Brown AND Caldwell

Prepared for City of Davis

Davis CALIFORNIA

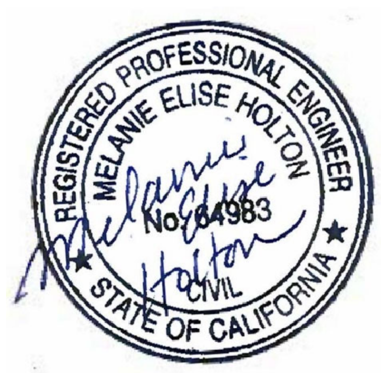
Integrated Water Resources Study Update

September 25, 2023

FINAL

Integrated Water Resources Study Update

Prepared for
City of Davis
Davis, CA
September 25, 2023



Brown AND Caldwell
11020 White Rock Road, Suite 200
Rancho Cordova, CA 95670

11020 White Rock Road, Suite 120
Rancho Cordova, California 95670
Tel: 916-444-0123

Brown AND Caldwell

September 25, 2023

Sherry Kimura
Water Quality Compliance Specialist
1717 5th St.
Davis, California 95616

Subject: Submittal of the Integrated Water Resources Study Update

Dear Ms. Kimura:

We are pleased to submit the Integrated Water Resources Study (IWRS) which is an update of the 2013 IWRS. The IWRS documents the City's future water needs, identifies and evaluates water management options, bundles the water management options into portfolios, screens the portfolios, and then recommends a sustainable water supply strategy. Please contact me at 916.853.5353 if you have any questions or comments.

Very truly yours,
Brown and Caldwell

Melanie Holton, PE No. 64983
Project Manager

REGISTERED PROFESSIONAL ENGINEER
MELANIE ELISE HOLTON
No. 64983
CIVIL
STATE OF CALIFORNIA

Project Participants

CITY OF DAVIS

Stan Gryczko

Sherry Kimura

Dawn Calciano

Matt Deusenberry

Adrienne Heinig

John Alexander

BROWN AND CALDWELL

Melanie Holton, Project Manager

Timothy Lee, Staff Engineer

Tiffany Tran, Staff Engineer

Paul Selsky, Reviewer

Dawn Schock, Document Preparation

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ac-ft	acre-feet
ac-ft/yr	acre-feet per year
ADWF	average dry weather flow
AMI	advanced metering infrastructure
ASR	aquifer storage and recovery
AWWA	American Water Works Association
CAAP	Climate Action and Adaptation Plan
CalWEP	California Water Efficiency Partnership
CEQA	California Environmental Quality Act
CII	commercial, industrial, institutional
CIMIS	California Irrigation Management Information System
City	City of Davis
CO_2e	carbon dioxide equivalent
CSA	community service area
DPR	direct potable reuse
DWR	California Department of Water Resources
EAT	East Area Tank
EO	executive order
ETo	evapotranspiration
Ft	feet
FY	fiscal year
GHG	greenhouse gas emissions
GPCD	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
HP	horsepower
in	inches
IPR	indirect potable reuse
IW	irrigation well
kWh	kilowatt hour
kWh/ac-ft	amount of energy used for each ac-ft of water supply
IWRS	Integrated Water Resources Study
lbs	pounds
LF	linear feet
LRV	log reduction values
M	million
MFR	multi-family residential
MG	million gallons
mgd	million gallons per day
NPDES	National Pollutant Discharge Elimination System
NRC	Natural Resources Commission
O&M	operations and maintenance
PG&E	Pacific Gas & Electric
PWUO	Public Works Utilities and Operations Department
RWA	raw water augmentation
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SFPUC	San Francisco Public Utilities Commission
SFR	single family residential
sq-ft	square feet
STI	secondary and tertiary improvements
SWRCB	State Water Resources Control Board
TWA	treated water augmentation
UCD	University of California, Davis
UWMP	Urban Water Management Plan
WAT	West Area Tank
WDCWA	Woodland Davis Clean Water Agency
WSOP	Water System Optimization Plan
WTP	water treatment plant
WWTP	wastewater treatment plant
WW	water conservation and waste reduction sector
YCCL	Yolo County Central Landfill
YSGA	Yolo Subbasin Groundwater Agency

Section 1

Introduction

This Integrated Water Resources Study (IWRS) is an update of the 2013 IWRS (Brown and Caldwell, 2013a) and presents the results of an evaluation of water management options conducted for the City of Davis (City). The water management options that could be implemented in addition to the City's existing groundwater and surface water supplies are the focus of this IWRS.

This IWRS does not address the existing groundwater and surface water supplies other than how the amounts or use of those supplies might be changed due to the implementation of water management options. This section presents the objectives of the IWRS, background on the City's previous water resources planning efforts including the 2013 IWRS, and the approach used to evaluate water management options.

1.1 Objectives

The overall objective of this IWRS is to develop a strategy for a sustainable water supply future that consists of a bundle or portfolio of water management options. For over 30 years, the City has studied and pursued water supply alternatives to meet three primary objectives: 1) provide a reliable water supply to meet existing and future needs, 2) improve the quality of the potable water provided to residents, and 3) anticipate and meet the regulatory and environmental requirements for a diversified and sustainable water system that services the City of Davis and its residents.

This IWRS evaluates a variety of water management options that could form the elements of a long-term sustainable water supply strategy for the City. The intent is to identify options that are practical to implement in addition to the City's current groundwater and surface water supplies. It is also important to identify the options that are not practical for the City to implement.

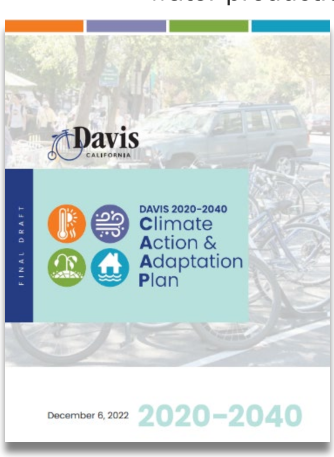
This IWRS seeks to answer the key questions of:

- What does a sustainable water supply for the City look like?
- What individual water management options are available?
- What are the tradeoffs between them?
- What options provide benefits such as increased reliability or a dry year supply?
- What options are not practical for the City to implement?
- How would the water management options interact with the City's existing groundwater and surface water supplies?
- What water portfolios make sense for the City to consider?

The following City-wide objectives will be considered when evaluating the water management options and portfolios.

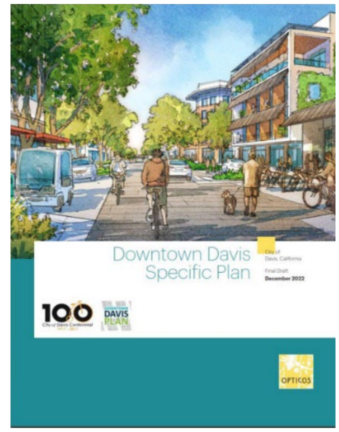
- City's estimated draft water use objectives gallons per capita per day (GPCD) targets as derived from California's long-term water use objectives as directed in water conservation legislation Senate Bill (SB) 606 and AB 1668 (Refer to Section 3 for more description of these objectives).
- City's 2020-2040 Climate Action and Adaptation Plan (CAAP)(City of Davis, 2022b) to conserve water in buildings and landscapes.

- City's Downtown Davis Specific Plan (City of Davis, 2022c) goal of modeling the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit".
- City Council 2021 – 2023 goals and objectives (City of Davis, 2021)
  - Goal 2, Objective 2 includes:
    - D. Explore technology options that will reduce costs while maintaining or improving service delivery expectations.
  - Goal 3, Objective 2 includes:
    - A. Develop and implement a planting and watering conservation strategy/plan.
    - B. Replant traditional turf species in greenbelts, planting strips or medians with low stature native or near-native grass species.
    - C. In conjunction with the Urban Forest Master Plan, implement urban forest management with an eye towards drought tolerance and climate resiliency of tree species in new plantings and in tree replacements. Maintaining quality and quantity of the City's water supply and wastewater treatment processes and promoting water conservation.
  - Goal 3, Objective 3 includes:
    - A. Continue to pursue reuse of wastewater treatment plant effluent for multiple purposes.
    - B. Maintain regular communication with the community on the importance of water conservation practices and encourage residents to sign up for AquaHawk to monitor and manage water use.
    - D. Undertake a leak detection survey on the City's water distribution infrastructure to detect areas with a higher concentration of structural concerns for inclusion in upcoming capital improvement projects.
    - E. Install pressure sensors within the City's water distribution system to identify needs for water pressure management.
    - F. Explore, quantify and prioritize ways to improve the long-term environmental impacts and costs of our waste system and align them with the City's water conservation, renewable energy and other goals.
  - Goal 4, Objective 1 includes:
    - Develop plans and funding strategies to address the long term needs of the community in planning for maintaining/enhancing city infrastructure and assets, including storm water, water production and distribution, and wastewater collections system.



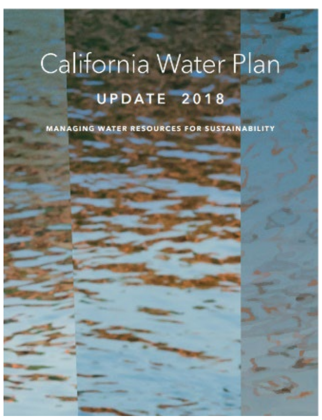
The City's 2020-2040 CAAP provides a framework to fulfil the Davis City Council objective to establish a roadmap of carbon reduction policies to achieve the Davis carbon neutrality goal by 2040. This goal stems from the City Council resolution declaring a climate emergency in 2019 for actions to achieve the greenhouse gas emission reduction targets adopted by the City Council in November 2008 and established in the City's first CAAP adopted in 2010. The CAAP also makes the City consistent and in compliance with California legislation to reduce greenhouse gas (GHG) emissions, address climate adaptation and incorporate environmental justice. The CAAP includes new emission reduction targets for 2030 that align with SB 32 as well as emission reduction targets through 2040 that align with executive order (EO) B-55-18 (Achieve Carbon Neutrality). The

CAAP includes objectives and actions in five sectors. The sector applicable to this IWRS is water conservation and waste reduction (WW). The WW sector has a goal to conserve water in buildings and landscapes. The CAPP identifies actions to reduce water use that include climate-ready private landscapes (WW.1) through incentives to support low-water landscaping and conserve water in buildings and landscape, public lawns, water pricing, Graywater reuse, and pool water consumption.



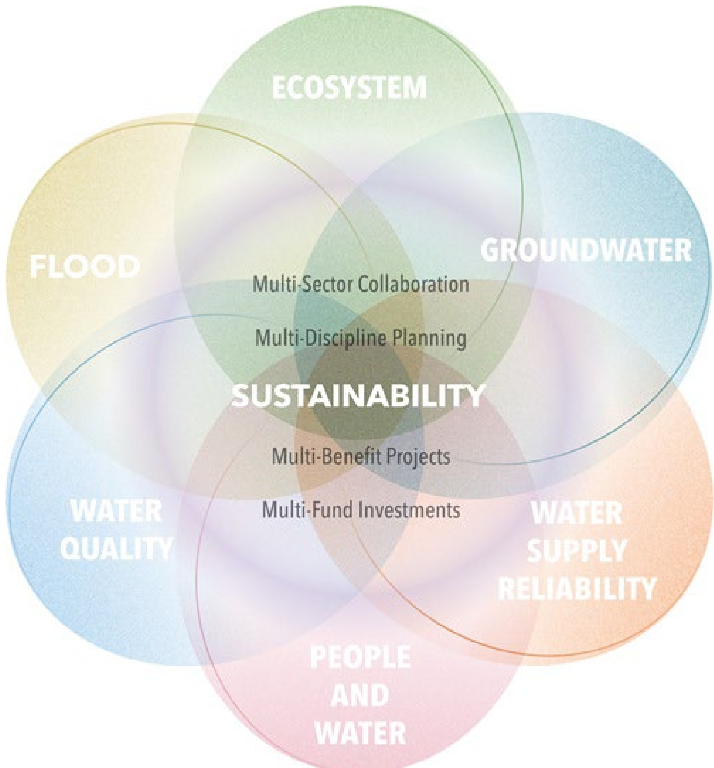
The Downtown Davis Specific Plan articulates the community's 2040 vision for Downtown, developed through an extensive public outreach process. It is compliant with the Davis General Plan's direction for Downtown, and provides goals, policies, and actions to deliver the vision.

Over the years, Davis has established a reputation as a progressive leader in promoting sustainability and has been at the forefront of initiatives and legislation that have made an impact at the regional and national level. The Downtown Davis Specific Plan seeks to further that legacy by extracting the most consistent and popular themes that emerged from the community engagement process and absorbing those into a unifying vision for Downtown. One of the most prominent themes to emerge was sustainability and for the City to become a national leader in sustainability. The vision for Downtown will reflect the community's commitment to a sustainable, inclusive, and healthy lifestyle. To model sustainability, the Downtown Davis Specific Plan recommends following the model of Triple Bottom Line sustainability that gives equal emphasis to "people, planet and profit". Widely accepted as an industry best practice, this concept encompasses environmental protection, social equity, and economic prosperity.



The City's desire to have a sustainable water future is in alignment with the water sustainability and reliability framework developed by the California Department of Water Resources (DWR) for the California Water Plan, Update 2018 (State of California, 2019). The California Water Plan provides recommended actions to overcome California's most pressing water resources challenges through six sustainability goals related to ecosystem and infrastructure improvements as well as systemic and institutional issues. The 2018 update of the California Water Plan presents a vision where all Californians benefit from desirable conditions such as reduced flood risk, more reliable water supplies, reduced groundwater depletion, and greater habitat and species resiliency – all for a more sustainable future, as illustrated in Figure 1-1.

This IWRS seeks to accomplish a similar objective for the City, which is to identify options that provide water sustainability and reliability that support and enhance the City's public health, quality of life, economy, and environment.



(Source: https://water.ca.gov/Programs/California-Water-Plan/Update-2018)

Figure 1-1. Managing water resources for sustainability requires alignment and integration among water sectors. It also requires additional effort, the outcome provides multiple benefits that accrue from the calibration, interdisciplinary planning, and pooled funding

1.2 Background

With this IWRS update, the City is taking a further step to chart the path to a long-term sustainable water supply. The City has been investigating its water future and pursued water supply alternatives for over 30 years. These alternatives have taken the form of installing wells in the deep aquifer, contributing to the development of the Woodland Davis Clean Water Agency (WDCWA) Water Treatment Plant (WTP) and beginning the WDCWA to provide potable water from the Sacramento River to City residents. In addition, the City has been a leader in water efficiency and conservation efforts to reduce per capita demand as the population grows.

Figure 1-2 depicts the planning documents and activities where the City has investigated various water management options. The report title, author, date, and purpose of some of these key documents are provided in Table 1-1.

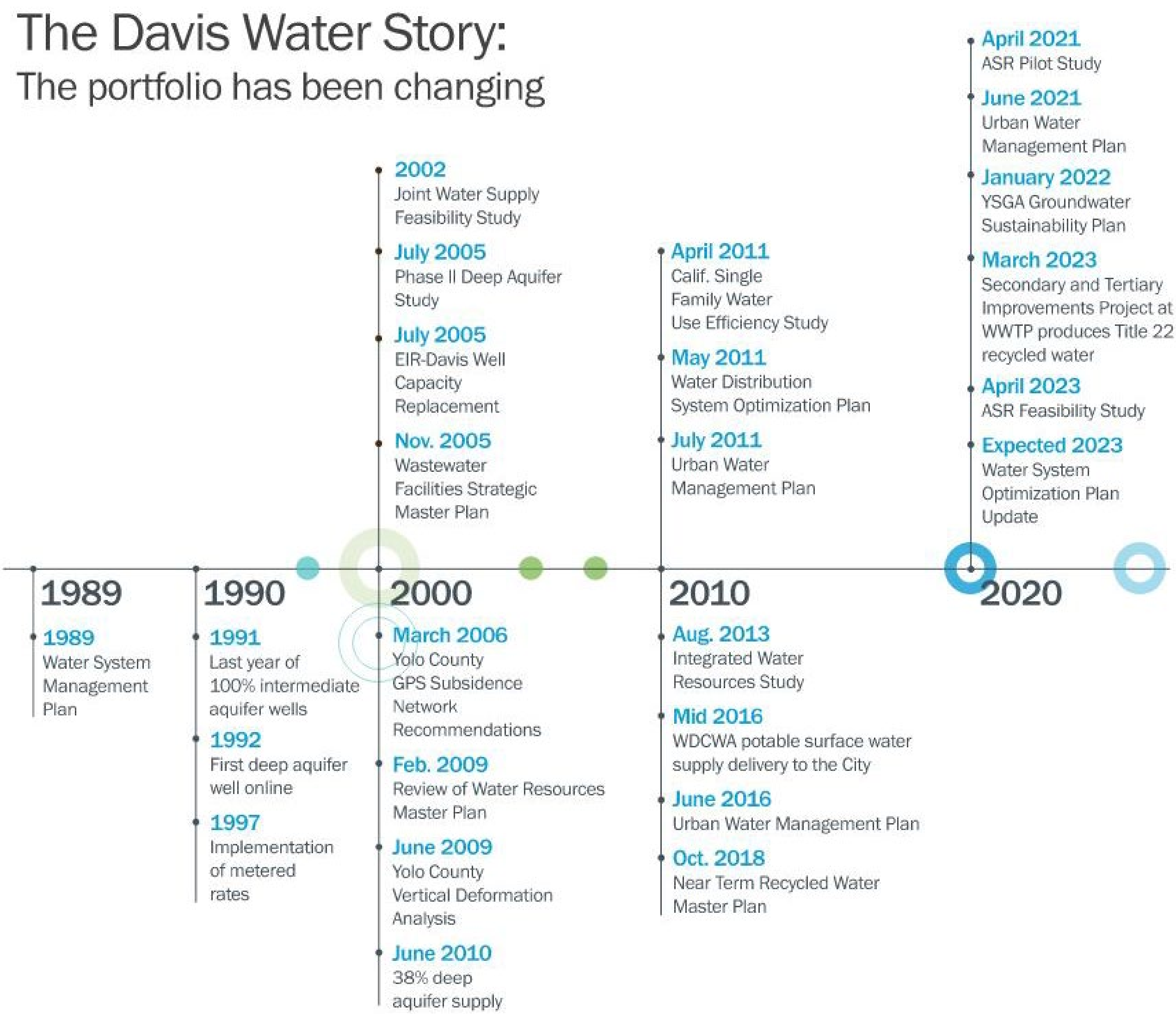


Figure 1-2. The City's consideration of water management options

Table 1-1. Key City of Davis Water Story Background Documents	
Report title, author, date	**Purpose**
City of Davis & University of California, Davis Joint Water Supply Feasibility Study West Yost and Associates September 2002	• Identifies the feasibility of various surface and groundwater supply options.
Wastewater Facilities Strategic Master Plan Carollo Engineers November 2005	• Develops recycled water alternatives.
Summary Report – Review of City of Davis Water Resources Master Plan Edward Schroeder, et al. February 10, 2009	• Reviews of studies peformed to date. • Ensures all feasible alternatives have been examined regarding potential solutions for water supply, wastewater treatment, and effluent dispersal issues.
Water Distribution System Optimization Plan Brown and Caldwell May 2011	• Presents updated demand projections. • Desktop condition assessment and hydraulic analysis of existing distribution system. • Recommends capital improvements.
2010 Urban Water Management Plan Brown and Caldwell July 2011	• Evaluates water conservation activities and approach to meeting the 167 GPCD target for 2020. • Presents historical and projected water use, • Requires submittal to DWR in accordance with the Urban Water Management Planning Act.
Summary Evaluated Alternatives to the Davis Woodland Water Supply Project West Yost and Associates November 15, 2011	• Summarizes information on the alternatives to the Davis-Woodland Water Supply project that have been studied over the past 20 years. • Presents cost information for the alternatives on a consistent cost basis.
Integrated Water Resources Study Brown and Caldwell August 2013	• Presents the results of an evaluation of water management options conducted for the City. • Presents cost and water supply information for water management options and recommends a water management portfolio.
Parks and Greenbelts Water Management Plan Brown and Caldwell October 2013	• Describes the City's current water use efficiency efforts. • Identifies the best opportunities for reducing water use. • Develops a multifaceted water management strategy with recommendations for specific actions in the immediate, short-term, and long-term.
2015 Urban Water Management Plan Brown and Caldwell June 2016	• Evaluates water conservation activities and approach to meeting the per capita target for 2020. • Presents historical and projected water use, • Requires submittal to DWR in accordance with the Urban Water Management Planning Act.
Near Term Recycled Water Master Plan West Yost and Associates October 2018	• Evaluates potential for delivering recycled water for agricultural irrigation reuse, municipal irrigation reuse, habitat creation and enhancement, and other non-irrigation uses.
2020 Urban Water Management Plan Brown and Caldwell June 2021	• Evaluates historical and projected water use, water supply sources and reliability. • Estimates unit water demand factors by customer sector. • Water shortage contingency planning.

Table 1-1. Key City of Davis Water Story Background Documents	
Report title, author, date	**Purpose**
	• Describes water conservation activities. • Requires submittal to DWR in accordance with the Urban Water Management Planning Act.
Groundwater Sustainability Plan Yolo County Groundwater Agency (YSGA) January 2022	• Documents conditions and establishes management criteria. • Identifies YSGA as the Groundwater Sustainability Agency for the entire Yolo Subbasin. • Defines a sustainability goal for the basin. • Proposes projects and management actions to meet the sustainability goal.

1.3 2013 IWRS

The 2013 IWRS recommended that the City proceed with the Conservation, Well Conversion, and aquifer storage and recovery (ASR) Portfolio.

- Conservation consisted of plumbing fixture retrofit, leak reduction, and irrigation management.
- Well conversion consisted of switching some of the irrigation supply for City parks from the potable water system by converting existing wells that pump from the intermediate depth aquifer to being irrigation only wells. The 2013 IWRS assumed that three existing intermediate depth wells would be converted to park irrigation use.
- ASR consisted of storing inexpensive winter surface water for use during the summer. It was recommended that the City conduct a study addressing frequency of need, best supply source, recharge wells, modeling (An initial single well groundwater transport model using aquifer characteristics and typical groundwater gradients developed in previous studies), regulatory (permit process with the California Department of Public Health and the Regional Water Quality Control Board), and costs. After the study, a pilot project would be the next step. The pilot project would consist of implementing one ASR well and testing of recharge and extraction operations. The pilot project would be conducted once surface water became available.

The City has implemented the 2013 IWRS recommendations for conservation and further analysis of ASR. The City has completed an ASR study and conducted a pilot ASR well using Well 27. The City has not yet converted wells to irrigation supply as the ASR study was recently completed in April 2023. Further analysis will be required to provide guidance on which wells should be used for ASR versus used for irrigation supply.

Additional 2013 IWRS recommendations included water marketing and further evaluation of recycled water for urban use/agriculture, rainwater catchment, stormwater, grey water, and dual local delivery systems. As described in Section 1.2 the City has conducted further planning and analysis to implement these recommendations.

1.4 IWRS Update Approach

The 2013 IWRS consists of the following water management options.

1. Recycled Water
2. Water Conservation
3. Well Conversion/Irrigation
4. Rainwater Catchment
5. Stormwater
6. Grey water
7. Aquifer Storage and Recovery
8. Dual Local Delivery Systems
9. Water Marketing
10. Atmospheric Harvesting

For this 2023 IWRS the following management options were revised:

- Recycled Water was modified and renamed: Recycled Water to Offset Groundwater Use based on current permit allowances.
- Water Conservation was expanded to two water management options: Residential and Commercial Water Use Efficiency and Municipal Water Use Efficiency.
- Rainwater Catchment, Grey Water, and Stormwater were combined to form one water management option: On-Site Water Reuse.
- Dual Local Delivery Systems was modified and renamed: Recycled Water Distribution System
- Water Marketing was removed.
- Atmospheric Harvesting was removed as it was determined the water supply would be negligible for the City of Davis as discussed in the 2013 IWRS.

The approach used in this IWRS consists of the following steps:

1. Identify and define water management options. Consider changes to the water management options evaluated in the 2013 IWRS (see Section 4).
2. Combine water management options into portfolios. The portfolios in the 2013 IWRS are updated in this IWRS. The portfolios represent plausible solutions to meeting the City's future water supply needs. The costs and water supply mix for each portfolio is quantified (see Section 5).
3. Develop criteria for screening the portfolios. The criteria used in the 2013 IWRS is not modified for this IWRS (see Section 5).
4. Rate the portfolios using the screening criteria (see Section 5).
5. Recommend strategies for near and long term implementation consisting of groups of portfolios or portions of portfolios to form robust strategies that perform well in many scenarios (see Section 6).
6. Provide an implementation timeline with key decision points (see Section 6).

In summary, this IWRS documents the City's future water needs, identifies and evaluates water management options, bundles the water management options into portfolios, screens the portfolios, and then recommends a sustainable water supply strategy. Figure 1-3 depicts the overall approach used for this IWRS.

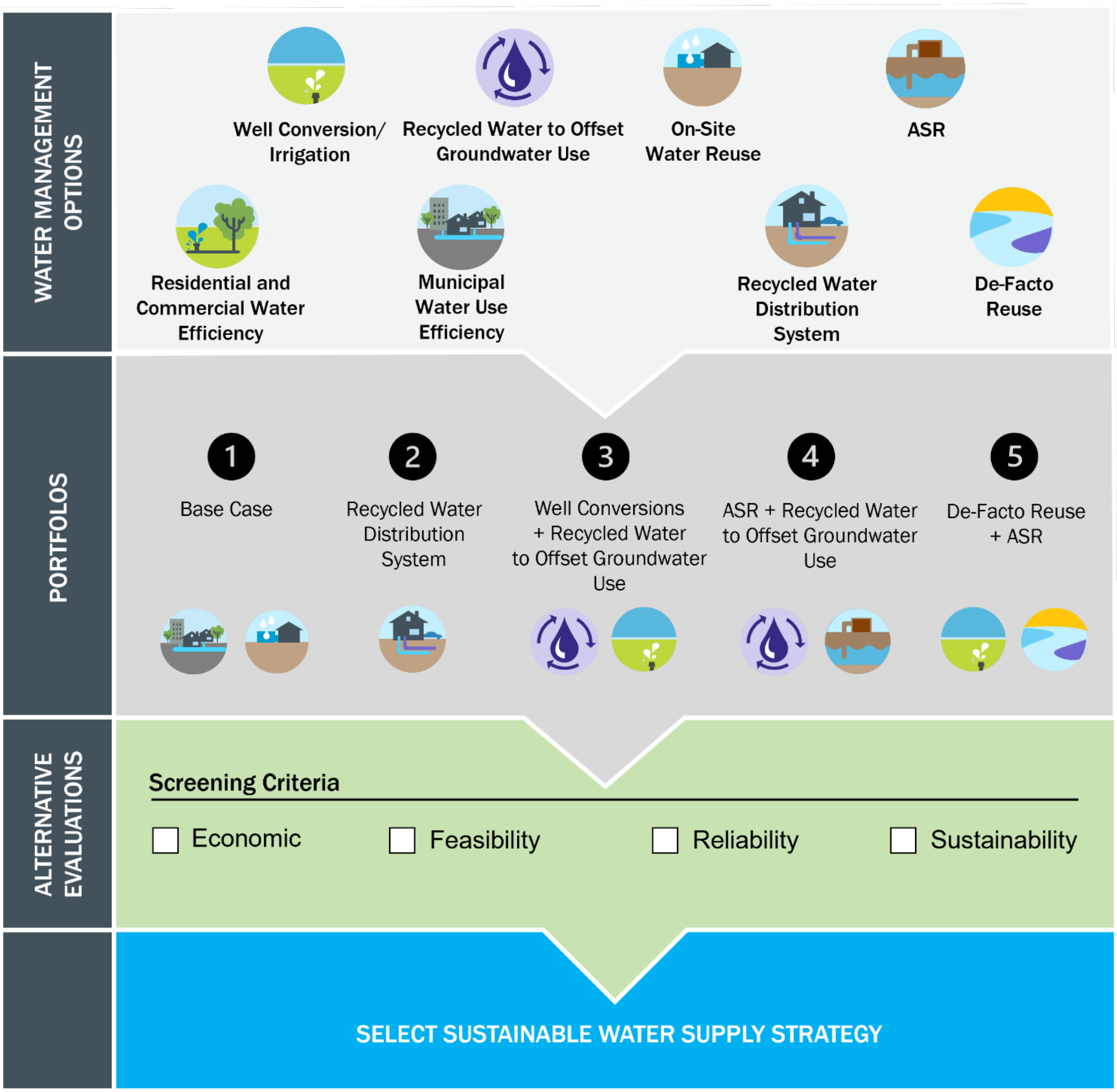


Figure 1-3. IWRS approach

Section 2

City Utility Systems Description

This section provides a description of the City's utility systems for water and wastewater. Key features of each utility system are described. Significant changes since the 2013 IWRS include the addition of surface water as a supply to water system in 2015 and upgrades to the wastewater treatment plant (WWTP) in 2018.

2.1 Potable Water System

The City currently relies on groundwater and surface water to meets its entire potable water demand. The City's potable water system consists of groundwater wells, pipelines, storage tanks, booster pump stations and interties, as shown in Figure 2-1. These potable water system components are described in this section.

2.1.1 Water Supply Facilities

The City has a conjunctive use water system supplied by surface water from WDCWA and groundwater from local wells. The City has nine active intermediate and deep groundwater wells as listed in Table 2-1. All of the wells pump directly into the distribution system. Some of the wells pump from the intermediate depth aquifer, and the newer wells pump from the better quality (lower hardness and salinity) deep aquifer. The deep wells have a reliable pumping capacity of 8,900 gallons per minute (gpm) which is a usable annual well capacity of 12,800 acre-feet per year (ac-ft/yr) (Brown and Caldwell, 2023a).

Table 2-1. Groundwater Wells

Well Number	Well Depth Classification	Capacity, gpm
23	Intermediate	1,600
24	Intermediate	1,600
26	Intermediate	1,500
27	Intermediate	1,300
30	Deep	2,300
31	Deep	2,500
32	Deep	2,650
33	Deep	1,800
34	Deep	2,300
Total Reliable Capacity (Deep Wells only)	--	8,900 (12.8 mgd)

The City also receives treated Sacramento River surface water from the WDCWA river diversion and WDCWA WTP conveyed via a transmission line that enters the City along Pole Line Road (County Road 102). The City allotment of 10.2 million gallons per day (mgd) (11,425 ac-ft/yr) enters the City's distribution system via transmission mains with control valves to optimize the spread of surface water into the water system. The transmission line also conveys an additional 1.8 mgd to the University of California, Davis (UCD).

2.1.2 Water Distribution System

The City's Public Works Utilities and Operations Department (PWUO) manages the City's potable water distribution system. The City's water distribution system operates as one pressure zone with one elevated tank and two ground level storage tanks with booster pump stations. The hydraulic grade in the system is based on the level in the elevated tank. The wells are controlled by a Supervisory Control and Data Acquisition (SCADA) system based on the level in the elevated tank.

2.1.3 Pipelines

The City's water system consists of 195 miles of piping ranging from 2 to 16-inches (in) diameter. 85 percent of the distribution system consists of 6 to 10-in diameter pipelines. The City's pipeline system was originally constructed to support localized supply, with wells spread throughout the City. This type of localized supply does not require large diameter transmission mains. With addition of the surface water to the City, additional transmission main pipelines were constructed to maximize the distribution of the surface water supply to City customers.

2.1.4 Storage Facilities/Booster Pump Stations

There are three storage tanks in the City's water system: elevated tank, West Area Tank (WAT), and East Area Tank (EAT). The three tanks have a combined storage of 8.2 million gallons (MG). The WAT has a booster pumping capacity of 3,750 gpm and the EAT has a total pumping capacity of 6,000 gpm. The tanks fill from the distribution system during off-peak demand periods and then the booster stations pump water back into the distribution system during peak periods based on time and system pressure.

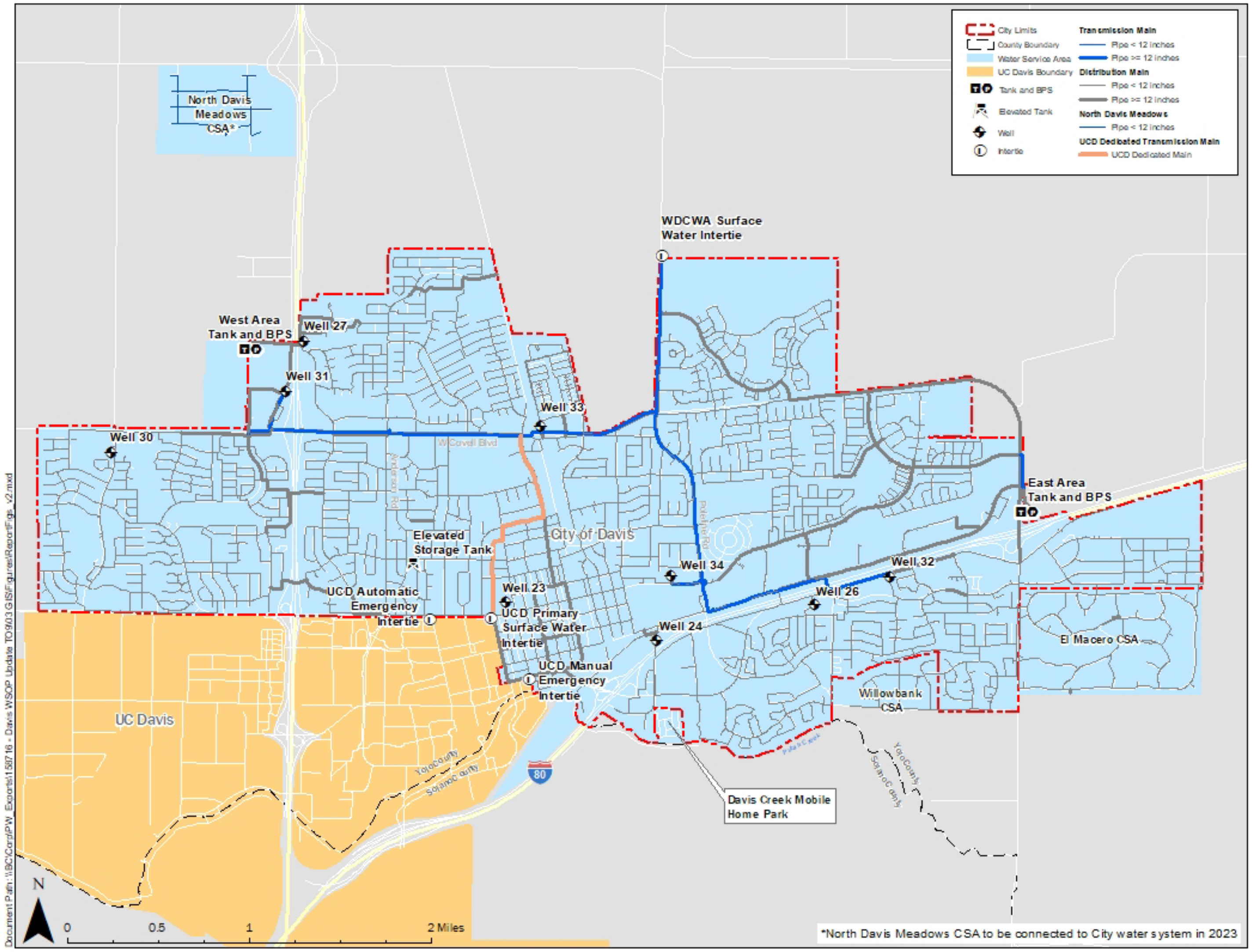


Figure 2-1. Water distribution system

2.1.5 Interties

UCD receives surface water supply to supplement UCD's groundwater supply from the WDCWA through one City of Davis intertie. Additionally, two emergency interties are available to transfer water between the City and UCD. UCD retains ownership and maintenance of all three interties. Operations staff of both the City and UCD coordinate to meet UCD flow requirements. UCD's surface water allotment is 1.8 mgd except during Term 91 conditions. A 16-inch diameter pipeline turns out from the City's surface water transmission main near Well 33. This pipe is a dedicated pipeline on F Street, owned and maintained by UCD, that runs south to UCD and enters UCD near A Street and Russell Blvd.

2.2 Wastewater System

The City's PWUO manages the wastewater collection and treatment for the domestic and industrial wastewater flows generated within the City and the County areas of the El Macero community service area (CSA), North Davis Meadows, Teichert Construction Company, and Davis Creek Mobile Home Park. The Willowbank Customer Service Area's wastewater is collected and handled via onsite systems and therefore is not collected or treated by the City. The wastewater collection system in the City is a network of pipes, and lift stations that transport wastewater from the wastewater collection system to the City's WWTP.

In 2018, the City completed the Secondary and Tertiary Improvements (STI) Project, which involved a major upgrade of the WWTP. The WWTP is permitted for an operating capacity of 7.5 mgd, with a current average dry weather flow (ADWF) capacity of 5.3 mgd per the ADWF defined in the City's Davis Wastewater Treatment Plant Capacity Analysis Report (West Yost and Associates, 2018). Current wastewater treatment at the waste WWTP includes the following liquid treatments and conveyance components:

1. Preliminary treatment
   a. Headworks with screening
   b. Aerated grit removal
2. Primary treatment
   a. Sedimentation
3. Secondary treatment
   a. Activated Sludge
   b. Aeration basins
   c. Secondary clarifiers
4. Tertiary treatment
   a. Disk filters
   b. Chlorine contact tank
   c. Dechlorination tank
   d. Reaeration tank

Treated effluent is either discharged to Willow Slough Bypass or is diverted to 260 acres of constructed wetlands for habitat management and potential discharge to Conaway Toe Drain. Further discussion on the permitted recycled water supply from the City's WWTP is provided in Section 4.5.

Section 3

Water Needs

The City's demographics, historical water use, water use characteristics, and projected demands are presented in this section. These topics are analyzed in detail in the draft 2023 Water System Optimization Plan (WSOP) (Brown and Caldwell, 2023a). This section summarizes the key assumptions and inputs from the 2023 WSOP that are used for this analysis. The reliability of the City's groundwater and surface water supply in terms of climate year type is also summarized.

3.1 Demographics

The City's water system currently serves a population of approximately 71,075 people and a total of 17,241 connections. The draft WSOP projects that the City will serve a population of 74,225 people and 18,383 connections by 2045. The City's number of connections by customer category for 2030 and 2045 are as shown in Figure 3-1.

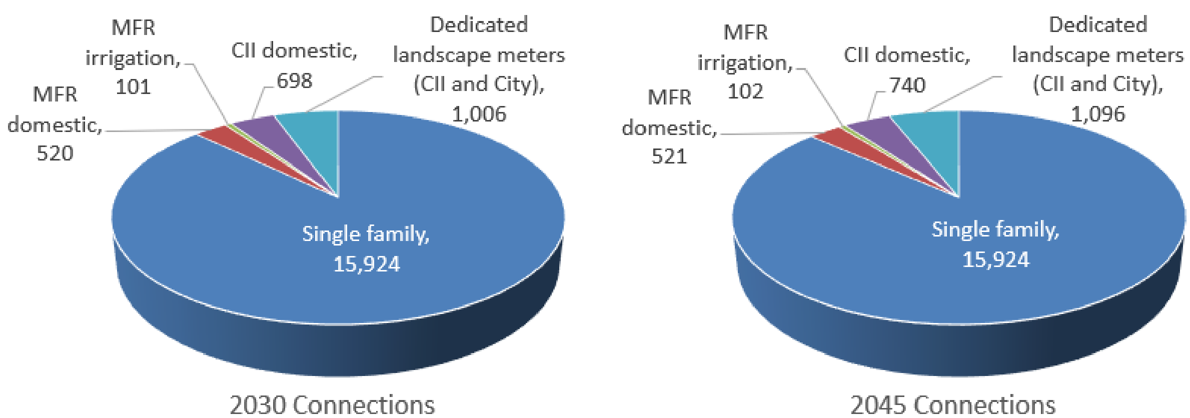


Figure 3-1. Number of connections by classification

MFR – multi-family residential

CII – commercial, industrial, institutional

3.2 Water Demands

The City's water demands are compared to the City's draft estimated water use goal. The City's projected annual water demands and variations in monthly water demands are presented.

3.2.1 Water Use Goal

Figure 3-2 illustrates the City's historical and projected water use in terms of GPCD as well as past GPCD targets and the most recent water use goal. With increased conservation activities the future per capita demand is projected to be less than the City's Natural Resources Commission (NRC) driven target of 134 GPCD and the draft estimated legislative driven water use goal of 126 GPCD by 2030.

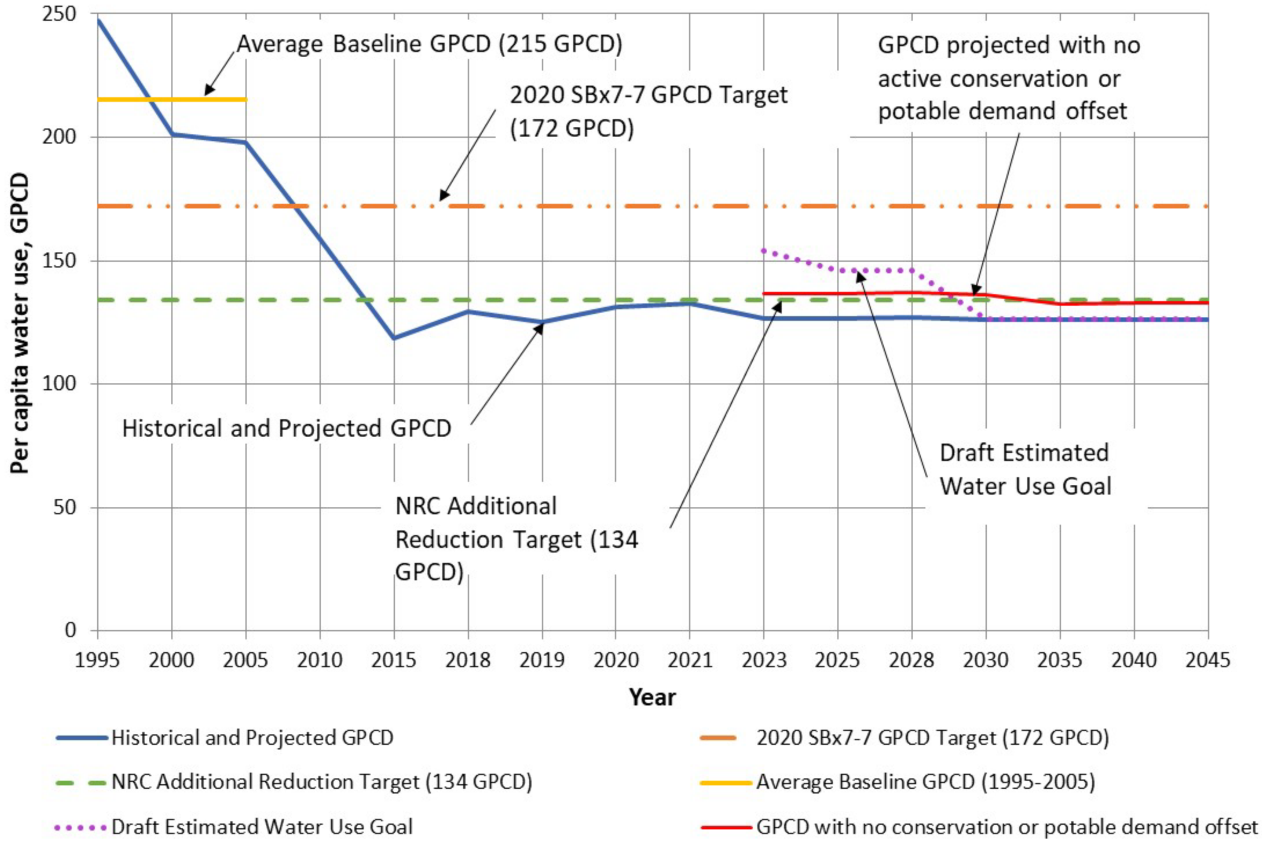


Figure 3-2. Historical and projected per capita water use versus past targets and new draft water use goal

The 2018 legislation, SB 606 and Assembly Bill 1668, directed the DWR, in coordination with the State Water Resources Control Board (SWRCB), to conduct necessary studies and investigations to recommend standards for outdoor residential water use, commercial, industrial, institutional (CII) outdoor irrigation of landscape areas with dedicated irrigation meters, appropriate variances for unique uses, guidelines and methodologies for calculating the Urban Water Use Objective, and performance measures for CII water use for adoption by the Water Board. On August 31, 2022, SB 1157 was passed including revised residential indoor water use objectives to amend Section 10609.4 of, and to add Section 10609.33 to the Water Code.

The City's draft estimated water use goal from 2023 through 2030 and thereafter as described in detail in the draft 2023 WSOP and illustrated in Figure 3-4 by customer category is estimated based on the current draft DWR Water Use Objectives by water use type combined with assumed water use goals for those water use types for which DWR Water Use Objectives are not yet provided (i.e. non-residential indoor and outdoor use and apparent losses). It should be noted that DWR and the SWRCB are still developing the guidance related to the draft water use objectives. It is likely these draft water use objectives that comprise the City's draft estimated water use goal will change as the State refines and further develops the water use objectives tool.

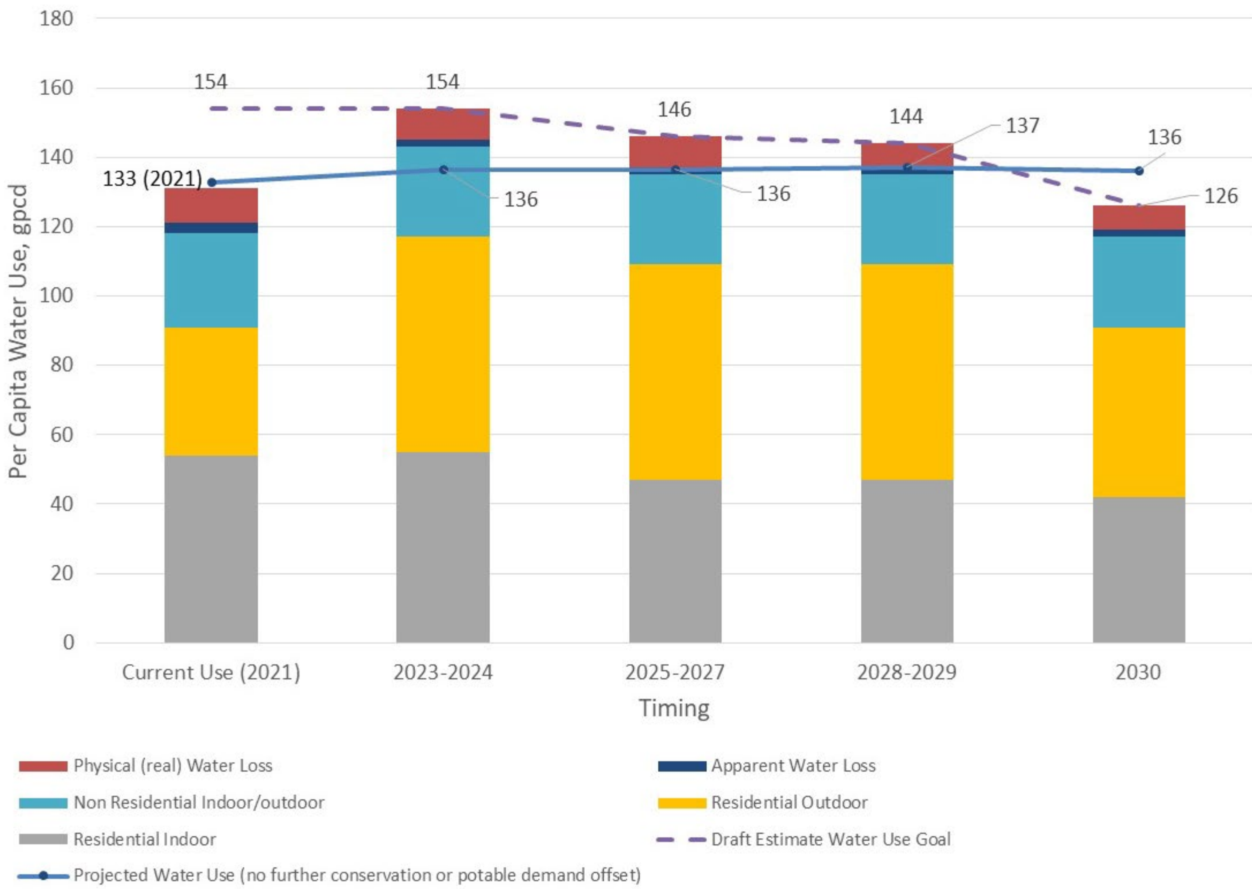


Figure 3-3. Per capita draft estimated water use goal versus current use

3.2.2 Projected Water Demands

Projected demands in Figure 3-4 are from the draft 2023 WSOP and include the assumption that the City will meet its draft estimated water use goal as well as including demand increases for climate change.

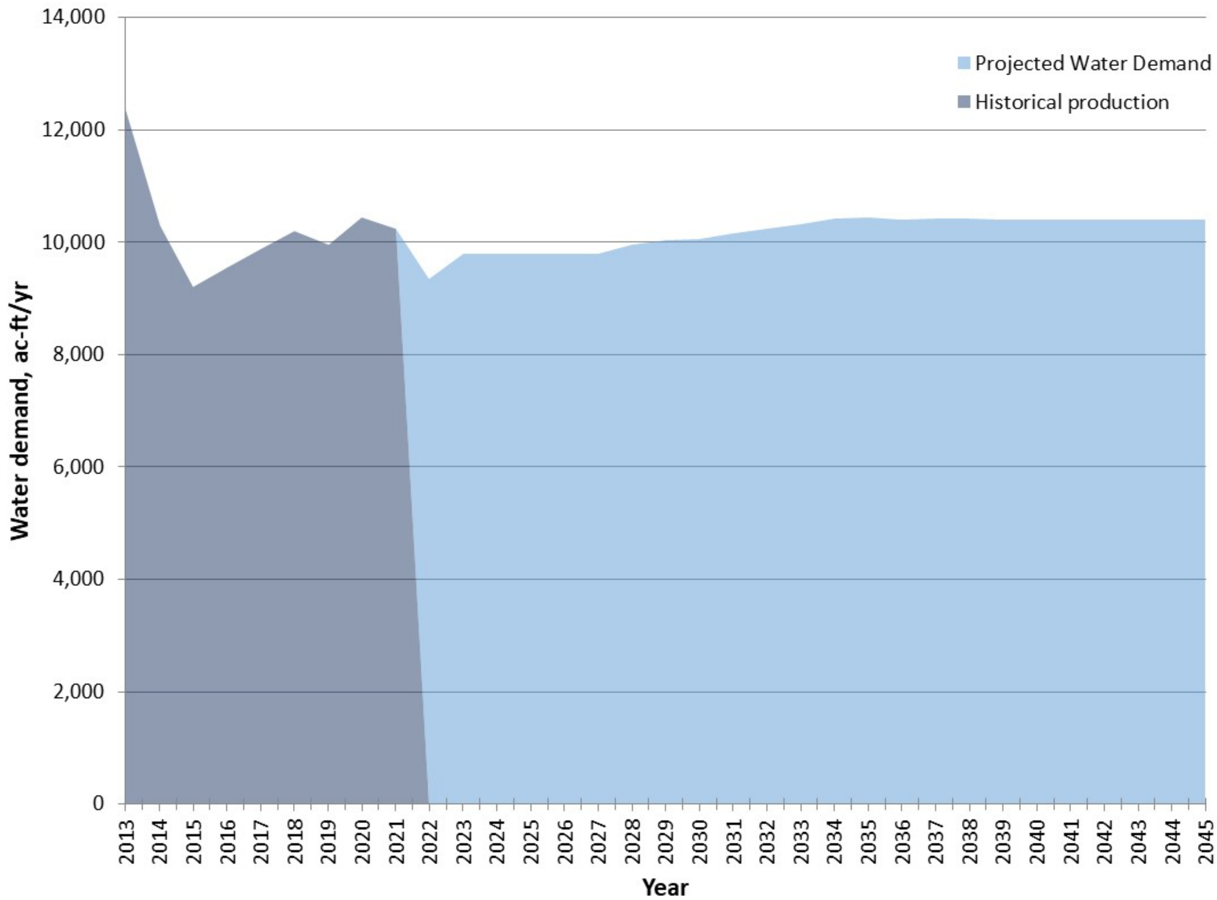


Figure 3-4. Projected water demand

3.2.3 Water Demand Variation

Water use varies continuously throughout a given day, as well as seasonally. Maximum water demands normally occur in June, July, August, and September, as shown in Figure 3-5. Increased landscape irrigation during the hot, dry weather is largely responsible for these higher demands. For the purposes of the monthly demand projections presented in Section 4 of this report, the three year average (2019-2021) monthly demand pattern was used.

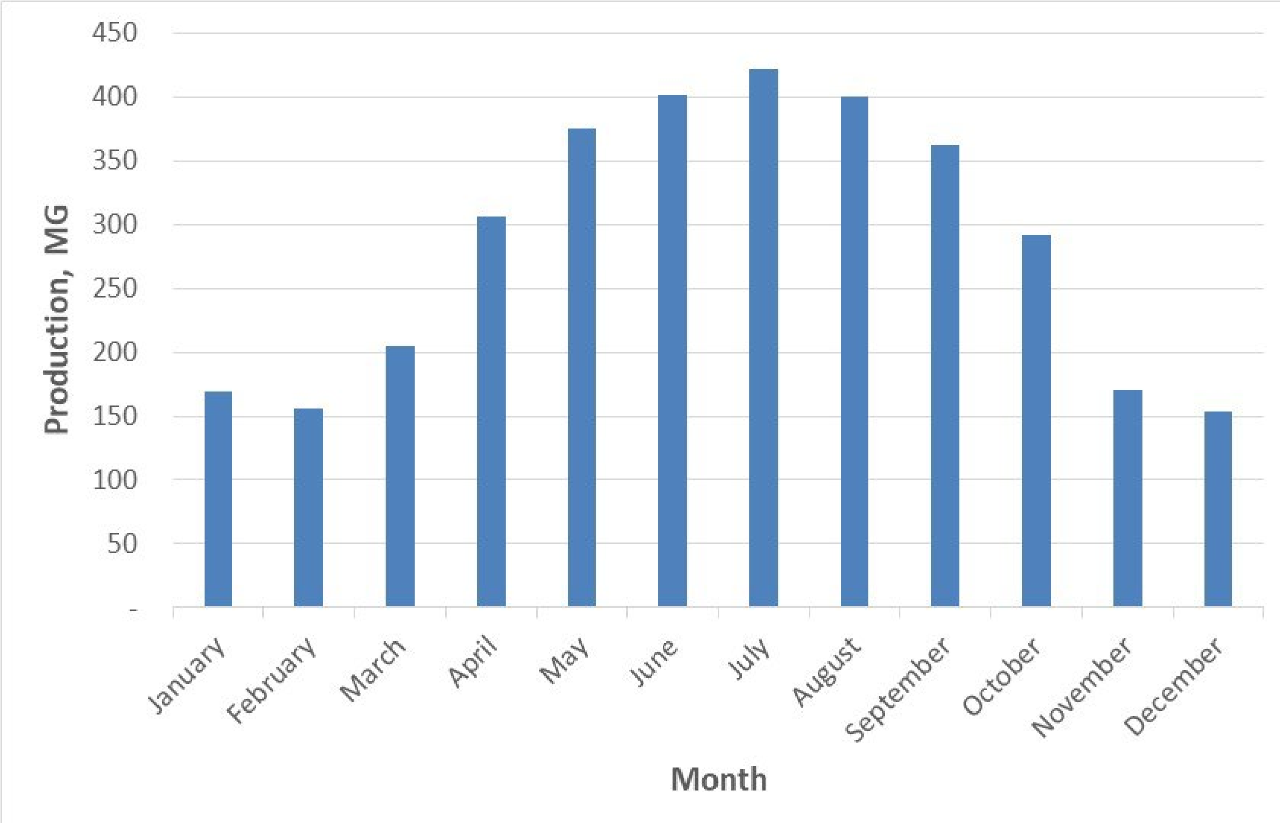


Figure 3-5. Total monthly water use

3.3 Water Supply Reliability

Based on the analysis in the draft 2023 WSOP, as shown in Figure 3-6, water supply shortages are not projected because the groundwater supply can meet demands during the dry years when minimal surface water is available. During a dry year, the City's surface water supplies would be reduced from 10.2 mgd (normal year) to 3 mgd (dry year). However, the use of groundwater supplies from the deep aquifer would be increased to help meet demands. At maximum day demand, intermediate depth wells could be used to meet peak demand as necessary. Figure 3-7 shows monthly supply and demand comparisons in normal years and dry years when Term 91 is in effect and with an assumed reduction of supplies due to future climate change impacts of 5 percent per the draft 2023 WSOP.

The draft 2023 WSOP estimates that the City will have sufficient supply (in both normal and dry years) to meet its projected demands in 2045. Furthermore, the draft 2023 WSOP projects that the City will be able to meet its 2045 demands with only groundwater supply from deep wells. The City would not rely entirely on reduced surface water supplies in dry years due to projected demands being much greater.

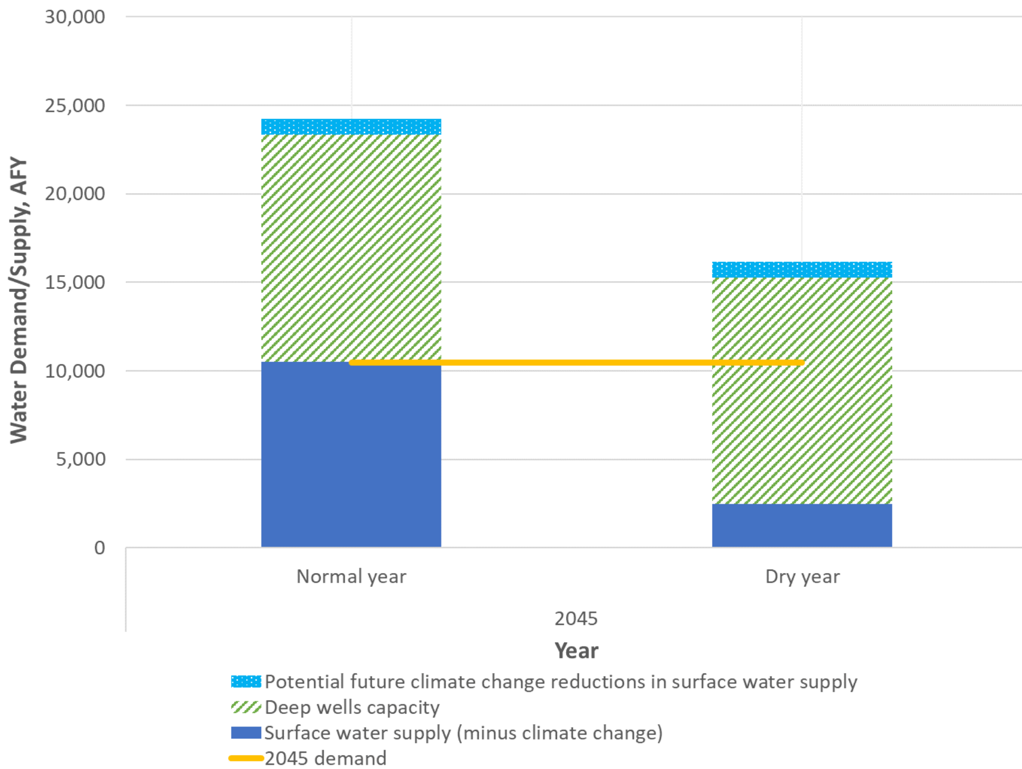


Figure 3-6. 2045 Water supply reliability

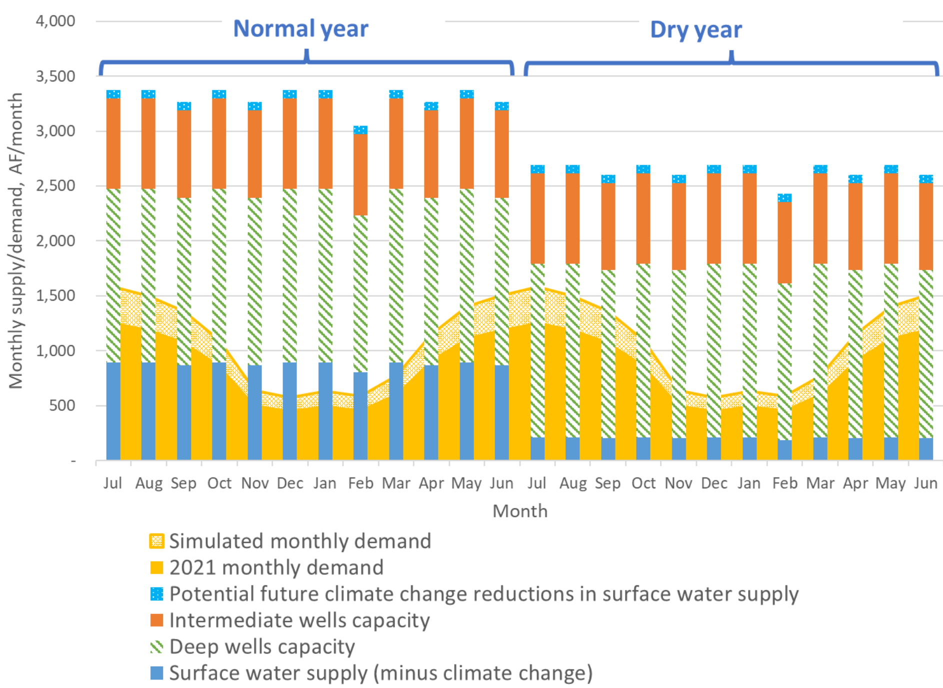


Figure 3-7. Monthly supply vs demand analysis

Section 4

Water Management Options

This section describes the water management options that are considered for this 2023 IWRS. These water management options have been updated from the 2013 IWRS as discussed in Section 1.3. The intent of the IWRS is to consider water management options that that might be useful in enhancing the City's water sustainability and reliability. The water management options that are considered as a potential supplement to the City's current groundwater wells and surface water supplies and described in this section are listed and summarized in Table 4-1.

Table 4-1. Water Management Options

Water Management Option	Summary
Residential and Commercial Water Use Efficiency	Water use efficiency programs in the residential and commercial customer sectors.
Municipal Water Use Efficiency	Water use efficiency programs at City owned facilities and properties.
Well Conversion/Irrigation	Existing or new wells used for non-potable irrigation only.
Aquifer storage and recovery	Municipal wells used to inject and store surface water in the aquifer during times when surface water is available and the recovery of the stored water when needed at a later time.
Recycled Water to Offset Groundwater Use	Recycled water to offset groundwater pumping for agricultural use, City tree watering, and other permitted uses.
Recycled Water Distribution System	Recycled water distribution system (purple pipe) to serve specified non-residential landscapes within the City.
On-Site Water Reuse	Rainwater cisterns, graywater, stormwater reused on-site.
De-Facto Reuse	Increase City surface water rights for use at the WDCWA WTP by the same amount of treated wastewater discharged from the City's WWTP into the Sacramento River.

The following information is provided for each water management option:

- Description
- Water supply (either potable demand offset or additional water supply and reliability)
- City implementation costs
- Conceptual infrastructure layout (if applicable)
- Considerations

The study period is assumed to extend from the present (2023) to 2045, which coincides with the timeline used in the City's 2020 Urban Water Management Plan (UWMP) (Brown and Caldwell, 2021) and the 2023 WSOP.

Most of the water management options would reduce demand on the potable water system. These reduced demands could result in cost savings for the potable water system in terms of smaller infrastructure needs and lower operating costs. The potable water system costs savings that could result from implementing water management options are not estimated in this IWRS.

4.1 Residential and Commercial Water Use Efficiency

The City has been successfully implementing water conservation measures that lower residential and commercial water use through active and passive savings for decades. Continuing and building off the success of previous water conservation efforts, this water management option includes three water use efficiency programs in the residential and commercial sectors.

Advanced Metering Infrastructure (AMI) Customer Portal – In 2019, the City completed the Water Meter Upgrade Project, which replaced all water meters City-wide. The meter upgrades included exchanging the previous water meters for new meters with AMI. AMI uses a low-powered communication device that is added to the new water meters to transmit hourly water usage information over a secure network approximately four times per day. Customers have access to their hourly readings in cubic feet and gallons in the City's customer water use portal, AquaHawk. AquaHawk was launched in September 2018 and as of December 2022 has over 7,800 registered users.

One primary benefit of AquaHawk is that it can be used by water customers to check their daily and hourly water use and to watch for continuous water use which could potentially indicate a leak on the customer's property. Customers can also set usage alerts in AquaHawk. A 2011 study of 102 City single family residences found an average leakage rate of 37 gallons per day (gpd) per house, a median rate of 24 gpd, and estimated the annual leakage to be about 10 percent of the total water production in 2012. (Aquacraft, 2011). The ability to monitor water usage and to set usage alerts enables customers and the City to potentially identify and stop leaks.

At the end of November 2018, the City began sending courtesy water usage notices twice per month to customers throughout the system, whether they are registered in AquaHawk or not. Courtesy notices are sent to accounts with continuous water use above 10 gallons per hour for a minimum of 24 hours. These notices from the City inform customers of unusual water usage and encourage them to register for AquaHawk if they are not already registered. In 2022, 5,600 courtesy notices were sent to water customers. The City also uses webpages within the City's water conservation site, SaveDavisWater.org, dedicated to provide information to customers on how to register for, read, and set alerts in AquaHawk. Additional outreach for AquaHawk has included the following:

- Postcards to all City of Davis property owners
- Ads in the Davis Enterprise
- Bill inserts on efficient irrigation practices

City staff are actively involved in the American Water Works Association's (AWWA) efforts to publish an AMI portal best practices guidebook to lead the industry as more water agencies are investing in similar advanced metering technology.

The AMI customer portal component of the residential and commercial water use efficiency water management option includes continuing this program as described above.

Public Education and Outreach – Prior to the 2020 Covid pandemic, the City implemented a public education and outreach campaign to spread awareness for water use efficiency and information on the most recent drought. These efforts are described below. The City is considering offering the in-person activities in the future as well.

- Environmental school assemblies for elementary schools within the City's service area prior to the recent pandemic with plans to bring back these programs in the future
- Educational workshops for water customers (in-person prior to the pandemic and virtual workshops during the pandemic)

- Public events including Celebrate Davis, Discover Davis, Arbor Day and other environmental events
- Outreach to specific water use sectors (multi-family residential, single-family residential, commercial)
- Greener Davis social media and monthly e-blast including special “Water News” e-blasts
- Press releases and ads in the local newspaper

Public education and outreach efforts in 2016 and 2017 focused on short-term water use reductions during the multi-year drought. The City contracted with a public relations consulting firm to assist with the implementation of public education and outreach efforts. The public information programs included the following:

- Tent cards for restaurants and hotels
- Door hangers for multi-family properties
- A pop-up banner at City Hall
- The SaveDavisWater.org microsite (transitioned over to the City’s website)
- E-mail messaging to different water user classes
- Press releases
- Newspaper and social media ads

Efforts also included updating the City’s water conservation/water waste door hanger, signage on parks and greenbelts for reduced irrigation and turf conversion, and report water leaks magnets on City vehicles.

Public education and outreach efforts in 2018 through 2020 shifted to long term water-use efficiency and maintaining the water use savings achieved during the prior multi-year drought. The City offers water conservation workshops to customers with topics including rain water retention, lawn conversion, irrigation systems, graywater systems, water-wise landscaping, and more. One of the largest projects relating to public education and outreach in the past two years is the launch of the City’s online customer water use portal, AquaHawk.

The public education and outreach component of the residential and commercial water use efficiency water management option includes continuing this program as described above.

Turf Conversion Rebate Program – When turf conversion program funding from the State’s Save Our Water program is available, the City dedicates staff time to leverage the program and make that rebate funding available to their customers. When the State offered turf conversion rebates during the last drought, 367 customers from City of Davis applied with 251 applications being approved and receiving state rebate funding The City promoted the State turf conversion rebate program through the SaveDavisWater.org website, social media, e-mail and press releases.

The turf conversion rebate program component of the residential and commercial water use efficiency water management option includes administering 50 rebates per year, should the State offer the program again.

4.1.1 Water Supply

The estimated potential water savings from this water management option are described below and summarized in Table 4-2.

Table 4-2. Estimated Water Supply		
Measure	2045 Water Savings, ac-ft/yr	Assumptions
AMI Customer Portal	800	• 7.8% reduction in total production (12% of residential water demand)
Public Education and Outreach	60	• 0.5% reduction in total production per year
Turf Conversion	250	• Average retrofitted landscape area 1,200 sq ft (15% of average 8,819 single family residential (SFR) lot) • Reference Eto 57 in/year, California Irrigation Management Information System (CIMIS) • Pre-program water usage 125% of Eto • Post-program water usage 40% of Eto • Water savings 30 gallons per square foot • 100 rebates per year (0.7 % of SFR connections) • Water savings life 30 years • Cumulative annual average from 2023 – 2045
Total	1,110	--

AMI Customer Portal – In 2019, the City estimated the potential water savings resulting from the courtesy notices by summing the savings from select accounts with the highest amounts of continuous water use for which courtesy notices were sent (select accounts were pulled each month for 2019). These selected accounts were residential accounts with continuous water usage at the time the notice was sent, where water usage dropped after the courtesy notice would have been received and prior to the delivery of the City's utility bill with that month's water usage. Water savings from the top 5 residential leaks in 2019 alone equated to approximately 7.8 million gallons of water, equivalent to about 0.25 percent of total production. Many customers have reported to the City that they would not have been aware of the continuous water use, or potential leaks, had the City not sent the courtesy notice. Additionally, the AWWA recently conducted a guidebook for practitioners titled "Increasing Consumer Benefits & Engagement in AMI-based Conservation Programs" (AWWA, 2022) which found that installing system-wide AMI and building additional conservation programming resulted in a 2-10 percent reduction in customer water use.

A 2011 study of 102 Davis single family residences found an average leak rate of 37 gpd per house with a median rate of 24 gpd (Aquacraft, 2011). Using the 2011 number of single family connections of 14,407 gives an annual leakage rate of approximately 600 ac-ft/yr. Night time water production during the winter months has been measured by the City at 3,000 gpm (Brown and Caldwell, 2013a). If some of night time winter water use is due to leaks and is assumed to be consistent year round, that amounts to annual leakage of 1,200 ac-ft/yr, or 10 percent of the total water production in 2012. As a result of the City's water conservation program residential water use has decreased from 69 GPCD in 2013 to 54 GPCD in 2021, a 22 percent decrease. Assuming this reduction is attributed in part to customers reducing water leaks, it is assumed that residential customer leaks are now approximately 800 ac-ft/yr, or 7.8% of total water production.

Public Education and Outreach – Water savings resulting from the City's residential and commercial public education and outreach program is assumed to be 0.5% reduction in total production per year.

Turf Conversion Rebate Program – Water savings resulting in a turf conversion rebate program is based on assumptions related to pre-program and post-program water usage, average size of turf conversion area per customer, and the rebate program participation each year. It is assumed the life of the water savings is 30 years given that the replacement involves a structural change in the landscape (Metropolitan Water District of Southern California, 2019). Studies provided by the California Water Efficiency Partnership (CalWEP) suggest a savings of 34.4 gallons per year per square foot. Based on the City's water outdoor usage for single family residential customers analyzed in the 2023 WSOP pre-program outdoor water use is approximately 125% of the reference evapotranspiration. It is assumed that post-program outdoor water use will be approximately 40% of reference evapotranspiration. This is a 30 gallons per year per square foot water savings and is assumed for this analysis. It is assumed that the program will continue with 100 participants per year. Based on the life of the savings and the assumed participation rate the incremental savings per year is assumed to be 11 ac-ft/yr. Cumulatively, the annual average savings from 2023 through 2045 is 131 ac-ft/yr, with savings of 250 ac-ft/yr by 2045.

This residential and commercial water use efficiency water supply would be available in all year types but would vary somewhat based on climate impacts on outdoor water needs. Seasonally, water savings would be higher in summer months, as shown on Figure 4-1. Annual water savings are shown in Figure 4-2.

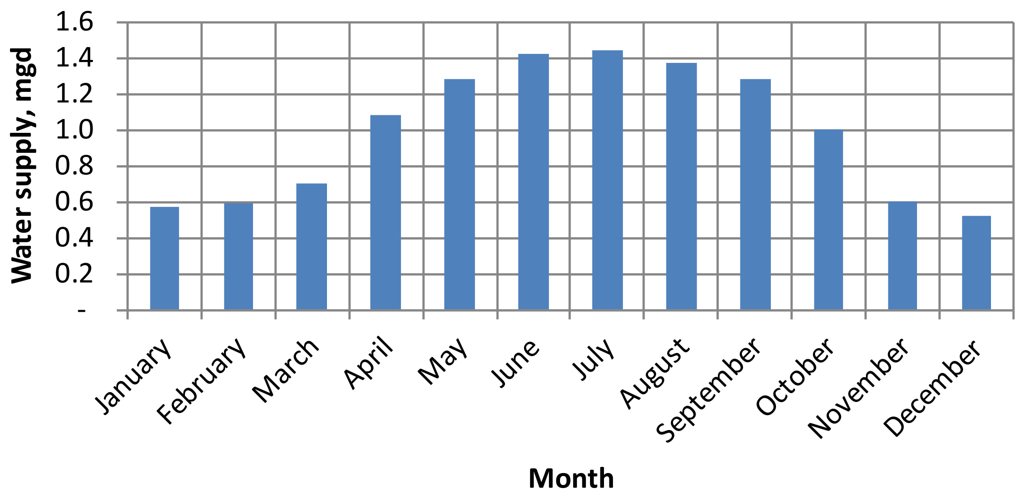


Figure 4-1. Residential and Commercial Water Use Efficiency seasonal water supply

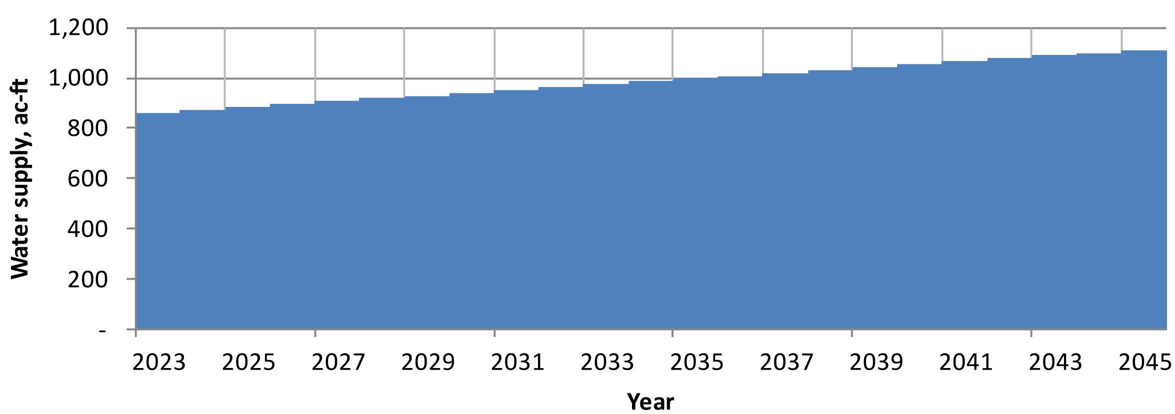


Figure 4-2. Residential and Commercial Water Use Efficiency annual water supply

4.1.2 Costs

The estimated cost of the components of this water management option are presented in Table 4-3. Capital costs include equipment or new software purchases whereas annual costs including ongoing administrative labor and materials required for ongoing program implementation. There are no capital costs for this water management option.

Table 4-3. Estimated City Implementation Costs

Measure	Capital	Annual	Assumptions
AMI Portal Program	--	$390,000	• 1.5 FTE combined operations staff and supervisor ($75/hour) • 1 FTE combined conservation staff and supervisor ($75/hour) • Maintain AMI portal • Meter/consumption checks at customer properties
Public Education and Outreach	--	$156,000	• 1 FTE combined water quality, conservation, and supervisor ($75/hour)
Turf Conversion	--	$117,000	• Rebates funded by DWR, other grant funds or General Fund • 0.75 FTE to administer program includes staff time to measure, confirm plantings, process rebates, coordinate with City Finance department and DWR ($75/hour)
Total	--	$663,000	--

Notes:

FTE full year= 2,080 hours

4.1.3 Considerations

Considerations associated with the residential and commercial water use efficiency water management option are summarized below.

- Reduced residential and commercial water use will help the City meet their water use objective as defined in California's long-term water use objectives in water conservation legislation SB 606 and AB 1668.
- Aligns with sustainability goals across multiple City plans including the:
  - 2020-2040 CAAP goal to conserve water in buildings and landscapes.
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability, giving equal emphasis to "people, planet, and profit".
  - City Council 2021-2023 Goal 2, Objective 2, D to explore technology options that will reduce costs while maintaining or improving service delivery expectations.
  - City Council 2021 – 2023 Goal 3, Objective 2, C to maintain quality and quantity of the City's water supply and wastewater treatment processes and promote water conservation.
  - City Council 2021-2023 Goal 3, Objective 3, B to maintain regular communication with the community on the importance of water conservation practices and encourage residents to sign up for AquaHawk to monitor and manage water use.

- Reduces potable water system demand, particularly the peak demand period which avoids costly expansion of the treated water system in the long-term, and results in a cost-effective water management strategy.
- Does not require additional capital investment to implement.
- Lower indoor water use could have adverse impacts for wastewater collection system operations.
- Requires ongoing administrative costs.

4.2 Municipal Water Use Efficiency

In addition to water use efficiency programs targeted toward residential and commercial usage described in Section 4.1, the City is working to increase municipal water use efficiency by reducing distribution wide leaks, increasing irrigation efficiency at public facilities and parks, and converting additional City-owned properties to water efficient landscaping.

Distribution System Leak Reduction – Often, large transmission leaks are not discovered until water is seen either in cracks in the roadway or seeping from other areas near the water main. In some cases, catastrophic failures can occur which cause roadway or sidewalk damage that must be repaired at considerable expense. The City's water system consists of 195 miles of pipelines. To ensure that the water system is operating efficiently without significant leakage and to remain in compliance with State regulations for water loss, AMI meter data is one tool that the City utilizes to detect end-use leaks and to conduct assessments of the City-owned water system piping.

For consideration in this water management option, the City has purchased mobile acoustic leak detection equipment from Zone Scan that will provide the City with more advanced technology to identify leaks in larger transmission and distribution pipelines throughout the system. The Zone Scan acoustic leak detection technology will assist the City to proactively identify main leaks and enable the City staff to prioritize and repair small leaks that might otherwise develop into major leaks, preventing considerable damage.

The new leak detection equipment includes 50 remote monitoring devices that connect and disconnect to existing valves or other water system components. City staff will be trained to install the devices. The installed devices communicate with the existing water meter data collection system and the data is then available for review by the Water Division team. The equipment software has geographical information system capability to accurately pinpoint areas of water leaking so repair operations are more efficient and with fewer roadway disturbances. Because the leak detection equipment is mobile and can be relocated throughout the system, each area of the water distribution system can be assessed in a systematic fashion. In the first year of operation, the 50 deployable units will be used throughout the water system with the option to purchase an additional 15 to 20 units per year. This equipment will provide a valuable tool to prioritize leaks by severity and proactively reduce water loss in the distribution system.

Parks Irrigation Efficiency – The City maintains 485 acres of landscaping across 36 parks and 55 miles of greenbelts and streetscapes. Following the 2014 to 2017 drought the City has continued to implement water efficiency measures resulting in reduced irrigation in some parks and greenbelts. The City continues to prioritize watering trees within the City's landscapes.

Continued water efficiency measures include irrigating select areas based on the landscape evapotranspiration requirements and operating the sprinkler systems in multiple shorter time-frame increments, known as cycle and soak irrigation. Through these efforts the City reduces water losses due to runoff and evaporation. Additionally, City staff have replaced damaged, aged, and poor performing sprinkler heads with approximately 400 new, low-flow heads. The City has installed SMART controllers and upgraded select irrigation controllers with flow sensors and master valves.

Parks irrigation efficiency efforts include multi-department coordination between staff in Parks, Finance and Public Works Utilities and Operations departments to review water use for irrigation of City property and ensure that staff have the necessary tools to effectively reduce water use and associated expenditures. Through this coordinated effort, the City has coordinated water use needs as they relate to water operations and peak timing for irrigation over the summer while receiving timely water usage data and billing.

Many of these City efforts have been driven by the Parks and Greenbelts Water Management Plan (Brown and Caldwell, 2013b). Progress on the Parks and Greenbelts Water Management Plan implementation is noted in Table 4-4. As shown in this table, the City has fully implemented the Parks Irrigation Efficiency implementation plan set forth in the Parks and Greenbelts Water Management Plan.

Table 4-4. Parks and Greenbelts Water Management Plan Parks Irrigation Efficiency Implementation Plan vs Actual To Date

Parks Irrigation Efficiency Measures	Parks and Greenbelts Water Management Plan Planned Activities						Actual To Date
	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	Total	
Replace Park Controllers	25	75	68	-	-	168	285 total, 130 being central based.
Upgrade to smart controllers		65	45	-	-	110	207 total, 77 with CalSense technology, 130 with flow sensing technology.

Water Efficient Landscaping Conversion on City Property – The City has conducted high-visibility water efficient landscaping conversion on various City properties included in Table 4-5. These landscape conversions were completed during the 2014-2017 drought to reduce water use from outdoor irrigation and thus highlighting the City's dedication to sustainability. The City converted a total of 66,250 square feet (1.52 acres) from turf to water efficient landscaping. Assuming a water efficient landscape uses approximately 40 percent of reference evapotranspiration, the converted landscapes to-date have resulted in an estimated 7.2 ac-ft/year in water savings.

Table 4-5. Completed Landscaping Conversion Projects

	Area converted (sqft)	Area Converted (acres)	Water Saved (ac-ft/yr)
Mace Ranch at Lillard	14,000	0.32	1.5
Mace Ranch Softball Fields	16,000	0.37	1.7
Mace Ranch Miscellaneous	9,500	0.22	1.0
Central Park Gandhi	1,250	0.03	0.1
Davis Art Center	12,000	0.28	1.3
Arroyo Park	10,000	0.23	1.1
Mace Ranch at Lillard	14,000	0.32	1.5
Train Depot	500	0.01	0.05
Richards Triangle	3,000	0.07	0.3
Total	66,250	1.52	7.2

In the 2013 Parks and Greenbelts Water Management Plan, staff set an initial goal to convert 10 acres of City-owned property to water efficient landscaping. As of 2018, approximately 1.5 acres have been converted (shown in Table 4-5), leaving 8.5 acres remaining to convert as part of this water management option.

4.2.1 Water Supply

The estimated potential water savings from this water management option are described below and summarized in Table 4-6.

Table 4-6. Estimated Water Supply

Measure	2045 Water Savings, ac-ft/yr	Assumptions
Distribution System Leak Reduction	255	Reduce water loss from 7.5% of total production to 5.4% of total production.
Water Efficient Landscaping Conversion on City Property	43	8.5 acres to be converted by 2030.
Total	298	

Distribution System Leak Reduction – The intent of the distribution system leak reduction program is to proactively reduce pipe break incidents by repairing underground (non-surfacing) pipe leaks prior to the pipe leaks developing into catastrophic pipe failures. While much water is lost from underground pipe leaks there is significantly more water lost every time there is a catastrophic pipe failure incident. Water loss in both instances is dependent upon several factors including pipe diameter, system pressure, size of break, and the duration of the break event before repair. Denver Water's article "Main breaks 101: Raising our infrastructure GPA" (Denver Water, 2017) analyzes water loss due to leaks and main breaks and estimates of range of water loss from 15,000 gallons lost in ¾-in diameter pipe leak or break to 1,125,000 gallons lost in a 16-in diameter pipe leak or break.

For this analysis it is assumed that this distribution system leak detection program would reduce the City's annual real (physical) water loss from its 2021 value of 7.5 percent of total water production (38.1 GPCD) to maintain an annual real water loss of 5.4 percent of total water production (31.1 GPCD) by 2028.

Parks Irrigation Efficiency – Table 4-4 shows the City has implemented the planned Parks Irrigation Efficiencies from the Parks and Greenbelts Water Management Plan. No additional water savings is included for the Parks Irrigation Efficiency component of this water management option.

Water Efficient Landscaping Conversion on City Property – Water efficient landscaping requires less irrigation water than traditional turf. It is assumed that water use on the converted acreage would use approximately 40 percent of reference evapotranspiration. Converting 8.5 acres to water efficient landscaping would result in an additional 40 ac-ft/year in water savings as shown in Table 4-7. It is assumed the remaining 8.5 acres will be converted by 2030, as shown in Table 4-7.

Table 4-7. Planned Water Efficient Landscape Conversion Areas and Water Savings											
	Completed as of 2023 (See Table 4-5)	Planned									
		2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
Land Converted (acres)	1.5	1	1	1	1	1	1	1	1	0.5	10
Incremental Water Saved (ac-ft/yr)	7.2	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	2.4	43

This municipal water use efficiency water supply would be available in all year types but would vary somewhat based on climate impacts on outdoor water needs. Seasonally, water savings would be higher in summer months, as shown on Figure 4-3. Annual water savings are shown in Figure 4-4.

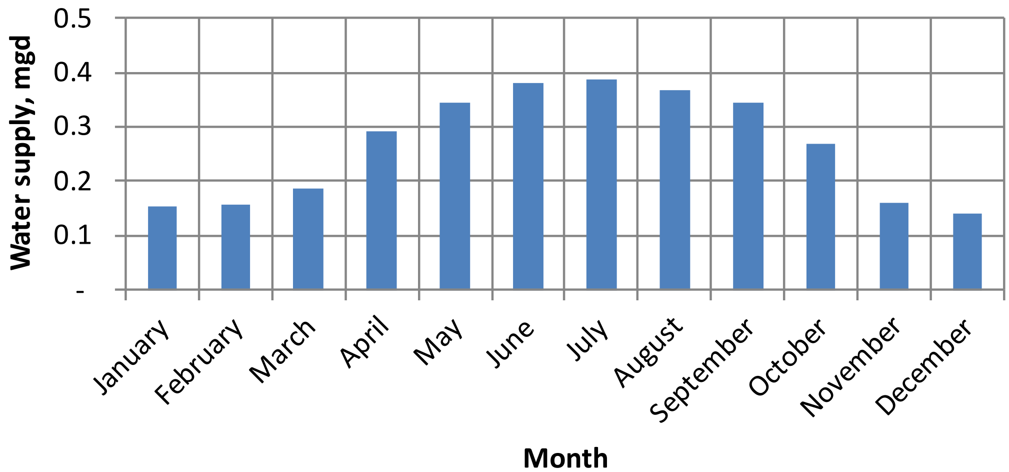


Figure 4-3. Municipal Water Use Efficiency seasonal water supply

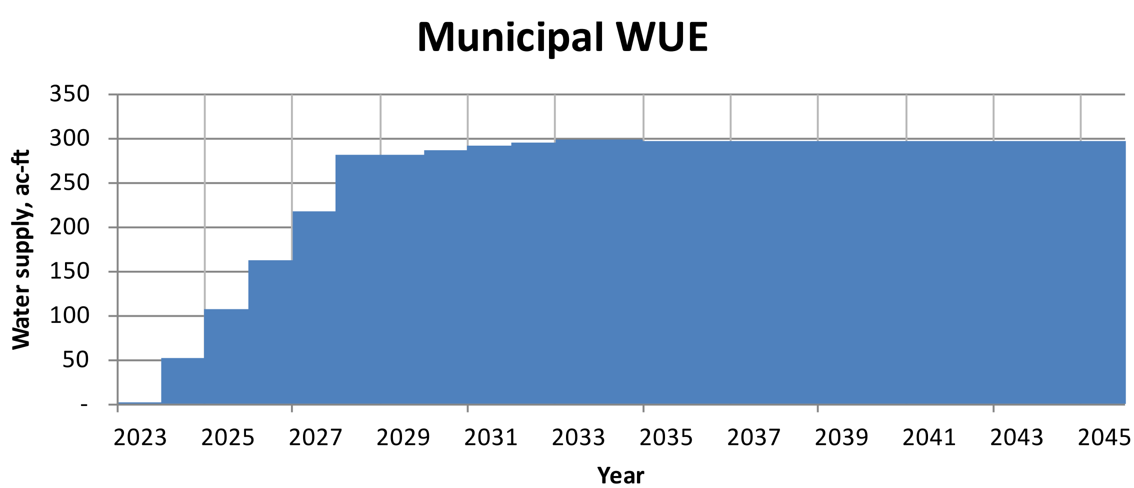


Figure 4-4. Municipal Water Use Efficiency annual water supply

4.2.2 Costs

The estimated cost of the municipal water use efficiency option components are presented in Table 4-8. The costs represent the added costs to further reduce the City's water use and are in addition to the costs of the City's existing conservation program.

Table 4-8. Estimated City Implementation Costs

Measure	Capital	Annual
Distribution System Leak Reduction[a]	$78,000	$62,400 (labor – 0.4 FTE[c] combined (1 day per week, two field staff) operations staff and supervisor ($75/hour)) $10,000 (additional deployable units)
Water Efficient Landscaping Conversion on City Property	$1,427,300 [b]	--
Total	$1,505,300	$72,400

a. *The cost of leak repairs after leaks are detected are not included in the estimated costs.*

b. *Water efficient landscaping conversion on City property costs in this table are scaled from 2011 dollars ($990,000 total) in the 2013 Parks and Greenbelts Water Management Plan to current dollars based on the Engineering News and Review Consumer Cost Index (ENR CCI) for June 2011 (10167.29) and the ENR CCI for December 2022 (14977.94).*

c. *FTE is 2,080 hours per year*

4.2.3 Considerations

Considerations associated with the municipal water use efficiency option are summarized below.

- Provides a community-facing example of the City's dedication to sustainability and "doing our part" in reducing potable water usage.
- Aligns with sustainability goals across multiple City plans including the:
  - 2020-2040 CAAP goal to conserve water in buildings and landscapes.
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit".
  - City Council 2021-2023 Goal 2, Objective 2, D to explore technology options that will reduce costs while maintaining or improving service delivery expectations.
  - City Council 2021 – 2023 Goal 3, Objective 2, B to replant traditional turf species in greenbelts, planting strips or medians with low stature native or near-native grass species.
  - City Council 2021 – 2023 Goal 3, Objective 3, C to implement urban forest management with an eye towards drought tolerance and climate resiliency of tree species in new plantings and in tree replacements in conjunction with the Urban Forest Master Plan.
  - City Council 2021 – 2023 Goal 3, Objective 3, D to undertake a leak detection survey on the City's water distribution infrastructure to detect areas with a higher concentration of structural concerns for inclusion in upcoming capital improvement projects.
  - City Council 2021 – 2023 Goal 3, Objective 3, E to install pressure sensors within the City's water distribution system to identify needs for water pressure management.
- Reduces potable water system demand, particularly the highly valuable peak demand period which avoids costly expansion of the treated water system in the long-term, and results in a cost-effective water management strategy.

- The costs for implementing the distribution system leak reduction program does not include the costs for repairing leaks after they have been detected.
- Requires capital investments and incurs ongoing administrative and training costs.

4.3 Well Conversion/Irrigation

Future demands on the potable water system would be reduced with the conversion of existing potable system intermediate depth wells to irrigation-only wells and the construction of new irrigation wells to serve non-potable demands at several parks, greenbelts, and other large landscaped areas. For this water management option it is assumed that three existing potable system intermediate depth wells would be converted to irrigation-only wells and three new irrigation well would be constructed. The water savings and costs presented for this water management option are based on the information presented in the Parks and Greenbelts Water Management Plan. Figure 4-5 depicts a typical well that could be converted.

Figure 4-5. Typical park irrigation well

There is potential overlap with wells considered for irrigation wells in this water management option and wells considered to be converted to ASR wells in the ASR water management option (Section 4.4).

Each of the irrigation wells would require separation of the irrigation water system at parks, schools and greenbelts from the existing distribution system to ensure there are no cross connections to the potable water system. Figure 4-6 illustrates the location of these wells and the landscape areas they would serve. The infrastructure needs for the wells selected for this option are presented below based on the information in the Parks and Greenbelt Water Management Plan.

P:\44000\144662 - Davis Water Modeling Services\03_Engineering\3_2_GIS-CAD\DavisFigure_basemap_201310_8x11.mxd

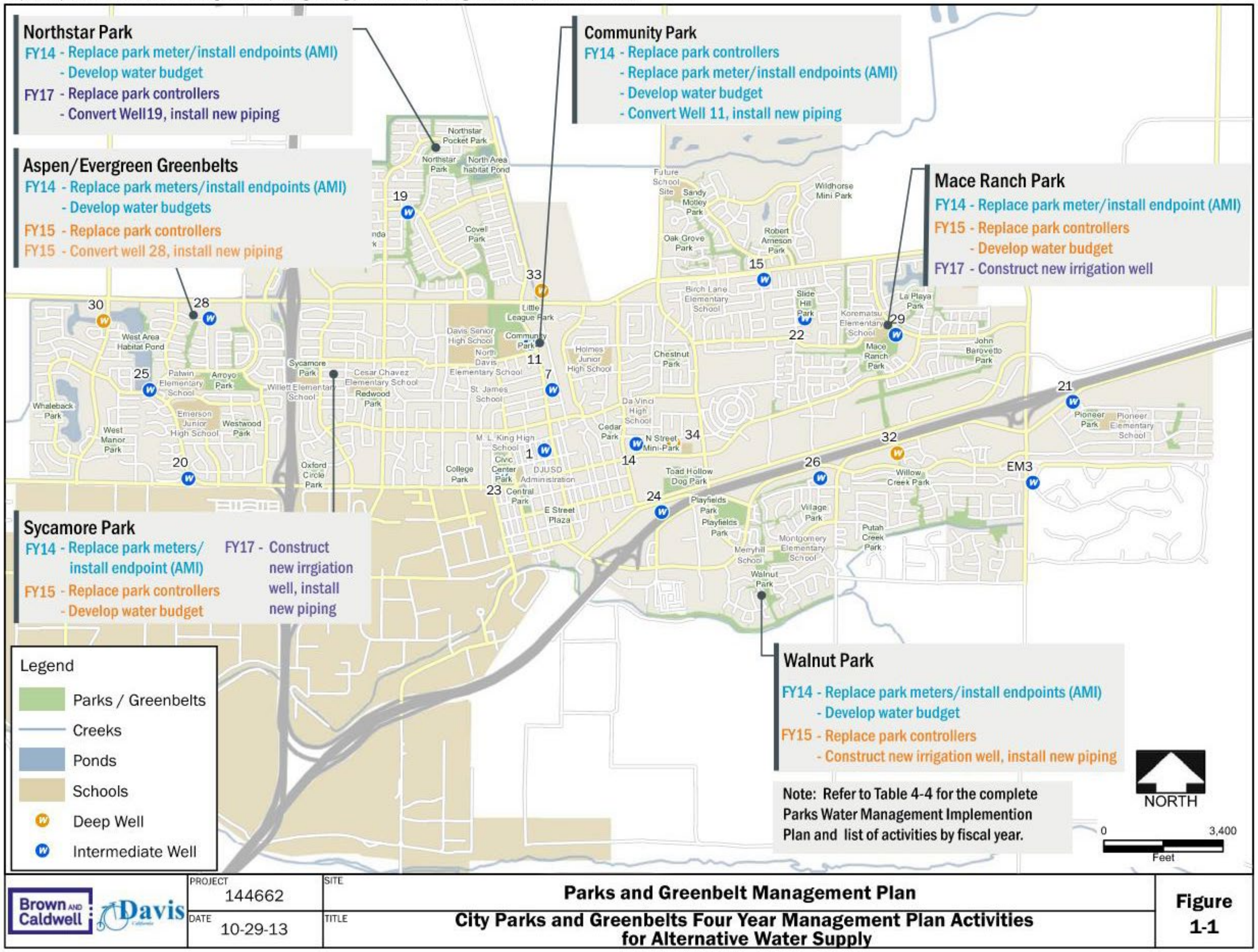


Figure 4-6. Well conversion/irrigation well locations

(Source: Parks and Greenbelts Water Management Plan (Brown and Caldwell, 2013b))

Note: Per Section 4.2 of this IWRS Update, the City has implemented controller improvements from the Parks and Greenbelts Management Plan.

The wells included in this water management option are described as follows:

1. Irrigation Well (IW)-11 Well 11 Conversion. Community Park/Little League Park (Figure 4-7) – Convert existing domestic Well 11 by constructing well modifications to meet the reduced irrigation demand requirements. The irrigation system improvements include 1,500 linear feet (LF) 4-inch irrigation main from existing Well 11 at Community Park to the Little League Park. Provide new potable water mains to the restrooms, swimming pool, drinking fountains and any other facilities served by the parks' existing water distribution system (that has been converted to an irrigation water system).
2. IW-13 Well 19 Conversion. Northstar Park/North Davis Greenbelt (Figure 4-8) - Construct well modifications to meet the reduced irrigation demand requirements. Disconnect potable water mains from irrigation mains in park and greenbelt. Provide new potable water mains to the drinking fountains and any other facilities served by the park and greenbelt existing water distribution system (that has been converted to an irrigation water system).
3. IW 28 Well 28 Conversion. Aspen/Evergreen Greenbelts (Figure 4-9) – Convert existing domestic Well 28 by constructing well modifications to meet the reduced irrigation demand requirements.

   The City should consider adding Arroyo Park into the IW 28 area to be served.

Figure 4-7. Community Park

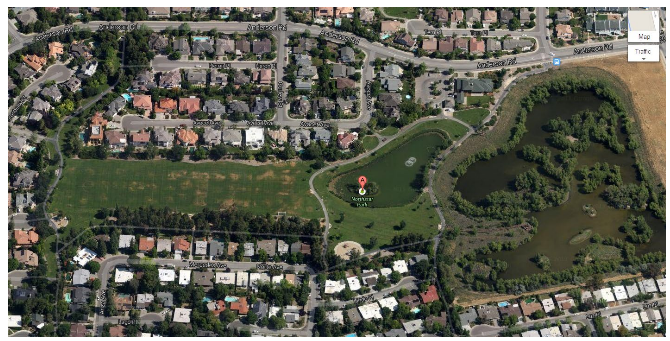


Figure 4-8. Northstar Park

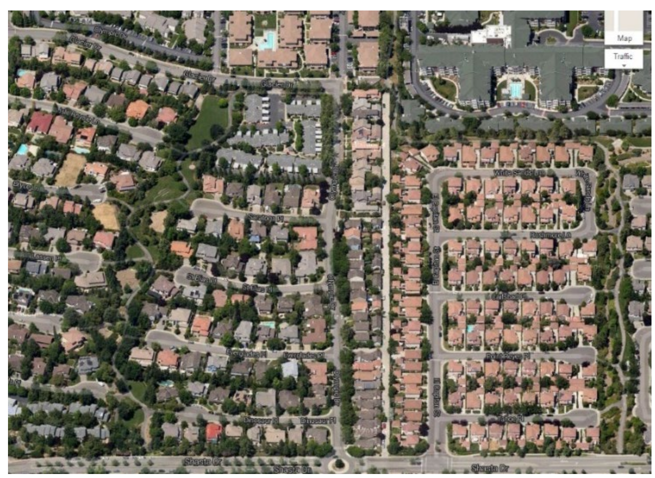


Figure 4-9. Aspen/Evergreen greenbelts

4. New Well IW-5. Walnut Park (Figure 4-10) - Construct a new well at a depth of 300 to 350 feet (ft). Provide new potable water mains to the restrooms, drinking fountains and any other facilities served by the park's existing water distribution system (that has been converted to an irrigation water system).

Figure 4-10. Walnut Park

5. New Well IW-9. Sycamore Park (Figure 4-11) - Construct a new well at a depth of 300 to 350 ft. Provide new potable water mains to the restrooms, drinking fountains and any other facilities served by the park's existing water distribution system (that has been converted to an irrigation water system).

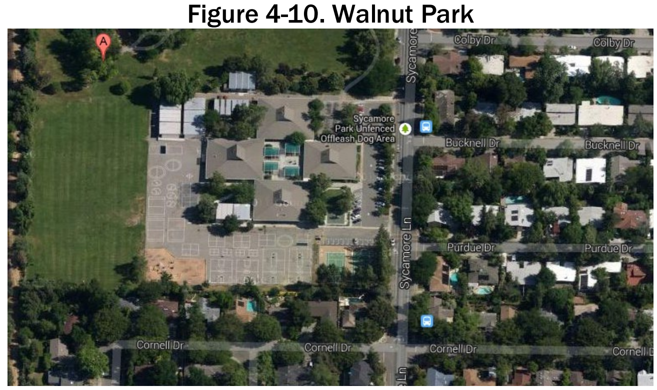


Figure 4-11. Sycamore Park/Willet Elementary School

6. New Well IW-10. Mace Ranch Park (Figure 4-12) - Construct a new well at a depth of 300 to 350 ft. Provide new potable water mains to the restrooms, drinking fountains and any other facilities served by the park's existing water distribution system (that has been converted to an irrigation water system).

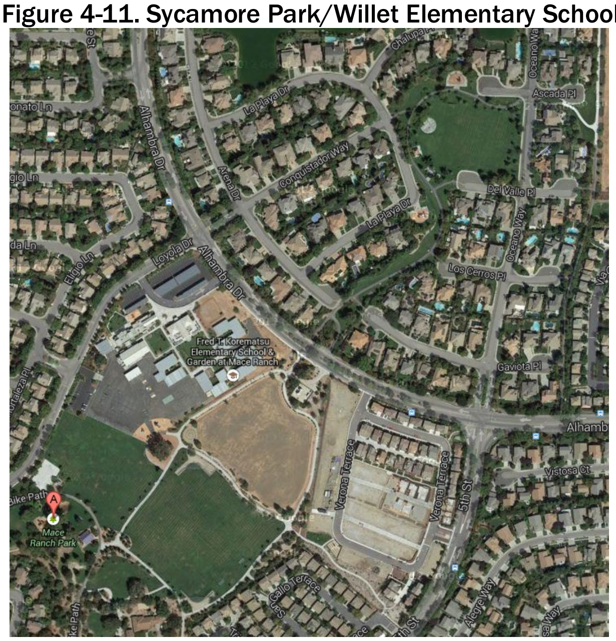


Figure 4-12. Mace Ranch Park and Greenbelt/ La Playa Park

4.3.1 Water Supply

The estimated demand for each well is from the Parks and Greenbelts Water Management Plan and is summarized in Table 4-9. The estimated annual water savings in potable demand that would result from this water management option would be approximately 369 ac-ft/yr for the wells identified in Table 4-9.

Table 4-9. Estimated Water Supply

Well No.	Potable Demand Offset, ac-ft/yr	Assumed start year
Well IW-11 (Convert Existing Domestic Well 11) Community Park/Little League Park	88	2027
Well IW-13 (Convert Existing Domestic Well 19). Northstar Park/North Davis Greenbelt	49	2029
Well IW-28 (Convert Existing Domestic Well 28). Aspen/Evergreen Greenbelts	67	2028
Well IW-5 (new well) Walnut Park	53	2030
Well IW-9 (new well) Sycamore Park	44	2030
Well IW-10 (new well) Mace Ranch Park	68	2030
Total	369	--

Seasonally, the supply would be used predominantly in the summer months, but also at a lower level during the spring and fall months, as shown on Figure 4-13. For this study it is projected the well conversion/irrigation well water supply would come online by from 2027 to 2030 as shown in Figure 4-14. The well conversion/irrigation well water supply is available in all year types and is not impacted by climatic variations from year to year.

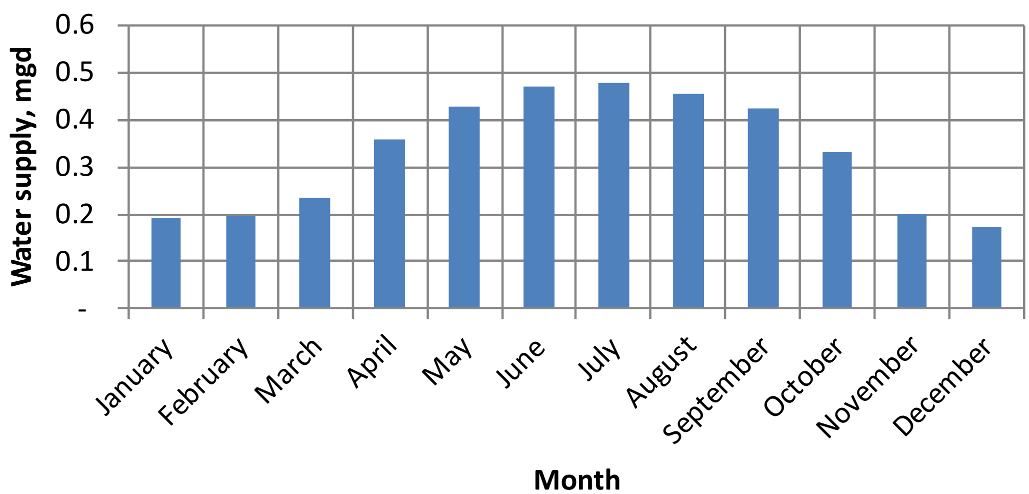


Figure 4-13. Well Conversion/Irrigation seasonal water supply

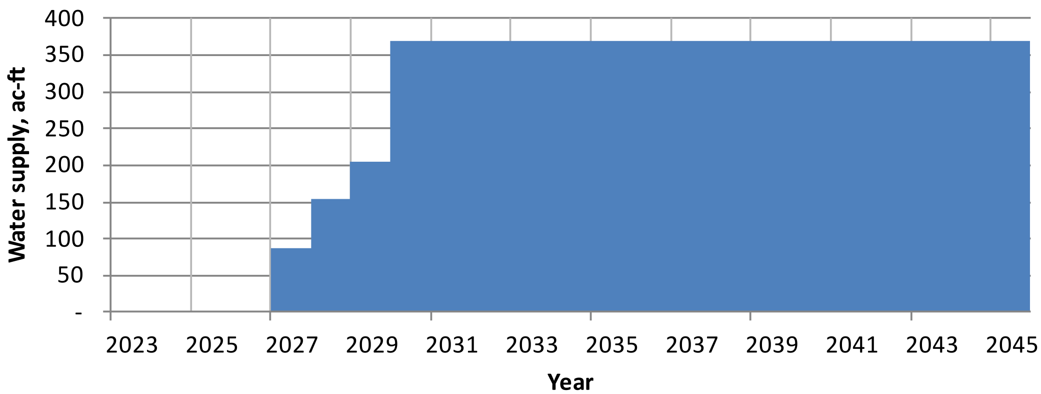


Figure 4-14. Well Conversion/Irrigation annual water supply

4.3.2 Costs

The total capital cost for converting three existing intermediate wells and construction of three new irrigation wells is shown in Table 4-10. These costs include the associated piping and ancillary facilities. Also shown are estimated annual operations and maintenance (O&M) costs including labor to maintain and operate the wells, pump maintenance, and pumping energy costs. It is assumed that the Parks department would construct and maintain these irrigation wells.

Table 4-10. Estimated City Implementation Costs [a]

Well	Capital [a,b]	Annual	Comments
Well IW-11 (Convert Existing Domestic Well 11) Community Park/Little League Park	$1,294,000	--	
Well IW-13 (Convert Existing Domestic Well 19). Northstar Park/North Davis Greenbelt	$1,186,000	--	
Well IW 28 (Convert Existing Domestic Well 28). Aspen/Evergreen Greenbelts	$1,537,000	--	
Well IW-5 (new well) Walnut Park	$1,390,000	--	
Well IW-9 (new well) Sycamore Park	$1,890,000	--	
Well IW-10 (new well) Mace Ranch Park	$2,265,000	--	
Operations and maintenance (labor)	--	$94,000	10 percent FTE[c] per well ($75/hour) for site visits by City staff, piping/valves maintenance, and site upkeep (assume no chemical costs)
Operations and maintenance (pumps)	--	$48,000	Pump rebuild and a well rehabilitation every seven years - with a major pump component replacement every other 5 to 10 years (assume every 7 years) ($55,000/well)
Pumping energy	--	$41,000	Groundwater unit power usage 361 kilowatt hour per acre-foot (kWh/ac-ft)[d] at $0.305/kWh
Total	$9,562,000	$183,000	--

a. *Source: Parks and Greenbelts Water Management Plan (Brown and Caldwell, 2013b)*

b. *Costs in this table are scaled from 2011 dollars ($1,912,250 total) in the 2013 Parks and Greenbelts Water Management Plan to current dollars by applying a multiplication factor of five based on well construction and equipping post-2013 drought and post-Covid costs increases observed in 2022 and 2023.*

c. *FTE is 2,080 hours per year.*

d. *Groundwater unit power usage from City of Davis 2020 UWMP.*

4.3.3 Considerations

Considerations associated with the well conversion/irrigation option are summarized below.

- Reduces potable water system demand, particularly the highly valuable peak demand period which avoids costly expansion of the treated water system in the long-term, and results in a cost-effective water management strategy.
- Provides use for intermediate aquifer groundwater supply without negatively impacting drinking water or wastewater treatment objectives.
- Increases irrigation efficiency because the irrigation wells would provide the optimum sprinkler system operating pressure.
- Aligns with sustainability goals across multiple City plans including the
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to “people, planet, and profit”.
  - City Council 2021 – 2023 Goal 3, Objective 2, A to develop and implement a planting and watering conservation strategy/plan.
  - City Council 2021 – 2023 Goal 3, Objective 2, C to maintain quality and quantity of the City’s water supply and wastewater treatment processes and promoting water conservation.
- Requires effort to ensure there are no cross connections to the drinking water system.
- Requires capital investments and incurs ongoing administrative and training costs.

4.4 Aquifer Storage and Recovery

ASR is the storage of water in the aquifer during times when water is available and the recovery of the stored water when needed at a later time. The City is in the process of conducting an ASR feasibility study and conducted an ASR pilot study on Well 27 in 2021. The information provided in this analysis is based on information from the ASR Feasibility Study (GEI, 2023) and the Well 27 pilot study. This ASR water management option involves the use of some of the existing intermediate depth municipal wells to inject surface water into the aquifer during times when the City’s surface water supplies and conveyance capacity exceed municipal demands, generally during the months of November to April in a typical year (GEI, 2023). Injected surface water is extracted using the same municipal wells during times when Term 91 surface water supplies are not sufficient to meet municipal demands, likely in the months of May through October. The frequency of withdrawals will be determined in future studies. Withdrawal frequency assumed in this section will likely change based on the outcome of future studies.

Indirect potable reuse (IPR) via the injection of treated wastewater to recharge the aquifer is another alternative approach. It would have higher costs than ASR with potable water as described in this water management option due to the distance that the treated wastewater would have to be conveyed to reach the recharge wells. The recharged recycled water would also have to be extracted at a different well and the process would have to be performed in accordance with blending, retention time, and other California Department of Public Health guidelines for indirect potable reuse. IPR is described further in Section 4.9.

Municipal groundwater production in the Davis area has been categorized as being from the “intermediate” and “deep” zones. The intermediate zone is considered to extend from approximately 200 feet to approximately 700 feet below ground surface. The deep zone extends from 700 feet below ground surface to roughly 1,800 feet below ground surface. The ASR option would store the banked surface water in the intermediate zone because the intermediate zone has better aquifer storage characteristics than the deep zone as well as to keep the ASR supply separate from the deep zone. The deep zone is intended to be utilized as the primary drinking water supply source. The City desires to maintain the deep zone solely for water production and to not receive injected surface water supply.

This ASR water management option would use five wells for ASR operations: four new wells at existing intermediate well sites (Well 19, 20, 22, and 27) and one new well at a new well site in the vicinity of Well 11. The location of these wells is shown in Figure 4-15 (GEI, 2023).

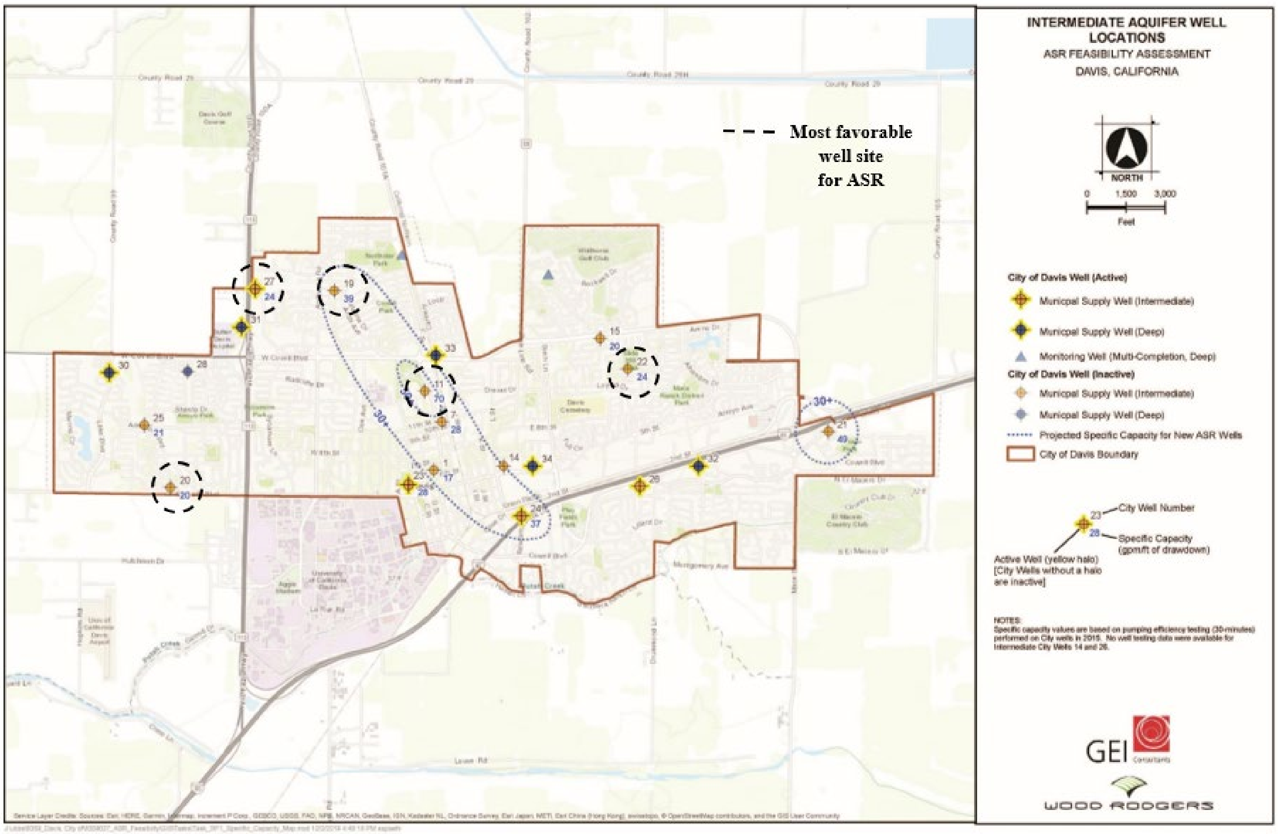


Figure 4-15. Potential ASR well locations

(Source: Figure 6 from ASR Feasibility Study (GEI, 2023))

4.4.1 Water Supply

The estimated annual water supply that would result from this water management option would be approximately 4,000 ac-ft/yr during dry years (Table 4-11).

Table 4-11. Estimated Water Supply

Measure	2045 Dry Year Supply, ac-ft/yr
ASR wells	4,000

The estimated anticipated unused capacity of the WDCWA WTP capacity (10.2 mgd) for the City and the amount of water that could be injected and extracted by ASR wells is presented in Figure 4-16 (GEI, 2023). The median demand for years 2012-2021 was used to estimate the typical monthly demand pattern (indicated as "Median Production" in Figure 4-16). Surplus surface water is estimated to occur in November through April in a normal year because the monthly demand is less than the City's 10.2 mgd portion of the WDCWA WTP.

The ASR Feasibility Study estimates recharge ranges from 300 to 500 gpm dependent upon the particular well. The number of months the wells can be recharged and the related annual recharge rates will likely vary based on water year type. The volume of surplus available water in 2045 is estimated to be 1,155 ac-ft, and five to eight ASR wells would be needed for this volume (GEI, 2023). The water recharged and stored would be extracted and delivered when demand exceeds the available surface water supplies generally in the months of May through October. An annual ASR recharge rate of 1,000 ac-ft/yr is assumed for this ASR water management option analysis.

A portion of the water stored by ASR operations may be lost and unavailable for recovery due to migration of the stored water with the movement and dispersion of groundwater in the intermediate zone. The amount of water lost would vary based on the local groundwater gradient near each ASR well. For this ASR water management option analysis 100 percent recovery of recharged water is assumed. Should a drought year occur once every five years, the ASR system could extract water from ASR wells over a six month summer period (May through October) to extract the 4,000 ac-ft that was stored during the four previous recharge seasons. The frequency of withdrawals will be determined in future studies. Withdrawal frequency assumed in this section will likely change based on the outcome of future studies.

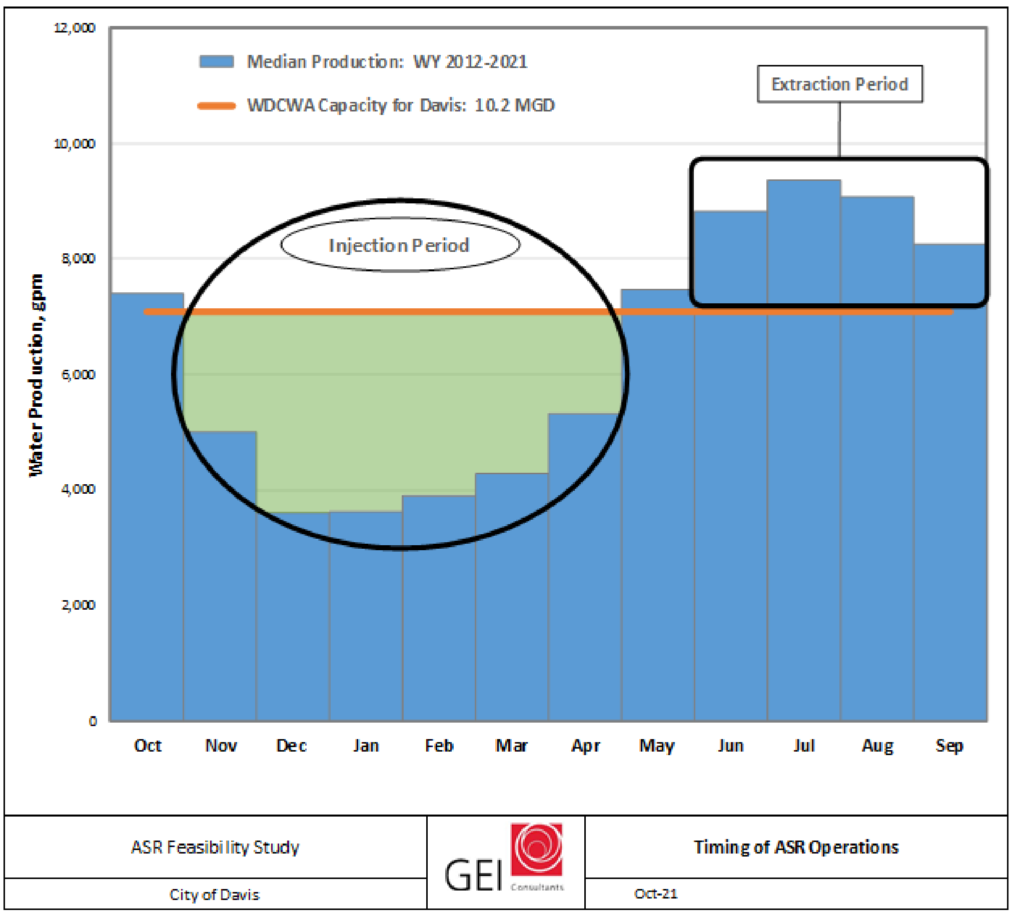


Figure 4-16. City demand versus WDCWA city capacity identifies injection and extraction periods

(Source: Figure 8 from Draft ASR Feasibility Study (GEI, 2023))

The ASR supply would be used predominantly in May through October as shown on Figure 4-17.

Although ASR water is water in storage and would not be impacted by climatic variations from year to year, it is assumed that ASR water supply would only be available in dry years since normal and wet years would be used to recharge the aquifer through injection. Figure 4-18 depicts the amount of banked surface water supply that would be available in dry years.

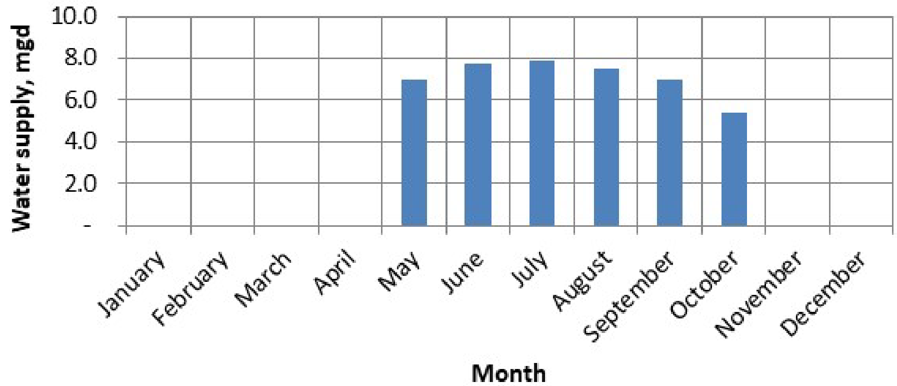


Figure 4-17. ASR seasonal water supply

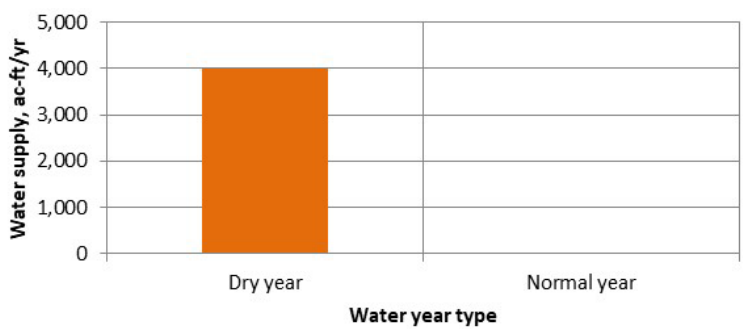


Figure 4-18. ASR water supply reliability by water year type

4.4.2 Costs

Costs for ASR include the costs of retrofitting four existing wells and constructing one new as well as the cost of permitting, the cost of treated surface water, and operations, is presented in Table 4-12. Infrastructure costs for existing well retrofits including installation of the recharge PRV valve and piping are a one time cost, as is permitting, while cost of surface water, pumping, and O&M are annual costs. The costs to operate the ASR wells would be similar to the costs to operate the existing deep wells, except that there would be the additional cost to purchase surface water for the recharge as well as the injection operation.

Table 4-12. Estimated City Implementation Costs			
Type	Capital[a]	Annual	Comments
Installation of New ASR Well	$30,000,000	--	5 wells
Permitting [b]	$150,000	--	Mitigated negative declaration per CEQA and revisions to City's ASR permit from RWQCB
Monitoring and reporting compliance [c]	$135,000	$65,000	$27,000 per well first year $13,000 per well each year thereafter
Operations and maintenance (labor)	$170,000	$300,000	Two additional staff t operate and maintain the ASR wells annually Initial $85,000 per vehicle (truck with cable crane) per position
Operations and maintenance (pumps)	--	$40,000	Pump rebuild and a well rehabilitation every seven years – with a major pump component replacement every 5 to 10 years (assume every 7 years) ($55,000/well)
Treated surface water for recharge	--	$662,000	$827 per ac-ft, 1,000 ac-ft/year, assuming four years of recharge out of every five years
Pumping energy costs to extract	--	$273,000	Groundwater unit power usage 361 kWh/ac-ft[d] at $0.30/kWh
Total	$30,455,000	$1,340,000	--

a. *Capital estimate costs from ASR Feasibility Study (GEI, 2023).*

b. *Permitting is considered a one-time cost.*

c. *Initial monitoring and reporting compliance costs are one-time costs. Annual monitoring and reporting are ongoing costs.*

d. *Groundwater unit power usage from the City of Davis 2020 UWMP.*

4.4.3 Considerations

Considerations associated with the ASR option are summarized below.

- The use of an ASR system provides numerous advantages in regard to water supply, including:
  - Improves supply stability and water quality during drought years.
  - Uses existing City facilities.
  - Uses the City's planned spare winter WDCWA WTP capacity.
- Aligns with sustainability goals across multiple City plans:
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit."
  - City Council 2021 – 2023 Goal 3, Objective 2, C to maintain quality and quantity of the City's water supply and wastewater treatment processes and promoting water conservation.
  - City Council 2021-2023 Goal 2, Objective 2, D to explore technology options that will reduce costs while maintaining or improving service delivery expectations.
- Energy loss for storage and energy usage for extraction.
- Requires capital investments and incurs ongoing administrative costs.

4.5 Recycled Water to Offset Groundwater Use

Using recycled water to offset groundwater use is in-lieu recharge. In-lieu recharge means accomplishing increased storage of groundwater by providing an alternative non-groundwater supply source to a water user who typically relies on groundwater as its primary supply source, to accomplish groundwater storage through the direct use of that alternative non-groundwater supply source in lieu of groundwater pumping. The City's conjunctive use of the WDCWA surface water supply is an example of how the City uses surface water resulting in in-lieu recharge of groundwater. Similarly, the City could use recycled water that also results in in-lieu recharge of the groundwater basin. This in-lieu groundwater recharge approach is consistent with projects and management actions defined in the Yolo Subbasin Groundwater Agency 2022 Groundwater Sustainability Plan (YSGA, 2022) that are recommended to enhance groundwater recharge through in-lieu uses of alternative supplies.

This Recycled Water to Offset Groundwater Use water management option is the use of recycled water as an alternative non-groundwater supply source to offset groundwater pumping for uses that would otherwise consume groundwater in or near the City, in the same groundwater sub basin as the City. These uses include the current and future uses described in the City's conditional acceptance for a recycled water permit (City of Davis, 2022a):

- Yolo County Central Landfill (YCCL) for dust control, phytoremediation, agricultural irrigation, and truck wash activities and Napa Recycled facility (at the YCCL) for fire protection, irrigation of compost sites, and dust control (adjacent to WWTP) (current demand)
- City of Davis tree watering on City property (current demand)
- Open space irrigation of overland of 160-acre site east of WWTP (current demand, in place)
- Agricultural irrigation of City-owned Howatt Ranch (future demand)

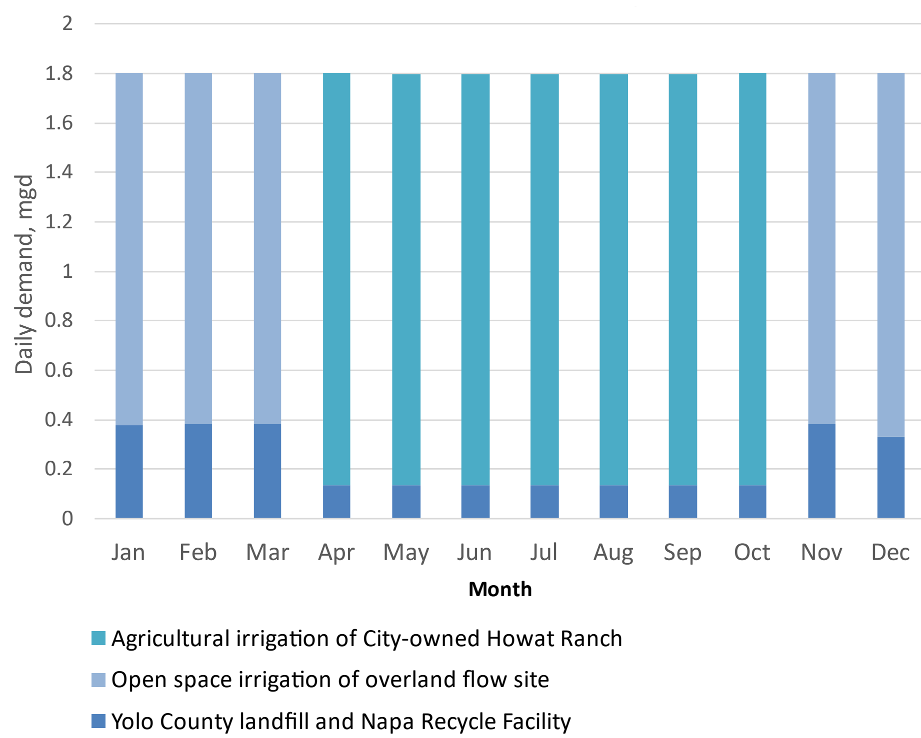
4.5.1 Water Supply

The City's current recycled water permit allows a maximum of 1.8 mgd to be used for recycled water uses not diverted from the Willow Slough bypass. The WWTP currently produces 4 mgd in tertiary treated recycled water. The maximum 1.8 mgd is the portion of the total 4 mgd supply that the City's recycled water change petition allows the City to not discharge into Willow Slough bypass. The City's conditional acceptance for a recycled water permit identifies four uses of this 1.8 mgd recycled water supply. These four users have requested a portion of this supply. The sum of the requested portions is larger than 1.8 mgd. Table 4-13 summarizes requested portion by use, and the assumed groundwater use offset by use for this Recycled Water to Offset Groundwater Use water management option equal to a total of 1.8 mgd.

The assumed use of recycled water by use in Table 4-13 is based on the recycled water permit in place by 2024 an assumed monthly usage pattern over the year. Some uses have more need during summer months whereas other uses can have a recycled water demand all year round. Figure 4-19 illustrates the monthly recycled water use for each user. Use of the recycled water supply would ramp up to full usage by 2028 as shown in Figure 4-20.

Recycled water would be available in all year types.

Table 4-13. Estimated Water Supply					
Recycled Water Use	Recycled Water demand, MG/yr	Estimated Recycled Water Use for Groundwater Use Offset		Assumed start year	Assumed usage duration, months
		MG/yr	ac-ft/yr		
Yolo County landfill and Napa Recycle Facility	236	84	258	2024	Jan - Dec, summer peaks, less in winter, average in spring/fall
City of Davis tree watering on City property	0.1	0.1	0.3	2026	May - September
Open space irrigation of overland flow site	210	216	663	2023 (in place)	Off peak usage in months when available
Agricultural irrigation of City-owned Howatt Ranch	710	357	1,094	2028	April - October
Total	1,156	657	2,016 (1.8 mgd)	--	--



Note: City of Davis tree watering on City property is not shown on graph (small amount compared to other options) 660 gallons per day from May to September

Figure 4-19. Recycled Water to Offset Groundwater Use seasonal water usage

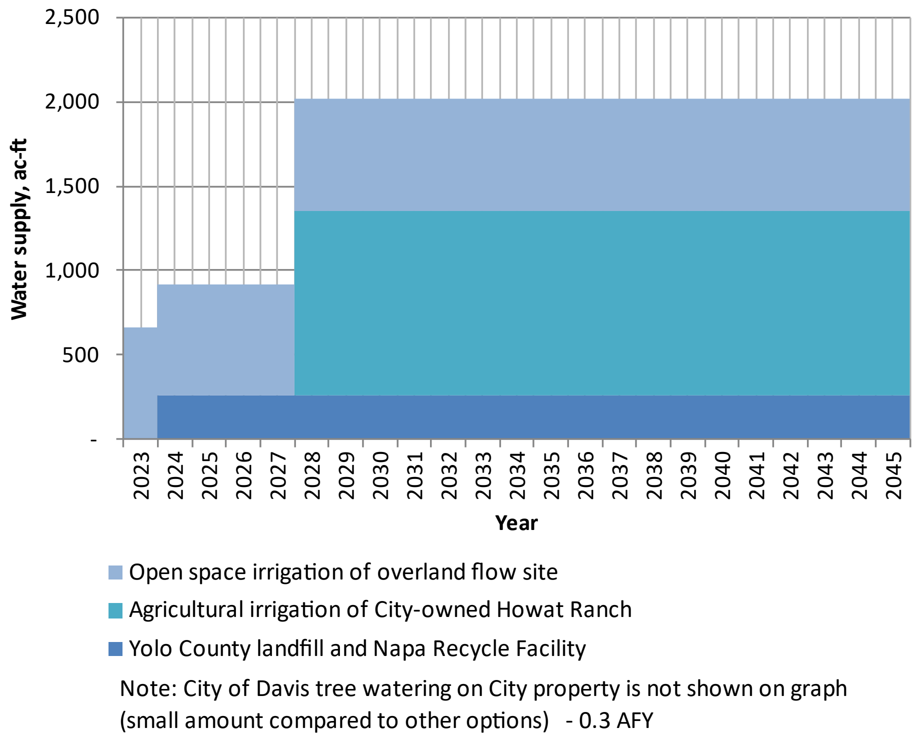


Figure 4-20. Recycled Water to Offset Groundwater Use annual water supply

4.5.2 Costs

The costs related to infrastructure needs for this Recycled Water to Offset Groundwater Use water management option could be minimal due to grant funding that the City would pursue for the infrastructure necessary to convey the recycled water to Howatt Ranch and to convey to the other uses as well. Grant funding for the conveyance of recycled water to Howatt Ranch could be as high as 50 percent of the project costs. The full planning level estimated capital costs to convey recycled water to Howatt Ranch are included in Table 4-14. There are also on-going operational and maintenance costs associated with meeting the recycled water demand. Table 4-14 summarizes the assumed capital and annual costs the City would incur to implement this water management option.

Table 4-14. Estimated City Implementation Costs [a]			
Recycled Water Use	Capital	Annual	Comments
Yolo County landfill and Napa Recycle Facility	--	$187,000	The ability to access the recycled water supply is already in place Cost of Recycled Water ($723/ac-ft)
City of Davis tree watering on City property	-- [a]	$87,000	Two temp FTEs[b]($50/hour), May – September Water truck, $50,000 per year Cost of Recycled Water ($723/ac-ft)
Open space irrigation of overland flow site	--	$480,000	The ability to access the recycled water supply is already in place Cost of Recycled Water ($723/ac-ft)
Agricultural irrigation of City-owned Howatt Ranch	$10,746,000 [c]	$807,000	10% FTE[a] ($75/hour) for City administrative costs associated with coordinatizing the sale of the recycled water Cost of Recycled Water ($723/ac-ft)
Total	$10,746,000	$1,561,000	--

a. Capital costs for tree watering distribution infrastructure such as sewer piping/other best management practices for possible spills at water tender station, conveyance trucks to transport the water, and storage needs are not included in these costs.

b. FTE is 2,080 hours per year

c. Planning level estimated capital costs to convey recycled water for agricultural irrigation of Howatt Ranch are from the 2023 Howatt Ranch Recycled Water Pipeline Preliminary Design Report (Brown and Caldwell, 2023b)

4.5.3 Considerations

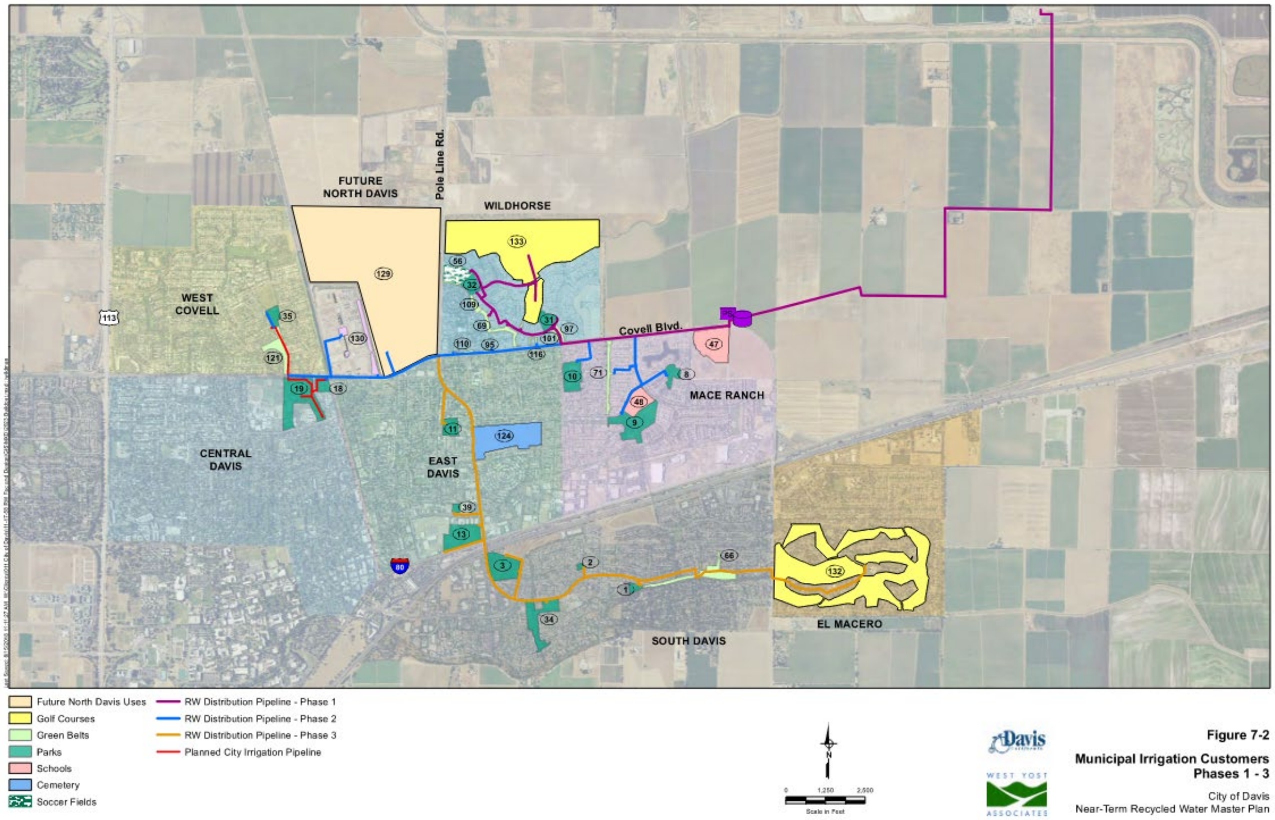
Considerations associated with the recycled water to offset groundwater use option are summarized below.

- Improves the reliability of the City's groundwater aquifer by allowing for groundwater storage through the direct use of an alternative, non-groundwater supply source in lieu of groundwater pumping.
- Provides wastewater disposal flexibility since urban reuse provides an alternative to surface water discharge, and might allow more flexibility to meet future discharge requirements and improve downstream water quality by reducing wastewater discharge to receiving streams.
- Creates a drought proof portion of the City's water supply.
- Maintains local control of the recycled water resource.
- Aligns with sustainability goals across multiple City plans including the
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit"
  - City Council 2021 – 2023 Goal 3, Objective 3, A. to continue to pursue reuse of wastewater treatment plant effluent for multiple purposes.
- Using vehicles to water trees on City property increases GHG emissions.
- May have potential impact to willow slough bypass habitat and downstream users such as Swanson Ranch if all discharge is diverted to RW purposes.

4.6 Recycled Water Distribution System

A recycled water pipeline system to distribute non-potable water to customers in the water system service area must be a separate pipeline system from the City's potable water system pipeline. Dual local delivery systems are water systems that have a potable water distribution system and a non-potable water distribution system in parallel. This Recycled Water Distribution System water management option consists of construction of a new recycled water distribution system (purple pipe) to distribute recycled water supply to future users within the City limits. The recycled water distribution system would be supplied recycled water supply from the City's WWTP. The recycled water demand, infrastructure, and costs for this Recycled Water Distribution System water management option is based on the municipal irrigation customers recycled water scenario in the Recycled Water Master Plan (West Yost and Associates, 2018) to distribute recycled water for the irrigation of parks, schoolyards, street medians, cemeteries, commercial sites, and golf courses.

Figure 4-21 illustrates the Recycled Water Master Plan municipal irrigation customers and pipelines to serve those municipal irrigation customers included in this Recycled Water Distribution System water management option. Note that the transmission main from the WWTP to the distribution system will likely have a modified alignment based on a recycled water pipeline feasibility study currently underway by the City. However, for this analysis the alignment and costs associated with this alignment from the Near-Term Recycled Water Master Plan are used. The Phase 1 municipal irrigation customers include the anchor site, Wildhorse Golf Club, as well as to area greenbelts, parks, Nugget Fields and Harper Jr. High School. The Phase 2 municipal irrigation customers include the Cannery and adjacent areas, Covel and Community parks, and irrigation sites south of Covel Boulevard including Slide Hill Park, Mace Ranch Park, and Korematsu Elementary School. The water demand, infrastructure, and costs associated with the Recycled Water Master Plan Phase 3 are not included in this Recycled Water Distribution System, water management option as Phase 3 timing is beyond the planning horizon of this IWRS analysis.



Note that the transmission main from the WWTP to the distribution system will likely have a modified alignment based on a recycled water pipeline feasibility study currently underway by the City. However, for this analysis the alignment and costs associated with this alignment from the Near-Term Recycled Water Master Plan are used.

Figure 4-21. Recycled water Phase 1 and Phase 2 infrastructure included in Recycled Water Distribution System water management option

(Source: Figure 7-2 from Recycled Water Master Plan (West Yost and Associates, 2018))

4.6.1 Water Supply

The total demand that would be supplied by this Recycled Water Distribution System water management option in 2045 would be approximately 967 ac-ft/yr. A portion of this total demand, 552 ac-ft/yr, is to offset demands by large water users that currently use groundwater from dedicated wells (non potable groundwater offset) as their sole irrigation supply, while 445 ac-ft/year of the total demand would offset demand from the areas that are currently served by the City's potable water system (potable water offset). The water supply in terms of non-potable groundwater offset and potable water offset is summarized in Table 4-15.

Table 4-15. Estimated Water Supply						
Recycled Water Master Plan Phase	Non-Potable Groundwater Offset		Potable Demand Offset		Total	Year available
	MG	ac-ft/yr	MG	ac-ft/yr	ac-ft/yr	
Phase 1	160	491	25	77	568	2028
Phase 2	170	522	145	445	967	2036

Seasonally, the supply would be used predominantly in the summer months, but it would also be used at a lower level during the spring and fall months, as shown in Figure 4-22. For this study it is projected the recycled water distribution system would come online by 2028 for Phase 1 and ramp up to full implementation by 2036 (Phase 2) as shown in Figure 4-23. The recycled water supply would be available in all year types and would not be impacted by year to year climatic variations.

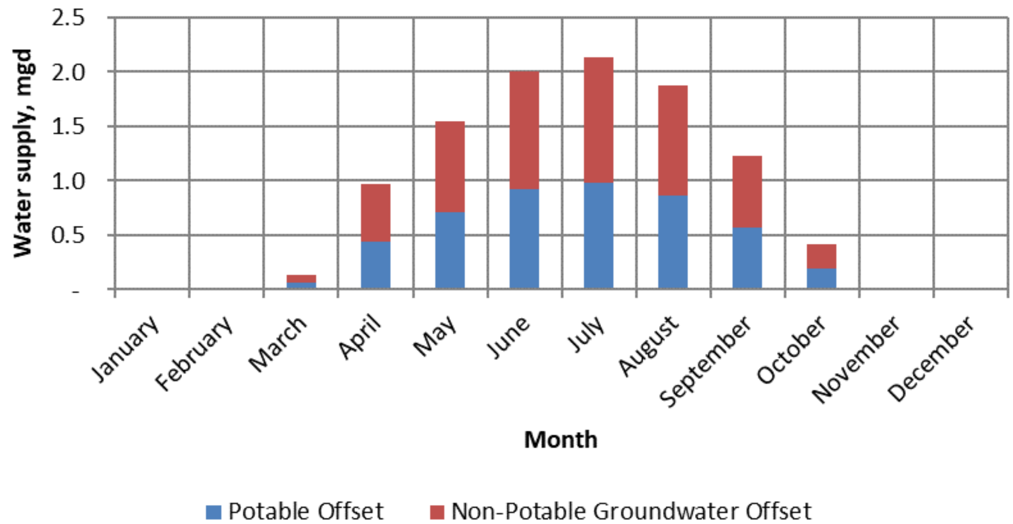


Figure 4-22. Recycled Water Distribution System Water supply - 2045

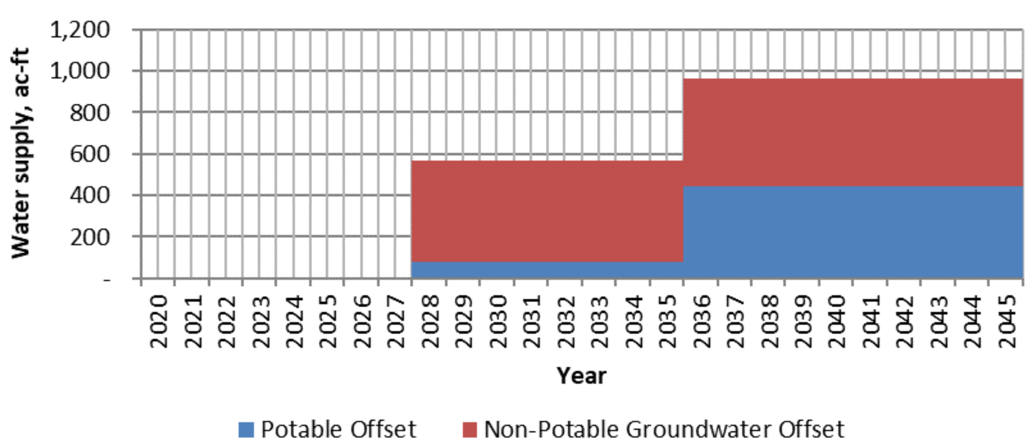


Figure 4-23. Recycled Water Distribution System annual water supply

4.6.2 Costs

The conceptual level cost estimate for this Recycled Water Distribution system water management option is presented in Table 4-16.

Table 4-16. Estimated City Implementation Costs [a]			
Recycled Water Master Plan Phase	Capital	Annual	Comments
Phase 1	$72,305,000	$572,000	Capital Willow Slough Bypass Crossing Phase 1 pipelines MG Storage Tank (2 MG) Booster Pump station (30 HP) Construction Contingencies Cost of Recycled Water ($723/ac-ft) Annual O&M of recycled water distribution system, 1 FTE ($75/hr) Pumping energy costs to pump from storage into the distribution system
Phase 2	$24,808,000	$863,000	Capital Phase 2 pipelines Booster Pump station (40 HP) Construction Contingencies Cost of Recycled Water ($723/ac-ft) Annual O&M of recycled water distribution system, 1 FTE ($75/hr) Pumping energy costs to pump from storage into the distribution system
Total	$97,113,000	$863,000	--

a. *Costs in this table are scaled from 2018 dollars 2018 Near-Term Recycled Water Master Plan to 2023 dollars based on the (ENR CCI) for June (12014.72) and the ENR CCI for December 2022 (14977.94).*

4.6.3 Considerations

Considerations associated with the Recycled Water Distribution System water management option are summarized below.

- Improves the reliability of the City's groundwater aquafer by allowing for groundwater storage through the direct use of an alternative, non-groundwater supply source in lieu of groundwater pumping. Reduces ground water pumping for some potable and non-potable demand.
- Reduces the potable water demand.
- Provides wastewater disposal flexibility since urban reuse provides an alternative to surface water discharge, and might allow more flexibility to meet future discharge requirements and improve downstream water quality by reducing wastewater discharge to receiving streams.
- Drought proofs a portion of the City's water supply.
- Aligns with sustainability goals across multiple City plans including the

- Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit"
- City Council 2021 – 2023 Goal 3, Objective 3, A. to continue to pursue reuse of wastewater treatment plant effluent for multiple purposes.

- Maintains local control of the recycled water resource.
- Reduces the size and cost of the potable water distribution system by removing demands on some outdoor landscaping.
- Results in capital costs that are relatively expensive because of the infrastructure needs of a dual system.

4.7 On-Site Water Reuse

The On-Site Water Reuse water management option consists of rainwater catchment, graywater reuse, and stormwater capture.

Rainwater Catchment – Rainwater catchment is the practice of collecting and using rainwater from hard surfaces such as roofs. Rainwater catchment involves systems that collect rainwater from rooftop catchments and other surfaces as an alternative source of water for use on a limited basis. Rainwater catchment works best in areas with climates that have year-round rainfall patterns which is not the Davis annual rainfall pattern. On a small scale, the practice of rainwater catchment is beginning to be considered in California in containers such as rain barrels or cisterns.

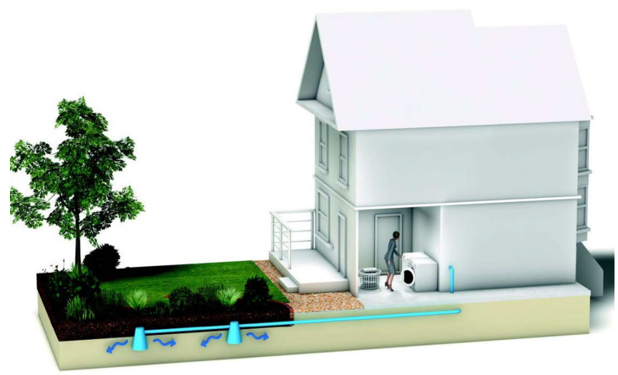
Cisterns

Rain barrels are designed to capture rainwater runoff from the roof so that the water can be later used for irrigation or other non-potable applications. Rain barrels are inexpensive, easy to install and maintain, and well suited to small-scale residential sites. They typically range in size, and the water they collect is most often used for irrigation. For this On-Site Water Reuse water management option the average rain barrel size is assumed to be 100 gallons for single family dwelling units. This size is adequate to irrigate the outdoor landscape of a typical single family residence for one to four days.

Cisterns are larger than rain barrels, ranging from 100 gallons on a small residential site to millions of gallons beneath schools and parks. They can be installed above or below ground, or even on the roof, depending upon site conditions. Water from cisterns can be stored until needed and used for irrigation and toilet flushing. For this On-Site Water Reuse water management option, the average cistern size is assumed to be 1,500 gallons for commercial customers.

The CAAP describes installing rainwater capture and harvesting equipment as part of its goal to conserve water in buildings and landscapes. The Downtown Davis Specific Plan describes using rainwater harvesting for non-potable use within a centralized water reuse district in the Heart of Downtown neighborhood as part of the third and most water conscious water reuse and projected demand scenario (Downtown Davis Specific Plan, Chapter 7.3). The Downtown Davis Specific Plan also incorporates rainwater harvesting in its matrix of potential green infrastructure project types where it describes rainwater harvesting as a potential and effective stormwater control measure and potable water demand offset.

In this On-Site Water Reuse water management option, the customer would be responsible for purchase, installation, and implementation of the rainwater catchment component on a voluntary basis. The City would pay for administrative costs to review and approve customer plans for rainwater catchment facilities. One example of a rainwater catchment program is in nearby City of Woodland that began offering rebates for rain barrels (two rebates allowed per property) beginning in 2011. The rebates are in the amount equal to the purchase price or $75, whichever is less. The cash rebates are offered to City of Woodland residential and commercial water customers. The City of Woodland provides a one-page rain barrels placement and maintenance instruction sheet, located at the following website: (https://www.cityofwoodland.org/710/Rain-Barrels). Any rebates for rain barrels potentially offered through City of Davis would need to come from a grant or General Fund source. Utility funds cannot be used to support rebate programs.



Example graywater system

Graywater Reuse – According to the California graywater standards (Chapter 16A of the 2007 California Plumbing Code), graywater is untreated household waste water that has not come into contact with toilet waste. This includes used water from bathtubs, showers, bathroom wash basins, clothes washing machines, and laundry tubs. Graywater does not include waste water from kitchen sinks, dishwashers, or laundry water from soiled diapers. Chapter 16A legalizes the use of graywater in California and allows the installation of limited types of graywater systems, such as simple washing machine systems, to be installed without a construction permit.

The CAAP considers graywater reuse as part of its goal: to conserve water in buildings and landscapes. Actions for consideration in the CAAP related to graywater include:

1. Develop financing/incentive options to promote the collection and reuse of graywater and recycled water in existing buildings and include specific provisions for vulnerable populations.
2. Develop policies that require graywater reuse in new construction and major remodels.

This concept of laundry-to-landscape is also incorporated in the Downtown Davis Specific Plan in two of the three water reuse and projected demand scenarios (Sustainable Reuse and Resilient Reuse).

The San Francisco Public Utilities Commission (SFPUC) developed a technical resource for homeowners and professionals who want to install graywater systems for outdoor irrigation in San Francisco. This manual provides a detailed step-by-step process for designing and installing laundry-to-landscape systems, as well as the basic steps for designing and installing branched drain and pumped systems. The manual provides an overview of the benefits of graywater systems, when and where to install these different systems, permitting requirements, what products to use, and operation and maintenance requirements. This manual can be found under the eligibility requirements section, “how to participate” subsection at https://sfpuc.org/learning/conserve-water/save-water-outdoors

In this On-Site Water Reuse water management option, graywater reuse only includes laundry water reuse for outdoor landscape irrigation purposes. The graywater option could be integrated with the rainwater catchment option. Information on the installation of grey water systems in Davis can be found at https://www.cityofdavis.org/city-hall/public-works-utilities-and-operations/water/water-conservation/saving-water-outdoors/grey-water

Stormwater Capture - Most communities manage stormwater to reduce runoff and pollutants because of regulatory water quality requirements for discharging stormwater. Low impact development is a stormwater management approach that uses best management practices to reduce runoff.

This stormwater capture component of the On-Site Water Reuse water management option consists of capturing stormwater that would otherwise drain into the City's stormwater system, and then percolating it into the groundwater. This would result in the increase of percolation of stormwater into the upper aquifer. The use of stormwater capture does not offset demand on the potable water system, however, percolation of additional water to the groundwater aquifer can help offset groundwater pumping in the region.

The CAAP describes green stormwater elements as a potential aspect of its Action C.1 Climate-ready private landscapes (as part of its goal to conserve water in buildings and landscapes).

The Downtown Specific Plan states that green infrastructure will be incorporated into the development of downtown using a variety of technologies at building and district scales as applicable. Potential stormwater related green infrastructure projects and best management practices that can provide treatment and attenuation of stormwater flows described in the Downtown Davis Specific Plan are as follows:

- Green roofs
- Rainwater harvesting
- Bioretention bulb-outs
- Permeable pavement (parking lots)
- Bioretention in parks and landscaping
- Drainage sidewalks to vegetated filter strips

4.7.1 Water Supply

The estimated potential water supply is based on water supply from the rainwater catchment and graywater reuse components of this On-Site Water Reuse water management option. The water supply from stormwater capture is not quantified in this analysis. The stormwater capture approach described above is assumed to attribute to increasing the City's groundwater supply reliability. The estimated water supply is summarized in Table 4-17. The assumptions and estimates for the rainwater catchment and graywater reuse components are also described below.

Table 4-17. Estimated Water Supply

Measure	2045 Water Savings, ac-ft/yr
Rainwater Catchment	8
Graywater Reuse	15
Total	24

Rainwater Catchment – The supply from the rainwater catchment component of this On-Site Water Reuse water management option is based on assumptions regarding the assumed number of customers who purchase and install rainwater catchment rain barrels or cisterns, average roof area to capture the rain, and size of barrels and cisterns that the customers install. The supply is also based on the historical average monthly precipitation within the City and irrigation need considering evapotranspiration rates. For the purposes of this analysis, the assumptions in Table 4-18 are used. As shown in Table 4-18, it is assumed that the percent of participating future customers in new developments would be higher than the percentage of participating existing customers. The rainwater catchment water supply based on these assumptions are shown in Table 4-19.

Table 4-18. Assumptions for Rainwater Catchment Water Supply

Assumption type	Assumption		
	SFR	Commercial	Units
Existing Development (2010)			
Assumed participants	2%	5%	Percent of existing 2021 connections
Assumed participants	301	32	connections
Future Development (2035)			
Assumed participants	25%	10%	Percent of future increment (2035 minus 2010) of connections
Assumed participants	223	7	connections
Total assumed participants	524	39	connections
Other Assumptions			
Median house size	1,800	--	sq-ft
Percent roof area	75%	--	--
Average roof area	1,350	5,000	sq-ft
Average runoff coefficient, c	0.85	0.85	assumed for roofs
SFR average rain barrel or cistem capture storage volume	100	1,500	gallons

Table 4-19. Rainwater Catchment Water Supply by Month

Month	Average rainfall, in	Standard average ETo, in	Single family residential				Commercial						Total		
							Supply from Customers not included in Downtown Davis Specific Plan								
			Rainwater runoff from roof area[(a)(b)] gallons/SFR connection, (assuming no capture storage limitations), gallon	Irrigation need gallons/per SFR connection[(d)] (Rainfall minus ETo)	Net rainwater capture supply gallons/ SFR[(c)(e)]	Total SFR rainwater supply, gallon	Rainwater runoff from roof area, gallons/ commercial connection (assuming no capture storage limitations)	Irrigation need, gallons/commercial connection [(d)](Rainfall minus ETo),	Net rainwater capture supply gallons/ commercial customer	Subtotal commercial rainwater supply, gallons	Supply from Downtown Davis Specific Plan commercial [(f)], gallons	Total commercial rainwater supply, gallon	Net rainwater capture supply , gallon	Net rainwater capture supply , mgd	Net rainwater capture supply , ac-ft
January	3.4	1.2	2,432	-	-	-	9,008	-	-	-	-	-	-	-	-
February	4	1.9	2,861	-	-	-	10,598	-	-	-	-	-	-	-	-
March	2.6	3.7	1,860	3,429	1,500	785,460	6,889	6,858	6,000	234,132	24,385	258,517	467,973	0.02	1.44
April	1.1	5.4	787	13,403	787	412,056	2,914	26,807	2,914	113,729	95,323	209,052	418,508	0.01	1.28
May	0.6	7.2	429	20,573	429	224,758	1,590	41,146	1,590	62,034	146,310	208,344	417,800	0.01	1.28
June	0.2	8.3	143	25,248	143	74,919	530	50,497	530	20,678	179,562	200,240	275,160	0.01	0.84
July	0.1	8.3	72	25,560	72	37,460	265	51,120	265	10,339	181,779	192,118	229,578	0.007	0.70
August	0.1	7.6	72	23,378	72	37,460	265	46,756	265	10,339	166,261	176,600	214,060	0.007	0.66
September	0.3	5.9	215	17,456	215	112,379	795	34,911	795	31,017	124,142	155,159	267,538	0.01	0.82
October	1.5	4.2	1,073	8,416	1,073	561,895	3,974	16,832	3,974	155,084	59,854	214,939	424,395	0.01	1.30
November	2.1	2.1	1,502	-	-	-	5,564	-	-	-	-	-	-	-	-
December	3.2	1.2	2,289	-	-	-	8,478	-	-	-	-	-	-	-	-
Annual	19.3	56.9	13,735	137,463	4,290	2,246,387	50,871	274,927	16,333	637,351	977,617	1,614,969	2,715,010	0.01	8.33

a. *c=0.85*

b. *Single Family Residential (SFR) average roof area is 1,350 sq-ft. Commercial average roof area is 5,000 sq-ft.*

c. *Assumed SFR capture storage size is 100 gallons. Assumed commercial capture size is 1,500 gallons.*

d. *Irrigation need based on rainfall minus ETo times the assumed irrigated area for SFR (5,000 ft^2) and for commercial (10,000 ft^2). No rainwater capture potable supply offset shown in months when rainfall exceeds the ETo.*

e. *Assumes rain barrel or cistern is emptied once per week, as available.*

f. *Downtown Davis Specific Plan identified 3 ac-ft/year for rainwater catchment*

Graywater – Graywater supply is based on multiple factors including the number of customers assumed to install a graywater system and the number of fixtures in the graywater system (i.e. a simple laundry system vs. a multiple plumbing fixture system that also includes showers, bathtubs, and washbasins). For this analysis the graywater demand is based on the assumptions listed in Table 4-20.

Table 4-20. Graywater Water Supply Estimate and Assumptions

Assumptions	SFR	MFR	Total	Units
Existing connections (2021)	15,032	486	15,518	Connections
Future increment of new connections (2045 minus 2021)	892	35	927	Connections
Dwelling units per connection	1	20	--	Dwelling units/connection
Existing dwelling units (2021)	15,032	9,941	24,973	Dwelling units
Water use for laundry	27	27	--	gpd/dwelling unit
Water use for laundry	27	550	--	gpd/account
Graywater reuse for existing (2021) customers through 2045				
Assumed participants	2%	1%	--	Percent of existing 2021 connections participating through 2045
Assumed participants (connections)	301	5	306	Participants (connections)
Graywater supply	8,087	2,674	10,761	gpd
Graywater supply	8	2	10	ac-ft/yr
Graywater reuse for future development customers through 2045				
Assumed participants	15%	10%	--	Percent of future new accounts (2045minus 2021) participating through 2045
Assumed participants (connections)	134	4	138	Participants (connections)
Graywater supply	3,599	1,926	5,525	gpd
Graywater supply	3	2	5	ac-ft/yr
Total graywater reuse				
Total assumed participants (connections)	434	9	443	
Total 2045 graywater supply	11,686	4,600	16,286	gpd
Total 2045 graywater supply	0.01	0.005	0.015	mgd
Total 2045 graywater supply	11	4	15	ac-ft/yr

a. *SFR = single family residential*

b. *MFR = multi-family residential*

The rainwater catchment and graywater supplies would be available in all year types. The quantity of rainwater catchment could be impacted by climatic variations from year to year whereas the graywater supply would not be impacted by climatic variations from year to year.

Seasonally the On-Site Water Reuse water supply would be used as illustrated in Figure 4-24, described as follows:

- Rainwater catchment water supply would be used predominantly in the winter as well as during the spring and fall months.
- Graywater water supply would be used predominantly in the summer months, but also at a lower level during the spring and fall months.

For this study it is projected the rainwater catchment and graywater supplies would come online by 2025 and ramp up to full supply by 2045 as shown in Figure 4-25.

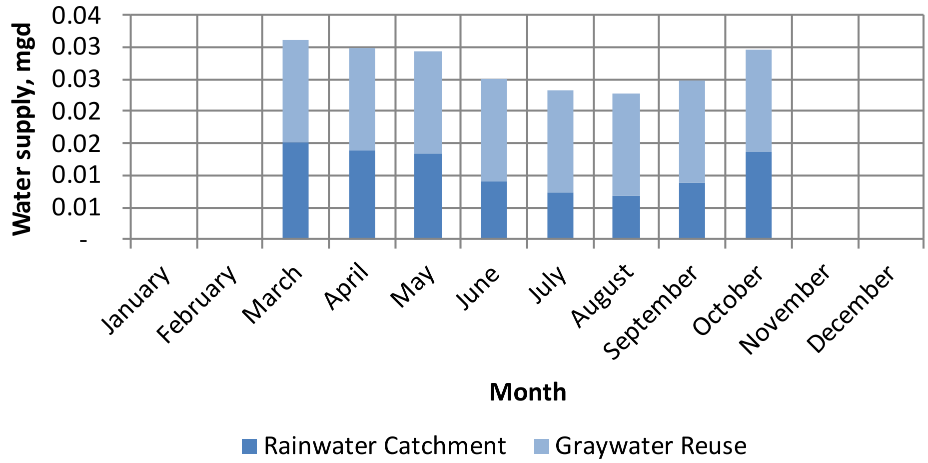


Figure 4-24. On-Site Water Reuse seasonal water supply

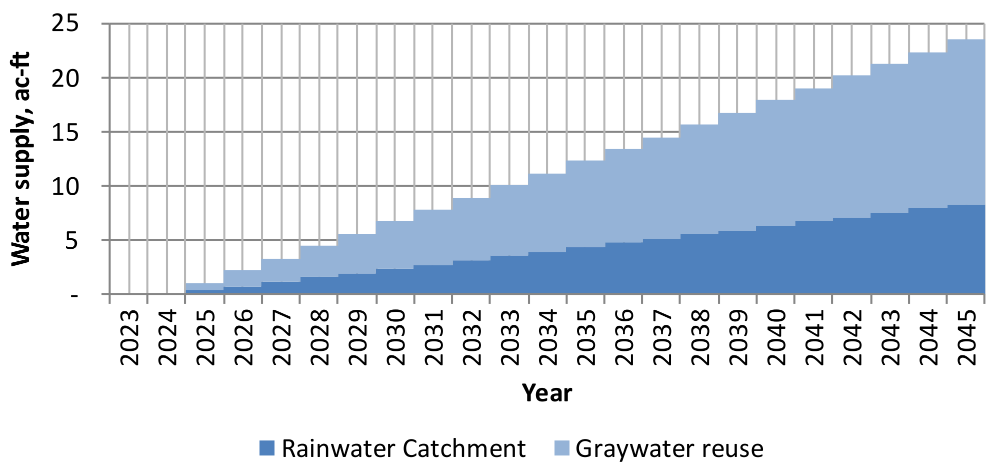


Figure 4-25. On-Site Water Reuse annual water supply

4.7.2 Costs

The City costs associated with each component of this On-Site Water Reuse water management option do not include any capital costs as the customers would purchase and install the infrastructure. It also does not include and energy related costs the customer would pay from necessary pumping out of the cisterns. The City's costs are associated with the annual costs to administer these programs including plan review, permit processing, and inspections as permanent features are constructed. The estimated costs are summarized in Table 4-21.

Table 4-21. Estimated City Implementation Costs

Measure	Capital cost	Annual	Assumptions
Rainwater Catchment	--	$39,000	0.25 FTE[a] combined operations staff and supervisor ($75/hour)
Graywater Reuse	--	$39,000	0.25 FTE[a] combined operations staff and supervisor ($75/hour)
Stormwater	--	$39,000	0.25 FTE[a] combined operations staff and supervisor ($75/hour)
Total	--	$117,000	--

a. *1 FTE = 2080 hours/year*

4.7.3 Considerations

Considerations associated with this water management option are summarized below.

- Aligns with sustainability goals across multiple City plans including the:
  - 2020-2040 CAAP goal to conserve water in buildings and landscapes.
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to "people, planet, and profit".
  - City Council 2021-2023 Goal 2, Objective 2, D to explore technology options that will reduce costs while maintaining or improving service delivery expectations.
- Stormwater:
  - Reduces stormwater flows and discharges.
  - Improves stormwater quality.
  - Increases groundwater recharge.
- Rainwater catchment
  - Reduces potable water demands for outdoor irrigation use.
  - Results in low costs for the City because it is a customer implemented option.
- Graywater
  - Drought-proofs a portion of the customers' outdoor water supply. Since more than half of indoor water can be reused as graywater, during shortages, when outdoor watering may be restricted, the customer will have a constant source of irrigation water.
- Stormwater
  - Does not offset potable water use.

- Rainwater Catchment
  - Provides relatively small amounts of water due to the area's climate characteristics and the small amount of storage provided by rain barrels and cisterns compared to the summer period outdoor irrigation demands.
- Graywater
  - Reduces wastewater flow that may cause reduced flow volume and velocity in the small-diameter extremity sewers.
  - Incurs potentially significant customer expense to install a graywater system.

4.8 De-Facto Reuse

De-facto reuse is not considered a classic recycled water project. For the City it would consist of discharging a certain amount of recycled water from the WWTP to the Sacramento River in exchange for an increased intake (by an equivalent amount) at the WDCWA WTP. The treated wastewater from WWTP could be discharged to the Sacramento River via an existing stream, canal, or waterway or a newly constructed pipeline. The increased intake of this equivalent amount for the WDCWA WTP would not require any additional infrastructure since it would take place at the existing WDCWA WTP facility intake.

The exchange approach is sometimes referred to as an "in the river swap" and would provide a drought proof supply of water. Though this water management option does have water rights implications, an example of a similar strategy has been successful in the City of Stockton under Water Code 1485. To implement this water management option, the City would work with WDCWA to apply for a water rights permit from the SWRCB. Figure 4-26 depicts potential conveyance and discharge locations of the City's recycled water into the Sacramento River as well as the location of the existing river intake.

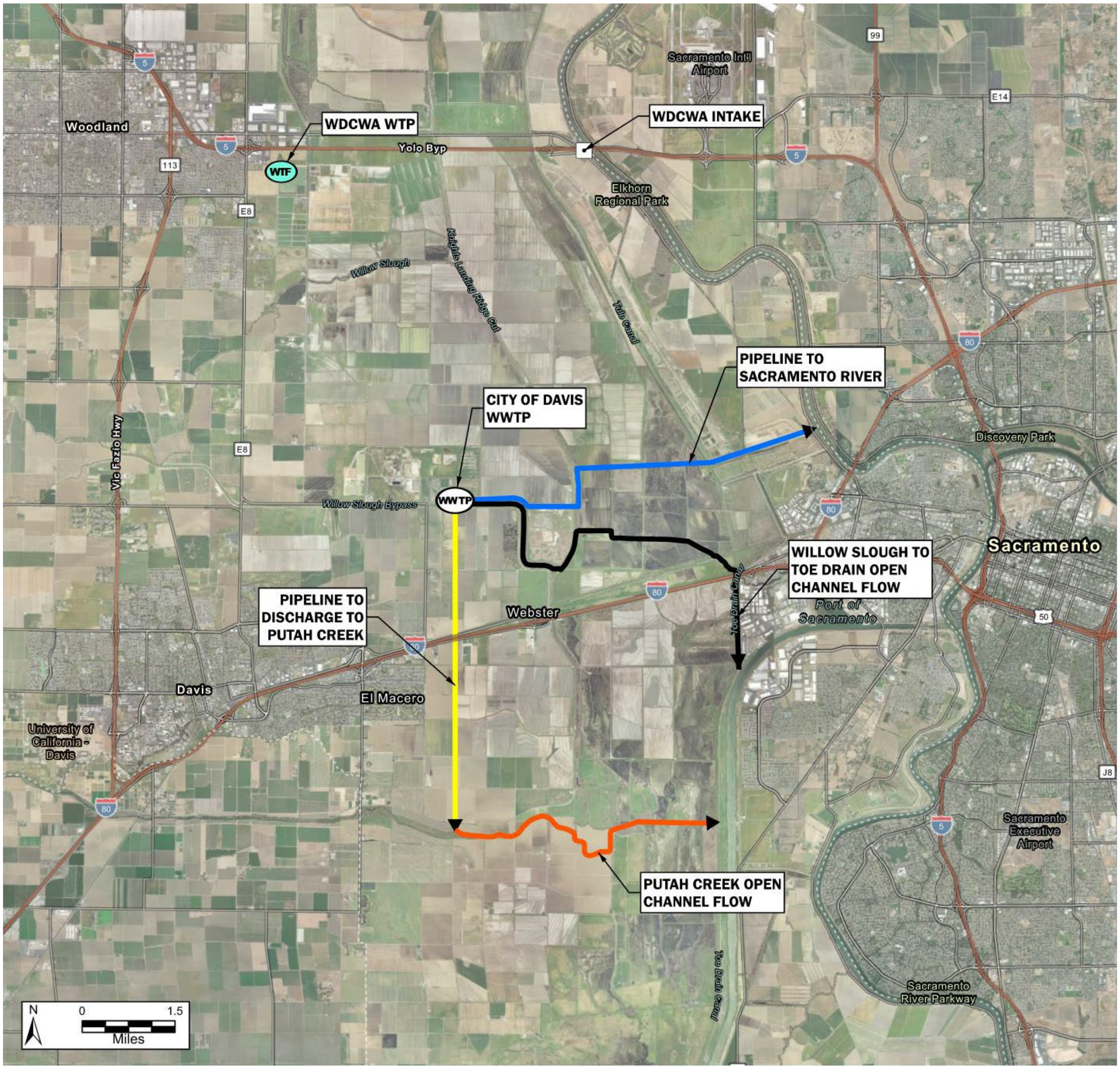


Figure 4-26. Potential conveyance and discharge locations of the City's recycled water into the Sacramento River and location of the existing WDCWA Sacramento River intake, WTP, and City of Davis WWTP

There are several potential administrative issues with this water management option, that should be considered:

- The proposed diversion at the WDCWA intake is upstream of the water source. Typically, the SWRCB Water Rights Division "follows the water" and only allows diversions of water downstream of the source water. Arguments in favor of this proposal being acceptable to the SWRCB include the Delta pool concept (if this portion of the Sacramento River could be considered part of the Delta pool), and the applicability of Water Code section 1486.
- This water management option would require an environmental evaluation of impacts.

- Possible impacts on Central Valley Project and State Water Project ability to meet Delta Standards would have to be considered. Any impacts could be mitigated with additional storage releases or reduced exports. Impacts could be negligible since the amounts of water proposed for this water management option (1.8 mgd) is small relative to the Sacramento River flow and impacts are likely not significant. The source water for this alternative would be from the City, and not natural or abandoned flow. Therefore, this should not be a water right issue.

An alternative option for the discharge would be to build a pipeline from the WWTP directly to the WDCWA WTP which would be considered direct potable reuse (DPR). DPR is considered raw water augmentation up stream of a drinking water treatment plant. This option is not considered in this report but is further discussed in Section 4.9. Challenges to this approach include the rigorous administrative requirements that would be required. Final regulations for DPR are expected in December 2023.

4.8.1 Water Supply

As described in Section 4.5.1 the City's current recycled water permit allows a maximum of 1.8 mgd to be used for recycled water uses not diverted from the Willow Slough bypass. The WWTP currently supplies 4 mgd in tertiary treated recycled water. The maximum 1.8 mgd is the portion of the total 4 mgd supply that the City's recycled water change petition allows the City to not discharge into Willow Slough bypass. This De-Facto Reuse water management option is assumed to use the full 1.8 mgd (2,016 ac-ft/yr) as seen in Table 4-22.

Table 4-22. Estimated Water Supply

Measure	Water Supply, ac-ft/yr
De-Facto Reuse Water Right	2,016 (1.8 mgd)

4.8.2 Costs

The costs related to this water management option could be extensive based on the infrastructure necessary to convey the City's recycled water from the WWTP to the Sacramento River as well as based on the length of time and effort necessary to secure the water right with the SWRCB. In absence of a natural water way to convey water to the Sacramento River, a 7 to 10 mile pipeline could be required in addition to pump stations necessary to pump water from the WWTP through the pipeline as well as over the levee to the Sacramento River.

Preparing the water rights permit application and the associated environmental document as well as related legal and administrative efforts would be a large component of the cost items for this alternative.

Planning level costs are summarized for this De-Facto Reuse water management option in Table 4-23.

Table 4-23. Estimated City Implementation Costs			
Item	Capital	Annual	Comments
Infrastructure	$63,000,000		Booster pump station at WWTP Booster pump station at Sacramento River 50,000 LF, 16-in diameter recycled water transmission main from City of Davis WWTP to the Sacramento River Contingency (100%)
Operations and Maintenance		$160,000	1 FTE
Environmental Evaluation, Water Right, and associated activities [a]	$10,000,000		Draft and final EIR ($5 million) Water Rights Application ($1 million) Legal Fees ($1 million) Public Outreach ($1 million) Miscellaneous other costs ($1million) Contingency ($1 million)
Total	$73,000,000	$160,000	

a. *Considered a one-time cost*

4.8.3 Considerations

Considerations associated with the de-facto reuse option are summarized below.

- Creates a drought proof portion of the water supply.
- Maintains local control of the recycled water resource.
- Reduces ground water pumping for potable and non-potable demand.
- Aligns with sustainability goals across multiple City plans including the:
  - Downtown Davis Specific Plan goal to model the Triple Bottom Line in sustainability which gives equal emphasis to “people, planet, and profit”.
  - City Council 2021-2023 Goal 2, Objective 2, D to explore technology options that will reduce costs while maintaining or improving service delivery expectations.
- May result in initial capital costs that are relatively expensive because of the potential infrastructure needs to discharge treated wastewater from the WWTP into the Sacramento River (if an existing, natural waterway is not viable).
- May require significant environmental documents and permits effort with SWRCB.

4.9 Other Water Management Options Considered

This section describes additional water management options that were considered but not further analyzed in this IWRS due to high cost, permitting, and logistical implementation issues. The City may desire to further consider some of these water management options at a later date as technology or legislative changes occur that resolve or reduce current implementation issues.

- Mobile desalination
- Cloudseeding
- Hydro panels
- IPR
- DPR

IPR is the planned augmentation of a surface or groundwater supply with treated municipal wastewater. IPR could be groundwater injection of purified water from advanced treatment at the City's WWTP. This type of IPR project is termed a "Groundwater Reuse Replenishment Project" by the Division of Drinking Water. The advanced treated purified water would mix with the native groundwater, undergo additional treatment in the aquifer and GWTP, and blend with other surface and groundwater supplies before reaching customers. IPR requires the following:

- An environmental buffer such as a groundwater basin or reservoir.
- The treatment train is membranes, reverse osmosis, and ultra violet advanced oxidation.
- Minimum two-month time of travel underground before water is suitable for potable consumption, however, typically, the Division of Drinking Water requires 6 months of travel time.
- 12/10/10 log reduction values (LRV). More LVRs are required for IPR using ASR.

IPR using a groundwater aquifer is currently practiced in several areas in California, including the Groundwater Replenishment System in Orange County. An indirect potable reuse option for the City would be to use recycled water to recharge the groundwater aquifer.

DPR uses recycled water as a source of drinking water where the influence of an environmental buffer is small, minimal, or absent. The existence of an environmental buffer, passage of recycled water through an aquifer or reservoir, is the key difference between IPR and DPR. DPR can be categorized as raw water augmentation (RWA) or treated water augmentation (TWA). RWA is upstream of a drinking water treatment plant where the water can enter into a small reservoir or a pipe upstream of the drinking water treatment plant. TWA is when the purified water is put directly into the distribution system. DPR requires the following:

- 20/14/15 LRVs plus a significant amount of monitoring if discharged directly to a distribution system.
- The treatment train is ozone and biological activated carbon, micro filtration, reverse osmosis, ultraviolet advanced oxidation, and likely chlorine disinfection. Credits can also be used from the drinking water treatment plant, but they would need to be validated per reuse regulations.

Draft DPR regulations were published in Aug 2021. There have been a number of public expert panel meetings, with their recommendations. The final DPR regulations are expected in December 2023. This will be followed by the administrative process where the regulations wills be codified, assumed to be by April 2024. There are many utilities currently evaluating DPR. Typically, these agencies are located in Southern California where there are less reliable water supply sources than the City.

4.10 Summary of Water Supply Options

This section presents the basis of the cost estimates and summarizes the key characteristics of each of the water supply options evaluated in this chapter. Section 5 of this IWRS bundles various combinations of these options into several portfolios for comparison.

4.10.1 Basis of Costs

The cost estimates in this IWRS have been developed using other City planning documents when available as well as planning level unit cost estimates when necessary. Consideration of both capital and annual maintenance and operating costs is necessary to provide the complete picture of the true life cycle cost of a water management option. The capital and operation and maintenance costs for each water supply option are discussed in each of the water supply options sections in this chapter. The economics of the water supply options are presented in this section in terms of present worth, equivalent annual cost, and cost per acre-foot.

Present worth is a means to compare alternatives with different staged construction and varied O&M costs. The present worth analysis recognizes that future expenditures of money have a smaller value in the present. The present worth is calculated using a real rate of 3 percent per year that is based on a discount rate of 5 percent per year and an inflation rate of 2 percent per year.

The unit cost per ac-ft of water is based on the assumption that the water management options are started in 2023 and is derived by dividing the present worth of all of the costs through 2045 by the discounted water supply through 2045 for each option. The benefit of using an approach that discounts future water benefits is that it gives greater value to near term water benefits and is consistent with benefit/cost calculations that typically discount both future benefits and costs. This approach that discounts both future costs and future water amounts results in a higher unit cost per ac-ft compared to using an approach that does not discount future water savings. Table 4-24 provides a summary of the general cost assumptions used in this analysis.

Table 4-24. General Cost Assumptions

Item	Value	Comments
Present value real rate	3%	Based on a discount rate of 5 percent per year and an inflation rate of 2 percent per year
Analysis period	2023 - 2045	
FTE annual hours	2,080 hours	
Operational staff labor rate	$75/hour	
Temp labor rate	$50/hour	
Pacific Gas & Electric (PG&E) average rate	$0.305/kWh	
Surface water costs	$827/ac-ft	WDCWA Annual Budget for City of Davis Share ($7.79M)/ac-ft sent in FY2022/2023
Groundwater supply	$286/ac-ft	
Recycled water supply	$723/ac-ft	Three year average based on PG&E charges and solar discount

The approximate unit cost of the water supplied by the City's deep wells is $286 per ac-ft. The assumed well utilization is 50 percent over a one year period. The assumptions for the costs of one well with treatment and its annual water supply are presented in Table 4-25. As shown in Table 4-25, the capital cost of one new deep well is assumed to be $6 million. The unit cost of the planned surface water supply is $827 per ac-ft based on the WDCWA annual budget and the City's share for fiscal year 2022/2023.

Table 4-25. Unit Cost of Deep Aquifer Well Supply	
Capital cost for 2,000 gpm well with treatment	$6 million
Annualized capital cost at 3%, 30 years	$307,000
Annual water supply at 50% utilization	1,613 ac-ft
Annual power cost at 361 kWh/ac-ft and $0.305/kWh	$178,000
Other annual O&M costs	$70,000
Total annual cost	$555,000
Unit cost of water supply, $/ac-ft	$344

4.10.2 Water-Energy Nexus

The water-energy nexus refers to the close link between water and energy. Energy is expended to treat and deliver water to customers and is referred to as the embedded energy in water. Sizeable energy benefits can be realized through efficient water use by end users and efficient energy use by water systems. The production of electrical energy results in GHG. GHG emissions in California are lower than elsewhere in the United States due to the large amount of hydroelectric electricity generation in the state. PG&E reports that the amount of carbon dioxide equivalent (CO_2e) emitted is 0.524 pounds per kilowatt hour (kWh). The GHG emissions from electrical power production is reported by the electric utilities. The energy used by the City to provide water supply is due to the pumping of groundwater from the City's wells and pumping of surface water from the WDCWA WTP. The amount of energy used for each ac-ft of water supplied (kWh/ac-ft) varies dependent upon the amount of groundwater and surface water used by the City in a given year. Per the City's 2020 UWMP this can range from 361 to 413 kWh/ac-ft when annual groundwater use ranges from 25 percent to 50 percent of total annual supply, respectively. The total energy intensity of the surface water supply from the WDCWA is 761 kWh/ac-ft (West Yost and Associates, 2021). As shown in Table 4-26, a total 677 kWh of energy is used for each ac-ft of water supplied to the City (kWh/ac-ft). The City's new recycled water supply source has a total 723 kWh of energy used for each ac-ft of recycled water produced. This is based on three years of data from the solar energy discount and PG&E billings.

Table 4-26. Embedded Energy in Water Supplies Supply				
	City Groundwater Wells [a]	WDCWA Surface Water Supply [b]	Total Surface Water and Groundwater	Recycled Water[c]
2020 Production, ac-ft/yr	5,195	19,574	24,769	--
2020 Power use, kWh	1,874,191	14,906,148	16,780,339	--
Unit power use, kWh/ac-ft	361	761	677	723
Pounds CO_2e emitted/kWh	0.524	0.524	0.524	0.524
Pounds CO_2e emitted/ac-ft	189	399	355	379
Embedded energy cost, $/ac-ft[d]	$110	$232	$206	$221

a. *City of Davis 2020 UWMP*

b. *WDCWA 2020 UWMP*

c. *City of Davis Staff, email communication March 20, 2023*

d. *Embedded energy based on $0.305/kWh PG&E average rate*

4.10.3 Summary of Water Management Options

Table 4-27 summarizes the water quantity, estimated present worth and unit costs, the embedded energy, and GHG emissions for each water management option. Below are some notes and observations on Table 4-27:

- The water management options that result in the most significant quantities of water savings or water supply as a percent of projected 2045 demand (before active conservation) are, Recycled Water to Offset Groundwater Use, De-Facto Reuse, Residential and Commercial Water Use Efficiency, Recycled Water Distribution System, and ASR.
- The other water management options result in relatively small amounts of water with each representing 4 percent or less of the City's projected 2045 demand.
- The Recycled Water Distribution System water management option has the highest present worth cost and the highest unit cost per ac-ft.
- Capital costs are included for the conveyance of recycled water to Howatt Ranch for Recycled Water to Offset Groundwater Use. The City may be able to secure up to 50 percent of these costs in grant funding but that is not know at this time.
- Not all of these water management options can be implemented concurrently as some of them may use the same supply source (for recycled water related water management options) or facilities (Well Conversion/Irrigation and ASR).

Table 4-27. Summary of Water Management Options					
Water management option	2045 Supply, ac-ft	Present worth cost [d], $ million	Unit cost, $/ac-ft	Embedded energy, kWh/ac-ft	GHG emissions, lbs CO_2e / ac-ft
Residential and Commercial Water Use Efficiency	1,111	$11.2	$682	b	b
Municipal Water Use Efficiency	298	$2.1	$502	b	b
Well Conversion/Irrigation	369	$10.1	$2,359	361	189
Aquifer storage and recovery (ASR) [a]	799	$41.5	$5,490	1,122	588
Recycled Water to Offset Groundwater Use	2,016	$31.9	$1,110	858	449
Recycled Water Distribution system	967	$88.1	$9,446	778	408
On-Site Water Reuse [c]	24	$1.2	$7,014	b	b
De-Facto Reuse	2,016	$52.3	$3,879	921	482

a. *Assume ASR supply is used annually.*

b. *Option has no embedded energy and GHG emissions.*

c. *Only includes the City's administrative costs, and excludes the customers' and developers' costs.*

d. *Present value of costs occurring 2023-2045.*

As shown in Table 4-27, some of the water management options have no embedded energy use and GHG emissions. Below are some observations and notes related to the water management options with embedded energy use and GHG emissions:

- The Well Conversion/Irrigation water management option has embedded energy use and GHG emissions that would be the same as the current groundwater supply.
- The ASR water management option has higher embedded energy use and GHG emissions than Well Conversion/Irrigation due to the need to pump the water twice, for both the recharge and the extraction modes.
- The Recycled Water to Offset Groundwater Use and Recycled Water Distribution System water management options have a high embedded energy use and GHG emissions because of the added pumping that would be needed to convey the recycled water from the WWTP to the City.
- All of these water management options, except for ASR and De-Facto Reuse, would result in a decrease of the demand on the City's potable water system, thereby reducing the energy use and GHG emissions due to the potable water system.

Figure 4-27 illustrates the unit water cost by water management option.

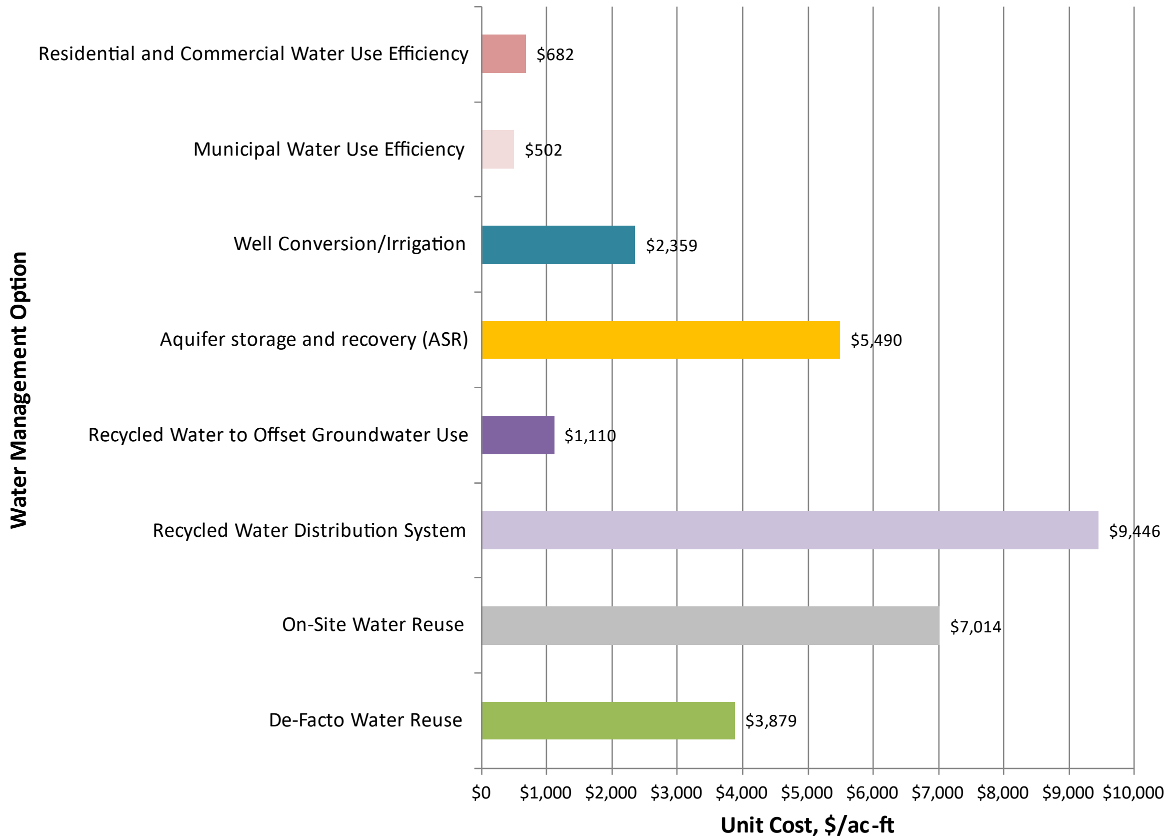


Figure 4-27. Unit cost of water by water management option

The present worth cost, 2045 water supply, and cost per ac-ft for each water management option are presented on Figure 4-28. Each option is represented as a circle or bubble, where the size of the bubble represents the cost per ac-ft of water supply. In Figure 4-28, the options that lie to the left and upward, and have the smaller bubble size represent the options that provide the best combination of lower present worth cost, greater annual water supply, and lower per ac-ft cost. Figure 4-29 presents another perspective with the size of the bubble representing the amount of 2045 water supply. The options located to the lower left with the larger bubble sizes represent the better options. The costs and water amounts are presented in more detail in Appendix A.

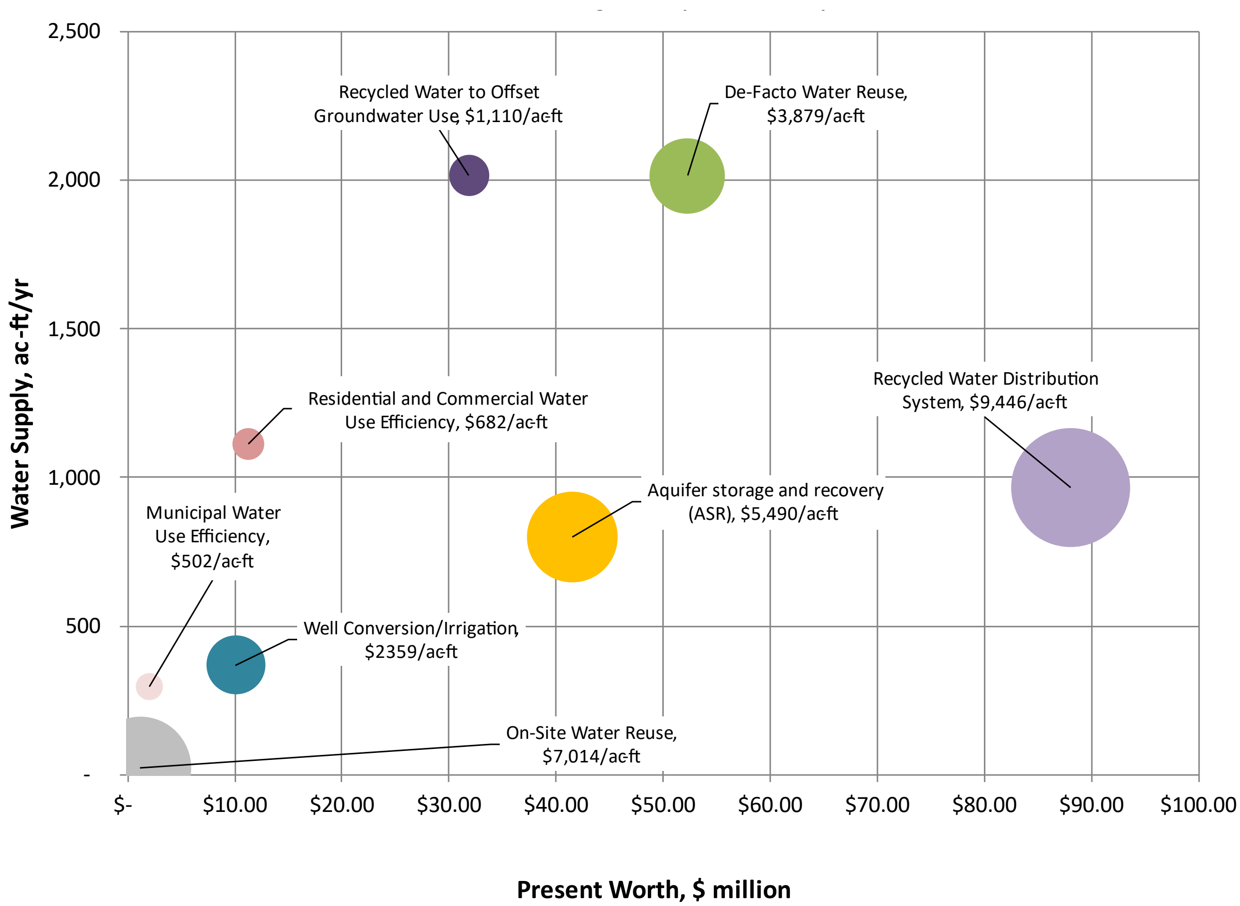


Figure 4-28. Water management options summary, water supply vs present worth

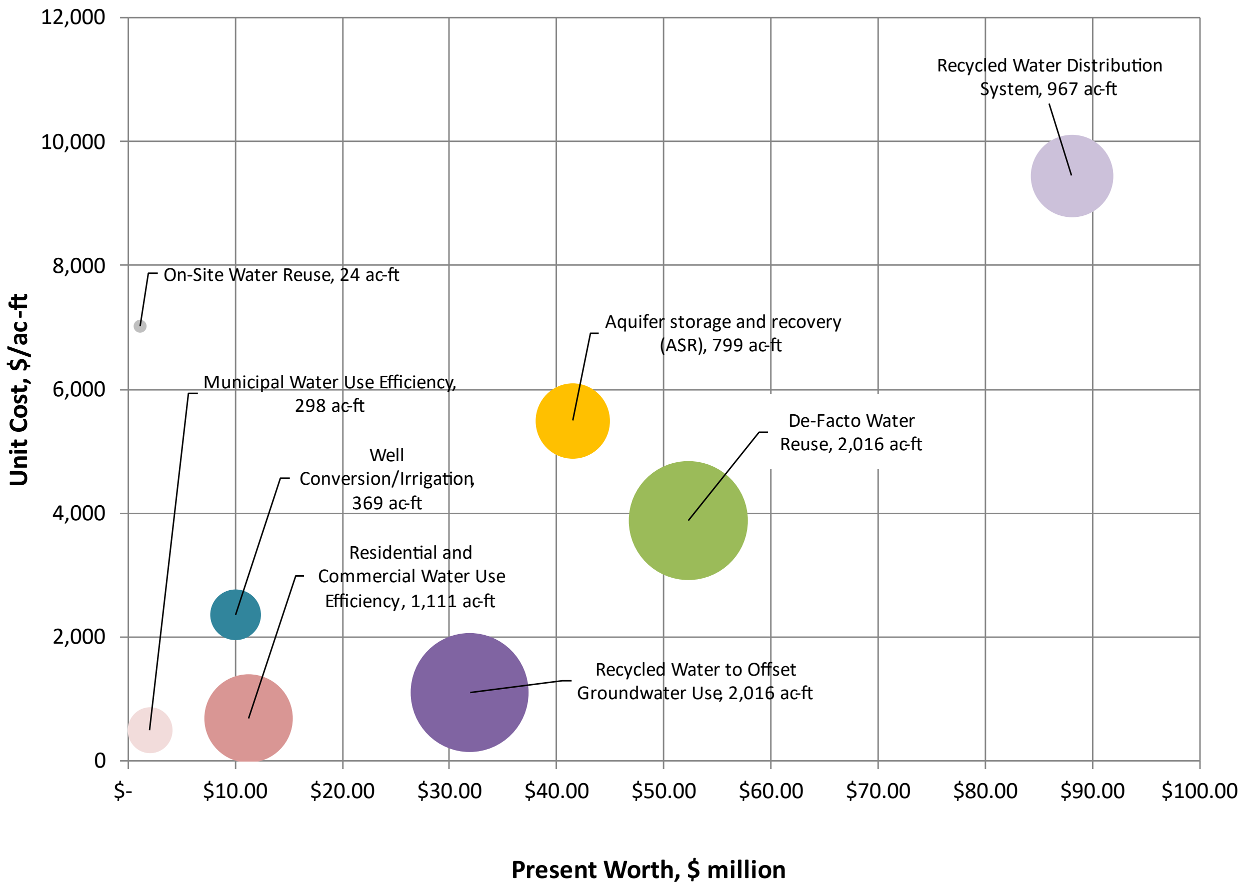


Figure 4-29. Water management options summary, unit cost vs present worth

Section 5

Identification and Evaluation of Water Management Portfolios

This section defines and evaluates combinations of water management options, referred to as water management portfolios. The costs and benefits of the portfolios are described. The water management portfolios are scored and compared based on screening criteria presented in this section.

5.1 Water Management Portfolios

The water management options defined and quantified in Section 4 are combined into several portfolios for evaluation. There are of course many combinations of options that could be developed into portfolios. The intent is to bookend the range of possible portfolios, and provide an evaluation to help better see the effects of implementing more than one option. Implementation of the Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-Site Water Reuse water management options are considered base case conditions and are included in all of the portfolios. They are not included in the names of the portfolios to keep the portfolio names reasonably brief. The annual and monthly supplies for each portfolio are presented for both normal and dry year conditions.

Portfolio 1. Base Case

Portfolio 2. Recycled Water Distribution System

Portfolio 3. Well Conversions and Recycled Water to Offset Groundwater Use

Portfolio 4. ASR and Recycled Water to Offset Groundwater Use

Portfolio 5. De-Facto Reuse and ASR

Some notes to consider when reviewing the water management portfolio results:

- Water supply graphs are presented for each portfolio that depict the amounts of annual and monthly supplies that would contribute to the City's potable demands by the water management options that make up the portfolio.
- Supply facility capacity and the seasonal variations in demands over the year is important to consider in addition to annual quantities when analyzing water supplies and demands. The monthly graphs identify why groundwater wells are an important supply for the City; they help meet peak demands during summer months. This nuance is not easily identified when only considering annual supplies.
- Water management options that do not offset potable water use (Recycled Water to Offset Groundwater Use, ASR, and De-Facto Water Reuse) are shown on the water supply graphs.
- It is assumed that the implementation of the water management options that are potable water use offsets would reduce the use of groundwater with the treated surface water being the priority or base supply source for the potable water system.
- It is assumed that the capacity of the WDCWA WTP for the City's usage is 10.2 mgd (11,425 ac-ft/yr) in normal conditions and 3 mgd (3,360 ac-ft/yr) in dry year (Term 91) conditions.

- The water supplies for each portfolio are presented in detail in Appendix B.

5.1.1 Portfolio 1. Base Case

The Base Case portfolio is based on the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency
- Municipal Water Use Efficiency
- On-site Water Reuse

The Base Case portfolio under normal and dry year (Term 91) conditions is described below.

Normal Year

- Figure 5-1 presents the Base Case portfolio annual water supply through 2045 for a normal year. Figure 5-1 also presents the City's actual use of intermediate and deep aquifer supplies since 2005. As can be seen in Figure 5-1, the use of the City's intermediate wells is not necessary with the introduction of surface water in a normal year. The use of deep groundwater wells is necessary due to peak demand in summer months (as seen on Figure 5-2).
- Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-site Water Reuse all offset potable demands. As shown in Figure 5-1 the potable demand is the sum of the groundwater and surface water supplies. The potable demand would be higher without the water management options in this portfolio.
- Figure 5-2 illustrates the monthly supply in 2045. It is assumed that the WDCWA WTP with a 10.2 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 10.2 mgd. The summer peak potable demands would be higher without the water management options in this portfolio.

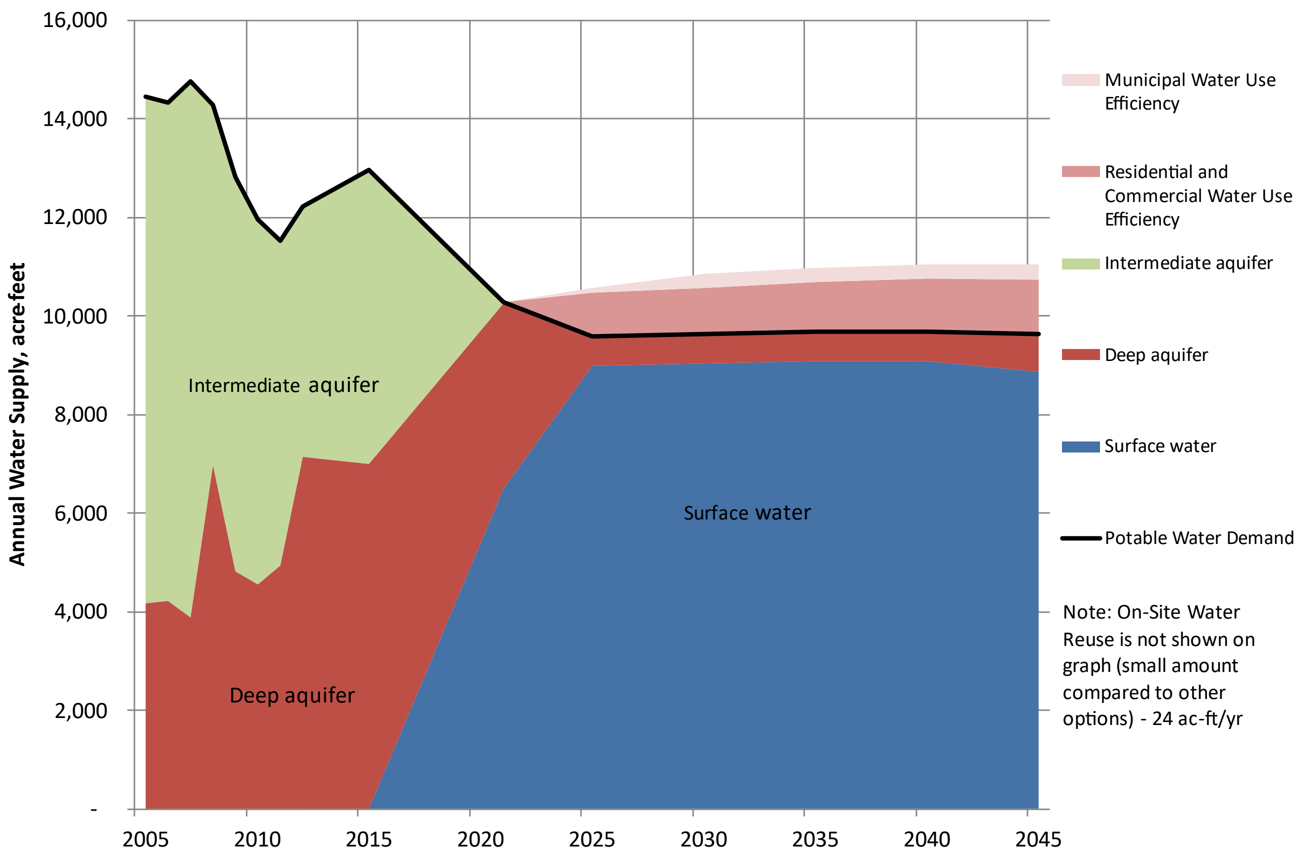


Figure 5-1. Portfolio 1 Base Case: annual water supply – normal year

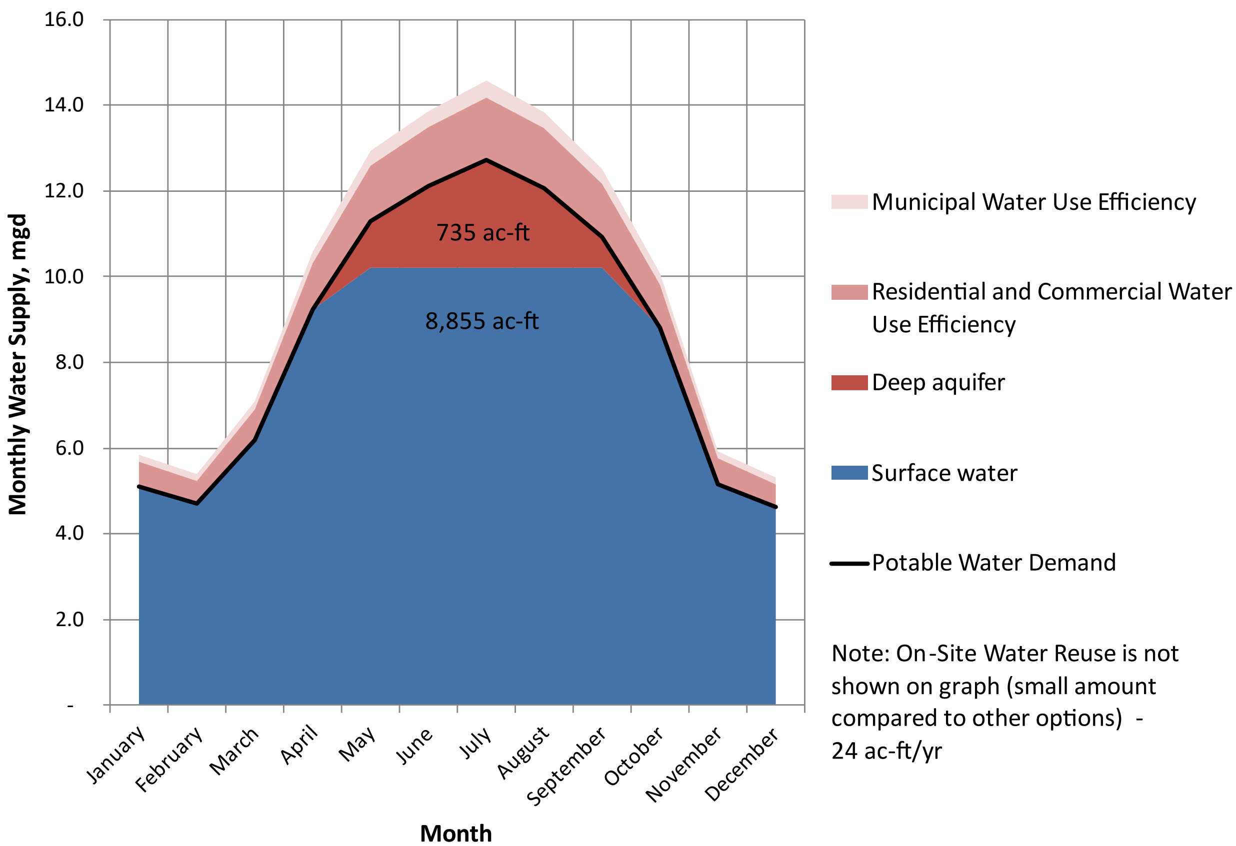


Figure 5-2. Portfolio 1 Base Case: 2045 monthly water supply – normal year

Dry Year

- Figure 5-3 presents the Base Case portfolio annual water supply through 2045 for a dry year. As can be seen in Figure 5-3, the use of the City's deep groundwater wells increases in dry years when the surface water supply is reduced.
- Figure 5-4 illustrates the monthly supply at 2045 for a dry year. It is assumed that the WDCWA WTP with a 3.0 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 3.0 mgd. The summer peak daily potable demand would be higher without the water management options in place.

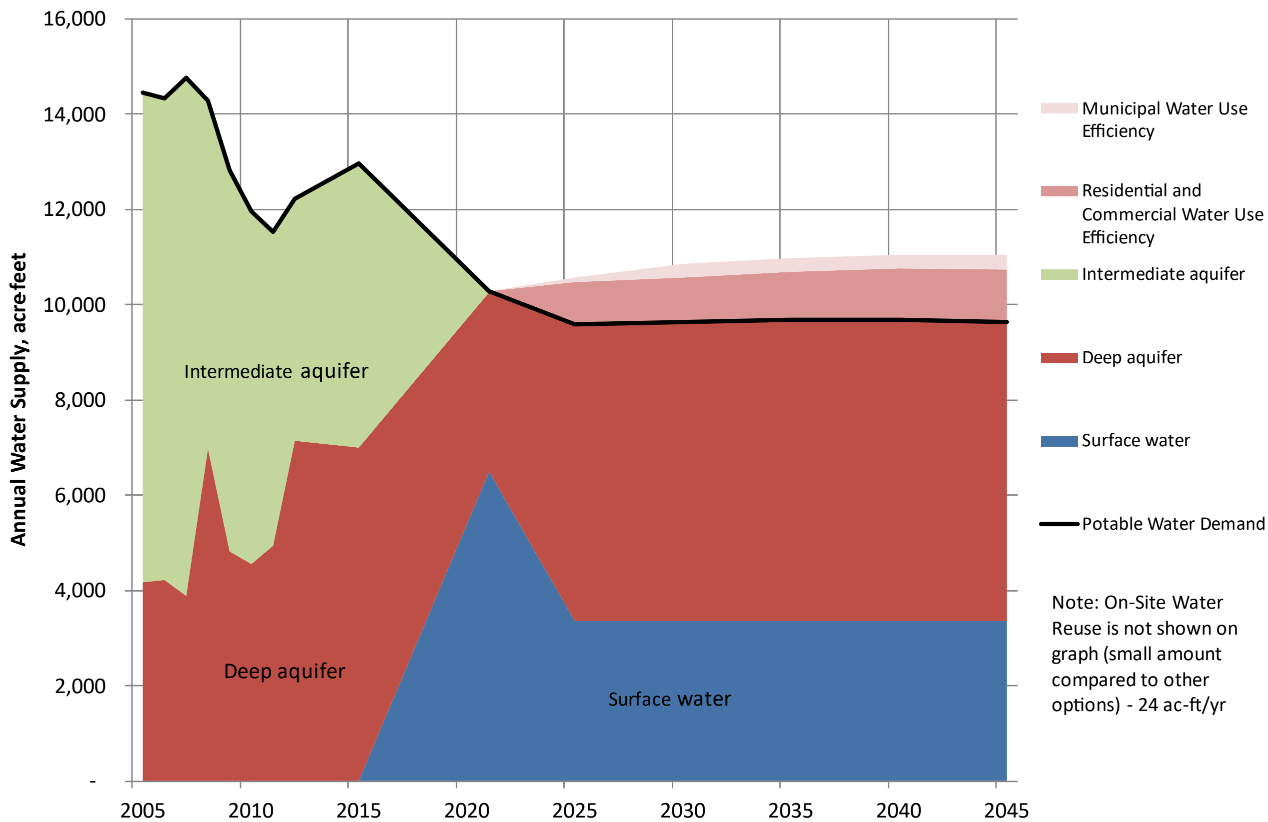


Figure 5-3. Portfolio 1 Base Case: annual water supply – dry year

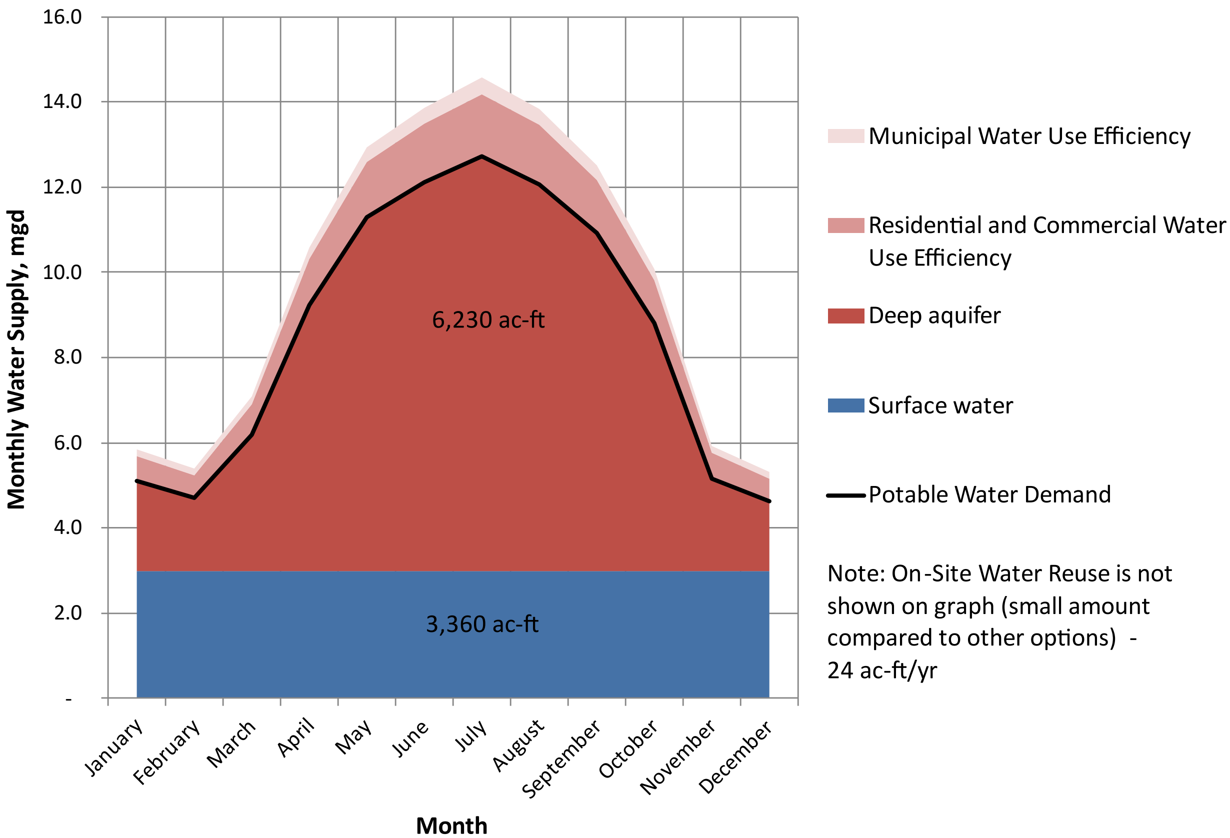


Figure 5-4. Portfolio 1 Base Case: 2045 monthly water supply – dry year

5.1.2 Portfolio 2. Recycled Water Distribution System

The Recycled Water Distribution System portfolio is based on the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency
- Municipal Water Use Efficiency
- On-site Water Reuse
- Recycled Water Distribution System

The Recycled Water Distribution System portfolio under normal and dry year (Term 91) conditions is described below.

Normal Year

- Figure 5-5 presents the Recycled Water Distribution System portfolio annual water supply through 2045 for a normal year. As can be seen in Figure 5-5, the use of the City's intermediate groundwater wells is no longer necessary with the introduction of surface water. The use of deep groundwater wells is necessary due to peak demand in summer months (as seen on Figure 5-6).
- As shown in Figure 5-5 the potable demand is the sum of the groundwater and surface water supplies. Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, On-site

Water Reuse, and the Recycled Water Distribution System all offset potable demands. The potable demand would be higher without the water management options in this portfolio.

- As shown in Figure 5-5 there is a portion of the Recycled Water Distribution System that does not offset potable demands. However, it does offset non-potable groundwater demands currently supplied by non-potable groundwater wells for private golf courses within the City. This non-potable groundwater demand offset is considered in-lieu groundwater recharge using recycled water (similar to the Recycled Water to Offset Groundwater Use water management option). The City's potable demands do not decrease as a result of this component of the portfolio, however there are integrated benefits to the City's groundwater subbasin.
- Figure 5-6 illustrates the monthly supply in 2045. It is assumed that the WDCWA WTP with a 10.2 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 10.2 mgd. The summer peak demands would be higher without the water management options in this portfolio.

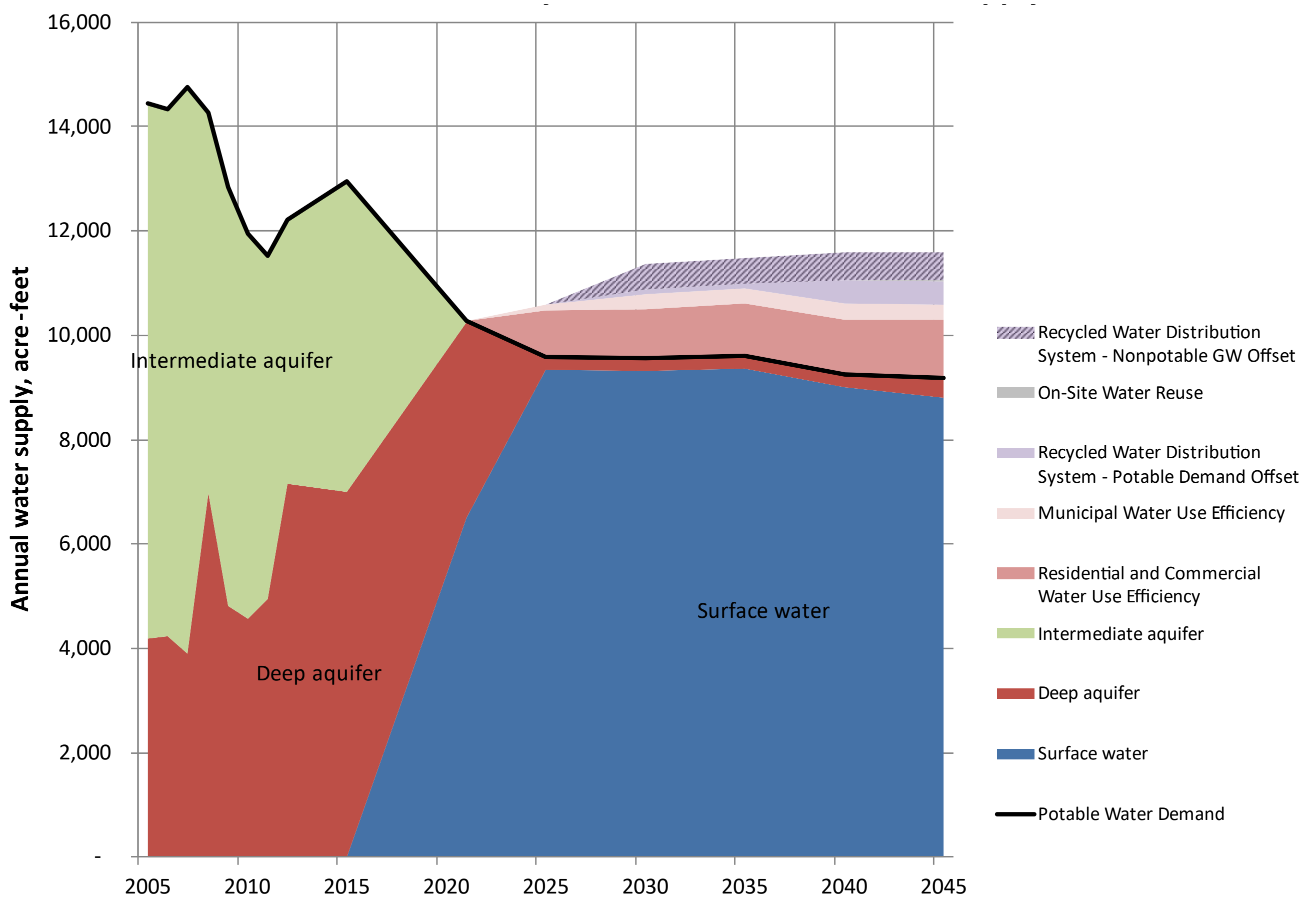


Figure 5-5. Portfolio 2 Recycled Water Distribution System: annual water supply – normal year

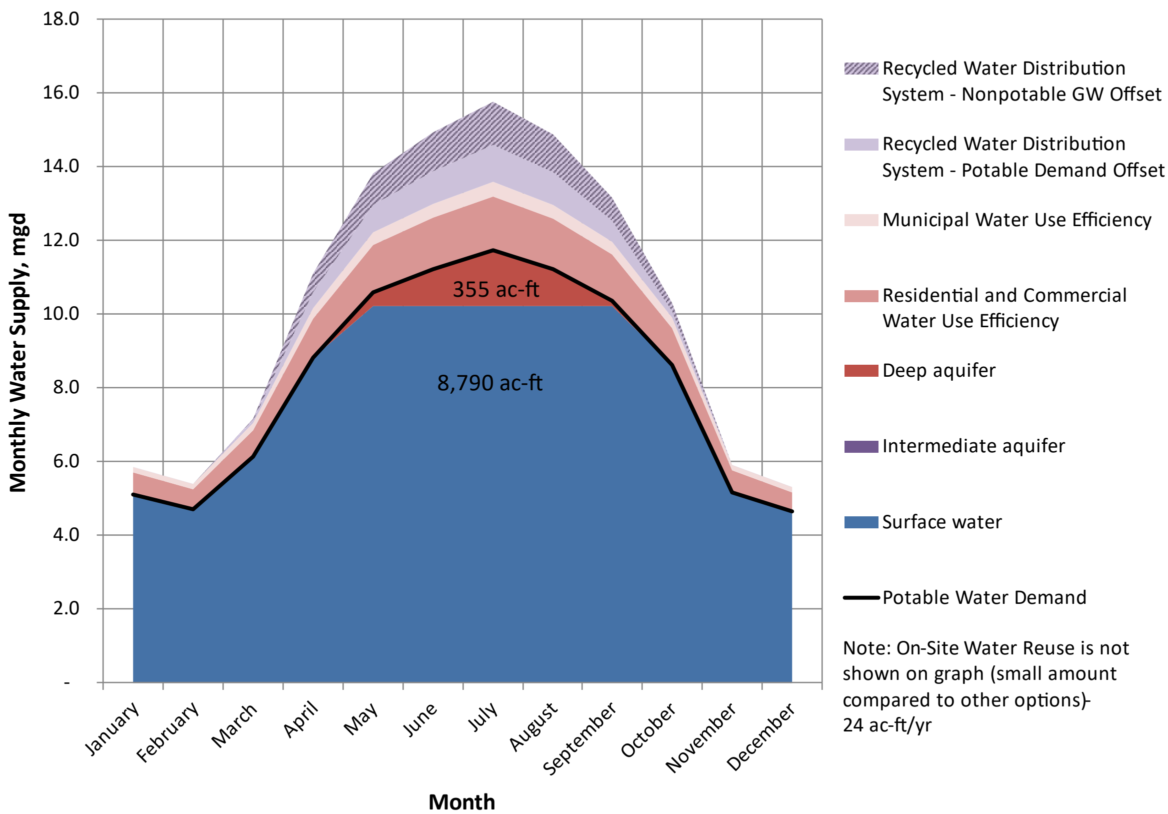


Figure 5-6. Portfolio 2 Recycled Water Distribution System: 2045 monthly water supply – normal year

Dry Year

- Figure 5-7 presents the Recycled Water Distribution System portfolio annual water supply through 2045 for a dry year. As can be seen in Figure 5-7, the use of the City's deep groundwater wells increases in dry years when the surface water supply is reduced.
- Figure 5-8 illustrates the monthly supply at 2045 for a dry year. It is assumed that the WDCWA WTP with a 3.0 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 3.0 mgd. The summer peak daily potable demand would be higher without the water management options in place.

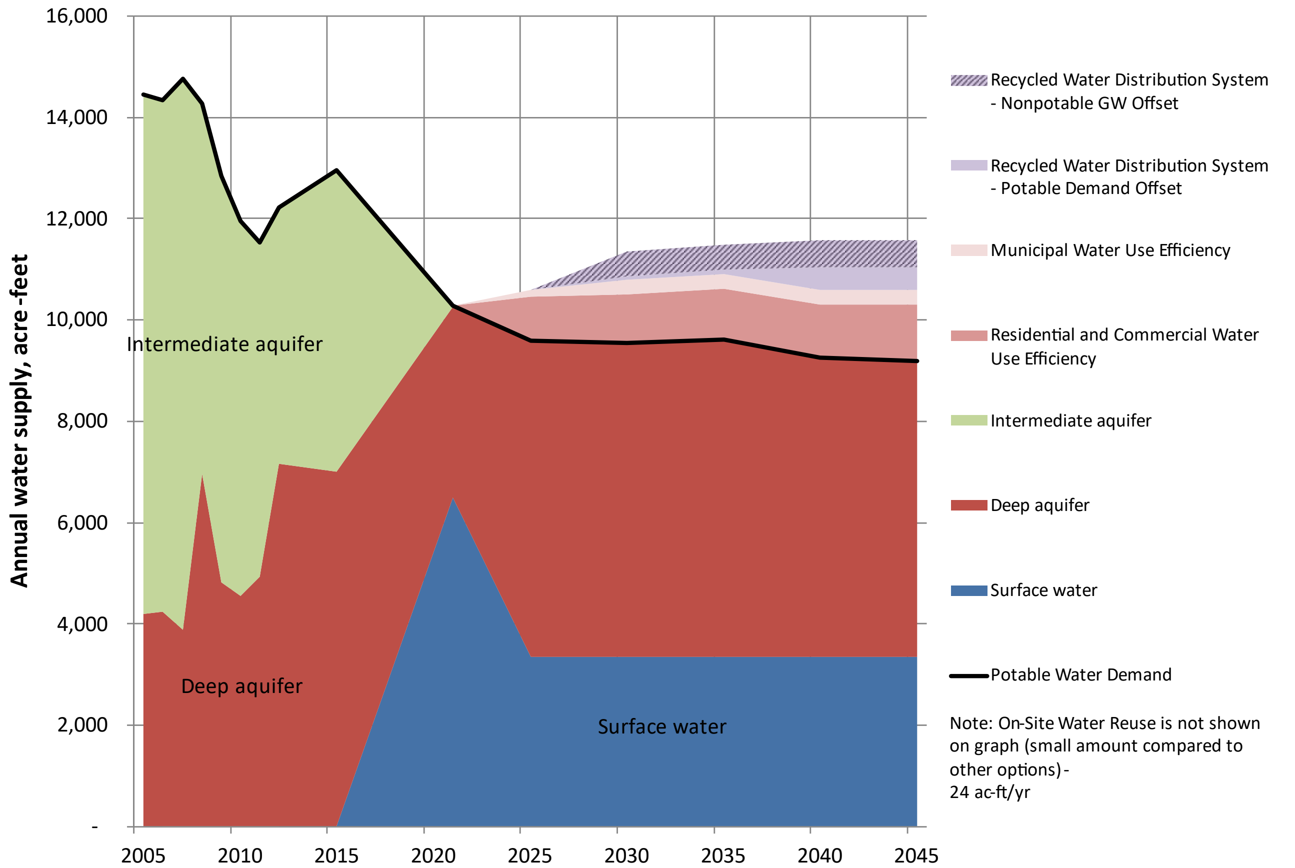


Figure 5-7. Portfolio 2 Recycled Water Distribution System: annual water supply – dry year

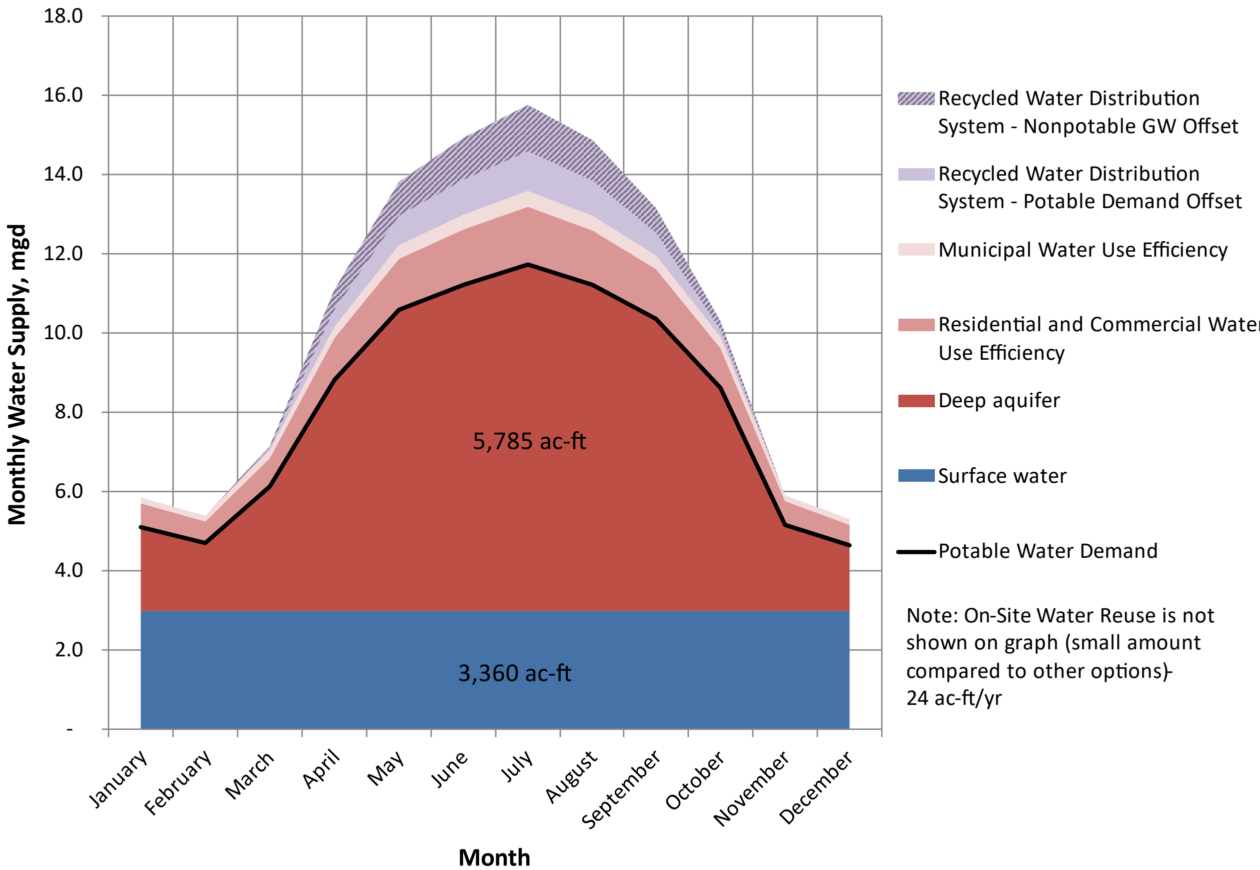


Figure 5-8. Portfolio 2 Recycled Water Distribution System: 2045 monthly water supply – dry year

5.1.3 Portfolio 3. Well Conversions and Recycled Water to Offset Groundwater Use

The Well Conversion/Irrigation and Recycled Water to Offset Groundwater Use portfolio is based on the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency
- Municipal Water Use Efficiency
- On-site Water Reuse
- Well Conversion/Irrigation
- Recycled Water to Offset Groundwater Use

The Well Conversions and Recycled Water to Offset Groundwater Use portfolio under normal and dry year (Term 91) conditions is described as follows:

Normal Year

- Figure 5-9 presents the Well Conversions and Recycled Water to Offset Groundwater Use portfolio annual water supply through 2045 for a normal year. As can be seen in Figure 5-9, the use of the City's intermediate groundwater wells is no longer necessary with the introduction of surface water. The use of deep groundwater wells is necessary due to peak demand in summer months (as seen on Figure 5-10).

- Figure 5-9 shows that the Well Conversion/Irrigation water management option is relatively small in comparison to the Recycled Water to Offset Groundwater Use water management option. However, the Well Conversion/Irrigation water management provides a potable demand offset while the Recycled Water to Offset Groundwater Use does not.
- As shown in Figure 5-9 the potable demand is the sum of the groundwater and surface water supplies. Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, On-site Water Reuse, and the Well Conversion/Irrigation all offset potable demands. The potable demand would be higher without these water management options in this portfolio.
- Although the Recycled Water to Offset Groundwater Use water management option does not offset potable water demands it does offset groundwater use in the subbasin and is considered as in-lieu groundwater recharge using recycled water. The City's potable demands do not decrease as a result of this component of the portfolio, however there are integrated benefits to the City's groundwater subbasin.
- Figure 5-10 illustrates the monthly supply at 2045. It is assumed that the WDCWA WTP with a 10.2 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 10.2 mgd.

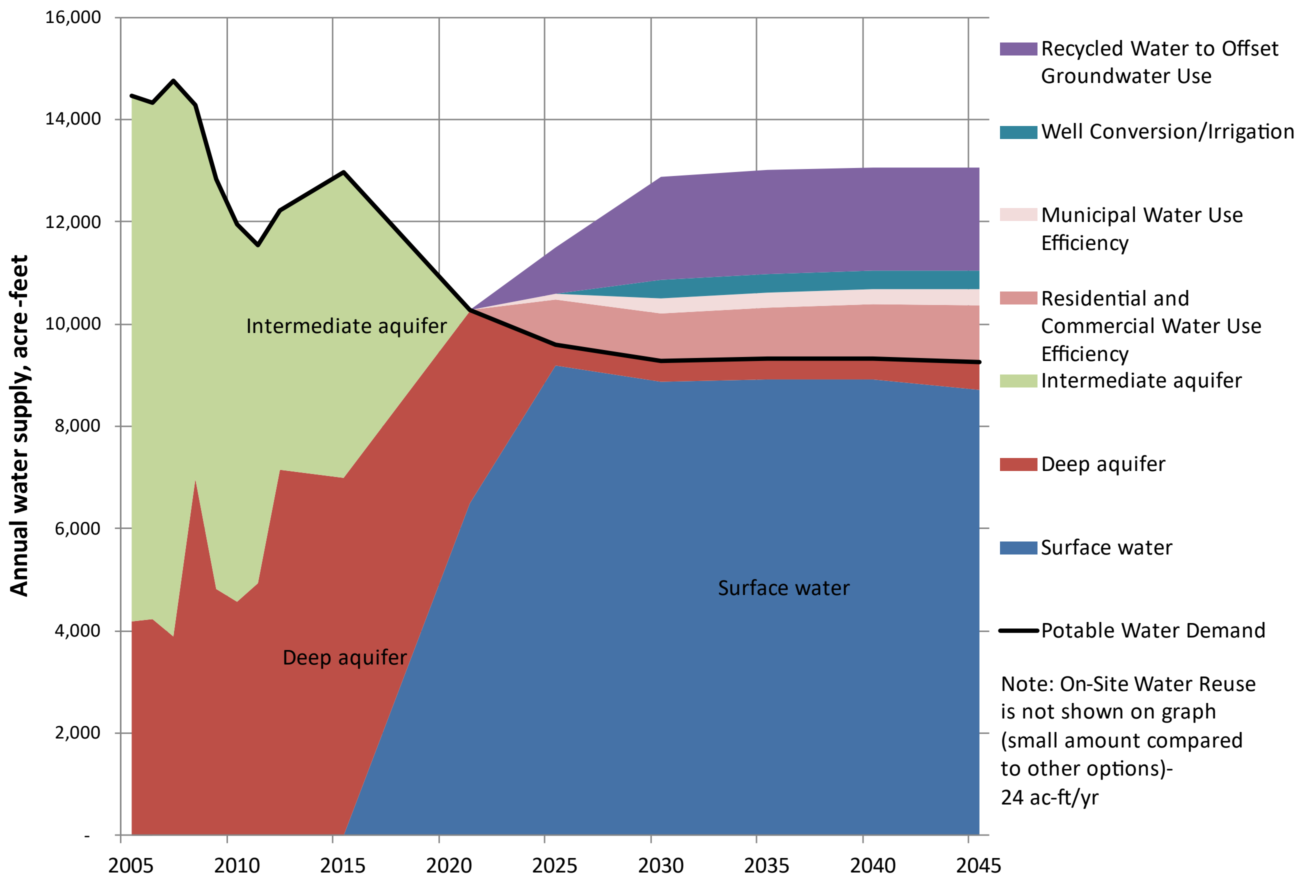


Figure 5-9. Portfolio 3 Well Conversions and Recycled Water to Offset Groundwater Use: annual water supply – normal year

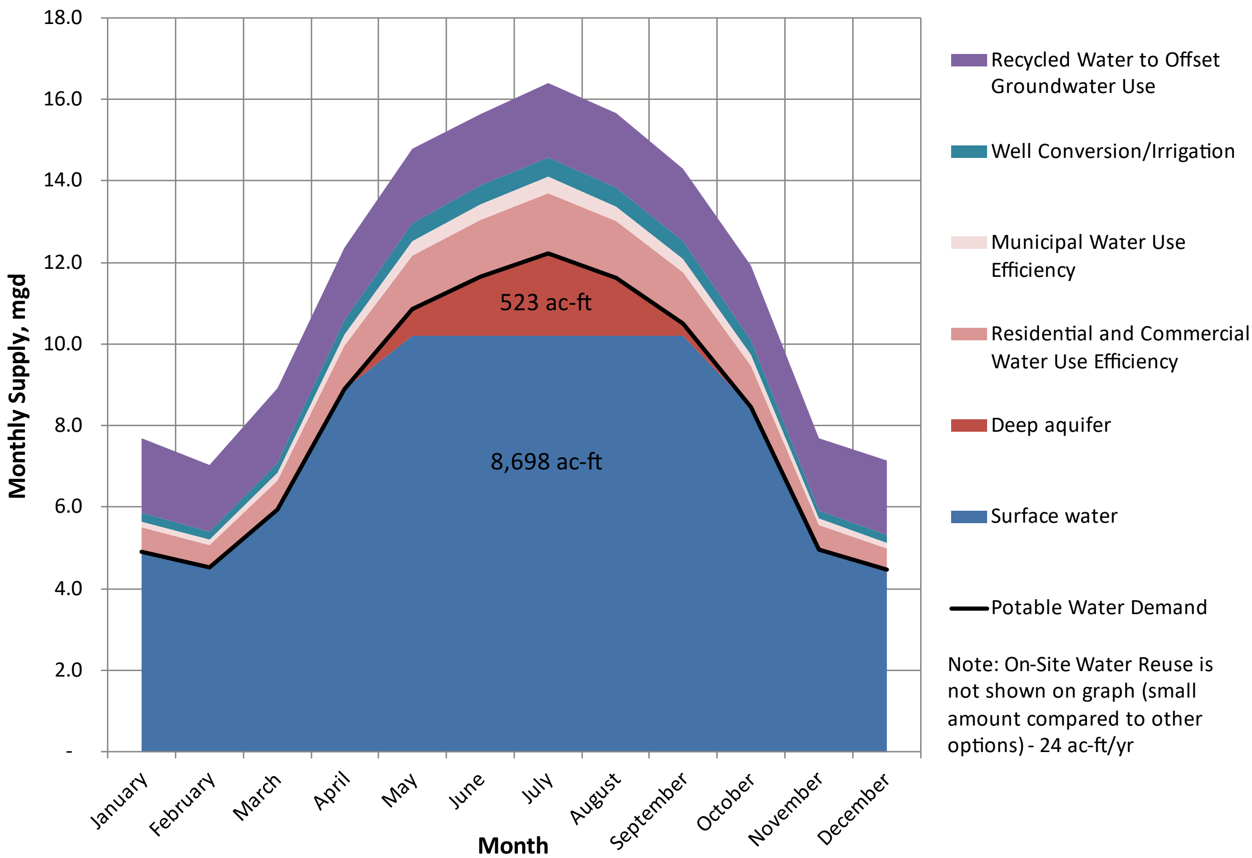


Figure 5-10. Portfolio 3 Well Conversions and Recycled Water to Offset Groundwater Use: 2045 monthly water supply – normal year

Dry Year

- Figure 5-11 presents the Well Conversions and Recycled Water to Offset Groundwater Use portfolio annual water supply through 2045 for a dry year. As can be seen in Figure 5-11, the use of the City's deep groundwater wells increases in dry years when the surface water supply is reduced.
- Figure 5-12 illustrates the monthly supply at 2045 for a dry year. It is assumed that the WDCWA WTP with a 3.0 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 3.0 mgd. The summer peak daily potable demand would be higher without the water management options in place.

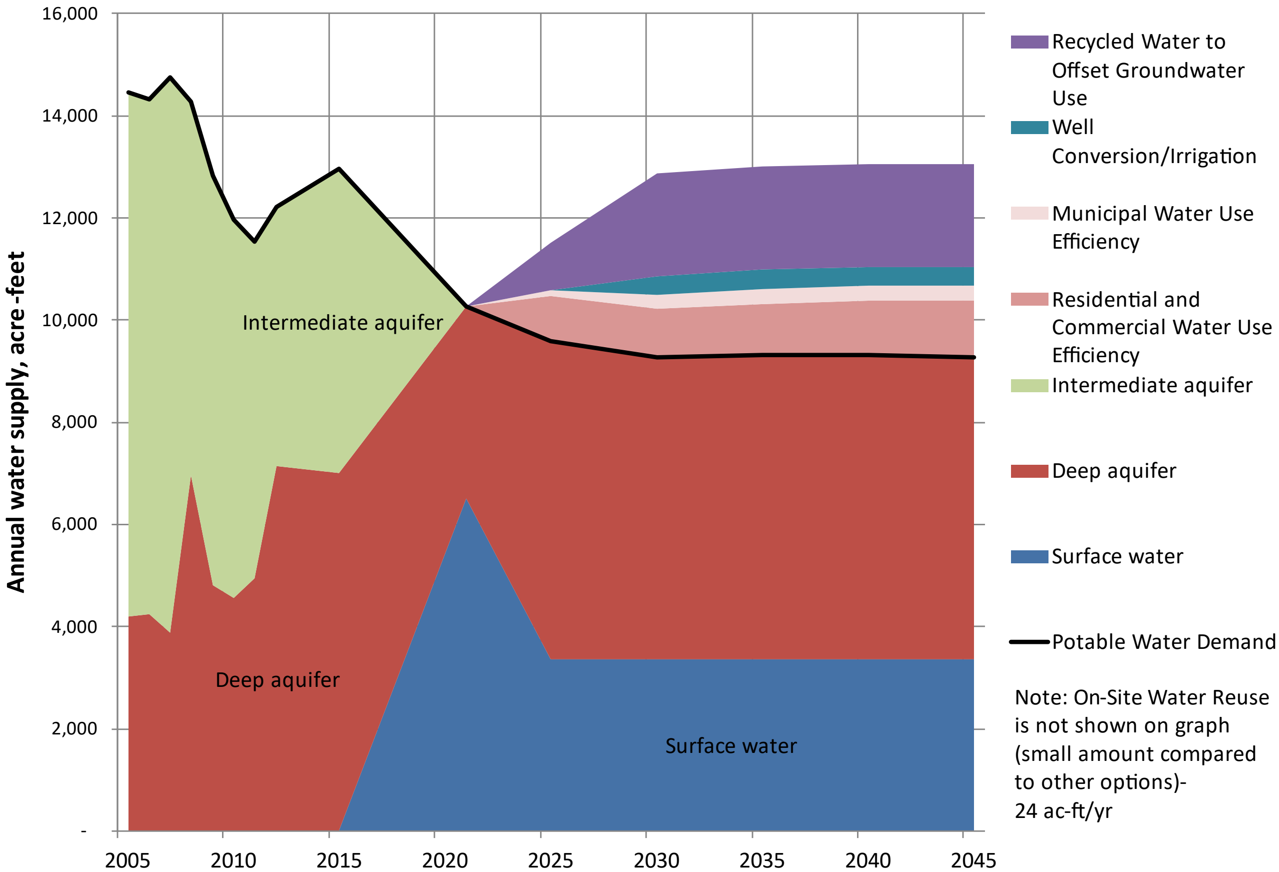


Figure 5-11. Portfolio 3 Well Conversions and Recycled Water to Offset Groundwater Use: annual water supply – dry year

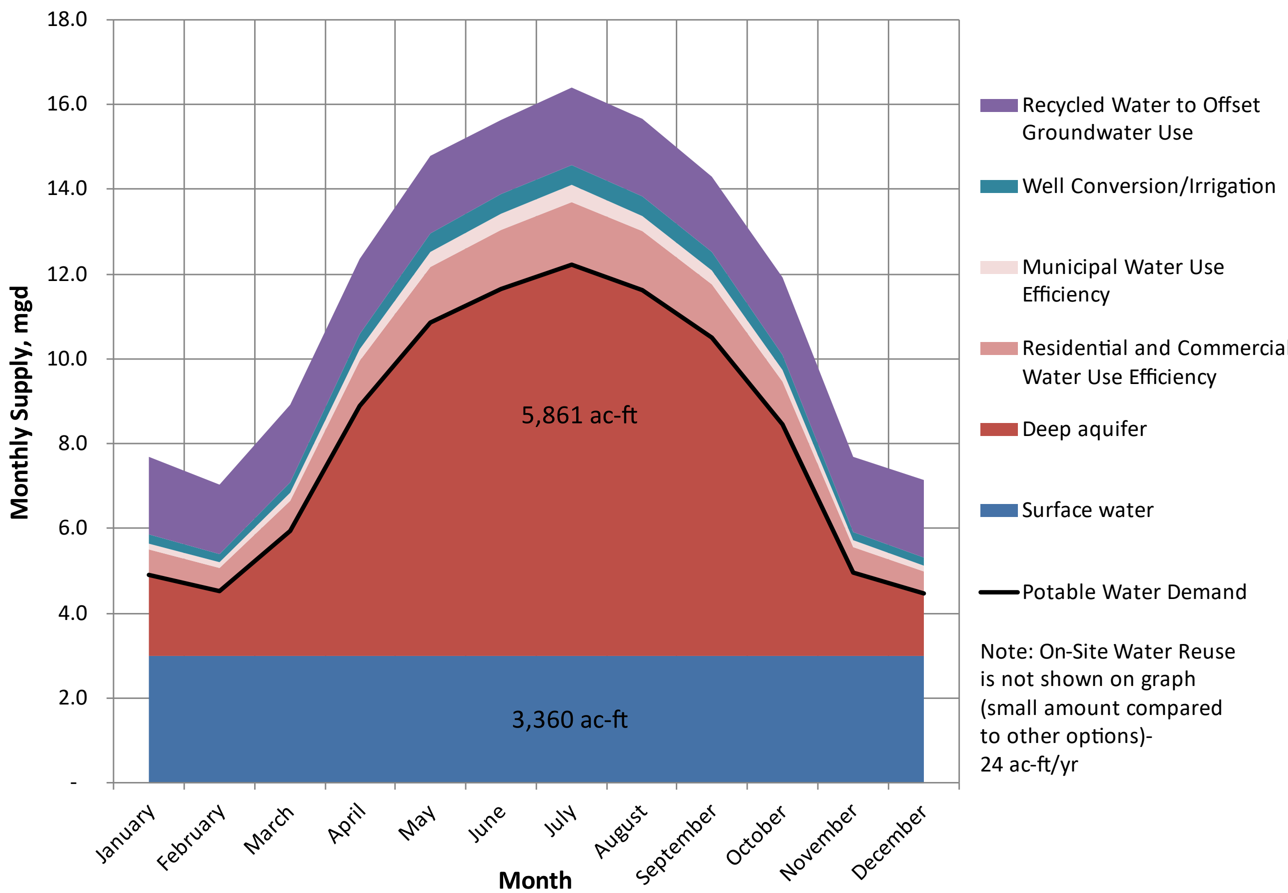


Figure 5-12. Portfolio 3 Well Conversions and Recycled Water to Offset Groundwater Use: 2045 monthly water supply – dry year

5.1.4 Portfolio 4. ASR and Recycled Water to Offset Groundwater Use

The ASR and Recycled Water to Offset Groundwater Use portfolio is based on the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency
- Municipal Water Use Efficiency
- On-site Water Reuse
- ASR
- Recycled Water to Offset Groundwater Use

The ASR and Recycled Water to Offset Groundwater Use portfolio under normal and dry year (Term 91) conditions is described below.

Normal Year

- Figure 5-13 presents the ASR and Recycled Water to Offset Groundwater Use portfolio annual water supply through 2045 for a normal year. As can be seen in Figure 5-13, the use of the City's intermediate groundwater wells is no longer necessary with the introduction of surface water. The use of deep groundwater wells is necessary due to peak demand in summer months (as seen on Figure 5-14).
- As shown in Figure 5-13 the potable demand is the sum of the groundwater and surface water supplies. Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-site Water Reuse water management options all offset potable demands. The potable demand would be higher without these water management options in this portfolio.
- Figure 5-13 shows additional surface water supply used for ASR recharge. As can be seen in Figure 5-14 this surface water supply is used during off peak demand periods to recharge the groundwater basin through the ASR wells. Although ASR does not offset potable water demands it improves groundwater subbasin conditions by increasing groundwater levels. The City's potable demands do not decrease as a result of this component of the portfolio, however there are integrated benefits to the City's groundwater subbasin.
- Figure 5-14 illustrates the monthly supply at 2045. It is assumed that the WDCWA WTP with a 10.2 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 10.2 mgd. Surface water supply for ASR recharge is pumped during November through March in normal years thus allowing the WDCWA WTP to use its full capacity to meet peak potable demands in summer months.

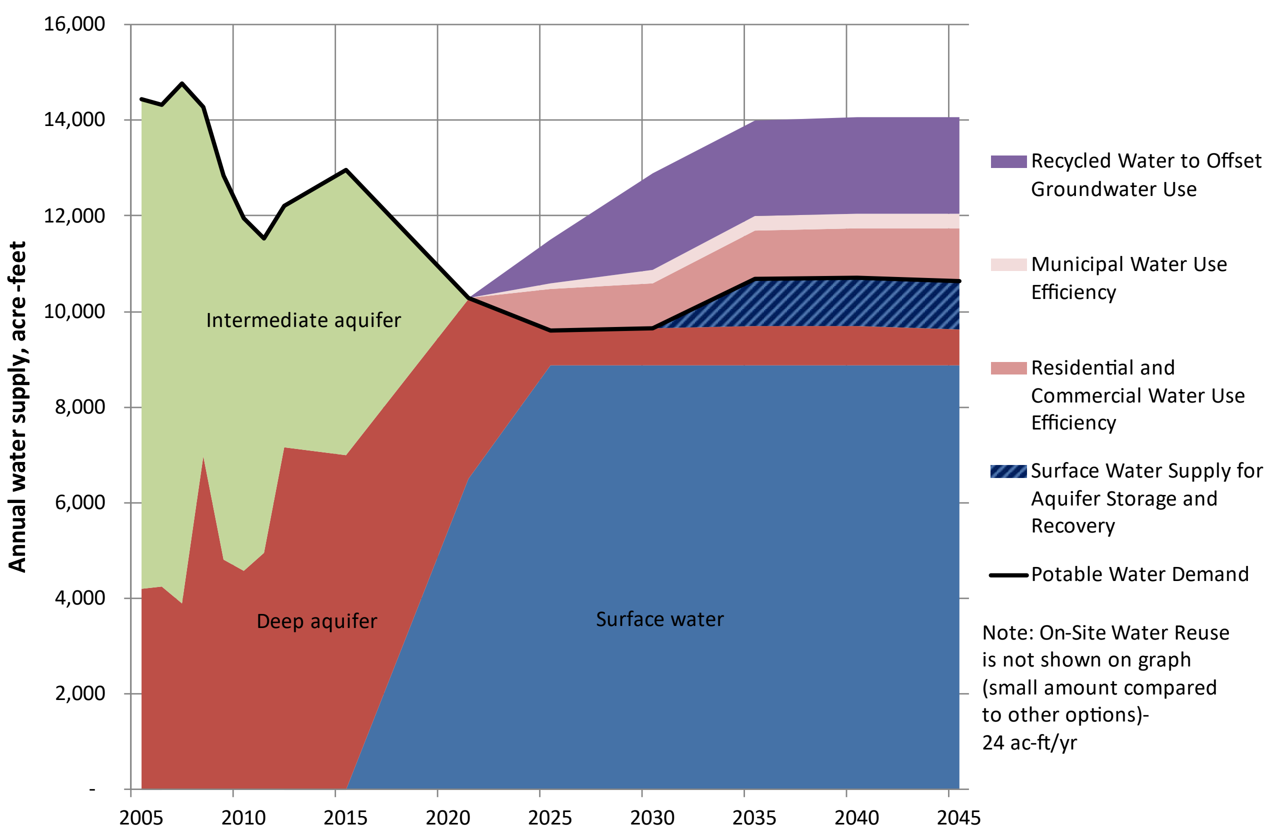


Figure 5-13. Portfolio 4 ASR and Recycled Water to Offset Groundwater Use: annual water supply – normal year

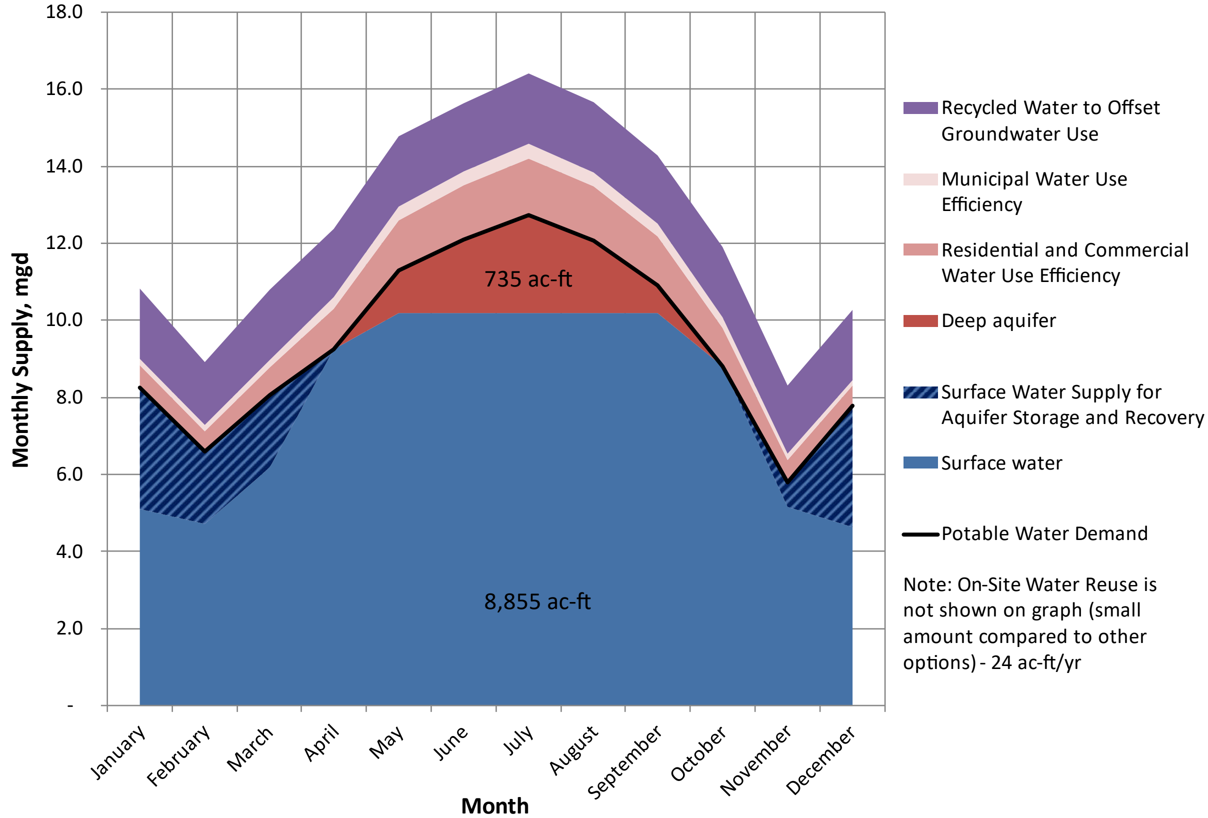


Figure 5-14. Portfolio 4 ASR and Recycled Water to Offset Groundwater Use: 2045 monthly water supply – normal year

Dry Year

- Figure 5-15 presents the ASR and Recycled Water to Offset Groundwater Use portfolio annual water supply through 2045 for a dry year. As can be seen in Figure 5-15, the use of the City's deep groundwater wells increases in dry years when the surface water supply is reduced. However, the use of the deep groundwater wells supply is also reduced in dry years due to the use of ASR wells dry year supply.
- Although Figure 5-15 shows ASR supply provided in consecutive years, on average the ASR supply would only be provided in dry years. The frequency of withdrawals will be determined in future studies. Withdrawal frequency assumed in this section will likely change based on the outcome of future studies.
- Figure 5-16 illustrates the monthly supply at 2045 for a dry year. It is assumed that the WDCWA WTP with a 3.0 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater and the ASR supply being used to supply demands that exceed 3.0 mgd.

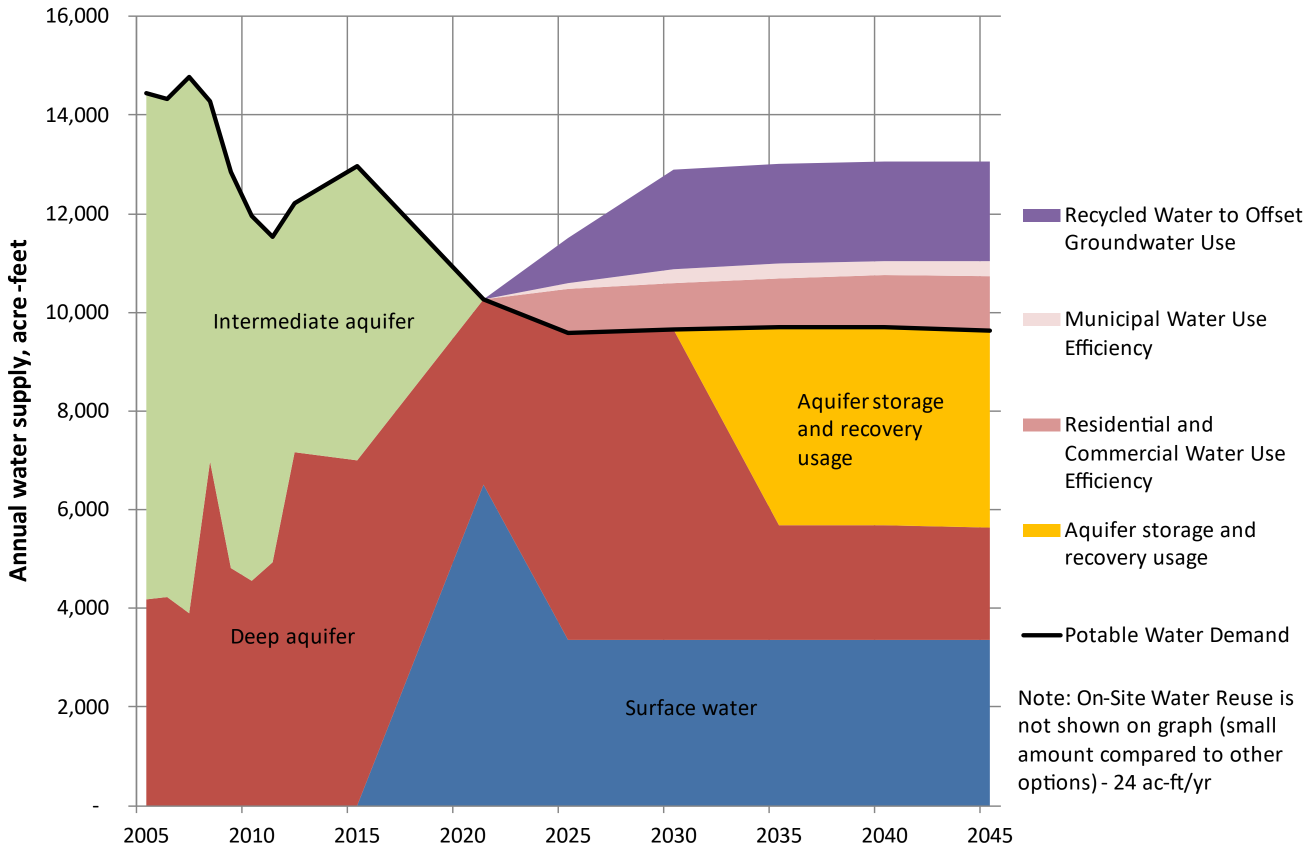


Figure 5-15. Portfolio 4 ASR Recycled Water to Offset Groundwater Use: annual water supply – dry year

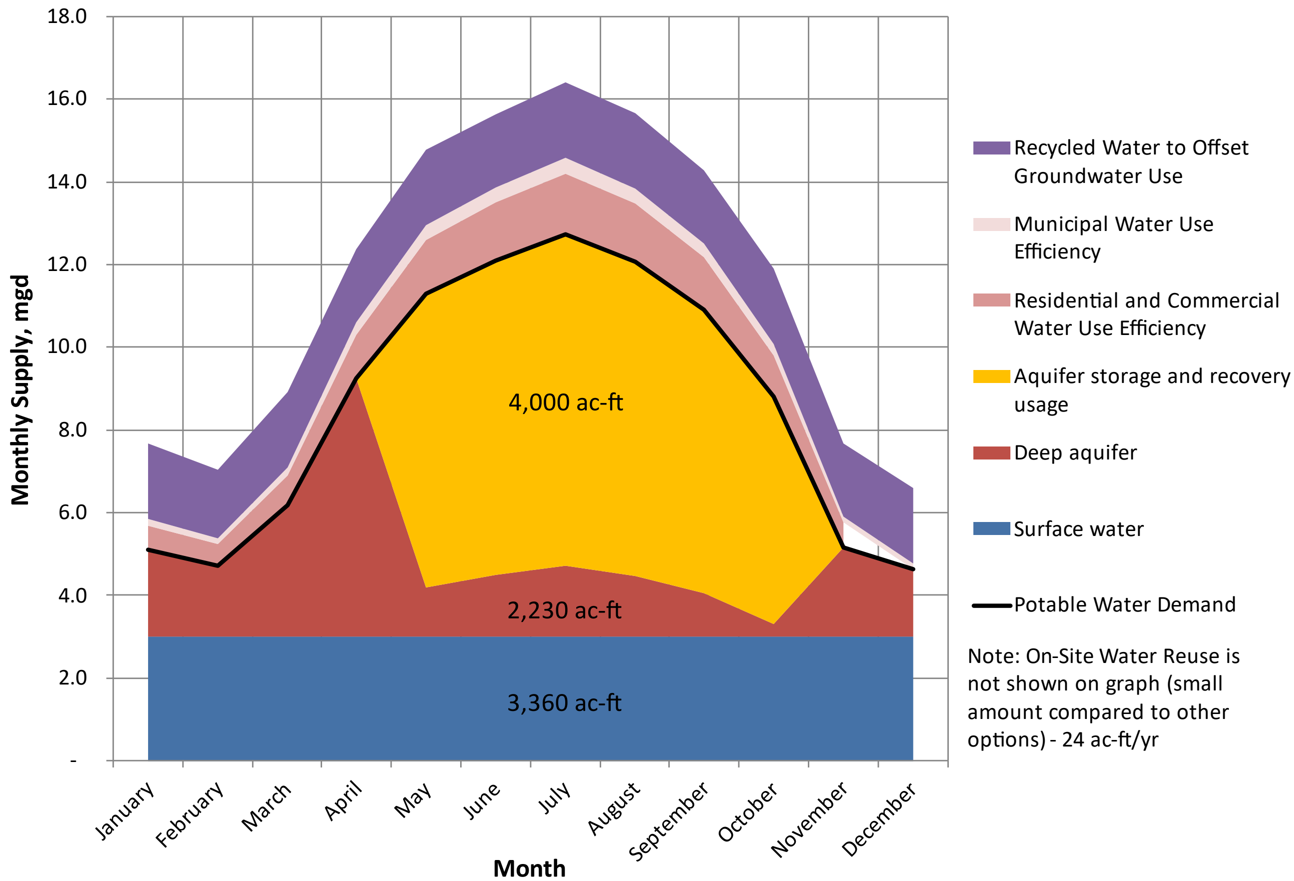


Figure 5-16. Portfolio 4 ASR and Recycled Water to Offset Groundwater Use: 2045 monthly water supply – dry year

5.1.5 Portfolio 5. De-Facto Reuse and ASR

The De-Facto Reuse and ASR portfolio is based on the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency
- Municipal Water Use Efficiency
- On-site Water Reuse
- De-Facto Reuse
- ASR

The De-Facto Reuse and ASR portfolio under normal and dry year (Term 91) conditions is described below.

Normal Year

- Figure 5-17 presents the De-Facto Reuse and ASR portfolio annual water supply through 2045 for a normal year. As can be seen in Figure 5-17, the use of the City's intermediate groundwater wells is no longer necessary with the introduction of surface water. The use of deep groundwater wells is necessary due to peak demand in summer months (as seen on Figure 5-18).

- Because the De-Facto Water Reuse water management option results in additional surface water supply water rights, Figure 5-17 shows the De-Facto Water Reuse water management option reducing the amount of surface water the City needs from its current water rights during normal years.
- As shown in Figure 5-17 the potable demand is the sum of the groundwater and surface water supplies (including the De-Facto Water Reuse water management option water right). Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-site Water Reuse. The potable demand would be higher without these water management options in this portfolio. De-Facto Water Reuse and ASR do not reduce potable demands.
- Figure 5-17 shows additional surface water supply used for ASR recharge. As can be seen in Figure 5-18 this surface water supply is used during off peak demand periods to recharge the groundwater basin through the ASR wells. Although ASR does not offset potable water demands it improves groundwater subbasin conditions by increasing groundwater levels. The City's potable demands do not decrease as a result of this component of the portfolio, however there are integrated benefits to the City's groundwater subbasin.
- Figure 5-18 illustrates the monthly supply at 2045. It is assumed that the WDCWA WTP with a 10.2 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater being used to supply demands that exceed 10.2 mgd. Surface water supply for ASR recharge is pumped during November through March in normal years thus allowing the WDCWA WTP to use its full capacity to meet peak potable demands in summer months. The De-Facto Water Reuse water management option reduces the amount of surface water the City needs from its current water rights during normal year peak demand periods.

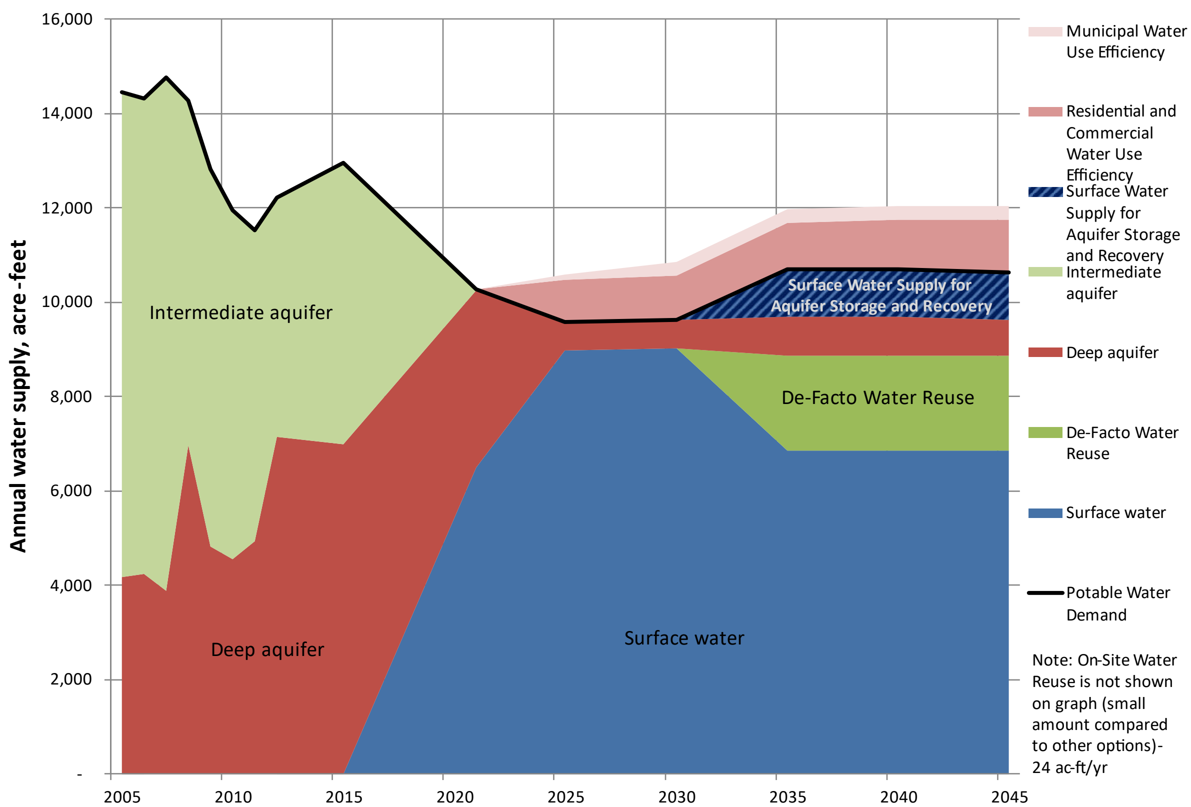


Figure 5-17. Portfolio 5 De-Facto Reuse and ASR: annual water supply – normal year

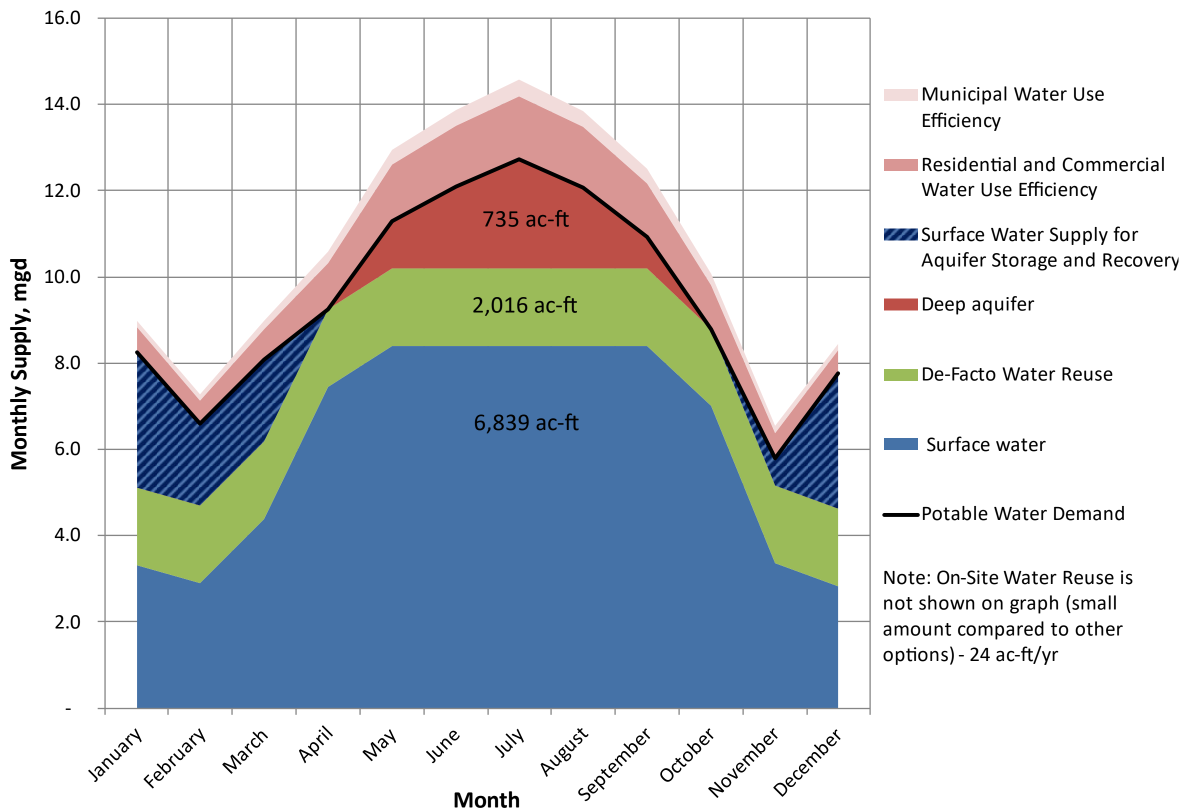


Figure 5-18. Portfolio 5 De-Facto Reuse and ASR: 2045 monthly water supply – normal year

Dry Year

- Figure 5-19 presents the De-Facto Reuse and ASR portfolio annual water supply through 2045 for a dry year. As can be seen in Figure 5-19, the use of the City's deep groundwater wells increases in dry years when the surface water supply is reduced. However, the use of the deep groundwater wells supply is also reduced in dry years due to the use of ASR wells dry year supply.
- Although Figure 5-19 shows ASR supply provided in consecutive years, on average the ASR supply would only be provided in dry years. The frequency of withdrawals will be determined in future studies. Withdrawal frequency assumed in this section will likely change based on the outcome of future studies.
- Because the De-Facto Water Reuse water management option results in additional surface water supply water rights, Figure 5-19 shows the De-Facto Water Reuse water management option reduces the amount of supply needed from deep ground water wells during dry years.
- Figure 5-20 illustrates the monthly supply at 2045 for a dry year. It is assumed that the WDCWA WTP with a 3.0 mgd capacity for the City's use would provide the base supply, with the deep aquifer groundwater and ASR being used to supply demands that exceed 3.0 mgd.

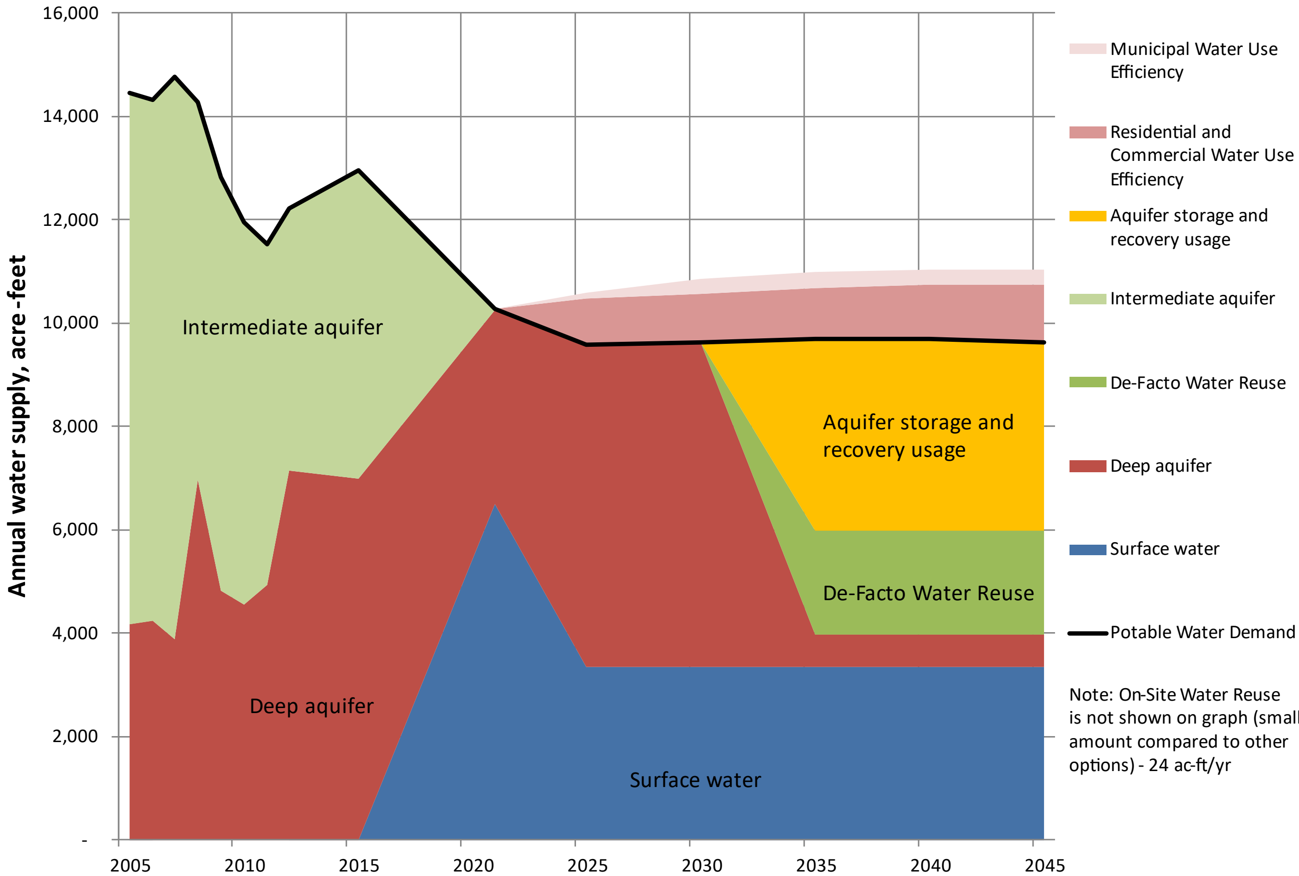


Figure 5-19. Portfolio 5 De-Facto Reuse and ASR: annual water supply – dry year

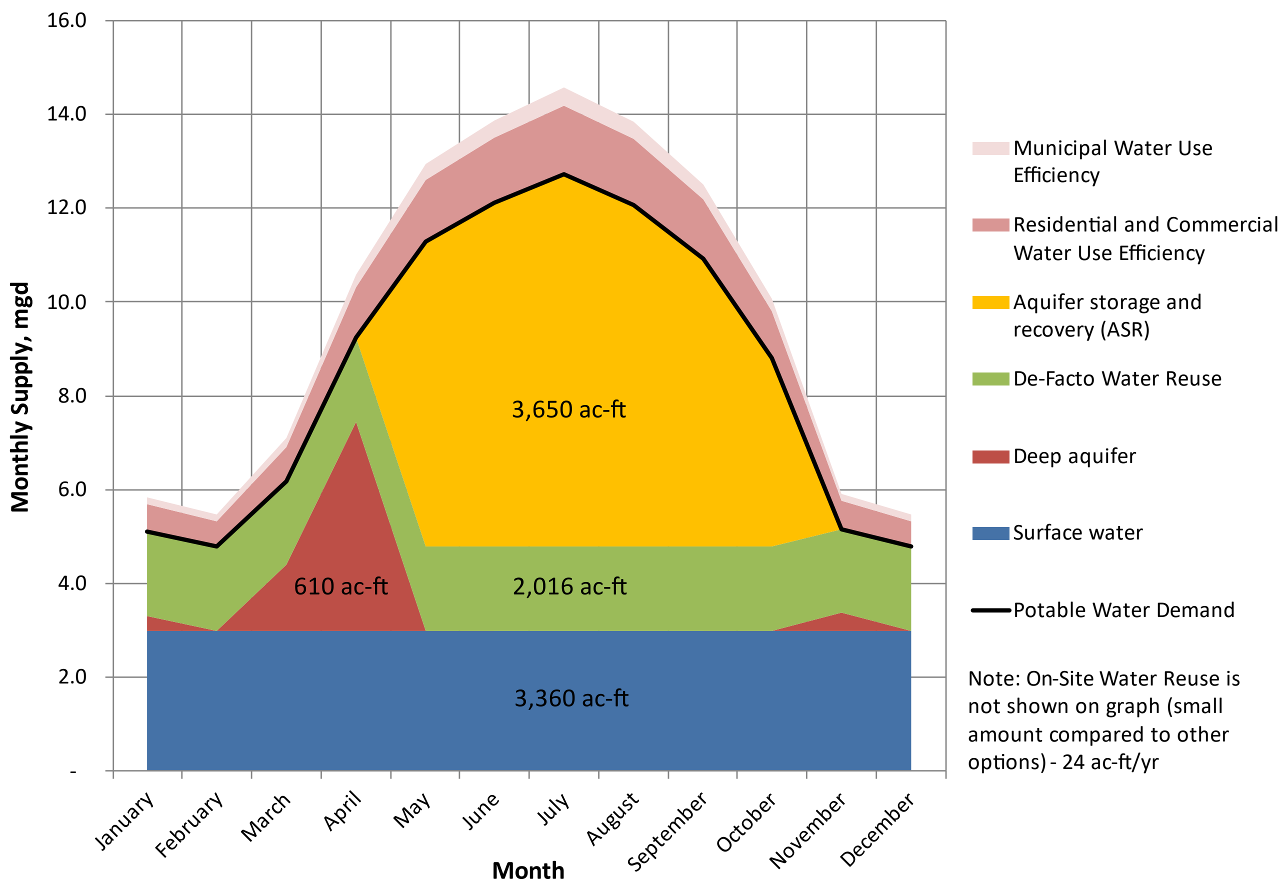


Figure 5-20. Portfolio 5 De-Facto Reuse and ASR: 2045 monthly water supply – dry year

5.1.6 Portfolios Impacts on Per Capita Water Use

Some of the portfolios have a greater impact on potable per capita water use than other portfolios. The ASR, Recycled Water to Offset Groundwater Use, and De-Facto Reuse water management options do not have potable demand reduction benefits. As a result the per capita water use for Portfolios 4 and 5 is the same as the per capita water use for Portfolio 1 (Base Case). Portfolio 2 has the largest potable demand offset resulting in the lowest per capita water use by 2045. It should be noted that the State may not consider recycled water use nor well conversions for non-potable irrigation as an excluded use from future GPCD calculations to meet State water use objectives. In this case all of the portfolios would result in the same future GPCD calculation.

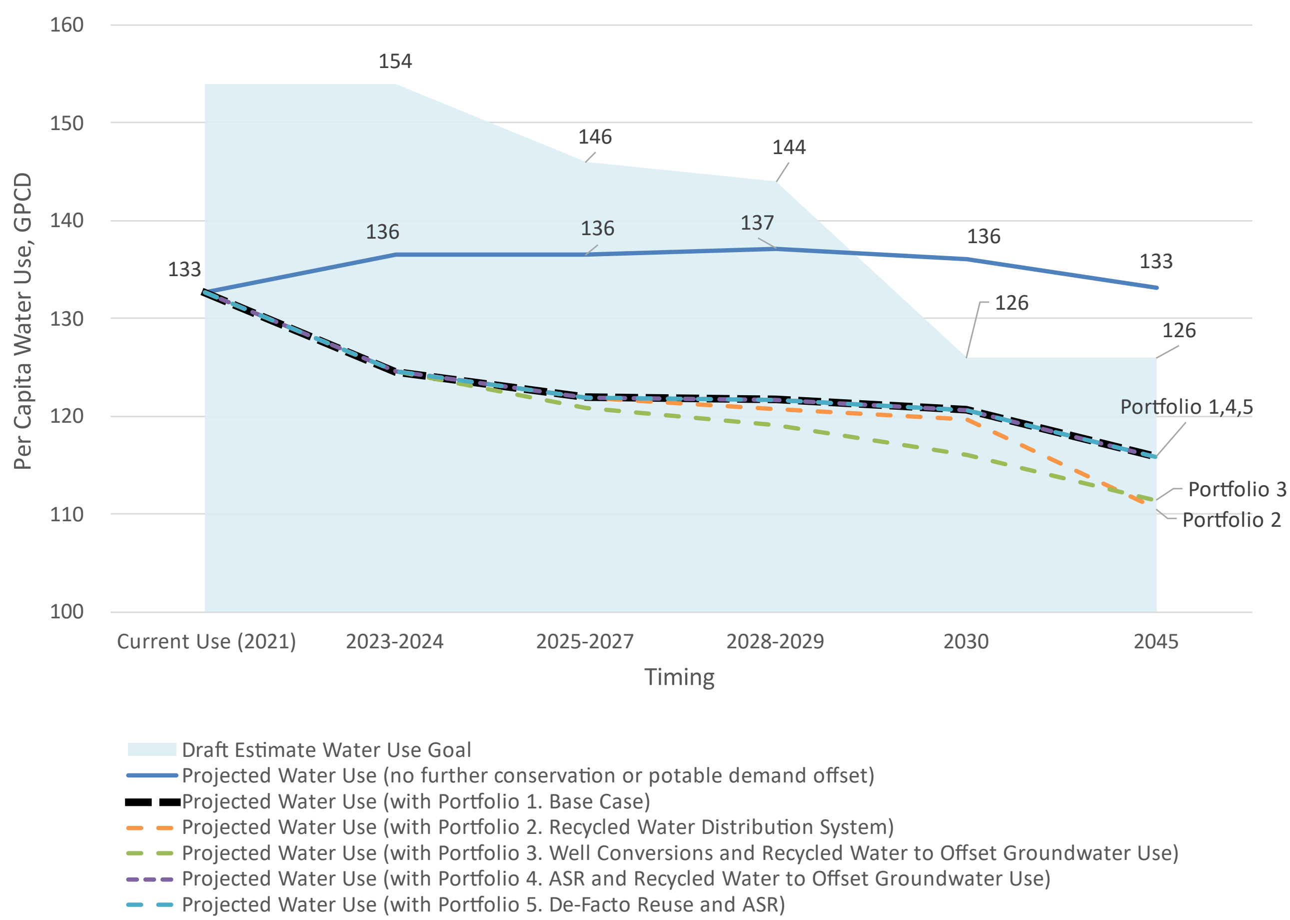


Figure 5-21. Portfolio impacts on per capita water use

5.2 Screening Criteria

This section presents and describes the screening criteria used to rank the water management portfolios described in Section 5.1. Screening criteria are grouped into four major categories; cost, feasibility, reliability, and sustainability. Each category of screening criteria has subcategories of criteria that make up the details of the larger criteria.

5.2.1 Economics

Consideration of both capital and annual maintenance and operating costs is necessary to provide the complete picture of the true cost of a portfolio. The economics include the present worth cost of the capital and O&M costs and the cost of water per ac-ft.

5.2.2 Feasibility

The feasibility criterion describes how likely it is that a portfolio could be developed and operated, and considers the anticipated hurdles or flaws. Feasibility includes constructability, implementability, regulatory, and permitting issues.

Constructability

Constructability refers to the difficulties that may be encountered in construction. These difficulties could lead to longer construction times, and greater potential for cost overruns.

Implementability

Implementability describes the challenges faced by deployment of a specific portfolio. Implementability considers agreements with other agencies and other hurdles to develop the portfolio. Portfolios that score well on implementability have less agreements, partnerships, and negotiations required. Poorly scoring portfolios have more agreements and hurdles to implementation.

Regulatory and permitting

This criterion refers to the permitting requirements to implement the portfolio, legal requirements, and site availability. This criterion also evaluates the difficulty of obtaining necessary permits, potential legal hurdles, and needs for siting. Compliance with California Environmental Quality Act (CEQA) is also considered in this criterion.

5.2.3 Reliability

Reliability refers to how consistent supply from a portfolio will be. Reliability includes four subcategories; risk and uncertainty, flexibility and adaptability, supply diversity, and operability.

Risk and uncertainty

The risk and uncertainty criterion assesses whether project performance will consistently meet expectations, and considers the consequences of possible system failures due to natural causes.

Flexibility and adaptability

There are obvious advantages to having a utility system which can be altered to meet changing patterns of use and changing drinking water regulations. Portfolios that can adapt to changes in demand, technology, or regulations are more flexible. Portfolios that are simpler to modify rate better.

Supply diversity

This criterion considers if the portfolio provides multiple sources of supply, and the ability to have adequate supplies during periods when some sources may be constrained, such as dry periods for surface water. More supply sources improve overall reliability of the water system.

Operability

This criterion refers to the system’s long term performance as measured by the probability and consequences of electrical, process, structural, and mechanical failures. A portfolio’s performance can be impacted by the type of facility or structure and the equipment required to effectively make the system operate.

5.2.4 Sustainability

Sustainability considers the larger context of the water cycle and natural resources as well as benefits to the environment of each portfolio.

Energy efficiency and greenhouse gas emissions

This criterion evaluates the energy use of the portfolio and related GHG emissions.

Water quality

This criterion considers the portfolio's water quality, both in the potable supply and at the wastewater discharge point.

Environmental impacts

The environmental impacts criterion considers effects on the environment that are caused by development and implementation of the portfolio.

Ecosystem Improvements

This criterion evaluates improvements to habitat and ecosystems that occur as part of or as a result of portfolio development.

Safeguard human and environmental health

This criterion considers affects and benefits to human and environmental health created by development of a portfolio. Health considerations may include contamination concerns, transmission of disease, and physical health risks.

5.3 Portfolio Evaluation

The proportion of water provided by each water management option for each portfolio in 2045 is presented on Figure 5-22. Notes and observations related to Figure 5-22 are as follows:

- The water management options in each portfolio that provide a potable demand offset are grouped as a component of each pie chart. They represent about 15 to 20 percent of the total demand in each portfolio, with Residential and Water Use Efficiency water management option being the largest component of the potable demand offset.
- The ASR, Recycled Water to Offset Groundwater Use, and De-Facto Reuse water management options are shown as separate pie chart components. The Recycled Water to Offset Groundwater Use is not a potable supply.

The key features of each portfolio are presented in Table 5-1. The unit embedded energy of each portfolio presented in Table 5-1 is that of the included water management options, and excludes the embedded energy of the surface water and groundwater supplies. The costs of the surface water and groundwater portions of each portfolio are not included in Table 5-1. The portfolio costs and water amounts are presented in more detail in Appendix B. Note that the Base Case Portfolio 1 is included in all portfolios. Notes and observations related to Table 5-1 are as follows:

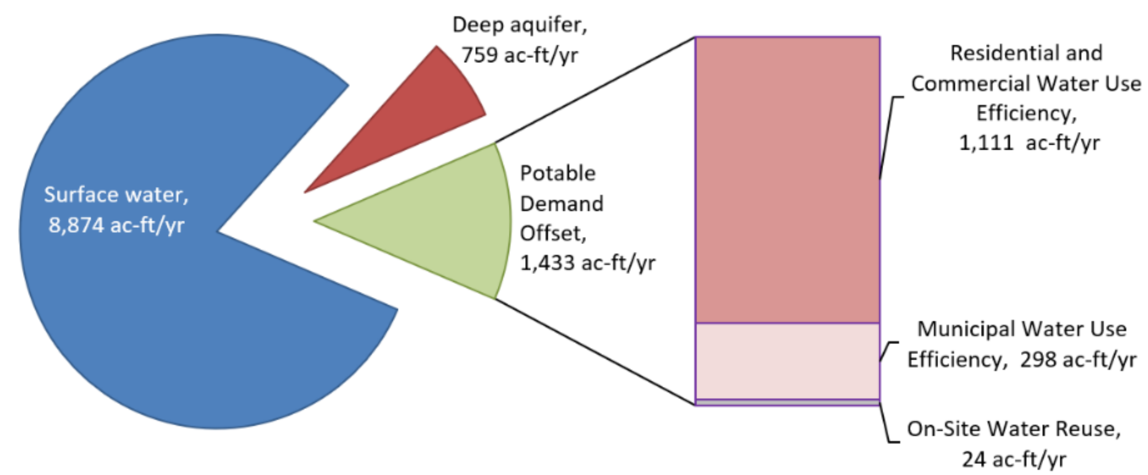
- Portfolio 1 has the lowest unit cost and present worth cost but also provides the least amount of water. Portfolio 1 unit cost is less than the production cost of recycled water and surface water.
- Portfolio 2 has the highest unit cost and present worth cost and provides less water than three other portfolios.
- Portfolio 3 has the second lowest unit cost and capital costs (just above Portfolio 1) and provides more water supply than Portfolios 1 and 2.
- Portfolios 4 and 5 provide the most water but Portfolio 4 has significantly less present worth costs and unit costs.

Table 5-1. Summary of Portfolios					
	1. Base Case [a]	2. Recycled Water Distribution System [b]	3. Well Conversions and Recycled Water to Offset Groundwater Use [b]	4. ASR and Recycled Water to Offset Groundwater Use [b]	5. De-Facto Reuse and ASR [b]
Present worth, $ million	$14.5	$102.5	$24.5	$55.9	$66.7
2045 Water supply, ac-ft	1,433	2,399	3,818	4,248 [c]	4,248 [c]
Water supply unit cost, $/ac-ft	$749	$4,252	$1,095	$1,812	$3,126
Embedded energy, kWh/ac-ft	--	313	488	618	648

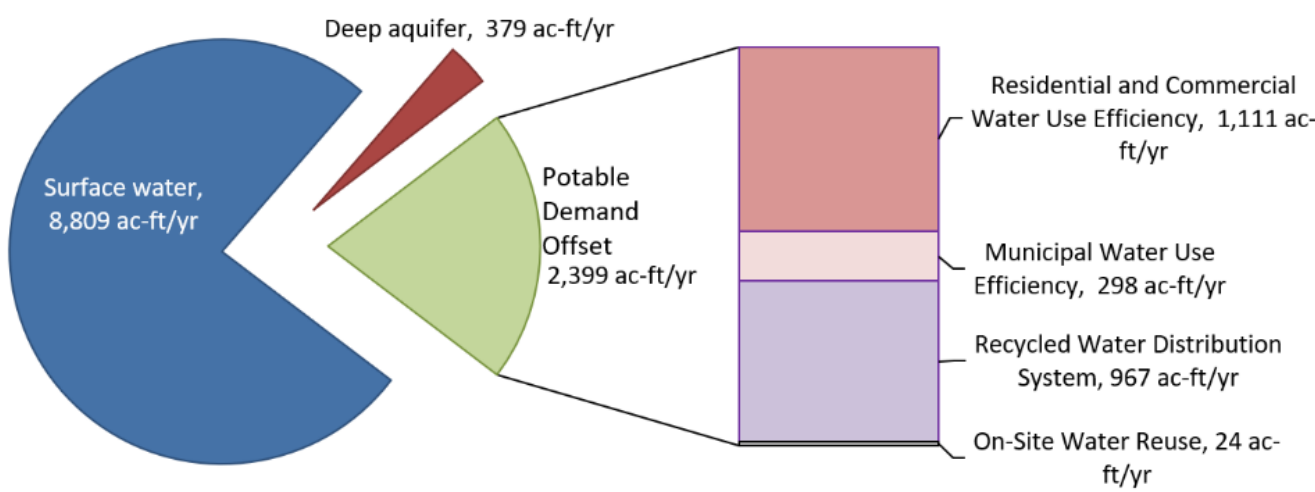
a. *Base Case includes Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-Site Water Reuse water management options.*

b. *Includes Base Case water management options.*

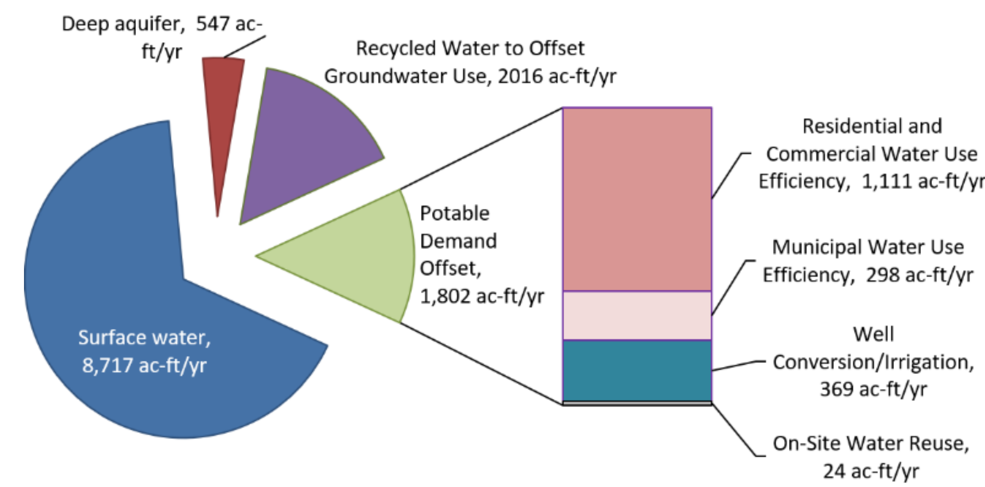
c. *Included is ASR average year supply is 799 ac-ft/year. It should be noted that dry year supply from ASR is 4,000 ac-ft/yr.*



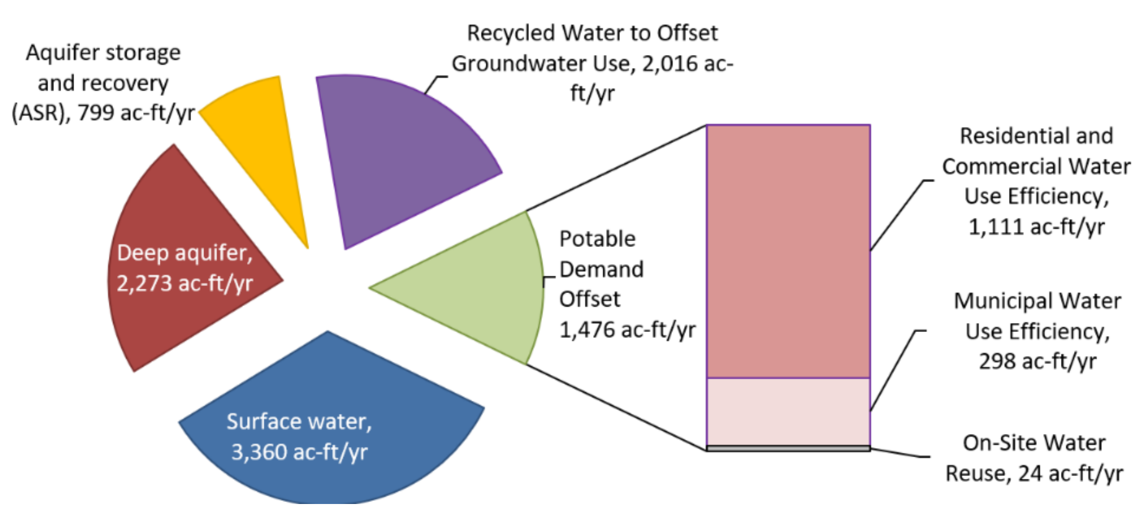
Portfolio 1 – Base Case



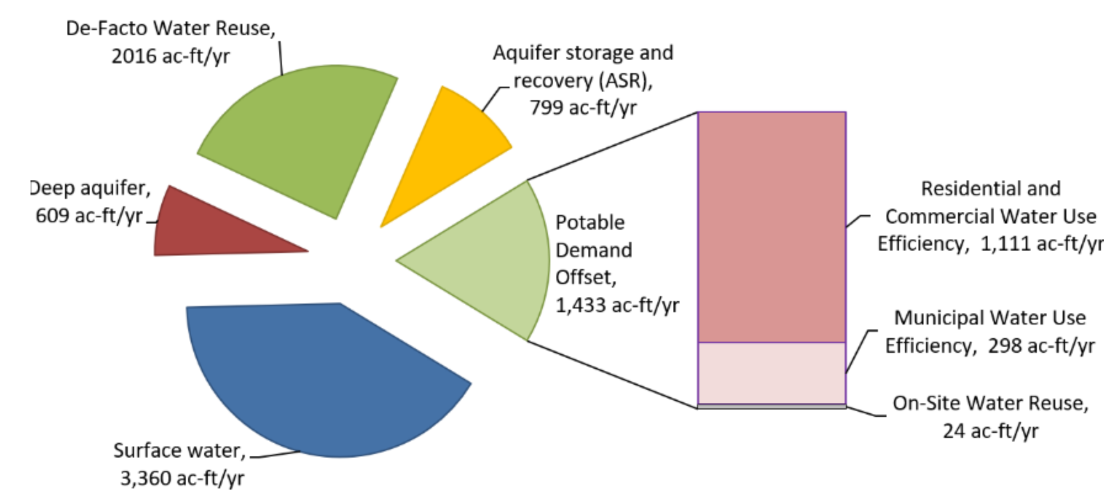
Portfolio 2 - Recycled Water Distribution System



Portfolio 3 –Well Conversions and Recycled Water to Offset Groundwater Use



Portfolio 4 – ASR and Recycled Water to Offset Groundwater Use



Portfolio 5 –De-Facto Reuse and ASR

Figure 5-22. 2045 normal year supply mix by portfolio

The present worth cost, amount of water supply, and per ac-ft unit cost for each portfolio are graphically presented in Figure 5-23. Each portfolio is represented as a circle or bubble in Figure 5-23, where the size of the bubble represents the cost per ac-ft of the water supply. Notes and observations related to Figure 5-23 are as follows:

- Portfolios 4 is in the area of the figure that represents more water and lower present worth cost.
- Portfolio 2 represents the highest present worth, lower water supply, and highest unit cost.

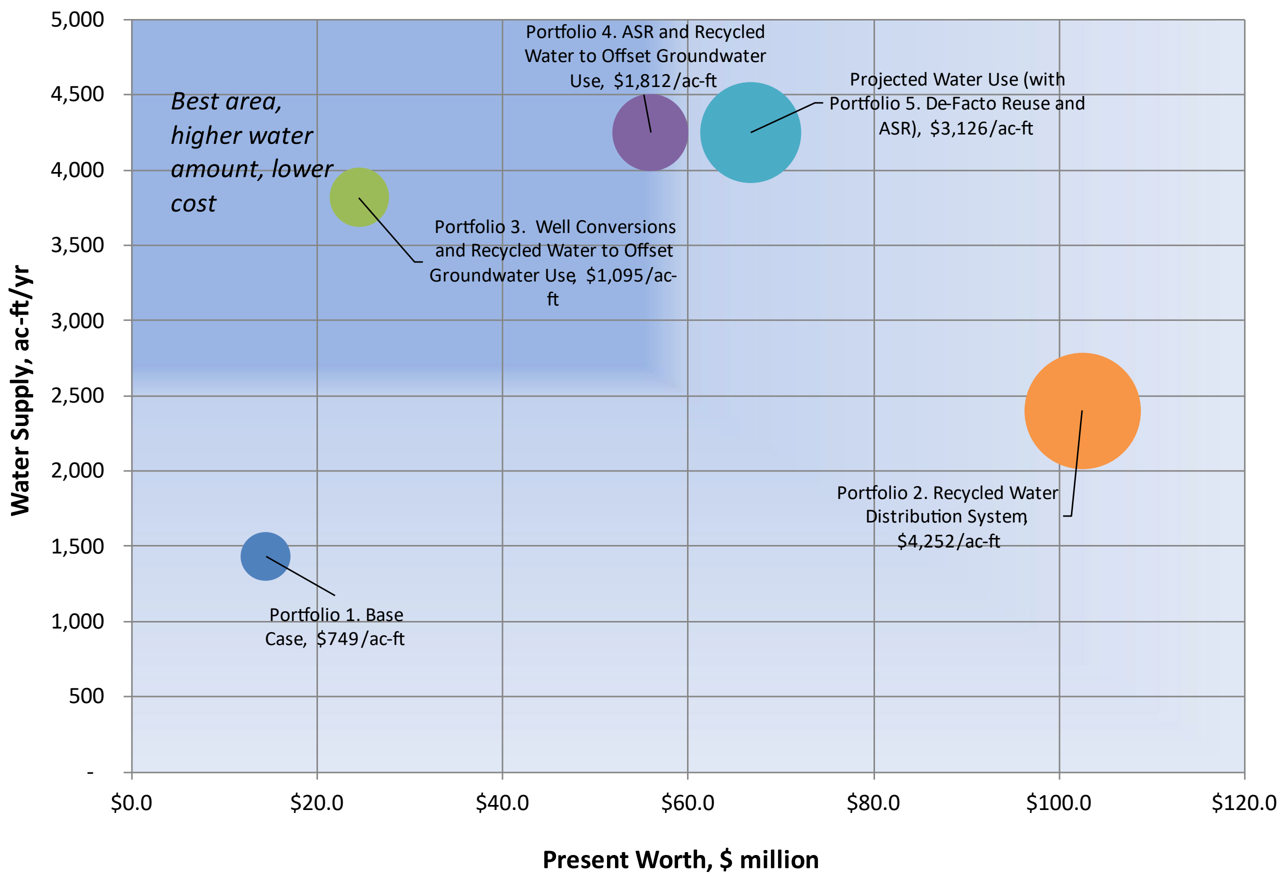


Figure 5-23. Portfolio summary, water supply vs present worth

Figure 5-24 presents a comparison of the present worth cost, per ac-ft cost, and water supply for each portfolio, with the bubble size representing the 2045 water supply amount. The portfolios located to the lower left corner with the larger bubble sizes represent the better portfolios. Notes and observations related to Figure 5-24 are as follows:

- Portfolios 1 and 3 are clustered relatively close together in the area of the figure that represents lower present worth cost and unit cost.
- Portfolio 2 represents the highest present worth, highest unit cost, and lower water supply.
- Portfolios 4 and 5 which include ASR also have higher unit costs.

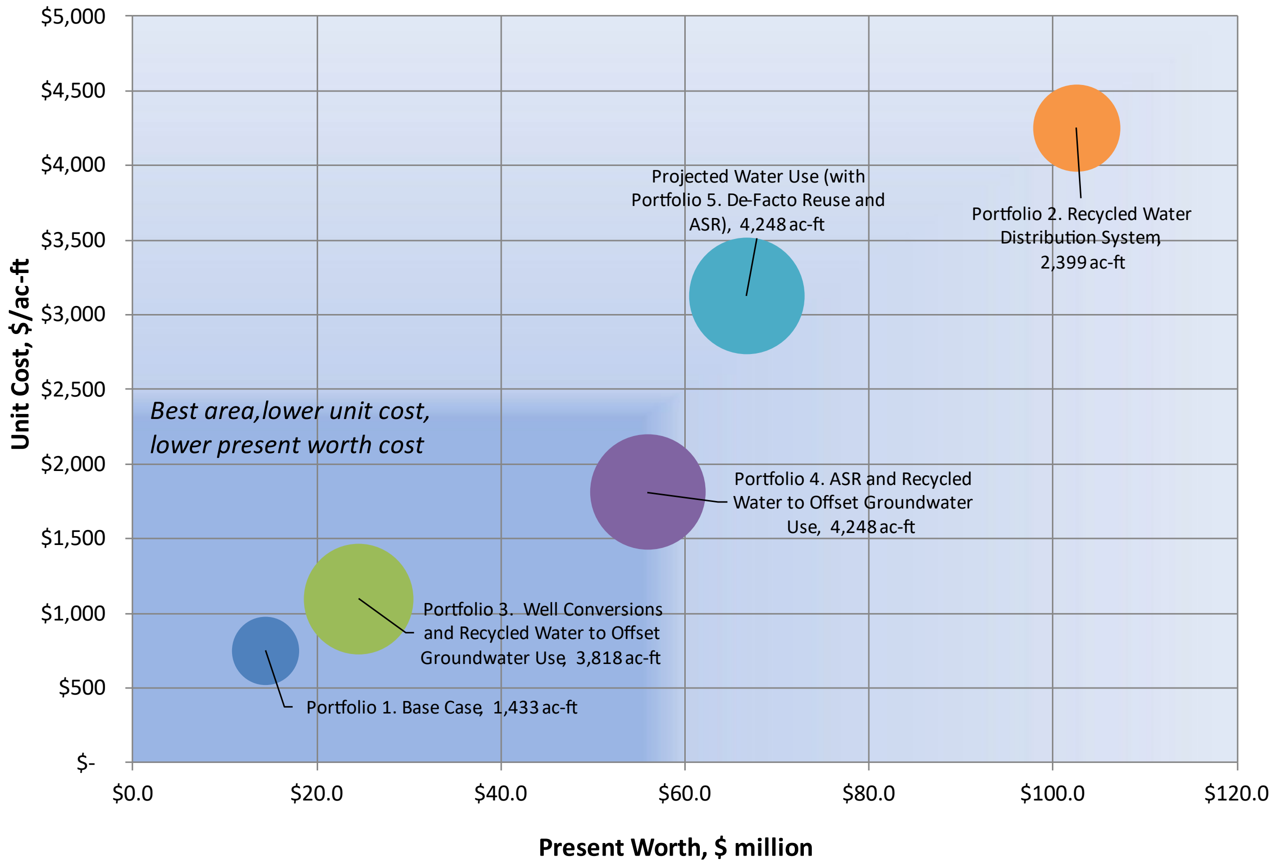


Figure 5-24. Portfolio summary, unit cost vs present worth

Each of the portfolios is rated using the screening criteria presented in Section 5.2. The portfolios are rated for each criterion using a scale of 1 to 4, with "4" representing a superior rating and "1" representing a poor rating. A total score is presented assuming an equal weighting factor for each of the criterion. The ratings and total score do not represent the proportional value of each portfolio compared to the others. Rather, it provides a means to simply compare the portfolios. The results of the screening are presented in Table 5-2. Notes and observations related to Table 5-2 are as follows:

- Portfolios 1 and 3 rate the best overall.
- For the economic screening criterion, portfolio 1 is rated as the best since only the cost of the water conservation option would be incurred by the City. However, portfolio 3 scores well also due to a significant greater amount of supply for slightly higher cost (relative to the other portfolios). Portfolio 2 is rated the worst due to the costs of the significant facilities that would have to be constructed with the recycled water distribution system.
- In terms of feasibility, portfolio 1 is rated as the best since only the water use efficiency and on-site reuse would have to be implemented. Portfolios 2 and 5 are rated as the worst due to the permitting, regulatory, and ongoing operational needs that would occur potentially with the recycled water distribution system and De-Facto Reuse.
- Reliability among the portfolios does not significantly vary. Portfolio 5 has a high reliability because it provides the most dry year water supply.

- For the sustainability criterion, portfolio 3 is rated the best since it focuses on water management options that link more fully with the overall water resources cycle and more fully utilize available water resources while avoiding options that would involve significant construction of facilities.

Table 5-2. Portfolio Evaluation Results [a]

Criteria	1. Base Case [b]	2. Recycled Water Distribution System [c]	3. Well Conversions and Recycled Water to Offset Groundwater Use [c]	4. ASR and Recycled Water to Offset Groundwater Use [c]	5. De-Facto Reuse and ASR [c]
Economic	4	1	4	3	2
Feasibility	4	1	3	3	1
Reliability	3	3	2	3	3
Sustainability	4	3	4	2	1
Total	15	8	13	11	7

a. *4 represents a superior rating, 1 representing a poor rating.*

b. *Base Case includes Residential and Commercial Water Use Efficiency, Municipal Water Use Efficiency, and On-Site Water Reuse water management options.*

c. *Includes Base Case water management options.*

The next section of this IWRS considers the result of this portfolio evaluation to develop a flexible and adaptable water strategy.

Section 6

Recommended Water Strategy

This section presents a long-term sustainable water strategy consisting of the City's future near term and long term water portfolio, along with a timeline for decisions and implementation. It is important to have a flexible and adaptive water strategy to be able to effectively respond to changing conditions such as with water use, climate, economics, and regulatory requirements. The strategy allows the City to implement the most promising water management options in a timely manner, while allowing for further consideration of those options that are currently less promising. The strategy includes making course adjustments as necessary to respond to changing conditions.

6.1 Recommendation Summary

Section 4 of this IWRS describes eight water management options that could potentially be implemented by the City in addition to the current groundwater supply and the planned surface water supply. Section 5 of this IWRS presents the evaluation of five portfolios consisting of different combinations of the water management options. Based on the evaluation of portfolios and input from the City, it is recommended that the City proceed with Portfolio 3 (Well Conversions and Recycled Water to Offset Groundwater Use), which consists of the City's current plan to utilize surface water and groundwater supplies plus the implementation of the following water management options:

- Residential and Commercial Water Use Efficiency (Section 4.1) by continuing the City's AMI customer portal, that provides customers access to their water use, continue the City's education and outreach program for residential and commercial water use efficiency, and the City's participation in State funded water use efficiency programs such as turf rebates.
- Municipal Water Use Efficiency (Section 4.2) by reducing water loss and water pipe breaks through acoustic leak detection and converting additional City-owned properties to water efficient landscaping
- On-site Water Reuse (Section 4.7) by supporting customer implementation of rainwater catchment, graywater reuse, and stormwater capture practices in alignment with current City plans including the CAAP and Downtown Davis Specific Plan.
- Well Conversion/Irrigation (modified) (Section 4.3) by converting three intermediate depth wells and constructing three new wells to serve irrigation demands.
- Recycled Water to Offset Groundwater Use (Section 4.5) by using the City's recycled water as an alternative non-groundwater supply source for current and future uses in the City's groundwater basin.

Portfolio 3 (Well Conversions and Recycled Water to Offset Groundwater Use) is recommended for the following reasons:

- Portfolio 3 has the lowest costs of all the portfolios (aside from Base Case Portfolio 1) with a unit cost of $1,095/ac-ft and $24.5 million present worth cost.
- Portfolio 3 provides 3,800 ac-ft/year (by 2045) of water supply over 2.5 times the water supply of Portfolio 1 (Base Case) and over 1.5 times more supply than Portfolio 2 (Recycled Water Distribution System).

- While Portfolio 3 provides water supply similar to Portfolios 4 (ASR and Recycled Water to Offset Groundwater Use) and 5 (De-Facto Reuse and ASR), Portfolio 3 present value costs are approximately 60% less than Portfolios 4 and 5.
- Portfolio 3 is feasible in terms of constructability, implementability, regulatory, and permitting requirements.
- Portfolio 3 is more sustainable than the other portfolios because it focuses on water management options that link more fully with the City's overall water resources cycle including groundwater sustainability.
- The City's per capita water use with Portfolio 3 is estimated to reach 111 GPCD by 2045, approximately 10% lower than the current draft estimated water use goal. As noted in Section 5.1.6, the State may consider well conversions for non-potable irrigation as an excluded use from future GPCD calculations to meet State water use objectives. In this case, all of the portfolios would result in the same future GPCD calculation.

The strategy described in this section includes near term implementation of a modified Portfolio 3 and future long term consideration of some of the other water management options that are not part of Portfolio 3.

6.2 Portfolio 3. Well Conversions and Recycled Water to Offset Groundwater Use

The water management options included in Portfolio 3 are described in this section.

6.2.1 Residential and Commercial Water Use Efficiency

Implementing this water management option consists of continuing and building off of the success of the City's water conservation efforts to-date in the residential and commercial sectors. This includes continuing the AMI customer portal, AquaHawk, that provides customers access to their hourly water use readings, with the intent of identifying leaks on the customer's property. The ability to monitor water usage and to set usage alerts enables customers and the City to identify and stop leaks. The City should continue activities to encourage customers to register for, read, and set alerts in AquaHawk. The City should continue to implement education and outreach to residential and commercial water use customers to spread awareness for water use efficiency including school assemblies, education workshops, and public information programs. As available the City will participate in the State's Save Our Water program for turf rebates.

The City should annually monitor progress in achieving water savings by tracking the annual per capita water use for residential and commercial customers. By 2026 the City should evaluate progress in generating savings to meet the overall legislative driven water use GPCD goal.

6.2.2 Municipal Water Use Efficiency

Implementing this water management option consists of working to increase municipal water use efficiency. The City should proactively reduce pipe break incidents by using the new Zone Scan acoustic leak detection technology to identify leaks. The City will repair underground (non-surfacing) pipe leaks prior to the pipe leaks developing into a catastrophic pipe failures. The City will also convert additional City-owned properties to water efficient landscaping.

The City should annually monitor progress in achieving water savings by tracking the annual per capita water use for municipal customers. By 2026 the City should evaluate progress in generating savings to meet the overall legislative driven water use goal.

6.2.3 On-Site Water Reuse

Implementing this water management option consists of supporting rainwater catchment, graywater reuse, and stormwater capture practices as defined in current plans such as the CAAP and the Downtown Davis Specific Plan recommendations. The City should administer these programs as part of the plan review, permit processing, and inspections as permanent features are constructed. The City should track which customers implement these on-site water reuse practices to be able to analyze their water use compared to customers who do not implement on-site water reuse practices in an effort to better quantify the value of the water efficiency improvements.

6.2.4 Well Conversion/Irrigation

Implementing this water management option consists of converting three intermediate depth wells to irrigation-only wells and constructing three new irrigation-only wells. Each of the irrigation wells would require separation of the irrigation water system at parks, schools, and greenbelts from the existing potable water distribution system. It is recommended that the City update the 2013 Parks and Greenbelts Water Management Plan to consider cost effectiveness of serving additional areas with irrigation wells such as Arroyo Park for IW-28 and La Playa Park for IW-10. In addition, the costs of the irrigation well conversions and new irrigation wells should be refined based on recent well construction and equipping market cost changes. The updated Parks and Greenbelts Water Management Plan should incorporate implementation steps with the Parks Department to understand roles and responsibilities between the water utility and the Parks Department for implementation of this water management option.

There is potential overlap with wells considered for conversion to irrigation wells in this Well Conversion/Irrigation water management option and wells considered to be converted to ASR wells as part of the current ASR studies and analysis. The activities related to well conversion for irrigation purposes should be coordinated with the ASR studies and analysis because ASR is not a viable option if this Well Conversion/Irrigation water management option moves forward.

The City should modify this water management option to delay the construction of IW-11 to provide more time to determine if that well location should be used instead for ASR purposes considering funding availability for each water management option. The possibility that the State will not continue to exclude irrigation wells water use from the calculation of the City's water system GPCD should also be considered.

6.2.5 Recycled Water to Offset Groundwater Use

Implementing this water management option consists of using recycled water as an alternative non-groundwater supply source to offset groundwater pumping for uses that would otherwise consume groundwater in or near the City, in the same groundwater sub basin as the City. These uses include the current and future uses described in the City's conditional acceptance for a recycled water permit (SWRCB, 2022). In Summer 2023 the City Council approved the CEQA document to petition the 1.8 mgd from Willow Slough Bypass. The recycled water permit will be adopted when the City's National Pollutant Discharge Elimination System (NPDES) permit renewal occurs in July 2024. This approach is in-line with the SWRCB permitting schedule.

- Yolo County Central Landfill (YCCL) for dust control, phytoremediation, agricultural irrigation, and truck wash activities and Napa Recycled facility (at the YCCL) for fire protection, irrigation of compost sites, and dust control (adjacent to WWTP) (current demand)
- City of Davis tree watering on City property (current demand)

- Open space irrigation of overland of 160-acre site east of WWTP (future demand)
- Agricultural irrigation of City-owned Howatt Ranch (future demand)

The City should track the usage of Recycled Water to Offset Groundwater Use and incorporate this water management approach into the next update of the Yolo Subbasin Groundwater Agency Groundwater Sustainability Plan.

6.3 Other Water Management Options to Consider (not part of Portfolio 3)

This IWRS describes and evaluates other water management options that are not part of Portfolio 3. While the below water management option is not part of Portfolio 3, specific consideration for the on-going economic and regulatory issues need to be further studied and resolved in the future as part of maintaining a flexible and adaptive water strategy.

6.3.1 Aquifer Storage and Recovery

Implementing the ASR water management option includes five new wells ASR operations: four existing intermediate well sites and (Well 19, 20, 22, and 27) and one new well site in the vicinity of Well 11. The City should look further into available funding for ASR as an incentive to move forward with this water management option. At the time of the IWRS Update the City has completed the final Aquifer Storage and Recover Feasibility Study (GEI, 2023). The location of the potential future ASR wells is subjective to further study, and City staff should conduct an additional ASR pilot study as necessary to gather the needed information to better understand treatment needs and supply reliability. In addition, constructing an ASR well in the vicinity of Well 11 should be evaluated in comparison to constructing IW-11 (Well Conversion/Irrigation water management option). The overall feasibility issue of introducing treated surface water to the aquifer near extraction of water from irrigation wells needs to be resolved.

6.4 Water Strategy Implementation

The recommended schedule for implementing the water strategy is presented in Figure 6-1. The implementation strategy consists of three phases through 2035 and defines activities that will need to occur for each water management option included in Portfolio 3, as described in Section 6.2. The City has already started implementing some of the activities shown in Figure 6-1.

Activities are also shown for the further study of the ASR water management option, as described in Section 6.3. Note that there is potential overlap with wells considered for conversion to irrigation wells in the Well Conversion/Irrigation water management option and wells considered to be converted to ASR wells as part of the current ASR studies and analysis. As such, there is a decision point in Phase 1 regarding the implementation of the Well Conversion/Irrigation water management option and the ASR water management option.

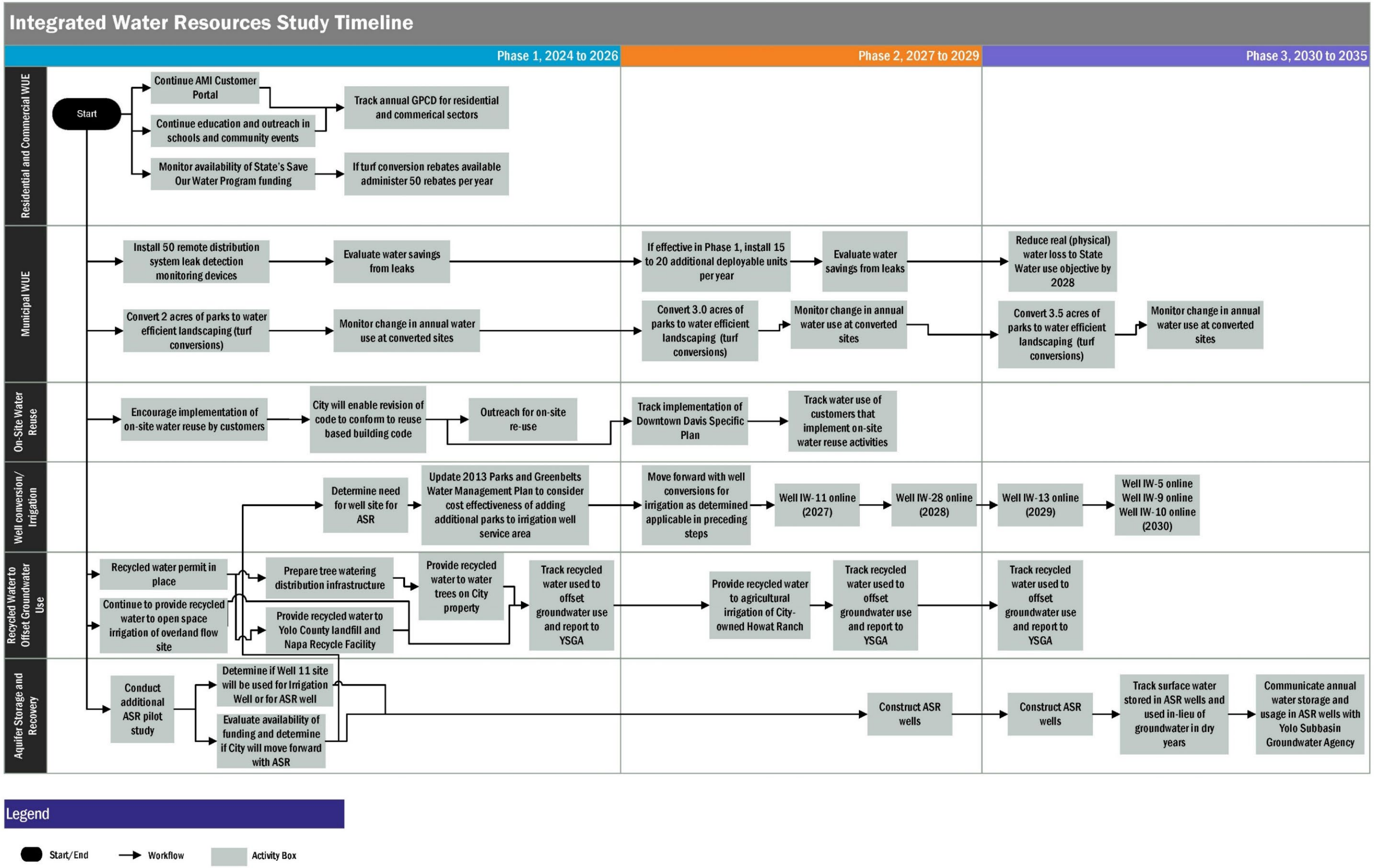


Figure 6-1. Integrated Water Resources Study Implementation Timeline

Brown AND Caldwell

References

American Water Works Association (AWWA). 2022. Increasing Consumer Benefits & Engagement in AMI-based Conservation Programs. January.

Aquacraft Water Engineering & Management. 2011. California Single Family Water Use Efficiency Study. April 20.

Brown and Caldwell. 2013a. Integrated Water Resources Study. August.

Brown and Caldwell. 2013b. Parks and Greenbelts Water Management Plan. October 30.

Brown and Caldwell. 2021. City of Davis 2020 Urban Water Management Plan. June.

Brown and Caldwell. 2023a. Draft Water Distribution System Optimization Plan. March.

Brown and Caldwell. 2023b. Howatt Ranch Recycled Water Pipeline Preliminary Design Report. May 31.

California Code of Regulations, Title 24, Part 5, Chapter 16A

CalWEP. https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Technical%20Reports/ami_guidebook_feb_2022.pdf

City of Davis. 2021. 2021-2023 City Council Goals. June 22

City of Davis. 2022a. SRWCB Conditional Acceptance of the Title 22 Engineering Report for Recycled Water Production, Distribution, and Use: City of Davis (5790004-700). January.

City of Davis. 2022b. Final Draft Davis 2020 – 2040 Climate Action and Adaptation Plan. December 6.

City of Davis. 2022c. Downtown Davis Specific Plan and Form Based Code Adoption. December 13.

Denver Water. 2017. Main breaks 101: Raising our infrastructure GPA. February 13. https://www.denverwater.org/tap/main-breaks-101-raising-our-infrastructure-gpa

GEI Consultants, Inc. 2023 Aquifer Storage and Recovery Feasibility Study, Davis CA. April.

Metropolitan Water District of Southern California. 2019. Water Savings from Turf Removal.

State of California. 2019. California Water Plan Update 2018. June.

State of California. 2005. Using Graywater in Your Home Landscape, Graywater Guidelines. January.

West Yost and Associates. 2018. Near-Term Recycled Water Master Plan. October.

West Yost and Associates. 2021. 2020 Woodland-Davis Clean Water Agency Urban Water Management Plan. June.

Yolo Subbasin Groundwater Agency. 2022. Groundwater Sustainability Plan. January 24.

Appendix A: Water Management Options Tables

Table A-1. Annual Costs

Year	Residential and Commerical Water Use Efficiency	Municipal Water Use Efficiency	Well Conversion/Irrigation	Aquifer storage and recovery (ASR)	Recycled Water to Offset Groundwater Use	Recycled Water Distribution System	On-Site Water Reuse	De-Facto Water Reuse
2023	$ 663,000	$ 150,400	$ -	$ -	$ 480,000	$ -	$ -	$ -
2024	$ 663,000	$ 72,400	$ -	$ -	$ 667,000	$ -	$ -	$ -
2025	$ 663,000	$ 215,132	$ -	$ -	$ 667,000	$ -	$ 78,000	$ -
2026	$ 663,000	$ 215,132	$ -	$ -	$ 6,127,000	$ -	$ 78,000	$ -
2027	$ 663,000	$ 215,132	$ 1,324,500	$ -	$ 6,127,000	$ -	$ 78,000	$ -
2028	$ 663,000	$ 215,132	$ 1,598,000	$ 30,455,000	$ 1,561,000	$ 72,881,000	$ 78,000	$ -
2029	$ 663,000	$ 215,132	$ 1,277,500	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2030	$ 663,000	$ 215,132	$ 5,728,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2031	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2032	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2033	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2034	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ -
2035	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 576,000	$ 78,000	$ 73,160,000
2036	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 25,680,000	$ 78,000	$ 160,000
2037	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2038	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2039	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2040	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2041	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2042	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2043	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2044	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
2045	$ 663,000	$ 72,400	$ 183,000	$ 1,340,000	$ 1,561,000	$ 872,000	$ 78,000	$ 160,000
Total (non-discounted)	$ 15,249,000	$ 2,599,590	$ 12,673,000	$ 53,235,000	$ 42,166,000	$ 110,441,000	$ 1,638,000	$ 74,760,000
Present worth	$ 11,229,176	$ 2,054,917	$ 10,058,838	$ 41,489,411	$ 31,882,254	$ 88,073,526	$ 1,167,351	$ 52,270,218
Annualized (based on future start date)	$ 704,602	$ 128,941	$ 631,166	$ 2,603,352	$ 2,000,528	$ 5,526,384	$ 73,248	$ 3,279,820
$/ac-ft	$ 682	$ 502	$ 2,359	$ 5,490	$ 1,110	$ 9,446	$ 7,014	$ 3,879

Table A-2. Annual Costs and Supply Present Value Analysis	**Residential and Commerical Water Use Efficiency**			
Year	Res/Com WUE	Res/Com WUE-discounted	Res/Come WUE-supply	Res/Come WUE-supply-discounted
	$	$	ac-ft	ac-ft
2023	663,000	663,000	861	861
2024	663,000	643,689	872	847
2025	663,000	624,941	884	833
2026	663,000	606,739	895	819
2027	663,000	589,067	906	805
2028	663,000	571,910	920	793
2029	663,000	555,252	930	779
2030	663,000	539,080	941	765
2031	663,000	523,378	953	752
2032	663,000	508,134	964	739
2033	663,000	493,334	975	726
2034	663,000	478,965	987	713
2035	663,000	465,015	998	700
2036	663,000	451,471	1,009	687
2037	663,000	438,321	1,021	675
2038	663,000	425,554	1,032	662
2039	663,000	413,160	1,043	650
2040	663,000	401,126	1,055	638
2041	663,000	389,443	1,066	626
2042	663,000	378,100	1,077	614
2043	663,000	367,087	1,089	603
2044	663,000	356,395	1,100	591
2045	663,000	346,015	1,111	580
Total (non-discounted)	15,249,000		22,689	
Present worth		$ 11,229,176		16,459
Annualized (based on future start date)		704,602		1,033
$/ac-ft (PW costs/PW Supply)				682
i=0.03				

Table A-2. Annual Costs and Supply Present Value Analysis	Muni Water Use Efficiency			
Year	Muni WUE	Muni WUE discounted	Muni WUE supply	Muni WUE supply discounted
	$	$	ac-ft	ac-ft
2023	150,400	150,400	2	2
2024	72,400	70,291	53	51
2025	215,132	202,782	108	102
2026	215,132	196,876	163	149
2027	215,132	191,142	218	194
2028	215,132	185,574	282	243
2029	215,132	180,169	282	236
2030	215,132	174,922	287	233
2031	72,400	57,153	291	230
2032	72,400	55,489	296	227
2033	72,400	53,872	299	222
2034	72,400	52,303	298	215
2035	72,400	50,780	298	209
2036	72,400	49,301	298	203
2037	72,400	47,865	298	197
2038	72,400	46,471	298	191
2039	72,400	45,117	298	186
2040	72,400	43,803	298	180
2041	72,400	42,527	298	175
2042	72,400	41,289	298	170
2043	72,400	40,086	298	165
2044	72,400	38,919	298	160
2045	72,400	37,785	298	155
Total (non-discounted)	2,599,590		5,854	
Present worth		2,054,917		4,095
Annualized (based on future start date)		128,941		257
$/ac-ft (PW costs/PW Supply)				502
i=0.03				

Table A-2. Annual Costs and Supply Present Value Analysis	Well Conversion/Irrigation			
Year	Well Conversion/Irrigation	Well conv/irr - discounted	Well conv-supply	Well conv-supply-discounted
	$	$	ac-ft	ac-ft
2023		-		-
2024		-		-
2025		-		-
2026		-		-
2027	1,324,500	1,176,801	88	78
2028	1,598,000	1,378,449	155	134
2029	1,277,500	1,069,886	204	171
2030	5,728,000	4,657,388	369	300
2031	183,000	144,462	369	291
2032	183,000	140,254	369	283
2033	183,000	136,169	369	275
2034	183,000	132,203	369	267
2035	183,000	128,353	369	259
2036	183,000	124,614	369	251
2037	183,000	120,985	369	244
2038	183,000	117,461	369	237
2039	183,000	114,040	369	230
2040	183,000	110,718	369	223
2041	183,000	107,493	369	217
2042	183,000	104,362	369	210
2043	183,000	101,323	369	204
2044	183,000	98,372	369	198
2045	183,000	95,506	369	193
Total (non-discounted)	12,673,000		6,351	
Present worth		10,058,838		4,265
Annualized (based on future start date)		631,166		268
$/ac-ft (PW costs/PW Supply)				2,359
i=0.03				

Table A-2. Annual Costs and Supply Present Value Analysis	Aquifer Storage and Recovery			
Year	ASR	ASR-discounted	ASR-supply	ASR supply-discounted
	$	$	ac-ft	ac-ft
2023		-		-
2024		-		-
2025		-		-
2026		-		-
2027		-		-
2028	30,455,000	26,270,751		-
2029	1,340,000	1,122,229		-
2030	1,340,000	1,089,543		-
2031	1,340,000	1,057,808		-
2032	1,340,000	1,026,998		-
2033	1,340,000	997,086	4,000	2,976
2034	1,340,000	968,045		-
2035	1,340,000	939,849		-
2036	1,340,000	912,475		-
2037	1,340,000	885,898		-
2038	1,340,000	860,095		-
2039	1,340,000	835,044	4,000	2,493
2040	1,340,000	810,722		-
2041	1,340,000	787,109		-
2042	1,340,000	764,183		-
2043	1,340,000	741,926		-
2044	1,340,000	720,316		-
2045	1,340,000	699,336	4,000	2,088
Total (non-discounted)	53,235,000		12,000	
Present worth		41,489,411		7,557
Annualized (based on future start date)		2,603,352		474
$/ac-ft (PW costs/PW Supply)				5,490
i=0.03				

Table A-2. Annual Costs and Supply Present Value Analysis	Recycled Water to Offset Groundwater Use				
Year	Recycled Water to Offset Groundwater Use	Recycled water-discounted	Recycled water supply	Recycled water supply-discounted	Recycled Water Distribution System
	$	$	ac-ft	ac-ft	$
2023	480,000	480,000	663	663	
2024	667,000	647,573	921	894	
2025	667,000	628,711	921	868	
2026	6,127,000	5,607,073	922	843	
2027	6,127,000	5,443,760	922	819	
2028	1,561,000	1,346,532	2,016	1,739	72,881,000
2029	1,561,000	1,307,313	2,016	1,688	576,000
2030	1,561,000	1,269,236	2,016	1,639	576,000
2031	1,561,000	1,232,268	2,016	1,592	576,000
2032	1,561,000	1,196,377	2,016	1,545	576,000
2033	1,561,000	1,161,531	2,016	1,500	576,000
2034	1,561,000	1,127,700	2,016	1,456	576,000
2035	1,561,000	1,094,854	2,016	1,414	576,000
2036	1,561,000	1,062,965	2,016	1,373	25,680,000
2037	1,561,000	1,032,005	2,016	1,333	872,000
2038	1,561,000	1,001,946	2,016	1,294	872,000
2039	1,561,000	972,764	2,016	1,256	872,000
2040	1,561,000	944,431	2,016	1,220	872,000
2041	1,561,000	916,923	2,016	1,184	872,000
2042	1,561,000	890,216	2,016	1,150	872,000
2043	1,561,000	864,288	2,016	1,116	872,000
2044	1,561,000	839,114	2,016	1,084	872,000
2045	1,561,000	814,674	2,016	1,052	872,000
Total (non-discounted)	42,166,000		40,639		110,441,000
Present worth		31,882,254		28,725	
Annualized (based on future start date)		2,000,528		1,802	
$/ac-ft (PW costs/PW Supply)				1,110	
i=0.03					

Table A-2. Annual Costs and Supply Present Value Analysis	**Recycled Water Distribution System**				
Year	Dual systems-discounted	Dual systems supply	Dual systems supply - non-potable groundwater offset	Dual systems supply - potable offset	Dual systems supply-discounted
	$	ac-ft	ac-ft	ac-ft	ac-ft
2023					-
2024					-
2025					-
2026					-
2027					-
2028	62,867,791	568	491	77	490
2029	482,391	568	491	77	475
2030	468,341	568	491	77	462
2031	454,700	568	491	77	448
2032	441,456	568	491	77	435
2033	428,598	568	491	77	422
2034	416,115	568	491	77	410
2035	403,995	568	491	77	398
2036	17,486,830	967	522	445	658
2037	576,495	967	522	445	639
2038	559,704	967	522	445	620
2039	543,402	967	522	445	602
2040	527,574	967	522	445	585
2041	512,208	967	522	445	568
2042	497,289	967	522	445	551
2043	482,805	967	522	445	535
2044	468,743	967	522	445	520
2045	455,090	967	522	445	504
Total (non-discounted)				5,063	
Present worth	88,073,526				9,324
Annualized (based on future start date)	5,526,384				585
$/ac-ft (PW costs/PW Supply)					9,446
i=0.03					

Table A-2. Annual Costs and Supply Present Value Analysis	On-Site Water Reuse			
Year	On-Site Water Reuse	On-Site Water Reuse-discounted	On-Site Water Reuse supply	On-Site Water Reuse supply-discounted
	$	$	ac-ft	ac-ft
2023			-	-
2024			-	-
2025	78,000	73,522	1	1
2026	78,000	71,381	2	2
2027	78,000	69,302	3	3
2028	78,000	67,283	4	4
2029	78,000	65,324	6	5
2030	78,000	63,421	7	5
2031	78,000	61,574	8	6
2032	78,000	59,781	9	7
2033	78,000	58,039	10	8
2034	78,000	56,349	11	8
2035	78,000	54,708	12	9
2036	78,000	53,114	13	9
2037	78,000	51,567	15	10
2038	78,000	50,065	16	10
2039	78,000	48,607	17	10
2040	78,000	47,191	18	11
2041	78,000	45,817	19	11
2042	78,000	44,482	20	12
2043	78,000	43,187	21	12
2044	78,000	41,929	22	12
2045	78,000	40,708	24	12
Total (non-discounted)	1,638,000		259	
Present worth		1,167,351		166
Annualized (based on future start date)		73,248		10
$/ac-ft (PW costs/PW Supply)				7,014
i=0.03				

Table A-2. Annual Costs and Supply Present Value Analysis	De-Facto Reuse			
Year	De-facto reuse	De-facto reuse-discounted	De-facto reuse supply	De-facto reuse supply-discounted
	$	$	ac-ft	ac-ft
2023		-		
2024		-		
2025		-		-
2026		-		-
2027		-		-
2028		-		-
2029		-		-
2030		-		-
2031		-		-
2032		-		-
2033		-		-
2034		-		-
2035	73,160,000	51,312,952	2,016	1,414
2036	160,000	108,952	2,016	1,373
2037	160,000	105,779	2,016	1,333
2038	160,000	102,698	2,016	1,294
2039	160,000	99,707	2,016	1,256
2040	160,000	96,803	2,016	1,220
2041	160,000	93,983	2,016	1,184
2042	160,000	91,246	2,016	1,150
2043	160,000	88,588	2,016	1,116
2044	160,000	86,008	2,016	1,084
2045	160,000	83,503	2,016	1,052
Total (non-discounted)	74,760,000		22,176	
Present worth		52,270,218		13,476
Annualized (based on future start date)		3,279,820		846
$/ac-ft (PW costs/PW Supply)				3,879
i=0.03				

Appendix B: Portfolio Tables

Portfolio 1. Base Case

Table B-1. Portfolio 1 - Base Case - Normal Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341					
Projected potable demand with portfolio, ac-ft/yr												9,591	9,641	9,691	9,695	9,633
Projected potable demand no portfolio, ac-ft/yr												10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	8,991	9,041	9,091	9,095	8,874
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	600	600	600	600	759
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)																
Recycled Water to Offset Groundwater Use																
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	10,999	11,066	11,066
Total potable supply	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	9,691	9,695	9,633
Water management option supply (from this portfolio) that is potable offset	-	-	-	-	-	-	-	-	-	-	-	992	1,235	1,308	1,370	1,433
Potable plus offset supplies	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	10,999	11,066	11,066
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	117	117	116

Table B-2. Portfolio 1 - Base Case - Dry Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341					
Projected potable demand with portfolio, ac-ft/yr												9,591	9,641	9,691	9,695	9,633
Projected potable demand no portfolio, ac-ft/yr												10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	3,360	3,360	3,360	3,360	3,360
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	6,231	6,281	6,331	6,335	6,273
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)																
Recycled Water to Offset Groundwater Use																
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	10,999	11,066	11,066
Total potable supply	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	9,691	9,695	9,633
Water management option supply (from this portfolio) that is potable offset	-	-	-	-	-	-	-	-	-	-	-	992	1,235	1,308	1,370	1,433
Potable plus offset supplies	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	10,999	11,066	11,066
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	117	117	116

Portfolio 2. Recycled Water Distribution System

Table B-3. Portfolio 2 - Recycled Water Distribution System, Normal Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	9,591	9,564	9,614	9,251	9,188
Projected potable demand no portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	9,341	9,314	9,364	9,001	8,809
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	250	250	250	250	379
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversions																
Aquifer Storage Recovery (ASR)																
Recycled Water to Offset Groundwater Use										-	-					
Recycled Water Distribution System - Potable Demand Offset										-	-	-	77	77	445	445
Recycled Water Distribution System - Nonpotable GW Offset												-	491	491	522	522
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	11,367	11,490	11,588	11,588
Total potable supply for portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,564	9,614	9,251	9,188
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	120	116	111	111

Table B-4. Portfolio 2 - Recycled Water Distribution System, Dry Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	9,591	9,564	9,614	9,251	9,188
Projected potable demand no portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	3,360	3,360	3,360	3,360	3,360
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	6,231	6,204	6,254	5,891	5,828
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversions																
Aquifer Storage Recovery (ASR)																
Recycled Water to Offset Groundwater Use										-	-					
Recycled Water Distribution System - Potable Demand Offset										-	-	-	77	77	445	445
Recycled Water Distribution System - Nonpotable GW Offset												-	491	491	522	522
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	11,367	11,490	11,588	11,588
Total potable supply for portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,564	9,614	9,251	9,188
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	120	116	111	111

Portfolio 3. Well Conversions and Recycled Water to Offset Groundwater Use

Table B-5. Portfolio 3 - Well Conversions and Recycled Water to Offset Groundwater Use, Normal Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	9,591	9,272	9,322	9,326	9,264
Projected potable demand no portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	9,191	8,872	8,922	8,926	8,717
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	400	400	400	400	547
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation										-	-	-	369	369	369	369
Aquifer storage and recovery (ASR)																
Recycled Water to Offset Groundwater Use												921	2,016	2,016	2,016	2,016
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	11,505	12,892	13,015	13,082	13,082
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,272	9,322	9,326	9,264
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	116	112	112	111

Table B-6. Portfolio 3 - Well Conversions and Recycled Water to Offset Groundwater Use, Dry Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	9,591	9,272	9,322	9,326	9,264
Projected potable demand no portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	3,360	3,360	3,360	3,360	3,360
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	6,231	5,912	5,962	5,966	5,904
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation										-	-	-	369	369	369	369
Aquifer storage and recovery (ASR)																
Recycled Water to Offset Groundwater Use												921	2,016	2,016	2,016	2,016
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	11,505	12,892	13,015	13,082	13,082
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,272	9,322	9,326	9,264
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	116	112	112	111

Portfolio 4. ASR and Recycled Water to Offset Groundwater Use

Table B-7. Portfolio 4 - ASR and Recycled Water to Offset Groundwater Use, Normal Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	9,591	9,641	9,691	9,695	9,633
Projected potable demand no portfolio, ac-ft/yr	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	8,874	8,874	8,874	8,874	8,874
Surface Water Supply for Aquifer Storage and Recovery												-	-	1,000	1,000	1,000
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	717	767	816	821	759
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)										-	-					
Recycled Water to Offset Groundwater Use												921	2,016	2,016	2,016	2,016
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	11,505	12,892	14,015	14,082	14,082
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	10,691	10,695	10,633
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	129	129	128

Table B-8. Portfolio 4 - ASR and Recycled Water to Offset Groundwater Use, Dry Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with por	-	-	-	-	-	-	-	-	-	-	-	9,591	9,641	9,691	9,695	9,633
Projected potable demand no portf	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	3,360	3,360	3,360	3,360	3,360
Surface Water Supply for ASR Recharge																
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	6,231	6,281	2,331	2,335	2,273
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)										-	-	-	-	4,000	4,000	4,000
Recycled Water to Offset Groundwater Use												921	2,016	2,016	2,016	2,016
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse																
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	11,505	12,892	13,015	13,082	13,082
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	9,691	9,695	9,633
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	117	117	116

Portfolio 5. De-Facto Reuse and ASR

Table B-9. Portfolio 5 - De-Facto Reuse + ASR, Normal Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with p	-	-	-	-	-	-	-	-	-	-	-	9,591	9,641	9,691	9,695	9,633
Projected potable demand no por	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	8,991	9,041	6,858	6,858	6,858
Surface Water Supply for Aquifer Storage and Recovery												-	-	1,000	1,000	1,000
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	600	600	816	821	759
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)										-	-					
Recycled Water to Offset Groundwater Use																
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse										-	-	-	-	2,016	2,016	2,016
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	11,999	12,066	12,066
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	10,691	10,695	10,633
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	129	129	128

Table B-10. Portfolio 5 - De-Facto Reuse + ASR, Dry Year

	2005	2006	2007	2008	2009	2010	2011	2012	2015	2021	2021	2025	2030	2035	2040	2045
Population	66,229	66,618	66,958	67,460	67,953	68,289	66,435	67,383	69,280	68,886	68,886	69,231	71,329	74,225	74,225	74,225
Actual annual demand, ac-ft/yr	14,452	14,333	14,762	14,219	12,835	11,954	11,529	12,218	9,211	12,341	12,341	-	-	-	-	-
Projected potable demand with p	-	-	-	-	-	-	-	-	-	-	-	9,591	9,641	9,691	9,695	9,633
Projected potable demand no por	-	-	-	-	-	-	-	-	-	-	-	10,584	10,876	10,999	11,066	11,066
Surface water	-	-	-	-	-	-	-	-	-	6,501	6,501	3,360	3,360	3,360	3,360	3,360
Surface Water Supply for Aquifer Storage and Recovery																
Intermediate aquifer	10,263	10,094	10,870	7,303	8,015	7,392	6,593	5,064	5,961	11	11	-	-	-	-	-
Deep aquifer	4,188	4,237	3,891	6,972	4,821	4,565	4,939	7,154	7,000	3,762	3,762	6,231	6,281	609	609	609
Residential and Commercial Water Use Efficiency										-	-	884	941	998	1,055	1,111
Municipal Water Use Efficiency										-	-	108	287	298	298	298
Well Conversion/Irrigation																
Aquifer storage and recovery (ASR)										-	-	-	-	3,705	3,710	3,648
Recycled Water to Offset Groundwater Use																
Recycled Water Distribution System																
On-Site Water Reuse										-	-	1	7	12	18	24
De-Facto Water Reuse										-	-	-	-	2,016	2,016	2,016
Total supply, including conservation	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	10,584	10,876	10,999	11,066	11,066
Total potable supply for this portfolio	14,451	14,331	14,761	14,275	12,836	11,957	11,532	12,218	12,961	10,274	10,274	9,591	9,641	9,691	9,695	9,633
Actual potable water gpcd	195	192	197	189	169	156	155	162	167	133	133	124	121	117	117	116

Brown AND Caldwell

Davis

202 Cousteau Place
Suite 175
Davis, CA 95618T

530.747.0650