INFORMATION PACKET
MEMORANDUM

To: Members of the Water Resource Advisory Board

From: Jeff Arthur, Director of Public Works for Utilities
Joe Taddeucci, Water Resources Manager
Bret Linenfelser, Water Quality Environmental Services Manager
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Date: October 17, 2016

Subject: 2016 Water Efficiency Plan Update

EXECUTIVE SUMMARY:

This memorandum summarizes the City of Boulder's (city) state mandated 2016 Water Efficiency Plan (WEP) update which was submitted to WRAB with the September 19, 2016 meeting packet. As no comments were received, the unchanged WEP (Attachment A) will be used to launch the official commencement of the state-required 60-day WEP public comment period starting at the October 17, 2016 WRAB meeting. The WEP will be available to the public through www.BoulderSavesWater.net and the Boulder Public Main Library and the public will be notified through online or print advertisements. Once the public comment period closes, staff will submit the WEP, with any comments received, to the state to meet the December 2016 deadline.

Per state requirements to update the WEP every seven years and include specific elements, the WEP details the city's historical treated water use, current water efficiency efforts and existing long-term goals. The 2016 WEP recommends the city maintain its existing water conservation goals as part of a "no regrets" planning strategy especially as concurrent projects like the 2016 Rate Study and Boulder Creek Climate model updates may significantly shape long-term water conservation planning goals.

Ultimately, the city's responsibility is to submit an efficiency plan that conforms to the state's requirements, and the state has given a preliminary indication that the 2016 WEP will be satisfactory based on a cursory review of a draft. Since completion of the previous plan in 2009, staff have checked-in with WRAB a number of times on water conservation initiatives, most recently at the January 2016 WRAB meeting. Water conservation planning, goals and major recommendations in the 2016 WEP are reflective of WRAB's input to date.

BACKGROUND:
The Water Conservation Program (WCP) was created in 1992 with WCP efforts originally directed at reducing peak demand and developing long-term sustainability goals. From 1992 to 2000, water use increased significantly with the highest use occurring in 2000. In response, the city developed the 2000 Water Conservation Futures Study (WCFS) which set a program goal of reducing total city water use at buildout by 10% with a WCP (or 20% without a WCP) as compared to the 1994 to 1996 baseline.[1]

The 2002 to 2003 drought (among the worst on record in Colorado) marked a stark change in both city and state water policies that would have significant and lasting impacts on customer water use and the role of the WCP. Most immediately, watering restrictions and surcharges played a role in altering customer behavior. However, lasting impacts from the drought also affected policy. The drought spurred the completion of the city's Drought Plan (2002), embedded water conservation efforts into utility planning, integrated climate impacts into water demand forecasting (beginning in 2003) and led to the approval of a 5-tier inclining block rate, water budget structure (implemented in 2007).

At the state level, the drought triggered the Colorado Water Conservation Board (CWCB) to develop and pass the 2004 Water Conservation Act. This required, among other things, municipalities to develop a state approved Water Conservation Plan (now called a Water Efficiency Plan) every seven years that must contain a list of specific elements. These include a profile of existing water supply systems, historical and future water demands, water efficiency activities and monitoring of these efforts. The city submitted and received approval from the CWCB for the original plan in 2009 with the first WEP update due in 2016.

In 2011, the Water Utilities Master Plan (WUMP) Volume 2 identified that the city's water conservation goals had largely been met but promoted the continuation of the WCP with several recommendations including an evaluation of program activities and leveraging resources. Acting on WUMP recommendations, WCP staff replaced the traditional rebate program with a service-oriented approach that allowed for greater leveraging of resources with larger sustainability initiatives (e.g. building on the water-energy nexus) and improved customer service.

More recently, the WCP merged with utility outreach, stormwater quality and inflow and infiltration mitigation programs to create the *Watershed Sustainability & Outreach Program.* This has allowed for enhanced community engagement, integration of WRAB supported efforts to better merge flood and drought response planning and continues to leverage larger city sustainability and resilience initiatives.

A summary of these most recent WCP activities and other efficiency planning efforts have been incorporated into the city's 2016 WEP (see Attachment A). This information was provided to WRAB with the September 19, 2016 WRAB meeting packet and no comments were received.

ANALYSIS:
The 2016 WEP update follows the CWCB's *Water Efficiency Plan Municipal Guide requirements*. This includes a history of the city's efficiency planning efforts and historical water demands which have consistently remained below 2000 water use levels due to a variety of reasons (efficient appliances, block rates; etc.). However, the WEP also focuses on future water demand forecasting, community trends and WCP recommendations to address projected increases in water use moving forward.

<u>Drivers That Can Increase Water Use</u>

[1] Meeting the WCFS goal would result in 21,690 acre feet or less water use at the then, 2025 buildout.

Increases in future water use are largely due to the following key drivers:

-***Demographic and Land Use Projections:*** Boulder's projections anticipate an increase in population, employment and density by 2040 which will increase total water use.

-***Climate Change Effects on Project Water Demands:*** There is general consensus that temperatures are expected to increase in the future which will likely increase outdoor water use.

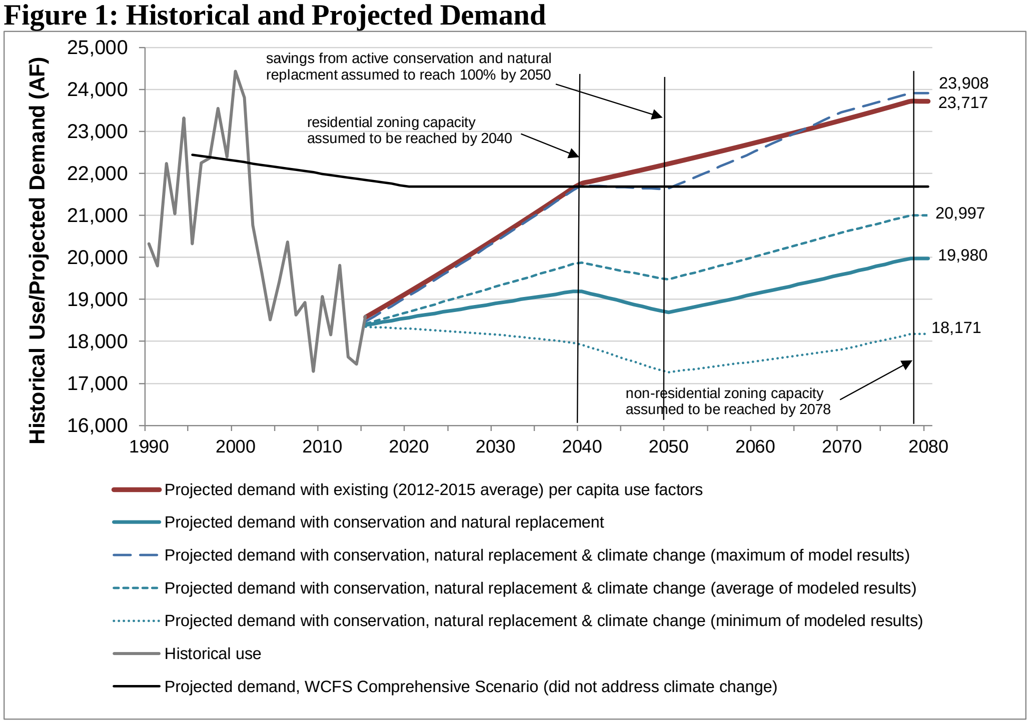
-***Natural Replacement of Fixtures:*** Efficient appliance and fixture technology, regulation and remodeling continues to reduce indoor water in the near-term, but as the population grows and the volume of new appliances and fixtures increase, long-term projections for indoor water use will increase slightly even if fixtures and appliances are more efficient.

As a result of the drivers above, maintaining existing WCP efforts are important to advancing conservation activities and behavior trends. Although there are many educational activities for which it is difficult to directly attribute water savings, WCP program tracking efforts confirm that service-based efforts have actively saved approximately 15 acre foot each year.

Projected Water Use and No Regrets Strategy

The combination of the drivers noted above indicate Boulder's total treated water demand will remain at current conditions in the short-term, but will likely increase overtime as shown in Figure 1.[2] Although the WCP and other current efficiency practices can meet this near-term demand, the city will need to be strategic in how it plans to meet its future demands. This is largely because the extent to which any one driver may impact future demand cannot be said with certainty. In fact, the WEP shows how future water use could vary by almost 6,000 acre-feet depending on how much factors like climate change influence water use.

Figure 1: Historical and Projected Demand



[2] Climate change impacts have been disaggregated into three outcomes to best reflect the range of climate model results.

Following the state's direction in the Colorado Water Plan, the WEP is using a "no regrets" approach to evaluating the range of future projections (or scenarios). No regrets strategies are justifiable near-term actions that make sense under any future scenario from an economic, social and environmental perspective. Taking a no regrets planning approach for the current WEP allows the city to sustain it's existing water conservation goals while monitoring trends and new information that can be used to inform whether new goals should be set prior to the 2023 WEP update. Any new goals the city would decide to establish will almost certainly be impacted by other projects the city is currently engaged in that stand to shape its water conservation goals.

Other Projects That Will Influence Water Conservation Planning

It is important for the WCP to factor in the outcomes of a number of ongoing city efforts prior to setting any new goals. These include:

-*Boulder Creek Climate Model Updates* will provide greater granularity and enhance climate projections that can be used to recalculate water use projections shown in the WEP.

-*Revisions to the Green Points Program* in 2017, designed to encourage the use of sustainable technologies via the new-construction and remodeling permit application process, may result in more stringent water conservation requirements for both indoor and outdoor.

-*Completion of the 2016 Rate Study* may result in changes to the current billing and water budget system that could ultimately have an impact on customer behavior with water use.

-*Energy Utility Municipalization* offers an opportunity to potentially upgrade city water meters with an integrated metering and billing system that could provide real-time water (and energy) data which could help reduce water loss.

Each of the items listed above are all expected to be completed prior to the next WEP update in 2023. Results from these activities will provide the information needed to decide if new city water conservation goals should be developed.

Maintaining Current Water Conservation Goals

The city has met all water conservation goals in each customer sector except for non-revenue water, also known as water loss (see Table 1). After reviewing water use trends, water demand drivers and projected water use, the city has determined that the current water conservation goals represent a no regret planning strategy which allows the city to continue meeting short-term water demand goals. New water conservation goals will be evaluated as part of the WEP update in 2023.

Table 1: Status of Boulder's Attainment of its Water Conservation Goal

Water Use Sector	1994-1996 Baseline Use	% Reduction Target	Water Use Target	2012-2015 Baseline	Water Use Target Met?	Units
Single Family	163	22%	127	123	yes	gallons per resident per day
Multi Family	87	26%	64	58	yes	gallons per resident per day
Commercial	62	14%	53	44	yes	gallons per employee per day
Municipal	6.1	1%	6	5.7	yes	gallons per capita per day
Non-revenue Water	8.5%	29.0%	6.0%	9.0%	no	% of treated water production

WEP Recommendations

In addition to maintaining the city's existing water conservation goals, the WEP recommends the following focus areas:

Water Loss, Customer Categorization and City Metering: The city can continue to focus on reducing citywide water loss through evaluating real-time reading metering options while continuing to improve system water loss detection and reduction.

Streamline Sustainability and Resilience Initiatives: Continue to identify and address where there can be both energy and water savings while also continuing to leverage resources to address multi-hazards (flood and drought), city climate goals, climate modeling and other resilience strategies.

Advance Green Infrastructure Connections: Green Infrastructure or low-impact development planning can provide multiple co-benefits for departments across the city. The WCP can play a role in maximizing these co-benefits while focusing on water conservation opportunities and community engagement.

Continue the Adaptive-Resilient Water Conservation Program: The WCP should continue to adapt to new data and changing conditions and consider if new water conservation goals should be a part of the 2023 WEP update.

The state recently performed a cursory review and had favorable feedback of the draft plan, which indicates the plan and and its recommendations will satisfy the state's requirements once the plan is formally submitted.

CONCLUSION:

The 2016 WEP update goals and recommendations represent a no regrets strategy for future planning. Based on preliminary feedback, the plan as drafted is expected to satisfy the state's requirements. In the near-term, staff will work to implement WEP recommendations and monitor concurrent efforts that can inform future water conservation goals (e.g. Rate Study; Green Points; Climate Modeling). The city can evaluate whether or not new water conservation goals are needed in advance of the next WEP update in 2023.

NEXT STEPS:

Attachment A will be used to launch the state-required 60-day public comment period starting October 17, 2016. Should WRAB have any additional feedback during this time period, it will be included, along with any other public comments staff receives, into the final WEP state submittal to meet the end of year deadline. The WEP will be made available through www.BoulderSavesWater.net and the Boulder Public Main Library. We will also be notifying the public about the public comment period through means such as newspaper advertisements or utility bill inserts.

ATTACHMENTS:

Attachment A – 2016 Water Efficiency Plan

Attachment A

2016 Water Efficiency Plan

September 2016

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Executive Summary

As required by the 2004 Water Conservation Act, the City of Boulder (city) developed a Water Efficiency Plan (WEP), previously called a Water Conservation Plan in 2009 (2009 WCP). The purpose of this 2016 WEP plan is to provide updated guidance for implementing the city's Water Conservation Program in a way that is compatible with the city's water supply system, adopted water conservation goal and programs, water resources management strategy, and community values. This update also serves to fulfill the statutory requirements to submit a revised plan to the Colorado Water Conservation Board every seven years.

Today, the city manages a wide range of water conservation measures designed to implement the city's Comprehensive Water Conservation Program, which was adopted by City Council as the city's water conservation goal. The intent of the Comprehensive Program is to reduce indoor and outdoor water uses within each customer class and to reduce the city's treated water losses. The Comprehensive Program has been expressed in terms of specific water use reduction targets including:

- 22 percent reduction in per meter use for the single-family residential sector;
- 26 percent reduction in per meter use for multifamily residential sector;
- 14 percent reduction in per meter use for the commercial/industrial sector;
- 1 percent reduction in overall municipal use, and
- real and apparent losses of water no greater than 6% of treated water use.

Long-term attainment of these targets is intended to achieve an approximate 20% reduction in overall per capita water demand by buildout. Achievement of the city's water conservation goal has largely been accomplished to date through an extensive Water Conservation Program that continues to develop and adapt to changing conditions.

The city provides potable water to approximately 114,400 residents in its service area (2012-2015 average), which encompasses a total of just under 26 square miles. The city's existing total annual treated water use is approximately 18,200 acre-feet (2012-2015 average), primarily supplied by surface water withdrawn from Boulder Creek, and secondarily from the Colorado-Big Thompson and Windy Gap Projects on the western slope. Residential single-family users make up most of the 29,305 active connections (2012-2015 average) to the city's water supply system, and represent about 65 percent of total water use. Across all sectors, citywide annual demand per connection totaled approximately 201,900 gallons averaged over 2012-2015.

The city's total daily per capita water use has varied from year to year from a low of 136 gallons per capita per day (gpcd) in 2014 to a high of 209 gpcd in 1988. The city's average per capita water use from 2012-2015 is 142 gpcd. From 2000 to 2015, per capita water use has significantly declined. However, future water use projections suggest total water use will begin to increase in the coming years.

Given the projected increase in water use and recommended actions that should take place prior to the city's next WEP update in 2023, this report demonstrates how attaining and maintaining the city's existing 2009 WCP goal and associated water use reduction targets continues to be a reasonable water conservation strategy. The 2016 WEP outlines this throughout four core chapters, which are summarized as follow.

Historical Treated Water Use

Boulder's average treated water for 2012-2015 was 22 percent less than in 2000, the year of Boulder's maximum annual treated water use (see Figure 4-1).[1] Boulder's treated water use has declined significantly in response to Boulder's Water Conservation Program, increased public awareness of the need for efficient water use in reaction to the drought of 2002-2006, and the city's imposition of mandatory water use restrictions in 2002, which contributed to an approximate 20 percent reduction in Boulder's treated water use during the ensuing year. Boulder's water use has not returned to pre-2002 levels and has continued to decline. See Chapter 4, Historical Treated Water Use, for more detailed information on indoor vs. outdoor usage, use by sector, peak day use and per capita use.

Future Water Demand Trends

Projections for Boulder's future water demands are based on trends in the following key areas:

- *Demographic and Land Use Projections* – Boulder's demographic projections anticipate increased population and employment growth and increased housing density. Given Boulder's balance of housing, employment and land use projections, it is not anticipated that densification will result in a significant increase in irrigation or overall per capita water use in Boulder.
- *Per Capita Water Uses* - Boulder's historical per capita water uses have declined significantly since 2006-2009. Boulder's total treated water used has averaged 142 gallons per capita per day (gpcd) over 2012-2015. Residential indoor use has averaged 48 gpcd. Boulder's current baseline water use is shown in Table 5-2, disaggregated by customer sector and indoor vs. outdoor use. It should be noted that residential uses are shown in two ways: separated into SF and MF components and also as combined residential uses.
- *Natural Replacement of Fixtures and Appliances* - It is expected that indoor per capita water use will continue to decline as the majority of aging water fixtures in Boulder are replaced with more efficient models that meet the EPA WaterSense standard per new state regulations.
- *Ongoing Water Conservation Savings* – In addition to savings from natural replacement, the city's ongoing Water Conservation Program water is expected to reduce per capita indoor and outdoor uses via installation of fixtures that are more efficient than EPA WaterSense standards, auditing and efficiency improvements to commercial, industrial and institutional (CII) uses, xeriscaping and urban irrigation system improvements.
- *Climate Change Effects on Projected Water Demands* - There is now broad recognition that the future climate will be different than the past and that this will affect the city's water demands. This is specifically true of outdoor water use where increased temperatures are likely to increase unit irrigation demand (which is consistent with current customer behavior patterns). Although Boulder's water supply system seems to be sufficiently robust to meet its reliability criteria, the effects of climate change

[1] Normalizing for irrigation water requirement.

combined with additional changes in Boulder's population and employment growth are likely to create upward pressure on Boulder's future water demands.

Projected Future Water Demands

Boulder's projected future water demands, reflecting the combined effects of the city's updated demographic projections, expected savings from continued natural replacement of fixtures and appliances, projected additional savings from the city's active Water Conservation Program, and the range of expected climate change effects on outdoor water uses are shown below.

Water Demand Projection Scenario	units	Projected Water Demand 2040	2050	2078
Projected demand with conservation and natural replacement	(AF)	19,191	18,696	19,980
	(gpcd)	126	123	131
Projected demand with conservation, natural replacement & climate change (minimum of modeled results)	(AF)	17,920	17,267	18,171
	(gpcd)	118	113	119
Projected demand with conservation, natural replacement & climate change (average of modeled results)	(AF)	19,875	19,478	20,997
	(gpcd)	130	128	138
Projected demand with conservation, natural replacement & climate change (maximum of model results)	(AF)	21,716	21,640	23,908
	(gpcd)	142	142	157

The Adaptive-Resilient Water Conservation Program

Boulder's current water conservation goal and associated water use reduction targets, coupled with a "no backsliding" principle, are still valid for curbing future water use increases. Achieving and maintaining the current Water Conservation Program goal will not cause a further drop in Boulder's water use but will instead reduce what would otherwise be a greater increase in projected water use. Uncertainties in future projections requires the Water Conservation Program to be adaptive. The Water Conservation Program has worked toward continuing to meet the water conservation goal but also adding value beyond its immediate mission through enhanced coordination with larger city efforts. Among other things, the Water Conservation Program supports the city's resilience goals, instream flow augmentation in Boulder Creek, agricultural water leasing, climate goals and stormwater quality.

Recommendations

The 2016 WEP study recommends action (see Chapter 8) in the following areas:

1. Have an Adaptive-Resilient Water Conservation Program
2. Streamline Sustainability and Resilience Initiatives
3. Advance Green Infrastructure Connections
4. Evaluate City Metering, Customer Categorization and Water Loss

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1 Introduction

1.1 Background

This 2016 Water Efficiency Plan (2016 WEP) is an update of the City of Boulder's (the city's) 2009 Water Conservation Plan (2009 WCP), and was completed to incorporate new information in key areas that affect the water demands and conservation activities of the Boulder community (Boulder), and in accordance with Colorado's statutory requirements for municipal water providers to review and update their water conservation plans at least once every seven years.

Water conservation has been an important part of the city's water management for over twenty-five years. In 1988, Boulder adopted a three-tiered increasing block rate structure to encourage water conservation during the peak summer demand season. In 1992, Boulder established its Water Conservation Program to promote efficient water use throughout the year.

In 2000, Boulder's Water Conservation Futures Study (WCFS) proposed a Comprehensive Water Conservation Scenario (Comprehensive Scenario), which included a range of educational and voluntary program elements to reduce indoor and outdoor uses. The Comprehensive Scenario was adopted as the city's water conservation goal as part of the city's 2000 Treated Water Master Plan and resulted in substantial revisions to and increased funding of Boulder's Water Conservation Program. The Comprehensive Scenario identified a range of Water Conservation Program elements that would result in an approximate 20 percent reduction in total per capita water use by buildout, compared to projected water use without water conservation.

The 2009 WCP provided guidance for achieving the Comprehensive Scenario and developed specific per meter and system-wide water use reduction targets for customer sectors, consistent with the Comprehensive Scenario's program elements, to be achieved by buildout. The 2009 WCP was approved by the Colorado Water Conservation Board (CWCB). Boulder's Water Utilities Master Plan (WUMP), approved in 2011, expressed the 2009 WCP's water use reduction targets as customer sector-specific per capita values, supported continuing the existing 2009 WCP measures and sustaining current program funding, but recommended that efforts be tailored to address current needs. The WUMP's conservation recommendations have largely been met via adjustments to conservation efforts, as discussed in Section 3.3.

Boulder's treated water use has declined significantly in response to the city's Water Conservation Program, public response to the need for efficient water use in reaction to the drought of 2002-2006, and the city's mandatory water use restrictions in 2002, which contributed to an approximate 20 percent reduction in Boulder's treated water use during the ensuing year. Boulder's water use has not returned to pre-2002 levels and has continued to decline.

A detailed list of the city's Water Conservation Program elements and water conservation planning efforts is provided in Appendix A. Along with its water conservation-related activities, the city has completed numerous water supply planning efforts and supply development and facilities projects that have improved its water supply system reliability. These activities and projects are summarized in Table 1.1. In addition, the city's ongoing efforts in infrastructure rehabilitation and maintenance have maintained and improved water supply system reliability.

Table 1-1: Summary of Water Supply Planning Activities and Projects

Activity/ Project	Date(s)	Description
Raw Water Master Plan	1988	Provided water supply system overview, developed raw water supply reliability criteria, projected future water demands, assessed existing system adequacy, evaluated alternative water supply plans.
Water Conservation Futures Study (WCFS)	2000	Characterized Boulder's water uses, updated Boulder's water demand projections, assessed the reliability of Boulder's water supply system and recommended a Comprehensive Water Conservation Scenario.
Treated Water Master Plan Update	2000	Updated the city's capital improvements planning and budgeting to reflect then-current conditions and integrated the 2000 WCFS's recommended Comprehensive Scenario.
Acquisition of Barker Reservoir System	2001	Increased Boulder's municipal water supply storage capacity in Middle Boulder Creek by approximately 3,700 acre-feet and provided for more operational control of Barker Reservoir.
Silver Lake and Lakewood Pipeline Reconstruction	1994-2004	Restored Boulder's raw water delivery rate from its North Boulder Creek sources from 12 mgd to 20 mgd.
Drought Plan (Volume 1 and 2)	2003	Guides Boulder's drought recognition and responses, which include voluntary efforts for mild/moderate droughts and mandatory measures for severe droughts. Response measures are designed to build on current WCP efforts and allow for further drought response actions.
Boulder Reservoir Water Treatment Plant Improvements	2006	Increased Boulder's treated water production capacity at the Boulder Reservoir Water Treatment Plant from 12 mgd to 16 mgd.
Climate Change Vulnerability Study	2009	Evaluated the vulnerability of Boulder's water supply system to climate change. Examined the effects of a range of climate change scenarios on stream flows and water rights. Incorporated paleo-hydrology derived from tree rings and assessed the reliability of Boulder's water supply system in the context of potential climate variability.
Water Conservation Plan	2009	Developed numeric water use reduction targets based upon the WCFS. Met the State's requirements and provided guidance in updating and implementing the city's WCP.[2]
Source Water Master Plan Update	2009	Provides a comprehensive framework for managing Boulder's water supply to meet future needs through drought periods without violating adopted reliability criteria. Incorporated recent projections of future water demands and the results of the drought plan and climate change vulnerability study. Provides guidance on use of excess municipal water supplies to meet non-municipal needs.
Drought Plan Update (Volume 1)	2010	Integrated Boulder's water budget rate structure into the Drought Plan as a possible drought response measure.
Water Utility Master Plan	2011	Integrated Boulder's water source, storage, treatment, and delivery master plans to facilitate coordinated capital improvement planning.

In December 2012, the city began updating its 2009 WCP to: (1) incorporate the WUMP's water conservation-related recommendations; (2) evaluate recent changes to the city's demographic projections, water use patterns and Water Conservation Program activities; (3) reflect recent enhancements to Boulder's source water supplies and delivery capabilities; and (4) consider new

[2] Municipalities with State approved water conservation plans are eligible for financial assistance from the CWCB and Colorado Water Resources and Power Development Authority.

information and technologies that could impact Boulder's water demands, including the effects of climate change. The results of these efforts are reflected in this 2016 WEP, which also meets the CWCB's water conservation planning requirements.

1.2 Purpose of the 2016 Water Efficiency Plan

The main purpose of the 2016 WEP is to assess the status of Boulder's efforts to meet its water conservation goal, as embodied in the Comprehensive Scenario and specified by the water use reduction targets in the 2009 WCP, considering trends in Boulder's water use patterns, the city's most recent demographic projections and the likely range of effects of climate change upon Boulder's water demands and supplies. This effort entailed the following:

- Review the city's existing 2009 WCP and evaluate historical water use from 2000 to 2015 in order to identify significant water use trends and review program effectiveness.
- Address factors that could impact Boulder's future water demands including updated demographic and land use projections, effects of natural replacement of fixtures and appliances with more efficient models, the effects of climate change, and the city's potential future decisions involving water demand and supply management.
- Develop a range of water demand projections that reflect the city's most recent demographic projections, trends in water use factors including the likely effects of natural replacement and the city's Water Conservation Program, and the likely range of climate change effects.
- Address how conserved water could potentially be used for alternate purposes including enhancing the reliability of Boulder's water supply system, maintaining or enhancing instream flows in Boulder Creek and its tributaries, and increasing water leases to local community-supported agriculture.
- Address how water conservation integrates into other aspects of Boulder's water supply system and sustainability goals, including the water-energy nexus, water rights considerations, quality of life and the quantity and quality of urban landscaping.
- Incorporate the results from the city's study of commercial, industrial and institutional (CII) water uses.
- Evaluate whether Boulder has met its water conservation goal in the short term and the likelihood that Boulder will continue to meet that goal over the long term.
- Recommend follow-up activities and studies to enhance the 2009 WCP and assist Boulder in meeting and refining its water conservation goal.

2 Profile of Existing Water Supply System

Boulder provides water supply, stormwater and wastewater services to a residential population of approximately 117,000 persons, a wide variety of CII customers and municipal government uses. The city's service area includes approximately 26 square miles of lands within Boulder's incorporated boundaries or within Planning Area II as designated by the Boulder Valley Comprehensive Plan (BVCP). Boulder's service area population has grown by approximately 8 percent in the past ten years and it is anticipated that it will continue to grow by another 16 percent until Boulder's residential zoning capacity is projected to be reached in 2040. There are currently about 101,400 jobs within the service area, and future employment is projected to ultimately grow by an additional 54 percent until Boulder's non-residential zoning capacity is projected to be reached by 2080.

Boulder's water supplies include direct flow, storage and exchange water rights in the Boulder Creek watershed and interests in Colorado-Big Thompson (CBT) and Windy Gap water projects.

Boulder's direct flow rights include originally decreed municipal rights associated with the Town of Boulder Ditch, the Boulder City Pipeline and the Boulder City Pipeline No. 3; and changed irrigation rights of the Anderson, Farmers, Harden, McCarty, Smith & Goss, North Boulder Farmers, and Lower Boulder ditches; which are diverted from North Boulder Creek via the Boulder City Pipeline, from Middle Boulder Creek via the City of Boulder Pipeline No. 3, and from Boulder Creek via the Farmers Ditch.

Boulder's storage rights are associated with Silver Lake, Island Lake, Goose Lake, Albion Reservoir and the Green Lakes in the North Boulder Creek watershed; with Barker Reservoir and Skyscraper Reservoir in the Middle Boulder Creek watershed; and with Baseline Reservoir and Wittemyer Ponds. The combined storage capacity associated with Boulder's storage rights is approximately 20,000 acre-feet. Boulder's trans-basin supplies include 21,015 CBT units and 37 Windy Gap units. Boulder's exchange rights allow Boulder to exchange its CBT supplies, Windy Gap supplies, Baseline Reservoir storage rights, some of its changed irrigation rights and some of its municipal return flows upstream for direct use or storage and subsequent use at its Middle Boulder Creek and North Boulder Creek points of diversion.

Water is treated at the city's Betasso and Boulder Reservoir water treatment plants (WTPs) and conveyed to customers through over 400 miles of water distribution pipelines. Wastewater is collected and treated at the 75th Street wastewater treatment facility. A full description of Boulder's water supply system is provided in Boulder's Source Water Master Plan[3].

Boulder leases some of its temporarily unused raw supplies to various agricultural users in the Boulder Creek and Left Hand Creek basins on a year-to-year basis. A relatively small number of properties within Boulder's service area, including a few parks and school grounds, the main University of Colorado campus, the NOAA/NIST campus and several private lots own shares in irrigation ditch companies and use non-potable irrigation water provided by those ditches.

Boulder's ability to implement water reuse is limited because most of Boulder's water rights are not reusable. A relatively small portion of Boulder's water supplies is fully consumable and could be reused. Boulder uses return flows from those supplies to meet its augmentation and return flow replacement requirements, and as an exchange supply.

Boulder's water supply system is not in a designated critical water supply area. Boulder is located in the Boulder County portion of the South Platte Northern Counties as defined by the Statewide Water Supply Initiative (SWSI) 2010 report. According the SWSI 2010 report, Boulder County appears to have no 2050 supply gaps.

Boulder has considered and adopted ordinances, regulations and policies that are designed to encourage efficient water use and to respond effectively to droughts. These include mandatory metering, Boulder's water supply reliability criteria, support of the city's ongoing Water

[3] City of Boulder. April 2009.

Conservation Program, Boulder's water budgets and associated water rate structure, Boulder's Drought Plan and the City Manager's authority to declare a drought and to restrict water uses, and Boulder's Green Points and SmartRegs programs, which "build-in" efficient water use into new construction, redevelopment and some existing development. The water savings associated with these ordinances, regulations and policies, while significant, cannot be readily separated from savings resulting from other factors including the city's Water Conservation Program.

2.1 Water Supply Reliability

During the development of its 1988 Raw Water Master Plan[4], Boulder adopted water supply reliability criteria, which set performance standards for raw water supply reliability that struck a balance between the costs and environmental impacts of increased reliability and the consequences of temporary water supply restrictions. Those criteria are described below.

- For water uses deemed essential to the maintenance of basic public health, safety and welfare such as indoor domestic, commercial and industrial uses and firefighting uses, Boulder shall make every effort to ensure reliability of supply against droughts with recurrence intervals of up to 1,000 years.
- For that increment of water use needed to provide continued viability of outdoor lawns and gardens, Boulder shall make every effort to ensure reliability of supply against droughts with recurrence intervals of up to 100 years. (The phrase 'continued viability of outdoor lawns and gardens' has been defined as provision, at a minimum, of the amount of water necessary to meet the basic survival needs of outdoor landscaping in general, including trees and shrubs.)
- For that increment of water needed to fully satisfy all municipal water needs, Boulder shall make every effort to ensure reliability of supply against droughts with recurrence intervals of up to 20 years.

Boulder has utilized the reliability criteria to formally assess the adequacy of its water supply system and to make water supply planning decisions. In its 2003 Drought Plan, Boulder developed drought response triggers and related demand reduction strategies for four different drought stages. Boulder analyzed the reliability of its water supply system, at projected buildout water demands and assuming attainment of Boulder's water conservation goal, against 300 years of paleo-hydrology reconstructed from tree ring data. That analysis showed that Boulder's water supply system would be capable of meeting its projected buildout demands (then projected to occur by 2020), plus a 10 percent safety factor, in a manner consistent with Boulder's adopted reliability criteria over the 300-year modeled period.

During 2006-2008 the city participated in a study of the vulnerability of Boulder's water supply system to the potential effects of climate change combined with long-term hydrologic variability (as evidenced by 437 years of paleo-hydrology)[5]. That study showed that Boulder's water supply system appears to be sufficiently robust to meet its two most important reliability criteria – supplying water uses deemed essential to basic public health, safety and welfare, and ensuring continued viability of outdoor lawns and gardens - in most of the future possible climate conditions modeled.

[4] WBLA, Inc., 1988.
[5] Smith et. al., 2009.

Both of the aforementioned reliability assessments assumed that Boulder's projected buildout water demand would be significantly greater than what is currently projected. Also, while the Climate Change Vulnerability Study used the best available climate change and hydrology modeling at that time, newer and significantly improved climate modeling and hydrology data are available. As described in Section 0, the city is updating its reliability assessment to reflect attainment of its water conservation goal, its most recent demographic projections, the latest available climate change information and the resulting updated water demand projections.

There are other factors, which were not explicitly addressed in the above-described reliability assessments, that could significantly affect the city's ability to provide municipal water supplies, including a potential Colorado River compact call, wildland fire, infrastructure failure or a major contamination event.

2.2 Supply-Side Limitations and Future Needs

Based on Boulder's previous water supply reliability assessment that considered climate change, Boulder has sufficient supplies to meet its projected future needs at the standards of its reliability criteria under a majority of future climate scenarios. This finding will be reviewed and updated as part of Boulder's updated reliability assessment, which is scheduled for completion later this year. The updated assessment will incorporate the results of the Fifth Assessment report from the Intergovernmental Panel on Climate Change, as well as the most recent downscaled climate modeling data developed by the State of Colorado in its Colorado Water Availability Study. The updated assessment will also incorporate Boulder's most recent projected buildout water demand, as presented below.

3 Water Conservation Program Overview

3.1 History of Boulder's Water Conservation Program

Boulder's initial water conservation efforts included a shift from a flat rate to a quantity charge for water used by metered customers, and required water meters for all new residential construction in 1952. The universal metering program was completed by 1964. The combination of universal metering and a quantity charge resulted in a 33% short-term decline in Boulder's overall per capita water use from a 1956-1962 average of 226 gpcd to a 1964-1970 average of 152 gpcd. Overall per capita use gradually increased to an average of 188 gpcd by the 1980s and 1990s but never returned to pre-1964 levels[6].

Faced with increasing peak-day water demands and limited water treatment capacity, in 1988 Boulder moved from a quantity charge to a three-tiered increasing block rate structure to encourage water conservation during the peak summer demand season. Boulder's 1990 Treated Water Master Plan (TWMP) recommended water conservation as the most cost effective means of increasing system flexibility. In 1990, Boulder's City Council approved implementation of an

[6] WBLA, Inc., 1988

enhanced Water Conservation Program with the primary purpose of deferring the expansion of the Boulder Reservoir WTP.

The Water Conservation Program was formally established in May 1992 to direct the efforts of reducing overall water consumption within the city and to reduce summer peak demand use. The Water Conservation Program was adopted by City Council as a single staff (one full-time equivalent) program and is currently managed under the Utilities Division (Utilities) under the Public Works Department in the Water Quality and Environmental Services (WQES) Group.

In 2000, Boulder completed its Water Conservation Futures Study (WCFS), which characterized Boulder's treated water uses, formulated and evaluated several water conservation scenarios, and projected Boulder's treated water demands under each of those scenarios from a 1994-1996 baseline condition through buildout, which was then assumed to occur by 2020. Boulder selected as its water conservation goal the WCFS's Comprehensive Conservation Scenario (Comprehensive Scenario), which included a range of program measures aimed at reducing both indoor and outdoor water uses within each customer sector, as well as reducing system treated water losses. The Conservation Scenario's program measures were specified in terms of adoption rates and expected savings for indoor and outdoor use for each customer sector. The Comprehensive Scenario did not include a specific goal for Boulder's total treated water use, although the WCFS did project that, given the city's demographic projections at that time, attainment of the Conservation Scenario's program measures would reduce Boulder's projected buildout water demand by 22 percent compared to projected buildout demand with no additional water conservation (i.e. no change in 1994-1996 baseline per capita water use factors). The Comprehensive Scenario was adopted by City Council as part of the 2000 TWMP and required substantial revisions to the city's existing Water Conservation Program and an increase in funding to support adopted water conservation initiatives.

Following the city's imposition of water use restrictions in response to severe drought conditions in 2002, the city began examining the use of customer-specific water budgets as an alternate method for reducing water demand in response to drought while providing more flexibility in individual customer responses, and as a way to encourage savings in water use in a manner tailored to individual customer's circumstances. This process led to Boulder's adoption of a water budget-based rate system including a five-tiered rate structure, described in more detail in Section 3.4.

In 2009, the city submitted the 2009 WCP to the CWCB, to comply with state law requiring submittals of Water Conservation Plans (now Water Efficiency Plans). The 2009 WCP provided guidance for implementing the Comprehensive Scenario, and developed customer sector-specific water use reduction targets, expressed as percent reductions in per meter water use and percent reductions in real and apparent water losses, compared to WCFS baseline uses, by buildout.

Boulder's WUMP was approved in 2011 and supported continuing the city's 2009 WCP measures and sustaining current program funding but suggested that efforts be tailored to address current needs. Relevant WUMP recommendations (Volume 2) include:

- Evaluating CII water budgets
- Coordinating with Boulder's Climate and Sustainability Division
- Targeting high volume water use customers
- Reviewing and revamping the water conservation rebate program

The WUMP's conservation-related recommendations have been addressed via various conservation efforts, as discussed in Section 3.3. Appendix B lists the key water conservation activities implemented since the 1992 Water Conservation Program began. These programs were designed to lower peak-day demands, delay certain capital improvement projects, reduce total water use at buildout and meet the water conservation future goal and associated water use reduction targets discussed above.

3.2 Current Water Conservation Program

Significant changes have been made to the Water Conservation Program since its inception in 1992. The current program focuses on all water customer sectors including single family (SF), multifamily (MF), CII, municipal and metered irrigation. Some of the activities are implemented solely by the city while others are in collaboration with other entities (see Section 7.1.5). Many of these changes have been implemented based on WUMP findings and evaluation of recent water use and trends as described in the following section. Boulder's existing Water Conservation Program elements are listed in Table 3-1. Details are provided in Appendices A and B.

Table 3-1: List of Boulder's Existing Water Conservation Program Elements

Water Conservation Office	Slow the Flow Audits
Water Budget Rate Structure	Xeriscape Demonstration Plots
CII Audits	M36 Water Audits & Loss Control Program
Xeriscape Seminars	Contracted Commercial & Residential Programs
Campaigns	Customer Education & Outreach
Free Ultra-Low Flow Toilet with Install	Operation Water Festival
Garden-in-a-Box Program	Turf Demonstration Plots
Water Efficiency Fund	Leak Notices

3.3 Status of Boulder's Current Water Conservation Goal

The city's WUMP confirmed that most of the water use targets of the city's water conservation goal had been met based upon water use and demographic data available at that time. An updated analysis, summarized in Table 3-2, reaches that same conclusion based upon 2012-2015 data. Only the target of reducing non-revenue water to less than 6 percent of treated water production remains unmet. Specific details of this updated analysis are provided in Appendix C.

Table 3-2: Status of Boulder's Attainment of its Water Conservation Goal

Water Use Sector	1994-1996 baseline use (corrected and updated)[1]	Water use percent reduction target	Water use target (corrected and updated)[2]	2012-2015 baseline use[3]	Water use target met?	Units
Single Family	163	22%	127	123	yes	gallons per resident per day
Multi Family	87	26%	64	58	yes	gallons per resident per day
Commercial/Industrial	62	14%	53	44	yes	gallons per employee per day
Municipal	6.1	1%	6.0	5.7	yes	gallons per capita per day
Non-revenue water[4]	8.5%	29%	6.0%	9.0%	no	% of treated water production

1. Derived from average 1994-1996 water uses, corrected customer sector-specific population calculations, and updated estimates of 1994-1996 service area population and employment. The outdoor portions of water uses were normalized to represent demand under average weather conditions.
2. Derived by applying the sector-specific and system-wide water use reduction goals from the 2009 WCP to the corrected and updated 1994-1996 baseline use.
3. Derived from average 2012-2015 water uses, service area population and employment. The outdoor portions of water uses were normalized to represent demand under average weather conditions.
4. Total annual treated water production minus total annual metered water use.

Applying the corrected and updated water use targets shown above to the city's current demographic projections, which are described in Section 5.3, results in a projected buildout year (2080) water demand of 24,973 acre-feet per year, as shown in Table 3-3.

Table 3-3: Build-out (2080) Water Demands Assuming Boulder's Previously Adopted Water Use Targets (updated and corrected)

Water Use Sector	Water use target	Units	Demographic Projection	Projected Water Demand, AF
Single Family	127	gallons per resident per day	49,767 SF residents	7,080
Multi Family	64	gallons per resident per day	86,333 MF residents	6,189
Comm./Ind./ Inst.	53	gallons per employee per day	156,500 employees	9,291
Municipal	6.0	gallons per capita per day	136,100 residents	915
Non-revenue water[3]	6.0%	% of treated water production		1,498
Total Treated Water Demand	147	gallons per capita per day	136,100 residents	**24,973**

The city's continued efforts under its Water Conservation Program, combined with the ongoing effects of natural replacement of existing water-using fixtures and appliances with more efficient models, are likely to further reduce current per capita water use factors over the short term. However, Boulder's future water use may rise over the longer term given the potential effects of climate change. Expected warmer temperatures are likely to increase outdoor water demands, which may increase per capita uses in each customer sector. Similarly, if future employment grows to reach the city's current zoning capacity, the city's total per capita use may rise due to the proportionately greater amounts of CII water use. These issues are discussed in Sections 5.3 and 5.6. Boulder's existing conservation goal and continued water conservation efforts are commensurate with a "no-low regrets" strategy as the city continues to move forward on related planning efforts, which can be reevaluated in the next WEP update in 2023. "no-low regrets" are further described in Section 5.2.1.

3.4 Water Use and the Block Rate Structure

Boulder had a uniform quantity charge water rate structure until 1988 when it first implemented a three-tiered increasing block rate structure.[7] In December 2004, Boulder adopted a new rate structure that combined an inclining five-tiered block rate structure with customer-specific water budgets. This new system was not implemented until 2007, in part due to the need to purchase a new utility billing system that could accommodate water budgets. The five-tiered block rate structure is based on Utility-established monthly water budgets, which include indoor and outdoor allocations. As shown in Table 3-4, customers using 60 percent of their water budget or less are in Block 1 and are charged ¾ of the base rate. Customers within 61 percent to 100 percent of their water budget are charged the base rate while customers exceeding their water budget are in either Blocks 3, 4 or 5 and are required to pay increasing rates based upon the degree to which they are over budget. Table 3-5 summarizes how the water budget for each customer sector is calculated.

Table 3-4: Water Budgets and Five-Block Rate Structure

Rate Block	% of Water Budget	Block Rate (per 1,000 gallons)
Block 1	0-60%	$2.76 (¾ base rate)
Block 2	61%-100%	$3.68 (base rate)
Block 3	101%-150%	$7.36 (2 x base rate)
Block 4	151%-200%	$11.04 (3 x base rate)
Block 5	over 200%	$18.40 (5 x base rate)

Table 3-5: Basis for Water Budgets

Accounts	Monthly Water Budget Calculation
Single Family	Indoor allotment (7,000 gallons/month, which assumes a 4-person household) + outdoor allotment (based on customer-specific irrigable area and seasonal watering needs).
Multi- Family	Indoor allotment (4,000 gallons/month/dwelling unit with 1-2 bedrooms) + outdoor allotment (based on customer-specific irrigable area and seasonal watering needs). A dwelling unit with more than two bedrooms may receive an additional 1,000 gallons/month, up to a maximum indoor allocation of 7,000 gallons/month.
Irrigation Only	Outdoor allotment is 15 gallons per square foot (based on customer-specific irrigable area and seasonal water needs).
CII and Municipal	**CII customers may choose from the following options:**
	Average Monthly Use (AMU) – (Default option). The AMU budget is calculated using the monthly average of 12 consecutive months of water use for an account, so that each month's water budget is the same. Customers can apply to change the time frame used for the 12-month average. (The default time frame is January through December 2005).
	Historical Monthly Use (HMU) - The HMU budget is calculated using a rolling three-month average for each individual month. For example, the average of the past three January's use would be next year's January budget.

[7] The three-tier structure used Average Winter Consumption (AWC), defined as the average December-March monthly use by each account, as the basis for the Block 1 allowance. Block 2 was set at 350 percent of Block 1 usage, which allowed for reasonable outdoor use, with any usage above this amount charged at the highest rate in Block 3.

Accounts	Monthly Water Budget Calculation
CII and Municipal	**Indoor/Outdoor** - The Indoor/Outdoor budget is comprised of both an indoor water allocation and an outdoor water allocation. The indoor allocation may be based on either the most recent Average Winter Consumption (AWC), AMU or HMU. The outdoor allocation is calculated based on irrigable area, including right of way, and seasonal watering needs.
	Efficiency-Standard - This option allows for a specific customized water budget. The customer must hire a professional engineer to evaluate and recommend a personalized indoor budget, which then must be reviewed and approved by the city. The customer will be charged a fee for the city review.
	PIF –This option is for new customers or customers who are significantly changing their use and a larger meter is needed. Customers can buy 25%, 50% or 85% of their water meter based on the customer's class average for that meter size.

Notes:

1. Most outdoor budgets provide an irrigation allowance of 15 gallons per square foot, which is equivalent to approximately 85 percent of the average irrigation water requirement (IWR) for Kentucky bluegrass assuming 80 percent irrigation efficiency. This is a reasonable allowance because the unit IWR for Kentucky bluegrass is greater than that for other types of landscaping, and because lots are rarely planted with 100 percent bluegrass. SF properties with more than 5,000 square feet of irrigable area have irrigation allowances of less than 15 gallons per square foot.
2. For outdoor use, such as the irrigation of parks, some allowance may be made for increased water use to offset damage done by higher foot traffic.

An analysis was conducted to identify the percent of accounts that exceeded 100 percent of their water budget during 2007-2011. The number of accounts that terminated in each block was initially summed on an annual basis to identify whether there were certain years in which a larger number of accounts exceeded their water budget. The results indicated that, while there was a typical percentage range of accounts that exceeded their water budget every year, there was not a particular pattern or trend in the data.

The number of accounts that terminated in each block was then averaged on a monthly basis by customer sector. The results of this are summarized in Table 3-6. Graphs providing more detailed results are included in Appendix G.

Table 3-6: Summary Results of Water Budget Analysis

	Percent of Accounts Staying Within				
	(in-budget)		(out-of-budget)		
Customer Sector	Block 1	Block 2	Block 3	Block 4	Block 5
Single Family	70.6%	21.0%	6.7%	1.3%	0.5%
Multifamily	58.3%	28.7%	9.2%	2.6%	1.2%
Commercial/Industrial/Institutional	53.3%	24.8%	13.2%	5.4%	3.4%
Municipal	65.3%	17.8%	9.5%	4.2%	3.2%

The greatest frequencies of water budget exceedances occur during the irrigation months of May to October, although a significant number of budget exceedances also occur during the non-irrigation months. The SF sector has the lowest percentage of exceedances in all months of the year. However, it should be noted that SF customers receive an indoor allotment of 7,000 gallons per month, which is relatively generous for households with less than four persons. SF customers who do not fully use their indoor water budget can therefore use the excess portion of their indoor budget for outdoor irrigation without exceeding their combined indoor/outdoor water budget. As noted above, the 15 gallon per square foot irrigation allowance is sufficient to supply approximately 85 percent of the average irrigation requirement for Kentucky Bluegrass. Customers who do not fully use their indoor budget for indoor uses could be irrigating at higher rates without exceeding their budget.[8]

Over 10 percent of CII and MF customers exceed their water budgets during the winter. The number of exceedances for the MF sector tends to be a little lower in February and March when compared to the trends in the other customer sectors. Additional studies entailing the sub-metering of individual units and tracking of fluctuations in occupancy levels due to seasonal student populations may be useful to identify why this may be occurring.

The CII sector has the largest percentage of exceedances in all months. This suggests that adjustments to the water budgets in the CII sector could be made to more appropriately reflect the use of individual customers. The city has evaluated whether benchmark-based billing could be a possible tool for better addressing CII water budgets but the results have shown that applying that methodology to billing is problematic, raises equity questions and may not result in water savings. Additional evaluation of CII water budgets and all customer classes is currently being accessed through the city's 2016 Utility Rate Study.

3.5 Water Rates and Budgets

Effective water rates are a key tool for managing demand as well as for generating sufficient revenue for operations, maintenance and capital improvement projects. The city conducts a water rate study every five to seven years to ensure that their water rates are sufficiently meeting these objectives. The city is currently conducting the next rate study, which will conclude in 2016. Numerous studies have shown that customer water use tends to decrease in response to an increased water rate price signal[9]. The ratio of percent change in water demand to percent change in price has been termed demand elasticity with respect to price. However, there are other drivers of customers' water use and the effectiveness of water budgets will be explored in the 2016 Utility Rate Study. While the downward trends in Boulder's historical per capita water uses appear to be generally correlated with changes in Boulder's water rate structures and increases in Boulder's water prices, no studies have specifically identified a price response in Boulder's case.

3.6 CII Water Budget Study

Under direction from City Council and the city's Water Resources Advisory Board (WRAB), Utility staff initiated a CII water use study in 2009 to explore alternate methods for setting efficiency-based water budgets for the CII customer sector in lieu of the existing method, which relies on historic use. The study explored options ranging from a no action alternative to equal reduction in water budgets across all sectors to establishing a benchmark approach. The WRAB recommended further analysis of benchmark-based water budgets as a possibly effective way to establish fair and equitable CII water budgets.

[8] Note: Single family indoor water use has generally declined since 2007 while the indoor water budget has remained at 7 kgal.
[9] Gibbons, 1986

Additional analysis recognized the high degree of variability in CII water uses and the need to allow for individual adjustments. In 2011, WRAB recommended that the city move forward with exploring a "combined approach" that relied on both benchmarks and water audits to establish CII water budgets. Benchmarks were developed in 2012 (using 2011 data) through a statistical approach to establish individual sub-sector categories within the CII sector (i.e. restaurants, hospitals, etc.). The methodology staff identified was presented to WRAB in 2013. In exploring the efficacy of this approach, staff determined that using benchmarks to bill customers would neither address water conservation nor equity concerns – the main issues of concern. Findings from the CII benchmarking study were presented to WRAB in 2015 and study results will be used to inform the city's larger 2016 Utility Rate Study.

4 Historical Treated Water Use

4.1 Data Sources and Calculation Methods Used

Several data sources and calculation methods were used to characterize Boulder's historical treated water uses as described below.

1. Boulder's WTP production records were used to quantify total water use, indoor use and outdoor use, combined for all customer sectors. Indoor and outdoor uses are differentiated as follows. For December-February, indoor use is assumed to be 100 percent of daily production; for March-November, indoor use is assumed to be the minimum of each day's production and the average daily production for December 1 - December 15 and January 16 - February 28 for that calendar year. This averaging method avoids periods of unusually low water use caused by holiday departures of University of Colorado students and other Boulder residents. Outdoor use was calculated and the difference between total daily use and calculated daily indoor use. Combined total, indoor and outdoor uses include metered uses and non-revenue water, which represents both real losses (distribution system leaks) and apparent losses (metering and reporting error and unmetered uses).
2. Monthly Utility billing records were used to quantify customer sector-specific total use, indoor use and outdoor use for the major customer categories in Boulder's billing system: SF; MF; CII; and municipal (use by city departments). For each customer sector, all metered uses for December-February were assumed to be indoor use. Metered uses for March-November were split into indoor and outdoor portions by assuming that indoor use is the minimum of each month's metered use and the average monthly metered use for December-February for that calendar year. The billing system also includes irrigation-only accounts, each of which represents separately metered irrigation use by an associated SF, MF, CII or municipal account. Irrigation-only accounts were categorized as outdoor water used by their associated customer sector. Irrigation-only accounts lacking sufficient information to identify their associated customer sector were not included in the analysis. The number of such accounts was low enough to not significantly affect the amount or proportion of water use by customer sector.
3. Estimates of historical service area population, housing and employment provided by the city's Planning and Development Services (Planning) were used to calculate per capita uses

for combined and customer sector-specific total water use, indoor use and outdoor use. Combined per capita uses were calculated by dividing the type of water use in question (total, indoor or outdoor) by the total service area population. Customer sector-specific per capita uses were calculated by dividing the type of water use in question by the estimated population for the customer sector. In the case of CII water use, service area employment was used. In the case of municipal water use (i.e. water use by city departments), total service area population was used. Combined per capita uses are not directly comparable to per capita uses for individual customer sectors because combined per capita uses are based upon treated water production records and include non-revenue water whereas per capita uses for individual customer sectors are based upon metered deliveries and exclude non-revenue water.

4. Historical monthly temperature and precipitation data from the Boulder NOAA weather station were used to calculate the annual irrigation water requirement (IWR) for the Boulder service area. IWR is the amount of water needed to supply the net evapotranspiration (ET) of a given type of plant, after considering precipitation. IWR is greater in years with relatively warm and dry irrigation seasons, and less in relatively cool and wet years. Annual IWR, expressed as a percent of 1950-2015 average, is used to evaluate trends in Boulder's outdoor use and to normalize Boulder's outdoor water use with respect to IWR[10]. IWR is estimated for Kentucky Bluegrass, a representative urban turf grass[11].

4.2 Reporting Periods

Boulder's historical water use is characterized for several reporting periods:

- Historical uses for 1971-2015 are shown to illustrate long term trends in Boulder's water use, which are useful in understanding the historical effects of Boulder's growth and development, Boulder's historical water conservation efforts and the 2002-2006 drought.
- Historical uses for 2003-2015 are shown to illustrate trends in Boulder's water use following the severe drought year of 2002, when the city imposed mandatory water use restrictions.
- Historical uses for 2012-2015, adjusted to normalize outdoor uses, are reported as Boulder's current water use baseline. These years were chosen because they represent the four most recent years of record. They therefore best reflect the cumulative effects of Boulder's Water Conservation Program to date, including its water budget rate structure.

[10] Outdoor use is normalized with respect to IWR by dividing the annual volume of outdoor use in a given year by the percent-of-average IWR for that year. For example, the city's outdoor use was 8,532 acre-feet in 2012, which was a relatively warm and dry year: the IWR for 2012 was 118% of average. Dividing 8.532 acre-feet by 1.18 results in a normalized 2012 outdoor use of 7,253 acre-feet, which is less than the actual 2012 outdoor use but can be compared to normalized outdoor uses for other years in a valid manner.

[11] Kentucky Bluegrass IWR is calculated using the modified Blaney-Criddle method and calibrated monthly crop growth stage coefficients published by Pochop et al (1984), adjusted to account for elevation. Effective precipitation, assumed to be 70% of monthly precipitation, is subtracted from ET to obtain IWR.

4.3 Issues with Calculating SF and MF Per Capita Water Uses

While total residential water use (combined SF and MF) is accurate, the SF and MF per capita water uses presented in this report should not be considered accurate in an absolute sense. This is because sector classification methodologies (e.g. SF vs. MF) are not the same between Planning and Utility Billing.

SF per capita use is calculated by dividing total SF metered water use (provided by Utility Billing) by the estimated SF population (provided by Planning). Similarly, MF per capita use is calculated by dividing total MF metered water use (provided by Utility Billing) by the estimated MF population (provided by Planning). However, it appears that Utility Billing does not categorize SF and MF customers the same way that Planning categorizes SF and MF dwelling units and associated population. For example, a strip of connected row homes may be labeled as MF by Planning but, because they have individual meters, they may be counted as SF by Utility Billing. The end result of these discrepancies is an overestimation of SF gpcd and an underestimation of MF gpcd. This disparity has apparently existed since the 1990s, and its effect can be demonstrated with information from the 2000 WCFS.

Using the 1994-1996 average annual volume of SF indoor water use (as reported by Utilities) and the estimated 1994-1996 average SF population (as reported by Planning), the average SF per capita indoor use is calculated as 83 gallons per capita per day (gpcd). This result is significantly greater than the result from direct measurement of SF indoor water use. The water uses of a representative sample of 100 single family Boulder homes were measured in 1996 as part of Boulder's participation in the AWWARF Residential End Uses of Water Study. The results of these measurements showed an average SF per capita indoor use of only 66 gpcd, a 26 percent disparity.

According to Planning data, SF dwelling units have consistently comprised between 43 percent and 45 percent of the total number of dwelling units in Boulder's service area since 1990. However, a review of the Boulder County Assessor's 2014 database suggests that SF dwellings may comprise at least 50 percent of the total dwelling units in Boulder's service area.

In spite of these issues, the calculated SF and MF per capita uses are useful for observing relative trends in uses. The question of whether Boulder has met its existing SF and MF water use reduction targets can still be meaningfully addressed using the SF and MF per capita uses as calculated, because the same assumptions and methods used to categorize SF and MF metered use and to estimate SF and MF population in 1994-1996 continue to be used to date.

However, the absolute accuracy of the SF and MF per capita uses, particularly the accuracy of MF per capita use, is a concern in projecting Boulder's future water demands. As currently calculated, Boulder's historical per capita MF use is significantly lower than SF use. Because most of Boulder's future residential population growth is projected to occur in the MF sector, if the MF per capita use factor used to project water demands is erroneously low, Boulder's projected future water demand may be underestimated.

4.4 Combined Total and Per Capita Treated Water Use

Figure 4-1 depicts Boulder's combined annual treated water use on a total and per capita basis for 1971 to 2015. From 1971 through 1988, Boulder's population grew at a rate of 1.6 percent per year and Boulder had only basic water conservation measures in place: universal metering and a uniform quantity charge. Boulder's treated water use increased significantly during this period on both a total and per capita basis. Growth in per capita use during this period was primarily caused by proportionately greater non-residential growth compared to residential growth, as Boulder was becoming a regional employment center.

From 1988 through 2001, Boulder's population growth rate slowed to 0.7 percent per year, and Boulder implemented a three-tiered increasing block rate structure in 1988. While total treated water use held relatively steady during this period, Boulder's per capita water use declined slightly. While there are no studies that demonstrate an explicit causal relationship, it is reasonable to assume that part of this decline in per capita water use is in response to Boulder's increasing block rate structure and Water Conservation Program.

From 2002 through 2015, Boulder's treated water use declined significantly on both a total and per capita basis in response to the drought of 2002-2006, Boulder's 2002 water restrictions, Boulder's Water Conservation Program and Front Range-wide drought awareness efforts, all of which resulted in reduced customer water use through modified behavior, landscape and irrigation changes and the installation of more water and energy efficient appliances, fixtures and devices. Technological advances in the latter have continued to make more efficient models that exceed industry standards, perform better and has increased market penetration. As discussed in Sections 4.6 and 4.7, significant declines have occurred across all customer sectors and in both indoor and outdoor uses.

The drought period of 2002-2006 and related local and Front Range-wide drought campaign efforts had a significant impact on Boulder's water customers. Customers reduced their water use by modifying their behaviors and by installing more water efficient devices. Boulder's Parks and Recreation Department also adopted more efficient irrigation practices. The drought also spurred the city to begin work on a series of water efficiency-based changes including finalizing a Drought Plan, developing a five-tier block rate structure and initiating water budgets. As a result, treated water use has fallen from a pre-drought (pre 2002) high of 24,433 acre-feet in 2000 to an average of 18,156 acre-feet for 2012 through 2015.

Boulder's lowest annual treated water use in the last thirty years (17,280 acre-feet) occurred in 2009. Since then, Boulder's annual treated water use has increased by an average of 0.4 percent per year in response to population and employment growth.

It is important to distinguish between pre- and post-2002, as Boulder's 2002 water use restrictions, continuing drought conditions through 2006, and customer responses have resulted in enduring change in Boulder's water use patterns. Boulder's treated water use has remained below 2002 levels. Normalizing for irrigation water requirement, Boulder's average treated water for 2012-2015 was 22 percent less than in 2000, the year of Boulder's maximum annual treated water use (see Figure 4-1).

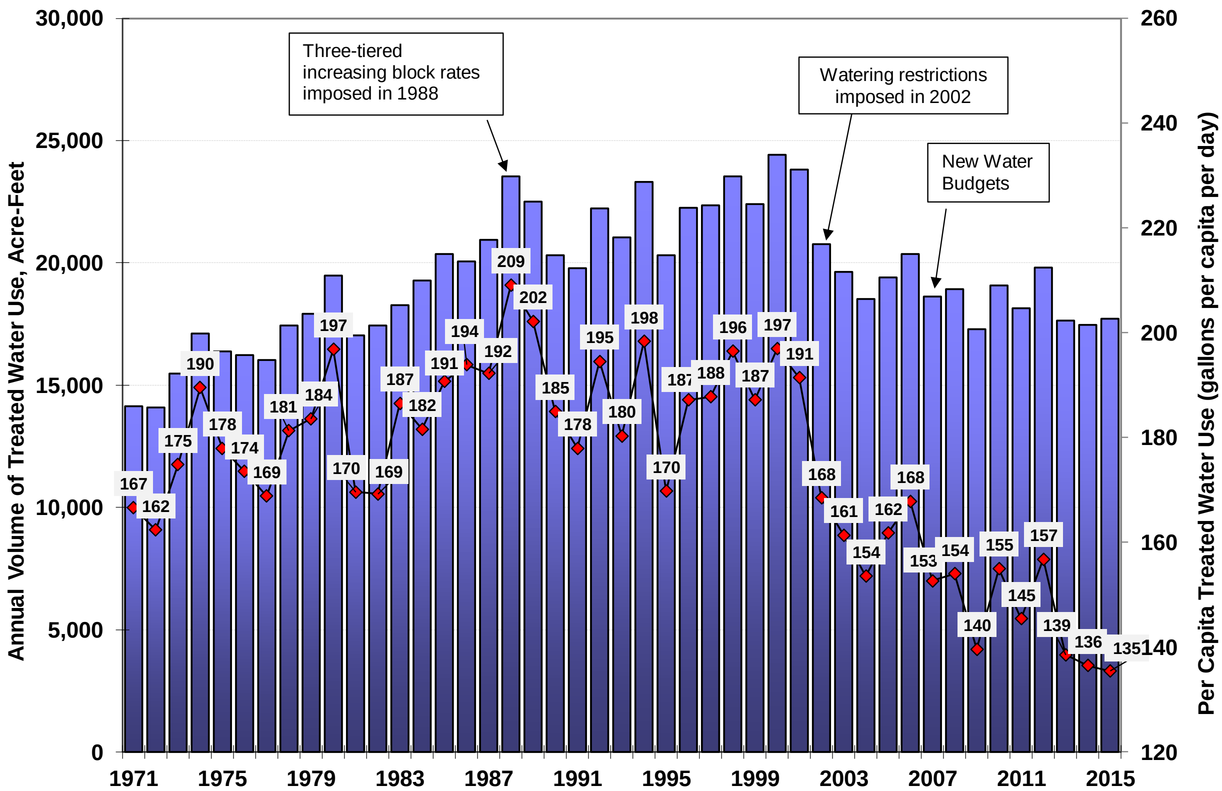

Figure 4-1: Annual and Per Capita Treated Water Use

As discussed in more detail in Section 4.7, much of the annual variation in Boulder's treated water use is due to annual variations in irrigation water requirement (IWR), caused by variable weather conditions, and its effects on outdoor use. While annual outdoor use continues to vary from year to year, Boulder's overall level of outdoor use declined significantly after 2002, although there has been a slight upward trend in outdoor use since 2002.

4.5 Peak Day Use

Peak day use is defined as the maximum combined daily volume of treated water produced at the city's two WTPs during the year. Boulder's historical peak day use is shown in Figure 4-2. Boulder's peak day use generally increased until 1989, the year following Boulder's implementation of an increasing block rate structure. Boulder's highest single day peak use was 50.5 MGD, which occurred on July 7, 1989. Peak use generally declined from 1989 until 2002, when the city imposed mandatory water use restrictions in response to the extreme drought conditions in 2002. Since 2002, Boulder's peak use has fluctuated between 31 MGD and 39 MGD with no apparent longer-term trend. By comparison, Boulder's treated water production capacity is approximately 61 MGD. Therefore, peak demand management is not currently a priority for Boulder's water conservation efforts.

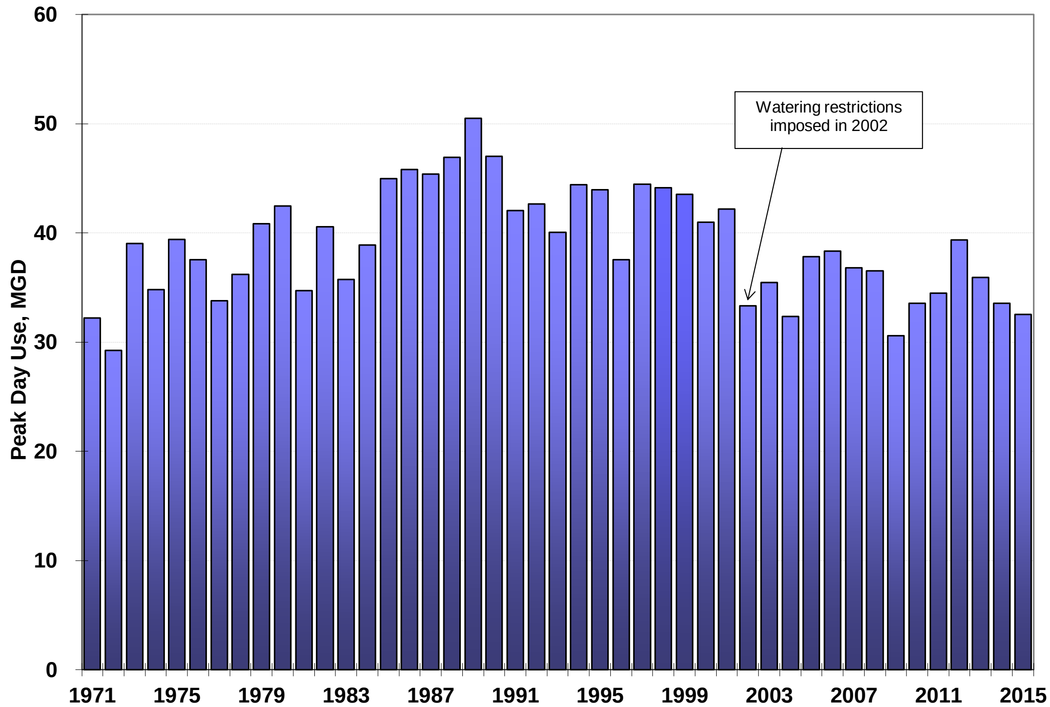

Figure 4-2: Boulder's Peak Day Use, 1971-2015

4.6 Water Use by Customer Sector

Figure 4-3 shows the average amounts of water use per year by Boulder's major customer sectors between 2012-2015. SF is the largest customer use category with an average water use of 6,535 acre-feet, comprising 40 percent of total water use. The CII sector is the second largest category, comprising 30 percent of water use at 5,035 acre-feet, followed by MF and municipal, respectively. Overall, residential use represents approximately 65 percent of total water use.

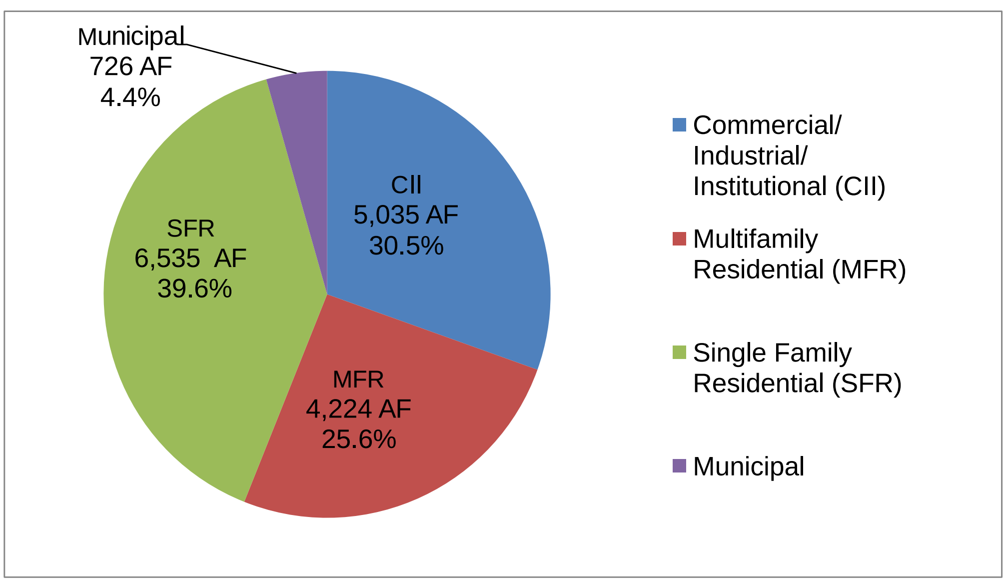

Figure 4-3: Average 2012-2015 Water Use by Customer Sector

The University of Colorado is the largest single water user in Boulder, followed by city municipal uses (principally outdoor use by Parks and Transportation), IBM and the Boulder Valley School District, although no single customer represents more than 6 percent[12] of total water use. Table 4-1 lists Boulder's largest individual water use customers, based on 2015 water use data. As part of its auditing program for CII water customers, the city's Water Conservation Program works actively with the city's large water use customers to identify water savings potential specific to the customer's circumstances.

Table 4-1: Boulder's Largest Water Use Customers

User name	Consumption (kgal)
University of Colorado	272,468
City of Boulder (all Departments)	257,012
IBM Corporation	121,018
Boulder Valley Schools	76,853
NIST	44,590

As shown in Figure 4-4, water use in each customer sector has declined significantly since 2002, although the relative proportions of water use among the sectors have remained fairly constant.

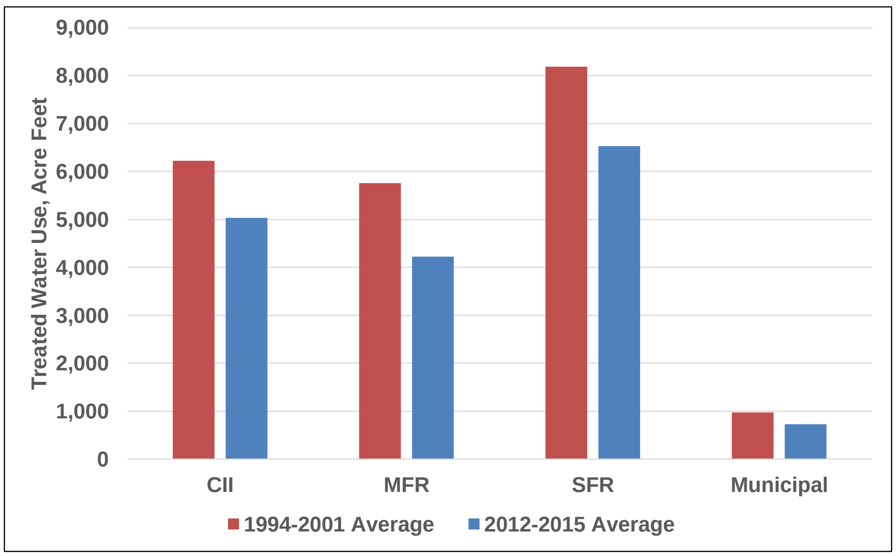

Figure 4-4: Pre-2002 and Current Water Use by Customer Sector

4.7 Indoor and Outdoor Water Use

Boulder's annual indoor water uses from 1971 to 2015 are shown in Figures 4-5 through 4-7. Indoor use averages 64 percent of Boulder's total use, with relatively little variation from 1971-2015. From 1971 to 2000, Boulder's indoor use grew rapidly in response to a 46 percent growth in population and a 170 percent growth in jobs. Boulder's jobs/population ratio increased from 0.56 to 0.94 between 1980 and 2000 as Boulder became a regional employment center[13]. This caused an increase in Boulder's per capita indoor use as well as total indoor use. From 2001-

[12] Source: City of Boulder Water Conservation Plan, August 2009.
[13] Trends Report, BVCP 2005 Major Update.

2015, Boulder's population grew at a lower rate while Boulder's jobs/population ratio remained fairly steady between 0.87 and 0.92. In spite of continued growth, Boulder's total and per capita indoor uses declined by 25 percent over this period in response to Boulder's Water Conservation Program, regional drought awareness efforts, and widespread availability of water-efficient fixtures and appliances, which have resulted in water savings from replacement of older less-efficient models. Further reductions in per capita indoor use are expected as older appliances and fixtures continue to be replaced with more water-efficient models.[14,15]

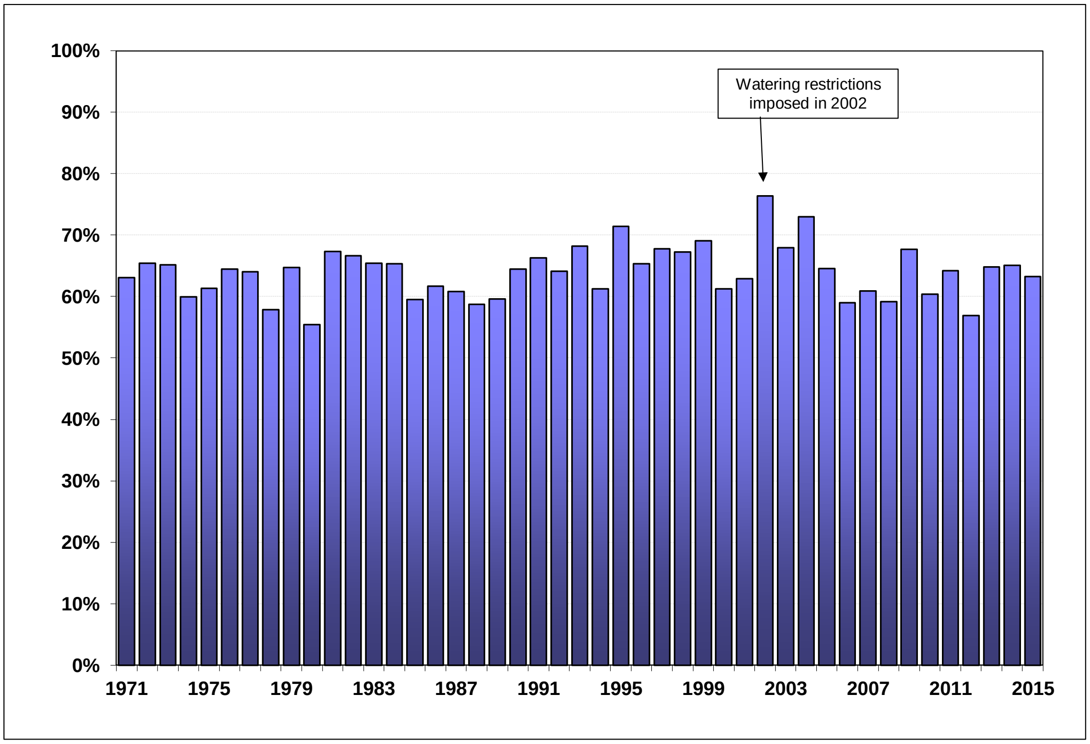

Figure 4-5: Indoor Water Use as a Percent of Total Use

[14] Several key legislative acts and government programs promote replacement of fixtures and appliances with more efficient models. These include the 1992 National Energy Policy Act, the 2009 US DOE Energy Efficient Appliance Rebate Program, the Energy Star Program, the Consortium for Energy Efficiency Standards, and Colorado Senate Bill 14-103, which prohibits the sale of fixtures that do not meet EPA's WaterSense standards.

[15] The continued reduction in indoor water fixtures and appliances statewide is supported in Colorado's Water Plan and the CWCB's SWSI 2010 Municipal and Industrial Water Conservation Strategies.

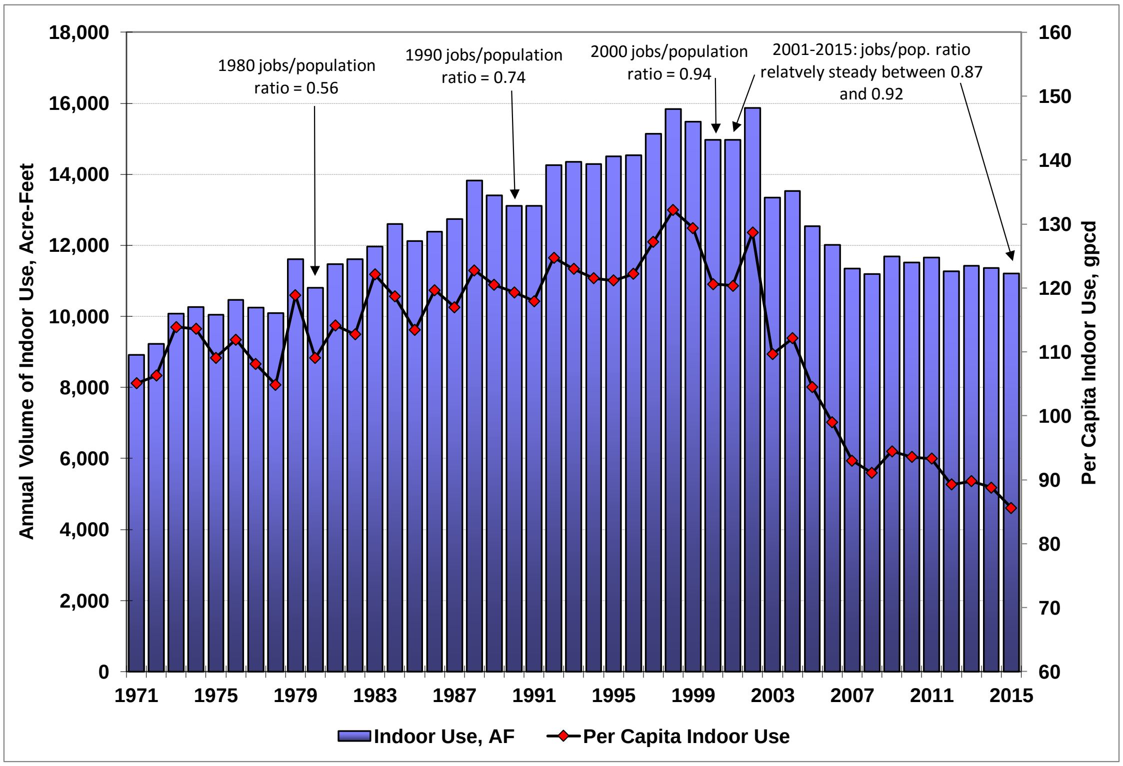

Figure 4-6: Annual and Per Capita Indoor Water Use

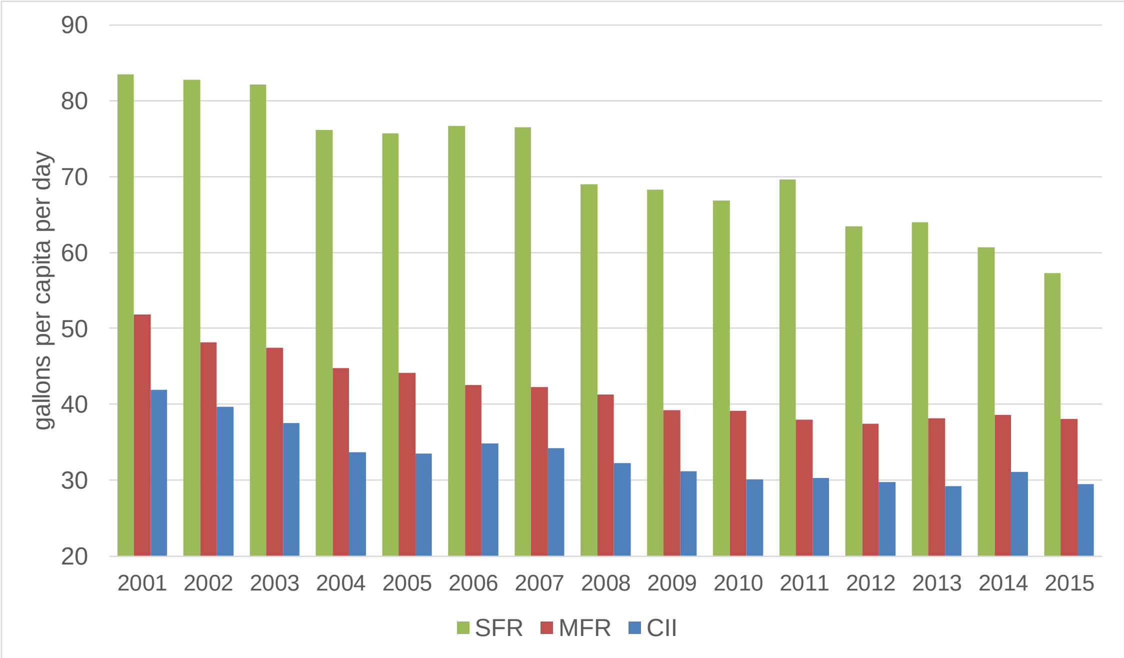

Figure 4-7: Per Capita Indoor Water Use by Customer Sector

Boulder's annual and per capita outdoor uses from 1971 to 2015 are shown in Figures 4-8 and 4-9. Annual outdoor use fluctuates much more than indoor use, in response to varying irrigation water requirements. Boulder's annual outdoor use generally grew from 1971 through 1988 due to population growth and development of Boulder's service area. Outdoor use held relatively steady from 1988 through 2001 despite continued population growth, as indicated by the generally declining outdoor per capita uses in Figure 4-9. Reduction in per capita outdoor use during this period is attributed to the effects of Boulder's inclining block rates as well as increased infill of Boulder's service area, which reduced the amount of irrigated land per capita.

Outdoor use declined drastically in 2002 in response to Boulder's water use restrictions that year. As shown in Figure 4-9, Boulder's per capita outdoor use declined from an average of 67 gpcd during 1988-2001 to 40 gpcd during 2002. Since 2002, the trend in outdoor use has been upward although outdoor remains well below pre-2002 levels. Per capita outdoor use averaged 53 gpcd during 2012-2015, a 20 percent reduction from the 1988-2001 average, in spite of average IWR being greater in 2012-2015 than in 1988-2001.

Annual fluctuations in outdoor use are due to customer's responses to annual variations in irrigation requirements. Outdoor water use is lower in relatively cool wet years and greater in relatively warm, dry years. The year 2002 was an exception, when mandatory watering restrictions reduced outdoor use in spite of high irrigation requirements. This is evident by comparing 2002 to 2012, which was also a warm and dry year. No watering restrictions were enacted in 2012, resulting in a much higher per capita outdoor water use compared to 2002 despite the fact that water budgets, a 5-tier block rate structure and a higher cost per 1,000 gallons of water were in place in 2012.

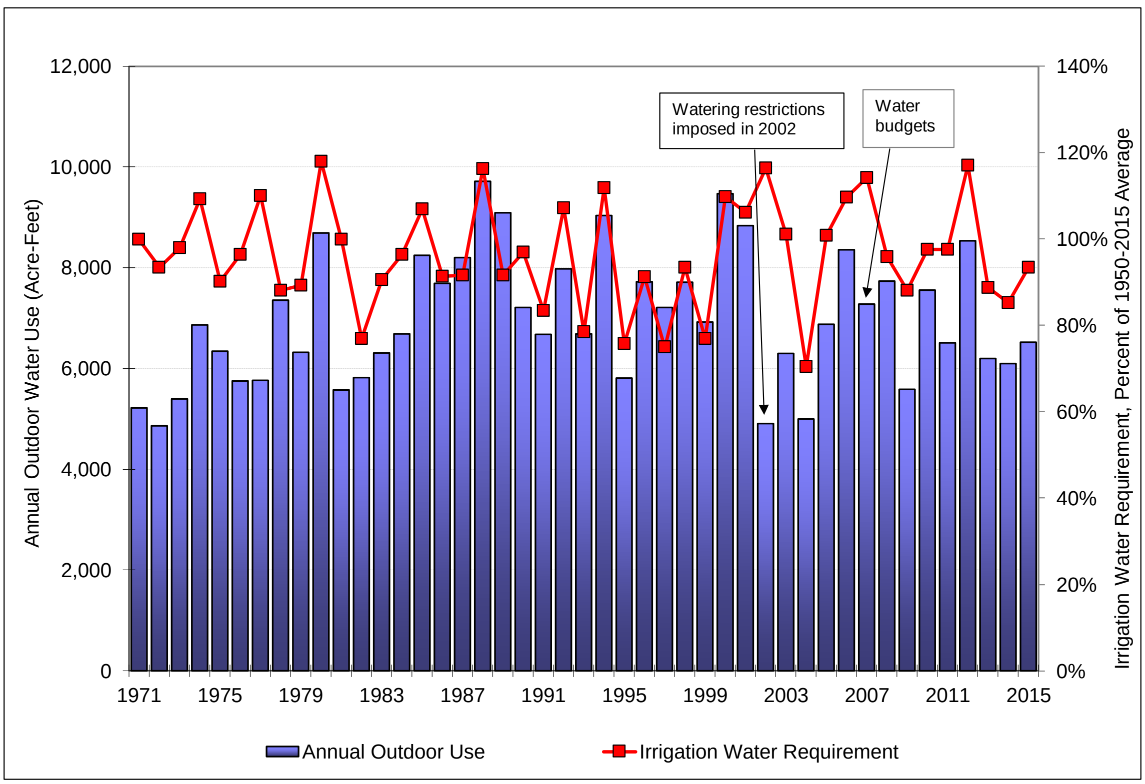

Figure 4-8: Annual Outdoor Water Use and Irrigation Water Requirement

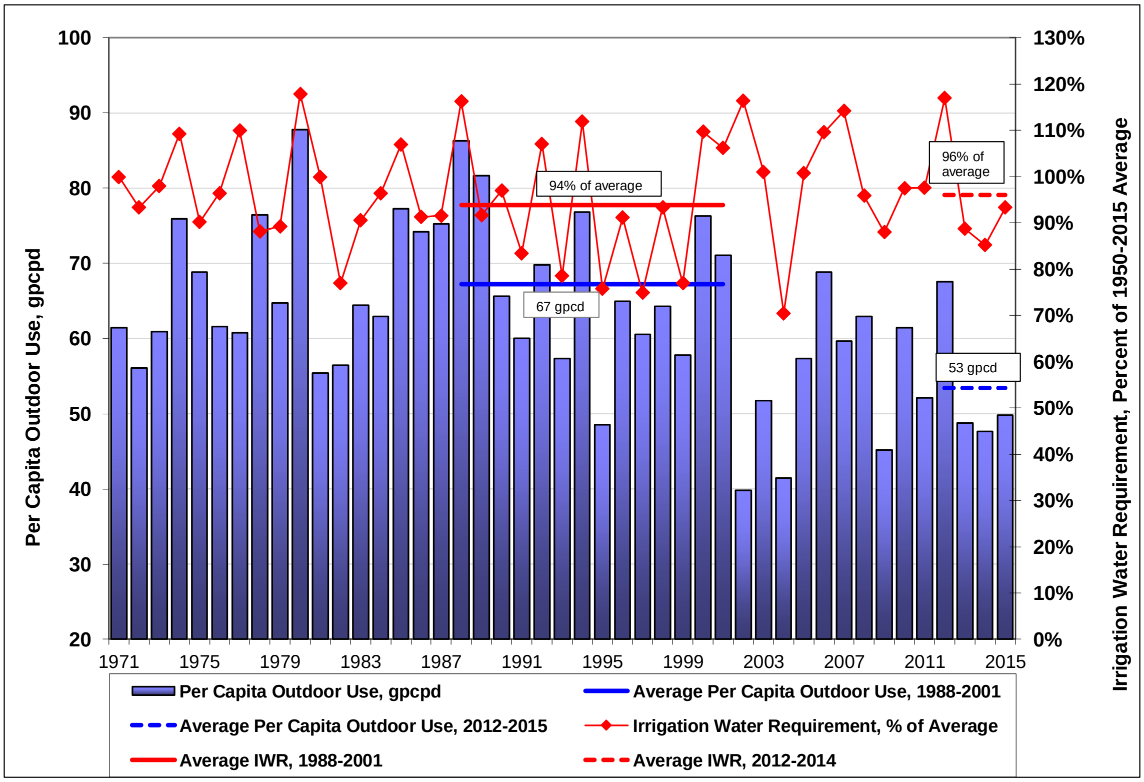

Figure 4-9: Per Capita Outdoor Water Use, Irrigation Water Requirement and Trends

Appendices D, E and F provide graphs showing indoor/outdoor use ratios and annual indoor and outdoor water uses for individual customer sectors for 2000-2015. Outdoor uses were significantly reduced in all customer sectors during 2002 through 2004, in response to the city's 2002 mandatory water restrictions and continuing drought awareness efforts.

5 Future Water Demands

5.1 Background

Municipal water supply planning in the Intermountain West has always had to deal with the uncertainties of erratic and variable supplies, a growing population that is susceptible to boom-bust cycles; and water use factors affected by customer behavior and variable outdoor watering needs. Traditional planning approaches sought to minimize those uncertainties. Typically, a single projection of future population was made, based upon historical growth, that stretched thirty or more years into the future. Historical water use factors were assumed to continue unchanged throughout the future planning horizon. The need for future water supplies and facilities was then determined assuming that the supply system should be sufficient to meet unrestrained water demand through a specified "worst case" drought (the 1950s drought was typically assumed for planning purposes in the South Platte basin).

Such efforts often resulted in over- or under-building of water supply systems, if population growth exceeded expectations or failed to materialize as planned. Drought restrictions, whether due to droughts more severe than anticipated or due to unexpected population growth coinciding with drought, invariably resulted in negative customer reactions.

Boulder has been a leader in departing from tradition in its water supply planning. Starting with its Raw Water Master Plan (RWMP) in the 1980s, Boulder recognized that no municipal water supply can ever be 100 percent reliable against all droughts and that the environmental and economic costs of reducing the risks of occasional water restrictions are significant. Boulder recognized that certain water uses (such as drinking water and firefighting) required an assured supply whereas other uses (such as lawn watering) can tolerate occasional restrictions.

Boulder therefore adopted reliability criteria that allowed for varying degrees of occasional water supply restrictions in response to droughts of varying severity. This required a fundamental change to Boulder's planning approach. Beginning with the RWMP in 1988, Boulder discarded the static approach of considering only recorded historical droughts and instead explicitly incorporated synthetic hydrology and paleo-hydrology derived from tree rings into its modeling of water supply. Boulder incorporated expected savings from conservation programs and water use trends into its demand projections. Beginning with its Drought Plan in 2003, Boulder incorporated the potential effects of a range of climate change scenarios into its modeling of water supply reliability. Beginning with its Climate Change Vulnerability Study in 2007, Boulder identified "no regrets" short term actions that would decrease the city's vulnerability to climate change without major or irrevocable commitments of resources. Boulder continues to use a single projection of population and employment growth in its water supply planning, which is due to a city-wide requirement that all master plans utilize the city's officially adopted demographic projections that are updated every five years as part of the BVCP update process.

5.2 Scenario Planning

The Colorado Water Plan, formally adopted by the Governor in 2015, recommends that water planners include scenario planning in assessments of future water needs. The scenario planning concept involves planning in a way that can adapt to multiple future scenarios rather than trying to predict and plan for a single "most likely" or "worst case" future scenario as has been the traditional approach. The scenario planning model is conceptually illustrated in Figure 5-1[16].

As described in Section 5.1, the city's reliability criteria exemplify the scenario planning concept because they allow the city to adapt to a myriad of future water scenarios. The Water Conservation Program is key to providing the flexibility needed to adapt to an uncertain future both through implementation of the city's drought plan during dry periods and in strategic planning in general. For example, if it is cooler and wetter than expected, outdoor landscaping programs may be less of a focus. However, if it were extremely hot and dry, code changes may need to be implemented to more directly reduce outdoor water consumption. In either case, the near-term, no-low regrets strategies will benefit the utility under any future scenario, and the Water Conservation Program will be the mechanism through which the strategies will be shaped and implemented.

[16] Adapted from Marra and Thomure, 2009

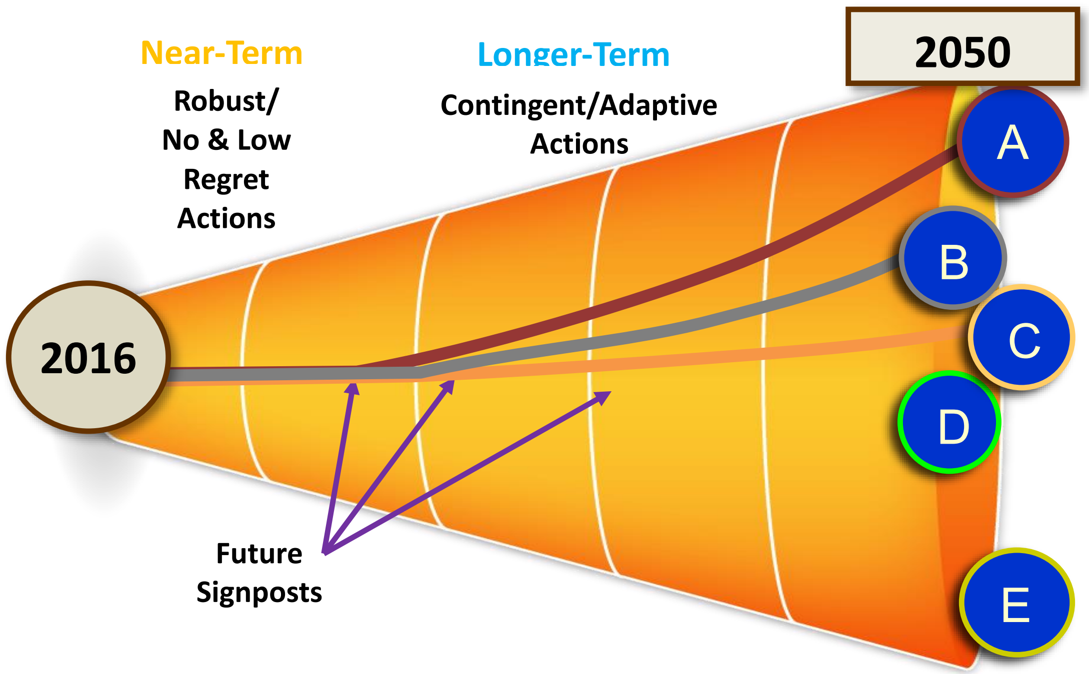

Figure 5-1: Adaptive Scenario Planning

The city's demographic projections are normally made as far into the future as necessary to reach a "build-out" or zoning capacity condition. The city's most recent projections assume that residential and non-residential growth will reach Boulder's respective zoning capacities by approximately 2040 and 2080, respectively. The city's current planning horizon is therefore 64 years, through the year 2080. Within that horizon and for the purposes of water demand management, appropriate near-term, no-low regrets plans and milestones for Boulder would be: (1) completion of the city's updated climate change modeling effort and water supply reliability assessment, which is expected later in 2016; (2) an update of the city's water supply reliability assessment using the next update of the city's demographic projections, which is expected as part of the 2020 update of the BVCP; and (3) development and submittal of the city's 2023 WEP.

As discussed in Section 0, the city's updated climate change modeling effort will utilize the most recent climate change modeling and downscaled hydrology data, along with the city's current demographic projections and projected water use factors to assess the reliability of Boulder's water supply system. This analysis will incorporate projected water demands that reflect the expected passive savings from continued natural replacement of fixtures and appliances was well as expected active savings from the city's ongoing Water Conservation Program. This effort will provide a comprehensive analytical platform for evaluating the potential need for additional water conservation goals.

As part of the BVCP update, Boulder is actively evaluating several focus areas including community resilience, the need for additional and more diverse housing and major redevelopment projects. The results of this process may lead to significant changes to the city's demographic and land use projections, which would affect water demands.

Development of the city's 2023 WEP will provide a well-timed opportunity to re-examine the city's existing water conservation goal and programs, considering the results of the updated climate modeling and BVCP update.

Scenario Factors for Affecting Water Demand

The city projects its future water demands based on projected population and employment within its service area and expected per capita water use factors for each of its customer sectors[17]. Both the city's demographic projections and the water use factors are subject to new information and several areas of uncertainty. Boulder's future water demands were most recently projected in Boulder's 2011 WUMP. The city's future water demand projections are updated in this 2016 WEP in order to reflect changes and updated information in the areas listed below that will affect future water demand, including the expected savings attributable to Boulder's active water conservation activities. Each of these factors is likely to affect Boulder's future water demands.

- **Demographic and Land Use Projections.** The city's demographic and land use projections were updated and substantially modified in August 2015 as part of the 2015 update of the BVCP.
- **Baseline Per Capita Water Uses.** Boulder's historical per capita water uses have declined significantly since 2006-2009, which formed the water use basis for the WUMP's future water demand projections. In this 2016 WEP, Boulder's baseline per capita uses are based upon historical uses for 2012-2015.
- **Natural Replacement of Fixtures.** With the passage of Colorado Senate Bill 14-103 and the updates to EPA's WaterSense specifications, the demand-reducing effects of ongoing natural replacement of water fixtures will be greater than previously considered.
- **Expected Savings from the City's Water Conservation Program.** Several ongoing components of the city's Water Conservation Program are expected to result in water savings in addition to those attributable to natural replacement of water fixtures.
- **Climate Change Effects on Projected Water Demands.** There is a reasonable basis for projecting the range of likely climate change effects on Boulder's future water demand.

Boulder's future water demands are projected, incorporating the most recent information in each of these five areas. The resulting range of projected water demands illustrates the scope of Boulder's likely potential water demand futures.

5.3 Demographic and Land Use Projections

The city's demographic projections were updated in August 2015 as part of the 2015 update to the BVCP, and are shown in Table 5-1. The updated projections are based upon current zoning and land use regulations in Planning Areas I and II as currently defined. According to the projections, Boulder will reach its residential zoning capacity by 2040, but will not reach its zoning capacity for additional jobs until approximately 2080.

[17] The use of per capita water use factors for projecting residential water demand has been cautioned by some researchers because of the nonlinear relationship between household size and per capita water use: household water use does not increase in proportion to household size. This is not a concern in Boulder's case because average household size is projected to remain constant.

Table 5-1: The City of Boulder's Demographic Projections

	Existing	Additional to 2040	2040 Total	Additional to Zoning Capacity	Zoning Capacity Total
Dwelling Units					
City Limits (Area I and III Annexed)	45,740	6,260	52,000	-	52,000
Area II	5,710	490	6,200	-	6,200
Total Service Area	**51,450**	**6,750**	**58,200**	**-**	**58,200**
Population (includng group quarters)					
City Limits (Area I and III Annexed)	104,810	18,190	123,000	-	123,000
Area II	12,030	1,070	13,100	-	13,100
Total Service Area	**116,840**	**19,260**	**136,100**	**-**	**136,100**
Employment					
City Limits (Area I and II Annexed)	98,510	18,490	117,000	34,200	151,200
Area II	2,920	580	3,500	1,800	5,300
Total Service Area	**101,430**	**19,070**	**120,500**	**36,000**	**156,500**

Sources: 2015-2040 Projections, Updated 8/28/15, Boulder Valley Comprehensive Plan. Boulder Valley Comprehensive Plan – 2015 Housing Unit, Population, and Employment Estimates and Projections Methodology.
https://bouldercolorado.gov/pages/2015-bvcp-phase-i-foundations-work

The city's updated demographic projections assume some amount of increased housing density, primarily via redevelopment in select locations, mostly along major corridors and/or in mixed use areas that are already relatively highly developed. Therefore, it is not anticipated that Boulder will experience a significant reduction in average irrigated area per household despite increased densification. Also, the city's updated demographic projections assume no change in the average number of persons per household. Therefore, no significant reduction in per capita water use is currently expected due to changes in land use patterns.

Some uncertainties exist in the city's demographic and land use projections. For example, Boulder may decide to modify its zoning and development regulations to allow for increased housing density in residential areas, or conversion of non-residential areas into residential or mixed-use areas, in order to achieve a better balance between employment and housing. Boulder formally modifies its demographic projections as part of the update of the BVCP, which has occurred every five years since 1990. The city's current projections are assumed for the purpose of this WEP, consistent with Boulder's planning guidelines. It is anticipated that Boulder will update its demographic projections prior to the next update of the WEP in 2023, and those updated demographic projections will be reflected in the next WEP update.

5.4 Baseline Per Capita Water Uses

A characterization of Boulder's existing water use and water use factors is necessary to provide a known starting point for future water demand and supply and management planning. For the purposes of this 2016 WEP, Boulder's current baseline water use is calculated as the average of historical 2012-2015 water uses, normalized for IWR. Boulder's current baseline water use is shown in Table 5-2, disaggregated by customer sector and indoor vs. outdoor use. It should be noted that residential uses are shown in two ways: separated into SF and MF components and also as combined residential uses. As previously discussed, per capita values for SF and MF water uses are questionable due to disparities in calculation methods, which probably result in erroneously high SF per capita values and erroneously low MF per capita values. This issue has been addressed for future water demand projection purposes by combining SF and MF water uses and populations and projecting residential SF and MF demand on a lumped basis.

Table 5-2: Baseline Water Use (Normalized 2012-2015 Average)

Customer Sector	Acre-Feet	Per Capita, gpcd
SFR Indoor	3,276	61
SFR Outdoor	3,309	62
SFR Total	6,585	123
MFR Indoor	2,842	38
MFR Outdoor	1,455	19
MFR Total	4,297	58
All Residential Indoor	6,118	48
All Residential Outdoor	4,764	37
All Residential Total	10,882	85
CII Indoor	3,447	30
CII Outdoor	1,639	14
CII Total	5,086	44
Municipal Indoor	94	0.7
Municipal Outdoor	637	5.0
Municipal Total	731	5.7
Unaccounted-for	1,636	13
Total All Sectors	18,335	143

In the context of Colorado's Water Plan, Boulder's baseline water use has already attained the South Platte Roundtable's water conservation goal for 2050 (145 gpcd total demand)[18].

5.5 Natural Replacement of Fixtures and Appliances

Boulder's indoor water use has been and will continue to be affected by national and regional trends in technology and regulations that have resulted in significant reductions in indoor per capita use. National water use surveys and water demand trends along the Front Range have shown a significant decrease in indoor per capita water use over the past few decades. Most of these reductions have been attributed to improved water efficiency technologies for indoor water fixtures and appliances. The 1992 Federal Energy Policy Act, made effective in Colorado in 1994, required improved water efficiency standards for various fixtures and appliances including toilets, faucets and showerheads.

Increased consumer confidence in these products, rebates supporting low-water products, the possibility to save money on water (and energy) bills and drought have all led customers and the market toward increasingly efficient products. Additionally, because older inefficient models are no longer allowed to be sold, there is now an ongoing natural replacement rate of these higher efficiency products. This trend helps reduce the burden on utilities to have to incentivize indoor efficiency and new laws ensure that higher efficiency products will remain the standard.

Colorado Senate Bill 14-103, passed into law in 2014, requires that plumbing fixtures sold in Colorado meet the standards set by the U.S. EPA's WaterSense partnership program. For

[18] Colorado's Water Plan, Figure 6.3.1-1.

residential fixtures, the current WaterSense standards specify a maximum of 1.28 gallons per flush for flush toilets, 1.6 gallons per minute for lavatory faucets and 2 gallons per minute for showerheads. These WaterSense standards are more stringent than those set by the 1992 Federal Energy Policy Act. Efficiency improvements to fixtures and appliances continue to occur such that some of the current best available technologies on the market exceed the WaterSense standards.[19] Furthermore, additional legislation has been passed to incentivize continued improvements in water efficient fixtures and appliances[20].

The expected continuing effects of natural replacement on indoor residential use in Boulder were evaluated based upon two studies done by Aquacraft Water Engineering and Management[21] that directly measured water use in single family homes.

In the USEPA Combined Retrofit Report, Aquacraft measured indoor water use in 100 homes in three utilities before and after a high-efficiency fixture and appliance retrofit. Before the retrofit, the water use in these homes was similar to what was found in the 1999 Residential End Uses of Water Study (REUWS). After the retrofit, indoor water use in these homes was reduced by more than 30 percent - to an average of 39 gpcd. In a second study, Aquacraft measured water use by 36 new homes built to meet the WaterSense new home specification (as of 2009), with the addition of a high-efficiency Energy Star–rated clothes washer. Indoor water use for this sample of homes averaged 36 gpcd.

Indoor Trends and Assumptions

Given that Colorado Senate Bill 14-103, will result in all residential water fixtures being at least as efficient as the WaterSense specification, it was assumed that natural replacement of aging water fixtures will result, by the year 2050, in all residences and group quarters in Boulder having water fixtures that meet WaterSense standards, and that 50 percent of all residences and group quarters will also have high-efficiency Energy Star water appliances. These assumptions result in an expected average residential indoor use of 39 gpcd by 2050, which represents a 19 percent reduction from the current baseline indoor residential per capita use.

The CII sector includes a wide range of business and service activities, and CII indoor water use is much more varied than residential indoor use. Industrial indoor water use is typically for four primary functions: heating and cooling, industrial process water, washing, and as an ingredient. Commercial and institutional indoor water use is typically for domestic purposes and for heating and cooling. The typical water savings potential for CII use has been estimated in the range of

[19] The city is currently working with the CRC in distributing 0.8 gallons per flush toilets to customers. These toilets exceed the 1.28 gallon per flush WaterSense standard and the 1.28 gallons per flush toilet currently available on the market to the general public.

[20] Several key legislative acts have or will influence the rate and type of fixtures and appliances that will be replaced These include updates to the 1992 National Energy Policy Act, 2002 California Energy Commission (CEC) Water Efficiency Standards, 2007 California Assembly Bill 715, the 2009 US Department of Energy State Energy Efficient Appliance Rebate Program and Colorado Senate Bill 14-103. Additionally, EPA's WaterSense partnership and the Energy Star Program and the Consortium for Energy Efficiency Standards play a role in incentivizing water efficient fixtures and appliances. The continued reduction in indoor water fixtures and appliances statewide is also supported in CWCB's SWSI 2010 Municipal and Industrial Water Conservation Strategies. The city participated on the Stakeholder Advisory Board providing predictions for replacement penetration rates by 2050.

[21] DeOreo, William B., and Peter W. Mayer, June 2012.

15 percent to 35 percent[22]. The effects of natural replacement of water fixtures and appliances on CII indoor water use has not been widely studied. Over the past 20 years, average CII per capita use in the Boulder service area has declined by 29 percent to 44 gpcd, including a 24 percent drop in indoor use (to 30 gpcd) and a 37% drop in outdoor use (to 14 gpcd), as a result of natural replacement and Boulder's water conservation efforts including its water budget rate structure. It is assumed that continued natural replacement will result in an additional 5 percent reduction in CII indoor per capita use by 2050.

Municipal indoor water use is a mixture of residential and commercial types of water uses and is expected to experience a reduction due to natural replacement that is between the expected reductions in residential and CII uses. It is assumed that the effects of natural replacement will result in an additional 12 percent reduction in municipal indoor per capita use by 2050.

It should be noted that the projected reductions in indoor per capita uses discussed above do not necessarily mean that Boulder's projected water demands will decrease, only that the per capita indoor uses are likely to decrease. Boulder's total water demands are projected to increase even with reduced per indoor capita use assumptions, because of projected increases in population and employment and because of the expected effects of climate change.

Table 5-3 shows the reductions in indoor per capita uses by customer sector that are expected to occur by 2050 in Boulder due to natural replacement of fixtures and appliances.

Table 5-3: Expected Reductions in Indoor Per Capita Uses from Natural Replacement

Per Capita Use (gpcd)	Indoor Residential	Indoor CII	Indoor Municipal
Baseline (2012-2014)	48	30	0.74
Expected 2050	39	28.5	0.65
Expected Reduction	9	1.5	0.09

Outdoor Trends and Assumptions

Unlike indoor uses, there does not appear to be any clear trend in outdoor uses that is attributable to passive savings from enhanced urban irrigation technologies. While such technologies certainly exist and are finding their way into the market, their meaningful effect on outdoor water use at scale seems to be dependent upon active conservation program measures that effectively promote their use. Therefore, no passive savings were assumed for outdoor uses.

On May 12, 2016, Colorado legalized the use of residential rain barrels in the state. The city does not expect that the use of residential rain barrels will result in a major savings of treated water[23]. However, rain barrel use will factor into the city's planning as an education tool that can help provide customers with a suite of outdoor water saving options.

[22] Vickers, 2002.

[23] Assuming a daily rainfall of 0.1 inches as the minimum necessary to allow filling of rain barrels, deployment of two 42-gallon barrels per participating household, and a 50% participation rate by residential dwelling units, residential rain barrel collection could produce up to an annual average of 187 acre-feet of nonpotable irrigation supply per irrigation season, which would be equal to approximately 2.7% of Boulder's existing outdoor use.

5.6 Water Conservation Savings

5.6.1 Savings Attributed to Boulder's Water Conservation Efforts

Colorado's statutes require that water providers quantify, to the degree reasonably possible, the water savings attributable to their previous demand management efforts. Boulder has had a Water Conservation Program in place since 1992. Boulder's water uses have declined significantly between 1992 and 2009 as evidenced by the significant drop in total and per capita uses as described in Section 4. Part of that decline is reasonably attributable to the efforts of Boulder's Water Conservation Program, but sufficient data are not available to specifically quantify those savings. Since the 2009 WCP, the city has monitored activities under its Water Conservation Program measures and has estimated the water savings from each of those measures as summarized in Table 5-5. Boulder's Water Conservation Program has undoubtedly had a major effect on Boulder's water uses, however, the full impacts of its collective outreach, education and targeted initiatives are not as easily measured compared to program specific savings. Boulder annually reports its water uses, water conservation activities and estimated savings due to its Water Conservation Program to the CWCB pursuant to Colorado's reporting requirements for water use and water conservation data (Colorado HB10-1051).

Table 5-4: Estimated Savings from Boulder's Water Conservation Program Since 2009

Estimated Water Conservation Savings, AF						
Year	Utilities rebate/ service programs[1]	Partner rebate/ service programs[2]	CRC Garden-in-a-box	CRC irrigation system audits	Annual Savings, Total	Cumulative Savings, Total
2009	10.1	0.0	0.1	1.3	11.6	11.6
2010	22.0	0.0	0.2	1.5	23.7	35.2
2011	14.8	1.6	0.2	1.6	18.3	53.5
2012	10.5	4.2	0.3	1.7	16.8	70.3
2013	5.3	5.8	0.5	1.9	13.4	83.7
2014	0.0	9.2	0.7	1.8	11.7	95.4
2015	0.0	9.4	1.0	2.0	12.3	107.7
Total	62.7	30.1	3.0	11.8	107.7	215.5

1. Since 2012, Utilities rebate programs have largely been shifted to partnership organizations.
2. Programs include PACE (pre-rinse spray valves, aerators and showerehads), LEAD (clotheswashers, faucets and showerheads) and CRC (0.8 gpf toilets).

5.6.2 Projected Future Savings from Water Conservation

The city's Water Conservation Program includes several ongoing measures and partnerships that actively promote conservation savings beyond that projected from natural replacement. These include partnerships with the Center for Resources Conservation (0.8 gpf toilet installs, Garden-in-a-Box landscaping kits, and Slow-the-Flow landscaping sprinkler consultations), and Partners for a Clean Environment (indoor audits for CII customers including installations of commercial pre-rinse spray valves, aerators and showers). The city's SmartRegs and Green Points programs also specify water efficiency standards for new residential construction, major remodels and residential rentals that include ultra-low flow toilets and EnergyStar washing machines. The city's Water Conservation Program also includes a water loss auditing and monitoring program that is supported by Utilities' capital improvements program and is expected to gradually reduce the city's water loss to below 6 percent of treated water production. Based upon recently reported savings by the two partnership programs and assuming a 2 percent annual growth in their effective operations, the additional projected water savings resulting from the continued operation of the city's existing Water Conservation Program are shown below. Savings are projected to occur linearly from 2015 through 2050, similar to the effects of natural replacement.

Table 5-5: Expected Reductions in Per Capita Uses from Active Water Conservation

Per Capita Use (gpcd)	Indoor Residential	Indoor CII	Indoor Municipal	Outdoor Residential	Water Loss (percent)
Baseline (2012-2015)	48	30	0.74	37	9%
Expected 2050 with Natural Replacement	39	28.5	0.65	37	9%
Expected Reduction with Natural Replacement	9	1.5	0.09	0	0%
Expected 2050 with Natural Replacement and Active Conservation	36	25.5	0.60	36,1	6%
Expected Incremental Reduction from Active Conservation	3	3	0.05	0.9	33%

5.7 Climate Change Effects on Projected Water Demands

There is now broad recognition that the future climate will be different than the past and that this will affect water demands and supplies. The potential effects of climate change should be considered in Boulder's water demand projections. More than one third of Boulder's water use is outdoor irrigation use, which is a function of IWR. A warmer climate will increase IWR, which will in turn increase outdoor water demand, assuming there is no change in the extent, type, code requirements for, or customer values placed on Boulder's urban landscaping.

The Colorado River Water Availability Study (CRWAS) incorporates the most recent range of peer-reviewed climate projections and provides downscaled modeling of temperature, precipitation and crop irrigation requirement (similar to IWR) for Colorado. While there is significant variability and uncertainty in CRWAS's climate projections, there is universal agreement among the projections that all areas of Colorado will be warmer in the future, as shown in Figure 5-2. For the Boulder area, the average of the CWAS projections show an increase in mean annual temperature of 3.4 degrees F by 2040 and 5.3 degrees F by 2070. This is consistent with the 2015 Colorado Climate Plan projections of 2.5 – 5.5 degrees F by 2050 which were also used to inform the Colorado Water Plan.

The outlook for future precipitation is less clear; as illustrated in Figure 5-3, the range of CWAS projections show both increases and decreases in future mean annual precipitation, although most of the projections show increased precipitation occurring primarily in the winter months.

The CRWAS modeling also projects future IWR, which integrates the effects of temperature and precipitation change. The April-October IWR for the Boulder area, as modeled by CRWAS, also varies widely as shown in Figure 5-4, although the average IWR is projected to increase significantly as shown in Table 5-4. As the table shows, the climate projections show relatively wide range of potential change in IWR, including potential increases or decreases. Given the uncertainties in climate modeling, the full range of potential change in IWR should be the focus of planning rather than any particular projection.

Table 5-6: Projected Percent Change in April-October IWR for Boulder

Year	Average of Projections	Maximum Projected	Minimum Projected
2040	8.4%	30.8%	-15.5%
2070	11.7%	45.2%	-20.8%

The range of projected changes in IWR was incorporated into the future water demand projections by proportionately increasing the outdoor demands to reflect the average, maximum and minimum projected changes in IWR by 2040 and 2070.

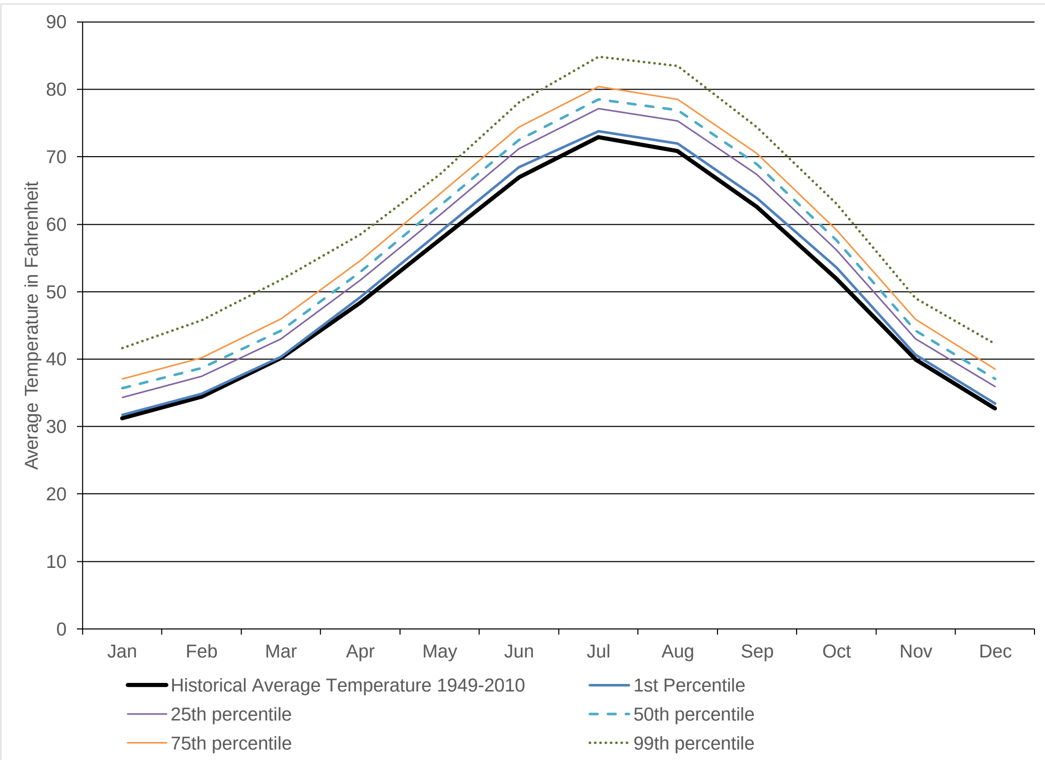

Figure 5-2: Range of Projected Average Monthly Temperature with Climate Change for Boulder, Year 2070

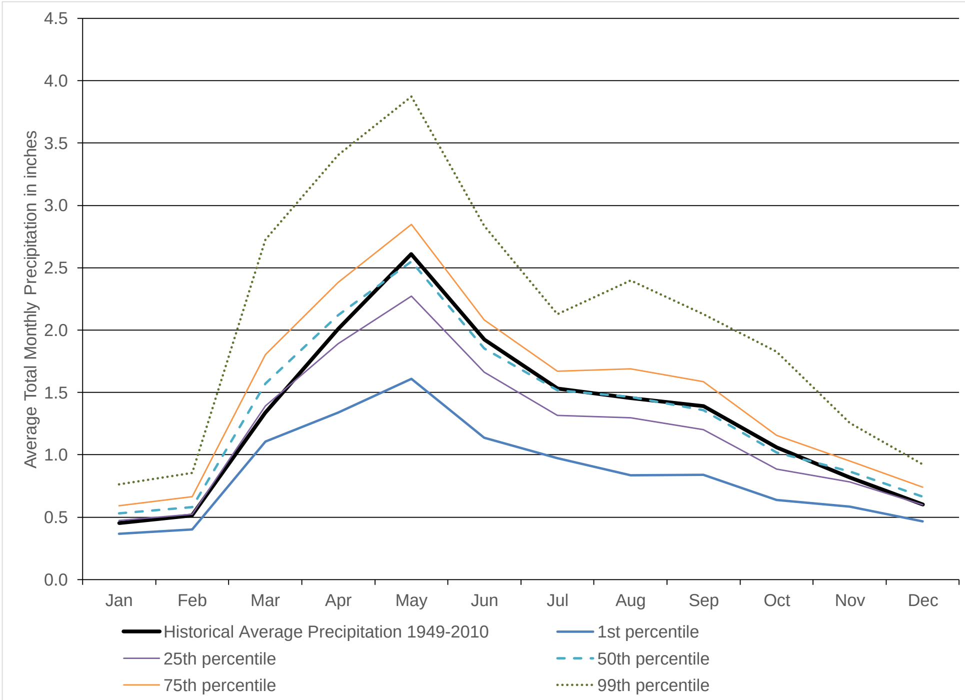

Figure 5-3: Range of Projected Average Monthly Precipitation with Climate Change for Boulder, Year 2070

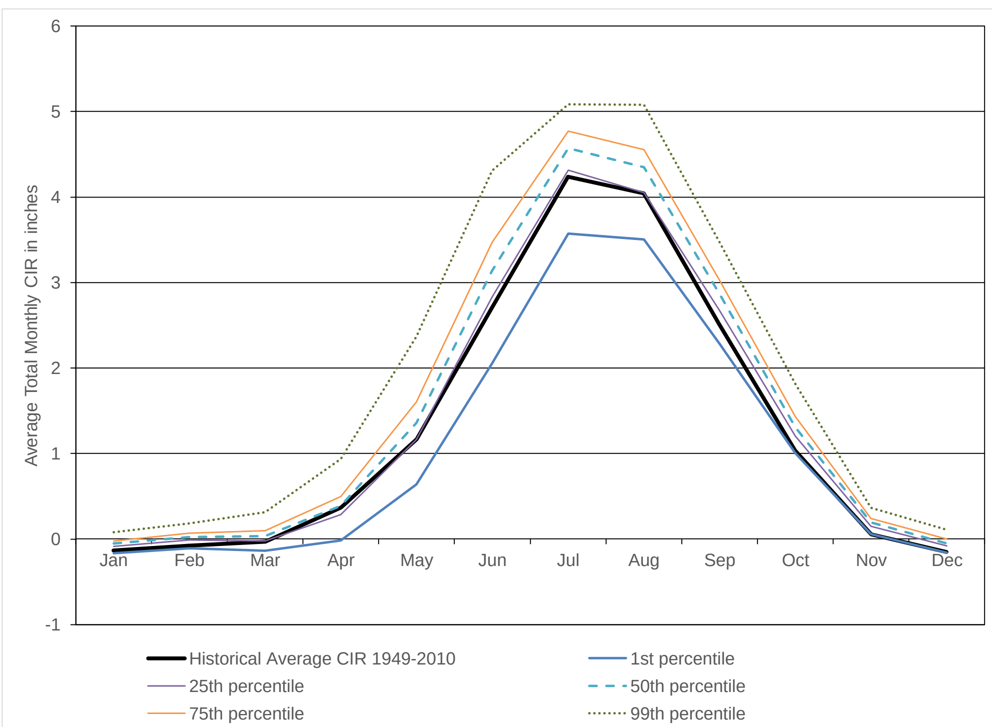

Figure 5-4: Range of Projected Average Monthly IWR with Climate Change for Boulder

5.8 Projected Water Demands

Figure 5-5 and Table 5-7 show Boulder's projected water demands reflecting the combined effects of the city's updated demographic projections, Boulder's updated baseline water use (normalized average 2012-2015), the expected effects of continued natural replacement of water fixtures and appliances, the projected additional savings from the city's active Water Conservation Program elements, and the range of expected climate change effects upon outdoor water uses. Boulder's historical water uses since 1990 and the WCFS's previous water demand projection for the Comprehensive Scenario are also shown for comparison purposes. It should be noted that the currently projected water demands assume average year-to-year weather conditions (as affected by climate change), whereas the historical water uses reflect actual weather conditions, which caused outdoor water uses to vary significantly from year to year.

As shown in Figure 5-5, Boulder's water demands are projected to increase going forward as a function of projected population and employment growth and climate change effects, following a period of significant decline in use from 2000 through 2004 and then a period of relatively steady use from 2004 through 2015.

The changes in slope in the lines for projected demands that occur in 2040 reflect the assumption that Boulder's population will reach its zoning capacity by 2040. The changes in slope in 2050 reflect the assumption the savings from the city's current active Water Conservation Programs and from natural replacement of fixtures and appliances will reach 100 percent penetration by 2050. The flattening of the lines in 2078 reflect the assumption that employment growth in Boulder will reach its zoning capacity by 2078.

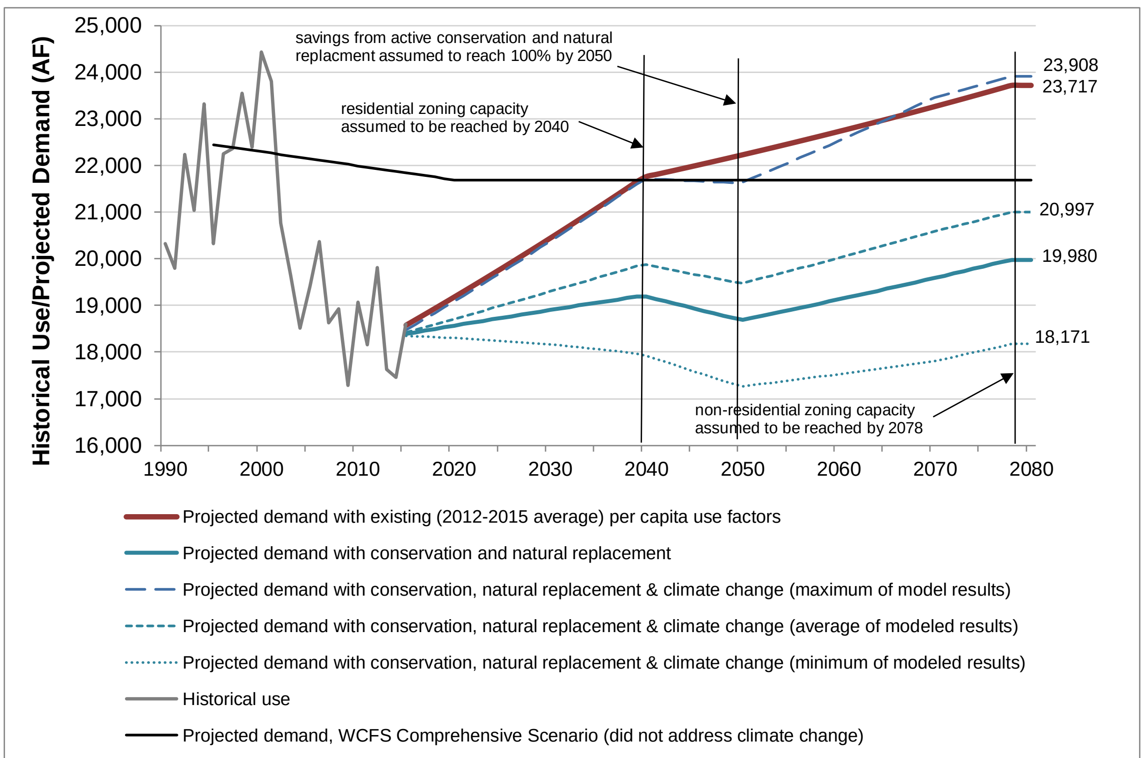

Figure 5-5: Projected Water Demands

Note: the "jump" between historical 2013-2014 demands and projected 2015 demand is due to the fact that IWR and associated outdoor use were significantly below average in 2013 and 2014, whereas projected demand in 2015 assumes average IWR and associated outdoor demand.

Table 5-7: Boulder's Projected Future Water Demands

Water Demand Projection Scenario	units	Projected Water Demand 2040	2050	2078
Projected demand with conservation and natural replacement	(AF)	19,191	18,696	19,980
	(gpcd)	126	123	131
Projected demand with conservation, natural replacement & climate change (minimum of modeled results)	(AF)	17,920	17,267	18,171
	(gpcd)	118	113	119
Projected demand with conservation, natural replacement & climate change (average of modeled results)	(AF)	19,875	19,478	20,997
	(gpcd)	130	128	138
Projected demand with conservation, natural replacement & climate change (maximum of model results)	(AF)	21,716	21,640	23,908
	(gpcd)	142	142	157

6 Planning Considerations

The primary purpose for the city's water conservation goal and program is to help assure that Boulder's water supply system will operate in a manner that meets the city's adopted reliability criteria in the face of variable water supply and demand conditions while satisfying the reasonable needs of its customers. Boulder's water conservation goal and program should also appropriately consider the city's other goals related to carbon footprint reduction, stormwater management/green infrastructure, instream flows and support of local agriculture, as well as regional and State water conservation objectives.

A Water Conservation Program plays an important role in demand management, outreach and education. A variety of factors are considered in developing future water conservation goals and options. Below are a series of questions that should be considered in developing new water conservation goals and programs.

1. How does water conservation affect water supply reliability and drought management?
2. Does Boulder need to set new water conservation goals based on findings in the 2009 WCP, 2011 WUMP and given current projected water use?
3. Will sufficient indoor water savings be achieved through natural replacement of fixtures and appliances?
4. What role does overall level of urban landscaping play in defining Boulder's quality of life? To what degree should additional outdoor water conservation be emphasized in the city's water conservation plan, and who should decide?
5. How can the Water Conservation Program align efforts with stormwater and other water quality programs?
6. How does Boulder's water conservation interact with energy consumption and production and greenhouse gas (GHG) emissions?
7. What are the water rights implications of water conservation?

Some of these questions were previously addressed in this report. A summary of the salient factors influencing Boulder's decision to retain its current conservation goal and targets is presented in the following sections. A discussion of other factors is presented in Appendix C.

Water Conservation and Water Supply Reliability

The first three questions listed above focus on the primary role of water demand management in helping to ensure the adequate reliability and resiliency of Boulder's water supply. Boulder's Utilities division has developed sophisticated modeling capabilities for assessing the performance and reliability of its water supply system, including the use of paleo-hydrology and output from global climate change modeling. Boulder most recently conducted a formal modeling assessment of its water supply reliability in 2008 as part of its climate change vulnerability study[24]. That analysis assumed a buildout water demand of 26,000 acre-feet per year. At that time, it was Utilities' policy to add a 10 percent safety factor onto its projected buildout demand to address potential modeling uncertainties, which resulted in a modeled demand of 28,600 acre-feet per year.

As discussed in Section 5.8, Boulder's water demand projections, reflecting the city's most recent demographic projections, the expected combined effects of the city's ongoing Water Conservation Program and natural replacement, and the range of projected climate change effects, result in buildout demands ranging from approximately 18,200 AF to 23,900 AF per year. As described in Section 3.3, attainment of Boulder's existing conservation goal would result in a buildout demand of approximately 25,000 AF per year, which is greater than the upper end of the range of currently projected buildout demands. The combined savings from the city's ongoing Water Conservation Program and from natural replacement are expected to keep the city's future water demand below 24,000 acre-feet per year, even with the highest projected increase in IWR due to climate change. Therefore, continuation of the city's existing Water Conservation Program will assure that the city meets its water conservation goal over the long term and will provide a buffer against the possibilities that climate change may result in warmer futures than currently projected and that Boulder may consider modifying its zoning capacity or service area to accommodate additional population than currently projected. Continuation of Boulder's existing Water Conservation Program makes sense as part of a no-low regrets strategy.

Boulder is in the process of updating its water supply system modeling to incorporate the latest peer-reviewed climate change modeling data and methods for assessing climate change effects upon the reliability of Boulder's raw water supply system, integrated with prehistoric natural flows reconstructed from tree ring records to examine long-term hydrologic variability. This assessment will help determine whether additional water conservation would be needed to meet Boulder's reliability criteria, and is expected to be completed end of 2016. The results of this assessment will be used to consider whether new conservation goals should be adopted as part of the city's 2023 WEP.

Water Conservation and Urban Landscaping

The city's existing 2009 WCP includes activities aimed at reducing outdoor uses, and long-term attainment of Boulder's existing water conservation goal will require restraint in outdoor uses. Current water use trends indicate that Boulder has achieved, and is maintaining, its water conservation goal in the near term. However, there has been a slight upward trend in per capita outdoor uses since 2002, and expected climate change effects will continue to put upward

[24] Smith et. al., 2009.

pressure on Boulder's outdoor uses. Additional water conservation efforts aimed at further reductions in outdoor uses, if needed, should be sensitive to the value of urban landscaping as a defining characteristic of Boulder's quality of life as perceived by its citizens. Preliminary analysis suggests that there is a wide range in the intensity of outdoor water use by Boulder's customers, and that some of Boulder's customers over-irrigate significantly. More refined studies of the amount of outdoor use needed to maintain the existing level of urban landscaping, particularly the existing urban tree canopy and of opportunities to reduce outdoor use without impairing the overall quality of urban landscaping would be beneficial. Boulder will continue to monitor outdoor use and will adjust its water conservation efforts related to outdoor use as part of an adaptable no-low regrets strategy. The need for additional outdoor water conservation efforts will be revisited as necessary in the next WCP update.

Watershed Sustainability – The Water Conservation-Stormwater Nexus

The city's Water Conservation Program, Stormwater Quality Program and Utility Outreach Program historically coordinated on community engagement efforts. Recognizing greater opportunities to leverage and enhance cross-program efforts, the city formally combined the three programs under a single Watershed Sustainability and Outreach Program in 2013.

This restructuring would allow for greater flexibility and creativity around how these programs are managed. For example, irrigation audits for water conservation could also be leveraged to talk about nutrient runoff from fertilizers. Outreach efforts could be easily shifted from drought to flood (as was the case in 2013). Instead of just promoting xeriscape, the city would have the opportunity to explore low-water rain gardens that could support both water quantity and water quality concerns.

As Boulder continues to grow, densification and land use changes will impact green spaces. Both water conservation and stormwater implications must be considered as the city continues to develop. This is particularly important with regards to ongoing city discussions around Green Infrastructure opportunities and urban ecosystem health. Green Infrastructure installations have multiple benefits including reduced runoff and reduced water use. If grass swales are installed for water quality or flood mitigation efforts, the type of turf used could have drastically different watering needs. If more trees are planted to improve urban ecosystem health and offset tree deaths due to Emerald Ash Borer, the amount and types of trees used will impact water use. Having the Water Conservation Program play an active role in these discussions will be important to the ultimate success of these initiatives.

Water Conservation-Energy-Greenhouse Gas Nexus

As a leader in municipal efforts to reduce human impacts on climate, Boulder is taking action in reducing its carbon footprint and is studying the feasibility of creating its own municipal utility. The city's activities in this area are described in Appendix C. Utilities works with other city departments and is involved in city-wide initiatives to leverage synergistic opportunities and minimize unintended consequences.

For example, the most water efficient washing machine might not be the most energy efficient. Supporting models that have the highest water conservation and energy savings offers the greatest benefit to the city and the community. Similarly, outdoor Water Conservation Programs that result in customers replacing plant material with hardscapes, could decrease the cooling effect for surrounding buildings and increase energy use. Additional hardscapes would also increase runoff from properties (see section above).

By reducing water use, water conservation has the potential to create net energy savings due to the energy used for diversion, conveyance and treatment of Boulder's source water supplies, distribution of treated water, customers' heating of treated water for various end uses, and treatment of wastewater. In order to assess the potential fossil fuel energy reduction benefits of water conservation, a preliminary energy budget analysis was conducted of the energy associated with various water uses, compared to the energy produced by the city's hydropower systems embedded in the water supply delivery system. The details of this analysis are described in Appendix C. Additional insight to the net amount of energy saved through water conservation may also be obtained by developing quantitative estimates of the amount of energy used for residential and CII customer end uses which require heating and industrial pre-treatment.

Considering all existing operations and water uses, Boulder's water supply system and its customers' uses of water is definitely a net energy consumer, largely due to customers' energy use to heat delivered water for various end uses. However, at the margin, any reasonable mix of water conservation measures is likely to result in only modest net energy savings (in range of 150 to 200 kWh per acre-foot of water conserved). This is because most of the expected savings from water conservation will come from unheated water uses: low volume flush toilets; xeriscaping and more efficient irrigation use; and reductions in distribution losses. Savings in heated water uses are expected to be relatively limited, because the relatively high energy cost of heated water use already serves as an incentive for efficient use, and because heated water uses are typically highly valued by residential customers. The energy saved from the reductions in water treatment and distribution, wastewater treatment and from the limited reductions heated water uses, will largely be offset by reductions in hydropower production.

7 An Adaptive-Resilient Water Conservation Program

Since the drought of 2002 and in response to the recent large variations in weather conditions from drought conditions during 2012 through early August 2013 followed by unprecedented rain September 2013 and relatively wet conditions in 2014 and 2015, the Water Conservation Program has operated in a manner that is both adaptive-resilient and supportive of other city efforts and partnerships. Significant efficiencies and benefits were achieved by partnering with other entities, including the Center for Resource Conservation (CRC), Local Environmental Action Division (LEAD), Partners for a Clean Environment (PACE) and the County's

EnergySmart Program. The elimination of the city's rebate program in 2012 reflected recent trends and statutory changes and re-focused rebate dollars on service-based programs in more targeted areas. These innovative changes not only saved resources but also resulted in the city receiving a 2013 EPA WaterSense Award for its efforts. Redeployed resources were used to enhance service-based programs that provided greater value for customers in addition to adding increased water loss monitoring, leak detection notifications and enhanced outreach to the city's largest water use customers.

Maintaining Boulder's Water Conservation Goal

After reviewing its water use trends, water demand drivers and projected water use, the city has determined that its existing water conservation goal and associated water use targets represent a prudent no-low regrets near-term strategy. While Boulder has met all but one of its water use reduction targets based upon 2012-2015 uses, in some cases by considerable margins, Boulder should monitor its per capita and total water uses to avoid "backsliding" in water use categories where it has already achieved its water use reduction targets, while recognizing that climate change will put upward pressure on per capita outdoor uses and ongoing water conservation efforts and natural replacement will tend to reduce indoor per capita water uses.

Boulder's near-term water use targets are expressed in terms of per capita uses, percent of treated water production, and year 2022 total treated water demand in Table 7-1. These targets are based upon Boulder's 2012-2015 baseline per capita water uses, and are adjusted to reflect expected increases in outdoor use due to climate change (the maximum of climate change model results) and expected decreases in indoor uses and water loss due to water conservation and natural replacement.

The city will monitor its water use through 2022 and will reconsider whether additional water conservation goals are needed as part of the 2023 WEP update, which will also consider the results of Boulder's updated water supply reliability assessment and the city's updated demographic projections at that time.

Table 7-1: Boulder's Near-Term Water Use Targets

Water Use Sector	Water use target	Units
Single Family	126	gallons per resident per day
Multi Family	57	gallons per resident per day
Commercial/Industrial	44	gallons per employee per day
Municipal	6.2	gallons per capita per day
Non-revenue water[1]	8.2%	% of treated water production
Total Treated Water Demand[2]	19,336	acre-feet

1. Total annual treated water production minus total annual metered water use.
2. Year 2022 treated water demand; assumes average IWR.

Proposed Water Conservation Measures

Boulder's proposed water conservation measures will be a continuation of Boulder's existing Water Conservation Program, which are tailored to meeting Boulder's existing water conservation goal and targets, and which have evolved to take advantage of partnerships with other local and regional entities and to leverage the city's water conservation funding. Boulder's existing Water Conservation Program will be continued (see Section 3 and details in Appendices A and B).

Continued Monitoring and Evaluation

Recommendations in the 2000 WCFS and 2011 WUMP all suggested that ongoing monitoring is critical to helping evaluate Water Conservation Program effectiveness. Evaluation since that time has shown that the Water Conservation Program is most effective when there is flexibility to improve the program on an annual basis while meeting water use reduction targets and Boulder's other needs. For instance, switching from rebate based programs to service based programs 2013 allowed for cost savings while providing several other benefits (as previously discussed). Additionally, 2012-2013 Water Conservation Program planning demonstrated how an adaptive program can collaborate with other city programs to develop a coordinated drought response.

Adjustments to the Water Conservation Program will be based upon program analysis. This will include monitoring of expenditures on water conservation activities, lessons learned, water uses and local weather data, water losses, customer input, industry trends, regulatory changes and the ability for program efforts to leverage other programs.

Coordination with Other City Initiatives

The Water Conservation Program has sought to maximize opportunities to enhance its investments by partnering with city departments and outside organizations. For example, after freeing up rebate dollars, the Water Conservation Program was able to leverage funds more effectively by partnering with the city's Climate and Sustainability Office to ensure that CII assessments include both water and energy. Through a shared city contract with the County's PACE program, efforts not only incentivize efficiency upgrades but have led to direct install programs for low-flow shower heads and pre-rinse spray valves that save both water and energy without one program shouldering the full cost of that investment. Furthermore, these partnerships have enhanced metrics and tracking through the annual PACE report.

Through the larger Watershed Sustainability and Outreach Program (see 6.1.3), the Water Conservation Program has had greater access and ability to coordinate and develop various cross-departmental efforts with Water Resources, Stormwater Quality, Flood, Drinking Water and other city programs. It has also allowed the Water Conservation Program to link water savings with larger resilience strategy and climate commitment efforts.

Coordination with Other Cities

The Water Conservation Program not only works with internal city departments but outside municipal departments as well. These partnerships have resulted in successful, large projects that can be equally shared amongst all partners while saving or using resources effectively.

The city's outreach efforts through the Keep It Clean Partnership reach residents and business across Boulder County. In partnership with Longmont, Lafayette, Louisville, Erie, Superior and with Boulder County staff, the city has lead outreach efforts that have largely focused on stormwater. However, in 2013 when drought concerns were prevalent, program efforts were expanded to include water conservation. At the same time, the city worked to ensure that stormwater runoff issues associated with E. coli and nutrients were added to existing water conservation landscaping seminars in partner cities.

In order to find new methods for outreach to students, the city partnered with Aurora Water and Denver Water to develop a one-of-a-kind theatre production that focused on water conservation. These three municipalities worked together alongside Metro State University and students from the One World One Water center to develop a theatre production focused on messaging the value of water for elementary students. This theatre production performed in eight different settings, educating more than approximately 3,000 students and even won an award from the Colorado Alliance for Environmental Education.

Seasonal Timing of Water Conservation Activities

Appendix C discusses how the seasonal timing of water conservation activities can influence the benefits of saved water and has implications on Boulder Creek stream flows. The city should explore further whether reductions in outdoor use during the runoff season, when Boulder is exclusively using its direct flow rights and its reservoirs are full or expected to fill, would provide any significant benefit. It may be advantageous to time the bulk of WCP outreach efforts to coincide to the times of year when Boulder is not on direct flow. This could also help maintain return flows to the stream in late summer and fall.

8 Recommendations

To benefit the city's future water conservation efforts, this study recommends that the city continue to:

- **Have an Adaptive-Resilient Water Conservation Program**- The Water

  Conservation Program should be increasingly adaptive and resilient to new information (e.g. demographics; climate; etc.) and changing conditions (e.g. wet and dry years). Projects that produce this detail, like the BVCP and the climate change-based reliability assessment with Water Resources, will offer data that can be used to refine Water Conservation Program efforts. This information, along with other trends and measures of program effectiveness, can then be used to determine if drought measures and water conservation goals need to be reevaluated prior the 2023 WEP update.

- **Streamline Sustainability and Resilience Initiatives –** Efforts to embed water conservation planning into larger resilience, climate and energy planning should be pursued. This could include energy mapping of water use, connections between water use and hydropower, ongoing program efforts that save both water and energy as well better utilizing "resilience" outreach as a means to talk about multiple hazards (e.g. drought, fire and flood). Continuing to collaborate with Climate Commitment, Climate Modeling and Resilience Strategies should be encouraged.

- **Advance Green Infrastructure Connections**- City discussions around Green Infrastructure and urban ecosystems highlight the importance of maintaining green spaces across the city. The Water Conservation Program should continue to play an active role in these discussions to help balance city water use and maximize the co-benefits of these initiatives (e.g. areas where irrigation runoff can be reduced). The Water Conservation Program should explore stakeholder engagement with other staff, master plans and community values regarding city urban landscaping with their quality of life[25]. This will be important if Boulder considers pursuing conservation efforts targeted at changing the existing urban landscape (i.e. replacement of turf grass with xeriscape).

- **Evaluate City Metering, Customer Categorization and Water Loss-** The Water Conservation Program has a role in helping evaluate metering options, ensure that customers are properly categorized and to limit water loss. As metering technology has improved, the Water Conservation Program can help evaluate Advanced Metering Infrastructure (AMI), options that would offer real-time meter reading, water use profiling, time of use billing, demand forecasting and response feedback, flow monitoring and leak detection. Beyond the immediate benefits of AMI, metering discussions may help identify opportunities to address system and customer water loss, municipal water budgets and existing categorization discrepancies between SF and MF customers.

[25] The city of Fort Collins recently conducted a survey to assess their customer's perspective on the level of green within their service area. Survey questions focused on perceptions of xeriscape vs. turf grass, the importance of turf grass on public spaces and the importance of trees.

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