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List of Acronyms

Acronym	Definition
AC	Air conditioning
AFY	Acre-feet per year
AMANDA	Application Management and Data Automation
AMI	Advanced metering infrastructure
ASR	Aquifer storage and recovery
CDP	Criterium Decision Plus®
CII	Commercial, institutional, industrial
COA	City of Austin
COM	Commercial
DDM	Disaggregated demand model
DPR	Direct potable reuse
DTI	Delphi, Trends and Imagine Austin
DWDR	Drought Worse than Drought of Record
EPA	Environmental Protection Agency
GIS	Geographic information system
GPCD	Gallons per capita day
GPM	Gallons per minute
HOA	Homeowners Association
ICI	Industrial, commercial and institutional
ILI	Infrastructure Leakage Index
IPR	Indirect potable reuse
IWRP	Integrated water resources plan
LCRA	Lower Colorado River Authority
MCDA	Multi-criteria decision analysis
MFR	Multi-family residential
MGD	Million gallons per day
NRW	Non-revenue water
OCR	Off channel reservoir
POR	Period of record
PRV	Pressure regulating valve
SFR	Single family residential
SOCRATES	Standardized Occupational Components for Research and Analysis of Trends in Employment System
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TWDB	Texas Water Development Board
ULF	Ultra-low flush
WAM	Water Availability Model
WHL	Wholesale customers
WMP	Water Management Plan

Acronym	Definition
WRI	Water reclamation initiative
WTP	Water treatment plant
WWTP	Wastewater treatment plant

SECTION 1: EXECUTIVE SUMMARY

Placeholder: The executive summary will be written at a near term future date. The executive summary will be written in a style that is accessible and engaging to the public.

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SECTION 2: INTRODUCTION

The City of Austin (the City) is the capital of the State of Texas and is located in the central part of the state. Central Texas falls within a transitional climate zone characterized by hot, humid summers and mild winter temperatures, with an average annual precipitation of 34 inches. There are numerous lakes, rivers, and waterways in the Austin area. The core water body in the region is the Texas Colorado River.

The section from above Austin down to the Gulf of Mexico is called the Lower Colorado. The Colorado is dammed several times upstream from Austin forming the Highland Lakes. Two lakes immediately upstream from Austin, Lake Buchanan and Lake Travis, act as reservoirs for the region and Austin's water supply. Those lakes are managed by the Lower Colorado River Authority (LCRA).

Funding for the dams was won by Congressman Lyndon Johnson early in his political career. They not only stabilized the water supply, but also brought electricity to the Hill Country west of Austin.

Below Lake Travis is Lake Austin, a steady level lake that runs through west Austin. Flowing through downtown Austin is Lady Bird Lake.

There are numerous other streams and springs in the Austin area including Barton Springs, the iconic swimming hole just across the Colorado from downtown, McKinney Falls in Southeast Austin, Barton Creek, Onion Creek, Shoal and Waller Creek that run on each side of downtown, and many more. All of these creeks and springs ultimately flow into the Colorado River. Also Lake Walter E. Long in northeast Austin began as a cooling reservoir for an Austin Energy natural gas powered generation plant, fed by the Colorado. Over the years it became a popular fishing spot.

These waterways are a vital part of the many eclectic neighborhoods where Austinites live, work, and raise families. Approximately one million people in the Austin area receive drinking water services from Austin Water, the City-owned water, wastewater, and reclaimed water utility.

Austin is one of the fastest growing cities in the United States and has been for some 40 years. This trend is projected to continue. Through the 1970s the primary elements of Austin's economy were state government and universities – the largest being the University of Texas at Austin. Since then, however, numerous other industries have flourished in Austin, led by the technology sector and also a growing

WATER FORWARD GUIDING PRINCIPLES

Austin's Water Forward is a program to develop a long-term integrated water resources plan for the next 100 years. The following represents the plan's guiding principles:

- *Recognizing that Colorado River water is Austin's core supply, continue a strong partnership between the City and LCRA to assure its reliability*
- *Continue Austin's focus on water conservation and water use efficiency*
- *Strengthen long-term sustainability, reliability, and diversity of Austin's water supply through maximizing local water resources*
- *Avoid severe water shortages during times of drought*
- *Focus on projects that are technically, socially, and economically feasible*
- *Continue to protect Austin's natural environment, including source and receiving water quality*
- *Ensure Austin's water supply continues to meet/exceed all federal, state and local public health regulations*
- *Align with Imagine Austin's "Sustainably Manage Our Water Resources Priority Program"*
- *Maintain coordination and communication with regional partners*
- *Engage the public and stakeholders throughout the plan development process*

healthcare/biotechnology sector. Numerous high-profile companies have major operations or headquarters in Austin, which contributes to a strong business environment. A reliable, high-quality water supply is vital to the City's economy and quality of life.

Central to Austin's economic vitality and high quality of life is a reliable, safe water supply. Currently, all the city's drinking water comes from the Lower Colorado River system, which include Lakes Travis and Buchanan, the region's water supply reservoirs. In the future, the Colorado River system will likely experience climate change impacts, additional droughts, and other uncertainties. Coupled with rapid growth and economic development, these factors make future water planning more challenging than in the past.

Additionally, Austin sits just east of the 98th meridian, a geological dividing line between more than 30 inches of rain annually and less than 30 inches annually. With climate change there is scientific concern that this line is shifting to the east.

The most recent drought, which occurred from approximately 2008 to 2016, was a historic drought and was a key driver for the development of this Integrated Water Resource Plan (IWRP). During the drought, inflows of water and combined storage in Lakes Travis and Buchanan were at historic lows. The Austin community and others throughout the river basin responded to calls for water conservation as a way to extend supplies while the region was gripped by severe drought.

In the future, potential climate change effects, as projected by global climate modeling, are expected to result in increasing average and maximum monthly temperatures, and greater variability in precipitation—both of which will likely result in more frequent and longer-duration droughts (Hayhoe, 2014). With climate change it is also expected that wet periods will be more intense, meaning that it is anticipated that overall, dry periods will be hotter and drier and wet periods will be wetter.

Utilizing an adaptive management approach, this Integrated Water Resource Plan seeks to face these challenges and ensure a diversified, sustainable, and resilient water future for Austin, with strong emphasis on water conservation.

2.1 Overview of Austin's Water Supply System

For more than 100 years, Austin Water has been committed to providing clean, safe, reliable, high quality, sustainable, and affordable water services to our customers. Austin Water consistently ranks among the best in the country in regard to water quality. Austin Water owns and operates three major water treatment plants (WTPs)—Ullrich WTP, Davis WTP, and Water Treatment Plant No. 4 —with a combined treatment capacity of 335 million gallons per day (MGD). The distribution system has over 3,600 miles of pipe and 35 pump stations that deliver water to 9 major pressure zones. Austin Water also operates two major wastewater treatment plants (WWTPs)— South Austin Regional WWTP and Walnut Creek WWTP—which discharge treated effluent into the Colorado River. The combined treatment capacity of these two WWTPs is 150 MGD. In addition, the utility operates multiple smaller wastewater treatment plants throughout the area.

All of Austin's drinking water comes from the Colorado River, which is available through a combination of State-granted run-of-river water rights and a water supply contract with the Lower Colorado River Authority (LCRA) for firm water from the Highland Lakes system. In October 1999, Austin entered into a key water supply agreement with LCRA. This agreement was an amendment to a previous 1987 agreement. The 1999 agreement provides firm backup (stored water from the

Highland Lakes) for Austin's run-of-river rights and additional firm water totaling up to 325,000 acre-feet per year (AFY). Under the 1999 agreement, Austin prepaid $100 million for supply reservation and use fees. Future water use payments to LCRA will be triggered the year after annual average use for two consecutive calendar years exceeds 201,000 AFY. At that point in time, Austin will begin paying for diverted amounts above 150,000 acre-feet per year.

Lakes Travis and Buchanan, which are part of the Highland Lakes, are managed by LCRA, as is the entire lower Colorado River system, from the watersheds flowing into Lake Buchanan to Matagorda Bay on the Texas Coast. Lake Travis is formed by Mansfield Dam and Lake Buchanan by Buchanan Dam. Lake Austin and Lady Bird Lake, which are smaller lakes downstream of Lakes Travis and Buchanan, are created by Tom Miller Dam and Longhorn Dam, respectively. Lake Travis and Buchanan vary in lake level and stored water volume depending on the amount of rain, inflows, evaporation, and releases from the dams. In contrast, Lake Austin and Lady Bird Lake are much smaller and the dams downstream and upstream of Lake Austin are operated to maintain them at a relatively constant level. When water is being diverted by the City or other users from Lake Austin, or when water is released downstream, that water is generally replaced by LCRA's river operations by releasing water through Mansfield Dam. The exception is if at the time of the diversions there are already sufficient inflows from rain falling onto the lake or stormwater draining into the lake to replace the diversions. Similarly, Lady Bird Lake is kept at a near constant level with releases from Tom Miller Dam. **Figure 2-1** presents the regional and local water system that provides drinking water for Austin.

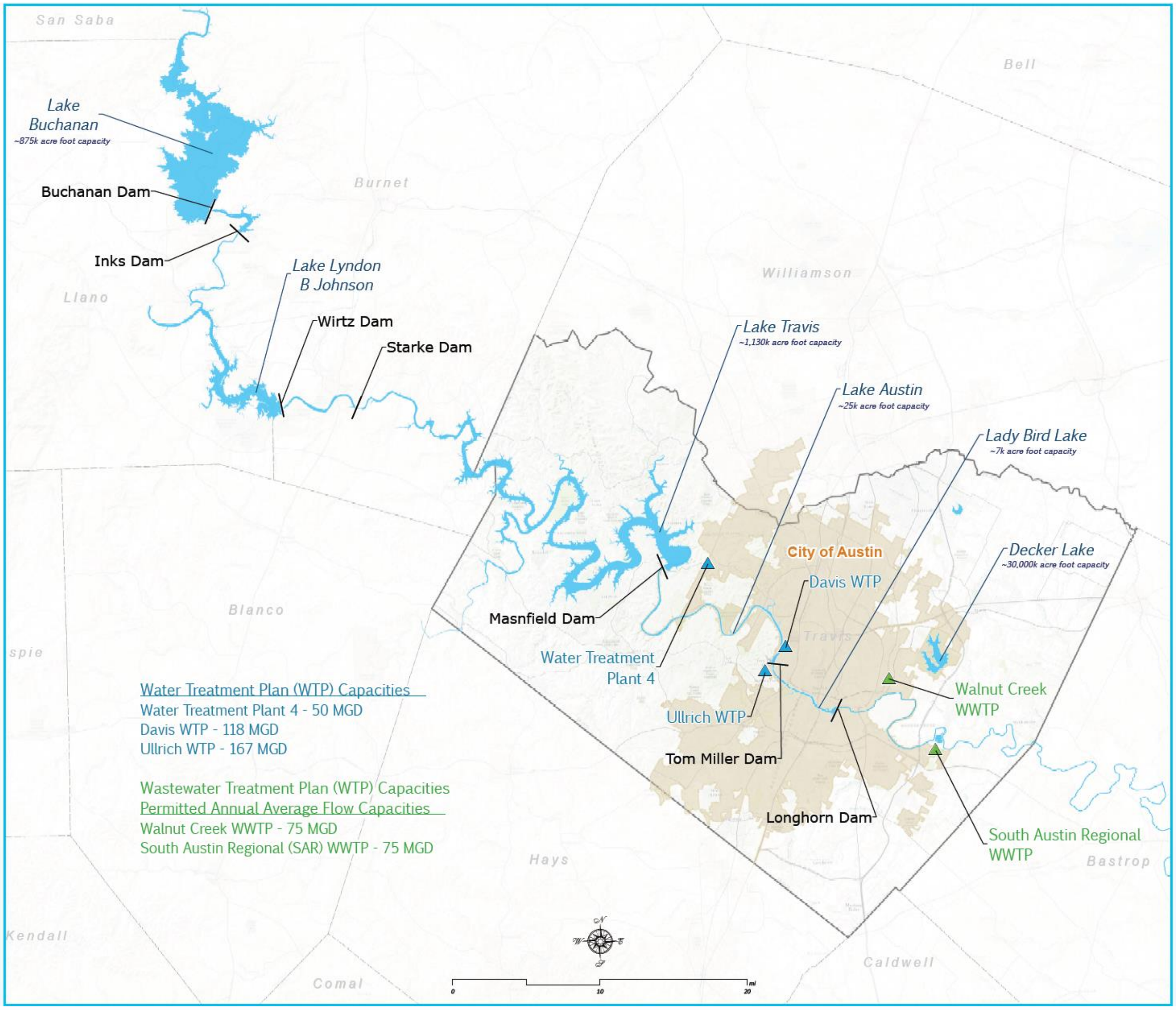

Figure 2-1. Regional and City Water System

2.2 Water Supply Conditions and Drought

The availability of water under Austin's water rights and firm water supply contract with LCRA is generally dependent on rainfall, inflows, and LCRA's management of the water stored in the Highland Lakes. LCRA manages lakes Travis and Buchanan through a state approved Water Management Plan (WMP), which was last updated in 2015. LCRA initiated another LCRA WMP update process in 2018.

The Austin area and the rest of Texas went through a historic drought from 2008 to 2016. As shown in **Figure 2-2**, the combined stored water volume in Lakes Travis and Buchanan dropped to 637,123 acre-feet on September 19, 2013, which is 32% of the total combined storage volume. That amount is second only to the minimum in the 1947-1957 drought, which caused the lakes to drop to a record low of 621,221 acre-feet of total combined storage, which is 31% of full. In addition to very low lake levels, the 2008-2016 drought also experienced the lowest annual inflows (i.e. water flowing into the lakes) since 1940 when the lakes were constructed. LCRA's WMP requires pro rata curtailment of 20% for firm water customers if the LCRA Board declares a Drought Worse than the Drought of Record (DWDR). The criteria for determining a DWDR are included in the LCRA WMP and involve drought duration, intensity and storage volume (triggered at 600,000 acre-feet or 30% of capacity, a level the combined storage has never reached).

As a result of the 2008-2016 drought, a 2014 Austin Water Resource Planning Task Force was convened by the Austin City Council. This 2014 Task Force was charged to: (1) evaluate the city's water needs; (2) examine and make recommendations regarding future water planning; and (3) evaluate potential water resource management scenarios for council consideration. A key recommendation of the 2014 Task Force was the development of an Integrated Water Resources Plan (IWRP).

Austin's Water Forward effort, which began in early 2015, is the process to develop the IWRP.

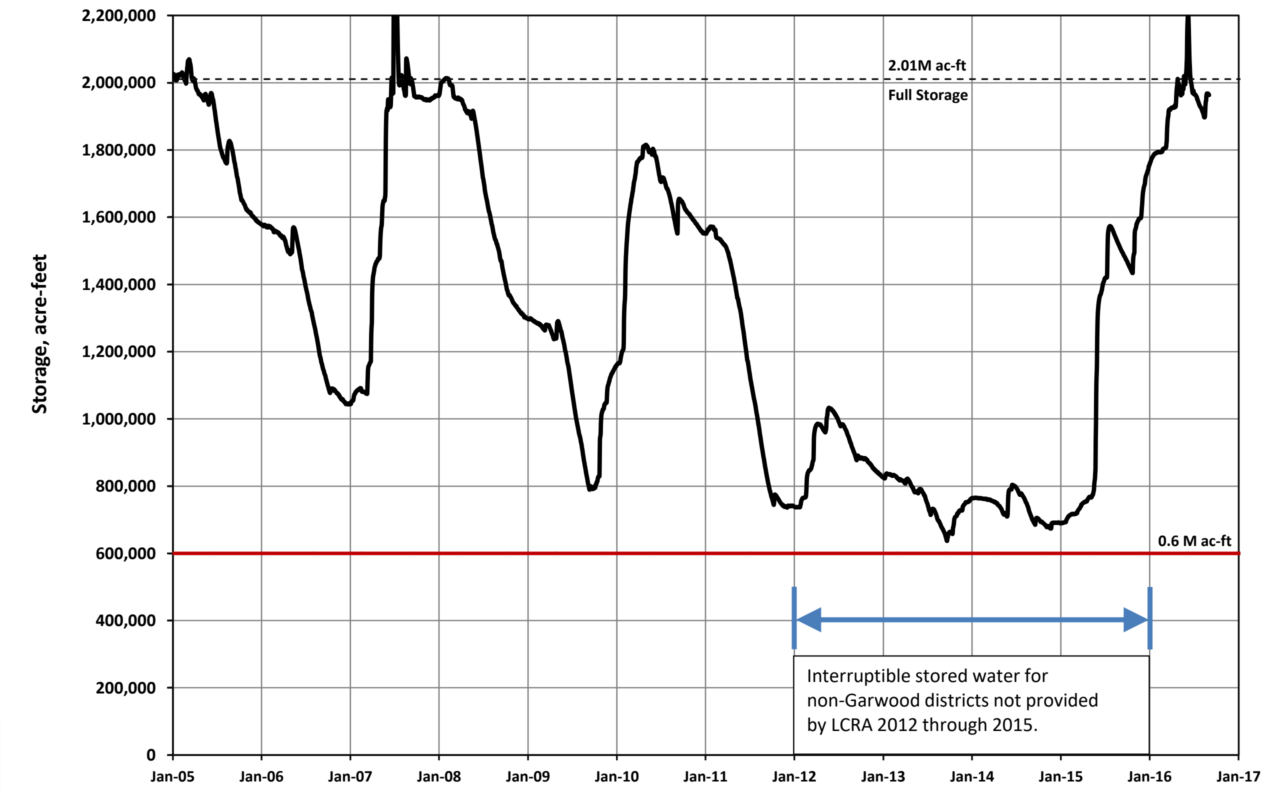

Figure 2-2. Combined Storage of Lakes Buchanan and Travis from 2005 – 2016

2.3 Water Forward IWRP Mission Statement

Austin Water is an industry leader in the delivery of water, wastewater, and recycled or reclaimed water services. As such, the City is taking a proactive step in developing its Water Forward IWRP which provides a high-level strategy document intended to provide information to decision-makers regarding the tradeoffs of future water resource investments, with a long-range viewpoint through a 2115 planning horizon. The IWRP evaluates water supply and demand management options with consideration of multiple planning objectives, and was developed using an open, participatory planning process. To guide the Water Forward process, Austin Water, in collaboration with the Water Forward Task Force, established a mission statement for the IWRP, as follows:

- The Integrated Water Resource Plan (IWRP) will provide a mid- and long-term evaluation of, and plan for, water supply and demand management options for the City of Austin in a regional water supply context.
- Through public outreach and coordination of efforts between City departments and the Austin Integrated Water Resource Planning Community Task Force (Task Force), the IWRP offers a holistic and inclusive approach to water resource planning.
- The plan embraces an innovative and integrated water management process with the goal of ensuring a diversified, sustainable, and resilient water future, with strong emphasis on water conservation.

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SECTION 3: COLLABORATIVE PLAN DEVELOPMENT PROCESS

Public outreach and education efforts for the IWRP gathered meaningful stakeholder input used to develop a plan that is representative of Austin community values. Water Forward's public involvement strived to address the following core areas:

- **Community Values** – Identify community values that should be reflected in the IWRP.
- **Diverse Stakeholder Input** – Seek input from stakeholders which reflect the diversity of Austin's population and customers.
- **Public Education** – Inform and educate the community throughout the plan development process.

The following sections describe the collaborative process that was used to engage the stakeholders and the public in developing the Water Forward Plan.

AT A GLANCE

- *Task Force Involvement*
- *Community Outreach Activities*

3.1 Task Force Involvement

In 2014, the Austin Water Resource Planning Task Force was convened during the height of the 2008 to 2016 drought and tasked with analyzing the City's water needs and making recommendations on how to augment the City's future water supply (see Resolution No. 20140410-033). On July 10, 2014, the Austin Water Resources Planning Task Force presented their recommendations to the Austin City Council which included recommendations on demand management and water supply strategies. This IWRP was a foremost recommendation of the 2014 Austin Water Resource Planning Task Force.

The Austin Integrated Water Resources Planning Community Task Force was created to support the development of the IWRP (see Resolution No. 20141211-119). Members of the Task Force included individuals representing each of the 10 City Council Districts as shown below.

- Sharlene Leurig (Chair) - appointed by Council Member Casar.
- Jennifer Walker (Vice-Chair)- appointed by Mayor Pro Tem Tovo.
- Bill Moriarty - appointed by Mayor Adler.
-
- Clint Dawson - appointed by Council Member Houston.

- Sarah Richards - appointed by Council Member Garza.
- Perry Lorenz - appointed by Council Member Renteria.
- Lauren Ross - appointed by Council Member Kitchen.
- Todd Bartee - representing District 6 – Council Member Flannigan
- Robert Mace- appointed by Council Member Pool.
- Marianne Dwight - appointed by Council Member Troxclair.
- Diane Kennedy - representing District 10 – Council Member Alter

The Task Force also included Ex Officio members from several City of Austin departments.

[List departments and Ex Officio Members]

The Task Force played an instrumental role in shaping the development of the Water Forward Process, providing input along the way to shape the planning process and recommendations that are included in the plan. Task Force meetings were held essentially on a monthly basis from May 2015 through [insert month year]. To view agendas, approved minutes and supporting documents, please visit: http://austintexas.gov/cityclerk/boards_commissions/meetings/132_1.htm.

3.2 Stakeholder and Public Involvement

Since 2016, Austin Water has collected public input through over 80 outreach events, including five Water Forward Public Workshops, four Targeted Stakeholder Meetings, and 10 Summer Series events (one in each City Council district). Austin Water has delivered presentations and/or outreach materials at more than 60 community events, information sharing sessions, community group meetings, seminars/professional events, and district town halls. The input received has been considered throughout the process of developing the plan and preparing the Draft Water Forward Plan Recommendations. The participation by and input received from the community and stakeholders are key to the success of the Water Forward Process.

The following describes the collaborative process that was used to engage the stakeholders and the public in developing the Water Forward Plan.

3.2.1 Collaborative Water Forward Public Workshops

A total of five Water Forward Public Workshops were held to educate the public about the Integrated Water Resources Plan and gather public input. A summary of the workshops follows:

- On September 7, 2016, Austin Water hosted the first of five public workshops in order to collect public input for the Integrated Water Resource Plan (IWRP). Twenty-four members of the community attended. The workshop gave stakeholders an overview of the IWRP, explained why a water plan is needed, and outlined some of the elements of a potential plan. Stakeholders were then given a chance to offer input on the portfolio evaluation criteria for the IWRP. Of the feedback collected, some key themes included value of infrastructure investment, affordability, how to pan for a 100-year time period, ideas for water conservation, prioritization of environmental justice, and the importance of outreach and education in the process of implementation.

- On February 8, 2017, Austin Water hosted the second of five public workshops in order to collect public input for the Integrated Water Resource Plan (IWRP). A total of 30 members of the community attended. The workshop featured presentations from the project team about the plan development process, stakeholder outreach, and supply and demand modeling. After the presentation, stakeholders were asked to give feedback on supply- and demand-management options in a brief exercise. Overall, stakeholders liked the options presentation at the workshop and placed an emphasis on Water Loss Control and Rainwater and Stormwater Capture.
- On April 4, 2017, Austin Water hosted the third of five public workshops in order to collect public input for the Integrated Water Resource Plan (IWRP). There were 22 members of the community in attendance. The workshop featured presentations from the project team about the plan development process, stakeholder outreach, and supply and demand modeling. After presentation, stakeholders were asked to give feedback on supply-management options in a brief exercise. Stakeholder feedback included decentralizing the wastewater for reuse, using incentives for conservancy, diversify water supplies for reliability.
- On August 16, 2017, Austin Water hosted the fourth of five public workshops in order to collect public input for the Integrated Water Resource Plan (IWRP), with 18 community members attending in person and 6 community members participating via online webinar. The workshop featured presentations from the project team about the plan development process including key process steps completed, stakeholder outreach conducted to date including emerging themes from stakeholder feedback, supply and demand options as well as portfolio development and evaluation. After presentations, stakeholders were invited to participate in two question and answer sessions followed by facilitated small group discussions. Stakeholder feedback included decentralizing the wastewater for reuse, using incentives for conservancy, diversify water supplies for reliability.
- On March 21, 2018, Austin Water hosted the fifth public workshop in order to collect public input for the Integrated Water Resource Plan (IWRP). Twenty-five community members attended in person and four community members participated via online webinar. The workshop featured presentations from the project team about the development of water supply portfolios and plan recommendations. After presentations, stakeholders were invited to engage in facilitated discussions about the recommended strategies.

3.2.2 Targeted Stakeholder Meetings

Austin Water invited a wide-range of stakeholders to the four targeted stakeholder meetings with discussions on demand management options as follows:

- January 19, 2017: Demand management option discussion with a focus on Landscape Transformation and Irrigation Efficiency Ordinances and Incentives with 23 stakeholders attending.

- January 24, 2017: Demand management option discussion with a focus on Alternative Water Ordinances and Incentives that may include rainwater, graywater, and A/C condensate with 15 stakeholders attending.
- January 26, 2017: Demand management option discussion with 12 stakeholders attending and a focus on:
  - Development-focused Water Use Estimates and Benchmarking.
  - Commercial, Industrial, and Institutional and Non-residential Ordinances.
  - Plumbing Codes and Ordinances and Fixture Incentives.
  - Reclaimed Water (centralized purple pipe system) Ordinances and Incentives.
- November 15, 2017: Discussion with 5 stakeholders on plan process, screened options, characterized information and initial portfolio compositions.

Although the general public was invited to participate in these targeted stakeholder meetings, invitations were specifically extended to landscape and irrigation professionals as well as stakeholders representing environmental interest groups, chambers of commerce, industry representatives, business leaders, and industry professionals. Stakeholders were invited to attend one or all of these depending on the topics most important to the stakeholder/organization. The goal with these smaller group discussions was to gather input from stakeholders to support refinement of demand management and water supply options.

3.2.3 Outreach Efforts

Additional outreach efforts gathered input from community members and representatives from partner organizations through:

- Summer Series,
- Community Events,
- Information Sharing,
- Community Group Meetings,
- Seminars/Professional Events, and
- District Town Halls.

The summary of outreach activities to date is presented in **Table 3-1** below.

Table 3-1. Summary of Outreach Activities as of May 1, 2018

Date	Event Name	Event Category / Description	Est. # of Attendees
8/3/16	Imagine Austin Speaker Series: Water Forward - Planning for the Next 100 Years	Community Event	62
9/7/16	Public Workshop #1	Water Forward Event	24
9/11/16	Planning & Zoning N. Burnet Rd. Better Block Event	Community Event	
9/14/16	AustinCorps High School Program	Community Event	
9/17/16	Carver Library Tabling	Community Event	
9/28/16	Austin Hotel & Lodging Expo	Seminar/Professional Event	
9/28/16	Commercial Programs Technical Workshop	Seminar/Professional Event	
10/1/16	National Night Out Kickoff Party	Community Event	300
10/3/16	South River City Citizen's Meeting	Community Group Meeting	
10/8/16	Southeast Branch Library	Community Event	
10/22/16	25th Annual Austin Arbor Day	Community Event	12
10/27/16	Talk Green to Me - A Gray Water Overview	Community Event	7
10/27/16	UT Campus Sustainability Week Local Impact Day	Community Event	35
10/29/16	AE Community Connection Resource Fair	Community Event	1,000
11/5/16	Northwest Austin Neighborhood Association	Community Group Meeting	10
11/19/16	Grow Green Homeowner's Training	Community Event	25
11/26/16	Chuy's Children Giving to Children Parade	Community Event	
12/9/16	Gilbert Elementary College and Career Fair	Community Event	125
12/10/16	Frost Bank Home Improvement Mini-Expo	Community Event	37
12/17/16	Pleasant Valley Market	Community Event	10
1/19/17	Targeted Stakeholder Meeting #1	Water Forward Event - Demand Management Options with focus on Landscape Transformation and Irrigation Efficiency Ordinances and Incentives	23
1/24/17	Targeted Stakeholder Meeting #2	Water Forward Event - Demand Management Options with focus on Alternative Water Ordinances and Incentives that may include rainwater, gray water, and A/C condensate	15
1/26/17	Targeted Stakeholder Meeting #3	Water Forward Event - Demand Management Options with focus on Development-focused Water Use Estimates and Benchmarking; Commercial, Industrial, and Institutional and Non-residential Ordinances; Plumbing Codes and Ordinances and Fixture Incentives; and Reclaimed Water (centralized purple pipe system) Ordinances and Incentives	12
1/31/17	Youth Career Fest 2017	Community Event	90
2/2/17	Central Texas Water Efficiency Network Symposium	Seminar/Professional Event	100

Table 3-1. Summary of Outreach Activities as of May 1, 2018

Date	Event Name	Event Category / Description	Est. # of Attendees
2/7/17	African American Heritage Network- Black History Luncheon	Community Event	150
2/8/17	Public Workshop #2	Water Forward Event - Future Water Supply Needs and Strategies to Meet Them	30
2/21/17	WaterWise Irrigation Professionals Seminar	Seminar/Professional Event	252
2/27/17	UT Graduate Class, Energy and Earth Resources program	Seminar/Professional Event	25
3/25/17	Zilker Garden Festival	Community Event	350
3/26/17	Interfaity Dialogue Event	Community Event	~50
3/26/17	Zilker Garden Festival	Community Event	250
4/4/17	Public Workshop #3	Water Forward Event - Future Water Supply Needs and Strategies to Meet Them	22
4/6/17	University of Texas City Forum	Seminar/Professional Event	~25
4/12/17	Texas Water Conference	Community Event	
4/18/17	IBM Earth Day	Community Event	125
4/20/17	TX Parks and Wildlife Earth Day Event	Community Event	75
4/20/17	IBM Earth Day	Community Event	80
4/21/17	Arboretum Plaza Earth Day	Community Event	
4/22/17	Earth Day ATX	Community Event	400
4/23/17	Sun Radio Earth Day	Community Event	100
5/4/17	Apartment Association Trade Show	Community Event	
5/5/17	Save Barton Creek Association Meeting	Community Group Meeting	~12
5/13/17	District 7 Town Hall	District Town Hall	40
5/22/17	Northwest Austin Coalition Meeting - District 6 Town Hall	District Town Hall	~15
5/25/17	El Concilio - A Coalition of Mexican American Neighborhoods	Community Group Meeting	~12
5/30/17	Montopolis Neighborhood Association Meeting	Community Group Meeting	~12
6/11/17	Cool House Tour	Community Event	
6/13/17	Austin Neighborhoods Council - East	Community Group Meeting	15
6/13/17	District 5 Town Hall	District Town Hall	40
6/19/17	District 10 Town Hall	District Town Hall - Tabling	~125
6/21/17	350.org	Community Group Meeting	5
6/22/17	UT Facilities	Information Sharing	~18
7/8/17	Summer Series - District 2	Water Forward Event - Emerging Themes from Public Input	1
7/12/17	Water and Wastewater Commission	Information Sharing	
7/14/17	NXP	Information Sharing	

Table 3-1. Summary of Outreach Activities as of May 1, 2018

Date	Event Name	Event Category / Description	Est. # of Attendees
7/15/17	Summer Series - District 7	Water Forward Event - Emerging Themes from Public Input	3
7/17/17	Summer Series - District 6	Water Forward Event - Emerging Themes from Public Input	3
7/19/17	Summer Series - District 9	Water Forward Event - Emerging Themes from Public Input	7
7/22/17	Summer Series - District 4	Water Forward Event - Emerging Themes from Public Input	4
7/29/17	Summer Series - District 3	Water Forward Event - Emerging Themes from Public Input	4
7/31/17	Summer Series - District 10	Water Forward Event - Emerging Themes from Public Input	6
8/5/17	Summer Series - District 8	Water Forward Event - Emerging Themes from Public Input	6
8/8/17	Summer Series - District 5	Water Forward Event - Emerging Themes from Public Input	7
8/12/17	Summer Series - District 1	Water Forward Event - Emerging Themes from Public Input	8
8/16/17	Public Workshop #4	Water Forward Event - Emerging Themes from Public Input	25
9/19/17	East Riverside Oltorf Neighborhood Association Meeting	Community Group Meeting	~20
9/28/17	Austin Board of Realtors	Community Group Meeting	6
10/4/17	AARO Energy and Water Committee		
10/19/17	L.B.J. Neighborhood Association	Community Group Meeting	7
10/19/17	TWCA	Seminar/Professional Event	
10/25/17	Friends of Riverside Neighborhood Association	Community Group Meeting	9
10/28/17	Hopefest	Community Event	100
11/15/17	Targeted Stakeholder Meeting	Water Forward Event - Update on plan process, screened option, characterized information and initial portfolio compositions	5
11/15/17	Water Utility Climate Alliance	Seminar/Professional Event	
11/27/17	Colony Park Neighborhood Association	Community Group Meeting	20
1/27/18	Georgian Acres Neighborhood Association	Community Group Meeting	12
3/12/18	Save Barton Creek Association Meeting	Community Group Meeting	7
3/21/18	Public Workshop #5	Water Forward Event – Draft Water Forward Plan Recommendations	29

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SECTION 4: WATER FORWARD PLANNING PROCESS

Water Forward is an integrated water resources planning process used to evaluate potential water supply and demand management options while building consensus and support with the public and other stakeholders that could be affected by the recommendations. This section describes the overall Water Forward process from development of objectives and performance measures, to option screening and characterization, through to portfolio development and evaluation.

AT A GLANCE

- *Evaluation Process Overview*
- *Plan Objectives and Performance Measures*
- *Options Screening and Characterization*
- *Portfolio Development and Evaluation*

4.1 Evaluation Process Overview

The IWRP evaluation process is based on a proven planning process that explores both demand-side and supply-side options in an integrated manner in order to meet multiple objectives. The IWRP process also explores risks and uncertainty related to drought and different potential hydrologic and climatic futures over the next 100 years. The following section provides an overview of the planning process; a comprehensive description can be found in **Appendix C.** Terminology that is used in the development of an IWRP evaluation is provided in **Figure 4-1**.

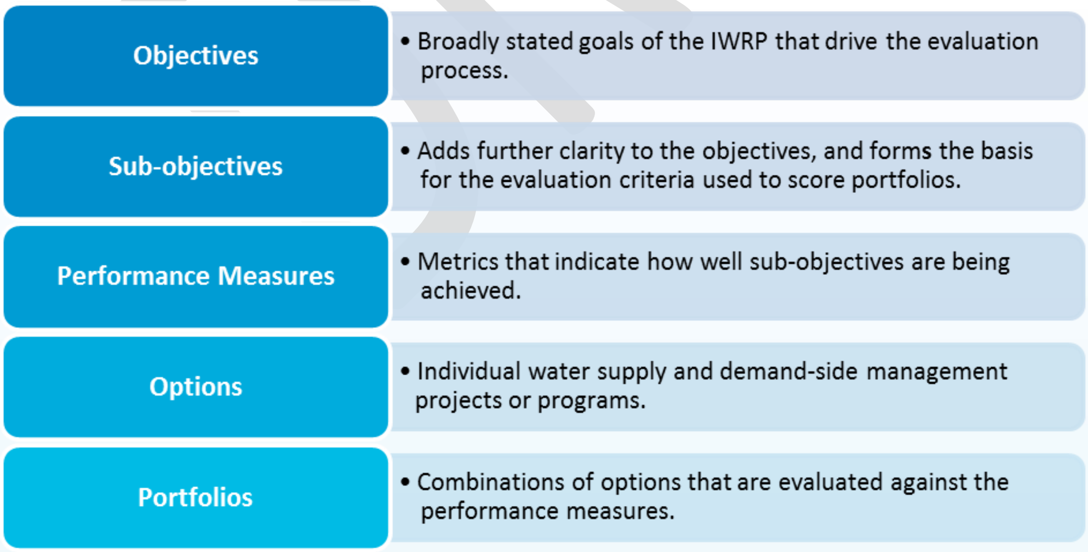

Figure 4-1. Integrated Water Resources Planning Terminology

The Water Forward process is summarized in **Figure 4-2**. The process begins with defining the objectives, sub-objectives, and performance measures. The sub-objectives together with the performance measures serve as the evaluation criteria which Water Forward portfolios are measured against.

The process starts with identification and characterization of various water supply and demand management options. Initially a large number of options are considered, which are screened down to a smaller number using a set of criteria. Those options that pass the screening process are evaluated and characterized in greater detail.

Because no single option can fully satisfy all the objectives and sub-objectives, multiple options are combined in various ways to develop portfolios. Each portfolio is evaluated in terms of how well it achieves the defined objectives under various hydrologic conditions (for example, historical hydrology and climate change scenarios). The initial portfolios are scored and ranked, and then additional hybrid portfolios are developed based on what was learned during the initial scoring. The aim of the hybrid portfolios is to improve upon the ability to meet the stated objectives. Following final scoring, a preferred strategy is recommended for implementation. The preferred strategy may be a combination of components from several high-ranking portfolios using an adaptive management approach that would implement various options within the portfolios based on triggers, such as demand growth, hydrologic conditions, and other factors.

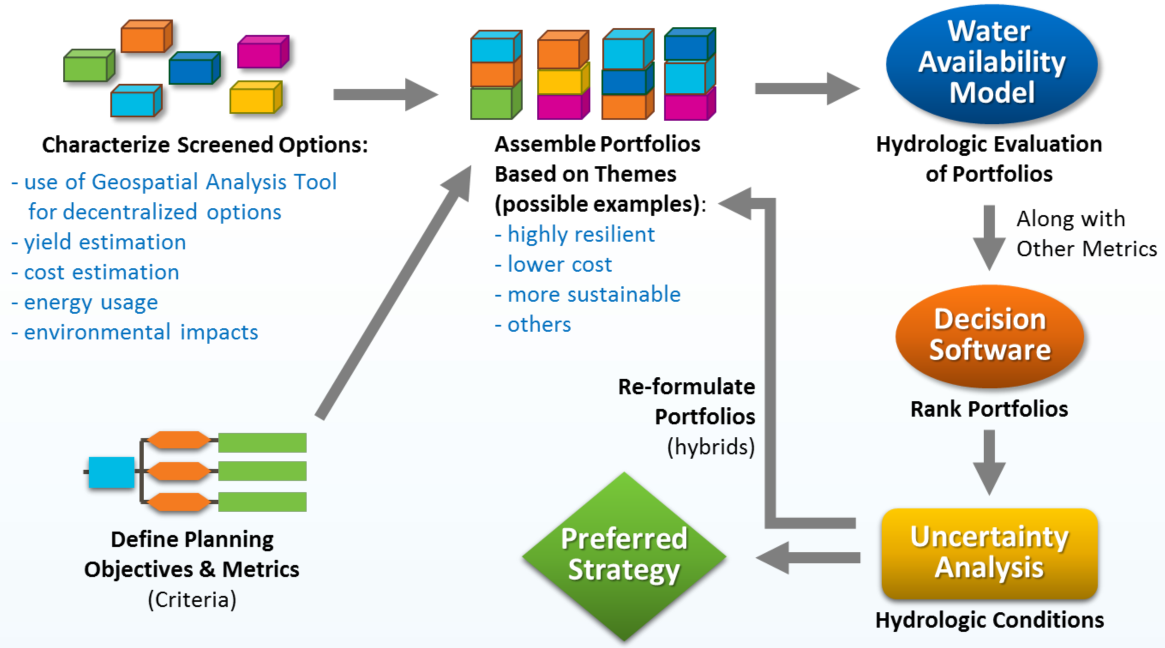

Figure 4-2. IWRP Planning Process

4.2 Plan Objectives and Performance Measures

The planning objectives serve as the framework for how the Water Forward Plan is developed. Objectives are usually categorized as either primary or secondary (sub-objectives). Primary objectives are more general, while sub-objectives help define the primary objectives in more specific terms. Sub-objectives should have the following attributes:

- **Distinctive:** to distinguish between one portfolio and another
- **Measurable:** to determine if they are being achieved, either through quantitative or qualitative metrics
- **Non-Redundant:** to avoid overlap and avoid bias in ranking the portfolios
- **Understandable:** to be easily explainable and clear
- **Concise:** to focus on what is most important in decision-making

The IWRP objectives and sub-objectives were developed by Austin Water with input from the Task Force. The objectives were formulated based on the previous 2014 Task Force and centered on principles of sustainability (balanced between economic, environmental, social needs). Initial sub-objectives were formulated with a "defining question" to establish the intent of the sub-objective.

For each sub-objective, a performance measure is required. The performance measure is used to indicate how well a sub-objective is being achieved. Where possible, quantitative performance measures were established based on a review of available data and anticipated output from the various IWRP analyses, tools, and modeling efforts. In certain instances, a qualitative score is the most suitable performance measure. **Table 4-1** presents the final list of primary objectives, sub-objectives, defining questions, and performance measures.

In any decision-making process, primary objectives are generally not all equally important. Thus, developing a set of weights is necessary to better reflect the difference in values and preferences among the various objectives. **Table 4-2** shows the final weights given to each objective and sub-objective as determined by Austin Water and the consultant team with input from the Water Forward Task Force.

Table 4-1 Objectives, Sub-Objectives, Defining Question, and Performance Measures

Primary Objective	Sub-Objective	Defining Question	Performance Measure
Water Supply Benefits	Minimize Vulnerability	How much of the Type 1, 2, and 3 water needs are met during 12-months of worst-case drought?	Geometric mean of model results from different hydrologic scenarios.
	Maximize Reliability	How many months are Type 1, 2, and 3 needs fully met during the period of simulation?	Geometric mean of model results from different hydrologic scenarios.
Economic Benefits	Maximize Cost-Effectiveness	What is the total capital (construction) and operations/maintenance costs of all projects/programs in the portfolio over the lifecycle, divided by the sum of all water yield produced by the portfolio?	Unit cost ($/AF) expressed as a present value sum of all costs over the lifecycle, including utility and customer costs.
	Maximize Advantageous External Funding	Does the portfolio have an opportunity for advantageous external funding from Federal, State, local, and private sources?	External Funding Score (1-5), where 1 = low potential and 5 = high potential
Environmental Benefits	Minimize Ecosystem Impacts	To what extent does the portfolio positively or negatively impact receiving water quality (e.g., streams, river, lakes), terrestrial and aquatic habitats throughout Austin, and net streamflow effects both upstream and downstream from Austin?	Ecosystem Impact Score (1-5), where 1 = high combined negative impacts and 5 = high combined positive impacts
	Minimize Net Energy Use	What is the net energy requirement of the portfolio, considering energy generation?	Incremental net change in kWh
	Maximize Water Use Efficiency	What is the reduction in potable water use from water conservation, reuse and rainwater capture for the portfolio?	Potable per capita water use (gallon/person/day)
Social Benefits	Maximize Multi-Benefit Infrastructure/Programs	To what extent does the portfolio provide secondary benefits such as enhanced community livability/beautification, increased water ethic, ecosystem services, or others?	Multiple Benefits Score (1-5), where 1 = low benefits and 5 = high benefits
	Maximize Net Benefits to Local Economy	To what extent does the supply reliability and water investments of the portfolio protect and improve local economic vitality, including permanent job creation?	Local Economy Score (1-5), where 1 = high negative impact and 5 = high positive impact
	Maximize Social Equity and Environmental Justice	To what extent does the portfolio support social equity and environmental justice, with emphasis on underserved communities?	Social Equity and Environmental Justice Score (1-5), where 1 = significant support and 5 = minimal support
Implementation Benefits	Minimize Risk	How significant are the major risks and uncertainties associated with implementation of projects?	Qualitative score (1-5), where 1=more water supply provided from high risk projects and 5 = less supply provided from high risk projects.
	Maximize Local Control/Local Resource	To what extent does Austin Water control operations of the water resource and does the resource reside within the local area?	Qualitative score (1-5), where 1=less water under Austin Water's control and 5=more water under Austin Water's control.

Table 4-2. Objective and Sub-Objective Weights

Primary Objective	Objective Weight	Sub-Objective	Sub-Objective Weight
▪ **Water Supply Benefits**	35%	Minimize Vulnerability	28%
		Maximize Reliability	7%
▪ **Economic Benefits**	20%	Maximize Cost-Effectiveness	15%
		Maximize Advantageous External Funding	5%
▪ **Environmental Benefits**	20%	Minimize Ecosystem Impacts	8%
		Minimize Net Energy Use	6%
		Maximize Water Use Efficiency	6%
▪ **Social Benefits**	13%	Maximize Multi-Benefit Infrastructure/Programs	5%
		Maximize Net Benefits to Local Economy	4%
		Maximize Social Equity and Environmental Justice	4%
▪ **Implementation Benefits**	12%	Minimize Risk	7%
		Maximize Local Control / Local Resource	5%

4.3 Options Screening and Characterization

Prior to developing portfolios for detailed evaluation, it was important to evaluate individual supply and demand management options to allow for more informed portfolio development and ultimately portfolios that are better suited to meet overall Water Forward objectives. To do this, two key steps were required: options screening and a standardized options characterization process.

4.3.1 Options Screening Method

After an initial process of combining options, a total of 21 water supply options and 25 demand management options were identified for screening by Austin Water. Through a screening process described in more detail below, these 46 options were narrowed down to a total of 13 supply and 12 demand management options that were carried forward for further characterization. The list of options identified for screening fell under the following main categories:

- Water Conservation Options
- Lot-scale Decentralized Options (e.g., rainwater harvesting, stormwater harvesting, graywater reuse, blackwater reuse, or A/C condensate reuse)
- Centralized and Community-Scale Decentralized Wastewater Reuse Options
- Storage Options (e.g., Aquifer Storage and Recovery or a New Off-Channel Reservoir)
- New Supply Options (e.g., desalination of brackish groundwater)

The screening process compared a high-level, order-of-magnitude unit cost of the options to an index score of implementation risks created specifically for option screening. All of the options were then plotted by these two parameters to see where outliers existed (meaning those options that have higher unit costs and higher implementation risks). The outlier options were recommended for elimination from more detailed characterization. More detail about the screening process can be found in **Appendix E** for demand management options and in **Appendix J** for water supply options.

4.3.2 Options Characterization Process

For options carried forward from screening to portfolio evaluation a summary characterization was developed using a standardized *Options Characterization Template*. During characterization, potential yields were estimated along with capital costs and annual operational costs. Option characterizations are based on the best available technical information; however, more detailed analysis of options will be required prior to implementation. The final set of option characterization sheets can be found in **Appendix F**.

4.4 Portfolio Development and Evaluation

Options that had been characterized were used as a "menu" to develop initial Water Forward portfolios. Water supply and demand management options were combined into portfolios that meet the identified water supply needs and targets under different hydrologic scenarios to various degrees of reliability.

Portfolios were developed based on themes important to Austin's community, identified as part of the Water Forward public outreach process. These portfolios were then evaluated against the IWRP sub-objectives using the various performance measures. The IWRP analyses were conducted for the forecast years 2020, 2040, 2070, and 2115, and portfolios were compared and ranked using combined scores factoring in the different forecasts.

4.4.1 Preliminary Water Needs Assessment

A fundamental objective for the IWRP is that identified future water needs for Austin Water are reliably met. For the purposes of portfolio development, three types of water needs were established (see Section 6 for more details): (1) new conservation and/or supply to manage risk associated with drought conditions triggering prolonged prohibition on outdoor water use; (2) new supply to manage risk associated with extremely low Highland Lake levels; and (3) new conservation and/or supply to provide for Austin water demands above the current LCRA contract of 325,000 AFY.

4.4.2 Method for Formulation of Portfolios

No single option identified in characterization can fully meet all the stated IWRP objectives and needs. Therefore, options are combined to form portfolios of supply and demand management options that can better meet the stated IWRP objectives and needs. The total number of potential combinations of options (i.e. portfolios) is too large to produce a meaningful analysis for the Water Forward process. As a result, portfolios are developed around major themes that align with the IWRP objectives. By developing these initial portfolios that "push" the limits of achieving each of the most important objectives, trade-offs can be identified in developing "hybrid" portfolios that are more balanced and have a better likelihood of meeting numerous objectives.

Initial portfolio themes included:

- **Minimize Cost:** Options with the lower unit costs ($/acre-foot) were selected.

- **Maximize Conservation:** Demand management options and those supply options seen to most sustainably utilize water already available as part of the existing water supply system, such as decentralized lot- and community-scale options.
- **Maximize Resiliency:** Options that produce consistent supply benefits under all hydrologic variability were considered for this portfolio.
- **Maximize Ease of Implementation:** Options that were considered easy or moderately easy to implement were selected for this portfolio.
- **Maximize Local Control:** Options in which Austin Water would have control over the projects and the water supply sources in terms of cost, yield, development, and operations.

4.4.3 Portfolio Evaluation Method

When evaluating a diverse set of portfolios against multiple objectives it is not possible to find a single portfolio that meets the needs or priorities of every stakeholder. Instead, the goal is to evaluate trade-offs between options and objectives, which will be used make an informed decision in selecting a preferred portfolio. To do this, the Water Forward process uses multi-criteria decision analysis (MCDA) to evaluate portfolios. The MCDA process relies on the performance measures and performance weights (outlined in previous sections) and a suite of computer-based tools. However, it is important to note that the plan recommendations are based on human judgement, not just computer model output. The computer model results helped inform the process of developing plan recommendations.

Overview of IWRP Tools

The MCDA process for evaluating portfolios is dependent upon output from other models and tools, as well as input from stakeholders and subject-matter experts. Each portfolio underwent modeling and assessment that generates raw quantitative and qualitative performance measure scores. **Figure 4-3** shows the portfolio evaluation workflow of IWRP tools. The models and tools used for the Water Forward process are briefly described below:

- **Colorado Basin Water Availability Model (WAM)** – This is a customized version of the computer-based simulation model, originally developed and used by the Texas Commission on Environmental Quality (TCEQ), quantifying the amount of water that would be flowing in the Colorado River and available to meet water rights under a specified set of conditions (e.g. water use, naturalized hydrology, etc.).
- **Disaggregated Demand Forecasting Model** – This is a water demand forecast model that projects demands geospatially by sector (e.g., single-family residential, multi-family, and commercial) and by end uses (e.g., toilet flushing, showers, landscaping, industrial process). The demand model also includes functionality to evaluate impacts of water conservation, weather and climate, and price of water.
- **Geospatial Decentralized Supply Suite of Tools –** These represent a set of geospatial analysis tools which incorporates the end uses of water demands by sector, and evaluates the potential demand met by alternative water options, cost, and avoided costs associated with stormwater and rainwater capture, graywater reuse, and blackwater reuse.

- **Portfolio Evaluation Spreadsheet Tool –** This spreadsheet tool was utilized to assemble options into portfolios based on supply needs and targets (difference between existing supplies and future demands and targets under different hydrologic scenarios); and also, was used to estimate total portfolio costs from individual unit costs for each option.
- **Criterium Decision Plus –** This is an industry-leading commercial MCDA software to compare and score portfolios (see below for detailed description).

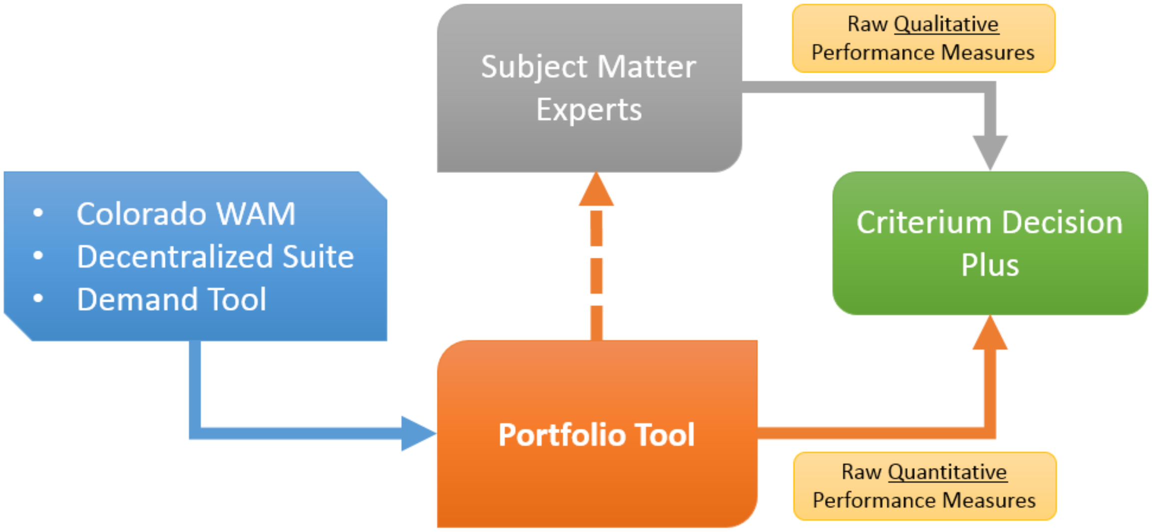

Figure 4-3. IWRP Portfolio Evaluation Workflow

Description of Criterium Decision Plus Software

CDP was used to rank portfolios. This software tool converts raw performance measures for each sub-objective, which each have different measurement units, into standardized scores so that the performance measures can be summarized into an overall value. Through CDP, a multi-attribute rating technique is applied to score and rank the selected portfolios. **Figure 4-4** summarizes the multi-attribute rating technique that is used by CDP to compare and score portfolios. The figure represents a generic scoring example and is meant as an illustration of the approach.

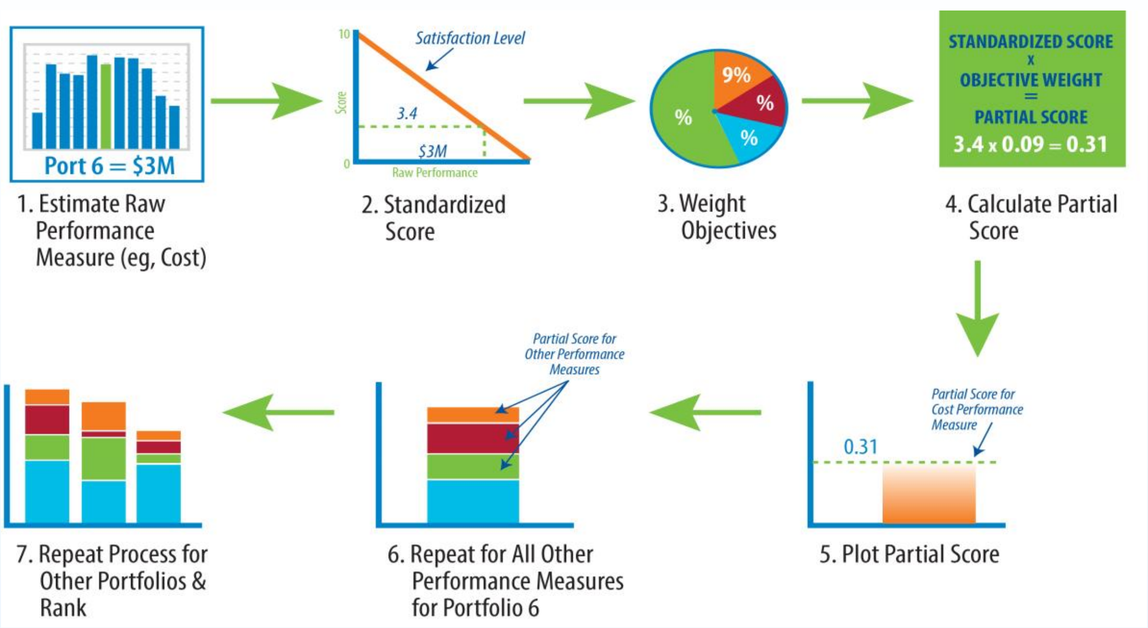

Figure 4-4. Multi-Attribute Rating Technique Used by CDP Software to Score Portfolios

Multi-attribute rating uses 7 steps to score and rank portfolios. In step 1, raw performance for all the portfolios is compared for a given criterion (for example, cost). Step 2 standardizes the performance into a score from 0 to 10. In this example, Portfolio 6's cost performance is fairly expensive, so its standardized score is fairly low (e.g., 3.4 out of 10). This step is important because performance is measured in different units (i.e., cost in dollars, energy in kWh). Step 3 assigns weights to the objective and Step 4 calculates a partial score for a given portfolio based on the multiplication of the standardized score (Step 2) and weight (Step 3). The partial score is plotted (Step 5), and then the whole process is repeated for a given portfolio for all the other performance measures (Step 6). This creates a total score that can then be compared to other portfolios. Steps 1-6 are repeated for all portfolios and compared so they can be ranked (Step 7).

Description of Colorado River Basin Availability Model

The Texas Commission on Environmental Quality (TCEQ) Water Availability Model (WAM) is a publicly-available computer modeling system for simulating surface water availability. The WAM System covers every river basin in Texas. It was created pursuant to Article VII of the 1997 Senate Bill 1, which required the development of new water availability models for the state's river basins. The WAM system is comprised to two components: generalized computer modeling software known as the Water Rights Analysis Package (WRAP) and a set of basin specific input files and supporting GIS coverages. WRAP was developed and is maintained by Dr. Ralph Wurbs at Texas A&M University. The basin specific input files and GIS coverages were developed in the late 1990's and are updated and maintained by TCEQ.

The WAM uses monthly naturalized streamflow, net lake evaporation minus precipitation, and a water management scenario as its three main inputs for every river basin. Naturalized streamflows are calculated from historical streamflow gaging records by reversing the historical water diversions, changes in reservoir storages, and return flows of all state granted water rights. The naturalized flows represent the total surface water production of the basin in the absence of state granted water rights. The WAM simulates surface water availability to the basin water rights using the naturalized hydrologic inputs and a water management scenario that specifies a level of water right utilization. Outputs of the WAM include water diversion, reservoir storage content, and remaining streamflow after accounting for the water management activities.

The Colorado River Basin WAM covers the entire portion of the river basin in Texas, from the border of southeast New Mexico downstream approximately 600 miles to the Matagorda Bay. The Colorado basin contains approximately 31,000 square miles of contributing drainage area. There are over 2,000 water rights and over 500 major and minor reservoirs represented within the Colorado WAM. The Colorado WAM uses naturalized hydrology with a period of record from January 1940 through December 2013. Extended synthesized hydrology was developed for Water Forward to cover the additional years of the recent drought through December 2016.

The City of Austin is using the Colorado River Basin WAM as a key modeling tool to examine water available to the City of Austin and the lower Colorado River Basin for the worst drought conditions in the historical period of record, drought conditions that are worse than observed in the period of record, and drought conditions that are reflective of future climate change. Water availability is simulated for a baseline water management scenario (no additional actions) to assess future needs, and a suite of portfolio options to assess the performance to meet those future needs.

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SECTION 5: WATER DEMANDS

Integrated water resource planning provides a blueprint that ensures residents and businesses in Austin have sustainable access to clean water now and into the future as the city continues to experience strong growth. To properly plan and manage Austin's water resources, it is critical to have a reasonable understanding and characterization of how and where water is currently used in the city as well as quantifiable estimates of how much water will be needed in the future. This section describes the primary tool used to characterize and explore water demands, referred to as the Disaggregated Demand Model (DDM). Using the tool, current water use is defined, as described in Section 5.2, and future demand is projected, as described in Section 5.3. These sections describe the City's water demand at the water source (*diversions*), at the water treatment plant (*pumpage*), and at the Austin Water customers' meters (*consumption*). As climate and weather patterns are a major defining factor in water use levels, Section 5.4 explores future water demands in relationship with projected climate variations.

AT A GLANCE

- *Disaggregated Demand Model*
- *Current Water Use Summary*
- *Future Baseline Water Demand*

5.1 Disaggregated Demand Model

The foundation of the IWRP water demand estimates is the underlying DDM, which was used to produce the baseline water demand assessment among other things. Austin Water staff began development of the DDM in advance of the IWRP and refinements to the DDM have continued throughout the process. The DDM is an Excel-based tool that models water use by sector, subsector, and end use at geographic planning units for current demands as well as the key planning periods of 2020, 2040, 2070, and 2115. The DDM provides the analytical environment for assessing potential water savings from demand management measures being evaluated in developing the plan. The DDM also includes functionality to assess water demands under future climatic scenarios and tracks water consumption by end uses (such as toilets, sinks, and irrigation) which informs the assessment of yield potential for decentralized supply options. The following sections describes the model attributes, development, and primary data sources.

5.1.1 Demand Model Attributes

For analysis purposes, it is useful to group water demands according to similar user characteristics. These groupings are known as sectors. The DDM model sector classifications are listed below. The water use sectors are further refined into subsectors and indoor end uses, as shown in **Figure 5-1**.

DDM Sectors:

- Single family residential (SFR).

- Multi-family residential (MFR).
- Commercial (COM), which includes large volume customers.
- Wholesale Customers (WHL).
- City of Austin (COA).

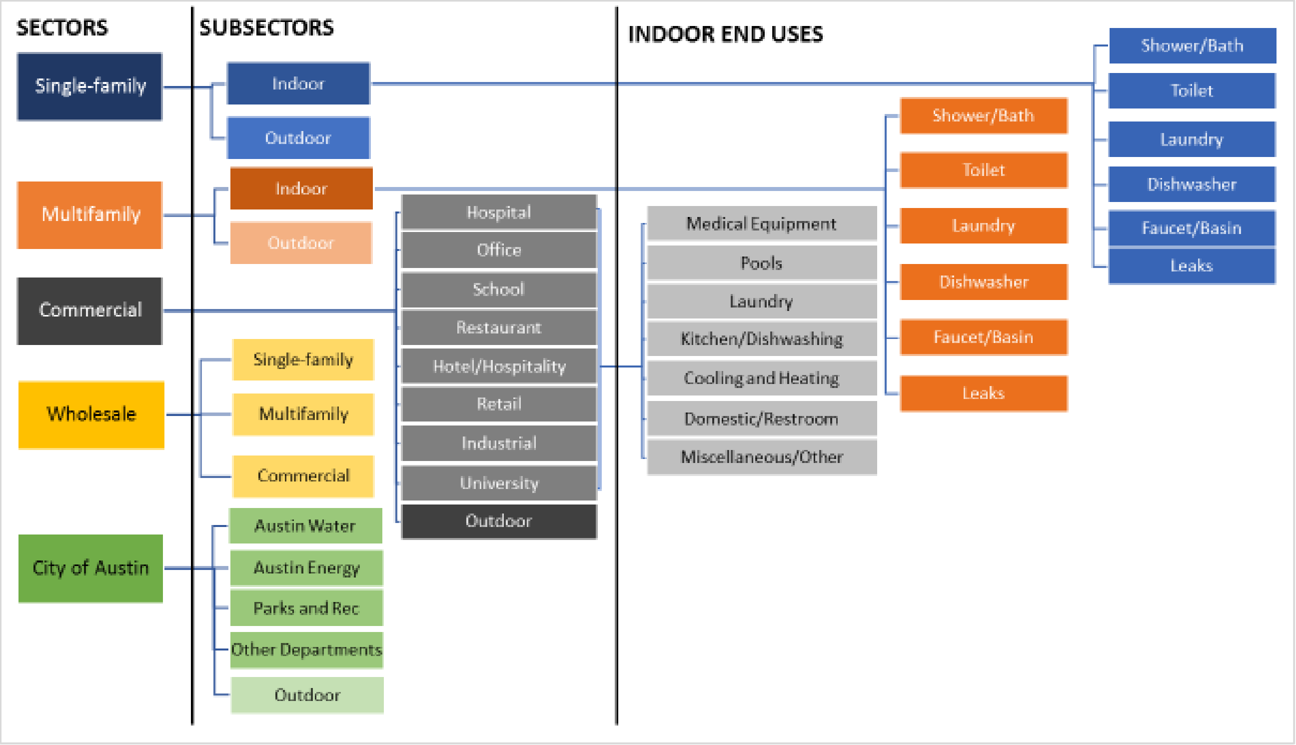

Figure 5-1. Disaggregated Demand Model Sectors, Subsectors, and End Uses

Analysis was conducted using geographic units developed in harmony with Imagine Austin, Austin's comprehensive plan. The geographic units are known as the Delphi, Trends, and Imagine Austin (DTI) polygons and they divide the city into 227 contiguous polygons. The area coverage by the DTI polygons includes the City of Austin's full and limited purpose jurisdictions as well as the city's extra-territorial jurisdiction, as shown in **Figure 5-2**. Census blocks within the DTI polygons are used to create a comprehensive baseline count of the demographics of the polygon, including population and employment. These demographics are the primary drivers of water use in the city. So, for each DTI polygon, an estimate of existing and future water demands by sector, subsector, and end use were able to be developed by the tool.

The DDM also produces a number of summary charts, tables, and graphics that support and inform the IWRP. For example, the tool allows for relatively quick assessment of the impact of a demand management measure on overall system, sectoral, or source water demand.

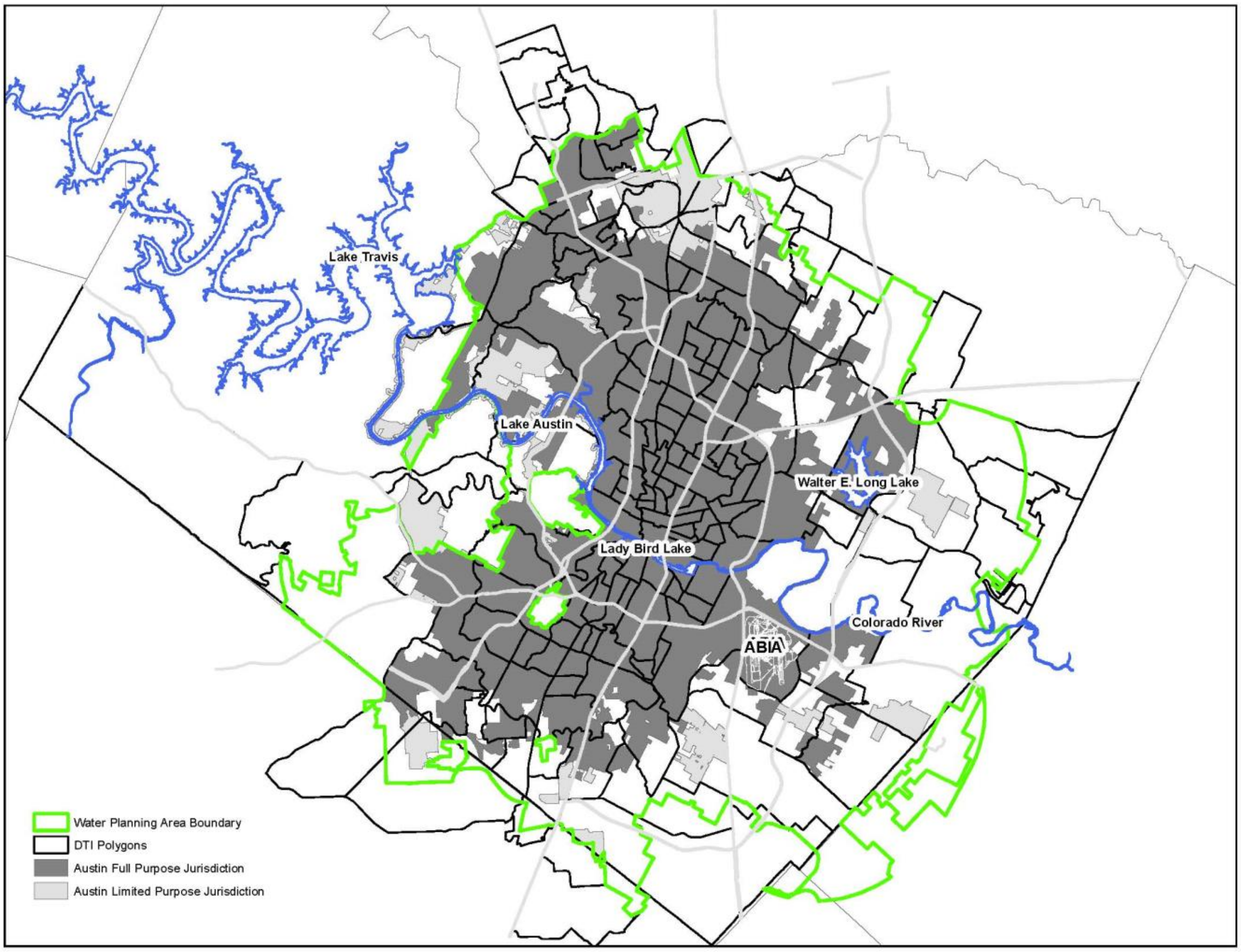

Figure 5-2. Disaggregated Demand Model DTI Geographic Units

5.1.2 Model Development

The DDM was developed by Austin Water staff using a bottom-up approach that relies on detailed, account-level billing data from 2010, 2012, 2013, 2014, and 2015. Data from 2011 was not utilized due to a change in billing systems which introduced errors into the data for that year. For each active account, the DTI polygon location was identified. Customer types and rate codes were used to determine the water use sector of the account. All billing sets were normalized to calendar month usage using the daily average of the billing cycle and the number of days in the billing cycle that occurred in each calendar month.

Water use data were then aggregated by subsector, DTI polygon, and month. Using the DTI polygon data for demographics and the aggregated water use, water use factors were calculated for each polygon for each year. Water use for single and multi-family residential customers was based on population within those housing types while commercial and City of Austin water use was based on employment within the sector.

The industry standard minimum month method was used to estimate the portion of monthly water demands that are used for outdoor, seasonal applications. Specifically, the lowest monthly water usage for each parcel without a dedicated irrigation meter was identified. This value was multiplied by 12 to estimate the total annual indoor usage for each parcel. The difference between the total parcel water usage and the calculated indoor usage was identified as annual outdoor usage. In instances where dedicated irrigation meters are present on a parcel for a given sector, all the water use from the meter was assigned the outdoor subsector and the meter representing indoor use was assigned to the indoor subsector.

To estimate current indoor end uses, research was done to identify and use best available data sources. Indoor end uses for single family residences were informed by the Water Research Foundation Residential End Uses of Water, Version 2 Report (2016). The multi-family residential and commercial indoor end uses are developed based on a comprehensive literature review of available information coupled with insight and guidance from Austin Water staff. Additional details can be found in Appendix A.1 and A.2.

For forecasting, the average water use factor from 2013 through 2015 was calculated and assumed to be the starting point of the forecast. This range of years serves to normalize water use with regard to weather as well as the different outdoor watering schedules adopted by the City. The water use factors were adjusted in the forecast years based on the given analysis scenario. The baseline scenario includes adjustments to the water use factors based on currently planned conservation activities and the best management practice of installing water efficient fixtures in the homes and businesses throughout the city. The baseline scenario, which reflects baseline levels of conservation and water reuse, was the metric against which the water needs are calculated. The baseline demand set was based on water use factors derived from the average of water use from 2013, 2014, and 2015 and represents average demand conditions, as opposed to hot dry demand conditions, which can increase the amount of water demand.

In support of the IWRP, the DDM was enhanced to allow for modeling of future demands under different weather conditions. Details on model enhancements can be found in Appendix A.3.

5.1.3 Data Sources

The primary data sources for developing the DDM are described below:

- DTI Polygons - Geographic unit of analysis for Austin Water DDM. The data include long-range, small-polygon-based population and employment forecasts produced by the City Demographer in conjunction with other city departments, including Austin Water. Contains estimates of water service population, wastewater service population, and similar employment figures for 2010, as well as projections for 2020 and 2040. Both single family and multi-family population served were developed by Austin Water for the DTI polygons. DTI projections of population and employment were extended to 2070 and 2115 in close consultation with the City Demographer.

- SOCRATES Employment Dataset - Standardized Occupational Components for Research and Analysis of Trends in Employment System (SOCRATES). Dataset created by the Texas Workforce Commission featuring a complete listing of employers within Austin as well as pertinent data (number of employees, North American Industry Classification System code, sales volumes, etc.) for the year 2010.

- Austin Water Billing Accounts and Consumption Data - Historical billing records (in the form of GIS feature point datasets) for every Austin Water customer in 2010 and 2012-2015. Note that 2011 data were excluded due to errors introduced when the city switched billing systems.
- COA Building Permit Data - All approved building permit data provided by the city's Development Services Department in the form of a database (the Application Management and Data Automation database known as AMANDA) and Shapefiles of permits by year.
- 2010 Land Use GIS polygon.

5.2 Current Water Use Summary

Over time, average annual water use on a per capita basis has been declining in Austin. This water use savings is through increased water use efficiency, and efforts by the Austin community to conserve and respond to calls for water use reduction during the recent drought. As shown in **Figure 5-3,** through much of the 1990's both water use and population were increasing at similar rates. With the onset of water conservation programs initiated by the City, like conservation-based water rates or outdoor watering schedules, as well as more efficient water fixture standards implemented by first the federal government in 1992, the City in 2007, and then the State of Texas in 2010, water use has declined despite continued population growth. On a per capita basis, annual water pumpage has declined from 190 gallons per capita per day (gpcd) in 2006 to a low of 122 gpcd in 2015 and 2016 as shown in **Figure 5-4**.

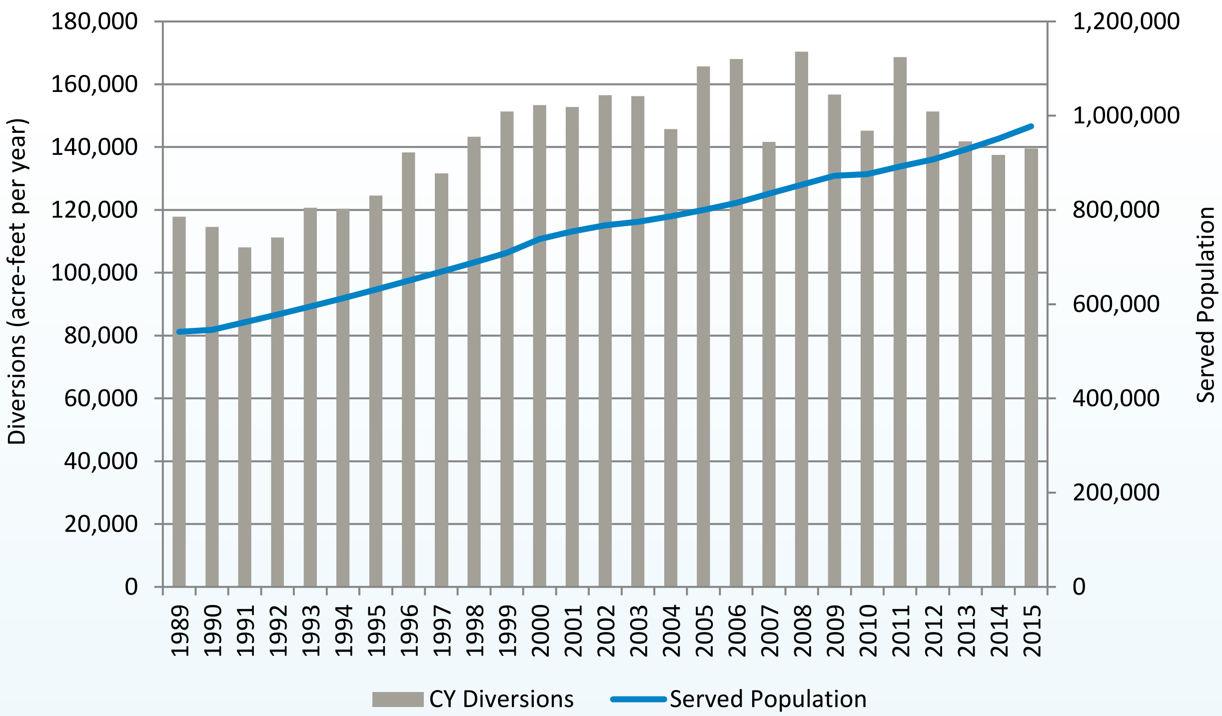

Figure 5-3. Water Diversions and Population from 1989 through 2015

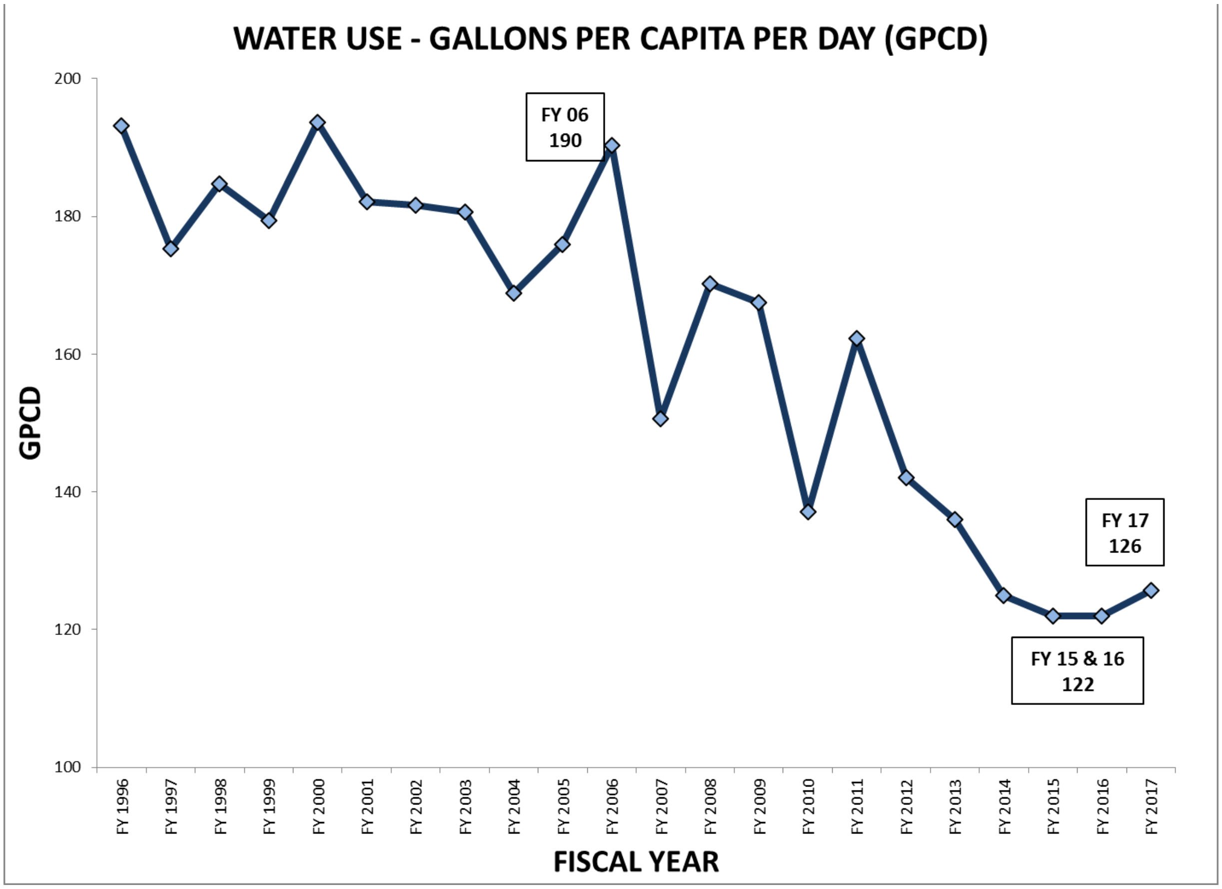

Figure 5-4. Historical Per Capita Water Demand

Austin Water and its customers use approximately 45.5 billion gallons (139,600 acre-feet) of raw water diversions each year (baseline estimate, average of 2013, 2014, and 2015). The baseline total pumpage of treated water into the distribution system per year is approximately 44.14 billion gallons (135,400 acre-feet). The difference between raw water diversions and treated water pumpage is attributable to several factors including use of some of that water in the treatment process itself, water loss due to evaporation, and metering differences. Baseline amounts of water consumed by Austin Water and its customers is approximately 39.4 billion gallons (120,900 acre-feet), based on an average of 2013, 2014, and 2015 water consumption. The difference between treated water pumpage and consumption makes up non-revenue water (NRW). Some NRW is lost through leaks in pipes on its way to customers, while other components of NRW include water used for flushing or fighting fires.

Of the water consumed, residential use accounts for 60% and commercial use accounts for 31% (**Figure 5-5**). Currently, outdoor use is estimated to be 27% of all single family residential use, 16% of all multi-family residential use, and 23% of total commercial use.

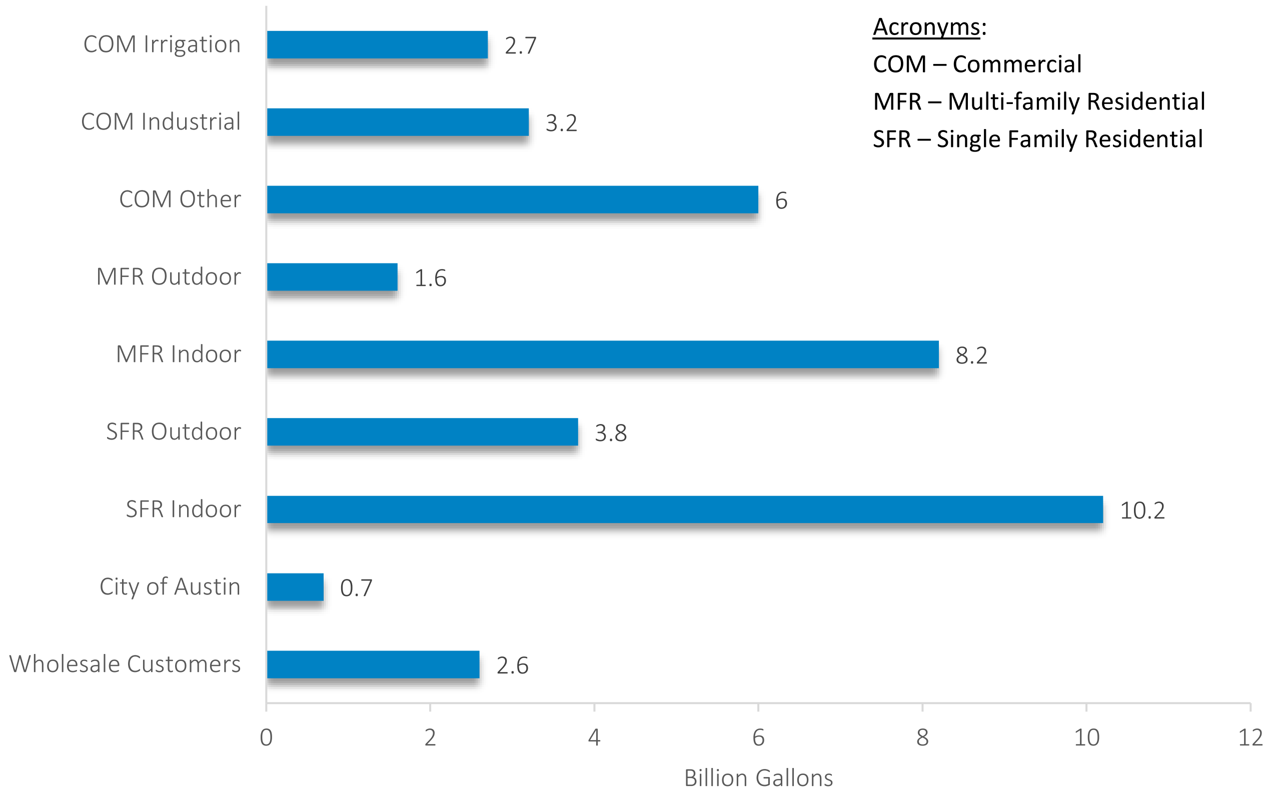

Figure 5-5. Current Water Consumption by Sector and Subsector

5.3 Future Baseline Water Demand

Baseline water demands are based on an average of 2013, 2014, and 2015 water consumption and represent future conditions based on demographic projections of population, housing, and employment in Austin. The baseline years were chosen to represent average year demands. Baseline water demands also incorporate projected passive conservation, which can result from reductions in water use from existing conservation and continued improvements primarily in indoor water using fixture efficiencies. As shown in **Figure 5-6**, under current baseline conditions, without potential future water strategies, the City is projected to need 148.13 billion gallons (or 454,600 acre-feet) of water by 2115 to serve a projected population of slightly less than 4 million people. This figure is based on treated water pumpage. Austin's corresponding baseline water diversion projection is XX acre-feet by 2115, which accounts for water used in the water treatment process. It is important to note that baseline water demands do not include future conservation savings from additional conservation programs, codes, or ordinances. Additionally, baseline demands do not reflect reductions in potable water demand due to future increases in centralized and decentralized alternative water use. Alternative water sources include highly treated reclaimed water from Austin Water's wastewater treatment plants, and onsite water sources such as rainwater, graywater, blackwater, AC condensate and stormwater. Demand projections that incorporate the implementation of Water Forward plan recommendations show a marked decrease in future projected demands from baseline demands.

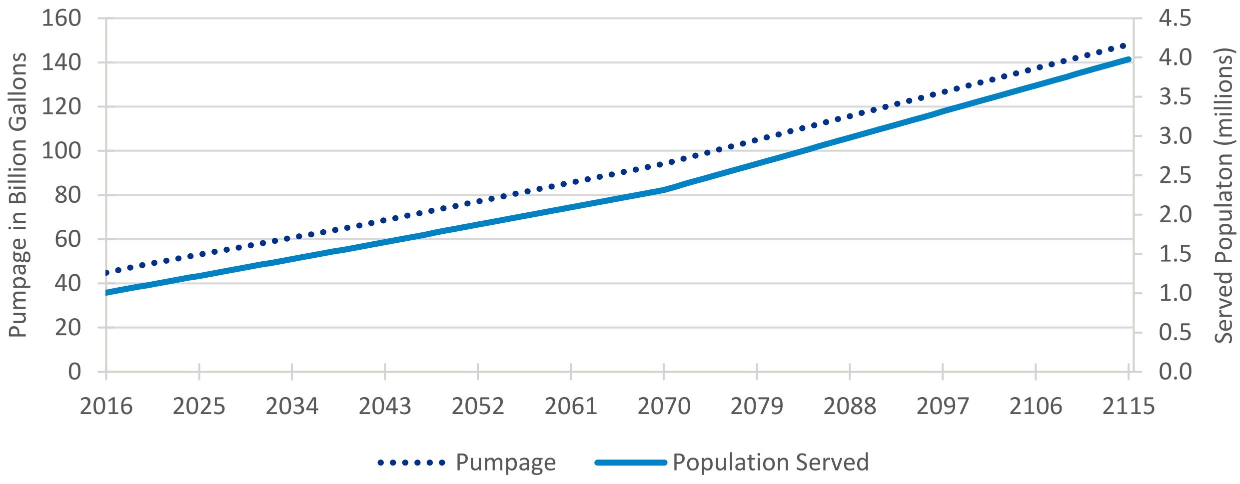

Figure 5-6. Baseline Water Pumpage Forecast with Population to 2115

Table 5-1 presents the baseline water demand forecast by sector. Baseline system pumpage is projected to grow by 236% from its current level over the next 100 years. Again, this projection does not include projected effects of water use savings of potential future demand management or other strategies that may be recommended as part of this plan. The commercial sector growth rate of nearly 270% captures the trend that employment is projected to grow at a rate greater than population served. **Figure 5-7, Figure 5-8**, **Figure 5-9** and **Figure 5-10** provide demand schematics for the forecast years.

Table 5-1. Baseline Water Demand Forecast by Sector to 2115 – Consumption, Pumpage, and Diversions

Sector	Current Demand (Billion Gallons)	Future Water Demand (Billion Gallons)			
		2020	2040	2070	2115
Single family residential	13.99	15.61	19.98	28.22	41.99
Multi-family residential	9.76	11.13	14.81	22.66	42.47
Commercial	12.03	13.16	18.02	27.60	44.39
Wholesale	2.64	2.43	2.79	3.32	3.53
City of Austin	0.70	0.89	1.48	2.05	3.07
Other	0.16	0.18	0.23	0.34	0.55
Consumption Total	39.29	43.40	57.30	84.19	136.0
Non-revenue Water	4.85	5.36	8.44	9.93	12.12
Pumpage Total	44.14	48.76	65.75	94.12	148.1
River Diversions Total	45.39	50.13	67.60	96.78	152.3

Insert Figure 5-7. Baseline Water Demand Schematic 2020

Insert Figure 5-8. Baseline Water Demand Schematic 2040

Insert Figure 5-9. Baseline Water Demand Schematic 2070

Figure 5-10. Baseline Water Demand Schematic 2115

SECTION 6: HYDROLOGY AND CLIMATE CHANGE MODELING

[Chapter Summary – To Be Developed]

AT A GLANCE

- *Definition of Water Needs*
- *Hydrologic and Climate Modeling*
- *Summary of Water Needs*

6.1 Definition of Water Needs

To guide the development and evaluation of IWRP portfolios, three types of water needs for the City of Austin were identified and assessed:

- **Type 1 Need**: This is a supply and/or conservation savings need equal to the estimated reduction in potable water demand from implementation of the City's Stage 4 Drought Contingency Plan implementation. Stage 4 water restrictions would include a prohibition on all outdoor water use and would be implemented at very low lake levels (Stage 4 is activated in the water availability model used for the IWRP at 450,000 acre-feet of combined storage). This need was established to mitigate societal, environmental, habitat, and economic impacts during prolonged droughts. Both demand management and water supply options can fill this need.

- **Type 2 Target:** This is a potable supply target developed to mitigate the risk of Austin having very little or no Colorado River supply due to severe drought, including droughts that may be worse than what the region has seen in the past. To ensure that Austin would have access to a potable water supply in a severe drought, the Type 2 target was set equal to 50% of the amount of water Austin would expect to receive from LCRA stored water, whether or not it was actually available in the model (see Appendix __ for a detailed description of how Type 2 needs were calculated). This target is triggered in the model only when combined storage in Lakes Travis and Buchanan is extremely low (less than 450,000 acre-feet or about 22% full). Only options that can readily provide potable water can fill this need.

- **Type 3 Need:** This is a supply and/or conservation savings need that is triggered when Austin's water demands are above its current 325,000 acre-feet contract with LCRA. Both demand management and water supply options can fill this need.

6.2 Hydrologic and Climate Modeling

Austin Water is using a customized version of the Colorado River Basin WAM as a key modeling tool to determine water availability from the Colorado River. For the IWRP, four hydrologic scenarios were examined to estimate the future water needs, these being hydrologic scenarios:

A. Period of record (1940-2016) with historical climate, often referred to as stationary climate

B. Period of record with climate change

C. Simulated extended period with historical climate (the 10,000 years extended period was developed to evaluate potential droughts worse than the drought of record)

D. Simulated extended period with climate change (the 10,000 years extended period was developed to evaluate potential droughts worse than the drought of record)

6.2.1 Climate Change Modeling

Rising temperatures, increased evaporation rates, and an acceleration of the hydrological cycle is increasing the duration and severity of droughts as well as the intensity of heavy precipitation in many places around the world (IPCC, 2012). These and other changes that have been attributed to human-induced climate change are projected to continue over the remainder of this century and beyond. Climate change effects are expected to be pronounced in Texas by the mid-21st century (Hayhoe, 2014). Summer daily high temperatures are expected to increase, and winter nightly low temperatures are expected to increase as well. Long-term average annual precipitation is not expected to change. However, it is expected that the duration of consecutive dry days will increase in frequency with punctuation by heavy rainfall events.

The Texas Commission on Environmental Quality (TCEQ) Water Availability Model (WAM) for the Colorado (River basin includes a historical period of record from 1940 through 2016. The Water Forward WAM contains demand management and water supply scenarios for 2020, 2040, 2070, and 2115. Therefore, to address potential changes to climate in future WAM simulation scenarios, global climate models are used to project hydrologic conditions for 2040, 2070, and 2115. The results of the global climate models form the basis of adjustments to the Water Forward WAM's historical period of record hydrology for these later time horizons.

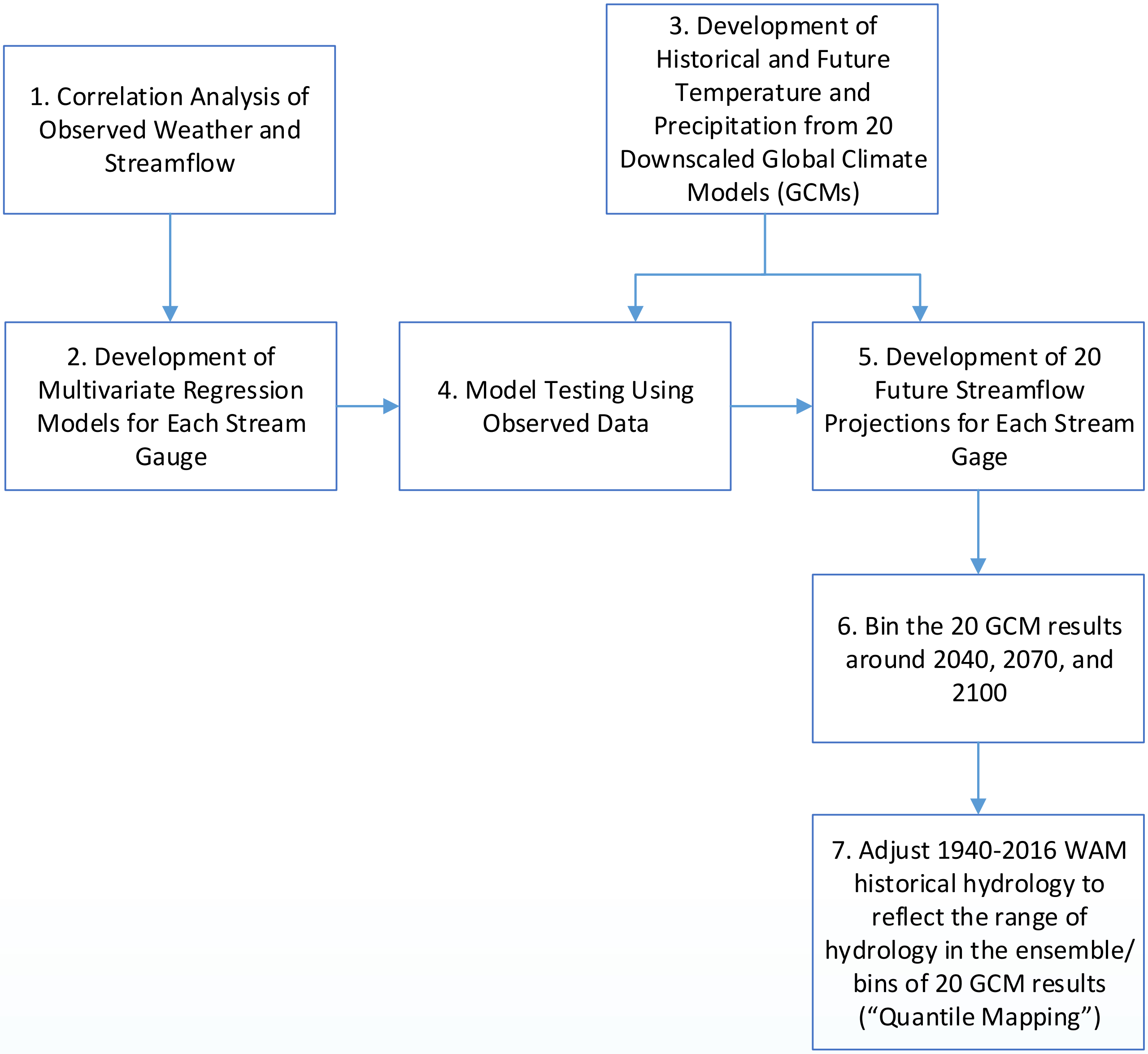

Fig. 6-1 Climate and Hydrology Analysis Process Graphic

1. Correlation Analysis of Observed Weather and Streamflow

Observed daily streamflow at 43 gaging locations in the Colorado River basin were correlated with a large number of weather variables (see **Figure 6-2**) reflecting variability in observed temperature and precipitation from 1950 through the present.

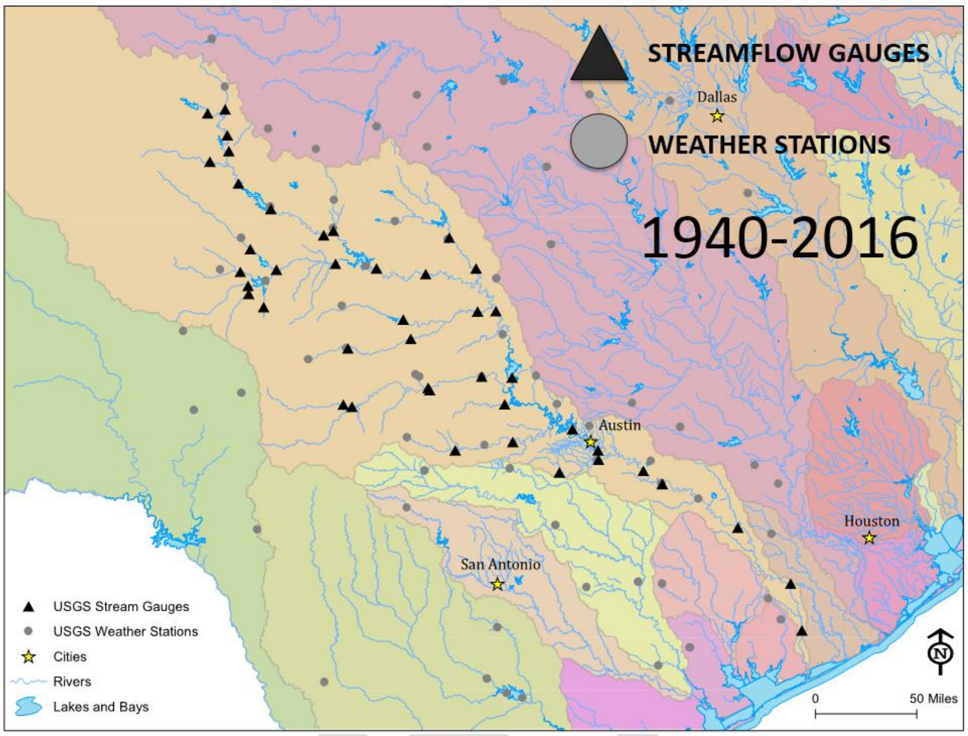

Fig. 6-2 Colorado River Basin Streamflow Gages and Weather Stations

2. Development of Multivariate Regression Models for Each Stream Gage

Statistical regression models of historical streamflow at each gage were built to predict streamflow as a function of the historical weather variables.

3. Development of Historical and Future Temperature and Precipitation from 20 Downscaled Global Climate Models (GCMs)

Next, high-resolution climate projections of temperature and precipitation from 20 global climate models under a higher and lower carbon emission scenario were downscaled to the same weather stations used to build the statistical models of streamflow at each gage. The higher emission scenario was selected for use in Water Forward as it represents the current trajectory of carbon emissions and serves as a distinctly different outcome of future hydrologic conditions when compared to the historical observations of basin hydrology.

4. Model Testing Using Observed Data

Each gage regression model was validated on observed data by dividing the historical data in odd and even years, using one set of the data to build the regression model, and the other for cross-validation, then switching (See **Figure 6-3**).

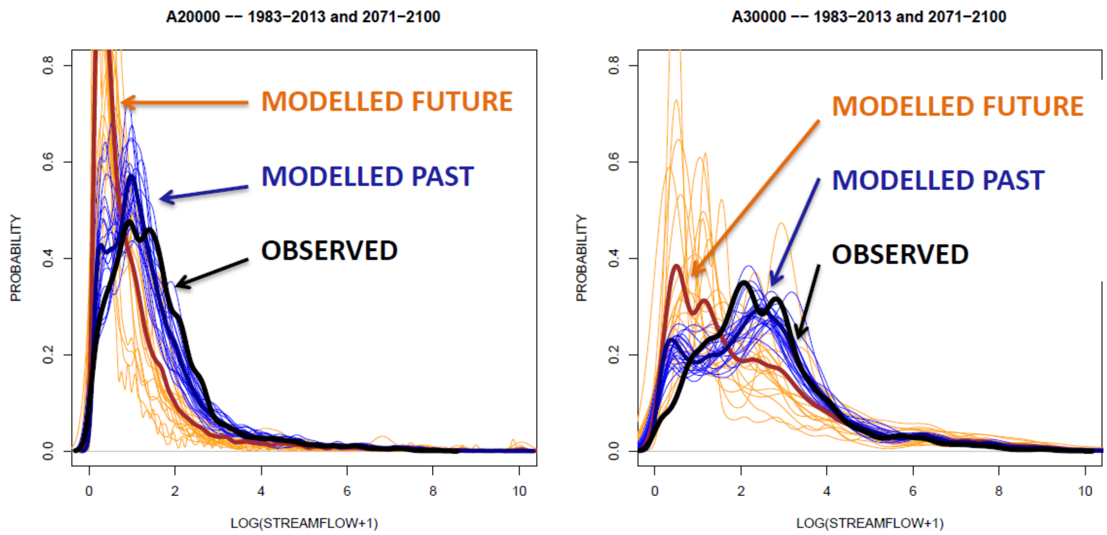

Fig. 6-3 Comparison of Observed, Modelled Past, and Modelled Future Streamflow for a Selected Stream Gage

5. Development of 20 Future Streamflow Projections for Each Stream Gage

The streamflow regression models were driven with the data from the global climate models to create projected streamflow conditions through 2100 (*Hayhoe et al., 2018)* (See **Figure 6-4**). The gage-specific streamflow projections as well as evaporation and precipitation projections were used to develop basin-wide inputs to the Water Forward WAM.

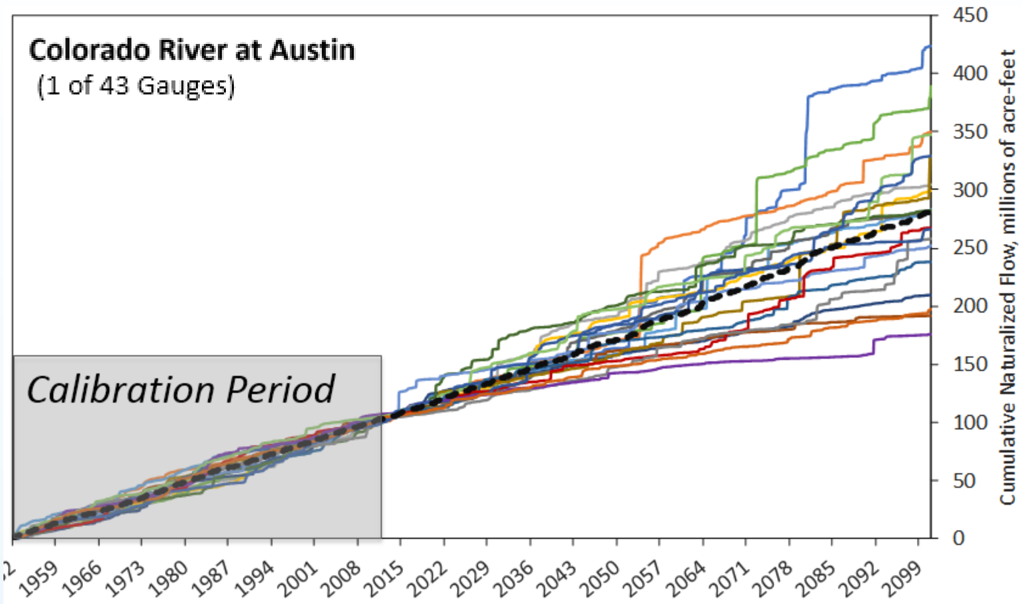

Fig. 6.4 Twenty Projections of Cumulative Naturalized Flow (Millions of Acre Feet) for the Colorado River at Austin Gage

6. Bin the 20 GCM results around 2040, 2070, and 2100

An ensemble of all 20 global climate model-derived future streamflows, precipitation, and evaporation were created for each stream gage. The ensembles were developed as 21-year spans of time centered around 2040 and 2070. Since data from the global climate models were only available through 2100, the ensemble for developing hydrology for the 2115 demand and water management scenario was taken as the period of projection from 2080 through 2100. The ensembles of global climate model derived hydrology are as follows: 2030 through 2050 (21 years centered on 2040), 2060 through 2080 (21 years centered around 2070), and 2080 through 2100 (the last 21 years of global climate model results) (See **Figure 6-5**). Each ensemble contains downscaled hydrology derived from all 20 climate models which creates 5,040 monthly samples of projected future hydrologic conditions at each gaging station.

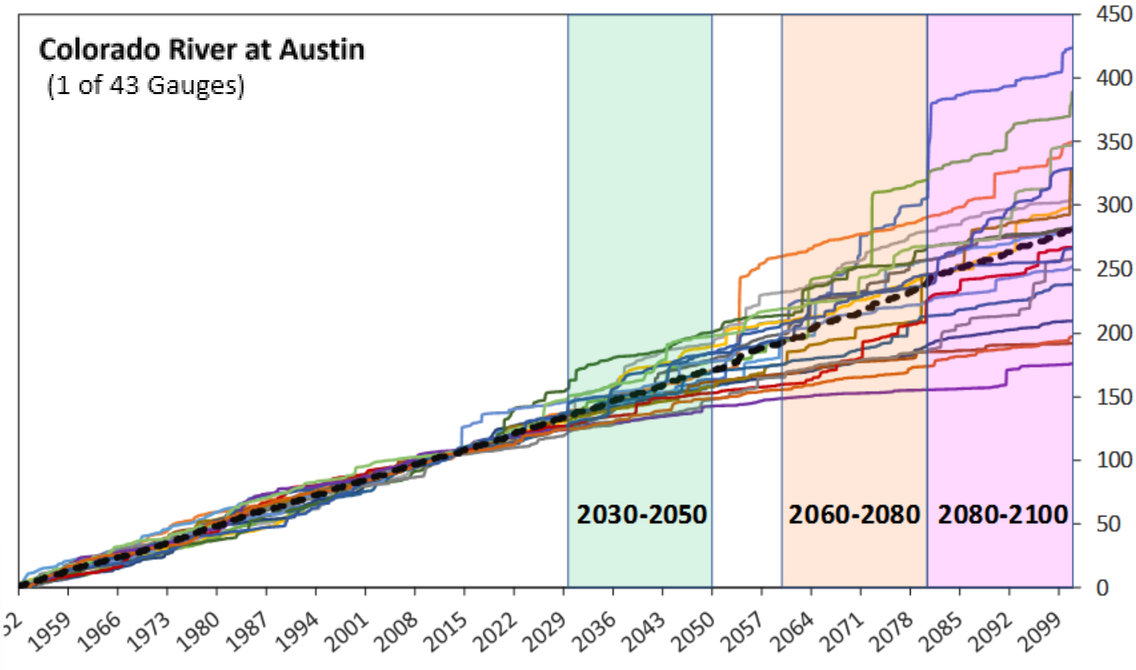

Fig. 6.5 Bins Used to Develop Streamflow Ensembles (2030 through 2050, 2060 through 2080, and 2080 through 2100)

7. Adjust 1940-2016 WAM historical hydrology to reflect the range of hydrology in the ensemble/bins of 20 GCM results ("Quantile Mapping")

Adjustments to the historical period of record hydrology were made using the ensembles of gage-specific streamflow projections and evaporation and precipitation projections. The statistical characteristics of the ensembles of future hydrology were mapped onto the existing historical period of record at each gaging location in the basin using a methodology known as "quantile mapping" (See **Figure 6-6**). Quantile mapping has been applied similarly in other long-term future water planning studies (Wood et al. 2002; Salathe et al. 2007; CH2M Hill 2008; Hamlet et al. 2009; Bureau of Reclamation 2010, California Dept. of Water Resources 2013). The statistical properties of the ensemble, such as the mean and variability, are transferred to the adjusted WAM hydrology, evaporation, and precipitation. Only the sequencing of dry and wet periods of the historical WAM hydrology is retained.

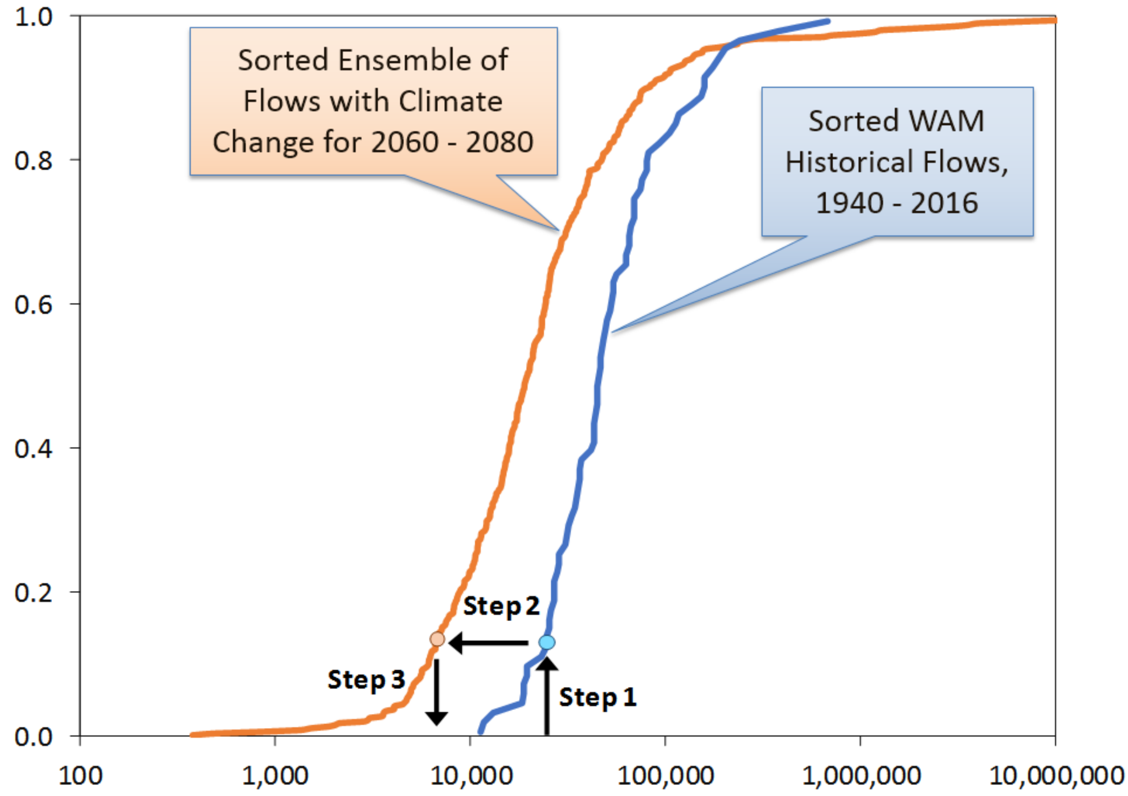

Fig. 6-6 Quantile Mapping Process Graphic

To demonstrate the projected impact of climate change, a comparison of annual naturalized flows at the Colorado River at Austin gage with historical hydrology and projected climate changed hydrology is shown in **Figure 6-7**.

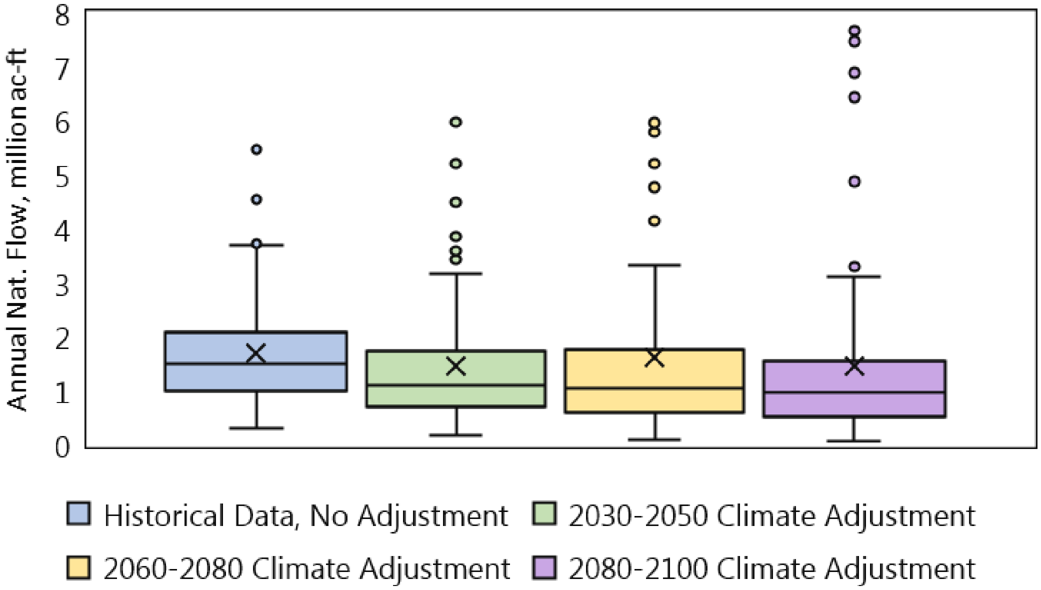

Fig. 6-7 Comparison of Annual Naturalized Flows at the Colorado River at Austin Gage

6.2.2 Extended Simulation Period

The historical hydrologic period of record for the Water Forward WAM covers 1940 through 2016. Within the historical period are two major droughts that are centered in the 1950's and 2010's. For the purposes of the Water Forward plan, the 2010's drought serves as the "drought of record" because the hydrologic conditions result in the lowest water supply from the Highland Lakes reservoirs. A water supply modeling objective of Water Forward is to analyze the impacts of droughts that are worse than the drought of record. Though this worse drought is yet to be observed, water supply planning should anticipate the likelihood of such an event occurring, especially over a 100-year planning horizon and against the backdrop of climatic changes.

The methodology used in Water Forward to create plausible hydrologic conditions for modeling droughts worse than the drought of record (DWDR) involves resequencing the period of record. The methodology is formally known as Monte Carlo Markov Chain (MCMC) sampling. Whole years of hydrology from the period of record are randomly selected and connected back-to-back in order to build a long and hypothetical sequence of flows. The random sampling is the Monte Carlo component of the methodology. The sampling is not entirely random. The probabilities of transitioning from wet years to dry years, or dry years to average years, for example, in the long sequence of sampled flows matches the same probabilities in the period of record. Maintaining the same probabilities of transition between years is the Markov Chain component of the methodology. Taken together, the random sampling with adherence to transition probabilities allows for the creation of a long and hypothetical sequence of flows that has the same long-term statistical properties of the period of record.

Using a long sequence of extended hydrologic conditions allows for the random occurrence of conditions that are both wetter and drier than contained in the period of record. Multi-year droughts in the extended hydrology can be worse than the 2010's drought. For example, the 2010's drought is punctuated by high flow events in early 2012 and mid-2015. If random sampling replaced the hydrology of 2012 or 2015 with a drier year in the extended hydrology, then the new drought sequence could be worse than the observed 2010's drought. The extended hydrology used for Water Forward covers 10,000 years of simulation. The length of this simulation is intended to be long enough for random chance to produce a large number of candidate droughts that are worse than the period of record. These candidate droughts are further ranked in the degree to which they are worse than the 2010's drought. Identifying new candidate DWDR's in the extended hydrology and ranking their severity allows Water Forward to test water availability in a statistical manner under DWDR conditions.

6.3 Summary of Water Needs

Using the methodology described in 6.2, the water needs for the IWRP are summarized in Figure 6-2.

[Graph to be inserted]

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SECTION 7: WATER CONSERVATION AND DEMAND MANAGEMENT STRATEGIES

Water conservation programs (i.e., demand management) have long been and will continue to be a critical element in Austin Water's management of water resources. Austin Water also continually evaluates its water conservation programs to determine whether they should be modified, phased out, or new programs implemented to achieve evolving conservation goals and to ensure pursuit of cost-effective strategies that reach all customers. This section: describes Austin Water's historical water conservation efforts, in Section 7.1; discusses Austin Water's current conservation measures, Section 7.2; and presents the selected demand management options under consideration for future project portfolios in support of the IWRP, Section 7.3.

AT A GLANCE

- *Water Conservation History*
- *Current Water Conservation Measures*
- *Water Conservation and Demand Management Strategies for the Future*

7.1 Water Conservation History

The first water conservation plan was developed for Austin in 1983. That came in response to dangers of demand exceeding treatment capacity after voters turned down bonds to expand treatment capacity and the City kept growing. Per capita water use dropped after the City instituted conservation programs, but total water use continued to rise commensurate with the level of growth. In the 1980s and much of the 1990s conservation was seen more as an emergency measure when there was a danger of exceeding treatment capacity.

Over the years, the City's water conservation efforts have evolved into programs designed to reduce both peak-day demand and average per-capita use, reduce system loss, increase reclaimed and alternative water use, focus more on reducing larger outdoor water use, and encourage innovative technologies and methods.

In 1999 the Austin City Council approved a long-term water supply agreement with the LCRA. That agreement featured a conservation incentive that has proven important as the years have gone by. Under the agreement, Austin prepaid $100 million for water. With this prepayment, the agreement specified that Austin will not pay additional amounts for water until the average of the City's diversions from the Colorado River/Highland Lakes for two consecutive calendar years exceeds 201,000 acre-feet. This was projected to occur around 2016 and the City planned to increase conservation to put the trigger off until 2021.

In the years following the LCRA Agreement water usage continued to increase with growth. Per capita usage had dropped during the 1980s, but by the mid-'90s had reached a plateau. This plateau continued into the early years of the next century.

Then came several turning points regarding water conservation in Austin. In 2005 the Water Conservation Division was moved from the Resource Management Department to Austin Water (then still known as the Austin Water and Wastewater Department). Prior to that time the philosophy had been that the conservation function should not be located within the utility because the utility was focused on selling water rather than conserving it.

As the Water Conservation Division was settling in to Austin Water, the utility revived a long-delayed project, Water Treatment Plant 4. The City Council, at public urging, wanted to ensure that absolutely every effort was being made to save water before building a new treatment plant. So in 2006 the Council created the Water Conservation Task Force (WCTF) with the charge of reducing peak day water use. The WCTF consisted of the Mayor, two Council Members and four representatives from City boards and commissions (Water Wastewater, Planning, and Resource Management Commissions and the Environmental Board).

The WCTF, working primarily with Austin Water conservation staff, concentrated on reducing peak load and developed 22 new programs and strategies designed to reduce peak demand by one percent (%) per year for 10 years.

The Council ultimately decided to move forward with both the task force recommendations and with building Water Treatment Plant 4 – after moving the site away from the head waters of Bull Creek. The recommendations of the WCTF were approved by the City Council in May 2007. The WCTF recommendations formed the foundation for dramatic drops in water usage in Austin. The biggest savings measure was the limitation of outdoor watering to two proscribed days per week.

Ironically, in 2007 the Austin region experienced one of the wettest summers in its history -- meaning low levels of water use due to the weather rather than any new rules or policies. The next year, in 2008, the two-day-per-week watering restrictions kicked in, the citizens of Austin responded, and per capita water use began dropping dramatically – never returning to 2006 levels.

The Council and the citizenry, however, were determined that Austin's water use drop even faster. In approving the WCTF plan, the Council had created another task force to serve in an advisory role during implementation of the WCTF recommendations. This task force was called the Citizens Water Conservation Implementation Task Force. In 2009 the Council expanded the task force's role, asking it to recommend additional strategies and programs to increase water conservation. The task force subsequently recommended a goal of 140 gallons per capita per day (GPCD) by 2020. Austin Water and the citizens of Austin embraced that goal and it was achieved several years earlier than the 2020 target.

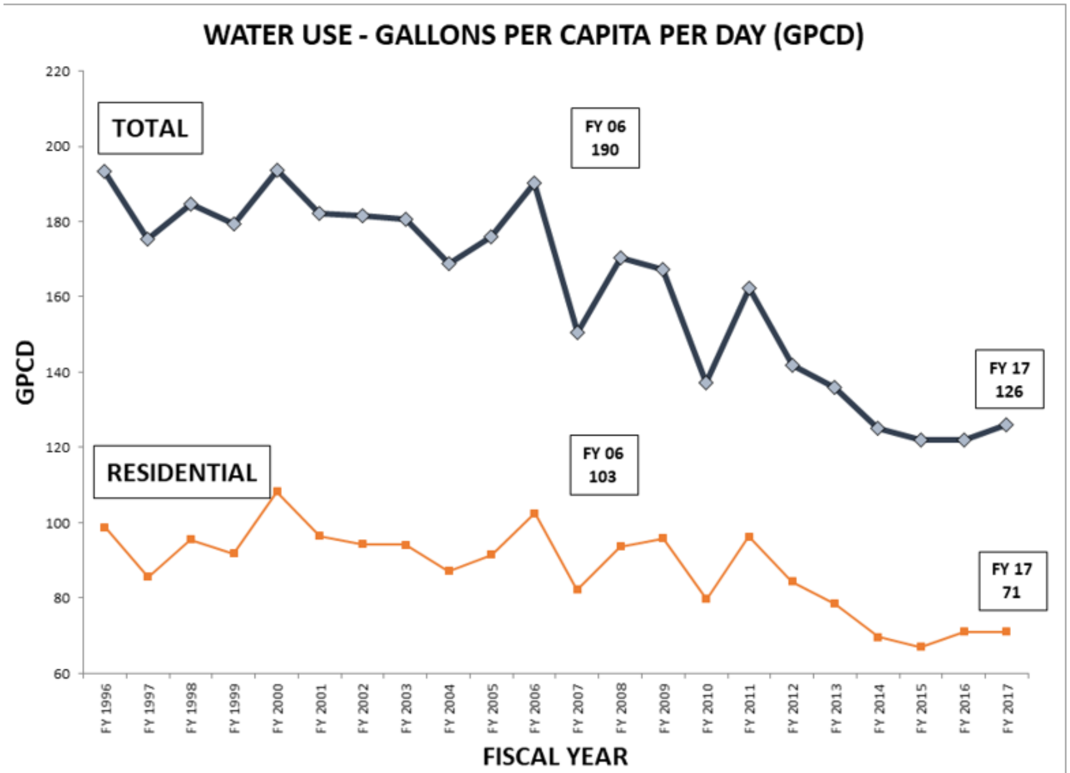

Fig. 7-1 City of Austin Water Use in Gallons Per Capita Per Day

Meanwhile the Central Texas region had entered a historic drought, which began in 2008. Based on the lake level triggers in the Drought Contingency Plan (DCP) Austin went to Stage 2 one-day-per-week watering restrictions in September 2011 and stayed there until 2016 except for a brief City-Manager ordered return to two-day-per-week in 2012. In 2012 Austin strengthened its Drought Contingency Plan.

The drought has come to be known as the worst drought since the lakes were built. Water volume in the lakes reached the second lowest level in history, and would have hit the lowest if not for the conservation response of Austin.

The drought was broken by huge rains in 2015 and 2016. The drought, combined with Austin's strengthened water conservation programs, led to historic drops in water usage in Austin. Since the Water Conservation Task Force recommendations were passed, Austin's per capita water usage has dropped 35%. And, even as the City continued its rapid growth, total water use has also dropped. The City now uses less water than it did at the turn of the century, although the population has increased by around 300,000 since then.

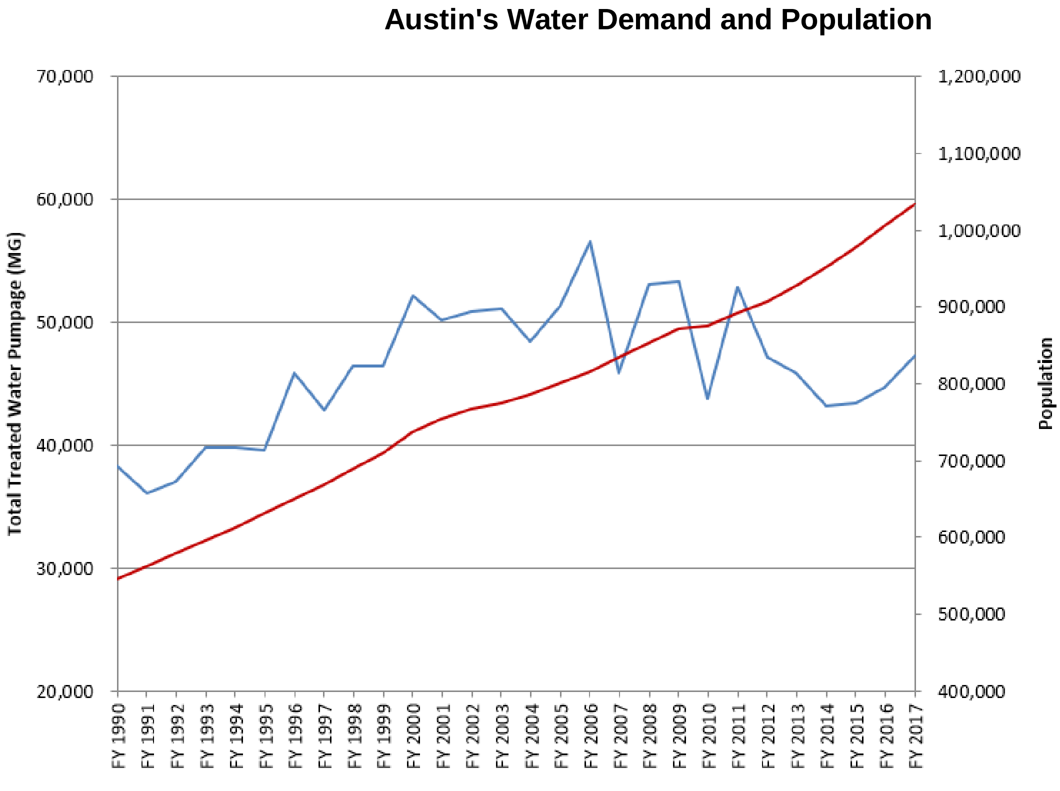

Fig. 7-2 Austin's Water Demand and Population

After these water conservation gains, the City is not expected to reach the LCRA payment trigger until the 2030s at the earliest.

Also, the theory that conservation could not be achieved with the Water Conservation function located within the utility proved to not be the case – as all the dramatic water conservation gains occurred after the transfer.

After the drought was broken Austin Water worked with the citizens of Austin to ensure that per capita water use would never return to pre-drought levels – as has happened in other places. For example, in 2016 Austin Water proposed and the City Council approved maintenance of one-day-per-week restrictions permanently for automatic sprinkler systems, the least efficient form of irrigation. In Conservation stage, hose end sprinklers can be used two days per week.

An overwhelming majority of citizens have remained conscious of the need for conservation and water usage has only increased slightly since the drought ended.

In 2017 the region experienced a dry year and 2018 has been relatively dry as well, meaning the area could be entering another drought. It is such events that Austin's Drought Contingency Plan, its water conservation programs, and the Water Forward plan are intended to address.

Austin Water's conservation program has received numerous awards over the years from state and national organizations. Awards received just within the last five years include:

- 2013 Promising New Program from the American Council for an Energy Efficient Economy and the Alliance for Water Efficiency;
- 2014 Water Conservation and Reuse Award, Texas Section of the American Water Works Association
- 2014 Municipal Blue Legacy Award in Municipal Water Conservation, Texas Water Conservation Advisory Council
- 2015 Municipal Blue Legacy Award in Municipal Water Conservation, Texas Water Conservation Advisory Council; and
- 2016 highest scoring water conservation program in Texas, Texas Living Waters Project (Lone Star Chapter of the Sierra Club, the National Wildlife Federation, and Galveston Bay Foundation).

An overview of Austin's water conservation incentive programs including those implemented during the early years are summarized below in **Table 7-1**.

Table 7-1. Summary of Historical Austin Water Conservation Incentive Programs

Water Conservation Program	Equipment or Service Issued	Program Description	Implementation Date /End Date
Landscape Irrigation Audits	Free Audit and hose timers	The City offers free landscape irrigation audits to both residential and commercial customers who water excessively outdoors. In 1998, the City offered free hose timers to customers who irrigated with hose-end sprinklers.	1985 since modified and still in effect
Toilet Rebate Program	Rebate for ULF[1] toilets	The City offered a rebate to residential customers to encourage replacing old toilets with ULF[1] models. The program initially offered a rebate of $60-$80 per toilet then increased to $200 per toilet depending on the model purchased.	1991 through June 2010
Free Toilet Program	Free ULF[1] toilets	The City offered the Free Toilet Program to encourage the replacement of older less efficient models with ULF models. This program was initially limited to low income residential customers, but was expanded to all residential customers, multi-family and commercial customers.	1994 through December 2011
High-Efficiency Washing Machine Rebate Program	Rebate for high-efficiency washing machines	The City offers the High-Efficiency Washing Machine Rebate for water-and-energy efficient washing machines identified by the Consortium for Energy Efficiency. The initial rebate was for $100 but was lowered to $50 in 2010.	1998 through 2013
ICI[2] Rebate/Bucks for Business	Free audit	The City offers a free service to commercial customers, where water conservation staff auditors would evaluate a business' water consumption and use and suggest ways to reduce water use.	1996 since modified and still in effect
Rainwater Harvesting Rebate/Rain Barrel Sales	Rebate for rain barrels	The City offers rebates for rainwater harvesting, which included a $30 rebate for purchasing approved rain barrels and rebate of up to $500 for implementing higher-volume pressurized rainwater systems. In 2001, the Water Conservation Department started to supply barrels to its customers at a reduced and subsidized price of $60 per barrel. The Rain Barrel Sales Program ended in 2009.	2000 since modified and still in effect
Xeriscape Program/Water Wise Landscape	Rebate for using native plants and turf grasses	The City initially launched an education program to promote the principles of Xeriscaping to emphasize the practice of using plants there were native or adapted to the climate in order to reduce or even eliminate the need for irrigation. In 1994, the program was modified, and a residential rebate was initiated to encourage the installation of plants and turf grassed that were better adapted to the climate.	1984 through 1998
Residential Landscape Conversion Incentive - Lawn Remodel Option	Rebate to replace turf with Bermuda or Buffalo grasses	The City offered residential customers a one-time opportunity to replace water-thirsty turf with Bermuda or Buffalo grasses. Rebates for this program ranged from $10 to $30 for every 100 square feet of turf converted.	October 2011 through September 2013
Restaurant Water Waste Program	Free audit and 1.6 gpm[3] spray valves	Water Conservation Department staff members preformed water audits for restaurants and replaced old spray valves with new 1.6 gpm[3] valves.	2004 through January 2006

[1]Ultra-low flush (ULF) toilets use 1.6 gallons per flush or less
[2]Industrial Commercial and Institutional (ICI)
[3]Gallons per minute (GPM)

7.2 Current Water Conservation Measures

Austin Water achieves water conservation progression through the passing of codified ordinances and programs implemented through the Water Conservation Division, including, but not limited to, rebates for water-saving equipment, dispersion of free equipment, and activities aimed at increasing public education on the importance of water conservation. The following section provides an overview of current water conservation measures; a more comprehensive summary can be found in **Appendix D.**

7.2.1 Ordinances

Austin's water conservation ordinances apply to commercial businesses and residences throughout the city. A comprehensive chronology of Austin's water conservation codes and ordinances adopted from 2007 through 2017 follows. [This will be converted to a timeline graphic once text is finalized]

2007

- Automatic irrigation systems prohibited from watering between 10:00 a.m. and 7:00 p.m. year-round.
- Allowed no more than two times per week residential watering from May thru September; commercial watering is permitted year-round.

2008

- Submeters required in new multi-family and mixed-use facilities.
- High-efficiency urinals using 0.5 gallons per flush required for new construction and retrofits.
- Commercial food waste and garbage disposal units prohibited.
- Liquid ring surgical and dental vacuum pumps prohibited.
- New or replacement cooling towers must achieve at least five cycles of concentration and have conductivity controllers, makeup and blowdown meters, overflow alarms, and drift eliminators.
- Car wash equipment efficiency and facility certification requirements.
- Automatic irrigation system design standards for new commercial and multi-family residential properties.
- Commercial landscape soil depth and plant requirements adopted.

2009

- Fifth tier residential water rate for use above 25,000 gallons per month.

2010

- High-efficiency toilets using 1.28 gallons per flush or less required for facilities built or renovated on or after October 1, 2010; waterless urinals allowed.
- Innovative Commercial Landscape Ordinance requiring new commercial developments to capture storm water to prevent runoff and for landscape irrigation.

2011

- Stormwater retention and irrigation required for new commercial properties.

2012

- Year round two times per week watering schedule for all customers.
- Morning automatic irrigation system watering reduced from midnight to 5:00 a.m.
- Mandatory reclaimed water hook-up.
- Graywater Allowances (UPC).

2013

- Revised rate structure to compress residential rate tiers including 5th tier to now apply to residential use above 20,000 gallons per month.
- Mandatory irrigation system audits every two years for commercial/multi-family/city properties over one acre.
- Mandatory annual vehicle wash facility efficiency assessment for commercial, multi-family and city facilities and related efficiency requirements. (WCO)
- Administrative enforcement process/penalties for water use violations.
- Requirement that water be served only at the customer request at restaurants.
- Hotels must have towel/linen exchange programs.

2016

- Year-round watering one time per week for automatic irrigation systems.

2017

- Requirement to install air conditioning (AC) condensate collection systems for new commercial and multi-family development with a combined cooling capacity equal to or greater than 200 tons.
- Require registration and inspection of all cooling towers using potable water to ensure that affected cooling towers are achieving a minimum of five cycles of concentration, have makeup and blowdown sub-meters, a conductivity controller, a drift eliminator, and an overflow alarm. Also ensure that new towers of 100 tons are greater are connected to the Building Energy Management System or Utility Monitoring Dashboard and either using reclaimed or onsite

alternative sources such as AC condensate as a part of their makeup water or are beneficially reusing blowdown water.

- Require all steam boilers to have conductivity controllers to control blowdown (for 50 HP or greater, this must be connected to the Building Energy Management System or Utility Monitoring Dashboard), a cold-water make-up meter, a steam condensate return system, and a blowdown heat exchanger to transfer heat from blowdown to the feed water.
- Adopted plumbing requirements consistent with the 2015 International Residential Code for residential facilities and the 2015 Uniform Plumbing Code for commercial facilities with local amendments including 1.28 gpm for commercial kitchen pre-rinse spray valves instead of the current requirement of 1.6 gpm.

7.2.2 Residential Customer Programs

Austin Water currently offers a variety of free indoor and outdoor conservation tools and rebates to help residential customers save water. These free include: water-efficient showerheads, kitchen and bathroom faucet aerators, soil moisture meters, water saver hose meters, and sunlight calculators. Rebates and programs offered by Austin Water include:

- "Controller 101" Workshops – Residential customers may attend a free hands-on workshop to review how irrigation controllers work and find out about hidden features and options that can help save water and money.
- Dropcountr - Free home water use reports available by mobile app and/or by internet can help save customers water and money by providing historical water use and rate tiers, comparisons to similar and efficient homes, water saving tips and links to applicable rebate programs.
- Irrigation System Evaluations and Rebates – Free Irrigation System Evaluations by a licensed irrigator from Austin Water for customers with in-ground sprinkler systems that have used either more than 25,000 gallons in one month or more than 20,000 gallons in two consecutive months. Customers can also receive rebates of up to $400 for improving the water efficiency of their irrigation system.
- Landscape Survival Tools Rebate - Residents can receive up to $180 for mulch, compost and yard aeration to help retain soil moisture and more efficiently water their lawns.
- Low Income Water Efficiency Assistance – Austin Water partners with Austin Energy to provide free high efficiency aerators and showerheads to low income customers through AE's Weatherization Assistance Program. AW is currently developing its own direct assistance plumbing repair program for low income single family customers as well as a new grant program for water lateral repair for low income single family customers similar to the current program for wastewater laterals.
- Pool Cover Rebate – Residents can receive a rebate for half of the purchase price up to $50 for a new manual pool cover or solar rings, or $200 for a new permanent, mechanical pool cover.
- Pressure Regulating Valve (PRV) Rebate – Residents can receive a rebate of up to $100 for the purchase and installation of a PRV.

- Rainwater Harvesting Rebate – Residential, multi-family, and commercial customers or qualifying water providers can receive up to $5,000 for purchasing equipment to capture rainwater.
- Watering Timer Rebate – Residents can receive a rebate of $40 or 50% of the cost of purchasing up to two hose timers.
- WaterWise Landscape Rebate – Residential customers may receive $35 for every 100 square feet (minimum 500 square feet) of converted landscape with a maximum rebate of $1,750.
- WaterWise Rainscape Rebate – Schools and homeowners can receive up to $500 for installing landscape features that direct and retain rainwater/runoff, such as berms, terraces, swales, rain gardens, porous pavement, and infiltration trenches.

7.2.3 Incentive Programs for HOAs and Multi-Family Facilities

Austin Water offers the following incentive programs for homeowner associations (HOAs) and multi-family facilities:

- Multi-Family Efficiency Program – Austin Water partners with Austin Energy to provide free high efficiency aerators and showerheads to multi-family facilities with low income tenants through AE's Multifamily Efficiency Program.
- Pressure Reduction Valve Rebate – Multi-family Facilities can receive a rebate of up to $500 for the purchase and installation of PRVs.
- Rainwater Harvesting System Rebate - Multi-family facilities can receive up to $5,000 for purchasing equipment to capture and use rainwater.
- Waterwise Landscape Rebate – HOAs may receive $35 for every 100 square feet (minimum 500 square feet) of converted landscape with a maximum rebate of $1,750.

7.2.4 Incentive Programs for Businesses

Austin Water offers a variety of water conservation incentive programs for businesses.

- Austin 2030 – Austin Water partners with the local South-central Partnership for Energy Efficiency as a Resource (SPEER) District 2030 program to help downtown businesses meet water and energy use reduction goals by 2030.
- 3C Business Challenge - A "desk top" water efficiency auditing tool that allows businesses the opportunity to show their commitment to saving water and gain information about ways to reduce water usage. The challenge also provides tools and information to help them incorporate sustainable practices and links to related rebate programs.
- "Bucks for Business" Commercial Rebate - This program offers rebates for equipment and process upgrades that save water and exceed city water efficiency requirements of up to $100,000. Rebates offered under this program include but are not limited to: air conditioner (AC) condensate recovery, ozone treatment systems for large commercial laundry facilities, cooling tower efficiency upgrades, process water reuse and recycling systems.

- Commercial Kitchen Rebate – This program offers up to $2,500 for EPA WaterSense/Energy Star labeled commercial kitchen equipment.
- Green Building Program – AW participates in Austin Energy's Green Building Program by providing information on water efficiency related code requirements, potential water use efficiency best management practices, alternative water recommendations, water use benchmarking data, and information on available incentive and rebate programs that can be used to achieve the desired or required rating. Certain City of Austin ordinances and programs (for example, the S.M.A.R.T. Housing Program) mandate that a particular AEGB star rating be achieved. In addition, an AEGB rating can be required through zoning ordinances of projects located in defined areas of the city such as high density/growth areas.
- Industrial, Commercial and Institutional (ICI) Audit Rebate – ICI customers may receive up to $5,000 for an independent audit of their facility to identify potential water and cost savings.
- Irrigation System Improvement Rebates, Austin Water offers a rebate of up to $5,000 for a central computer irrigation controller system. Additional rebates are available under this program for flow sensors, multi-stream nozzles, and master valves.
- PACE - Austin Water assists the Travis County Property Assessed Clean Energy (PACE) loan program in identifying eligible water conservation opportunities and retrofits that also qualify for an Austin Water rebate.
- Rainwater Harvesting System Rebate – ICI customers may receive up to $5,000 for purchasing equipment to capture and use rainwater.
- Reclaimed Water – Austin Water is expending its distribution system to provide less expensive municipal treated wastewater rather than potable water to meet non-potable water needs such as irrigation and cooling towers.
- Small Business – AW partners with Austin Energy's Small Business Program that helps identify ways for small commercial and non-profit customers to reduce water and energy use and related rebate programs.
- WaterWise Hotel Partnership Program - Offers free recognition for lodging facilities that use water-efficient measures and practices.

7.2.5 Water Loss Control

One of the primary conservation goals of Austin Water's utility is to manage water loss due to leaks in their distribution system. Austin Water has inspected more than 1,500 miles of water lines for leaks using acoustic technology. In 2013, a five-year program of inspecting the entire distribution system was completed and the information gained from these inspections is now being used to enhance Austin Water's active leak detection program. A common performance indicator for real water losses from a supply network is the Infrastructure Leakage Index (ILI). The Texas Water Development Board (TWDB) recommends an ILI between 3.0 and 5.0. Austin Water currently maintains a goal to achieve an ILI of 3.0 or less (lower scores are better) and often exceeds this goal through its accelerated leak response and repair program. Most known leaks are repaired in one day or less and almost 90% of emergency leaks are responded to within three days. Austin Water has also invested $125 million in the Renewing Austin program, a five-year program to replace and upgrade aging water lines and keep pace with the infrastructure demands of a growing city.

7.2.6 Advanced Metering Infrastructure Pilot Program

Recently, Austin Water has been investigating and studying the cost and feasibility of implementing Advanced Metering Infrastructure (AMI) and has implemented a pilot program, which involves installing ‘smart’ meters in a small portion of the city which can automatically report daily, hourly, or more frequent water usage to the utility and the customer. AMI can identify customers with the largest potential to conserve water by evaluating advanced analytics to provide precise water conservation targets. These calculations provide individual water conservation recommendations directly to customers based on climate, parcel size, vegetation coverage and other information derived from aerial imaging surveys. This project may also be expanded to include multi-family, commercial, institutional, and industrial customers depending on the results of the AMI Pilot Program.

7.2.7 Water Conservation Public Education Programs

Austin Water has several public educational programs to promote the City’s conservation incentive programs and water efficiency measures, as well as increase customer awareness of water usage and leaks. The following list provides a summary of the water conservation educational programs.

- WaterWise Partner Program - a program that recognizes commercial customers that have incorporated efficiency measures into the design of new properties or that have made comprehensive water-efficiency upgrades in the facilities.
- Dowser Dan Show – Targeting kindergarten through fourth grade students, the Dowser Dan show educates children and teachers about water conservation and reaches approximately 18,000 students each year.
- Mobile Classroom – The mobile exhibit is housed inside a 40-foot trailer and utilizes interactive exhibits and hands-on activities, functioning as a mobile science museum.
- Speakers Bureau – Allows area groups to schedule Austin Water staff members to speak on topics including, but not limited to, conservation measures, irrigation, leak detection, and water waste.
- WaterWise Irrigation Professional Seminar – Seminars that include information on water-efficient irrigation systems, water conservation programs, the mandatory watering schedule, electrical troubleshooting, irrigation auditing, and turf grass watering requirements so that licensed professional irrigators in the area can earn credits toward their license renewal.
- Annual Austin Water/LCRA ICI Water Conservation Technical Workshop – An annual free water conservation technical workshop on water saving measures, technologies, and rebate programs for ICI customers, facility managers and engineers.
- “Controller 101” Workshops – Residential customers may attend a free hands-on workshop to review how irrigation controllers work and find out about hidden features and options that can help save water and money.

- Online Information, Electronic Newsletters and Social Networking – Covers conservation related topics via www.WaterWiseAustin.org, Facebook, Twitter, NextDoor, YouTube, and an e-Newsletter that reaches approximately 30,000 customers.

7.3 Water Conservation and Demand Management Strategies for the Future

In support of the IWRP, candidate future water conservation and demand management strategies were identified to evaluate their potential to help the city meet their long-term water supply needs. Demand management measures were identified based on input from the Water Forward Task Force members, Austin Water staff, the public, the consulting team, and previous task force recommendations. Initially, 25 viable options were considered, but were screened down to 12 through the IWRP process (see Section 4 for discussion on the screening process). A summary of the 12 resulting options is provided in **Table 7-2.**

Table 7-2. Candidate Future Water Conservation and Demand Management Strategies

<table>
<tr><th>Option Number</th><th colspan="2">Option Name</th><th>Annual Community Unit Cost Per AF of Savings</th></tr>
<tr><td>D1</td><td colspan="2">Advanced Metering Infrastructure</td><td>$2,800</td></tr>
<tr><td>D2</td><td colspan="2">Water Loss Control Utility Side</td><td>$3,690</td></tr>
<tr><td>D3</td><td colspan="2">Commercial, Industrial, and Institutional Ordinances (Cooling Towers and Steam Boilers)</td><td>$71</td></tr>
<tr><td>D4</td><td colspan="2">Water Use Benchmarking and Budgeting</td><td>$21</td></tr>
<tr><td>D5</td><td colspan="2">Landscape Transformation Ordinance</td><td>$23</td></tr>
<tr><td>D6</td><td colspan="2">Landscape Transformation Incentives</td><td>$96</td></tr>
<tr><td>D7</td><td colspan="2">Irrigation Efficiency Incentives</td><td>$202</td></tr>
<tr><td>D8</td><td rowspan="5">Alternative Water Ordinances and Incentives</td><td>Lot Scale Stormwater Harvesting</td><td>$5,510 - $5,062</td></tr>
<tr><td>D9</td><td>Lot Scale Rainwater Harvesting</td><td>$2,619 - $2,960</td></tr>
<tr><td>D10</td><td>Lot Scale Graywater Harvesting</td><td>$3,898 - $10,666</td></tr>
<tr><td>D11</td><td>Building Scale Wastewater Reuse</td><td>$12,692</td></tr>
<tr><td>D12</td><td>Air Conditioning Condensate Reuse</td><td>$2,702</td></tr>
</table>

The following sections provide a short description of the candidate options. A more comprehensive summary for each option providing the conceptualized yield, the overall community cost, and assumptions made in developing each of the final demand management options can be found in **Appendix F**.

7.3.1 Advanced Metering Infrastructure (AMI)

The AMI option targets all customers and sectors and would provide Austin Water customers with real-time water use information. Savings are achieved through identification of customer leaks, behavior modification, and other water-saving opportunities that are realized because of: (1) improving customer meter accuracy, (2) reducing unauthorized consumption, (3) reducing data transfer/archive errors, and (4) reducing data billing errors.

7.3.2 Utility Side Water Loss Control

This option is focused on utility-side water loss control programs above-and-beyond what is currently a part of Austin Water's existing water loss program. There are currently approximately 3,387 miles of water pipeline citywide. From fiscal year 2013 to 2015, Austin Water lost an average of 4.88 billion gallons of water annually from leaks in the water distribution system which equates to an infrastructure leakage index (ILI) of 3.26. Austin Water's current plan is to continue to replace aged water mains at about 10 miles per year. This option includes an aggressive leak detection, correction, and prevention program to further achieve reductions.

7.3.3 Commercial, Industrial, and Institutional (CII) Ordinances

There are over 400 cooling towers in Austin which are designed to remove heat from a building or facility for the purposes of heating, ventilation, and air conditioning. In the process of cooling air, some water is evaporated, and the rest is recycled through the cooling tower. The number of cycles that the water is recycled, also known as cycles of concentration, the more efficient the cooling tower becomes. This option focuses on existing customers in the commercial, industrial and institutional sectors, requiring older cooling towers to meet water efficiency benchmarks and use efficient equipment.

The option also requires efficiency standards for steam boilers in new development. Implementation of this measure would entail changing the city code to require: (1) all cooling towers to meet same efficiency equipment standards currently only required for new and replacement towers since 2008; and (2) all steam boilers to have conductivity controllers, makeup meters, steam condensate return systems and blowdown heat exchangers for steam boilers. These code changes have already been approved by City Council in June 2017 and implementation is underway.

7.3.4 Water Use Benchmarking and Budgeting

Water-use budgeting and benchmarking can provide a way for Austin to save water over time. This option would be implemented in two phases.

Phase I

- Potential approaches to implement this requirement for pre-and post-development of multi-family and commercial facilities will be evaluated and include stakeholder outreach, review by Boards and Commissions and Council action.
- As part of this program:
  - Developers will provide information about all water-using equipment and fixtures associated with the site (including counts), proposed water sources, irrigated area, landscaped area, and other water-use, site, and building characteristics.
  - City staff will provide water efficiency related code requirements, potential water use efficiency best management practices, alternative water recommendations, water use benchmarking data, and information on available incentive and rebate programs for new and existing development. Implementation of the measure will look for ways to tie into the Service Extension Request (SER), Austin Energy's Green Building (AEGB) program, the city's Energy Conservation Audit and Disclosure (ECAD) program, and AMI customer portals for multi-family and commercial use.

Phase II

- Based on the water use benchmarking data developed through these programs, this strategy will be expanded in the future to include a water use budget for new development constructed after 2025 (compliance mechanism to be determined).

7.3.5 Landscape Transformation Ordinances

Landscape transformation is a process of transitioning from traditional landscaping practices to those that rely on regionally appropriate plants and have reduced supplemental water needs, with an emphasis on landscape function. This option would require development of new ordinances to encourage landscape transformation for commercial businesses and multi-family residences. If implemented, further details would need to be developed through subsequent implementation processes with future additional stakeholder and public input opportunities. Water savings use could be achieved through a variety of mechanisms, including reduction of irrigated area, installation of drought tolerant plants, and reduction of turf area.

7.3.6 Landscape Transformation Incentives

This option is similar to the previous option, except that it focuses on incentives to encourage water use efficiencies and reduce water needs for outdoor irrigation through regionally appropriate landscapes with an emphasis on landscape functionality. The current WaterWise landscape rebate offers $35 for every 100 square feet ($0.35/square feet) converted but has traditionally had low participation rates. The option would increase the rebate amount to encourage more participation in the voluntary program.

7.3.7 Irrigation Efficiency Incentives

Outdoor water use comprises over 20% of the water currently used by Austin Water customers with most of that water used for landscape watering. Over 89,000 homes and over 5,000 businesses have irrigation and sprinkler systems, which often are programmed to turn on at certain times of the day without regard to weather or plant water needs. This measure focuses on expanding existing Austin Water rebate programs to incentivize “smart” irrigation controllers that would improve irrigation system efficiency by responding to leaks, high pressure, and soils moisture and also make flow data accessible. There are currently approximately 89,300 single family residential irrigation systems and 5,030 commercial/multi-family irrigation systems.

7.3.8 Alternative Water Ordinance and Incentives

This option would require or incentivize on-site (building-scale) alternative water use of rainwater, stormwater, blackwater, and/or AC condensate through a mix of ordinances and incentive programs. This option would require development of new ordinances to require implementation of these projects through subsequent implementation processes with future additional stakeholder and public input opportunities. Details for each of the building-scale options are provided in more detail in the following sections.

More detail on the decentralized options is provided in **Appendix G.**

Lot Scale Stormwater Harvesting

Lot scale stormwater harvesting involves the capture and storage of stormwater runoff generated from impervious surfaces (including roof water) within the lot boundary of multi-family residential or commercial development. The collected stormwater is then used to supply a range of onsite demands. Implementing stormwater harvesting in new developments provides an opportunity to plumb the building with internal connections for toilet flushing, clothes washing or to cooling towers. Retrofitting existing buildings with internal connections to a dual supply source can be cost prohibitive and practically difficult. It is assumed for the purposes of this plan that stormwater harvesting at the lot scale for existing development would be used solely for irrigation/landscaping. Where used for irrigation/landscaping only, it is assumed that there will be filtration. Where used to supply indoor non-potable end-uses, it is assumed UV Disinfection is also required. Storage is assumed to be an underground tank/cistern.

Two scenarios were considered for establishing typical yields and costs for this option:

- A proportion of newly constructed multi-family and commercial buildings have an underground stormwater harvesting tank supplying outdoor end uses.
- A proportion of newly constructed multi-family and commercial buildings have an underground stormwater harvesting tank supplying outdoor end uses and indoor (non-potable) end uses via dual pipe network.

Lot Scale Rainwater Harvesting

Rainwater in urban areas is often routed to a storm drain pipe network and discharged to streams and flood control channels that lead to the ocean. Typically, this runoff carries with it pollutants and trash that have been picked up along parking lots, streets, and other impervious surfaces. Rainwater harvesting (lot scale) involves the capture and storage of roof water to supply a range of onsite demands at the lot/building scale.

Three scenarios were considered for establishing typical yields and costs for this option. The options include:

- A proportion of newly constructed single family, multi-family and commercial buildings have a rainwater tank supplying outdoor end uses.
- A proportion of newly constructed single family, multi-family and commercial buildings have a rainwater tank supplying outdoor end uses and indoor (non-potable) end uses via dual pipe network.
- A proportion of newly constructed single-family buildings have a rainwater tank supplying all end uses (i.e. potable supply).

Lot Scale Graywater Harvesting

Graywater harvesting is defined as the reuse of water from the laundry, shower and bath at the lot/unit scale to meet non-potable demands. There are two main types, greywater diversion devices and greywater treatment systems. Graywater diversion is untreated, and therefore cannot be stored and can only be used to supply sub-surface irrigation. They typically include a surge-tank and may include a filter. The system may be gravity fed or require a pump, depending on the site. Graywater treatment systems include treatment, storage and a pump. The treated graywater can be reused to supply outdoor end use demands as well as non-potable indoor end use demands (toilet flushing and clothes washing).

Two scenarios were considered for establishing typical yields and costs for this option. The options include:

- A proportion of newly constructed single family, multi-family and commercial buildings have a graywater diversion system supplying outdoor end uses.
- A proportion of newly constructed single family, multi-family and commercial buildings have a graywater treatment system supplying outdoor and indoor end uses.
- Both scenarios assume back-up supply from the centralized water distribution system.

Lot/Building Scale Wastewater Reuse

Building Scale Wastewater Re-use (or 'Blackwater Treatment Plants') is defined, for the purpose of this project, as involving the onsite capture and treatment of the wastewater stream generated from a building for onsite reuse via a dual (purple) pipe system to supply outdoor demands (irrigation/landscaping) and non-potable indoor demands (toilets and potentially also laundry and cooling towers). Blackwater treatment plants are most commonly installed in commercial buildings and high density, multi-story multi-family residential buildings. Treatment may be one or a combination of membrane bioreactor, moving bed biofilm reactor, passive (e.g. engineered wetlands) or other systems, with microfiltration or ultrafiltration, and ultraviolet disinfection and/or chlorination. Wastes (sludge) from the treatment process are typically discharged back to the wastewater network.

A single scenario was considered for establishing typical yields and costs for this option. The scenario considers that a proportion of newly constructed multi-family and commercial buildings have a blackwater treatment system supplying outdoor and non-potable indoor end uses. Two critical assumptions are made for blackwater systems:

- Blackwater reuse is not considered for outdoor end uses in Critical Water Quality Zones, floodplains, or the Edwards Aquifer Recharge Zone.
- All scenarios assume back-up supply from the centralized water distribution system.

7.3.9 Air Conditioning Condensate Reuse Ordinance

This option is focused on the collection of air conditioning (AC) condensate water from air handling units (AHUs) from new development with cooling capacity over 200 tons. The condensate water could be reused for beneficial use for any non-potable applicable including (but not limited to): cooling tower makeup water, irrigation, and indoor toilet flushing. This option is already in code and AW will continue to monitor its implementation.

7.3.10 Other Options Considered in the Planning Process

Of the initial demand management options, there were several that were identified as continuing best management practices rather than new options, and three were identified as necessary implementation components to other options. These include the following:

- The option to require or incentivize government-recognized energy and water efficiency-labeled residential and commercial fixtures was determined to be a "*continued best management practice*" to be included in demand offsets separately (i.e., off-the-top reduction from the baseline forecast that does not require evaluation through the IWRP process) and reflects Austin Water's longstanding programs to incentivize or require these fixtures.
- Three options were determined to be "*implementation components*" of a successful conservation program and were not further evaluated or screened. These measures include water rates and fees to promote water use efficiency while maintaining affordability, customer education enhancements, and use of social media programs and web-based content to promote conservation. These types of programs are indeed critical to a successful program but do not necessarily have significant water savings of their own, but rather they assure the successful implementation of other programs.

The options described in this section are considered options that are being implemented as part of Austin Water's ongoing commitment to implement demand management and conservation measures.

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SECTION 8: WATER SUPPLY STRATEGIES

The Colorado River is Austin's core water supply through a combination of State-granted water rights and firm water supply contracts with LCRA. The Colorado River has a series of reservoirs, known as the Highland Lakes, that are used by LCRA to store water for municipal, industrial, recreation, and agricultural water needs as well as to meet in-stream flow requirements throughout the River down to Matagorda Bay on the Texas Gulf Coast. The following section describes the current water supply infrastructure associated with Austin's existing Colorado River water supply. The section also describes future water supply options evaluated as part of the IWRP.

AT A GLANCE

- *Current Water Supply System*
- *Future Water Supply Options*

8.1 Current Water Supply System

The following sections describe Austin Water's current surface water and reclaimed water systems. It should be noted that additional future water and wastewater plant expansions along with collection and distribution system improvements will also be required to provide water and wastewater services through the 100-year planning horizon.

8.1.1 Surface Water System

Utility customers are supplied with drinking water from three surface water treatment plants, which draw water from the Colorado River as the river runs through Lake Travis and Lake Austin. The City's combined water treatment capacity is currently 335 MGD.

As described in Section 2.1, Austin's main sources of water supply are its own run-of-river water rights, backed up by a firm water supply contract with the LCRA. In 1999, Austin entered into a long-term firm water supply agreement with LCRA for 325,000 AFY. Austin paid $100 million in prepaid reservation and use fees for 325,000 AFY of firm water supply. Austin's annual municipal diversions were approximately 149,000 AFY in 2017. Additional water payments by Austin to LCRA will be triggered when average annual water diversions for two consecutive years exceeds 201,000 AFY. The current contract runs through the year 2050 with an option for Austin to extend the agreement to 2100. The IWRP assumes that the City will extend its current LCRA contract to 2100 and be able to enter into an agreement with LCRA to renew it at that time.

8.1.2 Reclaimed Water System

Wastewater is treated at two major wastewater treatment plants with a combined capacity of 150 MGD and various small-scale treatment plants. Austin Water operates and manages an expanding reclaimed water system which provides reclaimed water to customers for a variety of non-potable uses. The system currently has almost 50 miles of reclaimed water pipe covering three different service areas and supplies approximately 4,000 AFY of water to 35 metered customers annually.

Bulk reclaimed water is also available to customers at multiple pumping locations throughout the City.

8.2 Future Water Supply Options

In support of the IWRP, future water supply options were identified and evaluated to determine their potential to help the City meet identified water supply goals. A total of 21 water supply options were identified through a collaborative process, involving Austin Water staff, the current Task Force, the 2014 Austin Water Resource Planning Task Force report, and the public. These options were then screened as described in **Section 4** and **Appendix J** to identify a total of 13 supply options for further characterization and use within the portfolio development process. These 13 water supply options are summarized in **Table 8-1** and discussed in more detail in the following section.

Table 8-1. Candidate Future Water Supply Options

Option Number	Option Name	Option Type	Annual Unit Cost ($/AF)
S1	Aquifer Storage and Recovery	Storage / Surface Water	$1,053
S2	Brackish Groundwater Desalination	Desalination / Groundwater	$2,690
S3	Non-Potable Reuse - Master Plan	Reclaimed Water	$1,229
S3-A	Non-Potable Reuse - Expanded System beyond Master Plan	Reclaimed Water	$6,127
S4	Direct Potable Reuse	Reclaimed Water	$2,204
S5	Indirect Potable Reuse	Reclaimed Water	$605
S6	LCRA Additional Supply	Surface Water	$352
S7	Off Channel Reservoir	Storage / Surface Water	$846
S8	Seawater Desalination	Desalination	$3,032
S9	Distributed Wastewater Reuse	Reclaimed water / Decentralized System	$9,612
S10	Sewer Mining	Reclaimed water / Decentralized System	$3,030 - $6,444
S11	Community Stormwater Harvesting	Decentralized	$1,522 - $3,233
S12	Community Rainwater Harvesting	Decentralized	$9,612
S13	Conventional Groundwater Operated by Austin Water	Groundwater	$1,119

The following section provides a brief summary for each of the candidate options. A comprehensive summary for each option providing the projected yield, cost, and assumptions made in developing each of the final water supply options can be found in **Appendix F**.

8.2.1 Aquifer Storage and Recovery

Aquifer storage and recovery is a strategy in which water can be stored in an aquifer during wetter periods and recovered at a later date. Storing water underground can improve drought preparedness in the same way storing water in a reservoir does, while eliminating the water loss due to evaporation that occurs in open above-ground reservoirs. Although some water stored in ASRs is also lost through leakage or migration, the losses are much smaller than evaporative losses on an above-ground reservoir of commensurate size. ASR is currently being used by cities in Texas, such as San Antonio, Kerrville and El Paso. Exploring ASR as a potential option was a recommendation of the 2014 Task Force.

Austin has initiated feasibility analyses to better understand the geology and hydrogeology characteristics of the Northern Edwards and Trinity Aquifers to evaluate potential for recharge and extraction. The "Carrizo-Wilcox ASR – Conventional" option is considered the representative ASR water supply option for characterization and subsequent use in portfolio development. This option includes facilities to pipe treated drinking water from Austin's distribution system to an ASR wellfield for injection and storage in the Carrizo-Wilcox aquifer. Facilities also include a pump station and storage tank to convey recovered water from the ASR wellfield to the city's distribution system.

Potential implementation issues for ASR include:

- Understanding the potential migration of stored water and mixing with the native groundwater,
- Protection of stored water from recovery by others, and
- Navigating changing regulatory requirements for ASR.

8.2.2 Brackish Groundwater Desalination

Brackish groundwater is defined as groundwater containing between 1,000 and 10,000 milligrams per liter (mg/L) of total dissolved solids (TDS). Desalination is often required to remove dissolved solids from brackish groundwater, or brackish water can be blended with another low-TDS source water to reduce total TDS levels. The specific process used to desalinate water varies depending upon the total dissolved solids, the temperature, and other physical characteristics of the source water, but always requires disposal of concentrate, called brine, that has a higher total dissolved solids content than the source water. The City of El Paso has been treating 27.5 MGD of brackish groundwater since 2007, while the San Antonio Water System started up a 12 MGD brackish groundwater desalination project in 2016. Exploration of brackish groundwater desalination for the Water Forward process was a recommendation of the 2014 Task Force.

There are several aquifers within Central Texas which could be considered for brackish groundwater, including the Edwards, Trinity, Gulf Coast, and Wilcox Aquifers. For the purposes of this study, brackish groundwater is considered to be sourced from Wilcox Aquifer for use as a constant supply. Facilities associated with this option include the wellfield, pump station, storage tank, and reverse osmosis treatment facilities. Evaporation ponds were assumed to be used for brine disposal.

Potential implementation issues for brackish groundwater desalination include:

- Concentrate disposal, and
- Blending with current supply sources.

8.2.3 Direct Non-Potable Reuse (Purple Pipe System)

Direct non-potable water is also known as recycled water, reuse water, or reclaimed water. This is water that has been treated to Type 1 standards as defined by the Texas Commission on Environmental Quality (TCEQ) for use in public parks, school yards, residential lawns, athletic fields, non-food crop irrigation, and fire protection. As described in Section 8.1.2., Austin Water has a Water Reclamation Initiative (WRI) underway and the non-potable reuse option under consideration as part of the IWRP would expand this program to provide additional non-potable water supply through the centralized reclaimed water network. This expansion has been conceptualized to occur in two phases over the 100-year planning horizon.

The first phase is implementation of the Reclaimed Water Infrastructure Master Plan (2011) and the program described in the 2016 Lower Colorado Regional Water Plan. Facilities included in this phase consist of a total of nine reclaimed pump stations, ten storage facilities and approximately 110 miles of reclaimed pipeline transmission main.

The second phase would focus on direct non-potable use in anticipated growth areas based on demand model estimates between 2070 and 2115. Facilities included in this phase include a total of seven reclaimed pump stations, six storage facilities and approximately 66 miles of reclaimed pipeline transmission main. Additional cost was included to reflect community costs associated with dual-plumbing which is required for indoor non-potable water use.

Potential implementation issues for non-potable reuse include:

- Changing ordinances to allow for indoor dual-plumbing projects
- Requires voluntary customer participation to increase utilization,
- Challenges with public opinion and the need for public education on water safety, and
- Projects become less cost effective as users get further from the reclamation facilities.

8.2.4 Direct Potable Reuse

Direct potable reuse (DPR) represents a relatively new approach for maximizing the use of recycled water that involves advanced treatment of wastewater effluent for the purposes of meeting drinking water needs. Although new, several communities in Texas have implemented DPR projects to address their water supply needs. A full-scale project was implemented by the Colorado River Municipal Water District for the City of Big Springs in 2013 (2 MGD) and the City of Wichita Falls implemented a temporary project in 2012 (10 MGD) as a drought response strategy.

The option evaluated for this study would convey highly treated reclaimed water from one treatment train at South Austin Regional WWTP to the Ullrich WTP. The effluent would be treated on-site at Ullrich WTP using a new advanced water treatment train, potentially including microfiltration and reverse osmosis. The treated water would then be blended with raw water prior to being pumped back to the headworks of Ullrich WTP for treatment through the conventional water treatment process. Although direct potable reuse offers benefits such as a climate resilient supply, it presents significant regulatory uncertainty – which can impact when and if direct potable reuse projects can be implemented.

Potential implementation issues for direct potable reuse include:

- Regulatory uncertainty, and
- Challenges with public opinion and the need for public education on water safety.

8.2.5 Indirect Potable Reuse

Indirect potable reuse (IPR) represents a relatively new approach for maximizing the use of recycled water. The term "indirect" refers to the distinction that the purified water is mixed with a natural water source (groundwater or surface water) and before being used as a source to deliver to a treatment plant for providing drinking water. Many communities in the United States and throughout the world are currently practicing or are planning to implement IPR projects. The City of Wichita Falls recently implemented an IPR project which sends up to 16 MGD of wastewater to Lake Arrowhead, which provides a buffer prior to treatment at the surface water treatment plant.

The representative option evaluated for this study would convey highly treated reclaimed water from one treatment train at South Austin Regional WWTP to Lady Bird Lake and subsequently divert water by a new intake pump and piping system downstream of Tom Miller Dam to the Ullrich WTP. This approach would supplement water releases from Lakes Buchanan and Travis to extend water supplies during severe drought. This option is a drought strategy that would be recommended for implementation in the event of 400,000 AF of combined storage or less in Lakes Buchanan and Travis. In addition, this option would allow for the capture available spring flows into Lady Bird Lake and convey the water to Ullrich WTP through a potential new intake pump and piping system.

Potential implementation issues for indirect potable reuse include:

- Challenging permitting process, and
- Challenges with public opinion and the need for public education on water safety.

8.2.6 Additional Supply from Lower Colorado River Authority (LCRA)

Water from the Colorado River through its water rights and firm contract with LCRA is the primary source of all raw water for Austin; this water is treated and used to meet Austin's demands. This option would involve securing additional supply from the LCRA through a new or amended contract. Currently LCRA has approximately 54,600 acre-feet of water available for contracting (50,000 acre-feet of which is the LCRA Board of Director's reserve amount and is subject to contracting approval by the LCRA Board of Directors). The additional LCRA supply would be accessed using existing and future treatment and transmission infrastructure. There could be additional supply available for contracting over time as LCRA plans to continue to develop additional supplies in the future.

Potential implementation issues for contracting more LCRA supply include:

- Future availability of water includes uncertainties.

8.2.7 Off-Channel Storage Reservoir

This strategy would involve the construction of a new off-channel reservoir in the Austin region that Austin Water would own and operate. An off-channel reservoir is constructed outside of a main stem river channel and is filled by pumping water in from the main river channel to the reservoir. This type of reservoir requires additional infrastructure, such as impoundment structures and pump stations to move water from the main river channel.

The off-channel reservoir option being considered would use source water from the Colorado River during times when water is available. The approximate size of this reservoir would be up to 25,000 AF. An evaporation suppressant could be applied during summer months to reduce water lost through evaporation. The off-channel reservoir could also be used conjunctively with ASR, allowing further storage and evaporation management opportunities.

Potential implementation issues for an off-channel storage reservoir include:

- Land area requirements are significant, and
- The yield of the reservoir is dependent on the reliability of the source water.

8.2.8 Seawater Desalination

Desalination is the process of removing dissolved solids from seawater or brackish groundwater, often by forcing the source water through membranes under high pressure. The desalination process generates waste product known as brine that has a higher TDS content than the source water. Disposal of the brine may take the form of an injection well, evaporation beds, or an ocean outfall diffuser. This option would involve sourcing water from the Gulf of Mexico and treating it via a desalination plant where dissolved solids are removed by forcing the source water through membranes at high pressure. This option could be implemented through a regional partnership approach.

Potential implementation issues for seawater desalination include:

- Challenging permitting and regulatory issues, and
- Energy intensive leading to high per unit cost.

8.2.9 Distributed Wastewater Reuse

Distributed Wastewater Reuse is defined as the collection of wastewater from the sewage system in new development areas, treatment to Type 1 quality, and reuse at the local/community scale. These facilities would be separate from the centralized wastewater collection system. Reuse via a dual (purple) pipe system would then provide water for irrigation, landscaping, cooling, toilet, and potentially also laundry (clothes washing) demands. Treatment plants are sized to meet demand and also to manage peak wet weather flows.

Potential implementation issues for distributed wastewater reuse include:

- Changing ordinances to allow for indoor dual-plumbing projects,
- Challenges with public opinion and the need for public education on water safety, and
- Changing behavior to promote usage of the reuse water.

8.2.10 Sewer Mining

Sewer mining or local wastewater scalping is defined as the extraction (mining or scalping) of wastewater from the existing centralized sewage system, treatment to Type 1 quality, and reuse at the local/community scale.

The treatment plant is situated close to both the demand and to the sewer extraction point, to reduce piping and pumping costs. This option can be located either within existing open space or within a new development. Reuse is via a dual (purple) pipe system and will supply irrigation, landscaping, toilet and potentially also laundry (clothes washing) and cooling demands. Wastewater treatment plant wastes (sludge) from the treatment process are assumed to be discharged back to the centralized sewer for subsequent treatment at the downstream WWTPs.

Two scenarios were considered for this option:

- Water from sewer mining is used for a proportion of City of Austin outdoor end uses like irrigation.
- A proportion of newly constructed single family, multi-family and commercial buildings have outdoor and indoor (non-potable) end uses serves from sewer mining via dual pipe network as well as City of Austin outdoor end uses supplied for irrigation.

Potential implementation issues for sewer mining include:

- Changing ordinances to allow for indoor dual-plumbing projects,
- Challenges with public opinion and the need for public education on water safety, and
- Changing behavior to promote usage of the water.

8.2.11 Community Stormwater Harvesting

Stormwater harvesting is defined for the purpose of this project as the collection of excess stormwater runoff from urban areas (e.g. impervious surfaces including roads, pavement, and roofs), for treatment and reuse for irrigation/landscaping or reuse for dual pipe systems at the community scale.

Implementing stormwater harvesting in new developments provides an opportunity to plumb buildings with purple pipe internal connections for toilet flushing, clothes washing or to cooling towers. Retrofitting existing buildings with internal connections to a dual supply source can be cost prohibitive and/or practically difficult, and so it is assumed for the purposes of this study that stormwater harvesting for existing developed areas would be used solely for irrigation/landscaping of public open space**.** Where used for irrigation/landscaping only, it is assumed that the stormwater will undergo filtration. Where used to supply indoor non-potable end-uses, it is assumed UV disinfection is also required. Storage is assumed to be an underground tank/cistern or more typically open storage such as a wet-pond.

Two scenarios were considered for this option:

- A proportion of newly constructed single family, multi-family and commercial buildings have an underground stormwater harvesting tank supplying outdoor end uses.
- A proportion of newly constructed single family, multi-family and commercial buildings have an underground stormwater harvesting tank supplying outdoor end uses and indoor (non-potable) end uses via dual pipe network.

Potential implementation issues for community stormwater harvesting include:

- Changing ordinances to allow for indoor dual-plumbing projects,
- Changing behavior to promote usage of the water, and
- Verification that stormwater harvesting does not adversely impact instream flows downstream.

8.2.12 Community Rainwater Harvesting

Community scale rainwater harvesting is defined for the purpose of this project as the collection of roof water from new development areas from a dedicated (dual) roof water drainage network for storage at a central downstream location, for treatment and reuse via dual pipe systems at new developments at the community scale. This is assumed to require UV disinfection. Storage is assumed to be an underground tank/cistern.

A single scenario was considered for establishing typical yields and costs for this option. The option includes supplying both outdoor and indoor non-potable uses for single family, multi-family and commercial buildings for new development.

Potential implementation issues for community rainwater harvesting include:

- Changing ordinances to allow for indoor dual-plumbing projects, and
- Changing behavior to promote usage of the water.

8.2.13 Conventional Groundwater

There are several groundwater aquifers, including the Edwards, Trinity, and Carrizo-Wilcox aquifers in the region. This option would rely on fresh groundwater sourced from the Carrizo-Wilcox to the east of Austin. This option is considered an imported water supply option and assumes that Austin Water would acquire groundwater permits through the requisite Groundwater Conservation District(s) and develop all source water, treatment and disposal infrastructure.

Potential implementation issues for obtaining conventional groundwater supply include:

- Challenging permitting and regulatory issues, and
- Blending with current supply sources and chemical interaction between waters.

8.2.14 Other Options Considered in the Planning Process

The following options were originally considered for screening but were later determined to fall outside of the typical option classifications.

- **Lake Austin Operations:** Instead of being screened, this option was determined to be a best management practice drought response approach. The operational drought strategy involves varying the Lake Austin operation level during non-peak months (Oct-May) and after combined storage in the Highland Lakes falls below 600,000 AF. This strategy would allow local usage to draw the lake down to a maximum of three feet in order to catch runoff from local storm events. This approach would allow for use of this runoff, as opposed to excess runoff spilling over Tom Miller Dam to flow downstream. This strategy was assumed as part of the baseline water supply for the IWRP.
- **Regional Partnerships:** This option was determined to be an implementation strategy of other supply options on the screening list and was not screened individually. After the IWRP is complete, regional partnership strategies could be considered when implementing the selected and preferred portfolio of water supply options.

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SECTION 9: PORTFOLIO EVALUATION

As no single water demand management or supply option characterized in Sections 7 and 8 can fully meet the needs of Austin Water, portfolios of options are required. Portfolios are groupings of multiple options that come together to meet needs. Even with just a few options available there can be dozens of potential portfolios that can be developed. Thus, a structured process for defining and evaluating portfolios is used.

AT A GLANCE

- *Portfolio Definitions*
- *Raw Performance Scorecard*
- *Portfolio Rankings*
- *Summary of Findings*

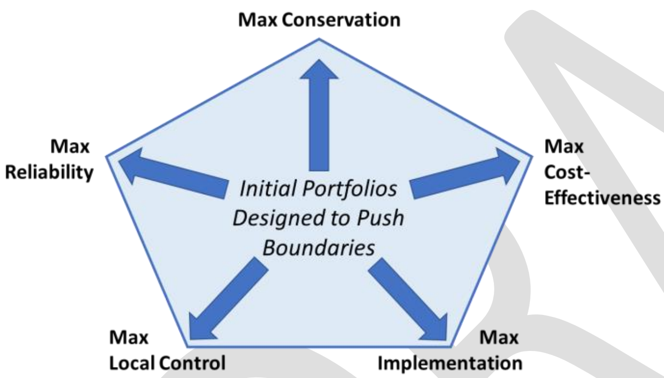

Figure 9-1. Initial Portfolios Centered Around Themes to Push Boundaries and See Trade-Offs

A proven method is to use themes around which options can be combined to form initial portfolios, such as "maximizing conservation" or "maximizing local control". Thematic portfolios are often defined to push the boundaries, thus allowing trade-offs to be more easily seen from the evaluation. For example, if an initial portfolio maximized water reliability, what would be the impact on cost or environmental impact? If another initial portfolio maximized local control, what would be the impact on implementation or social benefits? For the IWRP, five initial thematic portfolios were developed centered around maximizing certain objectives for the plan in order to see relative trade-offs (see **Figure 9-1**).

Each of these initial portfolios were comprehensively assessed in terms of how well they provided water supply, environmental, economic, and social benefits. In addition, the portfolios were also evaluated in terms of implementation risks and benefits.

Based on the evaluation of the initial portfolios, two hybrid portfolios were developed (see **Figure 9-2**). The intent of the hybrid portfolios was to extract the best performing traits from the initial portfolios, while minimizing those aspects that were less desirable—thus creating more superior alternatives.

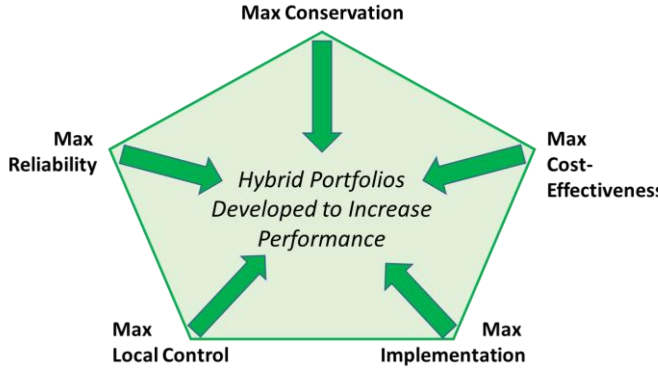

Figure 9-2. Process to Develop Hybrid Portfolios

9.1 Portfolio Definitions

Five initial portfolios were developed around objective-based themes. The themes represent achieving key objectives without regard for the other objectives. Their purpose is to push the boundaries to see the outcomes of portfolios with a single-objective focus to allow for a clearer analysis of trade-offs between objectives. The five initial portfolio themes were developed based on Austin Water, community, and Task Force input. Two hybrid portfolios were then developed which represent a more balanced approach to meeting multiple objectives. Descriptions of the portfolio themes are provided in **Table 9-1.**

Table 9-1. Portfolio Themes

Portfolio	Description
Maximize Cost-Effectiveness	Options with the lowest unit costs ($/acre-foot) were generally selected.
Maximize Local Control	Options in which Austin Water would have control over the projects and the water supply sources in terms of cost, yield, development, and operations
Maximize Implementation	Options that have a higher degree of potential implementation success were selected.
Maximize Reliability	Options that provide higher supply reliability and resiliency in terms of climate and hydrology were selected.
Maximize Conservation	Options that conserve potable water and maximize the reuse of treated wastewater and stormwater were selected.
Hybrid 1	Built from the initial Maximize Conservation portfolio with the intent of increasing water supply benefits, while not significantly impacting the environmental and social benefits. This was achieved by increasing storage and reuse options.
Hybrid 2	Built from the initial Maximize Reliability portfolio with the intent of increasing environmental and social benefits, while reducing cost and risk. This was achieved by increasing demand management options, scaling back on seawater desalination and eliminating direct potable reuse.

The initial portfolios were developed with the following goals:

1. Meet all identified water needs (Types 1, 2, and 3) reliably for the period of record with historical climate.
2. Meet most identified water needs (Types 1, 2, and 3) for the period of record with climate change.
3. Assess how well identified water needs (Types 1, 2, and 3) are met with extended period with climate change.

The hybrid portfolios were developed with the following goals:

1. Meet all identified water needs (Types 1, 2, and 3) reliably for the period of record with historical climate and with climate change (Hydrologic Scenarios A & B).
2. Meet most identified water needs (Types 1, 2, and 3) with extended period with climate change (Hydrologic Scenario D).

For reference, **Table 9-2** shows the preliminary identified water needs over time, as estimated by Austin Water's WAM for the hydrologic scenario "B" (period of record hydrology with climate change).

Table 9-2. Preliminary 12-Month Identified Water Needs for the Period of Record with Climate Change

Water Need Type	2020	2040	2070	2115
Type 1 - Water need in an amount equal to the estimated savings from City's Stage 4 Drought Contingency Plan implementation [1]	3,000 AFY	10,600 AFY	15,400 AFY	24,800 AFY
Type 2 - Fifty percent of the amount of water Austin expects to receive from LCRA supply when combined storage in Lake Travis and Buchanan is extremely low (less than 450,000 acre-feet or about 22% full)[2]	6,000	20,400	77,000	93,600
Type 3 – Amount of water above Austin Water's current LCRA contract of 325,000[1]	0	0	0	170,400
Total Water Needs - Preliminary	9,000	31,000	92,400	288,800

AFY = acre-feet per year
[1]Need can be achieved with new demand management and water supply options.
[2]Need can only be achieved with new water supply options resulting in readily available potable water.

Table 9-3 indicates which demand management and water supply options are included in each of the portfolios, while **Figure 9-3** shows the maximum annual water yield capacity for the new portfolio options in the year 2115. Note that the new options included in each portfolio are in addition to the City's current Colorado River water supplies, current reclaimed water supplies, and current conservation programs. These baseline supplies are the underlying core supplies present in every portfolio.

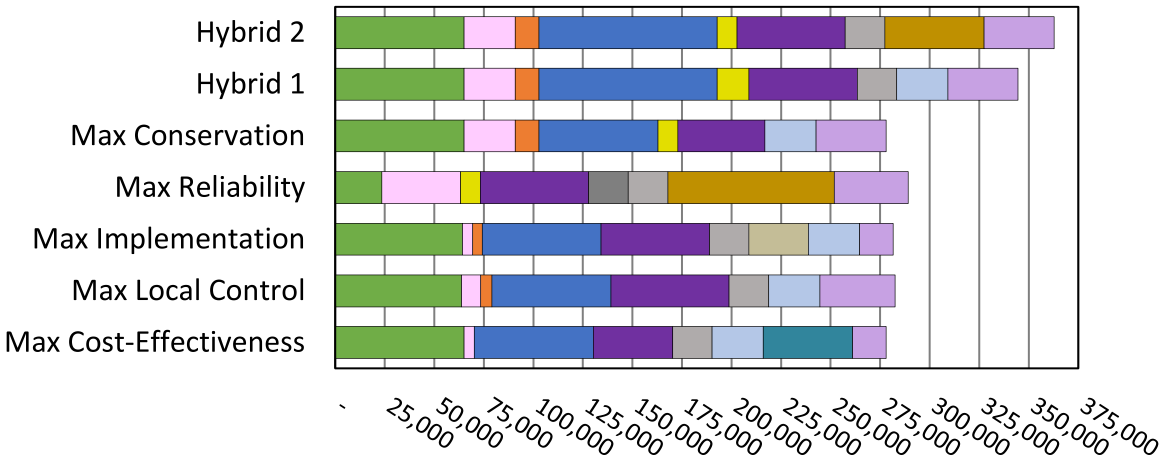

Figure 9-3. Maximum Annual Water Yield (AFY) in Year 2115 for the Portfolios

Table 9-3. Summary of Options Included in Portfolios

Options	Included in Portfolios						
	Max Cost-Effective	Max Control	Max Implem.	Max Reliability	Max Conserv.	Hybrid 1	Hybrid 2
Demand Management Options							
Advanced Metering Infrastructure	X	X	X	X	X	X	X
Water Loss Control Utility Side	X	X	X	X	X	X	X
CII Ordinance for Cooling Towers and Steam Boilers	X	X	X	X	X	X	X
Water Use Benchmarking and Budgeting	X	X	X		X	X	X
Landscape Ordinance	X	X	X		X	X	X
Landscape Incentives	X				X	X	X
Irrigation Efficiency Incentives	X		X		X	X	X
Stormwater Harvesting (Lot)					X	X	X
Rainwater Harvesting (Lot)		X	X		X	X	X
Graywater Harvesting (Lot)		X		X	X	X	X
Building Scale Wastewater Reuse				X	X	X	X
AC Condensate Reuse	X	X	X	X	X	X	X
Water Supply Options							
Aquifer Storage and Recovery	X	X	X		X	X	X
Brackish Groundwater Desal				X	X	X	X

Direct Non-Potable Reuse	X	X	X	X	X	X	X
Direct Potable Reuse				X			
Indirect Potable Reuse	X	X	X	X		X	X
Additional Supply from LCRA			X				
Off-Channel Reservoir w/ Lake Evaporation Suppression	X	X	X		X	X	
Imported Option Category - Seawater Desalination				X			X
Imported Option Category – Conventional Groundwater	X						
Distributed Wastewater Reuse	X	X	X	X	X	X	X
Wastewater Scalping (Sewer Mining)		X		X	X	X	X
Community Stormwater Harvesting		X			X	X	X
Community Rainwater Harvesting		X					

All of the portfolios met all identified water needs (Types 1, 2, and 3) for the period of record hydrology with historical climate (hydrologic scenario A). Of the initial themed portfolios, only the Maximum Reliability portfolio came close to meeting all identified needs under period of record with climate change (hydrologic scenario B) and extended period hydrology with climate change (hydrologic scenario D). Both Hybrid 1 and 2 portfolios met all identified water needs under hydrologic scenario B and came close to meeting all identified water needs for hydrologic scenario D.

9.2 Raw Performance Scorecard

As outlined in Section 4.4, the IWRP had five major objectives against which the portfolios were evaluated: (1) *Water Supply Benefits*; (2) *Economic Benefits*; (3) *Environmental Benefits*; (4) *Social Benefits*; and (5) *Implementation Benefits*. These five objectives were further defined by sub-objectives. For example, the objective *Water Supply Benefits* had two sub-objectives: *Vulnerability* and *Reliability*. No objective had more than three sub-objectives. Primary weights of relative importance were assigned to each of the five objectives and secondary weights of relative importance were assigned to each of the twelve sub-objectives (see **Table 9-4**).

Table 9-4. Objective and Sub-Objective Weights

Objective	Sub-Objective
Water Supply Benefits – **35%**	Minimize Vulnerability – **80%**
	Maximize Reliability – **20%**
Economic Benefits – **20%**	Maximize Cost-Effectiveness – **75%**
	Maximize External Funding – **25%**
Environmental Benefits – **20%**	Minimize Ecosystem Impacts – **40%**
	Minimize Net Energy Use – **30%**
	Maximize Water Use Efficiency – **30%**

Social Benefits – **13%**	Maximize Multi-Benefit Programs – **38%**
	Maximize Net Benefits to Local Economy – **31%**
	Maximize Social Equity – **31%**
Implementation Benefits – **12%**	Minimize Risk – **60%**
	Maximize Local Control/Local Resource – **40%**

For each sub-objective, one performance metric was established to measure how well the portfolios achieved the sub-objective. Most performance metrics were quantitative and based on modeling or detailed evaluations. The quantitative performance metrics were measured on a continuous scale (e.g., dollars); or in some cases measured on a constructed scale from 1 to 5 based on the quantitative measurements. Other performance metrics were qualitative and measured on a constructed scale from 1 to 5 based on expert judgement. For constructed-scale metrics, a score of 1 is inferior and a score of 5 is superior. Generally, constructed-scale metrics are designed to show distinction, where at least one portfolio (or options within the portfolio) must score close to a value of 1 and at least one portfolio (or options within the portfolio) must score close to a value of 5.

Table 9-5 summarizes the objectives, sub-objectives and performance metrics for the portfolios. A description of how the performance metrics were derived follows. **Appendix K and Appendix L** have further details.

Table 9-5. Raw Performance Scorecard

Objective	Sub-Objective	Performance Metric	Metric Type	Portfolio						
				Max Cost-Effect.	Max Control	Max Implem.	Max Reliable	Max Conserv.	Hybrid 1	Hybrid 2
Water Supply Benefits	Minimize Vulnerability	% of identified needs met during 12-months of worst-case drought[1]	Quantitative (WAM)	81%	77%	77%	95%	76%	89%	92%
	Maximize Reliability	% of months in period of simulation with no identified need shortages[1]	Quantitative (WAM)	93%	97%	97%	98%	97%	99%	99%
Economic Benefits	Maximize Cost-Effectiveness	Lifecycle unit cost ($/AF)[2]	Quantitative (Eng. Estimate)	$1,673	$2,044	$1,696	$3,827	$2,919	$3,315	$3,489
	Maximize External Funding	Grants and developer funding potential (score 1-5)[3]	Qualitative	1.7	2.4	2.0	4.0	3.6	3.6	3.5
Environmental Benefits	Minimize Ecosystem Impacts	Ecosystem impact, net diversions and stormwater capture (score 1-5)[2,3]	Derived from WAM	1.5	2.8	1.7	3.0	4.7	4.2	4.7
	Minimize Net Energy Use	Net change in energy requirement (millions of kWh/yr)[2]	Quantitative (Eng. Estimate)	124.7	66.4	48.0	315.4	97.3	144.4	282.1
	Maximize Water Use Efficiency	2115 potable water per capita demand (gallons/person/day)[2]	Quantitative (demand model)	81	68	77	73	67	67	68
Social Benefits	Maximize Multi-Benefit Programs	Stormwater capture/harvesting (score 1-5)[2,3]	Derived from Portfolio Mix	3.1	3.7	3.6	1.0	4.7	4.7	4.7
	Maximize Net Benefits to Local Economy	Positive economic impact (score 1-5)[2,3]	Derived from Cost Estimate	1.0	2.1	1.1	5.0	4.5	5.0	4.6
	Maximize Social Equity	social equity (score 1-5)[3]	Qualitative	3.1	3.3	3.5	2.9	3.4	3.3	3.3
Implementation Benefits	Minimize Risk	Portion of supply mix considered relatively high in risk (score 1-5)[3]	Qualitative	3.0	4.0	5.0	1.0	5.0	4.0	3.0
	Maximize Local Control/Local Resource	Portion of supply mix within local area and/or within AW's control of operations (score 1-5)[3]	Derived from Portfolio Mix	3.0	5.0	4.0	2.0	3.0	5.0	5.0

[1]Calculated by taking geometric mean of WAM results for hydrologic scenarios B and D; and for years 2040, 2070, and 2115.
[2]Based only on period of record with climate change (scenario B).
[3]Score of 1 = inferior, while score of 5 = superior

9.2.1 Water Supply Benefits

Performance metrics under the water supply benefits objective were calculated using output from Austin Water's WAM. For each portfolio the model was run under hydrologic scenarios B and D (using the period of record (POR) and extended period, both with climate change) for the time periods of 2040, 2070 and 2115. Both the vulnerability metric (calculated as how much of the Type 1, 2, and 3 water needs are met during the 12-months of worst-cast drought) and reliability metric (calculated as the percent of months without Type 1, 2, or 3 shortages during the period of simulation) were estimated by taking the geometric mean for hydrologic scenarios B and D, throughout the planning period, as shown in **Table 9-6** below.

9.2.2 Economic Benefits

Economic benefits were measured by estimating a simplified lifecycle unit cost and a qualitative assessment of advantageous funding. The simplified lifecycle unit cost for each portfolio is based on the following steps:

1) For options that are assumed to operational on a constant basis, regardless of hydrological condition (e.g., all demand management options, non-potable reuse, distributed wastewater, wastewater scalping and community-scale stormwater capture/harvesting), the total unit cost for each option is multiplied by the annual water supply for each option and then these costs are totaled for each year (2040, 2070 and 2115). Costs are not escalated or discounted, and thus can be interpreted as current year dollars. Escalating and discounting for 100 years is highly speculative. The total option unit cost represents the annualized capital cost plus the annual O&M cost, estimated using standard engineering methods. The annualized capital cost includes financing cost.

2) For options that are assumed to be operational only when needed or available (e.g., all storage options, indirect and direct potable reuse, brackish groundwater, imported seawater desalination and imported groundwater) the *average* utilized modeled water yield of the options from the WAM are multiplied by the annual O&M cost, while the annual water capacity for each option is multiplied by the annualized capital cost (with financing). These costs are then totaled for each year (2040, 2070, and 2115).

3) The costs for each year (2040, 2070, and 2115) from steps (1) and (2) are totaled and divided by the total Type 1, 2 and 3 water needs (in AF) for the portfolio over the entire planning period. This overall lifecycle unit cost is conducted using hydrologic scenario B (period of record with climate change).

The score for maximizing advantageous funding considers two factors: (1) the likelihood that a project can receive external funding and (2) the potential for project costs to be borne by developers. For the external funding component, each option was scored on a scale of 1 to 5 with a score of 1 indicating a low potential for external funding and a score of 5 indicating a high potential for external funding. Each portfolio's external funding score is then calculated as the weighted average based on the yields from each option. The score for potential developer contribution is based on the total cost of options seen as having potential for developer contribution. This calculated cost for each portfolio is then converted to a score of 1 to 5 where the portfolio with the highest total receives a 5, the portfolio with the lowest total receives a 1 and the other scores fall in between. The final score for advantageous external funding is then determined as 40% the external funding score and 60% the developer contribution score. See **Appendix K** for more details.

Table 9-6. Scoring for Water Supply Benefits

Portfolio	Percent of Identified Need Met During 12-Month Worst Drought		Percent of all Months without an Identified Need Shortage		Geometric Mean: Vulnerability	Geometric Mean: Reliability
	Scenario B: POR with Climate Change	Scenario D: Extended Period with Climate Change	Scenario B: POR with Climate Change	Scenario D: Extended Period with Climate Change		
Max Conservation						
2040	96%	87%	99%	99%	76%	97%
2070	96%	62%	99%	99%		
2115	67%	57%	92%	94%		
Max Cost-Effective						
2040	100%	92%	100%	100%	81%	93%
2070	95%	70%	98%	99%		
2115	72%	64%	83%	83%		
Max Reliability						
2040	96%	90%	99%	100%	95%	98%
2070	96%	94%	98%	98%		
2115	98%	98%	96%	97%		
Max Implementation						
2040	95%	82%	99%	99%	77%	97%
2070	93%	63%	98%	99%		
2115	70%	62%	91%	93%		
Max Local Control						
2040	95%	85%	99%	99%	77%	97%
2070	95%	64%	98%	99%		
2115	69%	61%	92%	94%		
Hybrid 1						
2040	100%	91%	100%	100%	89%	100%
2070	100%	73%	100%	99%		
2115	100%	74%	100%	99%		
Hybrid 2						
2040	100%	97%	100%	100%	92%	100%
2070	100%	73%	100%	99%		
2115	100%	86%	100%	99%		

Note that these vulnerability and reliability results are focused solely on the Type 1, 2, and 3 identified water needs being met. They do not reflect an overall water supply vulnerability or reliability metric, only as defined by Types 1, 2, and 3 identified needs.

9.2.3 Environmental Benefits

Environmental benefits were measured by three metrics: (1) ecosystem impacts; (2) net energy use; and (3) water use efficiency.

The ecosystem impact score is based on net diversions as output from the WAM using the period of record with climate change (hydrologic scenario B) and stormwater and rainwater. The net diversions for all the portfolios are compared, and the portfolio with the greatest net diversions receives a score a 1, while the lowest receives a 5, and the other portfolios are ranked in between. The net diversion results for all portfolios did not vary greatly from one portfolio to the next; however, to follow the process steps, the portfolios were scored across the full range of 1 to 5. For stormwater and rainwater capture, portfolios are scored along a linear scale with no stormwater capture receiving a score of 1 and the maximum potential stormwater capture of 14,357 AFY receiving a 5. The average of the net diversion and stormwater/rainwater capture scores is then calculated to give the raw performance score. See **Appendix K** for more details.

The incremental change in energy use considers the additional energy required to operate each option as well as energy savings from not having to treat the water for the demand management options. A portfolio's score is the summation of additional energy use or savings from each option in millions of kWh per year. Since the sub-objective is to minimize net energy use a lower score is better for this performance measure. See **Appendix K** for more details.

The sub-objective to maximize water use efficiency is measured as the potable water use of the portfolio in gallons per capita per day (gpcd). Total 2115 diversions in the WAM for the climate adjusted scenario were converted to pumpage by assuming a 2.74% loss percentage between the raw water diversion point and the treated water discharge point. The total non-potable supply options for each portfolio (direct non-potable reuse, distributed wastewater reuse, and wastewater scalping) was then subtracted from the total pumpage to get the potable supply. The potable supply was then divided by the estimated 2115 population to get the gpcd value. For this performance measure a lower score is better since it indicates a more efficient use of potable water. See **Appendix K** for more details.

9.2.4 Social Benefits

Social benefits were measured by assessing the potential for providing multi-benefits, benefits to local economy, and social equity. Options utilizing stormwater, rainwater, or providing landscape transformation benefits were used as a proxy for maximizing multi-benefit infrastructure. The total volume supplied from these options for each portfolio was summed and then assigned a score of 1 through 5 with a score of 1 indicating no supply coming from the multi-benefit options to a score of 5 if all the options were fully utilized. See **Appendix K** for more details.

The local economy score is based on options that have the potential to bring money or work to the local area. This could be through either; projects having locally-based construction, or through promoting Austin as a center for innovative water infrastructure. The yield from each of the options seen as benefiting the local economy was multiplied by its unit cost and the totals were summed for each portfolio. These dollar figures were then converted to a 1 to 5 scale with a score of 1 going to the lowest total, a score of 5 going to the highest total, and the other portfolios falling in between. See **Appendix K** for more details.

The social equity score is based on sub-scores for categories that the City uses for evaluating concepts related to social equity. These categories are: alignment, history, community engagement, advancing equity, unintended outcomes, impact, and access to benefits. Each option is scored according to these categories and then summed into a total composite score. The lowest composite score is then converted to a score of 1 and the highest converted to a 5, with the options falling in between assigned relative scores rounded to the nearest integer. The portfolios then receive a final score based on a weighted average by yield of their options. See **Appendix K** for more details.

9.2.5 Implementation Benefits

Implementation benefits was measured by an assessment of overall risk and local control. The risk score is based on the percentage of a portfolio's yield coming from high-risk options. For each option, ten different types of risk were considered, and a point was awarded for each of the ten types of risk the option was seen to contain. The risks included: institutional challenges, public/developer opposition, scalability issues after initial construction, geographic/distribution limitations, permitting/regulatory difficulty, infrastructure failure risks, supply/savings uncertainty, operations and maintenance challenges, siting/land acquisition challenges, and emerging technology/local innovation challenges. Nine options received a risk score of 4-7 and were considered to be the higher risk options. The percentage of yield coming from these higher risk options was calculated for each portfolio and converted into a score of 1 to 5, with 5 being assigned to the portfolio with the lowest percentage of higher risk options and 1 being assigned to the portfolio with the highest percentage of higher risk options. See **Appendix K** for more details.

The local control/local resource score was based on two components: (1) yield from options that AW controls and, (2) yield from options in the local area. The two totals were determined for each portfolio and then summed together. This combined value for each portfolio was then converted into a score of 1 to 5 with 5 being assigned to the portfolios with the highest totals. See **Appendix K** for more details.

9.3 Portfolio Rankings

Using the raw performance scores and weights for objectives and sub-objectives, the portfolios were ranked by the decision software Criterium Decision Plus (CDP), using the multi-attribute rating method. The portfolios were ranked based on the relative importance of each objective and sub-objective and how they performed within each of those objectives. **Figure 9-4** shows the ranking of portfolios. The figure not only shows which portfolios ranked the highest but also which objectives contributed the most to the scoring. The larger the color bar segment, the better the portfolio does in achieving a particular objective.

Details of scoring of each objective and sub-objective by portfolio are shown in **Appendix L**.

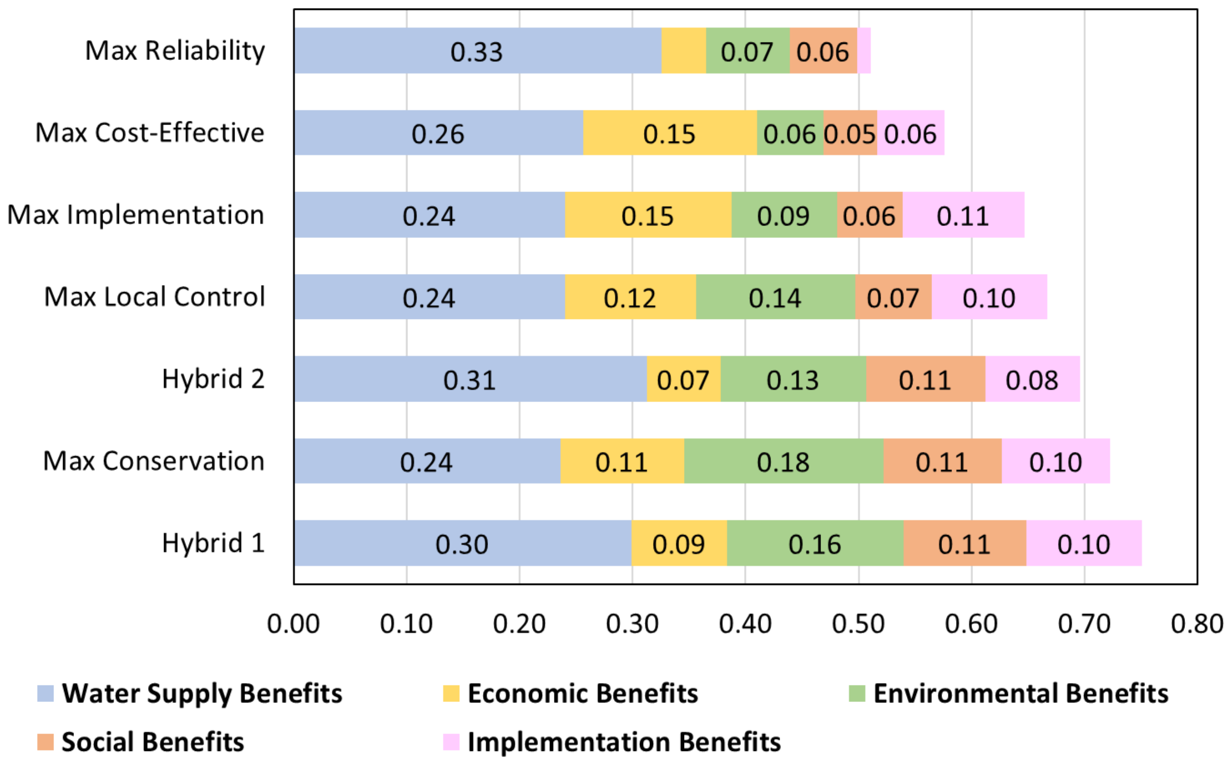

Figure 9-4. Scoring of Portfolios Using Decision Software

9.4 Summary of Findings

The results indicate that the Hybrid 1 portfolio scores highest among all the portfolios. Of the initial portfolios, only the Maximum Conservation portfolio scored in the top three positions (second highest score). The Hybrid 2 portfolio scored third. While the Maximum Reliability portfolio had the best overall score for water supply benefits, it scored lowest overall due to its higher cost and implementation risk, and lower environmental and social benefits.

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SECTION 10: RECOMMENDATIONS

The comprehensive evaluations of the five initial and two hybrid portfolios presented in Section 9 indicate that the Hybrid 1 Portfolio ranked highest overall. It also represented the best balance in meeting the multiple objectives of the IWRP. Therefore, the recommended strategy for ensuring a reliable, high-quality and sustainable water supply for Austin Water is the phased implementation of the Hybrid 1 Portfolio. **Table 10-1** presents the demand management and water supply options and projected yields for this recommended strategy.

AT A GLANCE

- *Plan Recommendations*
- *Adaptive Management*

Table 10-1. Options Included in Hybrid 1 Portfolio

Recommended Options	Yield Capacity (AFY)*		
	2040	2070	2115
Demand Management Options			
Advanced Metering Infrastructure (AMI)	3,882	5,766	9,371
Water Loss Control	9,326	10,918	13,064
CII Ordinances	1,063	1,063	1,063
Benchmarking	5,953	11,670	25,228
Landscape Ordinance	3,038	7,428	15,050
Landscape Transformation Incentive	321	633	929
Irrigation Efficiency Incentive	205	427	394
Lot Scale Stormwater Harvesting	329	869	2,275
Lot Scale Rainwater Harvesting	1,550	4,032	9,251
Greywater Harvesting	2,126	5,617	12,667
Building Scale Wastewater Reuse	1,323	3,672	7,875
AC Condensate Reuse	1,084	2,711	5,150
Sub-Total	30,202	43,437	77,961
Water Supply Options			
Aquifer Storage and Recovery	60,000	60,000	90,000
Brackish Groundwater Desal	-	5,000	14,000
Direct Non-Potable Reuse	12,000	25,000	54,600
Indirect Potable Reuse	10,000	20,000	20,000
Off Channel Reservoir	-	25,000	25,000
Distributed Wastewater Reuse	3,154	14,467	30,049
Sewer Mining	1,000	2,211	5,284
Community Stormwater Harvesting	158	236	504
Sub-Total	86,312	151,914	239,436
OVERALL TOTAL	**116,514**	**195,351**	**317,397**

* Yield capacity represents the maximum annual yield in ideal conditions. Actual yield will vary based on hydrology and need.

10.1 Plan Recommendations

The following section summarizes the plan recommendations for Austin Water's Integrated Water Resources Plan.

10.1.1 Core Colorado River Supplies

The Colorado River supply will continue to be Austin's core supply in the future. Planned actions to enhance supply include:

- Continued participation in the Lower Colorado River Authority/City of Austin Water Partnership
- Continue to engage on potential water supply development in the basin, which may include regional partnerships as a way to implement supply or demand management options
- Continued communication and information sharing with other entities in the basin
- Continued participation in LCRA's Water Management Plan update processes
- Continued participation in the Texas Water Development Board-administered Regional Water Planning process
- Broaden our understanding of basin-wide issues, including both upstream and downstream issues
- Share information and work with others to study potential future climate change impacts

10.1.2 Implementation of Best Management Practices

Austin Water will continue to implement best management practices and general implementation components required for the recommended options. These best management practices and option implementation components include:

- Best management practice options include:
  - Require or incentivize government-recognized energy and water efficiency-labeled residential and commercial fixtures (included in baseline assumptions in portfolios).
  - Incentivize or require toilet, urinal, and bathroom faucet aerator efficiencies (included in baseline assumptions in portfolios).
  - Lake Austin operational drought strategy.
- Options identified as implementation components:
  - Water rates and fees to promote water use efficiency while maintaining affordability.
  - Customer education enhancements.
  - Use of social media programs and web-based content to promote conservation.

10.1.3 Implementation of Water Forward Strategy Based on Hybrid 1 Portfolio

Austin Water will use an adaptive management framework to phase implementation of the recommended options. Implementation considerations include:

- Need to ramp up demand management options, as they take time to realize the full benefits.
- Need adequate time for engineering, field testing, public outreach and construction for new supply projects.
- Need process for adjusting strategy should one or more options not perform as expected, such as accelerating other options in Hybrid 1 Portfolio.
- Recognize that in the longer-term, other options not included in Hybrid 1 Portfolio might become more feasible and beneficial for implementation.

10.2 Adaptive Management

Given the long planning horizon for IWRP, Austin Water developed an adaptive implementation plan from 2020 to 2040 for all the components included in the Water Forward strategy. The timing of implementation of the various components is based on several factors, such as: (1) the need for sequential actions; (2) accounting for resource and budget constraints of the utility; and (3) time for engineering, field testing, public outreach and construction of supply projects.

An update to the IWRP to reconsider recommendations is planned on a five-year cycle.

Some potential metrics to monitor implementation and the need for plan adjustments include:

- Demands: Are they tracking with the IWRP projections?
- Supplies: What is the ratio of supply capacity to demand?
- Project Implementation:
  - Progression of projects and programs compared to estimated project milestones.
  - Estimated savings from implemented demand management options.
  - Estimated yield from implemented supply options.

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SECTION 11: REFERENCES

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