Water Master Plan Update 2025

Draft

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Abbreviations

ADD	average day demand
ADONA	4,8-Dioxa-3H-perfluorononanoic acid
ADU	accessory dwelling units
AF	acre-feet
AFY	acre-feet per year
AL	action level
AWWA	American Water Works Association
BEA	Basin Equity Assessment
bgs	below ground surface
BPP	Basin Production Percentage
BPS	booster pumping station
$CaCO_3$	calcium carbonate
CDR	Center for Demographic Research
cfs	cubic feet per second
CII	commercial, industrial, and institutional
CIP	Capital Improvement Program
City	City of Fullerton
CL	centerline
COF	Consequence of Failure
CRA	Colorado River Aqueduct
CUP	Conjunctive Use Program
DBP	disinfection by-product
DDW	Division of Drinking Water
Diemer	Robert B. Diemer
DMM	Demand Management Measure
DMU	Downtown Mixed Use
du/ac	dwelling units per acre

DWR	California Department Water Resources
EPS	extended period simulation
FAR	floor to area ratio
fps	feet per second
FY	fiscal year
GAC	Granulated Activated Carbon
GCP	Greenbelt Concept Project
GIS	geographical information system
GP	General Plan
gpcd	gallons per capita per day
gpd	gallons per day
gpd/du	gallons per day per dwelling unit
gpm	gallons per minute
GWRS	Groundwater Replenishment System
HAA5	haloacetic acids
HCO_3	bicarbonate
HGL	hydraulic grade line
HOA	homeowners' association
hp	horsepower
IX	single-use ion exchange
LCR	Lead and Copper Rule
LCRI	Lead and Copper Rule Improvements
lf	linear feet
LOF	Likelihood of Failure
LRAA	locational running annual average
MCC	motor control center
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal

MDD	maximum day demand
MG	million gallon
µg/L	micrograms per liter
µm	micrometer
µmho/cm	micromhos per centimeter
mg/L	milligrams per liter
mgd	million gallons per day
MTBE	methyl tert-butyl ether
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
MWELO	Model Water Efficient Landscape Ordinance
ND	Non-detect
NDMA	N-nitroso-dimethylamine
NL	notification level
OC Basin	Orange County Groundwater Basin
OCSan	Orange County Sanitation District
OCWD	Orange County Water District
OEL	operational evaluation levels
PCE	Tetrachloroethene
pCi/L	picocuries per liter
PFAS	per- and polyfluoroalkyl substances
PFBS	Perfluorobutane sulfonic acid
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	Perfluoro Hexane Sulfonic Acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid

PFOS	perfluorooctane sulfonate
PHD	peak hour demand
PHG	public health goal
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PQL	Practical Quantitation Level
PRV	pressure reducing valve
psi	pounds per square inch
PSV	pressure sustaining valve
PVC	polyvinyl chloride
PZ	pressure zone
RA	Replenishment Assessment
RHNA	Regional Housing Needs Assessment
RL	response level
RSSCT	Rapid small scale column testing
SCADA	supervisory control and data acquisition
SMCL	secondary MCL
SS	steady-state
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBA	tert-butyl alcohol
TCE	Trichloroethylene
TDH	total dynamic head
TTHM	total trihalomethanes
UCMU	Urban Center Mixed Use
USEPA	U.S. Environmental Protection Agency
UWMP	Urban Water Management Plan

VFD	variable frequency drive
VOC	volatile organic compound
WCHD	West Coyote Hills Development
WMP	Water Master Plan

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Executive Summary

This Water Master Plan (WMP) updates the City of Fullerton's 1997 Water Master Plan and serves as a guide for water system improvements to the year 2045, providing recommendations for prioritizing the Capital Improvement Program (CIP). This was accomplished through building and calibrating a new hydraulic model to analyze the capacity of the City's infrastructure, performing condition assessments, and expanding the City's asset management program. This WMP provides facility and operational recommendations to assist the City in servicing their customers with high-quality potable water supply that meets all applicable regulations, to supply adequate flows and pressures for water service and fire protection, to operate at high efficiency and low cost, and to maintain service reliability through redundancy.

Existing System

The City's water service area covers about 22.3 square miles, serving approximately 144,000 customers with 32,144 service connections (meters). The distribution system is comprised of four main pressure zones with twelve sub-zones. Storage reservoirs and pumping stations equalize flows and maintain adequate system pressures for each zone, which are interconnected through pressure regulating and flow control valves, as well as pressure relief and check valves. The water infrastructure includes 15 reservoirs with a combined storage capacity of 67.5 million gallons (MG), 14 booster pump stations (BPS), 8 active groundwater wells, 7 import water connections, 3 generators, and approximately 424 miles of pipeline.

Water Supply

The existing water distribution system delivers potable water to its customers from two primary supply sources: (1) groundwater pumped from the Orange County Groundwater Basin (OC Basin) and (2) treated imported water connections from the Metropolitan Water District of Southern California (MWD). Historical supply deliveries from both supply sources were analyzed based on ten years of recent water production data which revealed that the total average annual supply production required by the City to meet its water demands was 25,552 acre-feet per year (AFY). The largest annual supply production during this period was in FY 2013/14 at 30,058 AFY. However, between 2018 and 2022, the City's supply requirements have seen nearly a 9 percent reduction. This reduction in water supply resulted from diligent efforts in the promotion of water conservation as well as financial incentives for customers to retrofit their homes and businesses with water efficient devices and appliances.

The City's groundwater wells are the primary source of supply, historically producing an average of approximately 73 percent of the total supply. The City's groundwater supply has been impacted by levels of per- and polyfluoroalkyl substances (PFAS) detected in the City's groundwater wells at Kimberly Well 1A and at Main Plant Well 3A. In 2021, Kimberly Well 1A was retrofitted with an ion-exchange treatment facility. At the Main Plant, a PFAS treatment facility was constructed to treat Well 3A and will ultimately include additional facilities to also treat water from a new Well 7A; and a new configuration to treat Wells 5, 6, and 8.

Imported water provides the remaining approximately 27 percent of the City's supply source through seven MWD connections along MWD's Orange County Feeder, West Orange County Feeder, and Second Lower Feeder pipelines.

Water Quality

This WMP provides an update of the regulations impacting water utilities since the 1997 WMP. Drinking water quality is regulated by the California State Water Resource Control Board (State Water Board) Division of Drinking Water (DDW) and the U.S. Environmental Protection Agency (USEPA). Regulated contaminants include radionuclides, inorganic constituents, organic chemicals, disinfectant residuals in the water distribution system, and other constituents. The City's Water Quality Reports annually verify compliance with these regulations.

The USEPA has recently finalized the National Primary Drinking Water Regulation (NPDWR) Maximum Contaminant Levels (MCLs) for six PFAS chemicals. Therefore, it is important to ensure that PFAS treatment systems already constructed or designed in the City will comply not only with the State's regulations but also the new federal MCLs.

Microplastics are also a growing concern in water sources and are ubiquitous in drinking water. The State of California has legislated the implementation of a four-year plan to establish a standard method of testing and reporting of microplastics in drinking water (CA SB 1422), which can be found in the Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water (Policy Handbook) prepared by DDW in August 2022. The State Water Board has established an estimated risk to human health of microplastics through exposure via drinking water, through a two-phase iterative approach. Phase 1 will be performed by some large community water systems and wholesale water systems that serve more than 100,000 people, while Phase 2 will involve additional agencies. The Policy Handbook includes a list of potential water systems to perform the microplastics monitoring during Phase 1 – the City of Fullerton is not on this list. The Phase 2 list has not been made public yet.

A water quality assessment was conducted for the groundwater supply, treated imported water supply, and water quality within the distribution system. Year over year, the City's drinking water wells consistently provide the community with high quality drinking water that meets compliance with federal and state regulations without issue. The treated surface water complies with all current water quality regulations. The combined supplies in the distribution system are subject to the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule and monitoring of chlorine and fluoride residuals. Data sampled semi-annually from 2017 through 2022 shows no sample exceeding the fluoride MCL.

Water Use

The City's historical data of potable water production and consumption was evaluated to determine the water use characteristics and plan for future water usage. In addition to the historical water use information; seasonal variations, population growth, the City's General Plan and Zoning Map, and known development plans were taken into consideration to project the City's future water demands.

Historical water consumption was evaluated using available billing data. On average, the City's historical water consumption during the 10-year period evaluated is approximately 24,352 AFY or 21.74 million gallons per day (mgd). For the same historical 10-year period, the City's water production has averaged approximately 25,552 AFY. The difference can be attributed to real system losses such as leaking or broken mains and service lines, unbilled consumption such as hydrant flushing and fire-fighting, or apparent losses including unauthorized consumption, monthly billing estimates, and meter inaccuracies. Based on the comparison of water production against the water consumption data, the City's annual average water loss is 5 percent, with the last five years being steady between 3 and 5 percent.

Various methodologies are available in the industry when projecting future demands. For this WMP, methodologies used included population-based projections, land use-based projections using the City's General Plan and known development projects, and historical trends analysis. These future demand projections were then compared with the demand projections from the City's 2020 UWMP. Based on the results from each methodology, the demand projections from the 2020 UWMP are recommended for this WMP, as they also included a thorough analysis of the demand projections and reflect the 2021 Orange County Water Demand Forecast for Municipal Water District of Orange County (MWDOC) and OCWD study, considering indoor and outdoor water use as well as Regional Housing Needs Assessment (RHNA) allocation requirements. The 2020 UWMP projections were found to strike a balance between the population and the land use projections, validating that they are neither too conservative nor too aggressive.

Planning and Evaluation Criteria

Planning and evaluation criteria provide a means by which the hydraulic performance and reliability of an existing system can be evaluated, and for planning of facilities to meet future system conditions and demands. Criteria for this WMP was based on established criteria in the 2022 City of Fullerton Public Works Department Water Utility Specifications and the 2022 American Water Works Association (AWWA) guidelines for potable water system planning.

Model Development and Calibration

A new hydraulic model was created to reflect a one-to-one pipe relationship with the City's latest GIS database and further updated to include recently completed projects. The demands were allocated based on City water billing data, and the model was calibrated by conducting real-time fire hydrant flow tests at 19 locations throughout the City. Steady-state (SS) analysis and extended period simulation (EPS) scenarios were both created in the model. The calibrated model was used to predict system performance and identify system deficiencies, evaluate emergency scenarios, and develop recommendations to improve system performance.

Water production data from calendar year 2022 was used to reflect the most recent water use patterns and characteristics to determine the average day demand (ADD) and maximum day demand (MDD). Hourly SCADA data of the City's production facilities were used to determine the daily diurnal patterns for ADD and MDD conditions. These patterns are applied in the model to create a 24-hour EPS for existing, near-term, and future conditions.

Water System Evaluation

The new calibrated model was used to evaluate the City's water distribution system for three different demand conditions: existing, near-term (10-year planning horizon), and future (20-year planning horizon). The water distribution system was evaluated under normal operating and supply conditions to determine areas of low-pressure, high-pressure, and high pipeline velocity under ADD and MDD conditions. In addition, the distribution system was also evaluated under MDD plus fire flow conditions. Storage requirements, well pump capacity, and booster pump station capacity were evaluated for each planning horizon. It should be noted that the City also has interconnects with other agencies that are available for temporary emergency situations if needed but are not included in the existing system evaluation as these evaluations are geared towards self-sufficiency and reliability on the City's system. This WMP provides recommendations to address system pressures, pipeline velocities, pump station, and fire flow deficiencies. The future system evaluation included the West Coyote Hills Development and associated facility recommendations. Water age was also evaluated and locations predicted to have the highest water age were identified.

Planning Scenarios

Results and recommendations were provided for multiple planning scenarios evaluating future system conditions, including the following:

Maximizing Groundwater Supply: These model scenarios evaluated the distribution system for maximizing the City's current available groundwater supply, as well as the potential future 100 percent groundwater supply.

System Operations Efficiency: This scenario evaluated distribution system operational modifications to improve system efficiency.

System Reliability: Scenarios were performed to evaluate distribution system reliability under extreme supply outage assumptions.

Facility Condition Assessment

A visual inspection of the City's facilities was performed with the assistance of City operations and recommendations were developed for each pump station, reservoir, and well facility site observed.

Risk Assessment

An analysis and evaluation of the Asset Management Asset-Risk was conducted for the horizontal and vertical assets. Both the hydraulic analysis, which incorporated a fire-flow availability analysis, and the Asset Management Asset-Risk analysis were considered to create a series of recommended improvements for the CIP. Replacement recommendations for pipelines, wells, pump stations, and reservoirs considered aspects relating to asset condition, pipeline age, historical failures, soil corrosivity, type of critical customers served, groundwater scarcity, financial impacts, and other non-hydraulic factors.

Capital Improvement Program

The CIP projects recommended in this report are based on improvements derived from the hydraulic model evaluations, condition assessment, and risk-assessment analysis. The CIP identifies the proposed improvement projects, provides the estimated planning level cost estimates of the facilities, and develops an estimated timetable or prioritization for implementing these improvements to year 2045 and beyond. Categorized into short-term, near-term, and long-term priorities, CIP cost estimates are shown in Table ES-1 and CIP recommendations are summarized below:

Short-Term (2030):

- Conduct facility site improvements, replace pump equipment, and install new hydropneumatic tank at Upper Acacia BPS
- Conduct facility site improvements at Hermitage BPS, replace pumps and increase capacity at Hermitage 2B-3 BPS, and install new or rehabilitate existing hydropneumatic tank at Hermitage 2B-4C BPS
- Conduct facility site improvements, replace pump equipment, and increase capacity of pumps at Coyote BPS
- Conduct facility site improvements at Tank Farm Reservoir and BPS, rehabilitate Tank Farm 2D Reservoir tanks, and replace pump equipment at Tank Farm BPS
- Conduct facility site improvements, and repair electrical and control equipment at Christlieb Well 15A
- Replace and increase diameter of approximately 76,700 linear feet (LF) of pipeline to improve fire flow capacity

Near-Term (2035):

- Conduct facility site improvements, and replace pumps and increase capacity at Hillcrest BPS and Lower Acacia BPS
- Conduct facility site improvements and replace pumps at State College BPS
- Conduct facility site improvements, rehabilitate tanks, and demolish Well 12A at Coyote 1C Reservoir
- Repair and replace piping and appurtenances, and rehabilitate tank at Laguna 2A Reservoir

- Conduct facility site improvements and tank improvements at Hermitage 2B Reservoir, Upper Acacia 3A Reservoir, State College 2C Reservoir, and Hawks Pointe 3C Reservoir
- Conduct facility site improvements at Airport Well 9
- Construct new pressure reducing valve between Zone 3 and Zone 2
- Reconnect existing fire hydrants at two locations: Zone 1 at Orangethorpe and Citrus; and from Zone 2 to Zone 3 at Brea and Longview
- Install 7 permanent backup generators at 7 existing BPS sites
- Construct a new 7,000 LF 16-inch transmission main in Zone 3 on Harbor Boulevard from Valencia Mesa to Hillcrest BPS
- Zone 1 to 2 realignment
  - Relocate one zone break valve between Zone 2 and 1 near the intersection of Vista Verde Drive and West Union Avenue
- Zone 3 to 4C realignment
  - Relocate 3 zone break valves between Zone 4C and 3, near the intersection of Camino del Sol and Camino Rey, Atherton Circle and Camino del Sol, and between Applewood Circle and North Gilbert Street
  - Construct new pipeline segment (49-LF) to connect the former Zone 3 and newly realigned Zone 4C

Long-Term (2045 and Beyond):

- Construct new pipeline infrastructure to support the proposed West Coyote Hills Development and new Zone 4C service area; approximately 26,000 LF of 8-inch and 12-inch pipelines
- Construct new Zone 4C BPS for West Coyote Hills Development
- Construct new Zone 4C Reservoir for the West Coyote Hills Development
- Construct new Zone 5 BPS for the West Coyote Hills Development
- Conduct facility site improvements, replace pump equipment, and increase pump capacity at Hawks Pointe BPS
- Construct 2 new groundwater wells in Zone 1B with permanent backup generators
- Install 6 permanent backup generators at 6 existing groundwater well sites
- Replace pump equipment and increase pump capacity at Hermitage 2B-3 BPS
- Conduct facility site improvements and rehabilitate tanks at Hillcrest 1A Reservoir, Lower Acacia 1D Reservoir, and Las Palmas 3B Reservoir
- Replace approximately 70 LF of 8-inch pipeline with 12-inch diameter pipeline in Brookhurst Road
- Zone 4A to 3 realignment
  - Relocate one zone break valve between Zone 4A and 3, near the intersection of Pioneer Avenue and Rocky Road
- New Pressure Zone 2B Subzone

- Construct a new zone break valve near the intersection of Starbuck Street and Hughes Drive
- Construct a new PRV near the intersection of Gilbert Street and Hughes Drive
- Construct a new PRV near the intersection of Cusick Drive and Wright Lane

- New Pressure Zone 3B Subzone
  - Construct a new zone break valve and new PRV southeast of the intersection of Primrose Lane and Camelia Lane, near Rosecrans Avenue
  - Construct a new PRV at the intersection of Rosecrans Avenue and Emery Ranch Road
  - Construct approximately 2,600 LF of 8-inch pipeline along Emery Ranch Road and Muir Trail Drive, disconnecting laterals from the existing Zone 3 parallel pipeline and connecting to the proposed 8-inch pipeline

Table ES-1. CIP Cost Summary

Planning Horizon	Other Water Main Project Costs[a]	Booster Pump Station Project Costs[b]	Other Facility Project Costs[c]	Total Project Improvement Costs[d,e]	Pipeline Repair & Replacement Program Costs[f]	Total 20-Year CIP Costs
Short-Term	$42.9M	$11.6M	$4.5M	$59.0M	$101.9M	$160.9M
Near-Term	$6.3M	$9.6M	$17.1M	$33.0M	$101.9M	$134.9M
Long-Term	$16.2M	$9.6M	$33.2M	$59.0M	$203.8M	$262.8M
Total CIP	**$65.4M**	**$30.8M**	**$54.8M**	**$151.0M**	**$407.6M**	**$558.6M**

[a] Other Water Main project costs include fire flow improvements, proposed transmission main, and development-driven pipeline projects.

[b] Booster pump station project costs include facility improvements of respective booster pump stations.

[c] Other facility project costs include groundwater wells, reservoirs, pressure reducing valve, zone realignments, generators, and respective facility improvements.

[d] Total Project Costs are the sum of only the Other Water Main, Booster Pump Station, and Other Facility project costs.

[e] Project contingency is included in the project costs shown to account for unknown conditions when preparing general planning level cost estimates. Costs are based on 2024 dollars and do not include escalation.

[f] The Pipeline Repair and Replacement Program Costs of $407.6M assumes an annual budget of $20.4M over the 20-year CIP planning horizon for this Master Plan. The annual budget assumes a 60-year replacement cycle.

Implementation of the short-, near-, and long-term project improvements listed above would require an estimated annual budget of approximately $7.6 million per year, assuming a 20-year CIP planning horizon.

A well-managed CIP program also includes a strategy for pipeline replacements that involves a proactive approach to identifying and replacing aging or high-risk pipelines aiming to enhance system reliability, reduce leak risks, and reduce the rate of pipe breaks by upgrading the pipeline infrastructure over time. The proposed Pipeline Repair and Replacement Program assumes the City's distribution system is replaced over a 60-year period. Approximately 74 miles of the distribution system piping has been identified as high and very high risk and thus prioritized as high priority replacement projects. The annual budget estimated for the City's Pipeline Repair and Replacement Program is approximately $20,400,000. This annual budget is in addition to the project improvements identified for the 20-year CIP planning horizon for this Master Plan. The total 20-year CIP budget including the project improvement costs and Pipeline Repair and Replacement Program costs is estimated to be $558,600,000.

A GIS-based prioritization tool was created to determine the priority basis and identify projects to be implemented for each pipe within the Pipeline Repair and Replacement Program.

1.0 Introduction

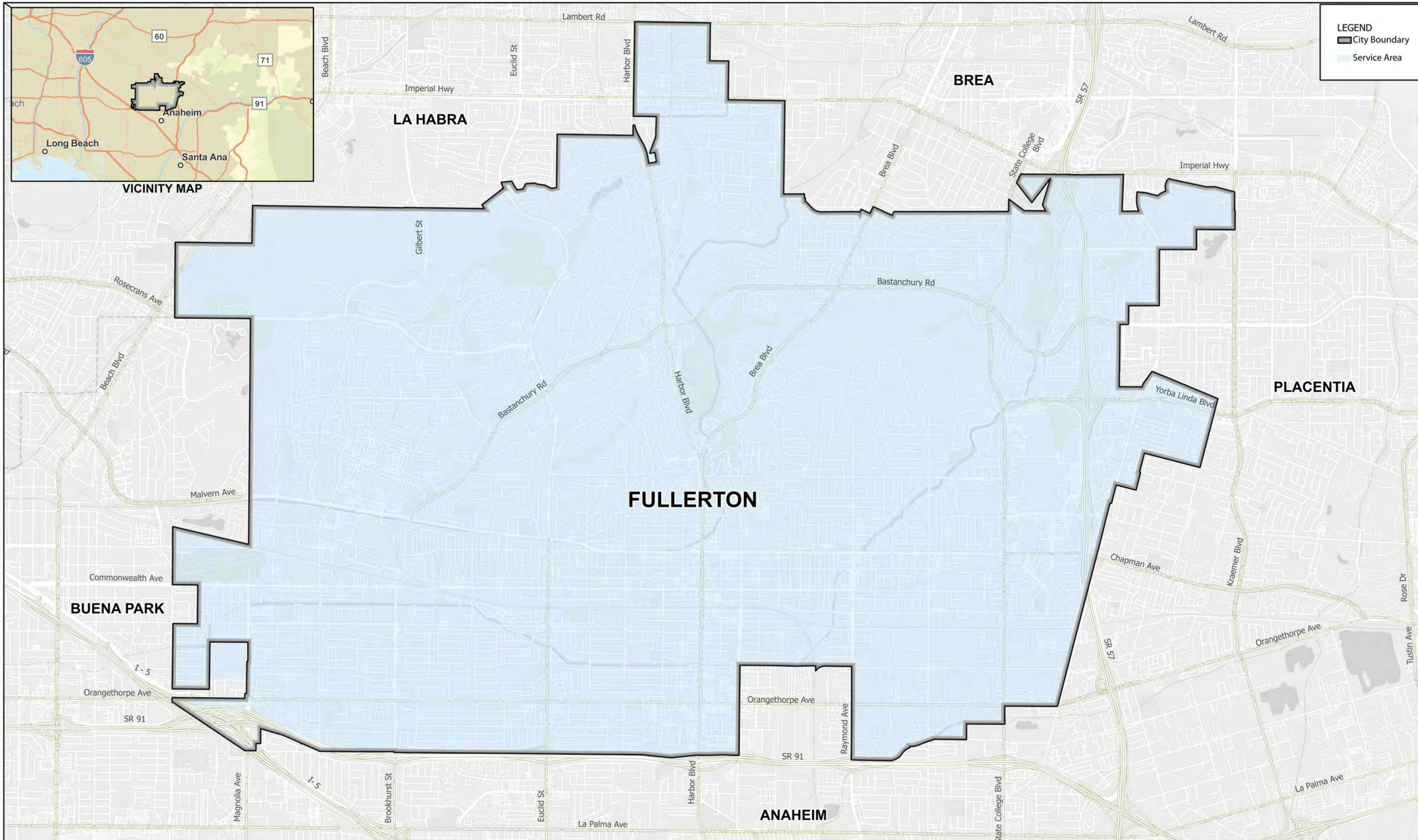
1.1 Purpose

The City of Fullerton (City) is updating their 1997 Water Master Plan (WMP) to serve as a guide for water system improvements through the year 2045, providing a phased Capital Improvement Program (CIP). This is accomplished through building and calibrating an updated hydraulic model to analyze the capacity of the City's infrastructure, performing condition assessments, and expanding the City's existing asset management program to evaluate the condition of the City's infrastructure. This updated WMP will provide improvement recommendations to assist the City in servicing their customers with a high-quality potable water supply that meets all applicable regulations, to supply adequate flows and pressures for water service and fire protection, to operate at high efficiency and low cost, and to maintain service reliability through redundancy. Note, the information in this study is accurate as of July 2024.

1.2 History and Background

The City is located 22 miles southeast of metropolitan Los Angeles, in the center of North Orange County, California and bordered by the Cities of La Habra and Brea to the north, Anaheim to the south, Placentia to the east, and Buena Park to the west, as shown on Figure 1-1. Fullerton is a full-service, general law city that was incorporated in 1904. Fullerton is renowned for its unique mix of residential, commercial, industrial, educational, and cultural environments and is known for being "the education community." Fullerton has 52 City parks, a museum, a cultural center, a public library, a golf course, and 29 miles of recreational trails and is home to California State University, Fullerton campus. Fullerton provides an outstanding quality of life for both residents and businesses. Fullerton is also one of the largest cities in Orange County by area and is the sixth most populous.

The City is a predominantly single and multi-family residential community. Recent and ongoing developments include various residential, commercial, industrial, and mixed-use projects. Moving forward, future planned developments may include accessory dwelling units (ADU).



0 1,500 3,000 Feet

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FULLERTON WATER MASTER PLAN UPDATE

Figure 1-1. Location Map and Service Area

11/18/2024

2.0 Existing System Facilities

The City's water service area covers about 22.3 square miles, serving approximately 144,000 customers. The existing water distribution system delivers potable water to its customers pumped from local groundwater supply as we well as from imported water connections from Metropolitan Water District of Southern California (MWD). The City's largest groundwater supply facility is the Main Plant located south of the City, on La Palma Avenue, in the City of Anaheim. The existing water distribution system is provided on Figure 2-1.

The distribution system comprises of twelve pressure zones. Storage reservoirs and pumping stations equalize flows and maintain adequate system pressures for each zone. Pressure zones are interconnected through pressure regulating and flow control valves, as well as pressure relief and check valves. The water infrastructure includes the following major facilities:

- 15 reservoirs with a capacity of 67.5 million gallons (MG)
- 14 booster pump stations (BPS)
- 8 active groundwater wells
- 7 import water connections
- approximately 424-miles of mainline pipes
- 3 generators
- 4 pressure zones with 12 sub-zones

The City's water system supplies 32,144 service connections (meters), with most meters being 5/8-inch and 1-inch. Most of the customers are residential users, followed by commercial, as shown in Table 2-1.

Table 2-1. Customer Connections

Land Use	Meter Size (inches)										
	5/8	1	1 1/2	2	3	4	6	8	10	12	Total
Residential	13,571	14,362	357	322	28	43	5	2	4		28,694
Commercial	510	578	392	465	63	50	12	2	4		2,076
Industrial	9	16	27	41	10	8	3	1			115
Fireline				7		129	133	230	65	2	566
Landscape	9	120	87	198	3						417
Municipal	28	84	33	92	10	16	4	7			274
Agricultural				2							2
Grand Total	**14,127**	**15,160**	**896**	**1,127**	**114**	**246**	**157**	**242**	**73**	**2**	**32,144**

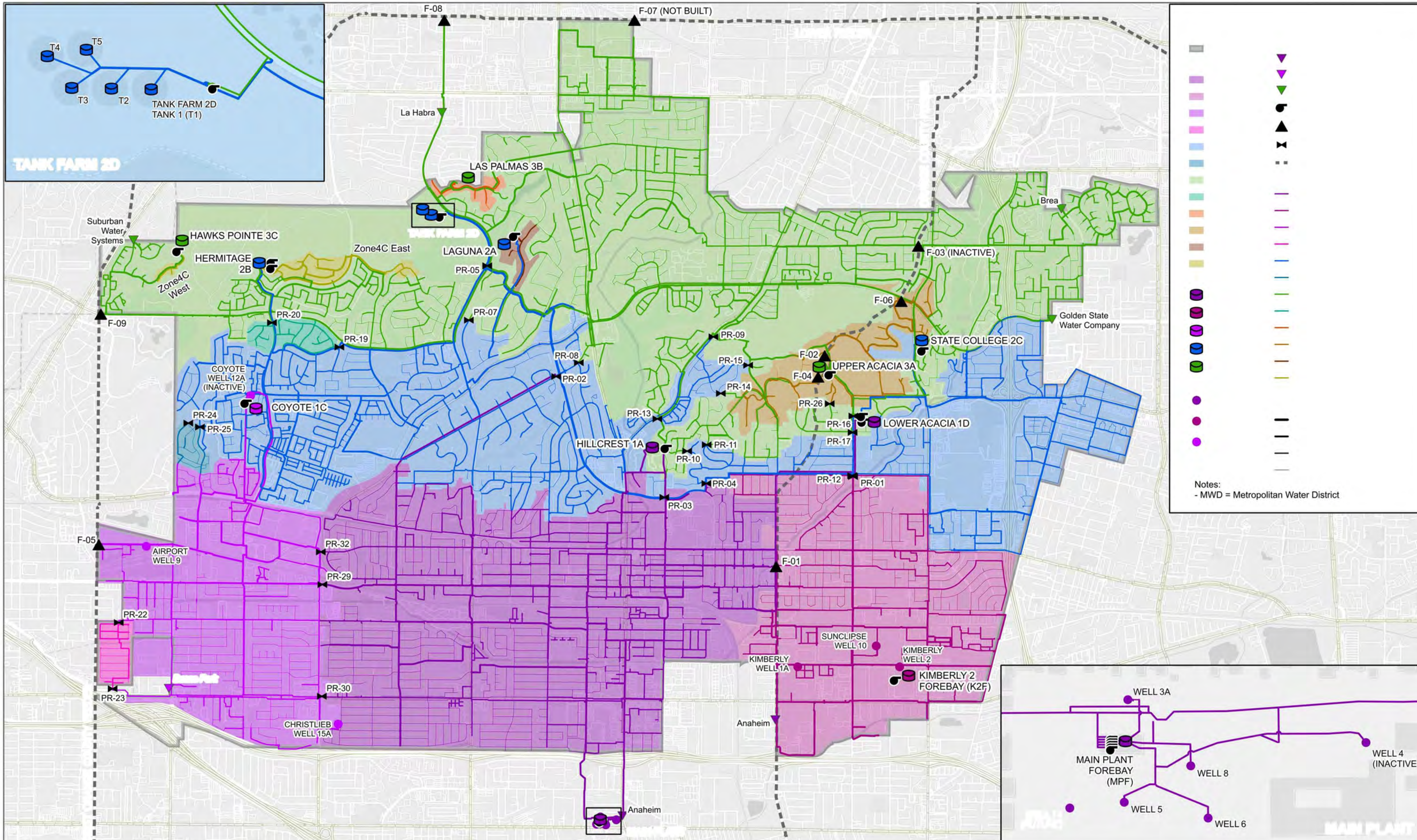

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Figure 2-1. Existing Water Distribution System

2.1 Pressure Zones

To maintain adequate pressures throughout the water distribution system regardless of varying topography, water systems are divided into hydraulic regions known as pressure zones. The City's operational service area is comprised of a total of twelve individual pressure zones. Pressure zone boundaries are based on ground elevations that match desired minimum and maximum system pressures and are separated by booster pump stations and pressure regulating, flow control, or system check valves.

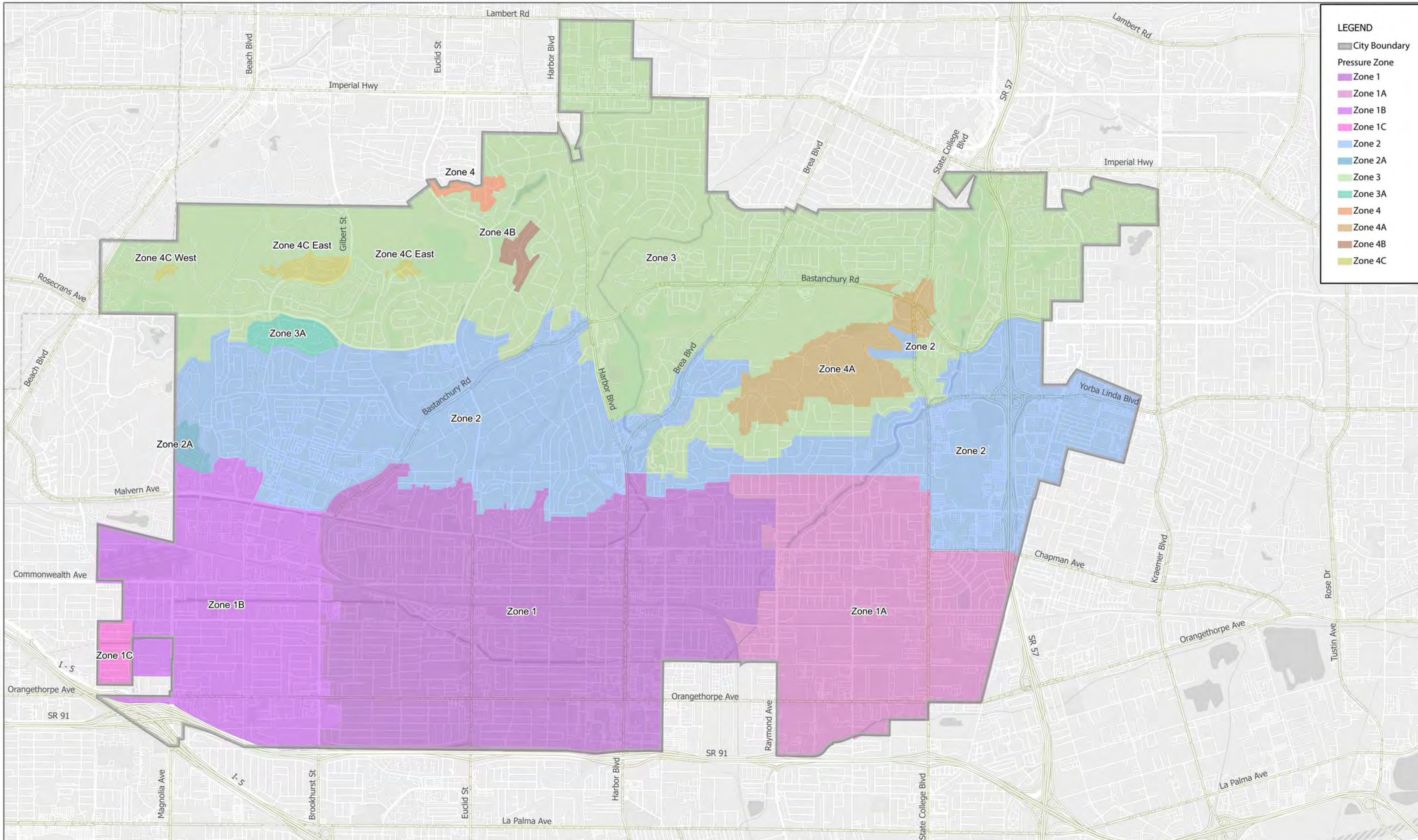
There are five gravity fed zones that are directly connected to a storage reservoir (Zones 1, 1A, 1B, 2, and 3) with the remaining seven zones either directly supplied through a pressure reducing valve or boosted through a pump station (Zones 1C, 2A, 3A, 4, 4A, 4B, and 4C). Pressure zones labeled with the number 1 serve the lowest elevations and zones labeled as 4 serve the highest elevations, generally extending from south to north. The City's pressure zones are summarized in Table 2-2.

The City's existing water distribution system pressure zone boundaries and hydraulic profile are shown on Figures 2-2 and 2-3, respectively.

Table 2-2. Existing Water Distribution System Pressure Zones

Pressure Zone	Hydraulic Grade Line (feet)	Pressure Range (psi)		Service Elevations[a] (feet)	
		Low	High	Low	High
1	327	48	105	85	215
1A	360	65	83	169	209
1B	281	46	86	82	174
1C	263	77	82	74	84
2	420	50	89	215	305
2A	323	39	56	194	234
3	510	48	143	180	400
3A	484	39	65	334	394
4	660	74	113	400	490
4A	605	50	89	400	490
4B	605	40	89	400	512
4C[b]	605/592	50	89	400	490

Notes:
[a] Elevations taken from City's Geographic Information System. Local grading may vary from elevations shown, resulting in changes to static service pressures.
[b] Zone 4C is comprised of two hydraulically separated service areas of similar hydraulic grade line requirements and considered as a Zone 4C (East) service area and Zone 4C (West) service area. Zone 4C (East) is served only by the Hermitage 3A-4C Booster Pump Station. Zone 4C (West) is a small separate service area supplied only by the Hawks Pointe 3C-4C Booster Pump Station. These service areas are to be considered as being combined in the future when development is implemented in the area. See Section 8.3 for further discussion on the future configuration of Zone 4C.



FULLERTON WATER MASTER PLAN UPDATE
Figure 2-2. Pressure Zone Boundaries
11/15/2024

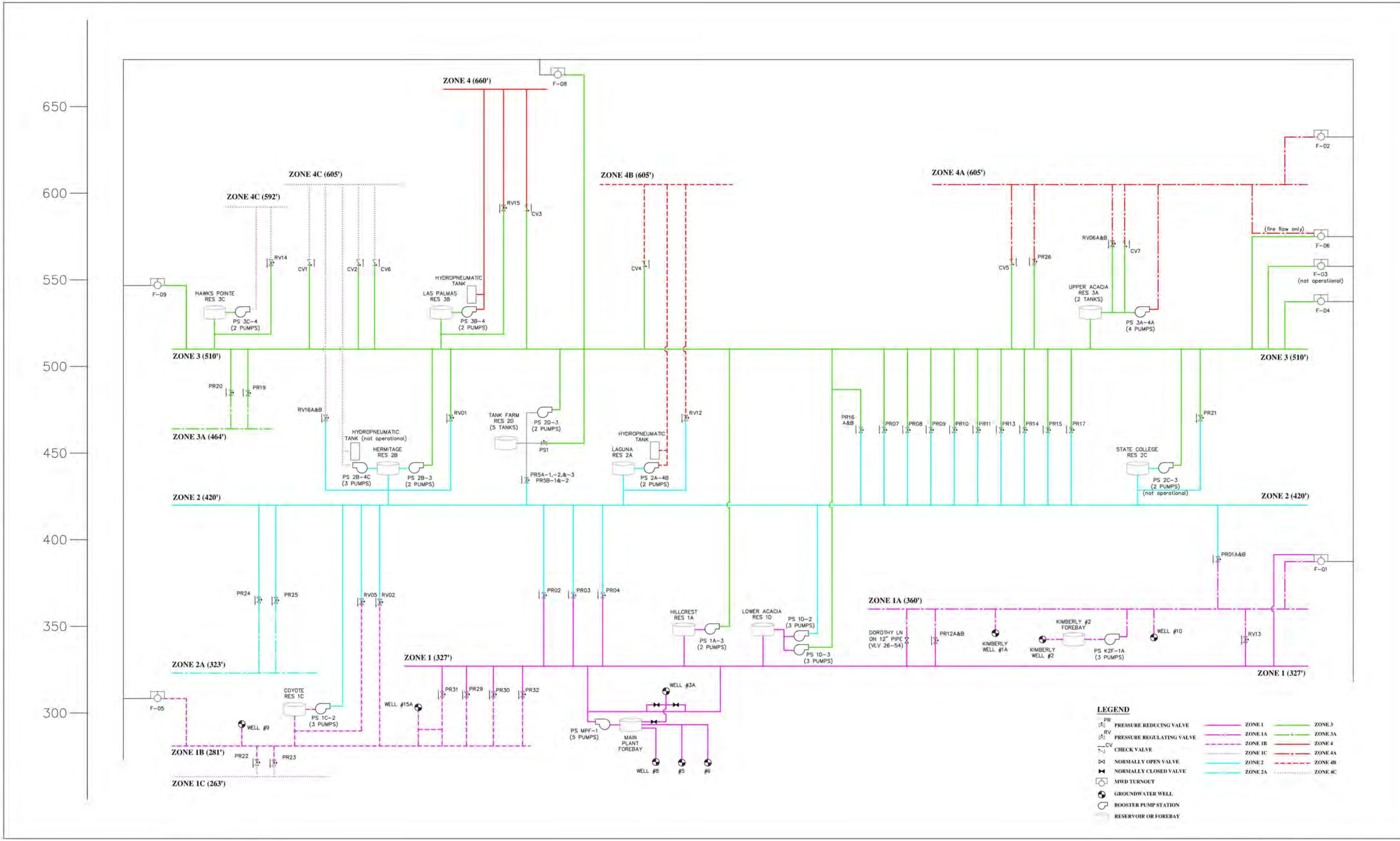


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Figure 2-3. Existing Water Distribution System Hydraulic Profile

11/15/2024

General descriptions of each pressure zone are provided in the following pages. Descriptions include a figure and a table summary of pressure zone attributes, including hydraulic grade line (HGL), static service pressure in pounds per square inch (psi), source water, supply facility and storage reservoirs. Source water can be groundwater, imported water or a combination referred to as blended. Each pressure zone's supply facility may include wells, MWD turnouts, pressure reducing valves (PRV), and pump stations, depending how water is supplied to the pressure zone. Generally, groundwater is pumped from the wells to supply Zones 1 and 1A and then can be pumped up to the higher-pressure zones. Zone 1B supply is blended, with most of the demand met by groundwater. Imported water is the primary supply directly feeding to Zone 3, and pressure reduced to Zone 2 and pumped up to Zones 4, 4A, 4B, and 4C. Zone 2 is a blended zone receiving both groundwater and imported water.

Pressure Zone 1: Pressure Zone 1 is the largest of the lower pressure zones, and it is located at the southern, central part of the City. See Table 2-3 for a summary of Zone 1 and Figure 2-4 for a map of the distribution system. Typically, groundwater is supplied to Zone 1 from the Main Plant Wells 3A through 8. Currently only Main Plant Wells 5, 6, and 8 are active. Wells 4 and 7 are inactive and are to be destroyed. Well 3A is inactive for the installation of a per- and polyfluoroalkyl substances (PFAS) treatment plant. In addition, water can be supplied to Zone 1 via three PRVs from Zone 2 and one PRV from Zone 1A. PRV 2 and 3 are used during a fire flow event. Operational storage for Zone 1 is stored in two below ground concrete reservoirs: Hillcrest 1A and Lower Acacia 1D. Also, the Main Plant has a forebay that provides operational storage for the Main Plant wells prior to being pumped to Zone 1 through the Main Plant BPS.

Pressure Zone 1A: Zone 1A is located in the southern portion of the City, east of Zone 1. See Table 2-3 for a summary of Zone 1A and Figure 2-4 for a map of the distribution system. Source water to this zone includes groundwater supplied by Kimberly Wells 1A and 2, and Sunclipse Well 10. In addition, water can be supplied from Zone 2 via two PRVs. Kimberly Well 2 currently pumps into a forebay and the Kimberly Plant 2 BPS then pumps the water to Zone 1A.

Zone 1 and Zone 1A are separate pressure zones; however, they are hydraulically connected through a pressure relief valve assembly, PRV station, and 12-inch pipeline located on Dorothy Lane. Currently the PRV (PR12A) is maintained in the open position and water can be freely conveyed between the two zones through the 12-inch pipeline. This allows the 12-inch pipeline to act as a hydraulic link between the two zones. There are also 11 additional connections between the two zones, however currently all of those connections are currently closed with isolation valves.

Pressure Zone 1B: Zone 1B is also located in the southern part of the City, west of Zone 1. See Table 2-3 for a summary of Zone 1B and Figure 2-4 for a map of the distribution system. Source water to this zone includes groundwater supplied from Airport Well 9 and Christlieb Well 15A and imported water received from MWD connection F-05 which is located on the far west side of the pressure zone. Additional water supply can be provided from Zone 1 via four PRVs, with PRV 29 providing water during a fire flow. Coyote Reservoir 1C provides distribution storage for Zone 1B. Coyote Well 12A is located at the Coyote Reservoir 1C site but is inactive due to water quality issues and low production and will be destroyed.

Pressure Zone 1C: Zone 1C is a small pressure zone, located southwest of Zone 1B, near Buena Park High School. See Table 2-3 for a summary of Zone 1C and Figure 2-4 for a map of the distribution system. Zone 1C serves about 260 homes via two PRVs from Zone 1B, which includes groundwater and imported water.

Table 2-3. Pressure Zone 1 Summary

PZ HGL (feet)	Static Service Pressure (psi)	Source Water	Supply Facility/BPS (# of pumps)	Storage Tank or Forebay	PRV[a]	PRV Flow from
1 327	48-105	Groundwater: Wells 3A[b], 4[c], 5, 6, 7[d],8 Imported water: MWD F-01[d]	Main Plant (5)	Main Plant Forebay Hillcrest 1A Lower Acacia 1D	PR2 (fire flow), PR3 (fire flow), PR4	Zone 2
					PR12B	Zone 1A
1A 360	65-83	Groundwater: Kimberly 1A, Kimberly 2, Sunclipse 10 Imported water: MWD F-01[e]	Kimberly 2 (3)	Kimberly 2 Forebay	PR12A (open)[f]	Zone 1
					PR1A, PR1B	Zone 2
1B 281	46-86	Groundwater: Airport 9, Christlieb 15A Imported water: MWD F-05	*None*	Coyote 1C	PR29 (fire flow), PR30, PR31, PR32	Zone 1
1C 263	77-82	Blended water from Zone 1B	*None*	*None*	PR22 (lead), PR23 (lag)	Zone 1B

Notes:
[a] PR100 and PR101 are in Zone 1, however they are not listed in the table because they are not pressure zone boundary valves serving Zone 1. These are maintained by the Water Division for other individual City Facilities; PR 100 serves the Independence Pool and PR101 serves the Community Center Pool.
[b] Main Plant Well 3A is temporarily out of service due to PFAS response levels (RL).
[c] Well 4 is inactive and to be destroyed.
[d] Well 7 is inactive and to be destroyed, and Well 7A is in construction to replace this well.
[e] F-01 was recently brought online in case of emergency, in response to PFAS taking out City wells and is not used during normal operations.
[f] PR12A is maintained in the open position and water can be freely conveyed between the Zone 1A and 1 through the 12-inch pipeline.

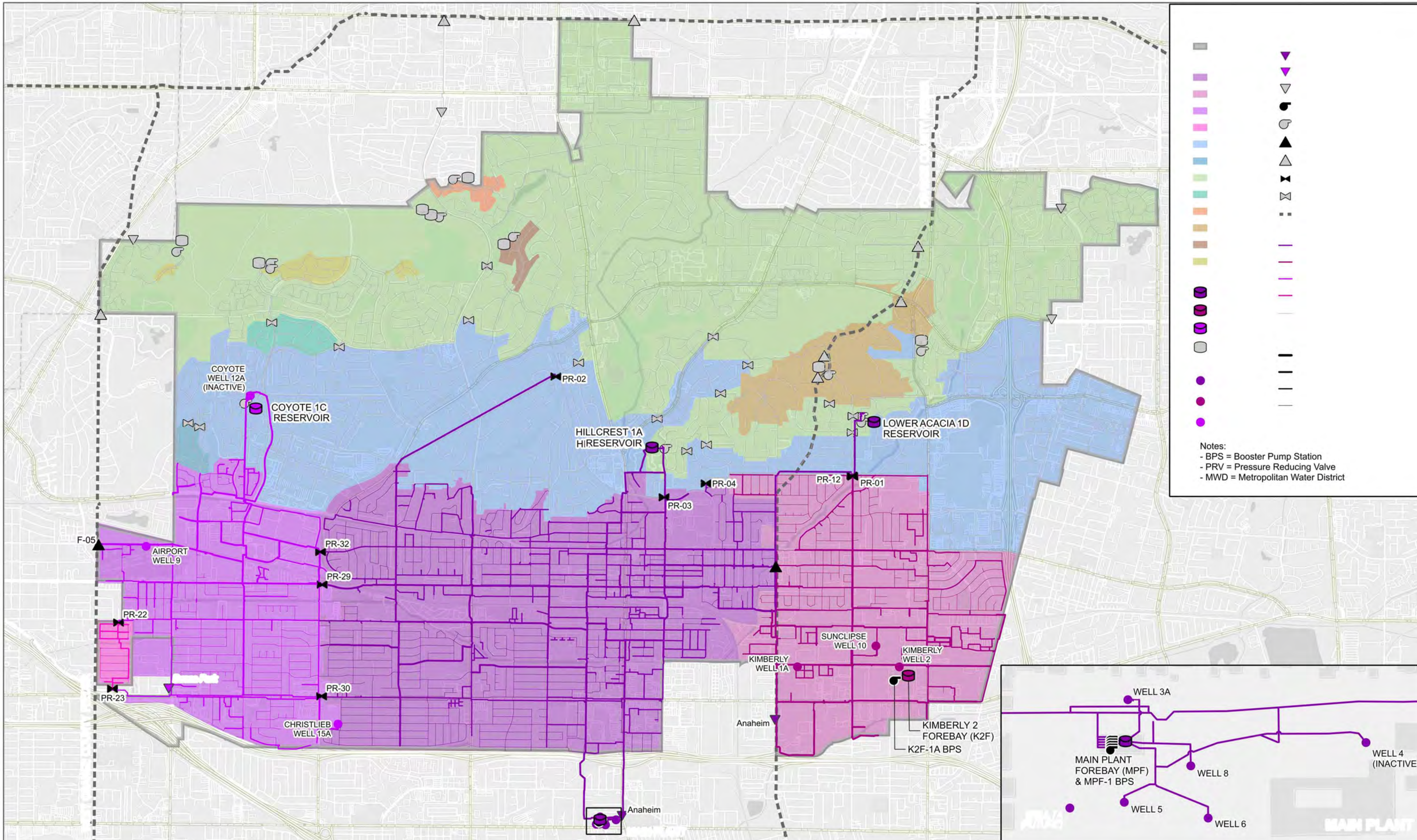

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Figure 2-4. Existing Water Distribution System - Pressure Zone 1

Pressure Zone 2: Zone 2 is located throughout the central part of the City, north of Zones 1, 1A, and 1B, extending between the easterly and westerly City boundaries. See Table 2-4 for a summary of Zone 2 and Figure 2-5 for a map of the distribution system. Generally, groundwater is supplied via the Coyote and Lower Acacia Pump Stations and imported water are supplied to Zone 2 from Zone 3 through various PRVs. Additional PRVs are provided for only during a fire flow event, PR9, PR10, and PR17 from Zone 3. Groundwater is delivered to Zone 2 via Lower Acacia Pump Station. Blended water is delivered via Coyote Pump Station. Storage is provided for the zone from four reservoir sites: Laguna, Hermitage, State College, and the Tank Farm.

The Tank Farm consists of a total of five tanks. However, only four of the tanks are active (T1-T4) and the fifth tank, T5, is out of service. Also, the Tank Farm elevations are higher than the other Zone 2 reservoirs but below the Zone 3 system HGL. Therefore, the Tank Farm does not “float” with the Zone 2 HGL. Supply to Zone 2 is pressure reduced from the Tank Farm through PR5A. Supply into the Tank Farm is provided only through a regulating valve from Zone 3, and primarily from MWD connection F-08.

Pressure Zone 2A: Zone 2A is a small service area, serving approximately 170 homes along the western end of Zone 2. See Table 2-4 for a summary of Zone 2A and Figure 2-5 for a map of the distribution system. Mix of groundwater and imported water is supplied from Zone 2 via two PRVs.

Table 2-4. Pressure Zone 2 Summary

PZ HGL (feet)	Static Service Pressure (psi)	Source Water	Supply Facility/BPS (# of pumps)	Storage Tank or Forebay	PRV	PRV Flow from
2 420	50 – 89	Groundwater: Coyote Well 12A[a] Blended water from other zones	Coyote (3) Lower Acacia (3)	Laguna 2A Hermitage 2B State College 2C Tank Farm 2D Tank 1 Tank Farm 2D Tank 2 Tank Farm 2D Tank 3 Tank Farm 2D Tank 4 Tank Farm 2D Tank 5[b]	PR5A, PR5B (isolation valve closed)	Tank Farm
					PR9 (fire flow), PR10 (fire flow), PR17 (fire flow), PR7, PR8, PR9, PR10, PR11, PR13, PR14, PR15, PR16A, PR16B, PR17, PR21	Zone 3
2A 323	39 – 56	Blended water from Zone 2	*None*	*None*	PR24 (lead), PR25 (lag)	Zone 2

Notes:
[a] Coyote Well 12A is inactive, to be destroyed.
[b] Tank Farm 2D Tank No. 5 is out of service.

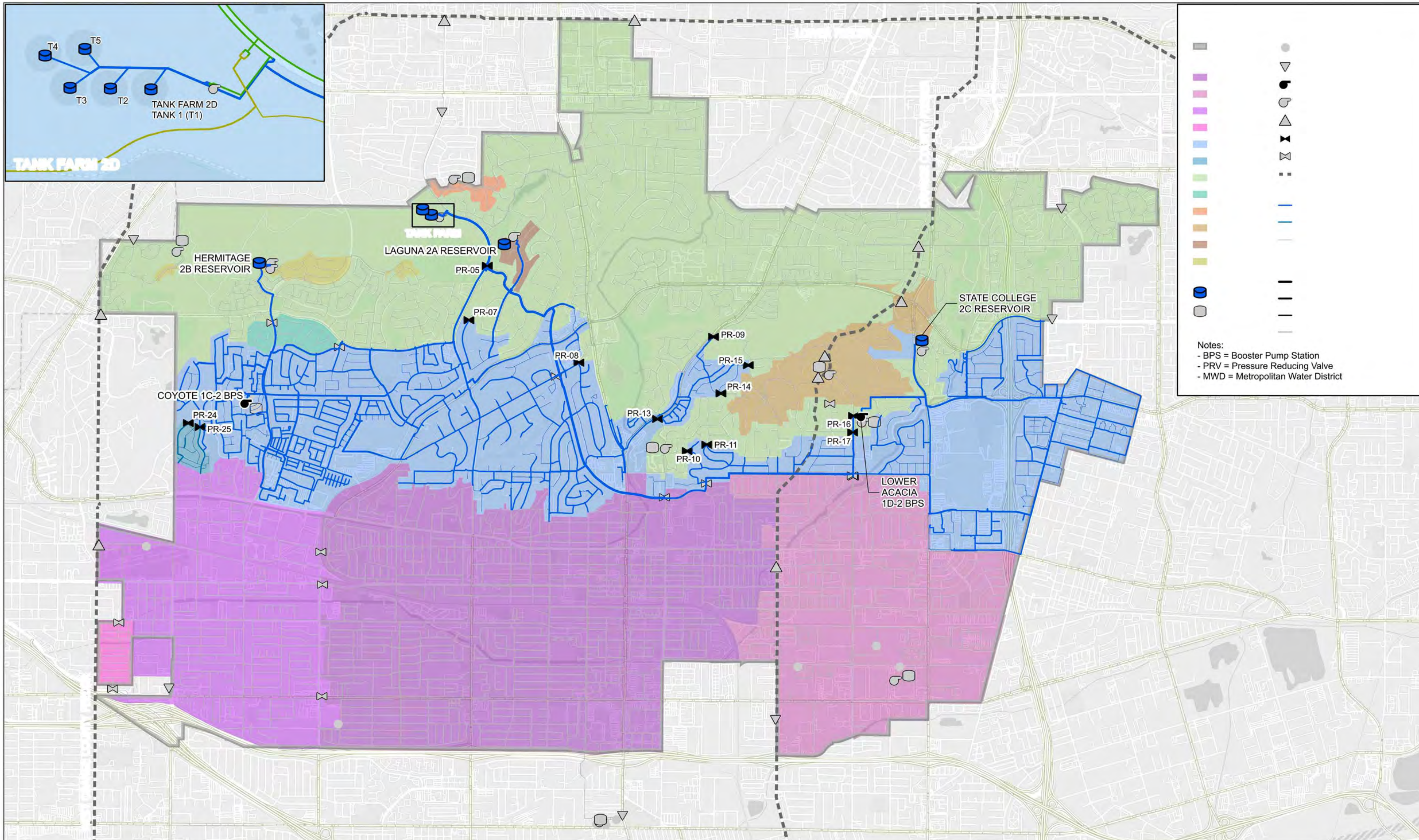

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Figure 2-5. Existing Water Distribution System - Pressure Zone 2

Pressure Zone 3: Pressure Zone 3 is located in the northern part of the City boundary, extending between the easterly and westerly City boundaries, similar to Zone 2. See Table 2-5 for a summary of Zone 3 and Figure 2-6 for a map of the distribution system. Zone 3 receives imported water via several MWD connections. Imported water can be delivered through connections F-03, F-04, F-06, F-08, and F-09. However, connection F-03 is not in operation. Connection F-08 is the largest primary supply and typically flows throughout the year. Connection F-06 is set to open based on pressure and operates on a seasonal basis during summer peak demands beginning in April and intermittently flows through October. In addition, water is supplied to Zone 3 from Zone 1 and Zone 2 via pump stations. To supplement pressure as needed, water can also flow back from Zone 4A through PR26. Storage capacity for Zone 3 is contained in Upper Acacia 3A, Las Palmas 3B, and Hawks Pointe 3C Reservoirs.

It should be noted that due to the Hawks Pointe Reservoir's inability to cycle properly, thus creating water quality issues within the reservoir, operations staff have closed a butterfly valve on the 16-inch transmission main along Rosecrans Avenue west of Sunny Ridge Drive. With this valve closed, the Zone 3 service area west of this location is isolated from the rest of Zone 3 and is supplied only by the F-09 imported water connection and Hawks Pointe Reservoir.

Pressure Zone 3A: Zone 3A serves about 175 homes in the south-western end of Zone 3, south of Rosecrans Ave. See Table 2-5 for a summary of Zone 3A and Figure 2-6 for a map of the distribution system. Imported water supply is delivered from Zone 3 through two PRVs.

Table 2-5. Pressure Zone 3 Summary

PZ HGL (feet)	Static Service Pressure (psi)	Source Water	Supply Facility/BPS (# of pumps)	Storage Tank or Forebay	PRV	PRV Flow from
3 150	48-143	Imported water: MWD F-03[a], F-04, F06, F08, F09	Hermitage (2) Hillcrest (2) Lower Acacia (3) State College (2) Tank Farm (2)	Upper Acacia 3A Tank 1 Upper Acacia 3A Tank 2 Las Palmas 3B Hawks Pointe 3C	PR26	Zone 4A
3A 484	39-65	Imported water from Zone 3	*None*	*None*	PR19 (lag), PR20 (lead)	Zone 3

Note:
[a] MWD Connection F-03 is not in operation.

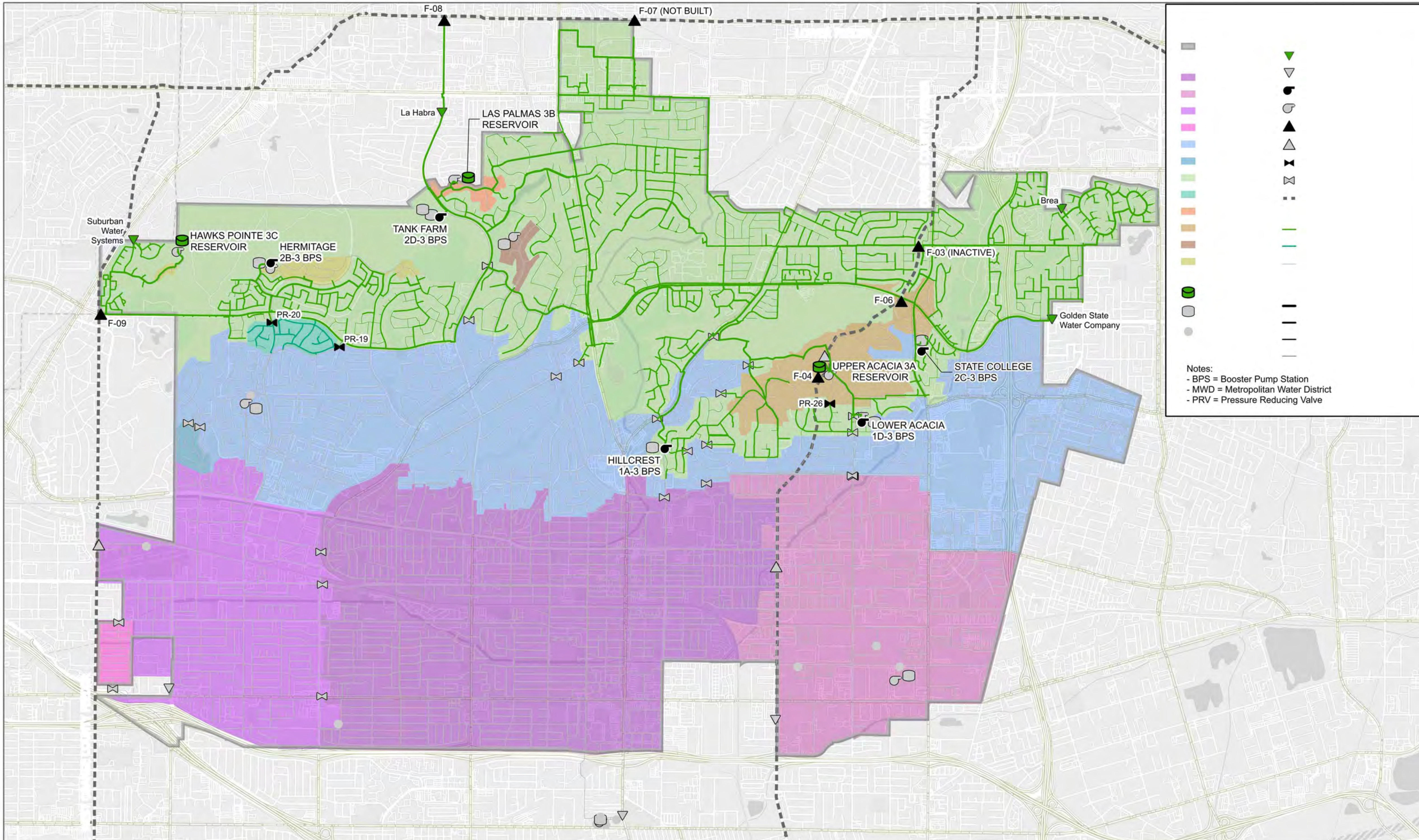

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Figure 2-6. Existing Water Distribution System - Pressure Zone 3

Pressure Zone 4: Zone 4 is located along the northwestern portion of Zone 3, near Euclid Avenue. See Table 2-6 for a summary of Zone 4 and Figure 2-7 for a map of the distribution system. Water supply is provided to this zone from Zone 3 by the Las Palmas Booster Pump Station, which also includes a 5,000-gallon hydropneumatic tank to control system pressure. There are no storage reservoirs in this zone.

Pressure Zone 4A: Zone 4A serves the high elevations known as the East Coyote Hills service area and is surrounded by Zone 3. See Table 2-6 for a summary of Zone 4A and Figure 2-7 for a map of the distribution system. The Upper Acacia Pump Station provides water supply to Zone 4A while MWD connections F-02 and F-06 provide additional fire flow protection. A pressure relief valve at the pump station is used to control pressures in the system. There are no storage reservoirs in this zone.

Pressure Zone 4B: Zone 4B is an isolated zone, serving approximately 50 homes near the Laguna Reservoir. See Table 2-6 for a summary of Zone 4B and Figure 2-7 for a map of the distribution system. Water is supplied to this zone from Zone 2 via the Laguna Pump Station. The Laguna Pump Station also includes a 4,000-gallon hydropneumatic tank to maintain system pressures in the zone. There are no storage reservoirs in this zone.

Pressure Zone 4C: Zone 4C consists of two separate service areas. See Table 2-6 for a summary of Zone 4C and Figure 2-7 for a map of the distribution system. The easterly service area located in West Coyote Hills receives supply from Zone 2, via Hermitage Pump Station, which also includes a 5,000-gallon hydropneumatic tank. The hydropneumatic tank is currently out of service and water is allowed to flow through the pressure relief valve back to Zone 2 to control system pressure. The westerly service area receives supply from Zone 3 via Hawks Pointe Pump Station. Note that the westerly and easterly service areas are proposed to be connected in the future when the West Coyote Hills Development is completed. Currently, there are no storage reservoirs in this zone.

Note that since Zones 4, 4A, 4B, and 4C do not have storage, they include pressure relief valves, protecting the respective zones from being over pressurized. In addition, the zones include check valves to allow lower pressure water from Zone 3 to provide support in case of pump station outages. Zone 4A also contains pipe risers throughout the zone to hook up a temporary pump during outages.

Table 2-6. Pressure Zone 4 Summary

PZ HGL (ft)	Static Service Pressure (psi)	Source Water	Supply Facility/BPS (# of pumps)	Storage Tank or Forebay	PRV	PRV Flow from
4 660	74-113	Imported water from Zone 3	Las Palmas (2)	*None*	*None*	*None*
4A 605	50-89	Imported water from Zone 3 and MWD F-02, F06	Upper Acacia (4)	*None*	*None*	*None*
4B 605	40-89	Blended water from Zone 2	Laguna (2)	*None*	*None*	*None*
4C 605	50-89	Blended water from Zone 2 and Imported water from Zone 3	Hermitage (2) Hawks Pointe (2)	*None*	*None*	*None*

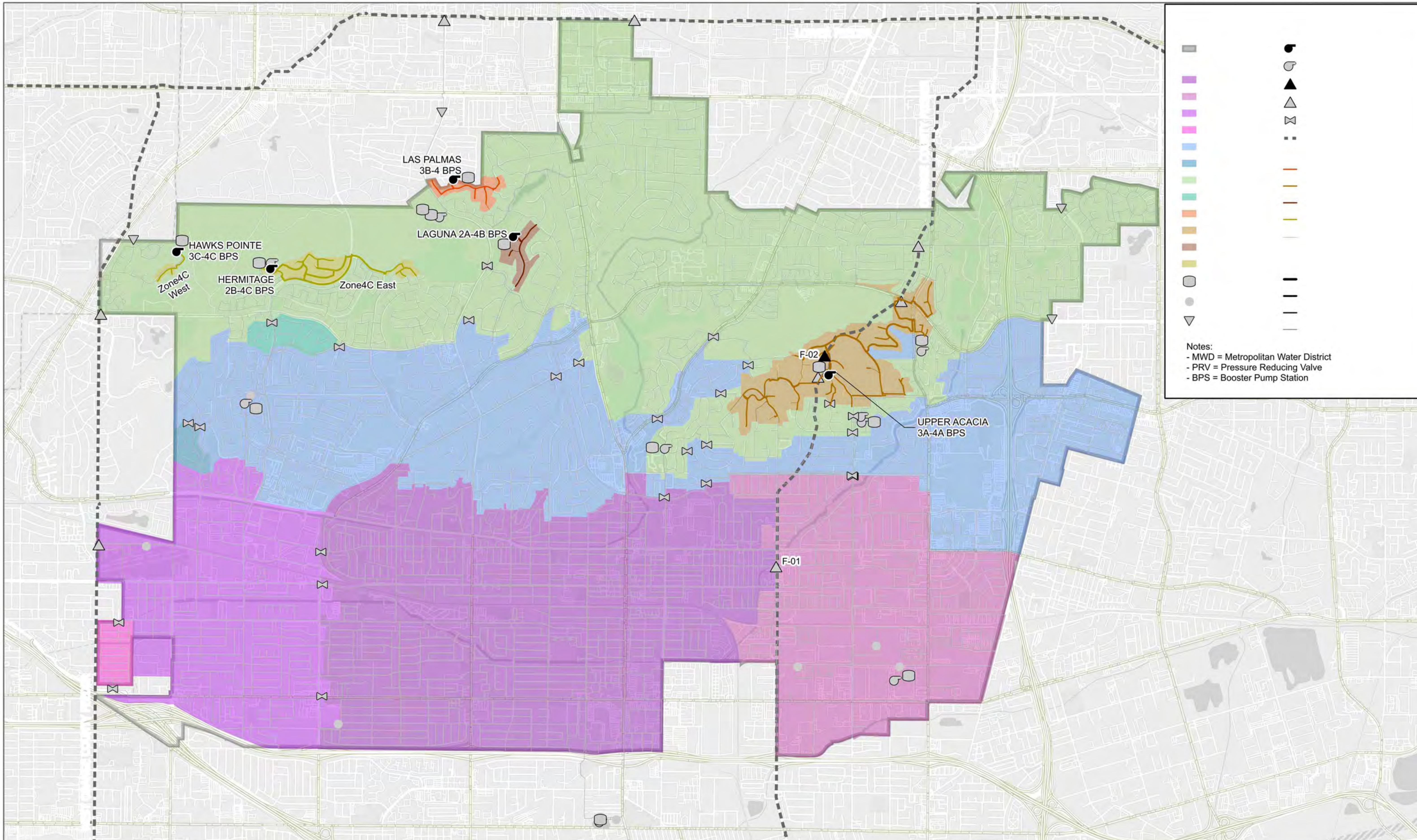

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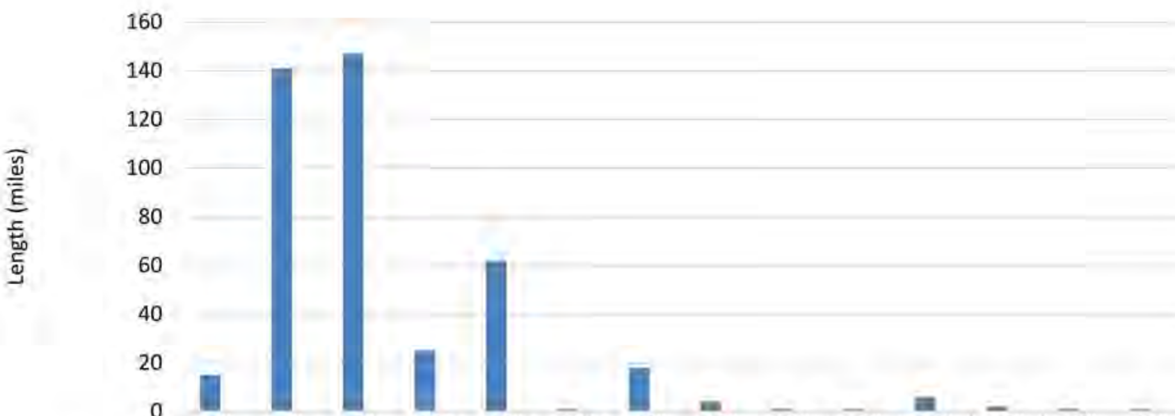
Figure 2-7. Existing Water Distribution System - Pressure Zone 4

2.2 Pipelines

The City operates and maintains an extensive water conveyance system, including approximately 423.6 miles of water pipelines, with pipelines ranging from less than 4 to 42 inches in diameter. In addition, MWD owns and maintains about 5 miles of water pipelines within City boundaries with pipes as large as 55 inches. A graph of the City's pipe size distribution and length is shown on Figure 2-8. Approximately 68 percent of system pipelines are 6 to 8 inches in diameter, followed by 12-inch-diameter pipeline which makes up approximately 15 percent.



	4"	6"	8"	10"	12"	14"	16"	18"	20"	21"	24"	30"	36"	42"
Length (miles)	15	141	147	25	62	1	18	4	1	1	6	2	1	1
Breakdown	3.5%	33.2%	34.6%	5.9%	14.6%	0.2%	4.2%	0.9%	0.2%	0.2%	1.4%	0.5%	0.2%	0.2%

Note: Lengths are rounded to nearest mile. Actual total length sums to 423.6 miles.

Figure 2-8. Existing Water Distribution System Pipe Diameters and Length

Pipeline age is summarized by decade in Table 2-7, to show the pipeline age in percentage. Approximately 2 percent of the City's pipes were installed prior to the 1950s, the oldest pipes being constructed as early as 1912. About half of the City's pipes (51 percent) were installed within the last 50 years since 1973. Approximately 48 percent of pipes were constructed between the 1950s and 1970s.

Table 2-7. Pipeline Age

Timeline	Unknown	Prior to 1950	1950s	1960s	1970s	1980s	1990s	2000s	2010-2024
Age (Years)	-	>73	73	63	53	43	33	23	<14
Breakdown	9%	2%	18%	16%	14%	8%	9%	13%	11%

Pipeline material is summarized in Table 2-8. The majority of system pipe material is cast iron, totaling 58 percent. The second most common material is ductile iron pipe, making up 29 percent of the system.

Table 2-8. Water System Pipe Material

Pipeline		Cast Iron[a]	Ductile Iron	Polyvinyl Chloride	Steel Cylinder Concrete Pipe	Steel	Reinforced Concrete Cylinder Pipe	Cast Iron Lined[b]	High Density Polyethylene
Diameter (inches)	Total Length (miles)[c]	Length per Material (miles)							
4	15	12	3	<1	<1	<1	-	-	-
6	141	127	13	1	<1	<1	-	<1	-
8	147	57	67	22	<1	<1	<1	<1	<1
10	25	18	7	<1	<1	<1	-	-	-
12	62	32	24	5	<1	<1	<1	-	-
14	1	1	<1	<1	<1	<1	-	-	-
16	18	2	9	1	5	1	<1	-	-
18	4	<1	<1	-	3	<1	-	-	-
20	1	-	-	<1	1	<1	-	-	-
21	1	<1	-	-	1	-	-	-	-
24	6	<1	-	-	6	<1	<1	-	-
30	2	<1	-	-	2	-	-	-	-
36	1	<1	-	-	1	-	-	-	-
42	1	-	-	-	1	-	-	-	-
Total	424	248	123	29	20	2	<1	<1	<1
Breakdown		58%	29%	7%	5%	<1%	<1%	<1%	<1%

Notes:
[a] For cast iron pipe material, it is unknown if the pipe is lined.
[b] Cast iron lined pipe indicates a CI pipe that was later lined.
[c] Individual diameter lengths are rounded to nearest mile. Actual total length sums to 423.6 miles.

2.3 MWD Connections

MWD delivers imported water from the Colorado River Aqueduct and State Water Project to the Fullerton service area through their Orange County, West Orange County, and Lower Feeder transmission pipelines. Fullerton has nine metered turnouts, of which seven are active and transfer water from the MWD pipelines into the City's distribution system. See Table 2-9 for a summary of MWD's connections. F-01, F-02, F-03, F-04, and F-06 are located on the Orange County Feeder, F-05 and F-09 are located on the West Orange County Feeder, and F-07 and F-08 are on the Lower Feeder. The upper portions of the Orange County Feeder and the Orange County Reservoir provide peaking capacity for Fullerton as well as for the cities of Brea and La Habra. Based on agreements with MWD, Fullerton can operate the MWD turnouts solely on system pressure, provided that during operation, Fullerton must take at least 10 percent of the turnout's rated capacity.

Table 2-9. MWD Connections

ID	Location	Feeder	Install Year (Rehab Year)	Capacity (cfs)	PZ	Valve Size	Valve CL Elev. (feet)	Pressure Setting (psi)	Note
F-01	Raymond Ave & Wilshire Ave	Orange County	1940 (2020)	4	-	-	160.60[b]	-	
F-02	Upper Acacia (Acacia Ave)	Orange County	1941 (1960)	5	4A	8”	461.74[a]	52	
F-03	Rolling Hills Dr & Live Oak Ave	Orange County	1941 (1956)	7.5	-	-	317.50[b]	-	Not Operational
F-04	Upper Acacia (Vista Del Mar Dr)	Orange County	1956 (None)	15	3	12”	455.90[b]	24	
					3	12”		24	
F-05	Artesia Ave (near Buena Park)	West Orange County	1956 (2020)	15	1B	12”	72.28[b]	105	
					1B	12”		100	
F-06	Bastanchury Rd (near Vista Park)	Orange County	1958 (1987)	15	3	8”	440.52[a]	25	
					3	10”		34	
					4A	8”		64	Fire flow; No SCADA
F-07	Lambert Rd (near Palm)	Lower	-	15	-	-	-	-	Not Built[c]
F-08[d]	Euclid Ave (in La Habra)	Lower	1961	30	3	12”	279.77[a]	86	
					3	12”		88	
					3	16”		-	Turbine
					3	20”		-	Turbine
F-09	Rosecrans Ave (near Buena Park)	West Orange County	1966	15	3	10”	153.86[a]	150	
					3	10”		150	

Notes:
[a] Valve CL elevations are based on surveyed data gathered as part of this Master Plan.
[b] Elevations are based on As-Built plans.
[c] City has approved MWD plans for F-07 that date to 1958. The F-07 piping is not constructed on the City's side, however the MWD turnout is built on the MWD side. The City has the option to construct F-07 should the need arise.
[d] A hydroelectric plant was constructed off F-08 that has not been in operation since 2015.
cfs = cubic feet per second
CL = centerline
SCADA = Supervisory Control And Data Acquisition

2.4 Groundwater Wells

The City owns eight active wells and three inactive wells. All the wells are located in the lower pressure zones of the distribution system. They pump from the Orange County Groundwater Basin. Table 2-10 provides a list of the City's wells.

Wells 3A, 4, 5, 6, and 8 and future Well 7A are located at the City's Main Plant, on land owned by the City of Fullerton, but within the City of Anaheim, just south of Fullerton's city boundary. Wells 5, 6, and 8 are currently active and Well 4 is inactive. Well 4 was taken out of service in 2018 due to a significant decrease in production from a crack in the pump column. In 2021, the City removed Well 4 from the City's permit, indicating that the well exceeded its operational life span and would likely need to be abandoned and re-drilled in the future.

Well 7 was also located at Main Plant but was destroyed in March 2021. The City is in the process of replacing Well 7 at the Main Plant with a new Well 7A. The City completed drilling this well in 2021 and in 2022 completed an equipping basis of design report. Equipping of Well 7A is expected to be completed in 2025. Well 3A was taken offline in 2020 due to elevated levels of per- and polyfluoroalkyl substances (PFAS). PFAS (per- and polyfluoroalkyl substances) are a group of man-made chemicals that include perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and is further expanded upon in Section 4.0. Well 3A is scheduled to be brought back online in 2024 with the completion of the first phase of the Main Plant PFAS Treatment Project. The first phase was designed to accommodate future treatment plant expansion to treat well discharge from Wells 5, 6, 7A, and 8.

In 2020, Kimberly Well 1A was temporarily offline due to the installation of single-use ion exchange (IX) treatment equipment at the well site, for removal of PFAS in the well feed water. Well 1A was back online in 2021 and will be rehabilitated and upgraded in 2025.

The City also previously used Fire Station Well 13 and Pioneer Well 14 among others, all of which have been abandoned. Coyote Well 12A has issues with water quality and low production and needs to be destroyed and removed along with its associated water treatment facilities. The City purchased the land where Pioneer Well 14 was located with water funds and has no future plans envisioned for the site.

Table 2-10. Groundwater Wells

Well	Name	PZ	Drill Year (Rehab Year)	Depth (feet)	Existing Capacity[a] (gpm)	Existing TDH (feet)[f]	Elevation (feet)	Casing Diameter (inches)
1A	Kimberly	1A	2002	1,243	2,800	401	165.88[h]	12
2	Kimberly 2	1A	1955 (2003)	652	1,875	160	181.94[h]	18
3A[b]	Main Plant	1	1995 (2023)	1,300	2,400	405	144.70[i]	16
4[c]	Main Plant	1	1927	415	1,500	-	145.50[i]	18
5	Main Plant	1	1959 (2018)	440	1,500	170	142.20[i]	18
6	Main Plant	1	1959[g]	430	1,500	170	141.90[i]	18
7A[d]	Main Plant	1	2021	1,400	3,000[d]	-	140.20[d]	-
8	Main Plant	1	1974 (2003)	458	2,000	170	141.90[i]	18
9	Airport	1B	1985 (2021)	1,080	2,500	360	85.15[h]	16
10	Sunclipse	1A	1990 (2000)	1,310	2,000	400	180.74[h]	16
12A[e]	Coyote	1B	1992 (2001)	940	-	-	272.10[i]	16
15A	Christlieb	1B	1992	1,350	2,000	355	107.60[h]	16

Notes:
[a] Data extracted from City's Water Facilities Worksheet. For Well 1A the TDH and Capacity are updated based on the consideration of the added treatment plant.
[b] Well 3A is inactive and scheduled to be brought back online in 2024 with the completion of the first phase of the Main Plant PFAS Treatment Project.
[c] Well 4 is inactive, to be destroyed.
[d] Well 7A is scheduled for construction in 2025. Capacity of 3,000 gpm is based on a pump test conducted in 2022. TDH and casing diameter have not yet been determined. Elevation of Well 7A is approximate based on the City's Topographic & Boundary Survey of the Main Plant conducted in 2003. (W.D. 2189)
[e] Coyote Well 12A is inactive, to be abandoned.
[f] Ongoing PFAS projects may change TDH.
[g] Well 6 rehabilitation project estimated to be completed in September 2024.
[h] Valve centerline elevations are based on surveyed data gathered as part of this Master Plan.
[i] Ground elevations are based on As-Built plans.

2.5 Booster Pump Stations

The City operates 14 BPS, which are each located adjacent to a storage reservoir. Pumps which are a part of groundwater wells are not included. Main Plant and Kimberly 2 pump stations pump from a forebay facility directly into the distribution system. See Table 2-11 for a summary of BPS attributes.

Table 2-11. Pump Station Summary

ID	Name	Install Year (Rehab Year)	Suction PZ	Disch. PZ	Firm Capacity[b] (gpm)	Pump	Design Flow (gpm)	Design Head (feet)	Type
MPF-1	Main Plant	[a]	-	1	4,500	4	1,500	231	Turbine
						5	1,500	231	Turbine
						6	1,500	231	Turbine
						7	[a]	[a]	Turbine
						8	1,600	204	Turbine
K2F-1A	Kimberly 2	1955	-	1A	2,000	1	1,000	[a]	Turbine
						2	1,000	[a]	Turbine
						3	1,000	200	Centrifugal
1A-3	Hillcrest	1988 (2007)	1	3	1,000	1	1,000	224	Turbine
						2	1,000	224	Turbine
1C-2	Coyote	1958 (1997)	1B	2	1800	1	900	176	Turbine
						2	900	176	Turbine
						3	900	176	Turbine
1D-2	Lower Acacia	1960 (2000)	1	2	1700	1	850	106	Turbine
						2	850	106	Turbine
						3	850	106	Turbine
1D-3				3	2,300	1	1,150	202	Turbine
						2	1,150	202	Turbine
						3	1,150	202	Turbine
2A-4B	Laguna[c]	1959 (2020)	2	4B	300	1	300	158	Turbine
						2	1500	158	Turbine
2B-3	Hermitage[c]	1978	2	3	500	1	500	94	Turbine
						2	1,000	107	Turbine
2B/3-4C		1981		4C	600	1	300	210	Turbine
						2	300	210	Turbine
						3	2,500	61	Turbine
2C-3	State College	1962 (2001)	2	3	720	1	720	120	Centrifugal
						2	1,200	120	Centrifugal
2D-3	Tank Farm	1966	2	3	[a]	1	[a]	[a]	Turbine
						2	[a]	[a]	Turbine
3A-4A	Upper Acacia	1994	3	4A	2,050	1	350	147	Turbine
						2	700	147	Turbine
						3	1,000	147	Turbine
						4	1,000	147	Turbine
3B-4	Las Palmas[c]	1962 (2022)	3	4	600	1	600	120	Centrifugal
						2	600	120	Centrifugal
3C-4C	Hawks Pointe	2004	3	4C	150	1	150	80	Turbine
						2	150	80	Turbine

Notes:
[a] Information not available.
[b] Firm capacity is defined to be the capacity of the pump station with the largest pump out of service.
[c] Equipped with hydropneumatic tank. See Section 2.7 for description of the hydropneumatic tanks.

2.6 Storage Reservoirs

Water distribution systems rely on stored water to regulate diurnal variations between supply and demand to provide sufficient water for daily use, and for emergency situations such as fires or unplanned outages of major supply sources. See Table 2-12 for a summary of storage reservoir attributes. The City operates 15 reservoirs with a total storage capacity of 67.5 MG and two forebays. The largest storage facility is the Tank Farm, consisting of five ground level tanks (four active tanks and one 6.5 MG tank that is out of service, requiring rehabilitation. However, with all five tanks in operation the City experienced water quality issues. The four tanks in operation at the Tank Farm provide a total active storage of 26 MG, which is approximately 43% of the City's 61 MG of available storage. The Tank Farm has space available for five additional 6.5 MG tanks. The terms "tank" and "reservoir" are used interchangeably in this report and is commonly understood in the industry.

Table 2-12. Reservoir Summary

<table>
<tr><th>ID</th><th>Name</th><th>PZ</th><th>Install Year (Rehab Year)</th><th>Material</th><th>Dia. (feet)</th><th>Height (feet)</th><th>Bottom Elev/ Max Level (feet)[a]</th><th>Capacity (MG)</th></tr>
<tr><td>1A</td><td>Hillcrest</td><td>1</td><td>2005</td><td>Concrete</td><td>230.00</td><td>18.3</td><td>314.63/ 330.93</td><td>5</td></tr>
<tr><td>1C</td><td>Coyote</td><td>1B</td><td>1952</td><td>Concrete</td><td>124.67</td><td>23.5</td><td>265.28/ 287.78</td><td>2</td></tr>
<tr><td>1D</td><td>Lower Acacia</td><td>1</td><td>1960 (2019)</td><td>Concrete</td><td>[b]</td><td>16</td><td>311.04/ 327.04</td><td>4</td></tr>
<tr><td>2A</td><td>Laguna</td><td>2</td><td>1958</td><td>Concrete</td><td>122.00</td><td>24</td><td>398.34/ 421.13</td><td>2</td></tr>
<tr><td>2B</td><td>Hermitage</td><td>2</td><td>1963 1978[c] (2008)</td><td>Steel</td><td>105.00</td><td>32</td><td>393.27/ 423.27</td><td>2</td></tr>
<tr><td>2C</td><td>State College</td><td>2</td><td>1963[d]</td><td>Steel</td><td>105.00</td><td>32</td><td>386.38/ 414.88</td><td>2</td></tr>
<tr><td rowspan="5">2D</td><td>Tank Farm Tank 1</td><td rowspan="5">2</td><td rowspan="5">1966 (1998 - Tank 2) (2008 - Tank 3) (2008 - Tank 4) (2015 - Tank 1)</td><td rowspan="5">Steel</td><td rowspan="5">170.00</td><td rowspan="5">40</td><td>422.39/ 458.64</td><td>6.5</td></tr>
<tr><td>Tank Farm Tank 2</td><td>422.34/ 458.59</td><td>6.5</td></tr>
<tr><td>Tank Farm Tank 3</td><td>422.40/ 460.68</td><td>6.5</td></tr>
<tr><td>Tank Farm Tank 4</td><td>422.41/ 460.69</td><td>6.5</td></tr>
<tr><td>Tank Farm Tank 5 (inactive)[e]</td><td>422.06/ 460.34</td><td>6.5[e]</td></tr>
<tr><td rowspan="2">3A</td><td>Upper Acacia Tank 1</td><td rowspan="2">3</td><td>1963 (1999)</td><td rowspan="2">Steel</td><td rowspan="2">168.50</td><td rowspan="2">32</td><td>480.59/ 510.59</td><td>5</td></tr>
<tr><td>Upper Acacia Tank 2</td><td>1966 (2000)</td><td>480.49/ 510.49</td><td>5</td></tr>
<tr><td>3B</td><td>Las Palmas</td><td>3</td><td>1962 (2009)</td><td>Steel</td><td>170.00</td><td>32</td><td>479.81/ 507.81</td><td>5</td></tr>
<tr><td>3C</td><td>Hawks Pointe</td><td>3</td><td>2004</td><td>Steel</td><td>127.50</td><td>32</td><td>474.66/ 506.66</td><td>3</td></tr>
</table>

Notes:
[a] Elevations are based on surveyed data gathered as part of this Master Plan for all reservoirs with the exception of Tank Farm 2D Tank 5, which is based on As-Built plans.
[b] Lower Acacia Reservoir is a trapezoidal rectangular shape, approximately 223.33 feet by 190.83 feet.
[c] Hermitage Reservoir was originally constructed in 1963 and relocated to its current site in 1978.
[d] State College Reservoir has had rehabilitation work, but date is unknown due to unavailable records.
[e] Tank 5 is out of service; capacity is not included in the total storage. Tank will need rehabilitation before it is placed back in service.

2.7 Hydropneumatic Tanks

Hydropneumatic tanks are designed to maintain on-demand pressurized water without the continuous use of a pump, providing a small amount of operational storage in small water systems. By regulating system pressures, hydropneumatic tanks provide efficient water supply to quickly meet fluctuations in system demand and avoid too frequent startup and shutdown of the pumps. The City has three hydropneumatic tanks at the discharge of three pump stations as shown in Table 2-13.

Table 2-13. Hydropneumatic Tanks

Pump Station	Tank Volume (gallons)	Type	Zone
Las Palmas	5,000	Compressed Air/Water	4
Laguna	4,000	Compressed Air/Water	4B
Hermitage[a]	5,000	Compressed Air/Water	4C

Note:
[a] The Hermitage hydropneumatic tank has not been used in a long time. After Zone 4C was extended to include a new tract, BPS 2B/3-4C continuously provides pressure to Zone 4C and any flow that is not used recirculates through one or both 4-in relief valves to the pump inlet header.

2.8 Fire Hydrants

There are 4,303 active fire hydrants within the City, with installation of the oldest hydrants dating back to at least 1922. Table 2-14 summarizes the number of hydrants in each pressure zone (PZ).

Table 2-14. Hydrants per Pressure Zone

Pressure Zone	1	1A	1B	1C	2	2A	3	3A	4	4A	4B	4C
Number of Hydrants	985	463	425	30	1,034	21	1,202	23	12	77	6	25

2.9 Valves

Pressure regulating, control, and check valves help maintain appropriate zone pressures and are further discussed below.

2.9.1 PRESSURE REDUCING VALVES

Pressure regulating stations reduce water pressure to manageable levels to protect from high-pressure impacts. See Table 2-15 for a summary of City's PRVs. Generally, PRVs are used to isolate one PZ from another and are normally closed and will open only when the downstream pressure is lower than the valve setting. Other times, PRVs are used as a primary water source to supply water from a higher-pressure zone to a lower pressure zone. The City has six regulating valves that are used as the primary supply source to three smaller PZs: 1C, 2A, and 3A. Also, several PRVs are used to meet fluctuating demands or supplement local system pressures in lower zones. For example, the PRVs between Zone 2 and Zone 1A are used as an additional supply source for Zone 1A to meet peak demands supplementing the wells supply.

Table 2-15. Pressure Reducing Stations

ID	Location	Pressure Zone		Install Year	Diameter	No. of Valves	Pressure Setting (psi)	Note
		From	To					
PR-1A	Acacia Ave - 20' s/o Dorothy Ln (West)	2	1A	a	12"	7	39	
PR-1B	Acacia Ave - 20' s/o Dorothy Ln (East)	2	1A	a	12"	7	43	
PR-2	Valencia Mesa Dr - 200' e/o Raintree Rd	2	1	1989	10"	3	20	Fire flow
PR-3	Berkeley Ave - 25' w/o Lemon St	2	1	1965	12"	4	Closed	Modified WD1438 1983, Fire flow
PR-4	Hornet Way - 10' s/o Dorothy Ln	2	1	1965	8"	1	55	
PR-5A-1	Euclid St - 10' n/o Laguna Rd (10")	2	2	1965	10"	15	60 - 65	Summer: 65 psi Winter: 60 psi
PR-5A-2	Euclid St - 10' n/o Laguna Rd (North)	2	2	1965	12"	15	55 - Open	Summer: Open Winter: Fire flow[b]
PR-5A-3	Euclid St - 10' n/o Laguna Rd (South)	2	2	1965	12"	15	Closed	
PR-5B-1	Euclid St - 10' n/o Laguna Rd (North)	2	2	1965	12"	15	Open	Removed; Isolation Valves Closed
PR-5B-2	Euclid St - 10' n/o Laguna Rd (South)	2	2	1965	12"	15	Open	Removed; Isolation Valves Closed
PR-7	Verona Dr - 500' w/o Ranch Cir	3	2	1964	6"	1	68	
PR-8	Valencia Mesa Dr - 20' e/o Sunny Crest Dr	3	2	(a)	8"	1	45	
PR-9	Brea Blvd - 950' n/o Panorama Rd	3	2	1958	8"	1	40	Fire flow
PR-10	Virginia Rd - 100' e/o Luanne Ave	3	2	1989	6"	1	42[b]	Fire flow[b]
PR-11	Longview Dr - 20' s/o Virginia Rd	3	2	1958	6"	1	38	
PR-12A	SW Corner of Dorothy Ln & Acacia (West)	1	1A	a	12"	6	Closed	
PR-12B	SW Corner of Dorothy Ln & Acacia (East)	1A	1	a	12"	6	Open	
PR-13	Brea Blvd - 100' w/o Lemon St	3	2	1960	8"	1	88	Pressure Sustaining: 110 psi

ID	Location	Pressure Zone		Install Year	Diameter	No. of Valves	Pressure Setting (psi)	Note
		From	To					
PR-14	Panorama Rd - 10' e/o Palisades Dr	3	2	1962 (replaced 2012)	6"	1	53	
PR-15	Smokewood Ave - 20' w/o Raymond Ave	3	2	1964	8"	1	63	
PR-16A	Acacia Ave - 200' n/o Dana Pl (West)	3	2	1959	10"	6	27	
PR-16B	Acacia Ave - 200' n/o Dana Pl (East)	3	2	1959	10"	6	30	
PR-17	Acacia Ave - 10' s/o Miramar Dr	3	2	1959	8"	1	20	Fire flow
PR-19	Camino Centraloma - 40' n/o Sunset Lane	3	3A	[a]	6"	[a]	85	
PR-20	Gilbert St - 100' n/o El Rancho Vista	3	3A	[a]	8"	[a]	58	
PR-21	Res 2C State College	3	2	1981	6"	-	7	
PR-22	West Ave & Meade Ave	1B	1C	1960	8"	1	68	
PR-23	Manchester Ave - 450' e/o Maxwell Ave	1B	1C	1961	8"	1	76	
PR-24	Wyckersham Pl - 10' e/o Newcastle Ln	2	2A	1974	6"	1	54	
PR-25	Burning Tree Rd - 70' s/o Pioneer Ave	2	2A	1974	8"	1	49	
PR-26	Lindendale Ave in cul-de-sac	4A	3	1960	6"	1	42	
PR-29	Commonwealth Ave e/o Brookhurst Rd	1	1B	1984	10"	3	70[b]	Fire flow[b]
PR-30	Orangethorpe Ave e/o Brookhurst Rd	1	1B	1984	8"	3	70	
PR-31	Well 15A Christlieb	1	1B	1984	12"	[a]	105	
PR-32	West end of Chapman near Railroad	1	1B	[a]	8"	[a]	70	
PR-100	Independence Pool	-	-	[a]	2"	[a]	[a]	
PR-101	Community Center Pool	-	-	[a]	2"	[a]	[a]	

Notes:
[a] Information not available.
[b] Fire flow setting based on assumption of 10 psi less than the downstream operating pressure.
e/o = east of
n/o = north of
s/o = south of
w/o = west of

2.9.2 PRESSURE RELIEF VALVES

In addition to pressure regulating stations, the City's water distribution system also uses pressure relief valves to prevent system over pressurization. Table 2-16 list these valves throughout the existing system. Some of the relief valves have been placed in the system such that the excess pressure in one zone can be released into a lower zone. Other relief valves are located adjacent to drainage facilities or flood control channels, and in the event of excessive pressures, discharge water into these channels or drains.

Table 2-16. Pressure Relief Valves

ID	Location	Pressure Zone		Install Year	Diameter (inches)	No. of Valves	Pressure Setting	Note
		From	To					
RV-1	Res 2B Hermitage	3	2	1963	6	-	65	
RV-2	Hughes Private Rd & 12" Main to Res 1C	2	1B	[a]	8	[a]	72[b]	
RV-3	Euclid Ave n/o RR Tracks n/o Bastanchury	2	-	[a] (replaced 2012)	2	2	115	Located in Meter Box
RV-4	Gilbert Ave n side of Flood Control Channel	1B	-	[a]	4	2	100	Modified WD1656 2004
RV-5	Res 1C Coyote	2	1B	1997	6	-	80	
RV-6A	Res 3A Upper Acacia (4")	4A	3	1994	4	-	57	
RV-6B	Res 3A Upper Acacia (6")	4A	3	1994	6	-	65	
RV-7	30' NW of Wilshire Ave & Raymond Ave (4")	1A	-	[a]	4	2	80	Located with RV-9
RV-8	SW corner of Imperial Hwy & Euclid Ave	3	-	1991	12	-	125	
RV-9	30' NW of Wilshire Ave & Raymond Ave (6")	1	-	[a]	6	2	90	Located with RV-7
RV-10	Magnolia at Flood Control Channel	1B	-	1960	6	2	115	
RV-12	Res 2A Laguna	4B	2	[a]	8	-	55	
RV-13	Dorothy Lane and Acacia Ave - Fowler	1A	1	1984	8	2	40[b]	
RV-14	Res 3C Hawks Pointe	4	3	2004	4	-	40	
RV-15	Res 3B Las Palmas	4	3	[a]	6	-	77	
RV-16A	Res 2B Hermitage (Lower)	4C	3	1988	4	-	100	
RV-16B	Res 2B Hermitage (Higher)	4C	3	1988	4	-	108	
RV-17	Well 1A Kimberly	1A	-	2002	6	-	85	
RV-18	Well 3A Main Plant	1	-	1995	6	-	90	
RV-19	Well 10 Sunclipse	1A	-	1990	6	-	80	

Notes:
[a] Information not available.
[b] Fire flow setting based on assumption of 10 psi less than the downstream pressure.

2.9.3 ZONE CHECK VALVES

A water check valve is used to ensure that water only flows in the desired direction and not backwards. The City has seven check valves that ensure water flows in one direction from one zone to another zone. The City's zones check valves are summarized in Table 2-17. Since the downstream zone for each valve is at a higher hydraulic grade, these valves are normally closed between the zones. These are installed at the highest zones that are reliant on having a working pump station and have no tanks above. They are safeguards in the event of a power outage.

Table 2-17. Zone Check Valves

ID	Location	Pressure Zone		Install Year	Diameter (inches)
		From	To		
CV-1	Applewood Cir e/o Hermitage Dr	3	4C	1993	10
CV-2	Atherton Cir s/o Camino Del Sol	3	4C	1993	8
CV-3	Rideout Way & Las Palmas Dr	3	4	1993	8
CV-4	Terraza Pl n/o Laguna Rd	3	4B	1993	10
CV-5	Excelsa Dr n/o Bastanchury Rd	3	4A	1995	8
CV-6	Trails Dr n/o Gilbert St	3	4C	1987	12
CV-7	Upper Acacia	3	4A	1969	8

2.10 Emergency Generators

The City has 17 water facility production sites and booster pump stations, with power supply details summarized in Table 2-18. Based on 2021 findings of visual inspections and testing, the City has three working emergency generators including Hawks Pointe, Main Plant, and Upper Acacia. Ten of the remaining facilities are provided a manual transfer scheme to allow for a portable generator hookup. Four facilities do not have a transfer scheme provided altogether: Kimberly 2, Airport Well 9, State College BPS, and Tank Farm BPS. Additional and site-specific information can be found in the City's 2022 Water Facilities Generator Study.

Table 2-18. Generator Summary

Name	Power Supply	Generator Type	Max Peak Load (kW)	Switchboard Protection	Transfer Switch Scheme
Main Plant	2000-amp, 480/277-volt service	Permanent	458	2000-amp main circuit breaker	2000-amp ATS connected to existing 500 kW generator (800-amp circuit breaker protection)
Main Plant Well 3A	1200-amp, 480/277-volt service	Portable	188	1200-amp main circuit breaker	Manual: Two (2) 1200-amp main circuit breakers
Kimberly 1A BPS	600-amp, 480/277-volt service	Portable	244	600-amp main circuit breaker	Manual: 600-amp main circuit breaker and 500-amp generator breaker
Kimberly No 2 Well	600-amp, 480/277-volt service	No generator capability	193	600-amp main circuit breaker	*None*
Sunclipse Well 10	600-amp, 480/277-volt service	Portable	206	600-amp main circuit breaker	Manual: 600-amp main circuit breaker and 600-amp generator breaker
Airport Well 9	800-amp, 480/277-volt service	No generator capability	500	800-amp main circuit breaker	*None*
Christlieb Well 15A	600-amp, 480/277-volt service	Portable	215	600-amp main circuit breaker	Manual: 600-amp main circuit breaker and 600-amp generator breaker
Hillcrest BPS	400-amp, 480/277-volt service	Portable	114	400-amp main circuit breaker	Manual: 600-amp manual transfer switch and 700-amp rated camlock connector
Coyote BPS	600-amp, 480/277-volt service	Portable	129	600-amp main circuit breaker	Manual: Two (2) 600-amp rated breakers
Lower Acacia BPS	400-amp, 480/277-volt service	Portable	225	600-amp main circuit breaker	Manual: 600-amp main breaker and 400-amp generator breaker
Laguna BPS	200-amp, 480/277-volt service	Portable	37	200-amp main circuit breaker	200-amp Manual Transfer Switch connected to existing 100-amp rated camlock connector
Hermitage BPS	150-amp, 480/277-volt service	Portable	70	150-amp main circuit breaker	Manual: 200A rated double throw switch with one set of 400A rated camlock connectors
State College BPS	300-amp, 480/277-volt service	No generator capability	2	300-amp main circuit breaker	*None*
Tank Farm BPS	400-amp, 480/277-volt service	No generator capability	89	400-amp main circuit breaker	*None*
Upper Acacia BPS	300-amp, 480/277-volt service	Permanent	86	300-amp main circuit breaker	260-amp ATS connected to 100 kW/125 kVA generator
Las Palmas BPS	200-amp, 480/277-volt service	Portable	60	200-amp main circuit breaker	Manual Transfer Switch
Hawks Pointe BPS	100-amp, 120/240-volt single phase service	Permanent	6	100-amp main circuit breaker	ATS connected to 35 kW/44 kVA generator

Notes:
ATS = Automatic Transfer Switch
kVA = 1,000 volt-amps
kW = kilowatt

2.11 Groundwater Treatment

In partnership with the Orange County Water District, the City of Fullerton constructed the new Kimberly Well 1A PFAS Treatment Plant, which began operation in June 2021. Kimberly 1A is a high producing water well that provides approximately 2,400 gallons per minute (gpm) of supply. The Kimberly Well 1A PFAS Treatment Plant uses an IX treatment equipment, made of highly porous resin that adsorbs and holds contaminants, removing PFAS from the well feed water.

A second PFAS treatment facility was constructed in FY 2023/24 at Main Plant to treat Well 3A discharge. Per the PFAS Treatment Systems Planning Study for the City of Fullerton, completed in April 2020, Granulated Activated Carbon (GAC) treatment will be designed for all existing and future Wells (Wells 3A, 7A, 5, 6, and 8), with the understanding that immediate construction of GAC treatment vessels will be sized for Well 3A only. The proposed treatment plant configuration includes a northern treatment plant to treat water from Well 3A and future Well 7A and a southern treatment plant to treat water from Wells 5, 6, and 8 in the future.

2.12 Supervisory Control and Data Acquisition

In 2012, the City upgraded its Supervisory Control and Data Acquisition (SCADA) system at the City's twenty-one remote sites and connected them in real-time to the City's SCADA control room central computers at the City Maintenance Yard. The system provides the City with accurate historical data by logging and archiving the data from the field into the central computer. The data can be transferred from the computer's hard drive periodically and stored on external electronic media. The City has used Wonderware software, now rebranded under AVEVA, for its SCADA system platform. Table 2-19 briefly describes the communication and operation at each site.

The Main Plant BPS has the capability to remotely monitor the station's flow rate but does not have a flow meter equipped. Other facilities have a flow meter to monitor the station's flow but are not connected to SCADA. These facilities include Coyote BPS, Hawks Pointe BPS, Hillcrest BPS, State College BPS, Tank Farm BPS, Hermitage BPS, Laguna BPS, and Las Palmas BPS.

Facilities without remote SCADA capabilities should be prioritized for CIP funding in the future.

Table 2-19. Supervisory Control and Data Acquisition Sites and Operations

Site Name	Facility	Monitoring Capability	Control	To Repeater
Airport	Well 9	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status	Level Mode – Coyote 1C Pressure Mode – Zone 1B	Hawks Pointe
Christlieb	Well 15A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status	Level Mode – Coyote 1C Pressure Mode – Zone 1B VFD Mode – Set Point	Hawks Pointe
Kimberly 1	Well 1A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status	Level Mode – Lower Acacia 1D Pressure Mode – Zone 1A VFD Mode – Set Point	Upper Acacia
Kimberly 2	Well 2, PS K2F-1A, and Kimberly Forebay	Flowrate Discharge Pressure Forebay Level Pump Run Status Valve Status	Well 2: Level Mode – Kimberly Forebay Level Mode – Lower Acacia 1D	Upper Acacia
			PS K2F-1A: Level Mode – Lower Acacia 1D	
Main Plant[a]	Wells 3A, 4, 5, 6, 7 & 8	Flowrate	Well 3A: Level Mode – Hillcrest 1A Pressure Mode – Zone 1	Upper Acacia
			Wells 4, 5, 6, 7 & 8: Level Mode – Main Plant Forebay	
	PS MPF-1 and Main Plant Forebay	Discharge Pressure Forebay Level Pump Run Status Valve Status	PS MPF-1: Level Mode – Hillcrest 1A Pressure Mode – Zone 1	
Sunclipse	Well 10	Flowrate Discharge Pressure Pump Run Status Valve Status	Level Mode – Lower Acacia 1D Pressure Mode – Zone 1A	Upper Acacia
F-02 & F-04	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status	F-02: Pressure Mode – Zone 4A Flow Mode – Set Point	Upper Acacia
			F-04: Level Mode – Upper Acacia 3A Pressure Mode – Zone 3 Flow Mode – Set Point	Upper Acacia
F-05	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status	Level Mode – Coyote 1C Pressure Mode – Zone 1B Flow Mode – Set Point	Hawks Ponte
F-06	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status	Pressure Mode – Zone 3 Flow Mode – Set Point	State College
F-08	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status	Flow Mode – Set Point	Las Palmas
F-09	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status	Level Mode – Hawks Pointe 3C Pressure Mode – Zone 3 Flow Mode – Set Point	Hawks Pointe

Site Name	Facility	Monitoring Capability	Control	To Repeater
Coyote[b]	PS 1C-2, Reservoir 1C & Well 12A[c]	Discharge Pressure Reservoir Level Pump Run Status Valve Status	Level Mode – Hermitage 2B Pressure Mode – Zone 2 VFD Mode – Set Point	Hawks Pointe
Hawks Pointe[b]	PS 3C-4C, Reservoir 3C	Discharge Pressure Reservoir Level Pump Run Status Valve Status	Pressure Mode – Zone 4C	City Yard
Hermitage[b]	PS 2B-3, PS 2B-4C, Reservoir 2B	Discharge Pressure Reservoir Level Bypass Flowrate Pump Run Status Valve Status	PS 2B-3: Level Mode – Las Palmas 3B Pressure Mode – Zone 3	Hawks Ponte
			PS 2B-4C: Pressure Mode – Zone 4C	Hawks Pointe
Hillcrest[b]	PS 1A-3, Reservoir 1A	Discharge Pressure Reservoir Level Pump Run Status Valve Status	Level Mode – Upper Acacia 3A Pressure Mode – Zone 3	Upper Acacia
Las Palmas[b]	PS 3B-4, Reservoir 3B	Discharge Pressure Reservoir Level Pump Run Status Valve Status	No controls in SCADA	Upper Acacia
Lower Acacia	PS 1D-2, PS 1D-3, Reservoir 1D	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status	PS 1D-2: Level Mode – State College 2C Pressure Mode – Zone 2	Upper Acacia
			PS 1D-3: Level Mode – Upper Acacia 3A Pressure Mode – Zone 3	Upper Acacia
Laguna[b]	PS 2A-4B, Reservoir 2A	Discharge Pressure Reservoir Level Pump Run Status Valve Status	Pressure Mode – Zone 4B	Las Palmas
State College[b]	PS 2C-3, Reservoir 2C	Discharge Pressure Reservoir Level Pump Run Status Valve Status	Level Mode – Upper Acacia 3A Pressure Mode – Zone 3	Upper Acacia
Tank Farm[b]	PS 2D-3, Tank Farm T1-T5	Discharge Pressure Reservoir Level Pump Run Status Valve Status Valve Percent Open	Level Mode – Las Palmas 3B Pressure Mode – Zone 3	Las Palmas
Upper Acacia	PS 3A-4A, Reservoir 3A Repeater Station	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status	Pressure Mode – Zone 4A	City Yard

Notes:
[a] Main Plant BPS does not have a flow meter but is capable of being monitored and connected to SCADA.
[b] Coyote BPS, Hawks Pointe BPS, Hermitage BPS, Hillcrest BPS, Las Palmas BPS, Laguna BPS, State College BPS, and Tank Farm BPS have a flow meter but are not connected to SCADA.
[c] Well 12A has been abandoned and has no SCADA monitoring capabilities.

2.13 Interagency Connections

The City has six interagency connections (interconnects) with neighboring water systems, with an additional one currently under design, to allow the sharing of supplies during short-term emergencies or during planned shutdowns of a primary supply source. Table 2-20 lists the City's interconnects.

Table 2-20. Interconnects

Interconnect City	Intersection	PZ	Static Pressure (psi)	Fullerton Pressure (psi)	Size (inches)	Capacity (cfs)	Installation Year
Anaheim	Raymond Ave n/o Discovery Ln	1A	68-78	72	10	8	1989
Anaheim	Harbor Blvd n/o La Palma Ave	1	79-89	81	8	11.8	1993
Brea	Placentia Ave n/o Cedarbrook Dr	3	72	70	8	11.8	1992
La Habra	Euclid St s/o Imperial Hwy (one way - to La Habra)	3	120-125	110	6	5	1998
La Mirada (Suburban Water Systems)	Hawk's Pointe Dr - Highlander Dr (two-way meter)	3	96	105-114	8	3.3	2006
Placentia (Golden State Water Company)	Bastanchury Rd e/o Cambridge Ave	3	70-120	69-74	10	8	1996
Buena Park	*Magnolia, n/o Orangethorpe (one way - to Buena Park)*	*1B*	*68-75*	*65-70*	*8*	*TBD*	*2024 (TBD)*

Note:
TBD = to be determined

3.0 Water Supply

The City receives its water supply from two sources: groundwater pumped from the Orange County Groundwater Basin (OC Basin) and treated imported water purchased from MWD. Historical supply was analyzed based on available production facilities data over a ten year period, between 2012 to 2022. This analysis shows that the average annual supply required by the City to meet its water demands was 25,552 AFY. The largest annual supply was in Fiscal Year (FY) 2013/14 at 30,058 AFY.

Since 2018, the City's supply requirements have seen a nearly 9 percent reduction through 2022, which had a supply of 23,619 AFY. This reduction in water supply results from diligent efforts in the promotion of water conservation as well as financial incentives for customers to retrofit their homes and businesses with water efficient devices and appliances. Table 3-1 provides a summary of the annual water production from each of the supply sources. The City's historically largest single water customer also closed their account in 2020, they previously used about 1,500 acre-feet (AF) annually, approximately 5-7% of the City's total production.

Table 3-1. Annual Water Production

Fiscal Year	Groundwater (acre-feet)	Imported Water (acre-feet)	Total Water Supply (acre-feet)	Basin Production Percentage	Groundwater	Imported Water
2012/2013	19,489	9,205	28,694	68%	68%	32%
2013/2014	21,279	8,779	30,058	70%	71%	29%
2014/2015	18,946	8,298	27,244	70%	70%	30%
2015/2016	17,541	5,842	23,384	75%	75%	25%
2016/2017	17,933	6,425	24,359	75%	74%	26%
2017/2018	17,104	8,844[a]	25,948	75%	66%	34%
2018/2019	18,373	5,564	23,937	77%	77%	23%
2019/2020	18,696	5,023	23,719	77%	79%	21%
2020/2021	17,630	6,924	24,554	77%	72%	28%
2021/2022	17,739	5,880	23,619	77%	75%	25%
Annual Average	**18,473**	**6,882**	**25,552**	**74%[b]**	**73%**	**27%**

Notes:
[a] FY 2017/18 was an outlier year due to availability of MWD water at equivalent cost to groundwater/pumping costs. Annual average excludes FY 2017/18 production.
[b] BPP is increased to 85% starting FY 2022/23 in anticipation of the opening of Phase 2 of the Groundwater Replenishment System.

The primary source of supply for the City is groundwater production from the OC Basin. The City's wells have produced on average of 18,473 AFY since FY 2012/13, which is approximately 73 percent of the total supply. The supply through its imported water connections supplements the remaining 27 percent of the City's annual average supply needs. Figure 3-1 illustrates the trend in production of the two supply sources between FY 2012/13 and FY 2021/22.

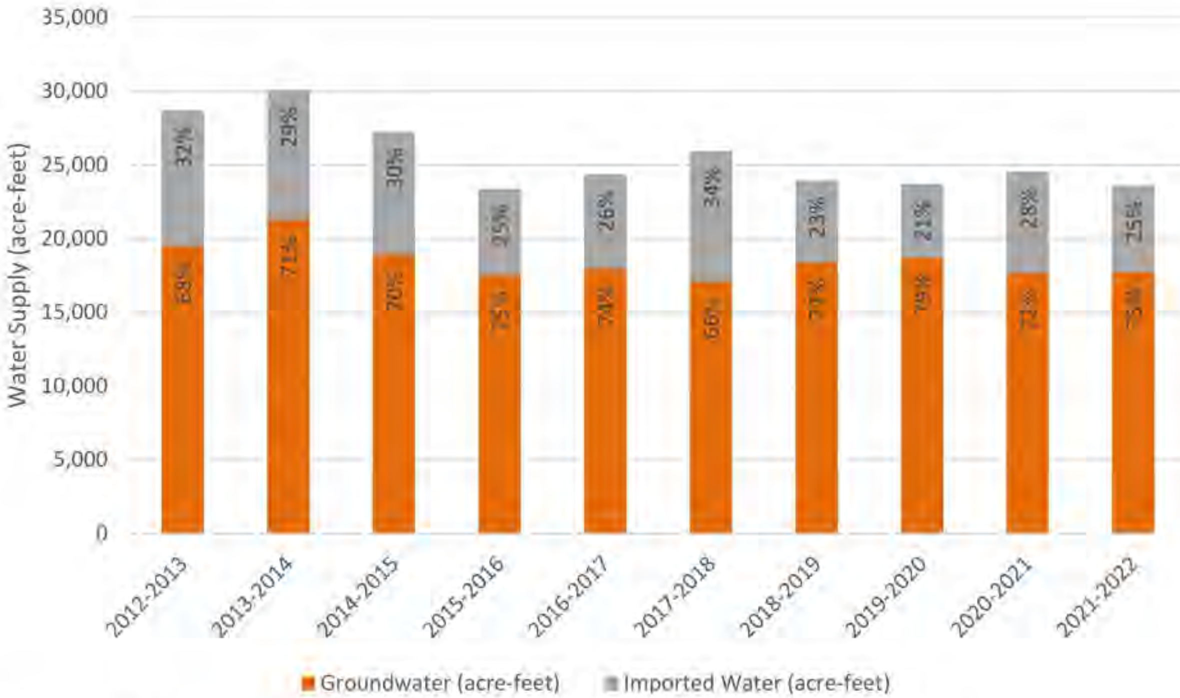


Figure 3-1. Annual Water Production (FY 2012/13 through FY 2021/22)

3.1 Groundwater

Groundwater levels are managed within a safe basin operating range to protect the long-term sustainability of the basin. The OC Basin is managed by the Orange County Water District (OCWD) and underlies the northerly half of Orange County. The OC Basin is subdivided into three major aquifer systems that are hydraulically connected and include the Shallow Aquifer, Principal Aquifer, and Deep Aquifer. The Shallow Aquifer, less than 200 feet below ground surface (bgs), has poor water quality and is generally pumped by small water systems for industrial and agricultural use. The Principal Aquifer is the largest water bearing strata between 200 and 1,300 feet bgs where most of the water (over 90 percent) is pumped for municipal use. Only a minor amount of groundwater is pumped from the Deep Aquifer that extends to an approximate depth of 2,000 feet bgs in the center of the OC Basin. The City only pumps potable water out of the Principal Aquifer.

OCWD was formed to manage Orange County's groundwater supply and protect north and central County's water rights to the OC Basin. In addition, OCWD operates the Groundwater Replenishment System (GWRS) in partnership with the Orange County Sanitation District (OCSan). GWRS can produce up to 130 MG of high-quality potable water per day for aquifer recharge OCWD manages groundwater levels by artificial recharge of stormwater, purified recycled water, and untreated imported water. OCWD also manages groundwater levels by regulating the annual amount of pumping through a process of financial incentives to encourage groundwater producers to pump a sustainable amount of water. The framework for the financial incentives is based on establishing a Basin Production Percentage (BPP), which is the percentage of each producer's total water demands that can be supplied from groundwater.

Groundwater production at or below the BPP is charged a Replenishment Assessment (RA) to offset the costs of basin management and recharge facility operation. While there is no legal limit as to how much an agency can pump from the OC Basin, there is a financial disincentive for pumping above the BPP. Water pumped in excess of the BPP is charged a Basin Equity Assessment (BEA) in addition to the RA. The combined RA and BEA rates approximately equal the cost of imported water, thus removing any financial incentive to pump excess groundwater. The BPP is set by the OCWD Board of Directors based on groundwater conditions, availability of imported water supplies, and basin management objectives.

In 2013, OCWD's Board of Directors adopted a policy establishing a stable BPP of 75 percent in FY 2015/16 to coincide with the first expansion of the GWRS. In 2019, the BPP was raised to 77 percent due to significant basin recharge, availability of excess imported water, and rainfall conditions.

Table 3-2 shows the annual production of each well between FY 2012/13 and FY 2021/22. Since FY 2012/13, on average, approximately 73 percent of City's water supply came from groundwater. Due to availability of MWD water, groundwater production dropped approximately 8 percent during FY 2017/18, reaching 66 percent in production as reflected by the reduction from the Main Plant wells, particularly Well 5. In addition, Airport Well 9 reduced production by around 20 percent. Groundwater production increased by FY 2018/19 to 77 percent and declined about 5 percent by FY 2020/21 due to PFAS detected in the groundwater wells.

Table 3-2. Annual Groundwater Well Production

Groundwater Well	Annual Water Production (acre-feet)									
	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22
Kimberly Well 1A[a]	1,465	2,355	2,907	2,047	1,901	2,322	1,903	3,762	1,431	3,563
Kimberly Well 2	1,782	3,024	1,960	1,547	1,587	1,764	2,923	1,845	2,387	1,132
Main Plant Well 3A[b]	3,017	3,065	1,672	4,126	3,691	3,825	3,395	2,146	-	-
Main Plant Well 4[c]	567	772	1,306	233	370	651	-	-	-	-
Main Plant Well 5	1,764	1,990	2,188	1,116	1,041	64	1,224	998	2,495	2,599
Main Plant Well 6	18	51	632	98	174	458	130	7	1,542	456
Main Plant Well 7[d]	864	425	1	-	-	-	-	-	-	-
Main Plant Well 8	2,872	2,622	2,477	2,365	2,483	2,611	2,637	2,675	2,522	2,272
Airport Well 9	2,270	1,937	1,888	2,035	2,270	1,865	2,004	2,477	1,560	2,231
Sunclipse Well 10	1,997	3,332	1,438	1,335	2,457	1,699	1,198	1,926	2,425	3,114
Christlieb Well 15A	2,875	1,707	2,477	2,640	1,960	1,845	2,958	2,860	3,267	2,373
Coyote Well 12A[e]	-	-	-	-	-	-	-	-	-	-
Total Groundwater	19,489	21,279	18,946	17,541	17,933	17,104	18,373	18,696	17,630	17,739
Total Water Supply	**28,694**	**30,058**	**27,244**	**23,384**	**24,359**	**25,948**	**23,937**	**23,719**	**24,554**	**23,619**
Groundwater	68%	71%	70%	75%	74%	66%	77%	79%	72%	75%

Notes:
[a] Kimberly Well 1A added PFAS treatment in 2021.
[b] Main Plant's PFAS Treatment Plant under construction in 2023 for Well 3A. Well 3A was taken offline in 2020.
[c] Well 4 located at the Main Plant has been offline since 2018 due to poor production and is recommended by the Main Plant Master Plan to be destroyed.
[d] Well 7 had been offline since 2014 and was destroyed in 2021 due to poor production and water quality concerns.
[e] Coyote Well 12A has been offline since October 2003 due to TBA detection and low production.

OCWD's most recent modeling of water supplies available for groundwater recharge and water demand forecasts anticipates being able to sustain a BPP at 85 percent, which is the current BPP as of FY 2022/23. The primary reasons for the higher BPP are the completion of the GWRS Final Expansion dedicated in April 2023 and the trend toward lower water demands.

Modeling and forecasts generate estimates based on historical averages. Consequently, forecasts use average hydrologic conditions that smooth the dynamic and unpredictable local hydrology. Variations in local hydrology are the most significant impact to supplies of water available to recharging the groundwater basin. The BPP projection of 85 percent is based upon average annual rainfall weather patterns. If southern California were to experience a protracted dry period (as occurred over the recent past), the BPP could be reduced to maintain water storage levels, by as much as five percent. However, for this study a BPP is assumed to be maintained at 85 percent for all planning scenarios beginning in 2025.

3.1.1 PER- AND POLYFLUOROALKYL SUBSTANCES IMPACTS

PFAS are a group of thousands of manmade chemicals that include PFOA and PFOS. PFAS compounds are commonly used in many products including, among others, stain- and water-repellent fabrics, nonstick products (e.g., Teflon), polishes, waxes, paints, cleaning products, and fire-fighting foams. Beginning in the summer of 2019, the California State Division of Drinking Water (DDW) began requiring testing for PFAS compounds in some groundwater production wells in the OC Basin.

OCWD's groundwater production in FY 2019/20 was expected to be approximately 325,000 AF county-wide but declined to 286,550 AF primarily due to PFAS impacted wells being taken offline around February 2020. OCWD expects groundwater production to continue to be reduced due to the currently idled wells and additional wells impacted by PFAS. As a result of these impacts, OCWD initiated a program to pilot test PFAS removal technologies and studied how treatment could be added to area wells. The OCWD Board also adopted a policy to administer treatment facility construction at producer sites. Under this policy, OCWD would pay for 100 percent of treatment capital costs and 50 percent of operating costs up to $75/acre-foot. As PFAS treatment systems are constructed, OCWD expects total annual groundwater production to slowly increase back to normal levels of between 310,000 to 330,000 AF.

The City's groundwater supply was reduced due to levels of PFAS detected at Kimberly Well 1A and at Main Plant Well 3A. Kimberly Well 1A was retrofitted with an ion-exchange treatment facility and construction was completed in 2021. This treatment facility was the first to be completed under OCWD's program. Limited Kimberly Well 1A production occurred in 2021 due to treatment plant construction and start-up. To make up this supply reduction, the Main Plant's Well 6 production was increased to meet demand. At the Main Plant, a PFAS treatment facility was constructed to treat Well 3A. Ultimately, the proposed treatment plant will include two separate treatment facilities at the Main Plant: a northern treatment plant to treat water from Well 3A and a new Well 7A; and a southern treatment plant configuration to treat Well 5, Well 6, and Well 8. It should be noted that Well 3A and 7A are deeper and discharge directly into the Zone 1 system transmission mains after treatment whereas Well 5, Well 6, and Well 8 are shallower and discharge to the forebay prior to being pumped into the Zone 1 distribution system.

Additional specific discussions related to PFAS and water quality characteristics are provided in Section 4.1.1.

3.1.2 RECYCLED WATER AND GROUNDWATER RECHARGE

The City does not own nor operate wastewater treatment facilities but owns and operates the wastewater collection system in its service area that sends all wastewater to OCSan for treatment. OCWD's GWRS produces highly treated water from OCSan for indirect potable reuse through the replenishment of the OC Basin. Although the City does not use recycled water directly, the City does benefit from the GWRS. Water from the GWRS is pumped to the Kraemer, Miller, and Miraloma Basins for recharge into the OC Basin.

3.2 Imported Water

The City supplements its local groundwater with imported water purchased from MWD, which is about 27 percent of total supply. MWD's sources of water are the Colorado River via the Colorado River Aqueduct (CRA) and the Lake Oroville watershed in Northern California through the State Water Project (SWP). For Orange County, the water from these sources is treated at the Robert B. Diemer Filtration Plant (Diemer) in Yorba Linda. Typically, Diemer receives a blend of Colorado River water from Lake Mathews through the MWD's Lower Feeder and SWP water through the Yorba Linda Feeder.

The City has a water purchase agreement with MWD that is a 10-year commitment to purchase a minimum quantity of water on an annual basis and a minimum quantity of water over the course of the 10-year commitment. In return, the City can purchase a greater percentage of imported water than otherwise allowed at the Tier 1 water rate. However, this agreement expired on December 31, 2024.

The City receives imported water through seven MWD connections along the Orange County Feeder, West Orange County Feeder, and Second Lower Feeder pipelines. The total available capacity from MWD is 107 cubic feet per second (cfs). Table 3-3 provides a summary of the annual imported water supply from each MWD connection. From FY 2012/13 to FY 2021/22, imported water supply averaged to approximately 26 percent of total water supply for the City.

Table 3-3. Annual Imported Water Purchased

Imported Water Connection	Annual Imported Water (acre-feet)									
	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22
F-01[a]	-	-	-	-	-	-	-	137	-	-
F-02[b]	-	-	3	-	-	-	694	2	22	-
F-04	1,273	43	511	779	403	802	399	359	355	729
F-05	740	2,181	1,767	1,207	1,711	2,522	49	1	1,678	230
F-06	369	299	227	77	344	82	49	34	136	179
F-08	6,554	6,043	5,582	3,634	3,763	5,202	4,147	4,312	4,623	4,641
F-09	269	214	207	145	203	236	226	178	110	101
Total Imported Water	9,205	8,779	8,298	5,842	6,425	8,844	5,564	5,023	6,924	5,880
Total Water Supply	**28,694**	**30,058**	**27,244**	**23,384**	**24,359**	**25,948**	**23,937**	**23,719**	**24,554**	**23,619**
Imported Water	32%	29%	30%	25%	26%	34%	23%	21%	28%	25%

Notes:
[a] F-01 connection became temporarily operational in 2021 as an emergency backup supply due to potential well production being reduced as a precaution from groundwater PFAS impacts. It has not been used since 2021.
[b] F-02 connection is normally not operational due to limited pressure on the MWD side of the turnout.

Imported water supply is normally delivered through five connections (F-04, F-05, F-06, F-08, and F-09). Historically, F-01 has not been operational and was at one point disconnected from the rest of the City's system. Due to impacts from PFAS on groundwater production, F-01 was reconnected for use as an emergency backup supply; usage in 2020 was for testing and activation of the newly reconnected connection. Similarly, F-02 was temporarily operational in 2020 due to construction in the vicinity. Normally F-02 is not used due to the equalized pressure between the MWD and the City's Pressure Zone 4A HGL; if not monitored and controlled, water can potentially flow from the City to MWD. F-02 is considered to be set for fire flow.

Since FY 2012/13, F-08 has been the City's primary source of imported water with annual average of 4,850 acre-feet or approximately 69 percent of total imported water supply. In FY 2021/22, F-08 accounted for nearly 79 percent of the imported water supply at 4,641 AF.

3.2.1 CONJUNCTIVE USE PROGRAM

In 2003, OCWD, MWD, and the Municipal Water District of Orange County (MWDOC) signed a historic 25-year agreement to store nearly 20 billion gallons of water in the OC Basin for use during dry years and emergencies. The agreement also provides for additional protection from seawater intrusion and improved groundwater quality. This program is referred to as the MWD's Conjunctive Use Program (CUP). The CUP agreement ends in 2028.

Currently, the CUP allows MWD to store up to 66,000 AF of water in the OC Basin during wet years, to be used by participating producers during dry years, instead of receiving imported water supplies. During dry years, droughts or emergencies, up to 20,000 AFY will be withdrawn for use. In exchange, MWD agreed to contribute to improvements in basin management facilities and pay an annual administrative fee. Improvements include installing eight new groundwater extraction wells for city and local water district participants to ensure that the stored water can be pumped in addition to the existing pumping demand. The operating cities and water districts can use Metropolitan's new wells as backups for their existing systems and ownership of these wells would transfer to them when the agreement expires in 25 years.

Participating agencies cities in this agreement include the cities of Buena Park, Fullerton, Garden Grove, Orange, Santa Ana, and Westminster, as well as the Golden State Water Company, and Yorba Linda Water District. In addition to water storage, the CUP would allow for MWD to fund seawater intrusion barrier improvements for OCWD, and the construction of the Diemer Bypass Pipeline, a bypass pipeline around MWD's Diemer Filtration Plant in Yorba Linda to redirect lower-salinity supplies from the State Water Project directly into OCWD's groundwater spreading basins in Anaheim. The water accounted for via the CUP is administered by OCWD and controlled by MWD to be withdrawn over a three-year period when needed.

3.3 Historical Monthly Supply Variation

The City increases its groundwater supply production during the summer months to meet the increased water demand.

Figure 3-2 shows the average monthly groundwater production versus imported water production for the calendar years 2012 through 2022. As illustrated, the imported water production remains consistent, and groundwater production varies to meet the monthly demand fluctuations.

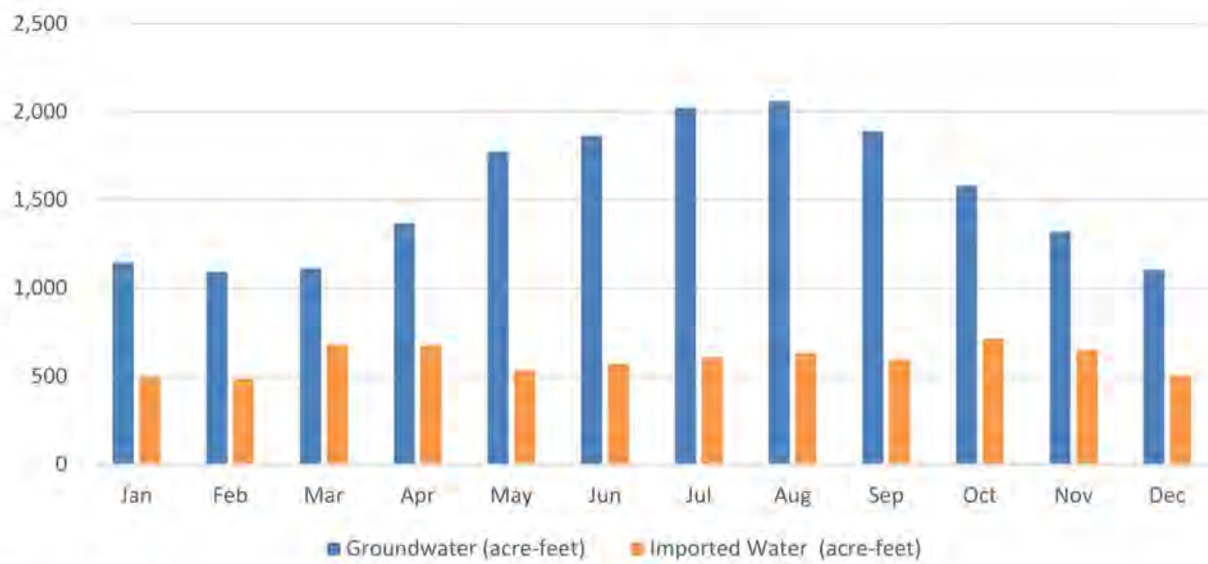


Figure 3-2. Average Monthly Water Production (2012 to 2022)

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4.0 Water Quality

4.1 Water Quality Regulation Update

The previous Water Master Plan Update performed for the City of Fullerton was prepared in 1997. This section provides an update of the regulations impacting water utilities since the previous update. Drinking water quality is regulated by the State of California Department of Drinking Water (DDW) and the U.S. Environmental Protection Agency (USEPA). Regulated contaminants include radionuclides, inorganic constituents, organic chemicals, disinfectant residuals in the water distribution system, and other constituents. A summary of regulations effective after 1997 is provided in Table 4-1. More information on these regulations can be found on the DDW website. The City of Fullerton's Water Quality Reports annually verify compliance against these regulations.

The following sections include discussion on regulatory updates for PFAS, volatile organic compounds (VOC), and microplastics. Additional regulations that are in process or planned or pending revision, include hexavalent chromium, arsenic, N-nitroso-dimethylamine (NDMA), styrene, and cadmium.

Table 4-1. Regulations Adopted by California Water Quality Control Board Since 1997

Regulation	Application Title	Effective Date
DW 2022-0001-DDW	General Order Requiring Monitoring for Per and Polyfluoroalkyl Substances	October 31, 2022
SBDDW-20-001	Perchlorate Detection Limit for Purposes of Reporting	July 1, 2021
SBDDW-20-002	Revised Total Coliform Rule	July 1, 2021
SBDDW-17-003	Point of Use/Point of Entry Treatment Permanent Regulations	March 22, 2019
SBDDW-16-02	Surface Water Augmentation Regulations	October 1, 2019
SBDDW-17-001	1,2,3-Trichloropropane Maximum Contaminant Level	December 14, 2017
SBDDW-16-01	Point of Use/Point of Entry Treatment Emergency Regulations	April 1, 2016
DPH-11-005	Hexavalent Chromium Maximum Contaminant Level	July 1, 2014[a]
DPH-14-003E	Groundwater Replenishment Using Recycled Water	June 18, 2014
DPH-09-014	Long Term 1 and 2 Enhanced Surface Water Treatment Rules	July 1, 2013
DPH-09-004	Disinfectant Residual, Disinfection Byproducts, and Disinfection Byproduct Precursors	June 21, 2012
DPH-10-011E	Point of Entry Treatment	September 22, 2011
DPH-09-007	Ground Water Rule	August 18, 2011
DPH-10-009E	Point of Use Treatment	December 21, 2010
DPH-06-009	Revision of Safe Drinking Water State Revolving Fund	December 21, 2010
DPH-04-017	Revision of Arsenic Maximum Contaminant Level	November 28, 2008
R-14-03	Water Works Standards	March 9, 2008
R-20-01	Interim Enhanced Surface Water Treatment Rule	January 12, 2008
R-16-04	Primary Maximum Contaminant Level for Perchlorate	October 17, 2007
R-21-03	Secondary Maximum Contaminant Levels	September 27, 2006
R-59-01	Public Notification Requirements for Drinking Water Violations	September 1, 2006
R-62-00	Disinfectants and Disinfection Byproducts	June 17, 2006
R-12-02	Radionuclide Drinking Water Regulations	June 11, 2006

Source: 2023 State of California https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Recentregs.html
Note:
[a] DPH-11-005 Hexavalent Chromium Maximum Contaminant Level was removed on September 11, 2017.

4.1.1 PFAS

Prior to April 10, 2024, California state notification and response levels (RL) were more stringent than federal PFAS limits. The USEPA has since finalized the National Primary Drinking Water Regulation (NPDWR) Maximum Contaminant Levels (MCLs) for six PFAS chemicals which are now lower than the current notification and response level in the State of California for PFAS. The standards for each regulatory agency can be found in Tables 4-2 and 4-3.

California's standards include notification and response levels for four PFAS chemicals. A notification level (NL) is a nonregulatory, health-based advisory level for contaminants in drinking water that do not have an MCL and requires notification of the exceedance to the governing bodies of customers in our service area. An RL is a concentration to signify a response is needed – agencies must either take the well out of service, install treatment at the well, or notify the public they are receiving water above the RL. California is in the process of establishing MCLs for various PFAS contaminants. A summary of the PFAS chemicals with notification and response levels in California is shown in Table 4-2. In addition to the chemicals identified in the table, the State of California has requested NLs and RLs for perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), and 4,8-Dioxa-3H-perfluorononanoic acid (ADONA). While federal limits are now more stringent, samples must still also be in compliance with the state regulations.

Table 4-2. Per- and Polyfluoroalkyl Substances Notification and Response Levels in the State of California

Abbreviation	Chemical name	Notification Level ng/L (ppt)	Response Level ng/L (ppt)	Date Issued
PFOA	Perfluorooctanoic acid	5.1	10	February 6, 2020
PFOS	Perfluorooctane sulfonic acid	6.5	40	February 6, 2020
PFBS	Perfluorobutane sulfonic acid	500.0	5000	March 5, 2021
PFHxS	Perfluorohexane sulfonic acid	3.0	20	October 31, 2022

Source: California State Water Resources Control Board, https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/pfas.html
Notes:
ng/L = nanograms per liter
PFBS = Perfluorobutane sulfonic acid
PFHxS = Perfluorohexane sulfonic acid
ppt = parts per trillion

Table 4-3 below shows the finalized USEPA limits for PFOA, PFOS, PFHxS, PFNA, and hexafluoropropylene oxide dimer acid (HFPO-DA) as contaminants with individual MCLs and MCL goals (MCLGs), and PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and PFBS using a Hazard Index MCL that the City must comply with.

Table 4-3. Proposed Maximum Contaminant Levels for Per- and Polyfluoroalkyl Substances Chemicals

Abbreviation	Chemical Name	MCLG	MCL ng/L (ppt)	Date Issued
PFOA	Perfluorooctanoic acid	Zero	4.0	April 10, 2024
PFOS	Perfluorooctane sulfonic acid	Zero	4.0	
PFHxS	Perfluorohexane sulfonic acid	10.0	10.0	
PFNA	Perfluorononanoic acid	10.0	10.0	
HFPO-DA (GenX Chemicals)	Hexafluoropropylene oxide dimer acid	10.0	10.0	
Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS		1.0 (unitless) Hazard Index[1]	1.0 (unitless) Hazard Index[1]	

Source: USEPA, https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

Sources: https://www.epa.gov/system/files/documents/2024-04/pfas_npwdr_faqsstates_4.8.24.pdf

$$\text{Hazard Index (HI)} = \left(\frac{[GenX_{water}]}{10\,ppt}\right) + \left(\frac{[PFBS_{water}]}{2000\,ppt}\right) + \left(\frac{[PFNA_{water}]}{10\,ppt}\right) + \left(\frac{[PFHxS_{water}]}{10\,ppt}\right)$$

Notes:

The denominators of the HI calculation are the Health-Based Water Concentrations levels which are non-enforceable levels that represent a level at which no health effects are expected for that Per- and Polyfluoroalkyl Substances. Non-Detect values are to be 0 in the above HI calculation if the detection limit (DL), reporting detection limit (RDL), etc. is below the Set Environmental Protection Agency Practical Quantification Level (PQL). The PQLs are 5 ppt for GenX Chemicals, 4 ppt for PFNA, 3 ppt for PFBS and PFHxS.

In addition to the MCLs, the USEPA has proposed a trigger level set at one-half of the MCLs for regulated PFAS, PFOA and PFOS 2.0 ppt, PFHxS, PFNA, and HFPO-DA at 5 ppt, and a Hazard Index of 0.5 (unitless) for mixtures of PFHxS, GenX Chemicals, PFNA, and PFBS.

It is important to ensure that PFAS treatment systems already constructed or designed in the City of Fullerton will also comply with the new federal MCLs.

4.1.2 COMPLIANCE WITH PROPOSED FEDERAL MAXIMUM CONTAMINANT LEVELS

To remain in compliance with the proposed federal limits, the City must conduct initial monitoring at each entry point to the distribution system (EPTDS) within three years of the new rule's finalization. The initial monitoring process is based on the size of the water system. As the City serves over 10,000 customers, it must conduct quarterly monitoring within a continuous 12-month period. Water systems may use recent existing quarterly PFAS occurrence data taken at each EPTDS.

Figure 4-1 below is adapted from the EPA's "Final PFAS National Primary Drinking Water Regulation" presentation. It outlines how a water system is required to show compliance with the EPA's new guidelines.

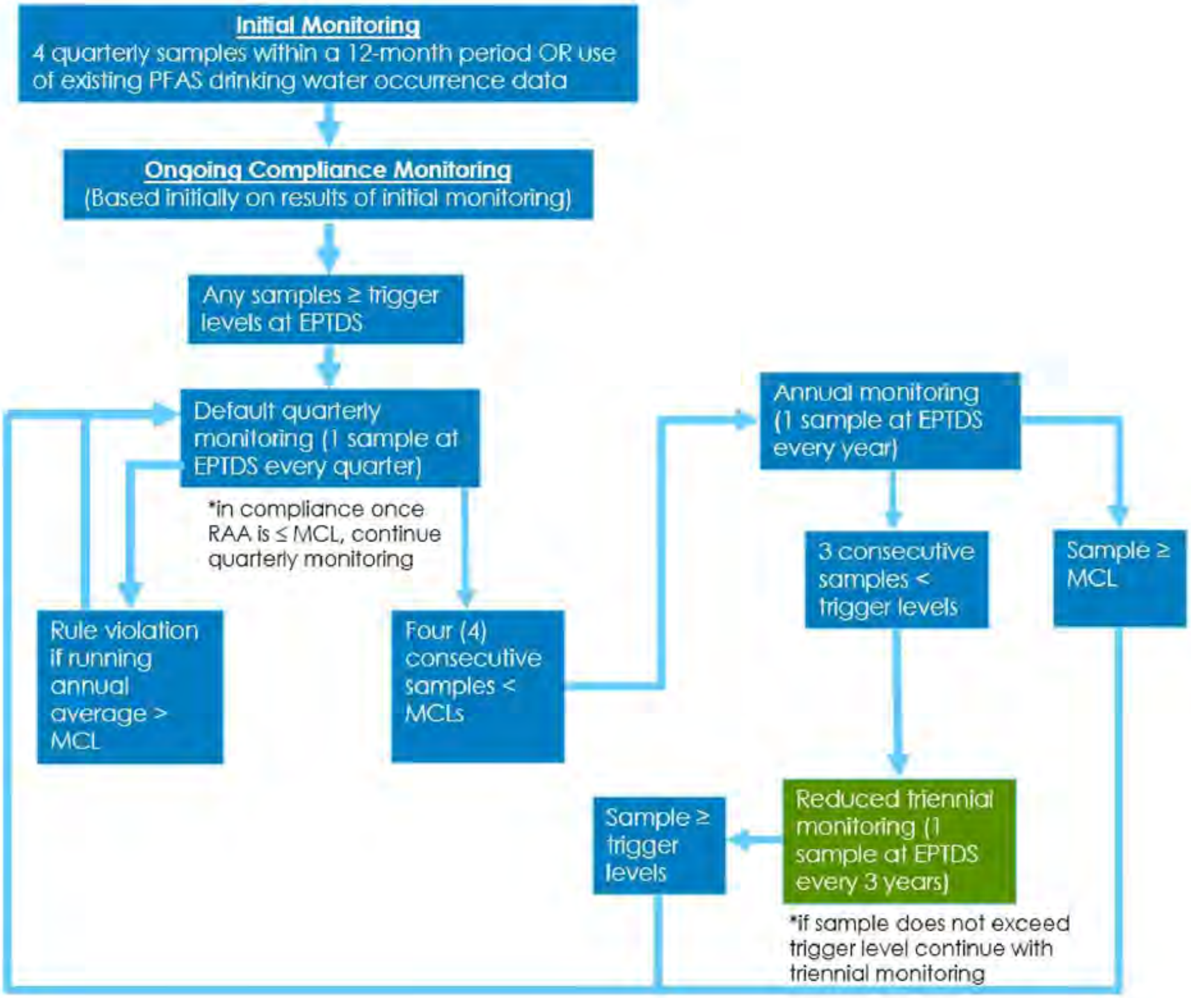

Figure 4-1. Implementation: Monitoring Requirements Summary

The flowchart depicts how a water system can reach compliance. If any sample exceeds the trigger level at an EPTDS default quarterly monitoring is triggered. Systems are considered in violation of an MCL if the running annual average is in exceedance after one year of quarterly sampling. Also, if a system takes more than one compliance sample during each quarter at a particular location, the system must average all samples taken at that location during that quarter. If there is an exceedance, the water system must provide notification of the MCL violation as soon as practicable but no later than 30 days after the system learns of the violation. The notification provides an alert to consumers of the violation and if there is a risk to public health.

If a water system's initial results are below the trigger levels, the system reduces compliance monitoring frequency for a system to once every three years. Any system that monitors less than quarterly and finds sample results at or above the rule trigger level reverts to quarterly monitoring.

The following is an example from an USEPA factsheet that shows how water systems should calculate their running annual average and report their results. Values below the USEPA's proposed Practical Quantification Level (PQL) are considered 0.0 (See Table 4-4):

"If the results of sampling for PFOA at a compliance location for the most recent four quarters are 2.0, 1.5, 5.0, and 1.5 ppt, the values used to calculate the running annual average would be 0.0, 0.0, 5.0, and 0.0. In this case the PFOA running annual average would be 1.3 ppt and in compliance."

Table 4-4. Practical Quantification Level

Compound	Practical Quantification Level (ppt)
PFOA	4.0
PFOS	4.0
PFNA	4.0
PFBS	3.0
PFHxS	3.0
HFPO-DA (GenX Chemicals)	5.0

Source: https://www.epa.gov/system/files/documents/2024-04/pfas_npwdr_faqsstates_4.8.24.pdf

Wells with federal MCL exceedances have 3 years (until 2027) to become in compliance once the new limits are passed. Once in compliance, the City can reduce to triennial monitoring. The City's plans to ensure compliance are presented in Section 4.1.4.

Starting in 2027, initial monitoring results must be included in Consumer Confidence Reports (also known as the Annual Water Quality Report), regular monitoring must begin and also be included in the reports, and public notification will be required for monitoring and testing violations.

Beginning in 2029, water systems must comply with the MCLs and continue notification when MCL violations occur. The City must also incorporate PFAS monitoring data into their Consumer Confidence Report. They would be required to report measured levels of PFOA, PFOS, PFHxS, GenX Chemicals, PFNA, and PFBS, and the Hazard Index for the mixtures of PFHxS, GenX Chemicals, PFNA, and PFBS.

4.1.3 PFAS RESULTS IN THE CITY OF FULLERTON

Based on the requirements outlined in the flowchart in Figure 4-1, the City will be required to conduct quarterly monitoring at the EPTDS as samples at all wells shown in Table 4-5 are greater than or equal to the trigger level. Quarterly monitoring will be required until the four consecutive samples are less than the MCLs which would lead to only yearly sampling or once the running annual average is less than or equal to the MCL which would lead to triennial monitoring.

Table 4-6 shows the historic PFAS running annual averages found in drinking water wells in the City of Fullerton calculated using the EPA's specified methods presented in Section 4.1.2. City only has one well that is non-detect (ND) for PFAS, which is Well 9.

Table 4-5. 2023 Fullerton Well PFAS Data (Potential Initial Monitoring Data)

Well/ Location	Compound/Chemical[a]	2023[b,c]			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Kimberly Well 1A	PFOA	**8.37**	**8.35**	**8.20**	
	PFOS	**18.23**	**17.60**	**16.95**	
	PFHxS	*6.37*	*6.60*	*5.80*	
	PFNA	0.00	0.00	0.00	
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	*0.64*	*0.66*	*0.58*	
Kimberly Well 2	PFOA	**9.00**	**9.10**	**8.90**	
	PFOS	**7.10**	**8.10**	**8.70**	
	PFHxS	4.20	4.30	4.30	
	PFNA	0.00	0.00	0.00	
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	0.42	0.43	0.43	
Main Plant Well 5	PFOA	**7.10**	**8.25**	**8.05**	
	PFOS	**13.60**	**15.65**	**14.65**	
	PFHxS	*6.20*	*7.80*	*6.75*	
	PFNA	0.00	0.00	0.00	
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	*0.62*	*0.78*	*0.68*	
Main Plant Well 6	PFOA	**5.30**	**6.30**	-	
	PFOS	**10.50**	**10.70**	-	
	PFHxS	4.50	4.80	-	
	PFNA	0.00	0.00	-	
	HFPO-DA	0.00	0.00	-	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	0.45	0.48	-	
Main Plant Well 8	PFOA	**7.30**	**7.40**	**8.70**	
	PFOS	**13.10**	**12.80**	**11.90**	
	PFHxS	*6.40*	*6.40*	*6.20*	
	PFNA	0.00	0.00	0.00	
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	*0.64*	*0.64*	*0.62*	

Well/ Location	Compound/Chemical[a]	2023[b,c]			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Sunclipse Well 10	PFOA	**6.20**	**6.90**	**6.80**	-
	PFOS	**13.20**	**13.30**	**13.80**	-
	PFHxS	4.00	4.30	4.00	-
	PFNA	0.00	0.00	0.00	-
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	0.40	0.43	0.40	
Christlieb Well 15A	PFOA	-	-	**5.60**	-
	PFOS	-	-	**15.40**	-
	PFHxS	-	-	*7.20*	-
	PFNA	-	-	0.00	-
	HFPO-DA	-	-	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	-	-	-	
Main Plant Forebay (blended water)	PFOA	**6.90**	**7.20**	**8.10**	
	PFOS	**13.10**	**11.80**	**13.20**	
	PFHxS	*6.00*	*5.80*	*5.40*	
	PFNA	0.00	0.00	0.00	
	HFPO-DA	0.00	0.00	0.00	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	*0.60*	*0.58*	*0.54*	

Notes:
[a] PFBS levels are 2 to 3 orders of magnitude below California's NL and RLs and are not shown on this table. EPA does not have an individual MCL for PFBS.
[b] Bold text represents a sample over the MCL.
[c] Italic text represents sample over the Trigger Level.

Table 4-6. Running Annual Average (RAA) of Regulated PFAS Chemicals

Well/Location	Compound/Chemical[a]	2019[b,c]				2020[b,c,d]				2021[b,c,d]				2022[b,c]				2023[b,c,d]			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Kimberly Well 1A	PFOA											**8.4**	**7.6**	**7.6**	**8.2**	**8.1**	**8.1**	**8.0**	**8.0**	**8.1**	
	PFOS								**22.0***			**17.3***							**17.1**	**17.0**	
	PFHxS									*6.6*	*5.6*	*5.3*	*5.1*	*7.2*	*8.0*	*7.7*	*7.2*	*6.8*	*6.4*	*6.2*	
	PFNA																			0.0	
	HFPO-DA																			0.0	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS									*0.8*	*0.7*	*0.7*	*0.6*	*0.7*	*0.8*	*0.8*	*0.7*	*0.7*	*0.6*	*0.6*	
Kimberly Well 2	PFOA										0.0	1.1	*2.3*	*2.3*	**4.9**	**7.1**	**7.1**	**8.3**	**9.3**	**9.0**	
	PFOS										**6.0**	**6.2**	**6.3**	*6.3*	**6.8**	**7.5**	**7.5**	**7.7**	**8.0**	**8.1**	
	PFHxS										1.5	2.4	2.5	2.5	3.0	4.3	4.3	4.5	4.8	4.5	
	PFNA										**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
	HFPO-DA										**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS										0.2	0.2	0.2	0.2	0.3	0.4	0.4	*0.5*	*0.5*	*0.5*	
Main Plant Well 5	PFOA				**10.3**	**10.9**	**10.9**	**10.8**	**10.4**	*9.0*	**8.2**	**8.4**	**7.9**	**7.5**	**7.0**	**6.6**	**6.6**	**6.7**	**7.0**	**7.4**	
	PFOS				**23.7**	**23.8**	**23.8**	**23.4**	**22.0**	**18.5**	**16.5**	**17.0**	**16.0**	**14.9**	**14.4**	**13.7**	**13.7**	**13.6**	**14.2**	**14.4**	
	PFHxS				*9.0*	*9.5*	*9.5*	*9.5*	*9.6*	*8.9*	*8.4*	*9.1*	*8.4*	*7.9*	*7.6*	*7.0*	*7.0*	*6.9*	*7.1*	*7.0*	
	PFNA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	HFPO-DA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS				*0.9*	*0.9*	*0.9*	**1.0**	*0.8*	*0.7*	*0.7*	*0.7*	*0.8*	*0.8*	*0.8*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	
Main Plant Well 6	PFOA				**6.6**	**6.8**	**6.8**	**6.8**	**6.8**	**6.9**	**6.8**	**6.8**	**6.6**	**6.3**	**5.9**	**5.5**	**5.5**	**5.4**	**5.6**		
	PFOS				**15.5**	**14.9**	**14.9**	**14.9**	**14.6**	**14.2**	**13.5**	**13.8**	**13.0**	**12.7**	**12.3**	**11.5**	**11.5**	**11.6**	**11.0**		
	PFHxS				*5.5*	*5.7*	*5.7*	*5.7*	*5.9*	*6.1*	*6.2*	*6.5*	*6.2*	*6.1*	*6.0*	*5.5*	*5.5*	*5.4*	*5.0*		
	PFNA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	HFPO-DA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS				*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.6*	*0.5*	*0.5*		
Main Plant Well 8	PFOA				**8.1**	**8.2**	**8.2**	**8.2**	**8.3**	**8.0**	**7.5**	**7.4**	**7.1**	**7.0**	**6.9**	**6.7**	**6.7**	**7.0**	**7.1**	**7.5**	
	PFOS				**17.7**	**17.1**	**17.1**	**17.1**	**17.0**	**16.9**	**15.9**	**16.0**	**14.9**	**14.6**	**14.5**	**13.9**	**13.9**	**14.0**	**13.4**	**12.6**	
	PFHxS				*7.0*	*7.0*	*7.0*	*7.0*	*7.3*	*7.8*	*7.9*	*8.2*	*8.0*	*7.9*	*7.9*	*7.6*	*7.6*	*7.4*	*7.0*	*6.5*	
	PFNA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	HFPO-DA				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS				*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.7*	*0.7*	*0.7*	

Well/Location	Compound/Chemical[a]	2019[b,c]				2020[b,c,d]				2021[b,c,d]				2022[b,c]				2023[b,c,d]			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Sunclipse Well 10	PFOA									**6.4**	**6.3**	**6.4**	**6.5**	**6.5**	**6.3**	**6.2**	**6.2**	**6.4**	**6.5**	**6.5**	
	PFOS									**14.3**	**14.0**	**14.1**	**14.3**	**14.2**	**14.0**	**13.7**	**13.7**	**13.9**	**13.6**	**13.5**	
	PFHxS									4.8	4.9	*5.0*	*5.2*	*5.2*	*5.2*	*5.0*	*5.0*	4.9	4.6	4.3	
	PFNA									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	HFPO-DA									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS									*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	0.4	
Christlieb Well 15A	PFOA							0*	__4.1*__											__5.6*__	
	PFOS							__9.7*__	__11.2*__											__15.4*__	
	PFHxS							_6.1*_	_7.4*_											_7.2*_	
	PFNA							0*	0*											0*	
	HFPO-DA							0*	0*											0*	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS																				
RES-FULLERTON-01	PFOA					**8.7**	**8.7**	**8.7**	**8.5**	**7.7**	**7.4**	**7.2**	**6.9**	**6.9**	**6.6**	**6.6**	**6.6**	**6.7**	**6.9**	**7.2**	
	PFOS					**14.4**	**14.4**	**14.4**	**18.1**	**16.5**	**15.5**	**15.8**	**14.7**	**14.1**	**14.0**	**13.7**	**13.7**	**13.8**	**13.5**	**13.2**	
	PFHxS					*7.9*	*7.9*	*7.9*	*8.0*	*7.6*	*7.7*	*7.7*	*7.2*	*7.2*	*6.9*	*6.8*	*6.8*	*6.7*	*6.5*	*6.1*	
	PFNA					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	HFPO-DA					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS					*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.6*	

[a] PFBS levels are 2 orders of magnitude below the RL, so they are only included in this table per EPA regulations as a part of a mixture with a Hazard Index (HI)
[b] Bold text represents an RAA over the MCL.
[c] Italic text represents an locational running annual average (LRAA) over the Trigger Level.
[d] The asterisk (*) represents data from one quarter, not an LRAA.

Values in Table 4-6 that are italicized exceed the DDW's notification limits and those bolded exceed the response level. The trends of the data are summarized below:

- PFOA is trending down in wells Main Plant Well 5, Main Plant Well 6, and Main Plant Forebay. PFOA is trending up in wells Main Plant Well 8, Sunclipse Well 10, Christlieb Well 15A, and Kimberly Well 2. PFOA has remained consistent at Kimberly Well 1A.
- PFOS is trending down in wells Sunclipse Well 10, Main Plant Well 5, Main Plant Well 6, Main Plant Well 8, Kimberly Well 1A, and RES-FULLERTON-01. PFOS is trending up in wells Kimberly Well 2 and Christlieb Well 15A.
- PFBS is trending down in wells Main Plant Well 5, Main Plant Well 6, Main Plant Well 8, and RES-FULLERTON-01. PFBS is trending up in wells Sunclipse Well 10, Christlieb Well 15A, Kimberly Well 1A, and Kimberly Well 2.
- PFHxS varies at wells Sunclipse Well 10, Main Plant Well 6, Main Plant Well 8, and Kimberly Well 1A. PFHxS is trending down in wells Main Plant Well 5 and RES-FULLERTON-01. PFHxS is trending up Kimberly Well 2 and Christlieb Well 15A.

4.1.4 PFAS TREATMENT IN THE CITY OF FULLERTON

The City of Fullerton has implemented or started construction on treatment solutions for two groundwater wells within the water system that historically had elevated levels of PFAS compounds. The treatment systems are as follows:

- Ion exchange treatment system at Kimberly Well 1A, which began operation in 2021; and
- GAC treatment system at the Main Plant treating water from Well 3A. Well 3A is scheduled to be brought back online early 2024 with the completion of the first phase of the Main Plant PFAS Treatment Project.

Both systems are designed to be operated to achieve ND PFAS levels.

The finalized EPA standards require testing at each EPTDSs, as shown on shown in Table 4-7, there are no exceedances for Kimberly Well 1A treated water with the exception of IX Vessel No. 3. However, the combined effluent is shown as ND, the combined effluent results would be the EPTDS for Kimberly Well 1A. This would apply to other wells that will have treatment structures designed in the future. As such, Table 4-7 shows the efficacy of the Kimberly Well 1A IX system.

Table 4-7. Kimberly Well 1A Ion Exchange Combined Effluent Results

Chemical Name	1/4/23	2/7/23	3/1/23	4/18/23	5/9/23	6/5/23	7/5/23	8/1/23	9/5/23	10/30/23	11/13/23	12/11/23
PFOA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFOS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFBS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFHxS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFNA	ND	ND	ND	ND	ND							
HFPO-DA	ND	ND	ND	ND	ND							
HI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

While the combined effluent is ND, Vessels No. 1 and Vessel No. 3 has seen PFOA breakthrough in 2023. See Table 4-8 for the breakthrough seen in December of 2023 in Vessel No. 1.

Table 4-8. Kimberly Well 1A Ion Exchange Vessel No. 1 Effluent Results

Chemical Name	1/4/23	2/7/23	3/1/23	4/18/23	5/9/23	6/5/23	7/5/23	8/1/23	9/5/23	10/30/23	11/13/23	12/11/23
PFOA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.1
PFOS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFBS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFHxS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFNA	ND	ND	ND	ND	ND							
HFPO-DA	ND	ND	ND	ND	ND							
HI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 4-9 shows the breakthrough in Vessel No. 3 seen during the second half of 2023. In December 2023, the PFOA level after treatment was above the MCL.

Table 4-9. Kimberly Well 1A Ion Exchange Vessel No. 3 Effluent Results

Chemical Name	1/4/23	2/7/23	3/1/23	4/18/23	5/9/23	6/5/23	7/5/23	8/1/23	9/5/23	10/30/23	11/13/23	12/11/23
PFOA	ND	ND	ND	ND	ND	ND	2.5	2.2	3.2	3.8	3.6	4.2
PFOS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFBS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFHxS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFNA	ND	ND	ND	ND	ND							
HFPO-DA	ND	ND	ND	ND	ND							
HI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

The City has numerous other wells in operation that show elevated concentrations of PFAS contaminants (see Table 4-5 and Table 4-6). Because of this, a PFAS treatment system planning study was prepared for the City and OCWD by Carollo Engineers, Inc. in August 2020, titled "Producer Report: City of Fullerton." When the study was conducted, it recommended treatment solutions for impacted wells based on the California DDW revised drinking water RLs of 10 ppt for PFOA and 40 ppt for PFOS that were proposed on February 6, 2020; however, the final treatment goal was set by OCWD in collaboration with producers to lower the concentration of PFOS and PFOA to ND levels, which is defined as 2 nanograms per liter (ng/L) or less. The following treatment systems were recommended by Carollo in this study to provide treatment for PFOA and PFOS based on the individual well water quality, site layouts, and life-cycle costs developed:

- Main Plant Wells (Wells 3A, 4, 5, 6, 7A, and 8) – Provide GAC treatment using 40,000-pound carbon vessels. This recommendation is based on the fact that many of the Main Plant Wells have the co-occurring contaminants trichloroethylene (TCE) and tetrachloroethene (PCE). Rapid small scale column testing (RSSCT) data from the OCWD's PFAS Treatment Testing Support Services project was not available at the time of this report. When the RSSCT data becomes available, it should be analyzed to determine the impacts of TCE and PCE on the removal of PFOA and PFOS. If these impacts are significant, a treatment train with TCE and PCE pretreatment may be the most economical approach. This GAC treatment will be designed for all existing and future Wells (Wells 3A, 5, 6, 7A, and 8), with the understanding that the immediate construction of GAC treatment vessels that is to be completed in 2023 will be sized for Well 3A only. Treatment for Wells 5, 6, 7A, and 8 will be customized and sized accordingly.
- Kimberly Well 1A – IX was recommended based on the limited space available for treatment. The IX treatment system was constructed and began operation in June 2021.

- Kimberly Well 2 – Study recommended to provide IX treatment for Kimberly Well 2 and Sunclipse Well 10 at this site. This recommendation is based on the limited space at Well 10 and sufficient area acquired from the developer of the previous Kimberly Clark site at the Kimberly Well 2 site.
- Sunclipse Well 10 – The study recommended pipe flow from Sunclipse Well 10 to the Kimberly Well 2 site for treatment. As a backup plan, the City could reach out to the nearby businesses to see if space could be leased or purchased at other locations for the IX treatment.

While these systems were designed with the intention of treating water to non-detect levels, there may still be an increase in anticipated operating costs due to an increase in changeout frequency of ion exchange resin or granular activated carbon required to operate to achieve ND levels.

4.1.5 VOLATILE ORGANIC COMPOUNDS

The City of Fullerton lies in the Orange County North Basin. In September 2020, the USEPA listed a six-and-a-half-square-mile portion of the groundwater aquifer as a superfund site on the National Priorities List due to a history of industrial pollution, mainly from VOCs, in the 1950s, 60s, and 70s.

The VOC plume shown in Figure 4-2 has resulted in some of the City's wells to be shut down and destroyed, the City's wells are denoted with red circles. Fire Station Well 13 and Kimberly Well 1 were shut down and destroyed in 2002 due to VOC contamination. Coyote Well 12A has been offline since October 2003 due to tert-butyl alcohol (TBA) detection and low production. Main Plant Well 7 was inactivated in 2014 and later destroyed in 2021, partly due to VOCs. The City's wells are denoted by red circles on Figure 4-2.

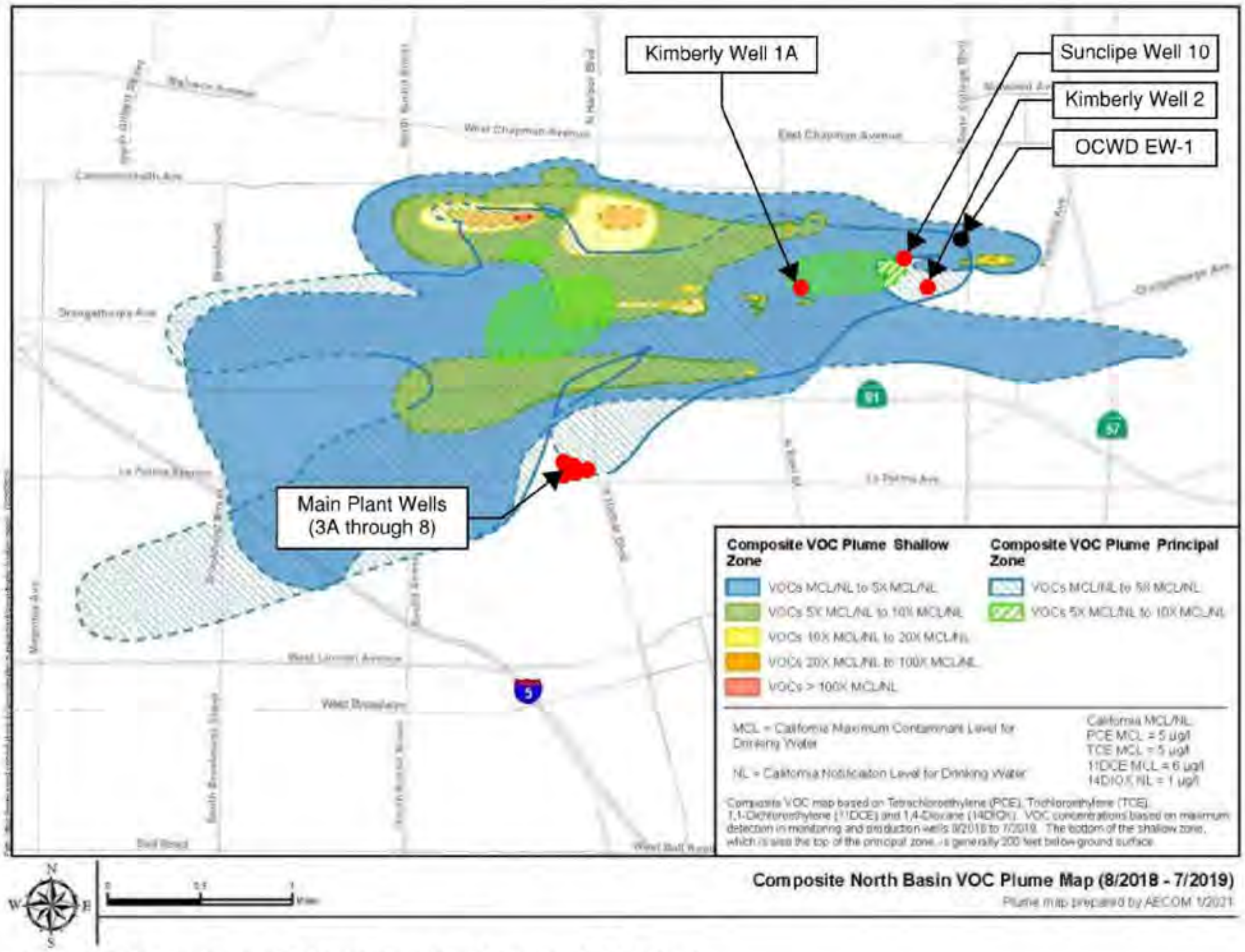

Figure 4-2. Orange County North Basin VOC Plume

In 2008, six extraction wells were installed by OCWD to contain the plume. In September 2017, OCWD started operating extraction well EW-1, represented as a black circle on Figure 4-2, as VOC-contaminated groundwater in the northeastern part of the North Basin VOC plume posed an imminent threat to City of Fullerton production wells. EW-1 was installed to stop VOCs from entering the wells in Zone 1A (Kimberly Well 1A, Kimberly Well 2, and Sunclipse Well 10).

Also, the City was previously required to blend the Main Plant water from Wells 4, 5, 6, 7, and 8 in the forebay to dilute VOC levels in accordance with approved Operation Plan dated September 16,1997. This mixing is no longer required as VOC levels have decreased.

Since 2000, the City has sampled its wells for 84 different VOC compounds. The City has detected 12 VOC compounds at levels above zero: 1,1-Dichloroethene (11DCE), Bromodichloromethane, Bromoform, Chloroform, Dibromochloromethane, Total Trihalomethanes (TTHM), Bromomethane, Methyl tert-butyl ether (MTBE), tert-butyl alcohol (TBA), PCE, TCE, and Trichlorotrifluoroethane (Freon 113). These 12 chemicals' regulatory thresholds are summarized in Table 4-10 and Table 4-11 below.

Table 4-10. VOC MCLs in the State of California

Abbreviation	Chemical Name	MCL, µg/L (ppb)[a,b]
11DCE	1,1-Dichloroethene	6
TTHMs	Total Trihalomethanes[c]	80
MTBE	Methyl tert-butyl ether	13
PCE	Tetrachloroethene	5
TCE	Trichloroethene	5
Freon 113	Trichlorotrifluoroethane	1,200

Source: California State Water Resources Control Board, https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.html

Notes:

[a] Tert-butyl alcohol does not have an MCL, but has an NL of 12 µg/L and RL of 1200 µg/L.

[b] Bromomethane was detected in the wells; however, there are no limited defined by California State Water Resources Control Board.

[c] The limit for Total Trihalomethanes is the sum of Bromodichloromethane, Bromoform, Chloroform, and Dibromochloromethane. These individual chemicals do not have limits defined by California State Water Resources Control Board and are limited by their sum.

Table 4-11. USEPA Federal MCLs for VOC Chemicals

Abbreviation	Chemical Name	MCLG, µg/L (ppb)	MCL, µg/L (ppb)
11DCE	1,1-Dichloroethene	7	7
DBP	Bromodichloromethane	0	-
DBP	Bromoform	0	-
DBP	Chloroform	70	-
DBP	Dibromochloromethane	60	-
TTHMs	Total Trihalomethanes	0	80
PCE	Tetrachloroethene	0	5
123-TCE	Trichloroethene	0	5

Source: USEPA, https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#six

Note:

Bromomethane, Methyl tert-butyl ether, tert-butyl alcohol, Trichlorotrifluoroethane (Freon 113) do not have Federal MCLGs or MCLs.

While the above chemicals have been detected in the City's wells, VOC values have been trending downward and there are currently no wells in exceedance of any regulatory limits. The historic VOC values are displayed as figures in Appendix A.

Downward trends may be related to the following:

- Dilution with uncontaminated groundwater as the plume spreads (through chemical diffusion and hydraulic mixing);
- Pumping occurring at other locations in the aquifer leading to plume movement;

- Effective management of the Plume by OCWD;
- Partitioning of VOCs into the soil potentially removing them from the water column; and,
- Potential dilution from rainwater; however, may be fairly unlikely due to time required to percolate 200 to 1,300 feet from the surface to the groundwater table.

As of March 2020, the City no longer has to sample for VOCs. Previously a blending plan at the Main Plant Forebay was required to meet the MCL requirements for PCE and TCE. In March 2020, PCE and TCE levels had decreased below the required monitoring triggers and monthly samples are no longer collected. OCWD continues to collect VOC samples as part of the required quarterly Title 22 sampling.

4.1.6 MICROPLASTICS

Microplastics are a growing concern in water sources and are ubiquitous in drinking water. To address this concern, an understanding of the fate and transport of microplastics in water, the impact on human health toxicity, and a standardized and affordable means of testing for microplastics are needed. Various research studies are underway to evaluate these concerns and identify a path forward. The State of California is implementing a four-year plan to establish a standard method of testing and reporting of microplastics in drinking water (Senate Bill (SB) 1422). The plan can be found in the Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water (Policy Handbook) prepared by DDW in August 2022 (included as Appendix B). The purpose and objectives of the four-year plan are the following:

- Adopt a standard methodology for microplastics testing in drinking water, which includes identifying surrogate methods of testing,
- Obtain four years of data from microplastics testing and reports,
- Move toward issuing a notification level or other guidance to aid interpretation of testing results,
- Accredit California laboratories to analyze microplastics.

The testing program is designed to understand the likelihood a water agency will have microplastics entering the system based on water source, the removal of microplastics based on the processes employed in the water treatment system, and whether there are surrogate methods to use to reduce the cost of microplastics testing. According to the Policy Handbook, past research has shown microplastics are more common in surface water than groundwater and are up to 5,000 micrometers (μm) in length, while several commonly used drinking water treatment technologies remove microplastics larger than 20 μm in length.

The State Water Board must establish an estimated risk to human health of microplastics through exposure via drinking water. To accomplish this, the State Water Board is using a two-phase iterative approach. Phase 1 (years one and two) will focus on characterizing the occurrence of microplastics larger than 20 or 50 μm in length in drinking water source waters, while Phase 2 (years three and four) will focus on characterizing the occurrence of microplastics smaller than and larger than 20 micrometers in length in treated drinking water. Phase 1 will be performed by large community water systems and wholesale water systems that serve more than 100,000 people, while Phase 2 will involve additional agencies. The Policy

Handbook includes a list of potential water systems to perform the microplastics monitoring during Phase 1--the City of Fullerton is not on this list. The Phase 2 list has not been made public yet.

The timeline for the microplastics testing is as follows:

- Summer, 2022: Environmental Laboratory Accreditation Program offered accreditation to qualified laboratories for microplastics in non-potable water and drinking water fields of accreditation.
- Fall, 2022: State Water Board issued monitoring orders in accordance with Phase One of planned monitoring, with monitoring requirements applicable between Fall 2023 – Fall 2025.
- Fall, 2025 – Spring, 2026: Interim period in which State Water Board staff will assess results from Phase One and determine best approach for Phase Two.
- Spring, 2026: State Water Board will issue monitoring orders in accordance with Phase Two of planned monitoring with monitoring requirements applicable between Fall 2026 – Fall 2028.
- Fall 2028: Completion of Phase Two of planned monitoring.

4.2 Water Quality Assessment

The City of Fullerton distribution system combines local groundwater with treated surface water from MWD. This section summarizes the groundwater quality, the treated surface water quality, and the water quality in the distribution system.

4.2.1 FULLERTON GROUNDWATER QUALITY SUMMARY

The City of Fullerton's drinking water wells consistently provide the community with high quality drinking water. Year over year, the water meets compliance with federal and state regulations without issue. The City regularly monitors their wells and address concerns that arise. A summary of the City of Fullerton groundwater quality as reported in the Fullerton Water Quality Reports from 2020 through 2022 is provided in Table 4-12. The data are from samples taken between 2019 and 2021. The groundwater used for drinking water complies with all current water quality regulations.

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Table 4-12. City's Groundwater Quality as Reported in 2020 Through 2022 (Data from 2019 to 2021)

Chemical	Unit	MCL	PHG (MCLG)	2020			2021			2022		
				Average	Min	Max	Average	Min	Max	Average	Min	Max
Radionuclides												
Combined Radium	pCi/L	5	0	<1	ND	1.09	<1	ND	1.09	-	-	-
Uranium	pCi/L	20	0.43	4.2	ND	11.7	3.7	ND	11.7	3.03	1.37	6.75
Organic Chemicals												
Tetrachloroethylene, PCE	ppb	5	0.06	<0.5	ND	1.7	<0.5	ND	1.9	<0.5	ND	2
Trichloroethylene, TCE	ppb	5	1.7	<0.5	ND	0.7	<0.5	ND	1.3	<0.5	ND	1.3
Inorganic Chemicals												
Arsenic	ppb	10	0.004	<2	ND	2	<2	ND	2	<2	ND	2
Fluoride	ppm	2	1	0.56	0.49	0.65	0.56	0.49	0.65	0.57	0.49	0.65
Nitrate	ppm as N	10	10	2.18	0.74	5.25	2.19	0.72	5.01	2.15	0.76	4.92
Nitrate+Nitrite	ppm as N	10	10	2.19	0.74	5.25	2.19	0.72	5.02	2.15	0.76	4.92
Perchlorate	ppb	5	1	n/a	n/a	n/a	n/a	n/a	n/a	<2	ND	2.7
Selenium	ppb	50	30	<5	ND	10.3	<5	ND	10.3	<5	ND	10.3
Secondary Standards												
Chloride	ppm	500	n/a	66.1	49.5	79	66.1	49.5	79	65.6	59.3	77.1
Odor	threshold odor number	3	n/a	<1	ND	2	<1	ND	2	<1	ND	2
Specific Conductance	μmho/cm	1600	n/a	766	550	1,140	767	550	1,140	749	550	1,140
Sulfate	ppm	500	n/a	134	83.2	249	134	83.2	249	136	103	249
Total Dissolved Solids	ppm	1000	n/a	451	288	722	454	332	722	457	338	708
Turbidity	NTU	5	n/a	<0.1	ND	0.3	<0.1	ND	0.3	<.1	ND	0.3
Unregulated Chemicals												
Alkalinity, total as $CaCO_3$	ppm	NR	n/a	146	101	233	146	101	233	142	101	233
Bicarbonate	ppm as HCO_3	NR	n/a	177	123	284	177	123	284	170	123	284
Boron	ppm	NL=1	n/a	0.18	ND	0.23	0.18	ND	0.23	0.19	ND	0.23
Calcium	ppm	NR	n/a	73	44	101	73	44	101	67.7	44	101
Hardness, total	grains per gallon	NR	n/a	14.3	8.4	23.4	14.3	8.4	23.4	13	8.4	23
Hardness, total as $CaCO_3$	ppm	NR	n/a	245	144	400	245	144	400	230	144	400
Hexavalent Chromium	ppb	NR	0.02	<1	ND	1.31	<1	ND	1.31	<1	ND	1.31
Magnesium	ppm	NR	n/a	15.4	8.2	36	15.4	8.2	36	14.9	8.2	36
Perfluoro Butane Sulfonic Acid (PFBS)	ppt	NL=500	n/a	-	-	-	<4	ND	4.6	<4	ND	4.7
Perfluoro Hexane Sulfonic Acid (PFHxS)	ppt	NL=3	n/a	-	-	-	6.7	ND	14.9	4.5	ND	9.5
Perfluorohexanoic Acid (PFHxA)	ppt	NR	n/a	-	-	-	<4	ND	6.3	<4	ND	6.3
Perfluoro Octane Sulfonic Acid (PFOS)	ppt	NL=6.5	n/a	26	14.9	48.1	15.4	ND	38.4	9.7	ND	18
Perfluoro Octanoic Acid (PFOA)	ppt	NL=5.1	n/a	10.5	5.7	19.2	6.7	ND	14.9	4.1	ND	8.8
pH	pH unit	NR	n/a	7.9	7.8	8	7.9	7.8	8	7.9	788	8
Potassium	ppm	NR	n/a	3.7	3	4.2	3.7	3	4.2	3.6	3	4
Sodium	ppm	NR	n/a	64.8	49.4	92.6	64.8	49.4	92.6	65.4	49.4	92.6

Notes:
a Dashed-line (-) indicates data was not available
b The data analyzed is from reports dated 2020 through 2022. Each report includes data taken from the previous year (from 2019 to 2021).
μmho/cm = micromhos per centimeter
$CaCO_3$ = calcium carbonate
HCO_3 = bicarbonate
NR = Nonregulatory
n/a=Not applicable (no regulatory limits)
ND = non-detected (less than method detection limit)
pCi/L = picocuries per liter
PHG = public health goal
ppm = parts per million

4.2.1.1 Unregulated Chemicals Requiring Groundwater Monitoring

Unregulated chemicals required to be monitored are summarized in Table 4-13. Manganese in the drinking water wells is well below the secondary MCL of 50 ppb. Secondary MCLs are established as guidelines for aesthetic considerations (taste, color, and odor) and are also considered to be safe for human consumption. Bromide, germanium, and TOC are monitored but not regulated. All data are from 2019, the most recent sampling date.

Table 4-13. Unregulated Chemicals

Chemical	Unit	MCL	PHG (MCLG)	Average	Minimum	Maximum
Bromide	ppm	NR	n/a	0.12	0.07	0.23
Germanium	ppb	NR	n/a	0.03	ND	0.40
Manganese	ppb	SMCL = 50	n/a	0.96	ND	5.80
Total Organic Carbon (unfiltered)	ppm	NR	n/a	0.25	0.17	0.40

NR = not required
SMCL = secondary MCL

4.2.2 MWD WATER QUALITY SUMMARY

Treated surface water supplied by MWD consistently provides southern California with high quality drinking water. A summary of the treated surface water reported in the Fullerton Water Quality Reports from 2020 through 2022 is provided in Table 4-14. The data are from samples taken between 2019 and 2021. The treated surface water complies with all current water quality regulations.

Table 4-14. Treated Surface Water from MWD as Reported in 2020 Through 2022 (Data from 2019 to 2021)

Chemical	Unit	MCL	PHG (MCLG)	2020				2021				2022			
				D Average*	W Average*	Min	Max	D Average	W Average	Min	Max	D Average	W Average	Min	Max
Radionuclides															
Alpha Radiation	pCi/L	15	0	-	-	-	-	<3	ND	ND	3	ND	ND	ND	3
Beta Radiation	pCi/L	50	0	-	-	-	-	<4	4	ND	7	5	5	4	6
Combined Radium	pCi/L	5	0	-	-	-	-	ND	<1	ND	2	ND	ND	ND	1
Uranium	pCi/L	20	0.43	-	-	-	-	2	2	1	3	2	2	1	3
Organic Chemicals															
Toluene	ppb	150	150	ND	0.6	ND	0.6	-	-	-	-	-	-	-	-
Inorganic Chemicals															
Aluminum	ppm	1	0.6	0.124	0.122	ND	0.1	0.137	0.149	ND	0.3	0.141	0.148	ND	0.24
Barium	ppm	1	2	n/a	n/a	n/a	n/a	0.107	0.105	0.1	0.1	0.111	0.11	0.11	0.111
Bromate	ppb	10	0.1	2	1.9	ND	8.1	1.9	2	ND	4.2	ND	ND	ND	7
Fluoride	ppm	2	1	0.7	0.7	0.1	0.9	0.7	0.7	0.5	0.9	0.7	0.7	0.6	0.9
Nitrate	ppm as N	10	10	0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-
Secondary Standards															
Aluminum	ppm	200	600	124	122	ND	110	137	149	ND	260	141	148	ND	240
Chloride	ppm	500	n/a	56	50	46	58	94	93	93	94	96	96	95	97
Color	color units	15	n/a	ND	ND	ND	1	1	1	1	1	1	1	1	1
Iron	ppb	300	n/a	ND	243	ND	243	-	-	-	-	-	-	-	-
Odor	threshold odor number	3	n/a	ND	1	ND	1	2	2	2	2	2	1	1	2
Specific Conductance	µmho/cm	1600	n/a	514	469	435	521	970	966	963	975	958	964	950	965
Sulfate	ppm	500	n/a	91	73	65	93	216	213	211	217	214	219	214	221
Total Dissolved Solids	ppm	1000	n/a	304	266	244	312	592	590	582	603	597	604	597	609
Unregulated Chemicals															
Alkalinity, total as $CaCO_3$	ppm	NR	n/a	72	68	67	74	118	118	117	120	125	126	123	128
Boron	ppm	NL=1	n/a	0.12	0.12	0.12	0.1	0.13	0.13	0.1	0.1	0.13	0.13	0.13	0.13
Calcium	ppm	NR	n/a	30	25	23	30	66	65	65	67	66	67	64	70
Hardness, total	grains per gallon	NR	n/a	7.4	6.3	5.9	7.6	15	15	15	16	16	16	16	16
Hardness, total as $CaCO_3$	ppm	NR	n/a	127	108	101	130	265	262	256	269	274	272	270	276
Magnesium	ppm	NR	n/a	14	12	11	14	26	26	25	26	25	26	24	36
Perfluorohexanoic Acid	ppt	NR	n/a	2.3	2.6	2.2	2.6	-	-	-	-	-	-	-	-
N-nitrosodimethylamine	ppt	NL=10	n/a	-	-	-	-	3.1	ND	ND	3.1	-	-	-	-
pH	pH unit	NR	n/a	8.4	8.5	8.4	8.5	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Potassium	ppm	NR	n/a	2.8	2.4	2.2	2.9	4.6	4.6	4.5	4.7	4.4	4.6	4.2	4.7
Sodium	ppm	NR	n/a	56	50	46	57	96	95	93	98	94	98	93	101
Unregulated Chemicals Requiring Monitoring															
Germanium	ppb	NR	n/a	0.1		ND	0.4	0.1		ND	0.4	0.1		ND	0.4
Manganese	ppb	SMCL = 50	n/a	2.2		0.8	3.3	2.2		0.8	3.3	2.2		0.8	3.3
Total Organic Carbon	ppm	NR	n/a	2.4	2.4	1.7	2.6	2.4	2.4	2.1	2.7	2.4	2.4	1.8	2.8

Note:
a The data analyzed is from reports dated 2020 through 2022. Each report includes data taken from the previous year (from 2019 to 2021).
D = Diemer
W = Weymouth

4.2.3 DISTRIBUTION SYSTEM WATER QUALITY

The Fullerton distribution system combines groundwater with import water from MWD. The combined water is subject to the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule and monitoring of chlorine and fluoride residuals, as well as monitoring of various unregulated contaminants.

4.2.3.1 Disinfection Byproducts Rule

The disinfection byproducts under the DPBR are TTHMs and haloacetic acid (HAA5). TTHMs and HAA5s are monitored by the locational running annual average (LRAA) and operational evaluation level (OELs). Data from 2018 through 2022 shows the LRAAs and OELs for TTHM and HAA5s are all well below the MCLs. A summary of the LRAA and OELs is shown in Table 4-15.

Table 4-15. Disinfection Byproducts (2018 - 2022)

Chemical	Unit	MCL	Highest LRAA	Highest OEL	Highest Individual Sample	Number of Samples
TTHM	ppb	80	30.1	31.7	35.4	160
HAA5	ppb	60	13.79	16.9	21.9	160

4.2.3.2 Chlorine and Fluoride Residuals

Chlorine is added during the drinking water treatment process to ensure the water will maintain a disinfection residual throughout the distribution system. The sites nearest the disinfection location will have higher concentrations of chlorine while those farthest away will have the lowest concentrations. Water entering the distribution systems must have a chlorine residual between 0.2 milligrams per liter (mg/L) and 4.0 mg/L and must have detectable chlorine at the furthest point in the distribution system.

Fluoride is in the distribution system either as an additive for dental health or from the naturally occurring weathering of rocks. The City of Fullerton does not add fluoride to the groundwater or the distribution system; however, the treated surface water from MWD has added fluoride. The American Dental Association recommends 0.7 mg/L of fluoride in drinking water, the City's average fluoride residual is slightly lower at 0.57 mg/L. Data sampled semi-annually from 2017 through 2022 shows no sample exceeding the fluoride MCL.

A summary of chlorine and fluoride residuals, for all monitoring locations in the distribution system, is shown in Table 4-16.

Table 4-16. Chlorine & Fluoride Residuals in the Distribution System (2017 - 2022)

Chemical	Unit	Target Range	MCL	Average	Maximum	Minimum	Number of Samples
Chlorine	ppm	0.2 - 1	4	1.54	5.5	0.12	160
Fluoride	ppm	<2	2	0.57	0.84	0.16	300

4.2.3.3 Unregulated Chemicals Requiring Monitoring in Distribution System

Chemicals to be monitored that do not have an MCL were summarized using data from 2019, which is the most recent sampling data available. A summary of unregulated chemicals monitored in the distribution systems is shown in Table 4-17.

Table 4-17. Unregulated Chemicals Monitored in Distribution System (2019)

Chemical	NL	PHG	Average	Minimum	Maximum
Bromochloroacetic acid	n/a	n/a	2.5	ND	4.9
Bromodichloroacetic acid	n/a	n/a	0.84	ND	2.1
Chlorodibromoacetic acid	n/a	n/a	0.82	ND	1.6
Dibromoacetic acid	n/a	n/a	1.7	ND	2.5
Dichloroacetic acid	n/a	MCLG = 0	2.8	0.4	8.9
Monobromoacetic acid	n/a	n/a	0.2	ND	0.5
Monochloroacetic acid	n/a	MCLG = 70	0.1	ND	3.1
Trichloroacetic acid	n/a	MCLG = 20	0.7	ND	1.9

n/a = not applicable
ND = non-detect

4.2.4 COYOTE SITE MANGANESE CONTAMINATION

The State of California has a notification level of 50 µg/L for manganese. Data between 1992 through 2003 from Coyote Well 12A shows manganese levels ranging from 20 µg/L to 93 µg/L, with an average of 66.4 µg/L. Due to the high levels of manganese, Coyote Well 12A was taken offline and is not anticipated to be put into use in the future.

4.2.5 RAYTHEON IMPACTS ON WELL 9

The Packer Testing System coordinated by the City and conducted by Raytheon (formerly Hughes Aircraft Company) in 2015 concluded that 1,1-DCE was likely entering Well 9 from the lower well screens. It was determined that the concentration of 1,1-DCE could be decreased below the detection limit by isolating the lower two screens. Well 9 was scheduled to be taken out of service in FY 2017/18 during the fall or winter. Raytheon agreed to implement mechanical and electrical upgrades to Well 9 and installed a semi-permanent packer, a new pump and motor, and various new controls equipment in January 2021.

Well disinfection and neutralization activities were conducted in March 2021, and startup testing occurred in the summer of 2021 and was completed in January 2022.

4.2.6 LEAD AND COPPER

The USEPA established the Lead and Copper Rule (LCR) to protect public health and reduce exposure to lead in drinking water. The MCLG for lead is zero because there is no level of lead exposure that is without risk. Lead is not commonly found in significant quantities in groundwater or surface water but can enter the drinking water system via lead pipes or other fixtures.

Data sampled between 2019 – 2022 show no exceedances of lead or copper at groundwater wells and is summarized in Table 4-18.

Table 4-18. Lead and Copper Groundwater Sampling Results (2019 – 2022)

Chemical	Unit	AL	PHG	90th Percentile Value	Sites Exceeding AL / Number of Sites	AL Violation?	Typical Source of Contaminant
Lead	ppb	15	0.2 (MCLG = 0)	ND	0 / 52	No	Corrosion of Household Plumbing
Copper	ppm	1.3	0.3	0.14	0 / 52	No	Corrosion of Household Plumbing

AL = action level

Copper was found in 31 homes, and none exceeded the regulatory action level (AL). Lead was found in 1 home and did not exceed the regulatory AL. The City complies with the LCR as of 2021.

The USEPA is developing a new proposed rule, the Lead and Copper Rule Improvements (LCRI) to strengthen the Lead and Copper Rule. The LCRI will be promulgated prior to October 16, 2024. Each agency will need to develop and maintain a lead service line inventory with the goal of 100% removal of lead service lines. By October 16, 2024, an initial lead service line inventory and replacement plan are required. The City began working with a consultant in late 2023 to create an inventory and replacement plan through a shared services agreement with MWDOC.

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5.0 Water Use

This section evaluates historical data of potable water production and consumption within the City's service area to plan for the City's future water usage. Historical water use, seasonal variations, population growth, the City's General Plan and Zoning Map, as well as known development plans are taken into consideration to project the City's future water demands.

5.1 Historical Water Use

Historical water production and consumption data were analyzed to understand water use trends in the City. Most recent available consumption, or customer meter billing data were used to estimate water duty factors for each land use category since the data provided water use per land use. The City provided daily water production and consumption data for FY 2012/13 to FY 2021/22, and additional data from July 2022 to December 2022, which was the available data at the time for preparation of this Master Plan.

5.1.1 HISTORICAL WATER CONSUMPTION

Historical water consumption was evaluated using available billing data for FY 2012/13 to FY 2021/22. The data were used to calculate historical annual water demand and average day demand (ADD), summarized in Table 5-1. On average, the City's historical water use during this 10-year period is approximately 24,352 AFY or 21.7 million gallons per day (mgd).

Table 5-1. Annual Water Consumption

Fiscal Year	Average Consumption	
	Annual (acre-feet)	Daily (mgd)
2012/2013	27,040	24.14
2013/2014	28,465	25.41
2014/2015	25,695	22.94
2015/2016	22,146	19.77
2016/2017	23,096	20.62
2017/2018	24,930	22.26
2018/2019	23,219	20.73
2019/2020	22,533	20.12
2020/2021	23,589	21.06
2021/2022	22,805	20.36
Annual Average	**24,352**	**21.74**

5.1.2 PER CAPITA CONSUMPTION

The City's historical water billing data was used to calculate annual water consumption and per capita water consumption for FY 2012/13 to FY 2021/22, as shown in Table 5-2 and on Figure 5-1. Per capita consumption is based on the historical annual water consumption divided by the population of that given year. Per the population data obtained from the Center for Demographic Research (CDR) at California State University, Fullerton, the population in the City grew from 2012 to 2018 and experienced a drop in population between years 2018 and 2021. The per capita water consumption did not follow the same trend as the population between 2013 to 2015. As population increased, per capita water consumption decreased from 182 gallons per capita per day (gpcd) to 139 gpcd and has been averaging around 145 gpcd. Of the recent analyzed data, the City's highest per capita water use was in FY 2013/14, at 182 gpcd. The lowest per capita water use was in FY 2015/16, which is the lowest out of all available records, going back to the early 1970s. The use of less water per person can be attributed to the water conservation efforts in 2015 and the reduction in per capita effort.

Note that the gpcd presented in this report reflects water use for all land use and is not only considering the residential use. According to the City's 2020 Urban Water Management Plan (UWMP), the City met its 2020 water use target and complies with the California Water Conservation Act of 2009 (SBx7-7); the actual 2020 residential consumption was 111 gpcd that is well below the 2020 target of 179 gpcd. The historical average per capita water consumption for all land use after 2015 conservation efforts is 145 gpcd per Table 5-2 and is also below the 2020 target of 179 gpcd. The 145 gpcd is based on gross water use within the City's water service area and does not account for exclusions allowed SBx7-7 as described in the 2020 UWMP Section 5.1.

Table 5-2. Historical Annual Water Consumption

Fiscal Year	Annual Consumption (acre-feet)	Average Daily Consumption (gpd)	Population[a]	Average Daily Consumption per Capita (gpcd)
2012/2013	27,040	24,139,756	138,370	174
2013/2014	28,465	25,411,914	139,506	182
2014/2015	25,695	22,939,018	140,785	163
2015/2016	22,146	19,770,675	142,081	139
2016/2017	23,096	20,618,780	142,846	144
2017/2018	24,930	22,256,070	142,996	156
2018/2019	23,219	20,728,587	142,251	146
2019/2020	22,533	20,116,166	142,070	142
2020/2021	23,589	21,058,902	141,974	148
2021/2022	22,805	20,358,992	142,732	143
			FY 2012/13 to FY 2021/22 Average	**145**

Notes:
[a] Population was obtained from Center for Demographic Research at California State University Fullerton (May 2022 CDR)

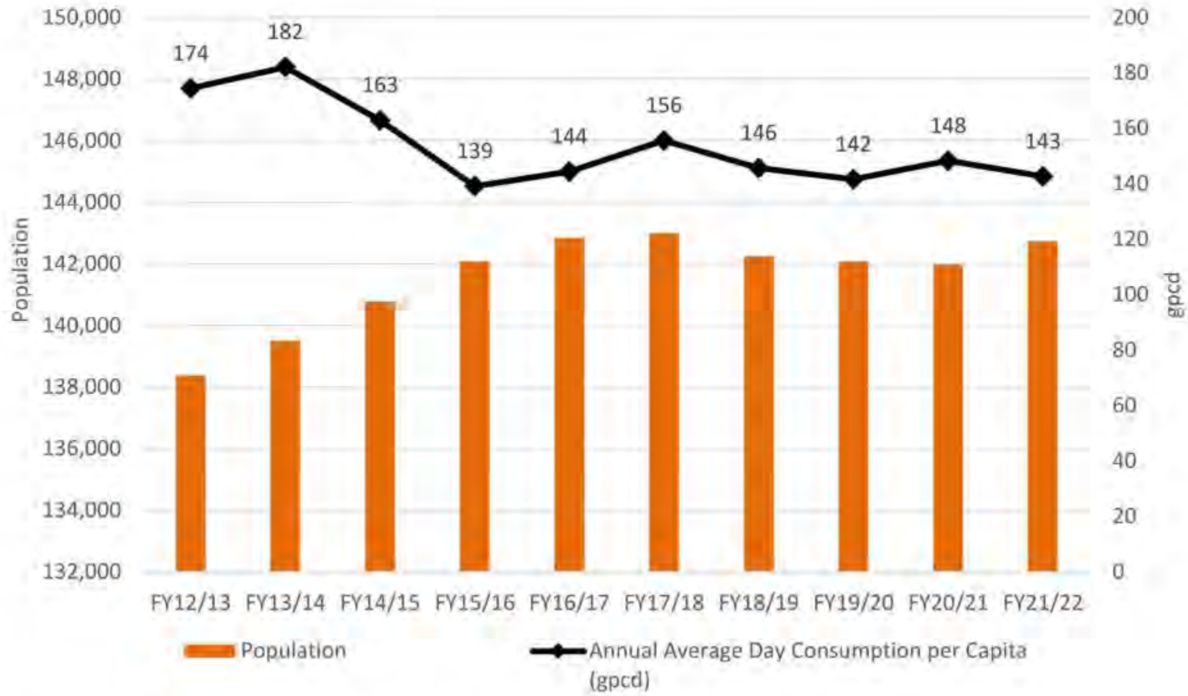


Figure 5-1. Historical Annual Water Consumption per Capita (gpcd)

5.1.3 HISTORICAL WATER PRODUCTION

As discussed in Section 3.0, several groundwater wells and MWD imported water connections provide the City's water production to meet the daily water demands. For the historical 10-year period, the City's water production has averaged approximately 25,552 AFY as shown in Table 5-3.

Table 5-3. Historical Annual Water Production

Fiscal Year	Total Water Production (acre-feet)
2012/2013	28,694
2013/2014	30,058
2014/2015	27,244
2015/2016	23,384
2016/2017	24,359
2017/2018	25,948
2018/2019	23,937
2019/2020	23,719
2020/2021	24,554
2021/2022	23,619
Average	**25,552**

5.1.4 HISTORICAL SEASONAL WATER PRODUCTION

There is considerable seasonal variation in water use mainly due to climate variations. As show in Table 5-4, there is variation through the years, wet years vs dry years. However, demands are the lowest in December to March when the weather is cold or there is rain. Typically in the winter months, Jan to March. Typically demands begin to increase in April, with higher demands from June to October. Over the historical ten fiscal year period, maximum demands mostly occurred in August followed by July.

Table 5-4. Historical Monthly Production

Description	Water Demand (AF)												
	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2016/17	FY 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22	Avg	Min	Max
July	2,993	3,024	2,985	2,190	2,500	2,665	2,768	2,554	2,494	2,512	2,669	2,190	3,024
August	3,133	3,066	2,903	2,396	2,576	2,689	2,765	2,631	2,552	2,548	2,726	2,396	3,133
September	2,923	2,929	2,774	2,146	2,412	2,416	2,468	2,452	2,338	2,305	2,516	2,146	2,929
October	2,618	2,651	2,558	2,110	2,193	2,394	2,203	2,361	2,229	1,987	2,330	1,987	2,651
November	2,131	2,196	2,158	1,956	1,927	2,046	1,960	1,944	1,858	1,868	2,004	1,858	2,196
December	1,423	1,993	1,551	1,709	1,593	1,959	1,477	1,373	1,824	1,419	1,632	1,373	1,993
January	1,685	2,222	1,787	1,474	1,247	1,746	1,434	1,570	1,539	1,492	1,619	1,247	2,222
February	1,646	1,838	1,804	1,594	1,165	1,693	1,153	1,642	1,441	1,616	1,559	1,153	1,838
March	2,090	2,006	2,275	1,639	1,767	1,556	1,470	1,395	1,690	1,828	1,772	1,395	2,275
April	2,445	2,334	2,220	1,888	2,191	2,091	1,997	1,464	2,017	1,892	2,054	1,464	2,445
May	2,719	2,923	2,043	2,042	2,379	2,280	2,010	2,130	2,227	2,130	2,288	2,010	2,923
June	2,890	2,874	2,185	2,253	2,455	2,402	2,190	2,281	2,364	2,142	2,404	2,142	2,890
Annual Average	**2,391**	**2,505**	**2,270**	**1,950**	**2,034**	**2,161**	**1,991**	**1,983**	**2,048**	**1,978**	**2,131**	**-**	**-**

Note:
Color gradient represents low water demand for lighter shading and higher demand for darker shading

To display the average and standard deviations in demands for the past ten years, minimum, maximum, and average water consumption is estimated for each month from FY 2012/13 to FY 2021/22, as shown in columns on Table 5-4. The overall monthly average demand for the FY 2012/13 to FY 2021/22 period was 2,131 AF. To determine the seasonal average, minimum, and maximum variation factors, the monthly average, minimum, and maximum demands are divided by the overall average demand of 2,131 AF. Figure 5-2 displays a graph of the average, minimum, and maximum factors for each fiscal year. The black line shows the graph of the average factors with a maximum average ratio occurring in the month of August.

Figure 5-2. Seasonal Production Variation for FY 2015/16 Through FY 2021/22

5.1.5 NON-REVENUE WATER

As required by the California Urban Retail Water Suppliers: Water Loss Management legislation (SB 555), the City has conducted annual water loss audits since 2015 per the American Water Works Association (AWWA) methodology to understand the relationship between water loss, operating costs, and revenue losses. Non-revenue water within the distribution system is defined as the difference between facility production volume or supply and billed authorized consumption. Water production, billed water consumption, as well as the non-revenue water loss is shown in Table 5-5 and on Figure 5-3 for FY 2012/13 to FY 2021/22.

Table 5-5. Annual Water Consumption vs. Water Production

Fiscal Year	Total Water Production (AF)	Total Water Consumption (AF)	Non-Revenue Water (AF)	Water Loss %
2012/2013	28,694	27,040	1,654	6%
2013/2014	30,058	28,465	1,593	6%
2014/2015	27,244	25,695	1,549	6%
2015/2016	23,384	22,146	1,238	6%
2016/2017	24,359	23,096	1,263	5%
2017/2018	25,948	24,930	1,018	4%
2018/2019	23,937	23,219	718	3%
2019/2020	23,719	22,533	1,186	5%
2020/2021	24,554	23,589	965	4%
2021/2022	23,619	22,805	814	4%

Figure 5-3. Historical Annual Non-Revenue Water Trend

Non-revenue water can be attributed to real system losses such as leaking or broken mains and service lines, unbilled consumption such as hydrant flushing and fire-fighting, or apparent losses including unauthorized consumption, monthly billing estimates, and meter inaccuracies. Table 5-5 shows the water system has had between 3 to 6 percent water loss since FY 2012/13. The highest apparent water loss was in FY 2012/13 to FY 2015/16, at 6 percent. Based on information provided by the City, average water loss equates to 5 percent. The water loss has been steady over the last five years, ranging between 3 percent and 5 percent.

5.2 Existing Water Demands

Water demand is defined as the water that is supplied and is conveyed through the water system and includes non-revenue plus actual water consumption. Therefore, monthly water production data were used to analyze seasonal demand variations. Additionally, for purposes of system evaluations for the hydraulic model analyses, the most current demands from the calendar year 2022 were used to determine the seasonal and existing daily and peak demands in the system.

The City provided daily production data and hourly facility SCADA data for calendar year 2022, which was the latest data available at the time this Master Plan was prepared. Daily production data was used to estimate the annual ADD and maximum day demand (MDD). The hourly SCADA data was used to determine daily diurnal pattern of water use, to account for peak hour demand (PHD) in the model. The ADD and MDD are applied in the model and diurnal patterns are assigned to each demand to account for hourly peaking of water use.

5.2.1 EXISTING AVERAGE DAY DEMANDS

The production data from calendar year 2022 was used to determine the existing ADD to reflect the most recent existing demand conditions. Based on the 2022 data, the existing system demands are 22,956 AFY. This equates to an average daily demand of 62.9 AF per day, or 20.5 mgd.

5.2.2 EXISTING MONTHLY DEMANDS

Daily production data were summarized into monthly water use and is shown on Figure 5-4. Average monthly water use was 1,913 AF in 2022. Like the historic monthly data analyzed above in Section 5.1.4, maximum monthly water use occurred in August, followed by July. Although Section 5.1.4 shows the FY 2012/13 to FY 2021/22 average minimum monthly water use occurred in February, followed by January then December, the 2022 data is similar in that the minimum monthly water use occurred in December and is followed by January.

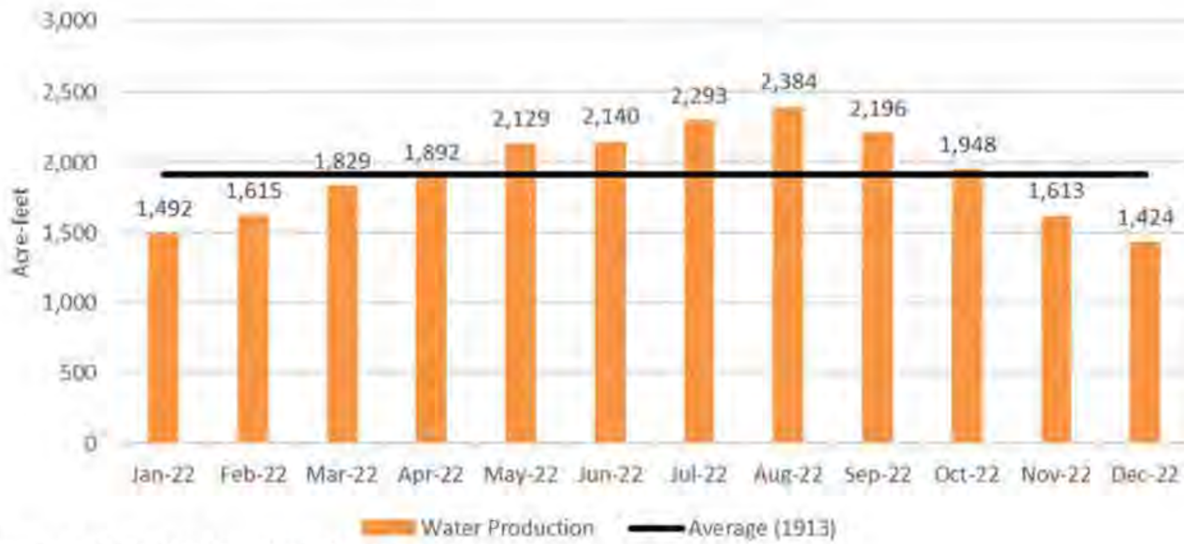


Figure 5-4. 2022 Monthly Demands

The maximum month demand for 2022 is 2,384 AF, occurring in August. To determine the maximum month peaking factor, 2,384 AY is divided by the monthly average of 1,913 AF, resulting in a peaking factor of 1.25, as shown in Table 5-6.

Table 5-6. Monthly Demand Factor

Demand Description	Demand (AF)	Peaking Factor	Notes
Monthly Average	1,913	-	From January 2022 to December 2022
Maximum Month	2,384	1.25	Occurred in August 2022

5.2.3 EXISTING MAXIMUM DAY DEMANDS

Using the 2022 daily production data, ADD and MDD water use were estimated to be approximately 62.9 and 92.4 AF, respectively. The MDD water use occurred on July 4, 2022, as show on Figure 5-5.

Figure 5-5. July to August 2022 Daily Water Production

Table 5-7 shows average and maximum daily water use for year 2022. The peaking factor for the daily maximum water use is 1.47. The daily MDD peaking factor is used in the hydraulic model to estimate maximum day demands for the system.

Table 5-7. Maximum Day Demand and Demand Factor

Demand Description	Daily Demands (AF)	Daily Demands (mgd)	Peaking Factor	Notes
Average Day	62.90	20.50		
Maximum Day	92.44	30.12	1.47	Occurred on July 4, 2022

5.2.4 DIURNAL DEMAND PATTERNS

Hourly SCADA data of the City's production facilities are used to determine the daily diurnal patterns for ADD and MDD conditions. These patterns are applied in the model to create a 24-hour extended period simulation for each condition. Per the most recent annual production data available at the time of the study, year 2022, it was determined that March 15, 2022, ADD was approximately 63 AF, close to the annual 2022 ADD of 62.9 AF. To study the ADD and MDD diurnal patterns, SCADA data was requested for March 15, 2022, and July 4, 2022.

SCADA data of pressure and flow data were available for most facilities. Pump data for pump stations included pressure data; however, most did not include flow data. Flow data for wells was available. Tank water level data were available for all tanks. SCADA data were not available for PRVs in the system. Because of the limited available SCADA data, it was not possible to obtain a diurnal pattern for all pressure zones. Pressure Zone 1, 1A ,1B and 4A had sufficient SCADA data to determine a diurnal pattern for each zone. Pressure Zone 2 and 3 were combined and treated as one zone since pump SCADA data between Zone 2 and 3 was missing. Zones 1C, 2A, 3A, 4, 4A, 4B, 4C did not have sufficient SCADA data, however these zones were like Zone 4A, such that majority of the users were residential customers. Therefore, Zone 4A diurnal pattern was applied to Zones 1C, 2A, 3A, 4, 4A, 4B, 4C. ADD and MDD diurnal patterns were estimated for the following pressure zones:

- Pressure Zone 1
- Pressure Zone 1A
- Pressure Zone 1B
- Pressure Zones 2 and 3 (combined)
- Pressure Zone 4A (used for zones used for 1C, 2A, 3A, 4, 4A, 4B, 4C)

The ADD and MDD diurnal patterns were studied, and it was determined that the ADD diurnal patterns were more representative of typical daily use due to missing data from the MDD SCADA data. Therefore, ADD diurnal patterns are used in the model and in this report for diurnal patterns for all zones. The patterns do not differentiate between residential and non-residential customers because available SCADA data did not allow for that level of analysis. The diurnal patterns include a combination of all land use customers.

5.2.4.1 Diurnal Pattern Zone 1

The City provided meter data in geographical information system (GIS) for 2022 water consumption that attributed to each meter, to determine water use per land use. Data revealed that in Pressure Zone 1, 22 percent of total water use comes from non-residential customers and 78 percent are residential users. Figure 5-6 shows the diurnal pattern for Zone 1 and reflects a more typical residential user diurnal pattern. There is more water used in the morning hours, as people shower, followed by a drop in water use and a little rise in the evening, when people are home from work and use more water. At the peak time, the peaking factor is approximately 1.8, which reflects the PHD factor.

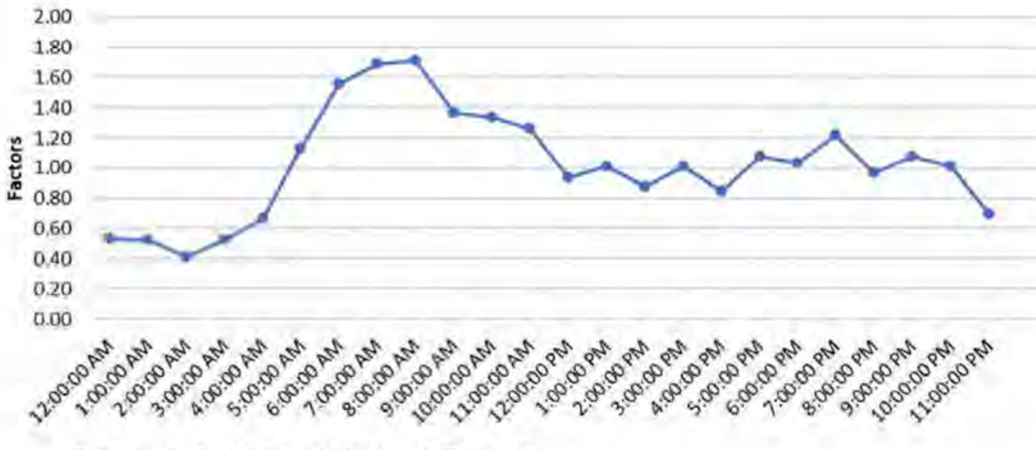


Figure 5-6. Diurnal Pattern Zone 1

5.2.4.2 Diurnal Pattern Zone 1A

The 2022 consumption data combined with the meter data provided in GIS revealed that in Pressure Zone 1A, 42 percent of total water use comes from non-residential users and 58 percent from residential users. Of those non-residential users, 33 percent of water use comes from industrial users, which impacts the pattern of use from a typical residential pattern. Figure 5-7 shows the diurnal pattern for Zone 1A, which is a flat line at a factor of 1, with very small variation. This shows a constant water use for this use with little to no change in usage. The PHD factor is assumed to be 1.0.

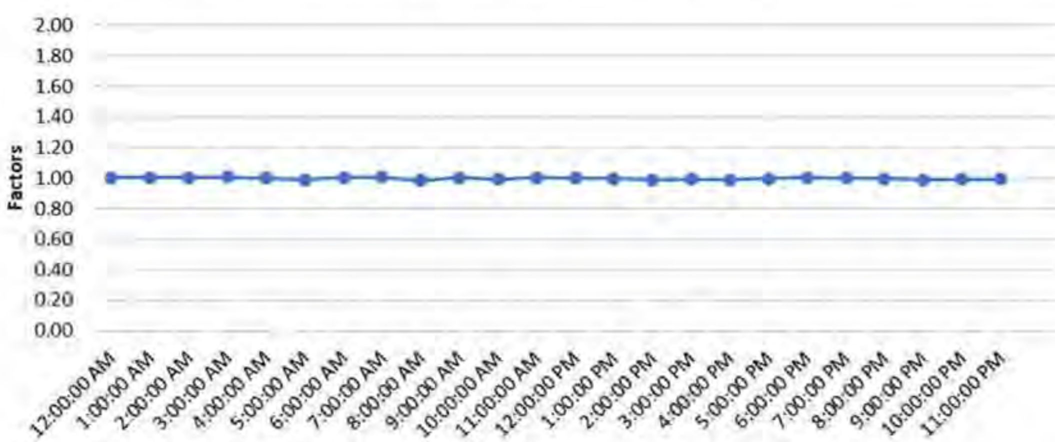


Figure 5-7. Diurnal Pattern Zone 1A

5.2.4.3 Diurnal Pattern Zone 1B

Like Zone 1A, water use in Pressure Zone 1B are split between non-residential and residential, 48 percent and 52 percent, respectively. Of those non-residential users, 35 percent water use is from industrial users. Figure 5-8 shows the diurnal pattern for Zone 1B. There is a slight drop in use between 8:00 AM and 10:00 AM, this could be due to the type of daily water use operations for non-residential or industrial users. The PHD factor is approximately 1.4.

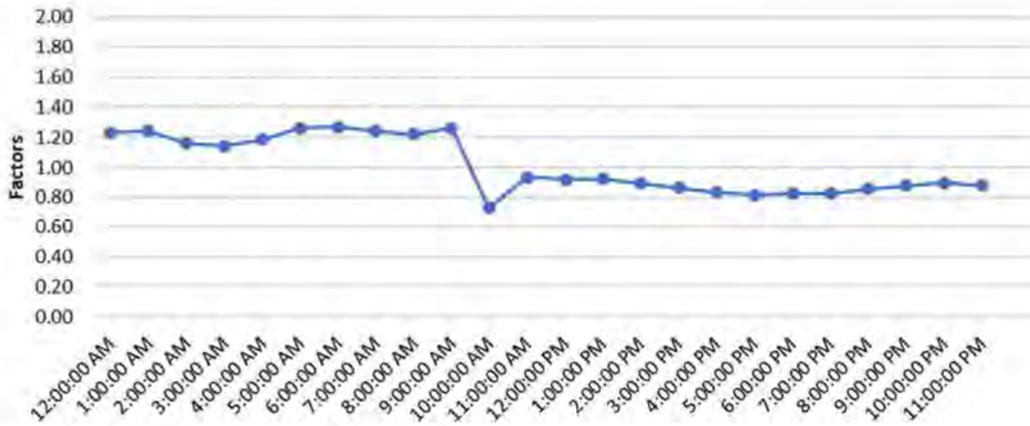


Figure 5-8. Diurnal Pattern Zone 1B

5.2.4.4 Diurnal Pattern Zones 2 and 3

Like Zone 1, Pressure Zones 2 and 3 have most of the water use from residential users, with 75 percent from residential users and approximately 25 percent water use from non-residential users. Figure 5-9 shows the diurnal pattern for Zone 2 and Zone 3, reflecting a more typical residential user pattern. At peak time, the peaking factor is approximately 1.62, which reflects the PHD factor.

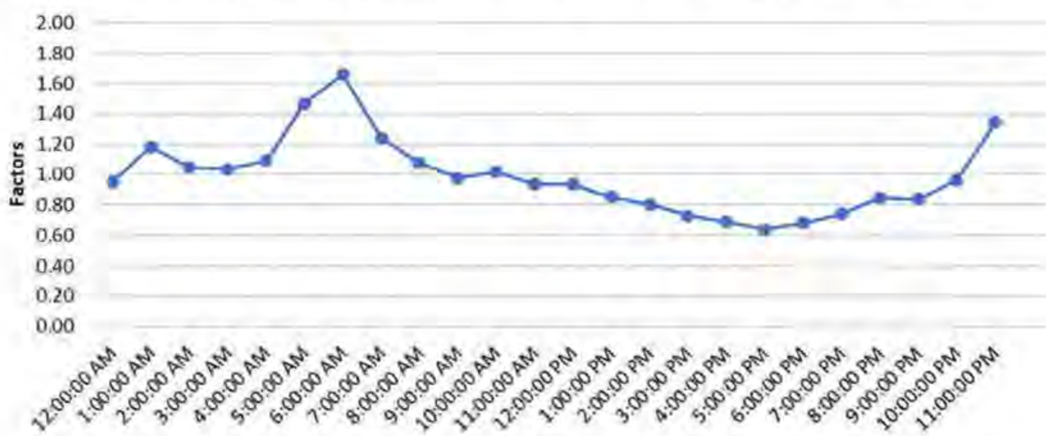


Figure 5-9. Diurnal Pattern Zones 2 and 3

5.2.4.5 Diurnal Pattern Zone 4A

Pressure Zone 4A has mostly residential users: with 85 percent from residential users and 15 percent water from non-residential users. Like Zone 2 and 3, Pressure Zone 4A patterns reflect a typical residential pattern. The peaking factor is approximately 1.97, which reflects the PHD factor. Pressure Zone 4A doesn't include industrial users, and has much lower number or commercial users, which can impact the PHD. Typical industry standard for PHD is approximately 2 times ADD, which is close to what is seen for Pressure Zone 4A on Figure 5-10. Since Pressure Zones 1C, 2A, 3A, 4, 4A, 4B, 4C include similar land uses with a majority of residential water users, the diurnal pattern for Zone 4A can be applied for those zones as well.

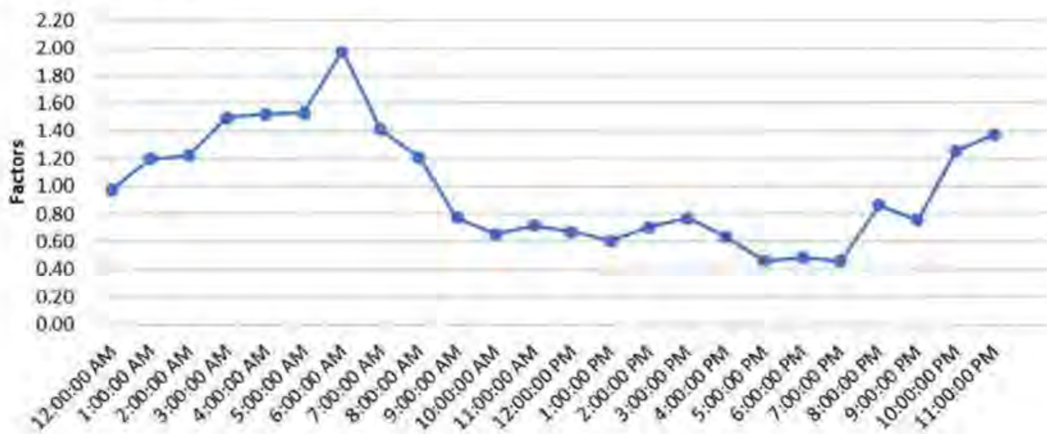


Figure 5-10. Diurnal Pattern Zone 4A

5.2.1 SUMMARY OF PEAKING FACTORS AND EXISTING DEMANDS

Table 5-8 below provides a summary of the resulting existing demands and peaking factors based on the data provided for 2022. The PHD demand factors shown are applied to the MDD for the zone to determine the PHD for that zone.

Table 5-8. Existing Demands and Factors Summary

Demand Description	Existing Demand (mgd)	Maximum Day Demand Peaking Factor
Average Day	20.50	-
Maximum Month	25.05	1.25
Maximum Day	30.12	1.47
Peak Hour Demand:		
Zone 1	-	1.80
Zone 1A	-	1.00
Zone 1B	-	1.40
Zones 2 & 3	-	1.62
Zones 1C, 2A, 3A, 4, 4A, 4B, 4C	-	1.97

5.3 Population Projections

To estimate future demand projections using the population method, population data were obtained from the CDR at California State University, Fullerton. CDR updates the population data annually and the latest data available during the preparation of this Master Plan reflects data published in May 2022, which reflects the 2020 census. Note that population data in the City's 2020 UWMP reflects data from CDR, however that data reflects the 2010 census, and therefore varies from data used in this Master Plan. Figure 5-11 shows a comparison of the population projections of the City's service area per this Master Plan and City's 2020 UWMP. Population projections change annually as more data is available.

Per the 2020 UWMP, based on the 2010 census, population growth was predicted to increase 33.9 percent from 141,648 in 2020 to 189,687 in 2045. This equates to annual population growth of 1.4 percent. However, the population projections in this Master Plan, based on 2020 census, show a projected population growth of 22.4 percent over the same time frame, from 142,070 to 173,936, respectively. This equates to annual population growth of 0.9 percent. Population projections change vastly as time goes on due to shifts in social and economic factors, and population densifies due to housing requirement allocations based on the Regional Housing Needs Assessment (RHNA) and ADU plans within the City.

Figure 5-11. Population Projections

5.4 Future Demand Projections

Various methodologies are available in the industry when projecting future demands. The methodologies evaluated in this Master Plan are based on population growth projections, land use changes based on the City's General Plan, development growth, and historical trends. Also, the demand projections from the City's 2020 UWMP are compared to the projections in this Master Plan. Based on the results from each methodology, a future projection methodology will be recommended.

5.4.1 2020 UWMP Methodology

In the 2020 UWMP, the population projections from the CDR provided a baseline projection for the City. The City revised the population and dwelling unit data developed by CDR to accommodate the growth due to the RHNA allocations of the City (2020 UWMP, Sections 3.4.3 and 3.5). Additionally, as stated in the 2020 UWMP, in 2021, MWDOC and OCWD, in collaboration with member agencies, led the effort to update water demand projections originally done as part of the 2021 OC Water Demand Forecast for MWDOC and OCWD. The updated demand projections were for the Orange County region as a whole and provided retail agency specific demands. The projections span the years of 2025-2050 and are based upon information surveyed from each Orange County water agency. This survey evaluated data for FY 2017/18, FY 2018/19, and FY 2019/20 water use by major sector, including number of accounts.

- For residential projections, water use of gallons per home per day was estimated. Water use was split into indoor and outdoor water use based on: Residential End Uses of Water (Water Research Foundation, 2016); California's plumbing codes and landscape ordinances; and California Department Water

Resources (DWR) Model Water Efficient Landscape Ordinance (MWELO) calculator.

- For commercial, industrial, and institutional (CII) water demands, unit demand from FY 2019/20 was used to estimate demands from 2020 to 2025, since demands have been stable from a unit use perspective (gallons/account/day). From 2030 to 2050, the average CII unit use from FY 2017/18 and FY 2018/19 was used. These unit use factors were then multiplied by an assumed growth of CII accounts under three broad scenarios: low, medium, high. For Fullerton, the mid-scenario was used since medium growth is expected for the City based on the UWMP. Note that the CII projections also accounted for the City's largest single industrial customer closing operations officially on June 30, 2020, and the replacement customer's projected water consumption being notably less.

For a detailed description of the methodology used to project future demands for the City's service area, please refer to the City's 2020 UWMP Section 4.3.1. Table 5-9 reflects the demand projections from the City's 2020 UWMP. It was projected that water use will increase by 16.2 percent by 2045.

Table 5-9. City's 2020 UWMP Future Demand Projections

Year	Existing 2020	2025	2030	2035	2040	2045
Projected Water Consumption (acre-feet)		24,806	26,535	26,649	26,755	26,928
Estimated Non-revenue Water[a] (acre-feet)		849	909	912	916	922
Projected Water Use (acre-feet)	**23,799[b]**	**25,655**	**27,444**	**27,561**	**27,671**	**27,850**
Demand increase (percent)	-	7.8%	7.0%	0.4%	0.4%	0.6%

Notes:
[a] 2020 UWMP assumed 3.4 percent water loss for non-revenue water.
[b] Existing 2020 production data reflects data from the City's 2020 UWMP.

5.4.2 POPULATION PROJECTION METHODOLOGY

This method uses the latest available population projection data (May 2022 CDR) and includes population growth due to RHNA and the addition of ADUs by year 2030. The increase in ADUs implies an increase in number of people per dwelling unit which translates to higher water demand. Per the 2020 UWMP Table 4.5, 39.3 percent of the City's allocated housing needs for the planning period from 2021 to 2029 are considered low-income housing, which is estimated to 3,198 very low income and 1,989 low-income households, totaling 5,187 households. For purposes of this Master Plan, and for conservative purposes to evaluate if the system can handle extreme growth, 5,187 households are assumed to be the number of future ADUs.

The City of Fullerton currently averages 3 people per dwelling unit and with a total of 5,187 additional households by year 2029, it is projected that this will result in an additional 15,561 people by 2030. Future demands were then projected using this updated population and the historical per capita water use of

145 gpcd calculated in Section 5.1.3. The future annual system projected demands are outlined in Table 5-10. Using the population methodology, it is projected water use will increase by 26.9 percent by 2045.

Table 5-10. Demand Projections per Population Methodology

Year	Existing 2022 Production[b]	2025	2030	2035	2040	2045
Population		147,696	151,606	153,996	156,742	158,323
Population including population for ADU			15,613	15,613	15,613	15,613
Total Population		147,696	167,219	169,609	172,355	173,936
Demand per Capita per Day (gpcd)		145	145	145	145	145
Average Daily Projected Water Consumption (mgd)		21.42	24.25	24.59	24.99	25.22
Projected Water Consumption (AF)		23,989	27,160	27,548	27,994	28,251
Estimated Non-revenue Water[a] (AF)		1,199	1,358	1,377	1,400	1,413
Projected Water Use (AF)	**22,956**	**25,188**	**28,518**	**28,925**	**29,394**	**29,663**
Demand increase (percent)	**-**	**9.7%**	**13.2%**	**1.4%**	**1.6%**	**0.9%**

Notes:
[a] This Master Plan assumes 5% water loss, average from FY 2019/20 to FY 2021/22
[b] Existing 2022 production data reflects data from this Master Plan

5.4.3 LAND USE METHODOLOGY

As anticipated, over time, population growth has slowed as the City approaches a completely built-out development. To estimate future water demands using the land use methodology, both existing and future land use are analyzed. Future land use reflects the City's General Plan (GP). Unit demand factors are determined for each existing land use and then applied to future land use to determine future demands. Unit demand factors are water use per day per land use category. In addition, the City currently has planned development projects that provide specific development information and will update the GP. These projects are scheduled to be built in the next few years. Demands for these projects are estimated and added to the near-term planning horizon, in the next five years.

5.4.3.1 Existing and Future Land Use

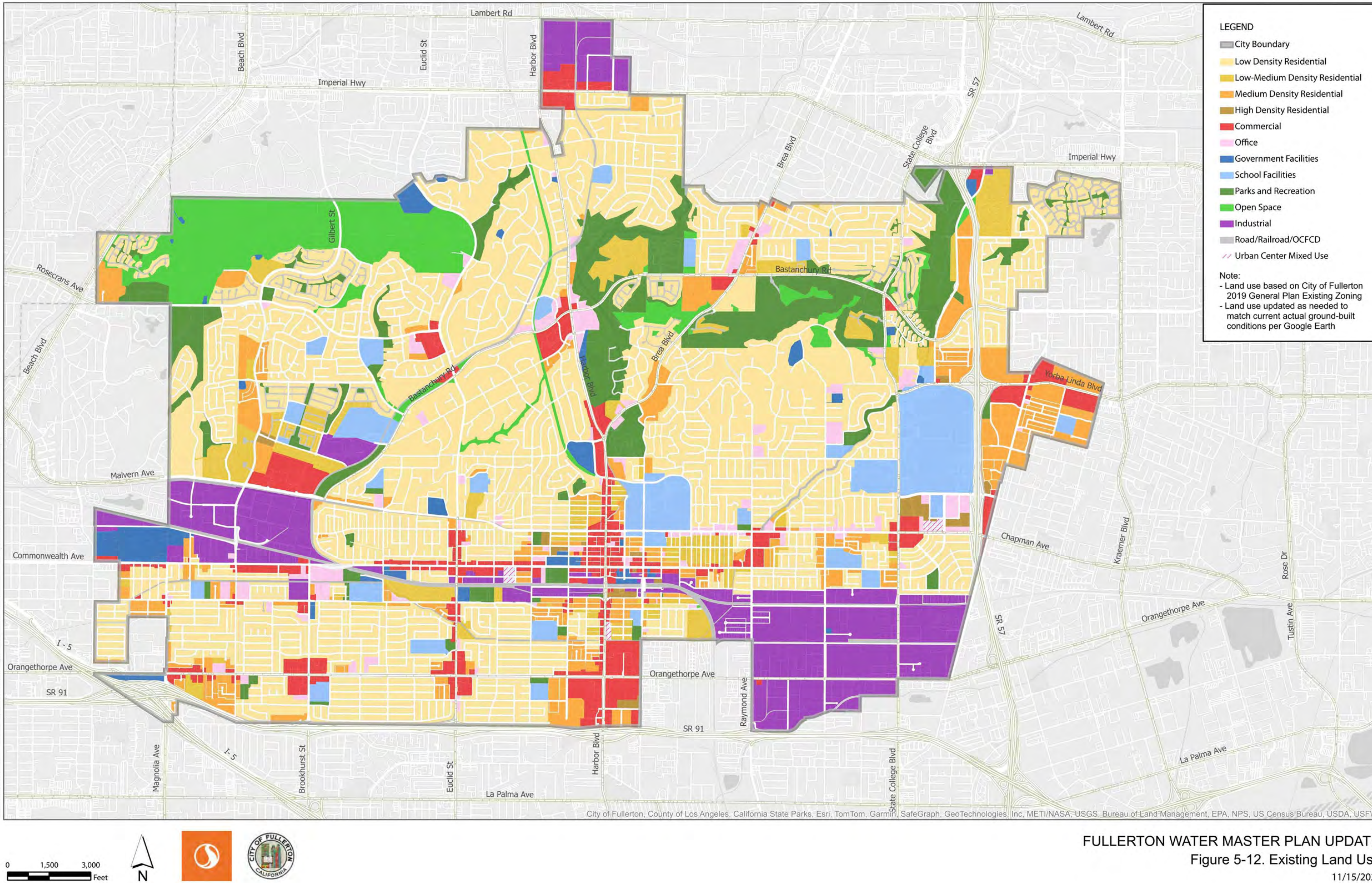
Existing land use information within the service area is based on GIS data provided by the City. Parcels are assigned zoning and general plan land uses based on over 30 land use designations. Since many of these land uses are similar in nature from a water use perspective, the land uses have been consolidated into 15 land use designations as summarized in Table 5-11. This Master Plan focuses on these land uses in determining current and future water demand allocations. Existing and future land uses are shown in Figure 5-12 and Figure 5-13, respectively. Figure 5-14 shows the future land use density increase compared to existing land use.

Table 5-11. Existing and Future Land Use Designation and Area

General Plan/Zoning Land Use	Water Master Plan Land Use Designation	Existing		Future (2045)		Delta
		Area (acres)	Percent	Area (acres)	Percent	Percent
R-1 One-Family Residential R-1-P One-Family Residential, Preservation	Low Density Residential	5,144	43.7%	5,304	45.1%	1.4%
R-2 Two-Family Residential R-2P Two-Family Residential Preservation R-G Garden-Type Multiple Residential R-MH Mobile Home Park	Low-Medium Density Residential	510	4.3%	456	3.9%	-0.5%
R-3 Limited Density, Multiple Family Residential R-3P Limited Density, Multiple Family Residential Preservation R-3R Restricted (Single Story) Multiple Residential R-4 Medium Density, Multiple Residential	Medium Density Residential	857	7.3%	875	7.4%	0.2%
R-5 Maximum Density, Multiple Residential	High Density Residential	53	0.5%	56	0.5%	0.0%
C-3 Central Business District Commercial C-G Commercial Greenbelt G-C General Commercial	Commercial	663	5.6%	600	5.1%	-0.5%
O-P Office Professional Religious Use	Office	257	2.2%	259	2.2%	0.0%
P-L Public Land	Government Facilities	202	1.7%	215	1.8%	0.1%
	School Facilities	661	5.6%	653	5.6%	-0.1%
C-M Commercial, Manufacturing M-G Manufacturing, General M-P Manufacturing Park	Industrial	1,197	10.2%	1,216	10.3%	0.2%
O-G Oil Gas O-S HA Open Space Hillside Area O-S PP Open Space Public Park O-S VP Open Space View Park O-S WH Open Space Wildlife Habitat	Open Space	790	6.7%	136	1.2%	-5.6%
O-S GC Open Space Golf Course O-S PR Open Space Private Open Space	Parks and Recreation	1,084	9.2%	992	8.4%	-0.8%
O-S PU Open Space Public Utility Use Not Zoned - Road Not Zoned - Railroad Not Zoned - Orange County Flood Control District (OCFD)	Road/Railroad/OCFCD	332	2.8%	325	2.8%	-0.1%

General Plan/Zoning Land Use	Water Master Plan Land Use Designation	Existing		Future (2045)		Delta
		Area (acres)	Percent	Area (acres)	Percent	Percent
Urban Center Mixed Use	Urban Center Mixed Use	14	0.1%	34	0.3%	0.2%
Downtown Mixed Use	Downtown Mixed Use	0	0.0%	39	0.3%	0.3%
Greenbelt Concept	Greenbelt Concept	0	0.0%	604	5.1%	5.1%
Total		**11,764**	**100.0%**	**11,764**	**100.0%**	**-**

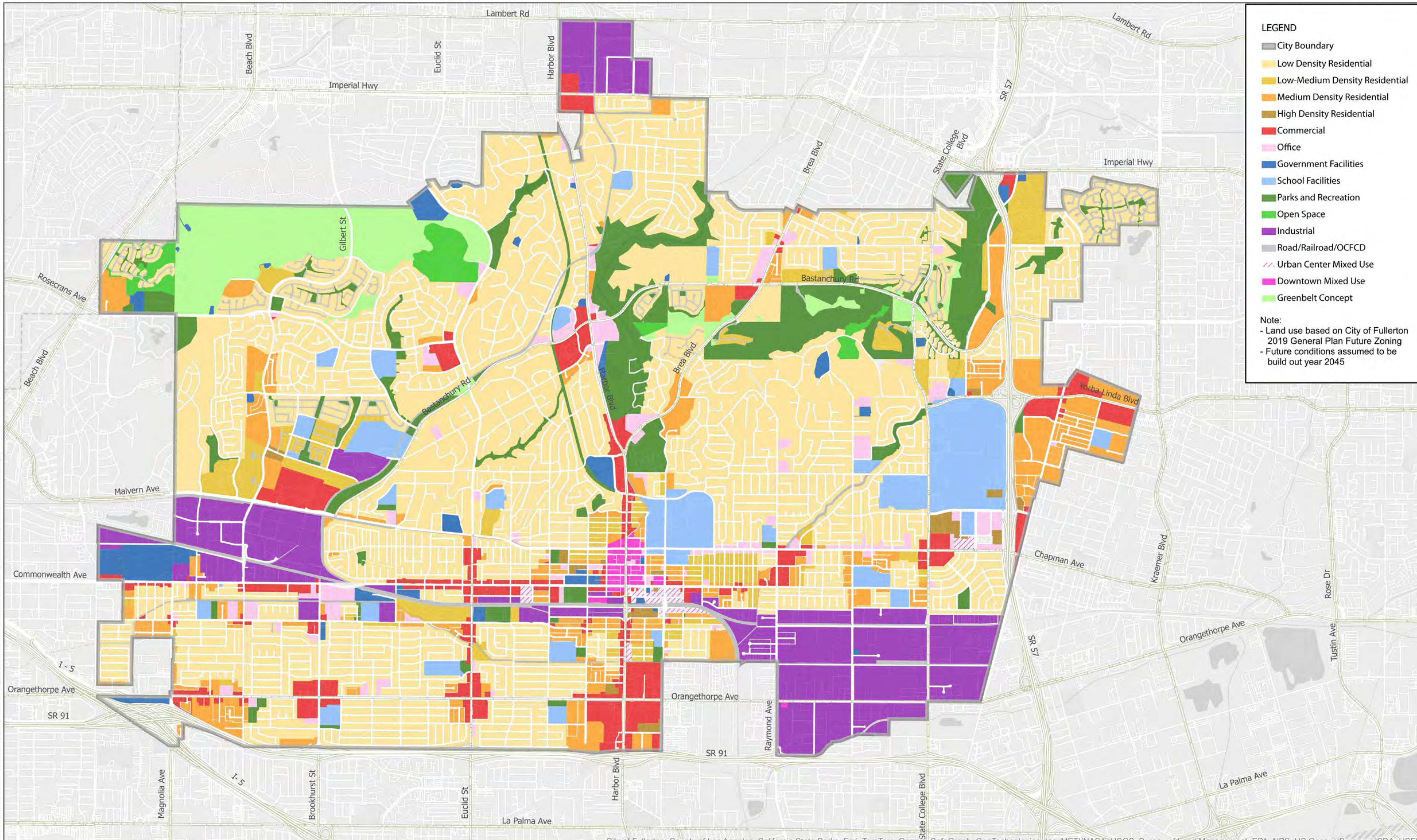
Note:
Although the City is 22.4 sq mi (14,336 ac), the total land use parcel acres do not include all roads and highways.
OCFCD = Orange County Flood Control District



FULLERTON WATER MASTER PLAN UPDATE

Figure 5-12. Existing Land Use

11/15/2024



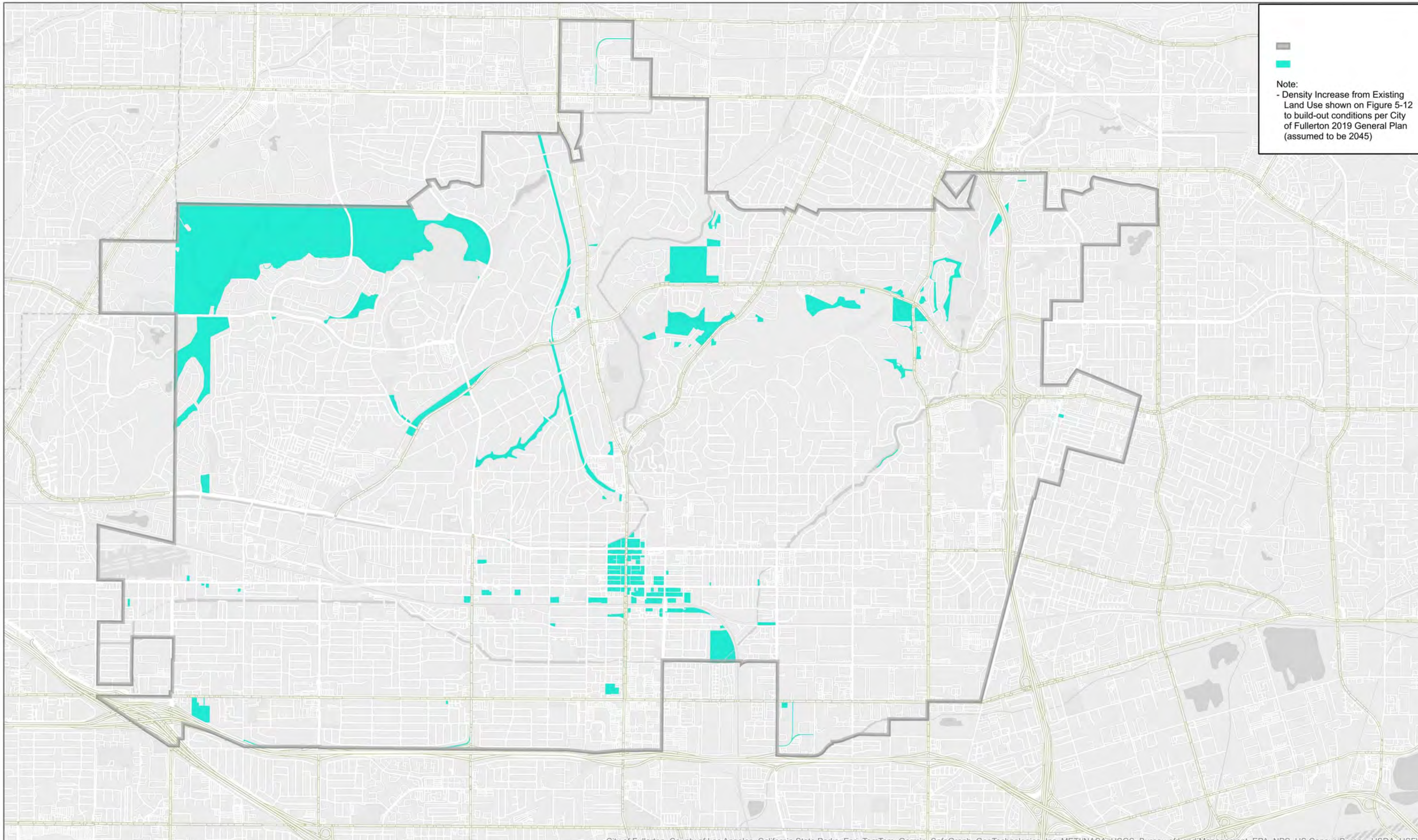
0 1,500 3,000 Feet

N

FULLERTON WATER MASTER PLAN UPDATE

Figure 5-13. Future Land Use

11/15/2024



FULLERTON WATER MASTER PLAN UPDATE

Figure 5-14. Land Use Density Increase between 2019 and 2045

5.4.3.2 General Plan Land Use Demand Projections

Water demands can be projected from existing water use and land use. Existing land use type and 2022 water consumption data was used to estimate water duty or unit demand factors for each existing land use as shown in Table 5-12. For example, the existing water duty factors for Low-Density Residential land use is approximately 1,869 gallons per day per acre (gpd/ac). This factor is multiplied by the land use area at build-out year to estimate future demands. Build-out year is assumed in 2045 for this Master Plan.

For future land use Urban Center Mixed Use (UCMU), Downtown Mixed Use (DMU), and the Greenbelt Concept Project (GCP), land use densities from Table 5 of the GP are used to estimate the unit demand factors, since there is no comparable existing land use. Per the GP Table 5, the maximum density of the UCMU, DMU, and GCP are 80, 60, and 3 dwelling units per acre (du/ac) respectively and the Low Density Residential maximum density is 6 du/ac. To project demands for the UCMU and the DMU, the High Density Residential factor is recommended since the densities per the GP Table 5 are similar. To project demands for the GCP, the factor for the Low Density Residential land use is recommended since the densities per the GP Table 5 are similar with only slight variation in range. The total land use for GCP is 604 acres of which approximately 150 acres has been planned for the West Coyote Hills Project, a long term planned project. The total build-out water demand projection is approximately 24,349 AF, which is about 6.1 percent higher than the 2022 water use of 22,956 AF. Note that this does not include demands from near-term planned development projects. Section 5.4.3.3 describes the addition of demands from near-term planned projects to complete the land use demand projection methodology.

Table 5-12. General Plan Land Use Method Demand Projections

Land Use	Existing Annual (AF)	Gallons per day (gpd)[a]	Existing Land Use (ac)	Existing Unit Demand Factors (gpd/ac)	Build-out Land Use (ac)	Build-out Demands (gpd)	Build-out Demands (AF)
Low Density Residential	10,769	9,614,186	5,144	1,869	5,304	9,913,227	11,104
Low-Medium Density Residential	1,264	1,127,995	510	2,212	456	1,008,560	1,130
Medium Density Residential	4,135	3,691,278	857	4,307	875	3,768,807	4,222
High Density Residential	426	380,370	53	7,177	56	401,901	450
Commercial	1,537	1,372,518	663	2,070	600	1,242,098	1,391
Office	500	445,951	257	1,735	259	449,422	503
Government Facilities	89	79,634	202	394	215	84,759	95
School Facilities	1,038	926,567	661	1,402	653	915,353	1,025
Industrial	1,686	1,505,554	1,197	1,258	1,216	1,529,452	1,713
Open Space (Parks and Recreation)	1,434	1,280,414	1,874	683	1128	770,708	863
Road/Railroad/OCFCD	0	0	332	-	325	0	0
Urban Center Mixed Use	78	69,329	14	7,177[b]	34	244,011	273
Downtown Mixed Use	-	-	-	7,177[b]	39	279,895	314
Greenbelt Concept	-	-	-	1,869[c]	454	848,530	950
West Coyote Hills	-	-	-	-	150[d]	280,351	314
Total Production	**22,956**	**20,493,796**	**11,764**	**-**	**11,764**	**21,737,075**	**24,349**

Notes:
Land use does not include Road/Railroad/OCFCD since water is not produced from this land use.
a Data was based on consumption data, assumed 5% loss to estimate water production and include non-revenue water.
b Urban Center Mixed Use factor of 7,177 gpd/ac is used to estimate duty factor for Downtown Mixed Use land use.
c Low Density Residential factor of 1,869 gpd/ac is used to estimate duty factor for the Green Belt Concept.
d West Coyote Hills project acres is estimated from the 2022 vesting tentative map (VTTM 17609).
GP = General Plan

5.4.3.3 Planned Development Demand Projections

In addition to the GP land uses proposed as shown in Table 5-12 in the previous section, the City's planning department provided details on recent development projects that are updates to the GP information. To estimate demands for these development projects, the existing unit demands per land use are further refined to include residential density, dwelling unit per acre. The City's GP defined land use densities are shown in Table 5-13. The GP provided ranges in densities and floor to area ratio (FAR) per land use. FAR is the measurement of a building's floor area in relation to the size of the lot/parcel that the building is located on.

Table 5-13. General Plan Land Use Density

Land Use	General Plan Table 5 Densities	Floor Area Ratio (FAR)
Low Density Residential	Up to 6 du/ac	Up to .35 FAR
Low-Medium Density Residential	Up to 15 du/ac, min 6.1 du/ac	Up to .35 FAR
Medium Density Residential	Up to 28 du/ac, min 15.1 du/ac	Up to .50 FAR
High Density Residential	no max du/ac, min 28.1 du/ac	Up to .65 FAR
Urban Center Mixed Use	Min Density: 30 dwelling units/acre Max Density: 80 dwelling units/acre	Min FAR: 0.75 Max FAR: 3.0
Downtown Mixed Use	Min Density: 30 dwelling units/acre Max Density: 60 dwelling units/acre	Min FAR: 0.9 Max FAR: 2.0
Greenbelt Concept	Up to 3 dwelling units/acre	NA
Commercial	NA	Min FAR: 0.30 Max FAR: 0.35
Office	NA	Min FAR: 0.30 Max FAR: 0.35
Industrial	NA	Min FAR: 0.30 Max FAR: 0.5

Max = maximum
Min = minimum
NA = not applicable

Per the City's direction, midpoint densities were chosen to define the unit demands shown in Table 5-14 and used to estimate the demand projections for the City's near-term development projects. Note that densities are unknown for these projects and a conservative unit demand was estimated for future ADUs assuming 65 percent of the unit demand for Low Density Residential land use, equating to 276 gpd per dwelling unit (gpd/du). As more ADUs get built and occupied, historical water use for these uses will become available, and the unit factor can be adjusted in the future.

Table 5-14. Unit Demand Factors per Land Use

Land Use	Existing Unit Demand Factors[a] (gpd/ac)	Density[b] (du/ac)	Residential Unit Demand Factor (gpd/du)
Low Density Residential	1,869	4	425
Low-Medium Density Residential	2,212	7	340
Medium Density Residential	4,307	22	200
High Density Residential	7,177	54	133
Residential ADU[c]	NA	NA	276
Urban Center Mixed Use	7,177	54	133
Downtown Mixed Use	7,177	45	159
Greenbelt Concept	1,869	3	425
Commercial	2,070	NA	NA
Office	1,735		
Government Facilities	394		
School Facilities	1,402		
Industrial	1,258		
Open Space (Parks and Recreation)	683		

Notes:
[a] Existing Unit Demand Factors reflect values shown in Table 5-12. These factors can be used to estimate demands for future land use where detailed information including building size and dwelling unit count for the developments are not available.
[b] Densities reflect the midpoint of densities defined in the GP and shown in Table 5-13 except for the Low Density Residential. Existing demands and number of Low Density Residential accounts was used to determine the density for the Low Density Residential category, since these reflect single family homes with one meter serving one dwelling unit.
[c] ADU Unit Demand (gpd/du) is estimated at 65% of Low Density Residential Land Use.
NA = not applicable

The City provided a list of projects with information regarding proposed dwelling units, building size, and land use information as shown in Table 5-15. Estimated planning horizons were also provided by the City in terms of existing, near-term (by 2035) and future (2045 and beyond). This information and the unit demand factors from Table 5-14 was used to estimate the near-term demands from the proposed developments. The near-term horizon reflects year 2035. It is anticipated that by year 2035, an additional 377 AF of water demand will be needed from planned developments.

Table 5-15. City's Near-term (by 2035) Development Projects and Demands

Project Name	Project Land Use	Area (ac)	Unit Factor (gpd/ac)	Dwelling Units (du)	Unit Factor (gpd/du)	Demand (gpd)	Demand (acre-feet)
Shoe City Billboard	Commercial	6.62	2,070	NA	NA	13,704	15
Commercial Remodel on W. Commonwealth							
Remodel of Bowling Alley							
New Restaurants on Santa Fe Ave							
Parkwest Project	Downtown MU	4.44	7177	140	159	54,126	61
Fox Block							
Fullerton Fox Theatre							
Fox Block Mixed-Use Development							
245 N. State College Blvd.	High Residential	NA	NA	485	133	64,505	72
The Hub							
Casa Bella							
Pathways of Hope							
Rexford Industrial Project – 1500 S. Raymond	Industrial	20.6	1,258	NA	NA	25,935	29
Rexford Industrial Project – 1901 Via Burton							
Acacia and Kimberly Industrial project							
Truck yard							
737 N Highland Avenue	Low Residential	NA	NA	17	425	7,225	8
Subdivision on Ladera Vista							
Parcel Map on Valley View							
New Mixed-Use Development, Streetlights	Medium Residential	NA	NA	405	200	81,000	91
321 E. Amerige Avenue							
Pointe Common							
New Residential Townhomes							
Law Office on E. Amerige	Office	1	1,735	NA	NA	1,735	2
Southwest corner of Orangethorpe and Brookhurst	Urban MU	8.26	7177	216	133	88,010	99
Hillcrest Project							
The Pines							
Total		**88**		**1,263**		**336,241**	**377**

Note:
Near-term planning horizon reflects year 2035.
NA = not applicable

5.4.3.4 Land Use Methodology Demand Projections

This section summarizes the demands projected from the changes in land use, reflecting the GP, the contribution of the 377 AF of water from planned developments and demands from future ADUs. For purposes of this Master Plan and as described earlier in Section 5.4.2 herein, 5,187 households are the number of future ADUs. To project future water demands from ADUs, the 5,187 units are multiplied by the unit factor for ADU, which is 276, as shown in Table 5-14. Total demand projections are shown in Table 5-16, by planning year from 2025 to 2045, at every 5-year increment. It is projected water use will increase by 13.4 percent by 2045.

Table 5-16. General Plan Land Use Method Demand Projections by Planning Year

	Existing 2022	2025	2030	2035	2040	2045
GP Land Use Method Demand Projections	22,956	22,662	23,411	23,743	24,130	24,349
Near-term Planned Projects		377	377	377	377	377
ADU Projects		1,604	1,604	1,604	1,604	1,604
Projected Water Use (acre-feet)	**22,956**	**24,643**	**25,392**	**25,724**	**26,110**	**26,329**
Demand increase % (assumed similar rate as population methodology)		6.8%	3.0%	1.3%	1.5%	0.8%

GP = General Plan

5.4.4 HISTORICAL DEMAND METHODOLOGY

Demand projections can also be estimated using historical water demand trends. For this method, FY 2015/16 to FY 2021/22 were used. Figure 5-15 features a graph of the historical demand from the early 1970s and its trendline, showing an overall decreasing trend in demand. The trendline is then projected to forecast demand to the year 2045, which is approximately 25,000 AF.

Figure 5-15. Historical Demand Trend

5.5 Summary of Demand Projections

A comparison of projected water demands from methodologies based on the 2020 UWMP, land use, population, and historical demands are shown in Table 5-17 and Figure 5-16.

- The population methodology demand projections align with the 2020 UWMP demand projections for 2030, however the population methodology projects higher demands in 2045.
- The land use methodology demand projections are lower than the 2020 UWMP and the population methodology projections. Future land use reflects the average densities as defined in the City's GP and does not consider the increase in population intensification.
- The historical trend line is showing a drop in demand and is based on historical population trends remaining consistent in the future. Additionally, not enough historical data was analyzed to adequately predict the future demands.

Table 5-17. Summary of Demand Projections

Methodology	2025	2030	2035	2040	2045	2020 - 2045 Percent Delta
	AFY					
City's 2020 UWMP Future Demand Projections	25,655	27,444	27,561	27,671	27,850	+16.2%
Demand Projections per Population Methodology	25,188	28,518	28,925	29,394	29,663	+26.9%
Land Use Method Demand Projections	24,643	25,392	25,724	26,110	26,329	+13.4%
Historical Demand Projection					25,000	

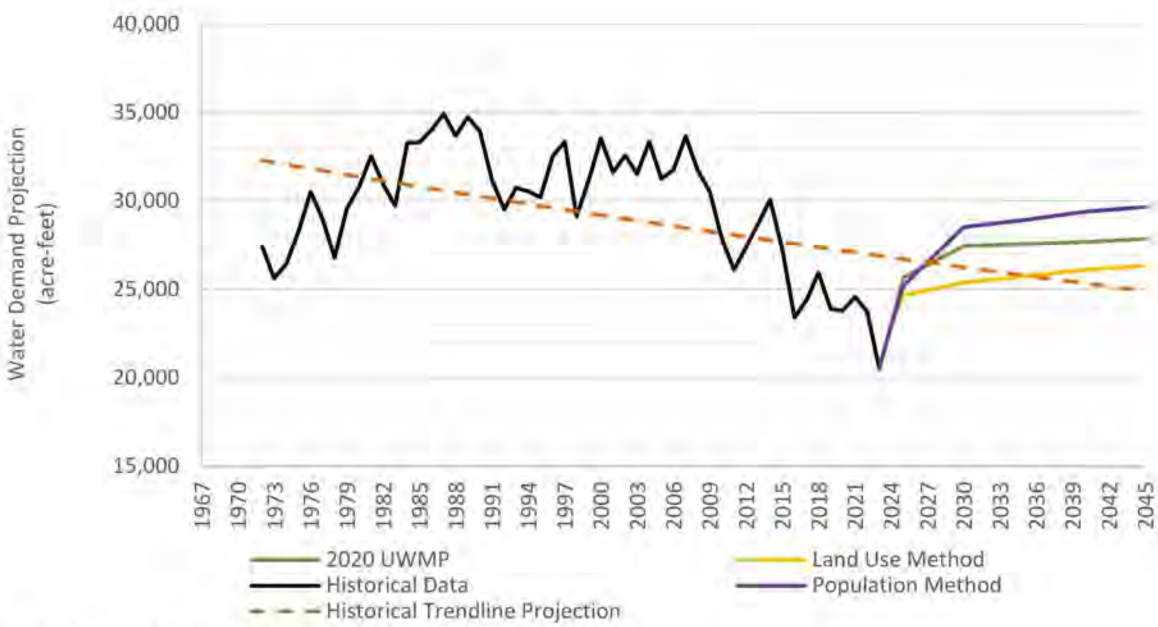


Figure 5-16. Graph of Demand Projections

5.6 Recommended Future Water Demand Projections

The 2020 UWMP included a thorough analysis of the demand projections and reflected the 2021 Orange County Water Demand Forecast for MWDOC and OCWD study, considering indoor and outdoor water use as well as RHNA allocation requirements. The 2020 UWMP projections fall between the population and the land use projections, validating that they are neither too conservative nor too aggressive. The demand projections from the 2020 UWMP are recommended for this Master Plan.

5.7 Drought Regulations and Water Conservation

The changing climate requires Californians to adopt permanent changes to make conservation a way of life, using water more wisely to prepare for more frequent periods of limited water supply.

5.7.1 DROUGHT REGULATIONS

On October 19, 2021, Governor Newsom expanded the drought emergency statewide, including Orange County, to reduce water consumption by 15 percent due to drought conditions in northern California and along the Colorado River. The 15 percent water conservation was voluntary, but standard conservation measures were enforced.

On January 4, 2022, the State Water Board adopted an emergency water use regulation. The water conservation requirements are as follows and available on State Water Resources Control Board (SWRCB) website:

<u>Effective until December 2023:</u>

1. Prohibited for all Californians prohibition on wasteful water uses remains in effect:
   - Outdoor watering that lets water run onto sidewalks and other areas (except incidental runoff)
   - Washing vehicles without an automatic shutoff nozzle
   - Washing hard surfaces like driveways or sidewalks that don't absorb water
   - Street cleaning or construction site preparation
   - Filling decorative fountains, lakes, or ponds without a recirculation pump
   - Outdoor watering within 48 hours after at least 1/4 inch of rainfall
   - Watering decorative grass on public medians
2. Additional requirements for Urban Water Suppliers
   - Follow all prohibitions listed in Item 1
   - If needed, exercise authority to adopt more stringent local conservation measures

On May 24, 2022, in response to Governor Newsom's March 28, 2022, Executive Order N-7-22, the State Water Board adopted an emergency water use regulation to endure more aggressive conservation by local water agencies across the state. The water conservation requirements are as follows and available on SWRCB's website: ***All urban water suppliers to implement conservation actions under Level 2 of their Water Shortage Contingency Plans.***

<u>**Effective until June 2024:**</u>

1. Prohibited for all Californians, for commercial, institutional, and homeowners' association (HOA) common areas

- Watering decorative grass in commercial, industrial, and institutional areas, including common areas of HOAs. Note: You may also be a customer of a local water supplier that adopted different and/or stricter water conservation measures; check with your supplier about its current restrictions.

2. Additional requirements for Urban Water Suppliers

- Follow all prohibitions listed in Item 1
- If needed, exercise authority to adopt more stringent local conservation measures

On March 24, 2023, Governor Newsom's Executive Order (N-5-23), reduced emergency drought requirements. This did not immediately terminate current State Water Board water conservation emergency regulations. The State Water Boards emergency regulations are still in effect except ***for urban water suppliers, statewide Level 2 demand reduction actions are no longer required.*** The requirement for urban water suppliers to implement demand-reduction actions that correspond to at least Level 2 of their water shortage contingency plans is no longer in effect since June 5, 2024. Local water suppliers may adopt different and/or stricter water conservation measures.

On June 7, 2024, the Fullerton City Council adopted Level 2 (20 percent conservation) of the Water Shortage Contingency Plan. Per the City's website, the following mandatory water use restrictions have been in effect since June 10, 2024:

- No watering lawns on Sundays. Even addresses water on Monday, Wednesday, and Friday. Odd addresses water on Tuesday, Thursday, and Saturday.
- Prohibit watering lawns on all days between the hours of 9:00 am and 6:00 pm.
- Prohibit using a hose to wash down paved surfaces such as sidewalks, driveways, and parking areas.
- All leaks from indoor and outdoor plumbing fixtures shall be promptly repaired.
- Must use a shutoff nozzle to wash a motor vehicle.

5.7.2 WATER CONSERVATION

Per the City's 2020 UWMP, the City met its 2020 water use target and complies with SBx7-7 (Senate Bill 7 as part of the Seventh Extraordinary Session), which was signed into law in 2010 and requires the State of California to reduce urban water use by 20 percent by 2020 from a 2013 baseline. Per City's 2020 UWMP, the reported 2020 consumption was 111 gpcd, well is below its 2020 target of 179 gpcd.

The City works closely with MWD and MWDOC to promote regional efficiency by participating in the regional water savings programs, leveraging MWDOC local program assistance, and applying the findings of MWDOC's research and evaluation efforts.

Section 9 of the City's 2020 UWMP reports the role of City programs in meeting new state regulations for complying with the SWRCB new Conservation Framework. The categories of demand management measures are as follows and detailed description is provided in the City's 2020 UWMP:

Water waste prevention ordinances are in accordance with Ordinance No. 3118 (2008) and Ordinance No. 3299. Ordinance No. 3118 was replaced On June 1, 2021. The City Council adopted Ordinance No. 3299, an updated Water Conservation Planning Ordinance. Prohibited uses include the following:

1. Water Waste Prevention Ordinances

   - Permitting the excess use or loss of water through leaks, breaks or malfunctions from indoor and outdoor plumbing fixtures
   - Water runoff from landscaped areas into adjoining streets, sidewalks, or other paved areas due to incorrectly directed or incorrectly maintained sprinklers or excessive watering
   - Cleaning, filling, or maintaining levels with potable water in decorative fountains, or other similar aesthetic structures, unless such water is part of a recirculating system
   - Washing motor vehicles, trailers, boats, and other types of mobile equipment with hose not equipped with a positive shutoff nozzle for quick rinses
   - Hosing off paved surfaces such as sidewalks, driveways, and parking areas, except as required for health and safety purposes
   - Outdoor watering of turf areas and other landscape areas with potable water during and within 48 hours after measurable rainfall
   - Irrigating ornamental turf on public street medians
   - Hand watering of plants and trees is encouraged during the early mornings and evenings

2. Metering

3. Conservation pricing

4. Public education and outreach

5. Programs to assess and manage distribution system real loss

6. Water conservation program coordination and staffing support

7. Other Demand Management Measures (DMM) that have a significant impact on water use as measured in gpcd, including innovative measures, if implemented

8. Programs to assist retailers with Conservation Framework Compliance

6.0 Planning and Evaluation Criteria

Planning and evaluation criteria provide a means by which the hydraulic performance and reliability of an existing system can be evaluated, and for planning of facilities to meet future system conditions and demands. Criteria has been recommended based on established criteria in the City of Fullerton Public Works Department Water Utility Specifications published in April 2022 as well as AWWA guidelines for potable water system planning, as summarized in Table 6-1.

Table 6-1. Summary of Planning Criteria

Potable Water Unit Demand Factors	Unit Demand Factors (gpd/acre)	Density (du/ac)	Residential Unit Demand Factor (gpd/du)
Low Density Residential	1,869	4	425
Low-Medium Density Residential	2,212	7	340
Medium Density Residential	4,307	22	200
High Density Residential	7,177	54	133
Residential ADU	NA	NA	276
Urban Center Mixed Use	7,177	54	133
Downtown Mixed Use	7,177	45	159
Greenbelt Concept	1,869	3	425
Commercial[a]	2,070	NA	NA
Office	1,735		
Government Facilities	394		
School Facilities	1,402		
Industrial	1,258		
Open Space (Parks and Recreation)	683		
Potable Water Distribution System	**Value**	**Unit**	
Minimum Pipeline Diameter	8	inch	
Average Day Velocity	<5	fps	
Peak Hour Velocity	<7.5	fps	
Max Day + Fire Flow Velocity	<15	fps	
Maximum Pressure	120	psi	
Minimum Pressure for Peak Hour	40	psi	
Minimum Pressure for MDD + Fire Flow	20	psi	
Fire Flow	**Value**	**Unit**	
Low Density Residential, Low-Medium Density Residential	1,500	gpm	
Medium Density Residential, High Density Residential	2,500	gpm	
Commercial[a]	3,000	gpm	
School Facilities	3,500	gpm	
Industrial	4,000	gpm	
Storage	**Value**	**Unit**	
Emergency Storage	1 x MDD	mg	
Operational Storage: *Low* and *Low-Medium Density Residential*	0.18	mg	
Operational Storage: *Medium and High Density Residential*	0.45	mg	
Operational Storage: *Commercial*[a]	0.54	mg	
Operational Storage: *School Facilities*	0.63	mg	
Operational Storage: *Industrial*	0.96	mg	

Notes:
[a] Includes commercial, office, government facilities, and parks and recreation land uses
fps = feet per second
NA = not applicable

6.1 Water Distribution System Criteria

Multiple water sources are recommended in combination with adequate emergency reserve either in gravity or pumped reservoir storage, and or groundwater pumping, equipped with emergency power sources to maintain pumping capacity. As much as possible, all water distribution system mains should be looped for reliability and fire protection. Dead-end mains with more than two fire hydrants are generally not acceptable to the City, except in phased development projects or where no potential for future interconnection of facilities exist. Approved dead-end mains that will not serve fire hydrants may be sized as hydraulically appropriate in residential areas and no less than 8-inches in diameter in commercial areas.

Pipeline Diameter: Pipe sizing and construction should be in accordance with the latest version of the City of Fullerton Public Works Department Water Utility Specifications. Unless otherwise specified by the Public Works Department, distribution water mains should be polyvinyl chloride (PVC) C900. If ductile iron is proposed, polyethylene encasing should be used. Water distribution pipeline diameter should be sized as required hydraulically to service meters and should be no smaller than 4-inches. However, the minimum pipeline diameter is 8-inches for fire hydrants service. All pipelines should be designed and sized for peak hour demands or MDD plus fire flow conditions, whichever is greater. The City does not use 10-, 14-, and 20-inch-diameter pipelines.

Pipeline Velocities: Maximum velocity in pipelines should not exceed 7.5 fps with certain exceptions such as pipes near pump stations or other supply facilities. However, the maximum velocity for MDD plus fire flow is 15 fps. Pipeline evaluation criteria are summarized in Table 6-2.

Table 6-2. Pipeline Velocity Evaluation Criteria

Operating Condition	Desired Range (fps)	Marginal Range (fps)	Deficient Range (fps)
Average Day Demand	Up to 5	5 to 7	Over 7
Peak Hour Demand	Up to 7	7 to 10	Over 10
Maximum Day Demand plus Fire Flow Analysis	Up to 15	-	Over 15

System Pressures: A municipal water system should be capable of providing a minimum of 40 psi service pressure for average day, maximum day, and peak hour demand conditions. Maximum service pressures should not exceed 120 psi. The minimum residual pressures during a fire flow event at fire hydrants should be greater than or equal to 20 psi based on flow requirements shown in Table 6-1.

6.2 Storage Criteria

The storage necessary for reliable potable water system operation is divided into three categories: emergency, operational, and fire flow emergency storage. These storage volumes are typically provided in system storage (reservoirs). Regional emergency storage is provided through the Orange County groundwater basin and MWD. In specific planning studies, the criteria can vary. A detailed discussion of when and how these criteria should be applied is presented below.

Emergency Storage Requirements. Emergency conditions will occur occasionally in all water systems. These emergencies can be either regional (typically source of supply outages) or localized (pipe, pump, or electrical failures). Demands can be met under these conditions provided provisions are made for appropriate emergency supply and/or storage. For this Master Plan, emergency storage is based on the volume required for one MDD.

Where two sources of supply to a pressure zone are available, the emergency storage requirement may be met from another zone such as pressure reduced from a higher pressure zone through a PRV or pumped up from a lower pressure zone. If emergency supply from another zone needs to be pumped, then the pump station must be equipped with emergency backup power. If two sources of supply are not practical, then the zone should have sufficient storage to meet all emergency criteria with the supply out of service. Storage should be within the pressure zone or can flow from higher pressure zone storage.

Operational Storage Requirements. Storage is typically provided in each pressure zone to balance the differences between the rate of supply and the hourly demand variation on a maximum day. Operational storage is also referred to as equalization storage.

Typically, the storage facility is replenished during hours when the demand is less than the supply rate and usually occurs in the night-time hours. For this Master Plan, the operational storage requirement is based on 30-percent of MDD.

Fire Flow Storage Requirements: Fire flow storage is based on the requirements in Table 6-3 and is a function of the required fire flow rate times duration.

Table 6-3. Fire Flow and Fire Storage Requirements

Land Use	Fire Flow (gpm)	Duration (hours)	Storage (MG)
Low Density and Low-Medium Density Residential	1,500	2	0.18
Medium and High Density Residential	2,500	3	0.45
Commercial[a]	3,000	3	0.54
School Facilities	3,500	3	0.63
Industrial	4,000	4	0.96

Note:
[a] Includes commercial, office, government facilities, and parks and recreation land uses

The fire storage volume provided for each pressure zone or storage service area should be based on the largest fire flow requirement for all the land uses within the zone or service area. Zones 1, 1A, and 1B include industrial land use as the largest fire flow requirement and would require a storage volume of 0.96 MG. Zone 2 includes school facilities land use as the largest fire flow requirement, with a storage volume requirement of 0.63 MG. The largest fire flow requirement in Zone 3 is commercial land use, requiring a storage volume of 0.54 MG.

6.3 Pumping Criteria

Booster pump stations must be capable of pumping the design flow rate with the largest pumping unit out of service. Therefore, a backup or stand-by pump is to be provided, equal to the largest pump in the station. The design flow rate should meet MDD for the zone being pumped to but will depend on whether there is adequate storage for operational and fire flow requirements. The pump station should be equipped with a permanent backup power source. A portable generator can also be considered acceptable as a backup power source for the station. However, portable generators should be considered on a case-by-case basis for each station and coordinated with operations to determine response times and number of portable generators required.

7.0 Model Development and Calibration

The City requested a new hydraulic model be created to reflect a one-to-one pipe relationship with their GIS data. Autodesk's InfoWater Pro 2023.3 software was used to develop and calibrate the new hydraulic model. A one-to-one model was built using the latest GIS database provided by the City (2022). The model was further updated to include projects currently in construction and improvements completed since 2022 based on as-built plans also provided by the City. The demands allocated in the model were assigned based on City water meter data from 2022. Additional details about the model development are summarized in Appendix C.

The hydraulic model was calibrated for both steady-state (SS) analysis and extended period simulation (EPS). Model calibration is the process of comparing model results with field results and adjusting model parameters where appropriate until the model results closely match corresponding field measurement data, within an acceptable difference of 10 percent. The goal is to calibrate the model to MDD conditions. An accurately calibrated model improves predicted system performance, which can then be used to identify system deficiencies, evaluate emergency scenarios, and make recommendations to improve system performance.

To calibrate the SS model, the water system is stressed by opening fire hydrants in the field at strategic locations. Actual system performance is then used to calibrate the model's supply sources, static pressures, pipe diameters and friction losses under extreme flow conditions. For this project, fire hydrant tests were conducted at 19 locations throughout the City in July 2023. Two of the locations (Tests 8 and 10) are within a subzone and were tested twice to evaluate the system with one or two PRVs active. As such, a total of 21 fire hydrant flow tests were evaluated. For each of the 21 tests, the static and residual pressures of the model results are compared with those of the field measurements, where a total of 42 data points were compared. The model was calibrated to match field static and residual pressures, as well as flow data, by adjusting the roughness coefficient (C-factor) of the system pipelines. Approximately 88 percent of the data points showed the model to be within the accepted 10 percent variation of the field records. The remaining 12 percent (6 data points) are evaluated and discussed in Section 3.2 of Appendix C.

The EPS calibration was performed for a 24-hour period for SCADA from July 4, 2022, which was during a historical MDD condition for the entire system. The model results of each facility were compared with actual data provided by the City from their SCADA data. The comparison of hourly model results versus SCADA data was performed to determine that the model reflects the actual system operating conditions. City SCADA data was limited and not available for all facilities. Several workshops were held with the City operations staff to verify facility controls and operations, including those that did not have SCADA. The EPS model calibration was within the accepted 10 percent difference.

Details about the SS and EPS calibrations are summarized in Appendix C, which also includes calibration data, graphs, and tables.

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8.0 Water System Evaluation

The new calibrated model was used to evaluate the City's water distribution system for three different demand conditions: existing, near-term reflecting a 10-year planning horizon, and future reflecting a 20-year planning horizon. The water distribution system was evaluated under normal operating and supply conditions to determine areas of low-pressure, high-pressure, and high velocity under ADD and MDD conditions. In addition, the distribution system was also evaluated under MDD plus fire flow conditions. Storage requirements, well pump capacity, and booster pump station capacity were evaluated for each planning horizon. It should be noted that interconnects are available for temporary emergency situations if needed but are not included in the existing system evaluation as these scenarios are geared towards self-sufficiency and reliability on the City's system.

8.1 Existing System Evaluation

The existing system evaluation was based on the City's existing normal operating conditions. The system was evaluated for a duration of 24-hours, under ADD and MDD conditions. The existing ADD is 20.5 mgd and the existing MDD is 30.1 mgd. Refer to Section 5.2 for calculation of the existing ADD and MDD.

8.1.1 SYSTEM PRESSURES

The water distribution system evaluation results in areas with low-pressure and high-pressure demand nodes, which represent one or more meters or appurtenances in the vicinity, are discussed below.

8.1.1.1 Low Pressure Areas

The system was evaluated based on the City's minimum pressure criteria of 40 psi. Table 8-1 lists the areas having low pressure, and Figure 8-1 shows where low pressures below 40 psi are located.

- Low pressure areas L1, L2, L5, and L6 are located in upper elevations of pressure zones. The City has not had any low-pressure complaints in these areas, thus far. However, the City should be on alert for any future low-pressure complaints and monitor pressures in these areas.
- Area L3 is a meter that serves a landscape area. This meter requires an individual booster pump to provide adequate irrigation pressures.
- Area L4 includes several meters where the model indicates low pressures between the hours of 1:00 am and 11:00 am. The meters in the area supply single family residential properties, where respective pressure zone demand diurnal patterns are applied, and high irrigation demand is used during this time frame. This area may need further monitoring and evaluation. Note the low pressures improve when MWD import connection F-06 is adjusted to increase flow. It is recommended that the City verify if there are low-pressure complaints and to monitor the pressures in the area.

Table 8-1. Existing System Low-Pressure Areas

Pressure Zone	Area No.	Location	Min Pressure (psi)	Modeling Note
1	L1	Vista Verde Dr	39	One hour, at hour 24
2	L2	Deerpark Dr & Amherst Ave	38	One hour, at hour 6
	L3	St College Blvd	28	All 24 hours – Landscape Meter
3	L4	Harrison Circle	23-38	Several nodes, near F-06, hours 1-11
	L5	Armstead Lane & Atherton Cir	30-33	Several nodes, hours 4-7
	L6	Hermitage Dr & Applewood Cir	34-39	Several nodes, hours 4-7

8.1.1.2 High Pressure Areas

The system was evaluated based on the City's maximum pressure criteria of 120 psi. It should be noted that any meter with pressure above 80 psi requires a pressure regulator. Table 8-2 lists areas of high pressure, and Figure 8-1 shows where pressures above 120 psi are located. Each of the areas are discussed below:

- Area H1 includes multiple meters that serve a commercial area in the lower portion of Zone 2, between Gilbert Street and Bastanchury Road and north of Malvern Avenue. The high pressures are above the 120 psi criteria with a maximum static pressure of 132 psi. To mitigate these pressures a small subzone can be created for this service area. Two PRVs can be constructed to create a Zone 2B with an HGL of 395 feet with a minimum pressure drop of 11 psi. The two PRVs can be installed at the intersection of N Gilbert Street and Windsong Way and at the intersection of Nicolas Way and Cusick Lane. A zone break valve would be needed at Starbuck Street and Chaffee Street. All proposed improvements are shown on Figure 8-2.
    - An alternative improvement was also evaluated by converting Area H1 to the lower zone, Zone 1B. For this alternative Area H1 would connect to Zone 1B to the west by installing a pipeline across N Gilbert Street near the intersection of Windsong Way to the south by installing a pipeline along Crossroads Way at the intersection of W Malvern Avenue, crossing the Brea Creek. However, the proposed pipeline crossing the Brea Creek would present multiple obstacles including, but not limited to, Orange County Flood Control District permitting, private property easements, trenching underneath the channel or constructing a pipe bridge, and traffic control at a busy intersection. Moreover, converting Area H1 to Zone 1B would create a significant pressure drop (approximately 70 psi) from what customers are now accustomed to and may create challenges for their existing operations and fire sprinkler systems. As such, the alternative improvement is not recommended for this Master Plan but could be further explored by the City and communications with the commercial area customers.

- Area H2 includes numerous meters that serve residential properties in the northwest corner of the City's water distribution system in Zone 3, north of Rosecrans Avenue and served by the Hawks Pointe 3C Reservoir. To mitigate these pressures, a small sub-zone can be created, identified as Zone 3B with an HGL of 440 feet. A new 8-inch diameter pipeline is proposed to be installed on Emery Ranch Road and Muir Trail Drive, parallel to the existing pipeline. The existing parallel line would remain as a dedicated transmission main to supply the Hawks Pointe 3C Reservoir. Two PRVs would be added from Rosecrans Avenue, one at the intersection of Emery Ranch Road and the other at approximately 550 feet east of Emery Ranch Road. In addition, the laterals from the existing parallel line would be moved over to the new 8-inch pipeline. All proposed improvements are shown on Figure 8-2. Although the evaluation was conducted for the existing system, these proposed improvements are recommended as a long-term Capital Improvement Project.
- Area H3 includes several meters that serve residential properties at three separate areas within Zone 4A. Area H3 is located within Zone 4A, which is a pressurized zone supplied only by the Upper Acacia BPS. Static pressures in this area exceed the criteria of 120 psi and are up to 132 psi. As shown in Table 8-2, the MDD pressures are higher than the static pressures because of the pumping operations of the Upper Acacia BPS. The pump station is oversized for the pressure zone's normal daily demands. It's recommended to downsize the pumps and add a hydropneumatic tank. Although some of the high pressures are mitigated with the pump station improvements, there are still high-pressure meters along Rocky Road north of Pioneer Avenue (Figure 8-2). To mitigate these pressures, the area can be converted to a lower pressure zone, from Zone 4A to Zone 3. Note that the residential meter service pressures would be reduced from 121-141 psi to 57-83 psi, a drastic decrease in pressure may cause pressure complaints from customers, especially if the customers are used to the high pressures, they may have installed their own pressure regulating valves at their homes. All of the proposed improvements are shown on Figure 8-2.

Table 8-2. Existing System High-Pressure Deficiency Areas

Zone	No.	Location	Max Static Pressure (psi)	Max MDD Pressure (psi)
2	H1	Retail Center north of Malvern Ave	124-130	121-129
3	H2	Large Area north of Rosecrans Ave and east of Beach Blvd	124-148	120-143
4A	H3	Rocky Rd and Pioneer Ave – Ladera Vista Dr to Rocky Rd	107-132	121-141[a]

Note:
[a] MDD pressures exceed the static pressures due to this being a pressurized zone supplied Upper Acacia BPS. During low demand periods the zone may experience higher pressures.

Two additional areas, H4 and H5 (Figure 8-1), exceeded the maximum pressure criteria but have no demand allocations, cannot be mitigated, and are not considered deficient areas:

- Area H4 includes several locations on Zone 3 pipelines that traverse a Zone 2 service area. The pressures are high because this section of the transmission main is in a low elevation area (203 to 214 feet) for Zone 3 and is within a Zone 2 service area, given the pipelines must cross Zone 2 to supply Zone 3.
- Area H5 includes a few locations on a Zone 3 transmission main. The pressures are high because this section of the transmission main is in a low elevation area (215 to 224 feet) in Zone 3 bordered by Zone 2, a lower pressure zone.

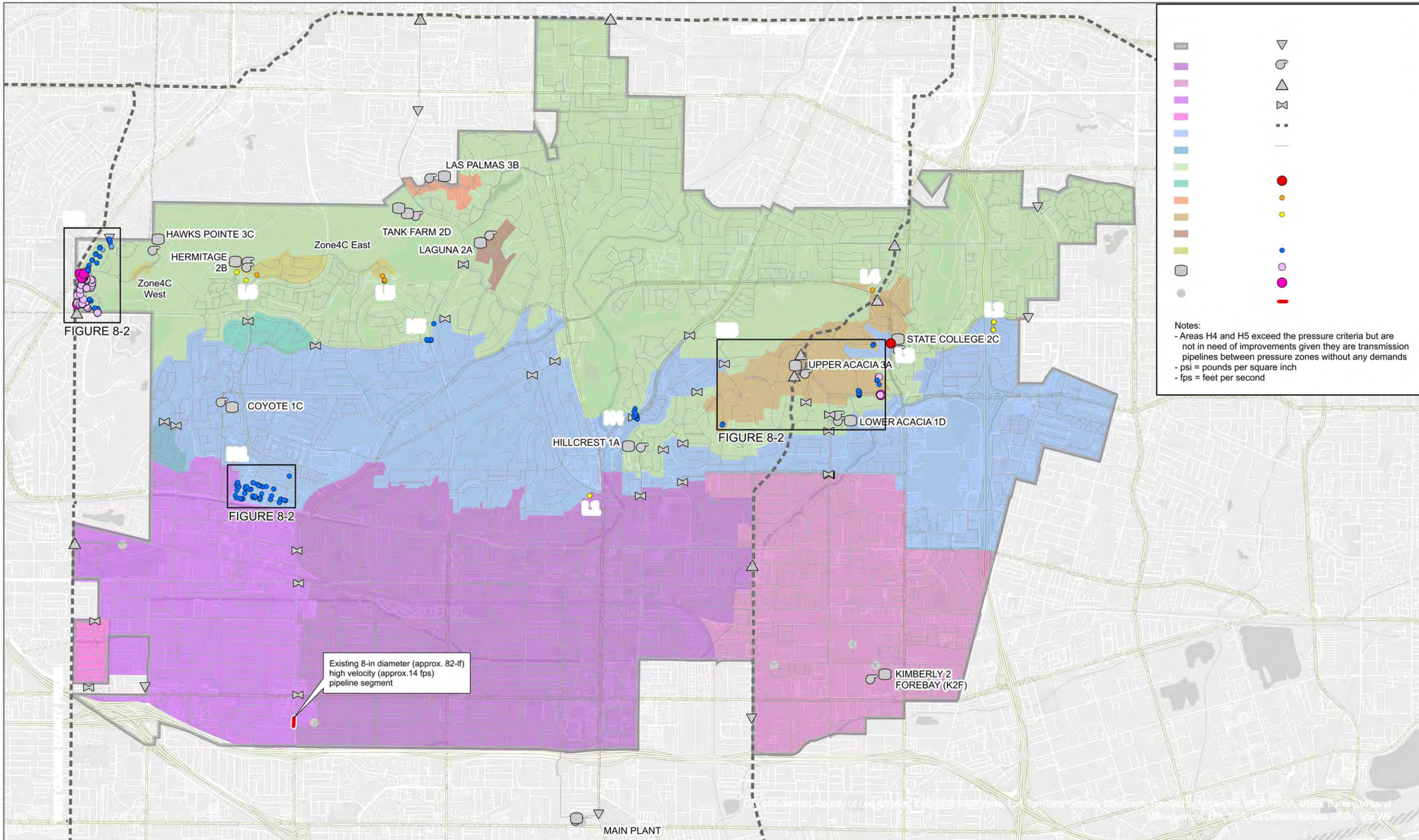

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Figure 8-1. Existing System Low- & High-Pressure Areas and High Velocity Pipes

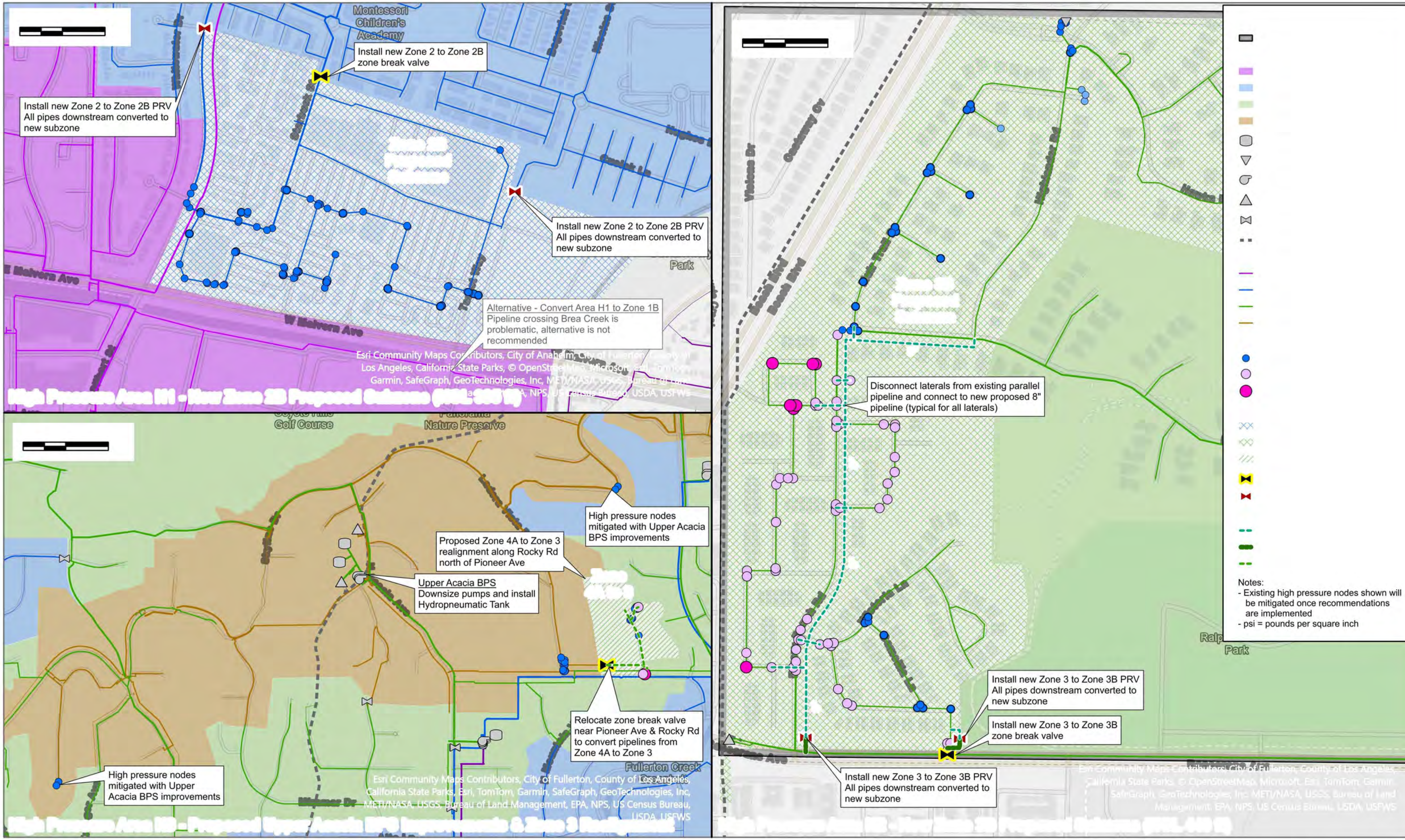

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Figure 8-2. High Pressure Areas H1, H2, and H3 Proposed Improvements

8.1.2 PIPE VELOCITIES

The system was evaluated based on the City's maximum velocity criteria of 7 fps. Figure 8-1 shows one area of the system that exceeded the velocity criteria, a segment of pipe in Brookhurst Road at the intersection of West Roberta Avenue. The pipeline velocity was approximately 14 fps between the hours of 1:00 am and 11:00 am. The pipeline diameter is 8 inches according to the GIS; however, it is connected between two 12-inch-diameter pipelines. As-builts were unavailable to confirm the diameter. If field investigations verify the existing pipeline is 8 inches, this area should be revaluated to consider upsizing the pipeline to 12 inches to reduce velocity and extend the life of the pipeline. Even though the pipeline exceeded velocity criteria, the pressures in the area were not negatively impacted and no improvements are recommended at this time.

8.1.3 STORAGE REQUIREMENTS

A storage volume analysis evaluated system requirements for operational, fire, and emergency storage based on the criteria described in Section 6.2. Analysis results are shown in Table 8-3. As noted in the table, Zone 1, 1A, and 1B each show a storage deficit. However, these deficits can be made up by the surplus volume contained in Zone 2 through the system's PRVs. Overall, the City has approximately 17.6 MG of surplus storage without the Tank Farm 2D reservoir T5 that is out of service.

Table 8-3. Existing System Storage Requirements

PZ[a]	Reservoir	Existing MDD (mgd)	Existing Capacity (MG)	Storage Requirement				Storage Surplus/ (Deficit) (MG)	Note
				Fire[b] (MG)	Oper.[c] (MG)	Emer.[d] (MG)	Total (MG)		
1	Hillcrest 1A		5.0						Deficit supplied from PZ 2 surplus thru PRVs
	Lower Acacia 1D		4.0						
	Subtotal Zone 1	**6.5**	**9.0**	0.96	2.0	6.5	**9.5**	**(0.5)**	
1A	-		0						Deficit supplied from PZ 2 surplus thru PRVs
	Subtotal Zone 1A	**2.6**	0	0.96	0.8	2.6	**4.4**	**(4.4)**	
1B	Coyote 1C		2.0						Assume deficit supplied from PZ 1 via PZ 2 surplus thru PRVs
	Subtotal Zone 1B	**3.6**	**2.0**	0.96	1.1	3.6	**5.7**	**(3.7)**	
2	Laguna 2A		2.0						
	Hermitage 2B		2.0						
	State College 2C		2.0						
	Tank Farm 2D T1-T4[e]		26.0						
	Subtotal Zone 2	**7.9**	**32.0**	0.63	2.4	7.9	**10.9**	**21.1**	
3	Upper Acacia 3A T1-T2		10.0						
	Las Palmas 3B		5.0						
	Hawks Pointe 3C		3.0						
	Subtotal Zone 3	**9.5**	**18.0**	0.54	3.0	9.5	**13.0**	**5.0**	
	Total	**30.1**	**61.0**				**43.5**	**17.6**	

Notes:
[a] Subzones are included as part of the main zones. Zone 1B includes subzone 1C; Zone 2 includes subzones 2A, 4B, and 4C (east); Zone 3 includes subzones 3A, 4, 4A, and 4C (west).
[b] Fire storage requirement is based on the largest of the fire flow required for the land uses within the zone in accordance with Table 6-3.
[c] Operational storage requirement is calculated as 30-percent of the MDD.
[d] Emergency storage requirement is the volume required for one MDD (see Section 6.2).
[e] The Tank Farm 2D T5 Reservoir has a capacity of 6.5 MG but is not in service and therefore not included in the total existing storage volume.

8.1.4 WELL AND BOOSTER PUMP STATION CAPACITY

All wells and booster pump stations were evaluated for the ability to meet system MDD. For long-term efficiency and overall life of the pump stations, it is recommended that the pump stations operate with dedicated duty pumps and dedicated standby pumps, where a standby pump can operate as a backup if a duty pump were to fail, allowing for redundancy. Although all well and booster pumps operated within their respective design capacity for both flow and total dynamic head (TDH), as shown in Appendix D, there is no redundancy at Coyote BPS.

Coyote BPS operates all three pumps for the entire 24-hour simulation to meet Zone 2 demands and replenish the Hermitage 2B Reservoir, resulting in the continuous use of the third pump that is meant to be used for backup purposes only. The existing firm capacity of the Coyote BPS is 1,800 gpm, an additional 1,200 gpm is needed to replenish the reservoir and allow for a standby pump to be available, all while still meeting Zone 2 demands. As such, the Coyote BPS needs to have an available total flow rate of approximately 3,000 gpm. Alternative solutions were investigated to provide the flow to Zone 2 from the upper Zone 3 area through adjusting settings at existing PRVs and adding a new PRV at Rosecrans Avenue. However, this alternative does not allow adequate reservoir operation to replenish the Hermitage 2B Reservoir and creates a negative impact to pressures within Zone 3. The recommended improvement therefore is to upsize and replace the pumps at Coyote BPS. Three new pumps at 1,500 gpm (100 horsepower (hp)) each are recommended to provide two duty pumps and one standby pump.

Note the State College BPS was not required to operate during the analysis. In addition, Kimberly Well 1A will undergo rehabilitation and pump upgrades in the Fall of 2024. Also, although the Christlieb Well 15A is currently being rehabilitated, it may not be available in the future.

8.1.5 FIRE FLOW ANALYSIS

MDD plus fire flow simulations evaluated the system's capability of meeting fire demands with a minimum 20 psi residual pressure. Fire flows were based on land use type. SS simulations were performed by applying the required fire flow at nodes representing existing fire hydrant locations to determine the residual pressure. For nodes resulting in a residual pressure less than 20 psi additional SS evaluations were performed to determine improvement recommendations. If a node was assigned a fire flow greater than 2,500 gpm and did not meet the criteria, the flow was split between two proximate nodes and re-tested. Pipeline improvements, such as replacing existing pipes with larger diameters, are recommended for most of the areas that did not meet fire flow criteria. In addition, all 4-inch distribution mains directly connected to fire hydrants are recommended to be upsized to 8 inches. The 6-inch pipes were upsized to 8-inch on an as needed basis. The proposed pipeline improvements are listed in Appendix E and are shown on Figure 8-3. The proposed Zone 2 and Zone 4C realignments are shown on Figure 8-4.

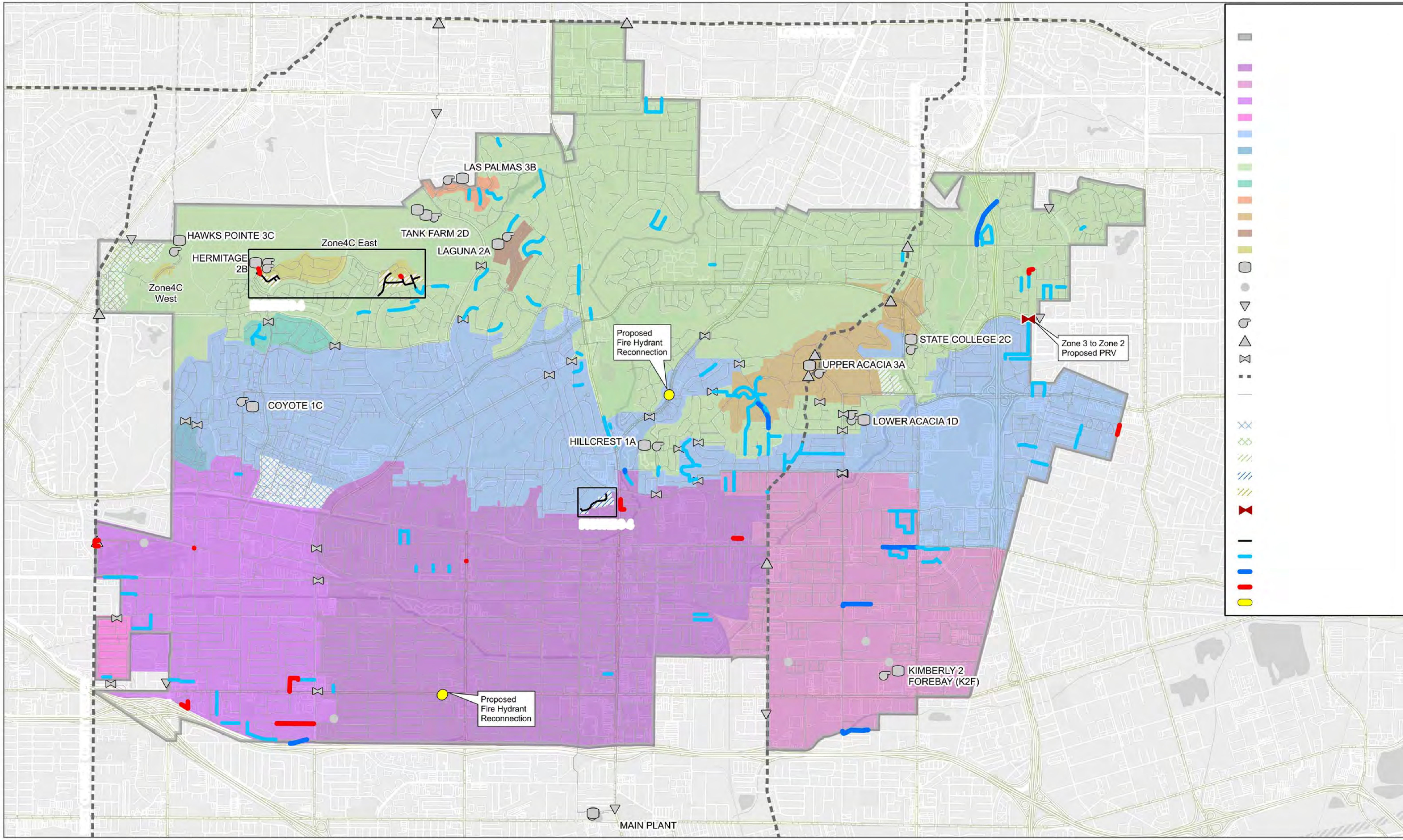

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Figure 8-3. Existing Fire Flow Analysis Proposed Improvements

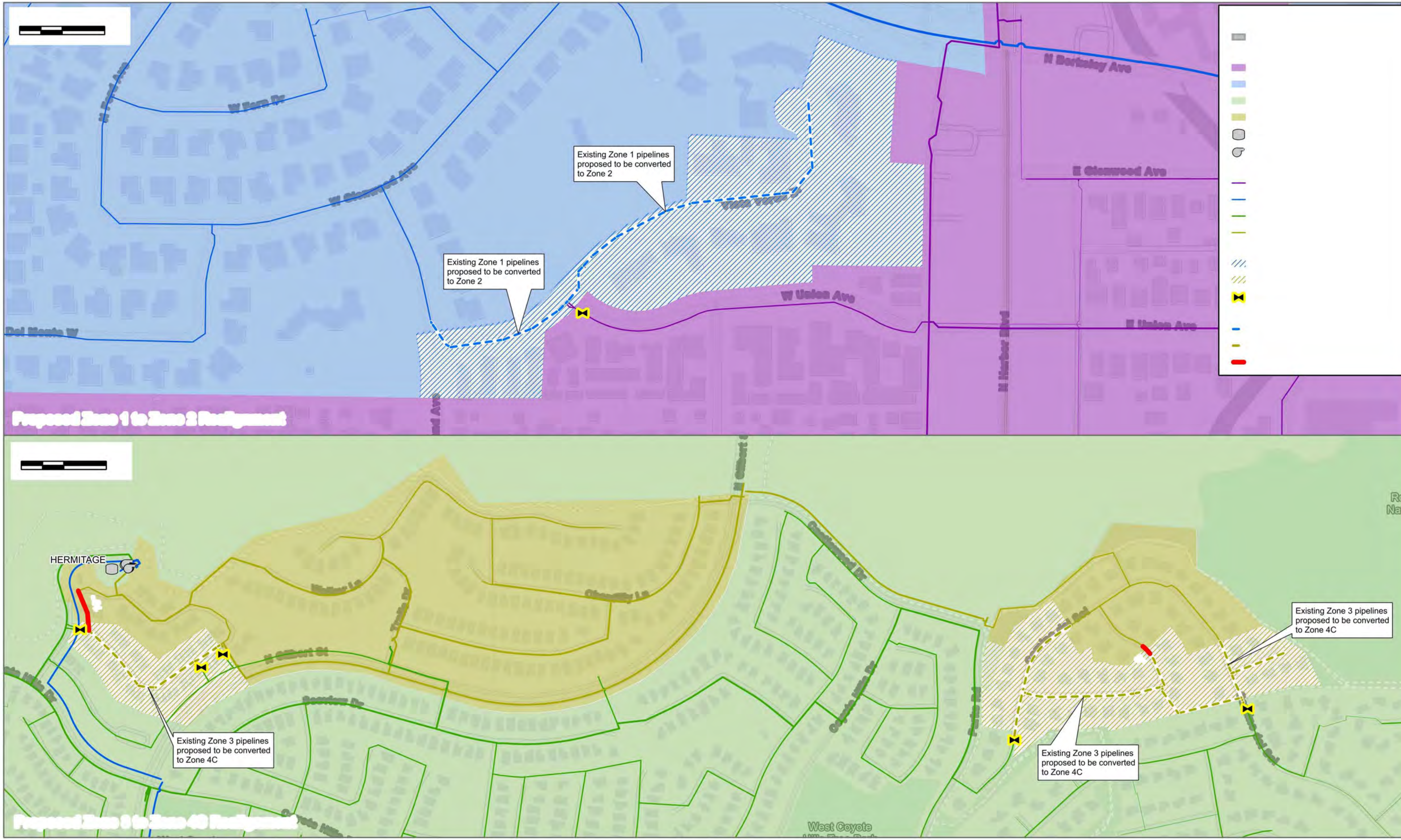

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Figure 8-4. Existing Fire Flow Analysis Proposed Zone 2 and Zone 4C Realignment

8.2 Near-Term System Evaluation

This evaluation reflects the near-term planning horizon, simulated for a MDD 24-hour duration. Total system near-term MDD is 36.0 mgd. This assumes the PFAS treatment project for Kimberly Well 2 and Sunclipse Well 10 is complete and in operation. A single PFAS treatment system for both wells is located at the Kimberly 2 site. The Kimberly 2 Forebay and booster pump station have been demolished.

In addition, a new Well 7A (3,000 gpm capacity) at the Main Plant is currently in design and will be online during near-term conditions.

8.2.1 SYSTEM PRESSURES

The near-term system pressures for each of the pressure zones are similar to those reported for the existing system analysis. The model analysis shows no additional low- or high-pressure areas.

8.2.2 PIPE VELOCITIES

The near-term pipeline velocities are similar to those reported for the existing system analysis. No additional pipeline velocity deficiencies were found in the model.

8.2.3 STORAGE REQUIREMENTS

A storage analysis was conducted to evaluate the near-term storage required. The analysis is shown in Table 8-4. As was the case for the existing storage evaluation, Zone 1, 1A, and 1B each show a storage deficit. However, the deficits can be made up by the surplus volume in Zone 2 through the system's PRVs. The City overall has approximately 10.1 MG of surplus storage without the Tank Farm 2D T5 Reservoir that is out of service.

Table 8-4. Near-Term System Storage Requirements

PZ[a]	Reservoir	Near-Term MDD (mgd)	Existing Capacity (MG)	Storage Requirement				Storage Surplus/ (Deficit) (MG)	Note
				Fire[b] (MG)	Oper.[c] (MG)	Emer.[d] (MG)	Total (MG)		
1	Hillcrest 1A		5.0						Deficit supplied from PZ 2 surplus thru PRVs
	Lower Acacia 1D		4.0						
	Subtotal Zone 1	**7.9**	**9.0**	0.96	2.4	7.9	11.3	(2.3)	
1A	-		0						Deficit supplied from PZ 2 surplus thru PRVs
	Subtotal Zone 1A	**3.1**	0	0.96	0.9	3.1	5.0	(5.0)	
1B	Coyote 1C		2.0						Assume deficit supplied from PZ 1 via PZ 2 surplus thru PRVs
	Subtotal Zone 1B	**4.4**	**2.0**	0.96	1.3	4.4	6.7	(4.7)	
2	Laguna 2A		2.0						
	Hermitage 2B		2.0						
	State College 2C		2.0						
	Tank Farm 2D T1-T5[e]		26.0						
	Subtotal Zone 2	**9.4**	**32.0**	0.63	2.9	9.4	12.9	19.1	
3	Upper Acacia 3A T1-T2		10.0						
	Las Palmas 3B		5.0						
	Hawks Pointe 3C		3.0						
	Subtotal Zone 3	**11.2**	**18.0**	0.54	3.4	11.2	15.1	2.9	
Total		**36.0**	**61.0**				51.0	10.1	

Notes:
[a] Subzones are included as part of the main zones. Zone 1B includes subzone 1C; Zone 2 includes subzones 2A, 4B, and 4C (east); Zone 3 includes subzones 3A, 4, 4A, and 4C (west).
[b] Fire storage requirement is based on the largest of the fire flow required for the land uses within the zone in accordance with Table 6-3.
[c] Operational storage requirement is calculated as 30-percent of the MDD.
[d] Emergency storage requirement is one MDD.
[e] The Tank Farm 2D T5 Reservoir has a capacity of 6.5 MG but is not in service and therefore not included in the total existing storage volume.

8.2.4 WELL AND BOOSTER PUMP STATION CAPACITY

The near-term modeling results for wells and booster pump stations are similar to those found for the existing conditions. Assuming the capacity upgrades are made to the Coyote BPS, no additional recommendations are needed for the booster pump stations. The State College BPS was not required to operate during the analysis.

As noted above, the existing Kimberly Well 2 pumps to the existing onsite Kimberly 2 Forebay are being abandoned. The near-term model simulations include the new PFAS treatment facility at the Kimberly 2 site, with capacity to treat the combined groundwater from Sunclipse Well 10 and Kimberly Well 2 that will be pumped directly into the Zone 1A distribution system. The model analysis required the Kimberly Well 2 pump and motor to be upsized to increase the pump head requirement. Further detailed evaluation of the Kimberly Well 2 pump design curve and motor requirements are recommended during the preliminary design phase of the project.

As previously mentioned, a new Well 7A (3,000 gpm) at the Main Plant is currently in the design phase and will be online during near-term conditions.

8.2.5 FIRE FLOW ANALYSIS

Assuming the pipeline improvement recommendations are constructed as summarized in Section 8.1.5 for the existing system analysis, the near-term system meets the minimum residual pressure criteria of 20 psi based on the required fire flow for each land use. No additional system improvements are proposed.

8.3 Future System Evaluation

This evaluation is based on the City's water distribution system for the future planning horizon. A future MDD 24-hour simulation used a total system demand of 36.5 mgd. The future planning horizon reflects build out conditions for the City as shown on Figure 8-5. Refer to Section 5.0 for discussion on future demands.

The West Coyote Hills Development (WCHD) in the northwest portion of the City is assumed to be fully developed and (for purposes of this evaluation) may require the following for water service to this area:

- New Zone 4C expanded service area pressure zone combining the existing Zone 4C West and East services areas, and a new Zone 5 pressure zone. Both pressure zones are shown on Figure 8-6.
- The Zone 4C expanded pressure zone may require a new storage reservoir and a booster pump station, which would be supplied from Zone 3. The proposed reservoir requires a capacity of at least 0.7 MG of storage, as such, a 0.7 MG storage reservoir is proposed (see Table 8-5). The proposed Zone 4C BPS is recommended to consist of two pumps (one duty and one standby) at 1,000 gpm (75 hp) each and is assumed to be located at the existing Tank Farm facility.

- The Hawks Pointe BPS is proposed to be upsized with two new pumps (one duty and one standby) at 1,000 gpm (75 hp) to meet storage requirements and demands in the proposed expanded Zone 4C and new Zone 5.
- The new Zone 5 pressure zone would be needed for the WCHD higher elevations, with an HGL of 715 ft. Zone 5 would be a pressurized closed system served by a proposed booster pump station with two pumps (one duty and one standby) at 150 gpm (10 hp) each and one high flow fire pump at 1,500 gpm (50 hp). The proposed Zone 5 BPS may also require a hydropneumatic tank.
- With the proposed development area and new pressure zone, the valve located on Rosecrans Avenue near the intersection of Utility Access Road (pipe ID P8055), between the Hawks Pointe and Hermitage facilities, is recommended to be 100 percent open. This valve has been closed due to water quality issues and low reservoir turnover in the Hawks Pointe 3C Reservoir. However, with the additional demand to be pumped out of Zone 3 to the proposed expanded Zone 4C, the fully open valve would help water circulation in this area and improve turnover in the Hawks Pointe 3C Reservoir.

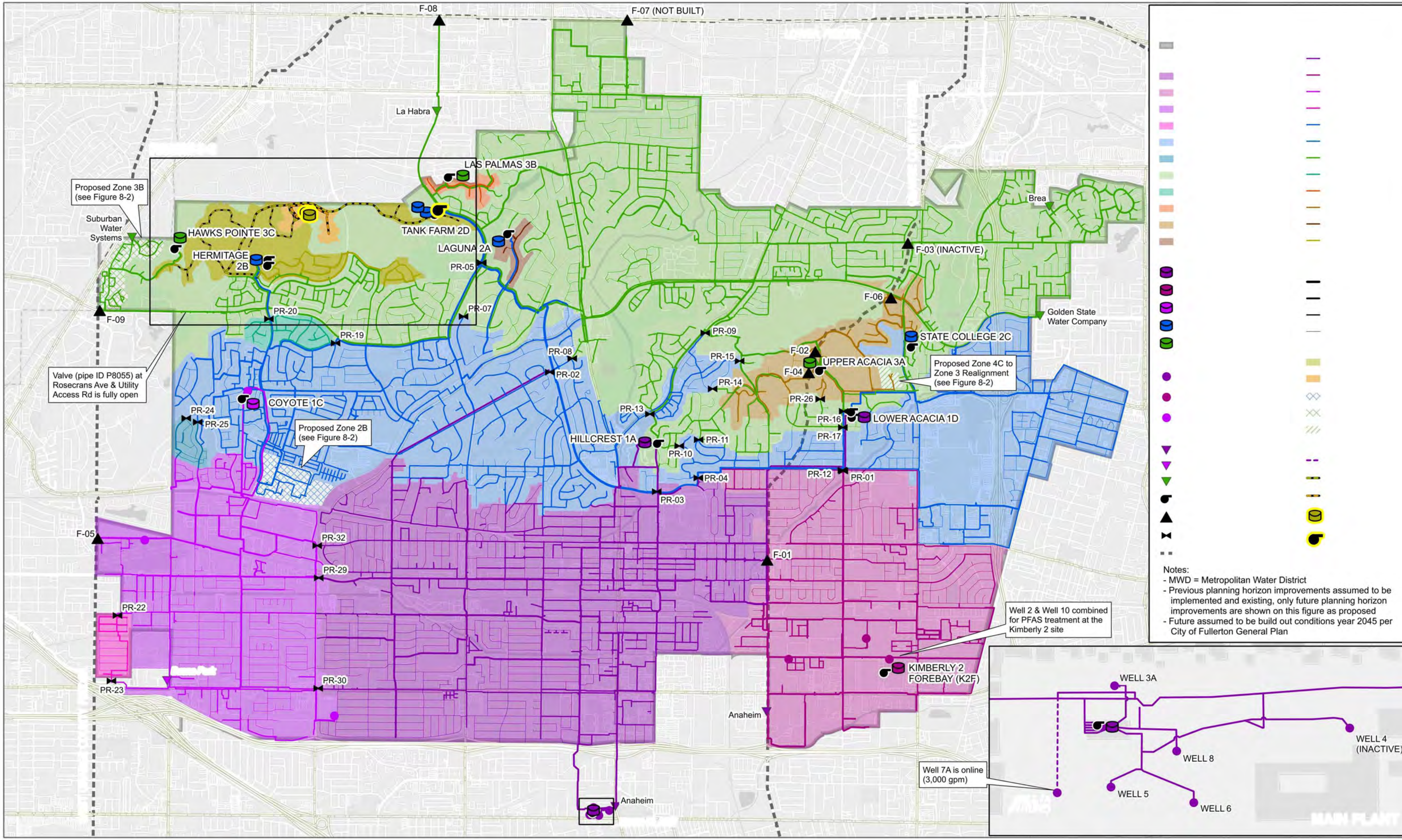

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Figure 8-5. Future Water Distribution System

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Figure 8-6. Future West Coyote Hills Development Proposed Zone 4C and Zone 5

8.3.1 SYSTEM PRESSURES

No additional low or high system pressure areas were found for the future system condition.

8.3.2 PIPE VELOCITIES

No additional pipelines exceeding the velocity criteria were found in the model for the future system conditions.

8.3.3 STORAGE REQUIREMENTS

A storage analysis was conducted to evaluate the future storage required. The analysis is shown in Table 8-5. As with the existing and near-term storage requirement evaluations, Zone 1, 1A, and 1B each show a storage deficit. However, the deficits can be made up by the surplus contained in Zone 2 through the system's PRVs. As described in Section 8.3, a new 0.7 MG storage reservoir is proposed in Zone 4C for the WCHD. A total system surplus of 9.2 MG is anticipated for the future conditions.

Table 8-5. Future System Storage Requirements

PZ[a]	Reservoir Name	Future MDD (mgd)	Existing Capacity (MG)	Storage Requirement				Storage Surplus/ (Deficit) (MG)	Note
				Fire[b] (MG)	Oper.[c] (MG)	Emer.[d] (MG)	Total (MG)		
1	Hillcrest 1A		5.0						Deficit supplied from PZ 2 surplus thru PRVs
	Lower Acacia 1D		4.0						
	Subtotal Zone 1	**8.0**	**9.0**	0.96	2.4	8.0	11.4	(2.4)	
1A	-		0						Deficit supplied from PZ 2 surplus thru PRVs
	Subtotal Zone 1A	**3.1**	**0**	0.96	0.9	3.1	5.0	(5.0)	
1B	Coyote 1C		2.0						Assume deficit supplied from PZ 1 via PZ 2 surplus thru PRVs
	Subtotal Zone 1B	**4.4**	**2.0**	0.96	1.3	4.4	6.7	(4.7)	
2	Laguna 2A		2.0						
	Hermitage 2B		2.0						
	State College 2C		2.0						
	Tank Farm 2D T1-T5[e]		26.0						
	Subtotal Zone 2	**9.4**	**32.0**	0.63	2.9	9.4	12.9	19.1	
3	Upper Acacia 3A T1-T2		10.0						
	Las Palmas 3B		5.0						
	Hawks Pointe 3C		3.0						
	Subtotal Zone 3	**11.2**	**18.0**	0.54	3.5	11.2	15.2	2.8	
4C	-								Deficit supplied by new proposed 0.7 MG reservoir
	Subtotal Zone 4C[f]	**0.4**		0.18	0.1	0.4	0.7	(0.7)	
Total		**36.5**	**61.0**				**51.8**	**9.2**	

Notes
[a] Subzones are included as part of the main zones. Zone 1B includes subzone 1C; Zone 2 includes subzones 2A, 4B, and 4C (east); Zone 3 includes subzones 3A, 4, 4A, and 4C (west).
[b] Fire storage requirement is based on the largest of the fire flow required for the land uses within the zone in accordance with Table 6-3.
[c] Operational storage requirement is calculated as 30-percent of the MDD.
[d] Emergency storage requirement is one MDD.
[e] The Tank Farm 2D T5 Reservoir has a capacity of 6.5 MG but is not in service and therefore not included in the total existing storage volume.
[f] The MDD of 0.4 mgd includes the existing Zone 4C West and Zone 4C East service areas in addition to the WCHD.

8.3.4 WELL AND BOOSTER PUMP STATION CAPACITY

Consistent with the existing and near-term conditions, the future conditions assume the Coyote BPS capacity improvements are constructed. With the upgrades at the Coyote BPS and Hawks Pointe BPS, recommended in Section 8.3, the remaining booster pump stations were evaluated and found to operate within their respective design capacities. The State College BPS was not required to operate during the future MDD analysis.

Although Well 7A was not needed during existing or near-term conditions, Well 7A operates during future conditions to meet demands. With Well 7A online and operating, all the groundwater wells operate within their respective design capacities.

8.3.5 FIRE FLOW ANALYSIS

Assuming the pipeline improvement recommendations are constructed as summarized in Section 8.1.5 for the existing system analysis, no additional deficiencies were discovered during the future fire flow analysis. Therefore, no additional recommendations are proposed.

8.4 Water Age

This analysis approximated the water age in the existing water distribution system. Water age is an important factor in water quality deterioration within distribution systems. As water ages disinfectants decay which can create favorable conditions for microbial regrowth and pathogen contamination, as well as allow more time for disinfection by-products (DBP) to form. In a water distribution system, water age can be used as a surrogate for reaction time for TTHM formation and nitrification potential (for chloraminated systems) and thus degraded water quality.

The analysis will focus on the existing ADD scenario because lower demands typically result in longer reservoir storage and pipeline travel times.

The following assumptions and limitations apply to the water age analysis:

- While water age is considered an effective surrogate for water quality, is it not a perfect surrogate. For example, water age increases linearly with time, whereas chlorine decay and trihalomethane formation typically follows first order exponential decay or growth kinetics, respectively. Therefore, evaluating water age cannot accurately predict actual TTHMs, for example.
- Model controls were used based on the model update and calibration. Any changes to operations could impact the water age.

8.4.1 APPROACH

This analysis was modeled as a 30-day EPS during existing ADD conditions with average water age reported for all tanks and nodes for the last 7 days, which is representative of stabilized water age results.

Model nodes with zero assigned demand (e.g., hydrants, facility nodes, etc.) were removed from the analysis. The model was run under the existing ADD of 20.5 mgd.

8.4.2 MODEL RESULTS

The water age model results were evaluated statistically as well as graphically.

8.4.2.1 Statistical Analysis

The average system-wide water age for the existing ADD conditions is provided on Figure 8-7.

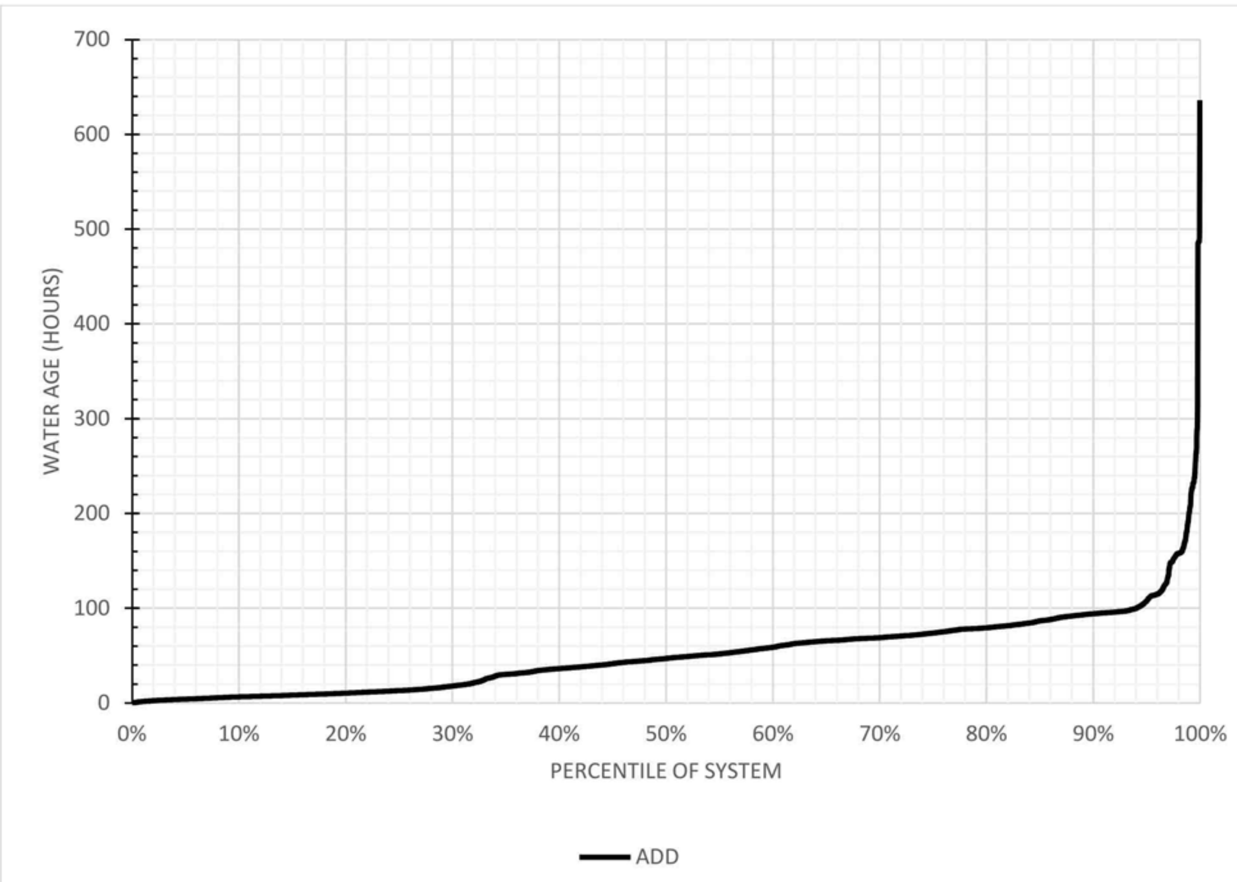

Figure 8-7. Percentile Plot of Average Water Age with Existing ADD Conditions

From Figure 8-7 approximately 75 percent of the system has a water age under 72 hours (3 days) and approximately one percent of the system has a water age over approximately 192 hours (8 days).

8.4.2.2 Graphical Analysis

Figure 8-8 shows the average water age under existing ADD conditions throughout the system. The average water age of all the nodes was approximately 51 hours (2.1 days). In general, portions of Zones 3, 4B and 4C had the oldest water in the system and could be problematic areas in terms of water quality and DBPs.

The average water age in storage varies from approximately 3.5 days at Hillcrest 1A Reservoir to over 20 days for the Laguna 2A Reservoir, and nearly 21 days for Tank Farm 2D T4 Reservoir.

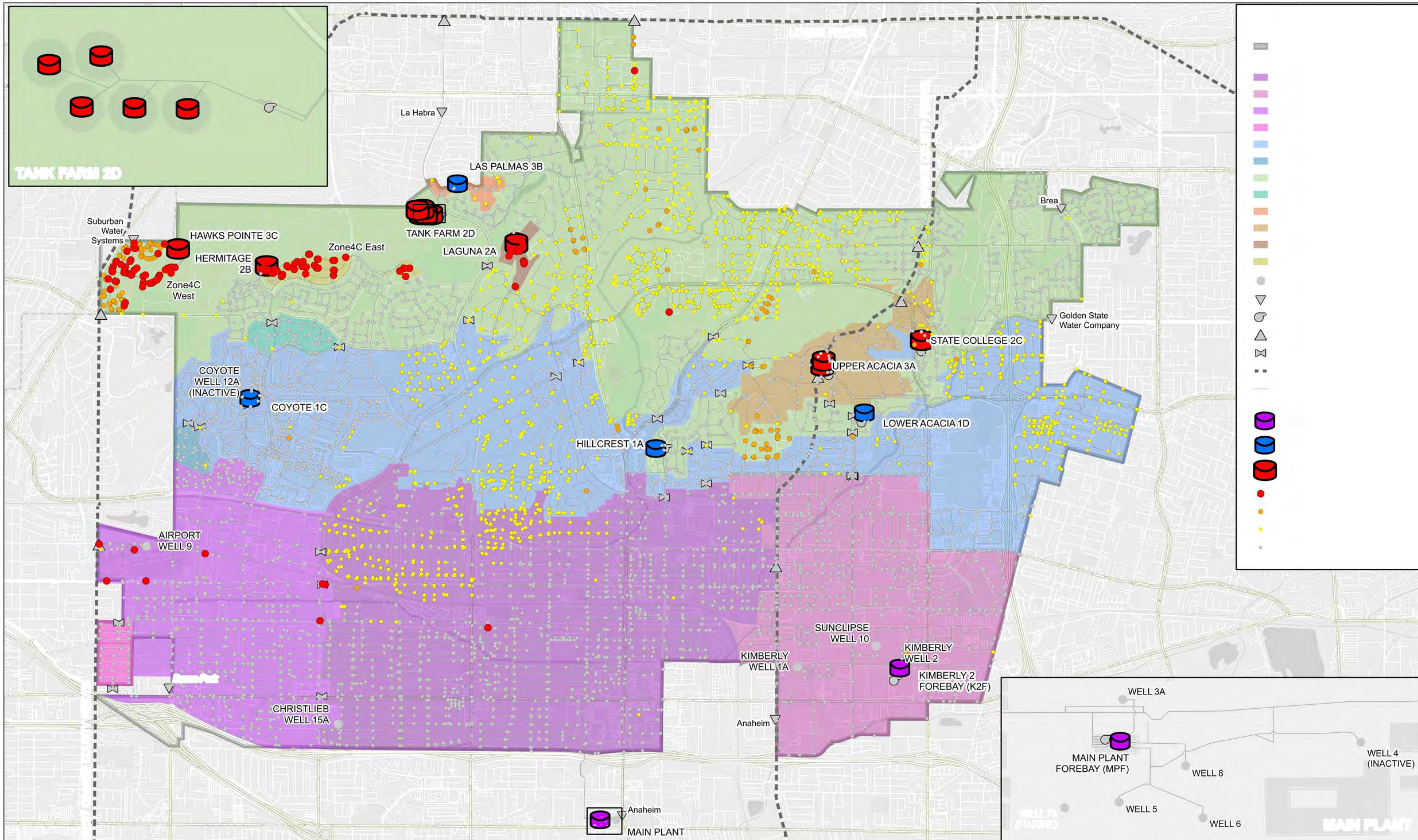

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Figure 8-8. Distribution System Average Water Age under Existing ADD Conditions

8.4.3 CONCLUSIONS AND RECOMMENDATIONS

The water age in the extremities of Zone 3, 4B, and 4C is some of the oldest in the system. The percentile plot of water age from Figure 8-7 above is shown in an alternative format for 25th, 50th, 75th, and 95th percentile water age on Figure 8-9 below.

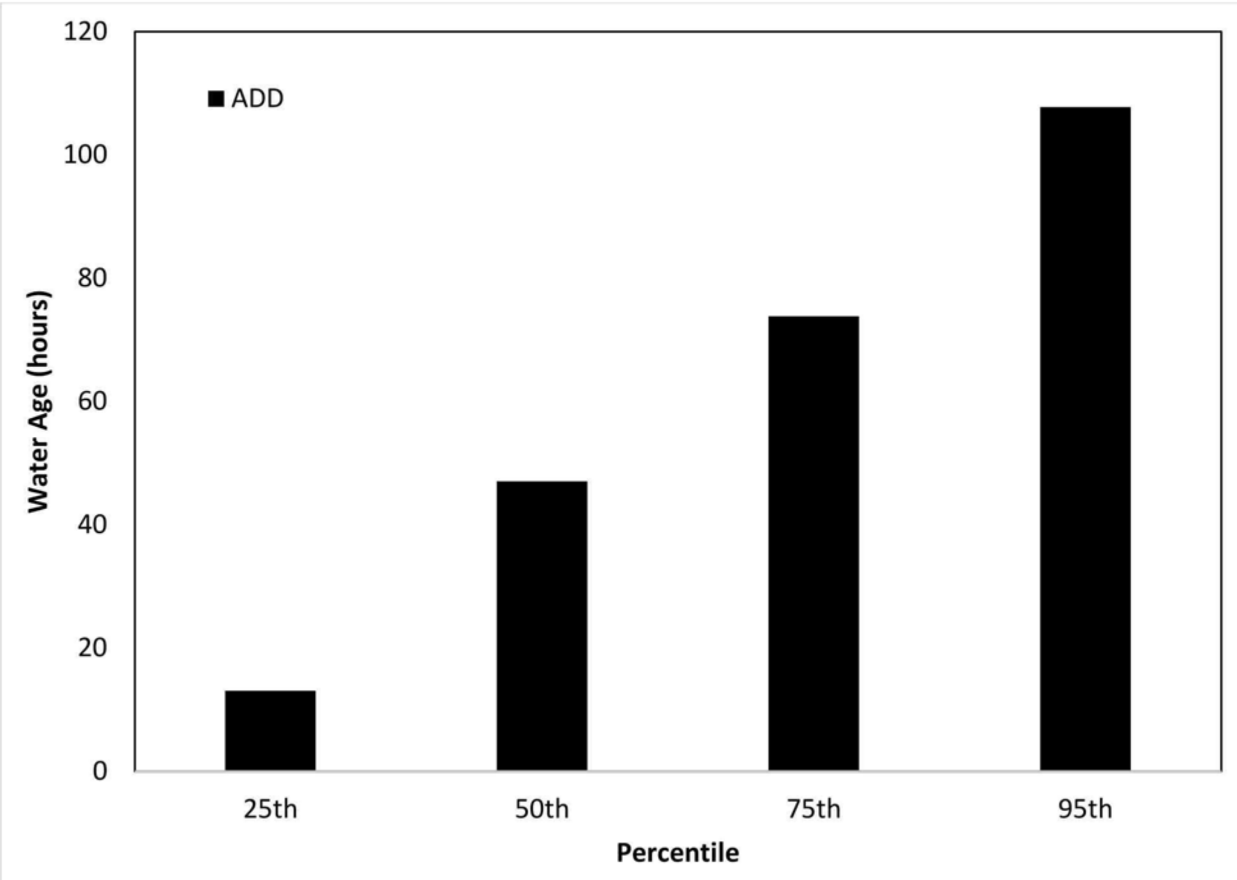

Figure 8-9. Average Water Age for Existing ADD Conditions by Percentile

The statistical analysis indicates that approximately three quarters of the system has a water age of 74 hours (approximately 3 days) or less, and that 95 percent of the system has a water age of 108 hours (4.5 days) or less (Figure 8-9).

The tank in the system with the oldest water was Tank Farm 2D T4 Reservoir which is fed from MWD import connection F-08, modeled as a supply, but is the last tank on the dead-end branch and the total tank farm inflow and outflow (1,500 gpm) is relatively small compared to the total volume of the five 6.5 MG tanks (32.5 MG total) shown on Figure 8-10.

Figure 8-10. Tank Farm Facility with Average Water Age for Existing ADD Conditions

The Las Palmas 3B Reservoir is also near the Tank Farm but is directly fed from the MWD import connection F-08 and is a single 5 MG tank with a 1,200-gpm inflow/outflow and therefore has an average water age of 4.6 days. The Laguna 2A Reservoir is fed from the Tank Farm 2D Reservoirs and therefore has older water (over 20 days old) due to the large volume at the Tank Farm Reservoirs.

However, water age does not directly indicate quality; even within each system, the water age may not be indicative of quality because the pipe walls themselves can influence water quality such as the rate of chlorine decay. For example, unlined cast iron pipe material has between 4-100 times faster decay rate than PVC pipe material (Kowalska, 2006). Further investigation is recommended at the locations predicted to have the highest water age to validate the model results, such as collecting water samples to verify chlorine residuals are within criteria.

There are several things that could help the City better baseline and improve water age as follows:

- Monitoring for DBPs at the locations with the highest water age in the late fall as system demands decrease and water temperature is elevated (higher water age and higher temperature facilitate formation of DBPs). It is recommended to monitor the locations with high water age, namely the locations shown on Figure 8-8 and listed below:
  - Zone 3 along Muir Trail Drive.
  - Zone 4B along Terraza Place near the Laguna 2A Reservoir.

- Zone 4C in the north along Somerset Lane, Chantilly Lane, Walker Lane, and Brooke Lane.
- It is recommended to review the tank level range set-points of the Tank Farm 2D Reservoirs, and specifically to explore opportunities for seasonal reductions in upper and lower tank operating levels to reduce water age. An effective mitigation strategy would likely be reducing the low set point of the tanks to increase the tank turnover, although any change to minimum level set-point requires a review of minimum fire flow volumes.

8.5 System Improvement Recommendations

The following projects are recommended for the overall improvement of the water distribution system:

- Upsize pipelines throughout the system for fire flow conditions and install proposed new pipe looping for fire flow conditions, approximately 91,100 lf (Figure 8-3)
- Construct PRV at the intersection of East Bastanchury Road and Hartford Avenue, between Zone 3 and Zone 2 (Figure 8-3)
- Reconnect Zone 1 fire hydrant to the existing 10" parallel pipeline, near the intersection of West Orangethorpe Avenue and South Citrus Avenue (Figure 8-3)
- Reconnect Zone 2 fire hydrant to the existing 12" parallel pipeline in Zone 3, near the intersection of Brea Boulevard and Barbara Boulevard (Figure 8-3)
- Zone 1 to 2 realignment (Figure 8-4)
  - Relocate one zone break valve between Zone 2 and 1, at the intersection of Vista Verde Drive and West Union Avenue
- Zone 4A to 3 realignment (Figure 8-2)
  - Relocate one zone break valve between Zone 4A and 3, near the intersection of Pioneer Avenue and Rocky Road
- Zone 3 to 4C realignment (Figure 8-4)
  - Relocate 3 zone break valves between Zone 4C and 3, near the intersection of Camino del Sol and Camino Rey, Atherton Circle and Camino del Sol, and between Applewood Circle and North Gilbert Street
  - Construct new pipeline segment (49-lf) to connect the former Zone 3 and realigned Zone 4C
- New Pressure Zone 2B Subzone (Figure 8-2)
  - Construct a new zone break valve near the intersection of Starbuck Street and Hughes Drive

- Construct a new PRV near the intersection of Gilbert Street and Hughes Drive
- Construct a new PRV near the intersection of Cusick Drive and Wright Lane

- New Pressure Zone 3B Subzone (Figure 8-2)
  - Construct a new zone break valve and new PRV southeast of the intersection of Primrose Lane and Camelia Lane, near Rosecrans Avenue
  - Construct a new PRV at the intersection of Rosecrans Avenue and Emery Ranch Road
  - Construct approximately 2,600 LF of 8-inch pipeline along Emery Ranch Road and Muir Trail Drive, disconnecting laterals from the existing Zone 3 parallel pipeline and connecting to the proposed 8-inch pipeline

9.0 Planning Scenarios

All the planning scenarios discussed in this section assume the future system conditions as summarized in Section 8.3. Recommendations for each planning scenario are independent of one another and are not acquired into the next scenario. The following planning scenarios were requested by the City:

Maximizing Groundwater Supply: These model scenarios evaluated the distribution system for maximizing the City's groundwater supply.

- **Scenario 1A – Maximum Available Groundwater Supply:** This scenario evaluated the future distribution system for a 72-hour simulation, assuming groundwater supply from all existing wells is maximized to meet future MDD. This analysis evaluated the capability of the system to convey all available groundwater supply to the upper pressure zones and minimize imported water supply.
- **Scenario 1B – 100 Percent Long Term Groundwater Supply:** This scenario evaluated the future distribution system for a 21-day simulation, assuming 100 percent of the future ADD is supplied by groundwater wells.

System Operations Efficiency: This scenario evaluated distribution system operational modifications to improve system efficiency by minimizing the amount of water pumped to upper zones that is then allowed to flow back to lower zones via system PRVs.

- **Scenario 2 – Pumping and PRV System Operations:** This future distribution system analysis assumes pump operating times are reduced, and downstream PRV pressure settings are increased to minimize flow from upper zones to lower zones. This scenario was modeled under 72-hour future MDD conditions.

System Reliability: The following scenarios were performed to evaluate distribution system reliability under extreme supply outage assumptions.

- **Scenario 3A – Import Water Outage:** This scenario evaluates the capability of the distribution system to meet future ADD during a 7-day MWD import water supply outage.
- **Scenario 3B – Pump Stations Offline:** This evaluates the capability of the future distribution system to meet future ADD during a 7-day pump station outage. This assumes that seven pump stations between pressure zones are offline (Main Plant, Coyote, Lower Acacia Zone 2 and 3, Hillcrest, Tank Farm, and Hermitage Zone 3 BPS). Five pump stations serving pressurized zones are assumed to be online (Las Palmas, Upper Acacia, Laguna, Hermitage Zone 4C, and Hawks Pointe BPS).
- **Scenario 3C – Groundwater Outage:** This scenario evaluates the capability of the future distribution system to meet future ADD during a 7-day groundwater well supply outage. All groundwater wells are assumed to be offline.

9.1 Maximizing Groundwater Supply

Two scenarios were developed in the hydraulic model to evaluate the goal of maximizing groundwater supply for the future planning horizon demand conditions.

9.1.1 SCENARIO 1A – MAXIMUM AVAILABLE GROUNDWATER SUPPLY

The goal of Scenario 1A is to increase the well production from all existing wells, including the proposed new Well 7A. This scenario was modeled under a 72-hour duration with future MDD conditions of 36.5 mgd.

With all groundwater wells operating at full capacity for the entire 72-hours, a total groundwater supply of approximately 29.4 mgd (Table 9-1) is produced, which is approximately 81 percent of the 36.5 mgd MDD.

Table 9-1. Scenario 1A: Proposed Groundwater Well Supply Production

Pressure Zone	Name	Design Capacity (gpm)[a]	Avg MDD Flowrate (gpm)	Total MDD Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	1,967	2.83
	Well 6 (Main Plant)	1,500	1,364	1.96
	Well 8 (Main Plant)	2,000	1,708	2.46
	Well 3A (Main Plant)	2,400	2,549	3.67
	Well 7A (Main Plant)[b]	3,000	3,092	4.45
Zone 1A	Kimberly Well 1A[c]	2,800	1,767	2.54
	Kimberly Well 2[d]	1,875	1,723	2.48
	Sunclipse Well 10[d]	2,000	2,082	3.00
Zone 1B	Airport Well 9	2,500	1,903	2.74
	Christlieb Well 15A[e]	2,000	2,263	3.26
	Totals	**21,575**	**20,418**	**29.39**

Notes:
[a] Design capacity data obtained from Water Facilities Worksheet provided by the City.
[b] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[c] Kimberly Well 1A to be rehabilitated and upgraded in 2025; however, this scenario assumes current well conditions. Note the average MDD flow rate matches SCADA collected during hydrant flow testing.
[d] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped with a new pump to deliver its well design capacity.
[e] Christlieb Well 15A is being rehabilitated but may not be available in the future. This scenario assumes current well conditions.

The remaining 7.1 mgd will be supplied from MWD imported water connections, as shown in Table 9-2.

Table 9-2. Scenario 1A: Proposed MWD Import Water Supply

Pressure Zone	Name[a,b]	Design Capacity (cfs)	Avg MDD Flowrate (cfs)	Total MDD Supply (mgd)
Zone 1B	F-05[c]	15	1.5	0.75
Zone 3	F-04	15	1.5	0.75
	F-06	15	2	0.91
	F-08	30	4	2.49
	F-09	15	5	2.21
Zone 4A	F-02	5	0	0.00
	Total	**95**	**14**	**7.11**

Notes:
[a] MWD Connections F-01 is not used. In 2021 it was brought online to serve as a backup supply for emergencies due wells being out of service at the time impacted by PFAS.
[b] MWD Connection F-03 is not operational.

9.1.1.1 Pump Capacity Evaluation

Wells 5, 6, and 8 pump directly to the Main Plant Forebay, and the Main Plant BPS pumps out of this forebay into Zone 1. The Main Plant BPS pumps are controlled by the tank level at the Hillcrest 1A Reservoir. Two of the five pumps at the Main Plant BPS operate under this scenario. With all the groundwater wells operating on a 24-hour basis, additional capacity is needed to pump the available groundwater supply to the higher-pressure zones. The existing pump stations are undersized for this scenario, as most of the MDD in the higher-pressure zones are historically met by MWD imported water. Given most of the demand is met by import water connection in the upper zones, upsizing the pump stations is recommended to meet the MDD by moving the available groundwater to the upper zones. Therefore, additional capacity is required at the Lower Acacia Zone 2 BPS and Hillcrest BPS. The Lower Acacia Zone 2 BPS pumps are proposed to be upsized by three new pumps at 1,500 gpm (75 hp) each. The Hillcrest BPS pumps are proposed to be upsized by two new pumps at 1,500 gpm (125 hp) each.

Based on the existing system evaluation, the Coyote BPS is assumed to be upgraded with three new pumps, each at 1,500 gpm. Note that the State College BPS and Tank Farm BPS were not needed for this scenario. The proposed booster pump station upsizing requirements are summarized in Table 9-3. The proposed number of pumps, capacity, and horsepower are provided for each of the booster pump stations. The proposed pumps would replace the existing pumps at each pump station.

Table 9-3. Scenario 1A: Proposed BPS Capacity Requirements

Facility	Number of Pumps		Pump Capacity (gpm)		Proposed Pump Horsepower
	Existing	Proposed[a]	Existing	Proposed	
Coyote BPS[b]	3	3	900	1,500	100
Hillcrest BPS	2	3	1,000	1,500	125
Lower Acacia Zone 2 BPS	3	3	850	1,500	75

Notes:
[a] Proposed number of pumps assumes two duty pumps and one standby pump configuration. Pumps proposed to replace existing pumps.
[b] Coyote BPS recommendation is consistent with existing conditions recommendation in Section 8.1.

9.1.1.2 PRV Evaluation

Additionally, to reduce the flow through PRVs from upper zones to the lower zones, the settings were adjusted for four PRVs as summarized in Table 9-4.

Table 9-4. Scenario 1A: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
				Existing		Proposed	
		Existing	Proposed	Average	Peak	Average	Peak
2 to 1	PR-4	55	50	383	441	0	0
Tank Farm to 2	PR-5A1	65	61	6,647	7,841	1,617	3,156
3 to 2	PR-7	68	55	632	643	232	273
	PR-14	53	40	399	475	0	0

With the recommendations as proposed, the system is capable of replenishing the reservoirs, maintaining a minimum service pressure of 40 psi, and having standby pumps readily available, while still meeting future MDD. The proposed recommendations for maximizing groundwater supplies are shown on Figure 9-1.

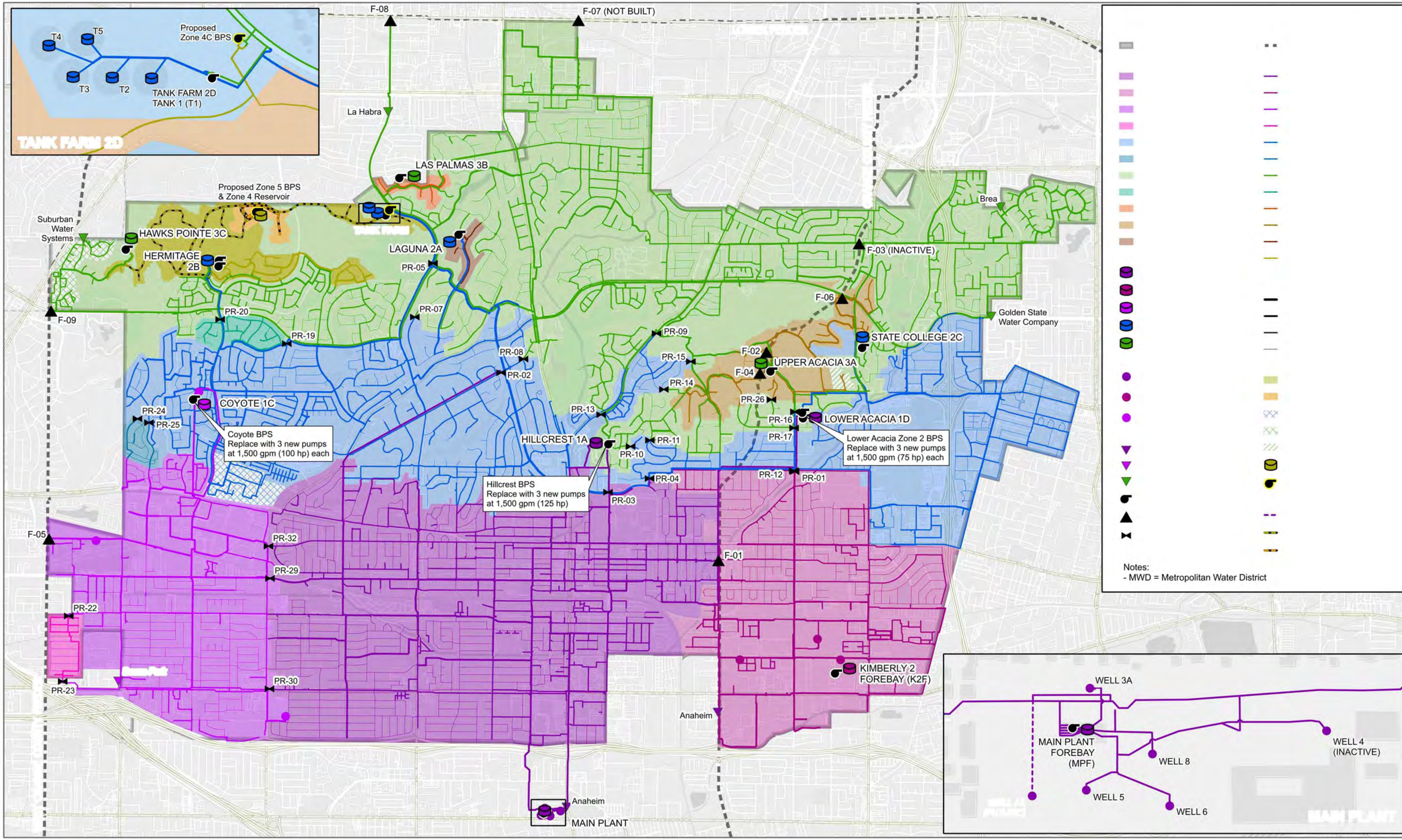

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Figure 9-1. Scenario 1A: Maximum Available Groundwater Supply

9.1.2 SCENARIO 1B – 100 PERCENT LONG-TERM GROUNDWATER SUPPLY

The goal of Scenario 1B is to completely rely on groundwater as a long-term supply operation. This scenario evaluated the operational capabilities of the future system with 100 percent groundwater supply while meeting future ADD, replenishing the reservoirs, and maintaining minimum service pressures of 40 psi. This scenario was modeled for a 21-Day EPS future system conditions with a total future ADD of 24.9 mgd.

To meet demands entirely by groundwater, additional well supply is needed. Without imported water supply from F-05 to Zone 1B, the two existing wells in Zone 1B are not able to meet demands in the zone and maintain tank levels at the Coyote 1C Reservoir. A well siting and capacity study should be conducted. This new groundwater well to Zone 1B is proposed to have a minimum capacity of 1,000 gpm. The proposed groundwater well supplies are summarized in Table 9-5. The new proposed well is shown on Figure 9-2; however, the location shown is temporary and only for the purposes of this report.

Table 9-5. Scenario 1B: Proposed Groundwater Well Supply

Pressure Zone	Name	Design Capacity (gpm)[a]	Avg Flowrate (gpm)	Total Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	0	0.00
	Well 6 (Main Plant)	1,500	1,379	1.99
	Well 8 (Main Plant)	2,000	1,732	2.49
	Well 3A	2,400	2,271	3.27
	Well 7A[b]	3,000	3,085	4.44
Zone 1A	Kimberly Well 1A[c]	2,800	1,713	1.52
	Kimberly Well 2[d]	1,875	1,667	2.40
	Sunclipse Well 10[d]	2,000	2,044	2.94
Zone 1B	Airport Well 9	2,500	2,532	3.65
	Christlieb Well 15A[e]	2,000	2,000	2.56
	Proposed Zone 1B Well	1,000	895	1.15
	Totals	**21,575**	**19,318**	**26.40**

Notes:
[a] Design capacity data obtained from Water Facilities Worksheet provided by the City.
[b] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[c] Kimberly Well 1A to be rehabilitated and upgraded in 2025; however, this scenario assumes current well conditions. Note the average MDD flow rate matches SCADA collected during hydrant flow testing.
[d] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped a new pump to deliver its well design capacity.
[e] Christlieb Well 15A is being rehabilitated but may not be available in the future. This scenario assumes current well conditions.

The Tank Farm 2D Reservoirs are at an elevation above the Zone 2 HGL but below the Zone 3 HGL and are only supplied by the MWD import water turnout F-08 through a control valve located at the Tank Farm facility. As a long-term operating scenario without supply from MWD, the Tank Farm Reservoirs are recommended to be removed from the system for this scenario only. Additional pumping from the lower zones up to Zone 3 would be required to fill the Tank Farm Reservoirs. However, the reservoirs only feed Zone 2 by gravity. Therefore, considering the large storage volume at the Tank Farm Reservoirs and significant pumping costs, the system operates more efficiently with the Tank Farm Reservoirs disconnected from the system. In addition, with the Tank Farm Reservoirs disconnected, the system would maintain better water quality in the upper zones.

The F-08 MWD connection is also used during normal daily operations historically to fill Las Palmas 3B Reservoir, with filling operations in conjunction with the control valve filling the Tank Farm Reservoirs. Therefore, to meet the needs for this scenario, the Las Palmas Reservoir is proposed to be filled by the Hillcrest BPS, where pump settings are adjusted to be controlled by the Las Palmas Reservoir level. In addition, for this scenario, a dedicated 16-inch (7,000 linear feet (lf)) transmission main is proposed to be installed in Zone 3 from the Hillcrest BPS to the intersection of North Harbor Boulevard and West Valencia Mesa Drive as shown on Figure 9-2.

9.1.2.1 Pump Capacity Evaluation

The Lower Acacia Zone 2 BPS and Hillcrest BPS each require upsizing all pumps with a capacity of 1,500 gpm each. Coyote BPS is also assumed to be upsized. For this scenario, additional pumping capacity is needed at the Lower Acacia Zone 3 BPS and Hermitage Zone 3 BPS, as listed in Table 9-6. Note that the State College BPS and Tank Farm BPS were not needed for this scenario. The proposed number of pumps, capacity, and horsepower are provided for each of the booster pump stations. The proposed pumps would replace the existing pumps at each pump station.

Table 9-6. Scenario 1B: Proposed BPS Capacity Requirements

Facility	Number of Pumps		Pump Capacity (gpm)		Proposed Pump Horsepower
	Existing	Proposed[a]	Existing	Proposed	
Coyote BPS[b]	3	3	900	1,500	100
Hillcrest BPS[c]	2	3	1,000	1,500	125
Lower Acacia Zone 2 BPS[c]	3	3	850	1,500	75
Lower Acacia Zone 3 BPS	3	3	1,150	1,500	100
Hermitage Zone 3 BPS	2	2	500/1,000	1,500	75

[a] Proposed number of pumps assumes two duty pumps and one standby pump configuration, except for Hermitage Zone 3 BPS with one duty and one standby pump. Pumps proposed to replace existing pumps.
[b] Coyote BPS recommendation is consistent with existing conditions recommendation in Section 8.1.
[c] Capacity recommendation is consistent with Scenario 1A Maximum Available Groundwater Supply during future MDD conditions.

9.1.2.2 PRV Evaluation

To minimize the flow of already pumped groundwater supply to the upper zones flowing back down to the lower zones, the settings were adjusted for five PRVs as summarized in Table 9-7.

Table 9-7. Scenario 1B: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
		Existing	Proposed	Existing		Proposed	
				Average	Peak	Average	Peak
2 to 1	PR-4	55	50	383	441	0	0
Tank Farm to 2	PR-5A1	65	60	6,647	7,841	0	0
3 to 2	PR-7	68	55	632	643	181	283
	PR-13	88	87	8	85	199	351
	PR-14	53	40	399	475	0	0

Since this scenario is a long-term supply operating condition and the Tank Farm 2D Reservoirs are not used for this operating condition, onsite permanent backup generators are proposed to be installed at groundwater wells 1A, 2, 3A, 9, 10, and 15A as well as the proposed well in Zone 1B. Onsite permanent backup generators are also proposed at the following booster pump stations: Coyote, Hillcrest, Lower Acacia, Laguna, Las Palmas, and Hermitage. Note that the State College BPS was not needed for this scenario. The proposed conditions for this scenario are shown on Figure 9-2.

9.1.2.3 Scenario 1B Alternative: Maintain Tank Farm Facility in Service

Demolishing the Tank Farm 2D Reservoirs is not recommended as a permanent solution as this facility provides valuable operational and emergency storage to the City. An additional evaluation was conducted to determine the minimum supply from the F-08 MWD connection while allowing the Tank Farm facility to remain in service and be used as part of the system. The evaluation was modeled under the same conditions as the 100 percent groundwater supply (Scenario 1B), with a total future ADD of 24.9 mgd.

At least one import water connection is needed to maintain the Tank Farm facility in service, with a minimum of two tanks operating (T1 and T2). Tables 9-8 and 9-9 summarize the groundwater wells and import water supply turnout required for this evaluation, with approximately 95 percent of demand met by groundwater. Aside from those proposed above for Scenario 1B, no additional recommendations are proposed for this alternative evaluation.

Table 9-8. Scenario 1B Alternative: Proposed Groundwater Well Supply

Pressure Zone	Name	Design Capacity (gpm)	Avg MDD Flowrate (gpm)	Total MDD Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	0	0.00
	Well 6 (Main Plant)	1,500	1,379	1.99
	Well 8 (Main Plant)	2,000	1,732	2.49
	Well 3A	2,400	2,272	3.27
	Well 7A[a]	3,000	3,085	4.44
Zone 1A	Kimberly Well 1A[b]	2,800	1,711	0.13
	Kimberly Well 2[c]	1,875	1,698	2.45
	Sunclipse Well 10[c]	2,000	2,065	2.97
Zone 1B	Airport Well 9	2,500	2,535	3.65
	Christlieb Well 15A	2,000	2,000	1.55
	Proposed Zone 1B Well	1,000	898	0.70
	Totals	**21,575**	**18,477**	**23.64**

[a] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[b] Kimberly Well 1A average MDD flow rate matches SCADA collected during hydrant flow testing.
[c] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped a new pump to deliver its well design capacity.

Table 9-9. Scenario 1B Alternative: Proposed MWD Import Water Supply

Pressure Zone	Name[a,b]	Design Capacity (cfs)	Avg MDD Flowrate (cfs)	Total MDD Supply (mgd)
Zone 1B	F-05	15	0	0.00
Zone 3	F-04	15	0	0.00
	F-06	15	0	0.00
	F-08	30	4	1.26
	F-09	15	0	0.00
Zone 4A	F-02	5	0	0.00
	Total	**95**	**4**	**1.26**

Notes:
[a] MWD Connections F-01 is not used. In 2021 it was brought online to serve as a backup supply for emergencies due wells being out of service at the time impacted by PFAS, however, it has not been used.
[b] MWD Connection F-03 is not operational.

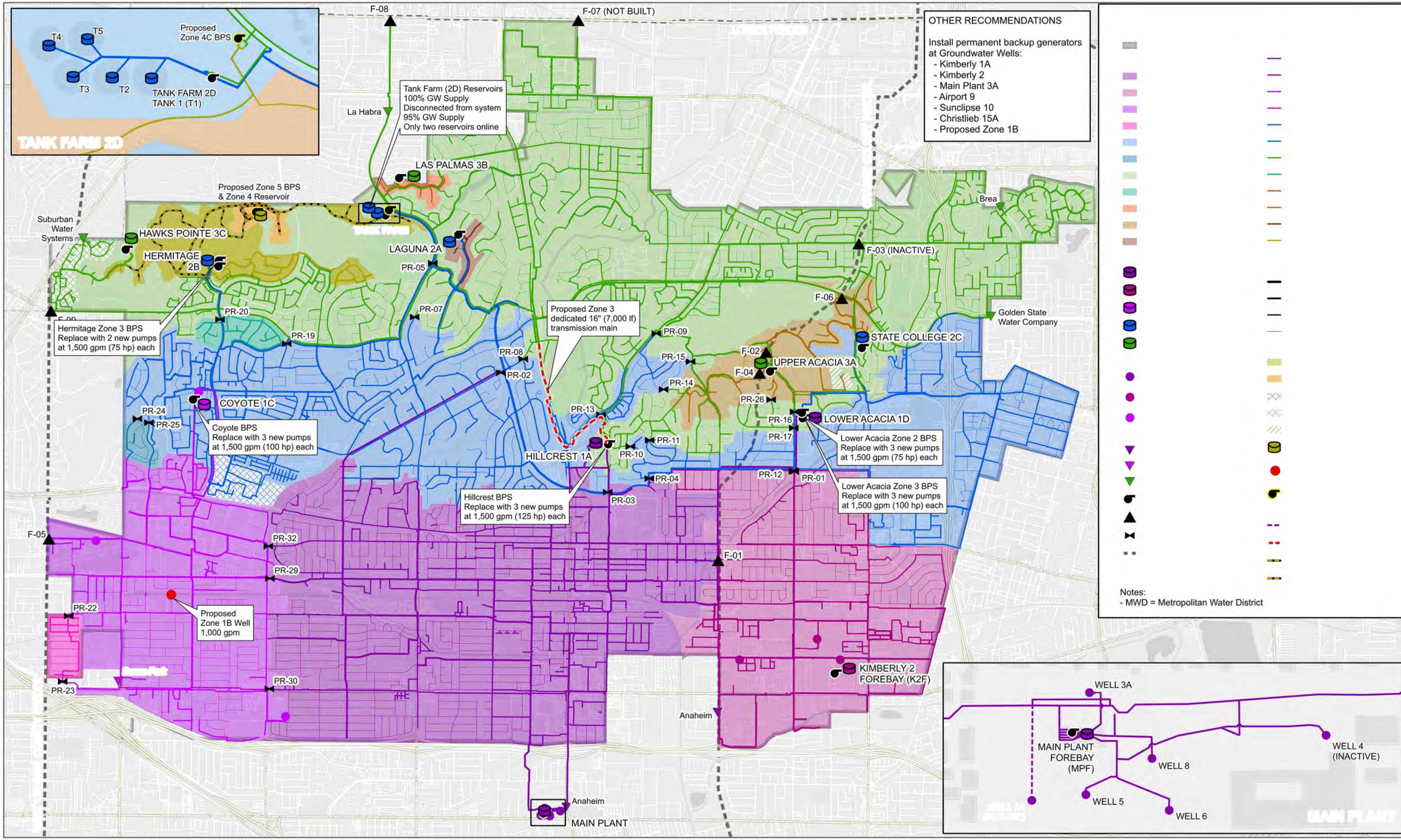

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Figure 9-2. Scenario 1B: 100% Long-Term Groundwater Supply

9.2 System Operations Efficiency

9.2.1 SCENARIO 2 – PUMPING AND PRV SYSTEM OPERATIONS

The goal for Scenario 2 is to minimize pumping hours as well as to minimize flow from upper zones to lower zones by evaluating PRV settings. Scenario 2 was modeled under 72-Hour EPS future MDD conditions with a total demand of 36.5 mgd.

Groundwater wells supplied approximately 23.9 mgd as summarized in Table 9-10. The remaining 12.6 mgd was supplied by MWD imported water (Table 9-11). Note the ratio between groundwater and MWD imported water are similar to existing conditions.

Table 9-10. Scenario 2: Proposed Groundwater Well Supply

Pressure Zone	Name	Design Capacity (gpm)[a]	Avg MDD Flowrate (gpm)	Total MDD Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	1,960	1.08
	Well 6 (Main Plant)	1,500	1,354	0.03
	Well 8 (Main Plant)	2,000	1,698	1.24
	Well 3A	2,400	2,618	3.77
	Well 7A[b]	3,000	3,188	4.59
Zone 1A	Kimberly Well 1A[c]	2,800	1,744	2.51
	Kimberly Well 2[d]	1,875	1,688	2.43
	Sunclipse Well 10[d]	2,000	2,058	2.96
Zone 1B	Airport Well 9	2,500	2,480	3.57
	Christlieb Well 15A[e]	2,000	2,154	1.70
	Totals	**21,575**	**20,943**	**23.89**

Notes:
[a] Design capacity data obtained from Water Facilities Worksheet provided by the City.
[b] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[c] Kimberly Well 1A to be rehabilitated and upgraded in 2025; however, this scenario assumes current well conditions. Note the average MDD flow rate matches SCADA collected during hydrant flow testing.
[d] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped a new pump to deliver its well design capacity.
[e] Christlieb Well 15A is being rehabilitated but may not be available in the future. This scenario assumes current well conditions.

Table 9-11. Scenario 2: Proposed MWD Import Water Supply

Pressure Zone	Name[a,b]	Design Capacity (cfs)	Avg MDD Flowrate (cfs)	Total MDD Supply (mgd)
Zone 1B	F-05	15	6	3.12
Zone 3	F-04	15	2	0.97
	F-06	15	5	2.89
	F-08	30	6	3.48
	F-09	15	6	2.15
Zone 4A	F-02	5	0	0.00
	Total	**95**	**24**	**12.61**

Notes:
[a] MWD Connections F-01 is not used. In 2021 it was brought online to serve as a backup supply for emergencies due wells being out of service at the time impacted by PFAS, however, it has not been used.
[b] MWD Connection F-03 is not operational.

9.2.1.1 Pump Capacity Evaluation

The model results indicate that there are three pump stations where at least one or more of the pumps operates on a 24-hour continuous basis. For long-term efficiency and overall life of the pump stations, it is recommended that the pump stations operate with dedicated duty pumps and dedicated standby pumps, where the standby pump can operate as a backup if a duty pump were to fail or taken offline for maintenance. However, to allow this operating condition, additional pumping capacity is needed at the three pump stations as listed in Table 9-12. The proposed number of pumps, capacity, and horsepower are provided for each of the booster pump stations. The proposed pumps would replace the existing pumps at each pump station.

Table 9-12. Scenario 2: Proposed BPS Capacity Requirements

Facility	Number of Pumps		Pump Capacity (gpm)		Proposed Pump Horsepower
	Existing	Proposed[a]	Existing	Proposed	
Coyote BPS[b]	3	3	900	1,500	100
Hillcrest BPS	2	2	1,000	1,500	100
Lower Acacia Zone 2 BPS	3	3	850	1,000	50

Notes:
[a] Proposed number of pumps assumes two duty pumps and one standby pump configuration, except for Hillcrest BPS with one duty and one standby pump. Pumps proposed to replace existing number of pumps.
[b] Coyote BPS recommendation is consistent with existing conditions recommendation in Section 8.1.

Two of the four closed system pressure zones, Zone 4C and Zone 4A, are supplied by pump stations that do not have hydropneumatic tanks or variable frequency drives (VFDs). These constant speed pumps typically pump significantly more than the daily system demands. To maintain system pressure these pumps circulate water back to the suction line through a control valve. To improve pump operating efficiency and reduce operating costs, hydropneumatic tanks are recommended at the Hermitage

Zone 4C BPS and Upper Acacia BPS. It should be noted that the Hermitage Zone 4C BPS does have a hydropneumatic tank system onsite, but has not been operating for several years. A further study of this facility should be conducted to determine if the hydropneumatic system can be rehabilitated or replaced. The State College BPS and Tank Farm BPS were not needed for this scenario.

9.2.1.2 PRV Evaluation

For large pressure zones, the goal of this analysis is to minimize the flow from the upper zones to the lower zones. To accomplish this, flow from Zone 3 to Zone 2 and from Zone 2 to Zone 1 was evaluated. To reduce the flow and maintain minimum service pressures of 40 psi, the settings for four PRVs were adjusted as summarized in Table 9-13.

Table 9-13. Scenario 2: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
		Existing	Proposed	Existing		Proposed	
				Average	Peak	Average	Peak
2 to 1	PR-4	55	50	383	441	0	0
Tank Farm to 2	PR-5A1	65	61	6,647	7,841	847	2,121
3 to 2	PR-7	68	55	632	643	205	253
	PR-14	53	44	399	475	141	200

The proposed conditions for Scenario 2 are shown on Figure 9-3.

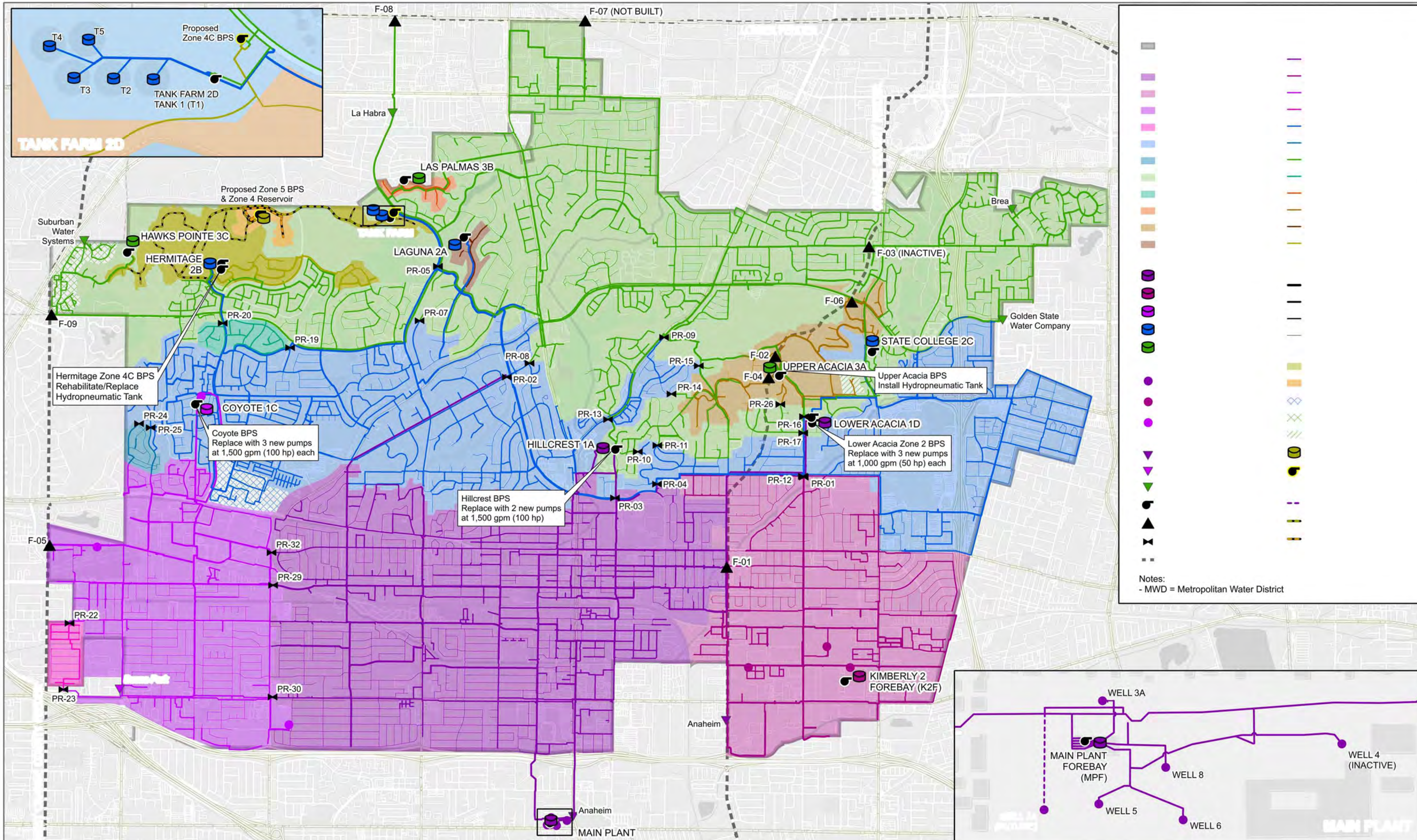

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Figure 9-3. Scenario 2: Pumping and PRV System Operations

9.3 System Reliability

9.3.1 SCENARIO 3A – 7-DAY IMPORTED WATER OUTAGE

The goal of Scenario 3A is to investigate the capability of the system to meet demands with a 7-day MWD imported water supply outage. This scenario was modeled under a 7-Day EPS future ADD of 24.9 mgd. During this type of emergency condition, the City would assume to curtail demands with mandatory use restrictions. However, for purposes of evaluating the system under this scenario, ADD conditions are assumed.

With imported water supply out of service, 100 percent of the demand will be met by groundwater supply as shown in Table 9-14. All groundwater well pumping is maximized and operating for the full 168 hours with the exception of Wells 1A and 15A. Well 1A is controlled by Lower Acacia 1D Reservoir levels and Well 15A is controlled by Coyote 1C Reservoir levels. However, additional supply is needed to meet Zone 1B demands and maintain the Coyote Reservoir levels. A new groundwater well in Zone 1B is proposed with a minimum capacity of 1,000 gpm (150 hp). The proposed groundwater well supplies are summarized in Table 9-14.

Table 9-14. Scenario 3A: Proposed Groundwater Well Supply

Pressure Zone	Name	Design Capacity (gpm)[a]	Avg Flowrate (gpm)	Total Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	0	0.00
	Well 6 (Main Plant)	1,500	1,379	1.99
	Well 8 (Main Plant)	2,000	1,732	2.49
	Well 3A	2,400	2,305	3.32
	Well 7A[b]	3,000	3,123	4.50
Zone 1A	Kimberly Well 1A[c]	2,800	1,724	1.28
	Kimberly Well 2[d]	1,875	1,681	2.42
	Sunclipse Well 10[d]	2,000	2,053	2.96
Zone 1B	Airport Well 9	2,500	2,533	3.65
	Christlieb Well 15A[e]	2,000	2,000	2.62
	Proposed Zone 1B Well	1,000	899	1.18
	Totals	**21,575**	**19,429**	**26.40**

Note:
[a] Design capacity data obtained from Water Facilities Worksheet provided by the City.
[b] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[c] Kimberly Well 1A to be rehabilitated and upgraded in 2025; however, this scenario assumes current well conditions. Note the average MDD flow rate matches SCADA collected during hydrant flow testing.
[d] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped a new pump to deliver its well design capacity.
[e] Christlieb Well 15A is being rehabilitated but may not be available in the future. This scenario assumes current well conditions.

9.3.1.1 Pump Capacity Evaluation

To pump groundwater from the lower pressure zones to higher pressure zones, additional pumping capacity would be needed at five booster pump stations as listed in Table 9-15. The number of pumps, capacity, and horsepower are provided for each of the BPS. The proposed pumps would replace the existing pumps at each pump station.

Table 9-15. Scenario 3A: Proposed Supplemental BPS Capacity

Facility	Number of Pumps		Pump Capacity (gpm)		Proposed Pump Horsepower
	Existing	Proposed[a]	Existing	Proposed	
Coyote BPS[b]	3	3	900	1,500	100
Hillcrest BPS[c]	2	3	1,000	1,500	125
Lower Acacia Zone 2 BPS[c]	3	3	850	1,500	75
Lower Acacia Zone 3 BPS[d]	3	3	1,150	1,500	100
Hermitage Zone 3 BPS[d]	2	2	500/1,000	1,500	75

Notes:
[a] Proposed number of pumps assumes two duty pumps and one standby pump configuration, except for Hermitage Zone 3 BPS with one duty and one standby pump. Pumps proposed to replace existing pumps.
[b] Coyote BPS recommendation is consistent with existing conditions recommendation in Section 8.1.
[c] Capacity recommendation is consistent with Scenario 1A Maximum Available Groundwater Supply during future MDD conditions.
[d] Capacity recommendation is consistent with Scenario 1B 100 Percent Groundwater Supply during ADD conditions.

For Scenario 3A, the Tank Farm BPS is needed to operate 7 to 8 hours per day over 6 days to meet Zone 3 demands and maintain the Las Palmas 3B Reservoir levels.

Note that the State College BPS is not needed for this scenario.

9.3.1.2 PRV Evaluation

To reduce flow from the upper zones to the lower zones and save pumping costs, the settings for three PRVs were adjusted as summarized in Table 9-16.

Table 9-16. Scenario 3A: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
		Existing	Proposed	Existing		Proposed	
				Average	Peak	Average	Peak
2 to 1	PR-4	55	50	383	441	0	0
3 to 2	PR-7	68	55	632	643	172	278
	PR-14	53	40	399	475	0	0

The proposed conditions for this scenario are shown on Figure 9-4.

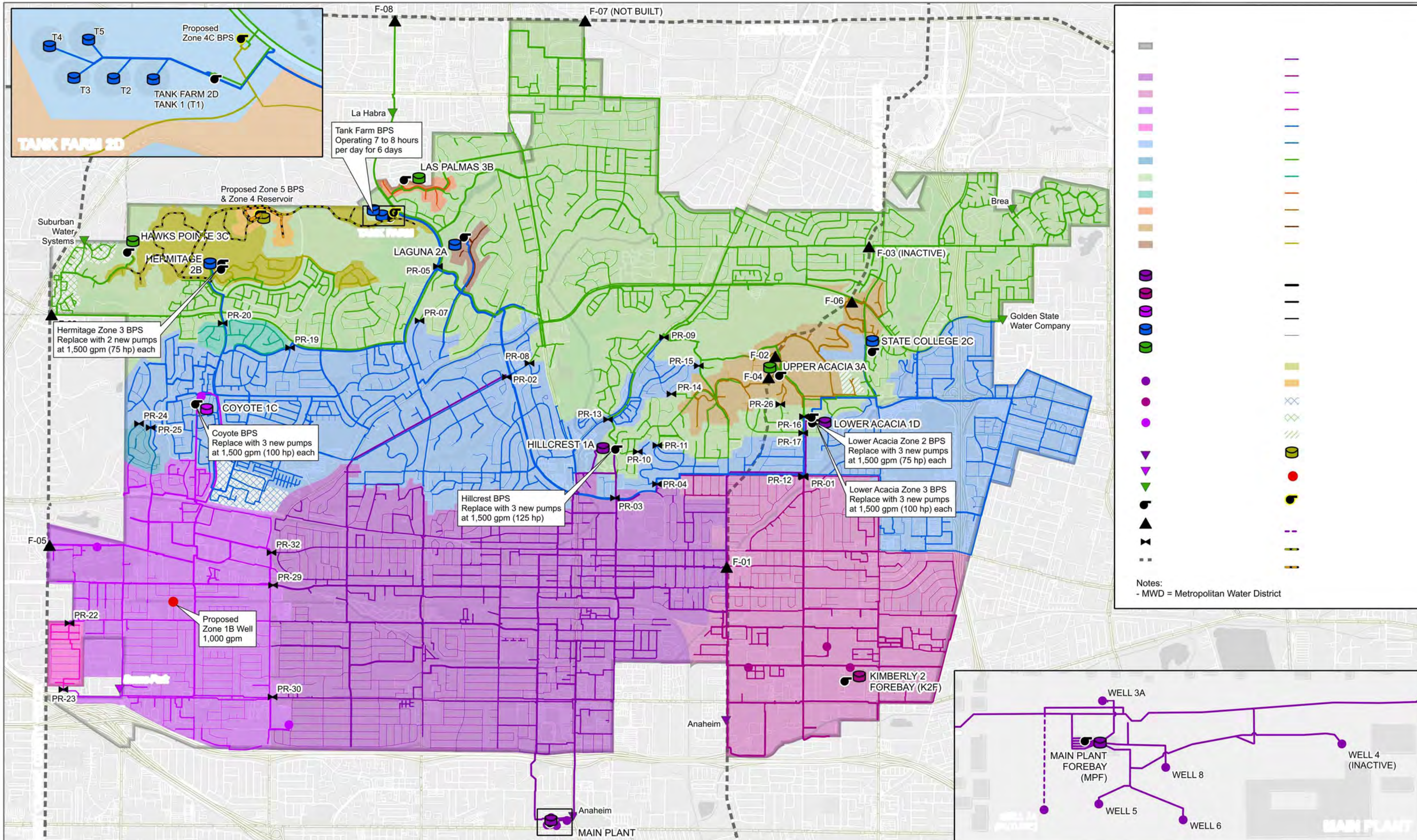

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Figure 9-4. Scenario 3A: 7-Day Import Water Outage

9.3.2 SCENARIO 3B – PUMP STATIONS OFFLINE

Scenario 3B investigated the impacts to and capability of the system during a 7-day pump station outage while meeting demands and maintaining minimum service pressures of 40 psi. This scenario assumes emergency generators are not available, except for generators at pump stations in closed zones. Scenario 3B was modeled under 7-Day EPS future ADD condition with a total demand of 24.9 mgd.

The groundwater wells supplied 9.3 mgd (see Table 9-17) and the MWD import connections supplied 15.6 mgd (see Table 9-18). The groundwater wells are in the lower pressure zones (Zones 1, 1A, 1B) and most of the MWD connections supply Zone 3. Therefore, with the pump stations between zones offline, the demands to Zone 3, Zone 2, and as required when demands exceed groundwater wells capacity in Zone 1, were met by the MWD import connections through PRVs in the system. Zones 4, 4A, 4B, 4C, and 5 are all closed zones only supplied by pump stations; therefore, these were the only booster pump stations assumed to remain in operation.

Table 9-17. Scenario 3B: Proposed Groundwater Well Supply

Pressure Zone	Name	Design Capacity (gpm)[a]	Avg MDD Flowrate (gpm)	Total MDD Supply (mgd)
Zone 1	Well 5 (Main Plant)	1,500	0	0.00
	Well 6 (Main Plant)	1,500	0	0.00
	Well 8 (Main Plant)	2,000	1,695	1.27
	Well 3A (Main Plant)	2,400	1,668	1.48
	Well 7A (Main Plant)[b]	3,000	3,799	3.37
Zone 1A	Kimberly Well 1A[c]	2,800	1,795	1.51
	Kimberly Well 2[d]	1,875	1,701	0.09
	Sunclipse Well 10[d]	2,000	2,044	0.09
Zone 1B	Airport Well 9	2,500	2,583	1.45
	Christlieb Well 15A[e]	2,000	2,193	0.06
	Totals	**21,575**	**17,478**	**9.31**

Notes
[a] Design capacity data obtained from Water Facilities Worksheet provided by the City.
[b] Well 7A capacity is currently in the design phase and based on the expected capacity. Well 7A and Well 3A will pump to a treatment facility located at the Main Plant and directly supply Zone 1.
[c] Kimberly Well 1A to be rehabilitated and upgraded in 2025; however, this scenario assumes current well conditions. Note the average MDD flow rate matches SCADA collected during hydrant flow testing.
[d] Kimberly Well 2 and Sunclipse Well 10 are assumed to pump to a common PFAS treatment facility located at the Kimberly Well 2 site prior to discharging to Zone 1A. Kimberly 2 is assumed to be equipped a new pump to deliver its well design capacity.
[e] Christlieb Well 15A is being rehabilitated but may not be available in the future. This scenario assumes current well conditions.

Table 9-18. Scenario 3B: Proposed MWD Import Water Supply

Pressure Zone	Name[a,b]	Design Capacity (cfs)	Avg MDD Flowrate (cfs)	Total MDD Supply (mgd)
Zone 1B	F-05	15	2	1.42
Zone 3	F-04	15	3	2.12
	F-06	15	6	3.56
	F-08	30	11	7.07
	F-09	15	2	1.42
Zone 4A	F-02	5	0	1.42
	Total	**95**	**25**	**15.59**

Notes
[a] MWD Connections F-01 is not used. In 2021 it was brought online to serve as a backup supply for emergencies due wells being out of service at the time impacted by PFAS, however, it has not been used.
[b] MWD Connection F-03 is not operational.

9.3.2.1 Pump Capacity Evaluation

Las Palmas, Upper Acacia, Laguna, and Hawks Pointe BPS in Zones 4, 4A, 4B, and 4C, respectively, were allowed to operate given they are the sole source to meet demands in the respective zones. In addition, the proposed new Zone 4C and Zone 5 BPS were allowed to operate for the same reasons. Backup power generators should be equipped for the Laguna and Las Palmas BPS and are currently in design.

9.3.2.2 PRV Evaluation

PRVs were used to supply demands in the lower pressure zones. As such, settings for two PRVs were adjusted as summarized in Table 9-19.

Table 9-19. Scenario 3B: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
				Existing		Proposed	
		Existing	Proposed	Average	Peak	Average	Peak
2 to 1	PR-3	55	60	0	0	907	2,404
Tank Farm to 2	PR-5A1	65	63	6,647	7,841	3,744	6,019

9.3.3 SCENARIO 3C – GROUNDWATER OUTAGE

The goal for Scenario 3C is to investigate the impacts to and capability of the system to meet demands during a 7-day groundwater well supply outage. Scenario 3C was modeled as a 7-day EPS future ADD conditions with a total demand of 24.9 mgd.

With groundwater wells out of service, 100 percent of the demand is met by imported water supply with flow from each MWD connection as summarized in Table 9-20.

Table 9-20. Scenario 3C: Proposed MWD Import Water Supply

Pressure Zone	Name[a,b]	Design Capacity (cfs)	Avg Flowrate (cfs)	Total Supply (mgd)
Zone 1B	F-05	15	7	4.39
Zone 3	F-04	15	4	2.88
	F-06	15	12	7.88
	F-08	30	13	8.64
	F-09	15	6	1.43
Zone 4A	F-02	5	0	0.00
	Total	**95**	**42**	**25.22**

Notes:
[a] MWD Connections F-01 is not used. In 2021 it was brought online to serve as a backup supply for emergencies due wells being out of service at the time impacted by PFAS, however, it has not been used.
[b] MWD Connection F-03 is not operational.

9.3.3.1 Pump Capacity Evaluation

Given there is no groundwater supply available to pump up to the higher zones, the only booster pump stations online are those in five closed pressure zones. Zones 4, 4A, 4B, 4C, and 5.

Las Palmas, Upper Acacia, Laguna, and Hawks Pointe BPS in Zones 4, 4A, 4B, and 4C, respectively, remained in operation. In addition, the proposed new Zone 4C and Zone 5 BPS remained online for the same reasons. Backup power generators should be equipped at the Laguna and Las Palmas BPS.

9.3.3.2 PRV Evaluation

Since most of the MWD import connections are in the higher zones, PRVs were used to supply demands to the lower pressure zones. Settings for nine PRVs were adjusted as summarized in Table 9-21.

Table 9-21. Scenario 3C: Proposed PRV Settings

From Zone To Zone	Name	Setting		Flow Rate (gpm)			
		Existing	Proposed	Existing		Proposed	
				Average	Peak	Average	Peak
2 to 1A	PR-1B	43	48	0	0	787	1,712
2 to 1	PR-2	20	30	900	1,217	2,391	2,703
	PR-3	55	60	0	0	1,735	2,822
3 to 2	PR-8	45	66	0	0	1,803	1,867
	PR-9	40	74	0	0	596	655
	PR-10	42	64	0	0	808	833
	PR-11	38	58	0	0	1,057	1,117
	PR-16B	30	32	22	301	785	1,647
	PR-17	20	63	0	0	410	470

9.4 Planning Scenario Recommendations

Although each planning scenario was evaluated independently, some planning scenarios have multiple recommendations in common. Table 9-22 and Figure 9-5 show a comprehensive summary of all facility and improvement recommendations for each planning scenario.

The following recommendations are proposed based on the evaluation of all the scenarios and considers the goal to increase groundwater supply capabilities to meet demands to the upper zones, becoming less reliant on imported water purchases:

- Coyote BPS: Replace existing pumps with 3 new pumps, two duty pumps and one standby pump, at 1,500 gpm (100 hp) each to allow for redundancy.
- Hillcrest BPS: Replace existing pumps with 3 new pumps, two duty pumps and one standby pump, at 1,500 gpm (125 hp) each to allow for redundancy.
- Lower Acacia Zone 2 BPS: Replace existing pumps with 3 new pumps, two duty pumps and one standby pump, at 1,500 gpm (75 hp) each to allow for redundancy.
- Lower Acacia Zone 3 BPS: Replace existing pumps with 3 new pumps, two duty pumps and one standby pump, at 1,500 gpm (100 hp) each to allow for redundancy.
- Hermitage Zone 3 BPS: Replace existing pumps with 2 new pumps, one duty pump and one standby pump, at 1,500 gpm (75 hp) each to allow for redundancy.
- Hermitage Zone 4C BPS: Rehabilitate or replace existing onsite inoperable hydropneumatic tank to meet minimum pressure criteria of 40 psi.
- Upper Acacia BPS: Install hydropneumatic tank to meet minimum pressure criteria of 40 psi.

- Zone 1B: Install new groundwater well, with a redundancy well, at 1,000 gpm (150 hp) each to meet capacity.
- Zone 3: Install new dedicated 16-inch 7,000-lf transmission main from the Hillcrest BPS to the intersection of North Harbor Boulevard and West Valencia Mesa Drive to maintain tank levels at Las Palmas 3B Reservoir.
- PRVs: Adjust setting at various PRVs to meet reservoir storage requirements and maintain minimum pressure of 40 psi in the respective zones.

Table 9-22. Planning Scenario Summary of Recommendations

Facility	Scenario 1A: Maximizing Groundwater	Scenario 1B: 100% Groundwater Supply	Scenario 2: System Operations Efficiency	Scenario 3A: Import Water Outage	Scenario 3B: Pump Stations Offline	Scenario 3C: Groundwater Outage
Coyote BPS	3 new pumps at 1,500 gpm (100 hp) each	3 new pumps at 1,500 gpm (100 hp) each	3 new pumps at 1,500 gpm (100 hp) each	3 new pumps at 1,500 gpm (100 hp) each	-	-
Hillcrest BPS	3 new pumps at 1,500 gpm (125 hp) each	3 new pumps at 1,500 gpm (125 hp) each	2 new pumps at 1,500 gpm (100 hp) each	3 new pumps at 1,500 gpm (125 hp) each	-	-
Lower Acacia Z2 BPS	3 new pumps at 1,500 gpm (75 hp) each	3 new pumps at 1,500 gpm (75 hp) each	3 new pumps at 1,000 gpm (50 hp) each	3 new pumps at 1,500 gpm (75 hp) each	-	-
Lower Acacia Z3 BPS	-	3 new pumps at 1,500 gpm (100 hp) each	-	3 new pumps at 1,500 gpm (100 hp) each	-	-
Hermitage Z3 BPS	-	2 new pumps at 1,500 gpm (75 hp) each	-	2 new pumps at 1,500 gpm (75 hp) each	-	-
Hermitage Z4C BPS	-	-	Rehabilitate or replace hydropneumatic tank	-	-	-
Upper Acacia BPS	-	-	Install hydropneumatic tank	-	-	-
Zone 1B Additional Supply	-	1 new well at 1,000 gpm (150 hp) & redundancy well	-	1 new well at 1,000 gpm (150 hp) & redundancy well	-	-
Zone 3 Additional Pipelines	-	Dedicated 16-in (7,000-lf) transmission line	-	-	-	-
PRV Settings Updated	PR-4 PR-5A1 PR-7 PR-14	PR-4 PR-5A1 PR-7 PR-13 PR-14	PR-4 PR-5A1 PR-7 PR-14	PR-4 PR-7 PR-14	PR-3 PR-5A1	PR-1B PR-2 PR-3 PR-8 PR-9 PR-10 PR-11 PR-16B PR-17
Onsite Permanent Backup Generators	-	Wells 1A, 2, 3A, 9, 10, 15A, & proposed Zone 1B; BPS Coyote, Hillcrest, Lower Acacia, Laguna, Las Palmas, and Hermitage	-	-	BPS Laguna and Las Palmas	-
Additional Recommendations	-	Remove Tank Farm 2D Reservoir operations	-	-	-	-

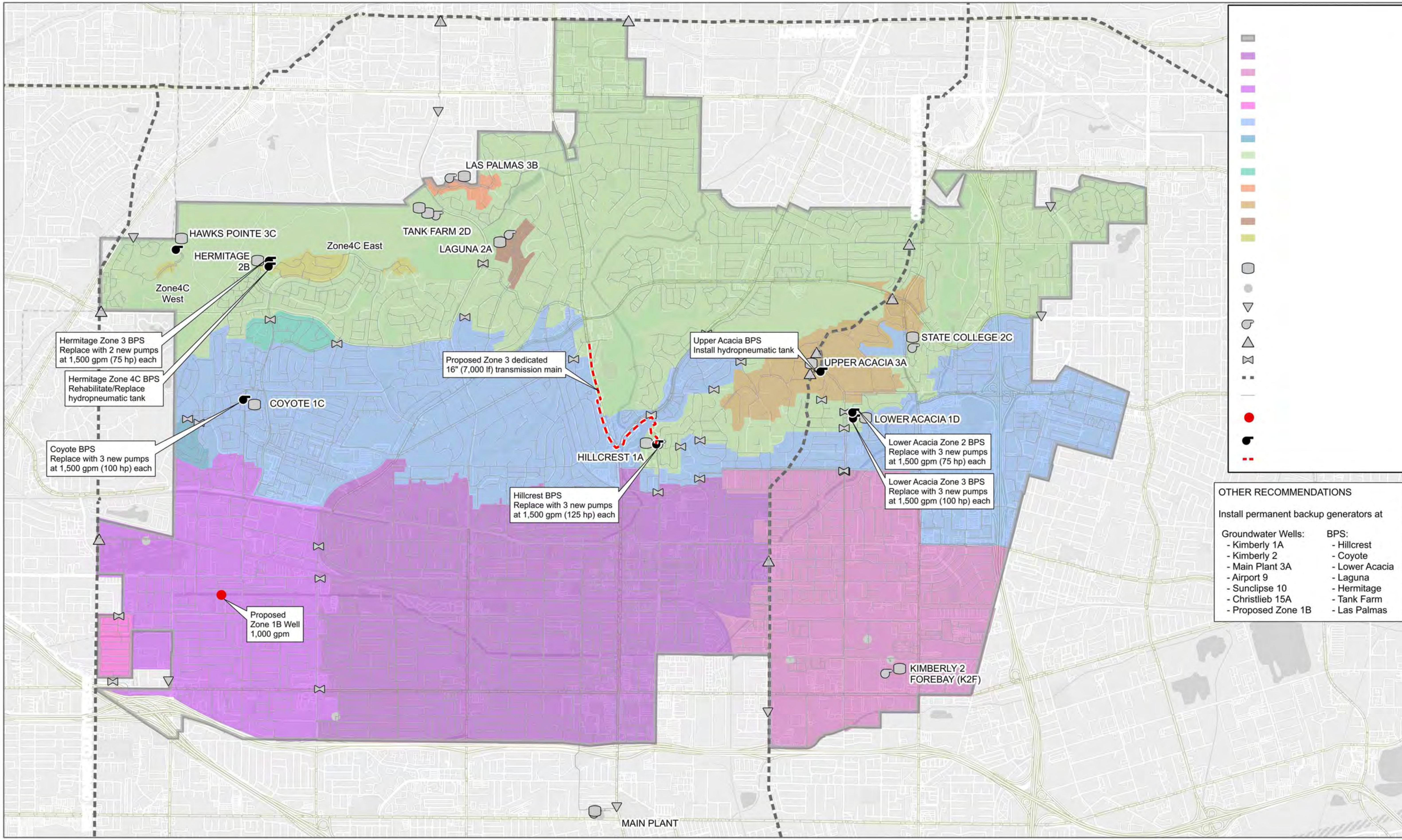

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Figure 9-5. Planning Scenario Recommendations

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10.0 Facility Condition Assessment

A visual inspection of the City's facilities was performed with the assistance of City operations staff on April 6, 2023, and August 10, 2023. The visual inspections were completed on the civil, mechanical, structural, and electrical components at the site. No testing of reliability or performance, including any material testing, was conducted on the infrastructure. Full details and results of the condition assessment are documented in Appendix F.

10.1 Methodology

The rating system is based on a scoring of 1 through 5, with 1 being very good to 5 being the worst, or very poor. Table 10-1 below provides guidance to the ratings generally used within the report.

Table 10-1. General Description for Scoring of Conditions of Assets

Grade	Classification	Action	Description
1	Very good	No Action required.	New or near new condition Some wear or discoloration but no evidence of damage. Can include repair assets where the repair is as good as the original.
2	Good	Monitor to see if there are changes	Deterioration or minor damage that may affect performance. Includes most repair assets.
3	Moderate	Consider specialist assessment	Clearly needs some attention but is still working. Structure in need of repair. Includes repaired where the repair is deteriorated.
4	Poor	Get specialist assessment	Either not working or is working poorly because of damage or deterioration. Condition of structure is poor or structural integrity in question.
5	Very Poor	Replace or repair	Needs urgent attention.

Table 10-2 below indicates the typical timescale for condition-related actions on longer life assets with a design life of 50 or more years (i.e., most civil structures) and shorter life assets, typically with a design life less than 20-25 years (i.e., mechanical, electrical assets, coatings, etc.).

Table 10-2. General Ratings and Timescale

Grade	Classification	Action	Timescale for Longer Life Assets	Timescale for Shorter Life Assets
1	Very good	No Action required.	No action needed within 20 years.	No action needed within 10 years.
2	Good	Monitor to see if there are changes	Some action needed within 20 years.	Some action needed within 10 years.
3	Moderate	Consider specialist assessment	Some action needed within 10 years.	Some action needed within 3 years.
4	Poor	Get specialist assessment	Action needed within 3 years.	Action needed within one year.
5	Very Poor	Replace or repair	Action needed within one year.	Action needed immediately.

10.2 Condition Assessment Recommendations

The following tables summarize the recommendations by general sites (Table 10-3), pump stations (Table 10-4), reservoirs (Table 10-5), and well facilities (Table 10-6).

In addition to these facility-specific recommendations, there are two general improvement recommendations that are applicable to all facility sites:

1. Miscellaneous site improvements such as new lighting around each site
2. Perform an Arc Flash Study and provide appropriate labeling for all applicable electrical equipment at each of the pump facilities.

Priority level for these general improvement recommendations depends on planning horizon of respective facility.

Table 10-3. Site Condition Assessment Summary

Site	Overall Condition Rating	Improvement Recommendations[a]
Kimberly Well 2	2	Canopies over well and booster pumps are poor condition, requiring replacement
Airport Well 9	2	Site cleanup including fence repair, weed maintenance and miscellaneous wiring laying around the site.
Sunclipse Well 10	3	Pavement surface repairs due to poor condition, significant cracking
Christlieb Well 15A	3	Site improvements including drainage capacity improvements and pavement surface repairs
Coyote 1C	4	Demolish and removal of Well 12A equipment, site improvements including surface repair, vault lid replacements, and bollard installations
Hermitage 2B	2	Perimeter site fencing repairs and improvements, and slope erosion control around hydropneumatic tank
State College 2C	4	Site improvements including surface pavement repair, drainage and fencing improvements
Tank Farm 2D	3	Site pavement repair and improvements, including slope erosion control around tanks, valve vault fencing, drainage improvements, and removal of irrigation system
Upper Acacia 3A	3	Site improvements including surface pavement repairs and slope erosion control

Note:
[a] Only facilities with recommended improvements are listed in the table. Facilities with a rating of 1 (good condition) are excluded from this table. These include Hillcrest 1A, Lower Acacia 1D, Laguna 2A, Las Palmas 3B, and Hawks Pointe 3C sites.

Table 10-4. Pump Station Condition Assessment Summary

Facility[a]	Install Year	Overall Condition Rating	Estimated Remaining Useful Life (years)	Improvements Recommended Timeframe (years)	Improvement Recommendations[b]
Hillcrest PS 1A-3	1988	2.8	15	10	Replace both existing pumps and motors, valving improvements, building roof member replacements and general roof repairs
Coyote PS 1C-2	1958	3.0	10	10	Replace all three pumps with larger capacity pumps to allow one standby unit, replace ball valves to reduce maintenance, replace MCC and switchboard
Lower Acacia PS 1D-2 & 1D-3	1960	2.5	20	30	Replace Pump #1 at 1D-2: including base plates repair and piping coatings repair for all pumps, repair of MCC cabling
Kimberly 2	1955	3.5	5	<5	Replace forebay, all electrical equipment, all booster pumps and structures recommended for replacement
Laguna PS 2A-4B	2020	1.0	50	20+	None recommended at this time
Hermitage PS 2B-3 & 2B-4C	1978/ 1981	3.8	5	<5	Pump Station 2B-3 and 2B-4C major rehabilitation: including replacing pumps, motor, electrical equipment, and pipe coating repairs, hydropneumatic tank rehabilitation or replacement, building improvements and roof replacement
State College PS 2C-3	1981	3.3	5	15	Replace both pumps and motors including pipe coatings and repair, and electrical improvements, new switchboard, and SCE power improvements
Tank Farm PS 2D-3	1966	3.5	10	10	Replace both existing pumps and motors, including electrical and switchboard replacement, coatings, and pipe repair of aboveground pipes
Upper Acacia PS 3A-4A	1994	3.8	5	<5	Replace pumps and motors, sized for pressure zone demands, install hydropneumatic tank, rehabilitate pressure relief bypass valve and assembly for flows, electrical building repairs and improvements. Foundation Settlement/Slope Stability Study
Las Palmas PS 3B-4	2022	1.5	50	20+	Replace 10kVA transformer at new location, minor pump station building and valve vault surface improvements
Hawks Pointe PS 3C-4	2004	1.8	40	20+	Minor corrosion and coating repair to Pump #1 pump base

Note:
[a] Main Plant BPS facilities are under construction with a recent condition assessment completed, therefore, an assessment for these facilities were deemed not necessary at this time.
[b] For detailed project specific improvement recommendations, refer to the discussion for each facility in this report.
MCC = motor control center
SCE = Southern California Edison Company

Table 10-5. Reservoir Condition Assessment Summary

Facility	Install Year	Overall Condition Rating	Estimated Remaining Useful Life (years)	Improvements Recommended Timeframe (years)	Improvement Recommendations[a]
Hillcrest 1A	2005	1.0	60	20+	None recommended at this time
Coyote 1C	1952	3.9	10	5	Tank rehabilitation; coatings, structural reinforcements and rehabilitation at manways, roof replacement, install overflow piping, vents, replacement piping, valves, vaults and ladders and appurtenances
Lower Acacia 1D	1960	1.7	40	20+	Replacement and repair of gaps left by damaged or removed filler material at reservoir expansion joints
Laguna 2A	1958	3.0	15	10	Coatings and tank surface repairs, aboveground pipe coating repair, and replace valving, ladders, and mixer
Hermitage 2B	1964	2.3	35	10	Repair aboveground piping coating systems, repair and/or replace sealant/grout at tank base
State College 2C	1962	2.0	40	15	Replacement of sealant at tank base, and repair of coatings in isolated areas and at tank vents
Tank Farm 2D	1966	3.0	10	5	T-2 Coatings repair and surface rehabilitation T-4 Settlement Study T-5 Tank Rehabilitation to bring into service All Tanks: Power and electrical service upgrades for rectifiers and mixers
Upper Acacia 3A	1963 (Tank #1) 1966 (Tank #2)	2.0	20	15	Tank #1: Coating repairs at tank base, overflow improvements, piping coating improvements, minor cathodic protection improvements Tank #2: Tank wall and foundation improvements, piping coating improvements, overflow improvements, minor cathodic protection improvements
Las Palmas 3B	1962	1.6	40	20	Minor localized coating repairs
Hawks Pointe 3C	2004	1.7	50	15	Minor sealant repairs and localized coating repairs, altitude valve repair to correct suspended connection to the tank wall with support

Note:
[a] For detailed project specific improvement recommendations, refer to the discussion for each facility in this report.

Table 10-6. Well Condition Assessment Summary

Facility[a]	Install Year	Overall Condition Rating	Estimated Remaining Useful Life (years)	Improvements Recommended Timeframe (years)	Improvement Recommendations[b]
Kimberly Well 2	1955	3.3	5	<5	Well rehabilitation, replace well pump and motor, and discharge piping facilities
Airport Well 9	1985	2.0	35	20	Site fencing repair, repair damaged coating on pipes, miscellaneous wiring repairs and cleanup
Sunclipse Well 10	1990	3.5	10	5	Well pump and motor replaced, including coating repair of pipes, valves and supports, replace electrical equipment and replace chemical feed system
Christlieb Well 15A	1992	3.3	20	10	Replace pump control valve, chemical feed system and enclosure, VFD, and MCC, including repairs to sound enclosure, drainage piping improvements, drain tank roofing and facia boards improvements

Note:
[a] Kimberlly Well 1A was back online in 2021 and will be rehabilitated and upgraded in 2025.
[b] For detailed project specific improvement recommendations, refer to the discussion for each facility in this report.

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11.0 Risk Assessment

An analysis and evaluation of the Asset Management Asset-Risk was conducted for the horizontal and vertical assets. Full details, including the methodology and results, are documented in the Condition Assessment Technical Memorandum in Appendix G. This analysis was conducted in parallel with a hydraulic analysis focusing on system improvements necessary to meet hydraulic design criteria and/or optimize system operations. The hydraulic analysis, which incorporated a fire-flow availability analysis, and the Asset Management Asset-Risk analysis were considered to create a series of recommended improvements for the Capital Improvement Program (Section 12.0). Replacement recommendations for pipelines, wells, pump stations, and reservoirs are based on aspects relating to asset condition, pipeline age, historical failures, soil corrosivity, type of critical customers served, groundwater scarcity, financial impacts, and other non-hydraulic factors.

11.1 Methodology

The risk-based prioritization methodology used an estimation of Likelihood of Failure (LOF), based on available information, and the asset's potential Consequence of Failure (COF), based on proximity to critical customers served and criticality of the asset. These two factors combined to calculate the risk level for each asset.

The Asset-Risk Due to Asset Failure was calculated with the following formula:

$$\text{Asset LOF} \times \text{Asset COF}$$

The LOF relates factors that contribute to an asset's modes of failure. The following equation was used to calculate the LOF for the wells, pump stations, and reservoirs. These scores were identified in the Condition Assessment Technical Memorandum from Stantec dated March 2024, which can be found in Appendix G.

$$\text{LOF Score} = \text{Condition Assessment Inspection Score}$$

Five specific evaluation criteria, each with unique averages, were considered for pipe segments. The evaluation criteria used included:

- Percentage Remaining Useful Life (weighted 50%)
- Soil Corrosivity (weighted 20%)
- Historical Failures (weighted 15%)
- Soil Saturation (weighted 10%)
- Seismic- Landslide and Liquefaction Risk Zones (weighted 5%)

The following equation was used to calculate LOF for pipe segments:

$$\text{LOF Score} = (w1)*(Cr1)+(w2)*(Cr2)+(w3)*(Cr3)+(w4)*(Cr4)+(w5)*(Cr5)$$

Where Cr1 = Criterion 1 (Percentage Remaining Useful Life), w1= weighting 1 (50%), etc.

Six specific COF evaluation criteria were considered for pipelines. The evaluation criteria used included:

- Provision of Safe and Reliable Water to Critical Customers (weighted 30%)
- Direct Cost Indicator- Existing Pipe Characteristics (weighted 25%)
- Direct Cost Indicator- Location Restraints Due to Utility Conflicts at Intersections (weighted 15%)
- Impact on Environmentally Sensitive Areas (weighted 12%)
- Balance and Equity (weighted 10%)
- Climate Change- Groundwater Scarcity (weighted 8%)

The following equation was used to calculate the COF for pipeline segments:

$$\text{COF Score} = (w1)*(Cr1)+(w2)*(Cr2)+(w3)*(Cr3)+(w4)*(Cr4)+(w5)*(Cr5) +(w6)*(Cr6)$$

For vertical assets, the five evaluation criteria considered were:

- Direct Cost Indicator (weighted 40%)
- Provision of Safe and Reliable Water to Critical Customers (weighted 30%)
- Impact on Environmentally Sensitive Areas (weighted 12%)
- Balance of Equity (weighted 10%)
- Climate Change- Groundwater Scarcity (weighted 8%)

The following equation was used to calculate the COF for pipeline segments:

$$\text{COF Score} = (w1)*(Cr1)+(w2)*(Cr2)+(w3)*(Cr3)+(w4)*(Cr4)+(w5)*(Cr5)$$

The COF and LOF calculations, as described above, were calculated and used in determining the risk category for each asset. Figure 11-1 below, details the risk category using the LOF and COF values. The numerical scores are not mathematically proportional to the condition of an asset (i.e., a score of 4 is not twice as poor as a score of 2). Note that within Figure 11-1 the risk appetite is represented by the boundary between the Medium and High categories of risk (light blue line), and the risk categories are represented as: (1) Low = green, (2) Medium = yellow, (3) High = orange, (4) Very High = red. The risk categories of High and Very High are the “At-Risk” assets and pipelines, while the Medium and Low risk categories are below the risk appetite.

Where a risk is identified that is above the risk appetite limit, City staff should determine actions to reduce the risk to below the agreed upon risk tolerance. The concept of risk appetite and tolerance is a driver for determining if a risk is unacceptable or broadly acceptable with the City’s risk appetite and tolerance being represented by the border of the risk levels of Medium and High.

		Consequence				
		1 Insignificant	2 Minor	3 Moderate	4 Major	5 Extreme
Likelihood	5 Almost Certain	Medium	High	High	Very High	Very High
	4 Likely	Medium	Medium	High	High	Very High
	3 Possible	Low	Medium	Medium	High	High
	2 Unlikely	Low	Low	Medium	Medium	High
	1 Rare	Low	Low	Low	Medium	Medium

Figure 11-1. Risk Matrix

11.2 Results

The following tables summarize the results of the Risk Analysis. Table 11-1 displays asset-risk results by pipe length and percentage for pipelines and Table 11-2 displays asset-risk results for the vertical assets.

Table 11-1. Horizontal Asset-Risk Results by Pipe Length and Percentage

Risk Category	Number of Watermain Pipeline Segments	Approximate Length (ft)	Percentage of Pipeline Segments
Low	4,841	354,768	24.46%
Medium	12,994	1,546,532	65.65%
High	1,949	391,969	9.85%
Very High	8	2,003	0.04%

Note: Risk categories are represented as: (1) Low = green, (2) Medium = yellow, (3) High = orange, (4) Very High = red

Table 11-2. Vertical Asset-Risk Results

Asset Type	Facility Identifier	LOF	COF	Risk Category	At-Risk
Pump Station	Upper Acacia BPS 3A-4A	Likely	Major	High	Yes
Well	Sunclipse Well 10	Likely	Major	High	Yes
Well	Christlieb Well 15A	Possible	Major	High	Yes
Pump Station	Hermitage BPS 2B-3 and 2B-4C	Likely	Moderate	High	Yes
Pump Station	Tank Farm BPS 2D-3	Likely	Moderate	High	Yes
Pump Station	Lower Acacia BPS 1D-2 and 1D-3	Possible	Major	High	Yes
Reservoir	Tank Farm 2D	Unlikely	Major	High	Yes
Well	Kimberly Well 2	Possible	Moderate	Medium	No
Pump Station	Coyote BPS 1C-2	Possible	Moderate	Medium	No
Reservoir	Coyote 1C	Likely	Minor	Medium	No
Pump Station	Hillcrest BPS 1A-3	Possible	Moderate	Medium	No
Well	Airport Well 9	Unlikely	Major	Medium	No
Reservoir	Lower Acacia 1D	Unlikely	Major	Medium	No
Reservoir	State College 2C	Unlikely	Moderate	Medium	No
Reservoir	Hermitage 2B	Unlikely	Moderate	Medium	No
Reservoir	Upper Acacia 3A	Unlikely	Moderate	Medium	No
Reservoir	Hawks Pointe 3C	Unlikely	Moderate	Medium	No
Reservoir	Hillcrest 1A	Rare	Major	Medium	No
Reservoir	Laguna 2A	Possible	Insignificant	Low	No
Pump Station	Hawks Pointe BPS 3C-4C	Unlikely	Minor	Low	No
Reservoir	Las Palmas 3B	Unlikely	Minor	Low	No
Pump Station	Las Palmas BPS 3B-4	Unlikely	Insignificant	Low	No
Pump Station	Laguna BPS 2A-4B	Rare	Insignificant	Low	No
Pump Station	State College BPS 2C-3	Possible	Insignificant	Low	No

Note: Risk categories are represented as: (1) Low = green, (2) Medium = yellow, (3) High = orange, (4) Very High = red

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12.0 Capital Improvement Program

The recommended CIP is based on improvements derived from the water system hydraulic model evaluations, condition assessment, and risk-assessment analysis. The CIP identifies the proposed improvement projects, provides the estimated planning level cost estimates of the facilities, and develops an estimated timetable or prioritization for implementing these improvements to the year 2045.

12.1 Cost Estimate Assumptions

Cost estimates are total project costs based on 2024 dollars. Total project cost estimates include estimated construction costs plus engineering, legal, administration, construction management, and contingency costs, including construction change orders. These “soft costs” are estimated to be 40 percent of the construction costs. Project contingency is included to account for unknown conditions when preparing general planning level cost estimates versus detailed design costs where the project components are very well defined. Costs are based on 2024 dollars and do not include escalation.

12.1.1 UNIT CONSTRUCTION COSTS

The cost estimates in this section are based on general planning level unit costs for construction and do not include future operations and maintenance costs. The appropriate use of these estimates is for planning and long-range budgeting and may not be an actual representation of construction costs. Estimates were prepared using a combination of parametric estimating factors, local experience in delivering projects similar those identified in the CIP, and recent actual bid prices on similar projects.

Water Pipelines – Table 12-1 shows a summary of the unit construction costs for water pipelines used to generate distribution and transmission system improvements. All improvements are assumed to take place in public rights-of-way under asphalt roads with an average minimum cover depth of 4 to 5 feet. All pipelines 16-inch diameter and smaller are assumed to be PVC material and pipelines larger than 16-inch diameter are assumed to be ductile iron material. Unit construction costs are intended to be all-inclusive and include items such as traffic control, pavement repair and restoration, service and lateral reconnections, testing and disinfection, and other appurtenant work.

Table 12-1. Pipeline Unit Costs

Pipeline Diameter (inches)	Unit Construction Cost ($/LF)
6	$ 275
8	$ 350
10	$ 400
12	$ 525
16	$ 645
18	$ 765
20	$ 990
24	$ 1,110
30	$ 1,300
36	$ 1,500

Due to fluctuations in market material prices, local variations in the construction bidding climate, and actual project implementation timelines, these unit cost values are meant to be conservative and based on 2024 dollars and are to be used for planning and budgeting purposes. More rigorous estimates should be prepared during the implementation process.

Cost estimates for reservoirs, groundwater wells, pump stations, PRV facilities, and pressure sustaining valve (PSV) facilities are described below and are based on recent similar projects within the City and surrounding agencies.

Reservoirs – Unit construction costs for new reservoir storage tanks are provided in Table 12-2 and listed by capacity. New reservoir facilities are assumed to be above-ground welded-steel tanks, including cathodic protection, site piping, valving, water quality features, and general site improvements.

Table 12-2. Reservoir Storage Costs

Capacity (MG)	Unit Cost ($/MG)
< 1	$4,500,000
1 to 3	$4,000,000
> 3	$3,500,000

Groundwater Wells – Unit construction costs are listed Table 12-3 by capacity and are lump sum costs assuming a new well drilled up to 1,200 feet in depth, including stainless steel casing with block wall building, disinfection requirements, pumps and motors, and wellhead piping and appurtenances. It does not assume land acquisition costs. These costs do not include special treatment for nitrates or PFAS.

Table 12-3. Groundwater Well Costs

Groundwater Well Capacity (gpm)	Lump Sum Cost Estimate
Up to 3,000	$5,000,000
> 3,000	$6,100,000

A new well at an existing site that would not require a new well building or site improvements is estimated to have a unit cost $2,600,000 for up to 3,000 gpm capacity and $3,200,000 for wells with greater than 3,000 gpm capacity. The cost assumes a well, including stainless steel casing, disinfection requirements, pumps and motors, and wellhead piping and appurtenances. The cost does not assume land acquisition costs or special treatment.

Pump Stations – Unit construction costs for a new or replacement booster pump station are provided in Table 12-4. Unit costs for new pump stations assume the pumps are housed in a building and include all site improvements, electrical and instrumentation. Expansion or replacement of a pump station does not assume a building and but does assume site improvements required. For pump stations larger than 300 horsepower (Hp), unit costs of $10,000 per Hp and $5,000 per Hp can be used for new pump stations and expansion or replacement pump stations respectively.

Table 12-4. Pump Station Costs

Pump Station Capacity (horsepower)	New Pump Station	Expansion/Replacement
100	$2,000,000	$670,000
200	$2,600,000	$1,040,000
300	$3,000,000	$1,500,000

PRV/PSV Facilities – New PRV/PSV facilities are assumed to have a unit construction cost of $300,000 each. This assumes the facility is constructed in an underground vault within public rights-of-way, and instrumentation and controls are not required.

Miscellaneous construction lump sum costs are estimated as shown in Table 12-5. The construction costs are based on similar projects for nearby water agencies.

Table 12-5. Facility Unit Costs

Facility	Construction Cost ($/Lump Sum)
Well Rehabilitation	$350,000 - $500,000
Conc. Reservoir Rehabilitation/Retrofits	$1,500,000 - $2,000,000
New Hydropneumatic Tank & Appurtenances	$300,000
Site Improvements & Repairs (for each Reservoir, Well, BPS)	$150,000 - $350,000
Backup Power Generator Well or Pump Station Capacity up to 1,500 gpm Well or Pump Station Capacity > 1,500 gpm	 $600,000 $1,000,000
PRV/PSV	$300,000

12.2 Project Priorities

To develop of a prioritized capital improvement program, the proposed projects have been grouped into three main planning horizons to year 2045:

- High Priority – Short-Term to Year 2030
- Medium Priority – Near-Term to Year 2035
- Low Priority – Long-Term to Year 2045

Projects that are considered for each planning horizon, or priority level, have been categorized according to the following criteria.

12.2.1 FACILITY IMPROVEMENTS

Facility improvements include recommendations for booster pump station, groundwater well, and reservoir facilities as described in the condition assessment summarized in Section 10.0 and risk assessment summarized in Section 11.0. Other facility improvements are recommended based on Planning Scenarios discussed in Section 9.0. Additionally, a new development project might trigger a facility to be constructed and added to the water distribution system to meet the demand and fire flow requirements. The planning horizon for these developments that trigger improvements is tied to the timing of the respective development project. Developer driven project schedules may change depending on the actual development timing.

12.2.2 PIPELINE IMPROVEMENTS

Pipeline improvements are prioritized according to the type or reason for the improvement or severity of the deficiency. The types of deficiencies considered for pipelines include fire flow, minimum and maximum pressure, maximum velocity, system operational improvements, water quality, and aging infrastructure.

12.2.2.1 Fire Flow Improvements Priority Criteria

Improvements required for fire flow protection are considered high priority and should be implemented within the Short-Term planning horizon. These pipelines are additionally prioritized based on fire flow deficiency severity and service to critical facilities, such as schools and hospitals, as identified in Table 12-4. The following criteria were used in evaluating the severity of fire flow deficiency:

- High – 0 to 50 percent fire flow available
- Medium – 51 to 70 percent fire flow available
- Low – 71 to 99 percent fire flow available

12.3 Capital Improvement Projects

Capital improvements projects were grouped by short-term, near-term, and long-term planning horizon. The total cost estimate of all the capital improvements projects is $151,000,000 and is summarized in Table 12-3.

12.3.1 SHORT-TERM (BY 2030) CAPITAL IMPROVEMENT PROJECTS

The short-term capital improvements are based on existing system deficiencies and severity of pipeline deficiency from the hydraulic model evaluations. There were several areas that did not meet fire flow requirements, which are included in this planning horizon. The short-term projects are listed in Table 12-7 by annual planning horizon until 2030. The short-term projects are also shown on Figure 12-1. The subtotal estimated cost for short-term projects is $59,000,000.

12.3.2 NEAR-TERM (BY 2035) CAPITAL IMPROVEMENT PROJECTS

The near-term capital improvement projects are based on system deficiencies with medium priority to the 2035 planning horizon. There are 17 near-term projects, as listed in Table 12-8 and shown on Figure 12-2. The subtotal estimated cost for near-term projects is $33,000,000.

12.3.3 LONG-TERM (2045 AND BEYOND) CAPITAL IMPROVEMENT PROJECTS

The long-term capital improvement projects are based on system deficiencies with low priority to the 2045 planning horizon and beyond. This planning horizon includes the large new development West Coyote Hills and associated improvements to existing infrastructure to support this development. There are 17 long-term projects, as listed in Table 12-9 and shown on Figure 12-3. The subtotal estimated cost for long-term projects is $59,000,000.

12.3.4 CAPITAL IMPROVEMENT PROJECT COSTS SUMMARY

Table 12-6 summarizes the short-term, near-term, and long-term combined cost estimate.

Table 12-6. CIP Cost Summary

Planning Horizon	Construction Cost (in 2024 dollars)	40% Admin/ Contingency	Total Project Cost (in 2024 dollars)[a]
Short-Term	$42,000,000	$17,000,000	$59,000,000
Near-Term	$24,000,000	$9,000,000	$33,000,000
Long-Term	$42,000,000	$17,000,000	$59,000,000
Total CIP	**$108,000,000**	**$43,000,000**	**$151,000,000**

[a] Costs are based on 2024 dollars and do not include escalation.

12.4 Pipeline Repair and Replacement Program

A well-managed pipeline replacement program strategy typically involves a proactive approach to identifying and replacing aging or high-risk pipelines aiming to enhance system reliability, reduce pipe leak risks, and reduce the rate of pipe breaks by upgrading the pipeline infrastructure over time.

The City's Pipeline Repair and Replacement Program improvements are prioritized based on the risk assessment recommendations summarized in Section 11.0, which prioritize pipelines with high and very high-risk scores. Based on this strategy, these high and very high priority pipelines account for the first approximately 74 miles of pipe to be replaced and are described in Appendix G. The total cost for these pipelines is estimated to be approximately $241,000,000 (not adjusted for inflation and including 40 percent contingency).

In addition to these high priority pipeline projects, the City's replacement program should include a replacement strategy that replaces the existing pipeline distribution over a 60-year period. Based on the diameters of the estimated 350 miles of pipe remaining, not including the aforementioned high priority pipelines, the total cost is estimated to be $982,000,000 (not adjusted for inflation and including 40 percent contingency).

Assuming the total distribution system of 424 miles of pipeline is replaced over a 60-year period, this would require an annual budget of $20,400,000 (not adjusted for inflation and including 40 percent contingency). Note the cost estimate for the Pipeline Repair and Replacement Program is not included in the overall CIP costs Table 12-6. Separating these pipeline improvements allows the projects to be budgeted and completed as a separate priority.

A GIS-based prioritization tool was created to determine the priority basis for each pipe of the Pipeline Repair and Replacement Program.

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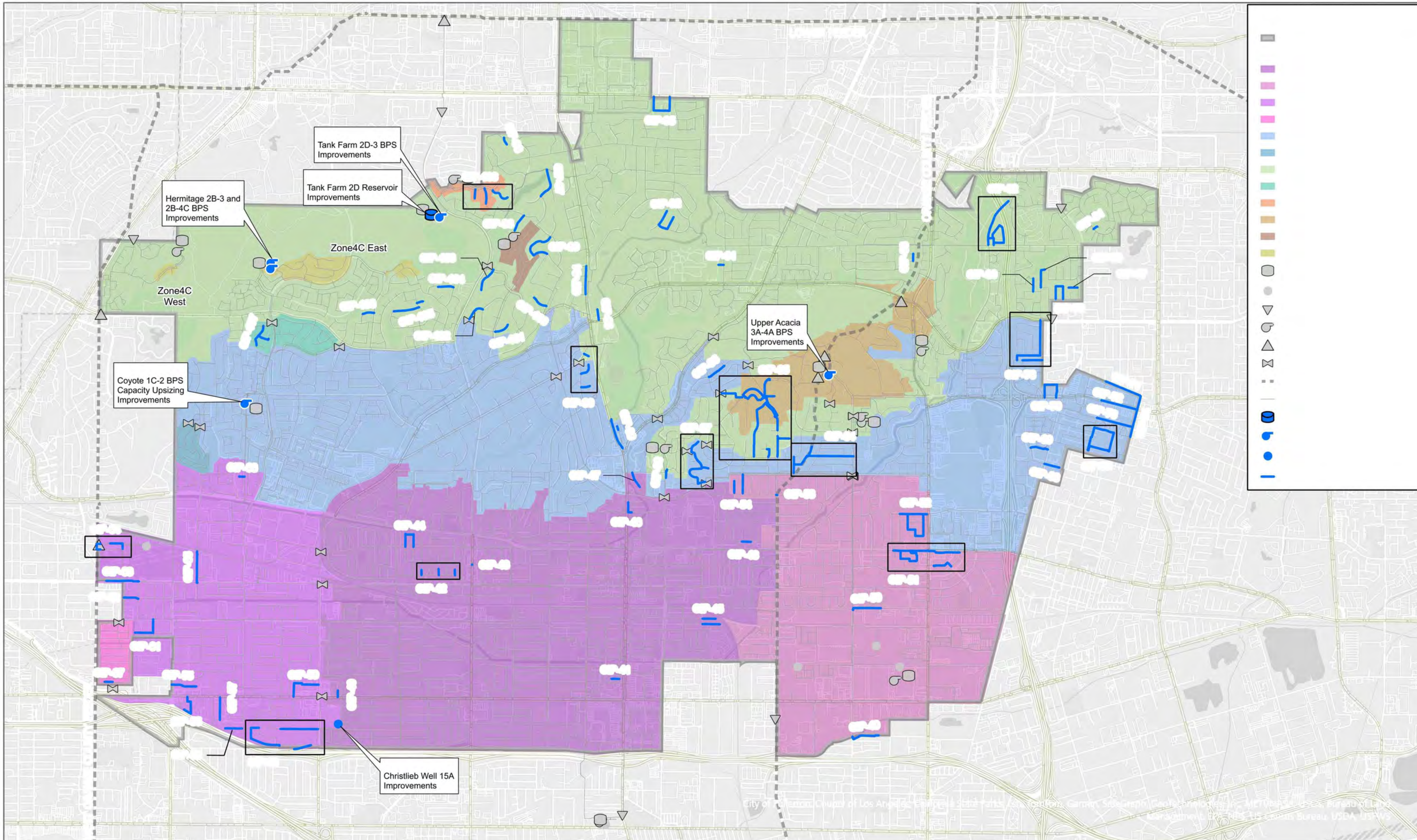
Table 12-7. Short-Term Capital Improvement Projects and Costs

ID	Project Name	Justification	Project Description	Prop Dia (in)	Quantity	Unit	Unit Cost	Total Construction Cost	Total Admin/ Contingency (40%)	Total CIP Cost	FY 2025/26	FY 2026/27	FY 2027/28	FY 2028/29	FY 2029/30
CIP-01	Upper Acacia BPS (3A-4A) Improvements	Efficiency, At-Risk, and Condition	New 5,000-gal Hydropneumatic Tank, Pump Equipment Replacement, and Additional Site Improvements	-	1	LS	-	$2,340,000	$936,000	$3,276,000	$3,276,000				
CIP-02	Hermitage BPS (2B-3 and 2B-4C) Improvements	Operation Efficiency, At-Risk, Condition	New 5,000-gal Hydropneumatic Tank (2B-4C), Pump Replacement and Upsizing (2B-3), and Additional Site Improvements	-	1	LS	-	$2,255,000	$902,000	$3,157,000		$3,157,000			
CIP-03	Coyote BPS (1C-2) Capacity Upsizing Improvements	Capacity, Reliability, Condition	Pump Equipment Replacement and Upsizing, Additional Site Improvements	-	1	LS	-	$2,360,000	$944,000	$3,304,000		$3,304,000			
CIP-04	Tank Farm BPS (2D-3) Improvements	Condition and At-Risk	Pump Equipment Replacement and Additional Improvements	-	1	LS	-	$1,355,000	$542,000	$1,897,000		$1,897,000			
CIP-05	Tank Farm 2D Reservoir Improvements	Condition and At-Risk	Surface Rehabilitation (T-2), Settlement Study (T-4), Tank Rehabilitation (T-5), and Additional Site Improvements	-	1	LS	-	$2,350,000	$940,000	$3,290,000			$3,290,000		
CIP-06	Christlieb Well 15A Improvements	Condition and At-Risk	Control and Electrical Repairs, Additional Site Improvements	-	1	LS	-	$850,000	$340,000	$1,190,000		$1,190,000			
CIP-40	W Orangethorpe Ave & S Pacific Dr	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	235	LF	$350	$82,203	$32,881	$115,084		$115,084			
CIP-41	W Southgate Ave & Harbor Blvd	Fire Protection	Replace existing 4" with 8" pipe	8	275	LF	$350	$96,322	$38,529	$134,851			$134,851		
CIP-42	N Marie Ave, N Michael Ave, and Russell Ave	Fire Protection	Replace existing 4" with 8" pipe	8	616	LF	$350	$215,544	$86,217	$301,761			$301,761		
CIP-43	N Euclid St & W Wilshire Ave	Fire Protection	Install new 6" pipe for looping	6	9	LF	$275	$2,492	$997	$3,489			$3,489		
CIP-44	N Wayne Ave and N Lee Ave	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	1,188	LF	$350	$415,800	$166,320	$582,120				$582,120	
CIP-45	E Truslow Ave and Patterson Way	Fire Protection	Replace existing 6" with 8" pipe	8	1,061	LF	$350	$371,519	$148,608	$520,127					$520,127
CIP-46	N Harbor Blvd & E Union Ave	Fire Protection	Install new 12" pipe for looping	12	473	LF	$525	$248,363	$99,345	$347,708	$347,708				
CIP-47	Eugene Dr	Fire Protection	Replace existing 6" with 12" pipe on Eugene	12	75	LF	$525	$215,593	$86,237	$301,830			$301,830		
			Replace existing 6" with 8" pipe on Eugene	8	503	LF	$350								
CIP-48	E College Pl	Fire Protection	Install new 8" pipe for looping	8	320	LF	$350	$111,858	$44,743	$156,602			$156,602		
CIP-49	Via Burton	Fire Protection	Replace existing 8" with 12" pipe	12	1,023	LF	$525	$537,042	$214,817	$751,858			$751,858		
CIP-50	E Walnut Ave	Fire Protection	Replace existing 8" with 12" pipe	12	1,053	LF	$525	$552,892	$221,157	$774,049	$774,049				
CIP-51	E Chapman Ave and San Carlos Dr	Fire Protection	Replace existing 6" with 12" pipe	12	1,209	LF	$525	$1,805,859	$722,344	$2,528,203				$2,528,203	
			Replace existing 6" with 8" pipe	8	3,346	LF	$350								
CIP-52	Concord Ave, Nutwood Ave, & Sycamore Ave	Fire Protection	Replace existing 6" with 8" pipe	8	3,026	LF	$350	$1,059,186	$423,674	$1,482,860			$1,482,860		
CIP-53	N Raymond Ave & E Glenwood Ave	Fire Protection	Replace existing 6" with 8" pipe	8	44	LF	$350	$15,316	$6,126	$21,442				$21,442	
CIP-54	N Lincoln Ave and N Yale Ave	Fire Protection	Replace existing 6" with 8" pipe	8	1,099	LF	$350	$384,535	$153,814	$538,348					$538,348
CIP-55	W Porter Ave	Fire Protection	Replace existing 6" with 8" pipe	8	876	LF	$350	$306,694	$122,678	$429,372		$429,372			
CIP-56	S Vine Ave & W Orangethorpe Ave	Fire Protection	Replace existing 6" with 8" pipe; Install new 8" for looping	8	980	LF	$350	$342,902	$137,161	$480,062	$480,062				
CIP-57	Peckham St	Fire Protection	Replace existing 6" with 8" pipe	8	793	LF	$350	$277,533	$111,013	$388,546	$388,546				
CIP-58	W Roberta Ave	Fire Protection	Replace existing 6" with 8" pipe	8	593	LF	$350	$207,404	$82,961	$290,365				$290,365	
CIP-59	S Brookhurst Rd & W Orangethorpe Ave	Fire Protection	Replace existing 6" with 8" pipe; Install new 8" pipe for looping	8	1,385	LF	$350	$484,889	$193,956	$678,845				$678,845	
CIP-60	S Pine Dr, W Houston Ave, and W Roberta Ave	Fire Protection	Replace existing 6" with 8" pipe; Install new 8" pipe for looping	8	3,025	LF	$350	$1,379,115	$551,646	$1,930,762	$1,930,762				
			Replace existing 8" with 12" pipe	12	610	LF	$525								
CIP-61	Franklin Ave and Olin St	Fire Protection	Replace existing 6" with 8" pipe	8	1,138	LF	$350	$398,140	$159,256	$557,397	$557,397				
CIP-62	Carol Dr	Fire Protection	Replace existing 6" with 8" pipe	8	526	LF	$350	$184,198	$73,679	$257,877	$257,877				
CIP-63	Commonwealth Ave	Fire Protection	Replace existing 6" with 8" pipe	8	1,144	LF	$350	$400,447	$160,179	$560,626	$560,626				
CIP-64	Dale Pl and Artesia Ave	Fire Protection	Remove and replace existing 6" pipe	6	630	LF	$275	$530,137	$212,055	$742,191	$742,191				
			Install new 18" pipe for looping	18	467	LF	$765								
CIP-65	N Pritchard Ave	Fire Protection	Remove and replace existing 6" pipe	6	1,142	LF	$275	$317,371	$126,948	$444,319	$444,319				
			Install new 8" pipe for looping	8	9	LF	$350								

WATER MASTER PLAN UPDATE 2025

Capital Improvement Program
March 2025

ID	Project Name	Justification	Project Description	Prop Dia (in)	Quantity	Unit	Unit Cost	Total Construction Cost	Total Admin/ Contingency (40%)	Total CIP Cost	FY 2025/26	FY 2026/27	FY 2027/28	FY 2028/29	FY 2029/30
CIP-66	Plaza de Vista	Fire Protection	Replace existing 4" with 8" pipe	8	194	LF	$350	$67,924	$27,169	$95,093				$95,093	
CIP-67	Maxwell Ave & W Porter Ave	Fire Protection	Replace existing 6" with 8" pipe	8	283	LF	$350	$99,101	$39,640	$138,741				$138,741	
CIP-68	Madison Ave	Fire Protection	Replace existing 6" with 8" pipe	8	542	LF	$350	$189,811	$75,925	$265,736	$265,736				
CIP-69	Deerpark Dr & Madison Ave	Fire Protection	Replace existing 4" with 8" pipe	8	629	LF	$350	$220,091	$88,037	$308,128		$308,128			
CIP-70	N Deerpark Dr & Yorba Linda Blvd	Fire Protection	Replace existing 6" with 8" pipe	8	1,333	LF	$350	$466,703	$186,681	$653,384		$653,384			
CIP-71	E Palm Dr	Fire Protection	Remove and replace existing 8" pipe	8	1,334	LF	$350	$467,049	$186,820	$653,869		$653,869			
CIP-72	Yorba Linda Blvd	Fire Protection	Remove and replace existing 8" pipe	8	1,288	LF	$350	$450,711	$180,284	$630,996		$630,996			
CIP-73	Topaz Ln & E Palm Dr	Fire Protection	Remove and replace existing 8" pipe	8	1,287	LF	$350	$450,438	$180,175	$630,613		$630,613			
CIP-74	N Bradford Ave	Fire Protection	Remove and replace existing 8" pipe; Install new 8" pipe for looping	8	1,444	LF	$350	$505,382	$202,153	$707,535	$707,535				
CIP-75	N Sapphire Rd, Quartz Ln, and Topaz Ln	Fire Protection	Replace existing 6" with 8" pipe; Remove and replace existing 8" pipe	8	2,444	LF	$350	$1,040,396	$416,159	$1,456,555	$1,456,555				
			Remove and replace existing 6" pipe	6	672	LF	$275								
CIP-76	Hartford Ave and Sherwood Ave	Fire Protection	Replace existing 6" with 8" pipe	8	2,906	LF	$350	$1,017,274	$406,909	$1,424,183	$1,424,183				
CIP-77	Sheffield Pl	Fire Protection	Replace existing 6" with 8" pipe	8	314	LF	$350	$109,757	$43,903	$153,660					$153,660
CIP-78	Salem Pl and Middlesex Pl	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	1,143	LF	$350	$400,055	$160,022	$560,078	$560,078				
CIP-79	Hartford Ave and Cambridge Ave	Fire Protection	Replace existing 6" with 8" pipe; Install new 8" pipe for looping	8	745	LF	$350	$260,648	$104,259	$364,908				$364,908	
CIP-80	Thorn Pl	Fire Protection	Replace existing 6" with 8" pipe	8	458	LF	$350	$160,265	$64,106	$224,370				$224,370	
CIP-81	Blackpine Ct	Fire Protection	Replace existing 6" with 8" pipe	8	158	LF	$350	$55,446	$22,179	$77,625					$77,625
CIP-82	Associated Rd and Private St	Fire Protection	Replace existing 8" with 12" pipe	12	3,684	LF	$525	$1,596,419	$638,568	$2,234,986				$2,234,986	
CIP-83	Mimosa Pl & Beechwood Ave	Fire Protection	Replace existing 4" with 8" pipe	8	255	LF	$350	$89,267	$35,707	$124,974					$124,974
CIP-84	Hollydale Dr, Kensington Dr, and Melody Ln	Fire Protection	Replace existing 6" with 8" pipe	8	3,142	LF	$350	$1,099,537	$439,815	$1,539,351		$1,539,351			
CIP-85	Skyline Dr, N Raymond Ave, Edgecliff Dr, and Kroeger Ave	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	8,433	LF	$350	$3,530,536	$1,412,214	$4,942,750			$4,942,750		
			Replace existing 6", 8", and 10" with 12" pipe	12	1,103	LF	$525								
CIP-86	Valvwood Dr	Fire Protection	Replace existing 6" with 8" pipe	8	672	LF	$350	$235,259	$94,104	$329,363	$329,363				
CIP-87	Dorothy Dr and Sheppard Dr	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	2,746	LF	$350	$961,204	$384,481	$1,345,685				$1,345,685	
CIP-88	N Lemon St	Fire Protection	Replace existing 4" with 8" pipe	8	314	LF	$350	$109,807	$43,923	$153,730			$153,730		
CIP-89	N Harbor Blvd & Brea Blvd	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	1,228	LF	$350	$429,954	$171,982	$601,936	$601,936				
CIP-90	N Johnston Knls, Sunny Knl, and Cristine Pl	Fire Protection	Replace existing 4" and 6" with 8" pipe	8	1,003	LF	$350	$350,929	$140,372	$491,301		$491,301			
CIP-91	Beechwood Ave	Fire Protection	Replace existing 6" with 8" pipe	8	187	LF	$350	$65,587	$26,235	$91,822	$91,822				
CIP-92	Altivo Pl, Arbolado Dr, and Madonna Dr	Fire Protection	Replace existing 6" with 8" pipe	8	1,380	LF	$350	$483,010	$193,204	$676,214					$676,214
CIP-93	Balboa Rd	Fire Protection	Replace existing 6" with 8" pipe	8	377	LF	$350	$132,023	$52,809	$184,832	$184,832				
CIP-94	N Harbor Blvd & Coronado Dr	Fire Protection	Replace existing 6" with 8" pipe	8	984	LF	$350	$344,365	$137,746	$482,111				$482,111	
CIP-95	Imperial Hwy & Termino Pl	Fire Protection	Replace existing 6" with 8" pipe	8	1,529	LF	$350	$535,041	$214,016	$749,058					$749,058
CIP-96	Via Codo	Fire Protection	Replace existing 6" with 8" pipe	8	268	LF	$350	$93,909	$37,564	$131,473					$131,473
CIP-97	Lakeside Dr	Fire Protection	Replace existing 6" with 8" pipe	8	1,105	LF	$350	$386,905	$154,762	$541,667					$541,667
CIP-98	Juanita Pl	Fire Protection	Replace existing 6" with 8" pipe	8	629	LF	$350	$219,992	$87,997	$307,989			$307,989		
CIP-99	Anacapa Pl	Fire Protection	Replace existing 6" with 8" pipe	8	1,153	LF	$350	$403,459	$161,383	$564,842					$564,842
CIP-100	Miguel Pl	Fire Protection	Replace existing 6" with 8" pipe	8	550	LF	$350	$192,427	$76,971	$269,398					$269,398
CIP-101	Rancho Cir	Fire Protection	Replace existing 6" with 8" pipe	8	543	LF	$350	$190,160	$76,064	$266,225				$266,225	
CIP-102	Verona Dr	Fire Protection	Replace existing 6" with 8" pipe	8	685	LF	$350	$239,736	$95,894	$335,630				$335,630	
CIP-103	Yuma Way	Fire Protection	Replace existing 6" with 8" pipe	8	872	LF	$350	$305,287	$122,115	$427,401					$427,401
CIP-104	Avenida del Corto	Fire Protection	Replace existing 6" with 8" pipe	8	547	LF	$350	$191,303	$76,521	$267,825				$267,825	
CIP-105	Paseo Grande	Fire Protection	Replace existing 6" with 8" pipe	8	1,136	LF	$350	$397,469	$158,988	$556,457					$556,457
CIP-106	Avenida del Norte	Fire Protection	Replace existing 6" with 8" pipe	8	412	LF	$350	$144,330	$57,732	$202,062					$202,062
CIP-107	Ave Selva, Calle Candela, & Cam Escondido	Fire Protection	Replace existing 6" with 8" pipe	8	1,190	LF	$350	$416,492	$166,597	$583,089		$583,089			
CIP-108	Flintridge, La Sombra Way, & Ride Out Way	Fire Protection	Replace existing 6" with 8" pipe	8	1,595	LF	$350	$558,166	$223,266	$781,432					$781,432
							TOTAL	**$42,116,980**	**$16,846,792**	**$58,963,772**	**$15,381,577**	**$15,583,186**	**$11,827,720**	**$9,856,550**	**$6,314,740**

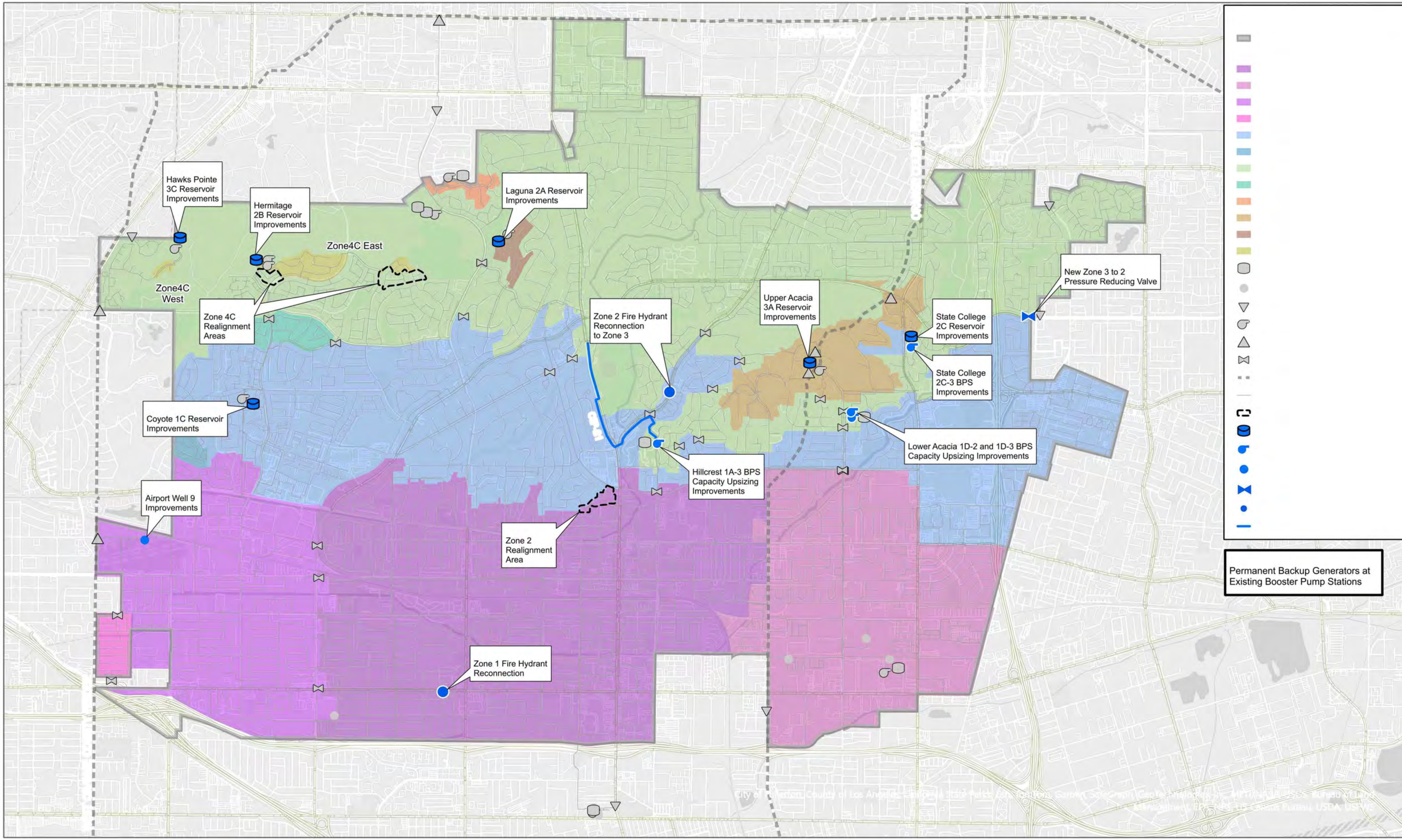


FULLERTON WATER MASTER PLAN UPDATE

Figure 12-1. Proposed Short-Term Capital Improvement Projects (CIP)

Table 12-8. Near-Term Capital Improvement Projects and Costs

ID	Project Name	Justification	Project Description	Prop Dia (in)	Quantity	Unit	Unit Cost	Total Construction Cost	Total Admin/ Contingency (40%)	Total CIP Cost
CIP-07	Hillcrest BPS (1A-3) Capacity Upsizing Improvements	Condition and Reliability	Pump replacement, Additional Site Improvements	-	1	LS		$2,300,000	$920,000	$3,220,000
CIP-08	Lower Acacia BPS (1D-2 and 1D-3) Capacity Upsizing Improvements	Maximize GW, Reliability, Efficiency, Condition	Pump replacement, Additional Site Improvements	-	1	LS		$3,867,500	$1,547,000	$5,414,500
CIP-09	Coyote 1C Reservoir Improvements	Condition	Reservoir rehabilitation, Demolish Well 12A, Additional Site Improvements	-	1	LS		$1,580,000	$632,000	$2,212,000
CIP-10	Laguna 2A Reservoir Improvements	Condition	Coatings and tank surface repairs, aboveground pipe coating repair, and replace valving, ladders, and mixer	-	1	LS		$150,000	$60,000	$210,000
CIP-11	Hermitage 2B Reservoir Improvements	Condition	Repairs, Additional Site Improvements	-	1	LS		$500,000	$200,000	$700,000
CIP-12	New Zone 3 to 2 Pressure Reducing Valve	Fire Protection	Install New Zone 3 to 2 PRV at E Bastanchury & Hartford Ave	-	1	EA	$300,000	$300,000	$120,000	$420,000
CIP-13	Zone 1 Fire Hydrant Reconnection	Fire Protection	Reconnect existing hydrant at Orangethorpe & Citrus from existing 6" to 10" parallel pipe	-	1	EA	$30,000	$30,000	$12,000	$42,000
CIP-14	Zone 2 Fire Hydrant Reconnection to Zone 3	Fire Protection	Reconnect existing hydrant at Brea & Longview from Zone 2 to Zone 3	-	1	EA	$30,000	$30,000	$12,000	$42,000
CIP-15	Permanent Generators at Existing Booster Pump Stations	Reliability	Install permanent backup generators at Coyote PS, Hillcrest PS, and Lower Acacia PS (pump station with capacity larger than 1,500 gpm)	-	3	EA	$1,000,000	$5,400,000	$2,160,000	$7,560,000
			Install permanent backup generators at Hermitage PS, Tank Farm PS, Laguna PS, and Las Palmas PS (pump station with capacity 1,500 gpm or less)	-	4	EA	$600,000			
CIP-16	State College BPS (2C-3) Improvements	Condition and Reliability	Pump replacement, Additional Site Improvements	-	1	LS		$670,000	$268,000	$938,000
CIP-17	Upper Acacia 3A Reservoir Improvements	Condition	Reservoir Improvements, Additional Site Improvements	-	1	LS		$1,500,000	$600,000	$2,100,000
CIP-18	State College 2C Reservoir Improvements	Condition	Reservoir Improvements, Additional Site Improvements	-	1	LS		$150,000	$60,000	$210,000
CIP-19	Hawks Pointe 3C Reservoir Improvements	Condition	Reservoir Improvements, Additional Site Improvements	-	1	LS		$150,000	$60,000	$210,000
CIP-20	Airport Well 9 Improvements	Condition	Site Improvements	-	1	LS		$150,000	$60,000	$210,000
CIP-21	New 16-inch Zone 3 Harbor Blvd Transmission Main	Maximize GW	Install new 16" transmission main on Harbor from Valencia Mesa to Hillcrest PS	16	7,000	LF	$645	$4,515,000	$1,806,000	$6,321,000
CIP-22	Pressure Zone 2 Realignment Area	Fire Protection	Realign pipelines from Zone 1 to Zone 2 near Vista Verde & West Union	-	1	LS		$500,000	$200,000	$700,000
CIP-23	Pressure Zone 4C Realignment Areas	Fire Protection	Realign pipelines from Zone 3 to Zone 4C near Applewood & Hermitage	-	1	LS		$1,800,000	$720,000	$2,520,000
							TOTAL	**$23,592,500**	**$9,437,000**	**$33,029,500**



FULLERTON WATER MASTER PLAN UPDATE

Figure 12-2. Proposed Near-Term Capital Improvement Projects (CIP)

Table 12-9. Long-Term Capital Improvement Projects and Costs

ID	Project Name	Justification	Project Description	Prop Dia (in)	Quantity	Unit	Unit Cost	Total Construction Cost	Total Admin/ Contingency (40%)	Total CIP Cost
CIP-24	New 8" Pipe for WCHD	New Development	Install new 8" pipe for WCHD in existing Zone 3, proposed Zone 4C and Zone 5	8	14,518	LF	$350	$5,081,290	$2,032,516	$7,113,806
CIP-25	New 12" Pipe for WCHD	New Development	Install new 12" pipe for WCHD in existing Zone 3, proposed Zone 4C and Zone 5	12	12,295	LF	$525	$6,455,105	$2,582,042	$9,037,147
CIP-26	Hawks Pointe BPS (3C-4) Capacity Upsizing Improvements	New Development	Pump Equipment Replacement and Upsizing, Additional Site Improvements	-	1	LS	-	$1,155,000	$462,000	$1,617,000
CIP-27	New Zone 4C BPS for WCHD	New Development	Install new pump station in Zone 4C for West Coyote Hills Development	-	1	LS	-	$3,000,000	$1,200,000	$4,200,000
CIP-28	New Zone 4C (0.7 MG) Reservoir in WCHD	New Development	Install new 0.7 MG reservoir in Zone 4C for West Coyote Hills Development	-	0.7	MG	$4,500,000	$3,150,000	$1,260,000	$4,410,000
CIP-29	New Zone 5 BPS for WCHD	New Development	Install new pump station in Zone 5 for West Coyote Hills Development	-	1	LS	-	$1,400,000	$560,000	$1,960,000
CIP-30	New Groundwater Wells in Zone 1B	Maximize GW, Reliability	Install 2 new groundwater wells in Zone 1B	-	2	EA	$5,000,000	$11,200,000	$4.4800,000	$15,6800,000
			Install 2 permanent backup generators for new wells in Zone 1B	-	2	EA	$600,000			
CIP-31	Permanent Generators at Existing Groundwater Wells	Reliability	Install permanent backup generators at groundwater Well 3A, 1A, 2, 9, 10, and 15A	-	6	EA	$1,000,000	$6,000,000	$2,400,000	$8,400,000
CIP-32	Hermitage BPS (2B-3) Capacity Upsizing Improvements	Maximize GW, Reliability	Pump Equipment Replacement and Upsizing	-	1	LS	-	$1,005,000	$402,000	$1,407,000
CIP-33	Las Palmas 3B Reservoir Improvements	Condition	Reservoir Repairs	-	1	LS	-	$150,000	$60,000	$210,000
CIP-34	Lower Acacia 1D Reservoir Improvements	Condition	Reservoir Repairs	-	1	LS	-	$150,000	$60,000	$210,000
CIP-35	Hillcrest 1A Reservoir Improvements	Condition	Reservoir Repairs	-	1	LS	-	$150,000	$60,000	$210,000
CIP-36	Las Palmas BPS (3B-4) Improvements	Condition	Pump repairs, Additional Site Improvements	-	1	LS	-	$350,000	$140,000	$490,000
CIP-37	Pressure Zone 3 Realignment Area	Maximum Pressure Criteria	Realign pipelines from Zone 4C to Zone 3 near Pioneer & Rocky	-	1	LS	-	$450,000	$180,000	$630,000
CIP-38	New Pressure Zone 2B Subzone	Maximum Pressure Criteria	Realign pipelines from Zone 2 to new Zone 2B Subzone near Gilbert & Malvern	-	1	LS	-	$500,000	$200,000	$700,000
CIP-39	New Pressure Zone 3B Subzone	Maximum Pressure Criteria	Realign pipelines from Zone 3 to new Zone 3B Subzone near Rosecrans & Buena Tierra	-	1	LS	-	$1,800,000	$720,000	$2,520,000
							TOTAL	**$41,996,395**	**$16,798,558**	**$58,794,954**

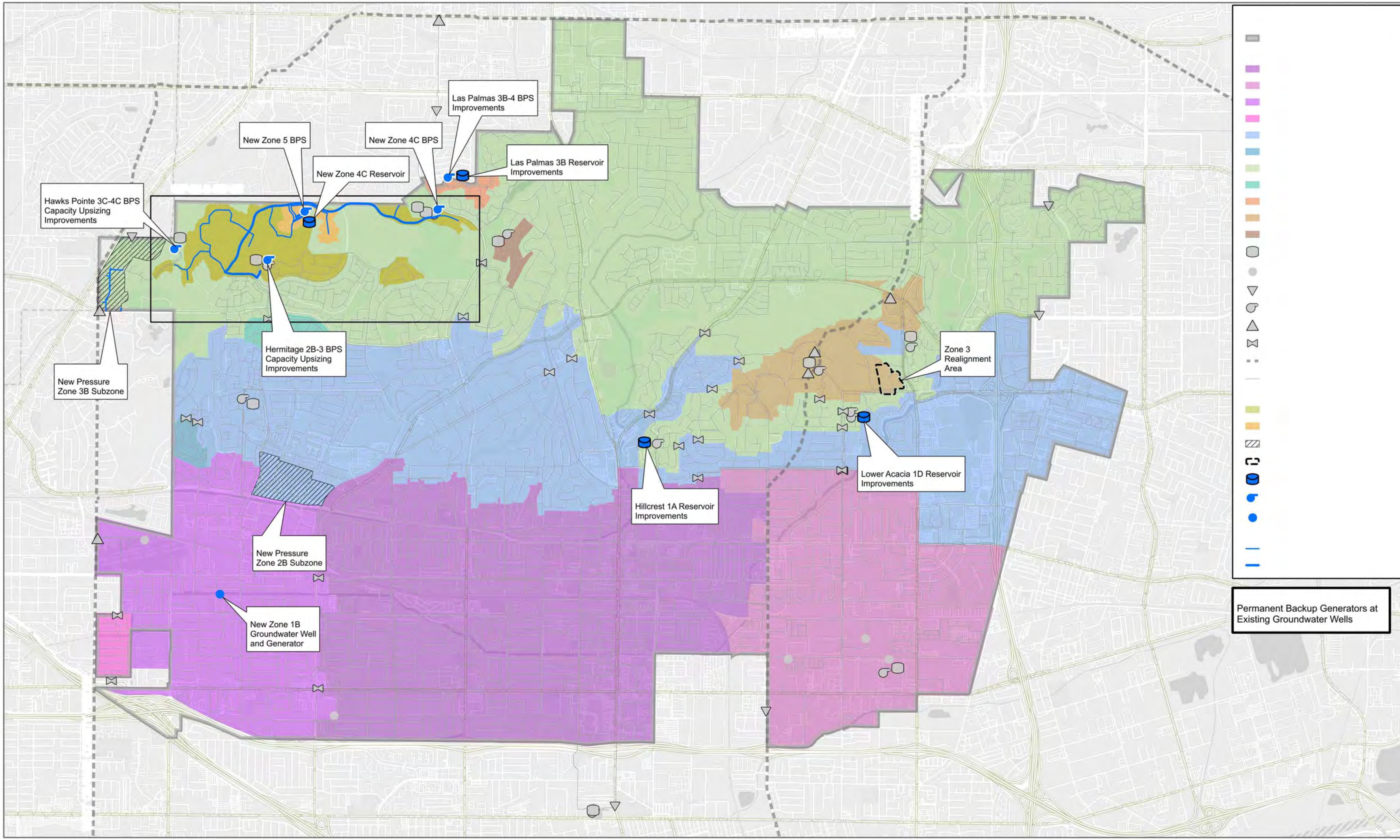


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Figure 12-3. Proposed Long-Term Capital Improvement Projects (CIP)

13.0 References

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Appendix A Historic Volatile Organic Compound (VOC) Data

A.1 Volatile Organic Compound (VOC) Figures

The figures in this Appendix show historic VOC data at the City of Fullerton's groundwater wells from 2000 to 2019. Horizontal lines representing either federal or State of California (State) limits are shown on figures where the chemical levels are close to or in exceedance of the limits.

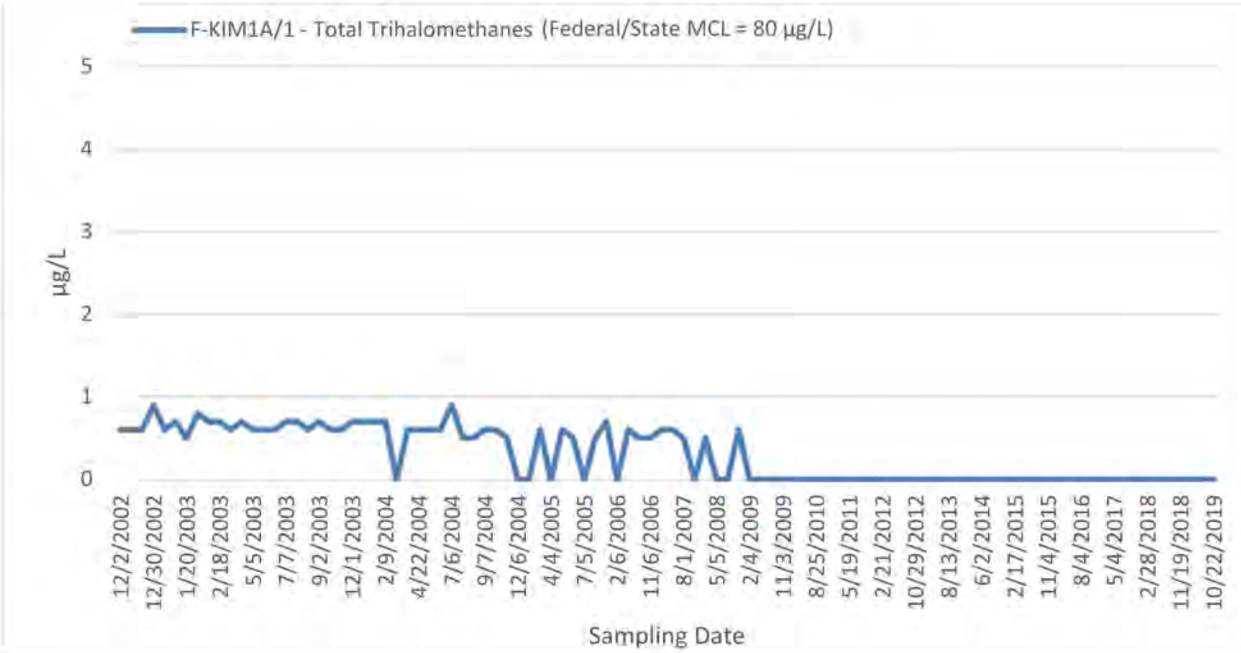
The following wells are still operational:

- Well KIM1A
- Well KIM2
- Well 5
- Well 6
- Well 8
- (Airport) Well 9
- (Sunclipse) Well 10
- (Christlieb) Well 15A

The following wells have been taken offline after the year 2000 for varying reasons:

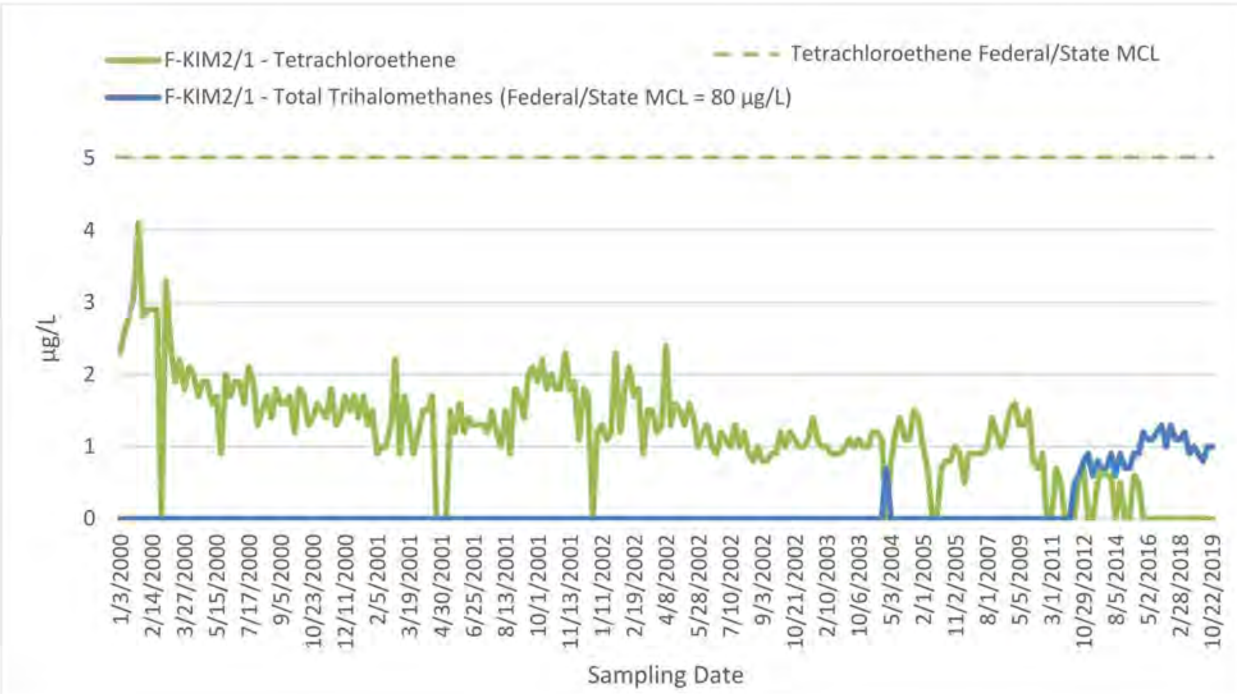
- Well KIM1
- Well 3A
- Well 4
- Well 7
- (Coyote) Well 12A

A.1.1 KIMBERLY WELL 1A



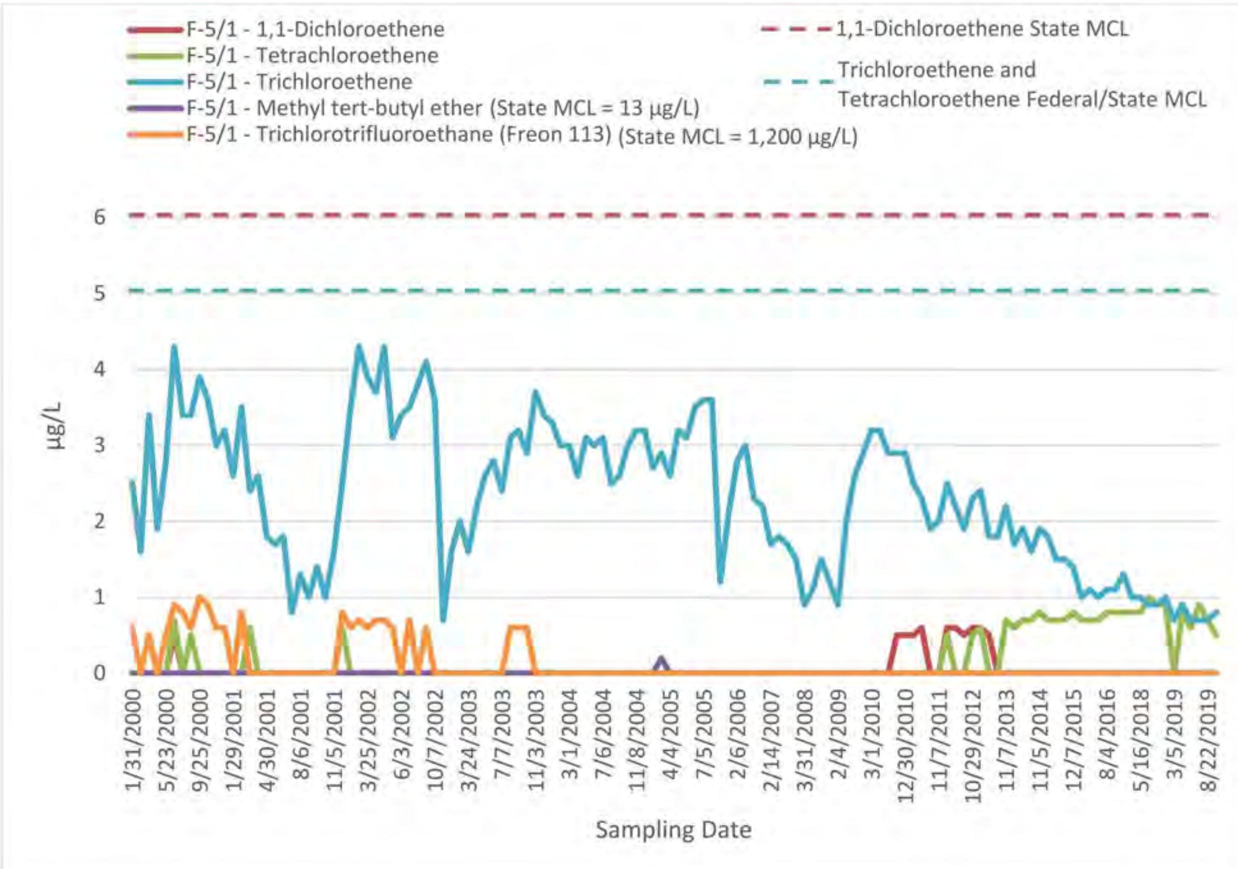
Values reported are significantly below the 80 micrograms per liter (µg/L) federal and State MCL for total trihalomethanes.

A.1.2 KIMBERLY WELL 2



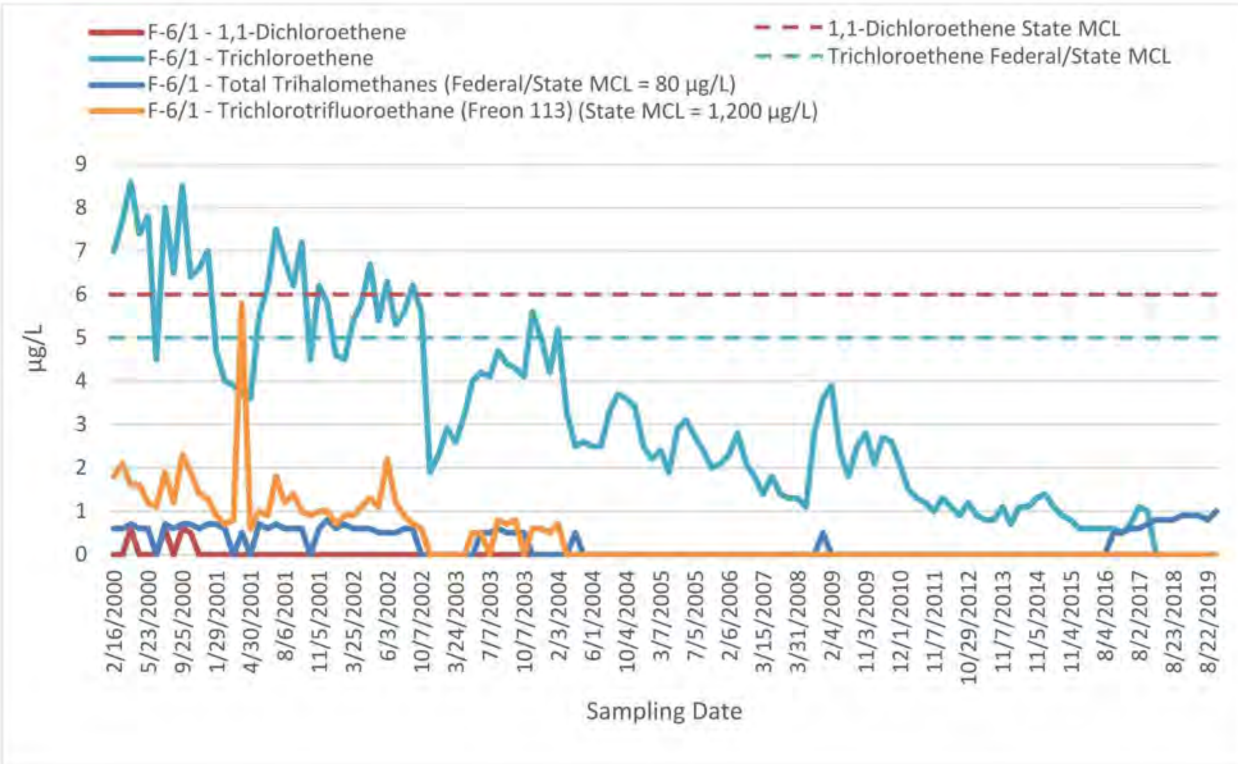
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and below 5 µg/L federal and State MCL for tetrachloroethene.

A.1.3 WELL 5



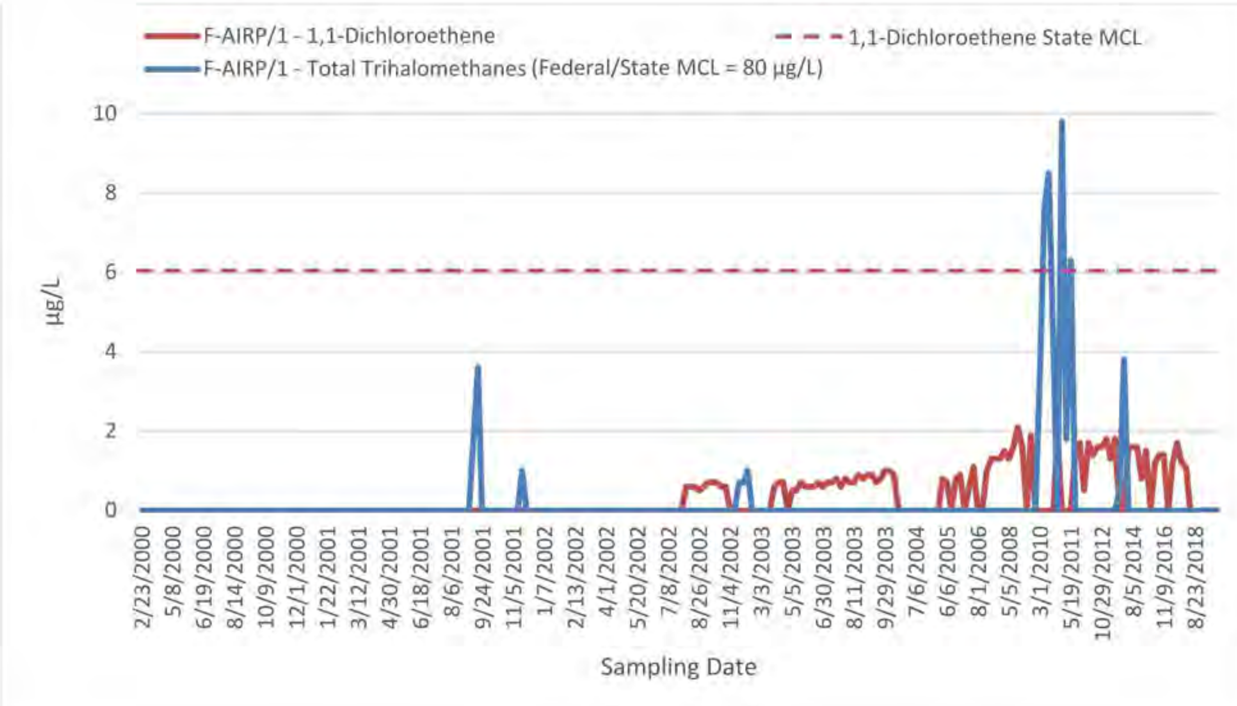
Values reported are significantly below the 1,200 µg/L State MCL for trichlorotrifluoroethane (Freon 113) and 13 µg/L State MCL for methyl tert-butyl ether (MTBE).

A.1.4 WELL 6



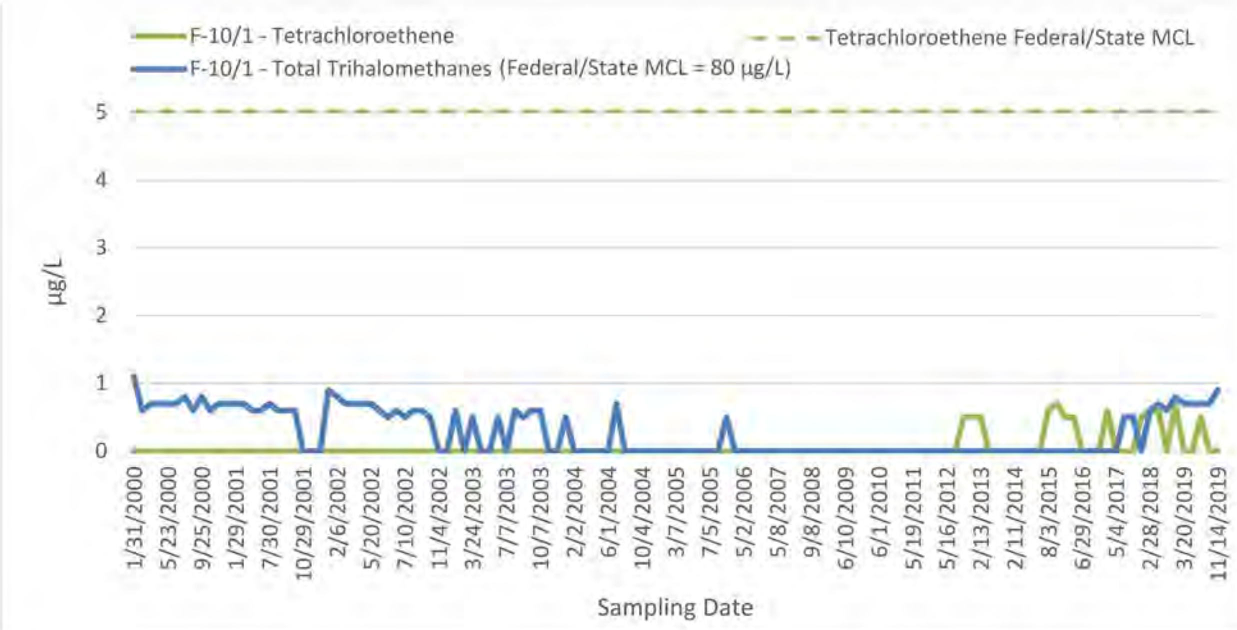
Values reported are significantly below the 1,200 µg/L State MCL for Freon 113 as well as below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.5 AIRPORT WELL 9



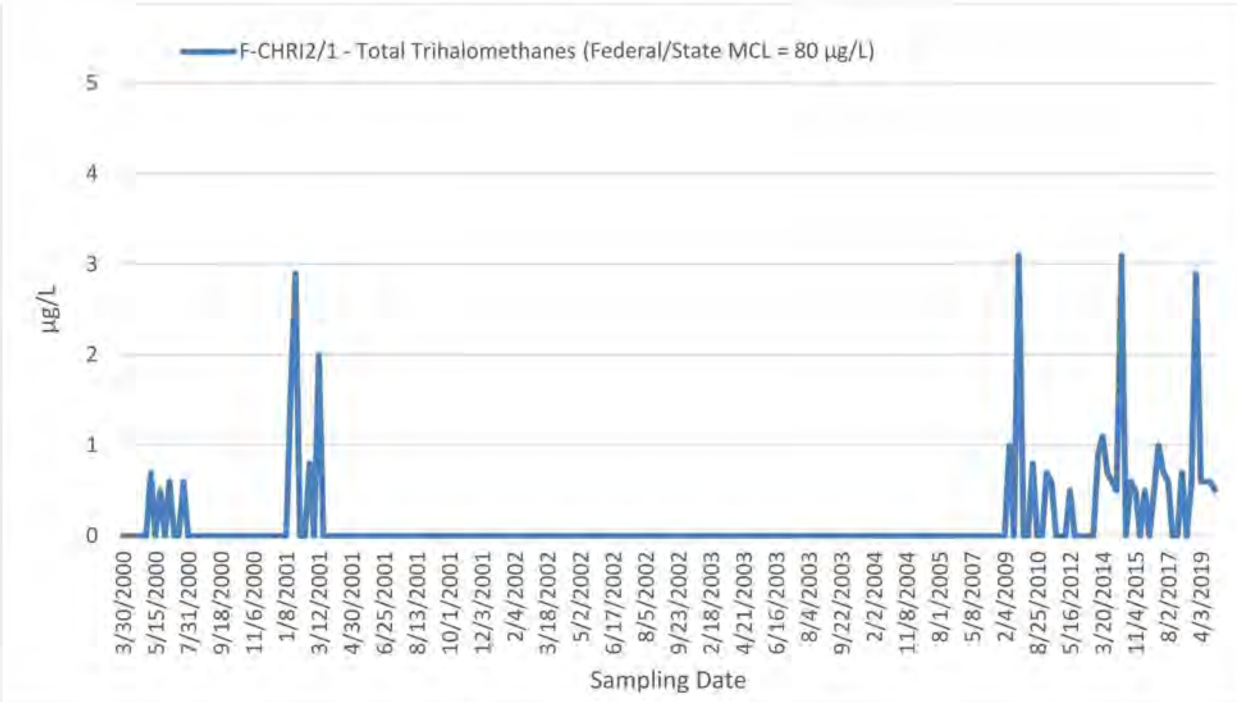
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.6 SUNCLIPSE WELL 10



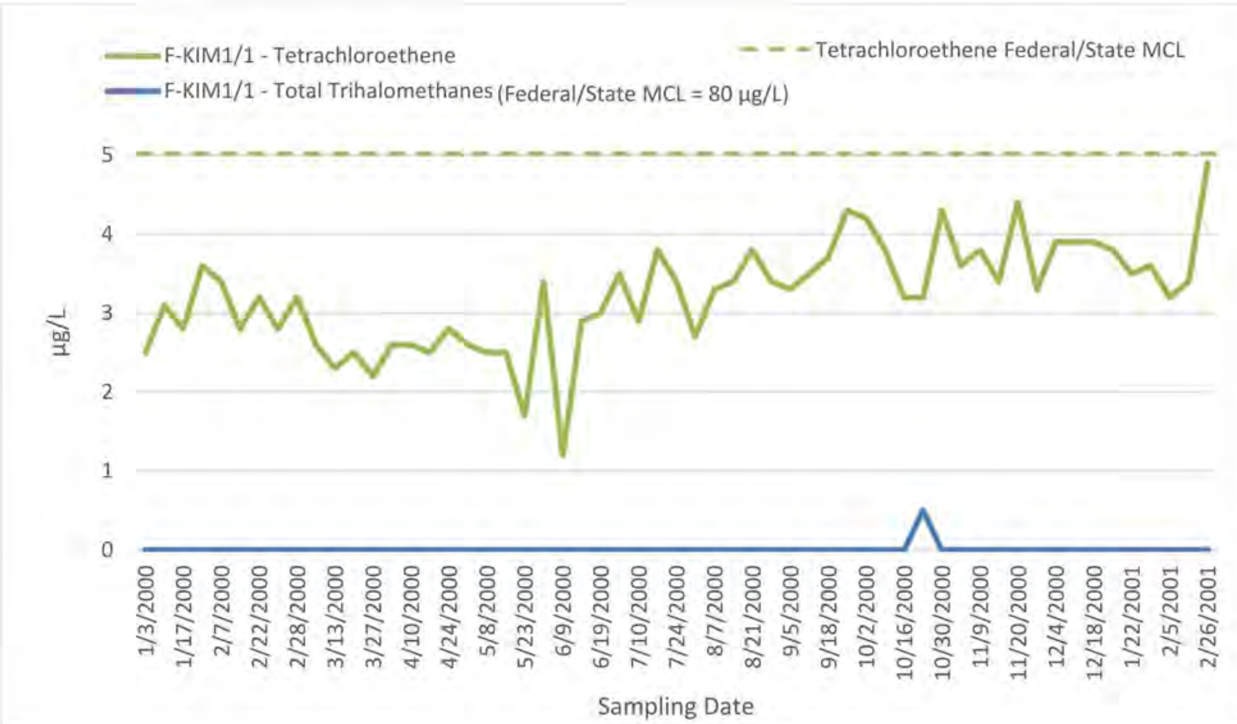
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and lower than the 5 µg/L federal and State MCL for tetrachloroethene.

A.1.7 CHRISTLIEB WELL 15A



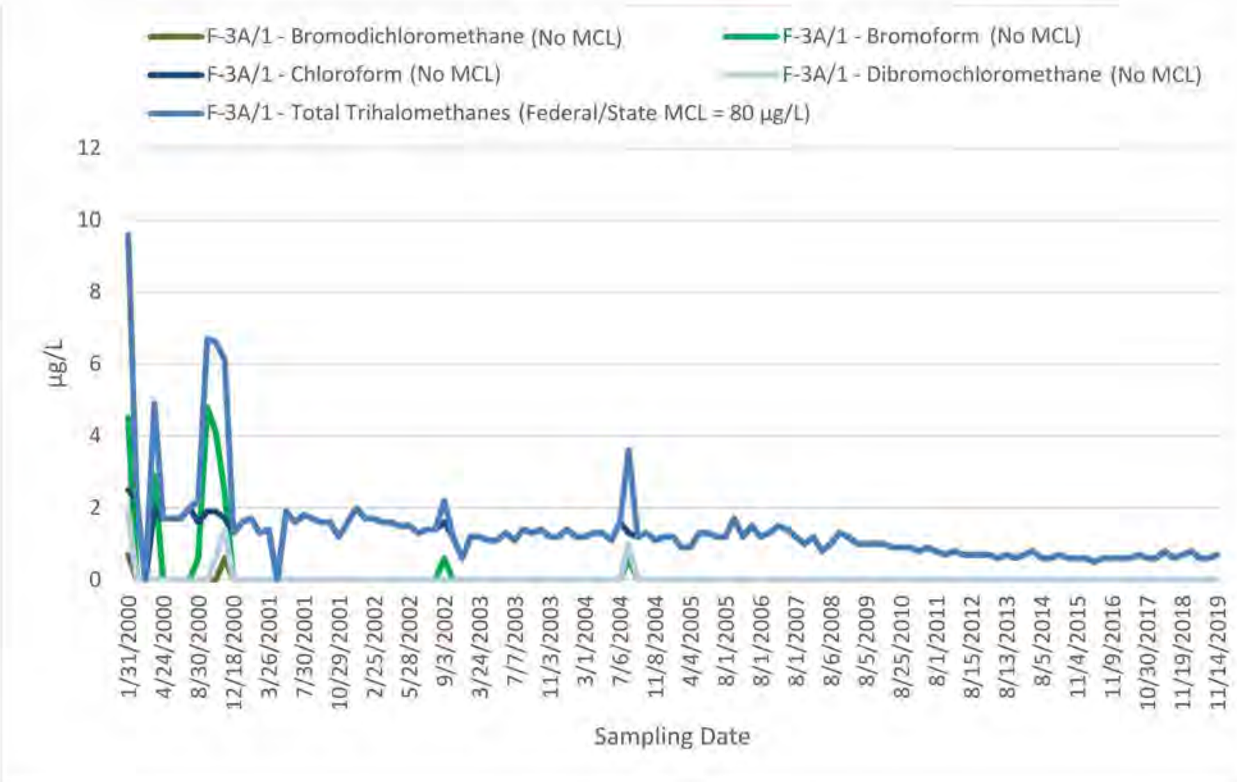
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.8 KIMBERLY WELL 1



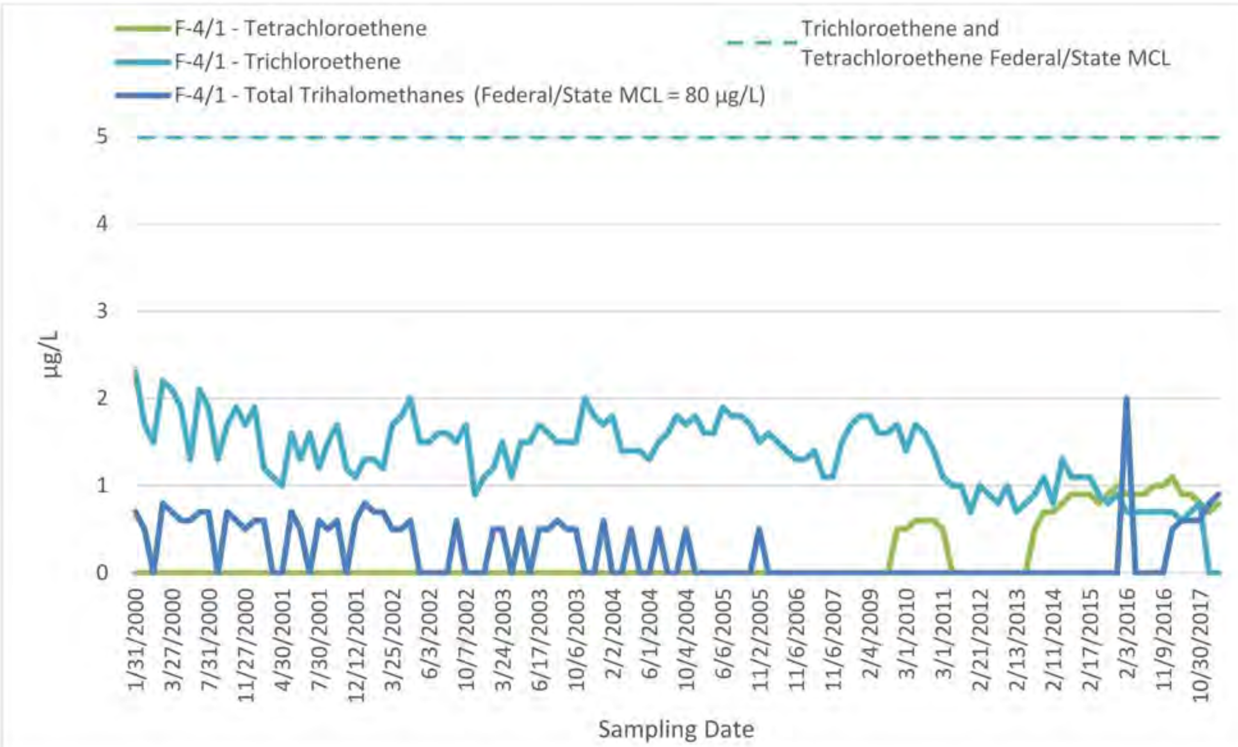
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes.

A.1.9 WELL 3A



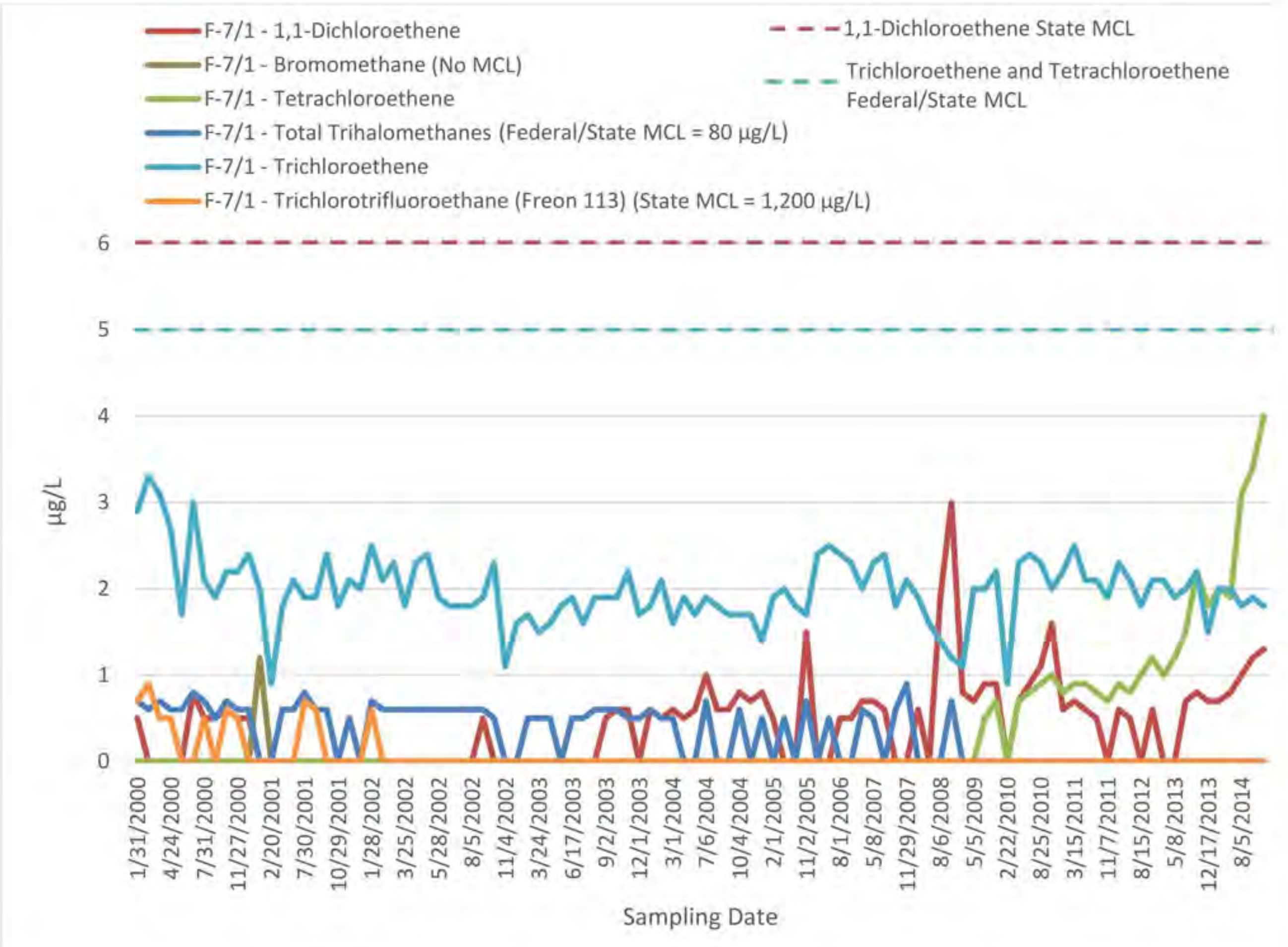
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes. The MCL for total trihalomethanes is the sum of bromodichloromethane, bromoform, chloroform, and dibromochloromethane. These individual chemicals do not have MCLs defined by the California State Water Resources Control Board and are limited by their sum. In addition, bromodichloromethane, bromoform, chloroform, and dibromochloromethane do not have federal MCLs.

A.1.10 WELL 4



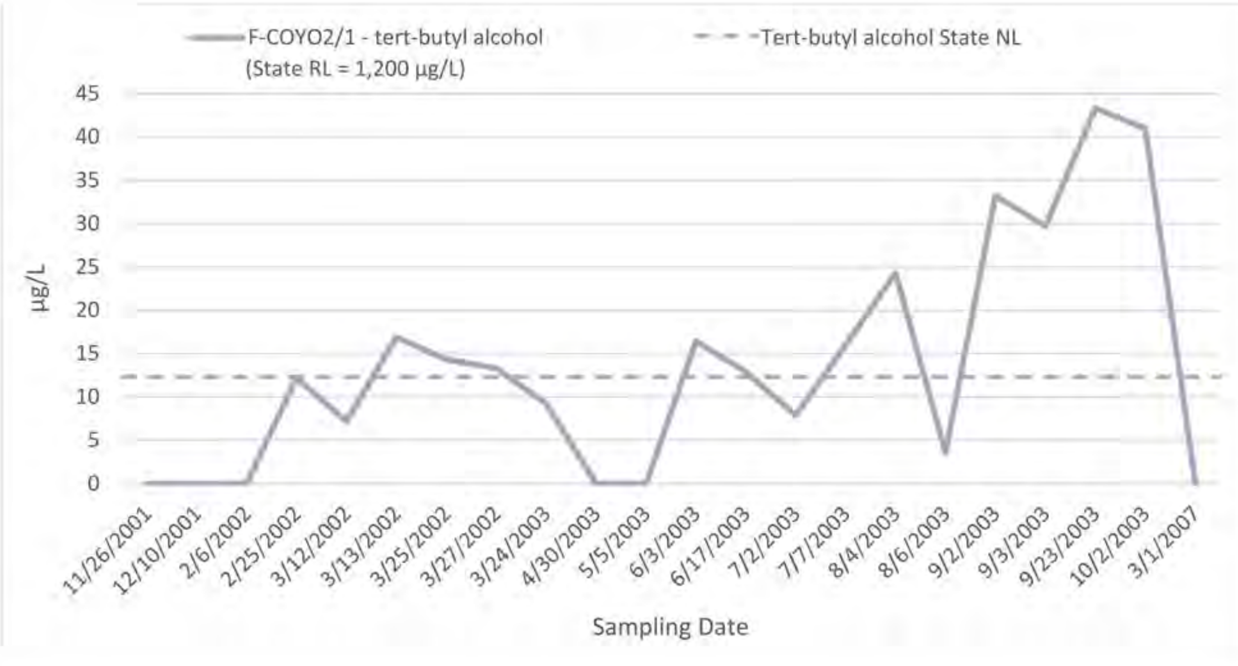
Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes and lower than the 5 µg/L federal and State MCL for both tetrachloroethene and trichloroethene.

A.1.11 WELL 7



Values reported are significantly below the 80 µg/L federal and State MCL for total trihalomethanes, significantly below the 1,200 µg/L State MCL for Trichlorotrifluoroethane (Freon 113), and slightly lower than the 6 µg/L State MCL for 1,1-Dichloroethene. There is currently no federal or State MCL for Bromomethane.

A.1.12 COYOTE WELL 12A



Tert-butyl alcohol does not have a federal or State MCL, but has a State Notification Level (NL) of 12 µg/L and Response Level of 1,200 µg/L.

Appendix B Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water prepared by the SWRCB of California's Division of Drinking Water

CALIFORNIA

Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

POLICY HANDBOOK ESTABLISHING A STANDARD METHOD OF TESTING AND REPORTING OF MICROPLASTICS IN DRINKING WATER

August 9, 2022

Prepared by:
THE DIVISION OF DRINKING WATER
STATE WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

1. INTRODUCTION

The purpose of this Policy Handbook Establishing a Standard Method of Testing and Reporting of Microplastics in Drinking Water (Policy Handbook) is to implement Health and Safety Code section 116376 by setting forth the requirements for conducting monitoring and reporting of microplastics in drinking water. The Policy Handbook includes an iterative, two-step, four-year plan for monitoring and reporting microplastics in a systematic and harmonized manner. To date, no government in the world has required monitoring for microplastics in drinking water, and the data obtained through the efforts detailed in this Policy Handbook will provide valuable insights for determining exposure to consumers through drinking water.

The State Water Resources Control Board (State Water Board) recognizes the emerging nature of microplastics and the potentially challenging effects (economically, technically, etc.) ordering a designated public water system to conduct monitoring may have on the public water system and community served. The State Water Board intends to use its monitoring authority carefully to minimize the unnecessary use of resources while obtaining necessary occurrence and exposure information to allow for more reliable characterizations of risk. The monitoring approach outlined in this Policy Handbook is informed by the method utilized by the United States Environmental Protection Agency's Unregulated Contaminant Monitoring Rule (UCMR) program.

This Policy Handbook includes flexibility for adaptation to the rapidly developing science and technology for monitoring microplastics.

2. PURPOSE AND OBJECTIVE

This Policy Handbook is adopted for the State Water Board's implementation of Senate Bill No. 1422 (2017-2018 Reg. Session) (SB 1422), which was approved by the Governor and filed with the Secretary of State on September 28, 2018. SB 1422 added Health and Safety Code section 116376 to require the State Water Board on or before July 1, 2020 to adopt a definition of microplastics in drinking water; and on or before July 1, 2021,[1] to:

- Adopt a standard methodology to be used in the testing of drinking water for microplastics;
- Adopt requirements for four (4) years of testing and reporting of microplastics in drinking water, including public disclosure of those results;
- Consider issuing a notification level or other guidance to aid consumer interpretation of testing results; and
- Accredit qualified California laboratories to analyze microplastics.

Health and Safety Code section 116376 allows the State Water Board to implement these requirements through adoption of a policy handbook that is not subject to title 22 of the Government Code, division 3, part 1, chapter 3.5, commencing with section 11340.

This Policy Handbook does not address areas outside the scope of the legislative directive.

3. DEFINITION OF 'MICROPLASTICS IN DRINKING WATER'

The term 'microplastics' in this Policy Handbook refers to the definition of 'Microplastics in Drinking Water' adopted by the State Water Board on June 16, 2020, which is as follows:

3.1. 'Microplastics in Drinking Water' are defined as solid polymeric material to which chemical additives or other substances may have been added,[2] which are particles which have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers. Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.

3.1.1. 'Solid' means a substance or mixture which does not meet the definitions of liquid or gas.

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[1] The COVID-19 emergency created challenges to complying with the July 1, 2021 deadline.

[2] Note that analytical methods used in this monitoring plan do not require analysis or reporting of plastic-associated chemicals. While the presence of such chemicals may cause spectroscopic interferences to the identification of microplastics, it shall not be used as justification to avoid reporting of contamination.

3.1.2. 'Liquid' means a substance or mixture which:

3.1.2.1. At 50 degrees Celsius (˚C) has a vapor pressure less than or equal to 300 kPa;

3.1.2.2. Is not completely gaseous at 20˚C and at a standard pressure of 101.3 kilopascal (kPa); and

3.1.2.3. Which has a melting point or initial melting point of 20 ˚C or less at a standard pressure of 101.3 kPa.

3.1.3. 'Gas' means a substance which:

3.1.3.1. At 50 ˚C has a vapor pressure greater than 300 kPa (absolute); or

3.1.3.2. Is completely gaseous at 20 ˚C at a standard pressure of 101.3 kPa.

3.1.4. 'Polymeric material' means either (i) a particle of any composition with a continuous polymer surface coating of any thickness, or (ii) a particle of any composition with a polymer content of greater than or equal to 1% by mass.

3.1.5. 'Particle' means a minute piece of matter with defined physical boundaries; a defined physical boundary is an interface.

3.1.6. 'Polymer' means a substance consisting of molecules characterized by the sequence of one or more types of monomer units. Such molecules must be distributed over a range of molecular weights wherein differences in the molecular weight are primarily attributable to differences in the number of monomer units. A polymer comprises the following:

3.1.6.1. a simple weight majority of molecules containing at least three monomer units which are covalently bound to at least one other monomer unit or other reactant;

3.1.6.2. less than a simple weight majority of molecules of the same molecular weight.

3.1.7. 'Monomer unit' means the reacted form of a monomer substance in a polymer.

3.1.8. 'Monomer' means a substance which is capable of forming covalent bonds with a sequence of additional like or unlike molecules under the conditions of the relevant polymer-forming reaction used for the particular process.

3.1.9. Size-based nomenclature within the dimensions' limits include:

3.1.9.1. "nanoplastics" (1 nanometer to <100 nanometers);

3.1.9.2. "sub-micron plastics" (100 nanometers to <1 micrometer);

3.1.9.3. "small microplastics" (1 micrometer to < 100 micrometers);

3.1.9.4. "large microplastics" (100 micrometers to <5 millimeters).

4. BACKGROUND

4.1. *Monitoring Authority*

Health and Safety Code sections 116271 and 116400 provide authority to the State Water Board to issue monitoring orders to public water systems[3] in accordance with conditions specified by the State Water Board, which shall be reported on a quarterly basis, unless the State Water Board finds that reasonable action requires more or less frequent analysis. Furthermore, Health and Safety Code section 116530 grants the State Water Board authority to issue monitoring orders to public water systems[3] to submit technical reports including, but not limited, to water quality information in the form and format and at intervals specified by the State Water Board.

4.2. *Health Effects*

Health and Safety Code section 116376, subdivision (b)(3) requires the State Water Board to consider issuing a notification level or other guidance to aid consumer interpretations of testing results for microplastics. State Water Board staff, in collaboration with the Southern California Coastal Water Research Project (SCCWRP) and subject matter experts, conducted research regarding the human health impacts of microplastics, and determined that there was insufficient evidence to issue a notification level or other numerical guidance for microplastics due to significant data gaps with respect to the concentrations at which effects occur in mammals, toxicity effect mechanisms (which are necessary to generalize across different particle shapes, sizes, and chemistries), and exposure through food and other potentially significant sources.[4] While numerical guidance could not be developed, this research determined that microplastics smaller than 10 micrometers in length have an increased likelihood of causing adverse health effects in mammals and should be prioritized for monitoring when possible.[4] While available analytical methods reliably quantify microplastics as small as 20 micrometers in length (Attachment D), such data is useful for estimating concentrations of smaller particles that are more relevant

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[3] Public water systems are defined in Health and Safety Code section 116275, subdivision (h).

[4] Coffin S, Bouwmeester H, Brander S, Damdimopoulou P, Gouin T, Hermabessiere L, et al. Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. Microplastics and Nanoplastics. 2022.

for human health through the application of well-conserved size distributions.[5] [4] Although a notification level or other numerical guidance was not developed, State Water Board staff developed qualitative health-based guidance language to aid consumers in their interpretation of monitoring results.

4.3. Methodology

4.3.1. Analytical Methods

State Water Board staff, in collaboration with the SCCWRP, conducted an inter-laboratory comparison study ("Method Study") to standardize methodologies for extracting and analyzing microplastics in drinking water. Two standardized analytical methods were developed through this study, which have undergone revisions since their introduction[6].

4.3.1.1. Infrared spectroscopy (Attachment C)
4.3.1.2. Raman spectroscopy (Attachment D).

The Method Study consisted of twenty-two laboratory participants and assessed precision, repeatability, cost, and other factors. Methods for sampling extraction via filtering/sieving, optical microscopy, infrared spectroscopy, and Raman spectroscopy were evaluated. Each laboratory received three spiked samples of simulated finished drinking water and a laboratory blank. Spiked samples contained known amounts of microplastics in four size fractions (1-20 micrometers, 20-212 micrometers, 212-500 micrometers, >500 micrometers), four polymer types (polyethylene, polystyrene, polyvinyl chloride, and polyethylene terephthalate), and six colors (clear, white, green, blue, red and orange).

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[5]Microplastics size distribution data and their applicability to human health are detailed in Kooi M, Primpke S, Mintenig SM, Lorenz C, Gerdts G. Characterizing the multidimensionality of microplastics across environmental compartments. Water Research. 2021;24. and in Mohamed Nor NH, Kooi M, Diepens NJ, Koelmans AA. Lifetime Accumulation of Microplastic in Children and Adults. Environmental Science. 2021;55(8):5084–96.

[6]Analytical methods were first released on September 24th, 2021 on the State Water Board website (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html) and were revised on May 27th, 2022.

Spiked samples also included false positives (natural hair, fibers and shells) that may be mistaken for microplastics. Overall, participants demonstrated excellent average recovery and chemical identification for particles greater than 20 micrometers and 50 micrometers in size using Raman spectroscopy and infrared spectroscopy, respectively, with opportunity for increased accuracy and precision through training and further method refinement.[7]

Additional method-harmonization efforts are ongoing at the time of writing this Policy Handbook, such as those being conducted by ASTM International, the European Commission's Joint Research Centre, Wageningen University and Research, and the Bundesanstalt für Materialforschung undprüfung (German). Methods developed through these or other efforts may be approved for use for required monitoring through an official request to the State Water Board. To demonstrate method equivalency, the method in question must be validated through an inter-laboratory comparison exercise and have an application for an Alternate Test Procedure using the format and guidance promulgated by the United States Environmental Protection Agency.[8]

4.3.2. Surrogate Methods

The Method Study determined that costs and analysis time for microplastics analysis using the standardized methodologies are higher than many unregulated and regulated contaminants.[7] Method Study participants evaluated the potential for inexpensive, rapid surrogate monitoring methods to indicate the presence of microplastics, which may be utilized to determine if additional monitoring using Raman or infrared spectroscopy is appropriate. While additional research is needed to determine the reliability of potential surrogates, examples of potentially

[7] Findings from the Method Study are reported in De Frond H, Thornton Hampton L, Kotar S, Gesulga K, Matuch C, Lao W, et al. Monitoring microplastics in drinking water: An interlaboratory study to inform effective methods for quantifying and characterizing microplastics. Chemosphere. 2022 Jul;298:134282.
[8] Alternate Test Procedure details and application may be found on the United States Environmental Protection Agency website https://www.epa.gov/dwanalyticalmethods/drinking-water-alternate-test-procedure-program

viable methods include techniques that are already commonly used in public water systems including: total organic carbon, turbidity analysis, and total suspended solids (Attachment B).

4.3.3. Laboratory Accreditation

At the time of writing this Policy Handbook, no government has required monitoring for microplastics, and there are few commercial or utility laboratories capable of monitoring microplastics.[9] Additionally, there are no commercial suppliers of proficiency testing samples representative of microplastics in finished drinking water, drinking water sources, or other aqueous matrices to independently assess the performance (e.g., recovery, precision, accuracy, etc.) of laboratories. Despite a lack of proficiency testing samples, laboratory performance for microplastics larger than 20 micrometers in length can be reliably assessed using quality assurance criteria developed through the Method Study in combination with commercially available laboratory fortified blank sample materials.

4.4. Sample Collection

At the time of Policy Handbook adoption, the State Water Board is aware of one standardized method for collecting samples for microplastics, which has been promulgated by ASTM International: "ASTM D8332-20: Standard Practice for Collection of Water Samples with High, Medium, or Low Suspended Solids for Identification and Quantification of Microplastic Particles and Fibers."[10] A significant drawback of the ASTM D8332-20 method in its dependence on open-air sieve stacks, which presents opportunities for contamination and therefore requires the collection of a field blank to determine atmospheric and self-

[9] At the time of writing, the State Water Board is aware of at least four independent laboratories seeking ELAP accreditation for microplastics analysis with the intention to analyze samples associated with this sampling and analysis plan. Anticipated laboratory capacity is factored into decisions regarding the number and frequency of samples required for monitoring pursuant to this plan. The State Water Board anticipates that additional laboratories will become available for microplastics analysis following the first phase of monitoring. Monitoring orders will include extension clauses for monitoring requirements of public water systems in the unlikely case that no accredited laboratories are available.

[10] ASTM D8332-20 may be obtained from https://www.astm.org/Standards/D8332.htm

contamination. As part of the Pilot Phase, the State Water Board is evaluating the suitability of an alternative sampling methodology described in the scientific literature but that has not yet undergone a formal rigorous evaluation by an authoritative body that utilizes in-line filtration—therefore eliminating the possibility of contamination during sample collection and the need for a sample blank (Yuan et al. 2022).[11] If the State Water Board deems this alternative sampling method described in Yuan et al. (2022) to be superior to the ASTM D8332-20 method in terms of feasibility and quality control, the State Water Board will issue a detailed guidance manual and provide training (including online materials and in-person interactive training sessions) for sample collectors to use this method, and will require its use during Phase I. The guidance manual and subsequent sampling requirements will pay particular attention to feasibility (e.g., time required to sample, accessibility, etc.).

4.5. Monitoring Plan

The State Water Board recognizes the rapidly evolving science regarding microplastics, including the limited laboratory capacity and lack of proficiency testing samples, and the relatively high amount of resources required to sample and monitor for microplastics. The State Water Board anticipates capacity for monitoring and assessing laboratories using proficiency testing samples will be developed as a result of required monitoring.

Research conducted by State Water Board staff suggests there is a high probability for the occurrence of microplastics as large as 5,000 micrometers in length in surface waters, and that several commonly used drinking water treatment technologies incidentally remove microplastics larger than 20 micrometers in length. Additionally, groundwaters typically have low detection frequencies and surface waters typically have high detection frequencies of microplastics. Microplastics concentrations vary spatially and temporally and depend on a number of known and unknown factors.

The State Water Board will employ a two-phase iterative approach for monitoring microplastics to obtain sufficient information to estimate risk through exposure via

[11] Yuan C, Almuhtaram H, McKie MJ, Andrews RC. Assessment of microplastic sampling and extraction methods for drinking waters. Chemosphere. 2022 Jan;286:131881.

drinking water. Each step will last two (2) years, with an interim period to allow for State Water Board staff to assess results from the first phase and plan the second phase of monitoring accordingly. For both phases, the State Water Board will issue orders to public water systems and/or wholesaler providers to monitor microplastics in source waters and/or treated drinking water. In Phase I, monitoring will focus on characterizing occurrence of microplastics larger than 20 or 50 micrometers in length in source waters used for drinking in accordance with the specifications in the method employed by the laboratory (Attachments C and D. Phase II monitoring will be directed towards characterizing occurrence of microplastics both smaller than and larger than 20 micrometers in length in treated drinking water.

4.5.1. Process for Laboratory Accreditation

The Environmental Laboratory Accreditation Program (ELAP) will offer accreditation to qualified laboratories to monitor for microplastics in drinking water as follows:

4.5.1.1. Laboratories wishing to become accredited for monitoring microplastics in water must apply through the online process[12] and list the appropriate field of accreditation corresponding to one of four microplastics analytes[13] in non-potable water and drinking water matrices using one of the approved analytical methods (Attachments C and D) with the corresponding instrumentation (i.e., Raman or infrared spectroscopy).

4.5.1.2. ELAP will provide accreditation of qualified laboratories for the two approved microplastics analysis methods listed in this Policy Handbook (Attachments C and D).

4.6. *External Scientific Peer Review*

In accordance with Health and Safety Code section 57004, the State Water Board requested external scientific peer review for the scientific components of

[12] Application information for ELAP is available on the State Water Board webpage: https://www.waterboards.ca.gov/drinking_water/certlic/labs/apply.html

[13] Microplastic analytes listed in ELAP's field of accreditations include: "microplastics > 500 micrometers"; "microplastics 500 to 212 micrometers"; "microplastics 212 to 20 micrometers"; and "microplastics 212 to 50 micrometers."

the draft policy handbook,[14] the definition of microplastics in drinking water adopted by the State Water Board,[15] analytical methods for monitoring microplastics developed by the State Water Board for the purposes of this Policy Handbook,[16] proposed health effects guidance language,[17] and underlying literature review.[18] Peer review comments received from four external experts[19] were used to inform the revised Policy Handbook and its underlying components (e.g. definition, analytical methods), the development of the pilot phase, research projects conducted by the State Water Board, and coordination with stakeholders (e.g. Microplastics Subcommittee of the Water Quality Monitoring Council). Revisions made in response to peer review comments received include the following:

4.6.1. The State Water Board is developing an open-source reporting tool to maximize usage of complex monitoring datasets and ensure data are reported in a harmonized manner that is consistent with the definition.[20] The reporting tool addresses a number of concerns from peer reviewers

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[14] Draft Microplastics in Drinking Water Policy Handbook (November 10, 2021). https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/microplastics/mcrplsts_plcy_drft.pdf

[15] Resolution 2020-0021 adopted on June 16, 2020. https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2020/rs2020_0021.pdf

[16] "Standard Operating Procedures for Extraction and Measurement by Raman Spectroscopy of Microplastic Particles in Drinking Water" (September 24, 2021); "Standard Operating Procedures for Extraction and Measurement by Infrared Spectroscopy of Microplastic Particles in Drinking Water" (September 24, 2021).

[17] Section 4.1.1 of Draft Microplastics in Drinking Water Policy Handbook (November 10, 2021). https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/microplastics/mcrplsts_plcy_drft.pdf.

[18] Coffin S, Bouwmeester H, Brander S, Damdimopoulou P, Gouin T, Hermabessiere L, et al. Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. Microplastics and Nanoplastics. 2022.

[19] Peer reviewer letters were received by Dr. Alan Hubbard, Dr. Denise Mitrano, Dr. José Carlos Pinto, and Dr. Tony R. Walker and are available on the State Water Board website: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html

[20] The microplastics data harmonization and reporting protocol is being developed by the State Water Board in collaboration with the Moore Institute for Plastic Pollution Research, San Francisco Estuary Institute, and The People Lab.

regarding the importance of data granularity in assessing human health risks, ensuring comparability between laboratories, and improving feasibility of following the definition.

4.6.2. The State Water Board provided additional clarification regarding the definition and how it pertains to the sampling and monitoring plan.[21]

4.6.3. Guidance for sampling protocols and requirements for sampling volumes will be provided based on evaluation and optimization research conducted by the State Water Board.[22]

4.6.4. Analytical methods (Attachments C and D) will undergo additional inter-laboratory validation using real-world water samples during the Pilot Phase. Laboratories seeking ELAP accreditation may volunteer to participate in this additional validation exercise.

4.6.5. Analytical methods were revised following guidance from peer reviewers and public comments.[23] Revisions include stricter requirements for laboratories to spectroscopically confirm the polymer identity of particles, expansion of the types of acceptable spectroscopic instruments to be used with each method, additional details regarding variability reporting, correction of several typos, and additional minor edits.

5. PLANNED AND ONGOING WORK

5.1. The State Water Board is conducting additional research and performing work to resolve scientific and logistical challenges related to monitoring. These efforts do not count towards the four years of monitoring and reporting required by Health and Safety Code section 116376 subsection (b)(2). Work related to these efforts are planned to occur between Summer 2022 and Summer 2023 and are referred to as the "Pilot Phase."

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[21] This version of the policy handbook was revised to ensure the size-based classifications in the definition are synonymous with Resolution 2020-0021, and clarity surrounding "…chemical additives or other substances…"

[22] Details regarding planned research by the State Water Board to refine sampling protocols and provide guidance and training to operators is described in the Pilot Phase section of this Policy Handbook.

[23] Revised analytical methods were released on May 27th, 2022 on the State Water Board website. (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html)

5.1.1. The primary goals of the Pilot Phase are to build infrastructure for monitoring and advance science to optimize utility of the subsequent phases.

5.1.2. The State Water Board has initiated a contract with the SCCWRP to accomplish the following scientific research goals:

5.1.2.1. Evaluate the reliability and feasibility of the ASTM D8332-20 sampling method alongside an in-line filtration method described in Yuan et al. (2022)[24] using environmental samples at a select number of volunteer public water systems;

5.1.2.2. If appropriate, develop a standardized sampling protocol using an in-line filtration based on an optimized method described first in Yuan et al. (2022)[4];

5.1.2.3. Measure microplastics levels and targeted potential surrogates in water samples from a small number of volunteer California public water systems, including treated and raw water samples;

5.1.2.4. Determine optimal sampling volumes based on source water characteristics, data quality objectives, and feasibility (e.g., ensuring sample collection times are achievable given documented time constraints of water system personnel);

5.1.2.5. If appropriate, determine if a field reagent blank should be included in the sampling protocols based on the quality control and quality assurance guidelines associated with the chosen optimized sampling protocol as described above (e.g., in-line filtration would effectively eliminate the possibility of contamination and therefore eliminate the need for a field reagent blank);

5.1.2.6. If appropriate, designate an upper limit of total particle concentrations for final samples.

5.1.3. Additional logistical and infrastructure-building goals of the Pilot Phase include:

5.1.3.1. Providing in-person and virtual training (e.g., videos, documents) to public water system operators in California for either sampling protocol that is determined to be most reliable and feasible as described above;

[24] Yuan C, Almuhtaram H, McKie MJ, Andrews RC. Assessment of microplastic sampling and extraction methods for drinking waters. Chemosphere. 2022 Jan;286:131881.

5.1.3.2. Developing guidelines and protocols for reducing sample interferences (e.g., sample digestion) from water with high organic content or non-plastic particulates (e.g., minerals);

5.1.3.3. If appropriate, developing guidance for surrogates correlated to microplastics concentrations;

5.1.3.4. Allowing time and providing resources for laboratories to become accredited through ELAP; conducting additional inter-laboratory validation using environmental water samples obtained through the aforementioned contract work; and developing a harmonized data reporting protocol using open-source code.[25]

5.1.3.5. Developing tools for communicating risks of microplastics to consumers.[26]

5.1.3.6. Providing resources and guidance for laboratory accreditation and monitoring.

5.1.4. Any monitoring conducted during the Pilot Phase will be optional and voluntary.

6. MONITORING AND REPORTING REQUIREMENTS

Health and Safety Code section 116376 directs the State Water Board to set forth requirements for public water systems to conduct monitoring of microplastics in drinking water. Monitoring orders will be issued to specific public water systems in two phases, requiring monitoring for a period totaling four (4) years. Those systems that receive an order shall be required to sample consistent with the following requirements:

6.1. Water System Selection

Public water systems have been selected for potential monitoring based on concepts utilized by the United States Environmental Protection Agency's UCMR program (Attachment A). The UCMR program establishes monitoring requirements for priority unregulated contaminants in drinking water for all large

[25] The microplastics data harmonization and reporting protocol is being developed by the State Water Board in collaboration with the Moore Institute for Plastic Pollution Research, San Francisco Estuary Institute, and The People Lab.

[26] Consumer guidance tools as well as laboratory accreditation and analysis resources are being developed by the State Water Board in collaboration with voluntary stakeholders through the Microplastics Subcommittee of the California Water Quality Monitoring Council. Anyone may participate in the Microplastics Subcommittee.

public water systems serving greater than 10,000 people, all small public water systems serving between 3,300 and 10,000 people, and a representative sample of small public water systems serving fewer than 3,300 people.[27]

Due to significant uncertainties regarding risks of microplastics through drinking water and substantial costs to reliably monitor microplastics, an adapted version of the UCMR approach will be utilized to minimize impacts to public water systems, while obtaining sufficient data to estimate general occurrence and potential human exposure through drinking water. Accordingly, in the first phase of monitoring, a small number of public water systems will be required to monitor, with a focus on characterization of sources which serve the greatest number of consumers and optimization to reduce the total number of sources necessary to obtain adequate representation of contamination in source waters in the state. Large community water systems and wholesale water systems that provide water to greater than 100,000 people will receive the vast majority of monitoring orders in Phase I. Public water systems that depend primarily on purchased water will not receive monitoring orders during Phase I. Additional factors included in the selection of public water systems included geospatial representation, treatment capabilities, and primary water sources (e.g., surface water, groundwater, groundwater under direct influence of surface water). The State Water Board will evaluate findings from Phase I to determine sampling locations for Phase II.

6.2. Sampling Requirements

6.2.1. Testing Phase[28]

6.2.1.1. *Phase I* (Fall, 2023 – Fall, 2025)

6.2.1.1.1. Public water systems potentially selected to monitor during Phase I (Attachment A) will test for microplastics occurring in drinking water sources using one of the approved standardized methods (Attachment C, Attachment D).

[27] Additional information regarding the United States Environmental Protection Agency's UCMR can be found on their website https://www.epa.gov/dwucmr/learn-about-unregulated-contaminant-monitoring-rule

[28]Dates listed are approximate, are not binding, and are subject to change.

6.2.1.1.2. Prior to issuing monitoring orders, State Water Board staff will hold a public workshop[29] with systems listed on Attachment B to discuss and agree upon monitoring details, including but not limited to: specific sampling locations; quality assurance and quality control protocols; sample holding times; procedures for reviewing, approving, and uploading data.

6.2.1.1.3. At minimum, laboratories must report concentrations of microplastics that are 50 micrometers long or the minimum size listed in the standardized method used by the laboratory (see Attachments C and D) – whichever is smaller. Monitoring for shorter microplastics is strongly encouraged.

6.2.1.1.4. Unless otherwise stated in monitoring orders issued to public water systems, monitoring will be limited to drinking water sources only.

6.2.1.1.5. Unless stated otherwise in monitoring orders, drinking water source samples shall be collected at the same location(s) where *Cryptosporidium* and *Giardia* are typically collected.

6.2.1.1.6. The potential surrogate techniques listed as being 'required' in Attachment B will be required for monitoring.

6.2.1.1.6.1. To reduce contamination of surrogate monitoring samples, identical quality assurance protocols as stated in Attachments C and D, and further detailed in forthcoming sampling guidance issued by the State Water Board, shall be implemented during sampling.

6.2.1.1.7. Testing is required for a period of two (2) years.

6.2.1.1.8. Public water systems, in cooperation with other agencies or water suppliers, may develop and submit a plan to the State Water Board that identifies sampling site(s) for (a) drinking water source(s) that is (are) shared by multiple public water system

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[29] Workshop anticipated to occur in Fall/Winter 2022 and will be open to the public. Water systems on draft list (attachment A) will be invited to submit oral and written proposals for planned sampling locations. Consolidation of monitoring between systems will be considered if sufficient evidence is provided detailing shared water sources. When available, details regarding workshop will be posted on the State Water Board website: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html

treatment plants and is representative of a drinking water source that is further treated and distributed to consumers. To make this demonstration, a public water system shall submit information to the State Water Board regarding the location and distribution of each sampling site, and water quality information for each sampling site. The State Water Board will use this information to determine whether the drinking water sources are used to produce finished drinking water through multiple public water system treatment plants. Upon approval of a submitted plan by the State Water Board, public water systems shall monitor at the identified sampling site(s). Monitoring conducted through an approved plan may be used to satisfy monitoring requirements upon approval by the State Water Board.

6.2.1.2. Phase II (Fall, 2026 – Fall, 2028)

6.2.1.2.1. Following a six-month interim between Fall, 2025 and Spring 2026, the State Water Board will issue additional monitoring orders for public water systems required to test subject to Phase II methodology. Public water systems subject to monitoring may include the same systems required during Phase I as well as additional systems.

6.2.1.2.2. For public water systems selected to monitor during Phase II, the system will test for microplastics occurring in finished drinking water as small as 5 micrometers in length, or the smallest microplastics for which ELAP provides accreditation at the time of the monitoring order issuance.

6.2.1.2.3. Unless stated otherwise in monitoring orders, finished drinking water samples shall be collected at the same location(s) where *Cryptosporidium* and *Giardia* are typically collected or following the final stage of treatment before entering the distribution system.

6.2.1.2.4. Public water systems without any detections of microplastics during Phase I may be exempt from monitoring during Phase II.

6.2.1.2.5. Testing is required for a period of two (2) years.

6.2.1.3. General Requirements

6.2.1.3.1. Public water systems who have been selected for monitoring shall submit a quality assurance project plan, standard operating protocol for sampling, and a plan for monitoring to the State Water Board for approval prior to conducting monitoring.

6.2.1.3.2. Exact sampling locations will be listed in monitoring orders issued to public water systems at a later date.

6.2.1.3.3. Unless specified otherwise in a monitoring order, public water systems shall utilize the standardized protocol for collecting water samples for microplastics as determined by the State Water Board[30].

6.2.1.3.4. Unless specified otherwise in a monitoring order, public water systems shall utilize one of the two (2) standardized protocols for analyzing samples of drinking water sources or finished drinking water for microplastics: infrared spectroscopy (Attachment C) or Raman spectroscopy (Attachment D).

6.2.1.3.5. Alternative analytical methods may be approved for use through an official request to the State Water Board. To demonstrate method equivalency, the method in question must be validated through an inter-laboratory comparison exercise and have an application for an Alternate Test Procedure using the format and guidance promulgated by the United States Environmental Protection Agency.

6.2.1.3.6. Public water systems must analyze samples with laboratories accredited by ELAP using an approved standardized methodology defined in the monitoring order.

6.2.1.3.7. Unless specified otherwise in a monitoring order, public water systems must submit water quality data for required surrogates and standard water quality monitoring parameters in Attachment B, including temperature, turbidity, total organic carbon, total dissolved solids, and total suspended solids collected during the same day of the microplastics sample at the same location. Water flow rate entering the treatment plant shall also be reported. Public water systems are encouraged to either collect

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[30] The standardized operating protocol for sampling microplastics is under development at the time of writing and will be posted on the State Water Board webpage https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html and will also be attached to monitoring orders.

samples in parallel using these surrogate monitoring methods (if possible) or collect and report these surrogate parameters at the start and finish of sample collection. Regardless of how surrogate parameters are collected, public water systems shall identify how such samples were collected. Public water systems are encouraged (but are not required) to report surrogate data from additional techniques listed in Attachment B.

6.2.1.3.8. Unless specified otherwise in a monitoring order, public water systems are not required to collect replicate samples for analysis of microplastics. Laboratory analytical variability shall be assessed through the use of laboratory fortified reagent blanks as specified in Attachment C and Attachment D.

6.2.1.3.9. All blank contamination and root cause, if known, shall be reported to the State Water Board through the manner specified in the monitoring orders.

6.2.1.3.10. Raw data shall be uploaded without blank correction alongside quality control and quality assurance data, or as specified in the analytical methods required for use.

6.2.1.3.11. Due to the known relatively low occurrence of microplastics in groundwaters used as drinking water sources,[31] monitoring orders will be directed primarily for surface waters used as drinking water sources.

6.2.1.3.12. Unless stated otherwise in monitoring orders, samples shall be collected twice between October – April (rainy season) and twice during May – September (dry season) of each year to determine the relative influence of rain and stormwater influence as well as atmospheric deposition. Accordingly, for each sampling location a minimum of eight (8) samples will be analyzed over the two-year period.

6.2.1.3.13. Analyses required pursuant to this Policy Handbook shall be performed by laboratories accredited by the State Water Board to perform such analyses pursuant to Health and Safety Code,

[31] Viaroli S, Lancia M, Re V. Microplastics contamination of groundwater: Current evidence and future perspectives. A review. Science of The Total Environment. 2022 Jun 10;824:153851.

division 101, part 1, chapter 4, article 3, commencing with section 100825.

6.2.1.3.14. Sample collection shall be performed by personnel trained to perform such sample collections and/or tests by:

6.2.1.3.14.1. The State Water Board;

6.2.1.3.14.2. A laboratory accredited pursuant to Health and Safety Code section 100825, subdivision (a);

6.2.1.3.14.3. An operator certified by the State Water Board pursuant to Health and Safety Code section 106875, subdivisions (a) or (b).

6.2.1.3.15. Public water systems shall take all samples during normal operating conditions, which exclude those circumstances covered under the California Code of Regulations, title 22, section 64533.5, subdivision (b).

6.3. Reporting Requirements

6.3.1. Monitoring results shall be reported to the State Water Board by the analyzing laboratory using the Electronic Deliverable Format in accordance with California Code of Regulations, title 22, section 64469 and in compliance with the format specified by the State Water Board.[32]

6.3.2. Analytical results shall be reported no later than the 10th day of the month following completion of the analysis.

6.3.3. Public water systems, as defined in Health and Safety Code section 116275, shall include positive detections of microplastics in their annual Consumer Confidence Report pursuant to Health and Safety Code section 116470, subdivision (a)(4). If monitoring data is available for finished drinking water samples, such data shall be reported in addition to data for drinking water source samples. Additionally, as stated in Health and Safety Code Section 66480, a community or non-transient, non-community water systems (NTNC)[33] that sells water to another community or NTNC water system shall deliver the required monitoring data to the purchasing system

[32] Specific guidance regarding reporting format, metrics, classifications, and metadata will be provided in monitoring orders issued to public water systems. The State Water Board is currently developing a harmonized data reporting tool to assist laboratories and public water systems.

[33] Community and NTNC water systems are defined in Health and Code section 116275.

by no later than April 1 of each year or on a date mutually agreed upon by the seller and the purchaser, and specifically included in a contract between the parties.

6.3.3.1. Unless stated otherwise in a monitoring order issued by the State Water Board or other regulation, public water systems shall include or provide a reference to health-based guidance language developed by the State Water Board to aid consumer interpretations of findings of microplastics in finished drinking water (or drinking water sources), which is as follows:

6.3.3.2. “Studies of rodents exposed to some types of microplastics through drinking water indicate potentially adverse effects, including on the reproductive system. However, more research is needed to understand potential impacts on human health, including determining concentrations at which effects may occur. California is monitoring microplastics in drinking water to understand its occurrence and is supporting ongoing research.”

6.3.4. A microplastics detection is a positive finding of a quantifiable amount above the minimum reporting level[34] established by the analytical laboratory.

6.3.5. Public water systems subject to monitoring shall analyze samples taken at the same location and date as the samples collected for microplastics monitoring using the required surrogate monitoring techniques in Attachment B and submit surrogate monitoring data to the State Water Board alongside microplastics monitoring results. Public water systems are encouraged but not required to monitor for additional surrogates listed as optional on Attachment B.

6.3.6. For all samples collected from a reservoir, the reservoir depth and turnover rates shall be reported.

6.3.7. Blending rates must be reported (when applicable).

6.3.8. Sampling volume shall be reported.

6.4. Timeline

To assist public water systems and laboratories in preparing for monitoring and reporting of microplastics, a general timeline is provided here. Note that dates are approximate and are subject to change under the microplastics monitoring

[34] The method for calculating a minimum reporting level for microplastics is detailed in Attachments C and D.

orders.

6.4.1. Summer, 2022: Environmental Laboratory Accreditation Program will offer accreditation to qualified laboratories for microplastics in non-potable water and drinking water fields of accreditation.
6.4.2. Fall, 2022: State Water Board will issue monitoring orders in accordance with Phase One of planned monitoring, with monitoring requirements applicable between Fall 2023 – Fall 2025.
6.4.3. Fall, 2025 – Spring 2026: Interim period in which State Water Board staff will assess results from Phase One and determine best approach for Phase Two.
6.4.4. Spring, 2026: State Water Board will issue monitoring orders in accordance with Phase Two of planned monitoring with monitoring requirements applicable between Fall 2026 – Fall 2028.
6.4.5. Fall 2028: Completion of Phase Two of planned monitoring.

List of Attachments

ATTACHMENT A – List of water systems potentially subject to monitoring during Phase I

ATTACHMENT B – Non-exhaustive list of potential surrogate monitoring methods for microplastics

ATTACHMENT C - Standard Operating Procedures for Extraction and Measurement by Infrared Spectroscopy of Microplastic Particles in Drinking Water: May 27th, 2022 [SWB-MP1-rev1]

ATTACHMENT D - Standard Operating Procedures for Extraction and Measurement by Raman Spectroscopy of Microplastic Particles in Drinking Water: May 27th, 2022 [SWB-MP2-rev1]

ATTACHMENT A – List of water systems potentially subject to monitoring during Phase I

pwsid	Water System Name	Primary Water Source Type	Population Served	CITY	Rationale for Inclusion
CA1910087	METROPOLITAN WATER DIST. OF SO. CAL.	Surface Water	18,962,000	LOS ANGELES	Largest Providers
CA1910067	LOS ANGELES-CITY, DEPT. OF WATER & POWER	Surface Water	4,070,679	LOS ANGELES	Largest Providers
CA3810001	SAN FRANCISCO REGIONAL WATER SYSTEM	Surface Water	2,600,600	SAN FRANCISCO	Largest Providers
CA4310027	SANTA CLARA VALLEY WATER DISTRICT	Surface Water	1,540,360	SAN JOSE	Largest Providers
CA0110005	EAST BAY MUD	Surface Water	1,438,500	OAKLAND	Largest Providers
CA3710020	SAN DIEGO, CITY OF	Surface Water	1,400,016	SAN DIEGO	Largest Providers
CA4310011	SAN JOSE WATER	Surface Water	1,007,514	SAN JOSE	Largest Providers
CA3410020	CITY OF SACRAMENTO MAIN	Surface Water	884,060	SACRAMENTO	Largest Providers
CA4910020	SONOMA COUNTY WATER AGENCY	Groundwater	600,000	SANTA ROSA	Groundwater with low filtration
CA1010007	CITY OF FRESNO	Surface Water	542,148	FRESNO	Geographically Diverse Systems
CA3010001	CITY OF ANAHEIM	Surface Water	450,000	ANAHEIM	Largest Providers
CA3010092	IRVINE RANCH WATER DISTRICT	Surface Water	422,000	IRVINE	Largest Providers
CA1910128	COVINA IRRIGATING CO.	Surface Water	382,349	COVINA	Surface Water with Low Filtration
CA3610050	UPLAND, CITY OF	Surface Water	375,509	UPLAND	Largest Providers
CA0110001	ALAMEDA COUNTY WATER DISTRICT	Surface Water	351,000	FREMONT	Largest Providers
CA3410021	SAN JUAN WATER DISTRICT	Surface Water	334,669	GRANITE BAY	Largest Providers
CA3310031	RIVERSIDE, CITY OF	Groundwater UDI Surface Water	312,214	RIVERSIDE	Largest Providers
CA3610129	MOJAVE WATER AGENCY	Groundwater	292,449	APPLE VALLEY	Groundwater with low filtration
CA0110010	ZONE 7 WATER AGENCY	Surface Water	226,840	LIVERMORE	Largest Providers

CA4810003	CITY OF FAIRFIELD	Surface Water	140,259	FAIRFIELD	Surface Water with Low Filtration
CA3710006	ESCONDIDO, CITY OF	Surface Water	137,941	ESCONDIDO	Geographically Diverse Systems
CA0710001	CITY OF ANTIOCH	Surface Water	113,061	ANTIOCH	Geographically Diverse Systems
CA1910045	ANTELOPE VALLEY EAST KERN WATER AGENCY	Surface Water	110,286	PALMDALE	Surface Water with Low Filtration
CA3610019	SAN BERNARDINO VALLEY WD	Groundwater	109,608	SAN BERNARDINO	Groundwater with low filtration
CA4510005	CITY OF REDDING	Surface Water	87,548	REDDING	Geographically Diverse Systems
CA1910225	LAS VIRGENES MWD	Surface Water	75,384	CALABASAS	Geographically Diverse Systems
CA3410004	CARMICHAEL WATER DISTRICT	Groundwater UDI Surface Water	37,897	CARMICHAEL	Groundwater under direct infiltration with low filtration
CA1503341	TEJON CASTAC WD - I5 & LAVAL RD	Surface Water	30,250	LEBEC	Surface Water with Low Filtration
CA1510055	CWS - NORTH GARDEN	Surface Water	24,313	BAKERSFIELD	Geographically Diverse Systems
CA3110001	NORTH TAHOE PUD - MAIN	Surface Water	5,300	TAHOE VISTA	Geographically Diverse Systems

ATTACHMENT B Non-exhaustive list of potential surrogate monitoring methods for microplastics

Potential Surrogate Method	Relative Availability	Pre-separation step required?	Can distinguish microplastics?	Required during Phase I?
Temperature	Common	No	No	Required
Treatment plant flow rate (to calculate particles entering plant)	Common	No	No	Required
Turbidity	Common	Yes	No	Required
Total organic carbon	Common	Yes	No	Required
Total suspended solids	Common	Yes	No	Required
Total dissolved solids	Common	Yes	No	Required
Total particle count (particles/mL)	Uncommon	No	No	Optional
Microbalance	Common	Yes	No	Optional
Thermogravimetric analyzer - Differential scanning calorimeter	Uncommon	Yes	No	Optional
NIOSH Method #5040 (elemental and organic carbon)	Uncommon	Yes	No	Optional
Imaging hemocytometer	Uncommon	Yes	Likely	Optional
Microscopy with nile red	Uncommon	Yes	Yes	Optional
SiMPore transmembrane pressure filtration	Novel	Unclear	No	Optional
Flowcam and cytometry with or w/o staining	Novel	Yes	Likely	Optional
Lucendi device	Novel	Unclear	Likely	Optional
Spectral Flow Cytometer	Novel	Yes	Likely	Optional

Appendix C   Model Calibration

1.0 MODEL DEVELOPMENT

The software used for the hydraulic evaluations is InfoWater v.13.0 provided by Innovyze. Although the previous master plan was performed in 1997, the City's current hydraulic operational model was last created in 2013 and last updated in 2015. Therefore, to match most closely with the existing GIS database, the hydraulic operational model was built from scratch based on a one-to-one approach for the pipelines.

The GIS database is continuously updated; the model used the most recent version available in 2022 to create the model. Additionally, available as-built or bid-set plans were obtained from the City for projects and improvements completed since the last GIS updates in 2022 or currently in construction. This enables the model to represent a complete version of the existing water system pipelines. For updates to pump facilities and controls, as-built plans were also used along with workshops conducted with the operations staff to verify current operations.

Although the system and GIS database include fire hydrants and relief valves, these were not included in the model. The GIS database provided by the City included individual layers for each facility type such as pipeline mains, pipeline laterals, hydrants, and valves. In several areas, multiple hydrants were located parallel to one pipeline main segment. To add the hydrants in the model, the pipeline mains would have to be "split". To avoid this confusion and to maintain the one-to-one approach for the pipelines, the hydrants were not included in the model. Relief valves were also not included in the model. Relief valves are typically included in hydraulic transient models (analyzing sudden pressure surges, rapid flow changes, abrupt pump failures, etc.), not hydraulic operational models (analyzing steady-state conditions, extended period simulations, normal operating conditions, etc.). Including the large quantity of relief valves would cause the model to crash and the valves are unnecessary for the purposes of a hydraulic operational model.

The demands allocated in the model were updated based on meter data from 2022 provided by the City. Then the demands were globally updated based on the MDD factor, and diurnal demand patterns were applied as described in Appendix C-3.

2.0 MODEL CALIBRATION APPROACH

The hydraulic model is calibrated to improve the accuracy of the model in predicting system performance, which can then be used to identify system deficiencies and recommend pipelines and facilities to address those deficiencies. The goal is to calibrate the model as close to MDD conditions as possible. The rationale being that hydraulic models under MDD conditions are stressed to a greater extent and, as such, a more accurate model can be developed.

Model calibration is the process of comparing model results with field results and adjusting model parameters where appropriate until the model results match corresponding field measurement data, within an acceptable difference. Typical adjustments include changes to system connectivity, operational controls, facility configurations, diurnal patterns, elevations, and roughness coefficients (C-factors) for pipelines. The pipes in the model are initially assumed to have a C-factor of 130. The C-factor was decreased for smaller diameter and older aged pipes. The C-factor was increased for larger diameter and younger aged pipes. The C-factors were also adjusted depending on location and material of the pipe. A general summary of C-factors are included in Table 2-1.

Table 2-1 Pipeline C-Factors

Material	Age	Diameter[a]				
		6” & Smaller	8”	10”	12”	14” & Larger
Cast Iron	< 30 Years Old	110 - 130	110 - 130	110 - 130	120 - 130	130 - 140
	30 - 60 Years Old	70 - 130	75 - 130	120 - 130	110 - 130	130 - 140
	> 60 Years Old	70 - 130	75 - 130	110 - 130	80 - 130	130 - 140
Ductile Iron	< 30 Years Old	80 - 130	100 - 130	120 - 130	120 - 130	100 - 140
	30 - 60 Years Old	80 - 130	85 - 130	90 - 130	90 - 130	100 - 140
	> 60 Years Old	70 - 110	75 - 130	90 - 130	80 - 130	100 - 140
HDPE	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
PVC	< 30 Years Old	100 - 130	110 - 130	110 - 130	120 - 130	130 - 140
	30 - 60 Years Old	100 - 110	110 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	100 - 110	110 - 120	120 - 130	120 - 130	130 - 140
RCCP	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
	> 60 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	130 - 140
SCCP	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	120 - 130
	30 - 60 Years Old	110 - 120	110 - 120	75 - 130	80 - 130	80 - 130
	> 60 Years Old	100 - 110	110 - 120	75 - 130	80 - 130	80 - 130
Steel	< 30 Years Old	100 - 110	110 - 120	120 - 130	120 - 130	130 - 140
	30 - 60 Years Old	100 - 110	110 - 120	110 - 120	120 - 130	100 - 140
	> 60 Years Old	100 - 110	100 - 110	100 - 110	105 - 130	100 - 140
Unknown	< 30 Years Old	120 - 130	120 - 130	120 - 130	120 - 130	120 - 130
	30 - 60 Years Old	110 - 120	110 - 120	110 - 120	120 - 130	120 - 130
	> 60 Years Old	100 - 110	100 - 110	100 - 110	120 - 130	120 - 130

[a] C-factors used based on pipe diameter, material, and age. Not all pipes with the same diameter and age assumed the same C-factor, individual adjustments were necessary for specific areas per the flow testing calibration.

Several indicators are used to determine if the model accurately simulates field conditions including water levels in storage tanks, supply flows, and static and residual pressures from fire flow tests. This also acts as the “debugging” phase for the hydraulic model where modeling discrepancies or data input errors are discovered and corrected.

The hydraulic model is calibrated based on steady-state conditions simulating fire hydrant flow tests in the model to match results from the days of field testing. Hourly SCADA information during the days of testing were used to provide reservoir, well, and pumping operations. However, flow and pressure data were not available for all the wells, MWD supply connections, and booster pump stations.

3.0 STEADY STATE PRESSURE CALIBRATION

3.1 HYDRANT FLOW TESTING

Field testing was conducted for three days, July 11 through 13, 2023; chosen because this period is close to the highest annual MDD measured on 7/4/22. . Flow tests were performed at 19 fire hydrant locations throughout the City. Tests 8 and 10 are within subzones and were both tested twice to evaluate the system with one or two PRVs active. As such, a total of 21 fire hydrant flow tests were evaluated. Additionally, four pressure loggers were provided for each day of testing (total of 10 pressure logger tests) within the pressure zones being tested. The locations of the tests are listed in Table 3-1 and shown on Figure 3-1.

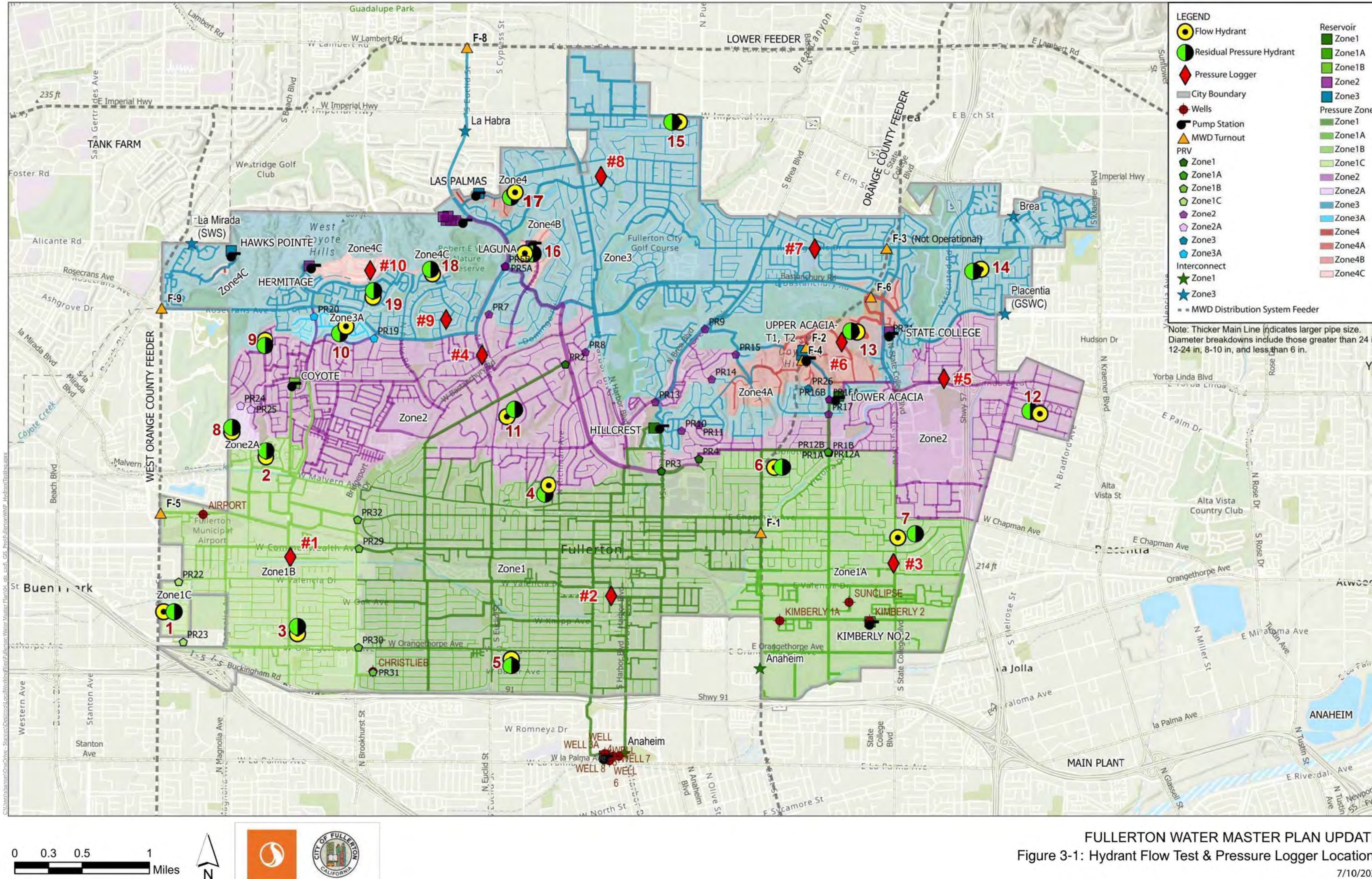
Table 3-1 Hydrant Flow Calibration Locations

Test No.	Zone	Test Location	Hydrant		
			Type[(a)]	Location	ID
1	1C	Flower Ave	Flow	800 Hastings Ave	H-21-12
			Pressure	4242 W Flower Ave	H-22-12
2	1B	Monterey Pl	Flow	2604 Monterey Pl	H-17-38
			Pressure	2628 Monterey Pl	H-2-38
3	1B	Pine Dr	Flow	2142 W Hill Ave	H-36-16
			Pressure	2142 W Cherry Ave	H-30-16
4	1	Drake Ave	Flow	644 Drake Ave	H-34-46
			Pressure	624 Drake Ave	H-41-46
5	1	Jefferson Ave	Flow	760 W Woodcrest Ave	H-9-5
			Pressure	754 W Gage Ave	H-10-5
6	1A	Glenwood Ave	Flow	1000 N Norman Pl	H-12-54
			Pressure	1000 Hollydale Dr	H-13-54
7	1A	Clarke Ave	Flow	2466 Clarke Ave	H-11-33
			Pressure	2400 Clarke Ave	H-10-33
8[(b)]	2A	Northampton Way	Flow	2791 Williamsburg Rd	H-46-37
			Pressure	2774 Sheridan Rd	H-42-37
9	2	Fairgreen Dr	Flow	1806 N Fairgreen Dr	H-10-63
			Pressure	1730 N Fairgreen Dr	H-13-63
10[(c)]	3A	Canyon Dr	Flow	2001 Canyon Dr	H-68-65
			Pressure	1909 Canyon Dr	H-67-65
11	2	Rodeo Rd	Flow	958 Rodeo Rd	H-15-45
			Pressure	934 W Rodeo Rd	H-10-45
12	2	Garnet Ln	Flow	3172 Garnet Ln	H-23-61
			Pressure	3130 Garnet Ln	H-26-59
13	4A	Edinburgh Way	Flow	1942 Edinburgh Way	H-17-81
			Pressure	1918 Edinburgh Way	H-13-81
14	3	Eucalyptus Pl	Flow	2824 Eucalyptus Pl	H-11-86
			Pressure	2800 Eucalyptus Pl	H-16-86
15	3	San Ramon Dr	Flow	730 San Ramon Dr	H-6-96
			Pressure	700 San Ramon Dr	H-5-96
16	4B	Madera Pl	Flow	821 Madera Pl	H-2-72
			Pressure	800 Madera Pl	H-3-72
17	4	Las Palmas Dr	Flow	831 W Las Palmas Dr	H-34-93
			Pressure	909 W Las Palmas Dr	H-33-93
18	4C	Atherton Cir	Flow	1416 Atherton Cir	H-3-70
			Pressure	2567 Camino Del Sol	H-1-70
19	3	Berkshire Dr	Flow	1975 Berkshire Dr	H-43-68
			Pressure	1999 Berkshire Dr	H-31-68

(a) "Flow" type refers to the hydrant opened to measure flow. "Pressure" type refers to the nearby hydrant installed with a pressure gauge to measure the residual pressure.

(b) Test 8 was conducted twice, the first time with pressure relief valve (PRV) PR-24 open and PR-25 closed, the second time with both PRVs open.

(c) Test 10 was conducted twice, the first time with PRV PR-20 open and PR-19 closed, the second time with both PRVs open.



FULLERTON WATER MASTER PLAN UPDATE

Figure 3-1: Hydrant Flow Test & Pressure Logger Locations

7/10/2023

3.2 HYDRANT FLOW TEST MODEL CALIBRATION

City operations staff provided screen captures of SCADA readings from the system control computers during the times of the testing. These images show major system valve flows, reservoir levels, and which pump stations and wells were operating. Reservoir level SCADA for every hour during the days of testing was also provided. The data included facility status and levels to be accurately estimated in the model based on the corresponding time of each flow test.

The model was updated with a calibration scenario that contains a total of 42 steady-state simulations. Although the evaluation included 19 test locations, Tests 8 and 10 were tested twice to evaluate the pressure subzones with one or two PRVs open. As such, a total of 21 fire hydrant flow tests were modeled and calibrated. For each of the 21 tests, the model simulates two scenarios – one “static” simulation prior to the hydrant being opened to flow and one “dynamic” simulation of the hydrant flowing, where the flow and residual pressure can be evaluated. For each flow test simulation, the model results are compared with the field measurements, where a total of 42 data points were compared. It is generally considered acceptable when model results match field results within a 10-percent tolerance.

The initial step in the calibration process was to update the demands in the system to match the demands for the day and time of the tests. This was done by analyzing the boundary supply conditions and production facilities from the SCADA information. After the demands and boundary conditions are satisfactorily calibrated, pressure logger and static readings are compared and verified with field data and ground elevations at each hydrant data point.

The model is ultimately calibrated to match field pressure and flow data at the test locations by adjusting the C-factors, or roughness coefficient, of the pipelines. The C-factor has a direct impact on the pipe headloss and therefore the resulting pressures at upstream and downstream model junction nodes. The C-factor is estimated based on pipe material and pipe age, or year of installation. An older pipe with small diameter and multiple service connections will be estimated to have a lower C-factor than a large new diameter pipe with no connections and smooth pipe material such as PVC. These model C-factors were adjusted accordingly for the model results to match the field testing results within the acceptable tolerance of 10-percent. Table 3-2 shows the model results compared with the field test results.

Table 3-2 – Hydrant Flow Test Results

Test #	Zone	Hydrant ID	Hydrant Type	Flow Rate (gpm)	Pressure (psi)							
					Static				Residual			
					Field	Model	Diff.	%. Diff.	Field	Model	Diff.	% Diff.
1	Zone 1C	H-21-12	Flow	949								
		H-22-12	Pressure		68	69	1	1%	63	60	-3	-5%
2	Zone 1B	H-17-38	Flow	888								
		H-2-38	Pressure		53	51	-2	-3%	51	49	-2	-4%
3	Zone 1B	H-36-16	Flow	1900								
		H-30-16	Pressure		80	75	-5	-7%	68	68	0	0%
4	Zone 1	H-41-46	Flow	1815								
		H-34-46	Pressure		51	50	-1	-2%	39	38	-1	-3%
5	Zone 1	H-9-5	Flow	1941								
		H-10-5	Pressure		82	84	2	2%	75	74	-1	-1%
6	Zone 1A	H-12-54	Flow	1253								
		H-13-54	Pressure		56	54	-2	-3%	38	40	2	4%
7	Zone 1A	H-11-33	Flow	1299								
		H-10-33	Pressure		56	53	-3	-6%	53	49	-4	-8%
8A	Zone 2A	H-46-37	Flow	1727								
		H-42-37	Pressure		55	57	2	4%	42	43	1	2%
8B	Zone 2A	H-46-37	Flow	1815								
		H-42-37	Pressure		55	57	2	4%	46	48	2	5%
9	Zone 2	H-10-63	Flow	1772								
		H-13-63	Pressure	251	67	69	2	3%	58	66	8	12%
10A	Zone 3A	H-68-65	Flow	1482								
		H-67-65	Pressure		69	71	2	3%	29	29	0	0%
10B	Zone 3A	H-68-65	Flow	1815								
		H-67-65	Pressure		88	95	7	7%	46	47	1	1%
11	Zone 2	H-15-45	Flow	2206								
		H-10-45	Pressure		74	76	2	3%	64	69	5	8%
12	Zone 2	H-23-61	Flow	1534								
		H-26-59	Pressure		60	58	-2	-3%	43	48	5	10%
13	Zone 4A	H-17-81	Flow	1633								
		H-13-81	Pressure		80	80	0	0%	43	42	-1	-3%
14	Zone 3	H-11-86	Flow	1633								
		H-16-86	Pressure		85	87	2	2%	50	71	21	30%
15	Zone 3	H-6-96	Flow	1534								
		H-5-96	Pressure		76	76	0	0%	44	44	0	0%
16	Zone 4B	H-2-72	Flow	1585								
		H-3-72	Pressure		60	65	5	8%	47	47	0	0%
17	Zone 4	H-34-93	Flow	1633								
		H-33-93	Pressure		80	88	8	9%	30	33	3	10%
18	Zone 4C	H-3-70	Flow	1314								
		H-1-70	Pressure		83	84	1	2%	15	14	- 1	-7%
19	Zone 3	H-43-68	Flow	1633								
		H-31-68	Pressure		63	66	3	5%	37	41	4	10%

Diff. = pressure difference between field and model results
%. Diff. = percent difference between field and model results

Approximately 88 percent, or 36 out of the 42 data points in Table 3-2, showed the model to be within 10 percent of the field records. Five hydrant tests resulted in a percent difference between 10 and 12 percent. Five tests required additional modifications to calibrate with the field data as described below.

Test 10A is located in Zone 3A, supplied by pressure reducing vales near the westerly portion of Zone 3, with PR-20 open and PR-19 closed. During initial calibration, the pressure hydrant results did not calibrate in the model showing residual pressures 38 percent higher in the model than in the field. Given its close proximity, the updates from Test 19 as described below were also applied to Test 10A. The C-factors for 8-inch pipelines in the zone were decreased to 100. In addition, minor loss was added to the PR-20 facility, at the 8-inch pipeline (ID P17755) immediately downstream of valve. After these updates were made to the model, the model results matched the field results within 1 percent.

Test 10B is the same as Test 10A with the exception that both PRVs open. All of the same updates were made to Test 10B as Test 10A. During initial calibration, the pressure hydrant results did not calibrate in the model also showing residual pressures 38 percent higher in the model than in the field. Minor loss was added to PR-19 at the 8-inch pipeline (ID P112201) immediately downstream of valve. After these updates were made to the model, the model results matched the field results within 1 percent.

Test 14 is also within Zone 3 and located in the easterly portion of the zone, east of the 57 Freeway. Calibration showed the pressure hydrant with a resulting modeled pressure 30 percent above the field residual pressure. To calibrate this test, the C-factors for localized 8-inch diameter pipelines were decreased to 100. The adjustments to the friction factor were not sufficient and pipes were closed in the vicinity to determine if perhaps a valve in the area is closed in the field. Field investigations of the valves in the area did not find a closed valve. The poor calibration at this location could have been due to a bad reading or misread gauge reading and is disregarded since better calibrated could not be achieved.

Test 17 is in Zone 4 near the Las Palmas Reservoir and Pump Station facility. During initial calibration, the pressure hydrant results in the model did not show enough of a pressure drop, yielding modeled pressure above the field residual pressures by 34 percent. To calibrate this test, C-factors were decreased for pipelines 60-years or older within the zone: 6-inch pipes were updated to a C-factor of 90, 8-inch pipes to 100, and 12-inch pipes to 105. In addition, the Las Palmas Pump Station pump curve for Pump #2 was updated to adequately supply fire flow and reflect the hydropneumatic tank operation. With these updates to the model, the model results match the field data within 10 percent.

Test 19 is located within the westerly portion of Zone 3, between the Hawks Pointe and Tank Farm facilities. The initial pressure hydrant results in the model did not show enough of a pressure drop and did not meet residual pressures in the field by 39 percent. The City indicated there is a closed 16-inch butterfly valve on Rosecrans Avenue (ID P8055), isolating everything west of it due to inadequate cycling of the Hawks Pointe Reservoir 3C. In addition to closing the pipe in Rosecrans Avenue, the control valve to the Tank Farm Reservoir was updated to have a setting of 25 psi. After these updates were made to the model to calibrate and match field conditions, the model results matched the field within 10 percent.

4.0 EXTENDED PERIOD SIMULATION (EPS) MODEL CALIBRATION

EPS model calibration provides a better understanding of the water distribution system operations than a steady-state model. The goal of the EPS calibration is to estimate the accuracy with which the model simulates the field operations over a 24-hour period. The EPS calibration is performed for each pressure zone for the 24-hour period comparing the model results with the hourly SCADA data on July 4, 2022, the maximum day demand in 2022, for each facility to determine if the model reflects the actual system operating conditions (Appendix C.1).

SCADA data was available for reservoir water levels. Discharge pressure and flow data was limited and was not included for all facilities. Pressure data for PRVs between zones was not available and therefore could not be calibrated. A list of facilities with SCADA is provided in Appendix C.2. Additionally, pump design curve data was not available for all the well pumps and booster pumps. Where pump curve data was not available, recent SCE test data was used to input pump flow and head operating points. A single design point was input for the model for the pumps that did not have design curve data or sufficient SCE test data.

The City also provided screenshots of pump, well, and MWD connection control settings in SCADA which indicated the facility control set points and is controlled by tank level, downstream pressure, or flow. The control settings in the EPS were calibrated using these control settings. For modeling purposes to achieve a successful EPS run, facilities controlled based on downstream pressure were instead controlled by tank levels.

Although relief valves were not added to the model, as indicated in Section 1.0, the only ones included were relief valves used for pump station operation to limit the discharge pressure to zone at Hawks Pointe 3C-4C, Hermitage 2B-4C, and Upper Acacia 3A-4A Pump Stations. The valves at these pump stations are used in the field to circulate flow to maintain pressures in the closed-loop zone.

The model calibration is considered achieved as the model output and SCADA data are within 10 percent difference.

4.1 CALIBRATION DEMANDS

Average day demands (ADD) of 20.46 mgd were allocated in the model based on the geolocation of meter data for each land use type and assigned to the adjacent junction node in the model. The demands in the model used for calibration were updated in the model and based on the MDD experienced on July 4, 2022. Production data from this day was used to determine the total supply for the day from each supply source. The MDD updated in the model is 27.0 mgd.

For each pressure zone service area where sufficient data was available to develop a diurnal demand pattern, a MDD diurnal pattern was applied to each demand node. Appendix C.3 provides the diurnal demand patterns used during the model calibration and based on the hourly SCADA available from July 4, 2022. Appendix C.3 also includes ADD diurnal patterns. MDD and ADD diurnal patterns may differ based on seasonal demands, MDD is based on summer water use patterns. ADD includes winter demands which typically includes the reduction of irrigation.

4.2 ZONE 1 AND 1A CALIBRATION

Updates to the facility controls and pump station operating setpoints were conducted based on the SCADA information provided. Additionally, Zone 1 and 1A are hydraulically connected through a pressure relief valve, two PRVs (PR12), and the 12-inch pipeline located on Dorothy Lane. Currently one of the PRVs at PR12 is maintained in the open position and water can be freely conveyed between the two zones through the 12-inch pipeline. This allows the 12-inch pipeline to act as a hydraulic link between the two zones. Water is allowed to flow freely through these two valves in between Zones 1 and 1A to maintain pressures.

The hydraulic connection also allows the Zone 1A wells (Kimberly Well 1A, Kimberly 2, and Sunclipse Well 10) to be controlled by and fill the Lower Acacia Reservoir 1D. The Main Plant Booster Pump Station is controlled by the water level in Hillcrest Reservoir 1A. The Main Plant Booster Pump Station has not had sufficient capacity to fill Lower Acacia Reservoir 1D. For the day of calibration, Well 3A and Well 6 were not in operation.

Comparison charts showing the model versus the SCADA for the wells and reservoir facilities in operation (including the Main Plant Pump Station and Forebay) are provided in Appendix C.1. The average flowrates and discharge pressures of the wells calibrated to be within ten percent of the SCADA.

4.3 ZONE 1B CALIBRATION

Zone 1B was calibrated based on SCADA data provided. Data was not available for Zone 1C since it is a sub-zone supplied through PRV stations. Zone 1B is supplied by Well 9 and Well 15A. Well 9 is controlled by pressure but was set to operate continuously all 24-hours per day. Sunclipse Well 15A is controlled by water level in Coyote Reservoir 1C. Imported water connection F-05 is also a supply source to Zone 1B but was not in operation for the day of calibration. According to staff, with Airport Well 9 operating most of the time, F-05 connection is opened only occasionally as needed under specific circumstances.

Comparison charts showing the model versus the SCADA for the wells and reservoir facilities are provided in Appendix C.1. The model was able to calibrate the flow rates at an average of 8 percent within SCADA for the wells and 2 percent for the water level in the Coyote Reservoir 1C and discharge pressures at the wells.

4.4 ZONE 2 CALIBRATION

Zone 2 was calibrated with model results for discharge pressure and reservoir levels, and were within 4 percent and 9 percent of SCADA results, respectively. Zone 2 receives imported water supply from F-08 and the Tank Farm through PRV stations (PR5A and PR5B) as well as several other smaller PRV stations throughout the zone. However, SCADA data was not available for these PRV stations. Groundwater is supplied to the zone through pump stations boosting the water from Zone 1A and 1B, via Lower Acacia 1D-2 and Coyote 1C-2 Pump Stations. There are three reservoirs that provide storage: Hermitage 2B, Laguna 2A, and State College 2C. The Lower Acacia 1D-2 Pump Station is controlled by water levels in State College Reservoir 2C. The Coyote 1C-2 Pump Station is controlled by the Hermitage Reservoir 2B water levels.

Comparison charts showing the model versus the SCADA for the pump station and reservoir facilities are provided in Appendix C.1.

4.5 ZONE 3 CALIBRATION

Zone 3 is supplied primarily from MWD imported water connections: F-04, F-06, F-08, and F-09. Additional supply can be provided from Zone 1 with groundwater pumped up through the booster pump stations at Hillcrest (1A-3) and Lower Acacia (1D-3). The F-08 turnout was calibrated using the total daily production data modeled as a flow pattern based on the hourly SCADA data. Flow from F-08 splits to fill either the Las Palmas Reservoir or the Tank Farm Reservoirs. The Las Palmas Reservoir floats on the Zone 3 hydraulic grade. The Tank Farm Reservoir elevations are between the Zone 2 and Zone 3 hydraulic grades and requires a pressure control and sustaining valve at the Tank Farm facility to control the flow into the reservoirs. The setting of this control valve was adjusted to a setting of 37 psi to provide the appropriate flow allocation to the zone and balance the Las Palmas Tank level to match SCADA.

The model also assumes that the 16-inch pipeline in Rosecrans Avenue (east of the Hawks Pointe Reservoir service area) has a closed valve, as per City staff. All supply facility flowrates and pressures are calibrated to within 10 percent of SCADA, with the exception of F-09. The flowrate through F-09 is calibrated to 28 percent, however, this percent difference equates to only 125 gpm out of 447 gpm (per SCADA) and is considered acceptable. Comparison charts showing the model versus the SCADA for the pump station and reservoir facilities are provided in Appendix C.1.

4.6 ZONE 4 CALIBRATION

Zone 4 is a closed-looped system supplied from the Zone 3 Las Palmas Reservoir 3B via the Las Palmas Pump Station 3B-4. The Las Palmas Pump Station is equipped with a 7,000-gallon hydropneumatic tank to control the discharge pressure and flow to meet the variation of demand in the zone. To represent this in the model, the pump station was modeled as a single pump with a flat curve to provide a consistent discharge pressure at various flowrates. The manufacturer's pump curve was modified accordingly to reflect the capacity of the two pumps plus the fire flow capability of the station based on the hydrant flow test data.

Flow data was not available for the pump station in SCADA, however discharge pressure was available for calibration. The model results are an average of 61 psi, within two psi of the average SCADA pressure of 59 psi with a 5 percent difference. The flow and pressure comparison charts are provided in Appendix C.1.

4.7 ZONE 4A CALIBRATION

Zone 4A is supplied from the Upper Acacia Reservoir via the Upper Acacia Pump Station 3A-4A and is a large closed-loop system. The Upper Acacia Pump Station is equipped four constant speed vertical turbine pumps. One small jockey pump (Pump #1) and three large pumps, with one of the large pumps as standby. One pump was operating during the calibration period, the large Pump #3. Pumps #3 and #4 are typically used with Pump #1 turning on only during peak demand periods.

This pump station is operated using the pressure relief valve bypass to regulate discharge pressure to meet the various flows demand by the pressure zone. Flow is allowed to recirculate through the bypass.

SCADA indicated an average flow rate of 404 gpm through the flow meter, which is located after the bypass assembly and represents the water demand to the zone. Pump #3 has a capacity of 1,000 gpm The setting of the pressure relief valve, which is modeled as a throttle control valve with a setting of 85. The model indicates the remaining average of 794 gpm flows back through the bypass valve assembly.

The model shows flow through the meter matches within 11 percent of SCADA on average, or 44 gpm, with an average flow of 360 gpm. The discharge pressure is modeled at 58.8 psi, within 1 psi of the SCADA pressure of 59.2 psi. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

4.8 ZONE 4B CALIBRATION

Zone 4B is a small closed-looped system with supply pumped from Zone 2 and Laguna Reservoir 2A through the Laguna Pump Station 2A-4B. The Laguna Pump Station is equipped with two constant speed vertical turbine pumps and a 5,000-gallon hydropneumatic tank. To model the pumps and hydropneumatic tank operation to meet the various demand conditions with a consistent discharge pressure, the pump station was modeled as a single pump with a flat curve to provide a consistent discharge pressure at the various flowrates. The manufacturer's pump curve was modified accordingly to reflect the capacity of the two pumps plus the fire flow capability of the station based on the hydrant flow test data.

The Laguna Pump Station does not have flow data available in SCADA, however pressure data was available. The pump station was modeled to flow at an average flowrate of 45 gpm. The discharge pressure was modeled to be an average of 53 psi. The SCADA discharge pressure was 52 psi, resulting in a calibration within 2 percent. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

4.9 ZONE 4C CALIBRATION

Zone 4C is two separate service areas and will be discussed for calibration purposes separately below as the Zone 4C East and Zone 4C West service areas.

4.9.1 Zone 4C East

Zone 4C East is a closed-loop service area that is supplied from Zone 2 via the Hermitage Pump Station 2B-4C, boosting water from the Hermitage Reservoir 2B. Although the Hermitage Pump Station has a hydropneumatic tank onsite, staff reports that this tank does not function. The pump station is allowed to recirculate water through the pressure relief bypass assembly to limit pressures in the zone while meeting the various flowrates demanded. The station is equipped with two constant speed vertical turbine pumps with a 300-gpm design capacity and one horizontal engine drive pump sized for a design flow of 2,500 gpm. As previously mentioned in Section 4.0, where pump curve data was not available, recent SCE test data was used to input pump flow and head operating points. The pump curves for Hermitage Pump Station were not available, as such, the SCE test was used to provide a design point for the duty pumps. The pressure relief valve was modeled as a throttle control valve, with a setting of 15. The model indicates the remaining average of 869 gpm flows back through the bypass valve assembly. One pump, Pump #2, was turned on and operated during the EPS scenario without any other controls or on/off setpoints.

SCADA flow information was not available for the pump flowrate calibration. Discharge pressure from SCADA averaged approximately 99 psi and the modeled pressure averaged approximately 101 psi, equating to a 2 percent difference. Pressure comparison charts of the model versus SCADA for the pump station are provided in Appendix C.1.

4.9.2 Zone 4C West

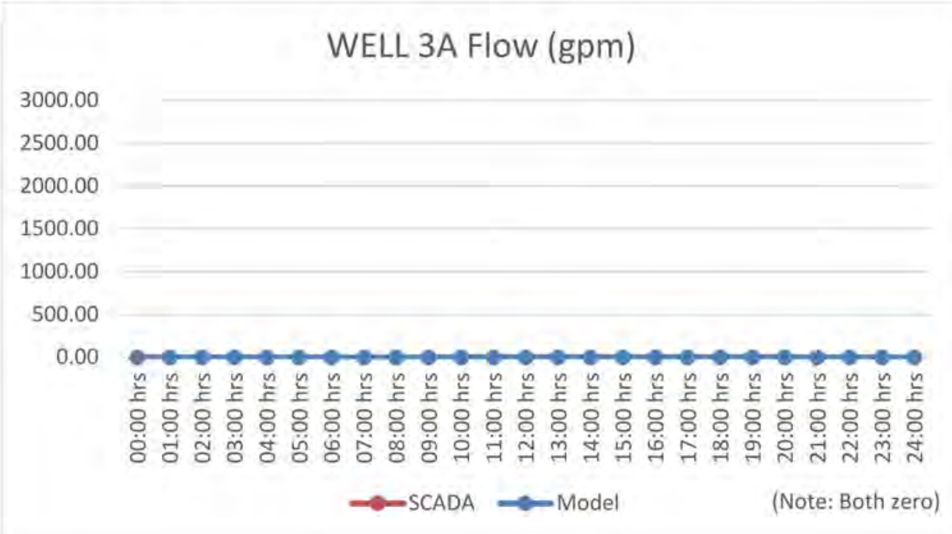
Zone 4C West is a small closed-loop service area that includes approximately 59 residential homes. Zone 4C is supplied by the Hawks Pointe Pump Station 3C-4C that boosts water to the zone from the Hawks Pointe Reservoir 3C. The Hawks Pointe Pump Station consists of two constant speed vertical turbine pumps. One pump, Pump #2, was on during the calibration scenario and allowed to operate during the EPS run without any control.

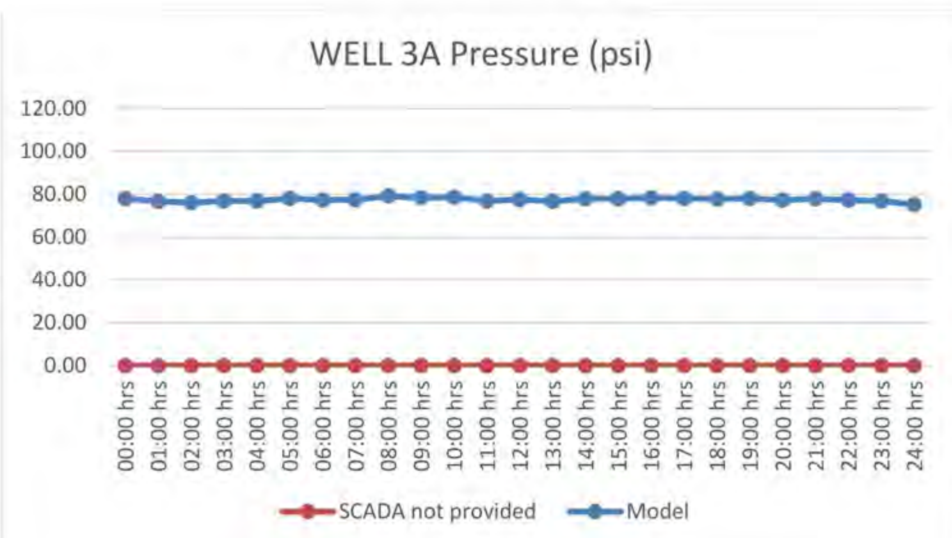
SCADA shows that the flowrate averages approximately 19 gpm and the modeled flow is 9 gpm. Although this represents a 52 percent difference with the SCADA, the modeled results differ by only 10 gpm and is likely due to the demands in the zone for the day of calibration. The discharge pressure at the pump station in SCADA is 59 psi and the modeled pressure is 53 psi, a difference of 10 percent. Flow and pressure comparison charts of the model versus the SCADA for the pump station are provided in Appendix C.1.

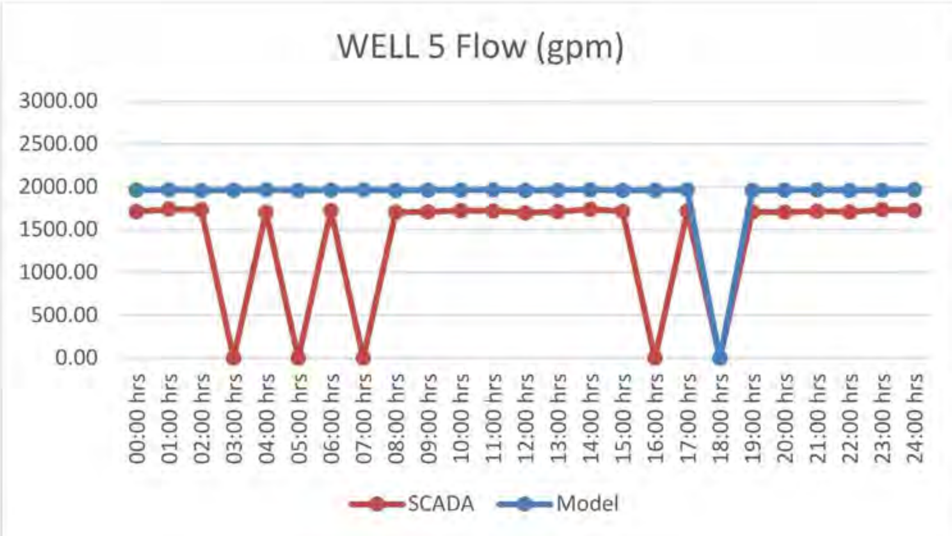
C.1 EPS Model Calibration vs SCADA Charts

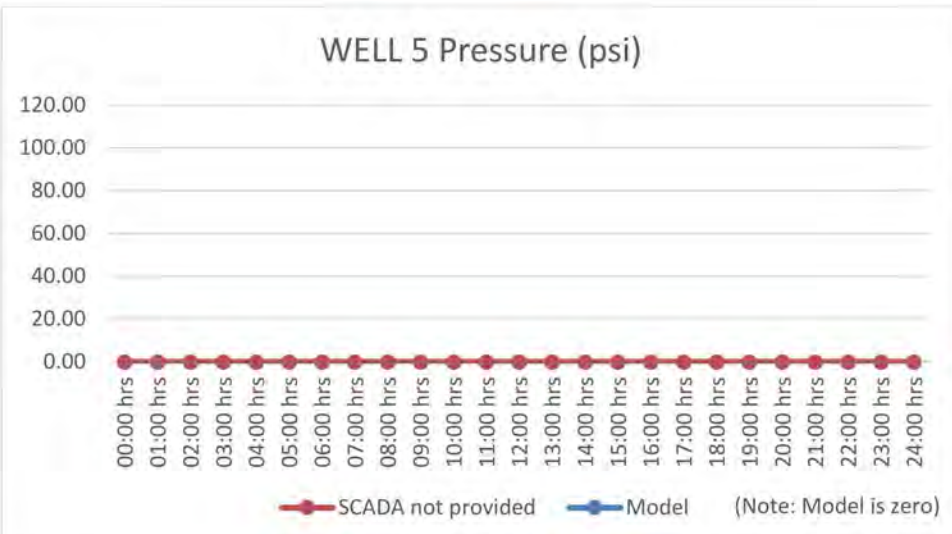
C.1.1 ZONE 1 EPS MODEL CALIBRATION VS SCADA CHARTS

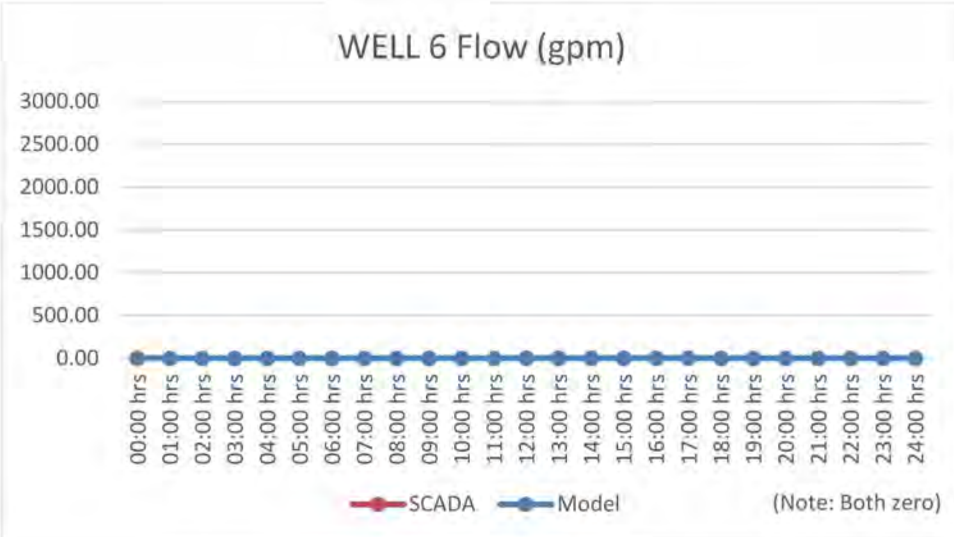
Zone 1 Wells

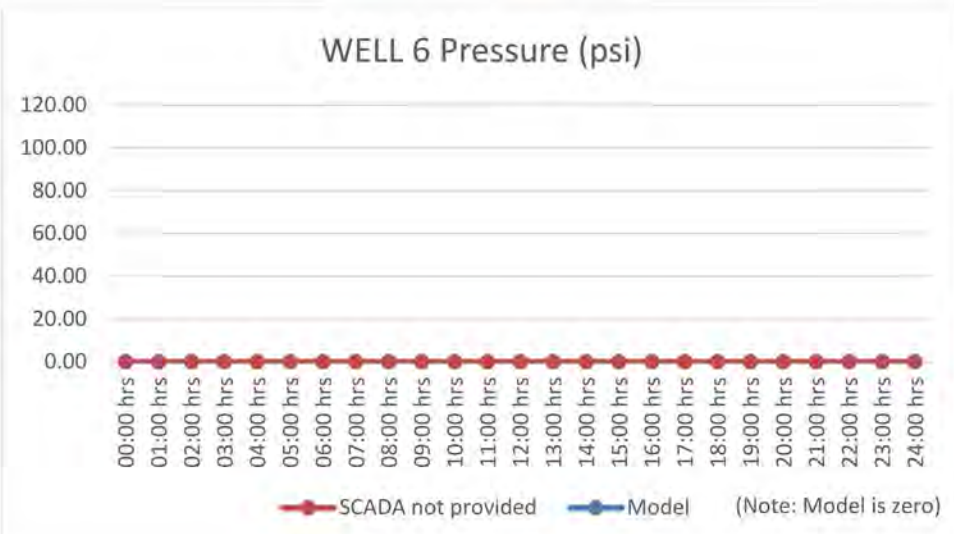


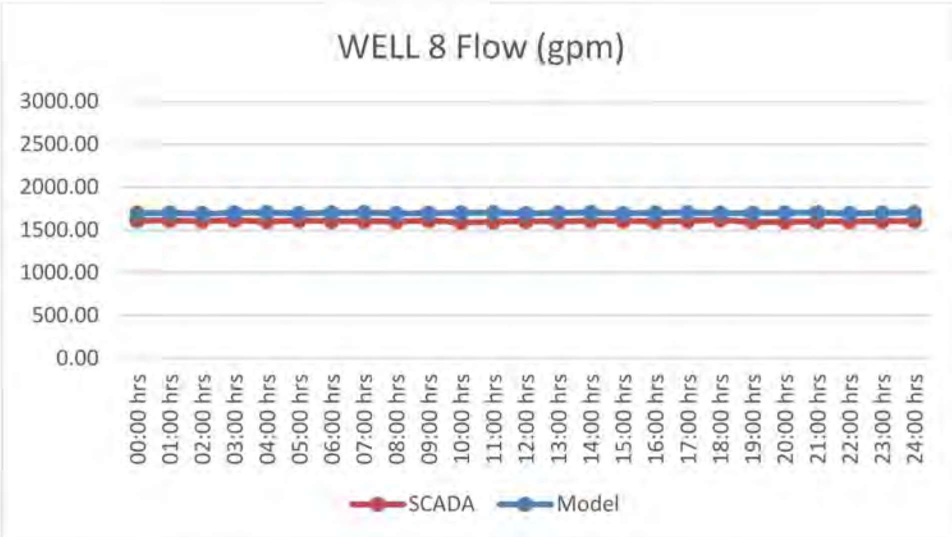



WELL 5 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model


WELL 5 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)


WELL 6 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model
(Note: Both zero)


WELL 6 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)


WELL 8 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
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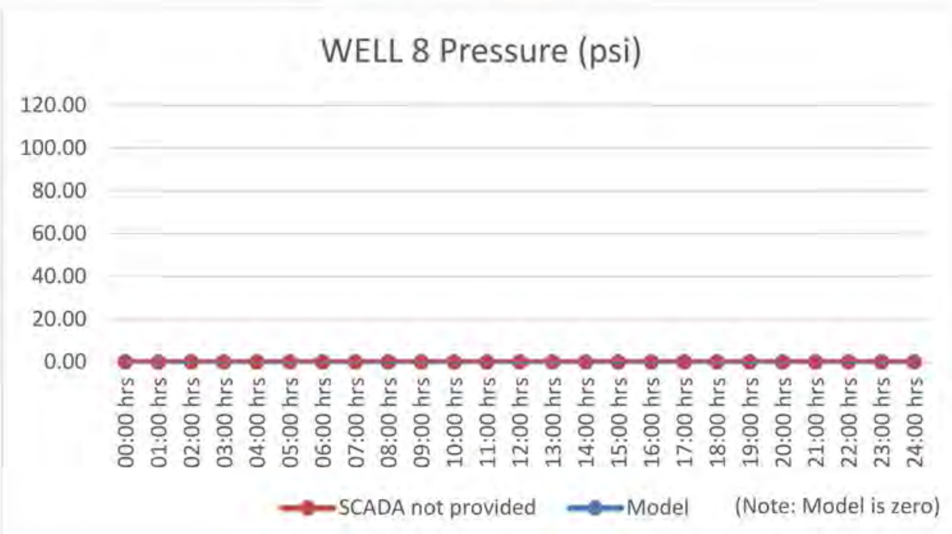
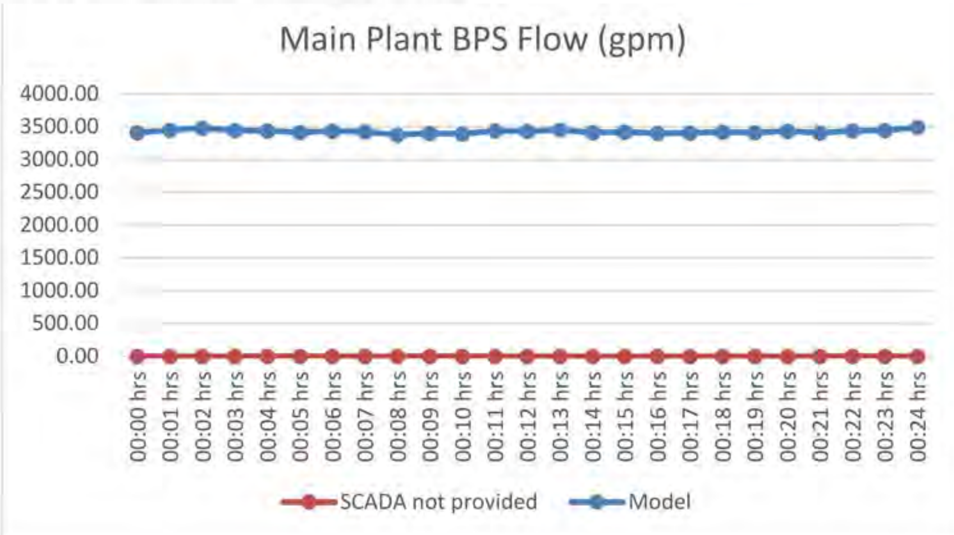
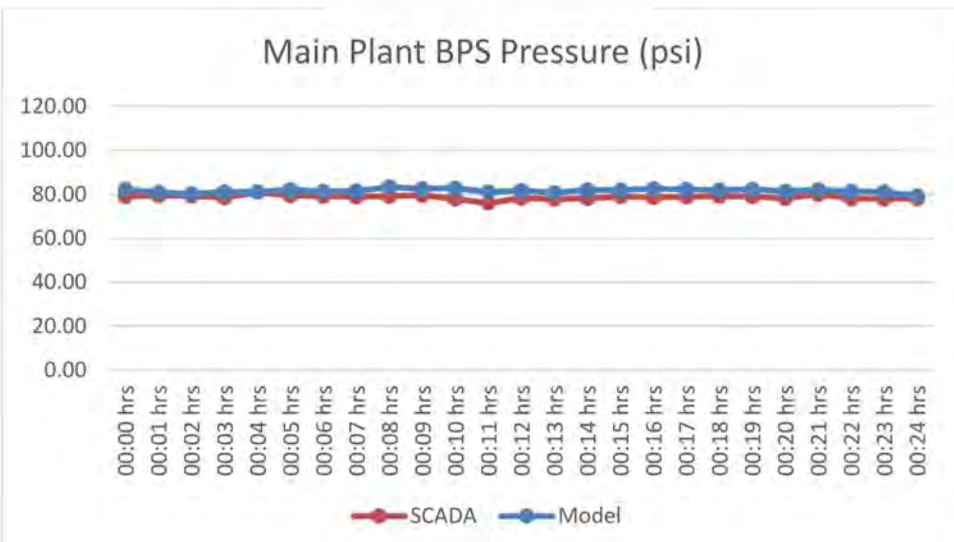
23:00 hrs
24:00 hrs
SCADA
Model

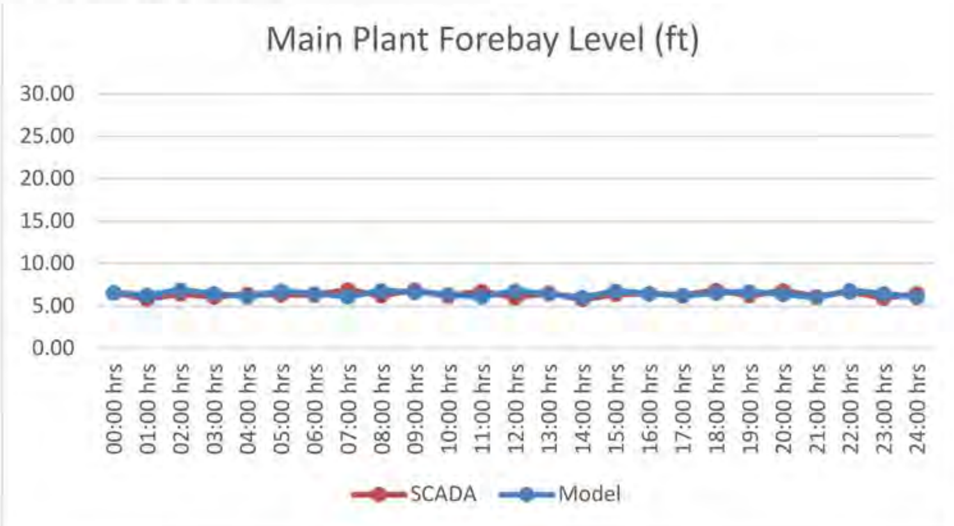

WELL 8 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA not provided
Model
(Note: Model is zero)

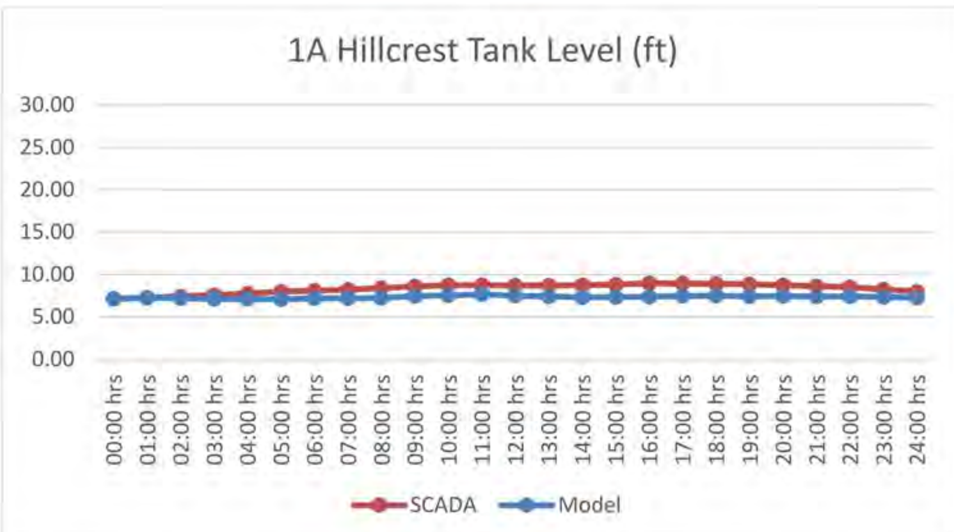
Zone 1 Booster Pump Stations

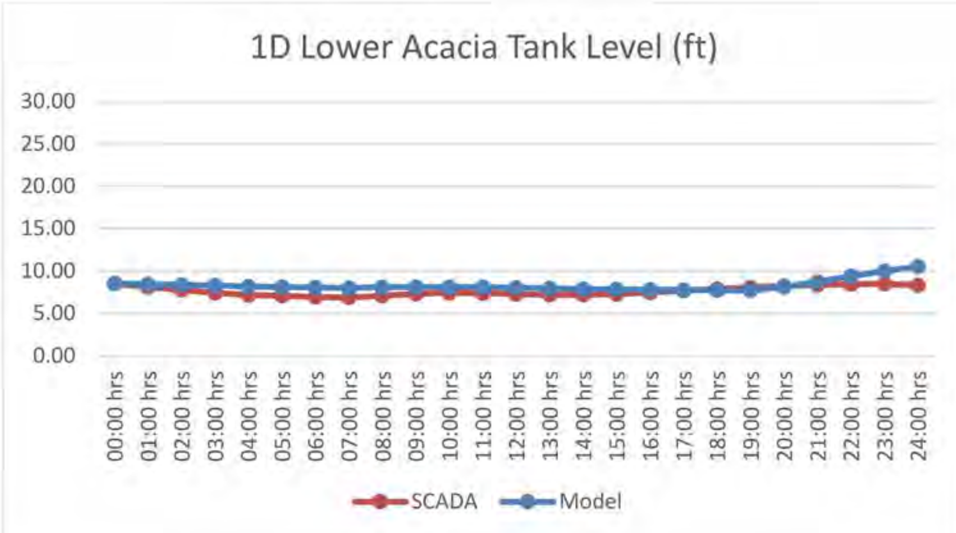




Zone 1 Reservoirs

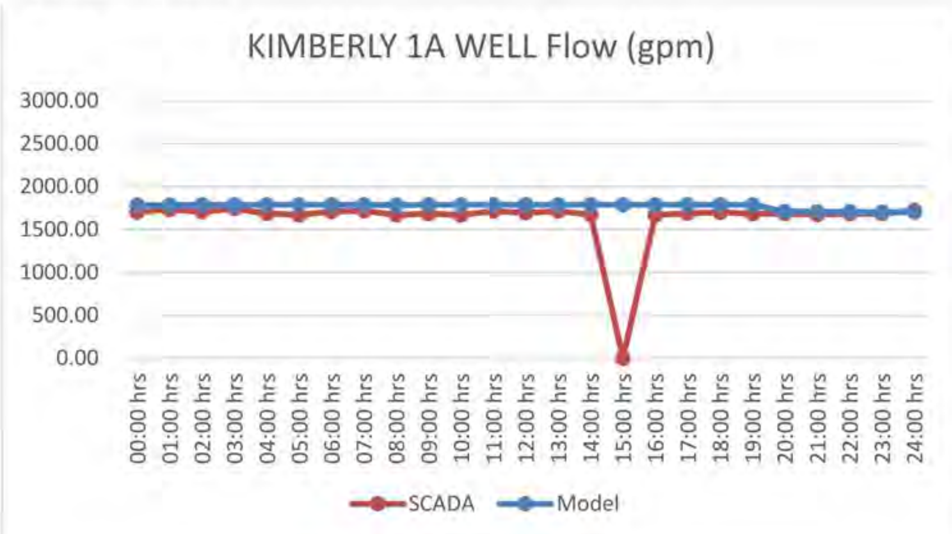


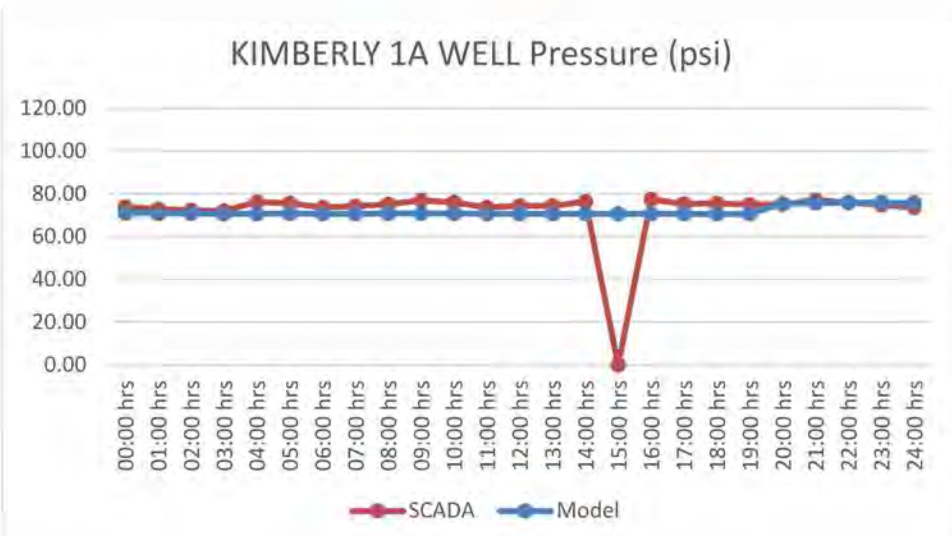


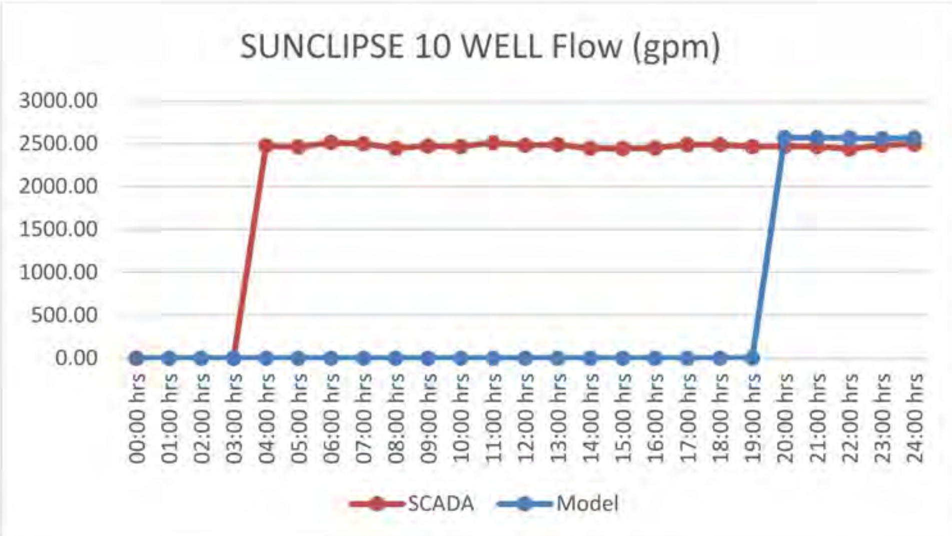

1D Lower Acacia Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

C.1.2 ZONE 1A EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 1A Wells






SUNCLIPSE 10 WELL Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
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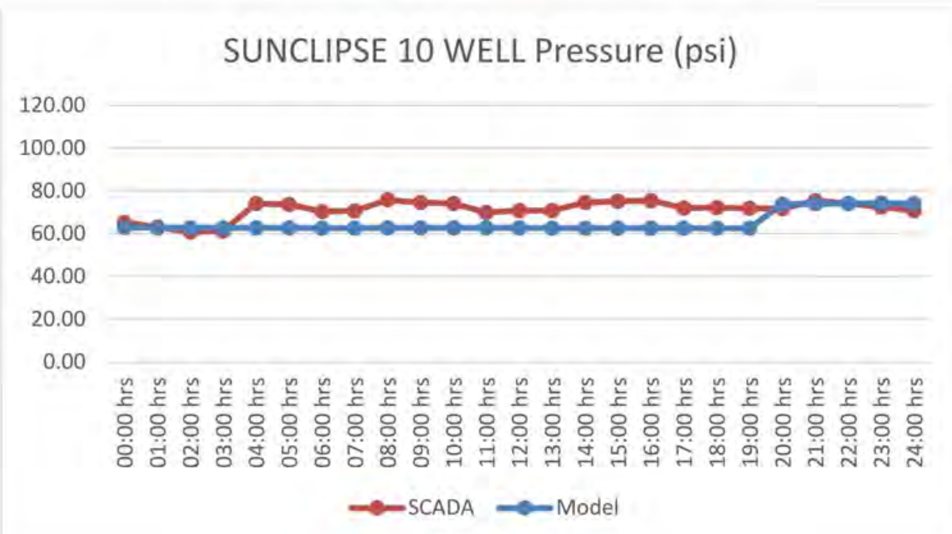
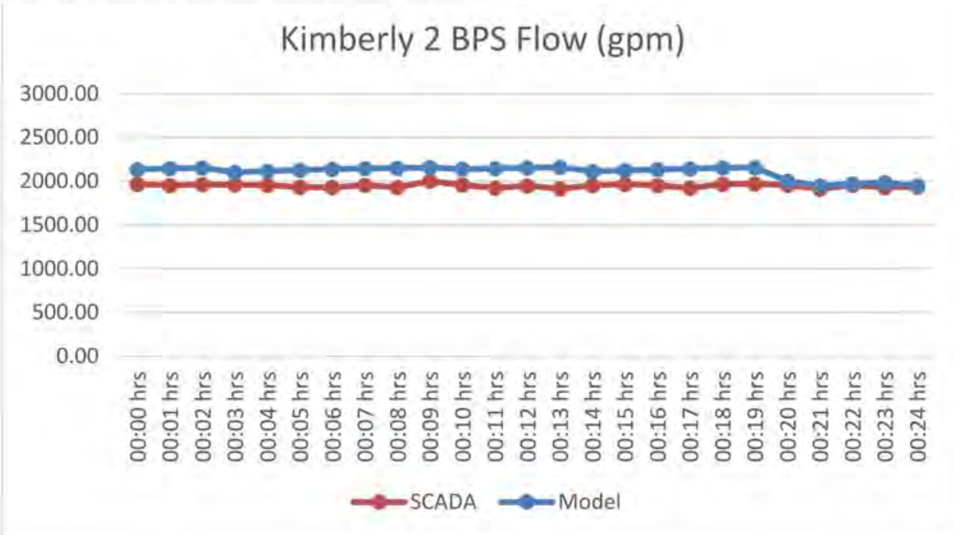
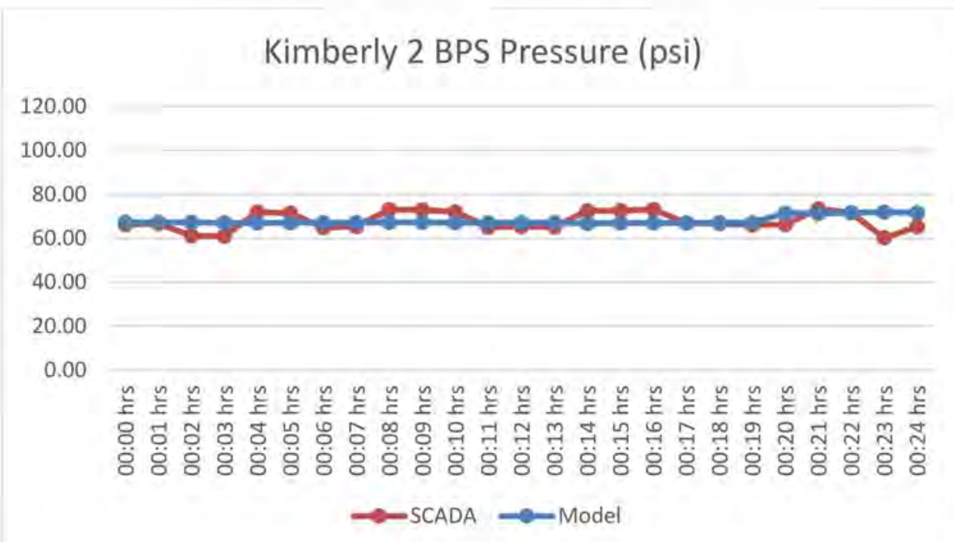
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

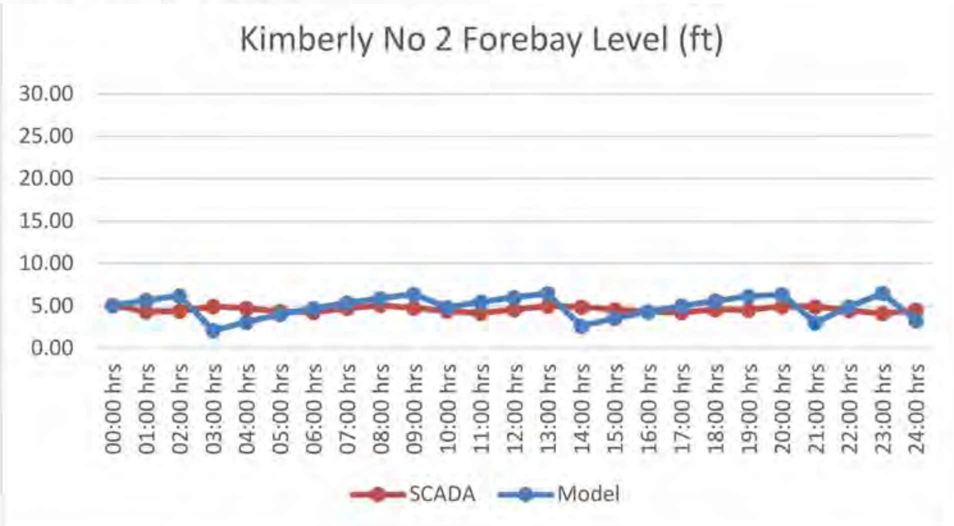

SUNCLIPSE 10 WELL Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

Zone 1A Booster Pump Stations



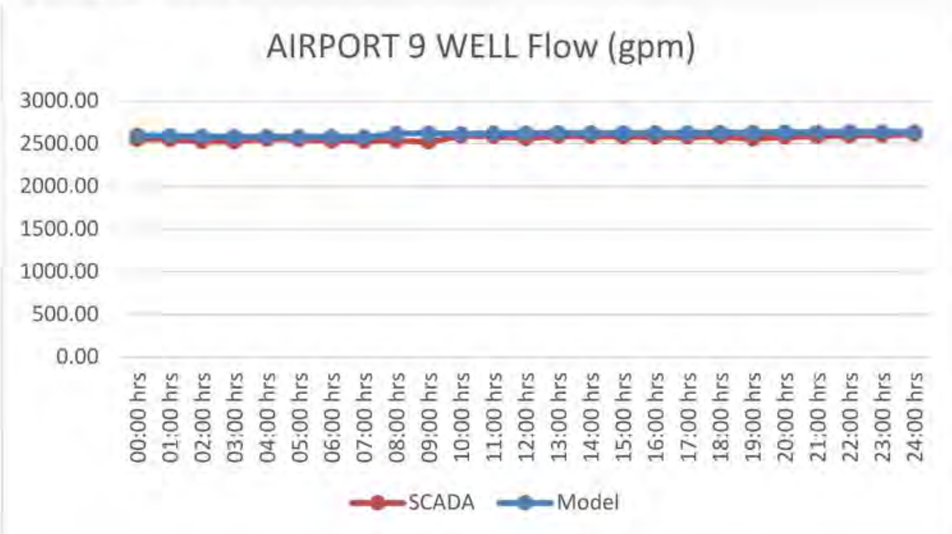


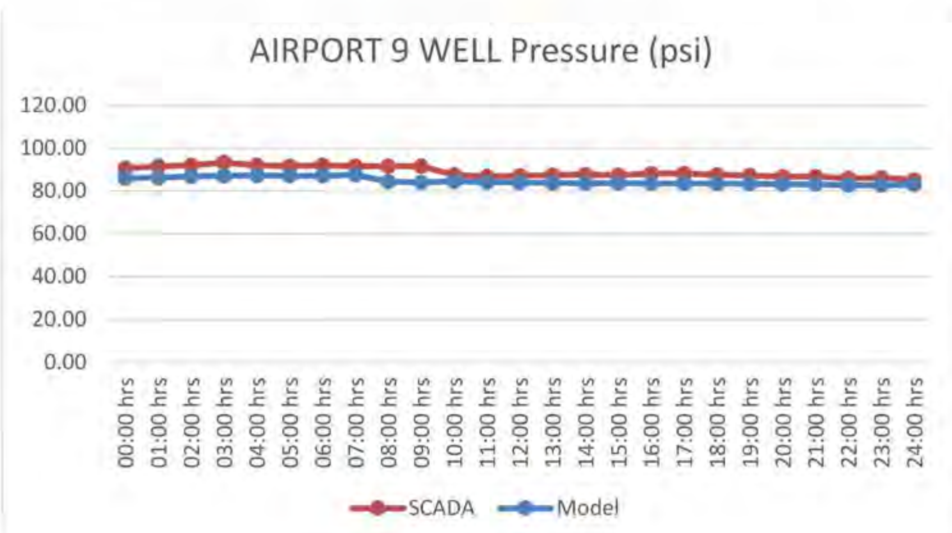
Zone 1A Reservoirs

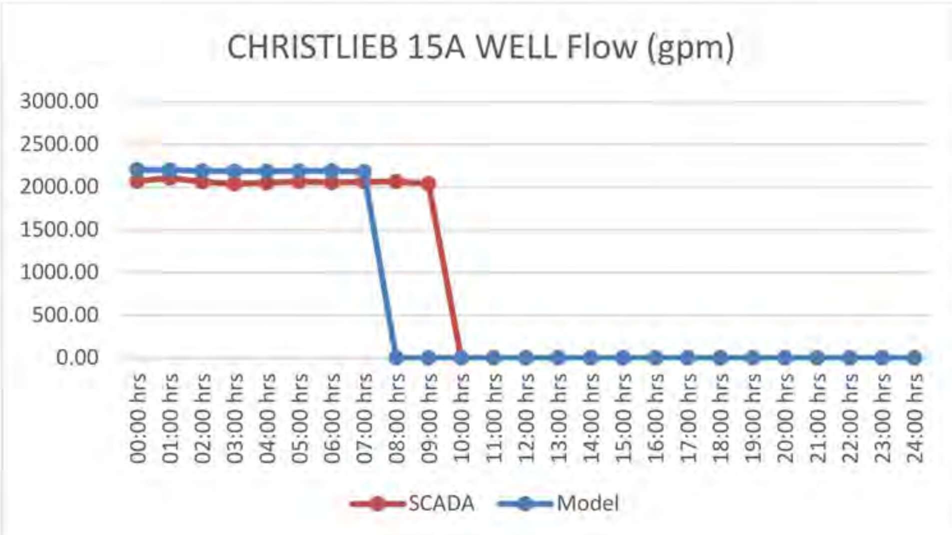


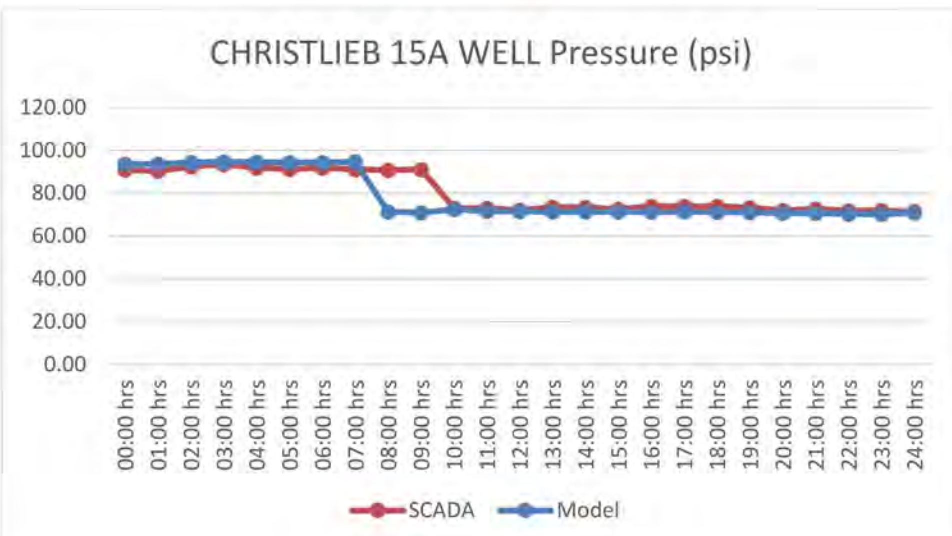
C.1.3 ZONE 1B EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 1B Wells

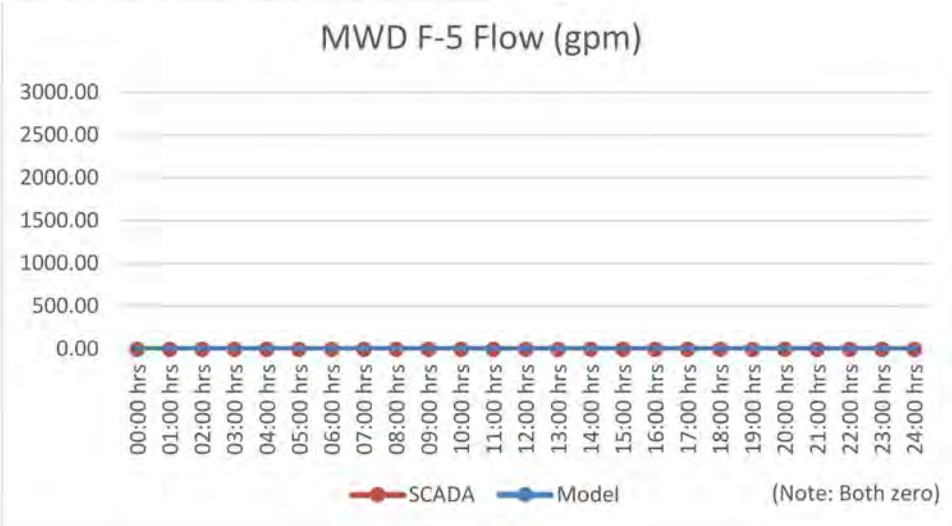


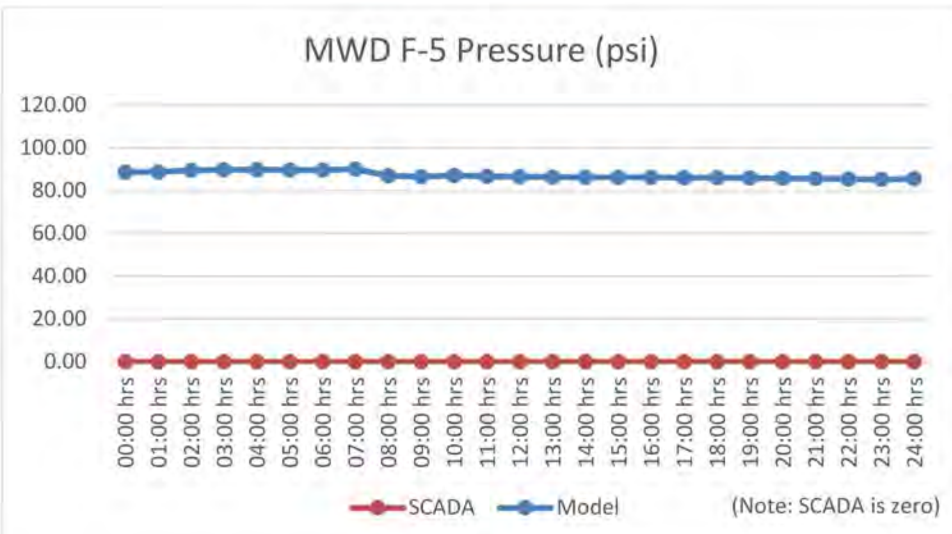



CHRISTLIEB 15A WELL Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

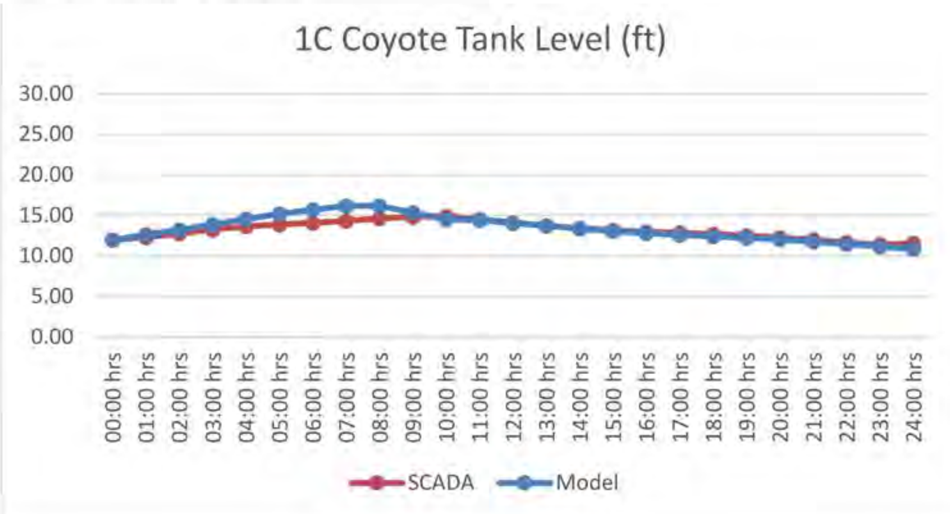

CHRISTLIEB 15A WELL Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

Zone 1B Import Turnouts



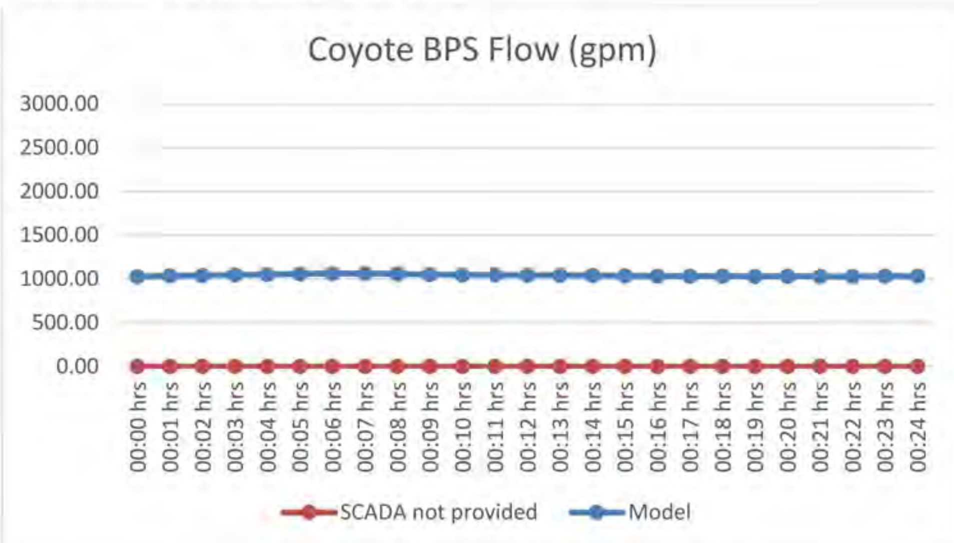


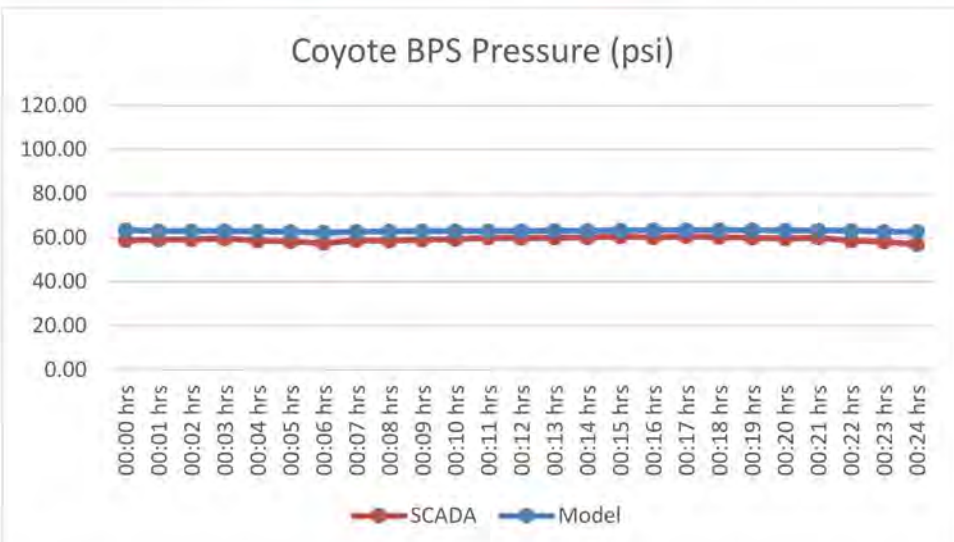
Zone 1B Reservoirs

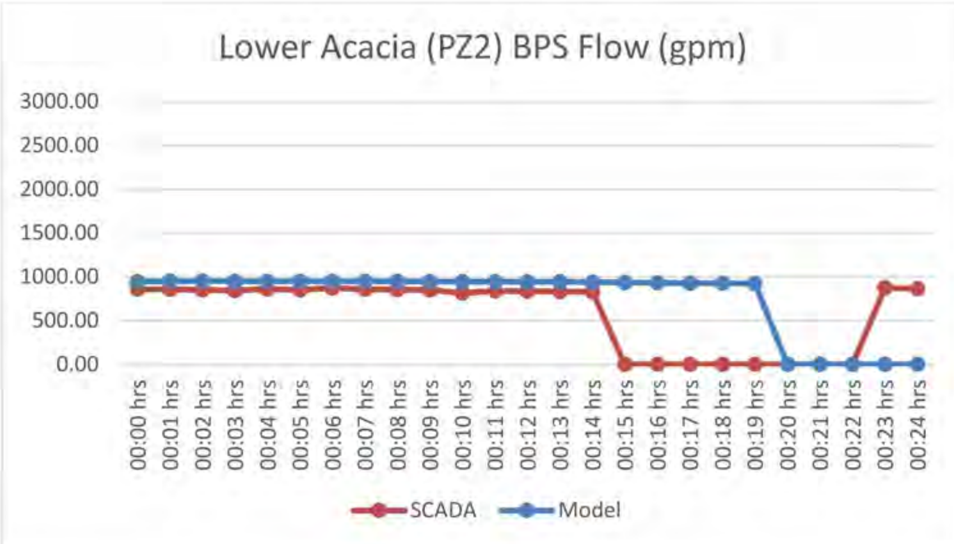


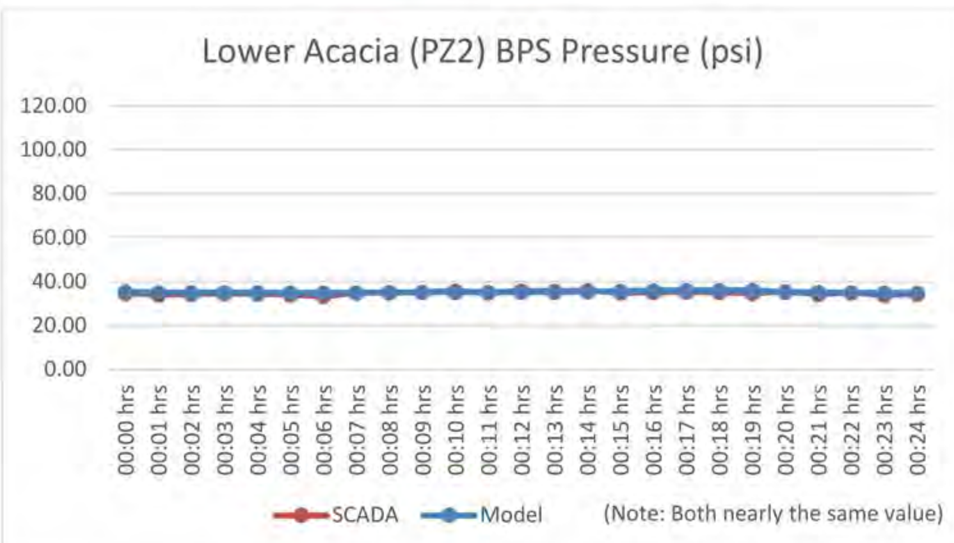
C.1.4 ZONE 2 EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 2 Booster Pump Stations

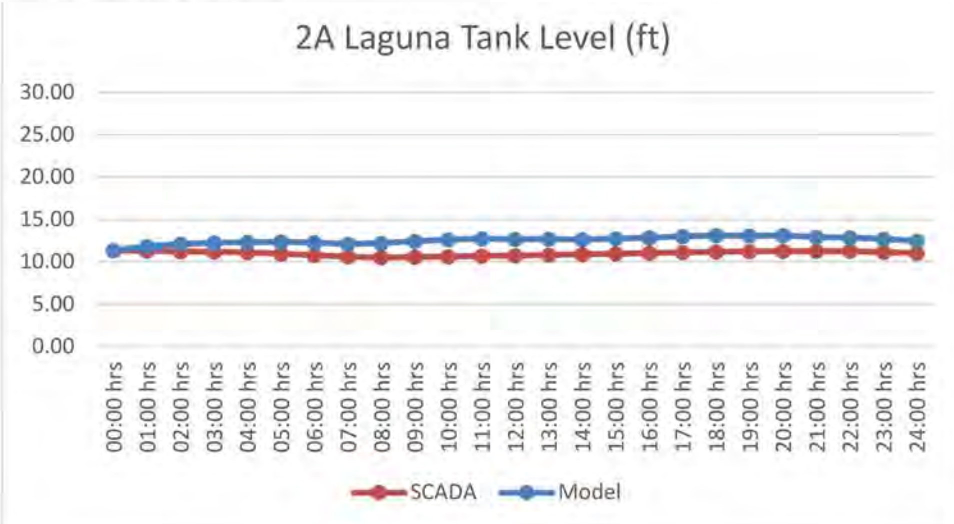


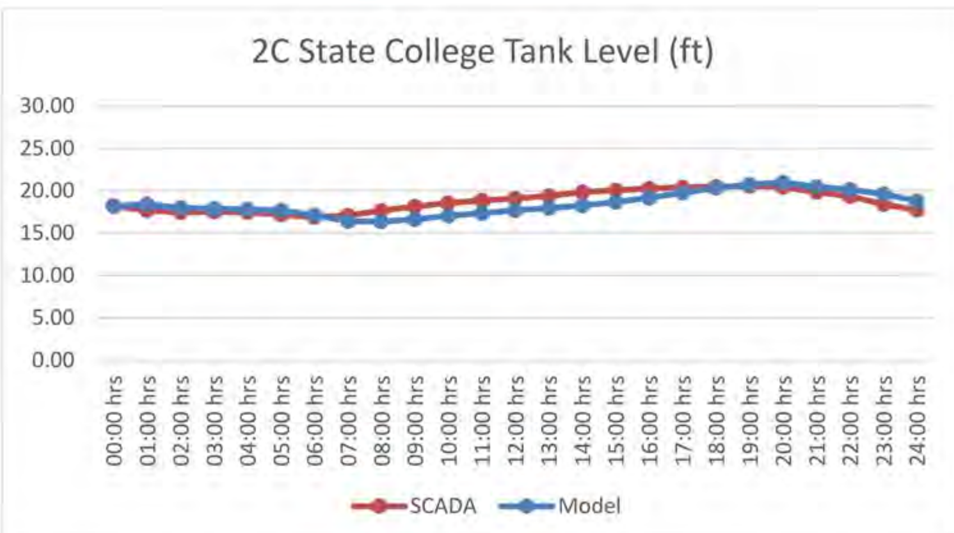


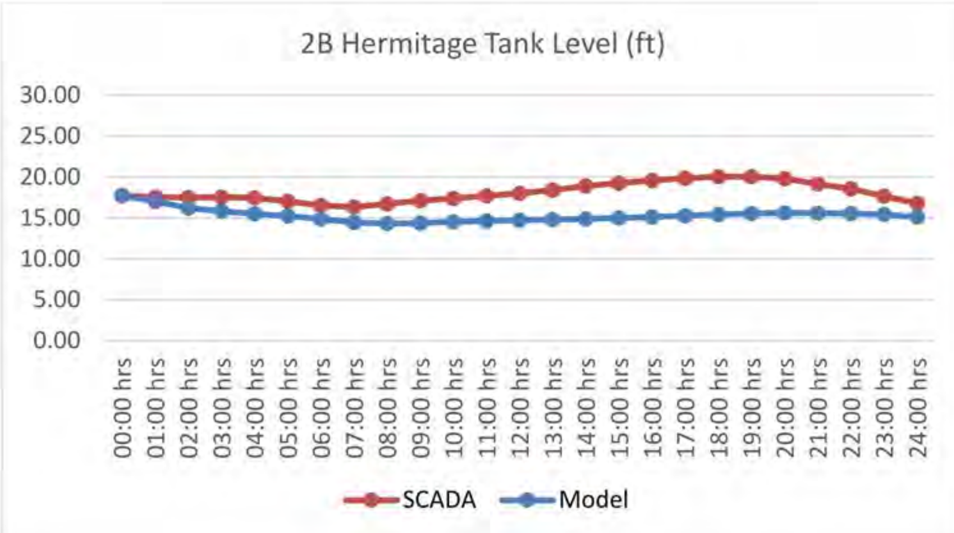

Lower Acacia (PZ2) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model


Lower Acacia (PZ2) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model
(Note: Both nearly the same value)

Zone 2 Reservoirs

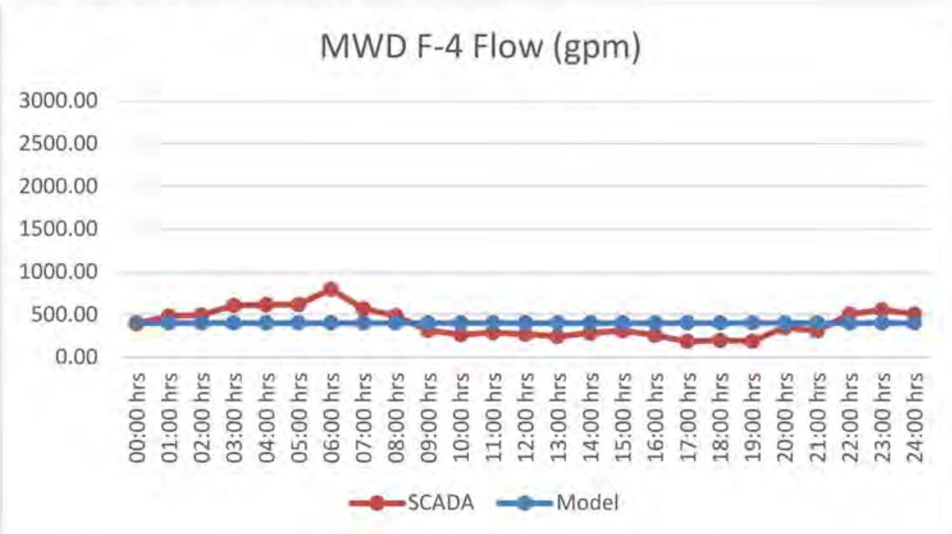


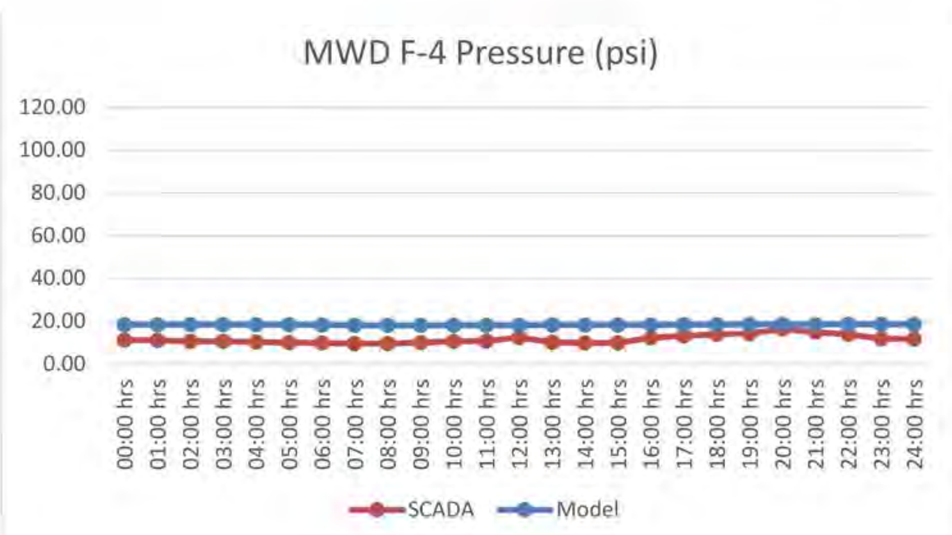


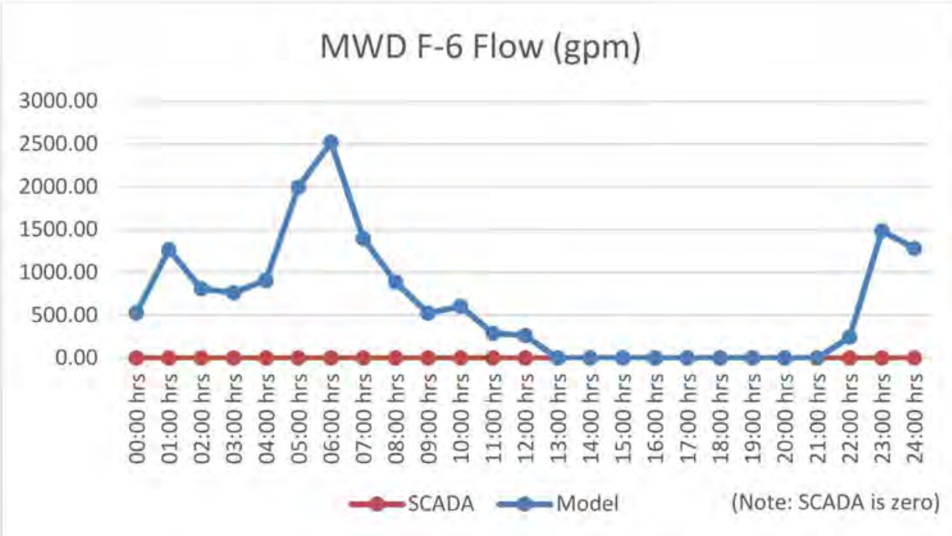

2B Hermitage Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

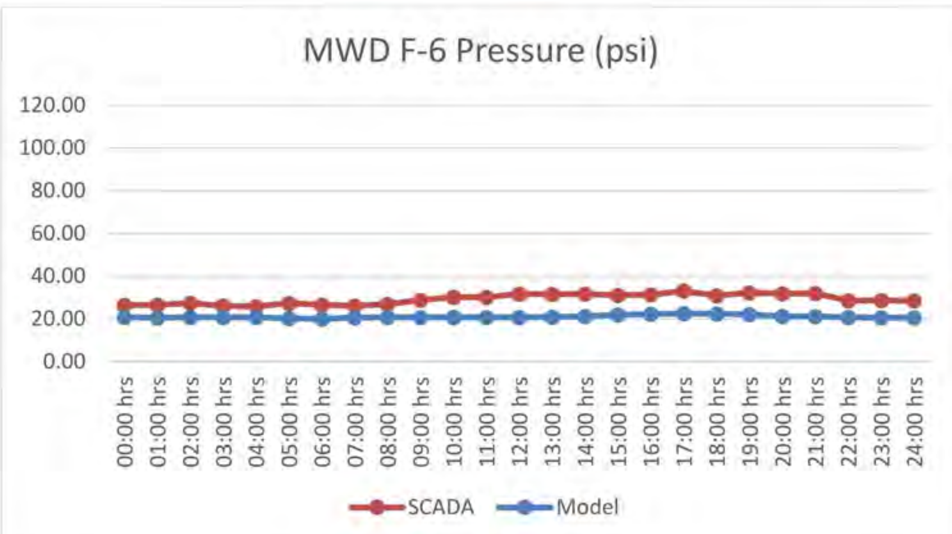
C.1.5 ZONE 3 EPS MODEL CALIBRATION VS SCADA CHARTS

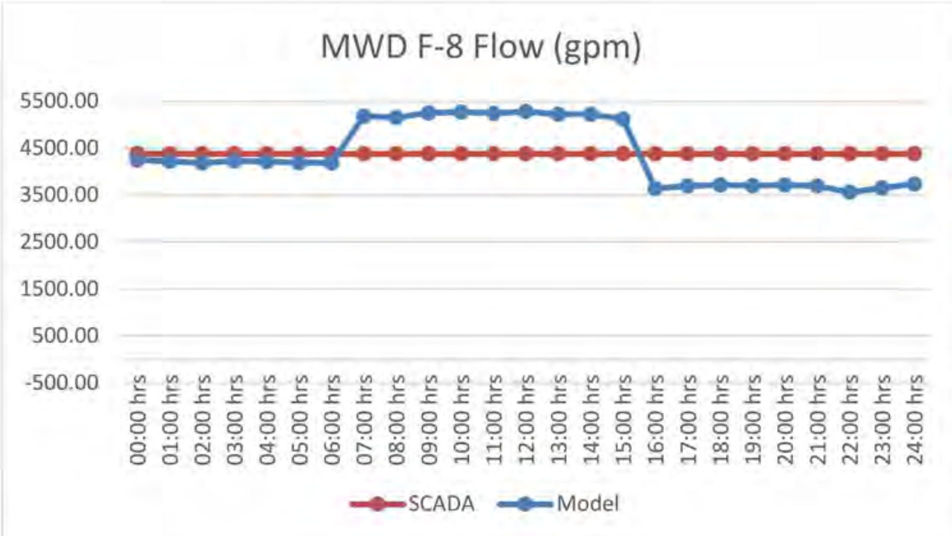
Zone 3 Import Turnouts

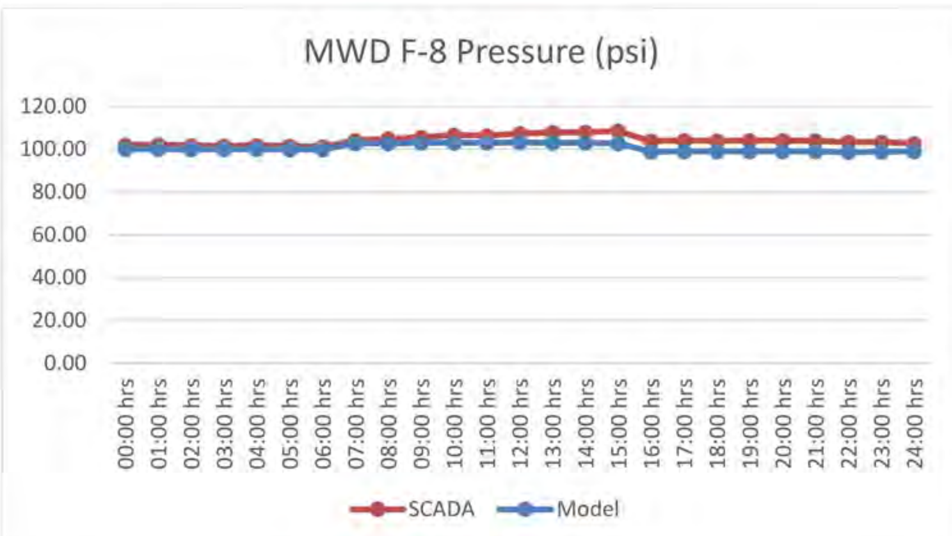


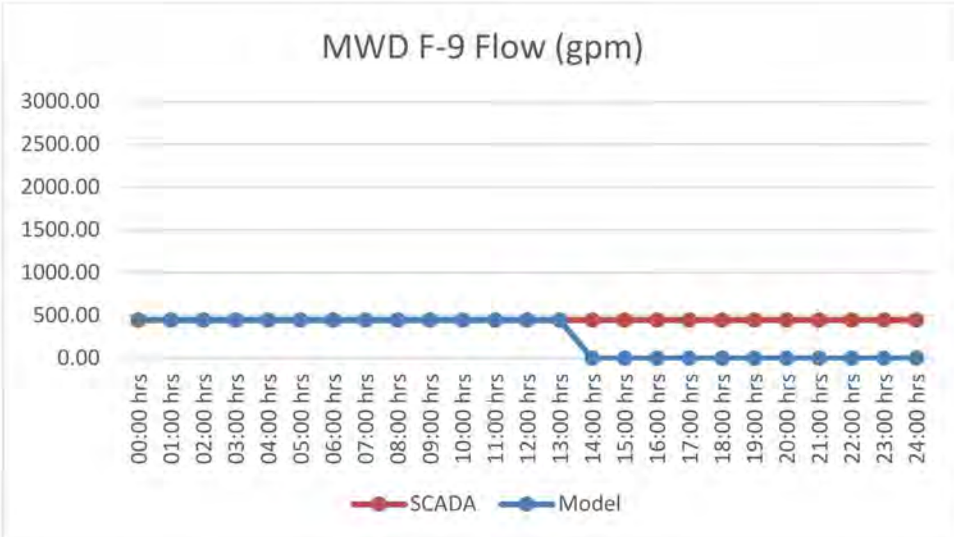


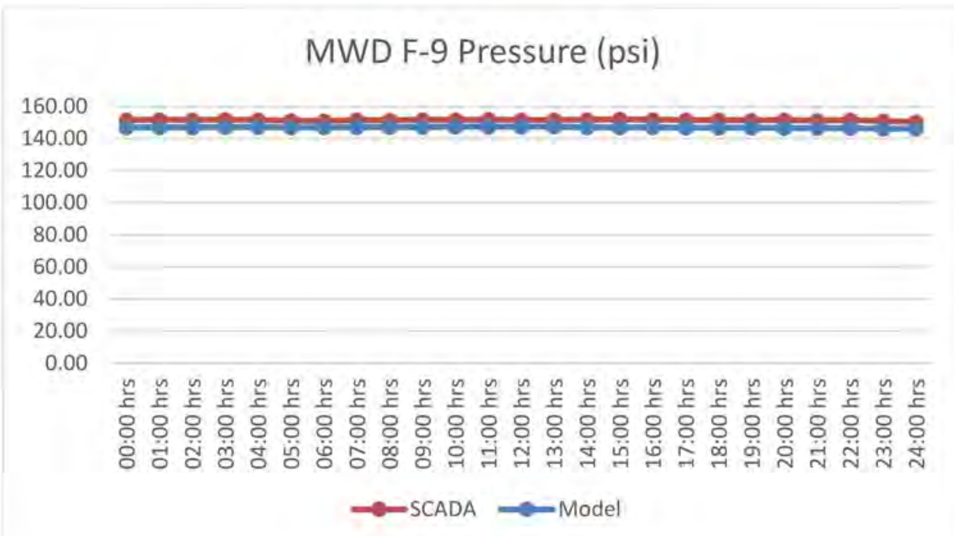

MWD F-6 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model
(Note: SCADA is zero)


MWD F-6 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

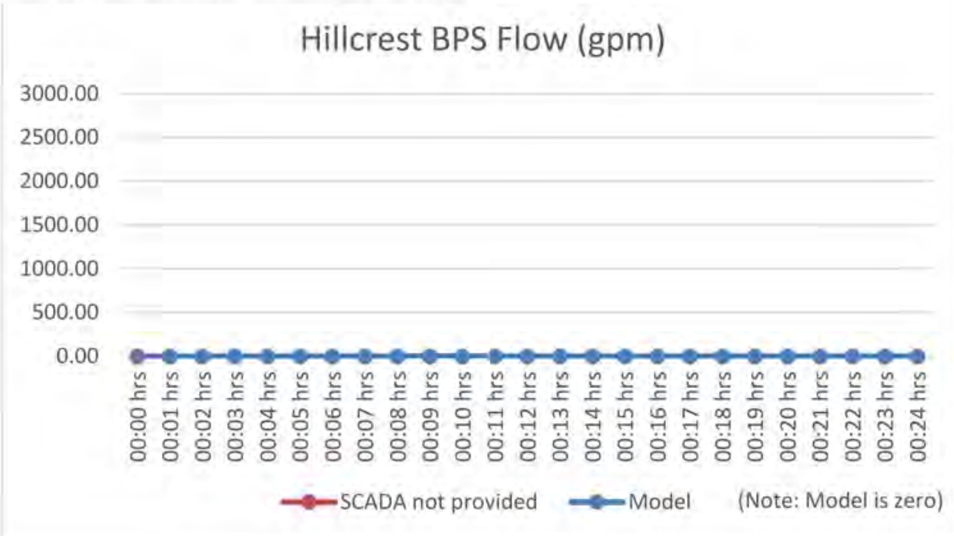

MWD F-8 Flow (gpm)
5500.00
4500.00
3500.00
2500.00
1500.00
500.00
-500.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

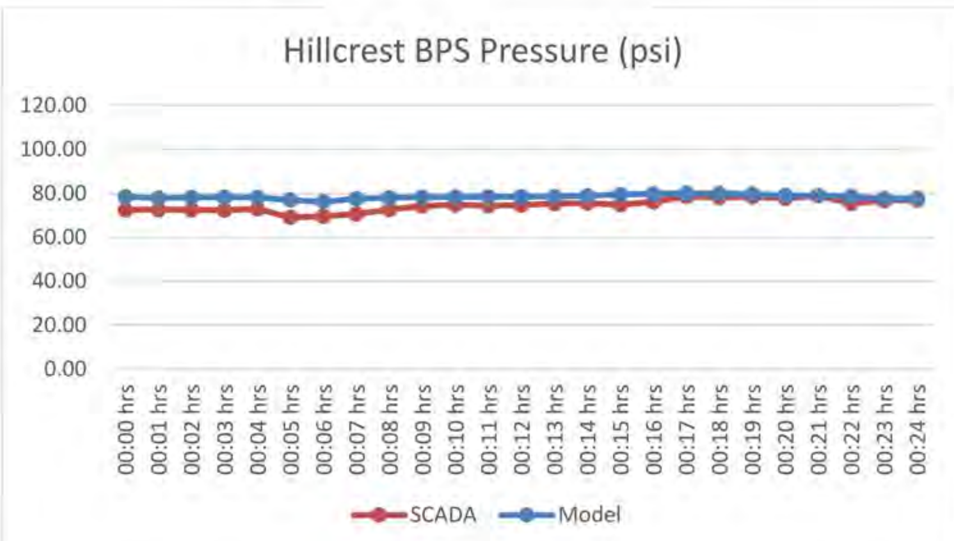

MWD F-8 Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

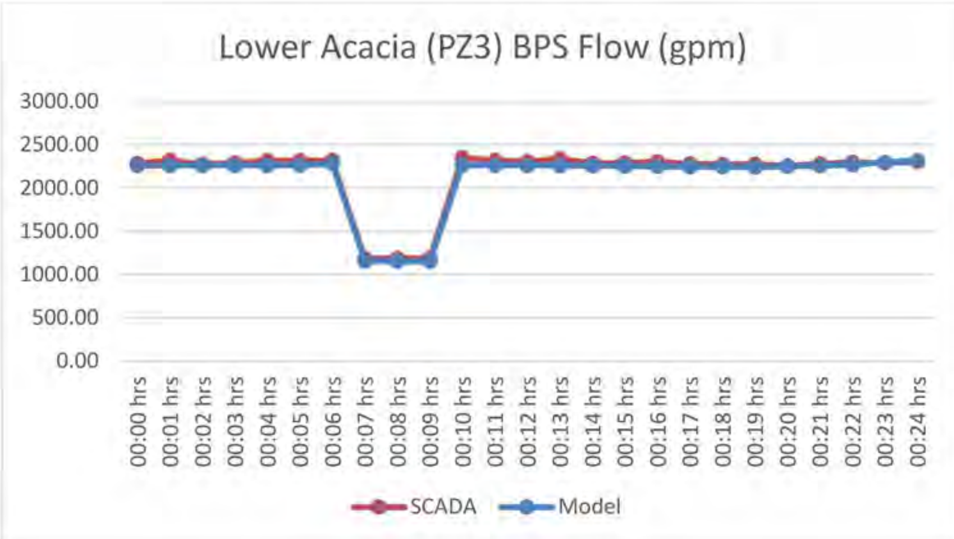

MWD F-9 Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

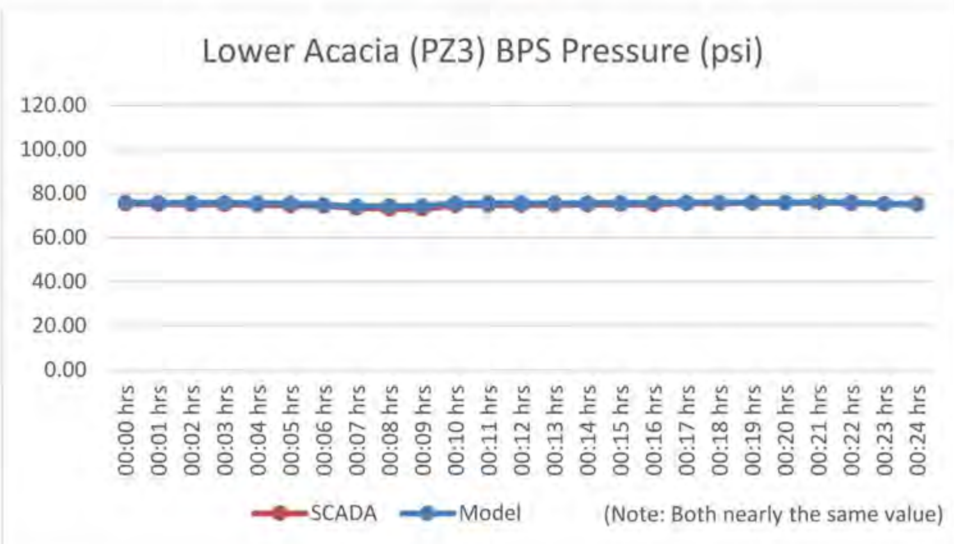

MWD F-9 Pressure (psi)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

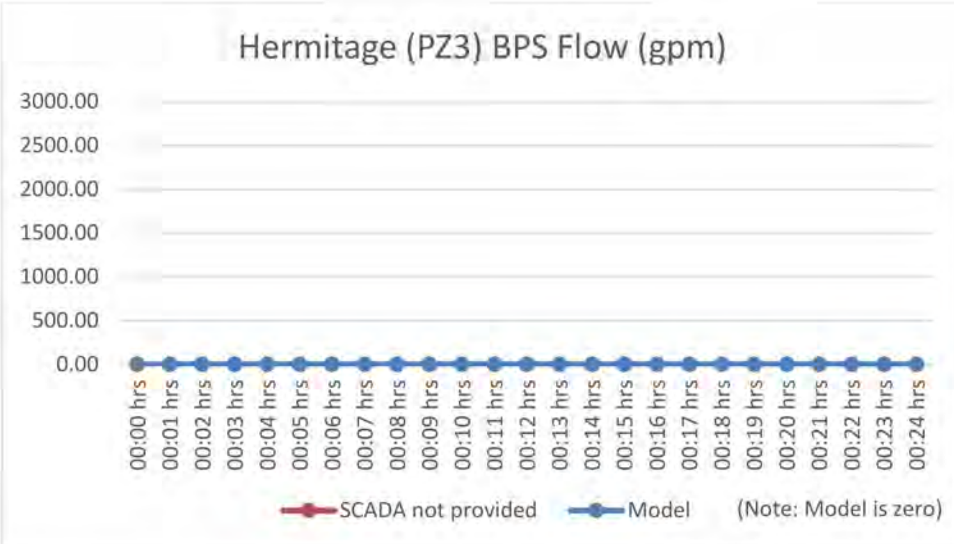
Zone 3 Booster Pump Stations

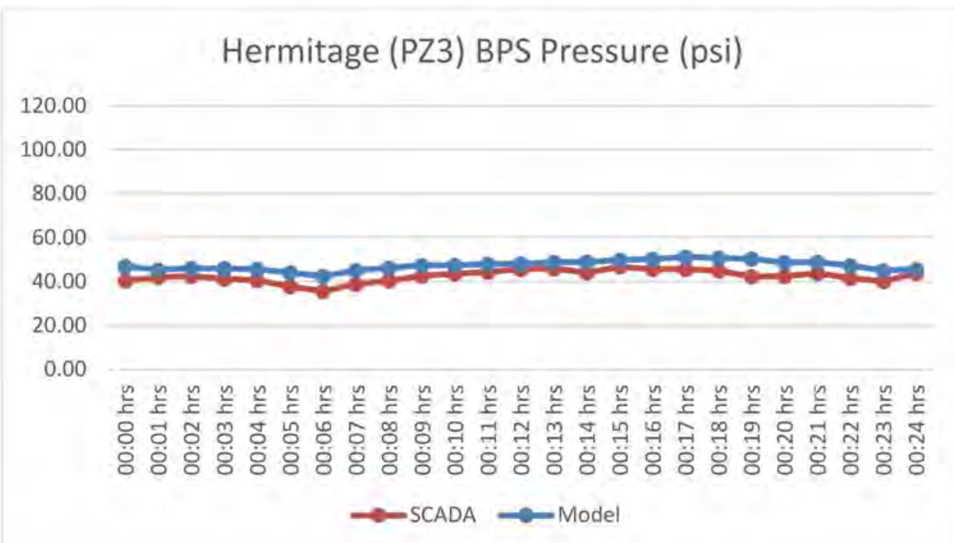


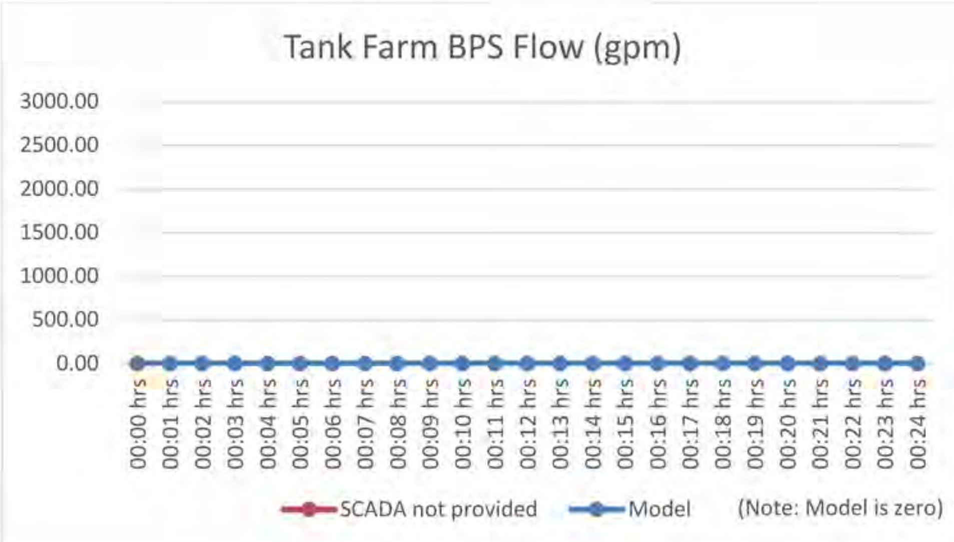


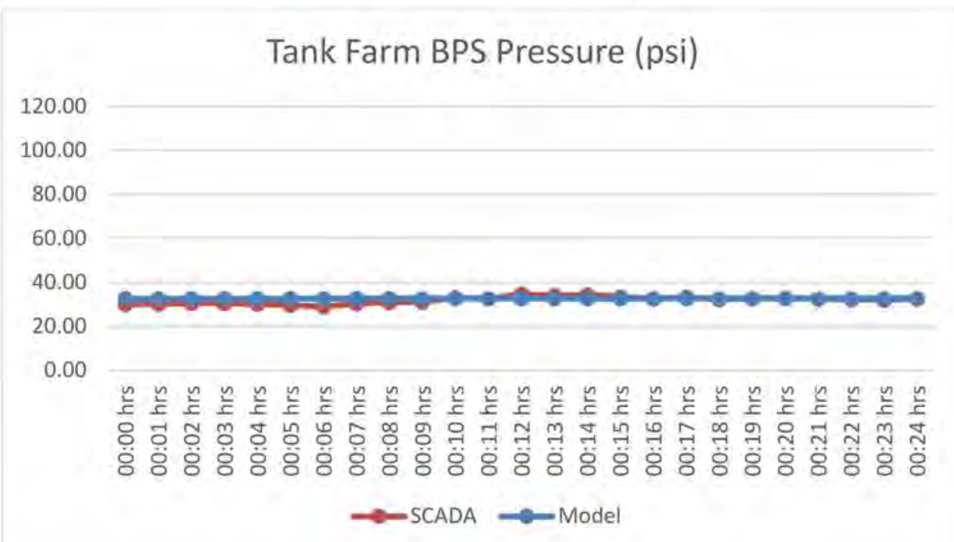

Lower Acacia (PZ3) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model


Lower Acacia (PZ3) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model
(Note: Both nearly the same value)

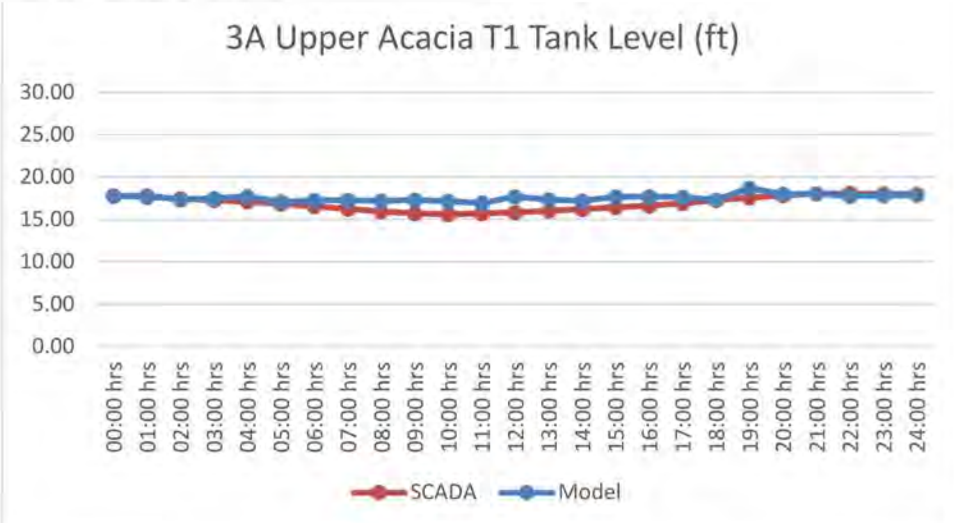

Hermitage (PZ3) BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA not provided
Model
(Note: Model is zero)

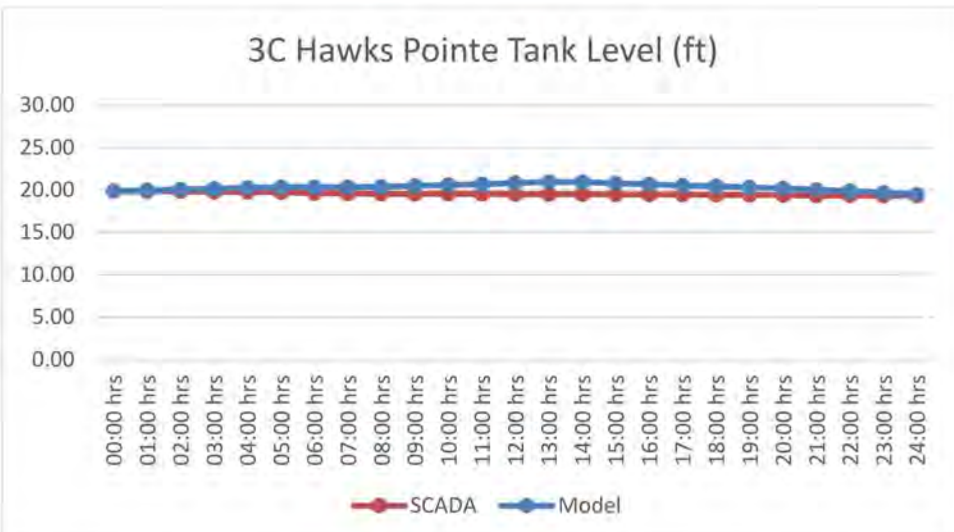

Hermitage (PZ3) BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model

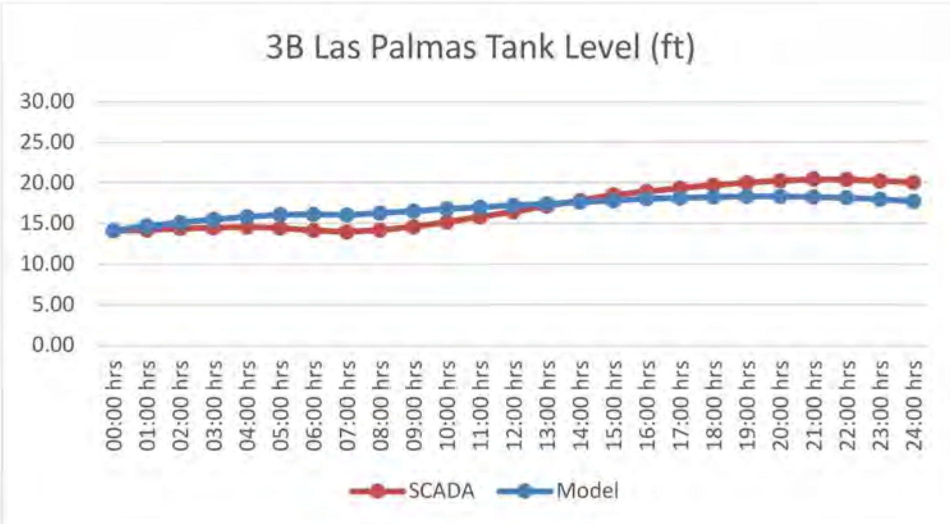

Tank Farm BPS Flow (gpm)
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA not provided
Model
(Note: Model is zero)

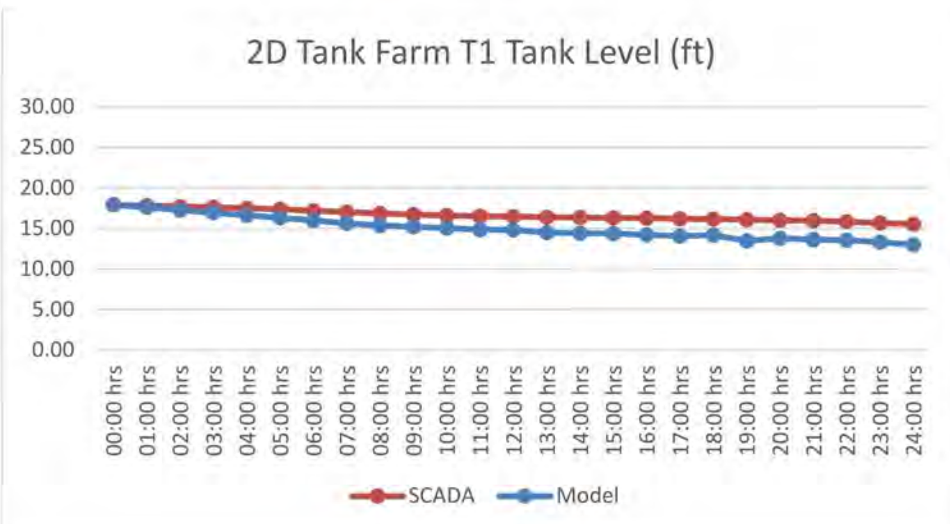

Tank Farm BPS Pressure (psi)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
00:00 hrs
00:01 hrs
00:02 hrs
00:03 hrs
00:04 hrs
00:05 hrs
00:06 hrs
00:07 hrs
00:08 hrs
00:09 hrs
00:10 hrs
00:11 hrs
00:12 hrs
00:13 hrs
00:14 hrs
00:15 hrs
00:16 hrs
00:17 hrs
00:18 hrs
00:19 hrs
00:20 hrs
00:21 hrs
00:22 hrs
00:23 hrs
00:24 hrs
SCADA
Model

Zone 3 Reservoirs



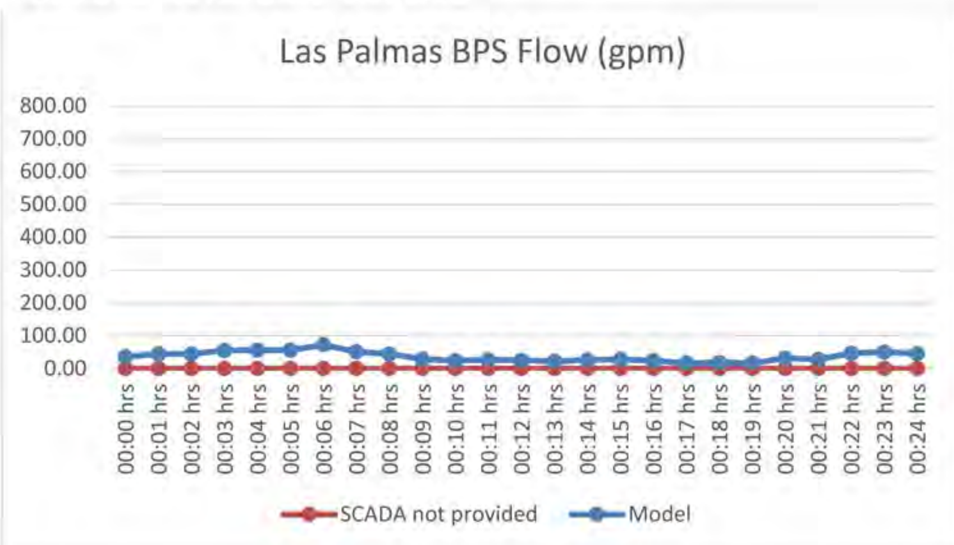


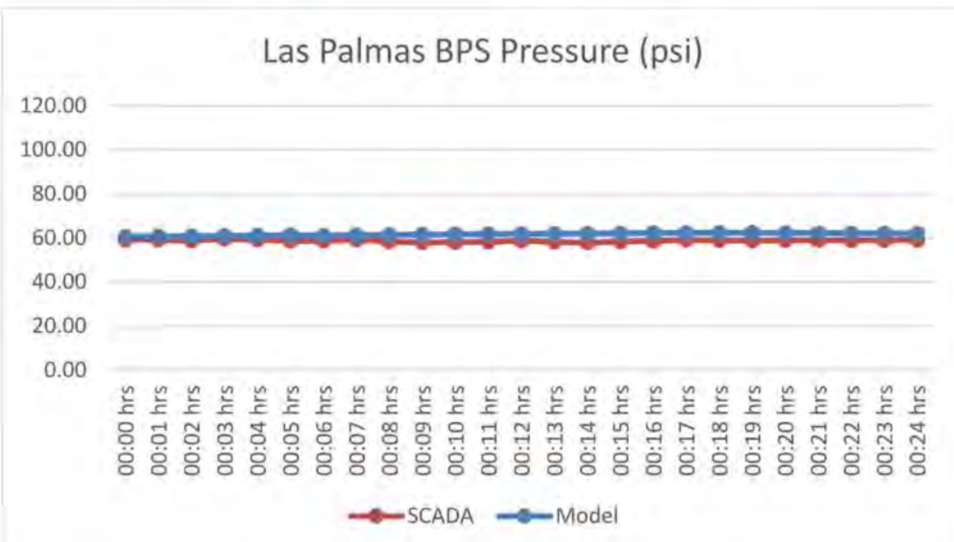

3B Las Palmas Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model


2D Tank Farm T1 Tank Level (ft)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
00:00 hrs
01:00 hrs
02:00 hrs
03:00 hrs
04:00 hrs
05:00 hrs
06:00 hrs
07:00 hrs
08:00 hrs
09:00 hrs
10:00 hrs
11:00 hrs
12:00 hrs
13:00 hrs
14:00 hrs
15:00 hrs
16:00 hrs
17:00 hrs
18:00 hrs
19:00 hrs
20:00 hrs
21:00 hrs
22:00 hrs
23:00 hrs
24:00 hrs
SCADA
Model

C.1.6 ZONE 4 EPS MODEL CALIBRATION VS SCADA CHARTS

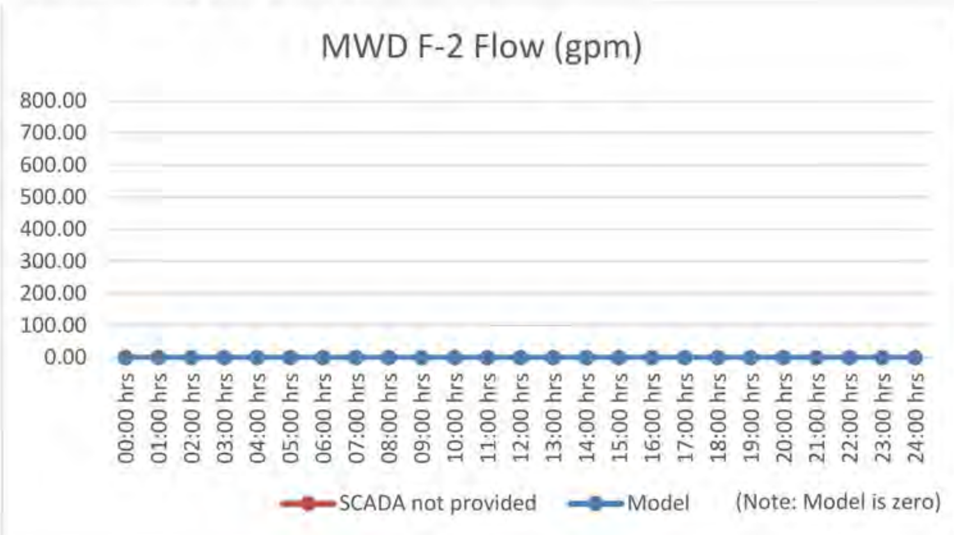
Zone 4 Booster Pump Stations

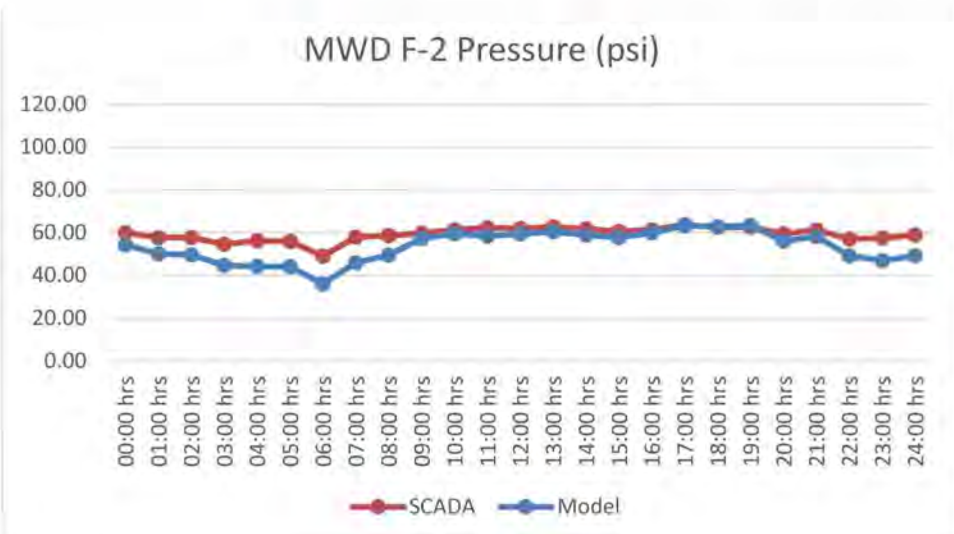




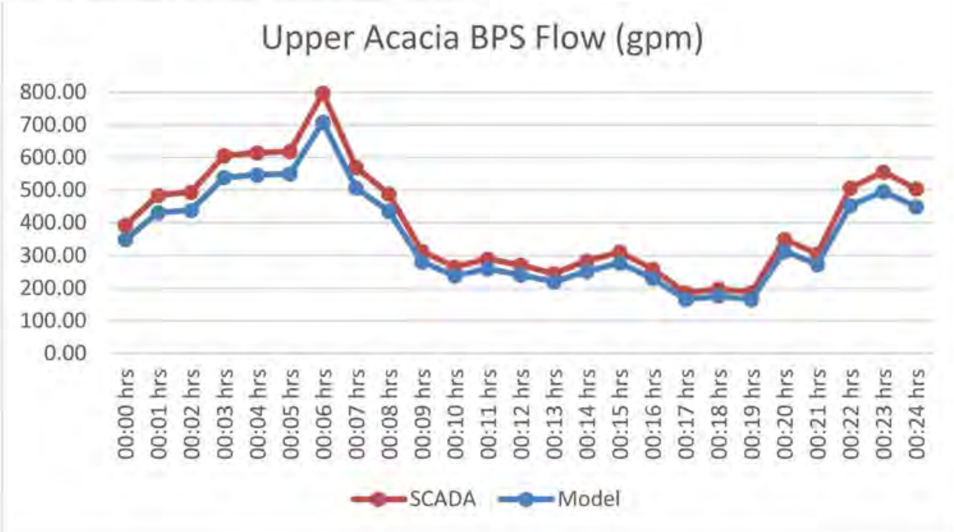
C.1.7 ZONE 4A EPS MODEL CALIBRATION VS SCADA CHARTS

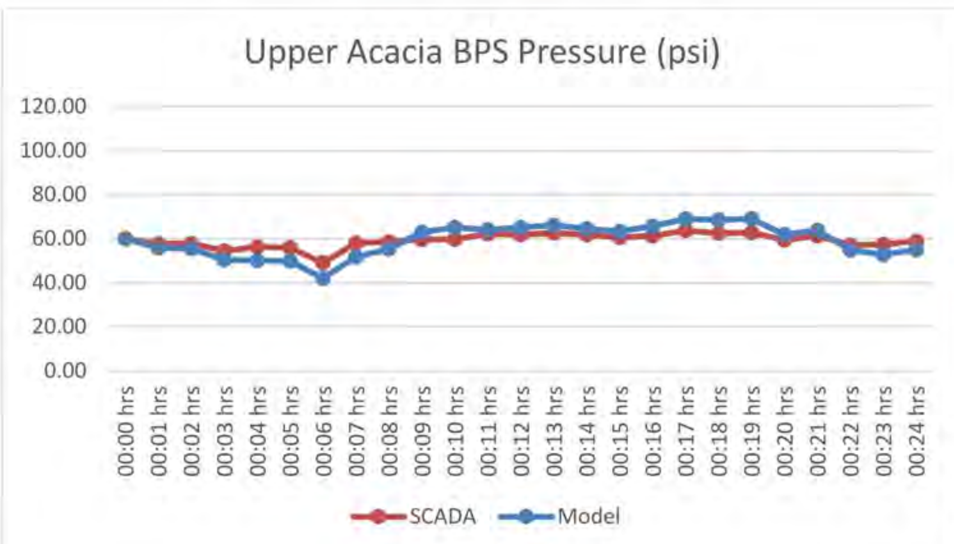
Zone 4A Import Turnouts





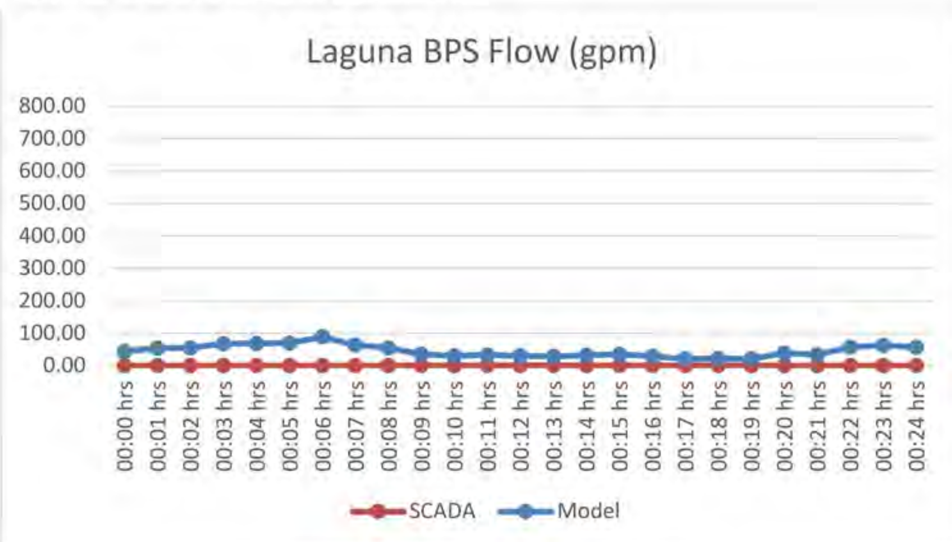
Zone 4A Booster Pump Stations

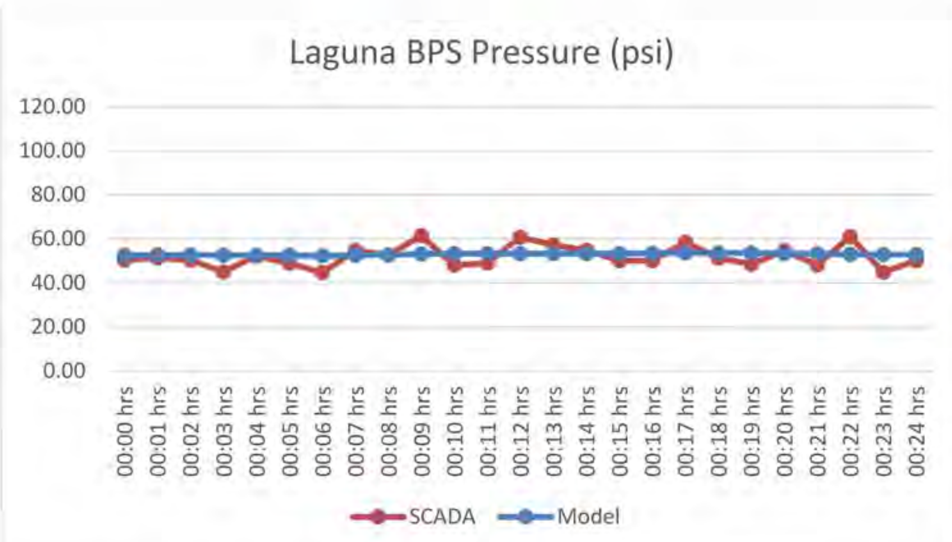




C.1.8 ZONE 4B EPS MODEL CALIBRATION VS SCADA CHARTS

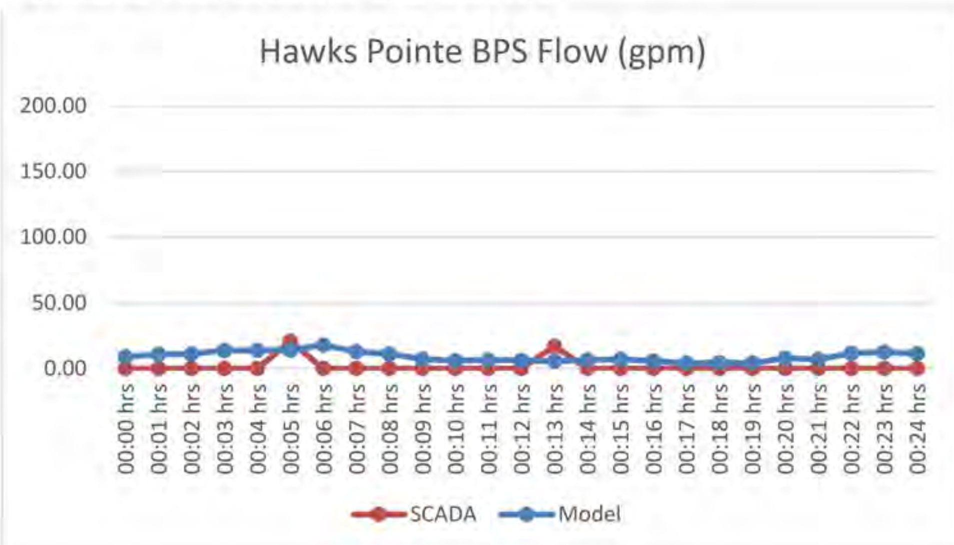
Zone 4B Booster Pump Stations

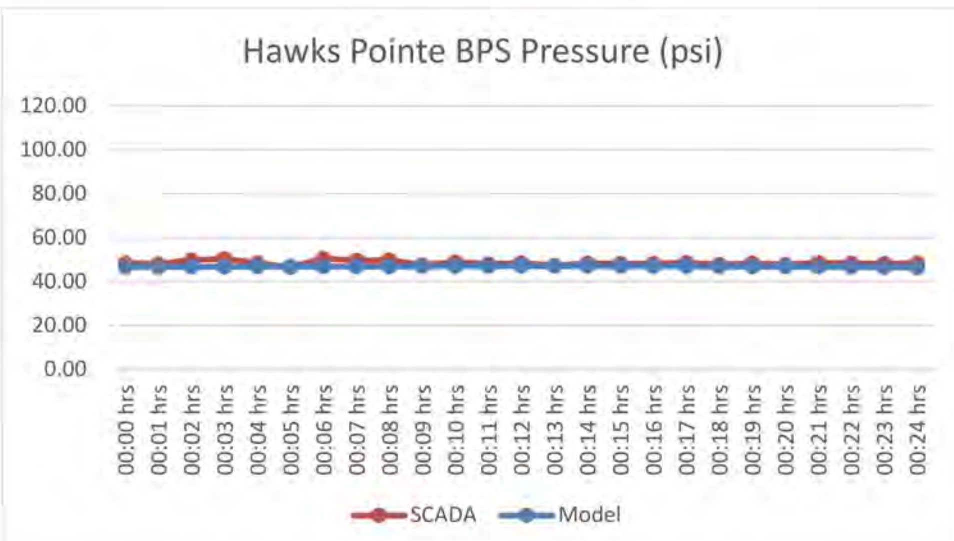




C.1.9 ZONE 4C WEST EPS MODEL CALIBRATION VS SCADA CHARTS

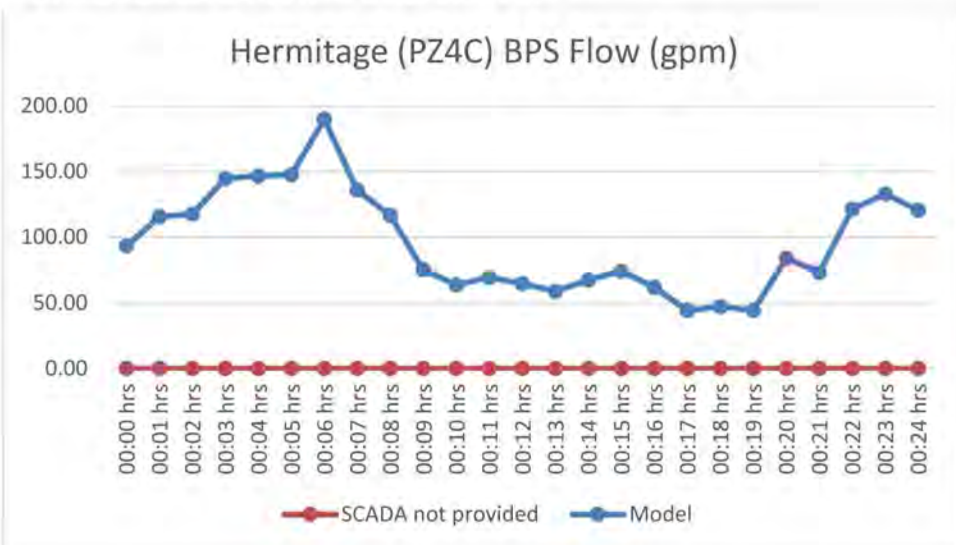
Zone 4C West Booster Pump Stations

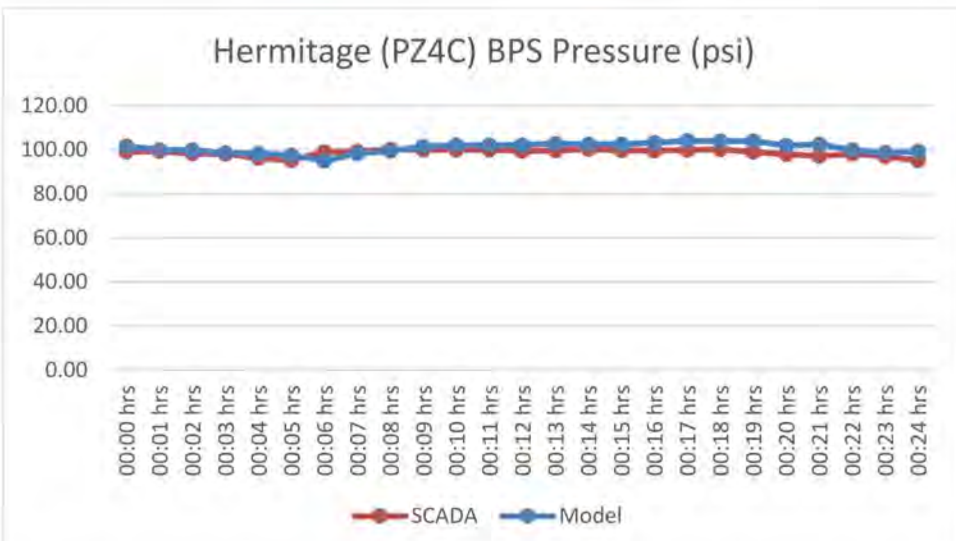




C.1.10 ZONE 4C EAST EPS MODEL CALIBRATION VS SCADA CHARTS

Zone 4C East Booster Pump Stations





C.2 List of Facilities with SCADA

Table C.2-1. List of Facilities with SCADA

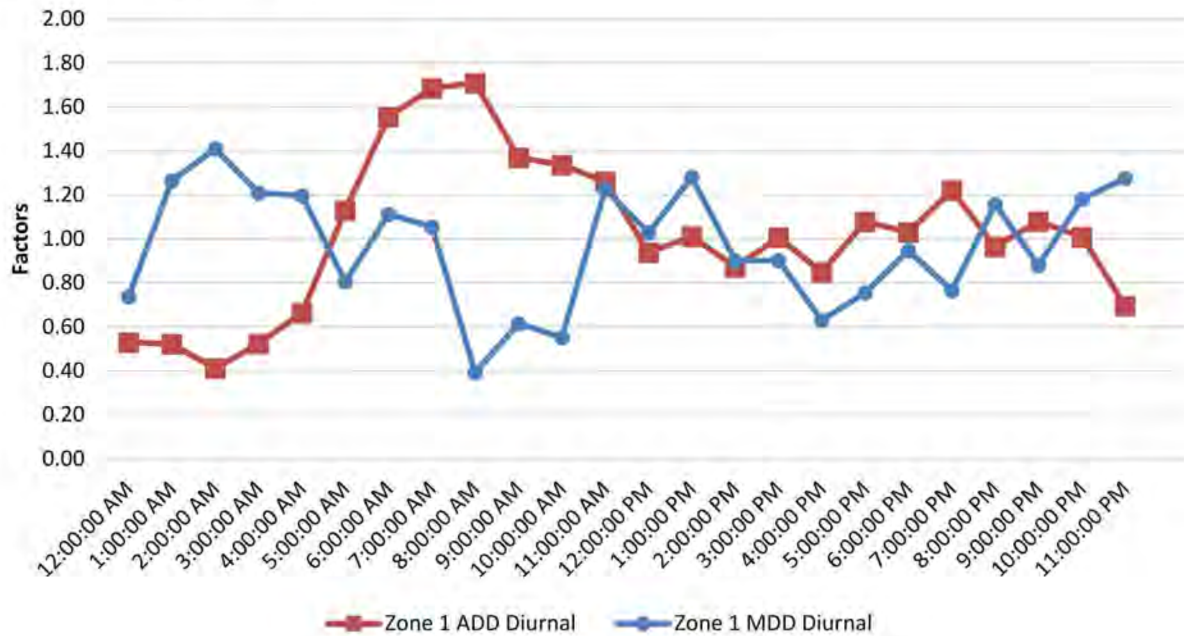
Site Name	Facility	Monitoring Capability
Airport	Well 9	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status
Christlieb	Well 15A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status
Kimberly 1	Well 1A	Flowrate Discharge Pressure Pump Run Status Bypass Valve Status Valve Status
Kimberly 2	Well 2, PS K2F-1A, & Kimberly Forebay	Flowrate Discharge Pressure Forebay Level Pump Run Status Valve Status
Main Plant[(a)]	Wells 3A, 4, 5, 6, 7, & 8	Flowrate
	PS MPF-1 & Main Plant Forebay	Discharge Pressure Forebay Level Pump Run Status Valve Status
Sunclipse	Well 10	Flowrate Discharge Pressure Pump Run Status Valve Status
F-02 & F-04	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-05	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-06	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-08	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status
F-09	MWD Connection	Flowrate Discharge Pressure Upstream Pressure Valve Status

Site Name	Facility	Monitoring Capability
Coyote[b]	PS 1C-2, Reservoir 1C, & Well 12A[c]	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Hawks Pointe[b]	PS 3C-4C & Reservoir 3C	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Hermitage[b]	PS 2B-3, PS 2B-4C, & Reservoir 2B	Discharge Pressure Reservoir Level Bypass Flowrate Pump Run Status Valve Status
Hillcrest[b]	PS 1A-3 & Reservoir 1A	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Las Palmas[b]	PS 3B-4 & Reservoir 3B	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Lower Acacia	PS 1D-2, PS 1D-3, & Reservoir 1D	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status
Laguna[b]	PS 2A-4B & Reservoir 2A	Discharge Pressure Reservoir Level Pump Run Status Valve Status
State College[b]	PS 2C-3 & Reservoir 2C	Discharge Pressure Reservoir Level Pump Run Status Valve Status
Tank Farm[b]	PS 2D-3 & Tank Farm T1-T5	Discharge Pressure Reservoir Level Pump Run Status Valve Status Valve Percent Open
Upper Acacia	PS 3A-4A, Reservoir 3A Repeater Station	Flowrate Discharge Pressure Reservoir Level Pump Run Status Valve Status

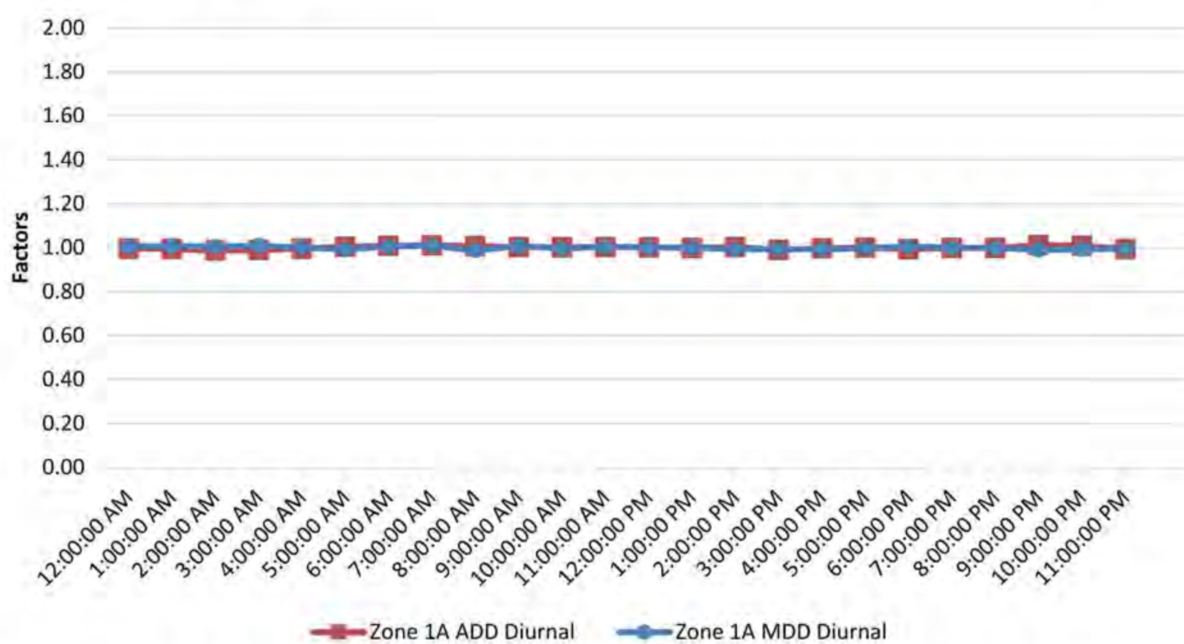
[a] Main Plant BPS does not have a flow meter but is capable of being monitored and connected to SCADA.
[b] Coyote BPS, Hawks Pointe BPS, Hermitage BPS, Hillcrest BPS, Las Palmas BPS, Laguna BPS, State College BPS, and Tank Farm BPS have a flow meter but are not connected to SCADA.
[c] Well 12A has been abandoned and has no SCADA monitoring capabilities.

C.3 Diurnal Patterns

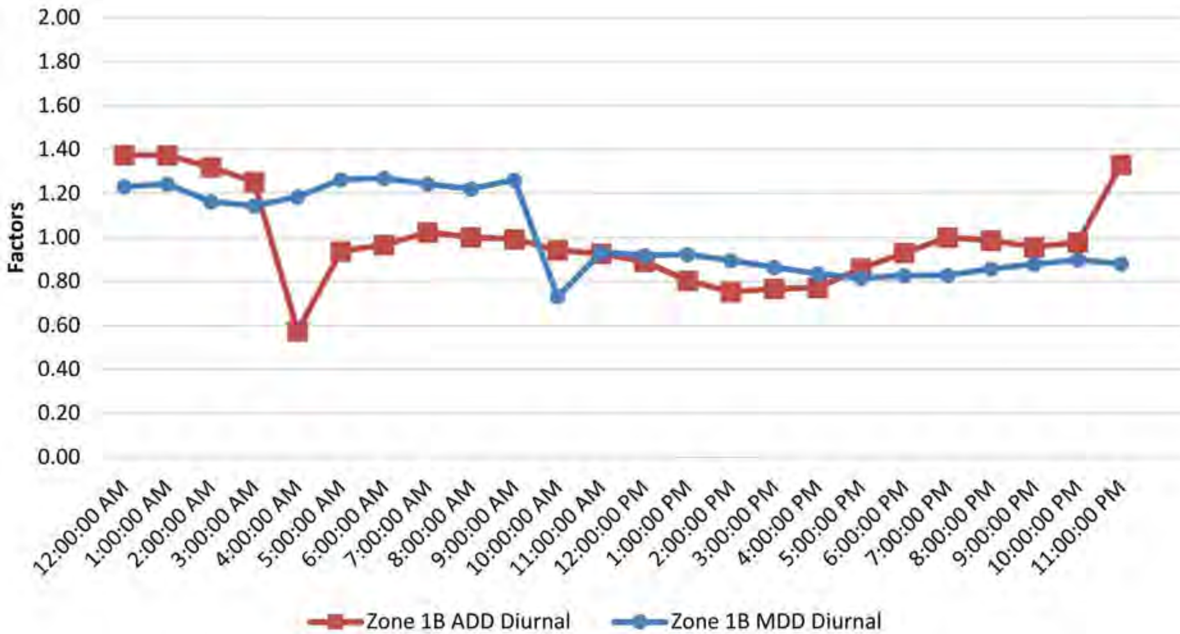
Zone 1 Diurnal Pattern



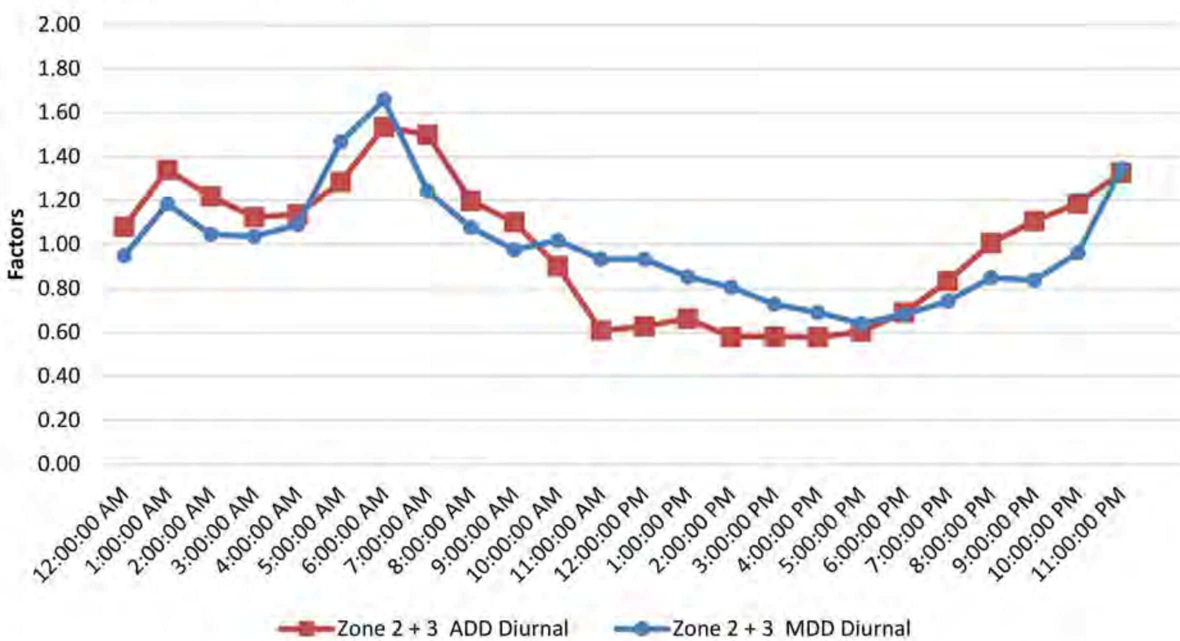
Zone 1A Diurnal Pattern



Zone 1B Diurnal Pattern

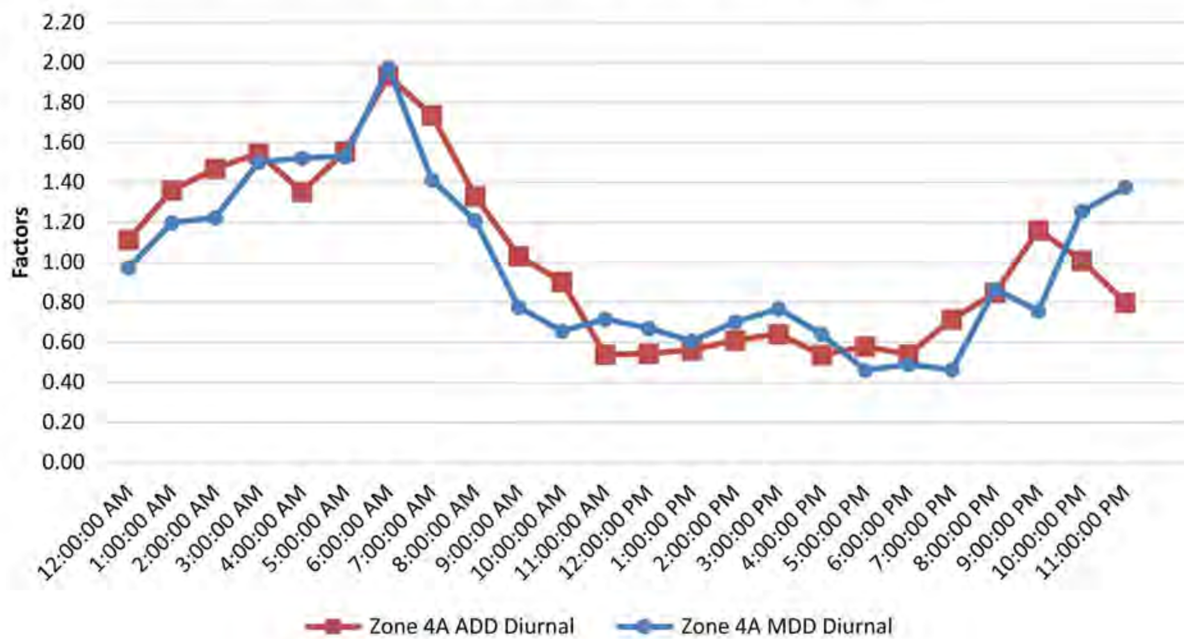


Zone 2 and 3 Diurnal Pattern



Zone 4A Diurnal Pattern

(Zone 4A Diurnal Pattern also used for Zones 1C, 2A, 3A, 4, 4B, and 4C)



Appendix D Pump Capacity Comparison

BOOSTER PUMP STATION PUMP CAPACITY COMPARISON

Pump Station Name	Pump Number	Design Capacity (gpm)	Design Operating Range Flow (gpm) [1]	Model Flow Range (gpm)	Pressure (spi)	
					Suction	Discharge
Main Plant	4	1,500	1,492 - 1,838	0	-4	77
	5	1,500	1,276 - 1,582	1,541 - 1,587	-4	77
	6	1,500	1,512 - 1,877	1,835 - 1,888	-4	77
	7	Unknown	1,456 - 1,695	0	-4	77
	8	1,600	1,455 - 1,680	0	-4	77
Kimberly No. 2	1	1,000	Unknown	0	1	71
	2	1,000	Unknown	1,937 - 2,122	1	72
	3	1,000	Unknown	0	1	71
Hillcrest	1	1,000	798 - 968	0	4	75
	2	1,000	719 - 958	0	4	75
Coyote	1	900	701 - 927	979 - 1,021	2	65
	2	900	705 - 887	962 - 1,005	2	65
	3	900	599 - 925	0	2	65
Lower Acadia Zone 2	1	850	Unknown	921 - 958	-3	36
	2	850	Unknown	0	-3	36
	3	850	Unknown	0	-3	36
Lower Acadia Zone 3	1	1,150	Unknown	0	-3	76
	2	1,150	Unknown	1,112 - 1,160	-3	76
	3	1,150	Unknown	0 - 1,143	-3	76
Laguna	1	300	95 - 453	31 - 101	-3	51
	2	1,500	350 - 2175	0	-3	51
Hermitage Zone 3	1	500	121 - 406	0	7	46
	2	1,000	877 - 1,059	0	7	46
Hermitage Zone 4C [2]	1	300	179 - 246	0	6	99
	2	300	176 - 212	942 - 1,076	6	99
	3	2,500	Unknown	0	6	99
Tank Farm	1	Unknown	1,238 - 1,644	0	6	33
	2	Unknown	1,135 - 1,688	0	6	33
Upper Acacia	1	350	Unknown	0	6	54
	2	700	Unknown	0	8	55
	3	1,000	Unknown	1,077 - 1,403	7	55
	4	1,000	Unknown	0	8	55
Las Palmas	1	600	300 - 850	0	7	60
	2	600	300 - 850	25 - 82	7	60
Hawks Point	1	150	Unknown	0	9	47
	2	150	Unknown	6 - 20	9	47

[1] Design operating flow range is based on available pump curves and SCE tests with multiple data points

[2] Hermitage Zone 4C Pump Station includes a hydropneumatic tank, as such, the pumps had to be modeled to take this into account and may not fall within the design operaing flow range

GROUNDWATER WELL PUMP CAPACITY COMPARISON

Well Name	Well Number	Design Capacity (gpm)	Design Operating Range Flow (gpm) (1)	Model Flow Range (gpm)	Pressure (spi)	
					Suction	Discharge
Kimberly	1A	2,800	Unknown	1,706 - 1,777	-77	75
	2	1,875	596 - 2,591	2,492 - 2,582	-3	2
Main Plant	3A	2,400	865 - 2,400	0	-78	78
	5	1,500	650 - 2,000	0 - 1,965	-48	-2
	6	1,500	Unknown	0	-46	-2
	8	2,000	750 - 2,600	1,692 - 1,704	-47	-2
Airport	9	2,500	750 - 3,245	2,547 - 2,618	-89	87
Sunclipse	10	2,000	2,217 - 2,477	0 - 2,598	-80	72
Christlieb	15A	2,000	1,771 - 1,978	0 - 2,220	-49	73

Appendix E   Proposed Pipeline Improvements

PROPOSED PIPELINE IMPROVEMENTS BASED ON EXISTING FIRE FLOW ANALYSIS

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Zone 1			
Replace existing 4" and 6" with 8" pipe, located between S Brookhurst Rd and S Pacific Dr, from W Orangethorpe Ave to north dead-end	8	235	LF
Replace existing 4" with 8" pipe located west of S Harbor Blvd between W Southgate Ave and W Hill Ave	8	275	LF
Replace existing 4" with 8" pipe on N Marie Ave from W Amerige Ave to north dead-end	8	204	LF
Replace existing 4" with 8" pipe on N Michael Ave from W Amerige Ave to north dead-end	8	187	LF
Replace existing 4" with 8" pipe on Russell Ave from W Amerige Ave to north dead-end	8	225	LF
Install new 6" pipe for looping at N Euclid St and W Wilshire Ave	6	9	LF
Replace existing 4" with 8" pipe for pipe loop between N Wayne Ave and N Lee Ave	8	284	LF
Replace existing 4" and 6" with 8" pipe on N Lee Ave from W Chapman Ave to loop at north end	8	444	LF
Replace existing 4" with 8" pipe on N Wayne Ave from W Chapman Ave to loop at north end	8	460	LF
Replace existing 6" with 8" pipe on E Truslow Ave from S Balcom Ave to east dead-end	8	454	LF
Replace existing 6" with 8" pipe on Patterson Way from S Balcom Ave to east dead-end	8	607	LF
Install new 12" pipe for looping on N Harbor Blvd from E Union Ave to E Glenwood Ave	12	473	LF
Replace existing 6" with 12" pipe on Eugene Dr from E Valley View Dr to 75-ft south	12	75	LF
Replace existing 6" with 8" pipe on Eugene Dr from proposed 12-in pipeline to south dead-end	8	503	LF
Install new 8" pipe for looping on E College Pl from N Lincoln Ave to N Cornell Ave	8	320	LF
Reconnect existing fire hydrant at W Orangethorpe Ave and S Citrus Ave from existing 6" pipe to existing 10" parallel pipe	-	1	EA
Zone 1A			
Replace existing 8" with 12" pipe on Via Burton from N Acacia St to east dead-end	12	1,023	LF
Replace existing 8" with 12" pipe on on E Walnut Ave from S Acacia Ave to S Hale Ave	12	1,053	LF
Replace existing 6" with 12" pipe on E Chapman Ave from Ladera Vista Dr to N State College Blvd	12	1,209	LF
Replace existing 6" with 8" pipe E Chapman Ave from N State College Blvd to Clarke Ave	8	1,149	LF
Replace existing 6" with 8" pipe for residential looping located south of E Chapman Ave between Ladera Vista Dr and N State College Blvd	8	1,466	LF
Replace existing 6" with 8" pipe on San Carlos Dr from Clarke Ave to N State College Blvd	8	732	LF
Replace existing 6" with 8" pipe on Concord Ave from Nutwood Ave to Sycamore Ave	8	1,043	LF
Replace existing 6" with 8" pipe on Nutwood Ave from Wilson Ave to N State College Blvd	8	957	LF
Replace existing 6" with 8" pipe on Sycamore Ave from Nutwood Ave to Concord Ave	8	1,027	LF
Replace existing 6" with 8" pipe on N Raymond Ave and E Glenwood Ave	8	44	LF
Replace existing 6" with 8" pipe on N Lincoln Ave from E Glenwood Ave to Dorothy Ln	8	681	LF
Replace existing 6" with 8" pipe on N Yale Ave from E Glenwood Ave to north dead-end	8	418	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Zone 1B			
Replace existing 6" with 8" pipe on W Porter Ave from Magnolia Ave to east dead-end	8	876	LF
Install new 8" pipe for looping south of S Vine Ave and W Orangethorpe Ave	8	517	LF
Replace existing 6" with 8" pipe on S Vine Ave from W Orangethorpe Ave to new 8" pipe loop	8	463	LF
Replace existing 6" with 8" pipe on Peckham St from W Orangethorpe Ave to south dead-end	8	793	LF
Replace existing 6" with 8" pipe on W Roberta Ave from Carbon Creek to S Gilbert St	8	593	LF
Replace existing 6" with 8" pipe, located between W Southgate Ave and W Orangethorpe Ave, from S Brookhurst Rd to west dead-end	8	580	LF
Install new 8" pipe for looping from west dead-end of existing 6" pipe (replaced with 8" pipe) to W Orangethorpe Ave, located east of S Cedar Ave	8	805	LF
Replace existing 6" with 8" pipe on S Pine Dr from W Roberta Ave to W Houston Ave	8	377	LF
Replace existing 8" with 12" pipe on on W Houston Ave from S Courtney Ave 640-ft east to the east dead-end	10	610	LF
Replace existing 6" with 8" pipe on W Houston Ave from W Roberta Ave to W Maxzim Ave	8	1,054	LF
Install new 8" pipe for looping on W Roberta Ave from S Courtney Ave 350-ft east to S Brookhurst Rd	8	1,314	LF
Replace existing 6" with 8" pipe on W Roberta Ave from S Pine Dr to W Maxzim Ave	6	280	LF
Replace existing 6" with 8" pipe on Franklin Ave from Olin St to west dead-end	8	627	LF
Replace existing 6" with 8" pipe on Olin St from W Valencia Dr to Franklin Ave	8	510	LF
Replace existing 6" with 8" pipe on Carol Dr from Edward Ave to west dead-end	8	526	LF
Replace existing 6" with 8" pipe on Commonwealth Ave from Edward Ave to west dead-end	8	1,144	LF
Remove and replace existing 6" pipe segment on Artesia Ave east of Dale Pl	6	630	LF
Install new 18" pipe for looping on Dale Pl from Artesia Ave to existing 8" pipe on Dale Pl	18	467	LF
Remove and replace existing 6" pipe on N Pritchard Ave from Artesia Ave to W Commonwealth Ave	6	1,142	LF
Install new 8" pipe for looping on N Pritchard Ave at the intersection of Artesia Ave	8	9	LF
Replace existing 4" with 8" pipe on Plaza de Vista from Carmel Cir to west dead-end	8	194	LF
Zone 1C			
Replace existing 6" with 8" pipe, located between W Porter Ave and Auto Center Dr, from Maxwell Ave to west dead-end	8	283	LF
Zone 2			
Replace existing 6" with 8" pipe on Madison Ave from N Placentia Ave to Cameo Ln	8	542	LF
Replace existing 4" with 8" pipe, located north of Madison Ave, from Deerpark Dr to N Placentia Ave	8	629	LF
Replace existing 6" with 8" pipe for residential looping located north of Yorba Linda Blvd between N Deerpark Dr to N Placentia Ave	8	1,333	LF
Remove and replace existing 8" pipe on E Palm Dr from Sapphire Rd to N Bradford Ave	8	1,334	LF
Remove and replace existing 8" pipe on Yorba Linda Blvd from Sapphire Rd to N Bradford Ave	8	1,288	LF
Remove and replace existing 8" pipe located northeast of Topaz Ln between E Palm Dr and N Bradford Ave	8	1,287	LF
Remove and replace existing 8" pipe on N Bradford Ave from E Palm Dr to Topaz Ln	8	1,092	LF
Install new 8" pipe for looping on N Bradford Ave near Topaz Ln	8	352	LF
Replace existing 6" with 8" pipe on N Sapphire Rd from Topaz Ln to Quartz Ln	8	1,021	LF
Remove and replace existing 6" pipe from Topaz Ln to Quartz Ln	6	672	LF
Remove and replace existing 8" pipe on Quartz Ln from N Sapphire Rd to 710-ft southeast	8	713	LF
Remove and replace existing 8" pipe on Topaz Ln from N Sapphire Rd to 710-ft southeast	8	710	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Replace existing 6" with 8" pipe on Hartford Ave from E Bastanchury Rd to Sherwood Ave	8	1,235	LF
Replace existing 6" with 8" pipe on Sherwood Ave from Deerpark Dr to Hartford Ave	8	1,671	LF
Replace existing 6" with 8" pipe on Hollydale Dr from Melody Ln to Dorothy Ln	8	572	LF
Replace existing 6" with 8" pipe on Kensington Dr from Hollydale Dr to Melody Ln	8	953	LF
Replace existing 6" with 8" pipe on Melody Ln from Kensington Dr to Acacia Ave	8	1,617	LF
Replace existing 6" with 8" pipe on Valvwood Dr from Panorama Rd to Lautrec Dr	8	672	LF
Replace existing 6" with 8" pipe on Dorothy Dr from Hornet Way to Sheppard Dr	8	257	LF
Replace existing 4" and 6" with 8" pipe on Sheppard Dr from Dorothy Dr to Virginia Rd	8	2,021	LF
Replace existing 6" with 8" pipe on Sheppard Dr from Virginia Rd to north dead-end	8	468	LF
Replace existing 4" with 8" pipe on Cristine Pl from W Valencia Mesa Dr to southeast dead-end	8	186	LF
Replace existing 4" and 6" with 8" pipe on N Johnston Knls from Sunny Crest Dr to east dead-end	8	313	LF
Replace existing 4" and 6" with 8" pipe on N Harbor Blvd from Brea Blvd to 1,150-ft northwest	8	1,228	LF
Realign pipelines from Zone 1 to Zone 2 near the intersection of Vista Verde Drive & West Union Avenue	-	1	LS
Install New Zone 3 to 2 PRV at E Bastanchury & Hartford Ave	-	1	EA
Reconnect existing fire hydrant at Brea Blvd and Longview Dr from Zone 2 existing 8" pipe to Zone 3 existing 12" parallel pipe	-	1	EA
Zone 3			
Replace existing 6" with 8" pipe on Sunny Knl from Sunny Crest Dr to northeast dead-end	8	503	LF
Replace existing 6" with 8" pipe on Sheffield Pl from Beacon St to west dead-end	8	314	LF
Replace existing 4" and 6" with 8" pipe on Salem Pl and Middlesex Pl as well as existing pipe loop between the streets, located north of Mystic Ave	8	1,143	LF
Replace existing 6" with 8" pipe on Hartford Ave from Winchester St to north dead-end	8	468	LF
Install new 8" pipe for looping from Hartford Ave dead-end to Cambridge Ave dead-end	8	276	LF
Replace existing 6" with 8" pipe on Thorn Pl from Winchester St to north dead-end	8	458	LF
Replace existing 6" with 8" pipe on Blackpine Ct from Cedarbrook Cir to east dead-end	8	158	LF
Replace existing 8" with 12" pipe on Associated Rd from Rolling Hills Dr to Gingerwood Cir	12	1,755	LF
Replace existing 6" with 8" pipe on Private St with Associated Rd to the west and Rolling Hills Dr to the south	8	1,929	LF
Replace existing 4" with 8" pipe, located east of Merlin Ave, from Mimosa Pl to Beechwood Ave	8	255	LF
Replace existing 6" with 8" pipe on Edgecliff Dr from N Raymond Ave to Kroeger Ave	8	418	LF
Replace existing 6" with 8" pipe on Kroeger Ave from Edgecliff Dr to Melody Ln	8	1,659	LF
Replace existing 4" and 6" with 8" pipe on Linda Ln from Skyline Dr to east dead-end	8	445	LF
Replace existing 6" with 8" pipe on N Norman Pl from N Raymond Ave to east dead-end	8	408	LF
Replace existing 6", 8", and 10" with 12" pipe on N Raymond Ave from Edgecliff Dr to Miramar Pl	12	1,103	LF
Replace existing 6" with 8" pipe on N Raymond Ave from Miramar Pl to Melody Ln	8	725	LF
Replace existing 6" with 8" pipe on N Raymond Ave from Skyline Dr to Kenwood Pl	8	951	LF
Replace existing 4" with 8" pipe on N Lemon St from Hillcrest Dr to Cannon Ln	8	314	LF
Replace existing 6" with 8" pipe on Beechwood Ave from Puente St to west dead-end	8	187	LF
Replace existing 6" with 8" pipe on Altivo Pl from Arbolado Dr to north dead-end	8	472	LF
Replace existing 6" with 8" pipe on Arbolado Dr from Madonna Dr to Altivo Pl	8	346	LF

Recommended Project Description	Proposed Dia (in)	Quantity	Unit
Replace existing 6" with 8" pipe on Madonna Dr from Arbolado Dr to Elinor Dr	8	562	LF
Replace existing 6" with 8" pipe on Balboa Rd from E Bastanchury Rd to north dead-end	8	377	LF
Replace existing 6" with 8" pipe on N Harbor Blvd from Coronado Dr to Miguel Pl	8	984	LF
Replace existing 6" with 8" pipe for residential looping located south of Imperial Hwy between N Palm St and S Puente St	8	1,529	LF
Replace existing 6" with 8" pipe on Via Codo from Via Codo to south dead-end	8	268	LF
Replace existing 6" with 8" pipe on Lakeside Dr from W Hermosa Dr to Terraza Pl	8	1,105	LF
Replace existing 6" with 8" pipe on Juanita Pl from Clarion Dr to southwest dead-end	8	629	LF
Replace existing 6" with 8" pipe on Anacapa Pl from Domingo Rd to Santa Barbara Ave	8	1,153	LF
Replace existing 6" with 8" pipe on Miguel Pl from Domingo Rd to northwest dead-end	8	550	LF
Replace existing 6" with 8" pipe on Rancho Cir from Terraza Pl to east dead-end	8	543	LF
Replace existing 6" with 8" pipe on Verona Dr from Rancho Cir to 685-ft west	8	685	LF
Replace existing 6" with 8" pipe on Yuma Way from Laguna Rd to southwest dead-end	8	872	LF
Replace existing 6" with 8" pipe on Avenida del Corto from Nicolas Dr to west dead-end	8	547	LF
Replace existing 6" with 8" pipe on Paseo Grande from Grissom Park Dr to Manzanita Dr	8	906	LF
Replace existing 6" with 8" pipe on Paseo Grande from Manzanita Dr to east dead-end	8	230	LF
Replace existing 6" with 8" pipe Ave del Norte from Parks Rd to west dead-end	8	412	LF
Replace existing 6" with 8" pipe on Ride Out Way from W Las Palmas Dr to southeast dead-end	8	729	LF
Zone 3A			
Replace existing 6" with 8" pipe on Avenida Selva from Calle Candela to Camino Recondito	8	220	LF
Replace existing 6" with 8" pipe on Calle Candela from El Rancho Vis to Ave Selva	8	561	LF
Replace existing 6" with 8" pipe on Camino Escondido from Calle Candela to east dead-end	8	409	LF
Zone 4			
Replace existing 6" with 8" pipe on Flintridge Dr from W Las Palmas Dr to 546-ft south	8	546	LF
Replace existing 6" with 8" pipe on La Sombra Way from W Las Palmas Dr to south dead-end	8	320	LF
Zone 4A			
Replace existing 6" with 8" pipe on Panorama Rd from Palisades Dr to Skyline Dr	8	837	LF
Replace existing 4" and 6" with 8" pipe on Skycrest Dr from Skyline Dr to Skyline Way	8	765	LF
Replace existing 6" with 8" pipe on Skyline Dr from Linda Vista Cir to N Raymond Ave	8	735	LF
Replace existing 6" with 8" pipe on Skyline Dr from Skyline Way to N Raymond Ave	8	883	LF
Replace existing 4" and 6" with 8" pipe on Skyline Way from Skyline Dr to Skycrest Dr	8	240	LF
Replace existing 6" with 8" pipe on Stanford Ave from Melody Ln to Virginia Rd	8	366	LF
Zone 4C			
Realign pipelines from Zone 3 to Zone 4C near the intersection of Applewood Cir & Hermitage Dr and Camino del Sol & Atherton Cir	-	1	LS
	Total	**83,770**	**LF**

Appendix F Condition Assessment Technical Memorandum

(Confidential)

Confidential Information is only available in the “Risk and Resiliency Assessment (SRR) Report”.

Access must be approved in advance by the Director of Public Works.

Appendix G Risk Assessment Technical Memorandum

(Confidential)

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