needs during water shortages. Thornton updates its Water Efficiency Plan at a minimum of every seven years with the latest update in 2018.
- Climate change – Climate change investigations have shown that the Front Range may experience earlier runoff, higher peak flows and a sharp decline in base stream flows. This could impact Thornton’s water supplies. In 2015, the Water Resources Division conducted a City Climate Change Vulnerability Assessment and the city is currently incorporating a climate change hydrology scenario in its water supply modeling efforts. Information from this effort will inform Thornton’s planning efforts to help ensure a reliable water supply in the face of a changing climate.

3.2 DROUGHT IMPACT ASSESSMENT

Thornton’s water supplies cover a large area, originating from the Clear Creek and South Platte basins. This provides a degree of redundancy if a drought is more pronounced in certain local watersheds than in others. The addition of Poudre Basin water supplies through the Thornton Water Project (TWP) will increase the city’s watershed area and may provide greater drought resiliency. Thornton’s dual WTPs also provide a degree of redundancy.

Thornton’s combination of senior water rights, junior water rights, and storage create a robust water supply system. The city has acquired enough water to meet projected demands in normal and wet years through buildout and is in the process of developing the infrastructure to deliver the remainder of this water through the TWP. Additionally, current modeling of Thornton’s raw water supply system indicates that Thornton’s senior water rights portfolio can meet projected indoor needs through buildout. However, this modeling incorporates a three-year drought in the 1950s as the critical drought period. While this period is commonly used by water providers throughout the Front Range as the “critical drought” for planning purposes, it is important to note that drought-related impacts could be more severe than anticipated if a drought exceeds severity of the 1950s drought and/or lasts longer than three years. Other events such as wildfires or compromised infrastructure could also exacerbate effects of drought. This emphasizes the importance of having an effective drought and water supply shortage response program.

Table 6 lists water shortage impacts that Thornton may experience in the future. They are prioritized as follows:

- Priority 1 impacts – Influences the reliability and quality of water available to the community. These impacts could significantly affect the whole community depending on the severity of the shortage. Proactive planning and infrastructure maintenance can avoid and/or reduce the severity of impact.
- Priority 2 impacts – Generally cannot be avoided when water supplies are limited. These impacts primarily have financial, water quality, landscaping and community/political implications within the city. The magnitude of impact can range from minor to severe depending on the severity and duration of shortage. Effective drought response can often lessen adverse effects.
- Priority 3 impacts – Primarily influences quality of life. These impacts are generally caused by shortage response actions taken by the city and community-at large to ensure water supplies are available to meet priority economic, health and safety needs.

Table 6: Future Vulnerability to Water Shortages

Themes					Potential Future Water Shortage Impacts
Infrastructure/ Supplies	Financial	Water Quality	Landscaping	Community/ Political	
Priority 1 Impacts					
X	X				Funding not available for needed CIP projects to help mitigate for drought
X					Significant delays in water projects (e.g. TWP, WTP delays, policy delays projects)
X					Harm to infrastructure from past events (e.g. floods)
X					Compromised storage to provide reserves during drought (e.g. damage to reservoir from flood prior to drought)
X					CIP project or maintenance that temporarily compromises system during drought
X					Need to operate Wes Brown WTP during the winter to maintain storage levels in Standley Reservoir
	X				Costs to acquire new supplies (e.g. leases)
		X			Degraded drinking water quality (taste and odor). TDS and other water quality degradations occur due to concentration from low reservoir levels. Also, typically the best sources of water are used first, with sources of lesser quality remaining.
				X	Community buy-in to making behavioral changes necessary to save water during drought
				X	Population exceeds growth projections increasing water demands above planning levels
X					Low stream flows result in more senior calls on the river
X					Reduction in storage reserves
X					Disruption of water supplies
X					Reduction in municipal well production
Priority 2 Impacts					
	X				Costs to increase water use efficiency during a shortage
	X				Loss of revenue from reduction in water sales
	X				Increased costs and staff time to implement drought plan
	X				Economic conditions can influence Thornton's resources in addressing a shortage
	X				Increase in staff resources to monitor and implement shortage response
	X	X			Higher water treatment costs (e.g. need for additional chemicals)
	X	X			Large scale drought can reduce availability of water treatment chemicals and increase costs
X		X			Wildfire in region which can result in sediment loading in the Poudre and Clear Creek basins causing water quality issues
			X	X	Impacts to commercial water users that must reduce water use
				X	Air quality effects particularly from wildfire throughout the State and intermountain west
			X	X	Loss of trees and other landscaping in parks
X			X		Outdoor water demands are higher from temperature increases and longer growth season
				X	Political will of promoting drought resiliency can influence ability to respond to drought (e.g. policy can be slow in responding to a drought situation)
				X	Heath impacts from higher temperatures
Priority 3 Impacts					
			X	X	Outdoor aesthetics, recreation, environment impacts such as stinky ponds, low flow in streams, etc.
			X	X	Loss of vegetation in parks and outdoor spaces, weeds invading, expense to replace it
				X	Heightened awareness about water efficiency lowers water demands
				X	Public favorable or unfavorable perception of Thornton regarding shortage response
				X	Community push back (e.g. water rates are exceeding what some customers can afford)

DROUGHT MITIGATION AND RESPONSE STRATEGIES

Thornton's drought mitigation and response strategies play a critical role in the city's drought preparedness and ability to respond to drought. The selected mitigation and response strategies provided below are consistent with the Plan's objectives and operating principles outlined in Section 1.2. In addition, these strategies are feasible from an implementation standpoint, provide added value for either preparing Thornton for a drought (mitigation strategies) or during a water shortage (response strategies) and collectively address a broad spectrum of impacts associated with drought.

4.1 MITIGATION

Thornton is committed to drought preparedness and sustainable management of its water resources. The mitigation measures described below highlight activities Thornton is engaged in to ensure the city is prepared for water supply shortages.

Planning Efforts

Proactive planning can reduce many of the impacts Thornton could experience during a water shortage. These planning efforts include the following:

Routinely update water supply planning efforts - Thornton is committed to ensuring a reliable water supply in the future to meet its growing community. As discussed in Section 3.1, Thornton updates its Water and Wastewater System Master Plan, Five-year CIP and Comprehensive Plans on a routine basis. In addition, the Water Resources Division actively incorporates climate change science in its long-term water supply planning efforts and uses a customized computer model to monitor and project future water supplies.

Integrate drought planning with other city planning efforts – Water shortages can impact many sectors of the community and consequently is important to consider in other city planning efforts. Efforts will be made to ensure that other city planning efforts are coordinated with this Plan.

Consider water shortages when scheduling maintenance and capital improvements – Drought and water supply shortage impacts can be exacerbated when facilities and other infrastructure is out of operation for maintenance and capital improvements. Thornton will coordinate efforts to best avoid the scheduling of maintenance and other capital improvements near the onset and during droughts and water shortages.

Mitigation vs. Response

For purposes of this Plan, mitigation refers to actions taken in advance of a water shortage that reduces impacts. Response strategies refer to actions taken when a water supply shortage occurs to address impacts and preserve water for essential needs.

Water Supplies

New infrastructure – Thornton is in the process of two significant infrastructure projects that will help provide future reliable supplies and improve the city's resiliency to drought. The TWP will bring water purchased by the city in the 1980s to Thornton customers from Larimer and Weld counties. Thornton is working with numerous cities and counties to obtain the necessary permits to build the pipeline. It is projected that the TWP will take several years to construct, with the first delivery of supplies projected to arrive in Thornton in the mid-2020s. This is the primary source of the additional water supply necessary to meet Thornton's future supply and water quality needs. Thornton is also in the process of constructing a new WTP to replace the 55-year old Thornton WTP. The new 20 mgd WTP is projected to be complete in 2020 and will provide treatment capacity in addition to the 50 mgd Wes Brown WTP.

Seek opportunities to acquire emergency supplies – Future opportunities may be available to acquire temporary supplies to alleviate future water shortages. Thornton will evaluate and if proven beneficial, capitalize on such opportunities by developing agreements prior to the onset of a shortage.

Maintain interconnections with other entities - Thornton shares interconnections with the treated water systems of Denver Water, city of Northglenn and the city of Westminster. The interconnections provide the opportunity to purchase and convey additional water into the city service area during water shortages. Agreements would be needed with Denver Water and Westminster for delivery of treated water to Thornton through these interconnects in times of shortage.

Water Efficiency

Manage the city's water supply system efficiently – Thornton manages its water supplies in a manner to optimize available storage capacity and minimize losses within its system. Thornton plans to adopt the AWWA M36 Water Audits and Loss Control Programs which requires the development of a water loss reduction goal and a program for distribution system leak detection.

Reuse backwash water - Thornton indirectly reuses backwash water from its WTPs by releasing the backwash into storage. The backwash then mixes with reservoir water and is recaptured for treatment.

Implement Water Efficiency Program that lowers water demands throughout the community – Thornton's Water Efficiency Program aims to become a model for water-efficient city development as an integral part of the city's overarching mission to secure a reliable and resilient water supply for the Thornton community. The Program promotes efficient water use through community incentives, policy, water rates, and community outreach. Efficient water use results in lower water demands during drought, improving the community's drought resiliency.

Support policy that promotes efficient and wise water use - Support existing and proposed future policy that promotes efficient and wise water use throughout the community.

Water Quality

Remain up-to-date on water treatment best practices and innovative advancements that could provide water quality benefits during shortages - Providing safe drinking water is a critical component of Thornton's services which ensures that the city's drinking water meets all state and federal drinking water standards. The city continues to remain up-to-date on the latest treatment advancements and industrial best practices.

Engage in watershed programs – Watershed programs addressing both wildfire and water quality can improve best management practices within watersheds and improve drought resiliency. They can also provide stakeholders with resources to better address water quality and wildfire challenges during drought. Thornton will continue to participate in such beneficial collaborative efforts.

Funding

Ensure financial resources are available for drought response – Annual fiscal planning ensures that Thornton can meet infrastructure needs while also allocating a reserve fund for water resources-related activities that are not directly tied to infrastructure. This includes funding for drought response.

4.2 SUPPLY-SIDE RESPONSE STRATEGIES

Thornton's supply-side response strategies focus on ways the city can obtain additional water supplies and make temporary operational changes to save water during a shortage. In past droughts, Thornton acquired temporary supplies from other entities which has proven to be an effective strategy. Thornton will continue to pursue this strategy during times of shortage. Arrangements may consist of the following:

- Leasing water from other municipal water providers
- Leasing agricultural water rights
- Temporarily use agricultural water rights owned by Thornton for municipal purposes. This may require the approval of a substitute water supply plan (SWSP) where water rights decreed for agricultural beneficial use, could temporarily be used for municipal use.

Drought and water supply shortages provide unique situations and the opportunity to think out of the box. Water supply options that tend to not be feasible in normal and wet years may be more attractive in drier years. Other strategies Thornton could pursue during shortages are provided in Table 7. Thornton will explore the feasibility, benefits and consequences of these strategies as needed.

Table 7: Additional Water Supply Strategies

Strategy	Description
Negotiate modification of existing water lease with the city of Westminster	This could yield an additional 2,240 AFY that Westminster annually leases from Thornton. However, financial impacts to Thornton and Westminster's water supply situation and willingness to engage in negotiations are significant factors that would need to be considered.
Engage in regional water supply options that could be implemented during drought	As the Front Range continues to develop, communities are starting to collaborate more on regional long-term water supply opportunities. In future droughts, temporary regional supply opportunities providing drought reserves could arise. Examples of opportunities that have been implemented or discussed at various scales in Colorado include cloud seeding, agricultural alternative transfer mechanisms (ATMs) and water banking.
Pump tributary wells in accordance with the city's decrees for potable use suitable replacement supply is available	This may require a replacement supply and approval of a SWSP by the Division of Water Resources.
Curtail deliveries of water from the Standley Lake Pipeline and treat aesthetic and raw water irrigation water for potable purposes	This would entail the treatment of raw water (currently only used for outdoor aesthetic and irrigation) for potable use. For this to be a possibility, the raw water rights would need to be in priority.
Use existing non-tributary groundwater wells as potable water	This would require the development of new infrastructure to treat groundwater and connect the groundwater with the potable distribution system. Development of such infrastructure would likely only be considered if Thornton is experiencing severe long-term shortages.
Explore new non-tributary groundwater options in the Denver Basin	This would entail the leasing of non-tributary groundwater from other entities or the development of new wells. Non-tributary wells can be drilled for use in times of extreme water shortage, but planning, permitting and development can take years. Development of non-tributary water would likely only be feasible if Thornton is experiencing severe long-term shortages.
Explore new storage opportunities that would provide additional yield during drought	New storage options could entail the lowering of reservoir intake structures and use of dead reservoir storage. These strategies would likely only be candidate options under severe long-term shortages.
Establish a water hauling program to provide water for drinking and other essential health and sanitary purposes	This would entail the delivery of potable water through train and vehicular transport. This would likely only occur under an extreme water shortage emergency where water through Thornton's water supply system is at risk of not being available for essential health and safety purposes.

During water shortages temporary modifications may be made to traditional operations to further increase water efficiencies and prolong storage in Thornton's water supply system. Table 8 highlights operational strategies that Thornton could implement during a water shortage.

Table 8: Operational Water Supply System Strategies

Strategy	Description
Divert poorer quality water that is normally not diverted into Thornton's raw water system	Drought along with wildfire can result in degraded water quality. This option is practical only if the water can be treated to meet safe drinking water standards or can safely be used for other non-potable purposes. Blending of poorer quality supplies could also be explored.
Reduce/prohibit using city water to fill ponds used for raw water irrigation and aesthetic purposes	Deliveries to ponds used for raw water irrigation and/or for aesthetic purposes can be limited or prohibited depending on the severity of shortage and outdoor water restrictions. For instance, if water restrictions prohibit outdoor irrigation, no deliveries will be made to ponds storing raw water and deliveries for aesthetic purposes will likely be prohibited.
Increase monitoring of inefficiencies in the distribution system and accelerate leak detection	Additional water distribution efficiency improvements could be made such as the installation of meters at key distribution points to isolate areas of overuse and/or probable leakage. As Thornton adopts advanced metering infrastructure (AMI) technology, more opportunities may arise to closely monitor and regulate the distribution system, minimize leaks, and increase overall efficiencies.
Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates.	Often well yields can be improved if wells are rehabilitated. Estimated yield improvements relative to the costs associated with the rehabilitation could be considered.
Reduce system distribution pressure	The reduction of pressure in Thornton's distribution system could reduce system-wide losses. This would likely only occur under an extreme long-term shortage and precautions would be needed to ensure that water deliveries could still be made to higher elevations of the service area.

4.3 DEMAND-SIDE RESPONSE STRATEGIES

Thornton's demand-side drought response strategies focus on ways the city and community can reduce water use during shortages. The strategies shown in Table 9 were initially selected by the Planning Team and further refined based on city staff and community input. These strategies are listed as specific response measures (actions) by drought stage in Section 6.

Table 9: Demand-Side Response Strategies

Category	Response Strategy
Outdoor Watering residential, commercial, city facilities, parks	Water restrictions on established turf lawns
	Water restrictions on annual and perennial flowers, vegetable gardens, shrubs, and established trees
	Water restrictions on city parks sports turf
	Water restrictions on city parks and right-of-ways
	Water restrictions on city Thorncreek Golf Course
	Promote outdoor irrigation efficiencies
	Restrictions on new landscape installations requiring water
Residential single-family attached, single-family detached, HOAs	Restrictions on nonessential outdoor uses including misting devices, vehicle washing at residences, sidewalk and driveway washing, ornamental fountains
	Restrictions on private outdoor swimming pools and hot tubs
Commercial businesses, schools, churches	Restaurants serve water only if requested by customers
	Implement policies to save water at hotels and motels
	Commercial car washes - promote installation of water recycling technology and other water efficient best management practices (BMPs)
	Specific businesses - Office/business water savings plan during drought.
City water use by Parks and city facilities, city-wide water management decisions	Drought surcharges
	Increase efforts to promote water efficiency through the water efficiency program. This may include: <ul style="list-style-type: none"> ▪ Toilet distribution and/or installs could be organized (rebate funds could be redirected)

Category	Response Strategy
	<ul style="list-style-type: none"> ▪ Increase irrigation system consultations (residential, HOA and commercial) ▪ Increase turf alternative rebate amounts ▪ Increase commercial water assessment efforts ▪ Increase commercial process efficiency incentives ▪ Accelerate supply-side leak detection efforts ▪ Use AMI to customize water budgets by customer and monitor adherence to watering schedule
	Limitations on new taps to city water distribution system
	Construction water for soil compaction, dust control, architectural uses, concrete mix, etc.
	Restrictions on washing of city-owned vehicles
	Restrictions on street cleaning
	Restrictions on hydrant flushing
Commercial and City	Restriction on public drinking fountains
	Restrictions on public outdoor swimming pools and hot tubs
	Restrictions on public indoor swimming pools and hot tubs

4.4 WATER SHORTAGE PUBLIC INFORMATION CAMPAIGN

The water use reduction public information campaign (water use reduction campaign) will be closely coordinated with Thornton’s Water Efficiency Program. During wet and normal periods when there is not a pending or existing water shortage, Thornton will rely on its Water Efficiency Program to increase community awareness on the importance of saving water and efficient water use. The water use reduction campaign will be initiated when there is a high likelihood of a drought or water shortage, educating the community on the implications of a shortage and promoting additional water savings beyond what is typically achieved through the Water Efficiency Program. Upon initiation, water resources staff will develop a campaign plan that incorporates the objectives, foundational information (Table 10), messaging and communication strategies (Table 11) and communication tools (Table 12) outlined below. The frequency of messaging and staff effort focused on reaching out to the community will be elevated relative to the Water Efficiency Program to help ensure that the community understands the implications of the water shortage and what they can do to contribute to achieving additional water savings.

The objectives of the water use reduction campaign are:

- Convey uniform messages on conditions, drought declarations, water restrictions, actions the city is taking to respond to drought, etc. in a manner that best meets the communication needs of the community.
- Empower the community to save water through effective messaging, education and resources.
- Ensure that the water shortage response is an inter-departmental effort and that the city serves as an example to the community by saving water.
- Foster effective two-way communication where the city educates, listens, learns and engages with the community in exchanging perspectives and ideas.

Table 10 lists the foundational information for the water use reduction campaign that will be conveyed during a drought and water shortage. Specific messages as well as the means and frequency in which the information is conveyed to the public will be customized to the drought and specific community needs.

A variety of tools will be used to communicate drought and water shortage messages to targeted audiences. At a minimum this will likely include website communications, social networking media and hard copy utility bill inserts. The water use reduction campaign will also include means for the

Table 10: Foundational Information for the Water Use Reduction Campaign

Foundational Information
Status of drought and water shortage conditions
What the declared drought stage means (e.g., “how does it affect me and the community” and “what can I do to help”)
Where to access the Drought Management Plan and other useful information
Background on Thornton’s water supplies and its vulnerability to drought
What the city is doing to obtain more supplies (e.g., leases)
How the city and Parks and Golf Division are saving water and how this may impact the community
Water restrictions and enforcement
Other water shortage response actions and enforcement
Water savings tips for the community and reminder about the water waste ordinance
Explanation of a drought surcharge (if applicable). See Section 7.6 for more information on drought surcharge messaging.

community to provide regular input on the city’s water shortage response actions and water restrictions. Community input during the shortage is essential since Thornton’s ability to maintain water in storage ultimately rests on community willingness to comply with water demand reduction measures. Also, community perception of fairness and reasonableness is critical and can be enhanced by providing a means for both public education and public input.

Routine updates will be made to City Council and relevant city departments to ensure a coordinated consistent water shortage response. The Water Resources Division, Communications Division and Parks and Golf Division will work together to ensure that messaging is effective and accurate. Coordination with neighboring water providers and other public entities may also be important. During regional droughts, efforts will be made to take advantage of synergies of using consistent drought-related messages shared among local water providers. Thornton will track local water providers’ drought-related response activities. This will enable the city to explain to its customers any differences between Thornton’s drought response activities and neighboring municipalities.

As stated above, a detailed plan for the water use reduction campaign will be developed by Thornton’s Water Resources Division near the onset of a drought and may be adjusted as the water shortage persists to address community needs. The general components of the water use reduction campaign plan will consist of messaging and communication strategies; communication methods and partnerships. Tables 11 through 13 below provides ideas for developing messaging, communication strategies and partnerships.

Table 11: Messaging and Communication Strategies for the Water Use Reduction Campaign

Messages and Communication Strategies	Targeted Audience				
	Community-at-large	City Departments/Council	Residential (HOA, wards, residences)	Commercial (businesses, schools, churches)	Targeted large users (golf course, developers, certain residences, etc.)
Messages					
Increase advertisement of water efficiency incentives	X	X	X	X	X

Messages and Communication Strategies	Targeted Audience				
	Community-at-large	City Departments/Council	Residential (HOA, wards, residences)	Commercial (businesses, schools, churches)	Targeted large users (golf course, developers, certain residences, etc.)
Advertise what the Parks and Golf Division is doing to save water (e.g. signage on brown grass)	X	X	X	X	X
Advertise how city staff is saving water (promote "we are all in this together" mentality)	X	X	X	X	X
Show graph of city water use compared to target use goal	X	X	X	X	
Information on what community can do if the shortage is anticipated to persist	X		X	X	X
Measures and/or impacts that community can expect if water shortage continues or intensifies	X	X	X	X	X
Factors that could influence costs and water supply service	X	X	X	X	X
Provide messages in Spanish and English where needed	X		X	X	X
Strategies for community to conserve water both indoors and outdoors	X		X	X	
Ways to clean sidewalks, driveways, and other hard surfaces without using water	X		X	X	
Do-it-yourself water waste reduction information	X	X	X	X	X
Promote water-wise landscape, demonstration gardens, instructional workshops, etc.	X		X	X	X
Water saving targets and actual consumption by Parks and Golf Division, city facilities, community sectors, and/or targeted users		X	X	X	X
How to reuse gray water legally	X		X	X	
Landscaping tips during a shortage (e.g., which plants to convert to drip, which to save, which to let die)	X		X	X	X
Instructions on how to track water use within the home	X		X		X
Distribute information on "do it yourself" household audit procedures for saving water	X		X		X
Provide information on how to protect trees and shrubs during shortages	X		X	X	
When applicable, provide warnings to homeowners and other property owners considering new landscaping that water restrictions may be put in place to prohibit new landscaping			X	X	
Two-Way Communication Strategies					
Advertise water budget program and intensify communication with those that exceed budget	X				X
Instructions and technical support on how to set up a water use plan for businesses				X	X
Publicize efforts of individuals and businesses as examples of how to reduce water use	X				
Public forums and discussions on drought with possibly having media present	X				
Establish a community advisory committee during shortage					X
Surveys to better understand community needs/concerns related to shortage			X	X	X
Hire public campaign contractor	X	X	X	X	X
Generate more public discussion and media involvement about ways to reduce water use	X				

Messages and Communication Strategies	Targeted Audience				
	Community-at-large	City Departments/Council	Residential (HOA, wards, residences)	Commercial (businesses, schools, churches)	Targeted large users (golf course, developers, certain residences, etc.)
Utilize water ambassadors for messaging and obtaining information from community	X		X	X	X
Ideas to Consider Coming out of Water Shortage					
Provide community with a Thornton drought report card at the end of the year showing monthly/annual water use pre-shortage and during the shortage	X	X	X	X	X
Post-drought landscape revival information	X		X	X	X
Surveys to gather information that can inform future water shortage response		X	X	X	X

Table 12: Communication Tool Options for the Water Use Reduction Campaign

Communication Tools	Priority for Consideration
Post card or letter to all water customers	Medium
Utility bill insert	High
City Voice	High
Channel 8 slides	Low
Sentinel Ads	Low
Denver Post Ads	Low
ThorntonWater.com and city Website	High
Press Release	High
Phone alerts – Reverse 911	Depends on drought stage
E-bill recipients' emails	High
Communications e-mail contacts	High
HOA and apartments - letters or email	High
ALCC, GreenCo notification	High
Business letter or email using Business License Database	High
Door hangers	Low/Medium
Door flyers	Low
Distribution of brochures at city buildings/Ward meetings	Medium
Monthly water use targets and actual consumption on water bills	Actual water consumption is currently on bills. Water use targets can be implemented with AML.
Water report card	Medium
Letters to targeted groups	Medium
Other media outreach	Medium
Pandora with Ads	Low
Use Water Smart App to convey messages	High
Mobile ads (banners)	Low
Search engine marketing (Adword banners)	Low
YouTube targeted to zip code and key interests	Medium
Facebook/Instagram/Twitter - targeted to zip code and key interests	High
Nextdoor	High
Communication via "Water Patrol" (Drought policy enforcement)	High

Communication Tools	Priority for Consideration
Drought hotline	High
Webinar	Medium
School outreach/educational programs (field trips, speakers, curriculum)	Medium
Distribution of water saving tools (rain meter, sink aerators, etc.)	Low
Booths at special events such as city festivals	Low
Billboards	Low/Expensive
Roadside electronic signs	High
Painting drought message on sidewalks in parks	Low
Lawn signs	Medium
HOAs – incentives to relax fines for brown grass or waiting to install sod/seed	Low
Effective images (pictures of reservoirs full vs empty)	High
Public meetings	Medium
Advertisement of water-wise demonstration gardens	Medium
Workshops on conservation topics such as water-wise landscaping	Medium

Table 13: Future Partnership Options for the Water Use Reduction Campaign

Ideas for Future Partnerships
Nearby water providers (e.g. Federal Heights, Northglenn, Westminster)
Exchange ideas with larger water providers on Front Range with drought outreach programs
Colorado Water Conservation Board - provides technical and financial support
Adams County
Regional Air Quality Council
DRCOG
Adams County Economic Development
Adams County CSU Extension Office
Xcel Energy
United Power / Touchstone Energy
Urban Drainage and Flood Control District
Metro Wastewater Reclamation District
Adams County Hazard Local Emergency Planning Committee (part of the Sheriff's office)
The Emergency Management offices of Weld, Larimer, and Jefferson Counties
Colorado Division of Homeland Security and Emergency Management
Colorado Municipal League
Metro North / Thornton Chamber of Commerce
Center for Resource Conservation
Associated Landscape Contractors of Colorado
GreenCo
Colorado Association of Home Builders
Tri-County Health Department
Adams County Aging Network
North Suburban Medical Center
Thornton Active Adult Center
Various Senior care/living facilities
The Center for People with Disabilities
Wards
HOAs
The School Districts that serve Thornton
Community of Faith / Churches in the community

DROUGHT STAGES, INDICATORS AND RESPONSE TARGETS

5.1 DROUGHT STAGES, INDICATORS AND RESPONSE TARGETS

Thornton's response to water shortages is based on the four drought stages shown in Table 14. Each drought is unique and information from many indicators influence drought declaration¹⁰ and the designation of a specific stage. However, projected storage capacity on July 1 serves as the main indicator.¹¹ As shown in Figure 12, the drought stages increase in severity as projected July 1 storage levels become less, calling for a higher demand reduction target (more water to be saved) with each elevating stage. The Stage 1 moderate shortage promotes efficient and voluntary reduction of water use among all five priorities detailed in Table 2. Voluntary programs are designed to increase the community's awareness of shortage conditions and to provide information on ways to reduce water use. Stages 2 and 3 entail mandatory restrictions while the Stage 4 exceptional drought, requires rationing to ensure that essential health and safety and revenue needs can be met.

Priorities for Water Service During Shortages

- 1 – Health and safety
- 2 – Economic vitality
- 3 – Established trees
- 4 – High priority outdoor irrigation
- 5 – Lower priority outdoor irrigation

The demand reduction targets call for a percentage water savings using a "baseline demand." The baseline demand is Thornton's recent running average per capita water use (gpcd).¹² During a shortage, the city monitors water use on a monthly basis and compares monthly water use to the respective monthly baseline demand.¹³ For instance, at the end of June, Thornton compares its current June water use to the June baseline demand.

Table 14: Summary of Drought Stages

Stage	Main Indicator - Projected July 1 Storage	Demand Reduction Targets	Summary of Drought Response
Stage 1: Moderate	75% to 65% of full capacity	Maintain baseline demand with allowance for demand increase as a result of elevated ET and lack of precipitation.	Voluntary Promote efficient water use and voluntary reductions for all five priorities.
Stage 2: Severe	70% to 45% of full capacity	Reduce baseline demands by 10% to 45%. The specific target percentage will depend on the severity of shortage.	Mandatory 10% to 24% reduction - Low priority irrigation (Priority 5) is limited. 25% to 45% reduction - Outdoor irrigation (Priorities 4 and 5) likely prohibited with exception to irrigation of established trees (Priority 3).
Stage 3: Extreme	50% to 35% of full capacity	Reduce baseline demands by more than 45%.	Mandatory Outdoor irrigation is prohibited (priorities 3 to 5) with limitations on uses associated with community vitality (Priority 2). A drought surcharge may be activated.

¹⁰ Information on the drought declaration process is provided in Section 7.3.

¹¹ Thornton prefers to use the terminology of "main indicator" as opposed to "drought trigger" since the city uses a suite of indicators. This wording is more compatible with Thornton's drought designation process where a drought designation is not "triggered" by a just one indicator.

¹² The specific years used to develop the average baseline may be modified as the city improves its understanding of the demand response target's applicability during drought.

¹³ The average per capita water use is calculated using water treatment plant data as opposed to billing data.

Stage	Main Indicator - Projected July 1 Storage	Demand Reduction Targets	Summary of Drought Response
Stage 4: Exceptional	Storage levels are critically low, and the shortage is projected to continue	Ration water according to assigned water budgets that consider city storage levels.	Rationing Same as stage 3 with additional limitations on Priority 2 uses. Strict rationing may also be enforced. A drought surcharge may be activated.

Note: The Projected July 1 Storage indicator ranges overlap for Stage 2 and Stage 3 droughts to provide a greater level of flexibility when declaring a shortage.

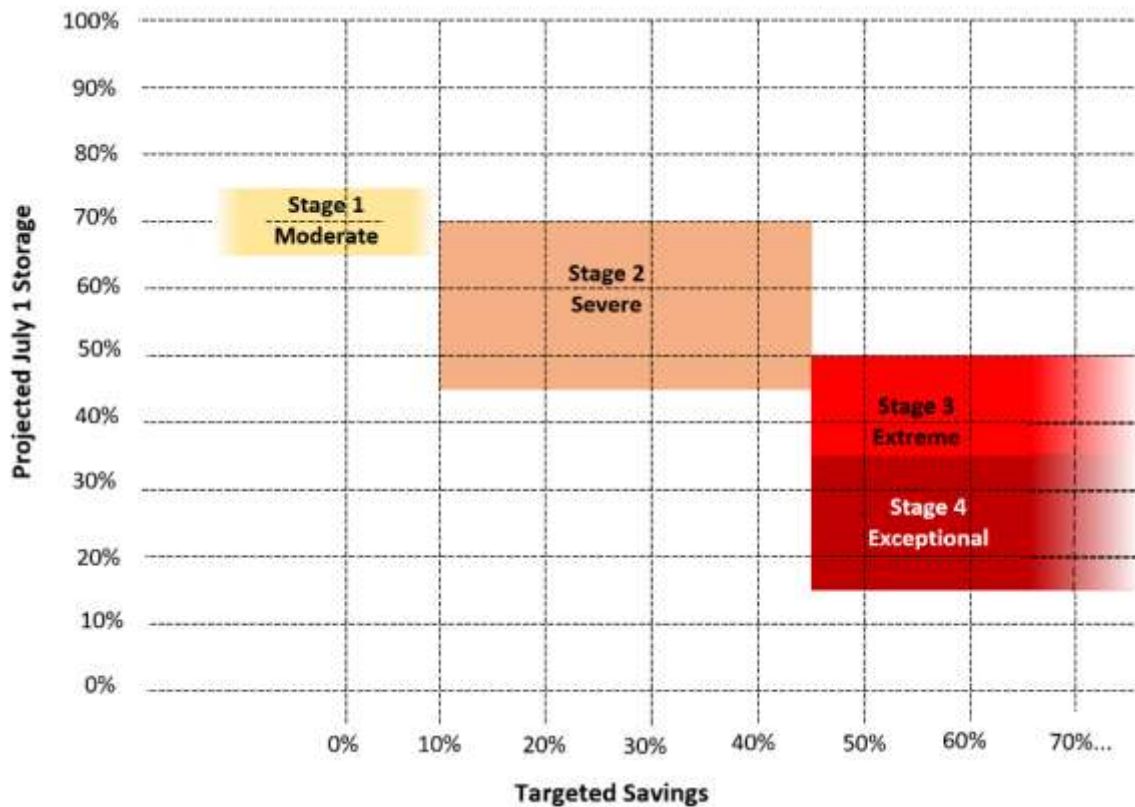


Figure 12: Illustration of Thornton's Drought Stages

As previously mentioned, each water shortage is unique and consequently may or may not “fit” within the exact parameters defined in Table 14. The projected July 1 storage and other indicators serve as guidelines for a water shortage declaration rather than a “set of rules.” Professional expertise coupled with other factors will contribute to staff recommendations and City Council’s decision on drought declaration and targeted shortage response. Furthermore, while the indicators and drought stages primarily focus on drought-related shortages in this section, these stages may be applied to water shortages that may not be drought-related. Such shortages could be induced by the damage to significant infrastructure as a result of natural or human-induced events.

Baseline Demands
During shortages, Thornton monitors demands on a monthly basis. The baseline demand is Thornton’s average capita water use over the past seven years for the designated month.

Description of Drought Stages

Stage 1 Moderate - The moderate drought stage is considered for declaration when projected July 1 storage levels are between 75% and 65% of full capacity. Thornton has historically observed increases in outdoor water demands during drought because of higher temperatures (higher evapotranspiration), longer growing seasons and less precipitation. Stage 1 moderate drought focuses

on limiting this increase to no more than 10% of baseline demand. This stage focuses on incentives and a water use reduction campaign that promotes voluntarily reductions for all five priorities.

Stage 2 Severe - The severe drought stage is considered when projected storage levels are between 70% and 45% of full capacity and climate outlooks forecast continued drought. The demand reduction target in this stage ranges from a 10% to 45% reduction in demand, depending on conditions. This target is determined at the onset of the drought stage and may be adjusted to reflect conditions as the shortage persists. Mandatory water restrictions coupled with an intensive public water use reduction campaign will be enacted. This stage covers a broad spectrum of mandatory shortage response efforts. When demand reduction targets are set at 10% to 24%, mandatory restrictions may primarily focus on low priority irrigation (Priority 5). When the shortage is of warranted severity, demand reduction targets are set within the 25% to 45% range. Mandatory restrictions may limit all outdoor irrigation (Priorities 4 and 5) except for established trees (Priority 3). These restrictions are intended to preserve water for needs related to health and safety and economic livelihood (Priorities 1 and 2).

Stage 3 Extreme - The extreme drought stage is considered when projected July 1 storage levels are between 50% and 35% of capacity and other indicators show that the drought is anticipated to persist. The demand reduction target may exceed 45%. The target is determined at the onset of the stage and may be adjusted as the shortage persists. Outdoor irrigation (Priorities 4 and 5) is prohibited including the watering of outdoor trees (Priority 3). Additional measures are implemented to reduce non-sanitary indoor uses and outdoor use for business and commercial purposes (Priority 2). This may lead to adverse economic impacts yet is necessary to conserve water for essential safety and health needs. A drought surcharge may be used to bolster revenue for operations and maintenance.

Stage 4 Exceptional - The exceptional drought stage is considered when July 1 projected storage levels are critically low (below 35% of full capacity) and other indicators show that the shortage is to persist. A shortage of this severity would likely only occur under a severe multi-year drought that exceeds historical records. Focus is placed on ensuring that the health and safety needs of the community can be met. All outdoor use is prohibited which may require the need for infrastructure capable of restricting total deliveries to customers (rationing). The reduction in water use could fail to generate enough revenue for normal operations and maintenance. This may require the collection of revenue outside the normal rate structure (drought surcharge), which would necessitate an amendment to Thornton's rate ordinance.

Stages - Indicators - Guidelines

Each water shortage is unique and consequently may or may not “fit” within the parameters of the drought indicators. The projected July 1 storage and other indicators serve as guidelines for drought declaration rather than a “set of rules.” Professional expertise coupled with other factors may contribute to staff recommendations and City Council’s decision on drought declaration.

5.2 DROUGHT DECLARATION AND PREDICTABILITY

Droughts in Colorado can appear quickly or slowly, last for a season or many years, and can occur locally, regionally, or statewide. Furthermore, a drought does not have a clearly defined beginning or end and is difficult to predict. For example, following the 2002 drought, snowpack accumulation in early 2003 was abnormally low and, if not for a single large snow storm event in mid-March 2003, many providers throughout Colorado would have been seriously stressed. Even though South Platte Basin supplies in 2003 were slightly above average, water demands (including demands to fill empty reservoirs) were well above average, resulting in a drought condition even with above-average supplies.

To address this variability, Thornton uses a suite of hydrologic and climate indicators. Thornton also takes into consideration changes in its water demand patterns and assesses scheduled infrastructure

modifications that could enhance or reduce the city's ability to store, treat and deliver water. This information is evaluated on a regular basis to determine whether conditions warrant a drought declaration or change to an existing drought stage.

Climate and Hydrologic Indicators

As discussed in Section 5.1, the main indicator is Thornton's projected storage on July 1. This indicator is developed using a model that forecasts what the city's water storage will be on a monthly basis, 18 months into the future.¹⁴ These monthly storage projections inform management decisions. Focus is placed on the July 1 storage forecast because it is after the Spring runoff, when Thornton is at or near peak day use, yet still must meet community water needs for the remainder of the year primarily relying on water in storage. Other hydrologic and climate indicators that aid in developing a comprehensive picture of Thornton's water supply situation are listed in the bullet points below.

- Snowpack on April 1st and snow accumulation below 10,000 feet in elevation
- NRCS stream flow forecasts
- U.S. Drought Monitor
- Water year (October 1 – September 30) accumulated precipitation
- Daily high and low temperatures from NRCS Snowpack Telemetry (SNOTEL)
- Standard Precipitation Index (SPI)
- Evaporative Demand Drought Index (EDDI)
- Surface Water Supply Index (SWSI)
- Palmer Drought Severity Index (PDSI)

Infrastructure Condition

Failures and modifications to Thornton's infrastructure can cause or contribute to a water shortage during drought. For example, reservoirs that are unusable due to maintenance activities could compromise Thornton's ability to store water during drought. Thornton routinely monitors the condition of its infrastructure and schedule for facility improvements that could impact water storage, treatment and delivery. This information can be useful in informing drought declaration decisions. Additionally, changes may be made to facility maintenance and capital improvement schedules to minimize adverse impacts if a water shortage is anticipated or predicted to persist.

Monitoring and Timing of Drought Declaration

Timing is critical when it comes to the declaration of a drought stage and is an important consideration by both city staff and Thornton's City Council when discussing drought conditions. If a drought is declared too late and/or actions are not taken early enough to reduce water use, supplies can be severely depleted. Strict water restrictions and economic impacts may be required that could have been avoided. Conversely, premature drought declarations can result in unnecessary mandatory water restrictions and the community can lose confidence in the declaration.

The changing climate presents additional challenges in identifying an appropriate period for declaring drought. It cannot be assumed that hydrologic and climate data from the past are indicative of what may happen in the future. To address this lack of stationarity, Thornton's drought indicators and response targets are designed to allow the city to assess drought conditions early in a drought cycle and therefore provide room for more agile responses as conditions deteriorate or improve. Typically monitoring is of highest diligence in late March until early May when nearly all the spring mountain snowpack has accumulated. This information is critical in quantifying available supplies for the

¹⁴ The storage forecast is a water budget spreadsheet model that calculates the change in Thornton's storage based on estimates of future available water supplies, reservoir evaporation and community demands. The suite of indicators identified in this section in addition to staff professional expertise inform the model.

upcoming irrigation season. Additional information on Thornton’s monitoring efforts is provided in Section 7.2.

STAGED DROUGHT RESPONSE PROGRAM

This section customizes the supply and demand-side drought strategies identified in Section 4, with response measures identified for each of the four drought stages. Following the declaration of a drought stage, Thornton water resources staff develops and enforces a set of Rules and Regulations approved by the City Manager that specifies the restrictions for the declared drought stage. In addition, water resources staff develops a water use reduction campaign that elevates the level of community messaging above typical communication associated with the Water Efficiency Plan. This helps ensure that the community understands the implications of the water shortage and what they can do to contribute to achieving additional water savings. Additional information on the water use reduction campaign is provided in Section 4.4.

This section outlines the basic response measures and serves as a guidance tool for developing the Rules and Regulations. Where needed, deviations may be made from the measures provided here to best address the circumstances of the water shortage.

6.1 STAGE 1 MODERATE

Main Drought Indicator: Projected July 1 Storage is 65% to 75%

Drought Stage and Main Indicator Summary: The moderate drought stage is considered for declaration when projected storage levels are between 65% and 75% of full capacity. Thornton has historically observed increases in outdoor water demands during drought because of higher temperatures, longer growing seasons and less precipitation. Stage 1 focuses on limiting this increase to no more than 10% of baseline conditions. This stage focuses on incentives and the public drought campaign to promote voluntarily reductions for all five water use priorities.

Supply-Side Response Measures

- Lease municipal water where available.
- Consider leasing agricultural water where legally possible.
- Consider filing SWSP to temporarily use city-owned agricultural water rights.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.
- Consider increasing monitoring of inefficiencies in the distribution system and accelerate leak detection.

Demand-Side Response Measures

Outdoor Watering (residential, commercial, parks and city facilities)

- Established turf lawns – Voluntary water restrictions. Watering limited to no more than 3 times a week. No watering from 10:00 am to 6:00 pm.
- Annual and perennial flowers, vegetable gardens, shrubs, established trees – Voluntary water restrictions. May be watered by hand or by automatic system. No watering from 10:00 am to 6:00 pm. This also includes water-wise landscapes although they should require less water than the gardens mentioned above.
- City parks sports turf – Voluntary water restrictions. Watering is reduced and closely monitored to ensure savings target of maintaining baseline demands is achieved. Watering may occur between 10:00 am to 6:00 pm.
- City parks and right-of-way – Voluntary water restrictions. Watering is reduced and closely monitored to ensure savings target of maintaining baseline demands is achieved. Watering may occur between 10:00 am to 6:00 pm.
- City golf course – Voluntary water restrictions. BMPs for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly.

- Irrigation system efficiency – Voluntary. City increase promotion of outdoor irrigation consultations that include a water audit and recommendations on how to improve water efficiency. Encourage conversion of sprinklers to high-irrigation.
- New landscape installations requiring water - May be watered as needed for the first month. Recommend outdoor irrigation consultations and installation of efficient irrigation systems. All landscapes must be installed to city code.

Residential (single-family attached, single-family detached and HOAs)

- Nonessential outdoor uses – Voluntary restrictions where water use is reduced or stopped. This includes misting devices, vehicle washing at residences, sidewalk and driveway washing and ornamental fountains.
- Private outdoor swimming pools and hot tubs – Voluntary. Minimize filling and cover to reduce evaporation.

Commercial (businesses, schools and churches)

- Restaurants – Voluntary. Restaurants are encouraged to only serve water upon request.
- Hotels/motels – Voluntary. Hotels/motels are encouraged to implement policy where signs are posted asking customers to conserve water during their stay (e.g., not have linens washed every night).
- Commercial car washes – Promote installation of water recycling technology and other water efficient technologies and practices.

City (city-wide water management decisions)

- Intensify water efficiency incentives for targeted users – Target incentives on high water users and other users where significant water savings may be achieved. Examples of incentives are provided in Table 9. These incentives are implemented through Thornton’s Water Efficiency Program.
- Construction water – Allowed with BMPs implemented to use water efficiently. This includes water for soil compaction, dust control, architectural uses, concrete mix, etc.
- Washing of city -owned vehicles – Voluntary restrictions. Reduce washing of city vehicles to once a month and take to commercial car wash that uses recycled water.
- Street cleaning – Allowed with BMPs in place for efficient water use.

Commercial and City

- Public outdoor swimming pools and hot tubs – Voluntary. Minimize filling and cover to reduce evaporation.
- Public indoor swimming pools and hot tubs – Voluntary. Use BMPs to limits spillage and evaporation.

6.2 STAGE 2 SEVERE

Main Drought Indicator: Projected July 1 Storage is 45% to 70%

Drought Stage and Main Indicator Summary: The severe drought stage is considered when projected storage levels are between 45% and 70% of full capacity. During a Stage 2 drought, climate outlooks are generally not favorable for precipitation to alleviate demands and improve hydrologic conditions before July 1. The demand reduction target percentage will be determined at the onset of the drought stage and may be adjusted to reflect conditions as the drought persists. Mandatory water restrictions coupled with an intensive public drought campaign will be enacted, however, this stage covers a broad spectrum on the degree of mandatory drought response. When demand targets are set at 10% to 24%, demand response primarily focuses on low priority irrigation (Priority 5). However, targets within the 25% to 40% range will limit all outdoor irrigation (priorities 4 and 5) with exception to established trees. The degree to which irrigation is limited will depend on the severity of drought and

corresponding water savings target. This is intended to preserve uses associated with health and safety and economic livelihood (priorities 1 and 2).

Supply-Side Response Measures

- Lease municipal water where available. Availability will become less with persistent severe shortage.
- Consider leasing agricultural water where legally possible.
- Consider filing SWSP to temporarily use city-owned agricultural water rights.
- Curtail deliveries of water from the Standley Lake Pipeline and treat aesthetic and raw water irrigation water for potable purposes.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.
- Consider reducing use of city water to fill lakes for raw water irrigation and aesthetic purposes.
- Increase monitoring of inefficiencies in the distribution system and accelerate leak detection.

Additional supply-side measures to consider when conditions deteriorate to level needing saving targets of 25% to 45% include:

- Consider negotiating modification of water lease with the city of Westminster.
- Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.

Demand-Side Response Measures with a Savings Target of 10% to 24%

Outdoor Watering (residential, commercial, parks and city facilities)

- Established turf lawns – Mandatory water restrictions. Watering limited to no more than 2 to 3 times a week. No watering from 10:00 am to 6:00 pm.
- Annual and perennial flowers, vegetable gardens, shrubs, established trees – Mandatory water restrictions. May be watered by hand or by automatic system every other day. No watering from 10:00 am to 6:00 pm. This also includes water-wise landscapes although they should require less water than the gardens mentioned above.
- City parks sports turf – Mandatory water restrictions. Watering is reduced and closely monitored to ensure savings target of 10% to 24% is achieved. Watering may occur between 10:00 am to 6:00 pm.
- City parks and right-of-way – Mandatory water restrictions. Watering is reduced and closely monitored to ensure savings target of 10% to 24% is achieved. Watering may occur between 10:00 am to 6:00 pm. Watering may occur between 10:00 am to 6:00 pm.
- City golf course – Mandatory water restrictions. Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Convert watering of the greens, greens surrounds, driving range tee and clubhouse grounds to alternating sources every other irrigation event (potable vs non-potable). This would be a 50% reduction in potable use.
- Irrigation system efficiency – Voluntary. City increase promotion of outdoor irrigation consultations that include a water audit and recommendations on how to improve water efficiency. Encourage conversion of sprinklers to high-irrigation.
- New landscape installations requiring water – New installations may require a permit or be prohibited. If allowed, may be watered as needed for the first month. Irrigation consultations and installation of efficient irrigation systems are required. If prohibited, alternative non-irrigated groundcover (e.g. mulch) will be required. All landscapes must be installed to city code.

Residential (single-family attached, single-family detached and HOAs)

- Nonessential outdoor uses – Misting devices and sidewalk and driveway washing are prohibited. Vehicle washing at residences and ornamental fountains that are on closed systems, recycling water, are allowed if implemented wisely without water waste.
- Private outdoor swimming pools and hot tubs – Mandatory. Minimize filling and cover to reduce evaporation.

Commercial (businesses, schools and churches)

- Restaurants – Mandatory. Restaurants are required to only serve water upon request.
- Hotels/motels – Voluntary. Hotels/motels are encouraged to implement policy where signs are posted asking customers to conserve water during their stay (e.g., not have linens washed every night).
- Commercial car washes – Promote installation of water recycling technology and other water efficient technologies and practices.

City (city-wide water management decisions)

- Intensify water efficiency incentives on target users – Target incentives on high water users and other users where significant water savings may be achieved. Examples of incentives are provided in Table 9. These incentives are implemented through Thornton’s Water Efficiency Program.
- Construction water – Allowed with BMPs implemented to use water efficiently. This includes water for soil compaction, dust control, architectural uses, concrete mix, etc.
- Washing of city-owned vehicles – Mandatory restrictions. Reduce washing of city vehicles to once a month and take to commercial car wash that uses recycled water.
- Street cleaning – Allowed with BMPs in place for efficient water use.

Commercial and City

- Public outdoor swimming pools and hot tubs – Mandatory. Minimize filling and cover to reduce evaporation.
- Public indoor swimming pools and hot tubs – Mandatory. Use BMPs to limit spillage and evaporation.

Demand-Side Response Measures with a Savings Target of 25% to 45%

Outdoor Watering (residential, commercial, parks and city facilities)

- Established turf lawns – Mandatory water restrictions. Watering limited to no more than 1 to 2 times a week. No watering from 10:00 am to 6:00 pm.
- Annual and perennial flowers, vegetable gardens, shrubs, established trees – Mandatory water restrictions. May be watered by hand, drip, deep root mechanical bubblers or sub-irrigated every other day. Established trees should only be watered twice a month. No hand watering between 10:00 - 6:00 pm. This also includes water-wise landscapes although they should require less water than the gardens mentioned above.
- City parks sports turf – Mandatory water restrictions. Watering is reduced and closely monitored to ensure savings target of 25% to 45% is achieved. Watering may occur between 10:00 am to 6:00 pm.
- City parks and right-of-way – Mandatory water restrictions. Watering is reduced and closely monitored to ensure savings target of 25% to 45% is achieved. Watering may occur between 10:00 am to 6:00 pm.
- City golf course – Mandatory water restrictions. Follow BMP’s for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Convert watering of the greens, greens surrounds, driving range tee and clubhouse grounds to alternating sources every other irrigation event (potable vs non-potable). This would be a 50% reduction in potable use.

- Irrigation system efficiency – Voluntary. City increase promotion of outdoor irrigation consultations that include a water audit and recommendations on how to improve water efficiency. Encourage conversion of sprinklers to high-irrigation.
- New landscape installations requiring water – Prohibited. Alternative non-irrigation groundcover (e.g. mulch) will be required.

Residential (single-family attached, single-family detached and HOAs)

- Nonessential outdoor uses – Misting devices, sidewalk and driveway washing, and vehicle washing at residences are prohibited. Ornamental fountains that are on closed systems, recycling water may be allowed if implemented wisely without water waste.
- Private outdoor swimming pools and hot tubs – Mandatory. Minimize filling and cover to reduce evaporation.

Commercial (businesses, schools and churches)

- Restaurants – Mandatory. Restaurants are required to only serve water upon request.
- Hotels/motels – Mandatory. Hotels/motels are required to implement policy where signs are posted asking customers to conserve water during their stay (e.g., not have linens washed every night).
- Commercial car washes – Limitations may be placed on car washes that do not use recycled water and water efficient technologies. Promote installation of water recycling technology and other water efficient technologies and practices.
- Specific businesses – City provide instructional resources to specific businesses on how to develop a water savings plan. Approved water savings plan may be required.

City (city-wide water management decisions)

- Water pricing - Consider drought surcharge.
- Intensify water efficiency incentives on target users – Target incentives on high water users and other users where significant water savings may be achieved. Examples of incentives are provided in Table 9. These incentives are implemented through Thornton's Water Efficiency Program.
- New development – Consider changes to review process and limitations on number of taps allowed.
- Construction water – Allowed with BMPs implemented to use water efficiently. This includes water for soil compaction, dust control, architectural uses, concrete mix, etc.
- Washing of city -owned vehicles – Mandatory restrictions. Limit washing of city vehicles to special circumstances and take to commercial car wash that uses recycled water.
- Street cleaning – Closely monitor water use with BMPs in place for efficient water use. May limit street cleaning to areas in special need.
- Hydrant flushing - Recommend use of tanker trucks to reclaim water.

Commercial and City

- Public drinking water fountains – Signs encouraged to promote efficient water use.
- Public outdoor swimming pools and hot tubs – Mandatory. Minimize filling and cover to reduce evaporation.
- Public indoor swimming pools and hot tubs – Mandatory. Use BMPs to limit spillage and evaporation.

6.3 STAGE 3 EXTREME

Main Drought Indicator: Projected July 1 Storage is 35% to 50%

Drought Stage and Main Indicator Summary: The extreme drought stage is considered when projected storage levels are between 35% and 50% and other indicators show that the drought is anticipated to persist. Targeted demands savings will exceed 45% and be determined at the onset of

the stage and possibly adjusted as the drought persists. Outdoor irrigation (priorities 4 and 5) is prohibited including the watering of outdoor trees (Priority 3). Other measures will be needed to reduce non-sanitary indoor uses and outdoor use for business and commercial purposes (Priority 2). This may lead to adverse economic impacts but is necessary to conserve water for essential safety and health needs.

Supply-Side Response Measures

- Lease municipal water where available.
- Lease agricultural water where legally possible.
- Consider filing SWSP to temporarily use agricultural water rights if water is available.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.
- Negotiate modification of water lease with the city of Westminster.
- Consider new regional water supply options if they arise through course of shortage.
- Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available.
- Curtail deliveries of water from the Standley Lake Pipeline and treat aesthetic and raw water irrigation water for potable purposes.
- Consider developing infrastructure necessary to use the city's existing non-tributary groundwater for potable use (currently it may only be used for irrigation).
- Consider exploring non-tributary groundwater options in the Denver Basin.
- Explore new storage opportunities (e.g. lower intake structures) that would provide additional yield during drought.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.
- Consider prohibiting use of city water to fill ponds used for raw water.
- Increase monitoring of inefficiencies in the distribution system and accelerate leak detection.
- Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates.
- Consider reducing water supply system distribution pressure.

Demand-Side Response Measures

Outdoor Watering (residential, commercial, parks and city facilities)

- Established turf lawns – Prohibited.
- Annual and perennial flowers, vegetable gardens, shrubs, established trees – Mandatory water restrictions. All outdoor watering is prohibited with exception to watering of established trees twice a month by hand, or by deep root mechanical bubblers or subirrigation. No hand watering between 10:00 am and 6:00 pm.
- City parks sports turf – Mandatory water restrictions. Watering is reduced and closely monitored to ensure savings target of greater than 45% is achieved. Watering may occur between 10:00 am to 6:00 pm. Signs may be posted if using non-tributary groundwater from Denver Basin wells.
- City parks and right-of-way – Prohibited. All outdoor watering is prohibited with exception to watering of established trees twice a month by hand, by deep root mechanical bubblers or by subirrigation. Watering may occur between 10:00 am to 6:00 pm.
- City golf course – Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Discontinue the use of potable water – convert all irrigation to 100% non-potable. This would be a 100% reduction in the use of potable water. Monitor the Big Dry Creek flows and consider limiting the use of non-potable water to lower priority areas (voluntarily).
- New landscape installations requiring water – New installations are prohibited. Alternative non-irrigated groundwater (e.g. mulch) will be required.

Residential (single-family attached, single-family detached and HOAs)

- Nonessential outdoor uses – Prohibited. This includes misting devices, sidewalk and driveway washing, vehicle washing at residences and ornamental fountains.
- Private outdoor swimming pools and hot tubs – May be prohibited. If allowed, minimize filling and cover to reduce evaporation.

Commercial (businesses, schools and churches)

- Restaurants – Mandatory. Restaurants are required to only serve water upon request.
- Hotels/motels – Mandatory. Hotels/motels are required to implement policy where signs are posted asking customers to conserve water during their stay (e.g. not have linens washed every night).
- Commercial car washes – Water use limitations may be placed on daily water use for all car washes. City promote installation of water recycling technology and other water efficient technologies and practices.
- Specific businesses – City provide instructional resources to specific businesses on how to develop a water savings plan. Approved water savings plan may be required.

City (city-wide water management decisions)

- Consider drought surcharge.
- Intensify water efficiency incentives on target users – Target incentives on high water users and other users where significant water savings may be achieved. Examples of incentives are provided in Table 9. These incentives are implemented through Thornton's Water Efficiency Program.
- New development – Consider changes to review process and limitations on number of taps allowed.
- Construction water – Must obtain permit for use of construction water. The issuance and conditions of permit may depend on the stage a project is at in the city planning review process. This includes water for soil compaction, dust control, architectural uses, concrete mix, etc.
- Washing of city-owned vehicles – Prohibited.
- Street cleaning – Closely monitor water use with BMPs in place for efficient water use. May limit street cleaning to areas in special need.
- Hydrant flushing - May be prohibited in certain circumstances. Recommend use of tanker trucks to reclaim water.

Commercial and City

- Public drinking water fountains – Signs encouraged to promote efficient water use.
- Public outdoor swimming pools and hot tubs – Mandatory. Minimize filling and cover to reduce evaporation. Use may be prohibited.
- Public indoor swimming pools and hot tubs – Mandatory. Use BMPs to limit spillage and evaporation.

6.4 STAGE 4 EXCEPTIONAL

Main Drought Indicator: Storage levels are critically low

Drought Stage and Main Indicator Summary: The exceptional drought stage is considered when projected storage levels are critically low and other indicators show that the drought is to persist. A shortage of this severity would likely only occur under a severe multi-year drought that exceeds all drought currently on historical record. Focus would be placed on ensuring that the health and safety needs of the community can continue to be met. Indoor rationing of water will be necessary and all outdoor irrigation will be prohibited.

Supply-Side Response Measures

New water supply measures include:

- Lease municipal water if available (although likely not available).
- Lease agricultural water where legally possible.
- Consider filing SWSP to temporarily use city-owned agricultural water rights if water is available.
- Negotiate modification of water lease with the city of Westminster.
- Consider new regional water supply options if they arise through course of shortage.
- Pump tributary wells in accordance with the city's decrees for potable use if suitable replacement supply is available.
- Curtail deliveries of water from the Standley Lake Pipeline and treat aesthetic and raw water irrigation water for potable purposes.
- Consider developing infrastructure necessary to use the city's existing non-tributary groundwater for potable use (currently it may only be used for irrigation).
- Consider exploring non-tributary groundwater options in the Denver Basin.
- Explore new storage opportunities (e.g. lower intake structures) that would provide additional yield during drought.
- If needed, establish a water hauling program to provide water for drinking and other essential health and sanitary purposes.
- Consider diverting poorer quality water that is normally not diverted into Thornton's water supply system if it can meet safety standards.
- Prohibit use of city water to fill ponds used for raw water irrigation and aesthetic purposes.
- Increase monitoring of inefficiencies in the distribution system and accelerate leak detection.
- Investigate benefits of rehabilitating/flushing existing wells to optimize flow rates.
- Consider reducing water supply system distribution pressure.

Demand-Side Response Measures

Outdoor Watering (residential, commercial, parks and city facilities)

- Established turf lawns – Prohibited.
- Annual and perennial flowers, vegetable gardens, shrubs, established trees – Prohibited.
- City parks sports turf – Prohibited.
- City parks and right-of-way – Prohibited.
- City golf course – Follow BMP's for golf course irrigation. Water only as needed and perform irrigation checks in the field to ensure efficiency and performance. Timely repair of any irrigation component not performing properly. Discontinue the use of potable water and convert all irrigation to 100% non-potable. Monitor the Big Dry Creek flows and reduce irrigation in the rough by 50%, reduce fairways and tees and clubhouse grounds by 25%. Carts to remain on paths at all times – no exceptions.
- New landscape installations requiring water – New installations are prohibited. Alternative non-irrigated groundwater (e.g. mulch) will be required.

Residential (single-family attached, single-family detached and HOAs)

- Nonessential outdoor uses – Prohibited. This includes misting devices, sidewalk and driveway washing, vehicle washing at residences and ornamental fountains.
- Private outdoor swimming pools and hot tubs – Prohibited.

Commercial (businesses, schools and churches)

- Restaurants – Mandatory. Restaurants are required to only serve water upon request.
- Hotels/motels – Mandatory. Hotels/motels are required to implement policy where signs are posted asking customers to conserve water during their stay (e.g. not have linens washed every night). Guests are likely subject to rationing.

- Commercial car washes – Prohibited.
- Specific businesses – City provide instructional resources to specific businesses on how to develop a water savings plan. Approved water savings plan will be required. Businesses will likely be subject to rationing.

City (city-wide water management decisions)

- Consider drought surcharge.
- Intensify water efficiency incentives on target users – Focus incentives on water efficiency needed to meet rationing requirements.
- New development – Consider changes to review process and limitation on number of taps allowed. Consider prohibiting all additional taps.
- Construction water – May be prohibited. If allowed, must obtain permit for use of construction water. The issuance and conditions of permit may depend on the stage a project is at in the city planning review process.
- Washing of city -owned vehicles – Prohibited.
- Street cleaning – Consider prohibiting. If allowed, closely monitor water use with BMPs in place for efficient water use. Limit street cleaning to areas in special need.
- Hydrant flushing – Only allowed for health and safety.

Commercial and City

- Public drinking water fountains – Prohibited unless fountains are used for rationing purposes.
- Public outdoor swimming pools and hot tubs – Prohibited.
- Public indoor swimming pools and hot tubs – Mandatory. Use BMPs to limit spillage and evaporation. May be prohibited.

IMPLEMENTATION AND MONITORING

7.1 MITIGATION ACTION PLAN

Mitigation is critical to ensuring the reliability of a city's water supplies and an appropriate level of resiliency to drought and other water supply shortages. Section 4.1 describes Thornton's drought mitigation measures. The Mitigation Action Plan provided in Table 15 outlines Thornton's mitigation measures and respective action items, milestones and lead department or division.

Table 15: Mitigation Action Plan

Category	Mitigation Measures	Action Items	Milestones	Lead Department or Division
Planning Efforts	Routinely update water supply planning efforts <ul style="list-style-type: none"> Complete Water and Wastewater System Master Plan Update 5-year CIP 	Routinely update plans. Continue to assess climate change.	Water and Wastewater System Master Plan anticipated to be completed in Fall 2019	Engineering Services Division
	Routinely update Comprehensive Plan	Routinely update plan	Anticipated to be completed in Fall 2019	City Development
	Integrate drought planning with other city planning efforts	Ongoing	Ongoing	Multi-division in Infrastructure Department
	Consider drought when scheduling maintenance and capital improvements	Ongoing	Ongoing	Water Resources Division
Water Supplies	New infrastructure <ul style="list-style-type: none"> TWP New Thornton WTP 	Ongoing	TWP – mid 2020s New WTP – anticipated completion in 2020	Water Resources Division
	Seek opportunities to acquire emergency supplies	Ongoing	Ongoing	Water Resources Division
	Maintain interconnections with other entities	Ongoing	Ongoing	Multi-Division
	Remain up-to-date on water treatment best practices and innovative advancements	Ongoing and replacement of Thornton WTP	WTP to be completed in 2020	Water Treatment and Water Quality
Water Efficiency Program	Manage the city's water supply system efficiently	Ongoing	Ongoing	Water Resources Division
	Implement water efficiency program that lowers water demands throughout the community	The Water Efficiency Plan will be updated in 2025.	Ongoing	Water Resources Division
	Reuse backwash water	Ongoing	Ongoing	Water Resources Division
	Support policy that promotes efficient and wise water use	Ongoing	Ongoing	Water Resources Division
Water Quality	Remain up-to-date on water treatment best practices and innovative advancements that could provide water quality benefits during shortages	Ongoing	Ongoing	Water Treatment and Water Quality
	Engage in watershed programs	Ongoing	Ongoing	Water Treatment and Water Quality

Category	Mitigation Measures	Action Items	Milestones	Lead Department or Division
Funding	Ensure monies are available for drought response	Drought response included in budget request to city	To be initiated in 2019	Water Resources Division Approved by Budget Office

7.2 MONITORING OF DROUGHT INDICATORS

Thornton's Water Resources Division is responsible for maintaining the water storage projection model and for obtaining information on the drought indicators, discussed in more detail in Section 5.2. Table 16 lists each of these indicators and main resources used to acquire data. The water shortage projection model and monitoring are conducted on a monthly basis. A briefing on key climate and hydrologic information is also distributed by email to Water Resources staff and other key staff throughout the city on a weekly basis.

Table 16: Drought Indicators and Monitoring Resources

Drought Indicators	Resources Used to Monitor Drought
<u>Climate and Hydrologic Indicators</u> <ul style="list-style-type: none"> Projected storage on July 1 Snowpack on April 1 and snow accumulation below 10,000' NRCS streamflow forecasts US Drought Monitor Water year (Oct 1 – Sep 30) accumulated precipitation Daily high and low temperatures from SNOTELs Standard Precipitation Index (SPI) Evaporative Demand Drought Index (EDDI) Surface Water Supply Index (SWSI) Palmer Drought Severity Index (PDSI) <u>Infrastructure</u> <ul style="list-style-type: none"> Condition of infrastructure Scheduling for capital improvement projects in relation to drought Maintenance schedules 	<u>Climate and Hydrologic Indicators</u> <ul style="list-style-type: none"> NRCS streamflow, precipitation and snowpack outlooks CPC Temperature and Precipitation Outlooks CPC Weekly, Monthly, and Seasonal Drought Outlooks Colorado Climate Center Webinar Colorado Flood and Water Availability Task Force Updates NIFC Wildfire Outlooks National Weather Service website National Integrated Drought Information Service Website <u>Infrastructure</u> <ul style="list-style-type: none"> Discussions with Water Treatment and city Engineering and Infrastructure

The intensity of monitoring increases from February to early May when most of the mountain snowpack has accumulated. During and near the onset of drought, monitoring may increase to once a week to ensure that decisions are being made with the most up-to-date information. The indicators are used by the Water Resources Division to characterize a pending water shortage and to develop a recommendation to City Council on the specific drought stage for designation. This recommendation may be modified as conditions change that either intensifies or reduces the severity of drought conditions.

Thornton will also monitor the drought-related actions of other water providers in the region and consider whether these actions are relevant to the city's water supply situation. This enhances Thornton's ability to provide a consistent message to the community on why the city's drought response (e.g., water restrictions) either corresponds to or is different from neighboring areas.

Water Demand Monitoring During A Shortage

In addition to the drought indicators listed in Table 16, during a water shortage Thornton will closely monitor its water demands to evaluate how well the community is saving water and whether

additional actions may be needed to promote or enforce water savings. The following two demand monitoring techniques are implemented to monitor demand. They address the combined effect of drought and drought response (e.g., water restrictions), where increased temperatures and lower precipitation can increase the consumptive use of outdoor vegetation yet water restrictions can lower outdoor water use.¹⁵

1. *Comparison of current monthly per capita demands to average historical monthly per capita demands* - For example, the per capita demand in June of 2021 may be compared to the average historical per capita demand observed in June from 2012 to 2020. This information can provide an indication of how well the community is saving water compared to what they have been saving in the past.
2. *Comparison of monthly demands to what demands would be assuming an increase in evapotranspiration (ET)* – Statistical methods using historical demand, temperature and precipitation data may be used to estimate what monthly demands would be based on current weather conditions.¹⁶ This information can help decipher how well the community is saving water given the current drought and weather conditions.

7.3 DROUGHT DECLARATIONS

As discussed in Section 5.2, Thornton recognizes the importance of declaring a drought in a timely manner. If a drought is declared too late and actions are not taken early enough to reduce water use, water storage can be severely depleted and strict water restrictions may be required, leading to economic impacts that could have been avoided. Conversely, premature drought declarations can result in unnecessary mandatory water restrictions with associated impacts while customers can lose confidence in the declaration.

Thornton's Water Resources Division is responsible for monitoring drought conditions and providing recommendations to City Council on the declaration of a drought. The projected July 1 storage and other indicators in Section 5.2 serve as guidelines for a water shortage declaration rather than a "set of rules." Professional expertise coupled with other factors will contribute to staff recommendations and City Council's decision on drought declaration and response.

Drought recommendations are to be presented by the Water Resources Manager to City Council. City Council will have an opportunity to discuss the recommendations, ask questions and ultimately decide whether the recommended drought stage should be officially declared. Chapter 74, Article III of the Thornton Municipal Code authorizes the City Council to declare a drought stage.

Thornton's Water Resources Division will develop, and upon approval by the City Manager, promulgate and enforce the Rules and Regulations. The Rules and Regulations define the response actions to be implemented given the drought conditions and declared drought stage. The Rules and Regulations will be customized to the conditions of the water shortage using

Water Shortage Declarations

While this Plan primarily focuses on water shortages related to drought, a water shortage may result from other factors such as natural or human-induced events that cause significant damage to city infrastructure. If this is the case, City Council may make a "water-shortage-declaration." The drought stages and response actions in this Plan will be used as guidance in developing the Rules and Regulations for such a declaration.

¹⁵ WTP production data is used for both techniques. These data are more readily available for analyses on a daily basis than monthly billing data.

¹⁶ See the following reference for more information: Kenney, Douglas. 2004. *Use and Effectiveness of Municipal Water Restrictions During Drought in Colorado*. Journal of the American Water Resources Association. This technique will be developed at a later date.

this Plan as foundational guidance and will be conveyed to the community through the water use reduction campaign discussed in Section 4.4

Efforts will be made to ensure that the Rules and Regulations are aligned with existing Thornton Municipal Code. Exemptions from certain mandatory actions may be permitted by the Rules and Regulations. Actions may also be specified to clarify what the community can and cannot do. For example, while watering may be restricted to twice a week, watering may also be needed to maintain vegetative landscaping per Thornton Municipal Code and HOA regulations. The Water Resources Division is responsible for leading the communication of water shortage messaging to Thornton's customers through the water use reduction campaign addressed in Section 4.4

7.4 IMPLEMENTATION OF A STAGED DROUGHT RESPONSE PROGRAM

There are many factors that can influence Thornton's ability to address a water shortage including economic conditions, allocation of city financial resources, political support, etc. These factors should be addressed at the onset of a water shortage and incorporated into the city's drought response. Additionally, prolonged water shortages will result in adverse impacts to the community. Where possible, it is important to anticipate these impacts, ensure priority water needs are met and sufficiently address impacts through public messaging and outreach. As the primary lead in planning and administering the drought response program, the Water Resources Division will consider these factors along with the operating principles listed in Section 1.2 when administering the drought response.

Table 17 provides a framework for administration of the drought response program listing the roles and responsibilities, timeframe and leads. While the Water Resources Division is leading most of these efforts, drought response is an inter-city departmental effort and well-coordinated execution is key to a successful program. The Water Resources Division will be providing a more detailed water supply monitoring and forecasting protocol for administration following finalization of this Plan. This protocol will be included as a supplemental to this Plan once completed.

Table 17: Roles and Responsibilities for Administering the Drought Response Program

Roles and Responsibilities	Timeframe	Lead
Monitoring of climate and hydrologic drought indicators and infrastructure conditions	Year round on a monthly to biweekly basis	Water Resources Division
Provide recommendations to City Council on whether to declare drought and at what stage	As early as possible prior to the onset of shortage	Water Resources Division
Develop drought response plan (include enforcement if applicable). This includes the draft Rules and Regulations.	As early as possible prior to the onset of shortage	Water Resources Division
Develop plan for the Water use reduction campaign	As early as possible prior to the onset of shortage	Water Resources Division in collaboration with Communications Division
Identify implementation costs and any additional staffing needs to implement and enforce drought response	As early as possible prior to the onset of shortage	Water Resources Division
Administer drought response plan and enforcement if applicable	For duration when city is in a declared drought stage	Water Resources Division
Administer the Water use reduction campaign and convey the drought declaration and key messages to the community. This includes consistent messaging on how water restrictions will be enforced and the appropriate level of penalties for infractions.	For duration when city is in a declared drought stage	Water Resources Division
Make modifications to drought response and Water use reduction campaign when needed	Ongoing	Water Resources Division

Roles and Responsibilities	Timeframe	Lead
Closely coordinate city drought response actions with other city departments and Division (e.g. Parks and Golf Division)	Include other city department and divisions during planning process and then closely coordinate during implementation	Water Resources Division
Monitor revenue changes and additional drought-related expenses. Coordinate with the Water Resources Division in developing a drought surcharge (if needed) and issuing citation fines if necessary.	For duration when city is in a declared drought stage	Finance and Water Resources Division
Closely follow drought response actions and water restrictions serving as a model in the community. Take opportunities to educate the community through day-to-day interactions.	For duration when city is in a declared drought stage	All city departments and divisions
Develop community messaging when coming out of a drought. Such messaging could explain why water restrictions are ending, emphasize the value of water as a natural resource and promote water efficiency.	End of drought declaration	Water Resources Division
Closely monitor drought response (See Section 7.7).	Planning of drought response to post-drought	Water Resources Division

Routine staff meetings will be initiated at the onset of a water shortage among key departments and city staff to ensure that the drought response Program is properly carried out. Items for discussion may include:

- Status update – Latest information on drought indicators, Thornton’s water supplies and water saving estimates
- Funds - Review of funds available for drought response
- Status on the Water use reduction campaign and key input from the community
- Status on city’s efforts to save water (city facilities and Parks and Golf Division)
- Number of citations, enforcement issues, etc
- Coordination among city staff
- Additional items of concern that need to be addressed

7.5 ENFORCEMENT OF THE STAGED DROUGHT RESPONSE PROGRAM

The level of enforcement needed to implement the drought response will be customized to the drought stage as well as to how responsive the community is to the mandatory drought response measures. The Water Resources Division will develop the enforcement strategy and manage enforcement and messaging through the water use reduction campaign. The following key considerations will be incorporated into the enforcement strategy:

- Level of enforcement necessary and enforcement actions
- Assignments to city staff and whether additional staff is needed
- New equipment that may be needed for enforcement
- Additional costs for new equipment and staffing needs
- Revenue and budgetary considerations (Section 7.6)

City enforcement may include patrol of neighbourhood and business districts to identify those that are in violation of mandatory restrictions and issuing warnings and citations. Enforcement may also be facilitated through peer pressure where members of the community can call the city to report water waste and other water restriction infractions. Enforcement of rules during the 2012 drought consisted of patrolling the city during business hours when folks should not have been watering, issuing warnings, and issuing citations.

A first-time warning will be given prior to issuing citations. Fines specific to the drought stages and number of violations are defined in Thornton's Municipal Code. Exceptions to water restrictions may be available for large properties that cannot be irrigated within the mandated watering times and for new landscaping that needs to be watered daily until established. These exceptions will be spelled out in the Rules and Regulations. Thornton also has an appeals process, where the customer or property owner may request a hearing before a hearing officer. If a basis for the violation is established, the penalty must be paid within 10 days or it will be placed on the water bill. The city may suspend water service per the Rules and Regulations after multiple repeated violations and/or fines are not paid.

Examples of Rules and Regulations from the 2018 Mandatory Water Restrictions

- a) A written Notice of Violation (Notice) will be personally served, posted on a structure on the property, or mailed by regular mail to the customer and the owner of the property, if different from the customer.
- b) The customer, or owner of the property notified of a violation, may file a written request for a hearing with the Infrastructure Department within ten days of notice. The hearing will be conducted before a hearing officer.
- c) If the basis for the violation is established, the hearing officer will order the charge paid within ten days and if not paid, it will be placed on the water utility bill.
- d) The city may suspend water service to the premises, in addition to or in lieu of a further Notice after an initial Notice has been sent giving the customer or owner a Notice of Suspension with an opportunity for an administrative hearing. A Notice of Suspension may be sent upon three violations by a customer within a twelve-month period or one violation if the customer expresses intent to ignore the Rules and Regulations by immediate and continued violations.

7.6 REVENUE IMPLICATIONS AND FINANCIAL BUDGETING PLAN

A reduction in community water use during drought reduces water sales and consequently could result in a revenue shortfall. Increased costs associated with implementation of the staged drought response program, water use reduction campaign, and enforcement could further intensify the shortfall. At the onset of a drought declaration, the Water Resources Division and Finance will estimate the costs necessary to implement and enforce drought response and Finance will project potential revenue shortfalls. Thornton does not have a drought response fund. If the Water Resources Division cannot cover a shortfall with existing operation and maintenance funds, budgetary changes may be made to reimburse the Water Resources Division. In addition, Thornton plans to seek available financial drought-related assistance (e.g., public drought-related loans, grants, etc.).

In a more extreme Stage 2 severe, Stage 3 extreme or Stage 4 emergency drought, the drought response plan also calls for the consideration of implementing a temporary drought surcharge that would be approved by City Council. This would only be implemented if projected revenue is less than funds available for operation maintenance and is necessary to compensate for reduced water sales and increased drought response costs. If the water shortage and corresponding water sale reductions are severe enough to warrant a surcharge, careful consideration would be given to potential impacts on the community and intensive public messaging would be implemented to convey the reasoning behind the surcharge. The drought surcharge by default provides an additional incentive to save water, however, would not be implemented for solely this purpose.

7.7 MONITORING THE EFFECTIVENESS OF THE DROUGHT MANAGEMENT PLAN

The monitoring of Thornton's drought mitigation and response actions is important to ensuring the city's success in preparing and responding to drought. The following data will be collected by the Water Resources Division and included in an annual report in years when Thornton enters a water shortage.

- Drought indicators – Record of drought indicator data collected prior to the onset and post drought
- Drought mitigation measures – Status of the mitigation actions and other relevant factors prior to the onset of drought
- Water demand monitoring data collected during the water shortage – See Section 7.2 for more information
- Administrative data on the drought response – This includes citations delivered to customers, summary of calls received, specific response measures that were enacted and enforced, etc. For example, Figure 13 shows the number of water-related phone calls during the 2012 to 2013 drought.
- Water shortage impacts and community perceptions – This information may be provided by the community at public city meetings, phone calls, electronic correspondence, etc. Public surveys may be considered to gather community input depending on the magnitude of the drought and monies available for drought response.
- Lessons learned – Any issues, challenges, and concerns that arose during implementation of the staged drought response program (if applicable), drought monitoring, mitigation activities, enforcement and the public drought campaign.

Lessons Learned from Previous Drought Patrol Efforts

- Need 2 to 4 additional staff to do drought patrol all week
- Need forms to report violations
- Need 2 dedicated drought patrol vehicles
- Develop a better system to check for previous warnings
- Target neighborhoods and zones

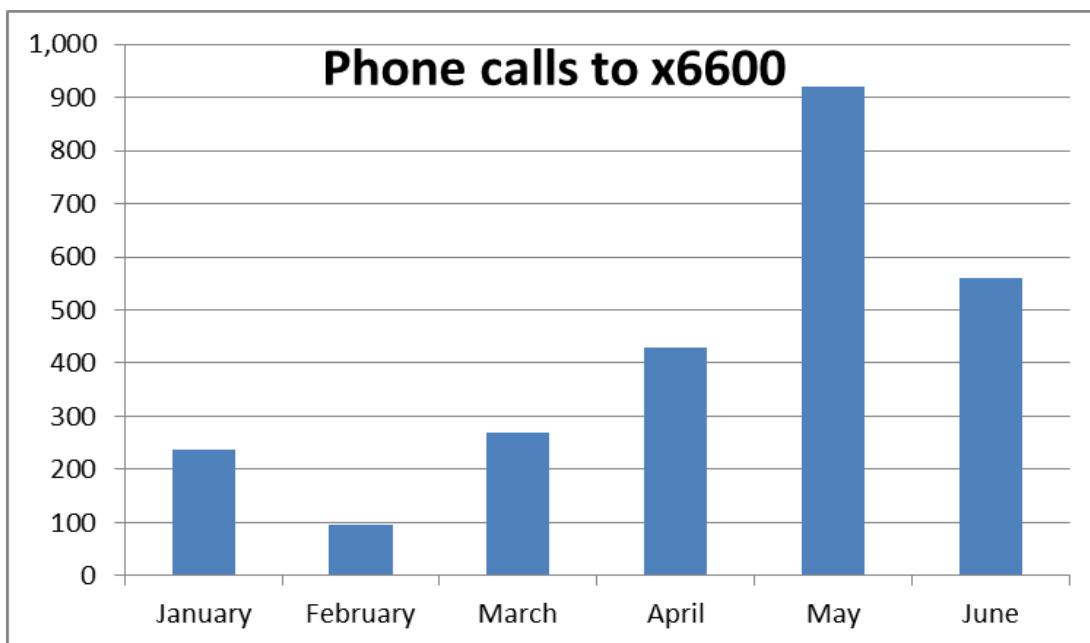


Figure 13: Water Related Phone Calls During the 2012 to 2013 Drought

FORMAL PLAN APPROVAL AND UPDATES

8.1 COMMUNITY ENGAGEMENT AND PUBLIC REVIEW PROCESS

Community engagement is a critical component to the success of drought response. During the Plan development, Thornton used a variety of methods to educate the community about the Plan and receive input. These are highlighted in the bullets below.

- Surveys asking the community to provide input on water priorities, drought response measures and how the city can best communicate were available to the community from October 2018 to April 2019. The survey was initially advertised through residential water bill inserts and then with the posting of the Plan in March 2019 on the city's website. Appendix C summarizes the survey results.
- In November and December of 2018, phone calls were made to targeted groups (e.g. HOAs, city wards, etc.) to introduce the Plan development process and enquire whether the groups would be interested in learning more about the Plan. Unfortunately, city staff did not receive the level of interest originally anticipated. As a result, more focus was placed on internal outreach within the city divisions and departments that interface with a broader spectrum of the community than just members of the original Planning Team.
- An inter-departmental city meeting was held in February 2019 educating city staff on the draft Plan and receiving input. Meeting attendees had the opportunity to review the Plan and comment.
- A 43-day public review process from March 2019 through April 2019 was held where the draft Plan was posted on the city's website and the community had an opportunity to review the Plan and submit comments. No public comments were received during this review period and hence did not warrant an update to the draft Plan prior to City Council adoption.
- A community meeting was held in April 2019. This meeting included an overview on the Plan and a drought table top exercise where participants were asked to assume it was March and were presented with climate data suggesting that the city was entering a drought period. The participants had to decide the appropriate drought stage to declare and select drought response actions. It was then revealed that the climate data presented during the exercise was from the 2012 drought. The city then revealed the drought stage that was declared that year and drought response efforts that were enacted. Comments provided by meeting participants focused on taste and odor issues and messaging of water restrictions. The comments coincided with the content of the Plan and did not warrant any Plan changes.
- The draft Plan was presented to the City Council during a City Council planning session and adopted during a City Council meeting on April 9, 2019. The Plan was adopted with the understanding that minor changes could be made to the Plan pending results from the community. The survey results coincided with the content of the Plan and did not warrant any changes to the Plan following adoption.

8.2 ADOPTION OF ORDINANCES AND OFFICIAL AGREEMENTS

Resolution C.D. No. 2019-039 was passed on April 9, 2019 adopting Thornton's Drought Management Plan. Thornton's Municipal Code will be modified to establish penalties and fines for the new four drought stages following a rate study the Fall of 2019. Other policy changes may be needed to support drought response if Thornton enters a Stage 3 extreme or Stage 4 exceptional drought. Such policy changes could be needed to address:

- Changes in water rates or a drought surcharge
- Changes to water tap fees, review process and limitations on number of taps allowed
- Prohibition of new taps in a Stage 4 exceptional drought
- Terms for rationing water in a Stage 4 exceptional drought

Thornton has a memorandum of understanding with the City of Northglenn to use Northglenn and Thornton's interconnect for supply purposes during water shortages. Thornton will consider entering future agreement(s) if such agreement(s) provide the city with drought mitigation and/or response benefits.

8.3 DROUGHT MANAGEMENT PLAN APPROVAL

Thornton's Drought Management Plan was approved by City Council on April 9, 2019 by Resolution C.D. No. 2019-039. Each City Council member had the opportunity to review the Plan and comment prior to finalization of the Plan and formal approval.

8.4 PERIODIC REVIEW AND UPDATE

Thornton's Drought Management Plan will be updated every seven years. The next update will be completed by January 1, 2026, be led by the Water Resource Division and will incorporate information from the annual monitoring reports discussed in Section 7.7.

REFERENCES

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APPENDIX A – RESOLUTION ADOPTING PLAN

C.D. No. 2019-039

RESOLUTION

A RESOLUTION ADOPTING A NEW CITY OF THORNTON DROUGHT MANAGEMENT PLAN.

WHEREAS, the City has developed a water supply system to meet the needs of its water customers; and

WHEREAS, the water supply can be uncertain and may not be adequate for all uses in all circumstances; and

WHEREAS, a drought management plan defines when a water supply shortage exists and defines the measures that are to be taken in response to a drought or water supply shortage to help protect the health, safety, and welfare of the customers of the City's water system; and

WHEREAS, on August 13, 2002, the City adopted a Drought Management Plan that is currently in place; and

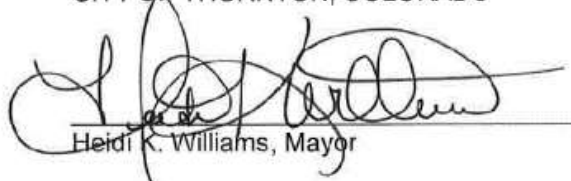
WHEREAS, the proposed 2019 Drought Management Plan will supersede the 2002 Drought Management Plan, if adopted.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF THORNTON, COLORADO, AS FOLLOWS:

The 2019 City of Thornton Drought Management Plan attached hereto and incorporated herein, is hereby adopted.

PASSED AND ADOPTED at a regular meeting of the City Council of the City of Thornton, Colorado, on April 9, 2019.

CITY OF THORNTON, COLORADO



Heidi K. Williams, Mayor

ATTEST:



Kristen N. Rosenbaum, City Clerk

APPENDIX B – DROUGHT SCENARIO PLANNING EXERCISE

B.1 - INTRODUCTION

A scenario planning exercise was developed by Headwaters Corporation (Headwaters) to inform the 2019 update of Thornton’s Drought Management Plan (Plan). The objective of the exercise was to use scenario planning principles (explained below) to determine how Thornton can best address impacts to its community during a range of possible drought scenarios using a forwarding-thinking, outside-of-the-box, collaborative approach. Special attention was given to priority areas in which the community was especially vulnerable to drought impacts. This exercise was carried out during two workshops attended by city staff members on the Planning Team (Table 1).

Scenario planning is commonly used in short-term, long-term and strategic climate change planning to foster a broad context for testing the implications of various future outcomes. In general terms, scenario planning facilitates the development of future scenarios (futures) that consider a diversity of potential outcomes, often independent of historical trends and patterns. It is assumed that these futures have an equal chance of occurring and encompass a broad spectrum of uncertainty surrounding one focal question. Once the futures are developed, participants can identify adaptation actions needed to address such futures.

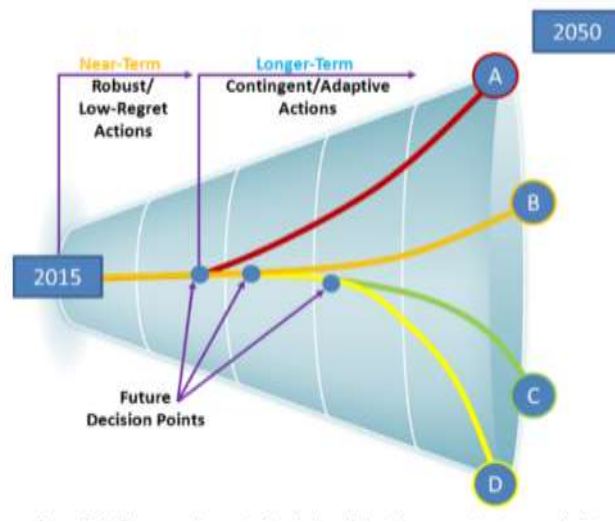


Figure B-1: Depiction of the Scenario Planning Concept

Figure B-1 illustrates the scenario planning concept over a 35-year planning horizon. Four futures (A, B, C, and D) are positioned within a future “cone of uncertainty.” As shown, at the onset of a planning period (in 2015 in Figure B-1), there is a series of robust/low regret actions that will be of benefit regardless of the future outcome. As we progress through time, there are point(s) where we orientate towards certain future(s) over others. These are key periods, when decision makers should evaluate and adopt contingent/adaptive actions customized towards the future(s) we are aligned with.

The focal question for Thornton’s scenario planning exercise was:

As a water provider, how can the city of Thornton best address impacts to its community during drought?

The planning horizon was assumed to be 10 years. During the workshops, participants developed a list of factors that could have future implications on how well Thornton can address impacts to its community during drought. These factors informed the development of four drought-related futures. These futures provided a contextual background to develop and prioritize a list of drought vulnerabilities, mitigation strategies and drought response strategies for inclusion in the Plan.

This appendix provides the results of the scenario planning exercise. Section B-2 summarizes the approach while Sections B-3 summarizes the factors affecting Thornton’s drought response. Section B-4 then outlines the four potential futures, and Section B-5 outlines common drought vulnerabilities, mitigation strategies and response strategies between futures. Section B-6 summarizes the results.

B.2 - APPROACH

The scenario planning exercise was carried out during two workshops attended by the Planning Team. The first workshop, on April 23, 2018, was focused on the brainstorming of factors that would inform the development of the four futures. The second workshop, on May 14, 2018, was focused on developing the four futures, and identifying vulnerabilities, mitigation and response strategies for each future.

Workshop 1 – Brainstorming and Identifying Vulnerability Factors

The scenario planning exercise focused on the ways Thornton could best address impacts to its community during drought. The first workshop entailed a brainstorming exercise that informed the development of the four futures. During the brainstorming exercise participants identified environmental, political, social, technological and economic factors that could have key future implications on Thornton’s drought response. These were eventually used to inform the common vulnerabilities between the four futures. Participants were asked to consider the following questions while brainstorming:

- As a water provider, what are your fears concerning drought?
- What are the major obstacles and/or challenges?
- What keeps you up at night?

Factors were written on large post-it notes and placed on a “sticky wall” for all to review. Participants were then asked to vote on the top four factors that had the highest degree of uncertainty and highest degree of importance by placing stickers (dots) on the corresponding post-it notes (Figure B-2). The results of this exercise are presented in Section B-3.



Figure B-2: Workshop Participants Voting on Important Factors

Workshop 2 – Development of Futures, Vulnerabilities and Response Strategies

Following the brainstorming exercise, participants were tasked with identifying two future drivers that would play key roles in how Thornton can best address community impacts during drought. Participants reviewed the factors of greatest uncertainty and importance from the brainstorming and voting exercise and identified the following two drivers: 1) level of demand, and 2) duration of the drought. Participants further characterized these drivers by their polar conditions depicted in Figure B-3. The duration of drought driver captures the range of the duration of drought that the city could experience. It ranges from short duration, 1- to 2-year droughts to long-term multi-year droughts lasting 10-plus years. The level of demand driver captures a range of demand scenarios Thornton could experience. It ranges from low levels of demand when Thornton’s infrastructure is operating at

optimum capacity and the community is conservation-focused, to high levels of demand when the city's infrastructure is compromised. Compromised infrastructure could be caused by routine maintenance, a natural/man-induced event that causes infrastructure to be offline (e.g. flood) or delayed development of critical infrastructure.

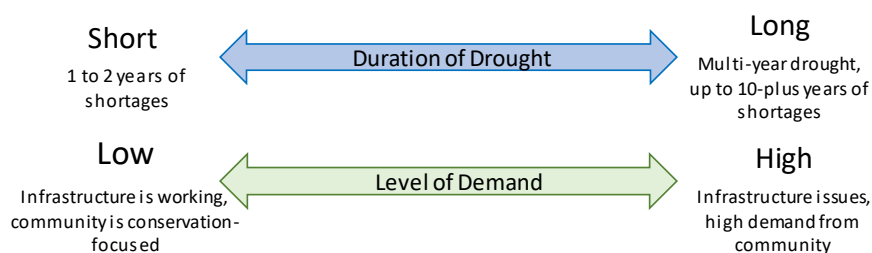


Figure B-3: Future Drivers

These drivers were charted, or combined, as shown in Figure B-4 to develop four futures that capture the spectrum of possible outcomes. Workshop participants then divided into four groups. Each group developed a “narrative” about their assigned future based on the following secondary drivers: economy, community values, status of planned infrastructure, temperature, water quality, growth, and political will. Section B-4 summarizes these narratives. Workshop 2 ended with a strategy session focused on identifying vulnerabilities, mitigation and drought responses for each future.

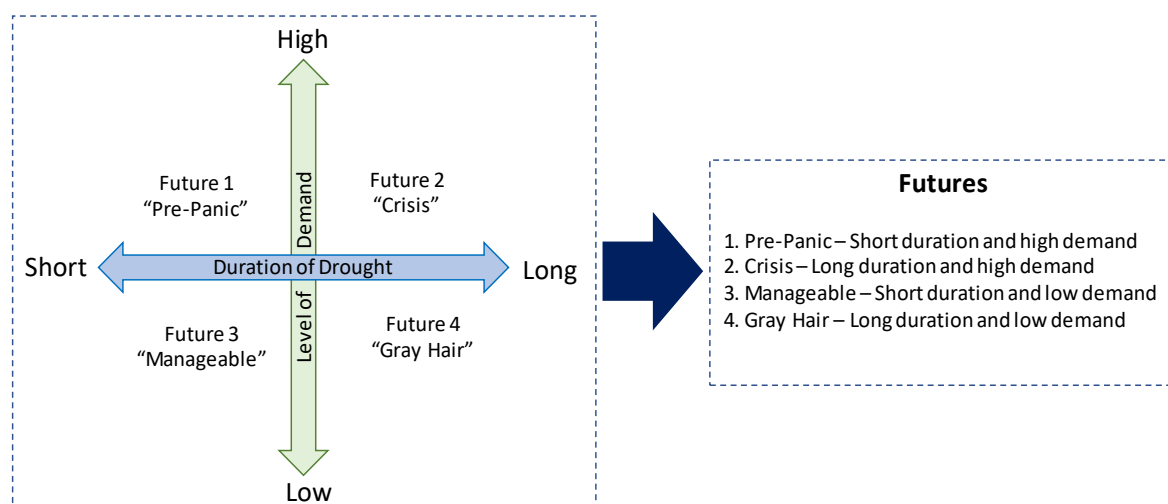


Figure B-4: Development of the Four Futures

B.3 - FACTORS

During the brainstorming session twenty-one environmental, political, social, technological and economic factors that could have key future implications on Thornton's drought response were identified by the participants. These factors are presented in Table B-1.

Table 1: Important Factors for Consideration by Thornton

Factors
Environmental
Different conditions in different watersheds
Wildfires
Growth rate
Economic conditions
Landscaping trends

Factors	
Short-term uncertainty in climate (e.g., year to year variability)	
Long-term uncertainty in climate (e.g., climate change)	
Political	
Reaching out to City Council	
Perception of shortage related to development	
Happenings in neighboring communities	
Collaboration opportunities with other providers	
Social	
Internal communication and coordination	
Messaging to the Community	
Technical	
Water quality (e.g., algae growth, taste and odor, etc.)	
Treatment costs	
Supply situation (e.g., quantification of volumes, supplies, etc.)	
Lag in process of obtaining water use data	
Infrastructure down or offline (e.g., from floods)	
Infrastructure change, improvements, adjustments, etc.	
Economic	
Budget constraints	
Rate adjustments during drought	
Staffing implications	
Revenue availability	

Nineteen of these factors were voted by the participants as having high degrees of uncertainty and importance. These factors are shown, along with the number of uncertainty and importance votes, in Table B-2. These factors were considered when developing the secondary drivers used to outline each of the futures.

Table B-2: Degree of Uncertainty and Importance Ranked by the Number of Votes

Uncertainty Votes	Importance Votes	Total Votes	Type	Factor
0	5	5	Technical	Water quality (e.g., algae growth, taste and odor, etc.)
0	4	4	Social	Messaging to the Community
3	0	3	Economic	Revenue Availability
3	0	3	Environmental	Short-term uncertainty in climate (e.g., year to year variability)
3	0	3	Technical	Infrastructure down or offline (e.g., from floods)
3	0	3	Political	Reaching out to City Council
3	0	3	Environmental	Growth rate
1	2	3	Technical	Supply situation (e.g., quantification of volumes, supplies, etc.)
2	0	2	Environmental	Long-term uncertainty in climate (e.g., climate change)
2	0	2	Environmental	Wildfires
2	0	2	Environmental	Economic conditions
0	2	2	Economic	Rate adjustments during drought

Uncertainty Votes	Importance Votes	Total Votes	Type	Factor
1	0	1	Technical	Lag in process of obtaining water use data
1	0	1	Environmental	Different conditions in different watersheds
0	1	1	Political	Collaboration opportunities with other providers
0	1	1	Economic	Budget constraints
0	1	1	Technical	Infrastructure change, improvements, adjustments, etc.
0	1	1	Social	Internal communication and coordination
0	1	1	Economic	Staffing implications

B.4 - FOUR POTENTIAL FUTURES

Participants developed four futures. These futures are outlined in Table B-3 and capture a broad spectrum of what could potentially happen based on the two primary drivers:

- 1) Duration of a drought – whether the drought is relatively short, with shortages lasting up to one or two years, or very long, with shortages lasting over 10 years.
- 2) Level of Demand – whether the level of water demand from the community is low, with the community focused on water conservation and all infrastructure working properly, or high, with the community not focused on water efficiency and/or infrastructure limitations inhibiting Thornton’s ability to treat, store and/or deliver water.

Table B-3: Summary of the Four Futures

Future	Duration of Drought	Level of Demand
Pre-Panic	Short duration (up to 1 or 2 years of shortages)	High Demand (community not water conservation focused, infrastructure limitations)
Crisis	Long duration (over 10 years of shortages)	High Demand (community not water conservation focused, infrastructure limitations)
Manageable	Short duration (up to 1 or 2 years of shortages)	Low Demand (community is water conservation focused, infrastructure at optimum performance)
Gray Hair	Long duration (over 10 years of shortages)	Low Demand (community is water conservation focused, infrastructure at optimum performance)

Pre-Panic Future

The pre-panic future assumes that Thornton experiences a relatively short-duration drought (up to 1 or 2 years) with high water demands from the community. The economy could be good or bad, but the community would not be as water efficiency-focused as desired. Likely, this would include the installment of turf in residential areas and parks, and a persistent desire for the community to remain green throughout the summer. Existing infrastructure projects would be out of commission (e.g., reservoir maintenance) and planned infrastructure projects would be delayed. The climate would likely be hot and dry. Water quality is negatively impacted and causes issues such as algae blooms, and taste and odor complaints. The community would be growing at a rapid rate, causing a high demand for turf permits and construction water. The political will is unknown but would likely result in some water restrictions and customers would likely be unhappy.

The following pre-drought mitigation could be implemented to reduce impacts to the community:

- Educate customers on water efficiency

- Delay taking reservoirs offline, and speed up timeline on planned projects
- Keep reservoirs as full as possible, same for recreation ponds
- Use water-wise landscape for traffic medians
- Water quality testing and only use high quality water, when possible
- Growth restrictions
- Educate City Council on drought

The following responses to drought could be implemented to reduce impacts to the community:

- Restrict planting of new landscapes, unless water-wise landscapes
- Setup water contracts to supplement water supply
- Do not add water to recreation ponds
- Only water sports fields, let medians go dry, and put parks on restrictions
- Use more chemicals for treatment and blend sources
- New water-saving plan for development
- Educate City Council on drought

Crisis Future

The crisis future assumes that Thornton experiences a long-duration drought (more than 10 years) with high water demands from the community. The economy would be impacted by long-term water shortages, creating less funding for new projects. The community would not be as focused on water efficiency as desired. The community's overall response would either not be adequate to reduce shortages or the community simply would not have the will to make changes. Existing infrastructure projects would be off line and planned projects would be delayed. Warming temperatures would increase demands, and the duration of the irrigation season would be increased due to the warmer temperatures. Water quality issues would exist due to wildfires and/or low flows in the rivers. The community would be growing at a rapid rate, and/or previous growth could result in increased demands. The political would not be enough to result in changes in policy or code to reduce demands.

The following pre-drought mitigation could be implemented to reduce impacts to the community:

- Prepare a drought plan than includes a crisis future
- Obtain political buy-in, and have code in place for crisis future
- Involve Thornton in watershed health programs
- Growth planning
- Sustainability programs
- Develop code to lower customer demand
- Put drought funding mechanism in place

The following responses to drought could be implemented to reduce impacts to the community:

- Implement intense water restrictions (only water trees?)
- Implement drought surcharges
- Customer outreach programs and public meetings
- Restrict new development
- No new turf
- Obtain emergency funding for alternative water supplies
- Wildfire prevention measures

Manageable Future

The manageable future assumes that Thornton experiences a relatively short-duration drought (1 or 2 years) with low demands from the community. Likely, the economy would be status quo, in that revenue expectations are met. The community would be water efficiency-focused, with strong buy-in to "green values" and water efficiency practices. Existing infrastructure would be operating as intended and there would be no delays in constructing planned projects. The climate would likely

remain average with respect to temperature and precipitation. Water quality would likely not be negatively impacted. The community would be growing at a reasonable or expected rate, and the City Council, staff and community are on the same page with respect to the importance of conservation and necessary measures. Mandatory restrictions would likely be enforced but there would be strong community buy-in.

The following pre-drought mitigation could be implemented to reduce impacts to the community:

- Educate on the importance of water efficiency
- Ensure there are cash reserves for drought and proper fiscal planning
- Develop code and policy changes to conserve water

The following responses to drought could be implemented to reduce impacts to the community:

- Implement mandatory water restrictions
- Continue to educate on the importance of conservation
- Implement growth restrictions
- Implement drought fines and/or surcharges

Gray Hair Future

The gray hair future assumes that Thornton experiences a long-duration drought (more than 10 years) with low community water demands. Low demands could be caused by a stagnant or declining economy resulting in many customers who cannot afford to use water excessively. Low demands may also be attributed to excellent efficiency, smart growth and a priority system for irrigating parks. Major planned infrastructure projects could be delayed. This along with abnormally dry conditions coupled with lack of community response to drought measures could result in the long-term shortage. Water quality challenges could persist due to high temps or low flows. The political would be such that policies promote/require water efficiency, but delay infrastructure projects. Policies would also promote and/or require smart and/or green growth.

The following pre-drought mitigations could be implemented to reduce impacts to the community:

- Develop a custom efficiency ethic
- Promote green growth
- Implement water supply capital improvements plan
- Perform prevention maintenance
- Watershed protection
- Establish water supply partnerships
- Financial contingency fund
- AMI
- Irrigate parks using priority irrigation
- Construct artificial sports fields
- Continue Thornton assistance plan

The following responses to drought could be implemented to reduce impacts to the community:

- Implement demand restrictions
- Implement drought surcharge and increased rates
- Implement partnerships
- Development of growth restrictions
- Emergency treatment

B.5 - VULNERABILITIES, MITIGATION AND RESPONSE STRATEGIES

The futures described in Section B-4 informed the development of common drought vulnerabilities, mitigations and responses. The participants voted on the vulnerabilities, mitigation and response

strategies that they deemed most important. The vulnerabilities, mitigation and response strategies along with the number of associated votes are listed in Tables B-4, B-5 and B-6, respectively.

Table B-4: Ranked Vulnerabilities Common to the Four Futures

Importance Votes	Drought Vulnerabilities
7	Community buy-in
6	Significant delays in future water infrastructures projects
5	Harm to infrastructure projects (floods, fire, etc.)
5	Degraded drinking water quality (taste and odor)
5	Irrigation demand – higher temperatures and longer irrigation season
4	Not enough storage (reservoir/infrastructure compromised)
1	Capital improvement plan projects in progress can affect infrastructure
1	Political will of promoting drought resiliency
1	Funding not available for capital improvement plan projects for drought mitigation
0	Availability of water treatment chemicals
0	Wildfire in region
0	Aesthetics, recreation, environment
0	Health impacts from hot temperatures

Table B-5: Ranked Mitigation Strategies Identified in the Four Futures

Importance Votes	Mitigation Strategies
4	Smart fiscal planning and drought funding
4	Planning, regulations and programs
4	Partnerships on water
3	Policies that promote green growth
2	Watershed source water programs (wildfire)
1	Water conservation – educate City Council
0	Prioritize parks irrigation in advance
0	Thornton assistance program
0	Keep reservoirs as full as possible when can

Table B-6: Ranked Response Strategies Identified in the Four Futures

Importance Votes	Response Strategies
6	Prioritize irrigation, prohibit new turf, permits
4	Drought fines, surcharges, increase rates
3	Emergency funding for supplies
3	Educate customers
2	Implement water supply protections
0	Educate council
0	Cost for treatment, innovative treatment
0	Growth restrictions in place
0	Evaluation of code and policies
0	Wildfire prevention

B.6 - KEY FINDINGS AND CONCLUSIONS

The scenario planning workshop proved to be successful in allowing the participants to brainstorm and think about drought issues in an outside-of-the-box manner while considering drivers they deemed important. Ultimately, the participants identified 17 new drought vulnerabilities, 14 new drought mitigation strategies and 15 new drought response strategies not considered through other planning efforts. These are summarized in Tables B-4, B-5 and B-6. These vulnerabilities, mitigation strategies and response strategies were then included as options to consider during the development of the Plan Management Plan.

APPENDIX C – COMMUNITY ENGAGEMENT SURVEY

C.1 - INTRODUCTION

The community engagement effort was an important piece of the 2019 update of Thornton’s Plan. It was designed to ensure that the Plan incorporated community values and priorities in its response to drought. A main component of the community engagement effort was a survey which was sent to residents asking for input on water priorities, drought response measures and other drought-related topics. These surveys were developed online and made available to the public. The public was notified via bill inserts, email, and phone contacts. In total, 32 residents voluntarily filled out the surveys between the fall of 2018 and spring of 2019. This appendix presents the results of the surveys, summarizes key findings that can be drawn from the results, and explains how these findings are reflected in the Plan update.

C.2 – SURVEY RESULTS

This section presents the results of the surveys. Each survey question is listed, a graph summarizing the results of each question is provided, and (where applicable) comments provided by the residents via open-ended inquiries are listed. In addition, a few observations are noted.

Question 1: Please rate the following concerns when you first hear: “We are in a drought.”

Question 1 asked residents to rank various concerns during a drought. Figure C-1 shows the concerns presented to the residents as well as the results of Question 1. For each concern, percentages of residents answering either “not concerned”, “moderately concerned” or “very concerned” are shown.

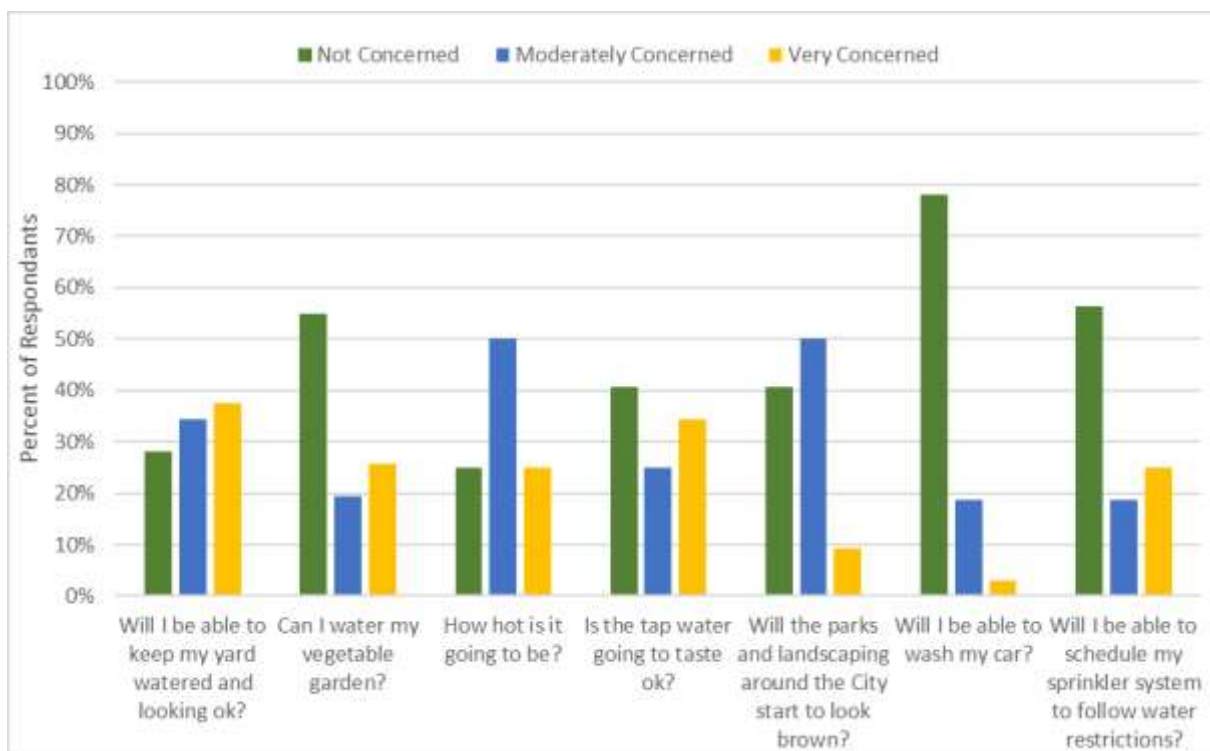


Figure C-1: Results for Question 1.

The two concerns which garnered the highest percentage of “very concerned” responses were “*will I be able to keep my yard watered and looking ok?*” and “*is the tap water going to taste ok?*”, while the three concerns which garnered the highest percentage of “not concerned” responses were “*will I be able to wash my car?*”, “*will I be able to schedule my sprinkler system to follow water restrictions?*”, and “*can I water my vegetable garden?*”.

In addition, residents were asked via an open-ended inquiry to list other concerns. Their responses are listed (verbatim) below:

1. *Will it impact how much water I can use indoors?*
2. *With additional building of homes without regard to how it effects existing residence. Raising water rates on existing residences without ensuring new building have zero scape landscaping. City adding green belts and landscaping while residence carry burden on higher water rates. As a side note I have never seen a dirty city vehicle how oftentimes are you washing them while you talk about drought management.*
3. *What can I do to reduce water use?*
4. *Some homes in city have larger lots and should not face higher charges than those that have small lots.*
5. *OUR HOA REQUIRES THAT 75% OF OUR YARD BE GRASS. THIS REQUIRES WATERING! WE HAVE TO KEEP IT UP.*
6. *Can I AFFORD the water price hike to water my yard, fill my 5000 gallon pool, and normal indoor use. The appeal for quality people to move in, is negatively affected by a water bill that is too high and dead lawns throughout the neighborhood. Community beauty and greenery are important advertising. What will Thornton display in 2019?*
7. *I live near a greenbelt and I have noticed that over the last many years, it has been watered very often (almost every day). It seems that a lot of water could be saved if that was reduced to two or three times a week, especially when we have restrictions. I only twice a week whether there are restrictions or not, so the following motivating ideas won't change what I do.*
8. *I have planted drought tolerant plant and grass. Have installed low flow toilets. And have attended the water wise event at the fire house. Thank you so much for your efforts to educate the city!*
9. *I don't have any concerns about water restrictions. I think every municipality should be implementing restrictions permanently. What concerns me is the cities and towns in metropolitan Denver continue to let developers install the cheap option of turf instead of native grasses in large park areas. These developers will pass the higher cost of installing native and/or low water grasses on the homeowners or associations, but in the long-term, the savings will be realized by the owner. More importantly, we will be preserving a very precious commodity. An area of sod is appropriate for playing at parks, but most areas of the parks across the metro area are not used for anything but looking nice. I think native grasses are beautiful and more parks and easements by sidewalks should be native grasses and/or low water plants. Thank you for the opportunity to express my opinion.*
10. *How high are my rates going to be for watering my yard?*
11. *Will apartment complexes continue to flood their properties with a ton of water then pass jacked up costs to residents in the form of "water bills". Ive seen this happen and believe the problem is out of control. Apartment complexes use "water" as another profit source encouraging waste.*
12. *We continue to cut back usage but the price of water continues to increase. Frustrating when we try to keep our yard looking nice while others in the neighborhood let their lawn die and then we are fighting their weeds and the code people do nothing. We always try ton conserve and still pay a very high price for water.*
13. *I wonder what monitoring system is in place for the large water consumers, i.e., apartment complexes watering their landscape. Often I see large amount of water running down the gutters from run off or over spray.*

14. *With all the new building of houses in Thornton it seems to me you could establish a code of 33% of zero scapping in front yard. Perhaps give current customers incentive to do the same.*
15. *Is the city selling any of its water to oil and gas industrial operations?*
16. *I am very concerned about the oil and gas water use and the impacts it has to Colorado's environment.*

Question 2: During severe droughts, communities often reduce or eliminate the use of water for certain purposes. Please order the importance of the following uses with the most important to maintain during a severe drought given a score of 1 and the least important use given a score of 10.

Question 2 asked residents to rank the importance of various water uses during a drought. Residents were provided 10 uses and were asked to rank them in order of most to least important. Although residents gave a score of 1 to the most important use and 10 to the least important use, the metric calculated to rank the uses was such that a higher ranking reflects greater importance. Figure C-2 shows the uses presented to the residents as well as the results of Question 2.

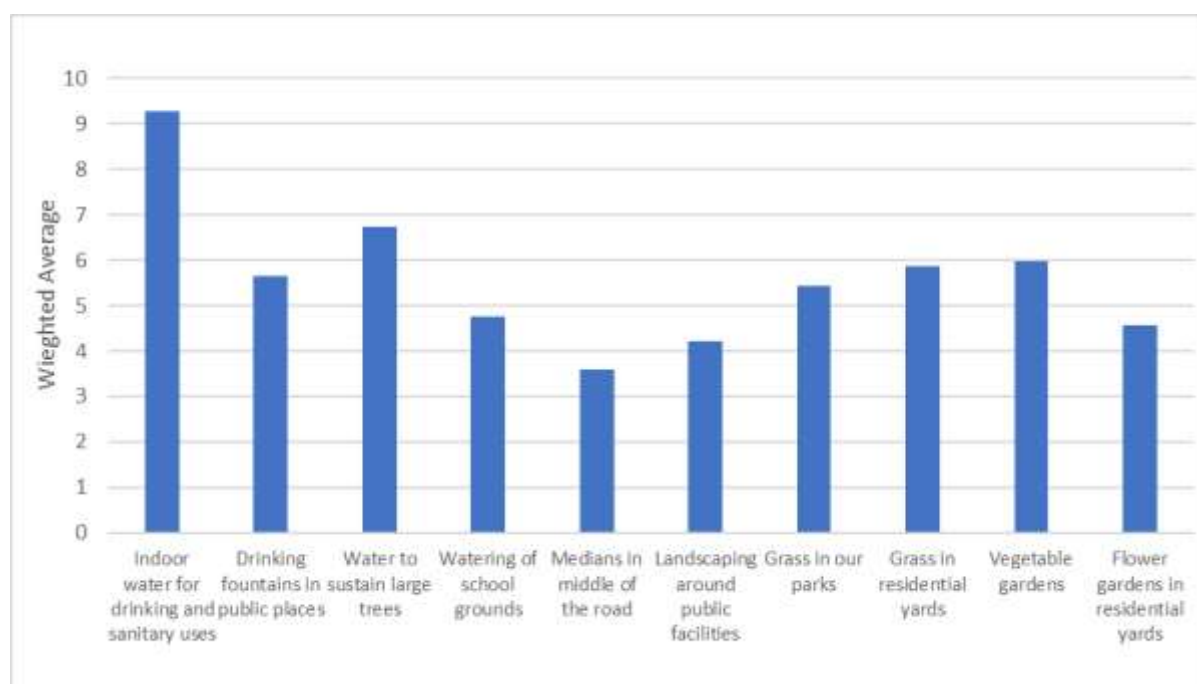


Figure C-2: Results for Question 2.

The use that was overwhelmingly listed as the most important to maintain was “indoor water for drinking and sanitary uses”, while the second most important to maintain was “water to sustain large trees.” These uses were followed in order by “vegetable gardens”, “grass in residential yards”, “drinking fountains in public places”, “grass in our parks”, “watering of school grounds”, and “flower gardens in residential yards.” The two uses that were listed as the least important to maintain were “medians in the middle of the road” and “landscaping around public facilities.”

Question 3: Please rate how the following would best motivate you to reduce your water use?

Question 3 asked residents if they would be motivated to reduce water use by various enforcement and/or outreach methods. For each method presented, residents were asked if it would be a “high motivator”, “moderate motivator”, or “not motivating.” Figure C-3 shows the methods presented to the residents as well as the results of Question 3.

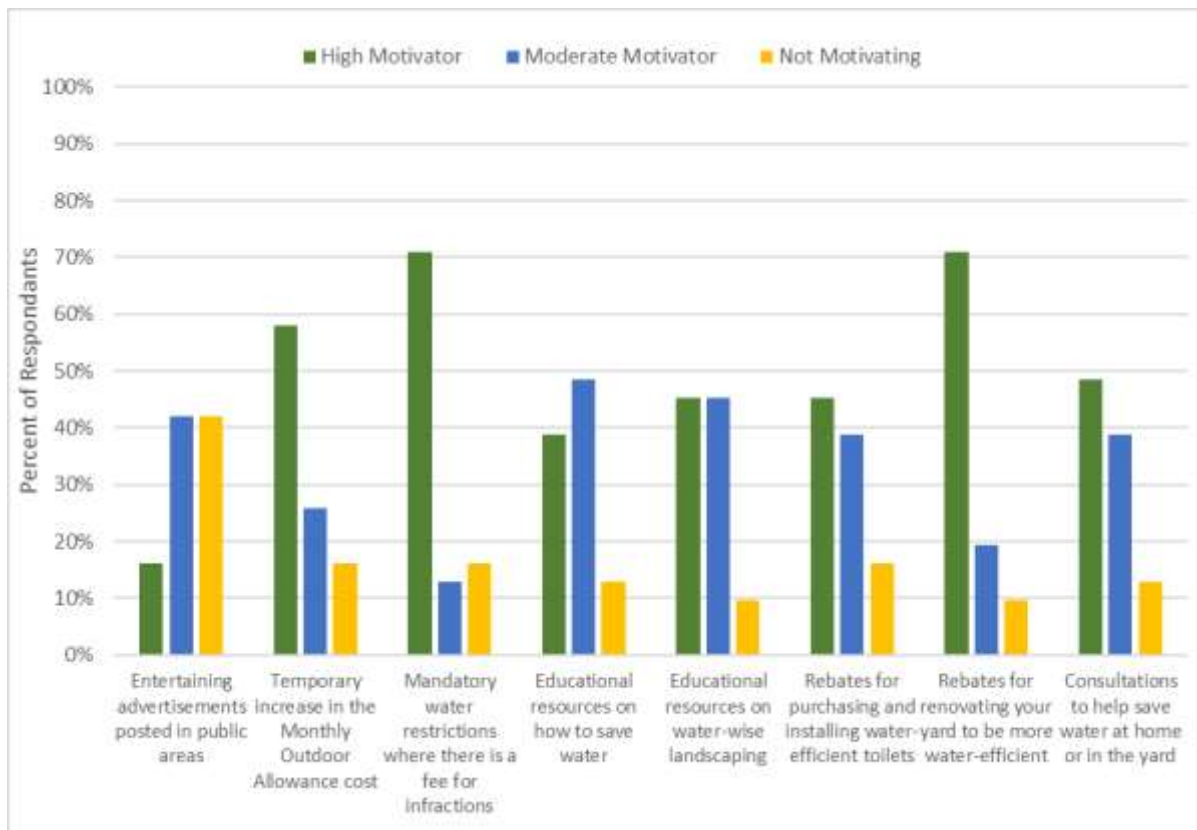


Figure C-3: Results for Question 3.

The two methods which garnered the highest percentage of “high motivator” responses were “mandatory water restrictions where there is a fee for infractions” and “rebates for renovating your yard to be more water-efficient.” A “temporary increase in the Monthly Outdoor Water Allowance cost per thousand gallons” garnered the third most “high motivator” responses. The least motivating method (by far) was “entertaining advertisements posted in public areas”, as it received the highest percentage of “not motivating” responses and the lowest percentage of “high motivator” votes.

Question 4: How can Thornton best communicate with you about drought and address your questions and concerns?

Question 4 asked residents how Thornton could best communicate with them about drought. Residents were provided with 12 methods of communication and were asked to specify if each method was a “great method”, “ok method”, or “not a good method”. Figure C-4 shows the 12 methods of communication as well as the results of Question 4.

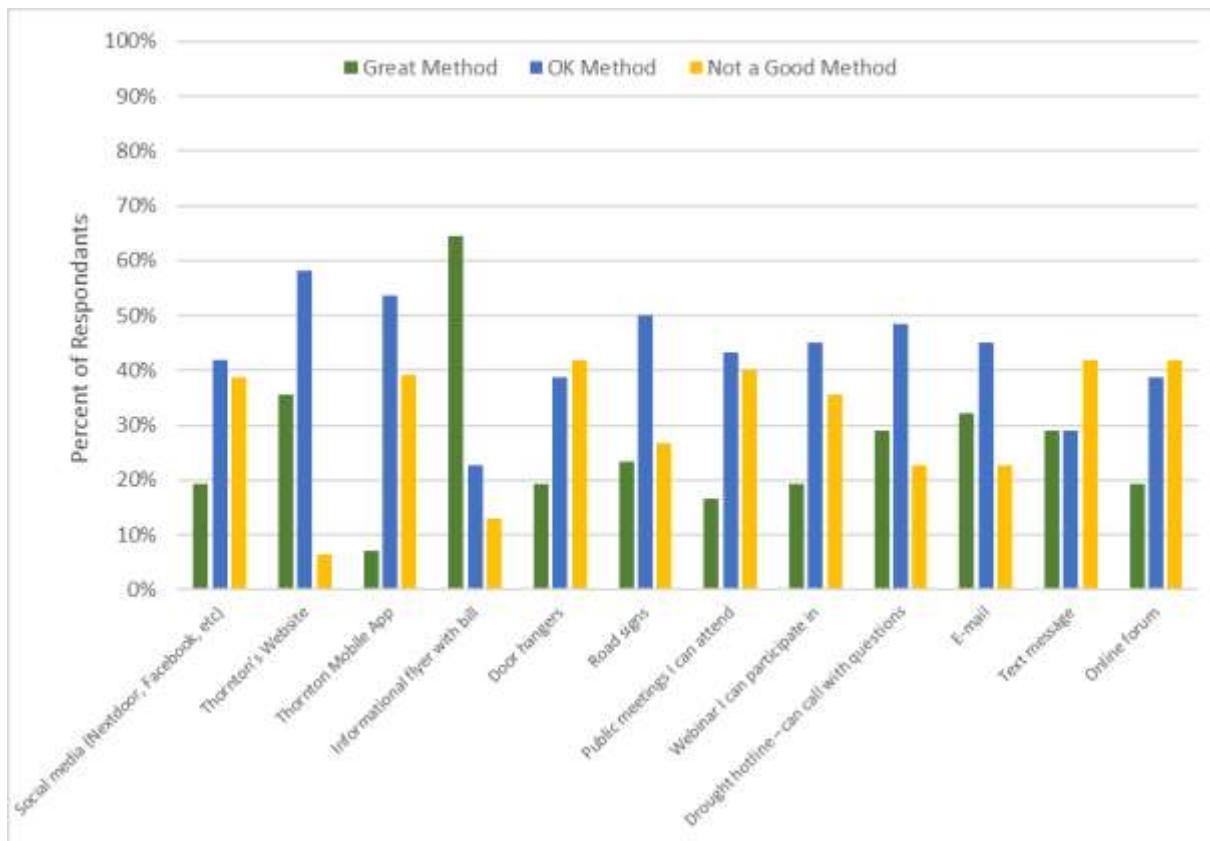


Figure C-4: Results for Question 4.

The method of communication that had (by far) the largest percentage of “great method” responses was an “informational flyer included with my water bill.” Communicating via “Thornton’s website” had the second highest percentage of “great method” responses, and the lowest percentage of “not a good method” responses. Several methods had a relatively high percentage of “not a good method” response including “door hangers”, “text message”, “public meetings”, and “online forums.”

Question 5: The picture below shows a water-wise landscape that consists of plants that do not use a lot of water. Please rate the use of water-wise landscaping for the following:

Question 5 showed a picture of a water-wise landscape (Figure C-5) and asked residents to rate the use of water-wise landscaping for several different applications. For each application, residents were asked to specify if each application was “highly favorable – want to see more in the community”, “moderately favorable – would like a little more in the community”, or “not favorable – prefer green grass.” Figure C-6 lists the five applications as well as the results of Question 5.



Figure C-5: Picture of water-wise landscape used in question 5 of the survey.

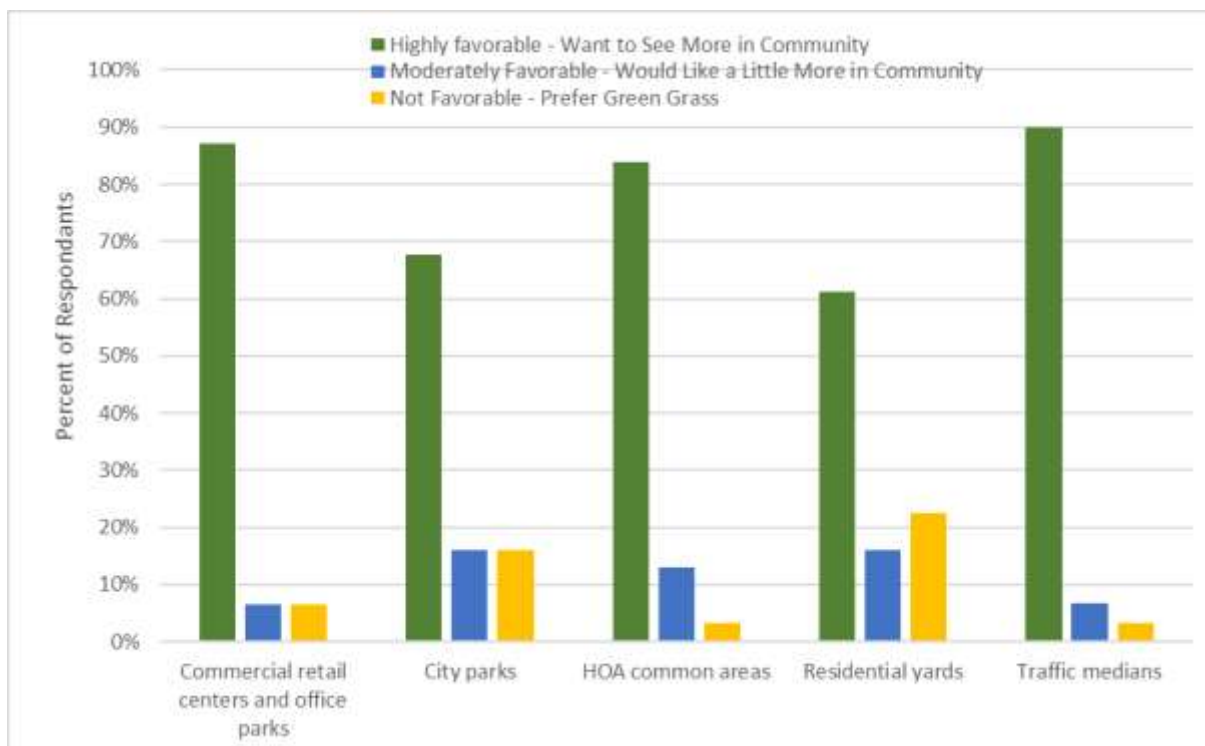
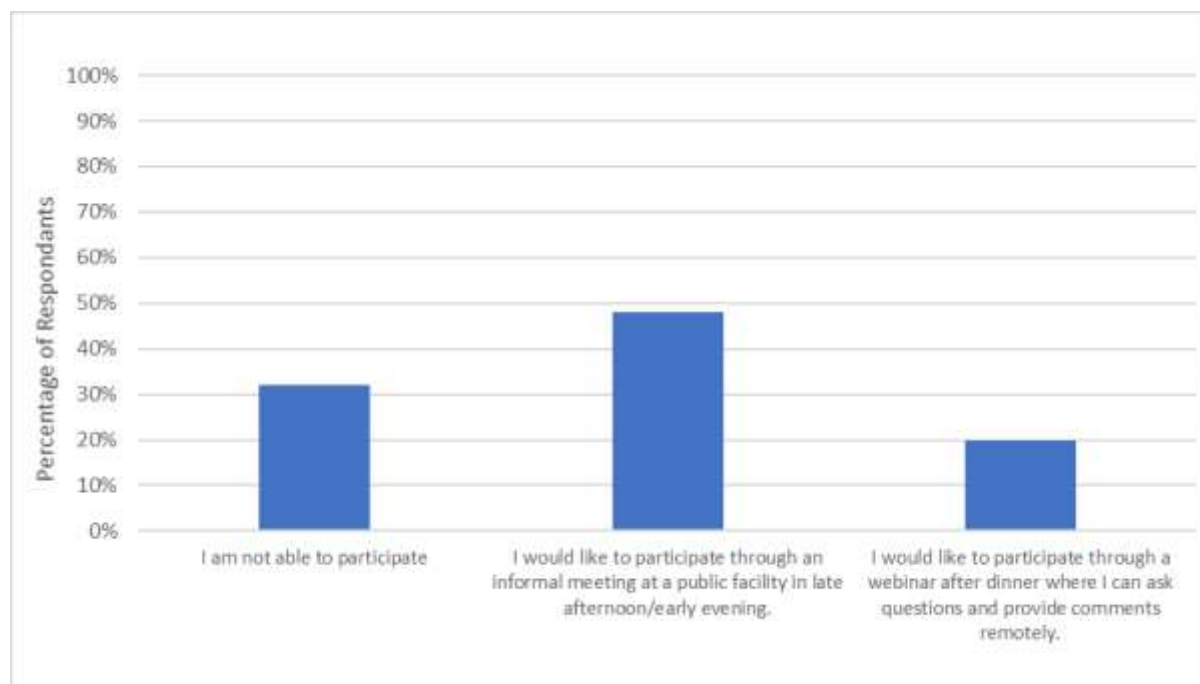


Figure C-6: Results for Question 5.

Overall, responders to the survey would like to see more water-wise landscaping in all five applications. The “*traffic medians*” received the highest percentage of “highly favorable” responses, but these responses far outweighed the “moderately favorable” and “not favorable” responses in every application provided to the residents.

Question 6: Would you like to continue be a part of this discussion? If so, how would you like to participate?

Question 6 asked participants if they would like to be a part of the discussion regarding drought and the Plan update beyond participating in the survey. The three responses were *“I am not able to participate”*, *“I would like to participate through an informal meeting at a public facility in late afternoon/early evening”*, and *“I would like to participate through a webinar after dinner where I can ask questions and provide comments remotely.”* Figure C-7 shows the results of Question 6.



The response that garnered the largest percentage of votes was *“I would like to participate through an informal meeting at a public facility in late afternoon/early evening.”* About 32 percent of residents marked *“I am not able to participate.”*

C.3 - KEY FINDINGS AND CONCLUSIONS

Key findings considering the responses to each of the survey questions are listed below. These are not all-inclusive but are intended to highlight major findings that are reflected in the Plan.

- During drought, residents are most concerned with upkeep of their yard and ensuring that the taste of their tap water is not negatively impacted.
- The open-ended inquiry into general concerns regarding water use and drought yielded a few common themes.
 - Residents would like to see water-wise principles applied to new developments and want to see that reductions in water use are being asked of not only them but of other large groups including the city (public areas), apartment complexes, and large HOAs.
 - Residents are also concerned about the cost of their water if penalties or rate increases are implemented during a drought. One pointed out the benefits of having an aesthetically pleasing community, while another pointed out that they are required by their HOAs to maintain green lawns.
- During drought, residents ranked indoor water for drinking and sanitary uses as the most important water use to maintain. Residents also listed water for large trees, residential lawns and residential vegetable gardens as important uses to maintain. Water for medians, and landscapes around public facilities were the least important of the options provided to maintain.

- Residents responded that they would most likely be motivated to cut water use by fees for not obliging to mandatory restrictions and rebates for water-wise renovations to their yards. Residents overwhelmingly responded that they would not be motivated by advertisements in public areas.
- Residents responded that mail inserts were the best form of communication when relaying drought and water use information.
- In general, residents are supportive of water wise landscapes throughout the community including at commercial and retail centers, parks, developments, yards, and traffic medians.

The Plan is consistent with resident responses in several key areas.

- First and foremost, residents surveyed responded that maintaining indoor water for drinking and sanitary uses was the most important water use to maintain. This is reflected in the Plan as indoor sanitary water uses are part of the highest priority use, which is health and safety (Table 2 in the Plan). Furthermore, although residents responded that they are concerned with the ability to maintain their yards, they also responded that they are “highly favorable” to using water-wise landscapes for several applications, including residential landscapes.
- Residents rated large trees as the second highest priority use to maintain during drought, and slightly more important than vegetable gardens and residential lawns. The Plan lists established trees as the third highest priority use, behind health and safety and community vitality uses (Table 2 in the Plan). Vegetable gardens are listed as a priority 4 use, and residential areas would largely fall under priority 5. Although, as mentioned, residents voted favorably for more water-wise landscapes in residential areas.
- The Plan is setup so that city staff can review pieces of the Plan during times of drought and select specific measures to implement. For example, Section 4.4 of the Plan outlines a public information campaign in which different outreach methods can be selected from an available list. When selecting measures for implementation, city staff should keep in mind the methods that residents said are most effective: bill inserts and links/information on the city’s website. Similar considerations can be given when selecting demand-management measures and incentives.

C.4 – FOCUS GROUP SURVEY

In addition to the residential surveys, focus group surveys were provided to specific interest groups (e.g., HOAs, commercial groups, etc.). Surveys were only received from 4 respondents. Only 1 of the respondents identified their organization, which was an HOA. The other 3 respondents did not identify who they were representing. The following summarizes key takeaways from the 4 respondents, much of which is consistent with the information collected from the residential surveys.

- In cases where respondents disagreed with the priority uses presented in Table 2, one comment concerned the inclusion of golf courses in priority 2 uses (stating that “...vast areas on golf courses which could go brown and cause no drop in the golf course’s economic viability”) and the other comment concerned the inclusion of HOA common areas in the lowest priority use (stating that “HOA common areas should not be lowest priority as they too have trees, shrubs, and grass [less important], we need to be able to keep trees and shrubs watered and alive). This is consistent with resident’s concern for their yards.
- All focus group respondents said that they would be highly motivated to reduce water use by “educational resources on water-wise landscaping” and “rebates for purchasing and installing water-efficient toilets”.
- There was not a common consensus as to how Thornton can best communicate about drought and address concerns. “Email to organization/entity leaders”, “signs around the community”, “text message”, and “email” all received a high percentage of “great method” responses.

- In general, as was the case with the residential surveys, respondents were “highly favorable” to seeing more water-wise landscapes throughout the community.