2020 Comprehensive System Water Master Plan and Asset Management Plan

MARCH 2023

SAN ANTONIO WATER COMPANY

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Prepared by Water Systems Consulting, Inc

ACKNOWLEDGEMENTS

The 2020 Comprehensive System Water Master Plan and Asset Management Plan was prepared by Water Systems Consulting, Inc. The primary authors are listed below.

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Water Systems Consulting, Inc. would like to acknowledge the significant contributions of San Antonio Water Company. The primary contributors are listed below.

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ACROYNMS & ABBREVIATIONS

ADD	Average Day Demand
AF	Acre-feet
AFY	Acre-feet per Year
APN	Assessor's Parcel Numbers
AWWA	American Water Works Association
BPS	Booster Pump Station
CCTV	Acronym
CIP	Capital Improvement Program
DWR	Department of Water Resources
ES	Executive Summary
EUL	End of Useful Life
FF	Fire Flow
GIS	Geographic Information Systems
GPM	Gallons per Minute
HGL	Hydraulic Grade Line
HP	Horsepower
ID	Identification
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
MSL	Mean Sea Level
NRW	Non-Revenue Water
NTU	Nephelometric Turbidity Units
OSY	Operating Safe Yield
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve

PVC	Polyvinyl Chloride
RZ	Rezoning
SAWCO	San Antonio Water Company
SCADA	Supervisory Control and Data Acquisition
SCAG	Southern California Association of Governments
TCP	1,2,3-Trichloropropane
TM	Technical Memorandum
TT	Treatment Technique
TTHM	Total Trihalomethanes
US	United States
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WMP	Water Master Plan
WSC	Water Systems Consulting, Inc.
WSCP	Water Shortage Contingency Plan
WTP	Water Treatment Plant

WATER MASTER PLAN

Executive Summary

San Antonio Water Company (SAWCo) is a private non-profit Mutual Water Company that owns and operates a small water distribution system in the unincorporated community of San Antonio Heights. SAWCo also provides non-potable water to various irrigation customers, including neighboring agencies. This Comprehensive System Water Master Plan and Asset Management Plan assesses the ability of the system to meet customer demands and identifies a list of improvements and anticipated costs to address condition and capacity deficiencies.

IN THIS SECTION

- Water Supply
- Booster Pump Stations
- Storage
- Distribution and Transmission Pipelines
- Recommended Improvements

Water Supply

SAWCo relies on local surface and groundwater supply sources through a diversion along the San Antonio Creek, groundwater infiltrated and conveyed through the San Antonio Tunnel, and from 11 groundwater wells within the Chino, Cucamonga, and Six Basins groundwater basins.

The domestic system is supplied by groundwater from the San Antonio Tunnel, by two wells within the Chino Basin, and one well within the Cucamonga Basin. Excess domestic water from the San Antonio Tunnel may be conveyed into the irrigation system to minimize water losses.

The irrigation system is supplied by surface water from the San Antonio Creek and by eight wells, five of which are located within the Cucamonga Basin and three within Six Basins.

The condition of groundwater wells was assessed based on well age, lost capacity, and efficiency. The evaluation only considers a few factors to help SAWCo prioritize wells that will need further investigation and planning for well rehabilitation efforts. Each well should include a thorough well and site investigation before any rehabilitation efforts or pump and motor replacements. SAWCo has prioritized redrilling Well 19 to increase reliability for the domestic system.

Booster Pump Stations

SAWCo maintains and operates six booster pump stations within the domestic system. All booster pump stations are adequately sized to meet maximum day capacity, except for BPS #18. However, although BPS #18 alone does not meet the required capacity, the southern portion of the pressure zone is fed directly from wells or can be supplied from another pressure zone. In addition, pump age and efficiency do not indicate any upgrades are required at this time.

SAWCo currently utilizes one booster pump station within the irrigation system. An additional booster pump station, BPS #9, is not currently used. It is recommended that additional analysis is completed to determine the feasibility of reinstating BPS #9.

Storage

SAWCo’s domestic distribution system contains six storage reservoirs that provide a total capacity of 6.8 million gallons of operational, emergency, and fire flow storage. There is sufficient capacity within the existing system to meet storage needs for all pressure zones. The domestic system has a total storage surplus of 1.97 million gallons under current conditions.

SAWCo’s domestic system is nearly built out, and any estimates of future development are likely to occur near the Holly Drive pressure zone, although development in this area is unlikely. Parcels identified as potential future development are estimated to add approximately 30 acre-fee per year demand, which would result in a 0.1 million-gallon storage deficit within the Holly

Drive pressure zone. SAWCo will continue to monitor development and address future storage needs, should they occur, through the development process.

It is recommended that all domestic storage reservoirs are inspected and cleaned using a professional dive team.

Distribution and Transmission Pipelines

SAWCo's water distribution system consists of approximately 50 miles of active distribution and transmission mains that range in size from 2-inch to 36-inch diameter. Approximately 28 miles compose the domestic system, and the remaining 22 miles serve the irrigation system.

The available fire flow and pipeline velocity was evaluated using the hydraulic model developed for this Water Master Plan. The majority of the system is sufficient to meet the required fire flow and not exceed the maximum velocity. Only one fire flow project is recommended to replace the existing 4-inch main with an 8-inch line at failure. Additionally, six fire hydrants are recommended for installation and construction of an additional pipeline within Hillcrest Drive to provide thorough coverage throughout the domestic system.

Pipeline condition was also evaluated based on pipe age and material. Approximately 1,200 feet of domestic mains and 12.5 miles of irrigation mains have exceeded its estimated end of useful life. Pipeline candidates for rehabilitation or replacement are identified and can be prioritized by SAWCo staff as needed. Additionally, many irrigation mains are identified for relocation from private yards to provide SAWCo better access to its assets.

Recommended Improvements

The total recommended projects to correct existing and anticipated future deficiencies cost approximately $9 million. The projects are categorized based on improvement type and are prioritized for completion over the next 10 years or beyond in Section 10.0. Table ES-1 summarizes the recommended capital improvement projects and planning level cost estimates. Cost estimates include markups for construction contingency and project design.

Table ES-1. Recommended Capital Improvement Projects

PROJECT	ESTIMATED COST	SECTION REFERENCE
REZONING	**$56,300**	
RZ-1: Expanded Holly Drive Zone Feasibility Study	$56,300	Section 7.1
FIRE FLOW	**$233,000**	
FF-1: Ponte Vecchino Ct Pipeline	$110,100	Section 6.2
FF-2: Hillcrest Drive Pipeline	$39,600	Section 6.2
FF-3: Hydrant Installation	$83,300	Section 6.2.2
REHABILITATION & REPLACEMENT	**$6,556,800**	
R&R-1: Well 19	$2,912,000	Section 4.1.1
R&R-2: Domestic Tank Inspections	$61,800	Section 8.2
R&R-3: San Antonio Tunnel Inspection	$524,200	Section 9.2
R&R-4: E 25th St Main Replacement	$110,200	Section 8.1
R&R-5: Belleview Rd Main Replacement	$29,200	Section 8.1
R&R-6: Irrigation Wells 22, 24, 25A, and 27 Evaluation	$110,000	Section 8.3.1
R&R-7: Main Box Surface Water Pipeline Replacement	$2,426,900	Section 8.1
R&R-8: Benson Ave Irrigation Replacement	$382,500	Section 8.1
OPERATION & MAINTENANCE	**$2,333,100**	
O-1: Annual Domestic Pipeline Replacement	$261,700	Section 7
O-2: Annual Irrigation Pipeline Replacement	$174,700	Section 7
O-3: San Antonio Creek to Upland tee Irrigation Pipeline Evaluation	$541,000	Section 7
O-4: Production Meter Upgrades/Replacement	$436,000	Section 7
O-5: Backup Well Generators	$687,500	Section 7
O-6: BPS #9 Analysis	$62,500	Section 7.4.1
O-7: Irrigation Valves	$69,700	Section 6.3.3

TOTAL ESTIMATED COST	$9,079,200

Note: Costs are provided in 2022 dollars. Total budget estimate for each project may span multiple years in the CIP.

WATER MASTER PLAN

1.0 Introduction

This Comprehensive System Water Master Plan and Asset Management Plan Update (Water Master Plan or WMP) guides SAWCo's planned capital project expenditures and asset management for its water system in an efficient and cost-effective manner. This section presents the main goals of the WMP and provides background information.

IN THIS SECTION

- Overview and Purpose
- Relation to Other Planning Documents
- Background Information

1.1. Overview and Purpose

The San Antonio Water Company (SAWCo) is a private non-profit Mutual Water Company formed in 1882 under the General Corporation Laws of the United States with the purpose to furnish, lease, or sell water for irrigation, milling, manufacturing and other purposes to the newly established Ontario irrigation colony. Land for the irrigation colony was sold primarily for the booming citrus industry at the time, and a share in SAWCo was also sold with every acre of land.

Each shareholder was entitled a portion of available local water, distributed equally by SAWCo amongst shareholders on a non-profit basis. Today, SAWCo exercises the same mission of providing beneficial water service to all shareholders based on established monthly entitlements and a total fixed number of shares: 6,389. SAWCo provides water to its shareholders within two separate systems: the domestic system that serves the unincorporated community of San Antonio Heights and the irrigation system, where SAWCo delivers raw water as a wholesaler to nearby agencies or for non-potable irrigation and industrial uses.

The primary purpose of this Comprehensive System Water Master Plan and Asset Management Plan, referred to as the Water Master Plan (WMP) Update throughout this report, is to evaluate both the domestic and irrigation systems and develop a comprehensive plan for water system improvements. The major project objectives include:

- Develop an accurate hydraulic model of the domestic and irrigation distribution systems.
- Identify existing and future system capacity deficiencies to meet current and projected water demands.
- Evaluate asset existing conditions to quantify and prioritize asset rehabilitation and replacement.
- Evaluate loss-risk of local supply sources and production facilities. Develop recommendations and potential water supply alternatives to reduce supply source risk.
- Develop a prioritized list of improvement projects, including anticipated costs, to address the system condition, deficiencies, assure reliability and capacity of the distribution system, and maintain an adequate annual capital expenditure budget.

1.2. Relation to Other Planning Documents

The purpose of a WMP is to identify improvements of the water distribution system necessary to meet existing and projected demands, and to develop a water facilities improvement program that will assist SAWCo in long-term planning and budgeting. Other documents were referenced during the preparation of the WMP, and this plan is likely to be relied upon when other planning documents are updated.

The following is a summary of other documents that are considered for SAWCo's water system planning and budgeting:

2015 and 2020 Urban Water Management Plans. The 2015 and 2020 Urban Water Management Plans (UWMPs) assess SAWCo's current and long-term sources of supply and complies with California State Department of Water Resources (DWR) criteria for water supply planning. The

UWMP and the WMP are complementary documents, with the UWMP focusing on source of supply and the WMP focusing on storage and distribution of the water.

2017 Water Master Plan. SAWCo's most recent WMP was completed in 2017 and was prepared by Civiltec Engineering, Inc. The 2017 WMP focused on the domestic distribution system and presents a capital improvement program with annual asset replacement costs, specific pipeline replacement projects, and recommendations for specific future developments.

2017 Water Rate and Fee Study. SAWCo's most recent Rate Study was completed in 2017 by Carollo Engineers and includes rate updates for water to accurately recover costs of providing service to the shareholders and stabilize revenue. This WMP analyses the current rates and expected annual revenues to develop an appropriate annual capital improvement budget.

1.3. Background Information

1.3.1. Location

SAWCo's Bylaws specify the service area is made up of a Basic Area and an Extended Area. The Basic Area generally coincides with the unincorporated community of San Antonio Heights located north of the City of Upland in San Bernardino County, shown in Figure 1-1. The Basic Area is bounded on the south by the City of Upland, on the north by the San Bernardino Mountains, on the west by the Los Angeles County Line and on the east by Cucamonga Creek. SAWCo provides retail service to all end users who reside in the Basic Area. The distribution system within the Basic Area is referred to as the Domestic System throughout this master plan.

The Extended Area includes all areas outside of the Basic Area, and predominantly includes wholesale shareholders. There are however a limited number of retail customers in the Extended Area including the Upland Hills Golf course, the Red Hill Golf Course, Redhill Homeowners Association, two rock companies and several grove irrigators. The distribution system in the Extended Area is referred to as the Irrigation System throughout this master plan.

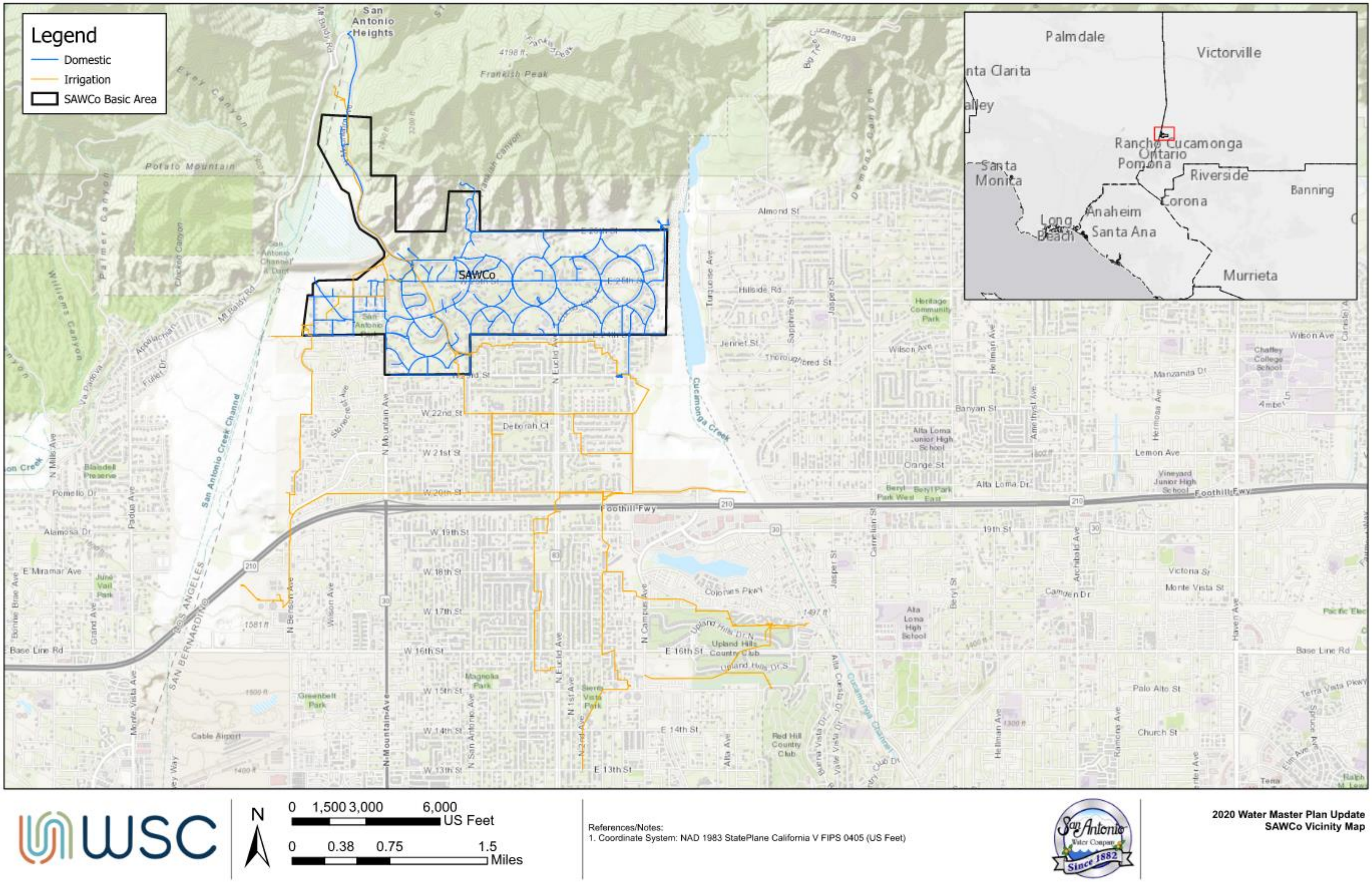


Figure 1-1. SAWCo Vicinity Map

1.3.2. Climate

SAWCo's service area is a semi-arid, Mediterranean environment with mild winters, warm summers, and moderate rainfall. Average monthly temperature ranges from 52 to 77 degrees Fahrenheit (°F), with an average annual temperature of 63 °F. The average annual precipitation at the San Antonio Dam was 22.6 inches between 1957 through 2015.

1.3.3. Population

SAWCo's basic area closely follows the boundaries of the census designated place of San Antonio Heights, which had a population of 3,371 in 2010 per the US Census (Datausa.io, 2017). At the time of this WMP, SAWCo was also developing its 2020 Urban Water Management Plan (UWMP). As part of the UWMP, SAWCo utilized the Department of Water Resources (DWR) 2020 UWMP Population Tool to estimate 2020 population. It was estimated that in 2020, SAWCo served a population of 3,303 people within the Basic Area. This is a slight decline from the 2010 population. According to the Southern California Association of Governments (SCAG), the population is expected to grow slowly through 2040. San Antonio Heights is primarily residential.

SAWCo also provides water for irrigation, industrial, agricultural, and wholesale in the extended area. Land use and planning in the extended area is under the jurisdiction of numerous cities and San Bernardino County.

1.3.4. Distribution System

SAWCo's domestic water distribution system is comprised of three (3) active, vertical groundwater wells, six (6) booster stations, and six (6) storage reservoirs that provide up to 6.8 million gallons (MG) of total storage. The system is divided into three (3) pressure zones and is composed of roughly 28 miles of distribution mains serving approximately 1,200 connections, most residential with a few commercial and institutional accounts.

SAWCo's irrigation water distribution system is comprised of eight (8) wells, one (1) booster station, and three (3) storage reservoirs that provide up to 2.25 MG. The irrigation system is composed of roughly 22 miles of irrigation mains.

1.3.5. Water Sources

SAWCo currently receives all its water supply from local sources including the San Antonio Creek, groundwater from the San Antonio Tunnel, and three groundwater basins: Chino Basin, Cucamonga Basin, and Six Basin. Surface water from San Antonio Creek are pre-1914 water rights, and annual water availability is influenced by rainfall. The San Antonio Tunnel is a deep rock tunnel 100 feet below ground surface that collects naturally percolated groundwater. The three groundwater basins are each adjudicated, and SAWCo's has water rights as defined by the various legal Judgements in place to protect and manage each basin. SAWCo also participates in groundwater recharge operations that enhance groundwater supply.

WATER MASTER PLAN

2.0 Existing System and Evaluation Criteria

This Section describes SAWCo's water distribution systems and evaluation criteria. SAWCo owns and operates two distribution systems: the domestic system and the irrigation system. The domestic system serves potable water to residences in San Antonio Heights and the irrigation system delivers raw water to customers and nearby agencies. The two systems operate independently of each other.

IN THIS SECTION

- System Components
- System Evaluation Criteria

2.1 System Components

SAWCo's potable water system includes four (4) pressure zones, three (3) active wells, six (6) booster pump stations (BPS), six (6) storage reservoirs, and approximately 28 miles of distribution mains. SAWCo's irrigation system includes eight (8) active wells, one (1) BPS, three (3) storage reservoirs, and about 22 miles of irrigation mains. Table 2-1 summarizes the domestic distribution system by zone and Table 2-2 summaries the irrigation system. A map of the entire SAWCo system is provided in Figure 2-1.

Table 2-1. Domestic System Summary

Distribution Zone	HGL (ft)	Supply		Gravity Storage	
		Source	Booster Station	Reservoir	Capacity (MG)
Holly Drive	2,675	---	Booster #19	Holly Tank A Holly Tank B[1]	0.12 0.12
High Zone	2,400	San Antonio Tunnel	Booster #14 Booster #16[3] Booster #20[3]	Reservoir 5 Reservoir 6	0.1 1.0
Low Zone	2,207	Well 15 Well 16 Well 32[2]	Booster #18	Reservoir 7 Reservoir 12	0.5 5.0
Canyon	2,714	High Zone	Booster #17	---	---

Notes:

[1]To be constructed in 2023.

[2]Well 32 may discharge directly into the Low Zone or pumped into Reservoir 12.

[3]Pump from the Low Zone to Reservoirs 5 and 6 for gravity storage.

Table 2-2. Irrigation System Summary

Distribution Zone	Supply		Gravity Storage	
	From	Booster Station	Reservoir	Capacity (MG)
Irrigation System	San Antonio Creek Well 2 Well 3 Well 22 Well 24 Well 25A Well 26 Well 27 Well 31	Booster #1	Reservoir 1 Reservoir 4 Reservoir 9	1.0 0.75 0.5

SAWCo serves water over a range of elevations from 1,360 feet to 2,520 feet above MSL. SAWCo uses BPSs to increase and maintain pressure as needed throughout the system. A hydraulic profile of the domestic distribution system is shown in Figure 2-2 and the irrigation distribution system in Figure 2-3.

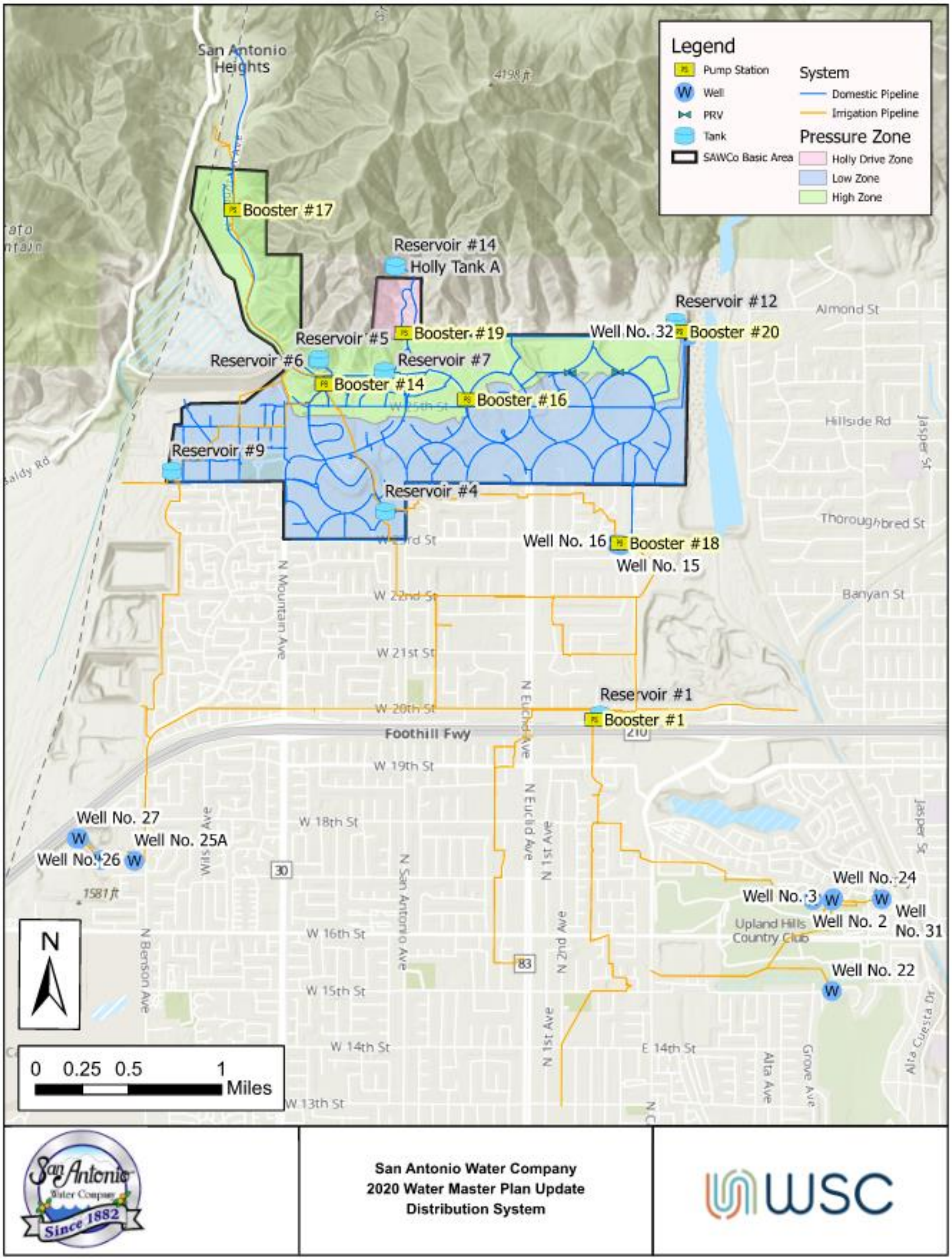


Figure 2-1. Distribution System

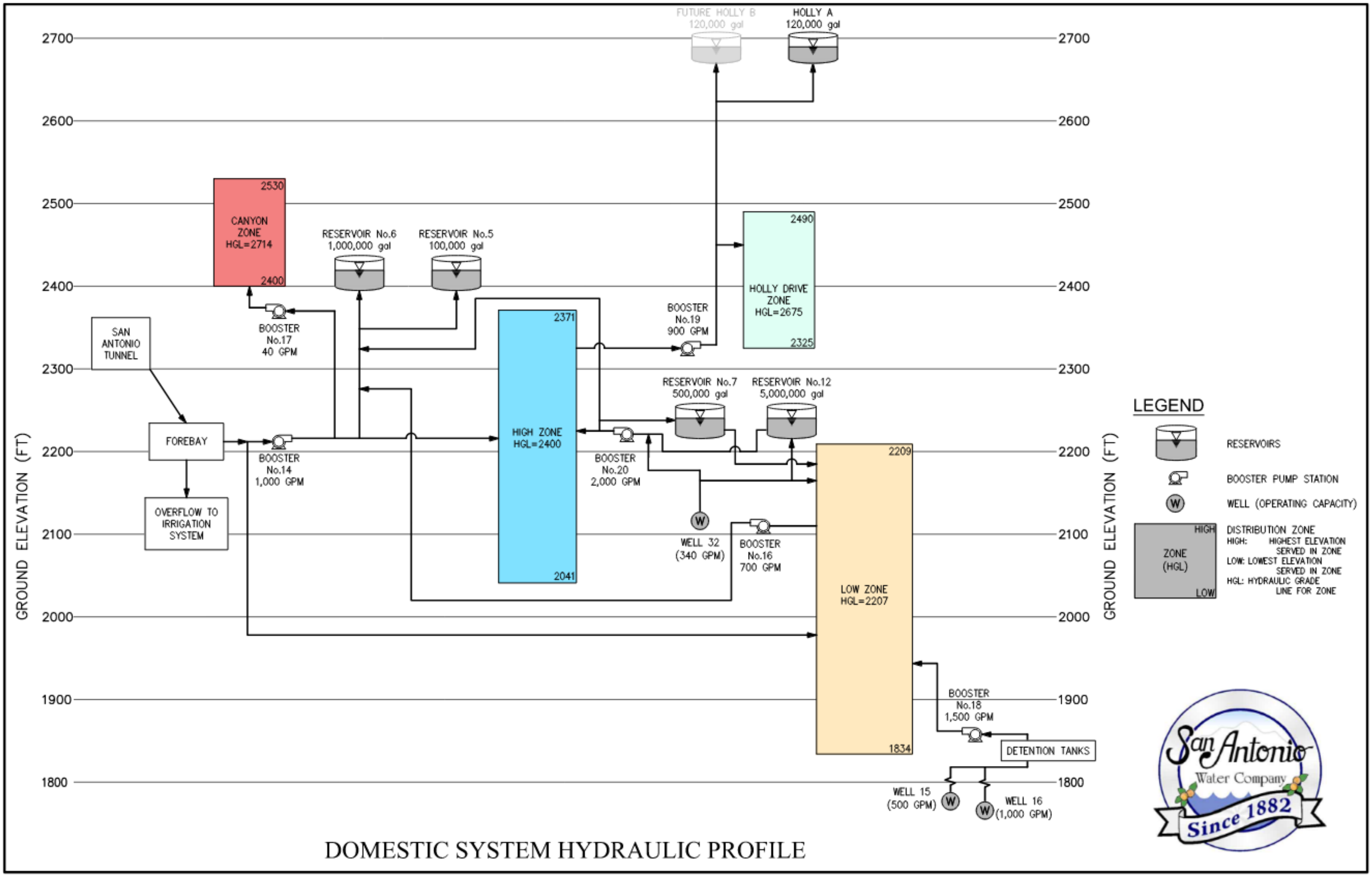


Figure 2-2. Domestic System Hydraulic Profile

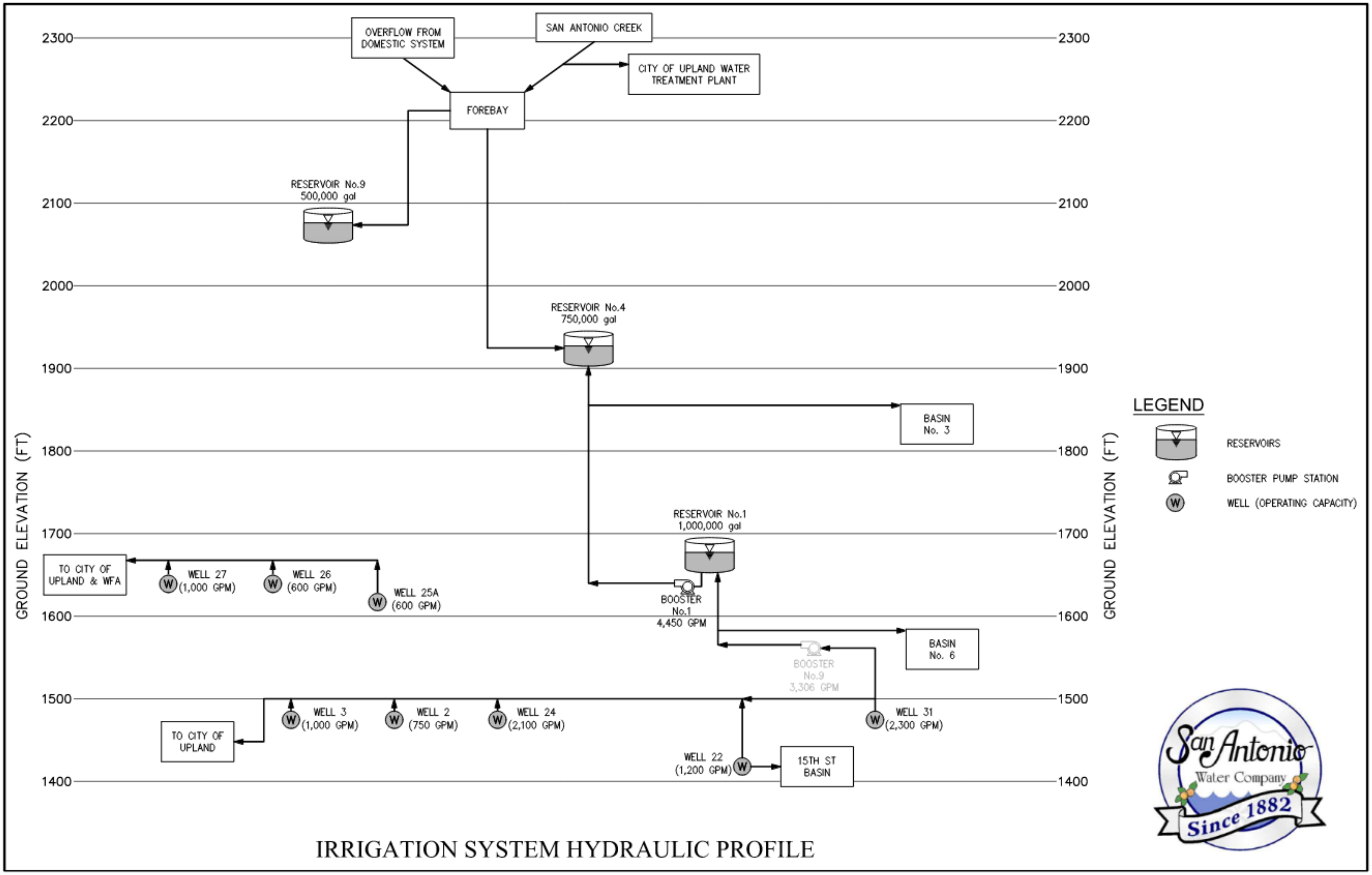


Figure 2-3. Irrigation System Hydraulic Profile

Each distribution zone's supply sources and associated facilities are described below:

Holly Zone: The Holly Zone begins at Holly Drive and 26th Street. The Holly Zone is served by a 0.12 MG reservoir constructed in late 2021. SAWCo plans to construct one more 0.12 MG reservoir in 2023. Booster #19 pumps water from the High Zone into the Holly Drive Zone and reservoirs. The Holly Zone has been identified as an area for potential development.

High Zone: The High Zone is supplied by three boosters, #14, #16 and #20. Booster #14, pumps San Antonio Tunnel water from the Forebay into the High Zone while both Booster #16 and Booster #20 pump from the Low Zone into Reservoir 5 for gravity storage. The High Zone contains two pressure reducing valve (PRV) stations that reduce pressures from the High Zone to serve the Low Zone. The PRV stations are located on Prospect Ave/Vista Drive and Cliff Road/Euclid Crescent East. The PRV at Cliff Road and Euclid Crescent East serve an isolated area: Thunder Mountain Road, Cypress Drive, and portions of Euclid Crescent East and Cliff Road. The High Zone also supplies the Canyon Zone through Booster #17.

Low Zone: The Low Zone is the largest zone within SAWCo's system. It is located at the southern part of the distribution system. The Low Zone is supplied by the San Antonio Tunnel by gravity, and Wells 15 and Well 16 supplement supply when demands are greater than Tunnel supply. Booster #18 pumps chlorinated water from Wells 15 and 16 into the Low Zone directly into the distribution system or into storage within Reservoirs 7 or 12. Well 32 is directly connected to the Low Zone and can pump chlorinated water into the Low Zone as well.

Canyon Zone: The Canyon Zone is supplied from the High Zone through Booster #17, which includes two 5 horsepower (HP) boosters that supply a small pressurized captive system to two residential services and the United States Forestry Station.

Irrigation System: The irrigation system is supplied by Wells 2, 3, 22, 24, 25A, 26, 27, and 31. Well 22 is used primarily to serve the (Redhill Country Club and can be used to serve the) City of Upland. The irrigation system contains three storage reservoirs: 1, 4, and 9. Booster #1 can be used to offset water deliveries due to system demand or flow issues. The irrigation system also contains one out of operation BPS (Booster #9).

2.1.1 Existing Supply Sources

SAWCo relies entirely on local surface water and groundwater supply sources through a diversion along the San Antonio Creek, groundwater infiltrated and conveyed through the San Antonio Tunnel, and 11 groundwater wells within three groundwater basin areas: the Six Basins, Cucamonga Basin, and Chino Basin. This section describes SAWCo's existing supplies and water rights.

SAWCo's surface water rights from the San Antonio Creek are pre-1914 water rights and have been supported by Court Judgements per a confidential report entitled "Opinion Re Water Rights of San Antonio Water Company," dated June 1993, prepared by the law firm of Lagerlof, Senecal, Drescher & Swift (Senecal Report). Water is diverted along the creek and apportioned to both SAWCo and the City of Pomona Utility Service Department (Pomona). SAWCo has rights to all the diverted water up to flows above 21.5 Miner's Inches (approximately 200 gpm), and then the diversion is split 60 percent to SAWCo and 40 percent to Pomona. During high flows, Pomona's allocations caps at 312 Miner's Inches (2,915 gpm) and additional flows are allocated to SAWCo up to its maximum allocation. SAWCo diverts some of its surface water to spreading grounds north of the San Antonio Tunnel, where it percolates into the tunnel and is conveyed to the distribution system. Surface water downstream of the spreading grounds is provided to the City of Upland where it is treated at their San Antonio Water Treatment Plant before entering the City's distribution system or delivered directly to minor irrigators, aggregate companies, golf courses, or used for ground water recharge.

The San Antonio Tunnel is a deep rock 6-foot by 6-foot rectangular tunnel located 100 feet below ground surface and is supported by redwood beans and solid rock. SAWCo has rights to all the water in the tunnel, which is limited by the available supply and physical capacity of the tunnel. Groundwater naturally percolates into the tunnel. Supply from the tunnel flow can vary greatly year to year depending on annual rain and snow.

The SAWCo service area overlaps the convergence of the Six Basins, Cucamonga Basin, and Chino Basin, shown in Figure 2-4. The Six Basins is bounded by the San Jose Hills to the south, Chino Basin to the east, the San Gabriel Mountains to the north, and the San Gabriel Basin to the west. It comprised of six adjacent groundwater basins including the Four Basins (Pomona Basin, Canyon Basin, Upper Claremont Heights Basin, and Lower Claremont Heights Basin) and the Two Basins (Ganesha Basin and Live Oak Basin). SAWCo's groundwater wells overly the Upper Claremont Heights Basins and SAWCo owns the right to produce 7.166-percent of the operating safe yield (OSY) of the Four Basins set forth in the Six Basins Judgment (Six Basins Judgment, 1998). The OSY is determined annually by the Six Basins Watermaster and tracks the annual water rights accounting for each user, which includes the annual rights based on OSY, any carryover water from the previous year, and the storage balance.

The Cucamonga Basin is bounded by the Chino Basin to the south and east, the Red Hill Fault to the west, and by the San Gabriel Mountains to the north. In 1958 a stipulated Cucamonga Basin Judgment specified water rights for individual groundwater producers, how much can be exported to non-overlaying areas, and specific requirements for spreading (Cucamonga Basin Judgment, 1958). There is currently no annual report prepared to document the implementation of the Judgment or accounting of the basin. The Judgment stipulates SAWCo's water production right is 6,500 AFY if they spread 2,000 AFY of imported water from the San Antonio Canyon. If the annual spreading is less than 2,000 AFY, the water rights also diminish to a minimum amount of 4,500 AFY. However, if the spreading exceeds 2,000 AFY, SAWCo can credit 95% of the excess up to a maximum of 8,500 AFY production.

The Chino Basin is one of the largest groundwater basins in Southern California. The basin contains approximately 5,000,000 acre-feet (AF) of water and has an unused storage capacity of approximately 1,000,000 AF. The Chino Basin consists of approximately 235 square miles of the upper Santa Ana River watershed and lies within portions of San Bernardino County, Riverside County, and Los Angeles County. SAWCo overlies a small portion of the basin in its northwest region. The groundwater pumping and storage rights in the Chino Basin were adjudicated pursuant to the Original Judgment in Chino Basin Municipal Water District vs. City of Chino et al (Judgment) in 1978. The Judgment also established the Chino Basin Watermaster to administer and enforce the provisions of the 1978 Judgment. The 1978 Judgement allocates water based on the OSY of the basin to three separate pools: the Overlying Agricultural Pool, Overlying Non-Agricultural pool, and the Appropriative Pool. SAWCo belongs to the Appropriative Pool and has a right to 2.748-percent of the total appropriate rights in the Chino Basin. The OSY of the basin was updated in 2020 and is currently 131,000 AFY. Based on the current OSY, SAWCo's appropriative right in the Chino Basin is 1,232 AFY.

Table 2-3 below summarizes SAWCo's existing supplies and water rights.

Table 2-3. SAWCo's Water Supply and Rights

Supply Source	Water Rights (AFY)
San Antonio Creek	Up to 13,864[1]
San Antonio Tunnel	2,500[2]
Six Basins	932.1[3]
Cucamonga Basin	5,996[4]
Chino Basin	1,232[5]

Notes:

[1] Based on the maximum diversion allowed year-round per the confidential Senecal Report. Actual right to divert water is limited based on total stream flow and is on average 4,300 AFY.

[2] Average supply, the water rights in the San Antonio Tunnel are not limited.

[3] Water rights determined annually by the Six Basins Watermaster based on OSY, carryover, and storage balance. Value listed is as of January 1, 2020.

[4] Minimum right to 4,500 AFY. Production can increase if water is spread in the basin from San Antonio Canyon to a maximum amount of 8,500 AFY.

[5] Based on the 2020 OSY.

SAWCo operates 11 vertical wells within the local groundwater basins that supply the distribution systems. Three wells (Well 15, Well 16, and Well 32) feed the domestic distribution system and meet all drinking water quality requirements. The additional eight wells serve the irrigation distribution system. SAWCo uses the groundwater wells to supplement flows from the San Antonio Creek and Tunnel to meet system demands. Table 2-4 summarize the active production wells, and their location in each groundwater basin is shown in Figure 2-4.

In addition to the supply sources listed above, SAWCo has two existing interties with the City of Upland that can be used to feed the Low Zone if needed. Each intertie is supplied from a metered 6-inch main and has a rated capacity to provide 500 gpm.

Table 2-4. Active Production Well Summary

Well	Water System	Ground-water Basin	Year Drilled	Motor Size (HP)	Design Production Capacity (gpm)	Observed Production Capacity (gpm)	Date Measured
Well 15	Domestic	Chino	1924	100	500	401	02/08/2018
Well 16	Domestic	Chino	1988	200	1,000	989	01/25/2018
Well 32	Domestic	Cucamonga	1987	60	340	287	04/11/2018
Well 2	Irrigation	Cucamonga	1924	150	750	801	08/08/2019
Well 3	Irrigation	Cucamonga	1924	150	1,000	1,164	02/01/2018
Well 22	Irrigation	Cucamonga	1931	200	1,200	1,890	02/08/2018
Well 24	Irrigation	Cucamonga	1947	350	2,100	2,627	08/08/2019
Well 25A	Irrigation	Six Basins	1958	125	600	301	09/22/2016
Well 26	Irrigation	Six Basins	1956	150	600	366	08/29/2019
Well 27	Irrigation	Six Basins	2001	150	1,000	515	08/08/2019
Well 31	Irrigation	Cucamonga	1957	360	2,300	1,887	02/01/2018
				Total	**11,390**	**11,228**	

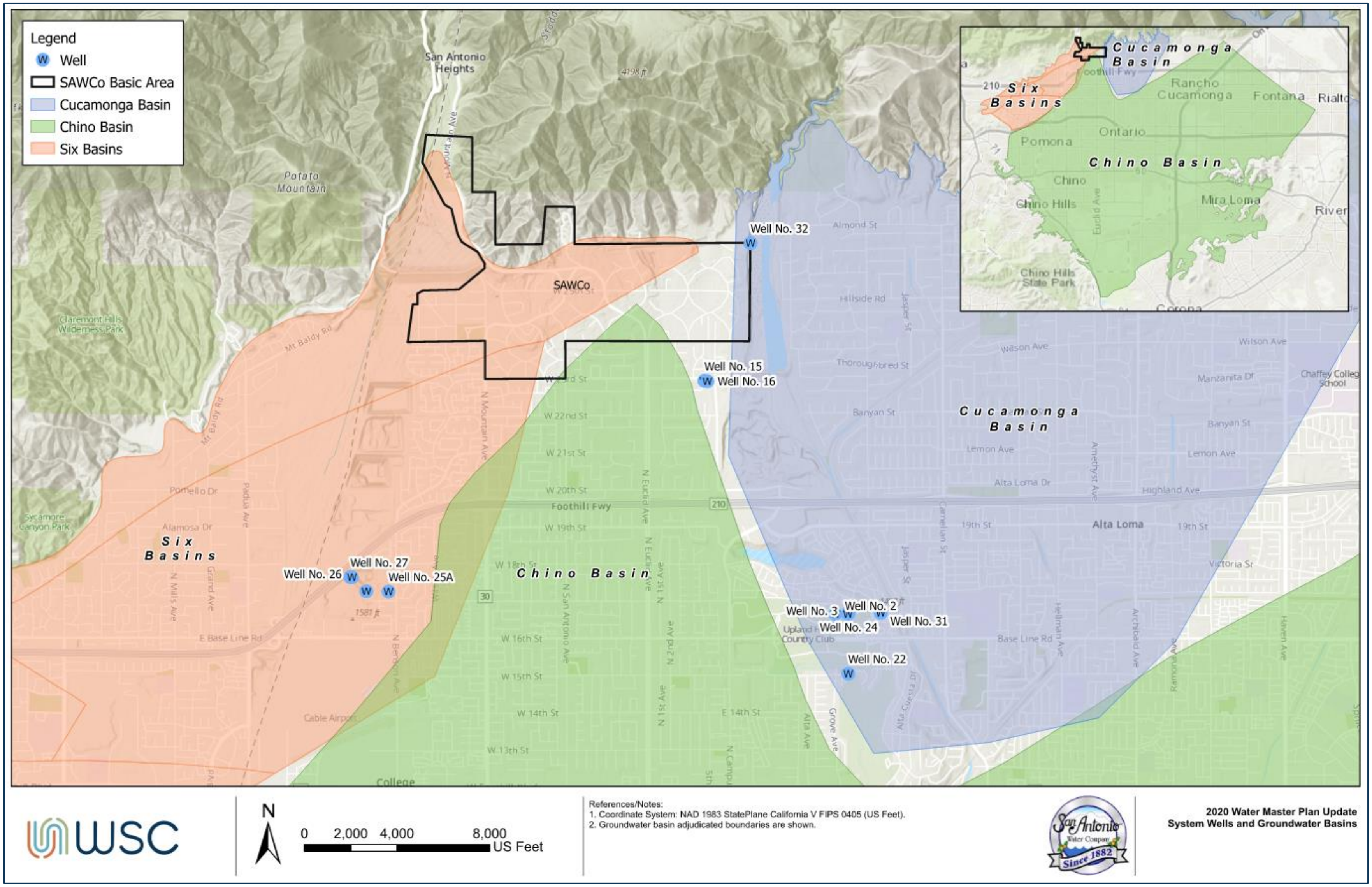


Figure 2-4. SAWCo Wells and Groundwater Basins

2.1.2 Booster Pump Stations

SAWCo maintains and operates six (6) BPSs within the domestic water distribution system, summarized in Table 2-5. Each pump station contains one or two pumps. SAWCo also owns two (2) BPSs within the irrigation system and described in Table 2-6. Figure 2-5 shows the location of the BPSs.

Table 2-5. Domestic System Booster Pump Station Summary

Booster Pump Station	Year Built	Pump	Pump Make and Model	Design Capacity	Design Total Head	Motor Size (HP)	Zone Pumping From/To
Booster #14 Forebay	2013	Booster 1 Booster 2	Peerless Vertical – 10MA	500 gpm 500 gpm	300 ft 300 ft	50 50	Tunnel Water/ High Zone
Booster #16 Euclid	2000	Booster 1 Booster 2	Armstrong 10-L-30	350 gpm 350 gpm	216 ft 216 ft	25 25	Low Zone/ High Zone
Booster #17 V-Screen	1950	Booster 1 Booster 2	Goulds e-SV 10SV6FB30	53 gpm 53 gpm	135 ft 135 ft	5 5	High Zone/ Canyon Boosted Area
Booster #18 Station 18	2004	Booster 2	Unknown	1,500 gpm	989 ft	125	Well 15 and Well 16/ Low Zone
Booster #19 Holly Drive	1982	Booster 1 Booster 2	Fairbanks 10M.4	450 gpm 450 gpm	296 ft 296 ft	41.5 41.5	High Zone/ Holly Drive Zone
Booster #20 26th Street	2007	Booster 1 Booster 2	Goulds Lineshaft 60 Hz 11CHC	1,000 gpm 1,000 gpm	235 ft 235 ft	75 75	Reservoir #6, Well 32, and Low Zone/ High Zone

Table 2-6. Irrigation System Booster Pump Station Summary

Booster Pump Station	Year Built	Pump	Design Capacity	Design Total Head	Motor Size (HP)
Booster #1 20th Street	2007	Booster 1	2,225 gpm	275 ft	200
		Booster 2	2,225 gpm	275 ft	200
Booster #9 16th Street[1]	1949	Booster 1	1,034 gpm	184 ft	60
		Booster 2	658 gpm	177 ft	50
		Booster 3	1,614 gpm	267 ft	150

[1] Booster #9 is currently inactive.

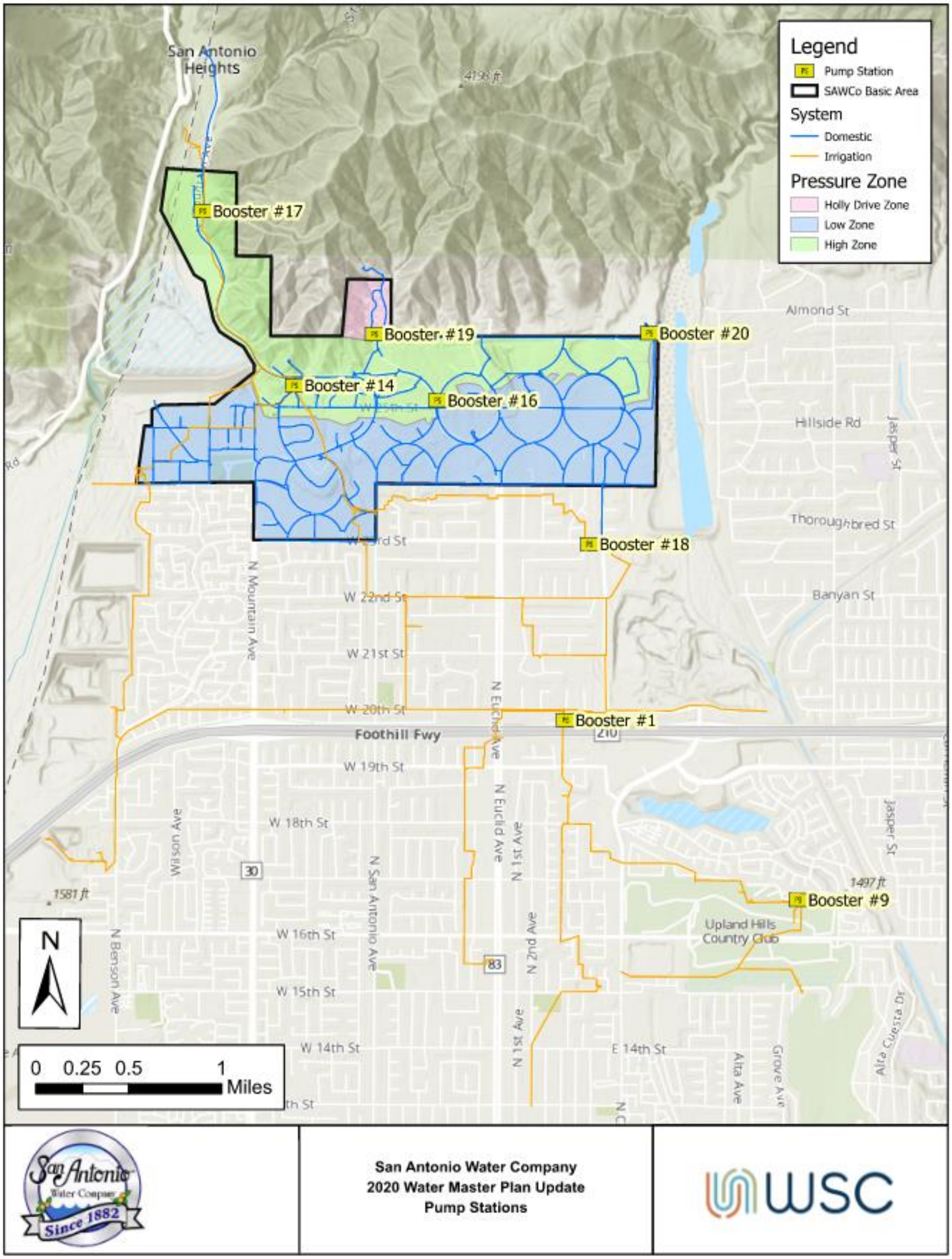


Figure 2-5. Booster Pump Stations

2.1.3 Storage

SAWCo's domestic system contains six (6) storage reservoirs that provide operational, emergency, and fire flow (FF) storage for the distribution system. The total storage capacity for the domestic system is 6.8 MG. SAWCo plans to construct an additional reservoir (Holly Drive B) in 2023. The total domestic system capacity includes the capacity of the Holly Drive B reservoir.

The irrigation system includes three (3) reservoirs for operational storage only, with a total storage capacity of 2.25 MG. Table 2-7 summarizes the storage reservoir characteristics and Figure 2-6 shows reservoir locations.

Table 2-7. Storage Reservoir Summary

SYSTEM	RESERVOIR NAME	YEAR BUILT	MATERIAL	GROUND ELEVATION (FT)	TANK DIAMETER (FT)	TANK HEIGHT (FT)	CAPACITY (MG)
DOMESTIC	Reservoir 5	2011	Steel	2,375	23	32	0.1
	Reservoir 6	1970	Steel	2,375	73	32	1
	Reservoir 7	1950	Concrete	2,206	75	15	0.5
	Reservoir 12	1983	Steel	2,171	163	32	5
	Holly Drive A	2021	Steel	2,667	40	10.5	0.12
	Holly Drive B	2023	Steel	2,667	40	10.5	0.12
	TOTAL DOMESTIC SYSTEM CAPACITY[1]						**6.84**
IRRIGATION	Reservoir 1 20th Street	1930	Concrete	1,646	130	10	1
	Reservoir 4 23rd Street	1951	Concrete	1,907	100	12	0.75
	Reservoir 9 Euclid Extension	1956	Concrete	2,041	73	16	0.5
	TOTAL IRRIGATION SYSTEM CAPACITY						**2.25**

[1] Holly Drive B is planned to be constructed in 2023. Total Domestic System Capacity includes Holly Drive A and Holly Drive B.

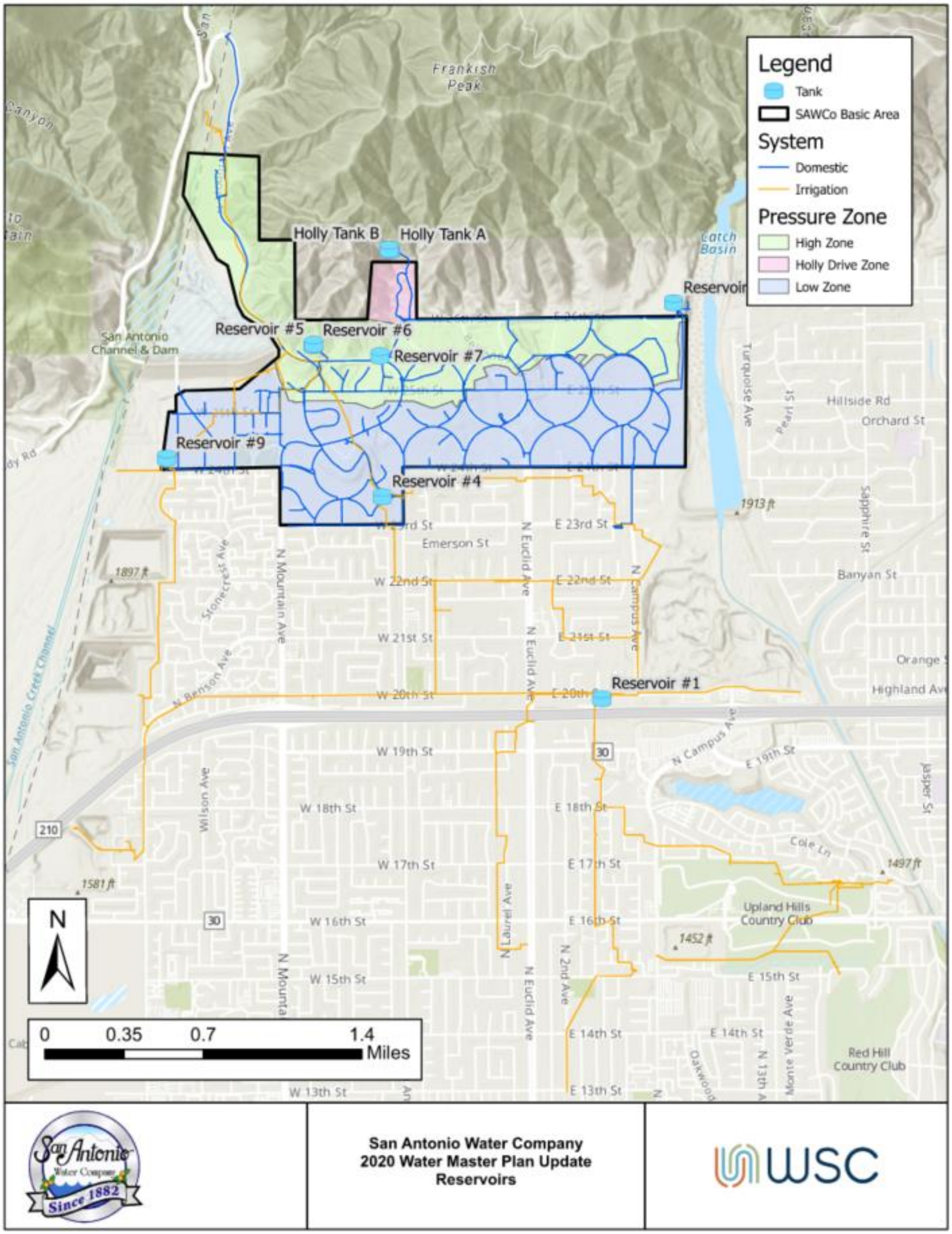


Figure 2-6. Reservoirs

2.1.4 Distribution and Transmission Mains

SAWCo's water distribution systems consist of approximately 50 miles of active distribution and transmission mains, which includes 28 miles in the domestic system and 22 miles in the irrigation system. Table 2-8 summarizes the length of pipe based on pipe diameter. Pipeline information was extracted from SAWCo's Geographical Information System (GIS) database, which includes the most up-to-date and accurate inventory of the SAWCo distribution system.

Table 2-8. Distribution and Transmission Main Summary

DIAMETER	DOMESTIC SYSTEM (FEET)	IRRIGATION SYSTEM (FEET)
2-inch	5,286	-
4-inch	13,516	570
6-inch	39,168	-
8-inch	28,720	11,271
10-inch	6,449	3,992
12-inch	43,265	9,393
14-inch	2,679	20,386
16-inch	1,680	36,467
18-inch	-	19,544
20-inch	-	6,203
22-inch	-	1,923
24-inch	1,523	7,893
30-inch	5,371	277
36-inch	1,580	84
TOTAL (FEET)	**149,238**	**118,003**
TOTAL (MILES)	**28.3**	**22.3**

2.1.5 Water Quality

SAWCo delivers high quality potable waters to its shareholders that meets all the Federal and State Drinking Water Standards. The irrigation system water is not subject to drinking water standards but is subject to salinity and nutrient water quality requirements set by the Santa Ana Regional Water Quality Control Board. Water utilities in California are required to provide an annual report to their customers that summarizes the water quality and explains important issues regarding their drinking water. Table 2-9 contains SAWCo's water quality reported in the 2021 Consumer Confidence Report (San Antonio Water Company, June 2022).

Table 2-9. 2021 Consumer Confidence Report

CONTAMINANT	UNIT	MAXIMUM CONTAMINANT LEVEL	AVERAGE DETECTED LEVEL
MICROBIAL			
Total Coliform Bacteria	% positive	0	0
Fecal Coliform & E. Coli	# positive	0	0
RADIONUCLIDE			
Gross Alpha Activity	pCi/L	15	2.75
Uranium	pCi/L	20	3.15
INORGANIC			
Fluoride	ppm	2	0.47
Lead	ppb	15	Non-Detect
Nitrate (NO_3)	ppm	10	2.8
Vanadium	ppb	No Standard	1.65
ADDITIONAL PARAMETERS			
Bicarbonate	ppm $CaCO_3$	No Standard	220
Calcium	ppm	No Standard	62.5
Chloride	ppb	500	8.75
Hardness ($CaCO_3$)	ppm	No Standard	205
Magnesium	ppm	No Standard	11.45
Odor-Threshold	Units	No Standard	1.0
pH	Units	No Standard	7.75
Aggressive Index		No Standard	11.96
Iron	ppb	No Standard	0.13
Alkalinity	ppm	No Standard	185
Potassium	ppm	No Standard	1.15
Sodium	ppm	No Standard	10.95
Specific Conductance	microohms	1600	430
Sulfate	ppm	500	23.5
Total Dissolved Solids	ppm	1000	265
Turbidity	NTU	TT	0.495
Total Trihalomethanes (TTHM)	ppb	80	2.8
Halo acetic Acids five (HAA5)	ppb	60	1.1
Perchlorate	ppb	6	Non-Detect
1,2,3 TCP	ppb	0.005	Non-Detect

Units: ppm = parts per million, ppb = parts per billion

2.2 System Evaluation Criteria

This section presents the desired performance criteria for the water distribution system that will be used to analyze the system and generate recommendations for improvements.

Water system criteria were developed from California Waterworks Standards, SAWCo Standards and preferences, California Fire Code, and engineering judgment. The evaluation criteria for the water system have been organized into two categories: System Reliability (Table 2-10) and System Capacity (Table 2-11) and defined for the domestic distribution system and the irrigation distribution system. System reliability criteria is generally consistent between both distribution systems, but capacity criteria vary between the two systems because the domestic system includes capacity for fire flows, while the irrigation system does not.

Table 2-10. System Reliability Evaluation Criteria

PURPOSE	REGULATION OR REFERENCE	ENGINEERING AND PLANNING CRITERIA - DOMESTIC SYSTEM & IRRIGATION SYSTEM
Reliable Supply	California Waterworks Standards	Calculate reliable supply by determining system capacity with SAWCo's largest source out of service.
Source/ Production Capacity	California Waterworks Standards	System must be able to meet Maximum Day Demand (MDD) with source capacity only, considering the reliability requirements identified above. System must be able to meet four hours of Peak Hour Demand (PHD) with source capacity and storage capacity. Combined production capacity sufficient to refill emergency and fire storage in 48 hours with all sources operating.
Pump Station Capacity / Zone Reliability	California Waterworks Standards; Accepted Engineering Practices	If gravity storage is available, pump station capacity must be able to meet MDD within the zone with the largest pump out of service. If gravity storage is not available, pump station capacity must be able to meet MDD plus fire flow (FF) or PHD, whichever is greater, with the largest pump out of service.
Emergency Power	Recommended Standards for Water Works	Emergency power must be sufficient to meet system average day demands and preparedness for other emergencies.
Pump Efficiency	SAWCo Preference; Accepted Engineering Practices	If pump efficiency falls below 65%, it becomes a candidate for maintenance and/or replacement to increase efficiency.
Fire Hydrant spacing	Engineer's Judgment and SAWCo Preference	At intervals not more than 330 feet, with no hydrants at the end of cul-de-sacs. Dead-ends without a hydrant shall have a blow-off installed (Applies only to the domestic system).
Valving	Engineer's Judgment and SAWCo Preference	No shut down of greater than 10 services on domestic system. Irrigation system valving at all pipeline intersections and services.

Table 2-11. System Capacity Evaluation Criteria

PURPOSE	REGULATION OR REFERENCE	ENGINEERING AND PLANNING CRITERIA - DOMESTIC SYSTEM	ENGINEERING AND PLANNING CRITERIA - IRRIGATION SYSTEM
DISTRIBUTION SYSTEM			
System Pressure	California Waterworks Standards and SAWCo Preference	40 psi minimum and 120 psi maximum under normal conditions (1) 150 psi during minimum hour demands 20 psi minimum residual at MDD plus FF	20 psi minimum and 120 psi maximum under normal conditions
Fire Flows	California Fire Code (Appendix B)	Residential – 1,500 gpm for two hours	N/A
Pipeline Velocities	Engineer's Judgment and SAWCo Preference	Less than or equal to 7 feet per second (fps) at MDD Less than 11 fps at FF plus MDD condition	Less than or equal to 7 feet per second (fps) at MDD
New Distribution Mains	Engineer's Judgment and SAWCo Preference	All new water mains must be 8-inch or greater	Size for new water mains will be based on system demands and velocity requirements
STORAGE			
Operational Storage	SAWCo Preference	30% of MDD for all zones with storage or 4 hours of PHD (whichever is larger)	30% of MDD
Fire Flow Storage	California Fire Code and County of San Bernardino Fire Prevention Office	Sufficient storage is required to meet fire flows	N/A
Emergency Storage	AWWA M19 Emergency Planning for Water Utilities and SAWCo Preference	24 hours at MDD	N/A

Notes:
Any service with pressure greater than 80 psi should have a shareholder owned pressure regulator after the meter.

WATER MASTER PLAN

3.0 Demand Projections

This section summarizes the historic, current, and projected water system demands. Based on the current system's population and projected growth rates, water demands are not anticipated to increase significantly through buildout, which is expected to occur in 2030.

IN THIS SECTION

- Current Demand
- Growth and Demand Projections
- Peak Demands

3.1 Current Demand

SAWCo provided metered water deliveries and production from 1991 through 2020 which were used to establish historical and current annual demand. Water consumption records include billed, metered water delivered to shareholders. Water production includes the total water measured entering the distribution systems from each supply source. Water demand is equal to the volume of water produced, which includes water consumption and non-revenue water (NRW). NRW includes water loss, either physically from leaking pipes, overflows at facilities, or as apparent losses resulting from meter inaccuracies. NRW varies significantly, and in some years, NRW was clearly influenced by meter inaccuracies. Domestic water, if not delivered to shareholders, is made available as additional supply to the irrigation system to avoid substantial water losses.

Figure 3-1 and Figure 3-2 illustrate the past demand within SAWCo's domestic and irrigation systems, respectively. The irrigation system demands include deliveries to customers and water SAWCo delivered to spreading basins for percolation.

Current demand was used as the baseline for future demand within SAWCo's system. Low demands in 2015-2016 are attributed to conservation during the most recent drought. Water use patterns in the domestic system have since recovered and are expected to remain flat in the future. In addition, majority of SAWCo's service area is built out with limited opportunity for growth. Anticipated growth is discussed later in this section.

Historically, irrigation demand has varied more than domestic demands. The variations in irrigation demand are likely dependent on the water year and amount of rainfall received within the region. Surface water deliveries to spreading basins are also highly dependent on rainfall and stream flows.

Over the last few years, SAWCo has focused on mitigating water losses. Based on historical data, it is clear that SAWCo experienced meter inaccuracies throughout the system. Investigation helped SAWCo locate areas where water losses occur. SAWCo identified substantial meter errors at a flow meter at the Basin 6 settling ponds. In early 2021, SAWCo fixed this meter, and since then, water losses have remained consistent. Based on data for January through April 2021, water losses have been recorded as 0.9% within the domestic system and 1% within the irrigation system. For future demand projections, the NRW is estimated as 1% of production.

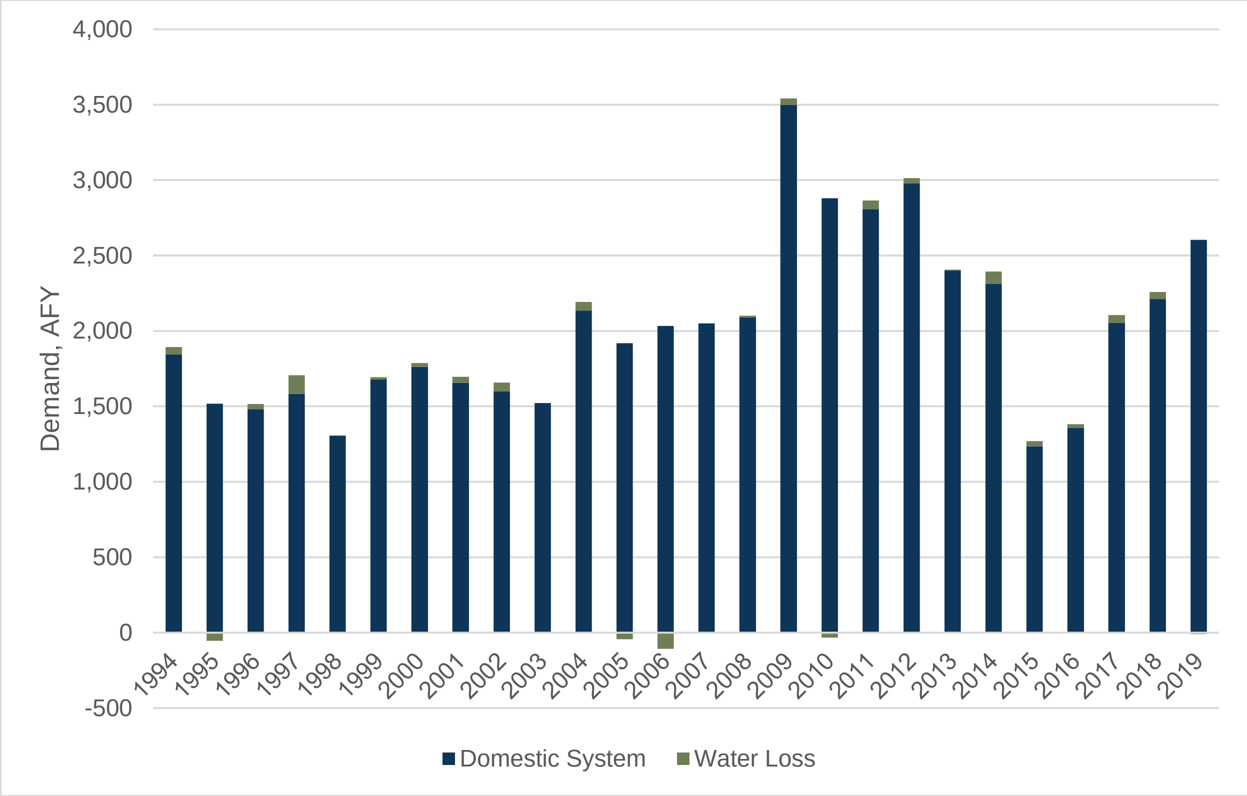


Figure 3-1. Historical Domestic System Demand

Negative values of water loss attributed to meter inaccuracies and have since been resolved.

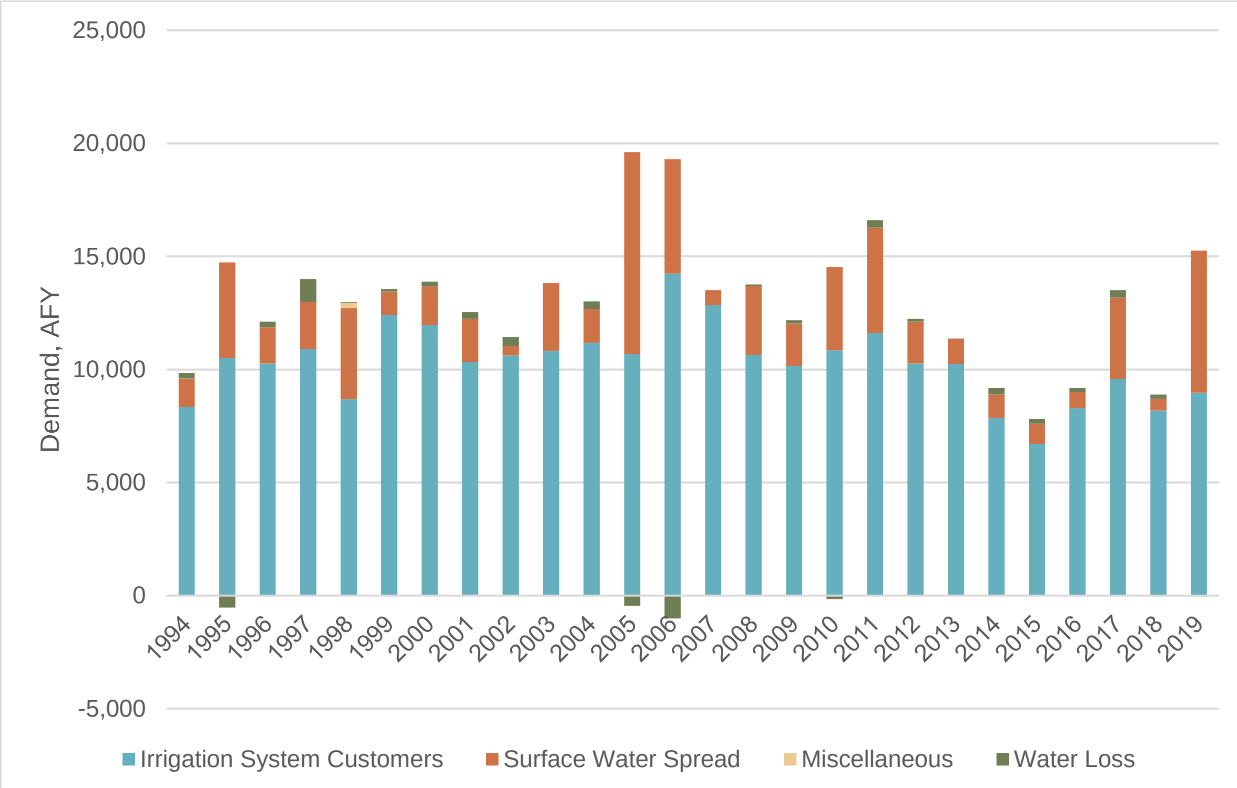


Figure 3-2. Historical Irrigation System Demand

Negative values of water loss attributed to meter inaccuracies and have since been resolved.

3.1.1 Assigning Demand to the Hydraulic Model

Spatially allocated demands were established based on historical annual water customer billing data for 2019 and production data from SAWCo's records and GIS parcel data. The billing data provided also contained Assessor's Parcel Numbers (APNs) for each customer and/or addresses which were used to identify the location of each demand. San Bernardino County parcel data was added as a shapefile and the centroid of each parcel was calculated using GIS tools and exported to Microsoft Excel. Using the APN field from SAWCo's billing data, customer data was matched with San Bernardino County parcel data (parcel centroid x and y coordinates). With the customer consumption matched to parcel information, the domestic demands were loaded into the model using the Demand Allocation Manager with a closest pipe relationship. This relationship automatically identifies the closest pipe to each meter and distributes the meter's demand to the junctions at either end of the pipe. The customer meter's assigned junction was manually checked for errors, especially near zone boundaries, and corrected as needed.

Several irrigation customers receive deliveries at multiple locations. To determine the amount of demand at each location, SAWCo provided addresses for each meter. The addresses were matched to San Bernardino County parcel data to determine the APN and coordinates. Irrigation demands were also loaded using a closest pipe relationship. The customer meter's assigned junction was manually checked for errors, especially near zone boundaries, and corrected as needed.

Figure 3-3 shows the spatially allocated demands loaded in the hydraulic model.

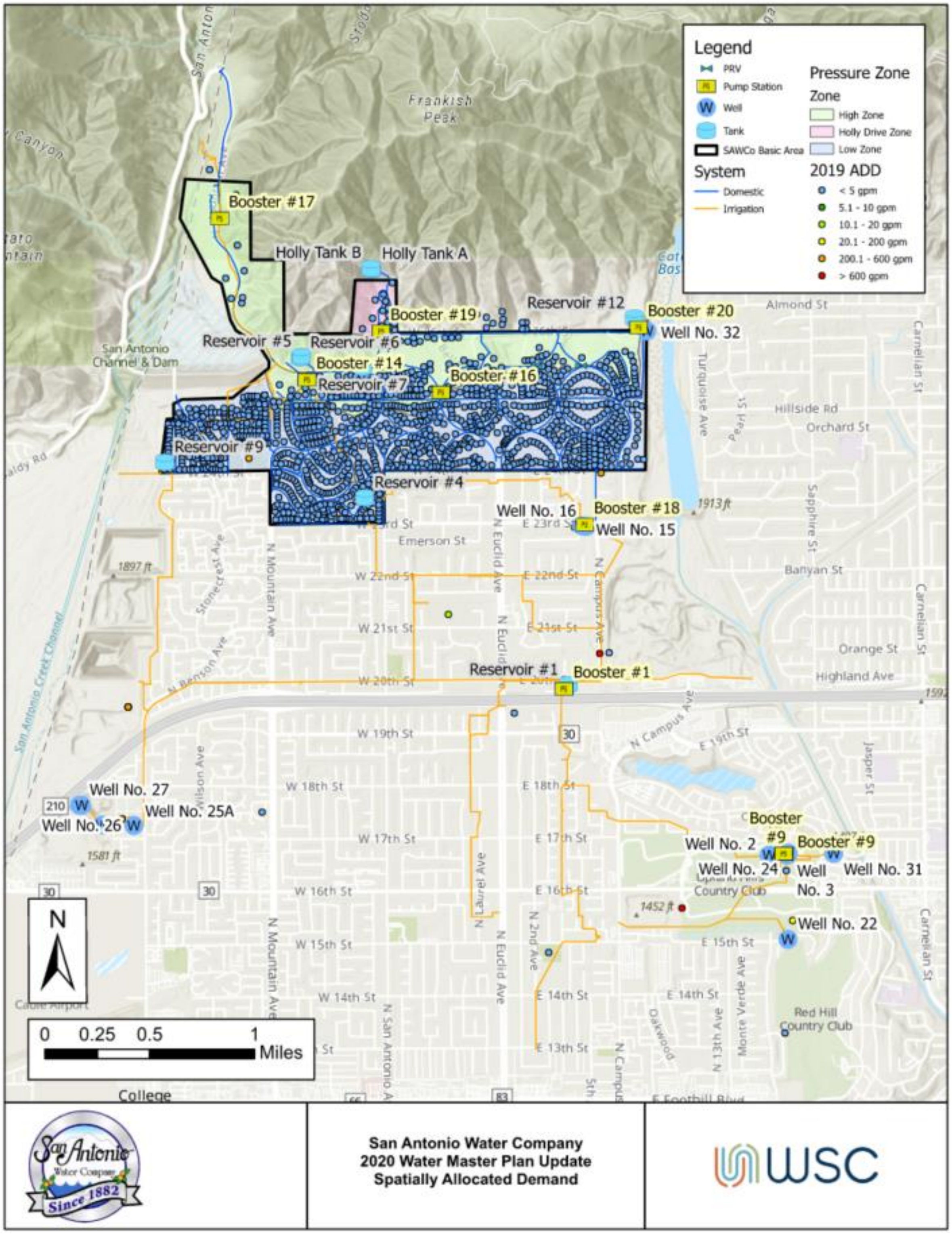


Figure 3-3. Spatially Allocated Demand within the Hydraulic Model

3.2 Growth and Demand Projections

Once current water demands were established and spatially allocated, additional growth and demands were assessed. SAWCo is expected to minimally increase in population and experience buildout by 2030. The majority of the San Antonio Heights is fully developed and any new developments are expected to occur along Holly Drive, in the San Antonio Heights area. These developments are anticipated to be single family residential and will require potable water.

To estimate future residential demand, the single-family residential water demand factor was calculated using 2019 consumption and parcel acreage. The parcels identified as future development within the Holly Drive Zone were developed in the 2017 WMP and are shown in Figure 3-4. No additional parcels for development have been identified since the 2017 WMP and are used in the WMP to estimate future demand.

The single-family residential demand factor was multiplied by the acreage of areas identified as possible development and added to the current demand to determine the total future demand for SAWCo's system. Table 3-1 presents the demand from future development and estimates that these new areas will add approximately 30 AFY of demand to SAWCo's domestic system. Future demands were added directly to the Holly Drive Zone within the model.

Table 3-1. Future Domestic Demand

AREA	ACRES	WATER DEMAND FACTOR (GPM/ACRE)	WATER DEMAND (GPM)	WATER DEMAND (AFY)
A[1]	33.8	1.036	17.53	10.9
B[1]	35.2	1.036	18.23	11.3
C	3.4	1.036	3.54	2.2
D	1.2	1.036	1.28	0.8
E	0.8	1.036	0.81	0.5
F	0.8	1.036	0.82	0.5
G[2]	5.9	1.036	6.09	3.8
		ADDITIONAL FUTURE DEMAND, AFY		**29.9**

Notes

[1]If developed, parcel expected to be half developed. Half of total parcel acreage used to determine future demand.

[2]Half of area identified as future development is highly unlikely to be developed. Southern portion of Area G owned by San Bernardino County Flood Control. Dashed lines in Figure 3-4 delineate area owned by San Bernardino County Flood Control.

It is possible that SAWCo will experience a future decrease in irrigation demands. The Upland Hills Country Club has recently entered into agreement with the City of Upland to receive water, which will decrease deliveries from SAWCo. To remain conservative, this WMP assumes that SAWCo's irrigation demands will remain constant since the timing of such efforts is unknown.

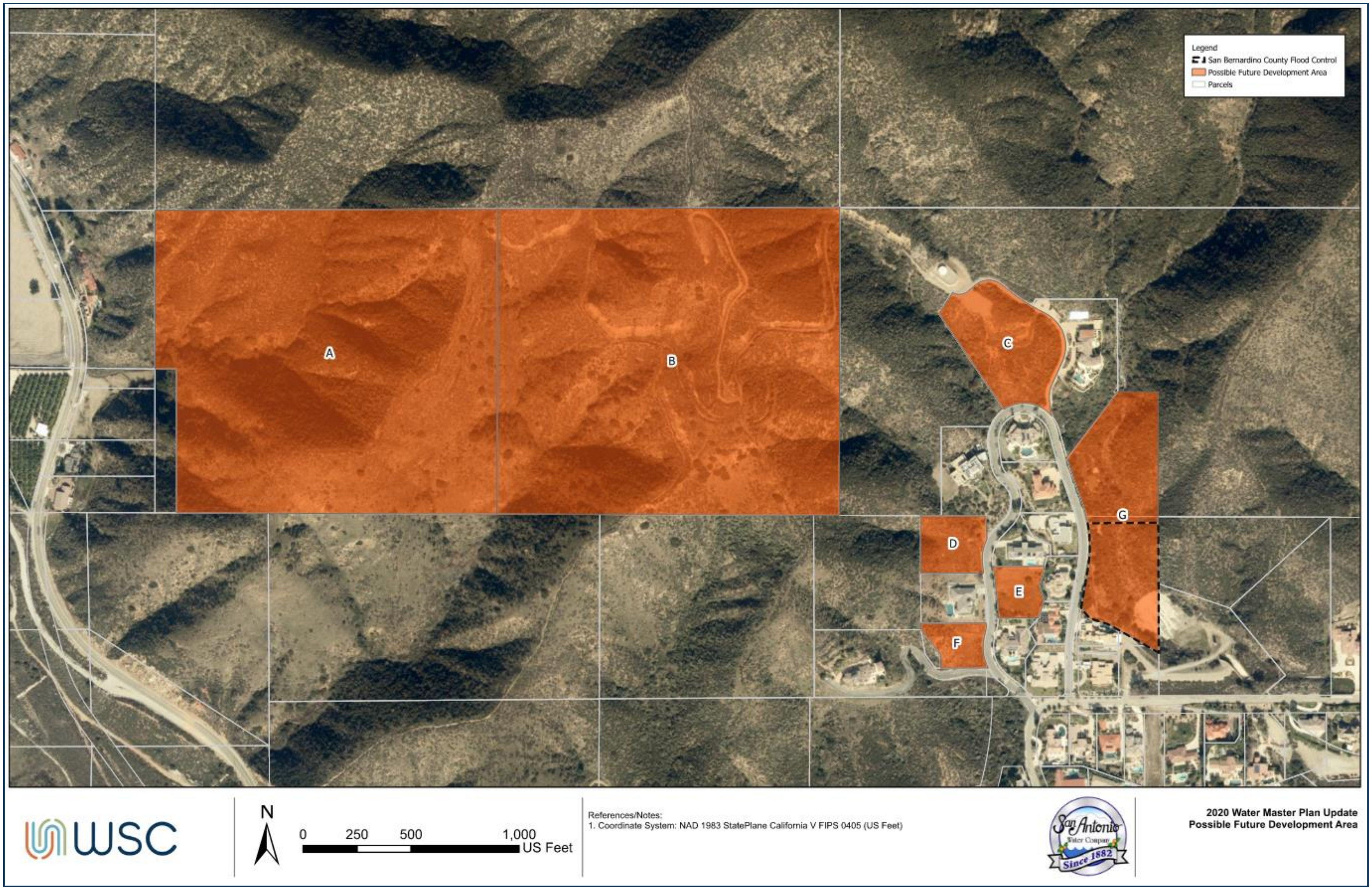


Figure 3-4. Possible Future Development

3.3 Peak Demands

Daily and hourly peak demand factors were developed to evaluate the system response under different demand conditions. The minimum and maximum day demands were determined by evaluating historic daily production data. Typically, the minimum day demand occurs in the cooler months from November through March, and the maximum day demand (MDD) occurs in June through August. Table 3-2 and Table 3-3 summarize the ADD, MDD, PHD, and the calculated peaking factors for the domestic and irrigation systems. SAWCo does not record hourly production data, so peaking factors were developed in accordance with the California Waterworks Standards. The MDD peaking factor is identified as 1.5 times the ADD and the Peak Hour Demand (PHD) factor is calculated as 1.5 times the MDD peaking factor. Based on the MDD peaking factor of 1.5, the PHD peaking factor calculates to 2.25 times the Average Day Demand (ADD). Minimum Day Demands (MinDD) were based on historical usage from 2017-2019 for the domestic system.

Table 3-2. Domestic Daily Demand Factors

DEMAND CONDITION	CURRENT (MGD)	BUILDOUT[1] (MGD)	PEAKING FACTOR[2]
Average Day Demand (ADD)	2.3	2.4	N/A
Maximum Day Demand (MDD)	3.5	3.6	1.5
Peak Hour Demand (PHD)	5.2	5.3	2.25
Minimum Day Demand (MinDD)	0.60	0.62	0.26

[1] Buildout is predicted to occur by 2030 with a projected population of 3,322 people.

[2] Peaking factors based on the California Waterworks Standards.

Table 3-3. Irrigation Daily Demand Factors

DEMAND CONDITION	CURRENT (MGD)	BUILDOUT[1] (MGD)	PEAKING FACTOR[2, 3]
Average Day Demand (ADD)	8.1	8.1	N/A
Maximum Day Demand (MDD)	10.5	10.5	1.5
Peak Hour Demand (PHD)	14.2	14.2	2.25

[1] Irrigation demands are anticipated to remain the same or reduce over time. For conservative estimates, the irrigation demands are planned to remain constant.

[2] Peaking factors based on the California Waterworks Standards.

[3] Peaking factors are applied to an ADD of 4.9 MGD. The remaining ADD of 3.2 MGD is provided to the City of Upland at Campus Ave. and 15th St. and remains constant in MDD and PHD conditions; therefore, the peaking factors were not applied to this portion of the irrigation demand. Details are provided in Section 5.

WATER MASTER PLAN

4.0 Production Analysis

Water is supplied to the various pressure zones through seven booster pump stations and stored within nine gravity reservoirs. This section evaluates the production capacity and storage volume against current and projected demands.

IN THIS SECTION

- Supply Production Analysis
- Booster Pump Station Analysis
- Storage Analysis

4.1 Supply Production Analysis

4.1.1 Domestic System

As previously described, SAWCo uses surface water and local groundwater sources to supply the domestic system that is conveyed through the San Antonio Tunnel and groundwater from three wells.

SAWCo's supply reliability criteria are included in Section 2.0, Table 2-10. Table 4-1 summarizes the design and observed capacities by source and Table 4-2 provides the results of the domestic production analysis.

Table 4-1. Domestic Supply Sources Design, Observed, and Firm Capacity

SUPPLY SOURCE	ZONE SUPPLIED	TOTAL DESIGN CAPACITY (GPM)[1]	TOTAL OBSERVED CAPACITY (GPM)[2]
Tunnel	Higher	Unlimited	1,350
Well 15	Lower	500	401
Well 16	Lower	1,000	989
Well 32	Lower Higher	340	287
Total		3,190+	3,027
Firm Capacity[3]		1,840	1,677

Notes:

[1] The total design capacity includes the capacity of all the supply sources. Total assumes 1,350 gpm from the tunnel (average tunnel production from 2000-2020).

[2] The observed capacity is from the most recent pump tests for each well and average yield from the tunnel. However, the tunnel supply can vary significantly.

[3] The firm capacity is the total capacity with the largest supply source out of service.

Table 4-2. Domestic Supply Capacity vs. Demand

DESCRIPTION	SUPPLY CAPACITY (GPM)
Current Capacity (All Sources)	3,027
Current Firm Capacity	1,677
2019 ADD	1,602
2019 MDD	2,403
Buildout MDD	2,475
Supply Surplus/Deficit[1]	-726
SUPPLY MEETS DEMAND	**NO**

[1] Based on Existing Demand. Development within the domestic system is not certain to occur. SAWCo will monitor and address additional capacity needs should they occur.

To mitigate the supply deficit, SAWCo plans to construct a new well within the Cucamonga Basin. This well, known as Well 19, is estimated to provide approximately 1,490 gpm of additional supply to the domestic system, bringing the total firm capacity to 3,027 gpm. With this well in service, SAWCo should experience a supply surplus of approximately 624 gpm.

4.1.2 Irrigation System

The irrigation system is supplied from local groundwater sources through eight wells and by surface water from the San Antonio Creek and are summarized in Table 4-3. When the domestic system is at capacity, excess potable water from the Tunnel can be introduce by overflowing into the irrigation system at the Forebay (Booster #14).

Table 4-3. Irrigation Supply Sources Design, Observed, and Firm Capacity

SUPPLY SOURCE	TOTAL DESIGN CAPACITY (GPM)[1]	TOTAL OBSERVED CAPACITY (GPM)[2]
Well 2	750	801
Well 3	1,000	1,164
Well 22	1,200	1,890
Well 24	2,100	2,627
Well 25A	600	301
Well 26	600	366
Well 27	1,000	515
Well 31	2,300	1,887
San Antonio Creek	Unlimited	2,738
Total	12,288+	12,289
Firm Capacity[3]	9,550	9,551

Notes:

[1] The total design capacity includes the capacity of all the supply sources. Total assumes 2,738 gpm from the San Antonio Creek (average creek production from 2000-2020).

[2] The observed capacity is from the most recent pump tests for each well and average yield from the tunnel. However, the creek supply can vary significantly.

[3] The firm capacity is the total capacity with the largest supply source out of service.

Table 4-4. Irrigation Supply Capacity vs. Demand

DESCRIPTION	SUPPLY CAPACITY (GPM)
Current Capacity (All Sources)	12,289
Current Firm Capacity	9,551
2019 ADD	5,626
2019 MDD	7,319
Buildout MDD	7,319
Supply Surplus	2,232
SUPPLY MEETS DEMAND	**YES**

Based on the analysis conducted in Table 4-4, the irrigation system has sufficient production capacity to meet demands.

4.2 Booster Pump Station Analysis

An important supply requirement involves BPS capacity. If BPSs do not have adequate pumping capacity, issues suppling tanks and customers may arise. This section provides an analysis on existing and future booster pump station capacity.

4.2.1 Domestic Pump Stations

Criteria for evaluating BPSs is listed in Table 2-11 and include the capacity and emergency power requirements listed below:

- If gravity storage is available, pump station capacity must be able to meet MDD within the zone with the largest pump out of service.
- If gravity storage is not available, pump station capacity must be able to meet MDD plus FF or PHD, whichever is greater, with the largest pump out of service.
- Emergency power must be sufficient to meet system average day demands and preparedness for other emergencies.

SAWCo's domestic system contains gravity storage for all pressure zones; therefore, the domestic pump station analysis was based on the initial criteria pertaining to MDD with the largest pump out of service.

SAWCo is in the process of acquiring portable generators to ensure service in an emergency. SAWCo also contracts with a local contractor to provide emergency support such as debris clearing, emergency generators and repairs.

An evaluation of the BPSs within the domestic system is provided in Table 4-5 below.

Table 4-5. Domestic Booster Pump Station Analysis

Pump Station	Zone Served	Design Capacity (gpm)	Firm Capacity[1] (gpm)	Zone Firm Capacity (gpm)	Current ADD (gpm)	Current MDD (gpm)	Required Capacity (gpm)	Surplus/Deficit Capacity (gpm)	Meets Supply Requirements
Booster #14 Forebay	High Zone	1,000	500	1,850	153	228	228	1,622	YES
Booster #16 Euclid	High Zone	700	350						
Booster #20 26th Street	High Zone	2,000	1,000						
Booster #17 V-Screen	Canyon	106	53	53	2	4	4	49	YES
Booster #18 Station 18	Low Zone	1,500	0	0	1,437	2,156	2,156	-2,156	YES, although the BPS alone does not meet the required capacity, the southern portion of the Low Zone is fed directly by wells or is supplied from the High Zone.
Booster #19 Holly Drive	Holly Drive	900	450	450	10	16	16	434	YES

[1] Booster station firm capacity is based on the largest pump out of service.

4.2.2 Irrigation Pump Stations

Similar to the domestic BPS analysis, the pump stations within the irrigation system were also analyzed. Currently, only one BPS serves the irrigation system. Majority of the irrigation system is supplied by wells or by surface water from the San Antonio Creek. Due to the magnitude of the irrigation system, it is not feasible nor realistic for the entire system to be supplied by the single pump station.

4.3 Storage Analysis

Storage capacity is important in water distribution systems to equalize fluctuations in hourly demands. Supply sources should be sized for peak hour demands (operational storage), provide water for firefighting (fire flow storage), and meet demands during an emergency, such as disruption of a major supply source (emergency storage). The storage criteria are listed in Section 2.0, Table 2-11, and include specific criteria for each of the three types of storage described.

Storage within the irrigation system is also analyzed. Irrigation water is not used for firefighting purposes, and therefore, is not evaluated in this analysis. Emergency storage is also not considered because in an emergency, it is highly likely that the domestic system would also be impaired and remain SAWCo's priority for restoration. It is anticipated that SAWCo's irrigation system will maintain the current level of demands or experience a reduction in demand in the future. Therefore, the irrigation system is evaluated based on current conditions only, as the most conservative approach.

4.3.1 Operational Storage

Operational storage is the volume of water needed to equalize supply and demand over the course of the day. Without operational storage, water supply facilities would need to be sized to meet instantaneous peak demands throughout the day. California Waterworks standards state a distribution system with 1,000 or more service connections shall be able to meet four hours of PHD with source capacity, storage capacity, and/or emergency source connections. As summarized in Table 2-11, SAWCo requires that operational storage meets 4 hours of PHD for each zone. Table 4-6 includes the operational storage requirements under current and buildout demands for the domestic system. Table 4-7 summarizes the current storage requirements for the irrigation system.

Table 4-6. Domestic Operational Storage Requirements

	CURRENT				BUILDOUT			
ZONE	ADD (GPM)	MDD (GPM)	PHD (GPM)	OPERATIONAL STORAGE (GALLONS)	ADD (GPM)	MDD (GPM)	PHD (GPM)	OPERATIONAL STORAGE (GALLONS)
Holly Drive Zone	10	16	23	5,638	58	87	132	31,718
High Zone	152	228	341	81,945	152	228	341	81,945
Low Zone	1,440	2,160	3,240	777,649	1,440	2,160	3,240	777,649
TOTAL	**1,602**	**2,403**	**3,605**	**865,231**	**1,650**	**2,475**	**3,714**	**891,312**

Operational storage is based on 4 hours of PHD only.

Table 4-7. Irrigation Operational Storage Requirements

	CURRENT			
ZONE	ADD (GPM)	MDD (GPM)	PHD (GPM)	OPERATIONAL STORAGE (GALLONS)
Irrigation	5,626	7,319	9,858	2,365,920

Operational storage is based on 4 hours of PHD.

4.3.2 Fire Flow Storage

The fire flow requirements are set by local fire officials and are determined by the California Building Code construction type and square footage of the fire area (California Fire Code). SAWCo's fire flow requirements were set by the fire department based on development type and are outlined in Table 2-11. The fire flow must be met during MDD conditions, and the system must maintain a minimum residual pressure of 20 psi. When assessing the available fire flow in each zone, the tanks are modeled as half full and all supply sources are turned off. With the supply sources off, the storage reservoirs are required to hold the volume of water required for firefighting. Each distribution zone's fire flow storage volume requirement is listed in Table 4-8.

Table 4-8. Domestic Fire Flow Storage Requirements

ZONE	FIRE FLOW REQUIREMENT (GPM)	HOURS	FIRE FLOW STORAGE (GALLONS)
Holly Drive Zone	1,500	2	180,000
High Zone	1,500	2	180,000
Low Zone	1,500	2	180,000
		TOTAL STORAGE REQUIRED	**540,000**

4.3.3 Emergency Storage

According to the American Water Works Association (AWWA) Manual M19 Emergency Planning for Water Utilities, emergency storage is water that is available for use by water system customers in the event of a longer-term disruption of water supply. “Emergency storage provides water during events such as pipeline failures, equipment failures, power outages, pumping system failures, water treatment plant failures, raw water contamination, or natural disasters” (American Water Works Association, 2001). The quantity of emergency storage is determined by the agency based on the required water system dependability, risk acceptance, and water quality in storage reservoirs. Oversized reservoirs can potentially have a negative impact on stored water quality because of increased difficulty in maintaining the chlorine residual and a higher risk of exceeding disinfection byproduct limits. SAWCo requires emergency storage to meet 24 hours at MDD for its domestic system. Table 4-9 lists the emergency storage requirements by distribution zone under current and buildout demands within the domestic system.

SAWCo does not currently require emergency storage for its irrigation system. In the event of an emergency, it is highly likely that SAWCo’s domestic system would be severely interrupted in addition to the irrigation system. SAWCo will prioritize the domestic system prior to delivering irrigation water. Therefore, SAWCo does not have any emergency storage requirements for its irrigation system.

Table 4-9. Domestic Emergency Storage Requirements

	CURRENT		BUILDOUT	
ZONE	MDD (GPM)	EMERGENCY STORAGE (GALLONS)	MDD (GPM)	EMERGENCY STORAGE (GALLONS)
Holly Drive Zone	16	22,550	87	126,873
High Zone	228	327,780	228	327,780
Low Zone	2,160	3,110,594	2,160	3,110,594
TOTAL	**2,403**	**3,460,925**	**2,475**	**3,565,248**

Emergency storage is calculated as 24 hours of the MDD.

4.3.4 Total Storage Requirement

The total storage requirement is the sum of the operational, fire flow, and emergency storage. Table 4-10 summarizes the storage requirements per zone within the domestic system. The existing system storage in each zone is compared to the required storage for each zone and the results of the existing system storage analysis based on 2019 demands. Each pressure zone has sufficient storage.

Table 4-11 summarizes the storage requirements for the irrigation system. Currently, the irrigation system does not meet the operational storage needs identified in this analysis. There is a minimal gap between the operational storage identified based on supplying 4 hours of PHD with existing available storage. Since the future of the irrigation system is expected to remain constant or decline in customers, it is highly likely that the current storage is sufficient to meet demands. It should be noted that irrigation customer demands are highly variable and may decrease in the future.

Table 4-10. Existing Domestic System Storage Analysis

ZONE	OPERATIONAL STORAGE, MG	FIRE FLOW STORAGE, MG	EMERGENCY STORAGE, MG	TOTAL REQUIRED STORAGE, MG	AVAILABLE EXISTING STORAGE, MG	STORAGE SURPLUS/DEFICIT, MG
Holly Drive Zone	0.01	0.18	0.02	0.21	0.24	0.03
High Zone	0.08	0.18	0.33	0.59	1.10	0.51
Low Zone	0.78	0.18	3.11	4.07	5.50	1.43
TOTAL	**0.87**	**0.54**	**3.46**	**4.87**	**6.84**	

[1] While these is currently a storage deficit in the Holly Drive Zone, SAWCo plans to replace the existing tank 0.06 MG tank with an additional 0.12 MG tank which will raise the total Holly Drive Zone storage to 0.24 MG to meet the existing storage needs.

Table 4-11. Existing Irrigation System Storage Analysis

ZONE	OPERATIONAL STORAGE, MG	TOTAL REQUIRED STORAGE, MG	AVAILABLE EXISTING STORAGE, MG	STORAGE SURPLUS/DEFICIT, MG
Irrigation	2.37	2.37	2.25	(0.12)

For future system analysis, the existing storage in each zone is compared with the required storage in each zone based on buildout demand for 2030. Anticipated development is expected to occur in the Holly Drive Zone only, adding approximately 30 AFY of additional demand. Table 4-12 presents the results of the future system storage analysis based on buildout demands. SAWCo will have sufficient storage for the High and Low Zones. However, Holly Drive may experience a deficit of 0.1 MG if buildout of the parcels identified within the Holly Drive zone would be developed. SAWCo will continue to monitor development and address future storage needs, should they occur, through the development process.

Table 4-12. Future Domestic System Storage Analysis

ZONE	OPERATIONAL STORAGE, MG	FIRE FLOW STORAGE, MG	EMERGENCY STORAGE, MG	TOTAL REQUIRED STORAGE, MG	AVAILABLE EXISTING STORAGE, MG	STORAGE SURPLUS/DEFICIT, MG
Holly Drive Zone	0.03	0.18	0.13	0.34	0.24	(0.10)
High Zone	0.08	0.18	0.33	0.59	1.10	0.51
Low Zone	0.78	0.18	3.11	4.07	5.50	1.43
TOTAL	**0.89**	**0.54**	**3.57**	**5.00**	**6.84**	

SAWCo's can store substantial amounts of water within its storage tanks. As shown in this analysis, majority of the required storage is due to fire flow or emergency storage needs. For discussion purposes, Table 4-13 illustrates the storage analysis if the total required storage was based on operational needs and the largest of fire flow and emergency storage needs. Using the modified total storage required, all pressure zones within SAWCo have adequate storage under future demands.

Table 4-13. Modified Future Domestic System Storage Analysis - Total Required Storage

ZONE	OPERATIONAL STORAGE, MG	FIRE FLOW STORAGE, MG	EMERGENCY STORAGE, MG	TOTAL REQUIRED STORAGE, MG[1]	AVAILABLE EXISTING STORAGE, MG	STORAGE SURPLUS/DEFICIT, MG
Holly Drive Zone	0.03	0.18	0.13	0.21	0.24	0.03
High Zone	0.08	0.18	0.33	0.41	1.10	0.69
Low Zone	0.78	0.18	3.11	3.89	5.50	1.61
TOTAL	**0.89**	**0.54**	**3.57**	**4.51**	**6.84**	

[1] Total storage required based on operational storage and largest of fire flow or emergency storage.

WATER MASTER PLAN

5.0 Hydraulic Model Development

This section summarizes the development of SAWCo's water distribution system hydraulic model and the model calibration results. For more detailed information on model development and calibration, see Appendix A - Hydraulic Model Development.

IN THIS SECTION

- Model Structure and Demands
- Model Calibration

5.1 Model Structure and Demands

The objective of model development is to create a calibrated, representative hydraulic model of the SAWCo distribution system. This model is used to simulate and predict the performance of the distribution system under a variety of demand and operational scenarios. The hydraulic model is also extremely useful for evaluating alternative configurations and capital project recommendations in order to provide the most valuable system configuration to meet SAWCo's needs.

SAWCo's complete GIS database was utilized to develop an all-pipes water model in InfoWater. Tools in InfoWater were used to evaluate and correct the connectivity of the system, so that it is representative of the actual water system.

Physical and operational data used in the model were extracted from multiple sources, including the GIS database, planning reports such as the 2017 Water Master Plan, as-built plans, and well hydraulic test results. Consumption data from 2019 was provided by SAWCo in Microsoft Excel format. Consumption was spatially allocated and scaled based on the total production for the same time period to account for non-revenue water. Demands were spatially loaded into the model based on APN or address so that demands throughout the model were reflective of reality.

Future domestic demand projections were developed from identified areas of future growth in the 2017 WMP, as described in Section 3.0. Irrigation demands are expected to remain constant throughout the planning horizon to allow for a conservative estimate of the future irrigation system. Irrigation demand supplied to the City of Upland at Campus Ave. and 15th St. were not scaled to MDD and PHD conditions. This demand (2,239 gpm), is supplied when the City of Upland contacts SAWCo to turn on wells in the southern portion of the system to fill their tanks east of Campus Ave. SAWCo fills these tanks at a constant rate and therefore the demand is not subject to MDD or PHD factors. The constant demand was added to the scaled MDD and PHD for the rest of the system to obtain a total demand under MDD and PHD scenarios. A summary of the modeled demands is provided in Table 5-1 and Table 5-2.

Table 5-1. Summary of Domestic Modeled Demands

	CURRENT			BUILDOUT			PEAKING FACTOR
	AFY	MGD	GPM	AFY	MGD	GPM	
Average Daily Demand (ADD)	2,579	2.3	1,602	2,628	2.4	1,632	N/A
Maximum Daily Demand (MDD)	3,869	3.5	2,403	3,941	3.6	2,448	1.5
Peak Hour Demand (PHD)	5,802	5.2	3,604	5,912	5.3	3,672	2.25

Buildout is predicted to occur by 2030 with a projected population of 3,322.

Table 5-2. Summary of Irrigation Modeled Demands

	CURRENT AND PROJECTED BUILDOUT			PEAKING FACTOR
	AFY	MGD	GPM	
Average Daily Demand (ADD)	9,058	8.1	5,626	N/A
Maximum Daily Demand (MDD)	11,784	10.5	7,319	1.5
Peak Hour Demand (PHD)	15,871	14.2	9,858	2.25

Irrigation demands are anticipated to remain the same or reduce over time. For conservative estimates, the irrigation demands are planned to remain constant.

Peaking factors are applied to an ADD of 3,386 gpm. The remaining ADD of 2,239 gpm is provided to the City of Upland at Campus Ave. and 15th St. and remains constant in MDD and PHD conditions; therefore, the peaking factors were not applied to this portion of the irrigation demand.

5.2 Model Calibration

To calibrate the steady-state model, existing demands were assigned to the model to correspond to the system demand at the time fire hydrant flow data were collected. The model was calibrated based on four hydrant tests across the distribution system. The model was refined by adjusting pipeline C-factors to better reflect the hydrant testing results. After model calibration, all modeled pressures were within 10 psi of observed system pressures. Appendix A - Hydraulic Model Development, provides additional details on model development and calibration.

WATER MASTER PLAN

6.0 Capacity Analysis

This section analyzes SAWCo's distribution system pressure, available fire flow, pipeline velocity, and fire hydrant and valve spacing. Areas that do not meet the pipeline capacity criteria and recommendations to improve the system are described in this section.

IN THIS SECTION

- Pressure Analysis
- Fire Flow Analysis
- Velocity Analysis
- Hydrant and Valve Spacing

6.1 Domestic System

6.1.1 Pressure Analysis

An important part of the water distribution system is the pressure supplied to shareholders. Pressures should be adequate to supply services, but not so high that appliances or pipelines are weakened and damaged. The pressure criteria used in this analysis is summarized below:

- 40 psi minimum and 120 psi maximum under normal conditions
- 150 psi during minimum hour demands
- 20 psi minimum residual at MDD plus FF

SAWCo's system pressures were evaluated under ADD, MDD, PHD, and minimum day demands (MinDD) for current and buildout demands. The pressure in the system depends on reservoir levels and the pressure supplied by pump stations. Because the pressure is dependent on these system conditions, two alternatives were used to evaluate system pressures. The first alternative simulates high pressures: reservoirs are set to 90% full, all wells operating, and a single booster pump at each pump station is turned on. The second alternative simulates low pressures: reservoirs are set to 50% full and all wells, pumps, and supply sources are turned off.

The difference in modeled pressures was minimal between all the demand scenarios under the same alternative with the same tank levels and pumps and well settings. The small pressure variance between the different demand scenarios is due to slight differences in system demands and small growth due to buildout. Table 6-1 summarizes the pressure ranges by zone estimated within the model.

Based on known system pressures, it is estimated that the model predicts pressures greater than reality by approximately 10 – 20 psi in some areas, while other areas are representative of current conditions. Based on discussions with operations staff, the actual estimated pressure range is also provided in Table 6-1.

The model calibrated well compared to fire flow tests conducted as part of this master plan effort but should continue to be inspected and modified as additional data points are collected to help fine-tune model outputs. It appears that the model is highly sensitive to elevation data and was constructed using data published by USGS. It is common for areas located with mountainous terrain to be sensitive to elevation data, which can impact modeled pressures. SAWCo may consider professionally surveying a few points within the distribution system, especially within the Low Zone, to help check model elevation and fine-tune areas where the model overestimates pressure.

Table 6-1. Average Pressure Ranges per Zone

ZONE	MODELED PRESSURE RANGE (PSI)	ESTIMATED PRESSURE RANGE (PSI)
Holly Drive Zone	62-165	60-145
High Zone	24-142	20-130
Low Zone	32-164	30-134

6.1.1.1 Holly Drive Zone

Pressures within the Holly Drive Zone range from 62 to 165 psi. All pressures meet the minimum pressure requirement of 40 psi. Customers are equipped with a pressure regulator per the Uniform Plumbing Code to mitigate excess pressures above 80 psi. Pressures are higher in the southern portion of the pressure zone near the Holly Drive BPS and are reduced as water flows north, due to the mountainous terrain. The model estimates the greatest pressure within the Holly Drive Zone to be 165 psi at the discharge of the Holly Drive BPS, while operations staff anticipate that actual pressure is closer to 145 psi at this location.

The SAWCo system also optimizes gravity by using booster pumps to feed the northern portion of the system, then allowing water to flow back down to the rest of the system.

6.1.1.2 High Zone

Pressures within the High Zone range from 24 to 142 psi. Pressures along the western portion of 26th Street, near Euclid Crescent W and the Holly Drive Zone, experience lower than ideal pressures, ranging from 20 to 37 psi. To mitigate these lower pressures and obtain full use of the newly constructed 0.1 MG tank within the Holly Drive Zone, recommended improvement project RZ-1 has been identified and is discussed in Section 7.1.

There are also several areas within the High Zone that experience pressures higher than 120 psi. Customers that experience pressures in excess of 80 psi are equipped with a pressure regulator to mitigate higher pressures. High pressure areas include:

- Dead-end of existing 4-inch main at San Antonio Crescent E and Euclid Ave (142 psi)
- Upstream of PRV at Prospect Ave (120 – 130 psi)
- Upstream of PRV at Euclid Crescent (128 - 140 psi)

6.1.1.3 Low Zone

Pressures within the Low Zone range from 32 to 164 psi. Pressures within the 30 to 40 psi range occur at the intersection of N Mountain Avenue and Mountain Drive. Despite being slightly below the minimum pressure during normal conditions, this area does not warrant any required upgrades because no deliveries are provided by this main.

The model estimates high pressure that exceeds the normal operating criteria of 120 psi in much of the southern portion of the Low Zone. Pressures are estimated to reach pressures up to 164 psi; however, SAWCo staff estimate that actual pressures reach only up to 140 psi. Pressures greater than 150 psi are estimated on the discharge side of Booster 18 and drop to 140 psi at 24th Street. Additional investigation should be completed throughout SAWCo's Low Zone and used to adjust the model moving forward.

SAWCo is aware of these higher than ideal pressures throughout the system and customers that experience pressures above 80 psi are equipped with a pressure regulator to mitigate impacts.

Figure 6-1 illustrates the pressure throughout the domestic system.

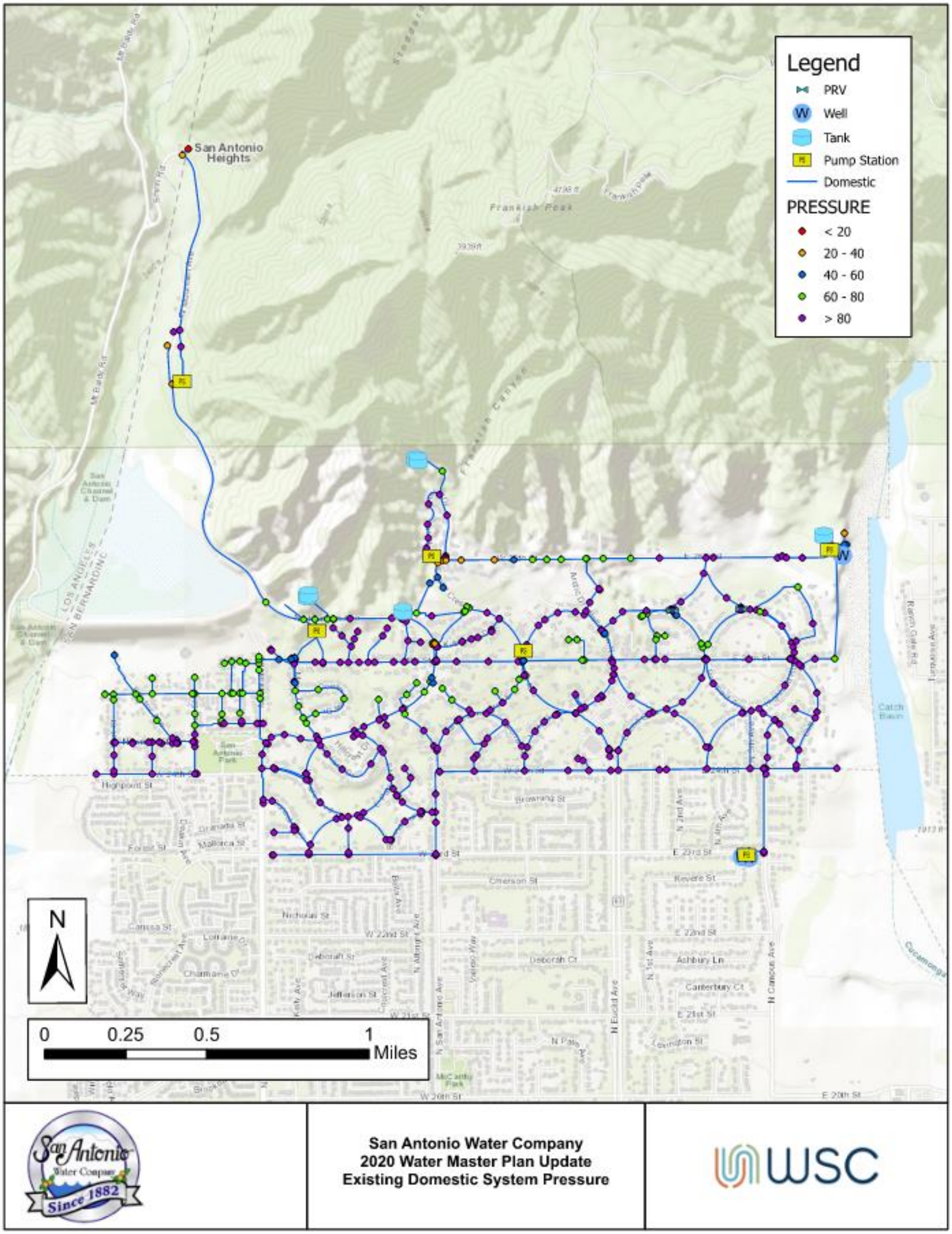


Figure 6-1. Domestic System Pressure Analysis

6.2 Fire Flow Analysis

An important function of a water distribution system is to provide adequate fire protection. Fire flow requirements are typically set using requirements set forth by the California Fire Code. As outlined in Table 2-11, SAWCo's domestic system serves only residential customers and is therefore subject to a fire flow requirement of 1,500 gpm, while maintaining system pressures above 20 psi.

The current available fire flow in the system is modeled using the calibrated hydraulic model. A fire flow analysis is run to determine the available fire flow that can be flowed from each hydrant within the domestic system while maintaining a minimum of 20 psi. For a conservative fire flow analysis, conditions are evaluated using MDD and reservoirs set to half full. Fire flow deficiencies under current demands are compared to buildout demands. The location of fire flow deficiencies under both current and buildout demands are similar.

Figure 6-2 displays the available fire flow throughout SAWCo's domestic system under the current MDD scenario. The available fire flow is highly dependent on the pipeline capacity in the system. Newer pipelines are typically 8-inch in diameter or greater and typically meet fire flow requirements. Fire flow pipeline improvement projects were identified based on fire flow needs, rather than other capacity constraints.

There are four hydrants that cannot currently provide 1,500 gpm of fire flow. Two deficient hydrants are located within the High Zone and two deficient hydrants are located within the Low Zone. Although these hydrants cannot individually meet the required 1,500 gpm, there are additional hydrants in the area that can supplement supply in a fire event to meet the fire flow requirements. Therefore, no fire flow specific projects are recommended at this time. The locations of these hydrants are shown in Figure 6-2.

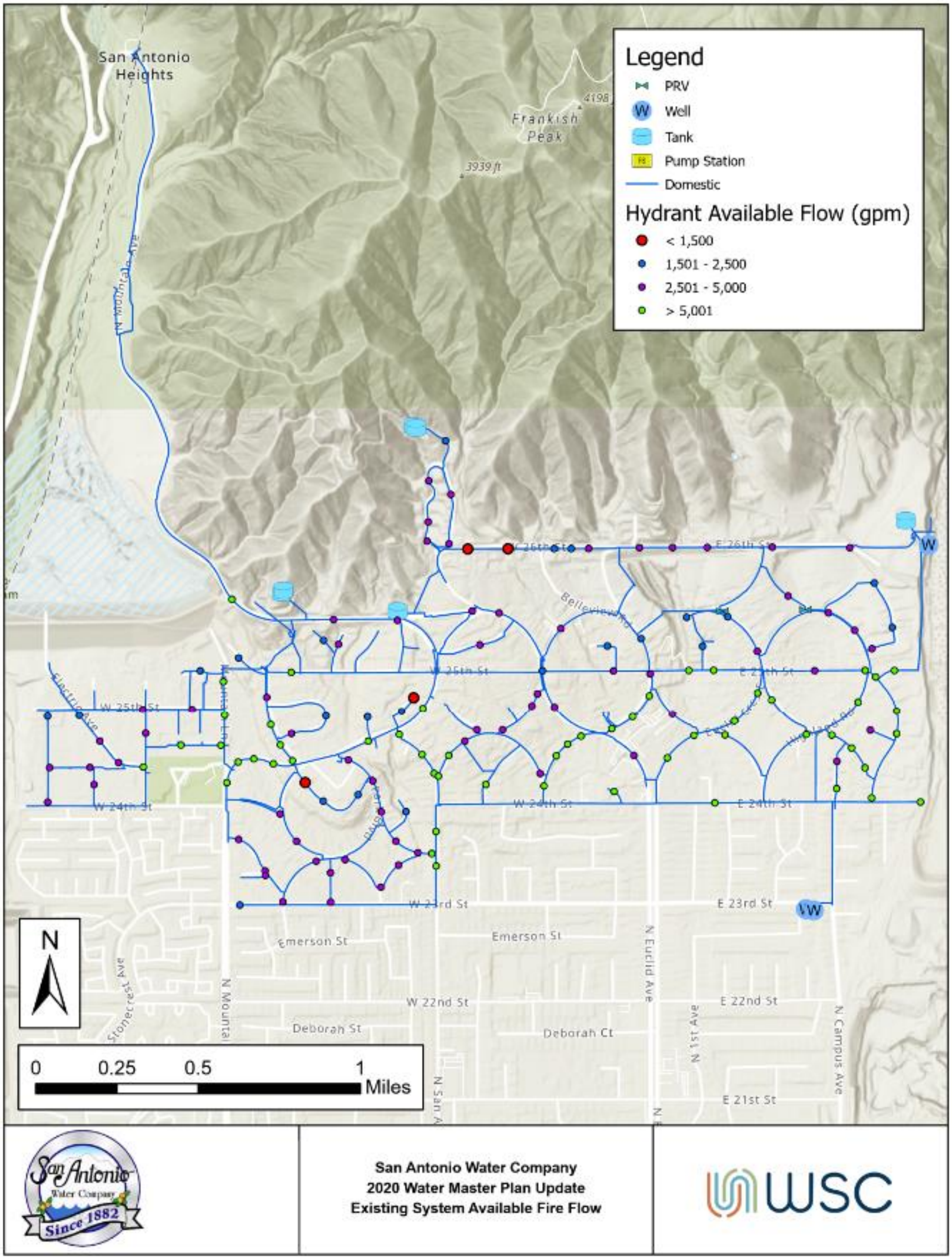


Figure 6-2. Existing Domestic System Available Fire Flow

Projects to improve fire flow were developed by upsizing small diameter pipelines that restrict fire flow then rerunning the model. Projects were iterated until the fire flow requirement was met while minimizing the costs of upgrade projects. Most of the recommended projects include upsizing existing 2-, 4-, and 6-inch pipelines that restrict the fire flow or constructing new mains for looping. In addition to fire flow calculation runs in the hydraulic model, the available fire flow was manually checked by applying large demands to multiple hydrants and observing the zone's pressure response. During a fire, it is likely that multiple hydrants will be used, and their combined flow rate should meet the fire flow requirements. A single hydrant with just under 1,500 gpm of available fire flow was considered adequate if the hydrant and an adjacent hydrant were modeled together providing 1,500 gpm while maintaining a 20-psi residual pressure.

One project is recommended to improve fire flow within the domestic system and meet the fire flow requirement at Ponte Vecchino Court. Discussions with SAWCo staff on the overall reliability of the system noted that one additional improvement could be completed to increase the reliability of the system. Staff recommend construction of an 8-inch pipeline within Hillcrest Drive for additional looping and fire protection within the domestic system.

An additional project, RZ-1, is included in this section. RZ-1 could potentially be a rezoning project to expand the Holly Drive zone while improving pressures and fire flow in W 26th Street. Details on Project RZ-1 are discussed in Section 7.1. Table 6-2 lists the recommended projects that are included in the final CIP.

Table 6-2. Recommended Improvement Projects

PROJECT NO.	PROJECT TYPE	ZONE	LOCATION	EXISTING SIZE AND MATERIAL	TOTAL NEW PIPE LENGTH (FT)	RECOMMENDED SIZE AND MATERIAL	RECOMMENDED PROJECT
FF-1	Pipeline Upgrade	Low Zone	Ponte Vecchino Ct	4-inch ductile	560	8-inch PVC	Replace existing 4-inch pipeline with 8-inch PVC when pipeline fails.
FF-2	Pipeline Construction	Low Zone	Hillcrest Drive	N/A	300	8-inch PVC	Improve system reliability and provide fire protection.
RZ-1	Expanded Holly Drive Zone	Holly Drive Zone/High Zone	Holly Dr and W 26th St	6-inch ductile and new pipe	700	8-and 12-inch PVC	Discussed in Section 7.1. Improves pressure and fire flow in the High Zone along W 26th St by moving 16 services in this area to the Holly Drive Zone. Includes construction of 50-feet of 12-inch pipe to connect the existing Holly Drive Zone to W 26th St, upgrade 200-feet of existing 6-inch main to 8-inch main within Euclid Crescent and construct 500-feet of 8-inch main within Euclid Crescent to construct loop to provide adequate pressure on suction side of Holly BPS. A detailed feasibility study of such changes is recommended prior to implementation.

6.2.1 Velocity Analysis

In addition to evaluating the pressure and available fire flow in the system, the calibrated hydraulic model was used to evaluate the pipeline velocity across the distribution system. The pipeline velocities were evaluated based on the following criteria:

- Velocity shall be less than or equal to 7 feet per second (fps) at MDD
- Velocity shall be less than or equal to 11 fps at MDD plus fire flow condition

The velocity was evaluated under current and buildout MDD. Only one pipeline within the distribution system demonstrated a velocity that exceeded the 7 fps at MDD. This pipeline conveys supply from the Holly Pressure Zone tanks into the distribution system. Under ADD, MDD, and PHD conditions, this pipeline is estimated to experience nearly 8 fps.

The velocity was evaluated under buildout MDD plus fire flow conditions by manually adding the fire flow requirement to a hydrant, running the model, and evaluating pipeline velocity. This was performed at multiple locations across the distribution system, focusing on locations with numerous small-diameter pipes where high velocity is more likely to become an issue. The model predicts that velocity could exceed 11 fps during MDD plus fire flow conditions if the fire occurred in a location with a high density of 2, 4, and 6-inch pipelines. When these pipelines reach the end of their lifespan, they should be replaced by an 8-inch line or larger to reduced velocities under MDD plus FF conditions.

6.2.2 Hydrant and Valve Spacing

SAWCo has established criteria for hydrant and valve spacing. Hydrant spacing was analyzed in GIS by creating a 330-foot buffer around each fire hydrant and visually inspecting locations that were not within a hydrant's practical coverage. A 330-foot buffer was used to visually determine if the required hydrant spacing was met. New hydrants, each with a 330-foot buffer, were added to locations outside a hydrant's coverage until all locations were within 330 feet. For areas with minimal development, proposed hydrants were added near existing residences to ensure adequate protection in the event of a fire emergency. In addition, staff field verified hydrant locations along SAWCo's boundary, to ensure these areas had adequate coverage. It is recommended that SAWCo install 6 new hydrants to ensure adequate coverage throughout its service area. These hydrants are shown in Figure 6-3. Additional hydrants may be installed north of the V-Screen BPS for additional fire protection around Mountain Road. Prior to hydrant installation in this area, the existing 4-inch pipeline should be replaced with a larger diameter pipeline to provide adequate fire flow.

Within SAWCo's domestic system, valves should be spaced so that no shut down is greater than 10 services, which is approximately 550 feet. Based on a similar analysis using a 550-foot buffer, no new valves were identified as part of this analysis. It was concluded that SAWCo's domestic system has an adequate number of valves in strategic locations.

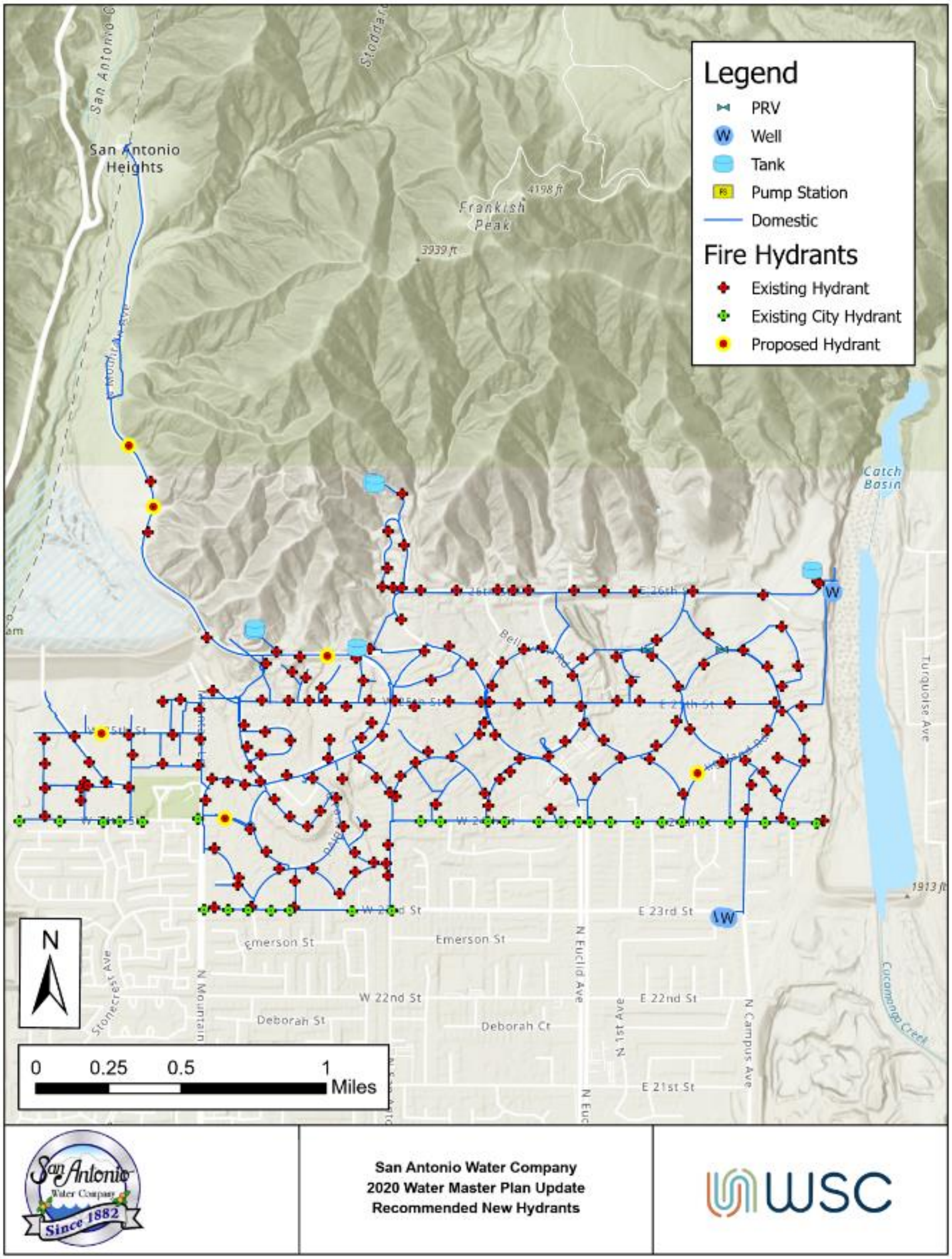


Figure 6-3. Recommended New Hydrants

6.3 Irrigation System

The irrigation system was evaluated to identify pressure, velocity, and valve spacing throughout the system.

6.3.1 Pressure Analysis

Similar to the domestic system, the irrigation system was analyzed under ADD, MDD, and PHD scenarios. SAWCo aims to operate the irrigation system within a 20 psi to 120 psi range during normal conditions.

The difference in modeled pressures was minimal between all the demand scenarios under the same alternative with the same tank levels and pumps and well settings. Demands for the City of Upland at Campus Ave. and 15th St. were modeled solely as average day demands in all scenarios. At this particular location, the City of Upland contacts SAWCo when the City of Upland needs to fill their tanks located to the west of Campus Ave. SAWCo provides water at a constant rate and is therefore not subject to MDD or PHD conditions. Average pressures within the irrigation system range from 15 psi to 163 psi and are shown in Figure 6-4.

Low pressure areas are located along the existing concrete line downstream of Reservoir 4 and east towards Campus Avenue and south of Reservoir 9 (less than 40 psi). Areas of high pressure (70-100 psi) are estimated along the mainline from the Forebay south to the Paloma Curve hydraulic break. Additional analysis on this main is being completed as a separate analysis from this WMP.

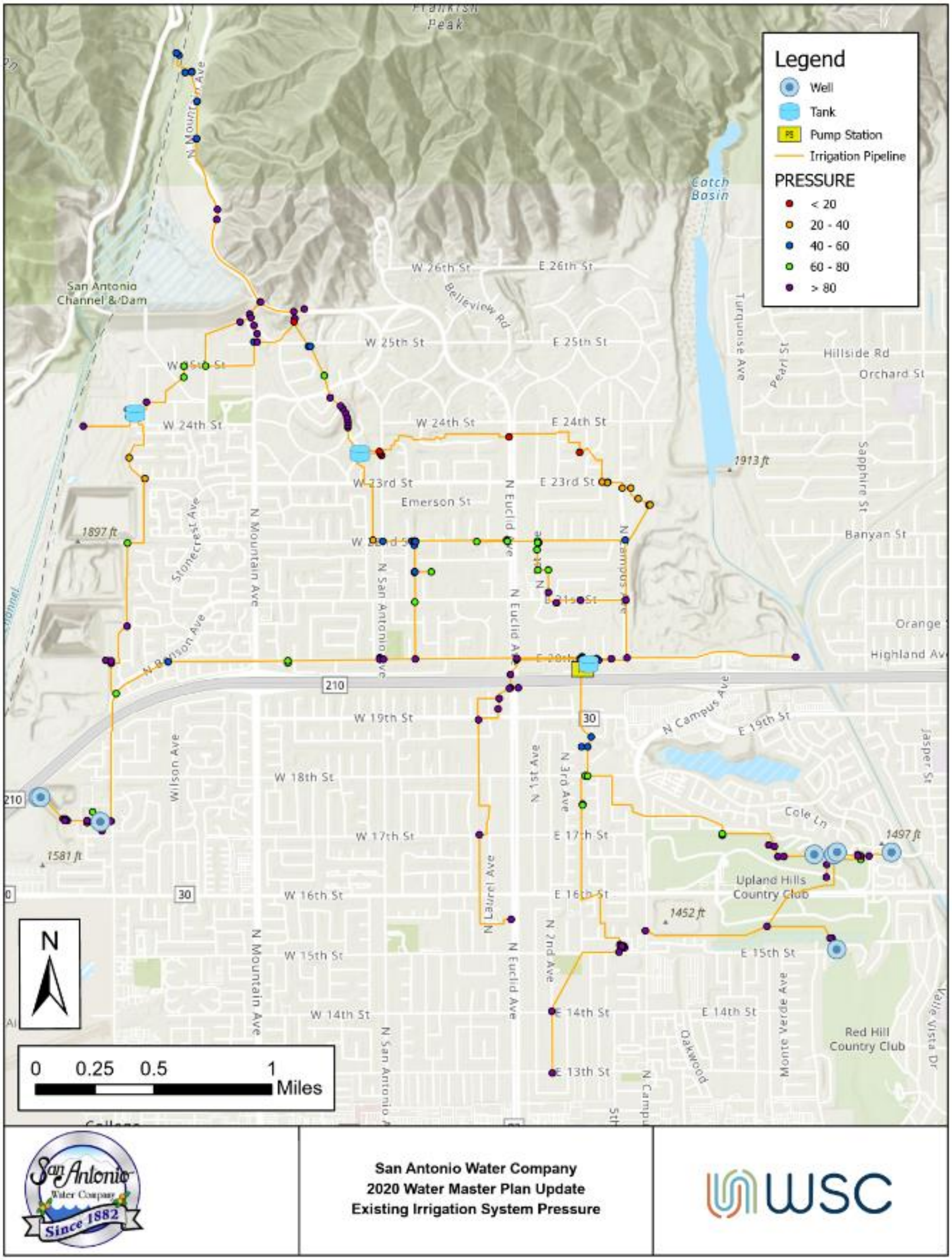


Figure 6-4. Irrigation System Pressure Analysis

6.3.2 Velocity Analysis

In addition to evaluating the pressure, the hydraulic model was used to evaluate the pipeline velocity across the distribution system. SAWCo evaluated pipeline velocities based on a maximum velocity of 7 fps. The velocity was evaluated under current conditions since it is anticipated that no growth will occur within the irrigation system, but rather, SAWCo may continue to see a decline in irrigation customers.

Overall, SAWCo's irrigation system typically operates at or below 7 fps except for the Forebay to Reservoir 4 mainline, which operates close to 11 fps (San Antonio Water Company, June 22, 2021). SAWCo had previously identified this pipeline for replacement within the right-of-way to improve access because it is currently within private property and residential backyards. When replaced, the pipeline should be upsized to reduce the velocity to 7 fps or less. SAWCo plans to evaluate this pipeline in more detail. Details on preliminary solutions for this area are discussed in Section 7.2.

In addition, there is an 8-inch pipeline that exhibits pressures between 7-11 fps at MDD and PHD conditions. This pipeline serves the City of Upland and Holliday Rock customers and was replaced in 2019 with PVC and therefore not recommended as a future replacement project at this time.

6.3.3 Valve Spacing

Valving on the irrigation system is typically installed at pipeline intersections and services. Based on inspection of existing valve locations and pipeline alignments, four (4) proposed valve locations were identified to better isolate pipelines, if required. The locations of existing and proposed valves for the irrigation system are shown in Figure 6-5.

Figure 6-5. Recommended Irrigation Valves

WATER MASTER PLAN

7.0 Operational Analysis

SAWCo operates its system in the most efficient manner possible and has identified several alternatives for consideration. Potential projects and anticipated impacts are discussed in this section.

IN THIS SECTION

- Rezoning
- Relocation
- Water Age Analysis
- Operational Improvement Projects

WSC met with SAWCo staff to discuss overall system operation and identify areas of improvement and concern. Overall, SAWCo's operational structure is in good shape. SAWCo is interested in exploring alternatives such as rezoning, pipeline relocation to improve access to infrastructure, and reinstating an out of operation booster pump station.

7.1 Rezoning

In 2021, SAWCo installed a new 120,000-gallon steel tank in the Holly Drive Zone. The existing 60,000-gallon tank is planned to be replaced with another 120,000-gallon tank in 2023, bringing the total storage in the Holly Drive Zone to 240,000 gallons. Currently, SAWCo experiences difficulty with turnover in the existing 60,000-gallon tank and is looking for solutions to increase reservoir turnover. Reservoir turnover will become even more difficult when the second 120,000-gallon tank is installed. One possible solution to increase reservoir turnover includes moving services along 26th Street that are part of the High Zone onto the Holly Drive Zone. This will increase the currently low pressures that can occur along 26th Street by moving them to the higher-pressure zone and assist in fire flow availability in this area.

Based on the model, SAWCo could reasonably serve 16 services from Holly Drive if several system modifications are made:

- Construct a 50-foot 12-inch main from Holly Drive to W 26th Street to connect High Zone services to the Holly Drive zone. Include a PRV with an estimated setting of 80 to mitigate high pressures along 26th Street.
- Construct 500-foot 8-inch main within Euclid Crescent W to create loop within system (connect existing 8- and 12-inch mains) and provide adequate pressure on the suction side of Holly Drive BPS.
- Close valve at the intersection of W 26th Street and Arctic Dr.
- Close valve at the intersection of W 26th Street and Holly Drive on the eastern side of the Holly Drive BPS suction main to isolate the suction and discharge areas of the Holly Drive BPS.
- Currently, services on 26th Street experience low pressure. Once rezoned to Holly Drive, pressure regulators will need to be installed.

With this new configuration, pressures are expected to increase from 23-66 psi to 92-134 psi within 26th Street and available fire flow will meet the minimum required flow in this area. However, SAWCo utilizes this area to convey water west from Reservoir 12 towards Reservoirs 5, 6, and 7. To ensure no severe disruptions to SAWCo operations occur as a result of rezoning, it is recommended that a more detailed rezoning feasibility analysis is completed prior to implementation.

To ensure adequate capacity is available, the Holly Drive BPS was analyzed with the addition of demands from the High Zone that would be served by the Holly Drive Zone. These services would add 11 gpm of demand to the Holly Drive Zone. Based on the analysis shown in Table 7-1, the Holly Drive BPS has sufficient capacity for additional demands as part of the RZ-1 project.

Table 7-1. Booster #19 Pump Station Analysis with RZ-1

PUMP STATION	ZONE SERVED	DESIGN CAPACITY (GPM)	BOOSTER STATION CAPACITY [1] (GPM)	ZONE FIRM CAPACITY (GPM)	CURRENT ADD (GPM)	CURRENT MDD (GPM)	REQUIRED CAPACITY (GPM)	SURPLUS/DEFICIT CAPACITY (GPM)	MEETS SUPPLY REQUIREMENTS
Booster #19 Holly Drive	Holly Drive	900	450	450	21	32	32	418	YES

[1] Booster station capacity is based on the largest pump out of service.

7.2 Relocation

SAWCo is focused on improving accessibility to system assets. As part of this WMP, pipelines located within private property were identified and alternatives to improve access to SAWCo's assets were evaluated. Seven locations were identified in the irrigation system with poor access and are recommended to be relocated within the right-of-way. Table 7-2 describes these projects and Figure 7-1 identifies the locations of these projects within the irrigation system. SAWCo may not need to relocate all pipelines identified and should consider only pipelines critical to providing deliveries to active irrigators.

Table 7-2. Irrigation System Relocation Projects

PROJECT NO.	PROJECT TYPE	LOCATION & DESRIPTION	EXISTING MATERIAL AND SIZE	PROPOSED PIPE LENGTH	RECOMMENDED SIZE AND MATERIAL
L-1	Pipeline Relocation	Replace existing pipeline from Forebay to Mountain Ln. Relocate existing pipeline from private property, tie-in at Canyon Dr, utilize Edison Easement to Mountain Ln.	22-inch Steel	620	24-inch PVC
L-2	Pipeline Relocation	Relocate 14-inch steel main from Reservoir 4 to Ravina Curve, W 23rd St and San Antonio Ave to W 22nd St.	14-inch Steel	1,300	14-inch PVC
L-3	Pipeline Relocation	Relocate pipeline to right-of-way in N San Antonio Ave and W 23rd St.	16- and 24-inch Concrete	5,600	24-inch PVC
L-4	Pipeline Relocation	Cut and cap existing pipeline east of Well 15 and 16 site. Install replacement pipeline within Campus Ave.	24-inch PVC and Steel	1,200	24-inch PVC
L-5	Pipeline Relocation	Relocate pipeline from private property of residents on Vallejo Way and relocate to N San Antonio Ave and W 21st St. Install new service.	8-, 10-, and 16-inch Concrete and Steel	3,700	12-inch PVC
L-6	Pipeline Relocation	Abandon existing pipeline in place and construct replacement in 1st Ave to E 21st St.	14- and 18-inch Steel	1,000	12-inch PVC
L-7	Pipeline Relocation	Cut and cap existing pipeline. Install replacement line in Euclid Ave.	8- and 14-inch Concrete	5,200	8-inch PVC
L-8	Pipeline Relocation	Cut and cap existing pipeline. Install replacement within 2nd Ave.	12- and 16-inch Concrete and Steel	7,500	12-inch PVC

Figure 7-1. Recommended Irrigation Mains to be Relocated

7.3 Water Age Analysis

The model was used to evaluate water age throughout the system. Water age is not a direct measurement of water quality, but many water quality issues are correlated with higher water age. There is not a recognized standard for water age, but it is generally accepted that the lower the water age, the higher the water quality. Long detention times can lead to the loss of the disinfectant residual, microbial growth, formation of disinfection byproducts, taste and odor problems, and other water quality issues (Environmental Protection Agency, 2002). According to AWWA, it is usually more difficult for smaller distribution systems to maintain a low water age because of lower demands and a smaller service area with more dead-end mains compared to larger systems (Environmental Protection Agency, 2002). Currently, SAWCo experiences high water age in the existing Holly Drive Reservoir. SAWCo maintains high water quality in their system through annual pipe flushing and water quality monitoring.

7.4 Operational Improvement Projects

Table 7-3 includes the recommended CIP projects to improve facility operations. These projects are listed in order of priority and are included in the final CIP with corresponding Project IDs. This list does not include all recommended operational improvements, only those that should be included in the CIP for budgetary purposes. Operational improvements at wells are not listed here and have been combined with recommended well rehabilitation and replacement projects described in Section 8.

7.4.1 Reviving BPS #9

SAWCo does not currently use existing BPS #9 within the irrigation system and is interested in reviving this BPS so that all assets can be used. BPS #9 is located in the southeastern portion of the irrigation system and could be used to boost water from Wells 2, 3, 24, and 31 up towards Reservoir 1. It is anticipated that irrigation deliveries will decrease in the future. SAWCo may consider replacing BPS #9 to supplement the domestic system in the southern portion of the system. To achieve this, additional treatment options and mainlines will be required to meet drinking water requirements and distribute water north into the Low Zone. Additional analysis is required to further analyze the feasibility of reviving BPS #9 for domestic system use and will require an analysis of existing irrigation wells, water quality, and treatment options.

Table 7-3. Recommended Operational CIP Projects

PROJECT ID	PROJECT TYPE	RECOMMENDED OPERATIONAL CIP PROJECT
O-1	Operation and Maintenance	Annual pipeline replacement program for the domestic system.
O-2	Operation and Maintenance	Annual pipeline replacement program for the irrigation system.
O-3	Operation and Maintenance	Evaluate the condition of the existing pipeline that conveys San Antonio Creek Water to the City of Upland tee in Mountain Ave. The existing pipeline is very old, comprised of 20- and 24-inch concrete/steel, and should be rehabilitated to ensure collection of surface water continues and to reduce leaks. Consider conventional replacement methods or slip-lining.
O-4	Operational Improvement	Replace or upgrade production meters for both the domestic and irrigation systems.
O-5	Risk and Resiliency	Obtain two backup well generators for supply resiliency.
O-6	Booster Pump Station Improvement	BPS #9 Analysis for future use as an irrigation asset or repurposed for domestic system use. Analysis should include hydraulic evaluation, water quality and treatment.
O-7	Operation and Maintenance	Install two additional valves within the irrigation system to better isolate pipelines and assist operational and maintenance activities.

WATER MASTER PLAN

8.0 Rehabilitation and Replacement

SAWCo understands the importance of establishing a routine replacement program for aging assets so that they can be replaced proactively. Proactive management allows SAWCo to avoid accumulating a backlog of replacement needs that can lead to service interruptions and/or sudden and significant financial impacts.

IN THIS SECTION

- Pipeline Asset Management
- Tank Condition Assessment
- Well Condition Assessment
- Pump Station Condition Assessment

As part of this WMP, WSC has evaluated asset age and expected useful lifetimes to establish appropriate rehabilitation and replacement (R&R) needs for the distribution system pipelines, tanks, wells, and booster pump stations. This analysis does not include a visual physical condition assessment of above ground structures, but future visual assessments can be used to update and refine the R&R recommendations.

8.1 Pipeline Asset Management

SAWCo is faced with the challenge of maintaining approximately 58 miles of domestic and irrigation mains in a cost effective and proactive manner. This analysis compares the material and installation year of mains with the expected useful life to forecast future potential replacement needs and provides guidance on the magnitude of potential future replacement costs and timing.

The mains that comprise the distribution systems are of various materials, ranging in size from 2- to 36-inch diameter, and installed in different time periods. Figure 8-1 and Figure 8-2 display the percentage of each material within the domestic and irrigation distribution systems, respectively. As shown, the domestic system is comprised of primarily ductile iron and steel pipe. The irrigation system is comprised of predominantly steel pipe, followed by concrete, ductile iron, and PVC pipelines.

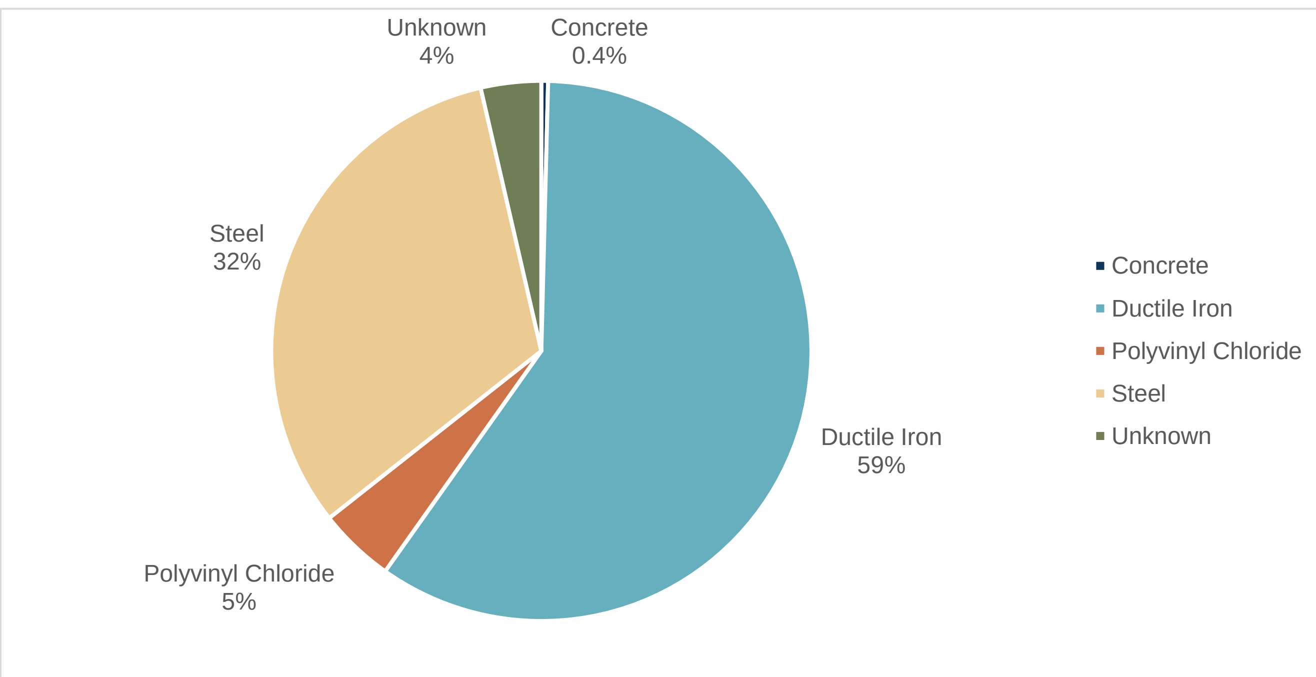


Figure 8-1. Percentage of Existing Domestic Pipe by Material

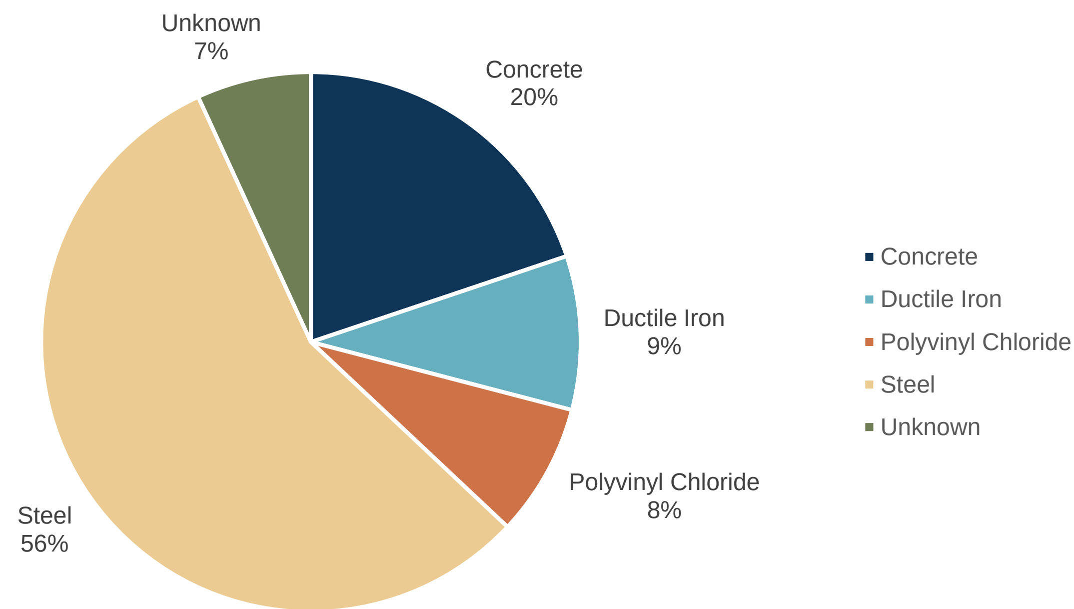


Figure 8-2. Percentage of Existing Irrigation Pipe by Material

Pipe installation data was provided by operations staff through marked up system maps and discussion. The installation year for each pipeline was added to the model to create a digital database of pipe ages. Pipeline end of useful life was estimated based on each pipeline's installation year and expected lifetime based on pipeline material using AWWA and industry accepted published useful lifetimes values, listed in Table 8-1. Starting with the pipe installation year and adding the assumed useful service life, the expected replacement year for each pipeline was estimated.

Table 8-1. Pipeline Estimated Useful Life Based on Material

MATERIAL	ESTIMATED USEFUL LIFE (YEARS) [1]
Concrete	75
Ductile Iron	80
Polyvinyl Chloride	70
Steel	80
Unknown	75[2]

[1] Estimated useful life is adapted from Deb, Arun, Herz, Raimund, et al: "Quantifying Future Rehabilitation and Replacement Needs of Water Mains"; WRF 1998, and AWWA Buried No Longer: Confronting America's Water Infrastructure Challenge Figure 5.

[2] Based on the average useful lifetime of known pipe materials, rounded to the nearest 5.

Figure 8-3 displays the estimated end of useful life by decade for the domestic system using the described methodology. As shown below, some pipelines are estimated to have already exceeded its useful lifetime beyond industry standards.

The cumulative expected end of useful life for all pipelines within the domestic system is shown in Figure 8-4. The analysis predicts that approximately 1,200 feet of pipelines that are not recommended for upgrades based on the capacity analysis have exceeded their useful life by 2020 or will exceed in the near future. These areas include E 25th St and Belleview Rd. These locations may be considered as priority replacements under SAWCo's annual maintenance program and should be evaluated in predesign to determine the condition and appropriate method of replacement, such as trenchless rehabilitation/slip-lining.

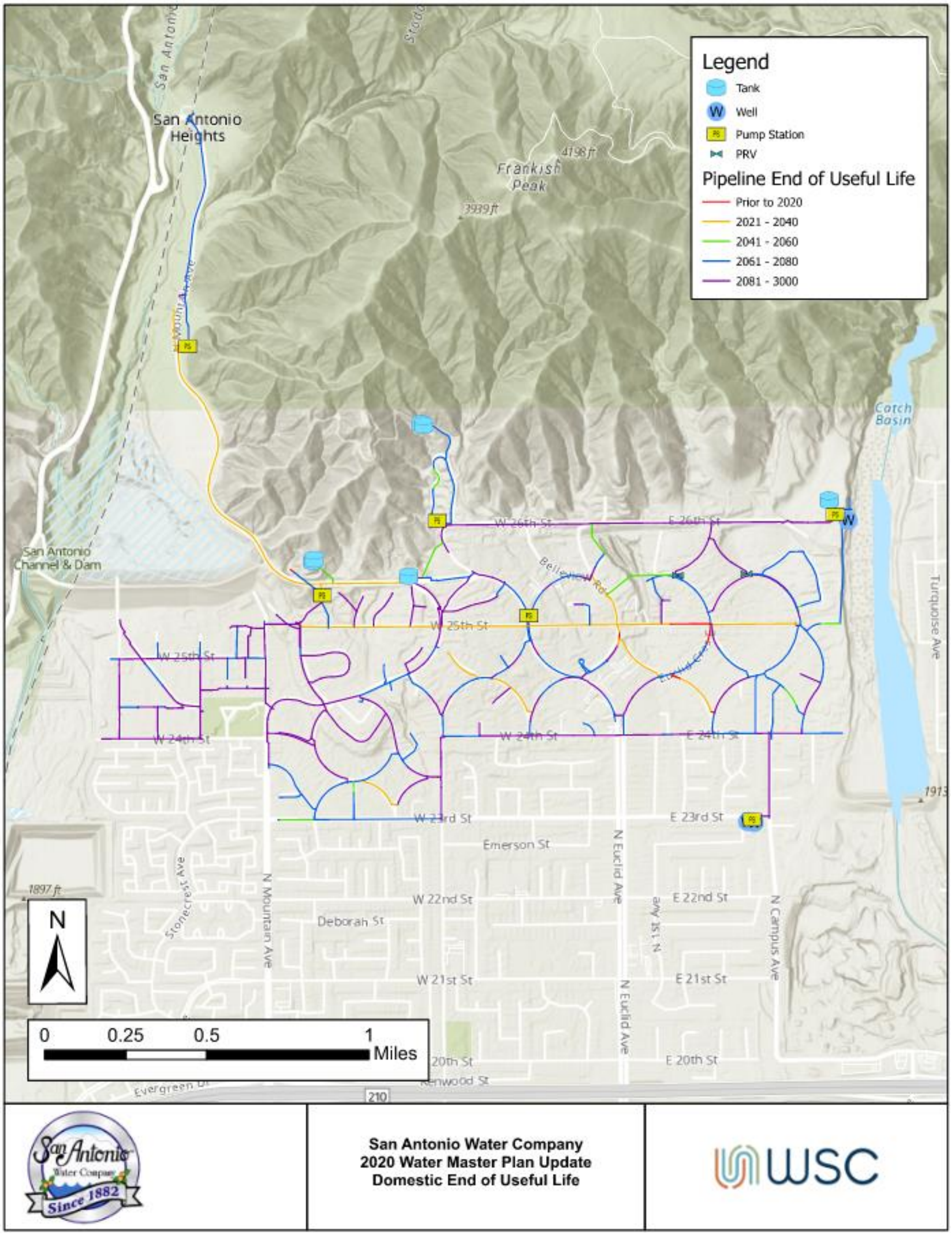


Figure 8-3. Domestic Pipeline End of Useful Life

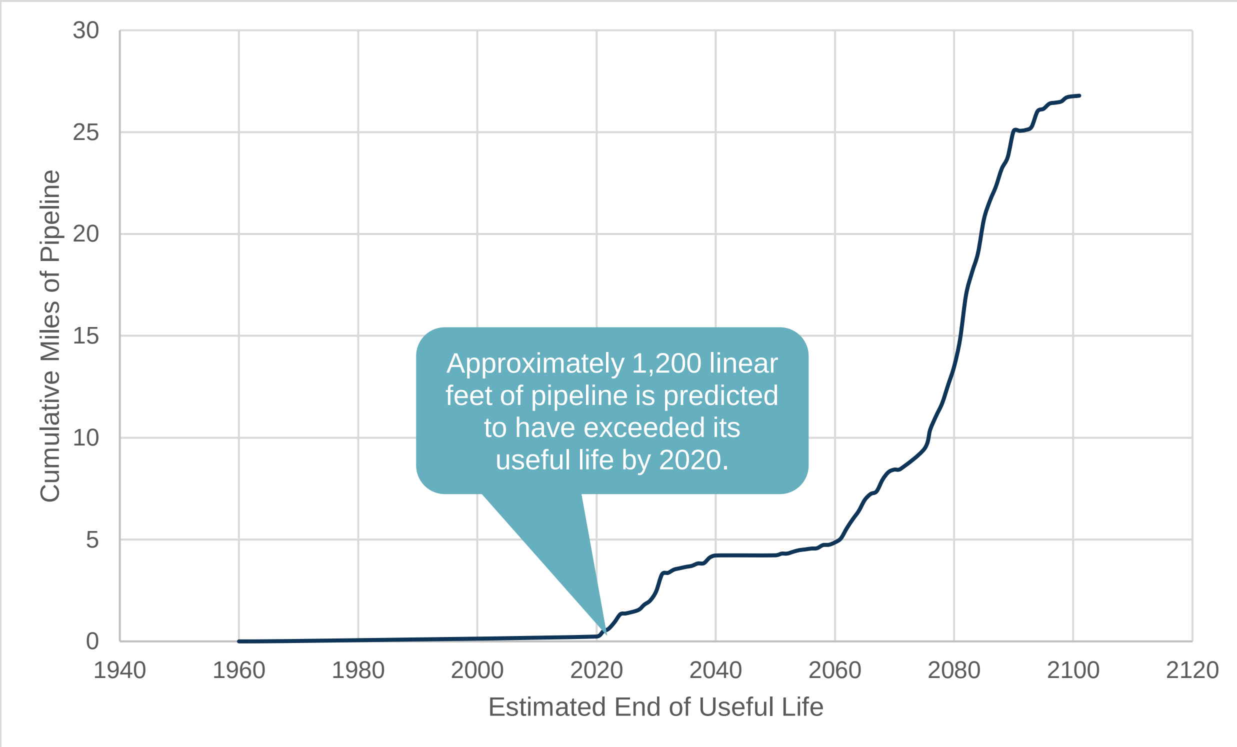


Figure 8-4. Estimated Cumulative Miles of Domestic Pipeline Failures

The majority of SAWCo's irrigation system pipelines are estimated to be operating beyond their useful life. As mentioned throughout this WMP, the future of the irrigation system is uncertain. It is highly possible that the irrigation system will be used less. Many of SAWCo's large irrigators no longer require large water purchases. It is anticipated that SAWCo's irrigation system may be repurposed for domestic use or portions of the southern irrigation system may be sold to the City of Upland and repurposed for recycled water use or for surface water transport to recharge basins. Despite the uncertainty, this WMP identifies locations that may require rehabilitation or replacement. The expected end of useful life for each pipeline is shown in Figure 8-5 while the cumulative expected end of useful life for all pipelines within the irrigation system is shown in Figure 8-6. It is recommended that although pipelines have been identified as having exceeded their useful life, pipelines should be replaced as needed under SAWCo's annual pipeline replacement program and to optimize system deliveries. Several key irrigation pipelines have been identified by SAWCo staff for improvements and are summarized in Table 8-2.

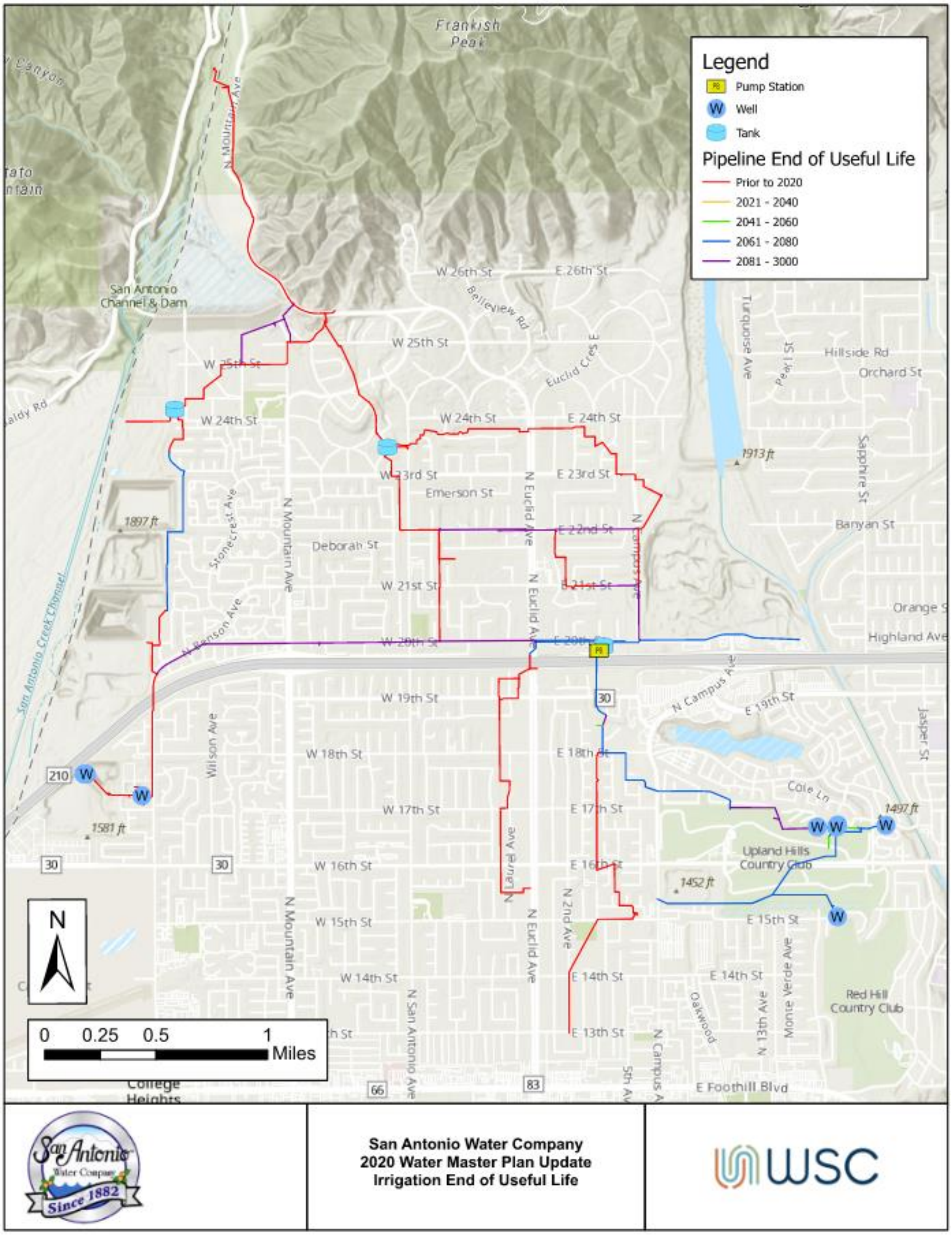


Figure 8-5. Irrigation Pipeline End of Useful Life

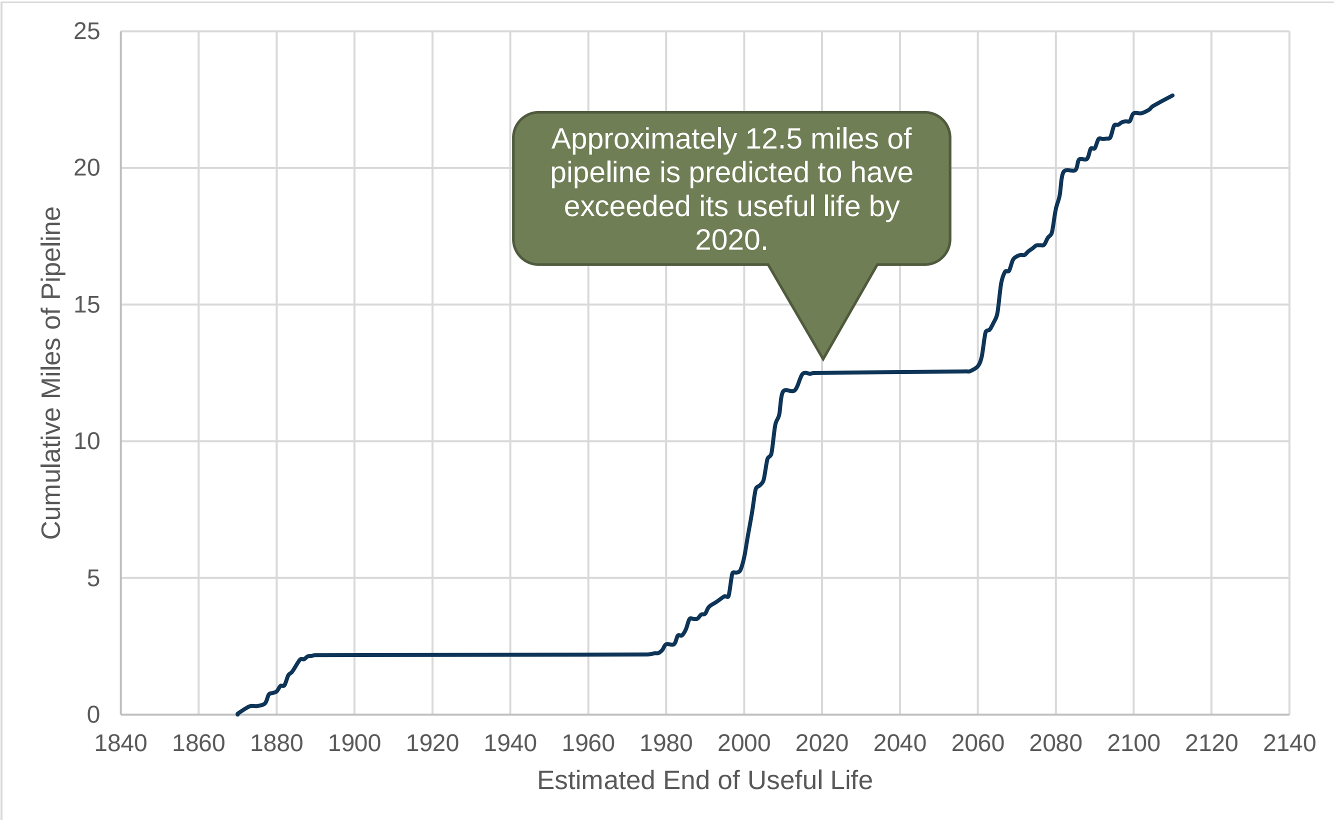


Figure 8-6. Estimated Cumulative Miles of Irrigation Pipeline Failures

Table 8-2. Irrigation Pipelines Identified for Rehabilitation & Replacement

NO.	LOCATION & DESRIPTION	EXISTING MATERIAL AND SIZE	PROPOSED PIPE LENGTH	RECOMMENDED SIZE AND MATERIAL
1	Surface water mainline from Main Box to Forebay	20-inch concrete and 24-inch steel	1.5 miles	24-inch PVC
2	Replace booster line from I-210 freeway south to 17th St. Consider future delivery capabilities to WFA.	14-inch steel	2,500 feet	14-inch PVC

Note: The areas identified above are areas noted with aging infrastructure and should be monitored and considered as a priority for main replacement. SAWCo should evaluate each location to determine the condition and appropriate method of replacement, such as trenchless rehabilitation/slip-lining. It is anticipated that such projects would be included under SAWCo's annual maintenance program.

This initial pipeline condition assessment is intended to inform SAWCo of potential asset liability that could arise in the future. This analysis is limited because it assumes that all pipes will fail at the end of their estimated useful lifetime. Many pipes will likely fail before their predicted end of useful lifetime, while some may exceed their end of useful life estimate. Based solely on pipeline ages, several areas have been identified as needed for replacement. SAWCo should continue to monitor conditions and select pipelines for replacement based on historical breaks, pipe conditions, and other information as available.

8.2 Tank Condition Assessment

The State Water Resources Control Board completed a sanitary survey of SAWCo's domestic tanks in 2015 and 2019. Overall, SAWCo's domestic tanks were in good condition at the time of the survey. It was noted that gaskets should be provided on the roof hatch at Reservoirs 6 and 12 and the exterior shell coating at Reservoir 7 was considered in poor condition. Despite these notes, no significant deficiencies were determined. It noted that all storage tanks should be professionally inspected and cleaned by contracted divers at least once every 3 to 5 years and that all domestic tanks were overdue for dive inspections and/or cleaning (Zuniga, January 27, 2020). SAWCo may consider inspecting the irrigation reservoirs as well.

8.3 Well Condition Assessment

Water wells require regular maintenance to ensure adequate water flow and continued drinking water safety. SAWCo has a robust well maintenance and rehabilitation plan to guarantee reliable supply for the distribution system. There are several categories of R&R work that apply to groundwater wells, described in Table 8-3. Costs for well R&R and replacement can vary significantly based on the well properties, it is most cost effective to perform regular well maintenance and R&R to prolong a well's lifetime opposed to well replacement.

Note, not all components of the wells were assessed, and the information presented below is to inform SAWCo of general well-R&R-type projects.

Table 8-3. Well Rehabilitation and Replacement Projects

WELL R&R TYPE	DESCRIPTION
Abandonment	When a well reaches the end of its useful life and/or SAWCo does not intend to continue use of the well, it must be abandoned in accordance with the California Well Standards, published as DWR Bulletin 74, to protect the groundwater and eliminate a physical hazard to humans and animals.
Well R&R	Over the life of a well, the screened portion of a well casing may become clogged and result in reduced production capacity and/or increased pumping drawdown. Well rehabilitation is intended to restore lost production capacity as well as lost water quality in some cases. Rehabilitation efforts consist of cleaning, inspecting, and rehabilitating the well as needed using a variety of chemical and/or mechanical methods.
Pump & Motor R&R	Pumps and motors wear over time and lose efficiency. To maintain them in efficient working order and prevent premature failure, routine maintenance includes removing the pump and motor to inspect, clean, and replace the pump, shaft, and column pipe as necessary, and rewind the motor and replace the bearing.
Electrical System R&R	The life and reliability of electrical equipment can be impacted by operating conditions such as exposure to moisture and chemicals, loading, temperature, vibration, and mechanical stress. Replacement of various components can be driven by technology changes or system efficiency and safety. The electrical components of the wells were not evaluated as part of this analysis.
Well Replacement	When a well must be completely replaced, a new well must be drilled and equipped. Well replacement is intended to replace an existing well and maintain supply capacity.

Note: Each facility should be assessed on a case-by-case basis to determine condition and assess appropriate costs required.

8.3.1 Rehabilitation and Replacement

SAWCo operates three wells within its domestic system and eight wells within its irrigation system. Well conditions were assessed using a scoring method based on well age, lost pumping capacity from the most recent pump tests completed in 2022, and pump efficiency. Weighting factors were applied to each criterion. Table 8-4 lists the well condition evaluation criteria, scoring, and weighting. The higher the score corresponds with a poorer well condition. The maximum score possible based on the weighted criteria is 18. All wells that received a weighted score of at least 70% of the maximum (a score of 12 or greater) are highlighted as candidates for R&R or replacement and are included in the CIP. Older wells should be considered for replacement rather than rehabilitation when other components begin failing (well casing, electrical components, etc.).

Table 8-5 through Table 8-8 list the well information and scoring based on the criteria described above. As an example of how each score is calculated, the score for Well 15's age (98 years) corresponded to a score of 3. This was multiplied by the weighting factor (value of 2) to obtain a total score of 6 for Well 15 well age evaluation.

Table 8-4. Well Condition Scoring

	SCORE	0	1	2	3
CRITERIA	WEIGHTING FACTOR				
Well Age	2	< 10 Years	10 – 29 Years	30 – 49 Years	< 50 Years
Lost Capacity	3	No Trend	< 25%	25 – 50%	> 50%
Efficiency	1	N/A	> 75%	50 – 75%	< 50%

Table 8-5. Domestic Well Condition Assessment

WELL	AGE		LOST CAPACITY				EFFICIENCY
	DATE DRILLED	AGE IN 2022	DESIGN CAPACITY, GPM	2022 CAPACITY, GPM	LOST CAPACITY, GPM	LOST CAPACITY, %	
Well 15	1924	98	500	409	-91	-18%	57.2%
Well 16	1988	34	1,000	977	-23	-2%	70.1%
Well 32	1987	35	340	287	-53	-16%	57.2%

Table 8-6. Domestic Well Scoring based on Weighted Criteria

	WELL AGE	LOST CAPACITY	EFFICIENCY	TOTAL SCORE
Well 15	6	3	2	**11**
Well 16	4	0	2	**6**
Well 32	4	3	2	**9**

Table 8-7. Irrigation Well Condition Assessment

WELL	AGE		LOST CAPACITY				EFFICIENCY
	DATE DRILLED	AGE IN 2022	DESIGN CAPACITY, GPM	2022 CAPACITY, GPM	LOST CAPACITY, GPM	LOST CAPACITY, %	
Well 2	1924	98	750	798	+48	6%	63.9%
Well 3	1924	98	1,000	1,096	+96	10%	63.9%
Well 22	1931	91	1,200	1,829	+629	52%	63.9%
Well 24	1947	75	2,100	2,618	+518	25%	66.8%
Well 25A	1958	64	600	270	-330	-55%	51.0%
Well 26	1956	66	600	496	-104	-17%	57.0%
Well 27	2000	22	1,000	482	-518	-52%	63.4%
Well 31	1957	65	2,300	1,909	-391	-17%	63.8%

Table 8-8. Irrigation Well Scoring based on Weighted Criteria

	WELL AGE	LOST CAPACITY	EFFICIENCY	TOTAL SCORE
Well 2	6	0	2	**8**
Well 3	6	0	2	**8**
Well 22	6	9	2	**17**
Well 24	6	6	2	**14**
Well 25A	6	9	2	**17**
Well 26	6	3	2	**11**
Well 27	2	9	2	**13**
Well 31	6	3	2	**11**

Based on the total weighted scores, four wells have a score greater than 12 and should be prioritized for rehabilitation or potential replacement depending on their age. Table 8-9 lists the recommended R&R projects for each well. The Project ID corresponds to that listed in the final CIP.

This evaluation only considers a few factors to help SAWCo prioritize wells that will need further investigation and planning for well rehabilitation efforts. Each well should include a thorough well and site investigation before any rehabilitation efforts or pump/motor replacements. This well R&R analysis should be periodically updated as additional information becomes available, including visual condition inspections, well component material and age, and length of time since the previous R&R work was completed for each well. Prior to rehabilitation of irrigation wells, SAWCo should evaluate which wells are most significant for the irrigation system and upgrade those first. Other irrigation wells may be considered for repurposing projects and switched to the domestic system in the future.

Table 8-9. Recommended Well R&R Projects

PROJECT ID	WELL	RECOMMENDED R&R PROJECT
WR&R-1	Well 19	Redrill Well 19 for domestic system reliability.
WR&R-2	Wells 22, 24, 25A, and 27	Conduct further evaluation of Wells 22, 24, 25A, and 27. Visually inspect and perform video inspection to determine the condition of each well. Develop well-specific rehabilitation and/or replacement plan.

8.4 Pump Station Condition Assessment

SAWCo operates six pump stations to fill the gravity reservoirs and supply the domestic system. The pump stations were not visibly inspected, but pump age and efficiency were used to evaluate the condition of each pump station. Industry accepted EUL for pump stations is 60 years and the EUL for pumps range from 10-20 years (Copeland, January 2008). SAWCo does not replace pumps based on a timed schedule but rather on the pump efficiency and motor tests, or at failure.

Any pump with efficiency below 60 percent is a candidate for pump and motor R&R. Table 8-10 lists the booster pump age and efficiencies, with the shaded cells indicating pumps that have exceeded their EUL or are operating at low efficiencies and are candidates for rehabilitation or replacement.

Table 8-10. Domestic Pump Station Condition Assessment

PUMP STATION	PUMP	DESIGN CAPACITY, GPM	2022 CAPACITY, GPM	LOST CAPACITY, GPM	PUMP INSTALLATION YEAR	PUMP AGE IN 2022	2022 PUMP EFFICIENCY
Booster #14 Forebay	Booster 1	500	505	+5	2013	9	53.4%
	Booster 2	500	512	+12	2013	9	51.3%
Booster #16 Euclid*	Booster 1	350	232	-118	2000	22	71.4%
	Booster 2	350	302	-48	2000	22	77.9%
Booster #18 Station 18*	Booster 2	1,500	953	-547	2004	18	70.9%
Booster #19 Holly Drive	Booster 1	450	283	-167	2018	4	64.9%
	Booster 2	450	299	-151	2018	4	66.8%
Booster #20 26th Street	Booster 1	1,000	1,008	+8	2007	15	77.2%
	Booster 2	1,000	892	-108	2007	15	74.6%

Shaded cells represent pumps that are candidates for replacement.

SAWCo does not complete pump tests for Booster #17 due to the small size (5 HP motors). Upgrades at Booster #17 were completed in 2021 and is in good operating condition.

*Booster #16 last tested in 2014 and results shown here. Planned to be tested in summer 2022.

*Booster #18 last tested in 2018 and results shown here. Planned to be tested in summer 2022.

Based on the existing booster pump ages, two have exceeded their estimated useful lifetimes. The oldest pumps should be prioritized for replacement when the pump efficiency and motor tests indicate a performance decline. Because these pumps are currently operating at an efficiency greater than 60%, their replacement is not scheduled nor included in the recommended pump station R&R projects. In addition, Booster #16 has exceeded its estimated useful lifetime, but is minimally used by SAWCo and in decent operating condition.

Similarly, the operating pump station within the irrigation system was also evaluated and results are provided in Table 8-11.

Table 8-11. Irrigation Pump Station Condition Assessment

PUMP STATION	PUMP	DESIGN CAPACITY, GPM	2022 CAPACITY, GPM	LOST CAPACITY, GPM	PUMP INSTALLATION YEAR	PUMP AGE IN 2022	2022 PUMP EFFICIENCY
Booster #1 20th Street	Booster 1	2,225	1,381	-844	2007	15	68.5%
	Booster 2	2,225	1,333	-892	2007	15	68.8%

WATER MASTER PLAN

9.0 Supply Risk and Resiliency Analysis

This section summarizes the findings and recommendations of the Supply Risk and Resiliency Analysis Technical Memorandum provided in Appendix B.

IN THIS SECTION

- Supply Risk and Resilience Analysis
- Recommendations

The Supply Risk and Resiliency Analysis TM analyses the existing supply sources, evaluates the top supply risks, and quantifies the impacts tops risks could have on SAWCo's ability to continue to provide a reliable and high-quality water to its shareholders. The main findings and recommendations from the TM are summarized in this Section. The complete Supply Risk and Resiliency Analysis TM is provided in Appendix B.

9.1 Supply Risk and Resilience Analysis

The supply risk and resilience analysis process is shown in Figure 9-1. The main process steps and findings are described below.

Figure 9-1. Supply Risk and Resilience Analysis Process

9.1.1 Analysis Goals and Planning Basis

SAWCo has a diverse supply portfolio consisting of surface water supplies from San Antonio Creek and groundwater from three overlying groundwater basin areas and the San Antonio Tunnel. Because these supplies are typically very reliable in most years, SAWCo's goal is to maintain their current level of service and meet all projected demands in the future, under all supply risk scenarios. In situations where this may not be possible, demands can be managed through the use of mandatory conservation with the Water Shortage Contingency Plan (WSCP).

9.1.2 Supply Source Risks

A multitude of potential supply source risks and uncertainties were identified and scored on likeliness of occurrence and impact to SAWCo's water system is they were to occur. The top identified risks are described below:

- **Earthquake / Loss of San Antonio Tunnel**. The largest impact from an earthquake would be damage to critical infrastructure, including the collapse of the San Antonio Tunnel.
- **Climate Change**. Climate change is expected to result in more extreme droughts, shifting rainfall patterns, more intense rainfall and flooding, and higher variability from surface water supplies. Climate change is occurring and the best mitigation SAWCo can take is to plan and prepare for climate related changes that will impact its supplies.
- **Mega-drought.** A mega-drought is a drought lasting two decades or longer, which would impact SAWCo's particularly vulnerable surface supplies and result in reduced recharge of groundwater basins through surface spreading and natural precipitation.
- **Regional Power Outage.** A regional power outage is likely to occur and could impact SAWCo's ability to produce groundwater; other supplies are gravity fed into the system. SAWCo is proactively

acquiring portable generators that could be used to continue operation of the water system during a regional power outage.

- **Increased Energy Costs.** Increased energy costs are highly likely to occur. This would impact the cost to pump and distribute water within both systems. SAWCo's largest supply sources from the San Antonio Creek and Tunnel are gravity fed into the system and therefore would be less impacted by the increasing energy costs. High energy costs will significantly impact operation costs during dry years when less surface water is available and SAWCo will need to pump more groundwater.
- **Reduced Groundwater Rights.** Each of the groundwater basins that SAWCo overlies are adjudicated and SAWCo has defined groundwater rights in each basin. There is a low likelihood that SAWCo's pumping rights will be reduced significantly in the future.
- **Groundwater Contamination.** Groundwater contamination could impact SAWCo's groundwater production facilities; however, this is considered a lower impact because SAWCo pumps from three separate groundwater basins and it is unlikely that contamination would impact all wells simultaneously.
- **Wildfires / Surface Water Quality Degradation.** Wildfires in the watershed of the San Antonio Creek could increase sedimentation and reduce the creek's surface water quality. All this water serves the irrigation system, and most is supplied to the Upland Water Treatment Plant for treatment and supply to the City of Upland. Sedimentation water quality impacts could impact the treatment process.

9.1.3 Supply and Demand Projections

Future conditions were evaluated against multiple supply and demand projections based on identified risks. Each scenario was evaluated using one supply and one demand projection to determine if under specific supply and demand conditions, there would be a gap between available supply and anticipated demand. Multiple scenarios that reflected different demand and supply amounts were analyzed.

9.1.3.1 Demand Projections

The demand projection used in most scenarios is described in Section 3. **The baseline demand projection includes a total demand of about 13,237 AFY by 2040, comprised of the following:**

- The current domestic system demand (2,290 AFY based on the last 3-years average demand) plus 30 AFY for future development within the domestic system.
- The current average irrigation system demand (8,917 AFY based on the last 3-years average demand).
- And a minimum of 2,000 AFY for surface water spreading.
- A 5% increase to account for non-revenue water including water loss.

To be conservative and evaluate the risk of demand rebound, a second demand projection was developed for this analysis assuming demands in the domestic and irrigation system increase to 2012 levels. Based on historic demand, pre 2012-2016 drought demand was much higher than current demands. During the drought, the demands dropped to the lowest ever due to conservation, and the current demand has recovered to about 85% of pre-drought levels.

The demand rebound projection includes a total demand of about 15,300 AFY by 2040, comprised of the following:

- The 2012 domestic system demand (3,000 AFY based on the last 3-years average demand) plus 30 AFY for future development within the domestic system.
- The 2012 irrigation system demand (10,270 AFY based on the last 3-years average demand).
- A minimum of 2,000 AFY for surface water spreading.
- A 5% increase to account for non-revenue water including water loss.

9.1.3.2 Supply Projections

A total of six supply projections were developed incorporating the top supply risks, shown in Figure 9-2 and described below:

- **Average Supplies**: This projection incorporates the average supply from the San Antonio Creek (about 4,000 AFY) and Tunnel (about 2,400 AFY), excluding outlying extreme wet and dry years. It also includes SAWCo's total groundwater rights from each basin, and assumes water is available for surface water spreading so 6,500 AFY is available from the Cucamonga Basin. The total volume available under this non-risk adjusted scenario is about 15,150 AFY.
- **Climate Change**: For the climate change supply projection, local climate change literature was reviewed to understand the impacts to SAWCo's supplies. Different climate change projections predict different impacts to rainfall, with some estimating more rainfall and other less rainfall in the future. Cal-Adapt Climate Projections for the Desert Region of San Bernardino County of which SAWCo overlies estimates a 2-to-4-inch decline in annual average rainfall by 2050 due to climate change (California Department of Public Health, 2017). However, all models predict shifting rainfall patterns with wetter winters and drier summers. Based on the various models two climate change projections were developed: (1) lower precipitation and (2) higher precipitation:
  - **Lower Precipitation**: the annual rainfall recorded at the San Bernardino San Antonio Heights Rain Gauge was plotted against the historic supplies from the San Antonio Creek and Tunnel to develop a trend between rainfall and supply volume from these sources. Using the plotted trends, a 4-inch annual average decline in rainfall corresponds with approximately a 20% decline in supply available from the San Antonio Creek and 10% decline in flow from the Tunnel. While Tunnel water is considered percolated groundwater, rainfall has a slight correlation with the supply from the Tunnel. For the climate change projections with lower future precipitation, the supply from the San Antonio Creek and Tunnel were decreased 20% and 10% from the average values respectively, corresponding with a new average of 3,200 AFY from the San Antonio Creek and 2,200 AFY from the Tunnel. Groundwater supplies are based on available rights and were not reduced based on climate change impacts. The total volume available under this climate change scenario is about 14,100 AFY.
  - **Higher Precipitation**: The higher precipitation scenario also assumes that the precipitation occurs over a shorter time period and is more intense. Generally, these more intense rainfall periods result in more runoff and less percolation in the groundwater. Because of this, the supply from the San Antonio Tunnel is still expected to be lower than the historic average and is assumed to be 90% of average (2,200 AFY) like the above climate change projection. The San Antonio Creek, however, is expected to have higher flows in the winter which could potentially be diverted to spreading basins and stored in the groundwater to be pumped later in

the summer. This projection assumes supply from the San Antonio Creek will increase 20% from average to about 4,850 AFY. However, the higher intensity rainfall and increased runoff could impact the water quality from the creek, which serves non-potable customers and the Upland Water Treatment Plant, and could impact the treatment plant operations. With no impact to groundwater, the total volume available under this climate change projection is 15,720 AFY.

- **Reduced Groundwater Yield**: While SAWCo's groundwater rights are defined through the adjudications of the groundwater basins, climate impacts and reduced outdoor water use due to aggressive State conservation efforts could impact the natural recharge of the basins. These impacts could result in future revisions and reductions to the rights of all pumpers in the groundwater basins. To understand the impact this could have on SAWCo, this projection incorporates a 10% reduction in all available groundwater supplies for a total available supply of about 14,300 AFY.
- **Tunnel Collapse**: The San Antonio Tunnel is one of SAWCo's main sources of water that is gravity supplied to the system and can be delivered directly to customers for potable uses with only disinfection for treatment. The projection assumes the San Antonio Tunnel is collapsed and no water is available from the Tunnel, reducing the average available supply from about 15,150 AFY to 13,900 AFY. While this projection includes all other supplies, the analysis considers the domestic and irrigation system separately, and without the Tunnel supply the domestic system loses its main supply source.
- **Mega Drought**: To project the water supplies during a mega drought, the historic water available from the San Antonio Creek and Tunnel were reviewed and sorted based on average rainfall and yield. The average yield from the driest 30% of the years were used in this projection, which includes an average yield from the San Antonio Creek of about 1,780 AFY and 1,550 AFY from the Tunnel. With the groundwater rights unimpacted, the total supply is about 13,900 AFY if 2,000 AF of the San Antonio Canyon water were used for spreading, or more likely a total supply of 11,800 AFY with no water used for surface water spreading.

Overall, the future supplies are projected to range between 11,800 AFY to 15,720 AFY.

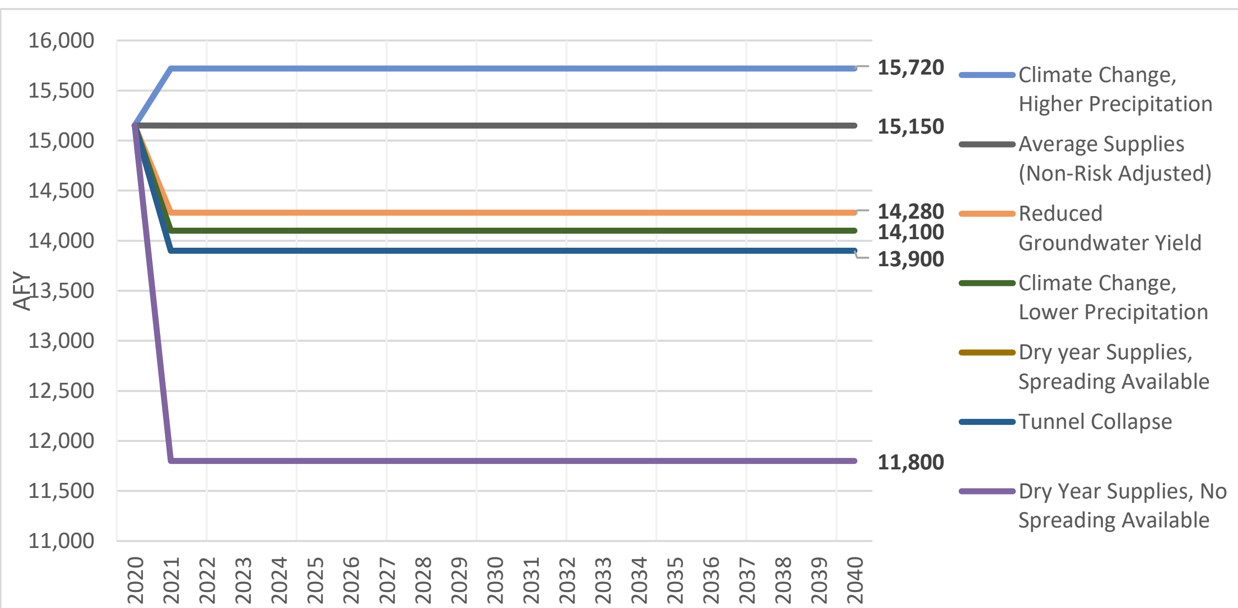


Figure 9-2. Average and Risk Adjusted Supply Projections

9.1.4 Gap Analysis

The supply projections were combined with a demand projection to create future scenarios. These scenarios were evaluated to find if there will be a supply shortage, or gap between projected supply and demands, under the scenario conditions. Table 9-1 lists the eight evaluated scenarios, including the results of the gap analysis. Appendix B includes more detail on how the gap analysis and surplus and shortfall values were developed.

As shown, scenarios 1A, 2, 3, and 6 do not have a supply shortfall, and any surplus San Antonio Canyon supply would be available for additional spreading each year. Scenario 1A represents current conditions, but may not be representative of the future.

Scenarios 1B, 4A, 4B, and 5 all project a supply deficit and will require conservation savings or potentially new and emergency supplies to meet all demands. Scenario 1B incorporate demands rebounding to pre-drought levels and shows that if this were to occur demands would likely exceed future supplies. While it is unlikely to rebound to pre-drought levels with new State mandated water use efficiency standards and urban water budgets expected in 2022, it is recommended SAWCo continues to promote conservation and implement future State water use efficiency standards and objectives to prevent demands increasing beyond supplies.

Scenario 4A and 4B incorporate dry year supplies to evaluate the impacts of a mega-drought against the baseline demand projection. Scenario 4A includes a 2,000 AFY demand for surface water spreading, which allows SAWCo to pump up to 6,500 AFY from the Cucamonga Basin. However, during an extended drought the supplies from the San Antonio Creek and Tunnel are most likely to be impacted, and there may not be available water from these sources to direct to spreading basin. Scenario 4B excludes the demand for surface water spreading and limits the supply from the Cucamonga Basin to 4,500 AFY. In both scenarios there is a supply shortfall compared to demands, and conservation savings of 14-15% are needed to close the gap.

Table 9-1. Scenario Gap Analysis

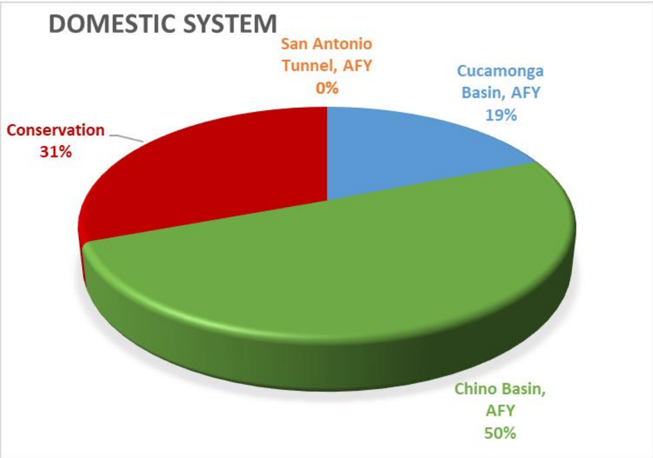
SCENARIO	DEMAND PROJECTION	SUPPLY PROJECTION	SUPPLY SURPLUS (+) OR SHORTFALL (-) AFY	IF SHORTFALL, HOW MUCH CONSERVATION IS NEEDED?
1A	**Baseline Demand** (Includes baseline domestic and irrigation demands plus a minimum 2,000 AFY for surface spreading)	**Average Supplies:** Total supply of 15,150 AFY	1,252	N/A
1B	**Rebound Demands** (Includes rebound/ increased to 2012 usage levels in the domestic and irrigation system, plus a minimum 2,000 AFY for surface spreading)	**Average Supplies:** Total supply of 15,150 AFY	-915	6%
2	**Baseline Demand**	Supplies with **Climate Change resulting in lower precipitation:** Total supply of 14,100 AFY	199	N/A
3	**Baseline Demand**	Supplies with **Climate Change resulting in higher precipitation:** Total supply of 15,720 AFY	1,816	N/A
4a	**Baseline Demand**	**Mega Drought:** Total supply of 13,900 AFY	-1,902	14%
4b	**Baseline Demand, no surface water spreading**	**Mega Drought:** Total supply of 11,900 AFY due to limited Cucamonga Basin Rights without surface water spreading	-1,802	15%
5	**Baseline Demand**	**Tunnel Collapse:** Total supply of 13,900 AFY	-1,191	9%
6	**Baseline Demand**	**Reduced Groundwater Yield:** Total supply of 14,280 AFY	386	N/A

Scenario 5 compares the baseline demand projection to supplies without the San Antonio Tunnel which could occur with a tunnel collapse due to a major earthquake or other natural disaster. In this scenario there is a supply deficit of over 1,000 AFY, which corresponds with a 9% demand reduction needed so demands do not exceed supplies.

In addition to the whole system evaluation presented above, the gap analysis considered limitation of supplies to serve the domestic and the irrigation system. When considering the operation of the two systems, all scenarios with a supply surplus (Scenario 1A, 2, 3, and 6) continue to have excess supply that can be used for additional surface water spreading.

Of the scenarios with a supply deficit, in Scenario 1B, 4A and 4B the required conservation can apply to either system. In these scenarios there are no supply or production limitations on providing the retail potable water demand to San Antonio Heights in the domestic system. A reduction in the share value, or volume of water each share is entitled, for wholesale customers based on the supply availability could be used to reduce demands to meet the available supply in these scenarios. Also, the model did not consider conjunctive use and any long-term storage of San Antonio Canyon water in the groundwater basins that could also be available to SAWCo when needed during dry years to reduce the conservation needed.

For Scenario 5, the domestic system has a much higher impact due to the loss of the tunnel than the irrigation system. Figure 9-3 below shows the supply break down for the domestic and irrigation system for Scenario 5. As shown, with the loss of the tunnel the domestic system will require more than 30% conservation to reduce demands to meet the available potable supplies while the irrigation system will only require minor reductions in demand. Alternatively, a new supply source or emergency supply could be used to augment the domestic system supply and reduce the amount of conservation required.



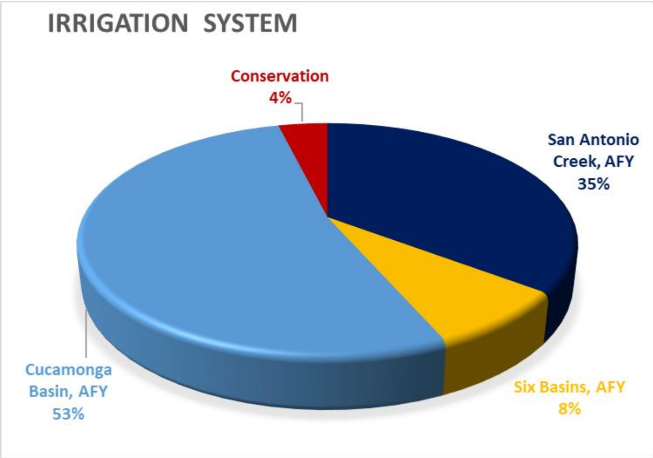


Figure 9-3. Scenario 5 Tunnel Collapse Supply Portfolio for the Domestic and Irrigation Systems

9.2 Recommendations

The gap analysis shows that under the future scenarios evaluated, SAWCo's well diversified supply portfolio is sufficient to meet projected demands in most scenarios and situations. However, it is important SAWCo maintains its current conjunctive use operation strategy, production facilities and infrastructure, and demand management measures. In addition to the active maintenance of its systems, new potential supplies are recommended for further investigation to serve the domestic system potable water in the event of the loss of the Tunnel supply.

Recommendations to maintain the current systems and supply portfolio:

- **Conjunctive use:** SAWCo currently diverts San Antonio Canyon Water in the winter during the rainy season for surface water spreading and recharge of groundwater basins. It is recommended to continue this practice to maximize the available San Antonio Canyon Water and store in the groundwater basins for longer term use. Building up groundwater storage through conjunctive use could help SAWCo meet demands and reduce or eliminate the need for the WSCP during extremely dry years.
- **Demand Management:** The analysis estimates that if demands rebound to pre-drought levels it could exceeded the normal supplies available to each year. While this is unlikely and current lower water use levels are expected to continue, SAWCo should maintain its demand management measures to prevent water waste and a potential rebound to unsustainable demand levels.
- **Infrastructure Maintenance:**
  - **Tunnel Inspection and Maintenance:** The San Antonio Tunnel is a high volume and important gravity fed source of potable water for the domestic system. As shown in Scenario 5, if the San Antonio Tunnel collapsed there will be a significant supply shortage for the domestic system. Firstly, the San Antonio Tunnel should be inspected via CCTV and evaluated by a structural engineer. The inspection can provide an assessment of the current condition of the San Antonio Tunnel and provide recommendations for improvements to maintain the lifespan of the tunnel, such as lining the San Antonio Tunnel or other retrofit recommendations. If significant issues are found that would require major improvements, SAWCo can plan for these improvements now instead of responding to these issues after an emergency such as a tunnel failure or collapse.
  - **San Antonio Creek Diversion and Maintenance:** Similar to the San Antonio Tunnel, the San Antonio Creek is a high volume and important gravity fed supply source. Currently all the water from the San Antonio Creek is diverted at one location and conveyed into the irrigation system via a single clay pipeline that is nearing the end of its useful lifetime. The pipeline should be inspected and evaluated for relining. The evaluation should consider the ideal relining materials and method, impacts to the pipeline capacity, and cost evaluation with a comparison to replacing the pipeline through a traditional replacement method.
  - **Well Maintenance:** SAWCo's groundwater wells are also important production facilities and regular testing, maintenance and upkeep is imperative to maintaining production capacity. While the loss of a single well has a less impact than the loss of the tunnel or creek pipeline, regular well upkeep can maintain well production capacity and extend

the well's lifetime. It is also recommended to obtain one or more back-up generators that can be used to operate the wells during power outages and emergency situations. Well maintenance also includes groundwater monitoring efforts to ensure existing wells can continue to produce should groundwater levels drop due to other risks identified in this WMP.

Recommendations for new supply sources:

- **Construct Well 19:** As described in Section 4, SAWCo plans to construct a new well within the Cucamonga Basin to mitigate the production deficit in the domestic system. Future Well 19 is projected to provide approximately 1,490 gpm of additional supply to the domestic system, which will help maintain service levels in the domestic system if the tunnel collapsed or other supplies were unavailable.
- **Emergency Connection:** In the past SAWCo has purchased water from the City of Upland. Due to the potable supply limitations to the domestic systems, and vulnerability of the San Antonio Tunnel, a new emergency connection is recommended for the domestic system to provide potable water for SAWCo's domestic customers. One potential location may be a direct connection with the City of Upland downstream of their Water Treatment Plant where SAWCo purchases back water supplied to the City that has now been treated, or through an agreement with the City to treat additional water for SAWCo. It is likely that additional connections will be required to meet emergency demand, as the existing connections are limited to roughly 500 gpm. SAWCo has previously explored imported water connections from Metropolitan Water District or the neighboring Cucamonga Valley Water District. However, no ideal locations have yet been identified. A future interconnection would ideally be located in the domestic system along an existing main with adequate capacity. Additional discussion with potential partnering agencies and evaluation of interconnection locations is needed to determine the preferred intertie location. At this time, no ideal location has been identified.
- **Repurpose Irrigation System Wells for use in the Domestic System:** SAWCo has multiple wells that currently only serve the irrigation system. These wells could be repurposed to serve the domestic system when needed. If required, new wellhead treatment could be constructed to meet potable water quality standards, and existing or new infrastructure repurposed or constructed to convey more groundwater water to the domestic system. However, additional domestic pipelines will need to be constructed to convey water north to reach domestic customers, or existing irrigation lines would need to be isolated and repurposed. An alternative to repurposed irrigation assets is the construction of a new domestic well, Well 19.
- **1 MGD Water Treatment Plant:** Currently, water from the San Antonio Creek serves only the irrigation system and is the main supply source for the City of Upland's surface water treatment plant. A new SAWCo owned and operated 1 MGD water treatment plant, located near the Forebay, could allow SAWCo to treat the creek supply to drinking water levels and serve the domestic system. The WTP would reduce the current vulnerability in the domestic system and allow additional sources of supply to serve San Antonio Heights. A 1 MGD plant corresponds to 1,120 AFY if operating a full capacity year-round, which would supply about 95% of the supply and demand gap in the domestic system if the tunnel were out of service. Additionally, the treatment plant would be available to provide water to the City of Upland when their treatment plant is out of commission.

WATER MASTER PLAN

10.0 Recommended Capital Improvement Program

This section summarizes projects identified in this master plan and recommended capital projects, costs, and implantation schedule.

IN THIS SECTION

- Cost Estimating Basis and Assumptions
- Improvement Projects Summary
- Implementation

Projects to improve performance, reliability, and lifespan of the wholesale system infrastructure have been identified in the previous sections. This section summarizes those identified projects, provides project costs, and a recommended capital improvement plan for the next 20 years.

10.1 Cost Estimating Basis and Assumptions

The cost opinions (estimates) with the recommended projects in this CIP have been prepared in conformance with industry practices as planning-level cost opinions. These cost estimates have been developed using a combination of data from RS Means CostWorks® and recent bids, experience with similar projects, current and foreseeable regulatory requirements, and an understanding of necessary project components. As projects progress, the designs and associated costs could vary significantly from the project components identified in this CIP. Detailed cost estimates are included in Appendix C.

The recommended projects and these cost opinions are based on the following assumptions:

1. For projects where applicable cost data is available in RS Means CostWorks® (e.g. pipeline installation), cost data released in Quarter 3 of 2022, adjusted for San Bernardino, California is used.
2. For projects where RS Means CostWorks® data is not available, cost opinions are generally derived from bid prices from similar projects with adjustments for inflation, size, complexity, and location.
3. Cost opinions are in 2022 dollars. When budgeting for future years, an escalation factor of 3% was applied.
4. Cost opinions are “planning-level” and may not fully account for site-specific conditions that will affect the actual costs, such as soil conditions and utility conflicts.
5. Construction costs include a 20% contingency based on the subtotal. For planning projects, construction costs are not included in the total project cost.
6. Total project costs include a 25% project development cost to cover administrative, alternative analysis, planning, engineering, surveying, etc. costs.

10.2 Improvement Projects Summary

Table 10-1 provides a summary of projects identified within this WMP and includes the estimated cost for each project. Each project listed includes the project number listed in the CIP, improvement project name, estimated cost, and the report section where discussion of the project is provided.

Table 10-1. CIP Projects Summary

PROJECT	ESTIMATED COST	SECTION REFERENCE
REZONING	**$56,300**	
RZ-1: Expanded Holly Drive Zone Feasibility Study	$56,300	Section 7.1
FIRE FLOW	**$233,000**	
FF-1: Ponte Vecchino Ct Pipeline	$110,100	Section 6.2
FF-2: Hillcrest Drive Pipeline	$39,600	Section 6.2
FF-2: Hydrant Installation	$83,300	Section 6.2.2
REHABILITATION & REPLACEMENT	**$6,556,800**	
R&R-1: Well 19	$2,912,000	Section 4.1.1
R&R-2: Domestic Tank Inspections	$61,800	Section 8.2
R&R-3: San Antonio Tunnel Inspection	$524,200	Section 9.2
R&R-4: E 25th St Main Replacement	$110,200	Section 8.1
R&R-5: Belleview Rd Main Replacement	$29,200	Section 8.1
R&R-6: Irrigation Wells 22, 24, 25A, and 27 Evaluation	$110,000	Section 8.3.1
R&R-7: Main Box Surface Water Pipeline Replacement	$2,426,900	Section 8.1
R&R-8: Benson Ave Irrigation Replacement	$382,500	Section 8.1
OPERATION & MAINTENANCE	**$2,333,100**	
O-1: Annual Domestic Pipeline Replacement	$261,700	Section 7
O-2: Annual Irrigation Pipeline Replacement	$174,700	Section 7
O-3: San Antonio Creek to Upland tee Irrigation Pipeline Evaluation	$541,000	Section 7
O-4: Production Meter Upgrades/Replacement	$436,000	Section 7
O-5: Backup Well Generators	$687,500	Section 7
O-6: BPS #9 Analysis	$62,500	Section 7.4.1
O-7: Irrigation Valves	$69,700	Section 6.3.3

TOTAL ESTIMATED COST	$9,079,200

Note: Costs are provided in 2022 dollars. Total budget estimate for each project may span multiple years in the CIP.

10.3 Implementation

SAWCo has historically maintained a $3.15 million budget for operation and maintenance. Based on the project's specified in Table 10-1, it's estimated that SAWCo could spend between $800,000 up to $2.5 million in a given year.

Table 10-2. 10-Year CIP

Project ID	System	Description	Pipe Length, feet	Diameter / Capacity	Project Total (2022 Dollars)	CIP Value in Future Year Dollars										
						2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Beyond 2032
						1	2	3	4	5	6	7	8	9	10	11+
Rezoning					***$56,300***	***$0***	***$0***	***$0***	***$61,521***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
RZ-1	Domestic	Perform a detailed feasibility study of potential rezoning at Holly Drive / High Zone to improve pressure, fire flow, and Holly Drive storage turnover / water quality.	N/A	N/A	$56,300				$61,521							
Fire Flow					***$233,000***	***$0***	***$0***	***$88,373***	***$43,272***	***$0***	***$0***	***$0***	***$0***	***$0***	***$143,656***	***$0***
FF-1	Domestic	Replace existing 4-inch pipeline with 8-inch PVC when pipeline fails within Ponte Vecchino Ct.	560	8-inch	**$110,100**										$143,656	
FF-2	Domestic	Install pipeline and associated appurtenances within Hillcrest Drive to improve system reliability and provide fire protection.	300	8-inch	**$39,600**				$43,272							
FF-3	Domestic	Install 6 hydrants to provide adequate fire hydrant coverage throughout the domestic system.	N/A	N/A	**$83,300**			$88,373								
Rehabilitation & Replacement					***$6,556,800***	***$1,980,200***	***$1,525,142***	***$26,225***	***$43,556***	***$63,816***	***$159,632***	***$998,785***	***$994,927***	***$1,024,775***	***$249,538***	***$257,024***
R&R-1	Domestic	Redrill Well 19 for domestic system reliability.	N/A	1,490 gpm	**$2,912,000**	$1,456,000	$1,499,680									
R&R-2	Domestic	Professionally inspect and clean all domestic storage tanks with divers.	N/A	6.72 MG	**$61,800**		$25,462	$26,225	$13,506							

Project ID	System	Description	Pipe Length, feet	Diameter / Capacity	Project Total (2022 Dollars)	CIP Value in Future Year Dollars										
						2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Beyond 2032
						1	2	3	4	5	6	7	8	9	10	11+
R&R-3	Domestic	Inspect the San Antonio Tunnel via CCTV and evaluate results by a structural engineer.	5,100	6' x 6'	**$524,200**	$524,200										
R&R-4	Domestic	Rehabilitate or replace 600-feet of 8-inch main within E 25th St approaching Euclid Crescent E.	600	8-inch	**$110,200**						$127,752					
R&R-5	Domestic	Rehabilitate or replace 200-feet of 6-inch main within Belleview Rd.	200	6-inch	**$29,200**					$32,865						
R&R-6	Irrigation	Conduct study to further evaluate the conditions of Wells 22, 24, 25A, and 27. Visually inspect and perform video inspection to determine condition of each well. Develop well-specific rehabilitation and/or replacement plan.	N/A	N/A	**$110,000**				$30,050	$30,951	$31,880	$32,836				
R&R-7	Irrigation	Rehabilitate or replace approximately 1.5 miles of 20-inch concrete and 24-inch steel surface water line from main box to Forebay.	7,920	24-inch	**$2,426,900**							$965,949	$994,927	$1,024,775		

Project ID	System	Description	Pipe Length, feet	Diameter / Capacity	Project Total (2022 Dollars)	CIP Value in Future Year Dollars										
						2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Beyond 2032
						1	2	3	4	5	6	7	8	9	10	11+
R&R-8	Irrigation	Replace 2,500 feet of existing 14-inch steel booster line from I-210 freeway south to 17th St within Benson Ave with 14-inch PVC. Consider future delivery capabilities to WFA.	2,500	14-inch	**$382,500**										$249,538	$257,024
Operation & Maintenance					***$2,233,100***	***$436,400***	***$449,492***	***$1,125,244***	***$715,081***	***$1,178,520***	***$904,408***	***$521,084***	***$536,717***	***$552,818***	***$569,403***	***$586,485***
O-1	Domestic	Annual pipeline replacement program for domestic system. Replace approximately 2,300 feet of domestic mains per year.	2,300 / year	8-inch	**$261,700**	$261,700	$269,551	$277,638	$285,967	$294,546	$303,382	$312,483	$321,858	$331,514	$341,459	$351,703
O-2	Irrigation	Annual pipeline replacement program for irrigation system. Replace approximately 1,200 feet of irrigation mains per year.	1,200 / year	12-inch	**$174,700**	$174,700	$179,941	$185,339	$190,899	$196,626	$202,525	$208,601	$214,859	$221,305	$227,944	$234,782
O-3	Irrigation	Evaluate the condition of the existing pipeline that conveys San Antonio Creek Water to the City of Upland tee in Mountain Ave. The existing pipeline is very old, comprised of 20- and 24-inch concrete/steel, and should be rehabilitated to ensure collection of surface water continues and to reduce leaks. Consider conventional replacement methods or slip-lining.	6,000	24-inch	**$541,000**					$608,900						

Project ID	System	Description	Pipe Length, feet	Diameter / Capacity	Project Total (2022 Dollars)	CIP Value in Future Year Dollars										
						2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Beyond 2032
						1	2	3	4	5	6	7	8	9	10	11+
O-4	Domestic & Irrigation	Upgrade and replace production meters in both the domestic and irrigation systems.	N/A	N/A	**$436,000**			$231,276	$238,214							
O-5	Domestic & Irrigation	Obtain one or more backup well generators for supply resiliency.	N/A	N/A	**$687,500**			$364,684			$398,500					
O-6	Irrigation	BPS #9 Analysis for future use as an irrigation asset or repurposed for domestic system use. Analysis should include hydraulic evaluation, water quality and treatment.	N/A	N/A	**$62,500**			$66,306								
O-7	Irrigation	Install two additional valves within the irrigation system to better isolate pipelines and assist operational and maintenance activities.	N/A	N/A	**$69,700**					$78,448						
					CIP Total ***$9,079,200***	***$2,416,600***	***$2,416,600***	***$1,974,634***	***$863,429***	***$1,242,337***	***$1,064,040***	***$1,519,869***	***$1,531,644***	***$1,577,593***	***$962,596***	***$843,509***

Note: Costs escalated at 3% per year.

REFERENCES

(2017). (San Anonio Heights, CA) Retrieved from Datausa.io: https://datausa.io/profile/geo/san-antonio-heights-ca/

American Water Works Association. (2001). *AWWA Manual M19, Fourth Edition. Emergency Planning for Water Utilities.*

California Department of Public Health. (2017). *Climate Change and Health Profile Report San Bernardino County.*

Copeland, A. (January 2008). *Can a Small System Develop an Effective Asset Management Program?* AWWA Opflow.

Cucamonga Basin Judgment, Case No. 92645 (1958).

Environmental Protection Agency. (2002). *Effects of Water Age on Distribution System Water Quality.* Environmental Protection Agency.

San Antonio Water Company. (June 2022). *2021 Water Quality Report.* Upland: San Antonio Water Company.

San Antonio Water Company. (June 22, 2021). *Paloma Curve Hydraulic Break, Agenda Item No. 6C.* Upland: San Antonio Water Company.

Six Basins Judgment, Case No. KC029152 (1998).

Zuniga, E. J. (January 27, 2020). *2019 Sanitary Survey of San Antonio Water Company (System No. 3610085).* State Water Resources Control Board, Division of Drinking Water.

A

Appendix A Hydraulic Model Development

COMPREHENSIVE SYSTEM MASTER PLAN AND ASSET MANAGEMENT PROGRAM

Hydraulic Model Development

San Antonio Water Company (SAWCo) has appointed Water Systems Consulting, Inc. (WSC) with the task of updating their Water Master Plan (WMP). Part of updating the WMP includes building and calibrating a new hydraulic model in Innovyze's InfoWater® hydraulic modeling software based on SAWCo's current system mapping. A calibrated hydraulic model is a valuable tool that SAWCo can use to evaluate the distribution system, determine system deficiencies, and predict the system response due to operational changes.

This technical memorandum (TM) describes how the model was built and calibrated, including assumptions made for missing or unknown data.

IN THIS SECTION

- Model Structure and Connectivity
- System Demands
- System Evaluation Criteria
- Model Calibration
- Extended Period Simulation

1.1. Model Structure and Connectivity

The first step in model development is to build the model structure, confirm the pipe and facility connectivity, and populate basic facility physical information. The model structure was built using SAWCo's Geographic Information System (GIS) database that contains a map of the distribution system's assets and information on the system's water mains, reservoirs, pump stations, wells, valves, meters, and other assets. The GIS data was carefully reviewed for pertinent information that would affect the system hydraulics and was prepared for transfer to the hydraulic model. Unique ID's that distinguished pipelines as domestic or irrigation (PD_XX versus PIR_XX) were created in GIS for the pipes and imported into the model. The unique Model ID links elements to the GIS database for seamless updates in both systems. Names for the reservoirs, wells, and PRVs were used as asset ID's.

The GIS Gateway Tool in Innovyze's InfoWater® software was used to easily transfer GIS data and attributes into the hydraulic model. Table 1 lists the water distribution system facilities and assets transferred into the hydraulic model from the GIS database as well as the relevant properties transferred for each asset.

Table 1. Attributes transferred into the Model from SAWCo's Geodatabase

InfoWater Facilities and Assets	Attributes Transferred from SAWCo's GIS Database	Notes
Pipe	Model ID	Unique Model IDs were created to distinguish domestic pipelines from irrigation pipelines. The pipelines were given unique numbers that were set as the Pipe ID in InfoWater by using the GIS Gateway Tool.
	Diameter	Pipe diameter.
	HWLDesc	The HWLDesc identified the zone the pipeline is located in (Upper, Lower, Holly Drive).
	HWL	The HWL identified the pipeline's head (2207, 2400, 2675, 2714). Pipelines are classified by the HWL in SAWCo's System Index Map.
	Material	Pipe material.
	Status	Only pipes with an active status were included in the model.
	ID	The ID attribute described pipeline work orders. This field was imported into the model for reference.
	System	The System attribute classified the pipelines as either domestic or irrigation and was used to quickly query the different systems in InfoWater.
Pump	Name	The pump station name was used as the pump ID. Additional pumps were manually added as needed to each pump station. Wells were imported as pumps and reservoirs added to simulate the head.
Reservoir (Well)	Name	The well name was used as the Reservoir ID. The wells were originally added to the model as pumps and the reservoirs were manually added and connected to each corresponding well pump.
	Install Year	Year well was installed.
	Status	Status of well (active/inactive).
	GW_Source	The groundwater basin that the well pumps from.
Tanks	Name	The reservoir name was used as the Tank ID.
	Install Year	Year tank was installed.

InfoWater Facilities and Assets	Attributes Transferred from SAWCo's GIS Database	Notes
	Material	Tank material.
	HWL	The HWL identified the pipeline's head (2207, 2400, 2675, 2714). Pipelines were classified by the HWL in SAWCo's System Index Map.
	Height	The height was used to populate the maximum level of the tank in InfoWater.
	Size	The capacity in million gallons of each tank.
Valves	Name	The valve name was used as the Valve ID.
	Comments	The comments field provided descriptions of the valve's location. The comments were imported as the InfoWater Description field.
	Status	Status of valve (active/inactive).
	Quantity	The number of valves at the PRV station.
	Sizes	The size of the valves located at the PRV station.

Once the GIS Gateway Tools was executed and the structure built, the system's connectivity needed to be confirmed. InfoWater® Network Review/Fix and Connectivity tools can use queries such as "nodes in close proximity", "pipe-split candidates", "orphaned nodes", "merge nodes", and more to review the connectivity and troubleshoot problems.

Disconnected nodes were added to the domain using the Facility and Domain manager to query selection sets. Then, the disconnected nodes were manually analyzed to determine which pipelines the nodes should be connected to. The Merge Nodes Tool was manually applied to a disconnected node and a node on a pipeline. The tool asks the user to identify which node to be dissolved and which node to classify as the destination to automatically adjust the pipeline alignment and fix connectivity, as shown in Figure 1. In general, the merge nodes process yielded accurate pipe connections and improved many of the connectivity issues from when the model was first built. The model was then manually reviewed a last time for other connectivity issues, with a focus at zone boundaries and tank and pump station connections.

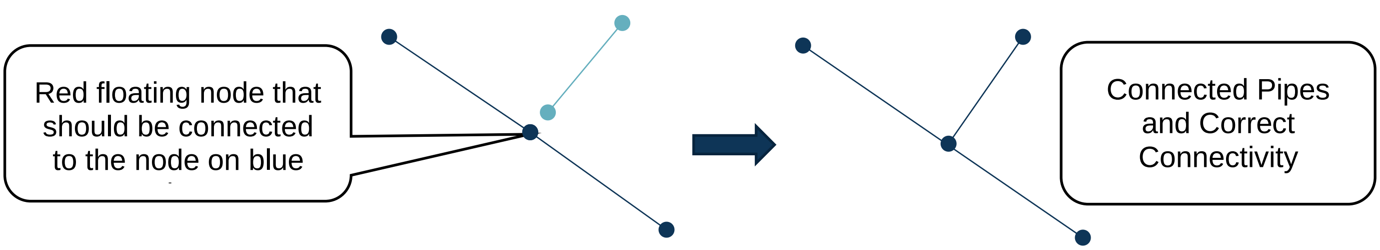


Figure 1. Merge Nodes tool was used to join pipes in the model and fix connectivity issues.

The last step in building the model structure is populating basic physical and operating information for the model and facilities. This information includes elevation data at the junctions and facilities, tank operating elevations, pump and well operating points or pump curves, and PRV settings. SAWCo's 2017 Water Master Plan, prepared by Civiltec Engineering, Inc., was the basis of much of the information in the water model as well as input from SAWCo. Table 2 lists the sources used to populate facilities.

Table 2. Source of Manually added Physical and Operating Data

Hydraulic Model Elements	Source
Pipe Connectivity	GIS Database, As-Builts, and input from SAWCo staff.
Pump Definitions	Pump Operating Points from 2017 pump and well tests, SCADA Set Points.
Tank Elevations and Dimensions	2017 Water Master Plan, input from SAWCo staff.
Elevation	USGS one (1) meter resolution digital elevation model files. These were downloaded as raster files and projected to the correct coordinate system in the model. Elevation data was extracted and converted to feet.
PRV Location and Direction	GIS Database and input from SAWCo staff.
Zone Boundary	GIS Database.

1.2. System Demands

To evaluate SAWCo's water distribution system, the location and quantities of water demands must be known and modeled. Spatially allocated demands were established based on historical annual water customer consumption for 2019 and production data from SAWCo's records and GIS parcel data. The 2019 water demand data included Assessor's Parcel Numbers (APNs) for each customer and/or addresses which were associated with GIS parcel data to determine each customer's location. Future demands, including buildout demands expected in 2035, were projected by applying a water demand factor from existing demands and parcel acreage to areas identified as future development in the 2017 WMP.

San Bernardino County parcel data was added as a shapefile and the centroid of each parcel was calculated using GIS tools and exported to Microsoft Excel. Customer billing data provided by SAWCo contained APN for each customer account. Using the APN field, customer data was matched with San Bernardino County parcel data (centroid x and y coordinates). With the customer consumption matched to parcel information, the domestic demands were loaded into the model using the Demand Allocation Manager with a closest pipe relationship. This relationship automatically identifies the closest pipe to each meter and distributes the meter's demand to the junctions at either end of the pipe. The customer meter's assigned junction was manually checked for errors, especially near zone boundaries, and corrected as needed.

Several irrigation customers receive deliveries at several locations. To determine the amount of demand at each location, SAWCo provided addresses for each meter. The addresses were matched to San Bernardino County parcel data to determine the APN and coordinates. Irrigation demands were also loaded using a closest pipe relationship. The customer meter's assigned junction was manually checked for errors, especially near zone boundaries, and corrected as needed.

The minimum and maximum daily demands were determined by evaluating historic daily production data from 2009 through 2019. The minimum and maximum production months were used to determine average day demands and to determine appropriate peaking factors. However, SAWCo does not record hourly production data, so the peak hourly demand was calculated as 1.5 times the maximum daily demand per California Waterworks Standards. Table 3 and Table 4 summarize the modeled demands and peaking factors for the domestic and irrigation systems.

Table 3. Summary of Modeled Domestic Demands

System Demand	Current (MGD)	Current (gpm)	Buildout[1] (MGD)	Buildout (gpm)	Peaking Factor
Average Daily Demand (ADD)	2.3	1,602	2.4	1,632	N/A
Maximum Daily Demand (MDD)	3.5	2,403	3.6	2,448	1.5
Peak Hourly Demand (PHD)	5.2	3,604	5.3	3,672	2.25

1. Buildout is predicted to occur by 2030 with a projected population of 3,322.

Table 4. Summary of Modeled Irrigation Demands

System Demand	Current (MGD)	Current (gpm)	Buildout[1] (MGD)	Buildout (gpm)	Peaking Factor
Average Daily Demand (ADD)	8.1	5,626	8.1	5,626	N/A
Maximum Daily Demand (MDD)	12.2	8,439	12.2	8,439	1.5
Peak Hourly Demand (PHD)	18.2	12,659	18.2	12,659	2.25

1. Irrigation demands are anticipated to remain the same or reduce over time. For conservative estimates, the irrigation demands are planned to remain constant.

It expected that future domestic demands will increase minimally. Areas identified as future development in the 2017 WMP were used to determine the total future demand SAWCo could expect to serve in the future and are shown in Figure 2. Portions of Areas A and B were identified as potential areas for development. Based on preliminary calculations completed in the 2017 WMP, approximately half of the total area for Areas A and B could be developed and as a result, half of the total area of those parcels were used to calculate future demands. It should be noted that half of Area G overlaps a parcel owned by San Bernardino County Flood Control, making it extremely unlikely to be developed. It is estimated that the total additional demand for future development will add 30 AFY of demand to SAWCo’s domestic system.

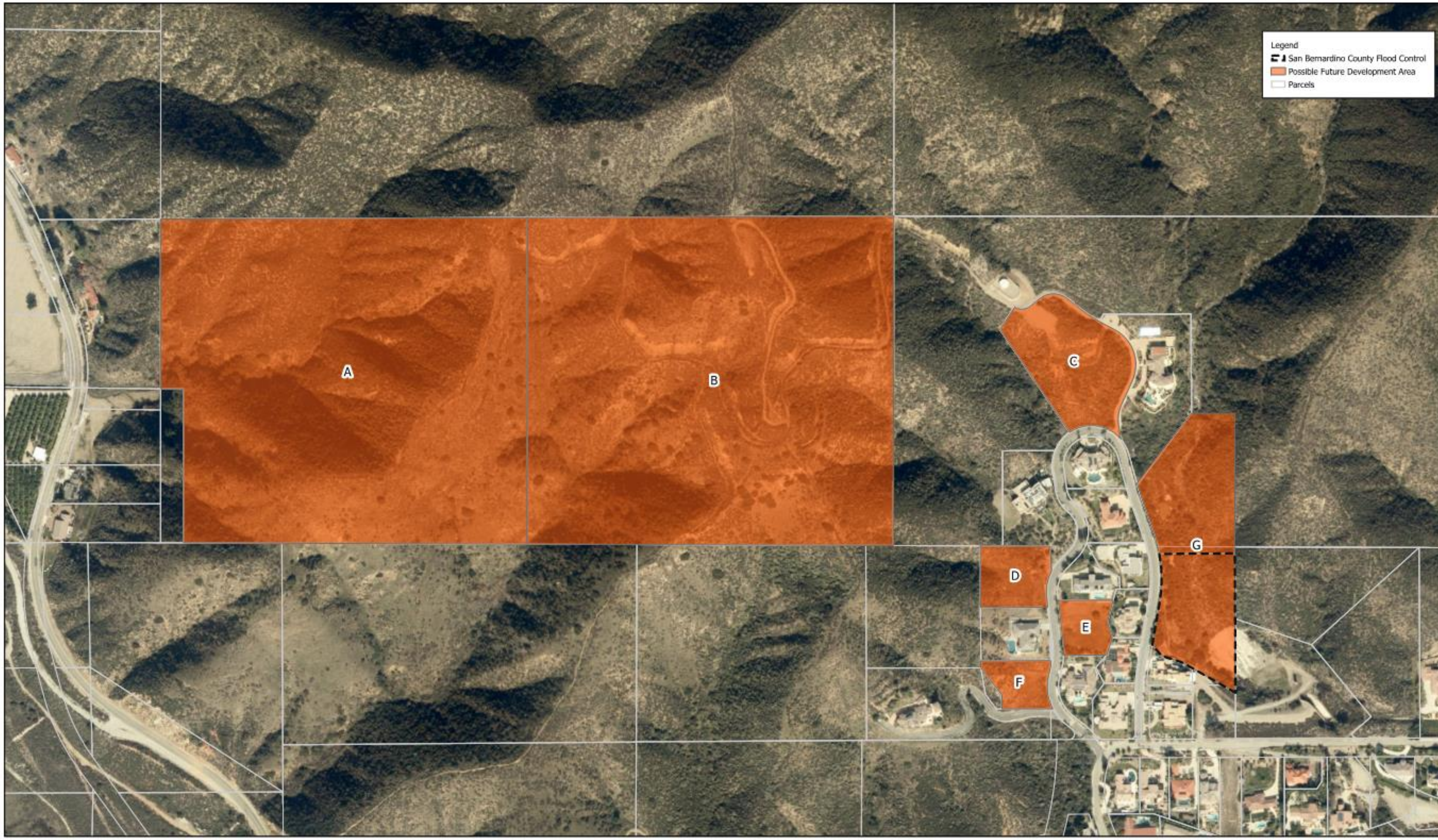
It is possibly that SAWCo will experience a decrease in irrigation demands. The City of Upland has recently entered into agreement with the Upland Hills Country Club (Country Club) to supply water. When the Country Club begins to receive water from Upland, it is expected that the demand required to be fulfilled by SAWCo will decrease. In 2019, the Country Club utilized 332 AF from SAWCo. It is also possible that as development occurs, the SAWCo irrigation system may be transferred to Upland and refurbished to supply potable demand within the City.

Table 5. Future Demand.

Area	Acres	Water Demand Factor (gpm/acre)	Water Demand (gpm)	Water Demand (AFY)
A[1]	33.8	1.036	17.53	10.9
B[1]	35.2	1.036	18.23	11.3
C	3.4	1.036	3.54	2.2
D	1.2	1.036	1.28	0.8
E	0.8	1.036	0.81	0.5
F	0.8	1.036	0.82	0.5
G[2]	5.9	1.036	6.09	3.8
			Additional Future Demand, AFY	**29.9**

Notes

1. If developed, parcel expected to be half developed. Half of total parcel acreage used to determine future demand.
2. Half of area identified as future development is highly unlikely to be developed. Southern portion of Area G owned by San Bernardino County Flood Control. Dashed lines in
3. **Figure 2** delineate area owned by San Bernardino County Flood Control.



N

0 250 500 1,000 US Feet

References/Notes:
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 (US Feet)

2020 Water Master Plan Update
Possible Future Development Area

Figure 2. Areas identified as Possible for Future Development.

1.3. System Evaluation Criteria

This section presents the desired performance criteria for the water distribution system that will be used to analyze the system and generate recommendations for improvements.

Water system criteria were developed from California Waterworks Standards, SAWCo Standards and preferences, California Fire Code, and engineering judgment. The evaluation criteria for the water system have been organized into two categories: System Reliability (Table 6) and System Capacity (Table 7) and defined for the domestic distribution system and the irrigation distribution system. System reliability criteria is generally consistent between both distribution systems, but capacity criteria vary between the two systems because the domestic system includes capacity for fire flows, while the irrigation system does not.

Table 6. System Reliability Evaluation Criteria.

Purpose	Regulation or Reference	Engineering and Planning Criteria - Domestic System & Irrigation System
Reliable Supply	California Waterworks Standards	Calculate reliable supply by determining system capacity with SAWCO's largest source out of service.
Source/ Production Capacity	California Waterworks Standards	System must be able to meet MDD with source capacity only, considering the reliability requirements identified above. System must be able to meet four hours of PHD with source capacity and storage capacity. Combined production capacity sufficient to refill emergency and fire storage in 48 hours with all sources operating.
Pump Station Capacity / Zone Reliability	California Waterworks Standards; Accepted Engineering Practices	If gravity storage is available, pump station capacity must be able to meet MDD within the zone with the largest pump out of service. If gravity storage is not available, pump station capacity must be able to meet MDD plus fire flow or PHD, whichever is greater, with the largest pump out of service.
Emergency Power	Recommended Standards for Water Works1	Emergency power must be sufficient to meet system average day demands and preparedness for other emergencies.
Pump Efficiency	SAWCo Preference; Accepted Engineering Practices	If pump efficiency falls below 65%, it becomes a candidate for maintenance and/or replacement to increase efficiency.
Fire Hydrant spacing[1]	Engineer's Judgment	At intervals not more than 330 feet, with no hydrants at the end of cul-de-sacs. Dead-ends without a hydrant shall have a blow-off installed.
Valving	SAWCo Preference	No shut down of greater than 10 services on domestic system. Irrigation system valving at all pipeline intersections and services.

1. Fire Hydrant Spacing Criteria only applies to the domestic system.

Table 7. System Capacity Evaluation Criteria

Purpose	Regulation or Reference	Engineering and Planning Criteria - Domestic System	Engineering and Planning Criteria - Irrigation System
Distribution System			
System Pressure	California Waterworks Standards and SAWCo Preference	40 psi minimum and 120 psi maximum under normal conditions [(1)] 150 psi during minimum hour demands 20 psi minimum residual at MDD plus fire flow (FF)	20 psi minimum and 120 psi maximum under normal conditions
Fire Flows	California Fire Code (Appendix B)	Residential – 1,500 gpm for two hours	N/A
Pipeline Velocities	Engineer's Judgment and SAWCo Preference	Less than or equal to 7 feet per second (fps) at MDD Less than 11 fps at FF plus MDD condition	Less than or equal to 7 feet per second (fps) at MDD
New Distribution Mains	Engineer's Judgment and SAWCo Preference	All new water mains must be 8-inch or greater	Size for new water mains will be based on system demands and velocity requirements
Storage			
Operational Storage	SAWCo Preference	30% of MDD for all zones with storage	30% of MDD for all zones with storage
Fire Flow Storage	California Fire Code and County of San Bernardino Fire Prevention Office	Sufficient storage is required to meet fire flows	N/A
Emergency Storage	AWWA M19 Emergency Planning for Water Utilities and SAWCo Preference	24 hours at MDD	24 hours at MDD

Note: Any service with pressure greater than 80 psi should have a shareholder owned pressure regulator after the meter.

1.4. Model Calibration

After the model was developed and demands allocated, the model needed to be calibrated for accuracy. WSC and SAWCo Staff worked together to select five (5) fire hydrant flow tests throughout the water distribution system. The testing locations were selected based on pressure zone, pipe size, and number of available hydrants in the area. Once in the field, it was determined that flow test 4 (FH-4) is served by a PRV station, and thus all pressures in the area would be based on the PRV. As a result, the flow test at FH-4 was not performed. The SAWCo water distribution system is comprised of three pressure zones: the Holly Drive Zone, the Upper Zone, and the Lower Zone. To obtain fireflow readings that are most reflective of the entire system, each pressure zone was tested at a minimum of one time. Only one fireflow test was conducted for the Holly Drive and the Upper Zone. Two test locations were conducted in the Lower Zone.

On November 11, 2020, WSC and SAWCo staff performed the four selected hydrant flow tests, shown in Figure 3. The fire hydrant flow tests were performed by using at least two hydrants. One hydrant is open and the flowrate is measured with a pitot gage, and the pressure drop from a nearby hydrant, known as the witness hydrant, is measured with a pressure gage. The pressure taken when the hydrant is closed is known as the static pressure, and the pressure taken when the hydrant is open is the residual pressure. Two flow hydrants may also be used if the difference between the static and residual pressure is less than 10 psi. In addition to the static and residual pressure at the flow and witness hydrant, four data loggers were also placed on nearby hydrants to monitor system pressure during the fire hydrant flow test and provide additional calibration points. The static and residual pressure recorded at all hydrants were used to calibrate the model. The fire hydrant flow testing results compared to the calibrated model results are provided in Table 9.

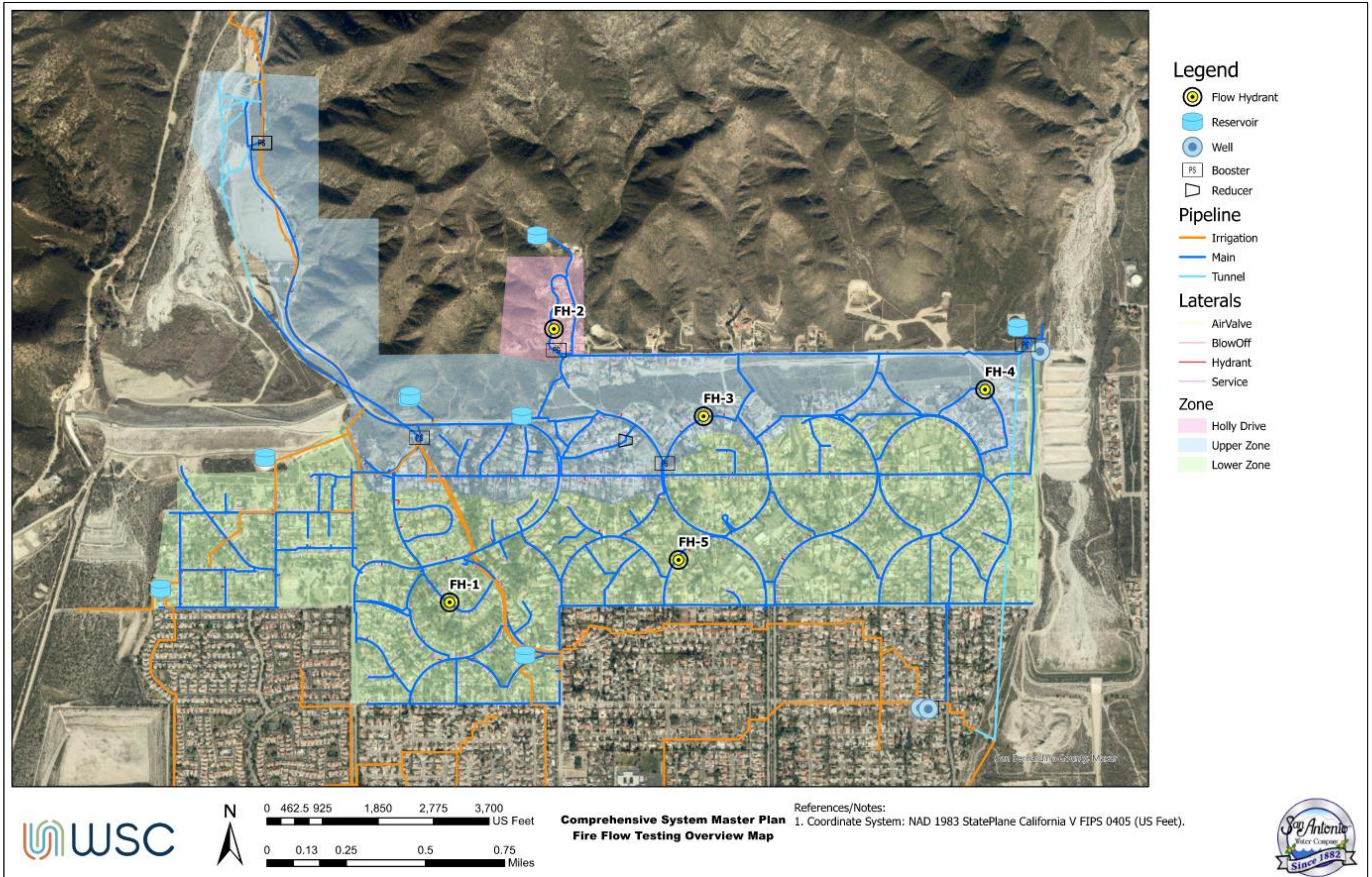


Figure 3. Location of Hydrant Flow Tests

To accurately calibrate the model with the hydrant flow testing data, the system conditions during testing are also required. These conditions, usually referred to as boundary conditions, include tank levels, pump and well status, and PRV settings. Average demands were loaded into the model, which is typical of a November weekday. The critical steady state boundary conditions for each hydrant flow test are shown in Table 8.

Table 8. Model Calibration Boundary Conditions

Hydrant Flow Test	Facility	Boundary Condition
1	Reservoir No. 7 Level	10.64 feet
	Reservoir No. 12 Level	28.49 feet
	Booster #20 Pump Station	All Pumps Off
	Well No. 15	Well Off
	Well No. 16	Well Off
	Well No. 32	Well Off
2	Holly Drive Reservoir Level	8.50 feet
	Booster #19 Pump Station	All Pumps Off
3	Reservoir No. 5 Level	25.0 feet
	Reservoir No. 6 Level	25.0 feet
	Booster #14 Pump Station	Pump 1 is turned on. Flowrate= 718 gpm
	Booster #16 Pump Station	All Pumps Off
	Booster #17 Pump Station	All Pumps Off
	Well No. 15	Well Off
	Well No. 16	Well Off
	Well No. 32	Well Off
4	*TEST NOT CONDUCTED – BASED ON PRV*	
5	Reservoir No. 7 Level	10.64 feet
	Reservoir No. 12 Level	28.49 feet
	Booster #18 Pump Station	Pump Off
	Booster #20 Pump Station	All Pumps Off
	Well No. 15	Well Off
	Well No. 16	Well Off
	Well No. 32	Well Off

Four new scenarios were developed in the model, one static and one dynamic scenario for each fire flow test. Each scenario was loaded with the allocated ADD and the boundary conditions recorded for each test. The flowing and witness hydrants were identified in the model, and the flowrate measured during the test was applied to the flowing hydrant in the model. The model was run under both static and dynamic conditions, and the modeled pressures were compared to the observed field data. Once results were tabulated, the model was adjusted to reflect observed pressures, including:

- Adjusted elevations based on Google Earth. The model assigns elevation to nodes by linearly interpolating between the 1-meter USGS contours. Due to variable sloping land in the foothills to the north of SAWCo's system, there is a potential for error in the assigned elevations. It is expected that some locations in the model will have slightly different pressures than observed in the system due to elevation inaccuracies.

- Lastly, the pipe C-factors were adjusted to reflect residual pressures for all the fire flow tests. During model construction, the default C-factor of 100 was assigned. This seemed appropriate as many of the distribution pipelines within SAWCo's system are relatively old. Initial model runs indicated that the model predicted greater headloss than observed in the field; thus, all C-factors within the model were raised to 130. Nearly 56% of the pipe within SAWCo's distribution system is composed of AC and PVC pipe. These pipe materials can stay relatively smooth over time and indicate that the greater C-factor should be used.

A batch run was completed again, and the adjustments continued as an iterative process. The target for attaining convergence was a maximum difference between modeled and observed pressures of ±5 psi. After multiple iterative runs and adjustments, the modeled results are all within the target convergence compared to the observed results. Table 9 includes the observed and modeled results.

Table 9. November 2020 Hydrant Flow Testing Results Compared to Modeled Pressures

					Observed Pressures			Modeled Pressures			Difference between Observed and Modeled Pressures (Goal is within ±5 psi)		
Test	**Location**	**Fire Flow ID**	**Hydrant Model ID**	**Measured Flow (gpm)**	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Drop (psi)**	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Drop (psi)**	**Δ Static Pressure (psi)**	**Δ Residual Pressure (psi)**	**Δ of the Pressure Drop (psi)**
1	Terrace Drive	FH-1	J288	1400									
		WH-1	J1064		78.5	72	6.5[1]	77.74	70.9	6.84	0.76	1.1	-0.34
		DL-1			71.5			73.5					
		DL-2			128			123.8					
		DL-3			82.7			82.7					
2	Holly Drive	FH-2	J1116	1190									
		WH-2	J1532		94	64	30	94.63	43.6	51.03	-0.63	20.4	-21.03
		DL-1			150	83.2	66.8	151.4	93	58.4	-1.4	-9.8	8.4
		DL-2			58.7			54.3	27.4	26.9	4.4		
		DL-3			103	53.3	49.7	102.5	53.6	48.9	0.5	-0.3	0.8
3	San Antonio Crescent East	FH-3	J1536	1550									
		WH-3	J1534		108	98	10	113.9	106.9	7	-5.9	-8.9	3
		DL-1			82			81.4					
		DL-2			113			119					
		DL-3			114			122					
5	Vista Dr	FH-5	J1538	1465									
		WH-5	J1540		100	94	6	103	97.1	5.9	-3	-3.1	0.1
		DL-1	J1574		95	93	2	98	93.5	4.5	-3	-0.5	-2.5
		DL-2	J1572		109.6			113	109.9	3.1	-3.4		
		DL-3	J1576		109	105	4	113.2	108.6	4.6	-4.2	-3.6	-0.6

[1] Field testing aims to obtain a minimum of **10 psi** pressure drop **to** be **consider**ed **an accurate test**; however, the model simulated similar results to field testing and was therefore assumed to be an accurate calibration point**.**

Figure 4 includes a graphical representation between the modeled and observed pressures at the flowing hydrant as well as the residual hydrant and other data logger locations.

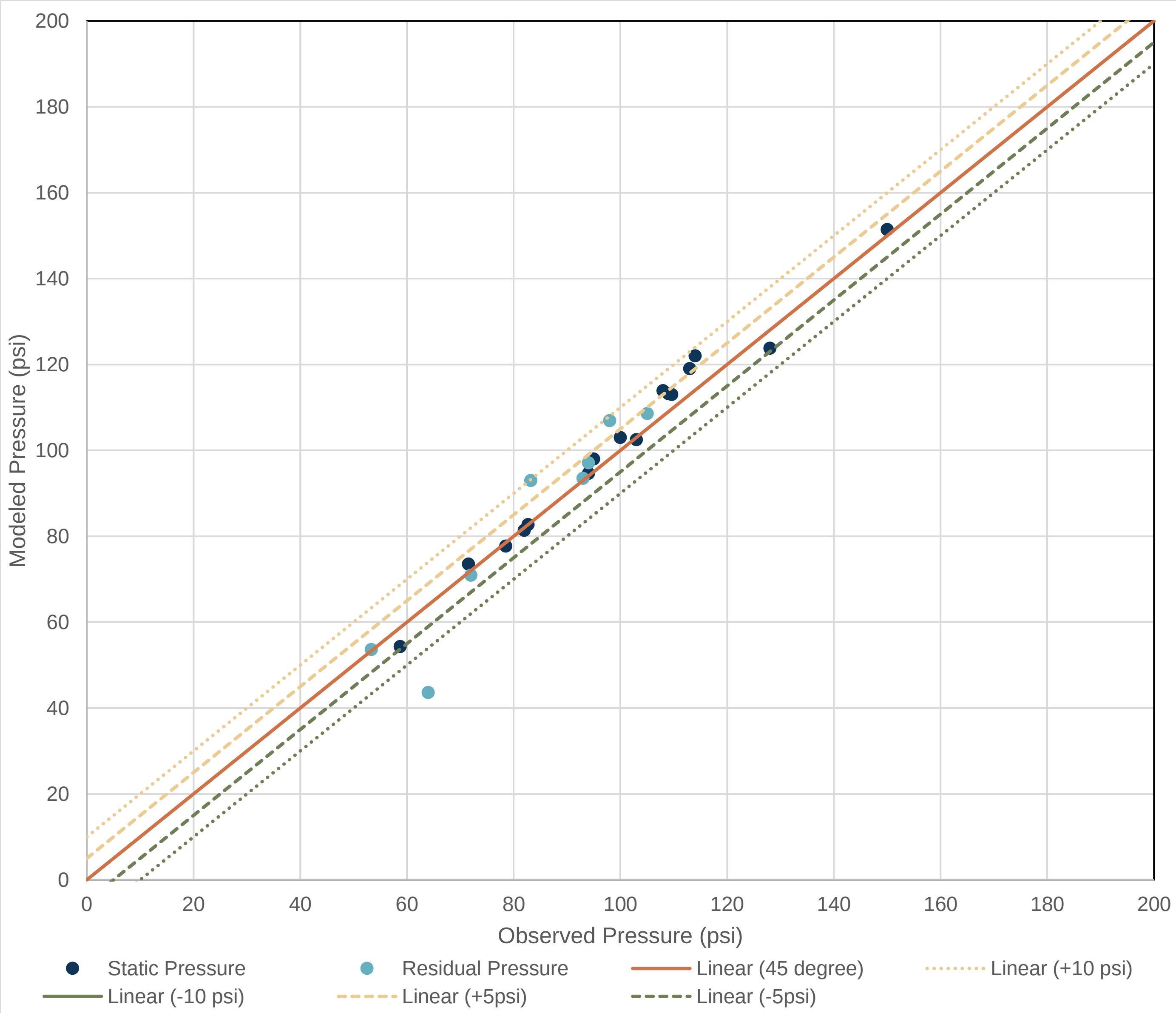


Figure 4. Linear Regression Relationship between Observed and Modeled Pressures for both Static and Residual Pressure Data from Fire Flow Test Simulations.

As mentioned, a good hydraulic model will have a maximum difference between modeled and observed pressures of ±5 psi (indicated on the graph as the purple and blue lines). Based on overall model results, it's possible that meter reading error was obtained during FH-2 at the witness hydrant. If desired, it is recommended that this test is completed again, but not required, as the rest of the data points collected fall within the ±5 psi desired range.

Once the model was calibrated it was determined to be effectively used for its intended purposed for the Water Master Plan Update and provide accurate steady state system simulations.

1.5. Extended Period Simulation

SAWCo provided the distribution system controls including pump on and off set points that were inputted into the hydraulic model. SCADA records from November 11 through November 15, 2020, were used to calibrate the extended period simulation (EPS) and refine the controls until the modeled tank levels matched the observed tank levels for the domestic system.

Currently there are no United States standards for criteria to determine the accuracy or validity for EPS models of water distribution systems[1], although Bentley Systems, Inc provides guidelines for calibration which have been published by the American Water Works Association (AWWA). Based on SAWCo's intended use of the hydraulic model, the following measures were chosen as an appropriate benchmark for the EPS calibration of the hydraulic model:

- Simulated tank level fluctuations shall be within three to six feet of observed tank levels;
- Simulated tank level fluctuations should follow a similar filing and emptying pattern as observed in the field.

Controls were added to pumps and wells in the model to simulate the controls used in the actual distribution system to maintain tank levels and adequate pressures and supply. The initial controls added to the model were taken directly from the controls in the SCADA system. The booster pump stations are controlled by tank level, and are shown in Table 7. Table 8 includes the well controls. Additionally, Reservoirs 5 and 6 are located at the same site and were modeled as a single reservoir (shown as Reservoir 6) for simplicity. This modified Reservoir 6 was enlarged to account for the volume of both tanks.

Once the EPS simulation was established, calibration was performed by adjusting control set points and diurnal demands until the simulated tank levels matched observed tank levels within 3-6 feet to observed tank levels.

Table 10. Pump Controls

Pump	Station Name	Action	Condition
Booster 14 – Pump 1	Forebay	Turn ON	If Reservoir 6 is below 20 feet
		Turn OFF	If Reservoir 6 is above 30 feet
Booster 14 – Pump 2	Forebay	Turn ON	If Reservoir 6 is below 18 feet
		Turn OFF	If Reservoir 6 is above 22 feet
Booster 18 – Pump 2	Station 18	Turn ON	If Reservoir 12 is below 10 feet
		Turn OFF	If Reservoir 12 is above 33 feet
Booster 19 – Pump 1	Holly Drive	Turn ON	If Reservoir 14 is below 6.5 feet
		Turn OFF	If Reservoir 14 is above 9.25 feet
Booster 19 – Pump 2	Holly Drive	Turn ON	If Reservoir 14 is below 6.5 feet
		Turn OFF	If Reservoir 14 is above 9.25 feet
Booster 20 – Pump 1	26th Street	Turn ON	If Reservoir 6 is below 20 feet
		Turn OFF	If Reservoir 6 is above 25 feet
Booster 20 – Pump 2	26th Street	Turn ON	If Reservoir 6 is below 8 feet
		Turn OFF	If Reservoir 6 is above 30 feet

[1] Source: *Advanced Water Distribution Modeling and Management*. 1st ed. Waterbury, CT: Haestead, 2003. Print.

Table 11. Domestic Well Controls

Well	Action	Condition
Well 15	Turn ON	If Reservoir 12 is below 10 feet
	Turn OFF	If Reservoir 12 is above 28 feet
Well 16	Turn ON	If Reservoir 12 is below 32 feet
	Turn OFF	If Reservoir 12 is above 33 feet
Well 32	Turn ON	If Reservoir 12 is below 19 feet
	Turn OFF	If Reservoir 12 is above 29 feet

Table 12. Irrigation Well Controls

Well	Action	Condition
Well 2	Turn ON	If Reservoir 1 is below 6 feet
	Turn OFF	If Reservoir 1 is above 7 feet
Well 3	Turn ON	If Reservoir 1 is below 7 feet
	Turn OFF	If Reservoir 1 is above 8 feet
Well 24	Turn ON	If Reservoir 1 is below 7 feet
	Turn OFF	If Reservoir 1 is above 8 feet
Well 25A	Turn ON	If Reservoir 9 is below 13 feet
	Turn OFF	If Reservoir 9 is above 15 feet
Well 26	Turn ON	If Reservoir 9 is below 13.5 feet
	Turn OFF	If Reservoir 9 is above 15.5 feet
Well 27	Turn ON	If Reservoir 9 is below 14 feet
	Turn OFF	If Reservoir 9 is above 15.9 feet
Well 31	Turn ON	If Reservoir 1 is below 5.5 feet
	Turn OFF	If Reservoir 1 is above 7 feet

The EPS scenario is more complex than the steady state model and requires more precise data and extensive calibration to produce an accurate model. Once the EPS scenario was calibrated to match the SCADA data it was considered adequate for the purposes of this Water Master Plan Update. Figure 5 includes a comparison of observed tank levels and the modeled tank levels for an average demand day. It should be noted that the EPS scenario is most accurate only for the 24 hours they are calibrated to. Everyday demands patterns can fluctuate, operators can make different decisions, and the system changes over time. The EPS scenario should occasionally be recalibrated to guarantee the model accurately reflects the systems operations. As mentioned, Reservoirs 5 and 6 were combined, depicted as Reservoir 6 calculated below, to account for both tanks at a single site and simplify modeling efforts.

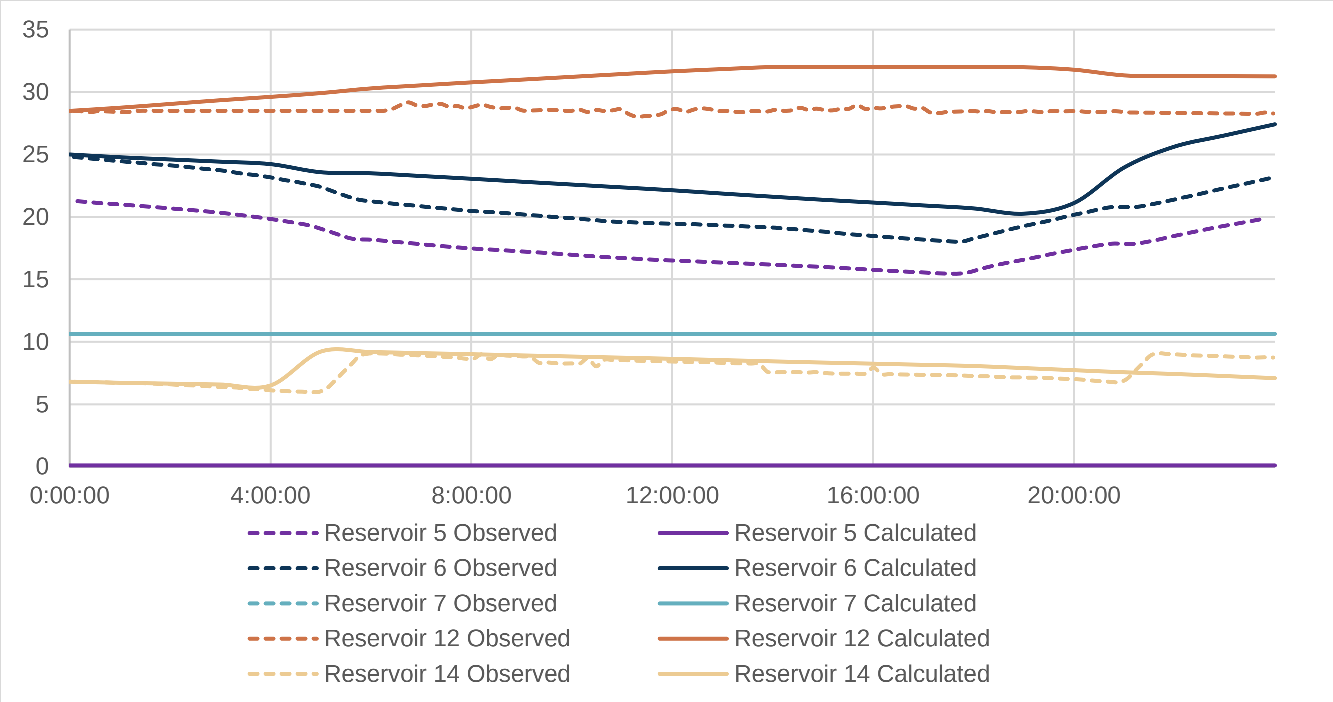


Figure 5. Average Demand Day EPS Comparison of Observed and Modeled Tank Levels

B

Appendix B Supply Risk and Resiliency Analysis Technical Memorandum

Technical Memorandum

Date: 1/7/2022

To: Brian Lee
San Antonio Water Company

Prepared by: Heather Freed, PE, Patricia Olivas, EIT

Reviewed by: Kirsten Plonka, PE

Project: 2020 Comprehensive System Water Master Plan and Asset Management Plan

SUBJECT: **SUPPLY RISK AND RESILIENCY ANALYSIS**

The San Antonio Water Company (SAWCo) is a private non-profit mutual water company that produces and distributes water to its shareholders, which includes San Antonio Heights and nearby cities. SAWCo currently receives all its water supply from local sources including the San Antonio Creek, groundwater from the San Antonio Tunnel, and three groundwater basins: Chino Basin, Cucamonga Basin, and Six Basin. Surface water from San Antonio Creek are pre-1914 water rights, and annual water availability is influenced by rainfall. The San Antonio Tunnel is a deep rock tunnel 100 feet below ground surface that collects naturally percolated groundwater. The three groundwater basins are each adjudicated, and SAWCo's water rights are defined by the various legal Judgements in place to protect and manage each basin. SAWCo also participates in groundwater recharge operations that enhance groundwater supply.

As part of SAWCo's Water Master Plan update, the existing supply sources were analyzed, the top risks to their supplies were evaluated, and the impacts these risks would have on SAWCo's ability to continue to provide a reliable and high-quality water to its shareholders quantified. **Figure 1** shows the main components of the analysis. This technical memorandum presents the supply risk and resiliency analysis and results and provides recommendations to strengthen the resiliency of SAWCo's supply sources.

Figure 1. Supply Risk and Resilience Analysis Process

1 Background and Planning Basis

SAWCo has a diverse water supply portfolio that serves two separate distribution systems: the domestic system and the irrigation system. The domestic system serves potable retail water to San Antonio Heights. The irrigation system serves non-potable retail water for irrigation or industrial needs, as well as wholesale to nearby cities that provide treatment before delivering to customers. Water in the domestic system is able to supply the irrigation system if needed, but not the other way due to the differing water quality in the two systems. The various supply sources, SAWCo's rights, and the distribution system they serve are described below:

- SAWCo has rights for up to 13,864 AFY of surface water from **San Antonio Creek**. However, the actual volume received depends on minimum stream flowrates and can vary significantly based on rainfall. SAWCo's supply from the San Antonio Creek since 1999 ranged from a low of 1,181 AF in 2018 to a high of 9,072 AF in 2005. The average volume from San Antonio Creek during years with average rainfall years is 4,042 AFY. All the water from the San Antonio Creek gravity flows into SAWCo's irrigation system and most is fed directly into the City of Upland's water treatment plant for treatment and subsequent distribution by the City of Upland.
- SAWCo also has rights to all the volume of water in the **San Antonio Tunnel**, which is a is a deep rock tunnel located 100 feet below ground surface and is supported by redwood beans and solid rock. Groundwater naturally percolates into the tunnel and can vary year to year based on rainfall and snowpack. SAWCo can also divert water from the San Antonio Creek spreading grounds north of the San Antonio Tunnel, where it is percolates into the tunnel and is conveyed via gravity to SAWCo's Forebay Tank and is predominately used in the domestic system but can also overflow into a separate tank for use in the irrigation system. The Tunnel has produced an average supply of 2,178 AF, based on data from 2000 through 2020. Tunnel yields have ranged from 727 AF in 2015 and up to 3,192 AF, as experienced in 2005.
- SAWCo has rights to 6,500 AFY from the **Cucamonga Basin** as long as it spreads 2,000 AFY of water in the basin from the San Antonio Canyon via the creek or tunnel. If the annual spreading is less than 2,000 AFY, the water rights also diminish to a minimum amount of 4,500 AFY. However, if the spreading exceeds 2,000 AFY, SAWCo can credit 95% of the excess up to a maximum of 8,500 AFY production. SAWCo operates six wells in the Cucamonga Basin, of which only one pumps into the domestic system and the others supply the irrigation system. Based on the production capacity of Well 32, up to 463 AFY is available for the domestic system and the remainder supplies the irrigation system.
- SAWCo has rights to 1,232 AFY from the **Chino Basin**. It produces this water through two wells that both supply the domestic system. If SAWCo produces less than its production rights the unused volume carryovers to the following year.
- SAWCo has rights to 932 AFY from the **Six Basin**. It produces this water through three wells that all supply the irrigation system. If SAWCo produces less than its production rights, 25% of the unused volume carryovers for the following year. SAWCo also has a Storage and Recovery Agreement with the Six Basin Watermaster where they can spread San Antonio Canyon water and store it in the basin for dry years and pump over their rights.

This analysis evaluates SAWCo's supply sources against future demand projections and anticipated risks and uncertainties that could impact future supplies for a 20-year period from 2020 to 2040. SAWCo desires to maintain their resilient supply portfolio and meet 100 percent of projected demands under future risk scenarios.

However, in some circumstances supply shortages can be mitigated through SAWCo's Water Shortage Contingency Plan (WSCP) if needed. The analysis considers both supply rights and production or distribution limitations in the two systems. The recommendations from this analysis include both maintaining existing supplies and production facilities and exploring alternative supply projects to expand the resilience of SAWCo's water portfolio for future conditions.

2 Demand Projections

Demands are projected separately for the domestic system, irrigation system, and water used at groundwater spreading basins served by the irrigation system based on a historical review of water usage and expected future growth. SAWCo determines the water for each share and shareholder annually based on the available water supplies. Because of this, the shareholders have a fixed water allocation from SAWCo that can decrease in drought periods when less supplies are available. However, SAWCo needs to plan for any demand growth within San Antonio Heights, where it provides 100 percent of the potable demand. This area includes the entire domestic system. While San Antonio Heights is mostly built out, there is some land available for development. As described in the 2021 Water Master Plan, the potential growth is expected to contribute 30 acre-feet per year (AFY) of new demand within the next 10 years. The normal year demand projections, which do not consider economic, or drought impacts to water use, are described below.

Domestic System Projections

Two domestic system demands projections were developed for this analysis. Both incorporate the projected 30 AFY growth by 2030, but use different baselines for the projection:

1. **Baseline Projection**: Assumes future water use will continue at similar rates of existing water use, based on the average water use from the last 3-year, plus 30 AFY of new demands due to Holly Drive buildout by 2030. This projection assumes domestic demands will increase to 2,320 AFY by 2030 and continue at this rate through the 2040 planning period.

2. **Demand Rebound**: Assumes future water use will rebound to pre-drought water use patterns by 2030 based on 2012 water use levels, plus 30 AFY new demands due to Holly Drive buildout. This projection assumes domestic demands will increase to 3,031 AFY by 2030 and continue at this rate through the 2040 planning period.

While it is unlikely demand patterns will return to 2012 levels, especially as California plans to release new water use objective goals in 2022 as part of the 2018 Conservation as a California Way of Life legislation, the demand rebound projection was incorporated in the analysis for prudent planning.

Irrigation System Projections

The irrigation system serves water to the surrounding entities and cities that have shares, including the City of Upland, Ontario, and Monte Vista Water District, as wells are non-potable water for irrigation, industrial, and agricultural applications. The demand on the irrigation system is expected to decline in the future as some irrigation demands may be served by recycled water provided by the surrounding cities in the future, however the timing is unknown. For this analysis, two irrigation system demand projection were considered matching the two domestic system projections:

1. **Baseline Projection**: Assumes the current water use based on the last 3-year average usage will remain constant through the planning period. This projection includes approximately 8,920 AFY of water demand for the irrigation system. However, this demand can fluctuate significantly with rainfall and available water supplies.
2. **Demand Rebound**: This projection corresponds with the domestic system demand rebound projection and is based on 2012 irrigation demands. This projection includes an irrigation system demand of 10,270 AFY. While it is unlikely that demands will rebound, this is considered for conservative supply planning.

Spreading Basin Projections

Additionally, SAWCo diverts San Antonio Canyon water from the creek or tunnel to spreading basins that help replenish the groundwater basins and is served via the irrigation system. In order to fully maximize their Cucamonga Basin groundwater rights, SAWCo must spread 2,000 AFY. For this analysis the 2,000 AFY spreading was included as a minimum water use for most scenarios. In years when there is excess San Antonio Canyon water available SAWCo will spread more and store water for dry periods when less San Antonio Canyon water is available. In normal years SAWCo is projected to have over 3,000 AFY of available surface water for spreading, however, this could increase in especially wet years and decline in dry years.

Water Losses

Water losses are also incorporated into the total demand projections. In the last five years losses represented on average 2% of the total water use. However, metering inaccuracies are expected to have contributed to the low water loss estimate because negative losses have been measured. Regular meter calibration and replacement of older meters is included as in SAWCo's capital improvement plan (CIP) to improve metering accuracies. For conservative demand projections, water losses are assumed to be 5% of the total water use in the future.

Figure 2 shows the historic and projected baseline and rebound demands for the domestic and irrigation system and for surface water spreading. As shown, all the projected demands are relatively flat because these are normal projections not influenced by economic or hydrologic conditions. The real demand will vary year to year similar to the historic demand based on many factors including annual rainfall and available surface supplies, particularly in the volume used for surface water spreading and the irrigation system demand. As shown from 2012-2016 during the most recent drought period, the total demand declined to its lowest of just over 9,000 AFY, with the most significant declines in the irrigation system and the volume of water used for surface water spreading.

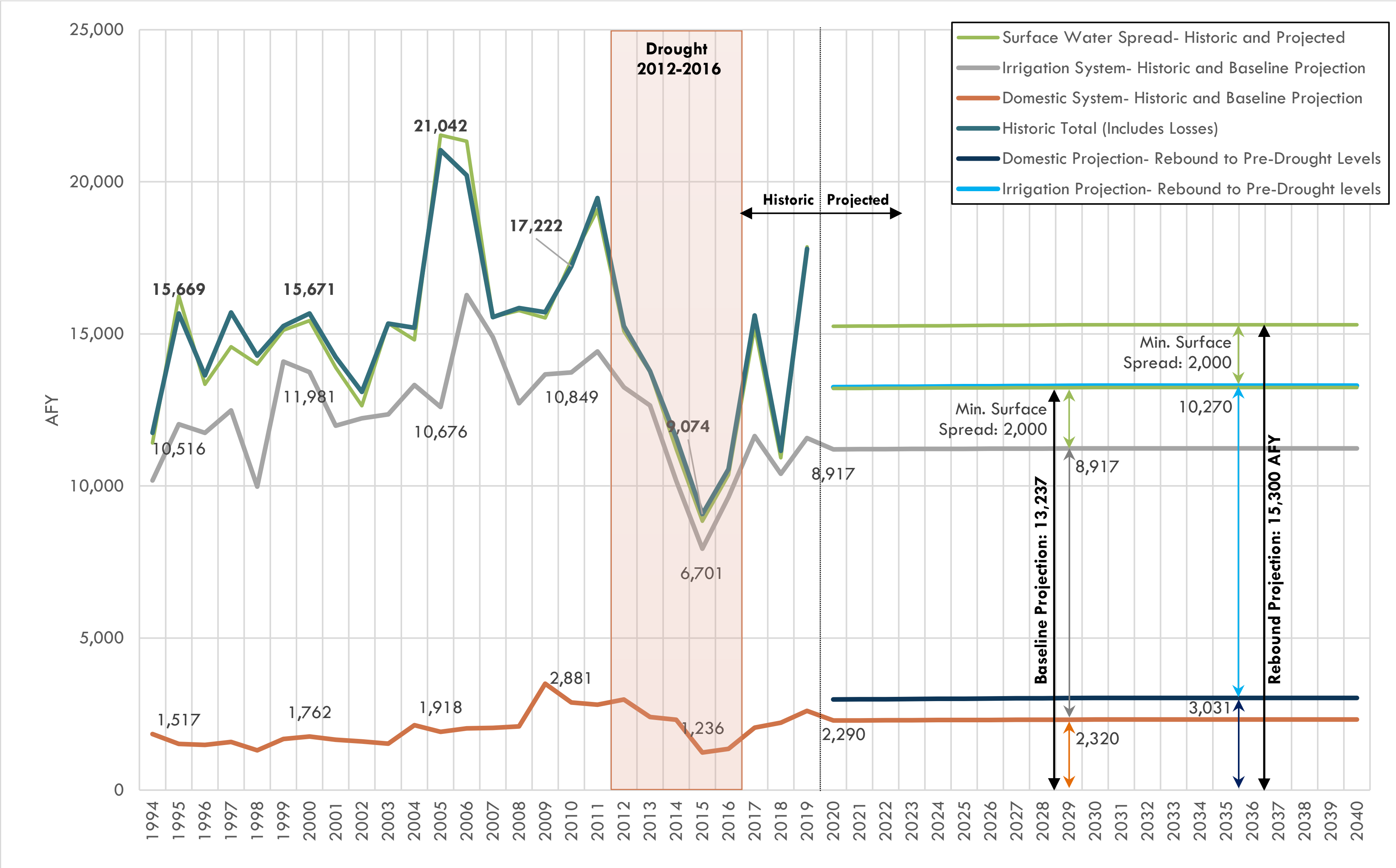


Figure 2. Historic and Projected Demand

3 Tops Risks

A multitude of potential risks and uncertainties that could impact SAWCo's existing supplies were identified and ranked based on likelihood of occurrence and impact to SAWCo's water systems if they were to occur. The identified risks and uncertainties include:

- **Climate Change**. Climate change is expected to result in more extreme droughts, shifting rainfall patterns, more intense rainfall and flooding, and higher variability from surface water supplies. Climate change is occurring and the best mitigation SAWCo can take is to plan and prepare for climate related changes that will impact its supplies.
- **Earthquake**. The largest impact from an earthquake would be damage to critical infrastructure, including the collapse of the San Antonio Tunnel.
- **Mega-drought.** A mega-drought is a drought lasting two decades or longer, which would impact SAWCo's particularly vulnerable surface supplies and result in reduced recharge of groundwater basins through surface spreading and natural precipitation.
- **Regional Power Outage.** A regional power outage is likely to occur and could impact SAWCo's ability to produce groundwater; other supplies are gravity fed into the system. SAWCo is proactively acquiring portable generators that could be used to continue operation of the water system during a regional power outage.
- **Increased Energy Costs.** Increased energy costs are highly likely to occur. This would impact the cost to pump and distribute water within the systems. SAWCo's largest supply sources from the San Antonio Creek and Tunnel are gravity fed into the system and would be less impacted by the increasing energy costs. High energy costs will most significantly impact operation costs during dry years when less surface water is available and SAWCo will need to pump more groundwater.
- **Groundwater Contamination.** Groundwater contamination could impact SAWCo's groundwater production facilities; however this is considered a lower impact because SAWCo pumps from three separate groundwater basins and it is unlikely that contamination would impact all wells simultaneously.
- **Reduced Groundwater Rights.** Each of the groundwater basins that SAWCo overlies are adjudicated and SAWCo has defined groundwater rights in each basin. There is a low likelihood that SAWCo's pumping rights will be reduced significantly in the future.
- **Wildfires.** Wildfires in the watershed of the San Antonio Creek could increase sedimentation and reduce the creek's surface water quality. All this water serves the irrigation system, and most is supplied to the Upland Water Treatment Plant for treatment and supply to the City of Upland. Sedimentation water quality impacts could impact the treatment process.

The likelihood of occurrence and impact to SAWCO's ability to provide reliable water supply was evaluated for each identified risk. The risks and uncertainties were scored based on both metrics, with the top risks identified as the loss of the San Antonio Tunnel by an earthquake, climate change, and a mega-drought. The risks and uncertainties are shown in **Figure 3** based on their likelihood and impact. The top risks and uncertainties were used to develop future supply and demand scenarios, as described in the next section.

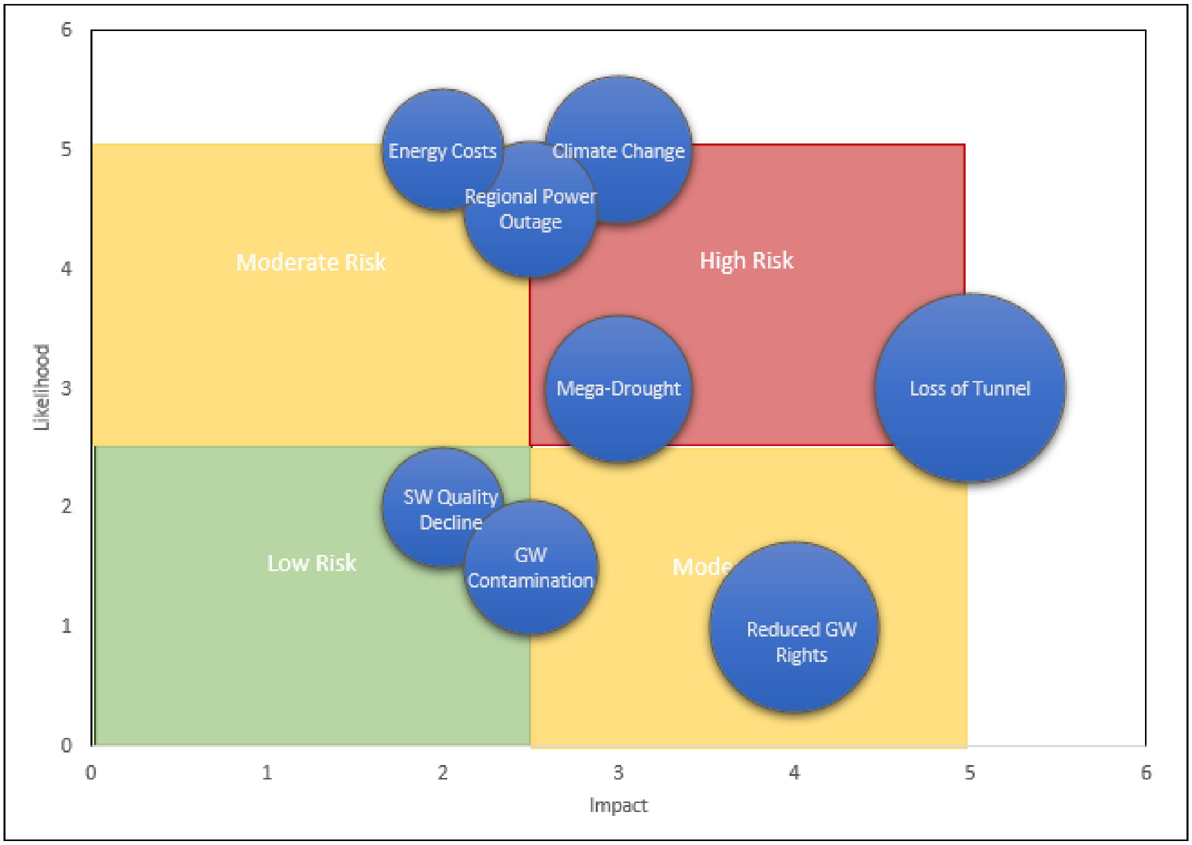


Figure 3. SAWCO Top Risks and Uncertainties

4 Supply Projections and Alternatives

Supply alternatives were developed to understand the impacts the top risks and uncertainties on SAWCo's supply projections. The overall supplies are compared to the demand projections presented in Section 2 to understand SAWCo's risks to provide reliable and high-quality water in the future.

The historic supply volumes and demands since 1994 are shown in **Figure 4**, along with the projected range in supplies incorporating risks. Generally, SAWCo prefers to use all their San Antonio Creek and Tunnel supplies first, as these are gravity fed into the system, and then pump from the Cucamonga Basin, Chino Basin, and then the Six Basin. As shown matching the historic demands, the supplies vary significantly year to year, and reach a peak of greater than 21,000 AF in 2005 and a low of close to 9,000 AF in 2015. The supply from the San Antonio Creek has the largest variability and is highly dependent on rainfall. Secondly, the supply from the Cucamonga Basin also has a high variability because the amount pumped is dependent on the San Antonio Creek water available for spreading. In wet years more can be spread and more can be pumped from the Cucamonga Basin. In a dry year, such as 2015, there was almost no water available for spreading and the volume SAWCo could pump from the Cucamonga Basin was limited to 4,500 AFY. The figure shows the projected range in supplies when incorporating risks and when water is and is not available for surface water spreading. Due to SAWCo's diverse supply portfolio, supplies are anticipated to range between about 11,800 AFY on the low end to 15,720 AFY when considering the identified risks.

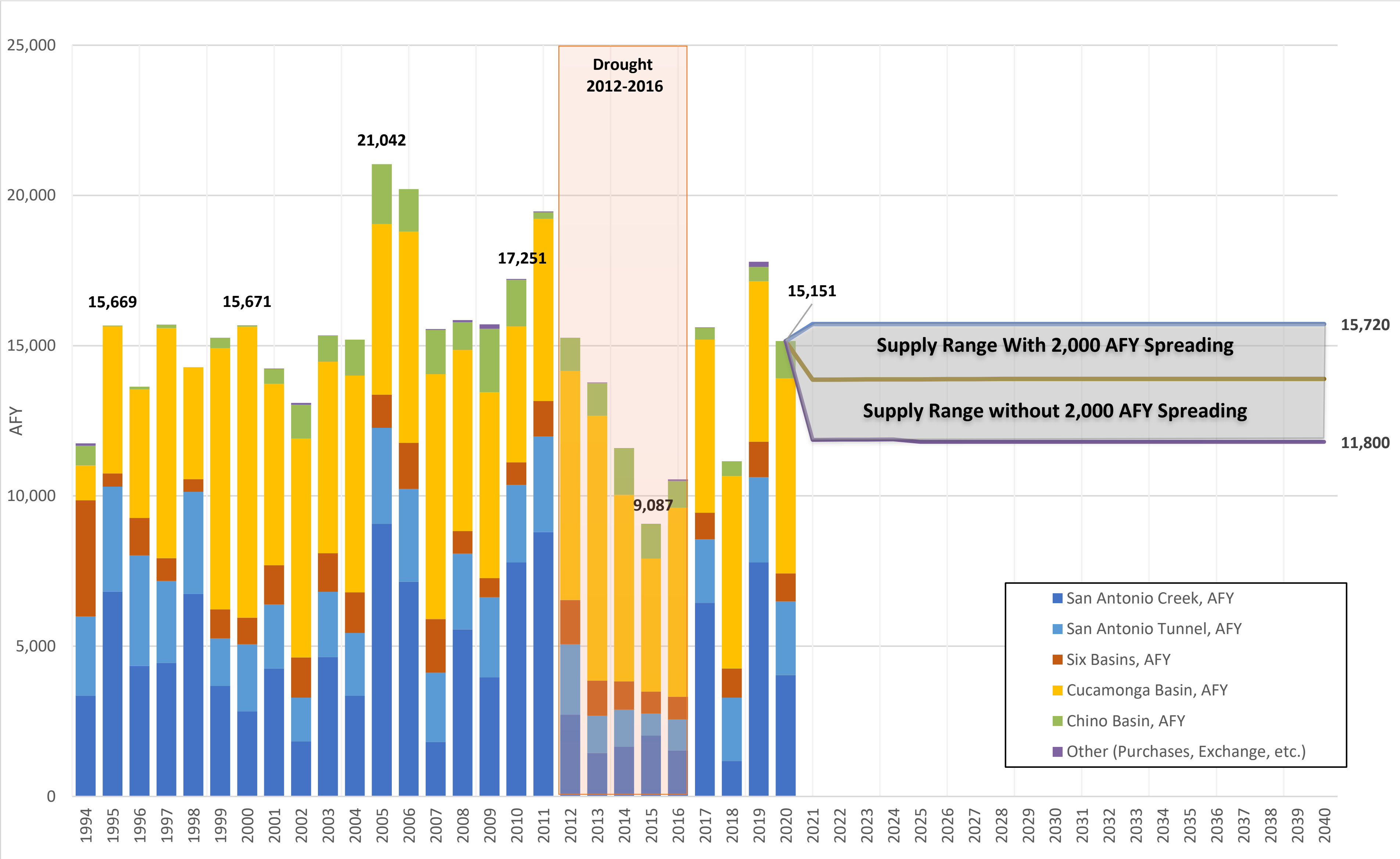


Figure 4. Historic Supplies and Demands

Each supply projection is shown in

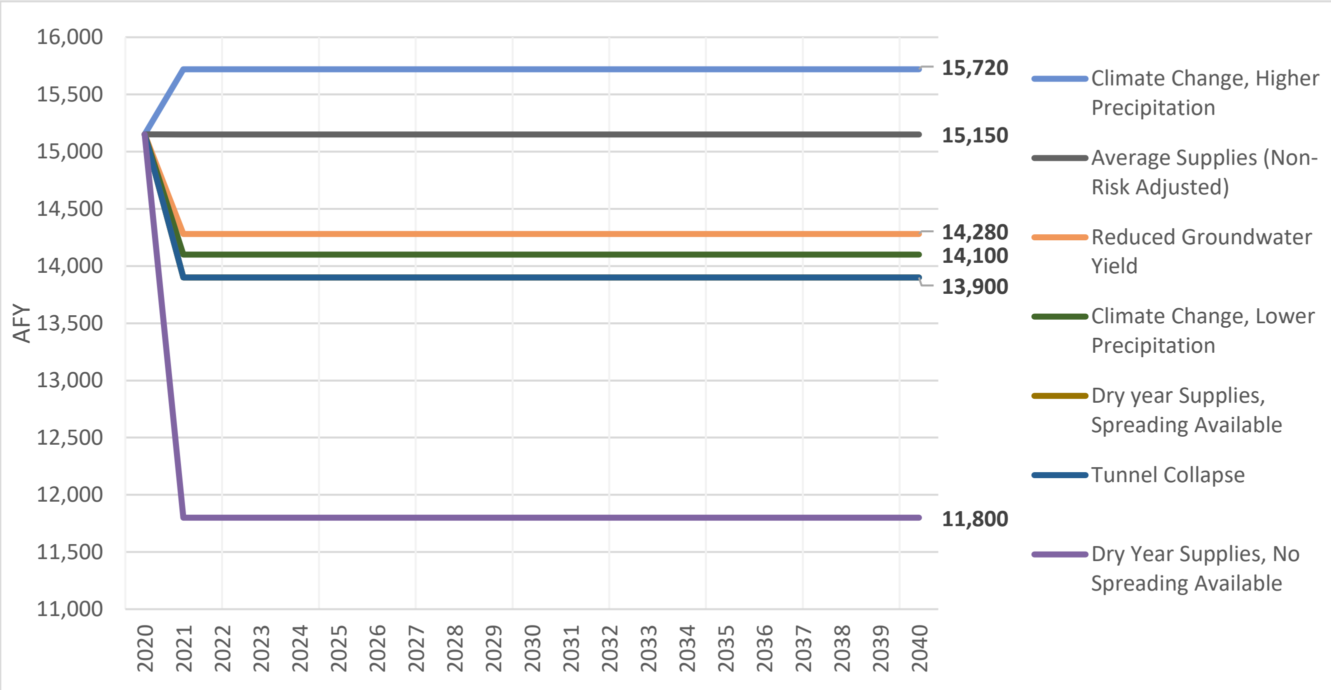


Figure 5 and incorporates different assumptions about how the risks will impact supply availability:

- **Average Supplies**: This projection incorporates the average supply from the San Antonio Creek (about 4,000 AFY) and Tunnel (about 2,400 AFY), excluding outlying extreme wet and dry years. It also includes SAWCo's total groundwater rights from each basin, and assumes water is available for surface water spreading so that 6,500 AFY is available from the Cucamonga Basin. The total volume available under this non-risk adjusted scenario is about 15,150 AFY.
- **Climate Change**: For the climate change supply projection, local climate change literature was reviewed to understand the impacts to SAWCo's supplies. Different climate change projections predict different impacts to rainfall, with some estimating more rainfall and other less rainfall in the future. Cal-Adapt Climate Projections for the Desert Region of San Bernardino County of which SAWCo overlies estimates a 2-to-4-inch decline in annual average rainfall by 2050 due to climate change (California Department of Public Health, 2017). However, all models predict shifting rainfall patterns with wetter winters and drier summers. Based on the various models two climate change projections were developed: (1) lower precipitation and (2) higher precipitation:
    - **Lower Precipitation**: the annual rainfall recorded at the San Bernardino San Antonio Heights Rain Gauge was plotted against the historic supplies from the San Antonio Creek and Tunnel to develop a trend between rainfall and supply volume from these sources. Using the plotted trends, a 4-inch annual average decline in rainfall corresponds with approximately a 20% decline in supply available from the San Antonio Creek and 10% decline in flow from the Tunnel. While Tunnel water is considered percolated groundwater, rainfall has a slight correlation with the supply from the Tunnel. For the climate change projections with lower future precipitation, the supply from the San Antonio Creek and Tunnel were decreased 20% and 10% from the average values respectively, corresponding with a new average of 3,200 AFY from the San Antonio Creek

and 2,200 AFY from the Tunnel. Groundwater supplies are based on available rights and were not reduced based on climate change impacts. The total volume available under this climate change scenario is about 14,100 AFY.

- **Higher Precipitation**: The higher precipitation scenario also assumes that the precipitation occurs over a shorter time period and is more intense. Generally, these more intense rainfall periods result in more runoff and less percolation in the groundwater. Because of this, the supply from the San Antonio Tunnel is still expected to be lower than the historic average and is assumed to be 90% of average (2,200 AFY) like the above climate change projection. The San Antonio Creek, however, is expected to have higher flows in the winter which could potentially be diverted to spreading basins and stored in the groundwater to be pumped later in the summer. This projection assumes supply from the San Antonio Creek will increase 20% from average to about 4,850 AFY. However, the higher intensity rainfall and increased runoff could impact the water quality from the creek, which serves non-potable customers and the Upland Water Treatment Plant and could impact the treatment plant operations. With no impact to groundwater, the total volume available under this climate change projection is 15,720 AFY.

- **Reduced Groundwater Yield**: While SAWCo's groundwater rights are defined through the adjudications of the groundwater basins, climate impacts and reduced outdoor water use due to aggressive State conservation efforts could impact the natural recharge of the basins. These impacts could result in future revisions and reductions to the rights of all pumpers in the groundwater basins. To understand the impact this could have on SAWCo, this projection incorporates a 10% reduction in all available groundwater supplies for a total available supply of about 14,300 AFY.
- **Tunnel Collapse**: The San Antonio Tunnel is one of SAWCo's main sources of water that is gravity supplied to the system and can be delivered directly to customers for potable uses with only disinfection for treatment. The projection assumes the San Antonio Tunnel is collapsed and no water is available from the Tunnel, reducing the average available supply from about 15,150 AFY to 13,900 AFY. While this projection includes all other supplies, the analysis considers the domestic and irrigation system separately, and without the Tunnel supply the domestic system loses its main supply source.
- **Mega Drought**: To project the water supplies during a mega drought, the historic water available from the San Antonio Creek and Tunnel were reviewed and sorted based on average rainfall and yield. The average yield from the driest 30% of the years were used in this projection, which includes an average yield from the San Antonio Creek of about 1,780 AFY and 1,550 AFY from the Tunnel. With the groundwater rights unimpacted, the total supply is about 13,900 AFY if 2,000 AF of the San Antonio Canyon water were used for spreading, or more likely a total supply of 11,800 AFY with no water used for surface water spreading.

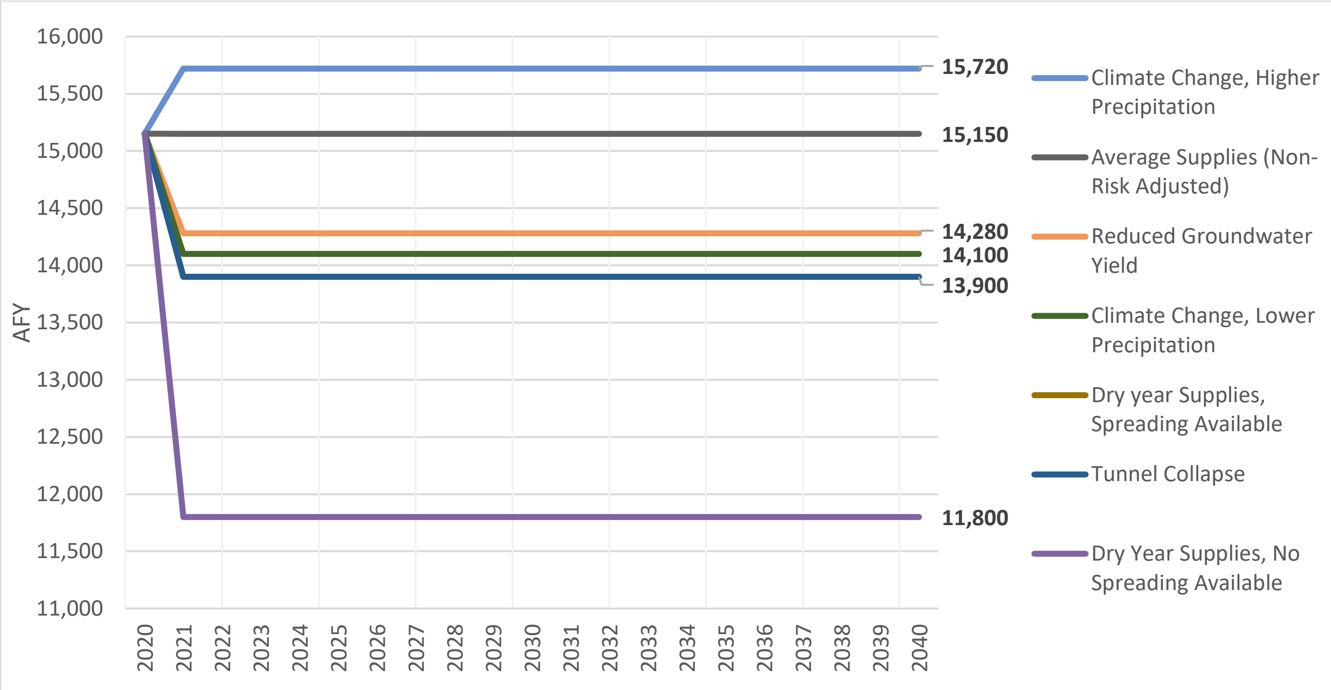


Figure 5. Risk Adjusted Supply Projections

5 Gap Analysis

Each of the described supply projection scenarios (Section 3) were compared to the demand projections (Section 2) to determine and quantify if there will be a gap between projected supply and demands for each scenario. As mentioned, SAWCo's goal is to meet 100 percent of the projected demands under the various risk scenarios, however this may not always be possible under every scenario. Some scenarios may result in the demands exceeding the supply, and the shortage can be mitigated through the enaction of the WSCP. SAWCo is presently updating their WSCP to comply with requirements of the California Water Code and the WSCP will list ways SAWCo can reduce demands through water use restrictions or augment existing supplies to eliminate the supply gap. Additional projects to reduce the risk and augment supplies are recommended in the last section of this TM.

A total of eight scenarios (six supply scenarios, two of which are run under two different demand scenarios) were evaluated, described in **Table 1** below.

Table 1. Supply and Demand Scenarios Evaluated

Scenario	Demand Projection	Supply Projection
1A	**Baseline Demand** (Includes baseline domestic and irrigation demands plus a minimum 2,000 AFY for surface spreading)	**Average Supplies**: Total supply of 15,150 AFY
1B	**Rebound Demands** (Includes rebound/ increased to 2012 usage levels in the domestic and irrigation system, plus a minimum 2,000 AFY for surface spreading)	**Average Supplies**: Total supply of 15,150 AFY
2	**Baseline Demand**	Supplies with **Climate Change resulting in lower precipitation**: Total supply of 14,100 AFY
3	**Baseline Demand**	Supplies with **Climate Change resulting in higher precipitation**: Total supply of 15,720 AFY
4a	**Baseline Demand**	**Mega Drought**: Total supply of 13,900 AFY
4b	**Baseline Demand, no surface water spreading**	**Mega Drought**: Total supply of 11,900 AFY due to limited Cucamonga Basin Rights without surface water spreading
5	**Baseline Demand**	**Tunnel Collapse**: Total supply of 13,900 AFY
6	**Baseline Demand**	**Reduced Groundwater Yield**: Total supply of 14,280 AFY

A simple Excel-Based model was developed to analyze the volume of each supply that would be used to meet the demands in the domestic and irrigation systems, and how much San Antonio Canyon water would be available for surface spreading for each scenario through the 2040 planning period. The model does not incorporate all the complexities of the water systems or inputs SAWCo considers when managing supply sources to meet demands but focuses on high-level annual planning and is useful to identify scenarios when demand may exceed supply so SAWCo can proactively plan to avoid or mitigate the situation.

Table 2 below lists the results from the gap analysis for each scenario listed in **Table 1**. For scenarios with surplus water available, additional water could be diverted for surface water spreading to help replenish and store in the groundwater basin. For scenarios where the demand exceeds the supply, conservation savings was assumed to make up the supply gap.

As shown, scenarios 1A, 2, 3, and 6 do not have a supply shortfall, and any surplus San Antonio Canyon water would be available for additional spreading each year. Scenario 1A does not have any adjusted supply or demand risks and is most representative of near-term conditions but may not represent long term conditions. Scenarios 2 and 3 are the two climate change scenarios, and both indicate that climate change impacts, while likely to occur, may not significantly impact SAWCo's ability to continue providing water to their shareholders. Scenario 6 incorporates a slight reduction in SAWCo's groundwater availability and shows even with the assumed reduction SAWCo can meet projected demands.

Scenarios 1B, 4A, 4B, and 5 all project a supply deficit and will require conservation savings or potentially new and emergency supplies to meet all demands. Scenario 1B does not incorporate supply risks but does incorporate demands rebounding to pre-drought levels. If this were to occur, demands are anticipated to exceed supplies, which could be mitigated through continued conservation and demand management measures or through the WSCP if needed. However, demands are unlikely to rebound to pre-drought levels with new State mandated water use efficiency standards and urban water budgets expected in 2022 that will drive down demand in the years following the standards adoption. It is recommended SAWCo continues to promote conservation and implement future State water use efficiency standards and objectives to prevent demands increasing beyond supplies.

Scenario 4A and 4B incorporate dry year supplies to evaluate the impacts of a mega-drought against the baseline demand projection. Scenario 4A includes a 2,000 AFY demand for surface water spreading, which allows SAWCo to pump up to 6,500 AFY from the Cucamonga Basin. However, during an extended drought the supplies from the San Antonio Creek and Tunnel are most likely to be impacted, and there may not be available water from these sources to direct to spreading basin. Scenario 4B excludes the demand for surface water spreading and limits the supply from the Cucamonga Basin to 4,500 AFY. In both scenarios there is a supply shortfall compared to demands, and conservation savings of 14-15% are needed to close the gap.

Scenario 5 compares the baseline demand projection to supplies without the San Antonio Tunnel which could occur with a tunnel collapse due to a major earthquake or other natural disaster. In this scenario there is a supply deficit of over 1,000 AFY, which corresponds with a 9% demand reduction needed so demands do not exceed supplies.

Table 2. Scenario Gap Analysis

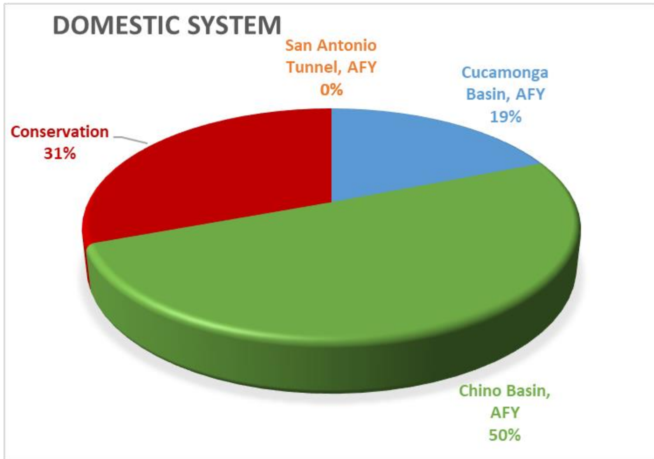
Scenario	**1A**	**1B**	**2**	**3**	**4A**	**4B**	**5**	**6**
Demand Projection	Baseline	Rebound	Baseline	Baseline	Baseline	Baseline, No Spreading	Baseline	Baseline
Supply Projection	Average	Average	Climate Change-less Rainfall	Climate Change-more Rainfall	Mega Drought	Mega Drought	Tunnel Collapse	Reduced Groundwater
Annual Supplies								
San Antonio Creek, AFY	4,042	4,042	3,233	4,850	1,777	1,777	4,042	4,042
Tunnel, AFY	2,443	2,443	2,199	2,199	1,554	1,554	0	2,443
Cucamonga Basin, AFY	6,500	6,500	6,500	6,500	6,500	4,500	6,500	5,850
Chino Basin, AFY	1,234	1,234	1,234	1,234	1,234	1,234	1,234	1,111
Six Basins, AFY	932	932	932	932	932	932	932	839
Total Supply, AFY	**15,151**	**15,151**	**14,098**	**15,715**	**11,997**	**9,997**	**12,708**	**14,285**
Annual Demands								
Domestic, AFY	2,320	3,031	2,320	2,320	2,320	2,320	2,320	2,320
Irrigation, AFY	8,917	10,270	8,917	8,917	8,917	8,917	8,917	8,917
Spreading Basins, AFY (Minimum Demand)	2,000	2,000	2,000	2,000	2,000	0	2,000	2,000
Losses, AFY	662	765	662	662	662	562	662	662
Total Demand, AFY	**13,899**	**16,066**	**13,899**	**13,899**	**13,899**	**11,799**	**13,899**	**13,899**
Retail & Wholesale Demand, AFY	**11,899**	**14,066**	**11,899**	**11,899**	**11,899**	**11,799**	**11,899**	**11,899**
Gap Analysis								
Supply Surplus/ Shortfall, AFY	1,252	-915	199	1,816	-1,902	-1,802	-1,191	386
Conservation Savings through WSCP, AFY	0	915	0	0	1,902	1,802	1,191	0
WSCP Demand Reduction Needed	N/A	6%	N/A	N/A	14%	15%	9%	N/A

In addition to the whole system evaluation presented above, the gap analysis considered limitation of supplies to serve the domestic and the irrigation system. The domestic system serves high quality potable water to San Antonio Heights using groundwater from the Cucamonga Basin and Chino Basin, plus high-quality water from the San Antonio Tunnel. The irrigation receives additional water from the Cucamonga Basin, Six Basin, and San Antonio Creek, plus it can receive water from the domestic system for wholesale and agricultural non-potable deliveries and surface water spreading. The irrigation system cannot be used to serve the domestic system because of the difference in water quality needs.

When considering the operation of the two systems, all scenarios presented in Table 2 with a supply surplus (Scenario 1A, 2, 3, and 6) continue to have excess supply that can be used for additional surface water spreading.

Of the scenarios with a supply deficit, in Scenario 1B, 4A and 4B the required conservation can apply to either system. In these scenarios there are no supply or production limitations on providing the retail potable water demand to San Antonio Heights in the domestic system. A reduction in the share value, or volume of water each share is entitled, for wholesale customers based on the supply availability could be used to reduce demands to meet the available supply in these scenarios. Also, the model did not consider conjunctive use and any long-term storage of San Antonio Canyon water in the groundwater basins that could also be available to SAWCo when needed during dry years to reduce the conservation needed.

For Scenario 5, the domestic system has a much higher impact due to the loss of the tunnel than the irrigation system. **Figure 6** below shows the supply break down for the domestic and irrigation system for Scenario 5. As shown, with the loss of the tunnel the domestic system will require more than 30% conservation to reduce demands to meet the available potable supplies while the irrigation system will only require minor reductions in demand. Alternatively, a new supply source or emergency supply could be used to augment the domestic system supply and reduce the amount of conservation required.



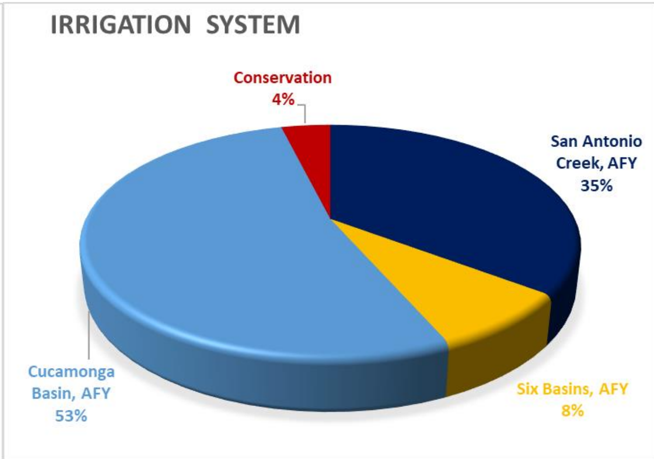


Figure 6. Scenario 5 Tunnel Collapse Supply Portfolio for the Domestic and Irrigation Systems

6 Recommendations

The gap analysis shows that under the future scenarios evaluated, SAWCo's well diversified supply portfolio is sufficient to meet projected demands in most scenarios and situations. However, it is important SAWCo maintains its current conjunctive use operation strategy, production facilities and infrastructure, and demand management measures. In addition to the active maintenance of its systems, new potential supplies are recommended for further investigation to serve the domestic system potable water in the event of the loss of the Tunnel supply.

Recommendations to maintain the current systems and supply portfolio:

- **Conjunctive use:** SAWCo currently diverts San Antonio Canyon Water in the winter during the rainy season for surface water spreading and recharge of groundwater basins. It is recommended to continue this practice to maximize the available San Antonio Canyon Water and store in the groundwater basins for longer term use. Building up groundwater storage through conjunctive use could help SAWCo meet demands and reduce or eliminate the need for the WSCP during extremely dry years.
- **Demand Management**: The analysis estimates that if demands rebound to pre-drought levels it could exceeded the normal supplies available to each year. While this is unlikely and current lower water use levels are expected to continue, SAWCo should maintain its demand management measures to prevent water waste and a potential rebound to unsustainable demand levels.
- **Infrastructure Maintenance**:
    - **Tunnel Inspection and Maintenance**: The San Antonio Tunnel is a high volume and important gravity fed source of potable water for the domestic system. As shown in Scenario 5, if the San Antonio Tunnel collapsed there will be a significant supply shortage for the domestic system. Firstly, the San Antonio Tunnel should be inspected via CCTV and evaluated by a structural engineer. The inspection can provide an assessment of the current condition of the San Antonio Tunnel and provide recommendations for improvements to maintain the lifespan of the tunnel. If significant issues are found that would require major improvements, SAWCo can plan for these improvements now instead of responding to these issues after an emergency such as a tunnel failure or collapse.
    - **San Antonio Creek Diversion and Maintenance**: Similar to the San Antonio Tunnel, the San Antonio Creek is a high volume and important gravity fed supply source. Currently all the water from the San Antonio Creek is diverted at one location and conveyed into the irrigation system via a single clay pipeline that is nearing the end of its useful lifetime. The pipeline should be inspected and evaluated for relining. The evaluation should consider the ideal relining materials and method, impacts to the pipeline capacity, and cost evaluation with a comparison to replacing the pipeline through a traditional replacement methods.
    - **Well Maintenance:** SAWCo's groundwater wells are also important production facilities and regular testing, maintenance and upkeep is imperative to maintaining production capacity. While the loss of a single well has a less impact than the loss of the tunnel or creek pipeline, regular well upkeep can maintain well production capacity and extend the well's lifetime. It is also recommended to obtain one or more back-up generators that can be used to operate the wells during power outages and emergency situations.

Recommendations for new supply sources:

- **Construct Well 19**: As described in Chapter 4 of the Water Master Plan Update, SAWCo plans to construct a new well within the Cucamonga Basin to mitigate the production deficit in the domestic system. Future Well 19 is projected to provide approximately 1,490 gpm of additional supply to the domestic system, which will help maintain service levels in the domestic system if the tunnel collapsed or other supplies were unavailable.

- **Emergency Connection:** In the past SAWCo has purchased water from the City of Upland and had a connection to Metropolitan Water District whose pipelines run through SAWCo's service area. Due to the potable supply limitations to the domestic systems, and vulnerability of the San Antonio Tunnel, a new emergency connection is recommended for the domestic system to provide potable water for SAWCo's retail customers. This could be through a direct connection with the City of Upland downstream of their Water Treatment Plant where SAWCo purchases back water supplied to the City that has now been treated, or through an agreement with the City to treat additional water for SAWCo. Additionally, SAWCo could also obtain imported water from Metropolitan through a new connection or an interconnection with an adjacent agency that received imported water and enter into a wheeling agreement. The interconnection would ideally be located in the domestic system along an existing main with adequate capacity. Additional discussion with potential partnering agencies and evaluation of interconnection locations is needed to determine the preferred intertie location.
- **Repurpose Irrigation System Wells for use in the Domestic System:** SAWCo has multiple wells that currently only serve the irrigation system. These wells could be repurposed to serve the domestic system when needed. If required, new wellhead treatment could be constructed to meet potable water quality standards, and existing or new infrastructure repurposed or constructed to convey more groundwater water to the domestic system.
- **1 MGD Water Treatment Plant. Currently, water from the San Antonio Creek serves only the irrigation system, and is the main supply source for the City of Upland's surface water treatment plant.** A new SAWCo owned and operated 1 MGD water treatment plant, located near the Forebay, could allow SAWCo to treat the creek supply to drinking water levels and serve the domestic system. The WTP would reduce the current vulnerability in the domestic system and allow additional sources of supply to serve San Antonio Heights. A 1 MGD plant corresponds to 1,120 AFY if operating a full capacity year-round, which would supply about 95% of the supply and demand gap in the domestic system if the tunnel were out of service. Additionally, the treatment plant would be available to provide water to the City of Upland when their treatment plant is out of commission.

C

Appendix C Cost Estimates

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

RZ 1

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Feasibility study to rezone a portion of the High Zone to the Holly Drive Zone. Includes evaluation of operational and system changes.	1	LS	$45,000.00	$45,000

Segment Label	Laterals	Diam in	Depth ft
RZ-1	0	N/A	6.0

Subtotal	$45,000
Project Development 25%	$11,300
Project Cost	**$56,300**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

FF 1

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	384	S.Y.	$10.39	$3,990
Hauling Pavement	32	L.C.Y.	$7.69	$246
Pavement Repair	42	Ton	$250.00	$10,500
Shoring	5264	SF Wall	$0.66	$3,474
Excavation-Trench	211	B.C.Y.	$8.88	$1,874
Pipe Bedding (sand import)	81	L.C.Y.	$25.55	$2,070
Bedding Compaction	81	E.C.Y.	$4.10	$332
Native Backfill & Compaction	130	E.C.Y.	$4.74	$616
Water Compaction	130	E.C.Y.	$2.22	$289
Hauling Excavation	253	B.C.Y.	$5.31	$1,343
8" PVC Pressure Pipe AWWA C900	560	L.F.	$22.39	$12,538
8" Gate Valve	1	Ea.	$1,700.00	$1,700
8" Tee	1	Ea.	$1,277.28	$1,277
8" 90 Bend	1	Ea.	$243.47	$243
Air Release Valve	1	Ea.	$6,000.00	$6,000
Pipeline Testing and Disinfection	560	L.F.	$1.50	$840
Saddle & Tap for Service	12	Ea.	$1,700.00	$20,400

Segment Label	Laterals	Diam in	Depth ft
FF - 1	12	8	4.7

Mobilization	3%	$2,032
SWPPP (per LF)	$2	$1,120
Traffic Control (per Day)	$500	$2,500
Subtotal		$73,385
Construction Contingency	20%	$14,677
Construction Total		**$88,062**
Project Development	25%	$22,015
Project Cost		**$110,077**

Note:

1. Costs are preliminary and may not represent actual project items

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	12/30/2022

FF 2

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	206	S.Y.	$10.39	$2,140
Hauling Pavement	17	L.C.Y.	$7.69	$131
Pavement Repair	23	Ton	$250.00	$5,750
Shoring	2820	SF Wall	$0.66	$1,861
Excavation-Trench	113	B.C.Y.	$8.88	$1,003
Pipe Bedding (sand import)	43	L.C.Y.	$25.55	$1,099
Bedding Compaction	43	E.C.Y.	$4.10	$176
Native Backfill & Compaction	70	E.C.Y.	$4.74	$332
Water Compaction	70	E.C.Y.	$2.22	$155
Hauling Excavation	136	B.C.Y.	$5.31	$722
8" PVC Pressure Pipe AWWA C900	300	L.F.	$22.39	$6,717
8" Tee	2	Ea.	$1,277.28	$2,555
Pipeline Testing and Disinfection	300	L.F.	$1.50	$450

Segment Label	Laterals	Diam in	Depth ft
FF - 2	0	8	4.7

Mobilization	3%	$693
SWPPP (per LF)	$2	$600
Traffic Control (per Day)	$500	$2,000
Subtotal		$26,384
Construction Contingency	20%	$5,277
Construction Total		**$31,661**
Project Development	25%	$7,915
Project Cost		**$39,577**

Note:

1. Costs are preliminary and may not represent actual project items

Client:	San Antonio Water Company
Project:	Paloma Curve Hydraulic Break Alternatives
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

FF 3

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Fire Hydrant Assembly (Furnish and Install)	6	Ea.	$8,500.00	$51,000
8-inch PVC Pressure Pipe AWWA C900 Hydrant Lateral	60	L.F.	$22.39	$1,400

Segment Label	Laterals	Diam in	Depth ft
FF-3	0	8	N/A

Mobilization	3%	$1,600
Traffic Control (per Day)	$ 500	$1,500
Subtotal		$55,500
Construction Contingency 20%		$11,100
Construction Total		$66,600
Project Development 25%		$16,700
Project Cost		**$83,300**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

R&R 1

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Well Drilling	1	Ea.	$1,500,000.00	$1,500,000
Emergency Generator	1	Ea.	$275,000.00	$275,000
Well Pump & Motor	1	Ea.	$100,000.00	$100,000

Segment Label	Laterals	Diam in	Depth ft
R&R-1	N/A	N/A	N/A

Mobilization	3%	$56,300
Traffic Control (per Day)	$ 500	$10,000
	Subtotal	$1,941,300
	Construction Contingency 20%	$388,300
	Construction Total	$2,329,600
	Project Development 25%	$582,400
	Project Cost	**$2,912,000**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Paloma Curve Hydraulic Break Alternatives
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

R&R 2

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Professionally inspect and clean storage tanks with divers	1	LS	$60,000.00	$60,000

Segment Label	Laterals	Diam in	Depth ft
R&R-2	0	0	N/A

Mobilization	3%	$1,800
	Project Cost	**$61,800**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/26/2022

WSC

R&R 3

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Inspect the San Antonio Tunnel via CCTV	5100	L.F.	$70.00	$357,000
Install inspection points	1	LS	$50,000.00	$50,000

Segment Label	Laterals	Diam in	Depth ft
R&R-3	0	0	N/A

Mobilization	3%	$12,300
	Subtotal	$419,300
	Project Development 25%	$104,900
	Project Cost	**$524,200**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	12/30/2022

R&R 4

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	411	S.Y.	$10.39	$4,270
Hauling Pavement	34	L.C.Y.	$7.69	$261
Pavement Repair	45	Ton	$250.00	$11,250
Shoring	5640	SF Wall	$0.66	$3,722
Excavation-Trench	226	B.C.Y.	$8.88	$2,007
Pipe Bedding (sand import)	87	L.C.Y.	$25.55	$2,223
Bedding Compaction	87	E.C.Y.	$4.10	$357
Native Backfill & Compaction	139	E.C.Y.	$4.74	$659
Water Compaction	139	E.C.Y.	$2.22	$309
Hauling Excavation	271	B.C.Y.	$5.31	$1,439
8" PVC Pressure Pipe AWWA C900	600	L.F.	$22.39	$13,434
8" Gate Valve	1	Ea.	$1,700.00	$1,700
8" Tee	1	Ea.	$1,277.28	$1,277
Pipeline Testing and Disinfection	600	L.F.	$1.50	$900
8" Cross	1	Ea.	$1,787.16	$1,787
Saddle & Tap for Service	13	Ea.	$1,700.00	$22,100

Segment Label	Laterals	Diam in	Depth ft
R&R - 4	13	8	4.7

Mobilization	3%	$2,031
SWPPP (per LF)	$2	$1,200
Traffic Control (per Day)	$500	$2,500
Subtotal		$73,426
Construction Contingency	20%	$14,685
Construction Total		**$88,112**
Project Development	25%	$22,028
Project Cost		**$110,140**

Note:

1. Costs are preliminary and may not represent actual project items

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	12/30/2022

R&R 5

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	133	S.Y.	$10.39	$1,382
Hauling Pavement	11	L.C.Y.	$7.69	$85
Pavement Repair	15	Ton	$250.00	$3,750
Shoring	1800	SF Wall	$0.66	$1,188
Excavation-Trench	67	B.C.Y.	$8.88	$595
Pipe Bedding (sand import)	25	L.C.Y.	$25.55	$639
Bedding Compaction	25	E.C.Y.	$4.10	$103
Native Backfill & Compaction	42	E.C.Y.	$4.74	$199
Water Compaction	42	E.C.Y.	$2.22	$93
Hauling Excavation	80	B.C.Y.	$5.31	$425
6" PVC Pressure Pipe AWWA C900	200	L.F.	$15.85	$3,170
6" Tee	1	Ea.	$826.11	$826
6" 90 Bend	1	Ea.	$406.49	$406
Pipeline Testing and Disinfection	200	L.F.	$1.50	$300
Saddle & Tap for Service	2	Ea.	$1,700.00	$3,400

Segment Label	Laterals	Diam in	Depth ft
R&R - 5	2	6	4.5

Mobilization	3%	$497
SWPPP (per LF)	$2	$400
Traffic Control (per Day)	$500	$2,000
Subtotal		$19,457
Construction Contingency	20%	$3,891
Construction Total		**$23,349**
Project Development	25%	$5,837
Project Cost		**$29,186**

Note:

1. Costs are preliminary and may not represent actual project items

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/26/2022

WSC

R&R 6

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Inspect Wells 22, 24, 25A, and 27 via CCTV	1	LS	$20,000.00	$20,000
Well Specific Rehabilitation / Replacement Plan	1	LS	$60,000.00	$60,000

Segment Label	Laterals	Diam in	Depth ft
R&R-6	0	0	N/A

Mobilization	3%	$2,400
	Subtotal	$82,400
	Project Development 25%	$20,600
	Project Cost	**$110,000**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	11/1/2022

R&R 7

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	6,600	S.Y.	$10.39	$68,600
Hauling Pavement	550	L.C.Y.	$7.69	$4,300
Pavement Repair	594	Ton	$250.00	$148,500
Shoring	95,040	SF Wall	$0.66	$62,800
Excavation-Trench	6,160	B.C.Y.	$8.88	$54,800
Pipe Bedding (sand import)	2,591	L.C.Y.	$25.55	$66,300
Bedding Compaction	2,591	E.C.Y.	$4.10	$10,700
Native Backfill & Compaction	3,569	E.C.Y.	$4.74	$17,000
Water Compaction	3,569	E.C.Y.	$2.22	$8,000
Hauling Excavation	7,392	B.C.Y.	$5.31	$39,300
24" HDPE Piping	7,920	L.F.	$114.09	$903,600
24" Tee	3	Ea.	$14,992.63	$45,000
24" 90 Bend	12	Ea.	$8,733.16	$104,800
Pipeline Testing and Disinfection	7,920	L.F.	$1.50	$11,900

Segment Label	Laterals	Diam in	Depth ft
R&R-7	0	24	6.0

Mobilization		3%	$46,400
SWPPP (per LF)	$	2	$15,840
Traffic Control (per Day)	$	500	$10,000
		Subtotal	$1,617,840
		Construction Contingency 20%	$323,600
		Construction Total	$1,941,440
		Project Development 25%	$485,400
		Project Cost	**$2,426,840**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	11/1/2022

R&R 8

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1,852	S.Y.	$10.39	$19,300
Hauling Pavement	154	L.C.Y.	$7.69	$1,200
Pavement Repair	188	Ton	$250.00	$47,000
Shoring	26,000	SF Wall	$0.66	$17,200
Excavation-Trench	1,284	B.C.Y.	$8.88	$11,500
Pipe Bedding (sand import)	523	L.C.Y.	$25.55	$13,400
Bedding Compaction	523	E.C.Y.	$4.10	$2,200
Native Backfill & Compaction	761	E.C.Y.	$4.74	$3,700
Water Compaction	761	E.C.Y.	$2.22	$1,700
Hauling Excavation	1,541	B.C.Y.	$5.31	$8,200
14" HDPE Piping	2,500	L.F.	$40.36	$100,900
14" 90 Bend	2	Ea.	$1,428.15	$2,900
Pipeline Testing and Disinfection	2,500	L.F.	$1.50	$3,800

Segment Label	Laterals	Diam in	Depth ft
R&R-8	0	14	6.0

Mobilization	3%	$7,000
SWPPP (per LF)	$ 2	$5,000
Traffic Control (per Day)	$ 500	$10,000
Subtotal		$255,000
Construction Contingency 20%		$51,000
Construction Total		$306,000
Project Development 25%		$76,500
Project Cost		**$382,500**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

O 1

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1576	S.Y.	$10.39	$16,375
Hauling Pavement	131	L.C.Y.	$7.69	$1,007
Pavement Repair	173	Ton	$250.00	$43,250
Shoring	21620	SF Wall	$0.66	$14,269
Excavation-Trench	867	B.C.Y.	$8.88	$7,699
Pipe Bedding (sand import)	333	L.C.Y.	$25.55	$8,508
Bedding Compaction	333	E.C.Y.	$4.10	$1,365
Native Backfill & Compaction	534	E.C.Y.	$4.74	$2,531
Water Compaction	534	E.C.Y.	$2.22	$1,185
Hauling Excavation	1040	B.C.Y.	$5.31	$5,522
8" PVC Pressure Pipe AWWA C900	2300	L.F.	$22.39	$51,497
Pipeline Testing and Disinfection	2300	L.F.	$1.50	$3,450

Segment Label	Laterals	Diam in	Depth ft
O - 1	0	8	4.7

Mobilization	3%	$4,700
SWPPP (per LF)	$2	$4,600
Traffic Control (per Day)	$500	$8,500
Subtotal		$174,459
Construction Contingency	20%	$34,892
Construction Total		**$209,351**
Project Development	25%	$52,338
Project Cost		**$261,689**

Note:

1. Costs are preliminary and may not represent actual project items

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	11/1/2022

O 2

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	867	S.Y.	$10.39	$9,100
Hauling Pavement	72	L.C.Y.	$7.69	$600
Pavement Repair	90	Ton	$250.00	$22,500
Shoring	12,000	SF Wall	$0.66	$8,000
Excavation-Trench	556	B.C.Y.	$8.88	$5,000
Pipe Bedding (sand import)	225	L.C.Y.	$25.55	$5,800
Bedding Compaction	225	E.C.Y.	$4.10	$1,000
Native Backfill & Compaction	331	E.C.Y.	$4.74	$1,600
Water Compaction	331	E.C.Y.	$2.22	$800
Hauling Excavation	667	B.C.Y.	$5.31	$3,600
12" HDPE Piping	1,200	L.F.	$36.18	$43,500
Pipeline Testing and Disinfection	1,200	L.F.	$1.50	$1,800

Segment Label	Laterals	Diam in	Depth ft
O-2	0	12	6.0

Mobilization	3%	$3,100
Traffic Control (per Day)	$ 500	$10,000
	Subtotal	$116,400
	Construction Contingency 20%	$23,300
	Construction Total	$139,700
	Project Development 25%	$35,000
	Project Cost	**$174,700**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/26/2022

O 3

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Inspect Irrigation Main from Main Box to tee towards Upland WTP via CCTV	1	LS	$420,000.00	$420,000

Segment Label	Laterals	Diam in	Depth ft
O-3	0	20	6.0

Mobilization	3%	$12,600
	Subtotal	$432,600
	Project Development 25%	$108,200
	Project Cost	**$541,000**

Note:
1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

O 4

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Upgrade and replace production meters in both the domestic and irrigation systems.	13	Ea.	$25,000.00	$325,000

Segment Label	Laterals	Diam in	Depth ft
O-4	0	0	N/A

Mobilization	3%	$9,800
	Subtotal	$334,800
	Construction Contingency 20%	$67,000
	Construction Total	**$401,800**
	Project Development 25%	$100,500
	Project Cost	**$436,000**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/26/2022

O 5

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Backup Well Generator	2	Ea.	$275,000.00	$550,000

Segment Label	Laterals	Diam in	Depth ft
O-5	0	0	N/A

Project Development 25%	$137,500
Project Cost	**$687,500**

Note:
1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

O 6

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
BPS #9 Evaluation	1	LS	$50,000.00	$50,000

Segment Label	Laterals	Diam in	Depth ft
O-6	0	N/A	N/A

Subtotal	$50,000
Project Development 25%	$12,500
Project Cost	**$62,500**

Note:

1. Costs are preliminary and may not represent actual project items.

Client:	San Antonio Water Company
Project:	Water Master Plan
Prepared By:	PO
Reviewed By:	KP
Date:	10/31/2022

WSC

O 7

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
18" Butterfly Valve	2	Ea.	$22,237.90	$44,500

Segment Label	Laterals	Diam in	Depth ft
O-7	0	N/A	N/A

Mobilization	3%	$1,335
Traffic Control (per Day)	$ 500	$500
Subtotal		$46,335
Construction Contingency 20%		$9,300
Construction Total		$55,635
Project Development 25%		$14,000
Project Cost		**$69,635**

Note:

1. Costs are preliminary and may not represent actual project items.