Prepared for
City of Antioch

Water System Master Plan Update

August 2014

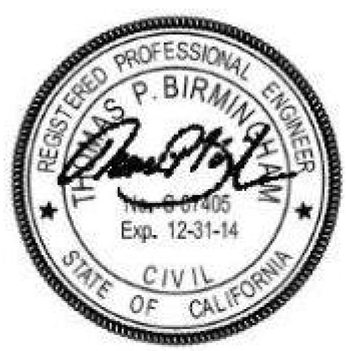
FINAL

Master Plan Update

Prepared for

City of Antioch, Antioch, California

August 2014



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List of Abbreviations

ABAG	Association of Bay Area Governments
ac-ft	acre-feet
AFY	acre-feet-year
ALs	action levels
amsl	above mean sea level
AWWA	American Water Works Association
BC	Brown and Caldwell
BDCP	Bay Delta Conservation Plan
BPS	Booster Pumping Station
Bureau	Bureau of Reclamation
Canal	Contra Costa Canal
CAP	Cryptosporidium Action Plan
CC	Contra Costa
CCCFPD	Contra Costa County Fire Protection District
CCI	Construction Cost Index
CCL	Contaminant Candidate List
CCP	concrete cylinder pipeline
CCWD	Contra Costa Water District
CDPH	California Department of Public Health
CDX	Central Data Exchange
cfs	cubic feet per second
ClO2	chlorine dioxide
CIP	Capital Improvement Program
CIP	cast iron pipeline
City	City of Antioch
CMMS	computerized maintenance management system
CRSB	Coast Range Sierra Block
CUWCC	California Urban Water Conservation Council's
CVP	Central Valley Project
D/DBP	Disinfection/Disinfection-By Product
DBP	disinfection by-products
DDSD	Delta Diablo Sanitation District
Delta	Sacramento-San Joaquin Delta
DIP	ductile iron pipeline
DMM	Demand Management Measures
DOF	Department of Finance
DPEIR	Draft Programmatic Environmental Impact Report
DSC	Delta Stewardship Council
DU/AC	dwelling unit/acre
DWD	Diablo Water District
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
ECPS	East Canal Pumping Station
EDCs	Endocrine Disrupting Compounds
FACA	Federal Advisory Committee Act
FR	Federal Register
ft	feet
GAC	granular activated carbon
gpcd	gallons per capita per day
gpm	gallons per minute
HAAs	haloacetic acids
Hp	horesepower
HPC	Heterotrophic Plate Count
ICR	Information Collection Rule
IDSE	Initial Distribution System Evaluation
IESWTR	Interim Enhanced Surface Water Treatment Rule
LRAA	Locational Running Annual Average
LT2ESWTR	Long-Term 2 Enhanced Surface Water Treatment Rule
M&I	Municipal and Industrial
MCLG	maximum contaminant level goals
MCL	maximum contaminant levels
MG	1.0-million-gallon
mg/L	milligrams per liter
mgd	million gallons per day
MOU	Memorandum of Understanding
MRDLG	maximum residual disinfectant level goal
MRDLs	maximum residual disinfectant levels
MTBE	methyl tert-butyl ether)
NDMA	nitroso-dimethylamine)
NL	Notification Levels
NPDWRs	National Primary Drinking Water Regulations

NTU	Nephelometric turbidity units
PEIR	Programmatic Environmental Impact Report
PN	public notification
PPCP	Pharmaceuticals, and Personal Care Products
PRS	Pressure Regulating Stations
PRVs	pressure reducing valves
psig	per square inch gage
PWS	public water system
RBWTP	Randall-Bold Water Treatment Plant
RPS	river pumping station
RTCR	Revised Total Coliform Rule
RWF	Recycled Water Facility
SB	Senate Bill
SCADA	supervisory control and data acquisition
SCVWD	Santa Clara Valley Water District
SDWA	Safe Drinking Water Act
SDWARS	Safe Drinking Water Accession and Review System
SFPUC	San Francisco Public Utility Commission
SODS	Save Our Delta Surveys
SOP	standard operating procedures
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TDH	Total Dynamic Head
TDS	total dissolved solids
THM	trihalomethane
TOC	total organic carbon
TT	Treatment Techniques
HAA	haloacetic acid
TTHMs	Total Trihalomethanes
UCMR	Unregulated Contaminant Monitoring Rule
UFC	Uniform Fire Code
USEPA	United States Environmental Protection Agency
ULFT	Ultra Low Flush Toilets
UV	ultraviolet
UWMP	Urban Water Management Plan
WCPS	West Canal Pumping Station
WSS	Water Sense Standard
WTP	water treatment plant
WUE	Water Use Efficiency
μg/L	micrograms per liter
μS/cm	micro Siemens per centimeter

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Executive Summary

This Water System Master Plan Update reviews changes in water supply, water use characteristics, drinking water regulations, and study area demographics and presents significant Brown and Caldwell (BC) findings, conclusions and recommendations for existing and future facilities through the year 2035. This update represents modification of the document prepared for the City of Antioch (City) by BC dated June 2013. It reflects major change including removal of the Chevron property from the City's sphere of influent and zoning changes for Roddy Ranch.

Since completion of the last Water System Master Plan Update in 2001, the City has transitioned from a 40-year period of rapid water system expansion to meet the demands of City growth to a period of maintenance and replacement of existing, aging facilities. Overall, the City water system has capacity to deliver flow and pressure in compliance with City-defined design criteria and State of California requirements. Localized upgrades are needed to improve service to some neighborhoods. The system generally performs very well as evidenced by extremely low water losses—less than 3 percent—and very few complaints about low pressures or the quality of delivered water.

Background

In 2012, the City water system served approximately 103,000 people within a 28.8-square-mile service area. As the economy recovers, the City's population will grow slowly. The maximum daily demand on the City water system, including unaccounted-for water, was about 26 million gallons per day (mgd) in 2012. The City's water treatment plant (WTP) has a maximum production capacity of about 37 mgd. The City currently has rights to buy 5 mgd of treated water from Contra Costa Water District (CCWD) with the option to purchase an additional 5 mgd. This capacity is sufficient for projected demands through 2035. The City is experiencing continued, albeit much slower, growth and development in its northeast, southwest and southeast areas.

Findings and Conclusions

The major findings and conclusions of this Master Plan Update are set out below.

Population Growth. Antioch continues its popularity as an East Bay residential community. The Population is projected to grow from approximately 103,000 (2012) to approximately 115,000 by 2035.

Water Requirements. From historical records, a maximum day to average day water ratio is 1.7, which is unchanged in the past decade. The projected year 2035 maximum day demand is about 30.9 mgd, about one-third reduction from 1999 projections (which anticipated much more aggressive growth in population and higher per capita use). Water use dropped off after the economic downturn in 2008 and likely will grow slowly owing to more efficient water use and state-mandated conservation. The 2035 peak hour demand would be approximately 49 mgd.

Water Supply

Using its supplies diverted directly from the San Joaquin River (when river water quality is acceptable) and water it purchases from CCWD, the City will have ample water supply through 2035. For the river supply, existing facility capacities limits pumping. However, minor piping improvements would allow the City to increase river pumping capacity by up to 25 percent. A rough cost comparison based on data supplied by City staff shows a cost advantage for pumping river water of about $1,850 per million gallons (MG) compared to purchasing raw water from CCWD using current CCWD raw water rates. The most cost-effective water purchase strategy for Antioch to follow is that presently in use; that is, pump as much river water as possible when water quality permits and otherwise depend on the Contra Costa Canal (Canal). In addition, the City may find it advantageous to explore developing new wells in the southeast, if only to offset irrigation needs for schools, playing fields, etc. The City also plans to expand its recycled water use wherever it is cost effective.

Water Quality

The Antioch WTP produces high-quality drinking water, which met all existing federal and state primary and secondary standards in 2012. Given the consistently careful operation of existing facilities, such performance is expected into the future. More stringent regulations that would require WTP modifications are not expected, at least for the next decade, but the City likely will need to carry out more sampling and analyses in response to federal and state concerns about currently unregulated constituents. The City now practices both pre-chlorination and post-chloramination to disinfect water. If future regulations on disinfection practices and results become more stringent, the City may want to consider using potassium permanganate to remove disinfection by-products (DBP) precursors and reduce trihalomethane (THM) precursors prior to chlorination. Converting to ultraviolet disinfection or applying ozone would be other options.

Raw Water. Owing to its age, the raw water system needs rehabilitation in several areas, which includes rehabilitating or reconstructing the river pumping station. An evaluation of the raw water pipelines connecting the Municipal Reservoir to the WTP is recommended and the City should consider connecting the raw water pipeline from the river to the WTP and constructing a parallel pipeline from the Municipal Reservoir to the WTP. The Municipal Reservoir may require some dredging or renovations to maintain or expand its storage capacity and water quality.

Water Distribution System. The existing water distribution system overall is in good condition but will require modifications and improvements to remedy existing deficiencies and to accommodate projected development in the northeast and southeast, especially Lone Tree Valley and areas further south. By elevation, much of the southeast area is at or above Zone IV East elevations. When development is planned for this area, a detailed analysis should determine the size required for the booster pump station (BPS), reservoir storage and water mains. Zones III East and IV East currently (or will) serve mainly new residential construction. The City could use existing and proposed pressure-regulating stations to transfer water from higher to lower zones to make up for storage shortfalls in Zone I and Zone III East.

Older neighborhoods with corroding or undersized water mains should have their water systems strengthened by selectively replacing these pipes to conform to current City standards. Since completion of the last Master Plan Update in 2001, the State of California has adopted an updated fire code that requires interior fire sprinklers for all new residential construction and major renovations. Operating fire sprinklers requires a pressure at the customer meter of about 55 pounds per square inch gage (psig), which is significantly above the previous City design pressure of 40 psig. In response, the City will need to modify its design criteria for new residential development.

The City's booster pumping stations generally have required capacity but will need ongoing upgrades and renovation (e.g., changing out the pumps, control valves, electrical equipment and controls for the Hillcrest BPS) as equipment wears. The Sunset BPS needs to be replaced since its fire flow pump is inoperative and its equipment is old and located in a below-grade vault.

The supervisory control and data acquisition (SCADA) system used to operate both the WTP and the distribution system is obsolescent and incomplete. To operate more efficiently, the City should develop a SCADA master plan to identify system improvements, costs, and implementation schedule.

Storage Requirements and Facilities. The City currently has approximately 20 MG of treated water storage in Zones I, II, III East, III West, IV East and IV West. Based on the criteria used by the City to calculate storage needs, existing storage is sufficient through 2035. This balance of capacity versus requirements assumes that some higher elevation storage is made available to lower zones through pressure-regulating stations, most of which already exist. Future development at elevation above Zone IV in the southeast and Sierra Vista in the southwest, will require additional storage.

Several existing reservoirs would benefit from internal mixing systems to help maintain distribution system water quality. All of the City's reservoirs currently are being evaluated for seismic durability. When those results become available, the City will add required projects to its capital improvement plan (CIP). The 3.0 MG and 0.5 MG reservoirs likely will require recoating in the next 20 years.

WTP Improvements. Adequate capacity exists now at the City WTP to provide the maximum day demand through the year 2035.

The City currently meets all federal and state regulations for its treated water. No currently proposed regulations would affect the City's water treatment processes, and no new regulations are expected at least in the next decade. Regulators likely will require additional monitoring for constituents that are unregulated now. Minor improvements and upgrades are recommended to continue the City's compliance with current and future regulations.

Capital Improvement Program. Based on the recommendations presented in this Master Plan Update, a CIP through the year 2035 has been prepared to provide safe and reliable water delivery to the City's residents and safe operating conditions for its staff. The total capital cost of the program is estimated at $57 million in January 2013 dollars. Table ES-1 provides a summary of the CIP, with costs divided among major project categories and by priority. The CIP focuses on recommended improvements for the raw water system, distribution system and WTP.

Table ES-1. Summary of 20-Year Water System Capital Improvement Plan

Category	Cost[a] (thousand dollars)		
	Priority 1	Priority 2	Total Cost
Raw Water	1,340	8,000[b]	9,340
Water Treatment	4,060	9,440	13,500
Water Mains	2,397	9,543	31,940[c]
Pressure Regulating Stations	640	105	745
Booster Pumping Stations	830	500	1,330
Reservoirs	-	300	300[d]
Reservoirs and Booster Pumping Stations - Seismic Durability Assessment	-	-	200
Total	9,267	27,888	57,3555

Notes:

[a]Costs are current to January 2013 order-of-magnitude cost for the San Francisco Bay Area.

[b]Includes $2.6 million for new Antioch Municipal Reservoir outlet tower and pipeline under the dam and $5.1 million for parallel raw water pipeline to WTP.

[c]Includes an annual expenditure of $1.0 million for 20 years for smaller water main replacement.

[d]Does not include possible interior recoating of 0.5 MG and 3.0 MG reservoirs since the date for this work is unknown.

Project priorities were established based on factors such as inadequate fire flow delivery with the current system, addressing potential health and safety risks, meeting current state codes, and minimizing operating costs.

Table ES-2 summarizes the more significant, higher priority projects that the City should consider implementing in the next 10 years.

Table ES-2. Proposed Higher Priority Projects

Category	Project Description	Cost[a] (thousand dollars)	Driver
Raw Water			
	River Pumping Station Reconstruction	460	Restoration of full capacity to save water purchase costs.
	Raw water pipeline condition assessment	300	Exploration of capacity limitations.
	Raw water pipelines cleaning	500	Debris removal from pipelines to improve hydraulic efficiency and water quality.
Water Treatment Plant			
	Sludge lagoon upgrade	1,800	More reliable WTP operation without surface water discharge.
	Miscellaneous smaller project	2,000	The WTP needs several improvements to address aging equipment (e.g., Plant A electrical equipment, new regulations, and upgrades to existing systems for better functionality.
	Plant sludge handling improvements	150 to 9,150[b]	Conduct an engineering study to determine whether the City should build new sludge thickening and dewatering facilities or continue to contract out for equipment and maintenance, determining which alternative is most cost effective. Design and construction a new sludge handling facility if necessary.
Water Mains/Water Distribution			
	Interconnection with neighboring agencies for mutual assistance	2,800	The City's water distribution system has limited capacity to transfer water to or receive water from adjacent communities. These projects would greatly enhance that capability.
	Annual water main replacement	10,000	Construct replacement, parallel or new water mains over the next decade, to replace deteriorated older mains, improving overall water service dependability and deliver required fire flows.
Water Supply			
	River pump to WTP direct connection	150	Install buried pipe, valves and fitting to connect the raw water pipeline from the River PS to the raw water transfer pipeline from the canal and Municipal Reservoir.
Pressure Regulating Stations			
	Priority 1 projects (as listed in Table 7-5)	640	The City uses pressure reducing stations (PRSs) to reinforce water delivery between pressure zones especially for fire flows and backup supplies during outages.
Booster Pumping Stations			
	Sunset BPS replacement	700	Aging equipment replacement, service improvement, and maintenance access.
Water Treatment and Distribution			
	Water system seismic durability evaluation	300[c]	Study of existing facilities to determine seismic durability and identify opportunities to make cost-effective improvements to enhance durability
Total		19,100 to 28,100[b]	

Notes:

[a]Costs are current to January 2013 order-of-magnitude cost for the San Francisco Bay Area.

[b]With and without new sludge thickening/dewatering facilities construction

[c]$100,000 for WTP and $200,000 for reservoirs and BPSs.

Recommendations

Selected major recommendations to improve water system reliability and operability and to address aging infrastructure include:

- Replace worn river pump and some peripheral equipment.
- Upgrade Antioch Municipal Reservoir for operability and water quality.
- Conduct raw water pipelines condition assessment. If condition assessment shows debris accumulation, clean the pipelines and also consider constructing a parallel raw pipeline from the Municipal Reservoir to the WTP with new outlet tower.
- Improve WTP for overall operability, reliability and safety.
- Prepare a SCADA system master plan as a first step to improve operability and security through a SCADA system upgrade.
- Update the water system distribution model periodically to incorporate new information based on water system improvements and more accurate data gathered from other sources, e.g., more accurate elevations from updated surveying and water demands extracted electronically from billing records.
- Revise pressure design criteria for new residential developments to ensure fire code compliance for interior fire sprinklers.
- Continue to replace older, smaller-diameter mains in older neighborhoods.
- Improve inter-zone connectivity with more pressure-reducing stations.
- Add new mains to deliver better fire flows to northeast Antioch.
- Replace the Sunset BPS.
- Consider implementing a computerized maintenance management system (CMMS) to plan and track preventative and corrective maintenance.
- Recondition the Wilbur BPS and construct new water mains to improve the City's capacity to receive water from and send water to adjacent utilities.
- Improve interconnections with the City of Pittsburg and Diablo Water District using new, parallel water mains and rehabilitation of the Wilbur Booster Pumping Station.

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Section 1

Introduction

The City of Antioch (City) population has grown from about 82,000 in 1998 to approximately 103,000 in 2012. Over the past decade, water use patterns have changed both in the City and throughout the state, and the City has expanded its water treatment plant and made other modifications to its system.

Brown and Caldwell (BC) has conducted the six prior major water system planning studies for the City, the most recent of which was entitled Water System Master Plan Update. This 2001 update was an amendment to the 1999 water system planning study. This report, which is a comprehensive update of the 2001 Water System Master Plan Update, estimates water demands through 2035 years and recommends raw water, water treatment facility and distribution system improvements to accommodate these demands and to address rehabilitation or replacement of aging facilities.

Section 2 provides a description of the existing distribution system that has the updated zoning and pressure zone maps, schematic representation of the distribution system, location for key facilities, population data, and tabulation of key facilities data. Section 2 also presents projected population increases and proposed expansions to the system service area.

Section 3 includes estimated water demands over the next 20 plus years and includes adjustments for water conservation, provision of recycled water and recent City projections of land use changes. Recycled water demand projections were made available from Delta Diablo Sanitation District (DDSD). Projected demands were divided among pressure zones and pressure zone boundary adjustments were recognized.

Section 4 includes an evaluation of the quality and quantity of existing water sources with respect to potential impacts of future development and of prospective state and federal regulations. Information is compiled for potential changes in the near term (5 to 10 years). Data and compliance by the City with possible modified regulations is evaluated. Information from the Contra Costa Water District (CCWD) and the Bay-Delta process summarizing the City's current water rights and available water resources are presented as well.

Section 5 includes an assessment of the City's water storage and pumping criteria. This assessment was completed using projected demands by pressure zone from Section 2. Existing storage and pumping were evaluated from past planning for the City. Current performance of the distribution system was analyzed. Flow tests were performed on approximately 20 fire hydrants throughout the City to develop a hydrant flow test protocol. Emergency water interties among Delta Diablo Water District, CCWD and the City of Pittsburg were documented.

Section 6 includes a review of the need for expanding and improving the existing water treatment facilities. An estimate of existing treatment capacity was made based on operating records and on-site evaluation. Options and schedules for continued renovation of the facilities were established. Factors such as changing regulations and options for treatment and disposal of water treatment residuals were considered.

Section 7 includes a prioritized Capital Improvement Program (CIP) with cost estimates for the identified improvement projects. Summaries for 10 of the capital projects within the first five years of the CIP are included, with descriptions of construction improvements and required planning, permitting, design and construction, and estimated time periods for all activities.

1.1 Authorization

The City authorized this study in an Agreement and Notice to Proceed dated August 15, 2012. In May 2014, the City authorized BC to modify the 2013 Update,

Section 2

Existing System and Study Area Characteristics

This section describes the existing water system facilities and summarizes the study area characteristics.

2.1 Service Area Description

The Antioch water system serves about 31, 300 connections within Contra Costa County (as of 2012). The existing service area covers 28.8 square miles serving elevations from near sea level up to about elevation 400 feet, and includes the area within the City limits and some adjacent land to the northeast and the west, as shown on Figure 2-1. The area's Mediterranean climate reduces winter water demands and causes much higher demands in hot summer months.

2.2 Existing Sources of Supply

The principal sources of raw water supply are the San Joaquin River and the Contra Costa Canal (Canal). Section 4 describes these sources in more detail. Canal water, purchased from CCWD, is pumped from Rock Slough and Old River in the western Delta and from the Victoria Canal in the central Delta. The City can pump water from the Canal either into the Municipal Reservoir or directly to the water treatment plant (WTP). The City has pumped river water to the Municipal Reservoir since about 1965 owing to the City's I wastewater effluent discharge near the river pumping station intake in the 1960s. The City's effluent discharge ended 30 years ago, thus the City is now exploring pumping river water directly to the WTP. The WTP has a maximum capacity of about 37 million gallons per day (mgd). Treated water flows into two 1.0 million gallon (MG) clearwells (Clearwells A and B) before entering the distribution system. The City also has a contract to purchase treated water from CCWD that is drawn from the CCWD Multipurpose Pipeline, and adds such water directly to the City's distribution system at the Hillcrest Booster Pumping Station (BPS).

2.3 Existing Distribution System

The existing distribution system serves six major and two smaller pressure zones as discussed below (see Figure 2-1 for pressure zone locations). In addition, the City has created three reduced-pressure zones that draw water from Zone II through pressure-regulating stations. Figure 2-2 presents a hydraulic schematic diagram of the existing water system. Table 2-1 summarizes the existing storage facilities and BPS by zone. Table 2-2 summarizes the existing normally operated control valves. The ground elevation ranges from 0 to 410 feet as summarized in Table 2-3. The distribution system has more than 1.7 million linear feet (about 320 miles) of water mains. Table 2-4 summarizes approximate pipe lengths by diameter in each pressure zone.

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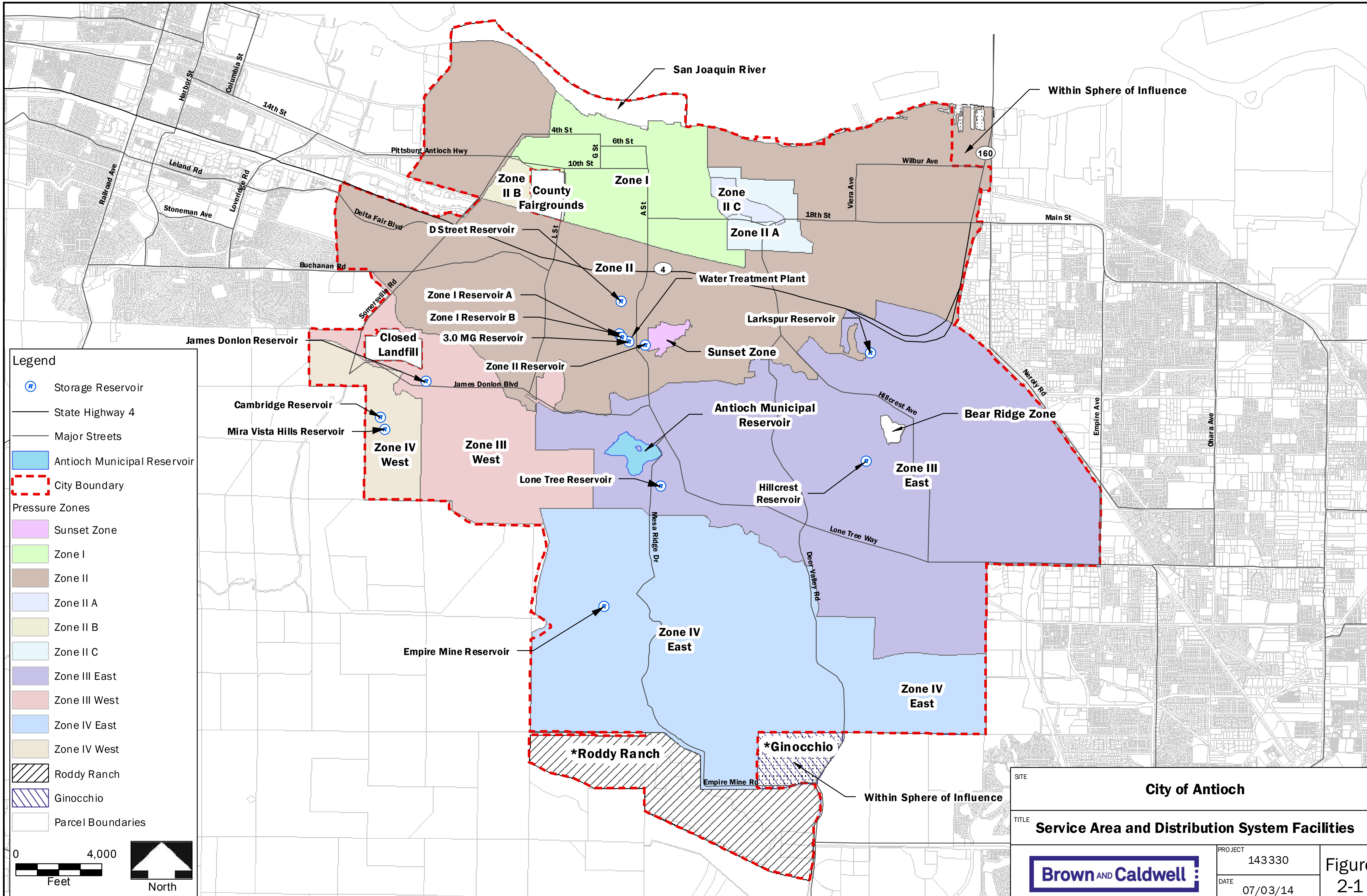

SITE

City of Antioch

TITLE

Service Area and Distribution System Facilities

Brown AND Caldwell

PROJECT 143330

DATE 07/03/14

Figure 2-1

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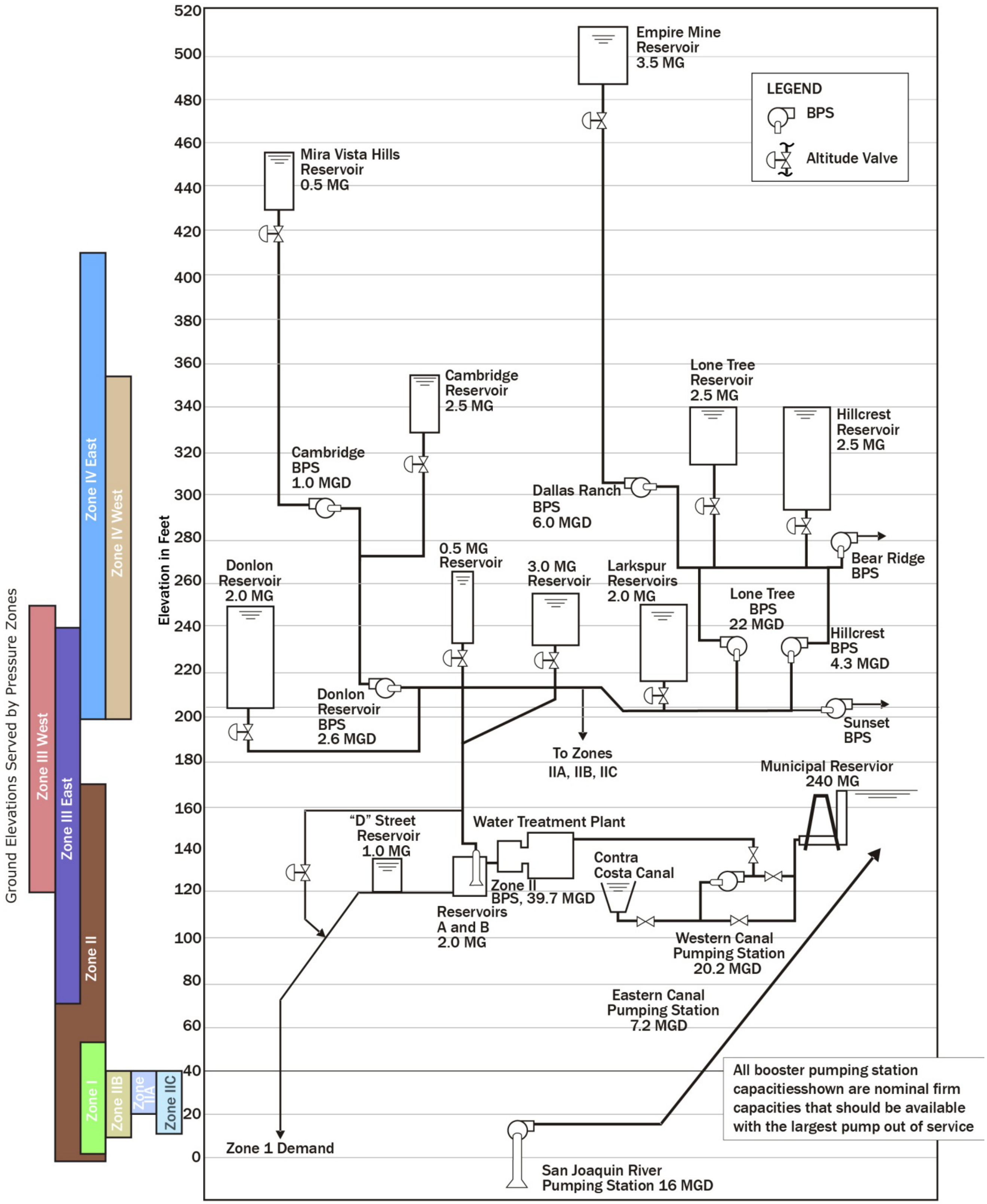


Figure 2-2. Existing Water System Schematic

Table 2-1. Existing Reservoir Storage and Booster Pumping Station Capacity[a]

Zone	Booster Pumping Station						Reservoir				Comments
	Name	Configuration, Number and gpm	Total Dynamic Head (TDH), ft	Firm Capacity[b], mgd	Intake Zone	Supply Zone	Name	Volume, MG	Key Elevations Overflow/Base, ft	Service Elevation Range, ft	
I	Zone I	3 @ 3,300 1 extra slot	120	9.5	Zone I	Zone I	"D" Street Clearwell A Clearwell B	1.0 1.0 1.0	133.5/120 133.5/118.5 133.5/118.5	0 to 50	
II	Zone II BPS A	4 @ 2,400 1 @ 800	125	39.7	Zone I	Zone II	0.5 MG 3 MG James Donlon Larkspur	0.5 3.0 2.0 2.0	264/229 256/230 248/200 248/216	0 to 170	
	Zone II BPS B	4 @ 4,800 1 @ 2,400	125		Zone I	Zone II					
	Wilber Avenue[c]	1 @ 2,000	265	5.8	Zone II/Diablo Water District/City	Zone II/Diablo Water District/City					
III East	Hillcrest	3 @ 1,500 1 extra slot	94	4.3	Zone II	Zone III East	Hillcrest Lone Tree	2.5 2.5	340/292 340/308	70 to 240	
	Lone Tree No.1	3 @ 1,800 1 extra slot	120	5.2	Zone II	Zone III East					
	Lone Tree No. 2	3 @ 3,600	130	10.4	Zone II	Zone III East					
III West	Donlon	2 @ 1,200 1 @ 600 + 1 slot @ 1,200	149 140	2.6	Zone II	Zone III West	Cambridge	2.5	355/320	130 to 255	
IV East	Dallas Ranch	4 @ 1,400	212	6.0	Zone III East	Zone IV East	Empire Mine	3.5	510/485	175 to 410	
IV West	Cambridge	2 @ 250	131	0.36	Zone III West	Zone IV West	Mira Vista Hills	0.5	455/417.5	200 to 355	
Bear Ridge	Bear Ridge	Four 5-hp@ 55	49	0.2	Zone III East	Zone Bear Ridge	--	--	--	--	
Sunset	Sunset Lane[d]	Two 5-hp (capacity unknown)			Zone III East	Sunset Zone	--	--	--	--	

[a] *These facilities are existing in 2012.*

[b] *Firm capacity is booster pumping capacity that should be available with the largest pump out of service.*

[c] *Currently out of service.*

[d] *Sunset BPS also includes a fire flow pump, but City staff does not use it because it raises the service pressure above acceptable levels City staff has no flow meter from which to record actual pump output.*

Table 2-2. Water System Control Valves (Pressure Reducing Valves [PRVs] and Zone Separation)

Location	Valve Type	Upstream Zone	Downstream Zone	Size (inches)	Operating Setting, psi
W. 4th & N Street	PRV	II	I	12	50
W. 10th Street & Crestview Drive	PRV	II	IIB	8	70
W. 18th Street & Auto Center Drive	PRV	II	IIB	6	70
W. 18th Street & L Street	PRV	II	I	6	45
Wilbur Avenue & Minaker Road	PRV	II	IIC	12	67
Cavallo Road & E. 13th Street	PRV	IIC	I	8	65
E 18th Street & Terrace Drive	PRV	IIA	I	8	62
E. 18th Street & Hillcrest Avenue	PRV	IIA	IIC	6	72
E. 18th Street & Hargrove Avenue	PRV	II	IIA	8	62
Hillcrest Avenue & Arzate Lane	PRV	II	IIA	8	48
James Donlon Boulevard & Blythe Boulevard	PRV	IIIE	II	6	56
James Donlon Boulevard & Nightingale Drive	Zone valve	NA	NA	6	56
James Donlon Boulevard & G Street	PRV	IIIE	II	6	70
Prewett Ranch Drive & Deer Valley Drive[a]	PRV	IVE	IIIE	12	50

[a]*Temporarily out of service.*

Table 2-3. Pressure Zone Service Elevations

Pressure Zone	Ground Elevations Served, ft
I	0 to 50
II	0 to 170
IIA	10 to 55
IIB	10 to 50
IIC	10 to 30
III East	70 to 240
III West	70 to 255
IV East	220 to 410
IV West	220 to 355
Sunset	95 to 222
Bear Ridge	225 to 270

Table 2-4. Pipeline Lengths by Diameter by Pressure Zone							
	Pipe Length, LF						
Pressure Zone	4-inch Diameter or Smaller	6- to 8-inch Diameter	10- to 12-inch Diameter	14- to 16-inch Diameter	20- to 24-inch Diameter	30- to 36-inch Diameter	Total
I	9,140	161,235	52,091	18	9,394	-	231,879
II	10,115	376,382	128,252	51,340	18,843	1,786	586,718
IIA	-	14,751	4,513	-	-	-	19,264
IIB	-	6,268	4,929	-	-	-	11,197
IIC	1,050	8,690	2,800				12,540
III East	1,894	345,772	152,427	68,458	23,736	-	592,287
III West	45	60,772	16,507	7,416	-	-	84,739
IV East	-	92,924	58,479	19,030	5,135	-	175,568
IV West	-	19,974	12,149	4,045	-	-	36,168
Sunset	-	1,828	2,049	-	-	-	3,877
Bear Ridge	30	1,800	2,200	-	-	-	4030

Note: Pipeline lengths were estimated from the City GIS data base.

2.3.1 Pressure Zone I

The Pressure Zone I distribution system serves the older residential sections of the City, the original central business district, and some major industrial users. Ground elevations range from sea level to 50 feet. Zone I has a static hydraulic grade of 133.5 feet. The principal water feed to Zone I is a 24-inch diameter gravity main from the Clearwells A and B. The City has not used the Zone I BPS since the 1970s. The Zone I BPS is out of service because the high demands from the food processing industry have disappeared, the City also had transferred some Zone I demands to Zone II (e.g., east along Wilbur Avenue), and the City has four pressure-reducing valves (PRVs) to support Zone I from Zone II. These PRVs are located on 4th Street near the Public Works Maintenance Center, on L Street north of Sycamore, on East 13th Street east of Cavallo (from Zone IIC) and East 18th Street near Terrace Drive (from Zone IIA). The City has several older emergency interconnections that could be activated in an emergency or in the event that the Zone I 24-inch diameter main is out of service and the PRVs cannot supply sufficient water.

Zone I has one 1.0 MG reservoir, "D" Street Reservoir, located on the 24-inch diameter main, to sustain adequate pressures during periods of high demand and to hold fire flow and emergency reserves. For planning purposes, the City also assumes that 1.0 M of 2.0 MG in Clearwells A and B is available to support Zone I.

The principal mains in Zone I are 6-, 8-, 10-, 12- and 24-inches in diameter. In this older area of the City, many of the distribution mains have 4- and 6-inch diameter mains. City line maintenance staff has reported that the 4- and 6-inch diameter mains are especially affected by tuberculation and, to some extent, external corrosion. During the past three decades, the City has initiated a program to replace such corroded or undersized pipes.

2.3.2 Zone II

Pressure Zone II serves primarily residential and commercial users and has ground elevations ranging from sea level to 170 feet. It also serves some industrial users along the eastern end of Wilbur Avenue. Zone II has a static hydraulic grade line of 256 feet.

The system is supplied by two Zone II BPS—one built in 1967 and one built in 1988—which take suction from the WTP Clearwells A and B. The older BPS (Zone II BPS A) contains four vertical turbine pumps, each rated at 2,400 gpm at 125 feet total dynamic head (TDH). The 1988 BPS (Zone II BPS B) now includes four pumps each rated at 4,800 gpm at 125 feet TDH, and a fifth pump rated at 2,400 gpm at 125 feet TDH. Another pump rated at 800 gpm at 125 feet THD is located directly over the Clearwell A. The total firm Zone II BPS capacity (assuming the largest pump in either BPS is out of service) is about 39.2 mgd. The WTP has two standby generators capacity available to operate three smaller and three larger Zone II booster pumps should a power outage occur (about 31 mgd capacity), with space for an additional emergency generator to support ultimate firm capacity.

Zone II has four water storage reservoirs. A 3.0 MG reservoir with an overflow elevation of 256 feet and 0.5 MG reservoir with an overflow elevation of 264 feet are located across Lone Tree Way from the WTP and on the WTP site, respectively. Two altitude valves prevent flow into the larger reservoir when the grade line exceeds an elevation of 256 feet. Donlon Reservoir in the west and the Larkspur Reservoir in the east are 2.0 MG reservoirs with overflows at an elevation of 248 feet. The City has reserved space available adjacent to the Larkspur Reservoir for a second reservoir of at least 2.0 MG.

Zone II also supplies one isolated area above 170 feet in elevation through the small Sunset BPS. This station contains no standby power equipment and is generally difficult to access and maintain since it is located in a below-grade vault. City staff cannot operate the Sunset BPS fire flow pump because it raises the local pressures excessively. For these reasons, City staff considers this equipment to be unreliable. About 4,000 feet of street separate this area from Zone III East.

The principal water mains in Zone II have 6-, 8-, 10-, 12- and 16-inch diameters.

2.3.3 Zone III East

Pressure Zone III East encompasses much of the newer residential and commercial growth in the City. Zone III East generally extends south from the canal, with some development north of the canal in the eastern portion of the City. It is bounded on the west by Contra Loma Regional Park and on the east by a Southern Pacific Railroad right-of-way. The zone border extends south to the city limits generally extending to about Sand Creek in its southeast area. Zone III East has a static hydraulic grade line of 340 feet.

Three BPSs, Hillcrest, Lone Tree No. 1 and Lone Tree No. 2, and two reservoirs, Hillcrest and Lone Tree, serve Zone III East. Hillcrest BPS contains three pumps, each rated at 1,500 gpm at 94 feet of TDH. Its firm capacity is currently about 4.0 mgd. There is space for a fourth matching pump, with a future firm capacity of up to 6.0 mgd. The Lone Tree No. 1 BPS has three 1,800 gpm pumps with a firm capacity of 5.2 mgd, supported with standby power facilities. The BPS has space for a fourth pump to increase the firm capacity to 7.8 mgd. The Lone Tree No. 2 BPS has three 3,600 gpm pumps with a firm capacity of 10.4 mgd, supported with standby power facilities. Both Hillcrest and Lone Tree Reservoirs have 2.5 MG capacity with an overflow elevation of 340 feet.

The principal water mains in Zone III East have 6-, 8-, 10-, 12-, 16-, 20-, and 24-inch diameters.

2.3.4 Zone III West

Zone III West is a developed residential area on the west side of the City. Most existing development is residential. After completion of the planned developments at Black Diamond Ranch, this zone will encompass about one square mile. It is bound by the Canal, Black Diamond Mines Regional Park, Contra Loma Regional Park, and the City limits. Donlon BPS serves Zone III West; the BPS fills the Cambridge Reservoir. Zone III West has a static hydraulic grade line of 355 feet when the Cambridge Reservoir is operated full.

Donlon BPS has two 1,200-gpm pumps and one 600-gpm pump, with space to add one additional 1,200 gpm pump. The current firm capacity of the BPS is 2.6 mgd, supported with standby power facilities. When the fourth pump is added, firm capacity will increase to 4.3 mgd. This BPS fills Cambridge Reservoir, which has a 2.5 MG capacity and an overflow at elevation 355 feet. City staff currently operates the Cambridge Reservoir with a maximum water surface elevation about 10 feet below its overflow, to maintain better distribution system water quality (discourage nitrification).

Water mains of 6-, 8-, 10-, 12-, and 16-inch diameters serve the existing Zone III West development.

2.3.5 Zone IV East

Zone IV East includes all of Higgins Ranch and parts of Dallas Ranch, Black Diamond Knolls, and Diablo West developments. Zone IV East is bound by Contra Loma Regional Park on the west, Zone III East on the north and east, and the Urban Limit Line on the south. The Dallas Ranch BPS serves Zone IV East. Zone IV East has a static hydraulic grade line of 510 feet. It includes four 1,400-gpm pumps (a firm capacity of about 6.0 mgd) and is supported with standby power facilities. The BPS conveys water to Zone IV East and to the Empire Mine Reservoir. The reservoir has a capacity of 3.5 MG and an overflow elevation of 510 feet. The Zone IV East development is served by 6-, 8-, 10-, 12- and 16 inch diameters mains.

2.3.6 Zone IV West

The Zone IV West facilities serve the higher elevations of the Mira Vista Hills Subdivision and the higher elevations in Black Diamond Ranch. Zone IV West has a static hydraulic grade line of 455 feet. The Cambridge BPS serves Zone IV West. It has standby power facilities to convey about 0.5 mgd into Zone IV West and the Mira Vista Hills Reservoir. The Cambridge BPS has two pumps producing about 250 gpm each with a firm capacity of about 0.36 mgd. In mid 2014, the City added two pumps (each rated at about 1,000 gpm) to the Cambridge BPS to increase its firm capacity to about 1.4 mgd. In the future, Zone IV West will be used to convey water to the south to the proposed higher-elevation Sierra Vista Development. Zone IV West is served by 6-, 8-, 10-, 12- and 16-inch diameters mains.

2.3.7 Land Use Characteristics

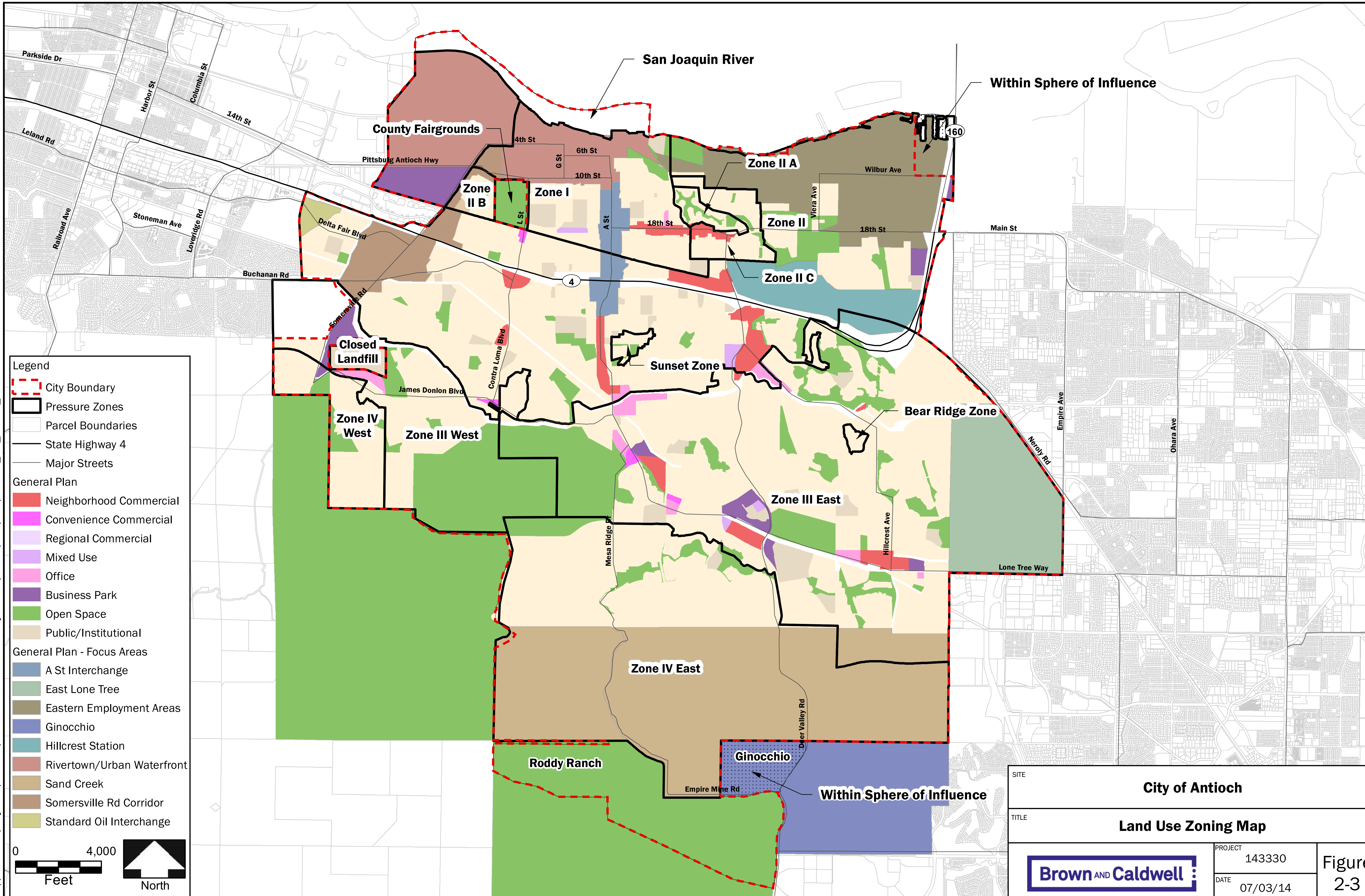
Current land use plans, proposed development, and population projections are factors that influence the pattern of future water demand throughout the system and thus the location of future system expansion. Information on future land use has been compiled from the current Antioch General Plan.

2.3.8 Study Area

For the purpose of analyzing future distribution system expansion, the study area has been defined as the area encompassing all land that may be developed through build-out and for which the City is likely to be relied on for water service. This area includes the existing service area. It extends as far south as Horse Valley and as far east as the Antioch Bridge. A total of approximately 32 square miles is contained within the study area. The study area extends to the boundaries for Antioch's Urban Limit Line as the probable ultimate physical boundaries and service areas for Antioch.

2.3.9 Population Forecasts and Future Development

The City divides the study area into industrial, commercial, and residential land use areas. Figure 2-3 provides an overview of existing land use planning designations based on the current Antioch General Plan and Use Element Map. Historical water records, described in Section 3, indicate that a more detailed differentiation between land use types is not required for distribution system planning.



SITE City of Antioch

TITLE Land Use Zoning Map

Brown AND Caldwell

PROJECT 143330

DATE 07/03/14

Figure 2-3

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Historical and projected population data are from the City's 2010 UWMP. Data from the California Department of Finance (DOF) serve as the basis for the City's past and current population (Table 2-5). Population projections have been based on statistics compiled by the Association of Bay Area Governments (ABAG). When compared to the 2009 ABAG Projections, DOF data are lower for years 2000, 2005, and 2010. Population projections, as shown in Table 2-5, for 2015, 2020, 2025, 2030 and 2035 are based on ABAG data and assume that the occupancy rate rises one percent per five-year period (i.e., 96 percent in 2015, 97 percent in 2020, 98 percent in 2025, and 99 percent in 2030 and 2035).

Table 2-5. Population by Pressure Zone

Pressure Zone	Year							
	2000	2005	2010	2015	2020	2025	2030	2035[b]
I	7,287	7,956	8,054	8,263	8,455	8,668	8,872	8,934
II	40,269	44,783	44,527	45,501	45,760	45,906	46,261	46261
IIA	645	705	693	709	720	730	740	740
IIB	401	443	469	482	500	521	539	539
IIC	1,726	1,845	1,821	1,867	1,896	1,923	1,952	1,952
III East	25,614	28,241	29,178	30,942	32,669	34,105	35,703	36833
III West	5,530	6,108	6,112	6,298	6,652	6,394	6,417	6,417
IV East	7,877	8,700	10,222	10,885	11,100	11,335	11,494	11,624
IV West	660	730	731	755	769	783	796	796
Sunset	344	344	344	344	344	344	344	344
Bear Ridge	178	178	178	178	178	178	178	178
Total Population[a]	90,952	100,0035	102,330	106,228	108,743	110,888	113,298	114,619

[a]*Total population for the years 2000, 2005, and 2010 are based on DOF data from Table 2: E-5 City/County Population and Housing Estimates (2010). Compared to ABAG Projections 2009: Forecasts for the San Francisco Bay Area for the City sphere of influence, DOF population estimates are lower because they account for occupancy rates. Future population projections for 2015, 2020, 2025, 2030 and 2035 are based on ABAG projections and assume that the occupancy rate rises one percent per 5-year period (i.e., 96 percent in 2015, 97 percent in 2020, 98 percent in 2025, and 99 percent in 2030 and 2035). During 2015 UWMP update, the City should recalculate these projections based on current information.*

[b]*Demand assumes 75% completion of proposed developments for FUA 1 (based on planning information from Carlson Barbee and Gibson via personal communication).*

Future industrial development likely will occur in Zones I and II along the major transportation routes. Zone III East also has small areas zoned as industrial. The remainder of the General Plan study area is likely to develop to residential and commercial uses. Residential water requirements vary on a per-acre basis, depending on the density of dwelling units and the number of persons per dwelling unit. Based on data from DOF, 3.0 is the average number of people per household.

Tables 2-5 and 2-6, respectively, summarize the population and land use acreage projections by pressure zone used in this study.

Table 2-6. General Plan Land Use by Pressure Zone

Land use	Land Use, Acres										
	I	II	IIA	IIB	III East	III West	IV East	IV West	Sunset	Bear Ridge	Total
Estate Residential 1 DU/AC[a]	-	-	-	-	0	81	215	158	-	-	454
Low Density Residential 4 DU/AC		82	-	-	1,339	165	-	36	-	21	1,643
Medium Low Density Residential 6 DU/AC	473	1,904	90	51	1,364	362	221	105	35	-	4,605
Medium Density Residential 10 DU/AC	13	60	-	-	32	0	-	-	-	-	105
High Density Residential Up To 20 DU/AC	62	206	0	6	39	0	-	-	-	-	313
Mixed Use	8	16	-	-	9	-	-	-	-	-	33
Neighborhood Commercial	28	180	20	-	91	-	-	-	-	-	319
Convenience Commercial	0	10	-	-	13	1	-	-	-	-	24
Office	4	23	-	-	67	22	-	-	-	-	116
Business Park	-	78	-	0	73	44	-	-	-	-	195
Public/Institutional	93	126	0	0	168	0	12	-	0	-	399
Open Space	57	280	6	6	787	625	1136	36	7	-	2,940
Focus Areas (Southeast Antioch)	483	2,282	0	28	1,710	195	1,579	-	-	-	6,277
Other	1	326	-	0	270	65	0	0	-	-	662
Total	1,222	5,573	116	91	5,962	1,560	3,163	335	42	21	18,085

Note: County Fairgrounds (77 acres) and Pittsburg Dump (76 acres) are not included in the acreage in this table.

Source: Landuse shapefiles provided by the City Public Works Department, GIS Division. Landuse Map updated in 2007/2008, updated to reflect deletion of the Chevron property from the City sphere of influence and revised land use for Roddy Ranch.

[a]DU/AC = dwelling unit/acre

Section 3

Projected Water Use

This section presents estimates of future water use based on historical water use, population projections, and land-use projections by pressure zone as presented in Section 2. The projected water requirements for average-day, maximum-day, and peak-hour demand are used as design requirements for planning the future distribution system needs in Section 5.

3.1 Historical Water Use

Table 3-1 presents historical water use from 1975 to 2012, and Figure 3-1 provides a graphical representation of Table 3-1's historic water use trends and the maximum-day demand to average-day demand ratios. In general, average day use steadily increased after the severe drought of 1976 to 1977 with several exceptions—demands declined in the early 1990s due to a drought, in 1998 likely due to the heavy El Niño rainfall, and from 2008 to 2012 potentially due to voluntary water conservation during a drought period and/or the economic recession. The recession has encouraged reduced water use directly to save money. As economic conditions improve and some drought-driven conservation abates, the City suspects that water use for existing developed areas may increase.

Table 3-1. Historical Water Production

Year	Average Day, mgd	Maximum Day, mgd	Ratio
1975	6.87	13.74	2.00
1976	5.98	12.43	2.08
1977	3.07	6.18	2.01
1978	4.93	9.13	1.85
1979	5.68	10.22	1.80
1980	5.86	10.44	1.78
1981	7.23	12.71	1.76
1982	6.64	11.62	1.75
1983	6.98	12.80	1.83
1984	8.00	14.02	1.75
1985	8.43	14.68	1.74
1986	9.05	15.01	1.66
1987	9.85	16.26	1.65
1988	9.95	16.50	1.66
1989	10.12	17.98	1.78
1990	11.60	19.16	1.65
1991	9.32	14.39	1.54
1992	10.75	16.98	1.58

Table 3-1. Historical Water Production			
Year	Average Day, mgd	Maximum Day, mgd	Ratio
1993	11.58	19.17	1.66
1994	12.81	21.48	1.68
1995	12.93	22.24	1.72
1996	14.27	24.29	1.70
1997	15.11	25.32	1.68
1998	13.64	25.94	1.90[a]
1999[b, c]	15.81	27.40	1.73
2000[b, c]	16.15	26.24	1.62
2001[b, c]	17.41	28.27	1.62
2002[b, c]	17.92	29.63	1.65
2003[b, c]	17.52	29.39	1.68
2004[b, c]	18.56	28.35	1.53
2005[b, c]	18.25	30.71[f]	1.68
2006[b, c]	17.50	32.47[f]	1.86
2007[b, c]	19.08	31.14[f]	1.63
2008[b, g]	18.12	28.86[f]	1.50
2009[b, g]	16.19	27.01	1.67
2010[d, g, h]	15.35	26.50	1.73
2011[e, g, h]	15.5	25.88	1.67
2012[g, h]	15.98	26.13	1.64

[a] *This value is high partly due to an atypically low average-day production.*

[b] *Source: Average day demand data obtained from Public Water System Statistics submitted by the City to the California Department of Water Resources.*

[c] *Source: Maximum day demand data received from Lori Sarti from the City via email on 11/08/12.*

[d] *Source: Data received from Phil Harrington from the City via email on 03/09/11.*

[e] *Source: Average day demand data received from Lori Sarti from the City via email on 11/08/12.*

[f] *Maximum day demand data include demand from the CCWD multipurpose pipeline.*

[g] *Source: Maximum day demand data received from Lori Sarti from the City via email on 01/07/13.*

[h] *The production data were received from the City after the 2010 UWMP was produced.*

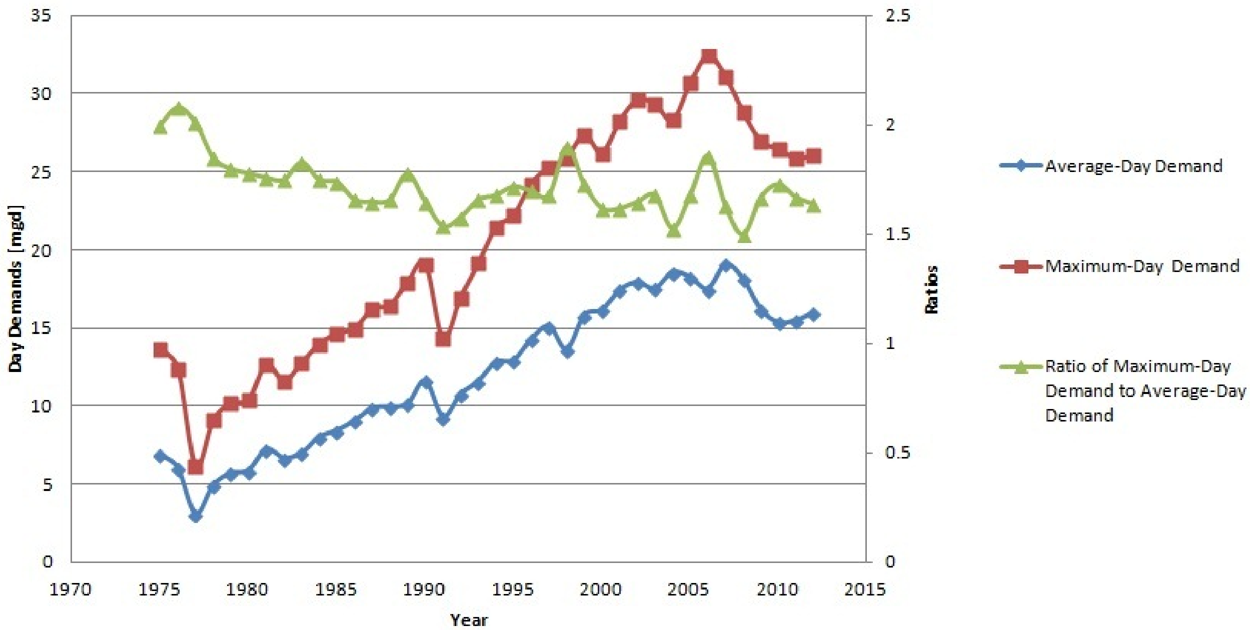

Figure 3-1. Historic Water Production

The ratio of maximum day demand to average-day demand has decreased and has generally remained steady around 1.7 mgd since the mid-1980s. When previous higher maximum-day ratios occurred, the water system served seasonal water-use-intensive industries such as canneries. Those operations have since closed.

As described in the Antioch 2010 Urban Water Management Plan (UWMP), system losses are the difference between the actual volume of water treated and the actual metered consumption. Such apparent losses always are present in a water system due to pipe leaks, unauthorized connections or use; faulty meters; and unmetered services such as fire protection and training, and system and street flushing. Table 3-2 summarizes the system losses from 2006 to 2012 as the difference between the annual production (including both treated and untreated water supplies) and annual sales. The average system losses reported in the City's 2010 UWMP was based on 2006 to 2010 data and comprised less than 3 percent of the total water produced. When considering 2011 and 2012 data, the average system loss from 2006 to 2012 is about 2 percent; however, the 3 percent water losses value is used for the purpose of this evaluation to maintain consistency with the City's UWMP. This percentage is very low compared to other California utilities that typically have 5 to more than 20 percent unaccounted for water. This lower percentage may be partly due to water meter addition for parks, medians, and school sites; regular meter maintenance; stringent construction standards applied to new facilities; replacement of deteriorated older pipes; and the relatively large portion of the system served by more modern facilities. The City's maintenance staff also actively pursues and corrects leaks. The year-to-year differences, including a negative value in the 2008 rate, may be due in part to a difference in time periods between production data and meter readings. The City measures water production daily and measures and bills water use monthly through meter readings. For example, water consumed in December is billed in January.

Table 3-2. Historical System Losses	
Year	System Losses, Percent of Annual Water Production
2006	2
2007	6
2008	-1
2009	5
2010	0
2011	1
2012	0.5
Average 2006 to 2012	2

3.2 Future Water Production Projections

Future water production projections are based on the City's 2010 UWMP and the per capita water use targets established by the City for Senate Bill (SB)x7-7 (SBx7-7) compliance. SBx7-7 requires that water utilities achieve mandated water use reductions by 2020. Based on SBx7-7 water use targets, per capita water use will decrease from a 10-year baseline of 186 gallons per capita per day (gpcd) to 176 gpcd by 2015 and to 165 gpcd by 2020. The City's 2010 UWMP includes water use projections (i.e., water demands) for 2015, 2020, 2025 and 2030 that do not include system losses. The projections for future water use shown in Table 3-3 incorporate an allowance of 3 percent of total water produced as system losses and the City sphere of influence and zoning changes in 2014. Values were interpolated for the single years between the UWMP water demand projections and extrapolated for years beyond 2030.

Table 3-3. Future Water Production Projections		
Year	Future Water Production Projections, mgd	Source
2013	17.09	Interpolation
2014	17.88	Interpolation
2015	18.68	2010 UWMP water demand + 3% water loss
2016	18.51	Interpolation
2017	18.35	Interpolation
2018	18.18	Interpolation
2019	18.02	Interpolation
2020	17.85	Updated per City changes in 2014+ 3% water loss
2021	17.91	Interpolation
2022	17.96	Interpolation
2023	18.02	Interpolation
2024	18.07	Interpolation
2025	18.13	Updated per City changes in 2014+ 3% water loss

Table 3-3. Future Water Production Projections		
Year	Future Water Production Projections, mgd	Source
2026	18.18	Interpolation
2027	18.24	Interpolation
2028	18.29	Interpolation
2029	18.34	Interpolation
2030	18.40	Updated per City changes in 2014+ 3% water loss
2031	18.45	Linear Extrapolation
2032	18.50	Linear Extrapolation
2033	18.56	Linear Extrapolation
2034	18.61	Linear Extrapolation
2035	18.75	Updated per City changes in 2014+ 3% water loss

3.3 Average-Day Water Demands

The historic and projected average day water demands are shown in Figure 3-2.

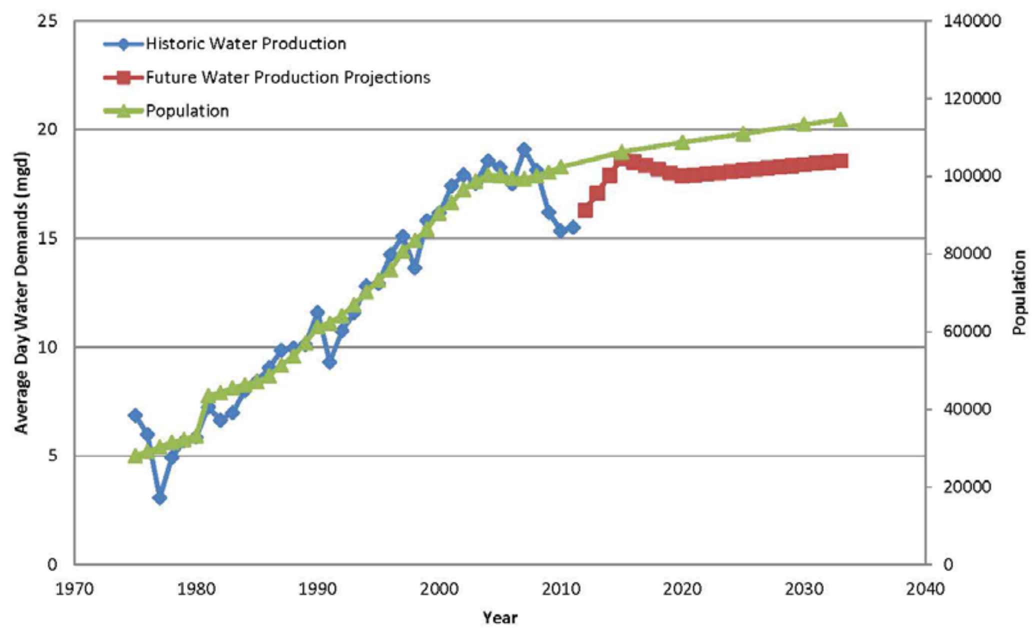

Figure 3-2. Average Day Water Use (1975-2030)

3.4 Water Demand by Pressure Zone

In the 1999 Water Master Plan, residential water meter records for January 7, 1997, to December 31, 1997, were used to determine the average-day residential use for different pressure zones in Antioch. This period was selected because it represented a typical year (i.e., it excludes the effects of El Niño on 1998 records among pressure zones). In June 2012, the City updated its water distribution system hydraulic model, based on the 1999 Water Master Plan projections for the year 2008.

Since the 1999 Water Master Plan, the City has defined three new pressure zones in its system. In the hydraulic model update, the 1999 Water Master Plan projections for 2008 by pressure zone were adjusted to account for the three new pressure zones. The 2008 demands by pressure zone served from the basis for distributing future demand projections across the City's pressure zones.

The average-day and maximum day water demand by pressure zone for 2010, 2020, 2030 and 2035 are shown in Table 3-4. The maximum day water use assumes that maximum day demand is 1.7 times average day demand. The difference in average day values between Tables 3-3 and 3-4 is the 3 percent allowance for unaccounted for water.

Table 3-4. Projected Total Water Demand Requirements by Pressure Zone[a,c]												
	2010		2015		2020		2025		2030		2035[b]	
Pressure Zone	Average Day (mgd)	Maximum Day (mgd)	Average Day (mgd)	Maximum Day (mgd)	Average Day (mgd)	Maximum Day (mgd)	Average Day (mgd)	Maximum Day (mgd)	Average Day (mgd)	Maximum Day (mgd)	Average Day (mgd)	Maximum Day (mgd)
Zone I	1.24	2.10	1.34	2.27	1.39	2.36	1.35	2.29	1.36	2.32	1.36	2.32
Zone II	6.46	10.98	7.03	11.94	7.13	12.12	6.77	11.52	6.70	11.39	6.70	11.39
Zone IIA	0.12	0.20	0.12	0.20	0.12	0.20	0.12	0.20	0.12	0.20	0.12	0.20
Zone IIB	0.10	0.17	0.10	0.17	0.10	0.17	0.10	0.17	0.10	0.17	0.10	0.17
Zone IIC	0.35	0.59	0.35	0.59	0.35	0.60	0.35	0.60	0.35	0.60	0.35	0.60
Zone III east	4.95	8.41	5.35	9.09	5.81	9.87	6.08	10.34	6.30	10.70	6.36	10.81
Zone III west	0.54	0.92	0.59	0.99	0.61	1.03	0.59	1.00	0.59	1.00	0.59	1.00
Zone IV east	1.14	1.93	1.23	2.09	1.54	2.61	1.94	3.30	2.05	3.48	2.31	3.93
Zone IV west	0.19	0.33	0.21	0.36	0.22	0.38	0.21	0.36	0.22	0.37	0.21	0.35
Zone Bear Ridge[d]	0.03	0.06	0.03	0.06	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05
Zone Sunset[d]	0.05	0.08	0.05	0.08	0.05	0.09	0.05	0.09	0.05	0.09	0.05	0.09
Total	**15.17**	**25.77**	**16.39**	**27.83**	**17.33**	**29.47**	**17.60**	**29.92**	**17.86**	**30.35**	**18.19**	**30.92**

[a]Future demands include demands from zones that are near or at completion of proposed development, including Zones IIA, IIB, IIC, Sunset, and Bear Ridge.

[b]Demand assumes 75% completion of proposed developments for FUA 1 and Roddy Ranch (based on planning information from Carlson Barbee and Gibson via personal communication).

[c]The values do no include the 3% allowance for unaccounted water.

[d]These zones are completely developed. Water demands will not increase in the future.

As in 1999, BC has continued to use an estimated overall peak hour factor of 2.69 multiplied by average day demand. In 2035 the peak hour demand would be about 49 mgd.

3.5 Recycled Water Use

DDSD is the agency responsible for treating and discharging wastewater for the cities of Antioch and Pittsburg and the unincorporated community of Bay Point. Currently, DDSD collects an estimated 14,700 acre-feet-year (AFY) of wastewater. Approximately 42 percent of that wastewater is recycled to supply for various uses. The remaining wastewater effluent is disposed of through an outfall into the Delta at New York Slough. In the future, DDSD expects to increase recycled water use.

The City owns and maintains a collection system that delivers raw sewage to DDSD pumping stations. In 1999, DDSD, in cooperation with Calpine Corporation, initiated a project to deliver recycled water from the DDSD wastewater treatment plant to two power plants and some park areas within the City of Pittsburg. DDSD has provided approximately 7 mgd of recycled water on average since completing construction of a 12.8 mgd recycled water facility (RWF) in 2001.

More recently, the recycled water system expanded to serve parts of Antioch. Currently, recycled water is used within the City to irrigate four City parks and the Lone Tree Golf Course. DDSD recently negotiated an agreement with CCWD to allow for the development of an additional 1,654 AFY of recycled water for urban landscape and golf course irrigation projects within the DDSD service area.

DDSD owns, operates and maintains a 1-MG recycled water storage tank located within the City's service area at the Lone Tree Golf Course.

About 0.25 percent of the City's potable use is currently offset by recycled water use.

Recently, DDSD and its contributing agencies have moved to expand recycled water use within DDSD's service area in order to:

- **Reduce Dependence on Delta Supplies**. Delta supplies are the primary water source in DDSD's service area. Recycled water would reduce Delta water diversions by CCWD and the City.
- **Improve Water Supply Reliability**. Recycled water is not affected by hydrologic variability, and provides additional dry-year reliability.
- **Preserve Potable Water Supplies**. Recycled water use can offset potable water supply demands by serving non-potable demands such as irrigation.
- **Reduce Wastewater Discharges**. Recycled water use reduces wastewater discharges, a benefit to DDSD because it reduces effluent discharge into the New York Slough. With increasingly stringent effluent discharge regulations, reusing wastewater helps DDSD in reducing effluent volume and mass of loadings to the receiving waters.
- **Better Use Existing Recycled Water Facilities**. DDSD's existing recycled water facilities are sized to deliver a peak flow of 12.8 mgd; however, the facilities are currently underused. The average demand for power plants and existing irrigation users has been approximately 7 mgd with peak flows of up to 12 mgd occurring less than 10 percent of the year (RMC, 2007). Delivery of recycled water in the City's service area will make use of available capacity.

Section 4

Water Quality and Water Supply

The 1999 Water System Master Plan Update and 2001 Water System Master Plan Update included a detailed discussion of the circumstances influencing future water quality and available quantity for the City. This section reevaluates the information in the 1999 Water System Master Plan Update and the 2001 Water System Master Plan Update, and presents a current assessment of water quality regulations and future available quantities from the City's existing sources of supply.

4.1 Water Quality

The United States Environmental Protection Agency (USEPA) and the State of California Department of Public Health (CDPH) regulate the water quality requirements for potable waters. The regulations set maximum contaminant levels (MCL) for a wide variety of physical, chemical, biological and radiological constituents to provide water that is safe for public consumption. CDPH oversees monitoring and enforcement of water quality requirements for the City's WTP. In addition, the City is required to operate its distribution system to maintain system water quality. As one example, system flushing to maintain a measurable disinfectant residential is sometimes necessary. The following sections summarize federal and state drinking water regulation updates as relevant to the City, and the compliance status of the City WTP.

4.1.1 Federal Regulations

The USEPA is responsible for developing and implementing drinking water regulations under the Federal Safe Drinking Water Act (SDWA) of 1974. States can either adopt the federal regulations or develop their own regulations with more stringent standards. USEPA has delegated the authority to implement drinking water regulations within the state to the CDPH Office of Drinking Water. For nearly all regulated drinking water contaminants, the state has adopted the federal regulations.

Table 4-1 presents a summary of the USEPA regulations. Federal regulations that are pertinent to the WTP operation are:

- National Primary Drinking Water Regulations (NPDWRs)
- Surface Water Treatment Rule (SWTR)
- Interim Enhanced Surface Water Treatment Rule (IESWTR)
- Total Coliform Rule (TCR)
- Revised Total Coliform Rule (RTCR)
- Stage 2 Disinfectants/Disinfection-By Product (D/DBP) Rule
- Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
- Filter Backwash Recycle Rule

In January 2006, USEPA promulgated two new federal regulations relevant to the WTP--the LT2ESWTR and the Stage 2 D/DBP Rule. These regulations supplement the previously promulgated regulations, the IESWTR and the Stage 1 D/DBPR. The goal of the new rules is to provide a higher level of protection against microbial contaminants, while limiting the production of potentially carcinogenic disinfection by-products (DBP).

Table 4-1. Update of Summary of USEPA Regulations Pertinent to Water Treatment Plant Operations

Regulation	Major Requirements
National Primary Drinking Water Regulations (NPDWRs)	Currently established for 92 contaminants, including turbidity; 8 microorganisms; 4 radionuclides; 19 inorganic contaminants and 60 organic contaminants. 83 of the contaminants have MCLs and maximum contaminant level goals (MCLG), with treatment technique requirements for the remaining 9. 15 additional contaminants have secondary (aesthetic) standards.
Total Trihalomethanes Rule *Promulgated in 1979*	Superseded by Stage 2 D/DBP Rule.
Surface Water Treatment Rule (SWTR) *Promulgated in 1989*	Requires that a detectable disinfectant residual be present in all portions of the distribution system (heterotrophic plate count [HPC] less than 500 colony forming units [CFU]/mL equivalent to a detectable residual). Requires 3-log *Giardia* inactivation/removal. Conventional systems receive a 2.5-log credit and direct filtration systems receive a 2-log credit for meeting filter effluent turbidity requirements. Remaining requirements must be met through disinfection. Requires 4-log virus inactivation/removal. Conventional systems receive a 2-log credit and direct filtration systems receive a 1-log credit for meeting filter effluent turbidity requirements. Remaining requirements must be met through disinfection. Requires combined filter effluent turbidity not exceed 0.5 Nephelometric Turbidity Units (NTU) in more than 5 percent of samples each month.
Total Coliform Rule (TCR)[1] *Promulgated in 1989*	Requires that less than 5 percent of distribution samples collected each month be positive for total coliform. Requires a detectable disinfectant residual at all points in the distribution system (Heterotrophic Plate Count [HPC] less than 500 CFU/mL considered equivalent to a detectable residual).
Interim Enhanced Surface Water Treatment Rule (IESWTR) *Promulgated in 1998*	Establishes an MCLG of zero for *Cryptosporidium.* Requires combined effluent turbidity of less than 0.3 NTU in 95 percent of samples collected each month. Establishes requirements for individual filter effluent turbidities, with associated requirements for a Comprehensive Performance Evaluation of underperforming filters. Requires that new finished water reservoirs be covered. Requires sanitary surveys at three year intervals. Requires disinfection benchmarking.
Stage 1 Disinfectants/Disinfection By-Products (D/DBP) Rule *Promulgated in 1998)*	Established MCLs for the following disinfection by-products (DBPs): trihalo-methanes (THMs) (80 µg/L), haloacetic acids (HAAs) (60 µg/L), bromate (10 µg/L) and chlorite (1 mg/L). THM and HAA compliance is based on a running annual average (RAA) of distribution system samples. Established maximum residual disinfectant levels (MRDLs) for the following disinfectants: free chlorine (4 mg/L), chloramines (4 mg/L), and chlorine dioxide (ClO_2) (0.8 mg/L). Compliance based on an average of distribution system samples. Enhanced coagulation requirements established required total organic carbon (TOC) removals based on raw water TOC and alkalinity. Purpose is to optimize removal of DBP precursors.
Modified Lead and Copper Rule *Promulgated in 2000*	Maintains MCLGs (0 mg/L for lead and 1.3 mg/L for copper) and action levels (ALs) (0.015 mg/L for lead and 1.3 mg/L for copper) established in the 1991 Lead and Copper Rule. Compliance requires that less than 10 percent of distribution system samples exceed action levels. Establishes additional requirements, including demonstration of optimal corrosion control, lead service line replacements, public education, monitoring, analytical methods, etc.
Arsenic Rule *Promulgated in 2001*	Establishes an MCL of 10 µg/L for arsenic.
Filter Backwash Recycle Rule *Promulgated in 2001*	Requires that all recycle streams be returned prior to or at the point of primary coagulant addition. Requires that information on recycle streams be provided to the CDPH for evaluation.

Table 4-1. Update of Summary of USEPA Regulations Pertinent to Water Treatment Plant Operations

Regulation	Major Requirements
Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) *Promulgated in 2002*	All system requires a 2-log removal (99%) of *Cryptosporidium.* Filtered systems are required to comply with strengthened combined filter effluent (CFE) turbidity performance, ensuring 2-log removal of *Cryptosporidium*. Conventional and direct filtration systems will continuously monitor the turbidity of individual filters. Compliance by the conventional and direct filtration systems with follow-up activities will occur based on the continuous monitoring. A profile of microbial inactivation levels will be developed by systems unless performing monitoring that demonstrates their DBP levels are less than 80% of the MCL established in the Stage 1 D/DBP Rule. Current lowest level of microbial inactivation and consultation with the state for approval is required by systems considering any significant change to disinfection practices.
Long-term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) *Promulgated in 2006*	Assigns utilities to one of four "bins" based on raw water *Cryptosporidium* concentrations. Each bin has associated requirements for additional *Cryptosporidium* treatment. Includes a toolbox of options for receiving *Cryptosporidium* reduction credits, including watershed control, disinfection, and filtration. Bin assignment is based on the average of the 12 consecutive highest months within a 2 year period of monthly *Cryptosporidium* samples.
Stage 2 D/DBP Rule *Promulgated in 2006*	Establishes MCLs for the following DBPs: Total Trihalomethanes (TTHMs) (80 µg/L), HAAs (60 ug/L), bromate (10 µg/L) and chlorite (1 mg/L). THM and HAA compliance is based on an location running annual average (LRAA) of distribution system samples. Establishes MRDLs for the following disinfectants: free chlorine (4 mg/L), chloramines (4 mg/L), and ClO_2 (0.8 mg/L). Compliance based on an average of distribution system samples. Requires an initial distribution system evaluation (IDSE) to identify sites with high DBP levels. Systems with no samples with total trihalomethanes/haloacetic acid (TTHM/HAA) levels exceeding 40/30 µg/L can apply for an IDSE waiver. Compliance schedule is based on population of the public water system. 6 to 8 years following promulgation, requires compliance with 80 µg/L TTHM and 60 µg/L HAA based on a LRAA at each site.

Notes:

As part of NPDWR review, USEPA published its decision to revise the TCR in July 2003. As of September 2010, USEPA is holding meetings and webcasts regarding potential changes to the Total Coliform Rule and the possible addition of distribution system requirements.

Maximum Contaminant Level - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

Maximum Contaminant Level Goal - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

4.1.1.1 Microbiological Constituents: Interim Enhanced Surface Water Treatment Rule (IESWTR)

In November 1998 USEPA finalized the IESWTR, as required by the 1996 Amendments to the SDWA. Table 4-2 lists microorganisms currently regulated under the SDWA.

Table 4-2. Currently Regulated Microorganisms		
Microorganisms	MCLG	MCL[a]
Cryptosporidium	0	TT–2 log removal
Giardia lamblia	0	TT -3 log removal
Heterotrophic plate count (HPC)	0	TT-<500/mL
Legionella	0	TT-No MCL
Total Coliform (including fecal coliform and *E. Coli*)	0	TT-<5% samples positive
Viruses (enteric)	0	TT-4 log removal

[a]Constituents regulated through Treatment Techniques (TT) require a treatment process to reduce the level of a contaminant in drinking water.

The IESWTR applies to all public water systems that use surface water or groundwater under the influence of surface water and serve 10,000 or more people. Major components of the IESWTR are as follows:

- The maximum contaminant level goal (MCLG) for *Cryptosporidium* is 0, and there is a 2-log *Cryptosporidium* removal credit for filtration.
- The monthly 95th percentile level for filtered water turbidity is 0.3 Nephelometric turbidity units (NTU) or less and a maximum turbidity of 1 NTU.
- A water treatment plant must continuously monitor turbidity of individual filters and monitoring of combined filter effluent every four hours.
- States are required to initiate sanitary surveys in all watersheds used as surface water resources.

The City complies fully with the IESWTR requirements.

4.1.1.2 Microbiological Constituents: LT2ESWTR

In January 2006 USEPA promulgated the LT2ESWTR with compliance required by 2008 under SDWA. The new regulations supplement the IESWTR to provide more equitable public health protection throughout the distribution system and to reduce exposure to *Cryptosporidium* and other pathogenic microorganisms. Under this rule, 24 months of source-water monitoring for *Cryptosporidium* must have been initiated by October 2006 for systems serving a population greater than 100,000. The regulations required completion of the initial round of source water monitoring by September 2008. By March 2009, filtered systems were required to report their “bin” classification to USEPA for approval.

As shown in Table 4-3, utilities will be assigned to one of four bins according to average levels of *Cryptosporidium* in their source water. The bin assignments have associated treatment requirements ranging from no additional treatment to a required 2.5-log removal. The treatment requirements listed in Table 4-3 will apply to the water purveyors if a conventional or direct treatment process is used. CDPH determines requirements for alternative filtration technologies. A unique aspect of *Cryptosporidium* regulation under the LT2ESWTR is that utilities can achieve credits for prevention, removal or inactivation through a number of pathways.

Table 4-3. US EPA LT2ESWTR Bin Assignment for Cryptosporidium Reduction Requirements[a]		
Bin Number	Average Cryptosporidium Concentration	Additional Treatment Requirements
1	<0.075/L	No additional treatment
2	≥ 0.075/L and < 1.0 /L	1-log additional treatment
3	≥ 1.0/L and < 3.0 /L	2-log additional treatment[b]
4	≥ 3.0 /L	2.5-log additional treatment[b]

[a]*For conventional treatment systems in full compliance with the SWTR, IESWTR, and LT1ESWTR*

[b]*Utilities falling under Bins 3 or 4 must meet 1.0 log of the required treatment using ozone, ultraviolet (UV), membranes, bag filtration, cartridge filtration, or bank filtration.*

The City has completed the required additional monitoring to comply with these new regulations. Specific actions taken in accordance with the LT2ESWTR are listed below:

- **Monitoring.** The City performed monthly *Cryptosporidium* and *Giardia* monitoring from October 2006 through September 2008 on the raw water entering the WTP. One detection of *Cryptosporidium* occurred in May 2008, while there were no detections of *Giardia*. As a result of the monitoring, the City is assigned to Bin 1. The City currently has no requirement for monitoring now. The next phase of LT2ESTR begins in 2014.
- **Cryptosporidium Treatment.** *Cryptosporidium* monitoring was conducted to determine treatment requirements. Systems that are identified as high risk are required to implement additional treatment and management strategies to achieve log reduction in *Cryptosporidium* based on monitoring results. The City was not required to take additional treatment measures.

The City currently meets LT2ESWTR requirements.

4.1.1.3 Total Trihalomethanes (TTHMs) and Haloacetic Acids (HAA5s): Disinfectants/Disinfection By-Products Rule

4.1.1.3.1 Stage 1 D/DBP Rule

Disinfection is the primary process in drinking water treatment. Drinking water disinfection has resulted in a major advance in public health by reducing acute illnesses from waterborne diseases; however, as a result of using chemical disinfectants—chlorine, chloramines, chlorine dioxide and ozone—DBPs form. Because disinfection practices also form potentially carcinogenic contaminants, in 1979 USEPA set an interim MCL for TTHMs of 0.10 milligrams per liter (mg/L). Section 6 describes the City's WTP and its processes.

Table 4-4 lists the MCLGs and maximum residual disinfectant levels (MRDL) required by Stage 1 D/DBP Rule. MRDLs are the highest level of a disinfectant allowed in drinking water, given the evidence that adding a disinfectant is necessary to control microbial contaminants. The terms MRDL and maximum residual disinfectant level goal (MRDLG), which are not included in the SDWA, were created during the negotiations to distinguish disinfectants (because of their beneficial use) from contaminants. The Stage 1 D/DBP Rule included monitoring, reporting and public notification requirements for these compounds.

Table 4-4. Water Quality Standards for Disinfectants and DBPs				
	MCL (mg/L)	MCLG (mg/L)	MRDL (mg/L)	MRDLG (mg/L)
Bromate	0.010	00.8	--	--
Chlorite	1.0	N/A	--	--
Haloacetic acids (HAA5)[a,c]	0.060	N/A	--	--
Total Trihalomethanes[b,c]	0.080	N/A	--	--
Chloramines (as Cl_2)	--	--	4.0	4.0
Chlorine (as Cl_2)	--	--	4.0	4.0
Chlorine dioxide (as ClO_2)	--	--	0.8	0.8

[a]HAA5 MCL is the total concentration of the five regulated haloacetic acids; monochloroacetic acid, dichloroacetic acid, tricholoroacetic acid, monobromoacetic acid, and dibromoacetic acid.

[b]Total THM (TTHM) Represents the total concentration of bromodichloromethane, bromoform, chlorodibromomethane, and chloroform.

[c]HAAs and TTHMs compliance based on a system wide running annual average (Stage 1 DBPR and a LRAA under Stage 2 DBPR.

TTHMs and HAA5s are currently regulated as a group on a LRAA basis at 80 micrograms per liter (µg/L) for TTHMs and 60 µg/L for HAA5 under the Stage 2 D/DBP rule, discussed below. Under potential future modifications to federal regulations on D/DBP rule, it is possible that TTHM and HAA5 regulations will change to single sample not to exceed the above numerical limits in the distribution system as opposed to LRAA. As more health effects data become available, it is possible that regulations may be directed to individual species of TTHMs and HAA5s to reduce associated health effects. Another possible scenario is that at least one more HAA species (possibly iodinated HAAs) will be added to the list (HAA6), but the numerical objective of HAA6 would continue to be 60 µg/L. Based on available City data and Federal Advisory Committee Act (FACA) information, it appears that the City should continue to achieve compliance into the future with continued competent operation of the existing water facilities.

4.1.1.3.2 Stage 2 D/DBP Rule

USEPA promulgated the Stage 2 D/DBP Rule in January 2006 with compliance required by 2008 under SDWA for systems serving greater than 100,000 customers. The new regulations supplement the Stage 1 D/DBP Rule to reduce DBP exposure and provide more equitable public health protection throughout the distribution system. The City has completed the required additional monitoring to comply with these new regulations. Specific augmentations according to the Stage 2 D/DBP Rule are listed below:

- Initial Distribution System Evaluation (IDSE).
  - Systems were required to be monitored and locations identified in the distribution system with high disinfection byproduct concentrations.
  - These locations then were used for Stage 2 D/DBP compliance monitoring, which began in April 2012.
- LRAA – Systems were required to obtain a LRAA at identified locations for compliance of THM and HAA requirements rather than running annual averages from all sample locations.

- Disinfection profiling was required to show that systems are maintaining protection against microbial pathogens while taking steps to reduce DBP formation. This approach will be increasingly important as the USEPA evaluates the reduction in DBP MCLs.
- Significant Excursions – Utilities are required to identify if they experience short-term peaks in DBP concentrations. If significant excursions are identified, utilities are required to review operational practices to prevent further DBP peak concentrations.

The City currently meets federal regulations.

4.1.1.4 Coliform: Proposed TCR Revisions

USEPA signed the proposed Revised Total Coliform Rule (RTCR) on December 20, 2012, and it has been published in the Federal Register (FR) on February 13, 2013. USEPA's RTCR (USEPA, 2012) call for the changes described as follow according to the USEPA website (http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/regulation.cfm), by April 1, 2016. USEPA intends that the RTCR will increase protection of public health by reducing the potential for fecal contamination to impact the distribution system. USEPA considers total coliforms an indicator that there is potentially a pathway for fecal contamination into the distribution system. Under the current TCR, effective through March 31, 2016, total coliform-positive samples trigger an assay for either fecal coliforms or *E. coli* with the total coliform-positive sample. The RTCR eliminates fecal coliforms and uses *E. coli* as an indicator of fecal contamination because it is more likely that *E. coli* originate from humans or animals than fecal coliforms. The RTCR introduces a MCLG and MCL for *E. coli* of 0 and eliminates the MCLs and MCLGs for total coliforms (and fecal coliforms) that are included in the current TCR. Monitoring provisions of the RTCR are similar to the current TCR with monitoring of total coliforms and *E. coli* according to a sample siting plan and schedule for each system. In terms of sample locations when there is a total coliform-positive sample occurrence, systems gain more flexibility and have the option to either retain the current repeat sampling locations within five locations upstream and downstream of the total coliform-positive sample location or to "propose repeat sample locations that best verify and determine the extent of potential contamination of the distribution system" (subject to state approval). The number of repeat samples required when there is a total coliform-positive sample for a public water system (PWS) does not change and remains at three.

Perhaps the most substantive change within the RTCR is the requirement of corrective action and the treatment technique under the RTCR. The treatment technique that the RTCR introduces requires a system to conduct an assessment when monitoring results demonstrate the system may be vulnerable to contamination. A Level 1 self-assessment or a more detailed Level 2 assessment may be required depending on how severe and how frequent the contamination. Any sanitary defects identified in Level 1 or Level 2 assessments must be corrected. Examples of sanitary defects[1] provided in the RTCR include cross-connection and backflow issues, operator issues, distribution system issues, storage issues, and disinfection issues like failure to maintain the disinfectant residual throughout the distribution system.

[1] Verbatim from the proposed RTCR: Examples of sanitary defects:

- Cross connection and backflow issues such as a required backflow prevention device not in place or not operating properly, or an unprotected cross connection found.
- Operator issues such as failure to follow standard operating procedures (SOP) that protect distribution system integrity and sanitary conditions.
- Distribution system issues such as inadequate inspection and maintenance of the distribution system; loss of distribution system integrity such as main breaks; failure to maintain adequate pressure; improper flushing operations; improper construction of new, replaced, or renovated lines; inadequate disinfection during and after repair/replacement activities; or inability to maintain required residual throughout the distribution system.
- Storage issues such as overflow, vents, hatches, and other penetrations not properly configured, screened, or sealed; inadequate maintenance of storage facilities; or inadequate disinfection during and after repair/ replacement activities.
- Disinfection issues such as inability to maintain required residual throughout the distribution system.

Treatment technique triggers for Level 1 and Level 2 assessments are summarized below. A Level 1 assessment is required when:

- Systems taking 40 or more samples per month have more than 5.0 percent total coliform-positive samples in a month.
- Systems taking less than 40 samples per month have two or more total coliform-positive samples in a month.
- A system fails to take every required repeat sample after any single total coliform-positive sample.

A Level 2 assessment is required when:

- There is an *E. coli* MCL violation including failure to collect repeat samples triggered by an *E. coli*-positive routine sample in the required amount of time.
- A second Level 1 trigger discussed above occurs in a rolling 12-month period.
- A Level 1 trigger occurs in two consecutive years for systems with approved annual monitoring.

Level 1 and Level 2 assessments are conducted to identify possible sanitary defects and possible defects in distribution system coliform monitoring practices. Level 2 assessments are more detailed and must be conducted by parties approved by the state (the state itself, a third party approved by the state or system staff who meet certification requirements set by the state). Corrective action must be taken to correct any sanitary defects identified through Level 1 and Level 2 assessments. Both Level 1 and Level 2 assessments should be reported to the primacy agency (i.e., CDPH) within 30 days and identify sanitary defects, if any, and corrective actions and schedules.

Finally, the RTCR makes changes to the public notification requirements. Under the current TCR, public notification is required for detection of total coliform. Under the RTCR, public notification would no longer be required upon detection of total coliform. Instead, a Tier 1 public notification (PN) is required immediately (within 24 hours) when the *E. coli* MCL is violated. A Tier 2 PN is required within 30 days when there is a treatment technique violation represented by failure to conduct assessments or corrective actions. The Tier 2 PN can be avoided if assessments are conducted and corrective actions taken to correct any sanitary defects identified as prescribed by the RTCR (see above discussion). A Tier 3 PN is required annually in the case of monitoring or reporting violations. The RTCR also proposes changes to Consumer Confidence Report requirements to be consistent with the public notification requirements of the RTCR.

Comparing the annual average of the monthly median total coliform data from the raw water from January 2007 through December 2012 from Table 4-5 to the California SWTR treatment requirements in Table 4-2, the source water to the WTP appears to be high quality with respect to bacteriological water quality. Based on bacteriological water quality data alone, water treatment should achieve a 3/4-log reduction (3-log *Giardia* and 4-log virus reduction). The treated water also meets the RTCR.

Table 4-5. Raw Water Total Coliform Data

Year	Range (MPN[a]/100 mL)	Average of Annual Median (MPN[a]/100 mL)
2007	54-24,196	2594
2008	59-64,880	4604
2009	46-1,203	250
2010	14-1,986	366
2011	23-1,553	264
2012	20-8,164	365

[a]*MPN = Most Probable Number*

4.1.1.5 Organic Chemicals

Despite the level of agricultural activity and pesticide and herbicide applications that occur upstream in the watershed, the City's source water monitoring has not detected these pollutants for both the San Joaquin River and the Municipal Reservoir.

4.1.2 California State Regulations

CDPH implements drinking water regulations within the state. CDPH regulations are promulgated under the State Safe Drinking Water Act and Related Laws, referred to as the "blue book." In June 2012 CDPH published the most recent updated version of the blue book. CDPH established health-based notification levels (NL) for selected emerging contaminants for which MCLs have not yet been established. Detection of contaminant levels that exceed the NL may require utilities to take further action, such as public notification or switching to an alternative source.

Table 4-6 summarizes CDPH regulations relevant to water purveyors that are more stringent than federal requirements.

Table 4-6. Summary of CDPH Drinking Water Regulations

Regulation	Major Requirements
State Primary Drinking Water Standards	State MCLs are more stringent than federal levels for 32 contaminants. The state also has NLs for 30 chemicals. NLs are health-based standards for contaminants without a current MCL. Exceedance may require public notification or switching to an alternative source.
Fluoridation	Established optimal fluoride levels and control ranges for treated water based on air temperature (see Table 4-7). The CDPH requires that fluoride be monitored daily.
Cryptosporidium Action Plan Established in 1995	Sedimentation/clarification basin effluent turbidity of 1 to 2 NTU. Combined filter effluent turbidity <0.1 NTU. Reclaimed backwash water turbidity <2 NTU. Filter effluent turbidity after filter backwash or filter-to-waste <0.3 NTU. Recycle flows limited to 10 percent of influent.

4.1.2.1 Microbiological Constituents, Cryptosporidium Action Plan (CAP)

Table 4-6 also includes requirements under the CAP, implemented by CDPH to promote protection of public health by optimizing the performance of water treatment plants to help prevent recycling of pathogens such as *Cryptosporidium* and *Giardia* to the WTP. CAP is not a regulation; however, CDPH enforces CAP like a quasi-regulation. CDPH was directed to implement the CAP through Section 116360 of the California Health and Safety Code, which was passed by the legislature in 1995. The City currently complies with state regulations.

4.1.2.2 Filter Backwash Recycling, CAP

The Safe Drinking Water Act stipulates that the USEPA should develop a regulation that governs filter backwash recycling in public water treatment systems. USEPA issued the final rule in April 2001. CDPH also has rules regarding recycling of backwash water under its CAP. Filters are backwashed periodically to remove accumulated solids, and the spent backwash water may be reintroduced to the influent, discharged to surface water, or placed in a settling lagoon. If the recycle rate is high, it may significantly increase the concentration of contaminants in the inflow and decrease the WTP's ability to produce high-quality drinking water. Since 2007 the City constructed and now operates WTP facilities to capture and treat spent filter backwash. The City's system recycles backwash water after treatment to remove solids to below 2 NTU, at a rate no greater than 10 percent of the raw water flow into the WTP. The City currently meets the turbidity requirements and percent recycle limitations.

4.1.2.3 Fluoridation

The CDPH has established optimal fluoride levels in treated water based on air temperature. Table 4-7 lists the optimal fluoride level and the control range. The CDPH requires that fluoride be monitored daily. The City currently complies with the fluoride regulation.

Table 4-7. Fluoride Control Ranges for Treated Water

Annual Average of Maximum Daily Average Air Temperatures		Optimal Fluoride Level, mg/L	Control Range, mg/L	
Fahrenheit	Celsius		Low	High
50.0 to 53.7	10.0 to 12.0	1.2	1.1	1.7
53.8 to 58.3	12.1 to 14.6	1.1	1.0	1.6
58.4 to 63.8	14.7 to 17.7	1.0	0.9	1.5
63.9 to 70.6	17.8 to 21.4	0.9	0.8	1.4
70.7 to 79.2	21.5 to 26.2	0.8	0.7	1.3
79.3 to 90.5	26.3 to 32.5	0.7	0.6	1.2

4.1.2.4 Radionuclides

Radionuclides are not commonly present in most surface water sources; however, they have been found to be present in some groundwater sources and are highly carcinogenic in drinking water. Since December 2003, new rules for radionuclides have been in effect. Monitoring requirements have increased to be more consistent with the other drinking water treatment standards and to provide adequate protection of public health. Table 4-8 lists the MCLs for regulated radionuclides set to limit associated cancers caused by exposure.

Table 4-8. Regulated Radionuclide Concentrations[a]

	MCL	MCLG
Alpha particles	15 pCi/L	None[b]
Beta particles and photon emitters	4 millirems/year	None[b]
Radium 226 and 228	5 pCi/L	None[b]
Uranium	30 µg/L[b]	None[b]

[a]*Rule effective December 30, 2003.*

[b]*MCLG for radionuclides when the SDWA was established in 1974, amended in 1986.*

Based on the City's compliance record, radionuclides have been low and usually within the counting error and were non-detectable from 2007 to 2011.

4.1.2.5 Asbestos

Asbestos fiber counts have always been very low and were non-detectable from 2007 to 2011.

4.1.3 Potential Future Regulations - Endocrine Disrupting Compounds (EDC): Pharmaceuticals and Personal Care Products (PPCP)

Regulations on EDCs and PPCPs are not likely to occur in the near future because of expensive detection methods and cost of modifying existing WTPs, as well as high operational cost of treating to remove or decrease these compounds at WTPs. To date the regulators have found a high level of uncertainty regarding human health effects and dose-response relationships for EDCs and PPCPs. Some researchers have stated that new regulations could be based on a common mechanism for toxicity (e.g., endocrine disruption) instead of by individual compound. Alternatively, regulations could require a specific treatment technology (e.g., granular activated carbon) for an array of chemicals, instead of setting standards for specific MCLs. In September 2009, USEPA published the final version of the third Drinking Water Contaminant Candidate List (CCL), which included 10 PPCPs. The SDWA requires USEPA to list unregulated contaminants that are known or anticipated to occur in public water systems and that may require future regulation. The PPCPs included on the CCL3 were one antibiotic (Erythromycin) and nine hormones. Erythromycin was already on the “starting list” because of concentrations reported in wastewater. The nine hormones, however, were added to the “starting list” because of possible future regulation. Based on the current state of regulation development, adding treatment for EDCs and PPCPs does not appear likely in the next decade.

4.1.4 Emerging Contaminants Review

This section provides a list of chemical and microbial contaminants that are not currently regulated but may be regulated in the future. Two major sources of information for this section were the USEPA CCL and the Information Collection Rule (ICR).

Published in 1998, the CCL includes 10 microbial, 6 inorganic and 44 organic contaminants. The CCL’s purpose is to identify contaminants that are not subject to any proposed or promulgated federal national primary drinking water regulation, are known or anticipated to occur in public water systems, and may require future regulation under the SDWA. The CCL-classified contaminants as either being ready for regulatory determination or in need of further research pertaining to one or more of the following—health effects, treatability, analytical methods and occurrence. Published in 2005, CCL 2 includes the contaminants on CCL 1 for which a regulatory determination was not made. CCL 2 does not include the 9 CCL 1 contaminants for which sufficient information existed to determine that NPDWRs need not be developed. These contaminants include one microbial and eight chemical contaminants. In October 2009, USEPA published the final CCL 3 list, which included 104 chemical contaminants and 12 microbial contaminants. The list includes, among others, pesticides, biological toxins, DBPs, chemicals and waterborne pathogens. USEPA stated that nominations for contaminants have been concluded in June 2012 for inclusion for the CCL 4 list.

Contaminants requiring further information on occurrence have been monitored under the Unregulated Contaminant Monitoring Rule (UCMR). Promulgated in 1999, the first cycle of the rule (UCMR 1) included a list of 34 contaminants. The contaminants were divided into three lists according to the availability of analytical methods, as shown in Table 4-9. All of the List 1 contaminants and 13 of the 15 List 2 contaminants were monitored by selected utilities for a 12-month period between 2001 and 2003. The method for *Aeromonas* was released in May 2002, with monitoring conducted in 2003.

Table 4-9. USEPA UCMR 1 Monitoring List		
List 1 Contaminants with Sufficient Analytical Methods Available	List 2 Contaminants with Analytical Method Requiring Further Refinement	List 3 Contaminants with Method under Development
2,4-dinitrotoluene 2,6-dinitrotoluene Acetochlor DCPA mono-acid degradate 2,2'-DDE EPTC Molinate MTBE Nitrobenzene Perchlorate Terbacil	2,3-diphenylhydrazine 2-methyl-phenol 2,4-dichlorophenol 2,4-dinitrophenol 2,4,6-trichlorophenol Diazinon Disulfoton Diuron Fonofos Linuron Nitrobenzene Prometon Terbufos *Aeromonas* Alachlor ESA RDX	Lead-210 Polonium-210 Cyanobacteria Echoviruses Coxsackieviruses *Helicobacter pylori* Microsporidia Caliciviruses Adenoviruses

In 2007, USEPA published the second cycle of the rule (UCMR 2). The UCMR 2 contaminant list is divided into two sub-lists—List 1 Assessment Monitoring chemical contaminants and List 2 Screening Survey chemical contaminants, as presented in Table 4-10. The Assessment Monitoring chemical contaminants are those that have established analytical methods. The Screening Survey chemical contaminants are those for which analytical methods recently have been developed and the associated methods may not be in wide use. The Assessment Monitoring contaminants include two pesticides, five flame retardants, and three explosives. The Screening Survey contaminants include acetanilide pesticide parent compounds and their degradation products and nitrosamines. All public water systems (PWS) serving more than 10,000 people, and a subset of those serving 10,000 or fewer, are required to monitor for the List 1 (Assessment Monitoring) contaminants. All PWSs serving greater than 100,000 people, and subsets of those serving 10,001 to 100,000 and 10,000 or fewer, are required to monitor for the List 2 (Screening Survey) contaminants. PWSs selected to monitor as part of the representative subsets of smaller systems will be notified in writing by their state or USEPA. UCMR 2 required four consecutive quarterly rounds of sampling at the entry points to the distribution system between 2008 and 2010.

Many of the contaminants monitored under the UCMR were identified in the ICR promulgated in May 1996. The ICR’s purpose is to collect occurrence and treatment information to help evaluate the need for possible changes to the current SWTR and evaluate the need for future regulation of disinfectants and DBPs. The data were published In December 1999 USEPA published the data.

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Table 4-10. USEPA UCMR 2 Monitoring List	
List 1 Assessment Monitoring	List 2 Screening Survey
Dimethoate Terbufossulfone 2,2',4,4'-tetrabromodiphenyl ether (BDE-47) 2,2',4,4',5-pentabromodiphenyl ether (BDE-99) 2,2',4,4',5,5'-hexabromobiphenyl (HBB) 2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153) 2,2',4,4',6-pentabromodiphenyl ether (BDE-100) 1,3-dinitrobenzene 2,4,6-trinitrotoluene (TNT) Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Acetochlor Alachlor Metolachlor Acetochlor ethane sulfonic acid (ESA) Acetochloroxanilic acid (OA) Alachlor ethane sulfonic acid (ESA) Alachloroxanilic acid (OA) Metolachlor ethane sulfonic acid (ESA) Metolachloroxanilic acid (OA) N-nitroso-diethylamine (NDEA) N-nitroso-dimethylamine (NDMA) N-nitroso-di-n-butylamine (NDBA) N-nitroso-di-n-propylamine (NDPA) N-nitroso-methylethylamine (NMEA) N-nitroso-pyrrolidine (NPYR)

On May 2, 2012 USEPA established the UCMR 3 which requires PWSs to monitor for 30 contaminants using "consensus organization analytical methods" and/or USEPA methods from January 2013 through December 2015 [http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/ucmr3/]. The UCMR 3 requires monitoring for 28 chemical contaminants and 2 viruses. UCMR 3 categorizes the contaminants into 3 lists, similar to UCMR 1. List 1 (Assessment Monitoring) has 21 contaminants that use typical analytical methods that need to be monitored by PWSs with more than 10,000 customers during a 12 month period. List 2 (Screening Survey) monitors seven contaminants using more specialized analytical methods and require monitoring by all PWSs serving more than 100,000 people. List 3 (Pre-Screen Testing) has been generated for the two viruses and would use more recent methods not typically used by drinking water laboratories and would have selected PWSs serving 1,000 or fewer that do not currently do disinfection. Therefore, the UCMR 3's List 3 is not applicable to the City. These three lists can be seen in Table 4-11, below. Reporting for the UCMR 3 is similar to the method of reporting for the UCMR 2. Laboratories doing the analysis on samples will enter the data onto the USEPA's online Safe Drinking Water Accession and Review System (SDWARS). Users of USEPA's SDWARS will use USEPA's electronic reporting system, the Central Data Exchange (CDX). The data will be reviewed and acted upon by the PWSs. The City's monitoring begins in April 2013 for List 1 and 2 contaminants.

Table 4-11. USEPA UCMR 3 Monitoring List		
List 1 Assessment Monitoring	List 2 Screening Survey	List 3 Pre-Screen Testing[a]
1,2,3-trichloropropane 1,3-butadiene Chloromethane (methyl chloride) 1,1-dichloroethane Bromomethane (methyl bromide) Chlorodifluoromethane (HCFC-22) Bromochlormethane (halon 1011) 1,4-dioxane Vanadium Molybdenum Cobalt Strontium Chromium Chromium-6 Chlorate Perfluorooctanesulfonate acid (PFOS) Perfluorooctanoic acid (PFOA) Perfluoronoanoic acid (PFNA) Perfluorohexanesulfonic acid (PFHxS) Perfluoroheptanoic acid (PFHpA) Perfluorobutanesulfonic acid (PFBS)	17-β-estradiol 17-α-ethynylestradiol (ethinyl estradiol) 16-α-hydroxyestradiol (estriol) Equilin Estrone Testosterone 4-androstene-3, 17-dione	Eneteroviruses Noroviruses

[a]*Not applicable to the City*

The CDPH has identified five contaminants of current interest listed below:

- Methyl tert-butyl ether (MTBE)
- Perchlorate
- N-nitroso-dimethylamine (NDMA)
- Chromium VI
- Arsenic

CDPH also has stated that "an enforceable MCL" for Chromium VI could be provided between July 2014 and July 2015 [http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx]. According to the City's 2011 Annual Water Quality Report data presented in Table 4-12 all five of the contaminants in which CDPH is currently interested were not detectable in the City's treated water. The levels of the five contaminants in the raw water sources are in current compliance, as explained in the "General Physical and Inorganic Parameters of Raw Water Sources" section.

Table 4-12. California Drinking Water Standards and Antioch Treated Water				
Treated Water Parameters			City Treated Water	
Chemical	Standard	MCL or [MRDL]	Range	Average
Aluminum (Al)	Primary	1 mg/L	ND	n/a
Barium (Ba)	Primary	1 mg/L	ND	n/a
Fluoride (F)	Primary	2 mg/L	0.7-1.09	0.87
Nitrate as NO_3	Primary	45 mg/L	ND	n/a
Turbidity[a]	Primary	TT	0.11	100% of samples met requirements
Bromate ($BrHO_3$)[b]	Primary	0.01 mg/L	ND	ND
Chloramines as Cl_2[b]	Primary	[4] mg/L	0.1-3.2	1.7
HAAs[b]	Primary	0.06 mg/L	0.0021-0.012	0.0054
Total Trihalomethane (TTHM)[b]	Primary	0.08 mg/L	0.035-0.060	0.048
Aluminum (Al)	Secondary	2 mg/L	ND	n/a
Chloride (Cl)	Secondary	500 mg/L	17–123	46
Corrosivity (SI)	Secondary	Non-corrosive	-0.05	n/a
Specific Conductance	Secondary	1600 μS/cm[c]	209-625	330
Sulfate (SO_4)	Secondary	500 mg/L	17-41	29
Total Dissolved Solids (TDS)[d]	Secondary	1000 mg/L	105-312	180
Turbidity (distribution system)	Secondary	5 NTU	0.05-0.13	0.07
General Water Quality				
Alkalinity ($CaCO_3$)	None	n/a	40-93	58 mg/L
Ammonia (NH_3)	None	n/a	n/a	n/a
Bromide (Br)	None	n/a	n/a	n/a
Calcium (Ca)	None	n/a	10-21	14 mg/L
Hardness ($CaCO_3$)	None	n/a	36-92	62 mg/L
Magnesium (Mg)	None	n/a	8.6-9.1	8.9 mg/L
pH	None	n/a	8.0-9.2	8.6
Potassium (K)	None	n/a	1.8-2.1	2.0
Sodium (Na)	None	n/a	36	n/a
Lead and Copper Study				
EPA Lead Study (Pb)[e]	Action Level	0.015 mg/L @ 90% Percentile	2 of 60 sites tested exceeded action limit	ND
EPA Copper Study (Cu)[e]	Action Level	1.3 mg/L @ 90% Percentile	0 of 60 sites tested exceeded action limit	ND
Physical				
Odor-Threshold	Secondary	3 units	ND	n/a
Microbiological				
Total Coliform		>5.0 % of monthly samples	ND	ND

Note: Only detected substances were listed
ND = Not Detected
n/a = not applicable/not analyzed
TT = Treatment Technique
[a]The value for the range is the "Maximum Value" and the average value given was the "Lowest Monthly Percent of Samples That Meets Requirements"
[b]MCL or [MRDL], the range was from the "Range of All Distribution Sites Tested," and the average was from the "Highest Quarterly RAA"
[c]μS/cm micro Siemens per centimeter.
[d]500 mg/L is recommended by CDPH.
[e]Analyzed in August 2012

4.1.4.1 Sulfate

Sulfate is currently listed on the CCL and is being further investigated by USEPA to determine whether or not regulation of sulfate would provide beneficial protection of public health (http://www.epa.gov/safewater/standards.html). Expert workshops and studies are currently being conducted by USEPA and are under review.

4.1.5 General Physical and Inorganic Parameters of Raw Water Sources

Nearly all the raw water monitoring performed by the City is on the WTP influent. The San Joaquin River is the single raw-water source regularly sampled. When in use, City staff samples the river daily for total coliform, heterotrophic plate counts (HPC), turbidity, temperature, pH, alkalinity, chlorides and hardness. Other than this monitoring, the City's raw water sources are monitored for Title 22 constituents as required. Table 4-13 summarizes general physical and inorganic water quality parameters for the Municipal Reservoir and the San Joaquin River, respectively. Data compiled for the Municipal Reservoir were bi-annual samples for years 2007 to 2009 and annually for years 2010 to 2011. The San Joaquin River was sampled bi-annually for years 2007 to 2010 and once for 2011. Values vary significantly due to salt-water intrusion in the Delta. This result is particularly evident when evaluating the wide range of values in Table 4-13 for total hardness, TDS, sodium, chloride and iron. Data for the Municipal Reservoir show less apparent variations compared to the values in the San Joaquin River, though the CCWD Canal water pumped into the reservoir also is affected by salt-water intrusion.

Table 4-13. California Drinking Water Standards and Antioch Raw Water Analysis

Regulated Inorganic Chemicals	MCL or [Action Levels]	Municipal Reservoir		Rock Slough	Old River	San Joaquin River		Victoria Canal	Contra Costa Canal[a]
		Range	Average	February 2013[b]	February 2013[b]	Range	Average	February 2013[b]	February 2013[b]
Total Hardness	n/a	75-140	98.6	130	110	73-470	172.6	90	110
Total Alkalinity	n/a	57-87	75.1	66[c]	69[c]	57-83	70.9	70	62
pH	n/a	7.6-9	8.1	8.8	8.0	7.3-8.1	7.8	7.8	7.6
Nitrate (mg/L)	45 mg/L	ND	ND	<2.0	<2.0	ND-2.5	n/a	<2.0	2.8
TDS (mg/L)	1000 mg/L	150-440	262.2	-[d]	-[d]	130-2100	796.7	-[d]	-[d]
Arsenic (As) (mg/L)[e]	0.010 mg/L	ND-0.0025	n/a	0.0021	0.0037	ND-0.0027	n/a	0.0025	0.002
Sodium (Na) (mg/L)	n/a	23-100	49.0	120	91	18-670	198.0	47	67
Chloride(mg/L)	500	83.44	80.13	220	160	20-1100	345.8	70	120
Cadmium (Cd)[e](mg/L)	0.005 mg/L	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
Chromium (Cr)[e](mg/L)	0.05 mg/L	ND	ND	<0.01	<0.01	ND	ND	<0.01	<0.01
Copper (Cu) (mg/L)	[1.3 mg/L]	ND	ND	<0.05	<0.05	ND	ND	<0.05	<0.05
Iron (Fe)[f](mg/L)	0.3 mg/L	0.2-1.1	0.53	0.190	0.110	0.460-2	1.18	0.140	<0.100
Lead (Pb) (mg/L)	[0.015 mg/L]	ND	ND	-[g]	-[g]	ND	ND	-[g]	-[g]
Magnesium (Mg) (mg/L)	n/a	9.4-19	13.1	20	16	8.6-90	31.1	11	14
Mercury (Hg)[e](mg/L)	0.002 mg/L	ND	ND	<0.001	<0.001	ND	ND	<0.001	<0.001
Selenium (Se)[e](mg/L)	0.05 mg/L	ND	ND	<0.005	<0.005	ND	ND	<0.005	<0.005
Silver (Ag)[f](mg/L)	0.10 mg/L	ND	ND	<0.01	<0.01	ND	ND	<0.01	<0.01
Radium 288[h]	n/a	n/a	ND	n/a		n/a	ND	n/r	r
Total Alpha[h]	15 pCi/L	n/a	ND	-[d]		n/a	ND	<3.0[a]	-[d]

ND = Not detected.
n/r = not reported.
[a]From CCWD data from http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Monitoringschedule/DistrictReports-Monitoring%20Page/SanFranciscoDistrict04.pdf
[b]The most current data available for these raw water sources was given only from one sample provided in a "Drinking Water Monitoring Schedule" by the CDPH in February 2013 (http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Monitoringschedule/DistrictReports-Monitoring%20Page/SanFranciscoDistrict04.pdf).
[c]Represents an approximate sum of bicarbonate, carbonate, and hydroxide alkalinities
[d]The concentrations of these contaminants have not been reported to CDPH as of February 22, 2013 and are stated to be "DUE" by the CDPH.
[e]From CDPH website(http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWdocuments/EPAandCDPH-11-28-2008.pdf)
[f]From CDPHs "List of Water Quality and Parameters (Excel)" (http://www.cdph.ca.gov/certlic/drinkingwater/Pages/EDTlibrary.aspx)
[g]Lead was not listed. CDPH stated that "any analyses not listed as required for testing has been Waive (not required) [sic]."
[h]Analyzed in 2007
Source: CCWD, 2011 Annual Water Quality Report and Watershed Sanitary Survey Data from the City, provided by Lori Sarti via email on 9/10/12.

The reason for the wide range of water quality is that the San Joaquin River is subject to tidal exchange when runoff is low and wide variations in runoff annually and seasonally. When the amount of salt water in the river increases, TDS, sodium chloride and total hardness levels increase dramatically while iron concentrations drop. When the water in the river is mostly Sacramento River or San Joaquin River water, the reverse occurs with TDS, sodium, chloride and total hardness levels falling and iron concentrations increasing.

The Department of Water Resources (DWR) and the City have an existing agreement that specifies that the City will be able to pump water with the chloride content less than 250 mg/L at least 208 days per year. If the long-term average days of river pumping are less than 208 days per year, DWR will pay for one-third of the incremental difference in cost to the City between using river water and Canal water. This contract was a 40-year contract that began in 1968. Since 2008, the contract has been extended year to year. When a pumping shortfall occurs, DWR now pays the City for one-third the incremental costs, including those added raw water costs associated with the Los Vaqueros Project. Also, the State Water Resources Control Board (SWRCB) has established water quality standards for the Delta, including a provision of 150 mg/L maximum concentration of chloride at Antioch's River pumping station for a minimum duration depending on net Delta outflow. If these standards are maintained, the river can continue as an intermittent, but important, water source for the City. Table 4-14 summarize both chloride standards for the river.

Table 4-14. Water Quality Standards for Chloride

Location	Maximum Concentration, mg/L	Frequency[a] days/yr	Water Year Classification
Contra Costa Canal intake at Rock Slough	250[b]	All	-
Contra Costa Canal intake at Rock Slough or Antioch intake on San Joaquin River	150[c]	240 190 175 165 155	Wet Above normal Normal Dry Critically dry

[a]*Number of days that chloride level has been less than 150 mg/L.*

[b]*Maximum mean daily concentration*

[c]*Maximum mean daily concentration at intervals of not less than 2 weeks' duration.*

Source:State Water Resources Control Board, Water Quality Control Plan for the Sacramento San Joaquin Delta.

In coming years, decisions and actions outside the City's control will continue to impact river water quality. Any decrease in the net flow from east to west in the San Joaquin River at Antioch will tend to reduce the availability of low chloride waters.

Other than the wide range in San Joaquin River total hardness, TDS, sodium, chloride and iron, the values for the remaining parameters presented in Table 4-9 occur within normal ranges and do not pose any unusual problems for the WTP. Metal concentrations are mostly low or non-detectable.

Historical water quality data review indicates that if the maximum daily mean for chloride is kept below 250 mg/L, the other drinking water standards should not be exceeded, with the possible exception of THMs. During disinfection of source water, organic carbon can react with chlorine to form carcinogenic compounds such as THMs and HAAs. The City currently is meeting all standards including those for DBPs. No problems are foreseen that will prevent the City from meeting future standards. The City expects no changes that will affect the WTP in the next decade but future regulations may require that the City carry out additional sampling and analyses.

4.1.6 Treated Water Analyses

Table 4-12 summarizes data for the City's treated water based on the latest annual water quality report.

4.1.7 Conclusion

The City currently complies with all federal and CDPH drinking water regulations.

4.2 Water Supply

Sources of water supply for the City remain the same as in 2001 and are unlikely to change in the near future. This section discusses the quantity of water available from each source and associated water quality issues; desalination is briefly discussed as a possible additional water resource.

The principal sources of raw water supply are the Sacramento/San Joaquin Rivers Delta and the Contra Costa Canal (Canal), which can be stored in the Municipal Reservoir. Table 4-15 summarizes the annual water supply from these water supply sources in 2010. Tables 4-16 and 4-17 summarize the City's existing water rights, reliability and reasons for inconsistency in the City's water supplies. Water rights are discussed in more depth in the following sections. Section 4.1 has explained water rights and agreements concerning water quality for the Sacramento/San Joaquin Rivers Delta

Table 4-15. 2010 Water Supplies, AFY

Water Supply Sources	Wholesale Supplied Volume	Volume (AF)
Surface water purchased from CCWD	Yes	17,843
Sacramento/San Joaquin Rivers Delta	No	7,550
Antioch Municipal Reservoir	No	380
Transfers in or out	No	0
Exchanges in or out	No	0
Recycled water from DDSD[a]	No	0
Desalination	No	0
Groundwater wells	No	0
Other	No	0
Total		25,773

[a]*Developed from recycled water projections in the Antioch/DDSD Recycled Water Facilities Plan, December 2007.*

Table 4-16. Supply Reliability – Current Water Sources, AFY

Water Supply Sources	Average/Normal Water Year Supply	Single Dry	Multiple Dry Water Years		
			Year 2011	Year 2012	Year 2013
CCWD	21,429	19,500	19,500	19,500	19,500
Sacramento/San Joaquin Rivers Delta	7,550	7,550	7,550	0	0
Antioch Municipal Reservoir	380	380	380	0	0
Percent of normal Year	100	93	93	66	66

Table 4-17. Factors Resulting in Inconsistency of Supply					
Name of Supply	Specific Source Name, if any	Legal	Environmental	Water Quality	Climatic
Surface water (wholesaler-provided)	Sacramento/San Joaquin Rivers Delta	None	None	Yes, potential impact	Yes, potential impact
Surface water	Sacramento/San Joaquin Rivers Delta	None	None	Yes, potential impact	Yes, potential impact
Surface water	Antioch Municipal Reservoir	None	None	Yes, potential impact	Yes, potential impact
Groundwater	N/A	None	None	None	None
Recycled water	DDSD	None	None	None	None

N/A = Not applicable; the City does not currently use this source of water.

Canal water purchased from CCWD is pumped from Victoria Canal in the central Delta, and Rock Slough and Old River in the western Delta. The pipelines from the Contra Costa Canal to the WTP have a capacity of more than 60 mgd, which is well above the maximum predicted future water demand. Water from the Canal can be pumped into the Municipal Reservoir or directly to the WTP. Water that the City withdraws from the Antioch San Joaquin River intake historically first has been pumped to the Municipal Reservoir before going to the WTP; however, to the City is exploring relaxing this methodology so that it may pump directly from the river to the WTP. The WTP has a maximum capacity of about 37 mgd. Treated water flows into two 1.0-MG clearwells (Clearwells A and B) before entering the distribution system. Figure 4-1 is a schematic diagram of the existing water system.

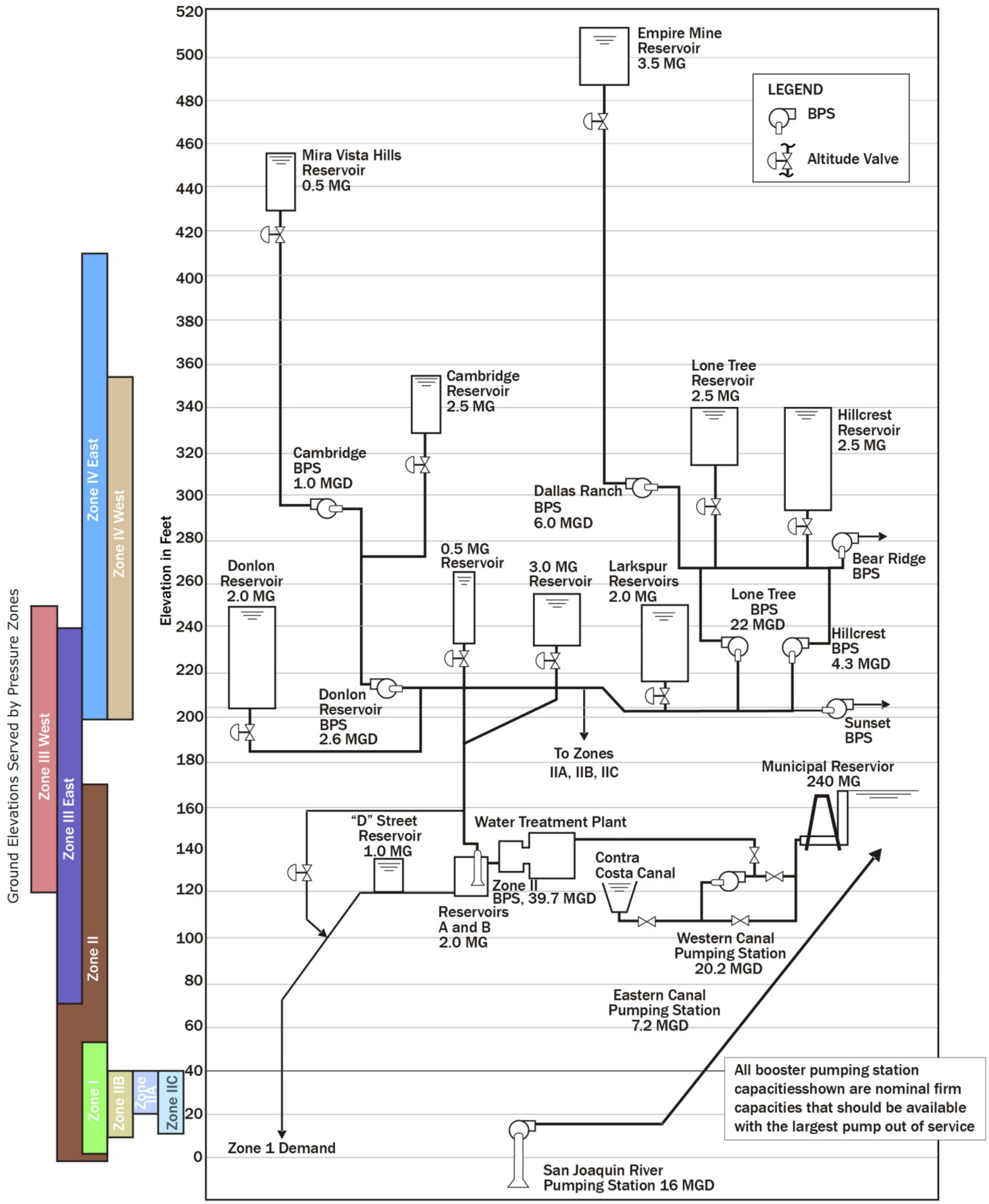


Figure 4-1. Existing Water System Schematic

In addition to expansion, the City improved water source reliability by purchasing treated water from CCWD produced at the Randall-Bold Water Treatment Plant (RBWTP), using a connection to the CCWD multipurpose pipeline at Hillcrest Avenue, the Diablo Water District (DWD) conveyance system, a new BPS at the RBWTP and a new pipeline.

4.2.1 Contra Costa Canal

CCWD supplies water to the City from diversions at Victoria Canal, Rock Slough and Old River in the Sacramento/San Joaquin Rivers Delta through the Canal, operated by CCWD for the United States Bureau of Reclamation (Bureau). According to CCWD's 2010 UWMP, the long-term Central Valley Project (CVP) contract between CCWD and Bureau was renewed in May 2005 for a term of 40 years. The contract allows CCWD a maximum annual allotment of 195,000 acre-feet (ac-ft) from the CVP. Reductions in the 195,000 ac-ft allotment are dependent on water shortages, including droughts and regulatory restrictions. The Bureau created the Municipal and Industrial (M&I) Water Shortage Policy, which establishes CVP water supply levels that could sustain urban areas and provide adequate levels of health and safety during continuing or severe droughts. The M&I Water Shortage Policy also allows a minimum allotment of 75 percent of adjusted historical use until irrigation allocations are below 25 percent. The M&I Water Shortage Policy defines historical use as "the average quantity of CVP water put to beneficial use within the service area during the last three years of water deliveries, unconstrained by the availability of CVP water."

The Raw Water Division of CCWD provides wholesale water to the City for about $1,816 per MG ($592 per ac-ft). In contrast, the cost for pumping from the San Joaquin River to the Municipal Reservoir or the WTP is about $225 per MG (including electricity, labor, and other maintenance). The City's current annual agreement is for a peak demand of 25,000 gallons per minute (gpm) (36.0 mgd). Unless constrained by drought conditions, CCWD is prepared to sell to the City all of the City's projected water needs through the year 2035. Based on recent studies, the existing Canal does not have sufficient capacity to carry the City's increased future flow together with those required by other customers, but CCWD has installed a pipeline parallel (multipurpose pipeline) to the Canal to satisfy such demands.

Historically, the quality of the water in the Canal has been beyond the direct control of CCWD. It depends on overall Delta water quality that is, in turn, affected by a multitude of factors, including weather, upstream reservoir releases, tidal changes, discharge of nearby agricultural users, export rates of the pumps for the State Water Project and CVP, and standards and objectives set by the SWRCB and USEPA. The Canal was one of the first units in the CVP. Bureau has a contract to deliver the water to the Canal, but the contract includes no water quality requirements. According to the contract, Bureau is "…to maintain the quality of the raw water to be delivered hereunder at the highest level reasonably attainable and consistent with municipal and industrial use." Bureau is not required to meet any specific water quality level for the Canal. The future water quality depends primarily on two factors:

- Operation of the Los Vaqueros Project.
- Outcome of the ongoing Bay-Delta planning efforts.

The Los Vaqueros Project, approved by the voters in November 1988, has resulted in a new 100,000 ac-ft storage reservoir located southwest of Brentwood. This project allows CCWD to draw low salinity (as measured by TDS or chlorides) water from the Delta during high runoff periods. This water is now available for blending with normal withdrawals from CCWD Delta sources. Los Vaqueros Reservoir also serves as emergency storage in the event of a chemical spill in the Delta or other disruption such as a levee failure. According to CCWD's 2010 UWMP, under Water Rights Permit No. 20749, CCWD has a maximum of 95,980 ac-ft that can be put into storage at the Los Vaqueros Reservoir through November 1 and June 30; however, during dry years, Los Vaqueros water rights are limited. More recently, CCWD expanded Los Vaqueros capacity to 160,000 ac-ft. The Los Vaqueros Water Rights supply can also be used in place of the CVP supply for CCWD. The equivalent amount of supply that is used from the Los Vaqueros Water Rights water is deducted from the CVP supply. Thus, the total annual allotment from Los Vaqueros Water rights and CVP water is 195,000 ac-ft.

4.2.2 Antioch Municipal Reservoir

The 735 ac-ft (240 MG) Antioch Municipal Reservoir provides supply reliability and volume for equalization storage for water pumped from the Canal and the Sacramento/San Joaquin Rivers Delta. The reservoir also serves the secondary purposes of flood control and impoundment of local runoff. Water production from the small (1,300 acre) tributary watershed, however, is of negligible importance particularly since most stormwater runoff from residential areas (about 600 acres) now is diverted around the reservoir.

The reservoir will continue to provide supply reliability and sufficient volume for equalizing the City's demand for raw water from the Canal and the Sacramento/San Joaquin Rivers Delta. Use of equalizing volume, for example, permits purchase of raw water at a constant rate for periods of a month or more, depending on the season of the year. Raw water is delivered at a constant rate to the reservoir and the WTP, and is withdrawn from the reservoir at varying rates to meet fluctuating demand conditions. In the past, the ability to purchase water at uniform rates has been of significant economic value to the City. Raw water reservoir equalization also may be of value in the future. The storage volume that will be needed for equalization purposes will therefore depend upon the rate schedule and service rules that will be promulgated in coming years. It is likely, however, that the 240 MG available in the Municipal Reservoir will be sufficient for this purpose.

4.2.3 Local Wells

The City does not currently use groundwater nor does it plan to use groundwater by the year 2035. The City may have potential groundwater resources in the southeast, for example, in Lone Tree Valley that have suitable quality, at least for irrigation.

4.2.4 Sacramento/San Joaquin Rivers Delta

The City and earlier local inhabitants have drawn water from the Sacramento/San Joaquin Rivers Delta as a primary source for more than 145 years. Before the growth of the irrigated rice industry around World War I, there was sufficient fresh water in the river year round; however, as this major summer diversion began and the flows into the Delta decreased, saline bay waters moved further upstream and replaced the fresh water. The City sought judicial relief and filed a suit asking the court to restrain the upstream Williams Irrigation District from diverting Sacramento River waters. The court granted an injunction in January 1921, but the California Supreme Court reversed it in March 1922. Since that time, the City has been able to pump from the Sacramento/San Joaquin Rivers Delta for varying periods up to more than 300 days per year depending on salinity levels caused by drought or upstream diversions and dams. No pumping occurred during the drought period of 1976 to 1977. Similarly, from 1986 to March 1991, the City was only able to pump seven days a year. The City generally stops pumping if the mean chloride concentration in the river water exceeds 250 mg/L. If the chloride concentration in the Municipal Reservoir water is particularly low, the City may continue limited pumping to the Municipal Reservoir when the chloride concentration exceeds 250 mg/L in the river. At no time does the City stop pumping if river water quality is acceptable for use as potable water after treatment.

Between 2005 and 2010, the City pumped an average of 6,050 AFY from the Sacramento/San Joaquin Rivers Delta. For planning purposes, in normal years, is the City assumes that this amount will be available. This assumption is more conservative than the existing agreement of 208 days per year at 16 mgd or about 10,200 AFY. In 1998, a very wet year, the quality of the water was sufficient to allow the City to pump 12,614 ac-ft. In comparison, between 2005 and 2010, the City has taken an average of 12,325 AFY from CCWD.

4.2.5 Impacts of Regulatory Processes for Water Conservation

The unpredictable water supply and ever-increasing demand on California's complex water resources have resulted in a coordinated effort by DWR, water utilities, environmental organizations, and other interested groups to develop a list of urban Demand Management Measures (DMM) for conserving water. This consensus-building effort resulted in the California Urban Water Conservation Council's (CUWCC) Memorandum of Understanding (MOU), as significantly amended on December 10, 2008 and less extensively on September 14, 2011. The MOU formalizes an agreement to implement these DMMs and makes a cooperative effort to reduce the consumption of California's water resources. Table 4-18 lists the MOU-defined DMMs. The MOU-defined DMMs are generally recognized as standard definitions of water conservation measures. The CUWCC administers the MOU. The City is not a signatory of the MOU, but currently implements water conservation practices in line with the MOU.

Table 4-18. Water Conservation Demand Management Measures Listed in MOU

Revised (Current) CUWCC BMP Category			Former DMM/CUWCC BMP Name	
Category	BMP No.	BMP Name	DMM/BMP No.	DMM/BMP Name
Foundational BMPs	BMP 1	Utility Operations		
	BMP 1.1	Operations Practices		
	BMP 1.1.1	Conservation Coordinator	12	Conservation Coordinator
	BMP 1.1.2	Water Waste Prevention	13	Water Waste Prohibition
	BMP 1.1.3	Wholesale Agency Assistance	10	Wholesale Agency Assistance Programs.
	BMP 1.2	Water Loss Control	3	System Water Audits, Leak Detection, and Repair.
	BMP 1.3	Metering with Commodity Rates	4	Metering with Commodity Rates for all New Connections and Retrofit of Existing Connections.
	BMP 1.4	Retail Conservation Pricing	11	Conservation Pricing.
	BMP 2	Educational		
	BMP 2.1	Public Information	7	Public Education Programs.
	BMP 2.2	School Education	8	School Education Programs.
Programmatic BMPs	BMP 3	Residential		
	BMP 3.1	Residential Assistance	1 & 2	Water Survey Programs for Single-Family and Multi-Family Residential Customer (Indoor) and Residential Plumbing Retrofit.
	BMP 3.2	Landscape Water Survey	1	Water Survey Programs for Single-Family and Multi-Family Residential Customer (Outdoor).
	BMP 3.3	High-Efficiency Clothes Washers	6	High-Efficiency Washing Machine Rebate Programs.
	BMP 3.4	Water Sense Standard (WSS) Toilets	14	Residential Ultra Low Flush Toilets (ULFT) Replacement Programs.
	BMP 3.5	WSS for New Residential Development	(new)	
	BMP 4	Commercial Industrial Institutional (CII)	9	Conservation Programs for Commercial, Industrial, and Institutional Accounts.
	BMP 5	Landscape	5	Large Landscape Conservation Programs and Incentives.

The MOU requires that a water utility implement only the DMMs that are economically feasible. If a DMM is not economically feasible, the utility may request an economic exemption for that DMM.

Previously, the DMM numbering system followed the CUWCC BMP numbering system. Since development of the 2005 Plan, the CUWCC has revised its classification of BMPs. Table 4-18 lists both the revised (current) and former BMP classifications.

Water conservation is a method available to reduce water demands, thereby reducing the City's water supply needs. SBx7-7 requires water providers to establish per capita water use targets using one of four methods. The City had selected to pursue the third method (SB7 Method 3) in the City's 2010 UWMP. The City's baseline water use (historical usage) is 186 gpcd, thus using the third method from SBx7-7 sets an interim 2015 target for the City's hydrologic region (Region 6) to 176 gpcd (i.e. 95 percent of the state interim hydrologic region target) and 165 gpcd by 2020 (95 percent of the state hydrologic region target by 2020). In 2009, water use had dropped to 164 gpcd, slightly less than the 2020 target. The City assumes that the recent, rapid decrease in per capita water use results from voluntary water conservation during a drought period and the economic recession. The recession has encouraged reduced water use directly to save money. The City also has invested in its WTP operations by capturing and re-treating its lost streams (backwash water and water in solids) to produce more potable water. And, as presented in Section 3, the City, in conjunction with DDSD, has constructed recycled water distribution facilities that went online in 2012.

4.2.6 Methods for Water Conservation

This section describes the City's water conservation program. As economic conditions improve and some drought-driven conservation abates, the City expects that per capita water use may increase. The City will continue its historical water conservation measures, better implement existing programs, and possibly add new programs. The City will use means other than DMMs to comply with the 2020 reductions. Table 4-19 summarizes the City's projects for achieving the 11 percent reduction.

The City conducts an ongoing water conservation program. As a raw water customer of CCWD, all of the City's customers are eligible for conservation programs provided by CCWD. These services were not regularly marketed to the City's customers until 2000. CCWD implements all DMMs and tracks most expenses and savings associated with the DMMs. The City helps market the programs and provides staffing assistance for some DMMs.

Table 4-19. Proposed Methods to Achieve 2020 Per Capita Water Use Goal					
Item	No. of Interventions	Water Savings per Intervention (gpd/intervention)	Annual Savings in year 2020 (AFY)	Projected Percent of Required Savings (%)	Comments
Water Treatment Plant Lost Water Recovery	N/A	N/A	660	27	Already implemented.
Use Offset with Recycled Water	N/A	N/A	1,000	41	About 50 percent implemented in 2011. Will be expanded incrementally.
DMM 1 Residential Water Surveys: Single Family	2000	44	99	4	Water savings based on 2002 data analysis for Save Our Delta Surveys (SODS) Water Use Efficiency (WUE) grant program. Assumes about 10% of single family residential (SFR) customers participate and have not been targeted previously.
DMM 2 Residential Plumbing Retrofits	2000	5	11	0	Water savings based on A&N BMP Costs & Savings Study, March 2005 City has over 18,600 pre-1992 single family residential units and over 3,700 pre 1992 multi-family residential units.
DMM 3 System Water Audits, Leak Detection, and Repair	N/A	N/A		0	City will implement this program, but no water conservation credit is taken.
DMM 5 Large Landscape Conservation Programs	500	6%	112	5	Water savings of 6% based on A&N BMP Cost & Savings Study. Assumes 50% of landscape accounts participate and have not previously participated.
DMM 6 High Efficiency Washing Machine Rebate Program	2000	81	181	7	Water savings based on A&N BMP Costs & Savings Study, March 2005. Assumes about 10% of SFR customers participate and have not been targeted previously.
DMM 9 Conservation Programs for Commercial, Industrial and Institutional Accounts	N/A	N/A		0	City will implement this program, but no water conservation credit is taken.
DMM 11 Conservation Pricing: Residential	33,935	5	190	8	City's most recent rate increase (in 2010) of about 11% is assumed to reduce water use by about 1.5 gpcd.
DMM 14 Residential Toilet Replacement Program	2500	33	92	4	Water savings are based on professional judgment. Assumes about 15% of SFR customers participate and have not been targeted previously.
Water Sense Standard--Efficiencies in New Residential Construction	3000	22	74	3	
Total	--	--	2,419	100	

Note: This table does not list DMMs where the City can attribute no direct measurable water savings.

4.2.7 Impacts of Regulatory Processes on the Sacramento/San Joaquin Rivers Delta

The City has pre-1914 water appropriative rights to divert water from the Delta as confirmed by the California Supreme Court. The City's pre-1914 appropriation does not have a maximum diversion limitation. The original appropriation included a plan of development to expand the City's water supply over the years as necessary to accommodate future growth, and the City continues to do so with reasonable diligence. Also, CDPH has no concerns over the City's use of San Joaquin River water when it is available. The City can presently draw no more than 16.0 mgd from the San Joaquin River when water quality permits any withdrawal because of the limited capacity of the river pumping station and the raw water pipeline from the river to the Municipal Reservoir. Water quality is one of the limiting factors impacting the City's ability to expand its water supply; however, in coming years, river water quality will continue to be impacted by decisions outside the City's control. State plans call for increased water diversions from the Delta to satisfy water demands in the San Joaquin Valley and areas south and west. Any decrease in the net flow from east to west in the Sacramento/San Joaquin Rivers Delta at Antioch will tend to reduce the availability of low chloride waters.

Other regulatory processes may affect the City's withdrawals from the San Joaquin River, due to the new direction in planning efforts for the Sacramento/San Joaquin Rivers Delta since the City's 2010 UWMP was developed. The Delta is a critical natural resource for California and the nation (in terms of agricultural production) and is considered to be in ecological crisis.

Since the City's 2005 UWMP, the state passed legislation to define a planning and implementation process for the Delta. The legislation is part of a comprehensive package of four policy bills and a bond measure. One of the bills is the Delta Protection Act of 2009, Senate Bill x7-1 (SBx7-1). SBx7-1 revised and recast the provisions of the Delta Protection Act. A brief description of SBx7-1 and the Delta Protection Act are explained below.

SBx7-1 includes the following:

- Formation of the Delta Investment Fund in the State Treasure to fund implementation of the regional economic sustainability plan and ecosystem restoration projects.
- Formation of the Sacramento-San Joaquin Delta (Delta) Conservancy. The conservancy acts as the primary state agency to implement ecosystem restoration in the Delta and supports environmental protection and economic well-being of Delta residents.
- Formation of a committee convened by the Secretary of the Natural Resources Agency to develop and submit recommendations for a strategic plan related to sustainable management of the Delta.
- Enactment of the Delta Reform Act of 2009 and establishment of the Delta Stewardship Council (DSC). The DSC is required to develop, adopt, and commence implementation of a comprehensive resources management plan (the Delta Plan) for the Delta. DSC was required to develop the Delta Plan by January 1, 2012. Development of the Delta Plan is a significant effort that requires integration with other planning efforts, such as the Bay Delta Conservation Plan (BDCP). The BDCP is a separate process that is also in development, which is intended to provide the basis for long-term permits for CVP and State Water Project operations. The February 2012 Administrative Draft Environmental Impact Report/Environmental Impact Statement for the BDCP defines alternatives for achieving the balance between ecosystem and water supply exports from the Delta. Since that draft was released Governor Brown and the Obama administration have announced a new direction for the BDCP that includes new water intake facilities with a total capacity of 9,000 cubic feet per second (cfs), which is significantly lower than a previous BDCP proposal for a 15,000 cfs facility.

DSC efforts are built upon past work by other related planning agencies. The Delta Protection Commission, established under by the Delta Protection Act of 1992, was formed to prepare and adopt a comprehensive long-term resource management plan for specified lands within the Delta.

The basic goals for the Delta planning process as defined by State Legislature are as follows:

- Achieve the two coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be "achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place."
- Protect, maintain, and, where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities.
- Have orderly, balanced conservation and development of Delta land resources.
- Improve flood protection by structural and nonstructural means to increase the level of public health and safety.

The component of the Delta Protection Act that most significantly affects the City and its wholesaler, CCWD, is the adoption of Delta flow criteria. In August 2003, the SWRCB adopted new flow criteria recommendations for the Delta that call for significantly increased flows into and through the Delta, particularly during the winter and spring. In September 2012, DSC approved the final draft of the updated Delta Plan. When the final draft of the Delta Plan is completed, it will be the foundation of an additional volume of the Draft Programmatic Environmental Impact Report (DPEIR) (http://deltacouncil.ca.gov/delta-plan/current-draft-of-delta-plan). The DSC adopted the final draft of the Delta Plan on May 16, 2013. The DSC also certified the Programmatic Environmental Impact Report (PEIR) and adopted regulations for the application of Delta Plan policies. The BDCP will be later incorporated into the Delta Plan when the BDCP is completed and permitted (http://deltacouncil.ca.gov/sites/default/files/documents/files/13-0516%20Council%20Adopts%20final%20Delta%20Plan.pdf).

4.2.8 Desalination Water

Desalination has been identified as a potentially viable additional source of water for several Bay Area water suppliers including CCWD. The following description of the SF Bay Area Desalinization Plant study is provided on the SFPUC website (http://www.sfwater.org). This project, entered into jointly by the four regional water systems—SFPUC, East Bay Municipal Utility District (EBMUD), Santa Clara Valley Water District (SCVWD) and CCWD (and later joined by Alameda County Flood Control and Water Conservation District Zone 7)—has studied the feasibility of constructing a seawater/brackish water desalination plant. The parties shared equally in initial feasibility study cost as well as pilot testing CCWD's intake at Mallard Slough. MOUs will be prepared for initial and subsequent phases that will address cost sharing of those phases. Parties also are pursuing federal and state funding that may be available for design and construction. Phase 1 of the Prefeasibility Study has been completed. It evaluated the different sites and recommended three sites for further study. Phase II of the Prefeasibility Study further evaluated these sites in greater detail and considered environmental factors, transmission capability, institutional arrangements and grant funding. Funding for additional phases will be requested as the project progresses and based on recommendations of each phase of the project. The City defers to CCWD for leadership regarding desalination.

A site located just northwest of Antioch, the East Contra Costa Power Plant site, ranked as one of the top three candidate sites (http://www.sfwater.org).

Section 5

Raw Water Conveyance and Treated Water Distribution

The City depends on pipelines, pumping stations and reservoirs to divert raw water to its WTP and deliver treated water to its customers. This section describes both the raw water and treated water systems, discusses their condition, and presents information on proposed upgrades, renovation and expansion.

5.1 Raw Water System

The raw water system includes the river pumping station, two canal pumping stations, the Municipal Reservoir, and connecting pipelines. This section provides information on the capacity, age and condition of these components.

5.1.1 River Pumping Station

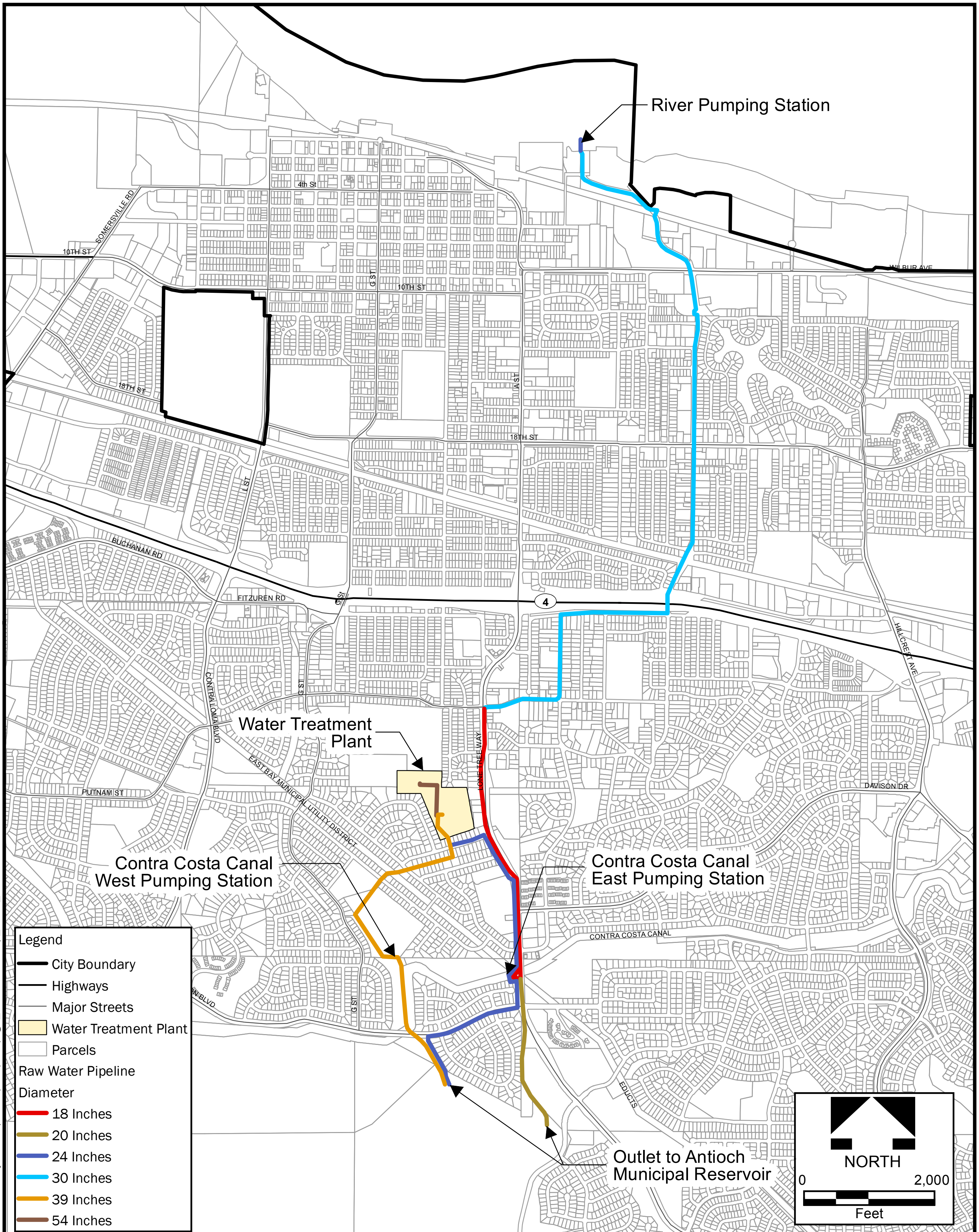
The City has diverted water from the San Joaquin River since the 1870s and as such has pre-1914 water rights. The river pumping station (RPS) is constructed on a pier that extends north over the San Joaquin River at the foot of Fulton Shipyard Road. The City rebuilt the RPS in the early 1990s and upgraded the river pump to a 1,250-horesepower (hp) vertical turbine pump in 1997. The pump bowls sit in a stainless-steel wedge-wire screen that prevents the entrainment of fish, fish larvae and debris. The screen is fitted with a compressed air scouring system. The City occasionally uses contract divers to inspect the pier and manually clean the screen exterior. As installed, the rated and measured capacity of the river pump was 16 mgd. This flow rate conforms to the permitted capacity for the intake screen as negotiated with the United States Army Corps of Engineers and National Marine Fishery Service in 1997. Based on information provided by the intake screen manufacturer, the City could operate the intake at up to 20 mgd with the existing screen and still comply with regulatory requirements for screen approach and through-screen velocities. In 2012, using a portable flow meter, City staff estimated that the current pump output is about 14 mgd. This value indicates that the pump suffers from wear owing to about 16 years' operation and needs rehabilitation to restore its capacity. As discussed in Section 4, the City operates the RPS only when river water quality meets City-defined limits.

Based on physical inspection and discussions with City staff, the river pump and some peripheral equipment are worn and need rehabilitation. The RPS also would be easier to maintain with some equipment relocation. Key projects include:

- Remove, rebuild and reinstall the pump and motor.
- Rebuild or replace the pump control valve and hydraulic surge control system.
- Consider relocating the main electrical panel to the north wall to improve pump access for monitoring and maintenance.
- Replace the leaking pipeline portion of pipeline where flow leaves the building, using heavier wall piping for greater future service life.
- Add a flow meter (e.g., magnetic or acoustic doppler) to the discharge pipeline, with metering data recorded locally and transmitted to the WTP control room.

5.1.2 Raw Water Pipeline

The City uses several pipeline segments to convey river water from the RPS to the Municipal Reservoir. Figure 5-1 shows raw water pipeline alignments. A short section of 24-inch diameter welded-steel pipe mounted beside the pier runs from the RPS. The 24-inch diameter pipe connects to a 30-inch diameter ductile iron pipeline (DIP) at the pier's south end installed in 1997. The 30-inch diameter pipeline follows City streets to the intersection of Lone Tree Way and Worrell, where it connects to an 18-inch diameter cast iron pipeline (CIP). The CIP, installed about 1940, runs south in Lone Tree Way to the south side of the Contra Costa Canal, where it connects to a 20-inch diameter concrete cylinder pipeline (CCP) that conveys water further south to the eastern side of the Municipal Reservoir. The CCP was installed in about 1965.



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DATE	PROJECT	SITE	
5-7-13	143330	**City of Antioch**	**Figure 5-1**
Brown AND Caldwell		**Raw Water Pipelines**	

The newer pipelines installed in 1997 are in excellent condition. Based on observations during construction of the 30-inch diameter DIP and during a more recent repair of the 18-inch diameter pipeline, the 18-inch diameter CIP is also in very good condition given its age. It is estimated that the City does not need to replace it in the next two decades unless the City decides to increase the capacity to divert river water beyond the existing system capacity as discussed below.

City staff requested that BC evaluate whether it would be feasible to pump raw water directly into the WTP instead of pumping it to the Municipal Reservoir. The City stopped pumping directly to the WTP in about 1965 at the direction of CDPH. At that time, CDPH had a concern because the City's WWTP discharged disinfected primary effluent near the San Joaquin River's north shoreline about one half mile from the RPS intake. In 1980, the City began conveying its raw sewage to Delta Diablo Sanitation District (DDSD) and ceased discharging through the City outfall. DDSD treats raw sewage from Antioch, Pittsburg and Bay Point and discharges much higher quality effluent about 2.5 miles downstream from the RPS intake, through a diffuser that achieves good initial dilution. Since past risks have disappeared, CDPH has indicated to the City that it would consider allowing direct pumping of river water to the WTP. BC carried out preliminary hydraulic analyses to test this option, assuming that the existing 18-inch diameter CIP would connect to the existing 24-inch diameter pipeline at Lone Tree Way and Terranova Drive. Those analyses showed that with the existing river pump (reconditioned to like-new capacity) and pipelines, the river diversion would increase to 19 to 20 mgd. During such operation the City should maintain open pipeline connections to the Municipal Reservoir, to protect against hydraulic surge. If the City implements direct pumping from the river to the WTP, it should explore whether raw water quality in the reservoir suffers, e.g., from decreased reservoir circulation and mixing or from treatability challenges resulting from direct treatment of river water.

5.1.3 Municipal Reservoir

The City created the Municipal Reservoir by building an initial dam in the early 1930s. The City later raised the dam to its current height. The City has evaluated and now maintains the dam as required by the State of California Division of Safety of Dams. The City last assessed accumulation of sediment and debris in the reservoir with a bathometric study completed in 2006. That survey showed some sediment accumulation, especially in the southeastern portion. Historically the City has dredged accumulated sediment and worked cooperatively to apply the sediment to the municipal golf course greens and fairways to improve soil conditions there. Recently the City completed preventative maintenance to the reservoir outlet structure so its control gates work better. The lowest gate still needs additional work. The 24-inch diameter inlet/outlet pipeline through the dam is part of the original dam construction but apparently functions properly without constriction. However, given its age (about 80 years) and its hydraulic capacity limitations, adding a parallel, larger diameter pipeline under the dam with a new outlet tower in the Municipal Reservoir would provide redundancy and improved hydraulic capacity. Since 2001, the City has installed four solar-power surface mixers to help control algae and attached plant growth within the reservoir.

Based on discussions with City staff and review of record information, BC has identified several needed improvements for the Municipal Reservoir:

- Replace leaking sluice gates between reservoir and storm drain bypass.
- Complete repairs to outlet tower control gates.
- Evaluate records further to determine how much sediment has accumulated and decide whether dredging is warranted. Periodic dredging may improve reservoir water quality by removing accumulated nutrients and fine sediment and discouraging algae and attached vegetation growth.
- Consider adding a parallel, larger diameter outlet pipeline under the dam connected to a second outlet within the reservoir, with the pipeline constructed by microtunneling. Just downstream of the

Brown AND Caldwell

dam, the new parallel outlet pipeline would connect to the existing pipelines to the WTP and possibly a new parallel transfer pipeline as discussed below.

5.1.4 Canal Pumping Stations and Raw Water Transfer Pipes

The City has two raw water pumping stations to transfer water from the Canal to the Municipal Reservoir and the WTP. Historically these pump stations have transferred up to about 27.2 mgd (about 19,000 gpm). This rate appears to be at or near the maximum capacity for the existing pumps. If the maximum WTP capacity is as great as 37 mgd (about 25,700 gpm) (see Section 6), the CPSs will need at least that capacity by 2035. This output would result in pipeline velocities of 5 to 6 feet per second. Since such high production would only occur briefly during high demand months and have limited duration, it is probably not necessary to have redundant pumping capacity since the City has about eights months per year to carry out preventative maintenance. These facilities are discussed below:

- The West Canal Pumping Station (WCPS), built in 1967, is equipped with a manually cleaned bar screen (1.0-inch bar spacing) at the canal turnout, a flow meter, a 36-inch diameter intake pipeline, and three vertical pumps with the nameplate characteristics in Table 5-1 below:

Table 5-1. Nameplate Characteristics

Pump	Motor size,[a]	Capacity, gpm
1	300 hp	8,000/12,000
2	125 hp	2,800/8,000
3	125 hp	2,800/7,000

[a]All two-speed motors.

  Based on testing by City staff, its maximum output in its current configuration is about 14,400 gpm with Pump 1 and either Pump 2 or Pump 3 operating at full speed. The City cannot operate all three pumps in parallel and achieve significantly higher output owing to hydraulic limitations caused by discharge piping connections. Pump 2 now connects to a tee that discharges to the Pump 1 and Pump 3 discharge pipelines but not directly to the 39-inch diameter transfer pipeline. Modifying the Pump 2 discharge piping should increase the overall pumping capacity by over 5000 gpm, delaying or even eliminating the need for more raw water pumping capacity.

  The WCPS is located on the north side of the Canal about 1,000 feet north of James Donlon Boulevard. Electric power transformer capacity currently prevents operating more than two pumps simultaneously. The City recently retrofitted the WCPS with 250-kilowatt, diesel-fueled standby generator. The generator has capacity to operate one small pump at high speed and one small pump at low speed simultaneously, for a combined output of about 15.5 mgd. That capacity would be more than a minimum day demand and, hence, would be suitable for emergency operations.

- The East Canal Pumping Station (ECPS) was originally constructed in 1949. It is located on the south side of the Canal just west of Lone Tree Way. The City closed it in 1967 and then rehabilitated it in 1997 by completely upgrading its electrical, instrumentation, and control systems and installing a new two-speed, 150-hp pump. CCWD recently installed a magnetic flow meter on the discharge piping. The City uses data from the CCWD flow meter to monitor pump output. Based on field observations, the pump capacity is about 2,500 or 5,000 gpm, depending upon its operating speed. This capacity is lower than its design capacity of 3,500 or 7,000 gpm, likely owing to pump wear and vortexing at the pump inlet. The City should arrange to recondition the pump and motor. Concurrently it could modify the wetwell with a baffled cylinder inlet to suppress vortexing and consider adding a bar rack screen to the canal inlet, to protect the intake better.

- The pipelines from the Canal to the WTP have a capacity of more than 60 mgd if maximum pipe velocities of 10 feet per second are allowed at peak flow. Since the maximum WTP capacity is about 37 mgd, the pipelines do not present a capacity limitation; however, the City may wish to further consider the need for redundant pipelines depending on results of remedial/rehabilitation work described below.
- Two raw water pipelines connect the Municipal Reservoir with the WTP. A 39-inch diameter CCP, built in 1967, runs from the reservoir to an undercrossing of the Canal about 2,000 feet west of Lone Tree Way, parallel to the Canal to the WCPS, and then to the WTP. A 24-inch diameter pipeline (likely some cast iron sections from the 1940s and some ductile iron sections from the 1980s) runs north from the base of the dam, parallel to the 39-inch diameter pipeline, to James Donlon Boulevard, east along James Donlon Boulevard to Lone Tree Way, north along Lone Tree Way by the ECPS, across the Canal to Terranova, and along Terranova to connect with the 39-inch diameter pipeline about 400 feet south of the south end of the Plant A sedimentation basins. Since the transfer pipelines are critical to successful and reliable WTP operation, working with City staff BC explored an option of adding a parallel pipeline from the dam to the WTP. Preliminary map reconnaissance resulted in a potential route as shown on Figure 5-2, generally paralleling the existing 39-inch diameter pipeline. This route would minimize construction in busy City streets such as James Donlon Boulevard and Lone Tree Way. It would require several new easements across public and private property. Route development assumed that the new pipeline would have an internal diameter of 42 inches and would connect to a new reservoir outlet pipeline constructed under the reservoir dam.

In 1997, BC completed an evaluation of transfer capacity from the Municipal Reservoir and the Canal to the WTP. Conclusions from the 1997 analyses, combined with input from City staff, include:

- The raw water transfer capacity from the Municipal Reservoir, in conjunction with pumping from the Canal, must be at least 16 mgd to accommodate the maximum diversion with the rebuilt river pump and raw water pipeline. The system has that capacity.
- The existing pumps and pipelines have sufficient capacity to transfer at least 27 mgd to the WTP based on the current facilities condition. Their capacity could be increased as noted above.
- Excessive frictional losses in the existing pipelines and the current pump configuration limit capacity. Engineering analyses indicate that a higher transfer should be possible if the pipelines performed with less frictional losses. The City plans to do further forensic work to evaluate the pipelines and their appurtenances, likely leading to cleaning both pipelines. If the friction is abnormally high after cleaning, then the City will need to install a low-head pumping station or a parallel pipeline to increase capacity as discussed above. If the pipelines prove to have a reasonable friction factor after cleaning, the City should carry out additional evaluation at the WCPS, possibly leading to modification of the connection to the canal to decrease intake frictional losses and to connect Pump 2 directly to the 39-inch diameter pipeline so that all WCPS pumps can operate simultaneously.

Figure 5-2. Preliminary Route for New Raw Water Pipeline from Antioch Municipal Reservoir to Water Treatment Plant

5.2 Treated Water Distribution System

The treated water distribution system includes water mains, BPSs and reservoirs. This section presents an evaluation of the distribution system and conclusions and recommendations for system upgrades to serve the study area adequately through the year 2035. The design criteria included projected flow, storage and pressure requirements.

As part of this evaluation, BC updated the water system hydraulic model and expanded it to incorporate anticipated future service areas in the northeast and the southeast. For the southeast, BC developed preliminary pipeline alignments and sizes based on planning information assembled by Carlson Barbee and Gibson (personal communication). The City should revisit water system expansion into the southeast once more detailed planning including number and type of units in each develop and elevations served. For example, as discussed further below, building upon higher elevation lots may require additional reservoirs and booster pumping stations. Computer analyses were made during conditions of maximum-day demand, maximum-day demand with fire flow, and peak-hour demand. Pipe sizes and locations were selected to meet the specific design criteria for all demand conditions.

5.3 Existing System

The system model includes all existing major distribution mains. Figure 5-3 shows a schematic of the existing system indicating the interrelationship among system components. Figure 5-4, included in the back of this report, shows the existing water distribution system with main diameters differentiated by color. The smallest mains shown have diameters of 6-inches. The model represents the entire system but does not include minor components such as 4-inch diameters and fire hydrant and irrigation connections that do not affect distribution system capacity. Appendix B presents a summary of how the BC developed and calibrated the model using fire hydrant flow testing data. Most of the model calibrates within a pressure of 5 pounds per square inch gage (psig). Where calibration deviated greater than 5 psig, it appears that elevation data from the GIS may be inaccurate when compared with field conditions. Such differences point to opportunities to fine tune the model with additional information taken from subdivision record drawings or from new topographic data added to the City GIS.

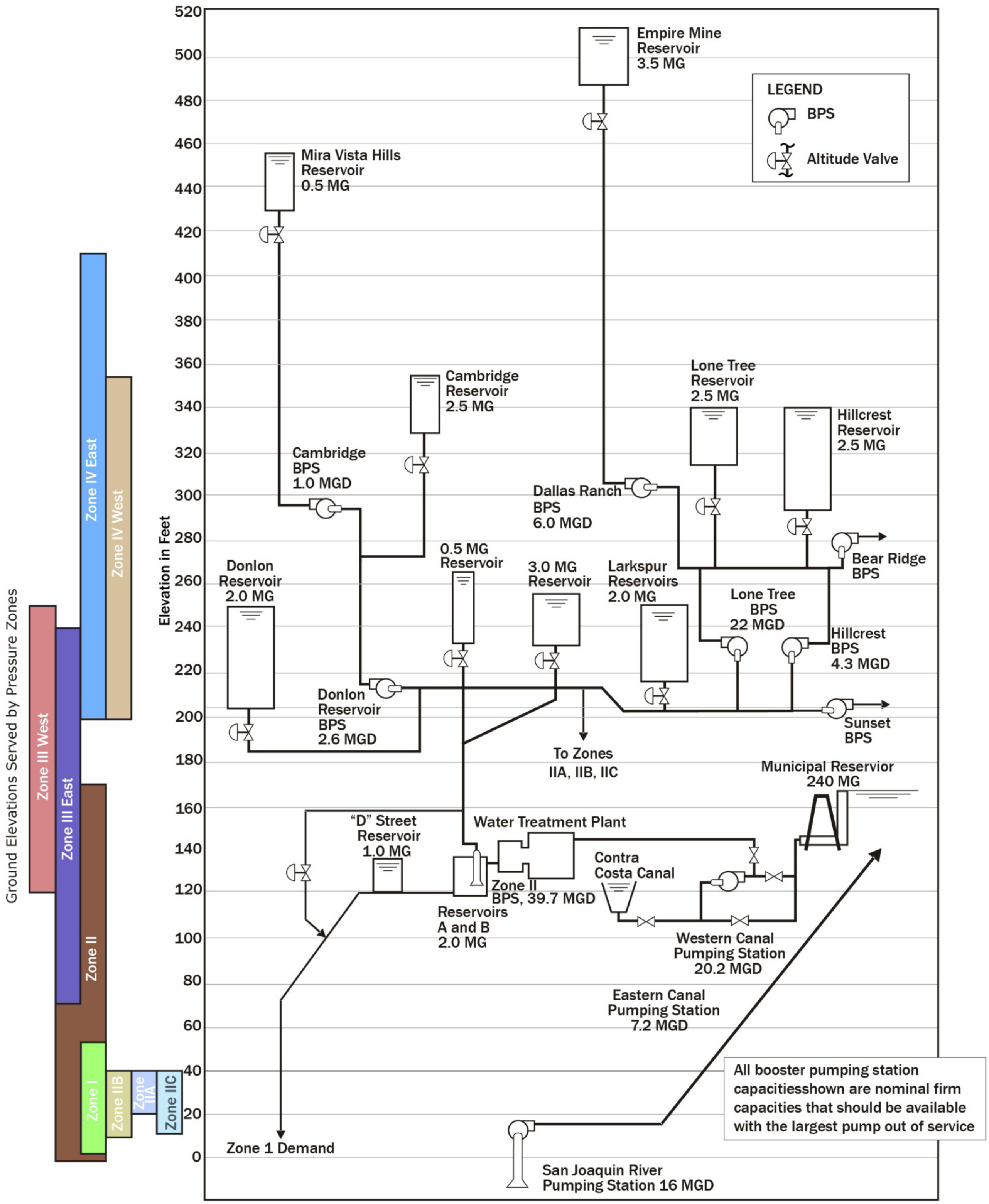


Figure 5-3. Existing Water System Schematic

Figure 5-4. Service Area and Distribution System Facilities

(See the back of this report for a 24x36 sheet.)

5.3.1 Design Criteria

Design criteria for analysis of the distribution system include projected water flow, storage and pressure requirements.

5.3.2 Water requirements

The year 2035 maximum day demand of 30.9 mgd and peak hour demand of 49 mgd presented in Section 3 were used to determine design flow rates for the pipe network. The distribution of future water use over the study area is based on existing and projected land use and on population projections by land use areas.

5.3.3 Storage and Storage Requirements

Storage. Section 2 presents more data for the storage reservoirs, including base and overflow elevations and storage volumes. Table 5-2 presents a summary of characteristics for the existing reservoir, including physical condition. In general, the reservoirs constructed of concrete are in good or very good condition. Several steel reservoirs require recoating and structural evaluation, but the City already has initiated projects to address those issues. Since the City constructed all reservoirs prior to adoption of the current, more stringent building code, the City prudently plans to assess the seismic durability of all its reservoirs.

Table 5-2. Summary of Reservoir Information

Reservoir and Approximate Construction Year	Volume (MG)	Condition	Comments
Clearwell A (1946)	1.0	Good	Reinforced concrete. Some rehabilitation in 1990 including addition of interior baffling to increase contact time and leveling and recoating roof. Structural durability checked in 1990s but should be rechecked based on current building codes. City should monitor roof and repair if required.
Clearwell B (1988)	1.0	Very good	Reinforced concrete (ACI350) with interior baffling. Not designed to current building codes so should be rechecked for structural durability but likely requires little modification. City should monitor roof and repair if required.
D Street (1940)	1.0	Good	Reinforced concrete. Structurally reviewed after 1989 and roof replaced. Structural durability should be rechecked based on current building codes.
0.5 Million Gallon (1957)	0.5	Good	Welded steel (American Water Works Association [AWWA] D100). Evaluated structurally in 1990 and perimeter anchoring into underlying rock added in about 1991. Recoated at the same time. City should monitor coatings and recoat as needed.
3.0 Million Gallon (1967)	3.0	Good	Welded steel (AWWA D100). Evaluated structural after 1989 and found to be code compliant then. Exterior over coated and interior stripped and recoated and interior mixing system added in lake 1990s. City should monitor coatings and recoat as needed. The City has undertaken aseismic structural durability evaluation of this reservoir.
Larkspur (1980)	2.0	Fair	Welded steel (AWWA D100). Structural evaluation, mixing system installation, and interior and exterior stripping and recoating will be complete in spring 2013.

Table 5-2. Summary of Reservoir Information			
Reservoir and Approximate Construction Year	Volume (MG)	Condition	Comments
Hillcrest (1980)	2.5	Very good	Welded steel (AWWA D100). Structural evaluation, mixing system installation, and interior and exterior stripping and recoating completed in spring 2010.
Lone Tree (1990)	2.5	Very good	Prestressed reinforced concrete (AWWA D110, Type 1). Almost fully buried, with foundation on bedrock. Even though designed and constructed to earlier building codes, should be seismically safe based on analyses of similar local prestressed concrete reservoirs. City should monitor roof and repair if required.
Donlon (1980)	2.0	Fair	Welded steel (AWWA D100), with foundation anchored into rock. Structural evaluation, mixing system installation, and interior and exterior stripping and recoating will be complete in 2013.
Cambridge (1990)	2.5	Very good	Prestressed reinforced concrete (AWWA D110, Type 1), partially buried with foundation on bedrock. Even though designed and constructed to earlier building codes, should be seismically safe based on analyses of similar local prestressed concrete reservoirs. City should monitor roof and repair if required.
Empire Mine (1995)	3.5	Very good	Prestressed reinforced concrete (AWWA D110, Type 1). Almost fully buried, with foundation on bedrock. City should monitor roof and repair if required.
Mira Vista (2003)	0.5	Very good	Reinforced concrete (ACI 350), partially buried with foundation on bedrock. Even though designed and constructed to earlier building codes, should be seismically safe based on performance of similar reservoirs. City should monitor roof and repair if required.

5.3.4 Storage Requirements

Treated water storage is usually located within water distribution systems to provide equalization of peak demands (i.e., to provide the difference between the rate of supply and the peak demands), a reserve for emergency conditions, and a reserve for fire flow. Table 5-3 summarizes the characteristics for the City's existing reservoirs.

- **Equalization.** The demand fluctuation on maximum day determines the storage volume that should be provided for equalization. The amount of equalization is usually expressed as a percentage of the average rate of demand on the maximum day. In California, equalization requirements typically vary from 10 to 25 percent of maximum day demand. Specific data to determine equalization requirement by pressure zone in the City are unavailable. On a conservative basis, it was assumed that equalization requirements are 25 percent of the maximum day demand.
- **Fire Flow.** The storage volume provided for fire flow must be adequate to deliver the required flow for the required duration. Based on a review of existing and planned development and discussions with the Contra Costa County Fire Protection District (CCCFPD), fire flows were established by area of the City, as shown on Figure 5-5. Durations of flow required for each pressure zone were as specified in the 2010 Uniform Fire Code (UFC) for the maximum fire flow required in that zone. For the larger pressure zones, two fire flows were included simultaneously, the largest commercial fire flow for a given zone, plus a residential fire flow. Dual fire flows apply to all pressure zones except Zone IV West, the Sunset Zone, and the Bear Ridge Zone. Fire flow durations are based on the California Fire Code.
- **Emergency.** A storage reserve for emergency conditions is provided for power outages and other unforeseen interruptions in supply such as earthquakes. The most secure storage for a water system is water that will flow by gravity instantaneously in response to demand. The next most reliable storage is that available by gravity from a pressure zone higher than that on which the demand is required. Such storage is typically available through PRVs. At a still lower reliability level is storage

located in ground-level tanks or in a lower pressure zone, made available through pumps activated automatically and equipped with emergency power generators.

Table 5-3. Characteristics of Existing Reservoirs

Pressure Zone Served	Name or Location	Volume, MG	Overflow Elevation, feet	Base Elevation, feet
I	Clearwell storage	2.0[a,b]	133.5	118.5
I	D Street Reservoir	1.0[b]	135	120
	Subtotal	3.0		
II	Water treatment plant	0.5[b,c]	264	229
II	3.0 MG (East of Lone Tree Way near Danridge Court)	3.0[b,d]	256	230
II	Donlon Reservoir	2.0[b,d]	248	200
II	Larkspur Reservoir I	2.0[b,d]	248	216
	Subtotal	7.5		
III	Cambridge Reservoir (West)	2.5[b]	355	320
III	Lone Tree Reservoir (East)	2.5[b]	340	308
III	Hillcrest Reservoir (East)	2.5[b]	340	292
	Subtotal	7.5		
IV	Mira Vista Hills Reservoir (West)	0.5[d]	455	435
IV	Empire Mine Reservoir I (East)	3.5[b]	510	485
	Subtotal	4.0		
	Total	22.0[e,f,g]		

[a]*Part of this (1.0 mg) storage is allocated for pumping equalization in the WTP and for WTP filter backwashes.*

[b]*Existing.*

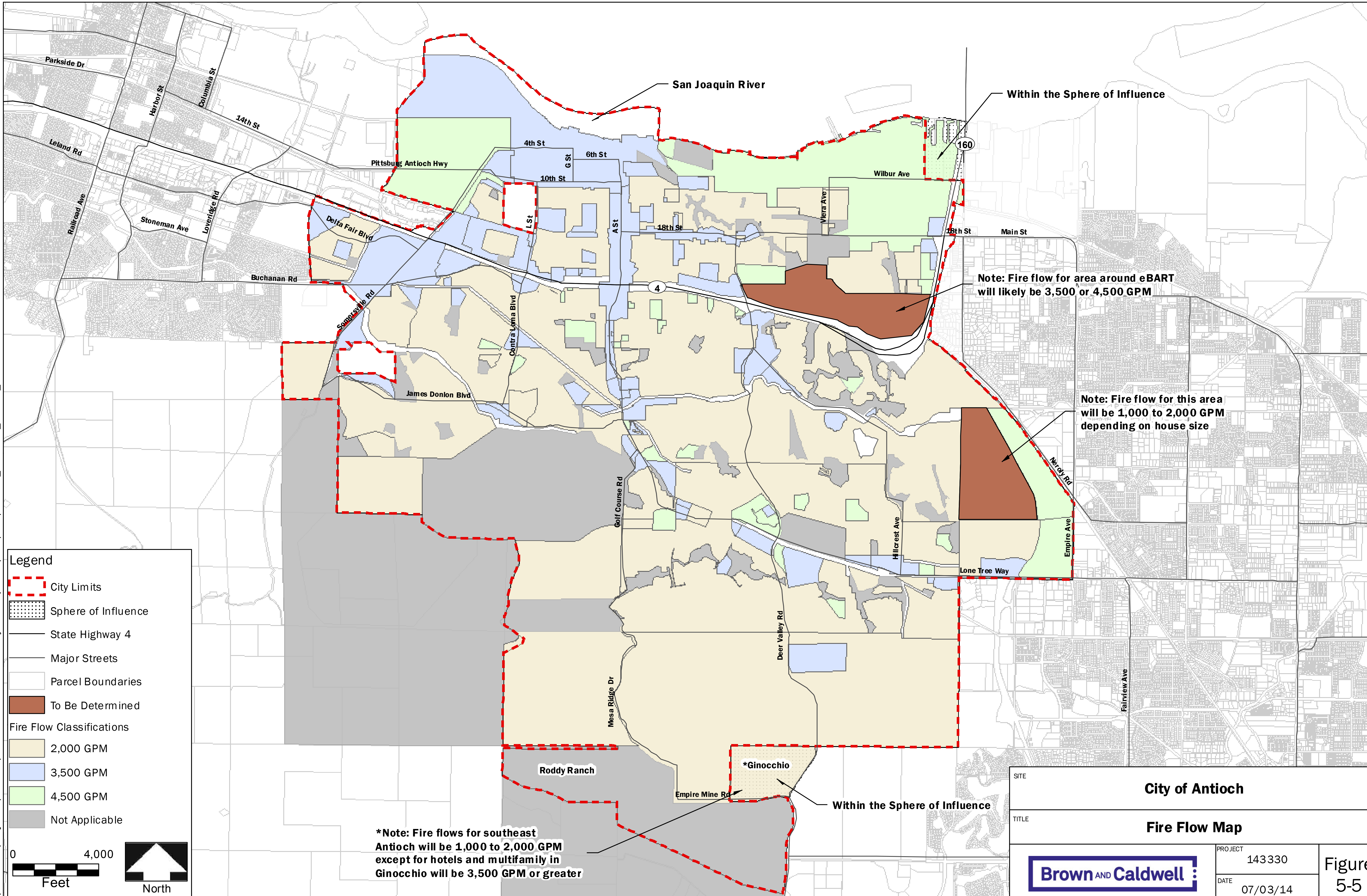
[c]*Not counted as part of Zone II storage since the overflow is above normal Zone II operating hydraulic gradeline.*

[d]*Located in Zone II but could provide some Zone I storage.*

[e]*Net storage available to the distribution system is 22.0 MG of which only 20.5 MG is counted as distribution system storage. One or more additional reservoirs would be required to serve areas adjacent to Roddy Ranch at an elevation above that for Zone IV East.*

[f]*The City has required that the developer for the Sierra Vista development construct a 0.3 MG reservoir as a condition of approval.*

[g]*If needed after 2035, proposed additional Zone III East storage could be constructed by constructing a second reservoir on the Empire*



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In arriving at prudent storage requirement, it is important to consider several key factors:

- Critical risk factors such as proximity to earthquake faults with associated surface rupture zones and service areas subject to wild fire hazard.
- Dependability of supply such as gravity feed of raw water and standby power availability for water treatment plant operations and treated water pumping.
- Distribution system water quality maintenance as required by state and federal regulations.

Since the general practices by other California water institutions and City staff have identified no factors that would change the City's approach to providing storage, the same approach that has been used for the last 30 years has been applied. For each pressure zone, storage should provide 0.25 maximum day demand (equalization storage) plus fire flow demand plus 0.33 times the sum of equalization storage plus fire flow demand (emergency). For all zones but Zone IV West, fire demand is the sum of the highest fire flow classification with the zone (refer to Figure 5-5) plus one 2,000-gpm residential fire flow. Table 5-4 presents a summary of projected required storage. Only Zones I and Zone III East show deficits based on 2035 demands. Since higher elevation zones would have surplus storage, it is possible that the City would not need to construct new storage based on the data presented in Table 5-4. The City could use proposed and existing pressure-regulating stations to transfer water from higher to lower zones to make up for apparent storage shortfalls in Zone I and Zone III East. In fact, the City directed construction of Empire Mine Reservoir with extra storage for Zone III East. Also note that for water quality reasons, the City currently operates the Cambridge Reservoir and Empire Mine Reservoir less than fully filled during part of the year; therefore, up to 1 MG of surplus shown for those reservoirs may be unavailable now. Changes in operating procedures and new water connections may recover some of that lost storage. In addition, development at higher elevations, e.g., the proposed Sierra Vista and higher elevation areas in FUA 1, would require additional smaller reservoir construction to increase the total system storage above the calculated minimum requirements.

Table 5-4. Summary of Storage Required for 2035 Demand by Pressure Zone

Zone	Existing Storage	Required Storage (MG)	Surplus or (Deficit) by Pressure Zone (MG)
Zone I	2.00	2.52[a]	(0.52)
Zone II	7.00	5.79	1.21
Zone III East	5.00	5.48	(0.48)
Zone III West	2.50	1.49	1.01
Zone IV East	3.50	2.46	1.04
Zone IV West	0.50	0.44	0.06
Total	20.50[b]	18.19	2.31

[a]Part of this (1.0 mg) storage is allocated for pumping equalization in the WTP and for WTP filter backwashes.

[b]Net storage available to the distribution system is 22.0 MG of which only 20.5 MG is counted as distribution system storage. One or more additional reservoirs would be required to serve areas adjacent to Roddy Ranch at an elevation above that for Zone IV East.

Table 5-2 does not list one-half of the 2.0 MG in Clearwells A and B. This storage is located at the WTP and is allocated separately from Zone I storage as a source of filter backwash water, a suction reservoir for the Zone II booster pumps, and an equalization volume to balance WTP production. Because its overflow elevation is above normal Zone II operating elevations, the existing 0.5 MG Zone II reservoir is not considered to contribute to the Zone II storage requirements in the year 2035.

5.3.5 Pressure Requirements

In the 1999 Water Master Plan Update the minimum required pressure at any location in all pressure zones was established at 40 psig during peak hour demand and 20 psig during maximum day demand coincident with fire flow. These criteria satisfy the requirements of Insurance Services Office for pressure under fire flow conditions and the regulations of the State Department of Public Health. Since 1999, the California Building Code has changed; it now requires that new residential construction or substantial remodeling of existing single-family dwelling units must include residential fire sprinklers. Fire sprinklers require higher pressures to operate properly than pressures previously planned by the City. Two options exist for delivering higher pressures. One option is to design water system expansion so that delivery pressure on the City side of a water meter is 55 psig or higher coincident with system-wide maximum day demand. The other option is to add individual pressure systems (booster pumps and controls) for each home. For expansions to the water system, the City plans to require new facilities to deliver 55 psig. For infill development or retrofit projects, the City will require that the property owner provide onsite pressure systems. Based on discussions with CCCFPD representatives, for homes with less than 3,600 square feet of floor space, CCCFPD will lower the required fire flow to 1,000 gpm for two hours where the homes are equipped with interior fire sprinklers. This reduction may affect water reservoir sizing for new smaller zones, higher than Zone IV East service elevations.

The Uniform Plumbing Code also limits internal pressures in any structure to 80 psig; therefore, structures in the lower areas of Zones II, III and IV will require individual pressure-regulating devices. The limitations by pressure zone in Table 5-5 are as follows.

Table 5-5. Limitations by Pressure Zone

Zone	Reservoir Overflow Elevation, ft	Lowest Service Elevation without Individual Pressure Reducing Device, ft amsl
II	264	85
IIIE	340	165
IIIW	355	180
IVE	510	335
IVW	455	280

5.3.6 Minimum Pipe Sizes

Based on the need to provide adequate fire flows and general transmission capacity, it is recommended that all new or replacement water mains within the City have a minimum diameter of 8 inches. The sole exception to this is cul-de-sacs for the single-family residential neighborhoods less than 200 feet long where 6-inch diameter pipe is acceptable. Based on the use of interior fire sprinklers in new residential development, the City may consider revisiting its minimum pipe diameter requirements where fire flows are 1,000 gpm, based on hydraulic modeling for proposed developments.

5.3.7 Booster Pumping Stations and Pumping Capacity

Table 5-6 presents a summary of characteristics, including physical condition, for the existing BPS. Section 2 presents more data for the BPS including number of pumps and their nominal capacities. In general, the BPSs are in good or very good condition with the exception of the Sunset, Hillcrest and Cambridge BPS. Sunset BPS needs replacement to ensure safe access and proper performance especially for fire flow pumping. Hillcrest BPS needs a major mechanical and electrical upgrade in the next five years to address its aging mechanical and electrical equipment. In 2013 the City is expanding capacity for the Cambridge BPS. All BPSs would benefit from upgrades to control systems and communications with the WTP control room and should have arc flash studies completed in compliance with current codes.

Table 5-6. Summary of Characteristics of Existing BPSs

Booster Pumping Station	Condition	Year Constructed	Comments
Wilbur Avenue	Not operating	N/A	Needs cleaning and assessment, possibly with controls upgrade.
Water Treatment—Plant A	Fair	1967	Rehabilitated several times since. City will change out motor control centers in next two fiscal years.
Water Treatment Plant—Plant B	Very good	1988	Expanded several times since constructed.
Sunset	Poor	1970s	Inoperable fire flow pump owing to control deficiencies; aging pumps and electrical equipment; located in below-grade vaults with difficult access.
Hillcrest	Fair	1980	Mechanical and electrical equipment is operable but due to be replaced owing to its age.
Lone Tree 1	Very good	1990	BPS has space for one additional pump.
Lone Tree 2	Very good	2004	N/A
Donlon	Good	1988	N/A
Dallas Ranch	Very good	1991	City recently added fourth 1,400 gpm pump
Cambridge	Fair	2003	City staff has a replacement for one original pump in winter 2013 and will install two higher capacity pumps (about 1,000 gpm each) summer 2013.

Notes:

All BPS outside of the WTP should receive SCADA and communications link upgrades.

City staff will continue to monitor condition and upgrade pumps, motors and electrical system as they wear and/or age.

5.3.8 Pumping Capacities

The American Water Works Association recommends that booster pumping stations be rated on firm capacity, i.e., the capacity with the largest pump (or one of the largest pumps if there are more than one) out of service. The firm pumping capacity into each pressure zone should be sufficient to supply the maximum day demand within that zone as well as the maximum day demand for all higher zones that draw from the lower zone. For example, in Antioch, Zone II firm pumping capacity must supply Zone II maximum day demand plus Zone III and Zone IV maximum day demands. All BPSs have adequate capacities through 2035.

5.3.9 Evaluation of the Existing Water Mains

The water mains in the distribution system range from very recent construction to mains well over 100 years old. Table 5-3 presents a listing of materials used for water main construction, together with information on expected life and durability, and commentary from City staff about conditions found in the field during construction, repair or replacement during recent years. The City has used materials with good durability that in general should have significant remaining useful life. Most water mains should not require replacement in the next 20 years. However, the older cast iron mains very likely suffer from interior corrosion since they were unlined. They may also suffer from exterior corrosion depending upon where and how they were installed. The City should plan to continue its ongoing replacement program, and focus on areas where it finds significant deterioration or where more capacity is needed as described below in Table 5-7.

Table 5-7. Summary of Pipelines and Pipelines Materials

Material	Approximate Years When Installed in Antioch	Typical Service Life (years)	Comments
Cast iron	System inception (1870s?) to 1920s	100 to 150 +	Typically unlined. Subject to both internal and external corrosion. City staff report that older CIP shows significant internal corrosion/tuberculation. Pipe can be cleaned and lined to restore interior condition if external condition/strength and size justify such expenditure rather than replacement.
Gray iron	1920s to 1960s	100 +	Older pipe is typically unlined. Some newer pipe may be cement-mortar lined. City staff report that older CIP shows significant internal corrosion/tuberculation. Pipe can be cleaned and lined to restore interior condition if external condition/strength and size justify such expenditure rather than replacement.
Ductile iron	1960s to present	75 +	Typically specified by the City as cement mortar lined. Subject to external corrosion if installed in corrosive soils without protection, e.g. southeast Antioch. Areas sampled by City staff through repairs generally show very good interior condition. External condition found to be very good in northeast Antioch where installed through well drained, sandy soils. More resistant to seismic events than cast or gray iron, especially when joints are restrained as often occurs in modern installations.
Welded Steel	1980s to present.	50 +	Lined with mortar or epoxy. In Antioch, limited to special applications, e.g., encased in concrete or above grade piping at WTP and in BPSs and used for crossing of East Bay Municipal Utility District aqueducts. Would be suitable for crossing areas where organic contamination risk do or could occur since all joints can be welded. Very strong resistance to seismic events.
Concrete cylinder	1960s (raw water) and 1960s and 1980s (treated water)	100 +	Durable pipe material. Raw water pipelines may require cleaning to restore capacity.
Asbestos cement	1940s to 1970s	90 +	Durable pipe material. City staff only have made infrequent repairs apparently attributable to poor installation practices or poor soil conditions. Interior condition is excellent whenever exposed. May suffer failures in seismic events since it is judged to be somewhat brittle relative to metallic pipe.
Polyvinyl chloride (PVC)	1980s to present	75 +	Corrosion resistant material for both interior and exterior. Typically installed with ductile iron fittings and metallic thrust restraint so still at risk as a system to corrosion attack. PVC pipe with heat fused joints is becoming more available, used in lieu of bell-and-spigot pipe. Also available as a liner for reconditioning existing pipelines or for pipe bursting.

5.4 Future System

To assess its current capacity, BC modeled the existing City distribution system according to the criteria developed above. Particular emphasis was placed on fire flow delivery capacity since fire flow demands typically stress a water system most severely. Inadequacies revealed in modeling the existing system were corrected, and a future system model was created and tested. The future system model also includes major pipes to serve new development in Zones III and IV. In both models, pressure requirements generally were satisfied by setting reservoir overflow elevations and sizing pipes for maximum day plus fire flow and peak hour conditions. The design year for the future system analysis is the year 2035. Figure 7-1, included in the back of this report, shows in solid red lines the future distribution system additions planned by the 2035, constructed by the City using City funds. As part of distribution system evaluation, the existing system was modeled to test peak hour and maximum day pressures, as reported in Appendix B. With the exception of a few isolated higher nodes and some older neighborhood, most of the system has a peak hour pressure of at least 40 psig. Even though it wasn't designed for addition of residential fire sprinklers, most of the system will deliver 55 psig during a maximum-day-demand scenario. Except for some isolated higher nodes and older neighborhoods, most of the system will deliver 55 psig.

The remainder of this section discusses system improvements in each zone.

5.4.1 Zone I

Zone I includes the oldest areas of the City and some older, smaller-diameter water mains, particularly in the downtown area. Over the next two decades, smaller diameter water mains in the older areas will require replacement. Zone I needs replacement mains for the older areas and possibly parallel water mains, especially to deliver adequate fire flows to longer dead end areas.

To maintain and enhance Zone I performance, it is recommended that the City continue to upgrade the distribution system, particularly replacing old 4-inch- and 6-inch diameter water mains with 8-inch diameter water mains in conjunction with other infrastructure rehabilitation, such as street repaving.

Pressure Regulating Stations (PRS). The model analysis showed significant improvements could be gained by placing pressure-reducing valves (PRV) at additional locations between Zones I and II as shown on Figure 7-1. These valves open automatically to maintain a set downstream pressure if a low pressure is detected, for example on the downstream Zone I side of the valve. The City has installed its PRVs so that the PRVs also allow reverse flow; that is, if the downstream pressure exceeds what is normally the upstream pressure, then the PRV allows flow opposite to the normal flow direction. With this provision Zone I actual supports the lower lying areas of Zone II during a system outage or fire flow.

Zone Boundary Relocations. No Zone I boundary relocations are recommended now.

5.4.2 Zone II

Zone II is generally in better condition than Zone I. City staff has noted difficulty in filling the Larkspur Reservoir when the Hillcrest BPS is operating during maximum day demand. This situation highlights the need for improved west-to-east water main capacity. To address minor system deficiencies, improvements would follow those outlined for Zone I i.e. replacement of older, smaller diameter water mains and adding parallel mains as needed to enhance fire flow delivery. The City will need to install new water mains to serve new development planned in the zone's eastern portion.

One isolated high area in the zone currently is served by the small Sunset BPS. It is located in vaults with limited access and staff cannot operate the fire flow pump without over pressurizing some connections, The City could eliminate the Sunset BPS by adding a new main (about 4,000 ft long). Preliminary analyses indicate that making a new water main connection to Zone III East would be over twice the cost for a new BPS. Zone III East to the Sunset Zone. Therefore, replacing the BPS is the better alternative.

Zone II also has an isolated area along View Drive near the WTP where low pressures currently occur during peak-hour conditions, but the City has received no customer complaints recently. Flows along View Drive are sufficient for fire flow requirements. The City could address this problem by installing individual booster pumps for the small number of homes with insufficient pressure. Alternatively, a small BPS could be added at the WTP. The City could use an existing pedestrian walkway to install a 3- or 4-inch diameter water main to provide normal residential service. Fire flows would still be supplied from the existing distribution system via check valves at the intersections of View Drive and Camby Drive, and View Drive and Terranova Drive.

New Water Mains. Figure 7-1 shows the recommended new water mains. These include:

- Reinforcement of the easterly feed from the 3.0-MG Reservoir with a 24-inch diameter main paralleling the existing 24-inch diameter main with a 20-inch diameter main angling north to meet the 20-inch diameter main in Hillcrest Avenue south of Highway 4. From the eastern end of the new 24-inch diameter main, add a 24-inch diameter main along Garrow to Davison Drive and a 20-inch diameter main along Davison Drive to Hillcrest Avenue. From the intersection of Davidson Drive and Hillcrest Avenue, add a 20-inch diameter main north along Hillcrest Avenue to tie into the 20-inch diameter main south of Highway 4.
- 12-inch diameter connection north along Somersville Road from Black Diamond Ranch to the existing water main south of Buchanan Road.
- Several new mains in the northeast to complete looping and to enhance fire flow delivery and system redundancy.

Zone Boundary Relocations. No Zone II boundary relocations are recommended.

PRSs. Converting the James Donlon Boulevard water main to Zone III service has created an opportunity to allow Zones III East and III West to support each other through a PRV in James Donlon Boulevard east of Tabora. The City also should construct a PRS on Somersville Road at the Zone III West/Zone II boundary and on Gentrytown Drive south of the Canal. For the PRs along Gentrytown Drive, the City may be able to install the valve in an unused building that once housed a small BPS.

5.4.3 Zones III and IV

Zones III and IV serve (or will serve) predominantly new residential construction designed to conform to current standards. One improvement will address a deficiency in fire flow delivery to the Tabora hill top area. Fire flow delivery is less than half of what is required. Constructing a parallel 12-inch-diameter water main would correct this deficiency.

Ongoing or new subdivisions will result in the major water main improvements for southeast Antioch. However, planning is ongoing so specific requirements are not yet known. Furthermore, development will bear the cost for such improvements. This Master Plan Update presents schematic improvements for the water system serving Lone Tree Valley and adjacent areas. Depending on the intensity of development in the Lone Tree Valley, the Dallas Ranch BPS might need to be expanded or to respond to increases in demand or the City could construct a new BPS in Lone Tree Valley after 2035.

Currently the City has one connection to the CCWD MPP adjacent to the Hillcrest BPS. To improve reliability and receive maximum benefit from the 5-mgd water capacity rights already purchased from CCWD, the distribution would benefit from a second MMP connection. Based on reviewing several potential locations, constructing it on the south side of the canal at the Somersville Road crossing would be a preferred site.

5.4.4 Higher Elevation Zones

Several properties may be developed north and south of Lone Tree Valley situated above Zone IV East. When development is planned for this area, particularly Future Urban Area 1, a detailed analysis should be conducted to determine the size required for the BPS, reservoir and water mains. Zone IV West has a potential higher elevation zone to the south referred to as Sierra Vista.

5.4.5 Seismic Evaluation of Existing Water System

In the mid-1990s, as part of the CCWD Seismic Reliability Improvement Project, the City arranged through CCWD for a preliminary seismic evaluation of its raw water, water treatment and Zone I distribution facilities. The work resulted in the following findings and recommendations:

- The most critical seismic events were identified as a magnitude 6.5 earthquake along the Concord fault about 11 miles west of the City and a magnitude 7.0 earthquake along the Coast Range Sierra Block (CRSB) fault zone. The City's water facilities lie within the CRSB fault zone, but no surface fault ruptures are expected from such an earthquake. Such events are expected to occur approximately once every 500 years, on average. The latter fault zone is expected to produce the more damaging event.
- Major raw water and treatment facilities are on solid ground, but distribution mains at the eastern and western ends of Zone I may experience significant liquefaction. Based on mapping in the report, the eastern and western ends of Zone II may also experience significant liquefaction. There were no landslides mapped near any major facilities.
- Water main breaks in areas subject to liquefaction could drain Zone I and Zone II storage; however, owing to system looping, it should be possible to feed most areas after isolating broken mains.
- The principal recommendations for responding to potential water main problems include avoiding future use of asbestos cement pipe (because of its fragility), purchasing and stockpiling repair parts, and developing a plan to identify and prioritize water main repairs after an earthquake.
- The Zone I D Street Reservoir could suffer damage sufficient to force taking it off line; however, because Clearwells A and B also supply Zone I, loss of the D Street Reservoir would not be critical to overall water system performance. The study recommended a structural evaluation to determine if seismic upgrades are warranted.

In 2012, the City initiated a preliminary seismic review of its storage reservoirs. That work is not yet complete. Based upon its findings, conclusions and recommendations, the City may undertake improvements to the reservoirs to improve their seismic performance, beyond improvements recommended in the Water System Master Plan Update.

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Section 6

Water Treatment Plant Improvements

This section describes the current status of the City's WTP and includes an assessment of existing capacity and recommendations for upgrading or rehabilitating water treatment facilities.

6.1 WTP Capacity Requirements

Water treatment facilities are typically sized to supply maximum day demand. Section 3 presents projected maximum day demands developed from historical data for the single-day event. Daily water demands also were evaluated over several consecutive day periods of high demand. The reported maximum day demand is influenced by water system and WTP operating procedures. The operators may allow the clearwell and reservoir levels to drop slightly over several hot days and then operate the WTP at a higher rate to refill storage. Table 6-1 summarizes the results. For purposes of evaluating available WTP capacity, it is suggested that using a maximum day demand equal to the average daily demand over the five consecutive days with the highest demand. This approach recognizes both storage capacity within the water system and City operational practices and would decrease the required maximum day capacity by about 5 percent based on recent records.

Table 6-1. Summary of High Water Demands over Extended Periods

Year	Maximum Day Demand (MG)[a]			
	1 day	3 day	5 day	7 day
2008	28.86[b]	27.33	27.43	26.35
2009	27.01	24.98	24.28	23.75
2010	26.50	25.06	24.23	24.52
2011	25.88	23.83	23.38	22.82
2012	26.13	25.51	24.89	24.36

[a]*Average daily demand over indicated period of high demand.*

[b]*Maximum day demand data includes daily water demand data from the Contra Costa Water District's (CCWD) multipurpose pipeline when applicable.*

In 2008, the average demand over the five consecutive days with the highest demand was 27.4 mgd. The rated capacity of the City's existing WTP is about 36 mgd. City staff has successfully operated Plant A and Plant B at higher rates, which allowed a short-term capacity of at least 37 mgd. In addition, the City has purchased 5.0 mgd of capacity from CCWD that is delivered through the CCWD Multi-Purpose Pipeline. The City considers this to be a reliable part of its overall supply. Based on the projected treated water needs presented in Section 3, the City appears to have sufficient capacity to serve 2035 needs without further expansion.

6.2 Existing WTP

The City WTP was constructed in two major sections. Plant A is the original facility, constructed in 1947, expanded first in 1956 and again in 1967. It is a conventional treatment facility with a firm capacity of 16 mgd. City staff reports that Plant A can operate reliably up to 17 mgd. Processes include flash mixing, flocculation, upflow/solids contact sedimentation, and dual-media filtration. In 1986, the City replaced anthracite media in the filters with granular activated carbon (GAC).

Since 1989, the City has completely overhauled Plant A. This work included the following improvements:

- New flash mixer.
- New flocculators.
- New sedimentation tank mechanisms.
- Addition of tube settlers to about one third of the basin area to reduce late-afternoon short-circuiting at high flows during summer's warmer weather.
- Reconstruction of all filters and new filter control consoles and upsizing of the filter rate control valves for Filters 1 through 4.
- Construction of a new control room.
- Reconstruction of the laboratory and staff facilities.
- Addition of baffles to Clearwell A.
- Addition of a scrubber to the chlorine storage facility.

The City increased GAC media from 18 inches to 48 inches to improve the contact time for taste-and-odor control.

Plant B was completed in 1989 and expanded in 2007. Plant B is also a conventional, complete treatment facility with a nominal capacity of 16 mgd. It uses hydraulic flocculation and horizontal "Camp" clarifiers. Tests have shown Plant B can be operated easily and stably to produce up to about 20 mgd. Total capacity (Plants A and B together) is now about 36 to 37 mgd. Using conventional technology, the Plant B site has the capacity for another flocculation and sedimentation module and two more filters, likely increasing Plant B capacity to about 30 mgd.

Thus, a total of 47 mgd of water treatment capacity could be installed at the existing WTP site using technology now installed. This is more than adequate for expected maximum day demand of about 33 mgd in 2035, especially recognizing that the City also has purchased 5.0 mgd of capacity from CCWD. No capacity expansion should be necessary through 2035.Alternative technology could be used to produce substantially more flow at the WTP site, if necessary.

Table 6-2 summarizes operating parameters for Plants A and B. These parameters are within CDPH and industry standards for well-operated water treatment facilities. As discussed in Section 4, treated water quality consistently meets all required state and federal standards.

Table 6-2. Water Treatment Plant Operating Parameters

		Flow rate, mgd					
		Plant A			Plant B		
	Industry standard	8	12	16	8	12	20
Rapid Mix							
G, sec^{-1}	600-1,000	400-700			400-500		
T, sec	<5	24	18	12	118	79	47
Flocculation							
G, sec^{-1}	10-60	10-80			20-80		
t, min	18-25	25	18.8	12.5	60	30	25
Gt	25,000-75,000	75,000	56,000	38,000	180,000[a]	90,000[a]	75,000[a]
Sedimentation							
Surfacing loading rate, gpm/ft^2	<4	0.69	1.04	1.37	0.5	1.0	1.25
Froude number	>10^{-5}	N/A	N/A	N/A	6.7×10^{-8}	2×10^{-7}	4×10^{-7}
Filtration							
Filtration rate, gpm/ft^2	<6	2.0	3.0	4.0	2.0	4.0	5.0
GAC contact time, minutes	N/A	16.4	12.3	8.2	15	7.5	6.2

[a]*Average G = 50 sec^{-1}*

6.2.1 Planned WTP Improvements

As discussed in Section 4, no new federal or state regulations that would affect water treatment are expected in the next decade and possibly two decades. The City has good options, such as ozonation or ultraviolet disinfection, if future regulations require more stringent control of DBPs. The City would pursue such options only if regulatory changes are imminent. Potassium permanganate addition to raw water is another proven process that can be used to reduce DBP precursors.

6.3 Backwash Water and Water Treatment Residuals

The City currently treats backwash water through its Actiflo©-enhanced sedimentation units. The concentrated solids stream from the Actiflo© combines with the sedimentation basin solids and is thickened and dewatered using dewatering equipment provided by a contract operator. The contract operator hauls and disposes the dewatered sludge at a very competitive cost compared to City hauling and disposal. City staff wants to determine what approach it should take long term for solids thickening and dewatering—continued contract operations or building, owning, operating, and maintaining a dedicated facility. This Master Plan Update recommends that the City complete a comprehensive business case evaluation for long-term solids processing and disposal, to determine which approach is most attractive on a life-cycle-cost basis.

6.4 Other Water Treatment Plant Issues

Based on BC review of the WTP and discussions with the WTP staff, the following minor improvements and upgrades are recommended to help provide reliable performance and compliance with future regulations:

- Replace Plant A switchgear and motor control centers, with new equipment installed in accordance with all current codes.
- Install new controls for sludge wasting from Plant A sedimentation basins to allow for reduced wasting and less volume production.
- Carry out a seismic structural evaluation of the WTP.
- Replace the Zone II flow meter, isolation valves and vault.
- Update laboratory equipment including a new total organic carbon analyzer.
- Evaluate interplant SCADA functionality to complement proposed distribution system SCADA.
- Provide a location where WTP staff can empty a flocculation/sedimentation train with a minimum volume of 0.8 MG.
- For Plant A, install a fire escape for second floor
- Provide large access hatches into the tops of the Plant A and Plant B clearwells to allow cleaning by a diver (4 foot by 4 foot) with sealed aluminum covers.
- Replace six 6-foot-square aluminum hatch covers (three for power manholes and three for signal manholes) in the access road to the dewatering equipment. New covers should be rated for H20 traffic loading.
- Install rock fall containment for the area above the backwash tank similar to draped chain-link-fence fabric used by Caltrans along highways.
- Provide insulated, heated structure around and over chlorine leak scrubber to prevent caustic soda freezing.
- Consider establishing a computerized maintenance management system to track and schedule all maintenance at WTP, reservoirs, and BPSs, e.g., annual cleaning of all switchgear and motor control centers, with thermal imaging checks.
- Carry out an arc flash survey and update every five years.

Section 7

Capital Improvement Program

This section summarizes the estimated cost for new or replacement water facilities needed in the City through the year 2035. In selecting the staging for different projects, the probability of changing plans and priorities was recognized; therefore, a detailed implementation schedule is not provided beyond recommendations for the first five years. A discussion about priorities and project importance used when prioritizing projects also was developed.

Capital costs in developing areas are assumed to be entirely borne by the developer; therefore, these costs are not included in this discussion. These developing areas include the majority of improvements in Zones III East and III West, and all improvements in Zones IV East and IV West, and Lone Tree Valley and areas further south.

7.1 Project Priorities

As identified in earlier sections of this update, the City needs facilities upgrades to continue safe and reliable water delivery to its residents and safe operating conditions for its staff. In allocating its limited monetary resources, the City Council will consider numerous factors. This section briefly presents some of those factors and how they relate to project priorities.

Table 7-1 summarizes preliminary descriptions of priorities applied to projects in this section, together with examples from the City water system needs.

Table 7-1. Description of Water System Project Prioritization Criteria

Description	Priority	Antioch Example
Reduce life safety risks for City staff.	1	Eliminate vaults with difficult access that requires confined space entries. Provide safe entry into tanks and basins.
Improve fire flow delivery for areas with largest deficiencies.	1	Install replacement or parallel mains for the eastern portion of Zone II
Avoid potential regulatory violations.	1	Rehabilitate and enhance the performance of sludge lagoon, to contain water from draining a flocculation/sedimentation train.
Have the best monetary return for the City.	1	Rebuild river pumping station equipment so that City uses river water if available rather than buying water from the Contra Costa Canal. Expand river pumping station capacity through raw water piping system modifications.
Make improvements where smaller investments have highly cost-effective returns.	2	Install additional pressure-regulating stations at zone boundaries.
Enhance long-term operability and dependability.	2	Upgrade controls for Plant A sludge pumps. Upgrade City-wide SCADA system.
Replace equipment as it reaches the end of its useful life.	2	Replace mechanical, electrical and control systems.
Provide water supply for new commercial and industrial development.	2	Install new Zone II mains from 3.0-MG Reservoir to northeast Antioch.
Improve fire flow deliveries to areas with minor deficiencies.	2	Replace older 4-inch- and 6-inch diameter mains in downtown area as part of City renewal/replacement projects.

7.2 Basis of Estimates

All costs in this section were adjusted to January 2013, when the ENR Construction Cost Index (CCI) was 10,355. When these estimates are updated in the future as part of the City's budget planning, the appropriate ENR CCI should be identified and applied, and the costs projected forward to the estimated construction midpoint.

7.2.1 Raw Water System

Capital costs for raw water system improvements and repairs are based on vendor quotations, information from cost estimating guides, and BC's internal cost estimating data.

7.2.2 Distribution System Water Mains

Capital costs for water mains were determined on a per-foot basis from recent BC projects and database values. Table 7-2 shows typical unit estimated costs for polyvinyl chloride pipe installed under pavement or across open ground. These costs do not include contingency costs or engineering, construction management, legal and administrative costs. Allowances were applied for contingencies (25 percent); and engineering, legal, and administrative costs (20 percent) to the unit costs shown in Table 7-2 to develop initial cost estimates shown in Table 7-4.

Table 7-2. Polyvinyl Chloride Pipe Costs

Pipe Size (inches)	Pressure Class (DR)	Pipe Cost (dollars per lineal foot)		Comments
		Pipe Under Open Ground	Pipe Under Pavement	
6	18	48	161	Gate valve every 500 feet
8	18	55	170	Gate valve every 500 feet
10	18	72	190	Gate valve every 500 feet
12	18	94	214	Gate valve every 500 feet
16	25	96	225	Butterfly valve with gear operator every 2500 feet
20	25	112	255	Butterfly valve with gear operator every 2500 feet
24	25	139	287	Butterfly valve with gear operator every 2500 feet

Notes:
All water mains would have 42 inches of cover.
Granular fill around water main with 6 inches of granular bedding below pipe and 6 inches of granular fill above pipe.
Sufficient trench width for proper compaction of pipe haunches.
For pipe under open ground, use select native for backfill to surface, 90 percent relative compaction.
For pipe under pavement, use imported granular as backfill, up to 16 inches below ground surface, then 12 inches of Class 2 AB and 4 inches of AC. All backfill shall be compacted to 95 percent.
Pipe shall be AWWA C900/C905.
Valves shall be MJ with restrained joints and valve can.
Costs include 15 percent for contractor's overhead and profit, 10 percent for general conditions, and 3.5 percent for bonds and insurance.
Cost are current for competitively bid projects constructed with union labor, in the San Francisco Bay Area, January 2013.
To arrive at capital costs, add 25 percent contingency and 20 percent for engineering, legal, and administrative costs to tabulated numbers (overall multiplier of 1.50).
For traffic control, add $22/ft.
Increase cost by 20 percent for rock or other difficult excavation or trench conditions.

7.2.3 Booster Pumping Stations

In the next decade, the City needs to make minor BPS improvements that City staff will install in existing facilities (adding or replacing pumps, motors, control valves, and starters). It likely will contract for larger projects like rehabilitation of the Hillcrest BPS mechanical, electrical and control systems and replacement of the Sunset BPS.

7.2.4 Reservoir Storage

As described in Section 5, the City should not need to expand its treated water storage before 2035 unless major water–use intensive development occurs either in the northeast or the southeast. Likely projects include recoating welded steel tanks as their coating systems age and possibly adding internal mixing systems to maintain distribution system water quality.

7.2.5 Water Treatment Plant

Improvement projects at the WTP were described in Section 6.3. Capital costs for water treatment improvements and repairs are based on vendor quotations, information from cost estimating guides, and BC's internal data.

7.3 Cost Estimates

Working from the bases described above, costs were developed for three groups of capital improvements have been developed:

- Raw water system
- Treated Water Distribution system
  - Water mains and pressure regulating stations
  - SCADA system
  - BPS
  - Storage reservoirs
- Water treatment plant

7.3.1 Raw Water System

Table 7-3 presents the estimated costs for raw water system improvements.

Table 7-3. Raw Water and Treatment and Storage Projects

Item	Priority	Estimated Cost, (thousand $[a])
River Pumping Station Reconstruction	1	460
New sluice gates installed at Antioch Municipal Reservoir	1	80
Access points installation for raw water pipelines inspection and preliminary condition assessment	1	300
Cleaning of raw water pipelines	1	500
Subtotal of Priority 1 Raw Water and Storage Projects		1,340
Antioch Municipal Reservoir dredging assessment	2	50
Raw piping connection at Lone Tree Way and Terranova Drive	2	150
West Canal Pumping Station Upgrades	2	100
Parallel raw water pipeline, Antioch Municipal Reservoir to WTP[b]	2	7,700
Subtotal of Priority 2 Raw Water and Storage Projects		8,000
Total		9,340

[a]*These estimated costs are January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

[b]*This estimated cost includes a new dam outlet ($2.6 million) and a new pipeline ($5.1 million).*

7.3.2 Distribution System

Proposed improvements to the distribution system include water mains, pressure regulating stations, the SCADA system, BPSs and reservoirs.

7.3.2.1 Distribution System Water Mains

Tables 7-4 and 7-5 summarize the proposed capital improvement projects for the distribution system through the year 2035. These proposed capital improvement projects have been subdivided into costs for new water mains and pressure regulating stations. To estimate water main quantities, lengths were scaled from distribution system maps or determined lengths from the City GIS. The recommended improvements shown in Figure 7-1 and Table 7-4 were determined by system modeling described in Section 5 and Appendix B. In addition, over the next 20 years the City plans to spend about $1,000,000 (in 2013 dollars) annually for replacing and/or upgrading older smaller diameter water mains. For new pipelines, the costs reflect open ground excavation since these water mains will be constructed ahead of new streets or through existing easements such as those for Pacific Gas & Electric Company power lines. These costs do not include new water mains for Lone Tree Valley since development will pay such costs. Replacement of existing water mains reflects costs for pipe under pavement, which include allowances for cutting and replacing pavement. These cost do not include allowances for difficult construction conditions such as excavation through areas with high groundwater, soft soils or hard rock

The estimated cost for the total water main distribution program is $32 million in January 2013 dollars, about $13 million for major projects/immediate needs (water mains and pressure-regulating stations) plus $20 million for small main replacement over the next 20 years. Figure 7-1, attached in the back of this report, shows the proposed projects for the Antioch water system.

7.3.2.2 Second MPP Connection

As described above, the City has one connection to the CCWD MPP. Adding a second connection, most likely on the south side of the Canal where it flows under Somersville Road, would allow greater flexibility and redundancy for the City in its operations, e.g., drawing water from the MPP during a WTP shutdown. The CIP does not include a cost for this connection since its configuration and special requirements are unknown until the City negotiates with CCWD.

Figure 7-1. Antioch Water System

(See the back of this report for a 22x34 sheet.)

Table 7-4. Proposed Water Main Improvements

Project ID	Diameter (inches)	Approximate Length (ft)	Location Description	New or Existing	Unit Cost ($/ft)	Priority	Total Capital Cost[a] (thousand $)
A	12	3,100	Somersville Road (connects Zone II and III West)	New	94	1	437
B	8	450	Silverado Drive/Dimaggio Way (Zone III West)	Existing	170	1	115
C	12	2,450	Tabora Drive (Zone III West)	Existing	214	1	786
H	12	600	Plymouth Lane (Somerset Place), (Zone IIC)	Existing	214	1	193
I	12	1,300	Hargrove Street (Zone IIA)	Existing	214	1	417
J	12	1,400	Lipton Street (Zone IIA)	Existing	214	1	449
Subtotal of Priority 1 Proposed Water Main Improvements							2,397
D	16	2,900	Viera Avenue Portion of Hillcrest and Viera Avenues (Zone II) Connection	Existing	225	2	979
E	12	2,600	Oakley Road (Zone II)	Existing	214	2	835
F	12	1,150	Phillips Lane and connects Almond Ridge Drive and East 18th Street (Zone II)	Existing	214	2	369
G	16	1,400	Connects Drive-In-Way and Wilbur Avenue (Zone II)	New	96	2	202
K	12	4,750	Other portion that connects Hillcrest and Viera Avenues (Zone II)	New	94	2	670
L	12	6,000	Delta Fair parallel main to Pittsburg/Antioch border for improved emergency interconnection with the City of Pittsburg for improved emergency connection with City of Pittsburg (Zone II)	Existing	214	2	1,926
M	12	1,800	Parallel main at east end of Wilbur	Existing	214	2	578
S	20	5,000	Utility easement from Tregallas Road/Harbour Drive to Ashburton Drive/Mountaire Drive (Zone II)	One half new/one half existing	183	2	1,373
W	20	3,700	Davison Drive between Ashburton Drive and Hillcrest Avenue (Zone II)	Existing	255	2	1,415
X	24	850	Utility easement north of Mountaire Drive between Ashburton Drive and Garrow Drive (Zone II)	New	139	2	177
Y	24	2,200	Utility easement north of Mountaire Drive between Garrow Drive and Lone Tree Way (Zone II)	Existing	139	2	459
Z	24	1,300	Ashburton Drive between Mountaire Drive and Davison Drive (Zone II)	Existing	287	2	560
Subtotal of Priority 2 Proposed Water Main Improvements							9,543
Total							11,940

[a] *These estimated costs are at January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

Table 7-5. Proposed Pressure Regulating Stations					
ID	Valve Type	Downstream HGL (ft)	Location Description	Priority	Capital Cost[a] (thousand $)
1	PRV	340	Intersection of James Donlon Boulevard and Tabora Drive (Zone III West to Zone III East)	1	90
2	Check Valves	-	Mayflower Drive (Zone II/Zone III East)	1	50
5	PRV	130	Intersection of D Street and Railroad Avenue (Zone II)	1	90
6	PRV	130	Intersection of Cavallo Road and Gary Avenue (Zone I)	1	90
7	Check Valve	-	Mayflower Drive north of Dandelion Circle (Zone II)	1	35
8	PRV and Relief Valve	130	West 10th Street (Zone I/Zone IIB)	1	95
9	Relief Valve	130	East 13th Street (Zone I/Zone IIC)	1	15
10	Relief Valve	130-	East 18th Street (Zone IIA/Zone IIC)	1	15
8	PRV	240	Somersville Road (Zone III West/Zone II)	1	80
13	PRV	240	Zone III West/Zone II at Gentrytown[b]	1	80
Subtotal of Priority 1 Proposed Pressure Regulating Stations					640
4	PRV	130	Intersection of Fulton Shipyard Road and Wilbur Avenue (Zone II/Zone I)	2	90
11	Check Valve	-	Tabora Drive (north zone boundary; Zone II/Zone III West)	2	15
Subtotal of Priority 2 Proposed Pressure Regulating Stations					105
	Total				745

[a]*These estimated costs are at January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

[b]*Possible cost reduction if located in unused BPS building*

7.3.3 SCADA System

The City's SCADA system for its reservoirs and booster pumping stations does not have capacity to gather and archive comprehensive data or to provide real time status and controls for all important functions. It was installed piece meal over the 30 years. Given the changes in technology since the original equipment was installed, the best first step would be to complete a system wide SCADA system master plan. Such a plan would inventory monitoring, operating and equipment needs; assess communications options; and recommend an overall upgrade. The City should budget up to $150,000 for this planning. The SCADA master plan output will include capital costs for system upgrades, not included in this CIP.

7.3.4 Booster Pumping Stations

BPS costs are for upgrading existing facilities, as summarized in Table 7-6. Since the City no longer uses the Zone I BPS located adjacent to the D Street Reservoir, it would be advisable to remove and properly dispose of all mechanical and electrical equipment, especially the variable speed drives, which may be oil or hydraulic-fluid filled.

Table 7-6. Proposed BPS Improvements

ID	Name	Upgrade	Preliminary Priority	Capital Costs[a] (thousand $)
P1	Sunset	BPS Replacement	1	700
P3	Wilbur	Controls Upgrade	1	100
P4	Zone I	Decommissioning	1	30[b]
Subtotal of Priority 1 Proposed BPS Improvements				830
P2	Hillcrest	Mechanical, Electrical, Controls Replacement	2	500
Subtotal of Priority 2 Proposed BPS Improvements				500
	Total			1,330

[a]*These estimated costs are at January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

[b]*Assume that removed materials and equipment would be recycled or disposed of as ordinary waste.*

7.3.5 Reservoir Storage

Table 7-7 presents recommended reservoir improvements. The Table 7-7 costs do not include costs for possible seismic upgrades.

Table 7-7. Proposed Reservoir Improvements

ID	Name	Upgrade	Priority	Capital Costs[a] (thousands of $)
R1	Cambridge	Mixing system	2	75
R2	Empire Mine	Mixing system	2	75
R3	Hillcrest	Mixing system	2	75
R4	Mira Vista	Mixing system	2	75
Total				300

[a]*These estimated costs are at January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

7.3.6 Water Treatment Plant

Estimated costs for renovation and expansion of the WTP; these costs are shown in Table 7-8.

Table 7-8. Proposed WTP Improvements

Proposed Project Description	Priority	Cost[a] (thousand $)
Replace Plant A switchgear and motor control centers, with new equipment installed in accordance with all current codes. Include an allowance for expanding maintenance shop so part of existing shop is available for new electrical equipment.	1	500
Replace the Zone II flow meter, isolation valves and vault.	1	125
Evaluate intraplant SCADA functionality to complement proposed distribution system SCADA.	1	150
A fire escape for second floor of Plant A.	1	25
Six 6-ft square aluminum hatch covers (three for power manholes and three for signal manholes) in the access road to the dewatering equipment. New covers should be rated for H20 traffic loading.	1	60
Replacement filter GAC.	1	1,100
A computerized maintenance management system, to track and schedule all maintenance, for example, annual cleaning of all switchgear and motor control centers, with thermal imaging checks.	1	50
Coordination study for electrical systems and update every five years (total of four times).	1	100
Study of water solids thickening and dewatering facility.	1	150
Sludge Lagoon Upgrade.	1	1,800
Subtotal of Priority 1 WTP Improvements		4,060
Water solids thickening and dewatering facility design and construction.	2	9,000
New controls for sludge wasting from Plant A sedimentation basins to allow for reduced wasting and less volume production.	2	25
Carry out a seismic structural evaluation of the WTP.	2	100
Update laboratory equipment by a total organic carbon analyzer.	2	25
Provide large access hatches into the tops of the Plant A and Plant B clearwells, to allow cleaning by a diver (4 ft by 4 ft) with sealed aluminum cover.	2	20
Install rock fall containment for the area above the backwash tank such as draped chain-link-fence fabric as used by Caltrans.	2	135
Insulated, heated structure around and over chlorine leak scrubbers, to prevent freezing of caustic soda (600 sf at $150/sf plus markups.	2	135
Subtotal of Priority 2 WTP Improvements		9,440
Total		13,500

[a]*These estimated costs are at January 2013 price levels and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).*

A summary of the CIP improvements are presented in Table 7-9, below.

Table 7-9. Summary of 20-Year Water System Capital Improvement Plan

Category	Cost[a] (thousand dollars)			Comments
	Priority			
	1	2	Total Cost	
Raw Water	1,340	8,000[b]	9,340	
Water Treatment	4,060	9,440	13,500	
Water Mains	2,397	9,543	31,940	Includes an annual expenditure of $1 million for 20 years (2013 dollars), for smaller water main replacement.
Pressure Regulating Stations	640	105	745	
Booster Pumping Stations	830	500	1,330	
Reservoirs	-	300	300	Does not include possible interior recoating of 0.5 MG and 3.0 MG reservoirs since the date for this work is unknown.
Reservoirs and Booster Pumping Stations - Seismic Durability Assessment	-	-	200	
Total	9,267	27,888	57,355	

Notes:

[a]These estimated costs are at January 2013 order-of-magnitude cost for the San Francisco Bay Area and include allowances for contingencies (25 percent), and engineering, legal and administrative costs (20 percent).[b]$2.6 million for new Antioch Municipal Reservoir outlet tower and pipeline under the dam and $5.1 million for parallel raw water pipeline to WTP.

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Section 8

Limitations

This document was prepared solely for City in accordance with professional standards at the time the services were performed and in accordance with the contract between City and Brown and Caldwell dated August 15, 2012. This document is governed by the specific scope of work authorized by City; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. BC has relied on information or instructions provided by City and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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Appendix A: References

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Appendix A

References

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Appendix B: Water Model Report

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Appendix B

Water Model Calibration and Development of Future Distribution System Needs

This appendix presents a summary of activities undertaken and results from calibration of the Antioch water system hydraulic model. Results from testing the system's existing capacity to deliver fire flows are presented, and the fire flow capacity after the City of Antioch (City) implements recommended improvements. In general, future performance with constructed improvements does not include replacement of older 6-inch-diameter mains with 8-inch-diameter mains since the City has no schedule for such improvements.

For most locations the model calibrated well when comparing model predictions with field measurements. Brown and Caldwell's (BC) work on model calibration was constrained because the Zone II flow meter at the water treatment plant was inoperative when City staff and BC carried out hydrant testing. Another likely constraint appears to be the hydrant elevations available through the geographical information system (GIS) maintained by the City. Further fieldwork by the City to confirm hydrant elevations and check for partially closed valves should eliminate slight calibration uncertainties.

B.1 Existing Model

BC constructed the original water system hydraulic model in 1966. Over the years, BC has updated the model software using proven commercial software, most recently in the mid1980s, to the KYPIPE model, developed by the University of Kentucky. In the 1990s, the City began building its GIS, which allowed use of the newer, more powerful hydraulic modeling software packages. The new software used was InfoWater Version 10.0, a product of Innovyze (formerly MWH Soft, Inc.), incorporates information from the completed GIS water system map. Completed as a draft in summer 2012, the updated water model contained:

- Most distribution mains, with the exception of noncritical 4-inch-diameter and smaller mains unless required to complete loops for areas of intensive water use.
- All storage reservoirs with dimensions and capacities.
- All booster pump stations (BPSs) with the exception of Sunset Lane BPS. The exclusion of the Sunset Lane BPS had no detrimental effects on overall model functionality because the area served by that BPS is very small and the pump curves were not readily available.
- Pressure reducing valve stations (PRVs) based on 2006 GIS information and subsequent input from City staff regarding recent changes.

After updating the water system data, BC calibrated the model and evaluated how well the results of the model would represent actual field conditions. To develop field data for model calibration, City staff and BC representatives completed hydrant testing in each major pressure zone.

B.1.1 Fire-Flow Tests

Fire-flow tests were performed for estimating the available fire flow from hydrants and used for calibrating the water distribution model. As described in the American Water Works Association (AWWA) Manual M-32 Computer Modeling of Water Distribution Systems, fire flow testing is a widely used method for estimating the available fire flow from specific fire hydrants within water distribution systems and for calibrating water models. Fire flow tests consist of measuring flow from a hydrant (flow hydrant) while measuring the pressure at an adjacent hydrant (residual or pressure hydrant). The flow hydrant causes a pressure drop (AWWA recommends a drop of 10 pounds per square inch, psi, or more in order to create sufficient "stress" on the water system to reveal its characteristics) measured at the residual hydrant. Flow rates from pumps and reservoir levels from supervisory control and data acquisition (SCADA) system were recorded at each test time to determine customer demand and operating parameters on the test day. The tests are simulated in the model by setting the pump operation and reservoir levels to match the field data and then imposing a flow hydrant in the model. Finally, the pressure drop at the residual hydrant in the model is then compared to the field data.

B.1.2 Assumptions

The pump curves, which were input into the model, have a dramatic effect on the results of the model. Since no pump testing was performed for the study, BC did not obtain actual pump performance data. However, BC adjusted the design pump curves based on the City's SCADA system, which measured pump flows during fire flow tests. This adjustment provided an accurate representation of pump performance.

The most efficient method that data was collected for calibration was performing fire flow tests with an accurate accounting of timing, using the measured static pressures obtained prior to the start of the hydrant flow, and logging the SCADA data for the system. Since the City's existing SCADA system does not currently have the capacity to collect real-time data for all BPSs and reservoirs and the Zone II production meter failed in 2012, BC selected steady-state modeling (steady-state modeling examines water distribution system hydraulics through a series of "snapshot" pictures) as the best current representation for the water system.

B.1.3 SCADA Data Collection

The City has a SCADA system with limited capability to supervise and manage the water system. For example, it records pump flows and reservoir water levels only for Zone III East, Zone IV East, Zone III West, and Zone IV West. While the SCADA system collects real-time data, it only records the previous 48-hour period data. Therefore, during testing City staff printed out screen shots of BPS operations and reservoir levels taken at the time of fire flow tests to estimate coincident system demands, to document system conditions during testing.

B.1.4 Demand Estimation

BC estimated the average daily demand for fire test days for Zone III East, Zone IV East, Zone III West, and Zone IV West by adding the reservoirs surplus/deficit and the BPS supplied water. The City also provided November 2011 supply data for the raw water supplied to the City's water treatment plant (WTP) and Zone II. Assuming 2 percent water loss through the WTP, BC developed demands for Zone I and II using the following 7 steps:

1. The average water supplied to the WTP during November 2011 was 8,488 gallons per minute (gpm). Assuming a 2 percent water loss through the treatment plant (0.02*8488 gpm = 170 gpm), the average total supply estimated is 8,318 gpm (8,488 gpm – 170 gpm= 8,318 gpm).

2. Demands for Zone's Sunset and Bear Ridge were estimated based on the number of domestic units, assuming 200 gallons per capita per day (gpcd) demand and three persons per house.
3. Demand for Zone Bear Ridge = 94 houses * 3 persons per house * 200 gpcd = 39 gpm
4. Demand for Zone Sunset = 62 houses * 3 persons per house * 200 gpm per person = 26 gpm
5. Estimated demands for Zone III East, Zone IV East, Zone III West, and Zone IV West were based on pumpage and reservoirs surplus/deficit (see Attachment C, D, E, and F for calculations).
6. The Zone II demand was estimated by deducting demands for Zone III East, Zone IV East, Zone III West, Zone IV West, Zone Bear Ridge, and Zone Sunset from the City's provided total Zone II supply.
7. The Zone I demand was approximated by subtracting the Zone II supply from the average water treatment supply (calculated in Step 1).

Table B-1 provided below summarizes the estimated demands for pressure zones used for the water model calibration.

Table B-1. Antioch Water System Estimated Demand (November 2012)

Pressure Zone	Demand (gpm)
I	1093
II (Including Zone IIA, IIB, and IIC)	3,072
III East	2,731
III West	585
IV East	685
IV West	87
Sunset	39
Bear Ridge	26
Total Demand	**8,318**

The water model contains demand estimated from surplus/deficit of storage reservoirs and pumpage observed on fire flow test days. The model does not contain diurnal demand patterns. Therefore, dynamic demand changes may prevent the demands from matching the demand that occurred at the time of testing. The model was simulated to match as closely as possible to the actual and projected scenarios by operating the proper number of pumps and keeping the storage reservoir level observed during the fire flow tests.

B.1.5 Field Testing

Field testing occurred on November 6, 7, and 8, 2012. Attachments A through F attached to this appendix summarize field data used for the model calibration and includes the following information:

1. Test site longitude, latitude, and street locations;
2. Water distribution demands;
3. Pressure logger data at fire flow test times;
4. Static and residual pressures at the time of fire flow test times;

5. Adjusted static and residual pressures with the calibration error; and
6. Water model and field data comparison results.

The pressure drop during the fire test was used to estimate the fire flow from the manufacturer's data for the testing equipment. The conversion of pressure drop to fire flow for fire flow tests are provided in Table B-2.

Table B-2. Fire Flow Calculation

Zone/Test No.	Static Pressure (psi)	Residual Pressure (psi)	Pressure Change (psi)	Flow (gpm)
Zone 1 (Test 1)	40	30	10	485
Zone 1 (Test 2)	40	12	28	804
Zone 1 (Test 3)	45	32	13	550
Zone 1 (Test 4)	47	38	9	474
Zone 1 (Test 5)	40	30	10	485
Zone 2 (Test 1)	67	40	27	790
Zone 2 (Test 2)	82	54	28	809
Zone 2 (Test 3)	82	54	28	804
Zone 2 (Test 4)	58	18	40	961
Zone 2 (Test 5)	72	46	26	775
Zone 2 (Test 6)	53	23	29	818
Zone 3 East	86	75	11	520
Zone 4 East	86	62	24	745
Zone 3 West	55	32	23	732
Zone 4 West	104	78	26	773

B.1.6 Calibration

The model calibration was performed following the review and update of the existing model for all pressure zones. As part of model calibration field data, such as reservoir levels and active BPSs, output recorded during fire hydrant testing were inserted into the water model. The model was then analyzed using the Average Day Demand (ADD) for the test days. The field-measured static pressures and residual pressures taken during the testing were then compared to the static pressure and residual pressures predicted by the model. Typically for a distribution system, a model is sufficiently calibrated when the static and residual pressure predicted by the model at the specific locations are within 5 psi of the field measured static and residual pressures. If there is some variance, the C-factor is adjusted to calibrate the model. The "C-Factor" is the Hazen-Williams coefficient for the friction of a pipe. It is used to measure the roughness of the interior surface of the pipe and minor losses through valves and fittings. The C-Factor was adjusted to bring the pressure predicted by the model into agreement with the field test data. However, when doing calibrations, the C-Factor adjustments are typically limited in magnitude to avoid distorting the model.

B.1.7 Zone I

Most Zone I pipes, particularly located in the downtown area, are cast iron and some over 100 years old. The zone has ductile iron pipes, installed around 1960, and polyvinyl chloride (PVC) pipes installed in the last two decades. Many existing water mains have higher friction factors owing to pipe age and complex system geometry. The C-Factor of the Zone 1 mains was adjusted to meet field conditions. Five fire flow tests were performed on locations such that most of the area in Zone I could be stressed during fire flow. A continuously recording pressure gauge (pressure logger) was installed at the intersection of C Street and Railroad Avenue to monitor “D” Street Reservoir levels, and static and residual pressure at 1-min intervals. Demand data summarized in Table B-1 for Zone I was allocated equally to the nodes. The fire flow test results are described below, with detail provided in Attachment A.

Test 1 – This test was performed on Marie Avenue on a water main located between East 13th Street and East 16th Street. The flow and residual hydrants were located approximately 400 feet apart on a 10-inch-diameter pipeline. In the model, the C-Factor was reduced from 110 to 100 to reflect the current pipe conditions. The water system at this location is very well looped; therefore, the pressure at the pressure hydrant dropped only 2 psi. The flow, and pressure hydrant model results were in agreement with field measurements, within +/- 3 psi.

Test 2 – This test was performed on Alpha Way near East 18th Street. The flow and residual hydrants were located approximately 1,000 feet apart on an 8-inch-diameter pipeline. The fire flow test was performed by closing a valve located near 2008/2009 Alpha Way. The model results were in agreement with the static field results, but were unable to meet the residual pressure observed in the field. The field residual pressure was 10 psi but model showed 30 psi. The 20-psi difference between the model and field pressure could not be corrected with reasonable changes in the C-Factor. There are other possible causes, such as other partially closed valves in the system or a significant pipe diameter decrease due to corrosion that may have caused a large drop in residual pressure. BC recommends that the City conduct a field investigation to determine whether or not valves located in the vicinity are closed.

Test 3 – This test was performed on West 4th Street on a 6-inch-diameter water main located between E Street and F Street. The flow and residual hydrants were located approximately 300 feet apart. The model static pressure was in agreement with the field pressure within +/- 3 psi. However, the residual pressure, had difference of 6 psi between the modeled and field pressure. Lowering the C-Factor reasonably would not correct this difference. This part of the water system has old pipes and pipe diameter has likely been reduced due to corrosion and/or deposits.

Test 4 – This test was performed on West 8th Street on an 8-inch-diameter water main located between L Street and O Street. The flow and residual hydrants are located approximately 350 feet apart. The model static and residual pressures were in agreement with the field pressure within +/- 3 psi.

Test 5 – This test was performed on Merrill Drive on an 8-inch-diameter water main located between Almond Street and Orchard Lane. The flow and residual hydrants are located approximately 330 feet apart. The model static and residual pressures were in agreement with field pressure within +/- 2 psi.

B.1.8 Zone II

Most of Zone II was developed more recently than Zone I and is in better condition when compared to Zone I. Six fire flow tests were conducted at various Zone II locations. Three continuously reading pressure gauges were installed to monitor the 3.0-million-gallon Donlon Reservoir and Larkspur Reservoir levels. BC allocated Zone II demands (see Table B-1) equally among the nodes. The fire flow test results are described below and in more detail in Attachment B.

Test 1 – This test was conducted on Mellissa Circle on a 6-inch-diameter water main located near Harris Drive. The distance between flow and residual hydrants is approximately 400 feet. The model static and residual pressures at the flow and residual hydrants were in agreement with the field pressure within +/- 2 psi.

Test 2 – This test was conducted on Almond Ridge Drive located between Filbert Street and Coffee Tree Way on the eastern part of the water distribution system on an 8-inch-diameter water main. The distance between flow and residual hydrants is approximately 350 feet. The model static and residual pressures at the flow and residual hydrant were in agreement with the field pressure within +/- 3 psi.

Test 3 – This test was conducted on Russell Drive on a 6-inch-diameter water main located between Newbury Avenue and Lawton Street. The distance between flow and residual hydrants is approximately 320 feet. The fire flow results show a difference of 3.6 psi between model and field static pressures, and a 9 psi difference between model and field residual pressures. For both static and residual pressures, the field pressures were lower. The model C-Factor was changed in an attempt to calibrate the model, but that changes the calibration results of other flow tests. Based on the comparison of field and model static pressure, BC recommends that the City checks residual hydrant elevation and closed valves in the field.

Test 4 – This test was conducted on Null Drive on a 6-inch-diameter water main located between Reimche Drive and Truman Court. The distance between flow and residual hydrants is approximately 360 feet. The model static pressures at the flow and residual hydrant were in agreement with the field pressure within +/- 2 psi. However, the model residual pressure does not meet the field residual pressure conditions. The residual pressure predicted on the model residual hydrant was 38.5 psi, while the field residual pressure was 26 psi. There is a difference of 12.5 psi between the model and field residual pressure. This difference could not be calibrated using the C-Factor. Other possible causes may be partially closed valve in the system, or a significant pipe diameter decrease due to corrosion that may have caused such a large drop in residual pressure. BC recommends that City conduct a field investigation to find if valves located in the vicinity are partially closed and also check hydrant elevations.

Test 5 - This test was conducted on Mira Vista Court on an 8-inch-diameter water main located between Rio Grande Drive and Mission Drive. The distance between flow and residual hydrants is approximately 380 feet. The model static and residual pressures at the flow and residual hydrants were in agreement with the field pressure within +/- 2 psi.

Test 6 – This test was conducted on Blythe Drive on an 8-inch-diameter water main located near Shaw Circle. The distance between flow and residual hydrants is approximately 350 feet. The model static and residual pressures at the flow and residual hydrant were in agreement with the field pressure within +/- 4 psi.

B.1.9 Zone III East

Zone III East was developed the late 1970s, thus this zone is relatively new and serves predominantly new residential construction. A fire flow test was performed in the southeast portion of the water system. Pressure loggers were installed to monitor Lone Tree and Hillcrest Reservoir levels. The fire flow test was conducted on Roscommon Way on an 8-inch-diameter water main located between Leitrim Way and McFarlan Ranch Drive. The flow and residual hydrants are 450 feet apart. The model static and residual pressures at the flow and residual hydrant were in agreement with the field pressure within +/- 4 psi (see Attachment C).

B.1.10 Zone IV East

This zone currently serves only residential areas. A single fire flow test was performed in the south-east portion of the water system on the Observation Way. A pressure logger was installed near the reservoir access road to monitor the Empire Mine Reservoir water level. The fire flow was conducted on Observation Court on an 8-inch-diameter water main. The flow and residual hydrants are located 320 feet apart. The model static and residual pressures at the flow and residual hydrant were in agreement with the field pressure within +/- 2 psi (see Attachment D).

B.1.11 Zone III West

Zone III West is a relatively new zone and consists of new ductile iron and PVC pipelines. A fire flow test was performed on Chardonnay Way. A pressure logger was installed on the pipeline located on Cambridge Drive to monitor the Cambridge Reservoir water level, but the logger was mistakenly installed on the pipeline in the Zone IV West. Results of the pressure zone simulations show that model static pressure was lower than the field pressure by 2.8 psi, and the model residual pressure was lower than the field pressure by 7.4 psi (see Attachment E). Based on the model and the field static pressure comparison, the discrepancy is likely due to the node elevation in the model. BC recommends that the City conduct a field investigation to confirm the elevations of hydrants where residual pressure were measured during hydrant testing.

B.1.12 Zone IV West

Zone IV West is a newly constructed pressure zone (less than 20 years old) and mostly consists of ductile iron and PVC pipelines. A fire flow test was conducted on an 8-inch-diameter water main on the West Ridge Court. A pressure logger was installed on the Cambridge Drive to monitor the Mira Vista Reservoir water level. Results of the pressure zone simulations show that the static and residual pressures from the model were within +/-3 psig of the field test results (see Attachment F). The C Factor was set at 130. No adjustment was required for the C Factor in order to calibrate the model.

B.1.13 Water Model Conclusion

Based on the water distribution analysis, the water model is satisfactorily calibrated within acceptable levels compared to the field condition. As described above, it is recommended that field checks be completed for hydrant elevations and closed or partially closed valves.

B.1.14 Fire Flow analysis

Fire flow simulation (FFS) provides an instantaneous snapshot of the amount of water available to any connection in the system while maintaining a minimum 20-psig residual pressure. FFS is typically run under Maximum Day Demand (MDD) conditions and fire district minimum fire flow requirements, which depend upon the type of structure being protected. FFS was conducted using the MDD condition and assuming that each storage reservoir was 5 feet below the maximum water level.

In this fire flow analysis, a 2,000-gpm fire flow rate was applied to the nodes in the model (excluding nodes located near the storage reservoirs and nodes at the inlet side of the BPS). Figure B-1 presents the fire flow available at the nodes. The existing fire flow analysis indicates that under the current conditions, the water system is not capable of providing a minimum fire flow of 2,000 gpm for all residential areas. Some commercial and industrial areas also showed fire flow delivery short falls.

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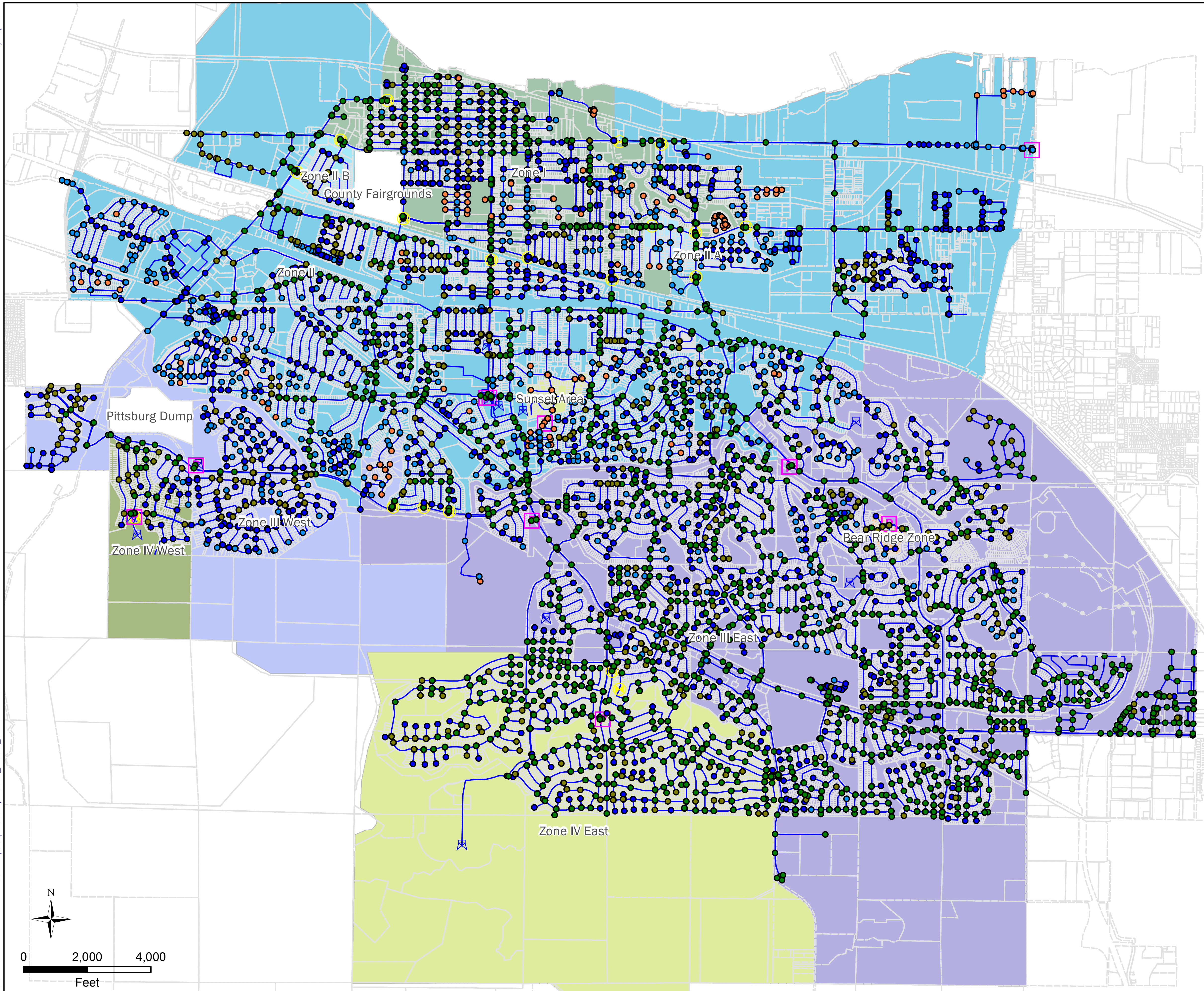
Figure B-1: Existing Water System Available Fire Flow (gpm)

Conditions:
-2015 Max-Day Demand (x1.7 ADD)
-Tank Level @ -5 ft
-Minimum 20 psi Residual Pressure



Legend

AVAIL_FLOW
- less than 1,000
- 1,000 to 2,000
- 2,000 to 3,500
- 3,500 to 4,500
- greater than 4,500

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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For the Sunset Zone, all nodes showed shortfalls because the fire flow pumps were activated. Currently City staff has the fire flow pump switched off owing to pressure control issues.

B.1.15 Water System Upgrade Recommendations

Starting with the calibrated model and projections for existing fire flow delivery and for future City growth, BC developed potential projects (principally new, parallel or replacement water mains and pressure reducing stations). As a starting point many projects presented in the 1999 Master Plan Update were included. Projected fire flow delivery capacity for the existing system was also reviewed when compared with the fire flow delivery goals that were developed when BC worked with the Contra Costa County Fire Protection District. The Capital Improvement Projects (CIP) was added to the distribution system model and checked for fire flow delivery coincident with 2035 maximum day water demands. Figure B-2 present available fire flow with CIP improvements and modeling results. Figures B-3 and B-4 present model results for both projected peak-hour demand and maximum-day demand for the existing system, respectively. Figures B-5 and B-6 present model results for both projected peak-hour demand and maximum-day demand proposed improved system, respectively. Figures B-3 through B-6 show that most nodes meet the demands and fire flow goals, except for the older neighborhoods of downtown. With proposed projects in place from Figure B-2, fire flow delivery improves significantly for the Zone II area along Somersville Road south of Highway 4 and for northeast Antioch along the Wilbur corridor. Adding smaller mains in the Lake Alhambra vicinity would improve delivery significantly in that area. The analyses included no changes to either BPSs or reservoirs since those facilities generally have required capacity already. Most areas already meet the peak hour design criteria of 40 psig, with some improvement after adding new mains and PRVs. Similarly, with the exception of older Zone I and Zone II neighborhoods, much of the system will deliver 55 psig on a maximum day, again with some improvement after adding new mains and PRVs.

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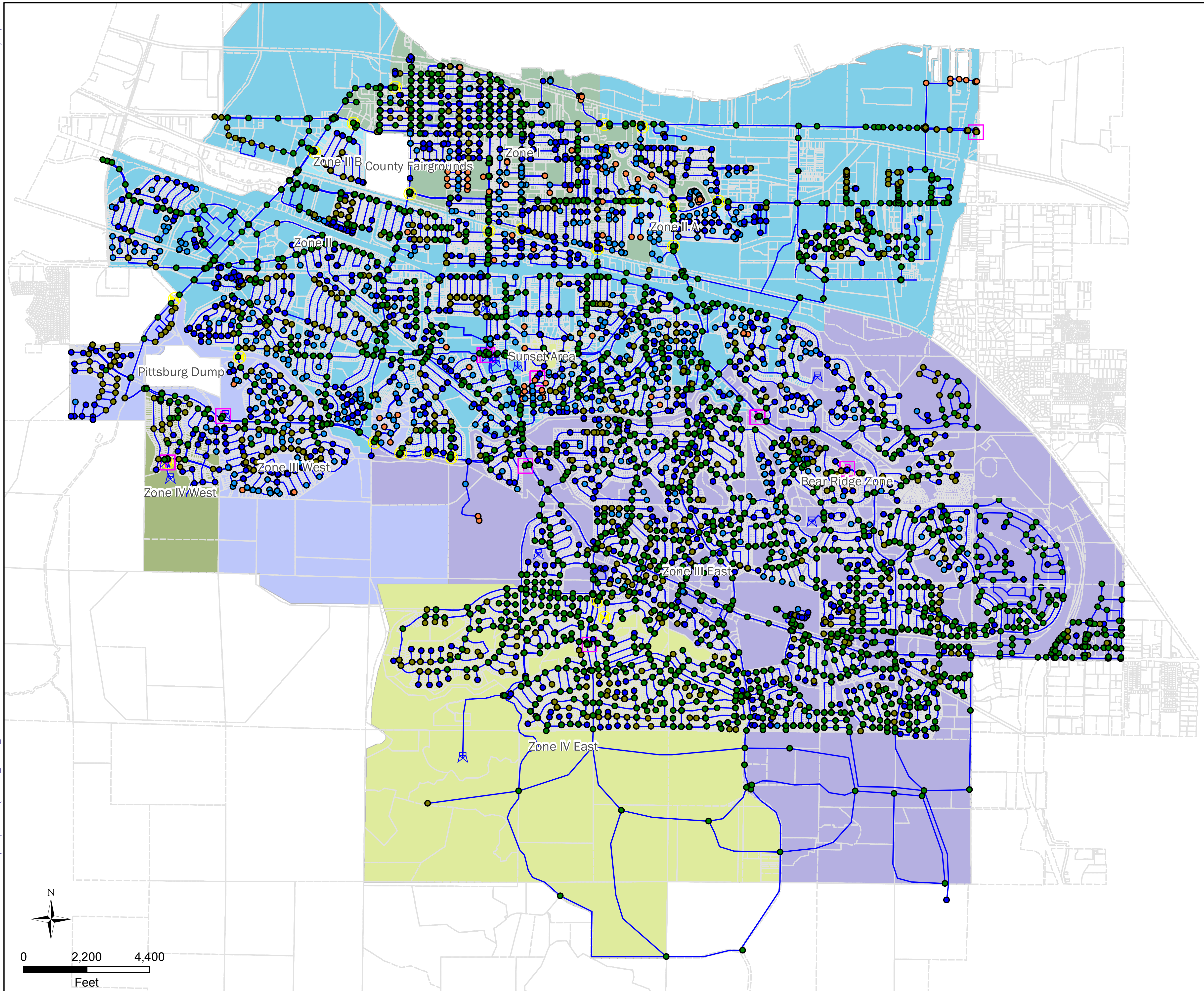

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Figure B-2: 2035 Water System Available Fire Flow (gpm)

Conditions:
-2035 Max-Day Demand (x1.7 ADD)
-Tank Level @ -5 ft
-Minimum 20 psi Residual Pressure

Legend

AVAIL_FLOW
- less than 1,000
- 1,000 to 2,000
- 2,000 to 3,500
- 3,500 to 4,500
- greater than 4,500

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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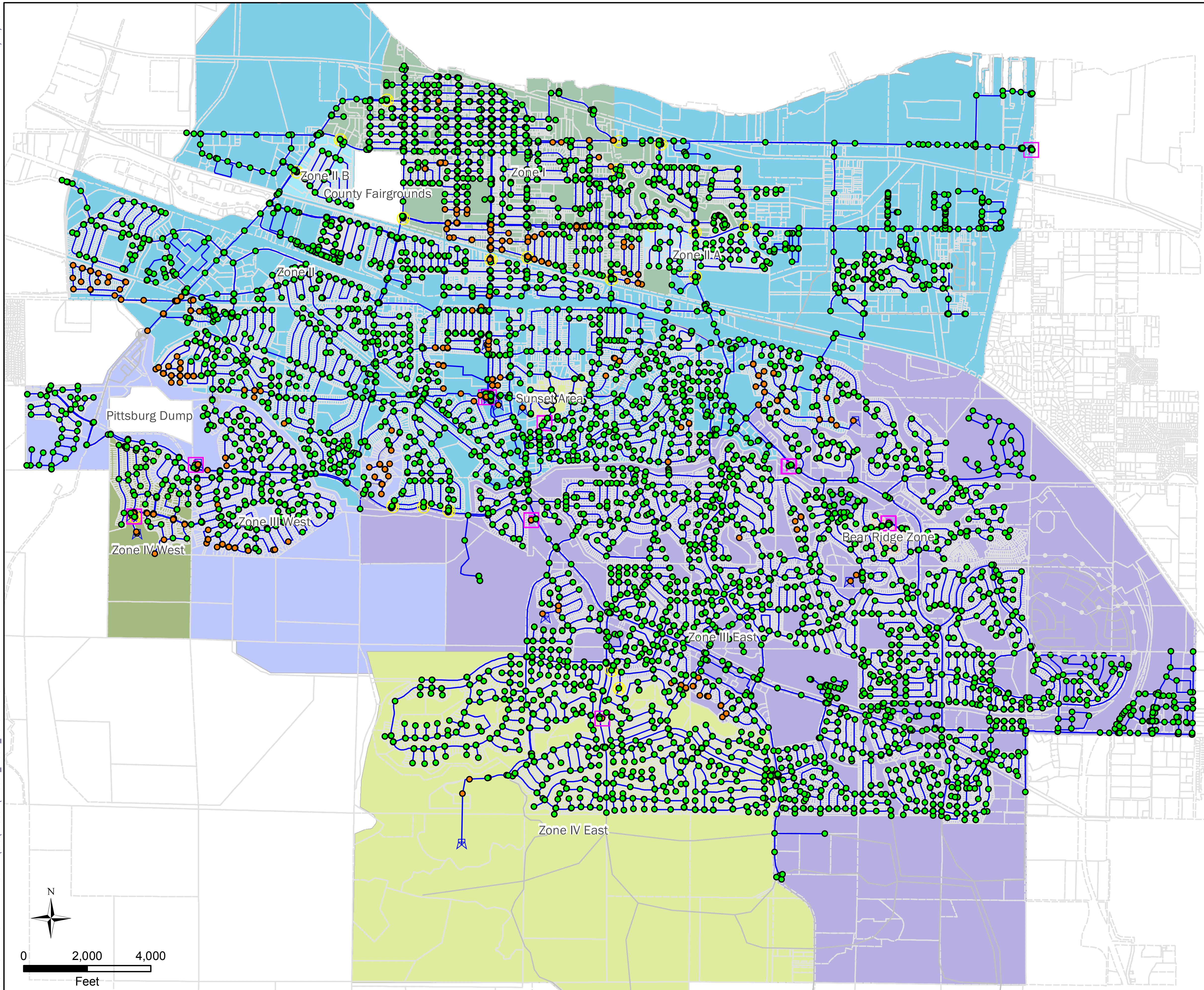

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Figure B-3: Existing Water System Pressure

Conditions:
-2015 Peak Hour Demand (x2.69 ADD)
-Tank Level @ -10 ft

Legend

PRESSURE
- less than 40 psi
- greater than 40 psi
- <all other values>

TYPE
- Active
- Domain
- Inactive
- <all other values>

TYPE
- Active
- Domain
- Inactive
- <all other values>

TYPE
- Active
- Domain
- Inactive
- <all other values>

TYPE
- Active
- Domain
- Inactive

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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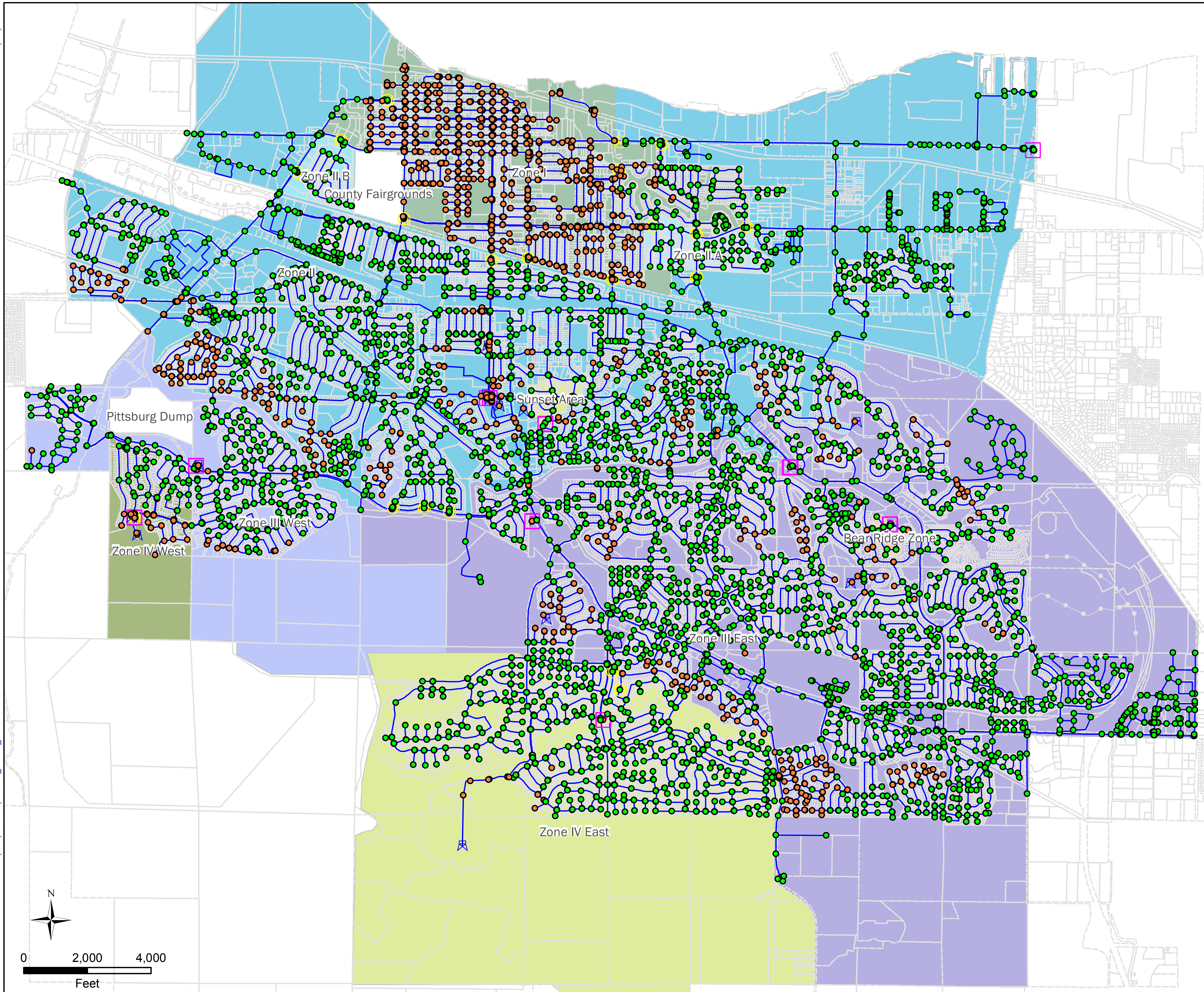

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Figure B-4: Existing Water System Pressure

Conditions:
-2015 Max-Day Demand (x1.7 ADD)
-Tank Level, Full

Legend

MAX_PRESS
- less than 55 psi
- greater than 55 psi

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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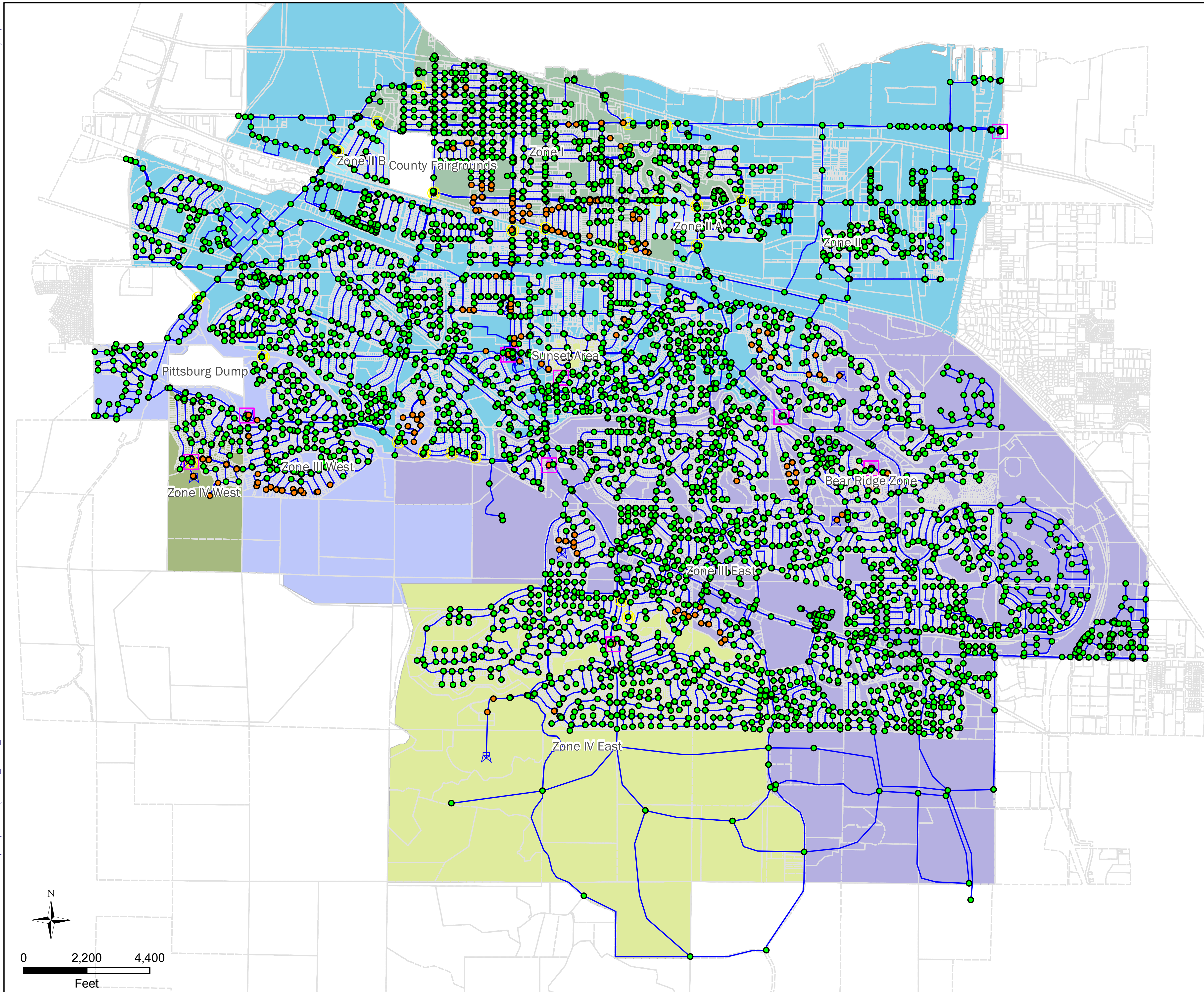
Figure B-5: Future Water System Pressure

Conditions:
-2035 Peak Hour Demand (x2.69 ADD)
-Tank Level @ -10 ft



Legend

PRESSURE
- less than 40 psi
- greater than 40 psi

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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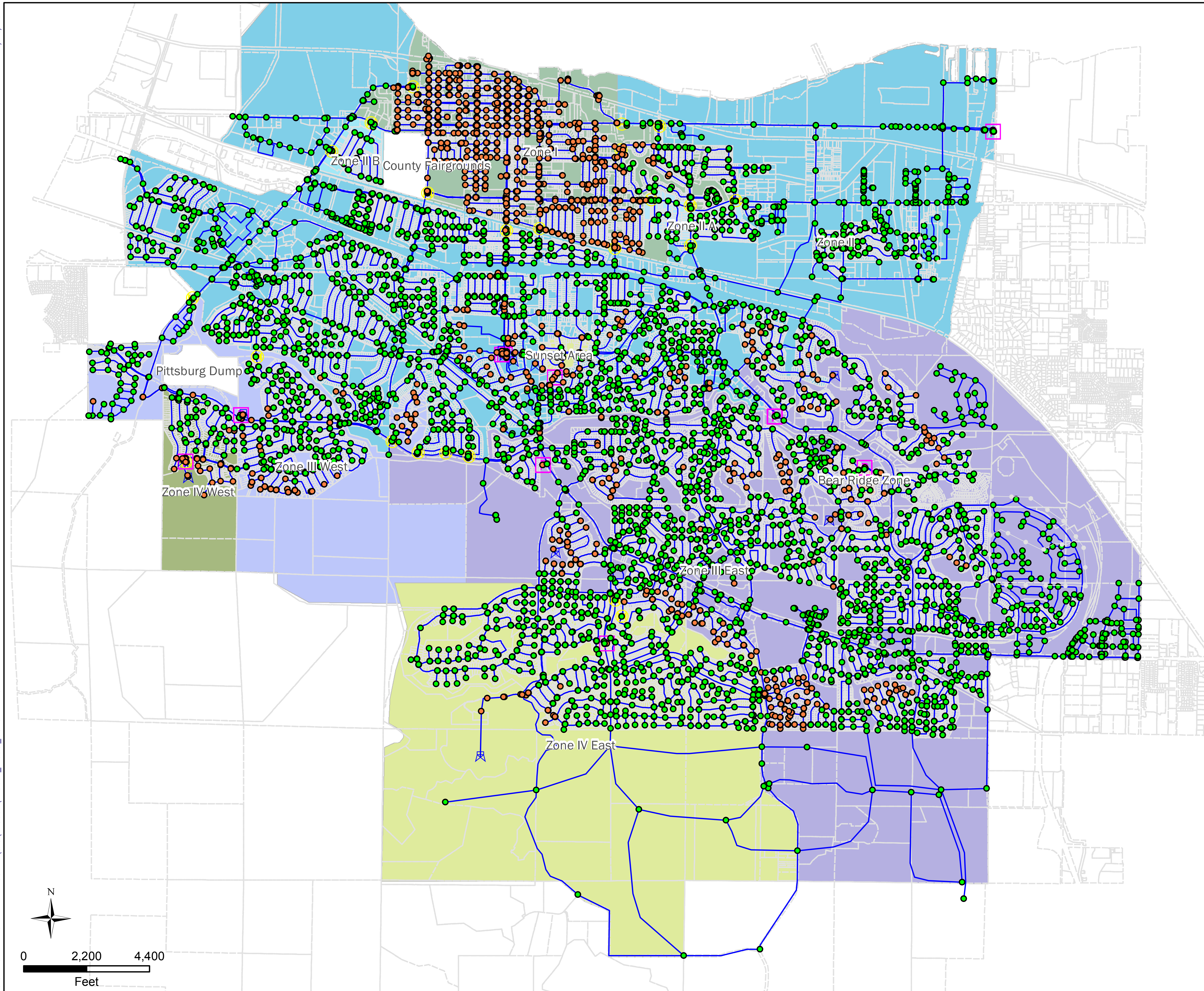

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Water System Master Plan Update

Figure B-6: Future Water System Pressure

Conditions:
-2035 Max-Day Demand (x1.7 ADD)
-Tank Level, Full

Legend

MAX_PRESS
- less than 55 psi
- greater than 55 psi

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

TYPE
- Active
- Domain

Pressure Zones
- Bear Ridge Zone
- Sunset Area
- Zone I
- Zone II
- Zone II A
- Zone II B
- Zone II C
- Zone III East
- Zone III West
- Zone IV East
- Zone IV West

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Attachment A

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Table A-1. Summary of Fire Flow and Model Test Results										
					Hydrant Testing				Model Results	
					Pressure Hydrant[1]		Flowing Hydrant			
Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 1 (Test 1)	Marie Ave.	Lat: 38.00774167N; Long: 121.7992083W	Not Available	11/8/2012 10:12 A.M.- 10:19 A.M.	44	42	570	30	45.3	44.6
	C St./Railroad Ave	Lat: 38.00282; Long: -121.80872)			34	33.2	-	-	34.1	33.7
Zone 1 (Test 2)	Alpha Way	Lat: 38.0016N; Long: 121.80061W	Not Available	11/8/2012 10:36 A.M.- 10:55 A.M.	39	10	804	12	41.8	31.9
	C St./Railroad Ave	Lat: 38.00282; Long: -121.80872)			34	32.3	-	-	34.1	33.4
Zone 1 (Test 3)	West 4th Street	Lat: 38.0155389N; Long: 121.81242W	Not Available	11/8/2012 11:19 A.M.- 11:30 A.M.	40	36	550	32	42.8	42.2
	C St./Railroad Ave	Lat: 38.00282; Long: -121.80872)			34	31.2	-	-	34.2	33.8
Zone 1 (Test 4)	West 8th Street	Lat: 38.012569N; Long: 121.820824W	Not Available	11/8/2012 11:44 A.M.- 11:51 A.M.	48	45	474	38	48.4	47.5
	C St./Railroad Ave	Lat: 38.00282; Long: -121.80872)			34.3	33.6	-	-	34.2	33.8
Zone 1 (Test 5)	Wilbur Avenue	Lat: 38.012062N; Long: 121.802437W	Not Available	11/8/2012 2:37 P.M.- 2:52 P.M.	40	38	485	30	39.7	38.6
	C St./Railroad Ave	Lat: 38.00282; Long: -121.80872)			35.5	34.7	-	-	35.4	34.9

Table A-2. Adjusted Gauge/Logger Pressure Data

Zone	Gauge/Logger ID	Calibration Error (psi)	Test	Measured Pressure (psi)	Adjusted Pressure (psi)
Zone 1 (Test 1)	WC-1 (Residual Hydrant)	2	Before Test	46.0	44.0
		2	During Test	44.0	42.0
		2	After Test	46.0	44.0
	BC-8 (Flowing Hydrant)	-2	During Test	28.0	30.0
	P100-3 (Residual Hydrant and Monitoring 'D' Street Tank Level)	1	Before Test	35.0	34.0
		1	During Test	34.2	33.2
		1	After Test	35.0	34.0
Zone 1 (Test 2)	WC-1 (Residual Hydrant)	2	Before Test	41.0	39.0
		2	During Test	12.0	10.0
		2	After Test	40.0	38.0
	BC-8 (Flowing Hydrant)	-2	During Test	10.0	12.0
	P100-3 (Residual Hydrant and Monitoring 'D' Street Tank Level)	1	Before Test	35.0	34.0
		1	During Test	33.3	32.3
		1	After Test	35.0	34.0
Zone 1 (Test 3)	WC-1 (Residual Hydrant)	2	Before Test	42.0	40.0
		2	During Test	38.0	36.0
		2	After Test	42.0	40.0
	BC-8 (Flowing Hydrant)	-2	During Test	30.0	32.0
	P100-3 (Residual Hydrant and Monitoring 'D' Street Tank Level)	1	Before Test	35.0	34.0
		1	During Test	32.2	31.2
		1	After Test	35.0	34.0
Zone 1 (Test 4)	WC-1 (Residual Hydrant)	2	Before Test	50.0	48.0
		2	During Test	47.0	45.0
		2	After Test	50.0	48.0
	BC-8 (Flowing Hydrant)	-2	During Test	36.0	38.0
	P100-3 (Residual Hydrant and Monitoring 'D' Street Tank Level)	1	Before Test	35.3	34.3
		1	During Test	34.6	33.6
		1	After Test	35.0	34.0
Zone 1 (Test 5)	WC-1 (Residual Hydrant)	2	Before Test	42.0	40.0
		2	During Test	40.0	38.0
		2	After Test	42.0	40.0
	BC-8 (Flowing Hydrant)	-2	During Test	28.0	30.0
	P100-3 (Residual Hydrant and Monitoring 'D' Street Tank Level)	1	Before Test	37.0	36.0
		1	During Test	35.7	34.7
		1	After Test	37.0	36.0

Table A-3. Fire Flow Calculation				
Zone/Test No.	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Loss (psi)**	**Flow[1] (gpm)**
Zone 1 (Test 1)	40	30	10	485
Zone 1 (Test 2)	40	12	28	804
Zone 1 (Test 3)	45	32	13	550
Zone 1 (Test 4)	47.5	38	9.5	474
Zone 1 (Test 5)	40	30	10	485

Note:

[1] Flow rate estimated from pressure drop vs. flow rate table provided by fire flow equipment manufacturer

Table A-4. Pressure Zone 1 Water Model Field Testing Results

Hydrant Flow Test Pressure Zone: Zone 1

Collected By: Kevin Kai/Sean Flores Date: 11/8/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
1	Lat: 38.00670278N; Long: 121.7992056W	WC-1	Before:	1012	46	1	Lat: 38.00774167N; Long: 121.7992083W	BC-8	28	Waterline between flowing and pressure hydrants is 10" CIP. Pressure did not drop adequately during test. Pressure Zone 1.
			During:	1019	44	2				
			After:							
2	Lat: 38.00436389N; Long: 121.80061389W	WC-1	Before:	1036	41	1	Lat: 38.0016N; Long: 121.80061W	BC-8	5-10	Waterline between flowing and pressure hydrants is 8" CIP. Pressure Zone 1. Prior to testing a valve was closed near 2008/2009 Alpha Way.
			During:	1052	12	2				
			After:	1055	40					
3	Lat: 38.0155361N; Long: 121.811411W	WC-1	Before:	1119	42/42	1	Lat: 38.0155389N; Long: 121.81242W	BC-8	24/30	Waterline between flowing and pressure hydrants is 6" CIP. Pressure Zone 1. (Recorded with valve at F St. & 4th St. CLOSED/Recorded with valve at F St. & 4th St. OPEN)
			During:	1125/1129	38/39	2				
			After:	1126/1130	42/42					
4	Lat: 38.012569N; Long: 121.822078W	WC-1	Before:	1144	50	1	Lat: 38.012569N; Long: 121.820824W	BC-8	36	Waterline between flowing and pressure hydrants is 8" PVC. Pressure Zone 1.
			During:	1149	47	2				
			After:	1151	50					
5	Lat: 38.012060N; Long: 121.803590W	WC-1	Before:	1437/1450	42/42	1	Lat: 38.012062N; Long: 121.802437W	BC-5	26/28	Waterline between flowing and pressure hydrants is 8" DIP. Pressure Zone 1. (Recorded with valve at Merrill & Orchard OPEN/Recorded with valve at Merrill & Orchard CLOSED)
			During:	1442/1451	40/36	2				
			After:	1444/1452	42/42					

* Latitude and Longitude were obtained using Google Earth

Table A-5. Pressure Zone 1 Water Model Field Pressure Logger Locations

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zones 1

Date: 11/8/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-3	Pressure monitoring at tank during flow testing	1	C St./Railroad Ave. (Lat: 38.00282, Long: -121.80872)	11-8-12/0956	11-8-12/1505	Monitor D St. Tank
P100-6	Pressure monitoring at tank during flow testing	3-West	Finch Dr./Cambridge Dr. (Lat: 37.9794972; Long: -121.847389)	11-8-12/1252	11-8-12/1417	Monitor Cambridge Tank
P100-7	Pressure monitoring at tank during flow testing	4-West	Pintail Dr./Cambridge Dr. (Lat: 37.97962; Long: -121.84841)	11-8-12/1255	11-8-12/1419	Monitor Mira Vista Hills Tank

* Latitude and Longitude were obtained using Google Earth

Table A-6. Model Water Distribution Demand	
System Demand	1093
No. of Nodes	1068
Demand Each Node	1.0234

Attachment B

Table B-1. Summary of Fire Flow and Model Test Results

Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Hydrant Testing				Model Results	
					Pressure Hydrant		Flowing Hydrant			
					Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 2 (Test 1)	Mellissa Cir	Lat: 37.99293N; Long: 121.784783W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 11:22 A.M.- 11:30 A.M.	59	54	790	40	58	53
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			51.6	51	-	-	52	51.8
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			58.6	58.5	-	-	67.3	67.3
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			37	36.4	-	-	36.6	36.5
Zone 2 (Test 2)	Almond Ridge Dr	Lat: 38.00231N; Long: 121.767061W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 11:50 A.M.- 11:55 A.M.	84	75	809	54	82.3	78
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			51.6	51.2	-	-	51.9	51.9
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			68	68	-	-	67.3	67.3
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			37.3	36.6	-	-	36.8	36.6
Zone 2 (Test 3A)	Russel Drive	Lat:38.002772N; Long: 121.813472W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 12:42 P.M.- 12:46 P.M.	77	67	804	54	80.6	76.1
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			50.1	49.4	-	-	50	49.8
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			67.9	67.8	-	-	67.3	67.3
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			36.8	36.3		-	37	36.9
Zone 2 (Test 4)	Null Drive	Lat: 37.9995583N; Long: 121.849767W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 1:17 P.M.- 1:28 P.M.	54	26	961	18	54.8	38.5
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			50.5	50.3	-	-	50.3	50.2
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			68	67.8	-	-	67.3	67.3
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			36.6	36.9	-	-	36.8	36.7

Table B-1. Summary of Fire Flow and Model Test Results

Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Hydrant Testing				Model Results	
					Pressure Hydrant		Flowing Hydrant			
					Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 2 (Test 5)	Mira Vista Ct	Lat: 37.9968N; Long: 121.8294389W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 1:55 P.M.– 2:02 P.M.	72	66	775	46	72.3	67.9
	Mira Vista Ct	Lat: 37.9962056N; 121.828494W.			72	66			72.3	66
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			50.8	50.3	-	-	50.7	50.6
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			68	67.8	-	-	67.3	67.3
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			36.9	36.8	-	-	37	37
Zone 2 (Test 6)	Blythe Drive	Lat: 37.98192N; Long: 121.81913W	Zone 2 BPS A - ON; Zone 2 BPS B - ON	11/7/2012 2:31 P.M.– 2:38 P.M.	52	35	818	23	55.5	36.5
	33 Walton Lane	Lat: 37.9910083, Long: -121.8065472			51	50.5	-	-	51.2	51
	Donlon Pump Station	Lat: 37.9838194; Long: -121.8418972			68	67.8	-	-	68	67.8
	3102 Larkspur Drive	Lat: 37.98790278; Long: -121.7719472			38.5	36.9	-	-	38.5	38.5

Table B-2. Adjusted Gauge/Logger Pressure Data

Zone	Gauge/Logger ID	Error (psi)	Test	Measured Pressure (psi)	Adjusted Pressure (psi)
Zone 2 (Test 1)	BC-5 (Residual Hydrant)	4	Before Test	63.0	59.0
		4	During Test	58.0	54.0
		4	After Test	63.0	59.0
	BC-8 (Flowing Hydrant)	-2	During Test	38.0	40.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	52.6	51.6
		1	During Test	52.0	51.0
		1	After Test	52.7	51.7
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	60.1	58.6
		1.5	During Test	60	58.5
		1.5	After Test	60.1	58.6
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	38.5	37.0
		1.5	During Test	37.9	36.4
		1.5	After Test	38.7	37.2
Zone 2 (Test 2)	BC-5 (Residual Hydrant)	4	Before Test	88.0	84.0
		4	During Test	79.0	75.0
		4	After Test	88.0	84.0
	BC-8 (Flowing Hydrant)	-2	During Test	52.0	54.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	52.6	51.6
		1	During Test	52.2	51.2
		1	After Test	52.3	51.3
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	69.5	68.0
		1.5	During Test	69.5	68.0
		1.5	After Test	69.3	67.8
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	38.8	37.3
		1.5	During Test	38.1	36.6
		1.5	After Test	38.9	37.4
Zone 2 (Test 3)	BC-5 (Residual Hydrant)	4	Before Test	81.0	77.0
		4	During Test	71.0	67.0
		4	After Test	81.0	77.0
	BC-8 (Flowing Hydrant)	-2	During Test	52.0	54.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	51.1	50.1
		1	During Test	50.4	49.4
		1	After Test	50.7	49.7
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	69.4	67.9
		1.5	During Test	69.3	67.8
		1.5	After Test	69.4	67.9
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	38.3	36.8
		1.5	During Test	37.8	36.3
		1.5	After Test	38.1	36.6

Table B-2. Adjusted Gauge/Logger Pressure Data					
Zone	**Gauge/Logger ID**	**Error (psi)**	**Test**	**Measured Pressure (psi)**	**Adjusted Pressure (psi)**
Zone 2 (Test 4)	BC-5 (Residual Hydrant)	4	Before Test	58.0	54.0
		4	During Test	30.0	26.0
		4	After Test	59.0	55.0
	BC-8 (Flowing Hydrant)	-2	During Test	16.0	18.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	51.5	50.5
		1	During Test	51.3	50.3
		1	After Test	51.7	50.7
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	69.5	68.0
		1.5	During Test	69.3	67.8
		1.5	After Test	69.5	68.0
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	38.1	36.6
		1.5	During Test	38.4	36.9
		1.5	After Test	38.5	37.0
Zone 2 (Test 5)	BC-5 (Residual Hydrant)	4	Before Test	76.0	72.0
		4	During Test	70.0	66.0
		4	After Test	76.0	72.0
	BC-8 (Flowing Hydrant)	-2	During Test	44.0	46.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	51.8	50.8
		1	During Test	51.3	50.3
		1	After Test	52.1	51.1
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	69.5	68.0
		1.5	During Test	69.3	67.8
		1.5	After Test	69.4	67.9
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	38.4	36.9
		1.5	During Test	38.3	36.8
		1.5	After Test	38.2	36.7
Zone 2 (Test 6)	BC-5 (Residual Hydrant)	4	Before Test	56.0	52.0
		4	During Test	39.0	35.0
		4	After Test	56.0	52.0
	BC-8 (Flowing Hydrant)	-2	During Test	21.0	23.0
	P100-3 (Residual Hydrant and Monitoring Zone 2, 3.0 MG Tank Level)	1	Before Test	52.0	51.0
		1	During Test	51.5	50.5
		1	After Test	52.0	51.0
	P100-5 (Residual Hydrant near Donlon BPS)	1.5	Before Test	69.5	68.0
		1.5	During Test	69.3	67.8
		1.5	After Test	69.4	67.9
	P100-7 (Residual Hydrant and Monitoring Larkspur Drive Tank Level)	1.5	Before Test	40.0	38.5
		1.5	During Test	38.4	36.9
		1.5	After Test	39.3	37.8

Table B-3. Fire Flow Calculation				
Zone/Test No.	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Loss (psi)**	**Flow (gpm)**
Zone 2 (Test 1)	67	40	27	790
Zone 2 (Test 2)	82.3	54	28.3	809
Zone 2 (Test 3)	82	54	28	804
Zone 2 (Test 4)	58	18	40	961
Zone 2 (Test 5)	72	46	26	775
Zone 2 (Test 6)	53	23	29	818

Note:

[1] Flow rate estimated from pressure drop vs. flow rate table provided by fire flow equipment manufacturer

Table B-4. Pressure Zone 1 Water Model Field Testing Results

Hydrant Flow Test Pressure Zone: Zone 2

Collected By: Kevin Kai/Sean Flores Date: 11/7/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
1	Lat: 37.99313056N; Long: 121.78592W	BC-5 (Backup) BC-6 (Main)	Before:	1122	63	1	Lat: 37.99293N; Long: 121.784783W	BC-8	38	Waterline between flowing and pressure hydrants is 6" ACP. Pressure Zone 2.
			During:	1127	58	2				
			After:	1130	63					
2	Lat: 38.00184N; Long: 121.76801W	BC-5 (Backup) BC-6 (Main)	Before:	1150	88	1	Lat: 38.00231N; Long: 121.767061W	BC-8	56	Waterline between flowing and pressure hydrants is 8" ACP. Pressure Zone 2.
			During:	1153	79	2				
			After:	1155	88					
3A	Lat: 38.00236389N; Long: 121.81271W	BC-3 (Main) BC-5 (Backup)	Before:	1242	81	1	Lat:38.002772N; Long: 121.813472W	BC-8	52	Waterline between flowing and pressure hydrants is 6" DIP. Pressure Zone 2.
			During:	1244	71	2				
			After:	1246	81					
4	Lat: 37.9987583N; Long: 121.850489W	BC-3 (Main) BC-5 (Backup)	Before:	1317	58	1	Lat: 37.9995583N; Long: 121.849767W	BC-8	16	Waterline between flowing and pressure hydrants is 6" ACP. Pressure Zone 2.
			During:	1324	30	2				
			After:	1328	59					
5	Lat: 37.9958N; Long: 121.8278389W	BC-3 (Main) BC-5 (Backup)	Before:	1355	76	1	Lat: 37.9968N; Long: 121.8294389W	BC-8	44	Waterline between flowing and pressure hydrants is 8" PVC. Pressure Zone 2. Took pressure measurements at an intermediate hydrant during flow. Before: 1400 - 68 psi; During: 1401 - 60 psi. Intermediate hydrant location: Lat: 37.9962056N; 121.828494W.
			During:	1401	70	2				
			After:	1402	76					

* Latitude and Longitude were obtained using Google Earth

Table B-5. Pressure Zone 1 Water Model Field Testing Results

Hydrant Flow Test Pressure Zone: Zones 2

Collected By: Kevin Kai/Sean Flores Date: 11/6/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
6	Lat: 37.982678N; Long: 121.81853056W	BC-3 (Main) BC-5 (Backup)	Before:	1431	56	1	Lat: 37.98192N; Long: 121.81913W	BC-8	21	Waterline between flowing and pressure hydrants is 8" ACP. Pressure Zone 2.
			During:	1435	39	2				
			After:	1438	56					

* Latitude and Longitude were estimated using Google Earth

Table B-6. Pressure Zone 1 Water Model Field Pressure Logger Locations

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zone 2

Date: 11/7/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-3	Pressure monitoring at tank during flow testing	2	33 Walton Lane (Lat: 37.9910083, Long: -121.8065472)	11-7-12/1006	11-7-12	3.0 MG Tank
P100-5	Pressure monitoring at tank during flow testing	2	Donlon Pump Station (Lat: 37.9838194; Long: -121.8418972)	11-7-12/1045	11-7-12	Donlon Tank
P100-7	Pressure monitoring at tank during flow testing	2	3012 Larkspur Dr. (Lat: 37.98790278; Long: -121.7719472)	11-7-12/1110	11-7-12	Larkspur Tank

* Latitude and Longitude were obtained using Google Earth

Table B-7. Model Water Distribution Demand	
System Demand	3137
No. of Nodes	3243
Demand Each Node	0.9673

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Attachment C

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Table C-1. Summary of Fire Flow and Model Test Results										
					Hydrant Testing				Model Results	
					Pressure Hydrant[1]		Flowing Hydrant[1]			
Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 3 East	Roscommon Way	Lat: 37.965778°N; Long:-121.742136°W	Lone Tree BPS - Off Hillcrest BPS - ON Dallas Ranch BPS - Off	11/6/2012 12:33 P.M.– 12:42 P.M.	85	80	600	77	81.6	80.9
	Cache Peak Drive	Lat: 37.971878°N; Long:-121.802100°W			39.8	37.8	-	-	36.8	36.6
	Via Dora Drive	Lat: 37.974352°N; Long:-121.768917°W			55.1	52.5	-	-	53.1	51.1

Table C-2. Adjusted Gauge/Logger Pressure Data					
Zone	**Gauge/Logger ID**	**Error (psi)**	**Test**	**Measured Pressure (psi)**	**Adjusted Pressure (psi)**
Zone 3 East	BC-06 (Residual Hydrant)	1	Before Test	86	85
			During Test	81	80
			After Test	85	84
	BC-08 (Flowing Hydrant)	-2	During Test	75	77
	P-100-03 (Residual Hydrant and Monitoring Lone Tree Tank Level)	1	Before Test	40.8	39.8
			During Test	38.8	37.8
			After Test	40.8	39.8
	P-100-07 (Residual Hydrant and Monitoring Hillcrest Tank Level)	1.5	Before Test	56.6	55.1
			During Test	54	52.5
			After Test	56.6	55.1

Table C-3. Fire Flow Calculation				
Zone/Test No.	Static Pressure (psi)	Residual Pressure (psi)	Pressure Loss (psi)	Flow (gpm)
Zone 3 East	86.6	75	11.6	520

Table C-4. Pressure Zone 3 East Water Model Field Testing Results

Hydrant Flow Test

Pressure Zone: Zones 3 East

Collected By: Kevin Kai/Sean Flores

Date: 11/6/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
1A	Lat: 37.96688056N; Long: 121.741478W	BC-5 (Backup) BC-6 (Main)	Before:	1233	86	1	Lat: 37.96578N; Long: 121.7421361W	BC-8	75	Waterline between flowing and pressure hydrants is 8" PVC. Pressure Zone 3-East. Test is in-lieu of invalid test 1.
			During:	1238	81	2				
			After:	1242	85					

* Latitude and Longitude were obtained using Google Earth

Date 11/6/2012 Time of Fire Flow - 1233 to 1242

Lone Tree Tank Level - 13.5 feet
Hillcrest Tank Level - 35.5 feet
Lone Tree BPS Flow - 0 gpm
Hillcrest BPS Flow - 2,250 gpm
Dallas Ranch BPS Flow - 0 gpm

Total Demand (11/05/2012 3:00 PM - 11/06/2012 3:00 PM) -1,447,958 gallons; 1006 gpm
No. of Nodes in Zone 3 East - 3054
Demand on each node = 1006/3054 = 0.3294 gpm

BC-06 Error Adjustment = 11 psi
BC-6 Pressure - 86-11 = 75 psi
BC-6 Pressure - 81-11 = 70 psi

BC-8 Error Adjustment = -2 psi
BC-8 Pressure = 75+2 =77 psi
Change in Pressure = 86.6-75 =11.6 psi
Fire Flow = 520 gpm

Model Results

Before Test
Pressure Hydrant - 81.5 psi
Flow Hydrant - 86.6 psi

During Test
Pressure Hydrant - 80.7 psi
Flow Hydrant - 85.7 psi

Table C-5. Pressure Zone 3 East Water Model Field Pressure Logger Locations

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zones 3 East

Date: 11/6/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-3	Pressure monitoring at tank during flow testing	3-East	4880 Crestone Needle (Lat: 37.971878; Long: -121.8021)	11-6-12/1036	11-6-12/1345	Lone Tree Tank
P100-7	Pressure monitoring at tank during flow testing	3-East	4513 Via Dora Wy (Lat: 37.97435278; Long: -121.7689167)	11-6-12/1135	11-6-12/1331	Hill Crest Tank

* Latitude and Longitude were obtained using Google Earth

Table C-6. Zone 3 East Water Demand (11/05/2012 3:00 PM - 11/06/2012 3:00 PM)					
In/Out/Off	Type	Status	Elevation (ft)	Flow (gallons)	Intake/Supply Zone
		Tanks			
IN/OUT	Hillcrest Tank	Active	292	-119,792	-
IN/OUT	Lone Tree Tank	Active	308	-93,750	-
		Pumps			
IN	Hillcrest BPS	Active	113	1,539,000	Zone 2
IN	Lone Tree BPS	Active	146	1,544,000	Zone 2
OUT	Dallas Ranch BPS	Active	275	1,376,500	Zone 4 East
OUT	Bear Ridge BPS	Active	253	45,000	Zone Bear Ridge
			Net Consumption (gallons)	1,447,958	
			Net Consumption (gpm)	1,006	

Attachment D

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Table D-1. Summary of Fire Flow and Model Test Results

Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Hydrant Testing				Model Results	
					Pressure Hydrant[1]		Flowing Hydrant[1]			
					Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 4 East	Observation Way	Lat: 37.95445278N; Long:121.8019194W	Dallas Ranch BPS - Off	11/6/2012 2:34 P.M.– 2:40 P.M.	75	69	745	64	76.7	71.2
	Empire Mine Rd. & Tank Rd.	Lat: 37.9544472N; Long:121.800689W			46.5	45	-	-	46.5	44.7

Table D-2. Adjusted Gauge/Logger Pressure Data					
Zone	**Gauge/Logger ID**	**Calibration Error (psi)**	**Test**	**Measured Pressure (psi)**	**Adjusted Pressure (psi)**
Zone 4 East	BC-06 (Residual Hydrant)	11	Before Test	86	75
			During Test	80	69
			After Test	86	75
	BC-08 (Flowing Hydrant)	-2	During Test	62	64
	P-100-06 (Residual Hydrant and Monitoring Empire Mine Tank Level)	1.5	Before Test	48	46.5
			During Test	45	43.5
			After Test	48	46.5

Table D-3. Fire Flow Calculation				
Zone/Test No.	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Loss (psi)**	**Flow[1] (gpm)**
Zone 4 East	86	62	24	745

Note:

[1] Flow rate estimated from pressure drop vs. flow rate table provided by fire flow equipment manufacturer

Table D-4. Pressure Zone 4 East Water Model Field Testing Results

Hydrant Flow Test

Collected By: Kevin Kai/Sean Flores

Pressure Zone: Zones 4 East

Date: 11/6/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
3A	Lat: 37.95711N; Long: 121.7915583W	BC-5 (Backup) BC-6 (Main)	Before:	1434	86	1	Lat: 37.9579972N; Long: 121.7915972W	BC-8	62	Waterline between flowing and pressure hydrant is 8" PVC. Pressure Zone 4-East. Test is in-lieu of invalid test 3.
			During:	1437	80	2				
			After:	1440	86					

* Latitude and Longitude were obtained using Google Earth

Date 11/6/2012 Time of Fire Flow - 1434 to 1440

Empire Mine Tank Level - 10.0 feet
Dallas Ranch BPS Flow - 0 gpm

Total Demand (11/05/2012 3:00 PM - 11/06/2012 3:00 PM) -986,410 gallons; 685.0 gpm
No. of Nodes in Zone 4 East - 835
Demand on each node = 685/835 = 0.82 gpm

BC-06 Error Adjustment = 11 psi
BC-6 Pressure - 86-11 = 75 psi
BC-6 Pressure - 80-11 = 69 psi

BC-8 Error Adjustment = -2 psi
BC-8 Pressure = 62+2 =64 psi
Change in Pressure = 86-62 =24 psi
Fire Flow = 745 gpm

Model Results
Before Test
Pressure Hydrant - 76.7 psi
Flow Hydrant - 74.5 psi

During Test
Pressure Hydrant - 71.2 psi
Flow Hydrant - 67.5 psi

Table D-5. Pressure Zone 4 East Water Model Field Pressure Logger Location

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zones 4 East

Date: 11/6/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-6	Pressure monitoring at tank during flow testing	4-East	Empire Mine Rd & Tank Rd (Lat: 37.95725278; Long: -121.80735)	11-6-12/1100	11-6-12/1453	Empire Mine Tank
* Latitude and Longitude were obtained using Google Earth						

Table D-6. Zone 4 East Water Demand (11/05/2012 3:00 PM - 11/06/2012 3:00 PM)					
In/Out/Off	**Type**	**Status**	**Elevation (ft)**	**Flow (gallons)**	**Intake/Supply Zone**
Tanks					
IN/OUT	Empire Mine Tank	Active	485	-390,090	-
Pumps					
IN	Dallas Ranch BPS	Active	275	1,376,500	Zone 3 East
			Net Consumption (gallons)	986,410	
			Net Consumption (gpm)	685	

Attachment E

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Table E-1. Summary of Fire Flow and Model Test Results

Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Hydrant Testing				Model Results	
					Pressure Hydrant[1]		Flowing Hydrant[1]			
					Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 3 West	Chardonnay Way	Lat: 37.978150N; Long:121.840349W	Donlon BPS - ON Cambridge BPS – Off	11/8/2012 1:12 P.M.– 1:14 P.M.	71	64	732	32	68.2	56.6
	Finch & Cambridge Dr.	Lat: 37.9794980N; Long:121.847390W			52.4	52.1	-	-	10.24	9.82

Table E-2. Adjusted Gauge/Logger Pressure Data

Zone	Gauge/Logger ID	Calibration Error (psi)	Test	Measured Pressure (psi)	Adjusted Pressure (psi)
Zone 3 West	WC-1 (Residual Hydrant)	2	Before Test	73	71
			During Test	66	64
			After Test	74	72
	BC-05 (Flowing Hydrant)	4	During Test	36	32
	P-100-06 (Residual Hydrant and Monitoring Cambridge Drive Tank Level)	1.5	Before Test	53.9	52.4
			During Test	53.6	52.1
			After Test	53.8	52.3

Table E-3. Fire Flow Calculation			
Zone/Test No.	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Loss (psi)**
Zone 3 West	55.2	32	23.2

Note:

[1] Flow rate estimated from pressure drop vs. flow rate table provided by fire flow equipment manufacturer

Table E-4. Pressure Zone 3 West Water Model Field Testing Results

Hydrant Flow Test

Pressure Zone: 3-West

Collected By: Kevin Kai/Sean Flores

Date: 11/8/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
5	Lat: 37.978150N; Long: 121.840349W	WC-1	Before:	1312	73	1	Lat:37.978150N; Long: 121.840349W	BC-5	36	Waterline between flowing and pressure hydrants is 6" ACP. Pressure Zone 3-West.
			During:	1314	66	2				
			After:	1314	74					

* Latitude and Longitude were obtained using Google Earth

Date 11/8/2012 Time of Fire Flow - 1312 to 1314

Cambridge Tank Level- 21.0 feet
Donlon BPS Flow - 2,900 gpm
Cambridge BPS Flow - 0 gpm

Total Demand (11/07/2012 3:00 PM - 11/08/2012 3:00 PM) -841,996 gallons; 584.7 gpm
No. of Nodes in Zone 4 West - 448
Demand on each node = 584.7/448 = 1.305 gpm

WC-1 Error Adjustment = -3 psi
WC-1 Pressure - 73+3 = 76 psi
WC-1 Pressure - 66+3 = 69 psi

BC-5 Error Adjustment - 4 psi
BC-5 Pressure = 36-4 = 32 psi
Change in Pressure = 55.2-32 =23.2 psi
Fire Flow = 732 gpm

Model Results
Before Test
Pressure Hydrant - 69.69 psi
Flow Hydrant - 56.7 psi

During Test
Pressure Hydrant - 61.33 psi
Flow Hydrant - 45.25 psi

Table E-5. Pressure Zone 3 West Water Model Field Pressure Logger Locations

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zones 1, 3-West and 4-West

Date: 11/8/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-6	Pressure monitoring at tank during flow testing	3-West	Finch Dr./Cambridge Dr. (Lat: 37.9794972; Long: -121.847389)	11-8-12/1252	11-8-12/1417	Monitor Cambridge Tank

* Latitude and Longitude were obtained using Google Earth

Table E-6. Zone 3 West Water Balance (11/07/2012 3:00 PM - 11/08/2012 3:00 PM)					
In/Out/Off	Type	Status	Elevation (ft)	Flow (gallons)	Intake/Supply Zone
Tanks					
IN/OUT	Cambridge Drive Tank	Active	360	11,121	
Pumps					
IN	Donlon BPS	Active	315	971,875	Zone 2
OUT	Cambridge BPS	Active	191	141000	Zone 4 West
Net Consumption (gallons)				841,996	
Net Consumption (gpm)				585	

Attachment F

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Table F-1. Summary of Fire Flow and Model Test Results

Pressure Zone	Location	Location Latitude & Longitude	BPS Status	Date/Time	Hydrant Testing				Model Results	
					Pressure Hydrant[1]		Flowing Hydrant[1]			
					Static pressure (psig)	Residual pressure (psig)	Flow (gpm)	Pressure (psig)	Static Pressure (psig)	Residual Pressure (psig)
Zone 4 West	West Ridge Ct.	Lat: 37.98969N; Long:121.859005W	Cambridge BPS – Off	11/8/2012 1:35 P.M.– 1:39 P.M.	101	92	773	78	102.01	95.05
	Cambridge Drive	Lat: 37.989660N; Long:121.860336W			50	48	-	-	50.03	48.7

Table F-2. Adjusted Gauge/Logger Pressure Data					
Zone	**Gauge/Logger ID**	**Calibration Error (psi)**	**Test**	**Measured Pressure (psi)**	**Adjusted Pressure (psi)**
Zone 4 West	BC-03 (Residual Hydrant)	3	Before Test	104	101
			During Test	95	92
			After Test	104	101
	BC-05 (Flowing Hydrant)	4	During Test	82	78
	P-100-07 (Residual Hydrant and Monitoring Mira Vista Tank Level)	1.5	Before Test	51.8	50.3
			During Test	49.7	48.2
			After Test	51.7	50.2

Table F-3. Fire Flow Calculation				
Zone/Test No.	**Static Pressure (psi)**	**Residual Pressure (psi)**	**Pressure Loss (psi)**	**Flow[1] (gpm)**
Zone 4 West	104	78	26	773

Note:

[1] Flow rate estimated from pressure drop vs. flow rate table provided by fire flow equipment manufacturer

Table F-4. Pressure Zone 4 West Water Model Field Testing Results

Hydrant Flow Test

Pressure Zone: Zone 4-West

Collected By: Kevin Kai/Sean Flores

Date: 11/8/2012

Test No.	Pressure Hydrant		Pressure Readings			Flow Hydrant Readings				Notes
	Location*	Gauge ID	Reading	Time	Pressure (psi)	Diff-user	Location*	Gauge ID	Pressure (psi)	
6	Lat: 37.989697N; Long: 121.859005W	BC-3	Before:	1335	104	1	Lat: 37.989660N; Long: 121.860336W	BC-5	82	Waterline between flowing and pressure hydrants is 8" PVC. Pressure Zone 4-West.
			During:	1337	95	2				
			After:	1339	104					

* Latitude and Longitude were obtained using Google Earth

Date 11/8/2012 Time of Fire Flow - 1335 to 1339

Mira Vista Tank Level - 27.5 feet
Cambridge Tank Level- 21.5 feet
Cambridge BPS Flow - 0 gpm

Total Demand (11/07/2012 3:00 PM - 11/08/2012 3:00 PM) -125,580 gallons; 87.2 gpm
No. of Nodes in Zone 4 West - 126
Demand on each node = 87.2/126 = 0.692 gpm

BC-03 Error Adjustment - 3 psi
BC-3 Pressure - 104-3 = 101 psi
BC-3 Pressure - 95-3 = 92 psi

BC-5 Error Adjustment - 4 psi
BC-5 Pressure = 82-4 = 78 psi
Change in Pressure = 104-78 =26 psi
Fire Flow = 773 gpm

Model Results
Before Test
Pressure Hydrant - 106.35 psi
Flow Hydrant - 104.18 psi

During Test
Pressure Hydrant - 99.38 psi
Flow Hydrant - 93.74 psi

Table F-5. Pressure Zone 4 West Water Model Field Pressure Logger Location

Pressure Loggers Collected By : Kevin Kai/Sean Flores Pressure Zone: Zones 4 West

Date: 11/8/2012

Logger ID	Reason for Logger (e.g. FF Test, 24-Hr)	Zone / Facility	Location*	Date / Time Installed	Date / Time Removed	Notes
P100-7	Pressure monitoring at tank during flow testing	4-West	Pintail Dr./Cambridge Dr. (Lat: 37.97962; Long: -121.84841)	11-8-12/1255	11-8-12/1419	Monitor Mira Vista Hills Tank

* Latitude and Longitude were obtained using Google Earth

Table F-6. Zone 4 West Water Demand (11/07/2012 3:00 PM - 11/08/2012 3:00 PM)

In/Out/Off	Type	Status	Elevation (ft)	Flow (gallons)	Intake/Supply Zone
		Tanks			
IN/OUT	Mira Vista Hills Tank	Active	400	-15,420	-
		Pumps			
IN	Cambridge BPS	Active	315	141,000	Zone 3 West
			Net Consumption (gallons)	125,580	
			Net Consumption (gpm)	87	

Appendix C: Single Page Project Summaries

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Appendix C

Single Page Project Summaries

This appendix presents one-page summaries for significant projects described in Section 7 of the Water System Master Plan Update. The summaries include brief project descriptions together with information on the projects' location, function within the water system, drivers, alternatives considered, brief alternative evaluations and capital costs. Cost estimating was carried out at an order-of-magnitude accuracy level to produce AACEI Class 5 estimate, to which allowances of 25 percent for contingencies and 20 percent for engineering, legal, and administrative costs were added. More information on AACEI estimating is included at the end of this appendix. Note that all costs are given in winter 2013 dollars. The City of Antioch (City) should escalate the costs to reflect the time of project implementation.

Project: 1. River Pump Rehabilitation

Function: Raw water diversion from San Joaquin River

Location: River Pumping Station, north end of Fulton Shipyard Road

Description: Allows the City to divert raw water from river whenever quality is acceptable rather than purchased from Contra Costa Water District at significantly greater cost. The river pumping station is shown in Figure C-1.

Drivers: Pump and motor and ancillary equipment installed in 1997 are badly worn and need rehabilitation to maximize diversion rate and operate efficiently, saving money for the City.

Required Work: Remove pump and motor with crane barge, rehabilitate or rebuild facilities, reinstall with a crane barge. Replace leaky discharge pipeline. Rehabilitate or replace surge control and pump control valves. Evaluate possible relocation of main electrical panel. Add building ventilation system. Add flow meter on discharge pipeline.

Alternatives Considered and Alternatives Evaluation:

1. Renovate existing facilities. This alternative maximizes City capacity to divert raw water and reduces the amounted raw water purchased by the City.
2. Make no modifications. This alternative requires no capital expenditure; however the decreasing diversion rate increases City expenditures for raw water. Lack of rehabilitation to this facility will eventually lead to a loss of the capability to divert raw water from the San Joaquin River.

The City selected Alternative 1 since it saves money in the long term and preserves the City pre-1914 water right.

Estimated Capital Cost: $460,000

Figure C-1. River Pumping Station is constructed on pier above the San Joaquin River. The PS needs interior renovation and some improvements to the discharge pipeline.

Project: 2. Raw Water Pipeline Condition Assessment and Cleaning

Function: Raw water transfer from the Municipal Reservoir and Contra Costa Canal to the Water Treatment Plant (WTP)

Location: Two separate routes with 24-inch- and 39-inch-diameter pipelines from Antioch Municipal Reservoir dam to WTP, as shown in Figure C-2.

Description: Allows the City to transfer raw water from municipal reservoir and Contra Costa Canal to WTP using pipelines constructed in around 1940 and 1980 and 1967 (39-inch). Hydraulic analyses in the 1990's indicated that the pipelines have excessive headlosses that could indicate an accumulation of sediment reducing the cross sectional area. Flow testing by City staff also showed degraded quality of the raw water after pipeline shutdowns, producing water that the WTP cannot treat successfully. To assess the pipelines' internal condition, the City needs to install access points and carry out internal inspections. Excessive sediment accumulation may require cleaning of the pipelines to restore a higher flow capacity.

Drivers: Pipelines show excessive headloss which reduces the City's diversion capacity and/or increases energy costs. Poor water quality could compromise the City's ability to produce the highest possible treated water quality.

Required Work: Design and contract for installation of several access points. Contract for interior inspection and condition assessment. Carry out cleaning if inspection reveals excessive sediment accumulation.

Alternatives Considered and Alternatives Evaluation:

1. Construct access points, inspect pipeline interior, and assess cleaning requirements. Clean pipelines if excessive sediment accumulation is found. This alternative allows the City to understand pipeline interior conditions and make appropriate decisions about cleaning. It ultimately should decrease energy costs and protect water quality.
2. Make no modifications. This alternative requires no capital expenditure but does not address the current headloss within the system. Transfer rates from the Municipal Reservoir and Contra Costa Canal to the WTP will continue to decrease and higher energy costs and lower water quality can be expected.

The City selected Alternative 1 since it saves money in the long term and preserves water quality. It also may allow the City to defer some canal water pumping station improvements and possible construction of a parallel raw water pipeline.

Estimated Capital Cost: $800,000

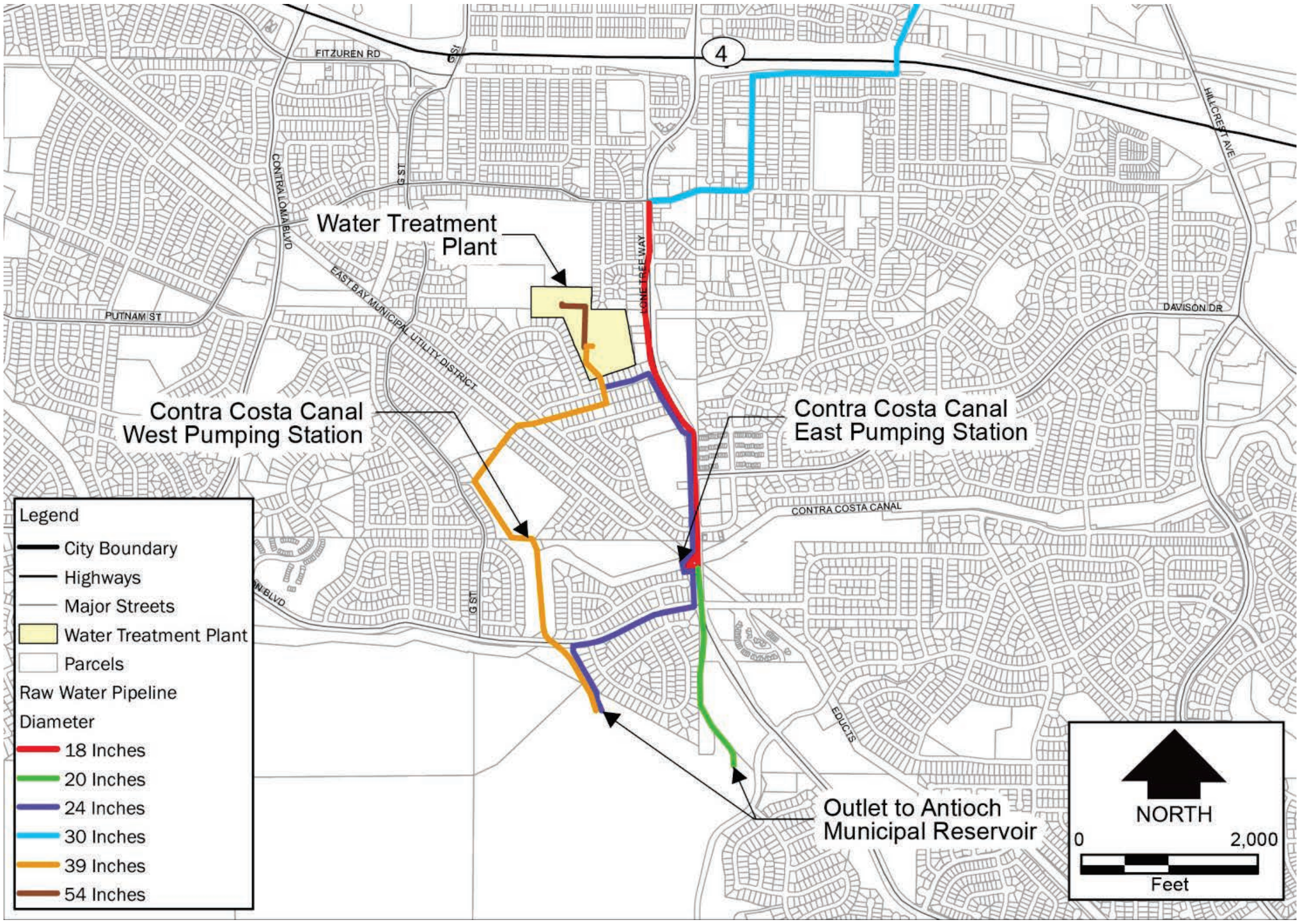

Figure C-2. Raw Water Pipeline Condition Assessment and Cleaning

The raw water transfer pipelines (24-inch and 39-inch, blue and yellow/orange on the figure above) need internal inspection and possibly cleaning, to restore full flow capacity

Project: 3. Interconnection with Neighboring Agencies for Mutual Assistance

Function: Water Distribution

Location: City Boundaries with Pittsburg, Diablo Water District, and Brentwood

Description: City's water distribution system has limited capacity to transfer water to or receive water from adjacent communities. The projects shown in Figure C-3 would greatly enhance that capability.

Drivers: Better connectivity and capacity with neighboring water agencies will allow City, Pittsburg, DWD, and Brentwood to assist each other during both planned and unplanned outages. Improvements include new water mains, reconditioning the Wilbur Booster Pumping Station (BPS), and possibly purchase of a trailer-mounted, engine-driven pump.

Required Work: Design and construct new water mains as shown on Master Plan Figure 7-1 (see below) and assess Wilbur BPS condition and hire a contractor to complete any repairs or refurbishment.

Alternatives Considered and Alternatives Evaluation:

1. Reconstruct existing facilities. This alternative increases the system capacity and brings the Wilbur BPS back into operation, with increased output for the pumping system.
2. Make no modifications. This alternative requires no capital expenditure but greatly limits the water system capacity to transfer water.

The City selected Alternative 1 since it increases overall water distribution system flexibility and dependability.

Estimated Capital Cost: $2,800,000

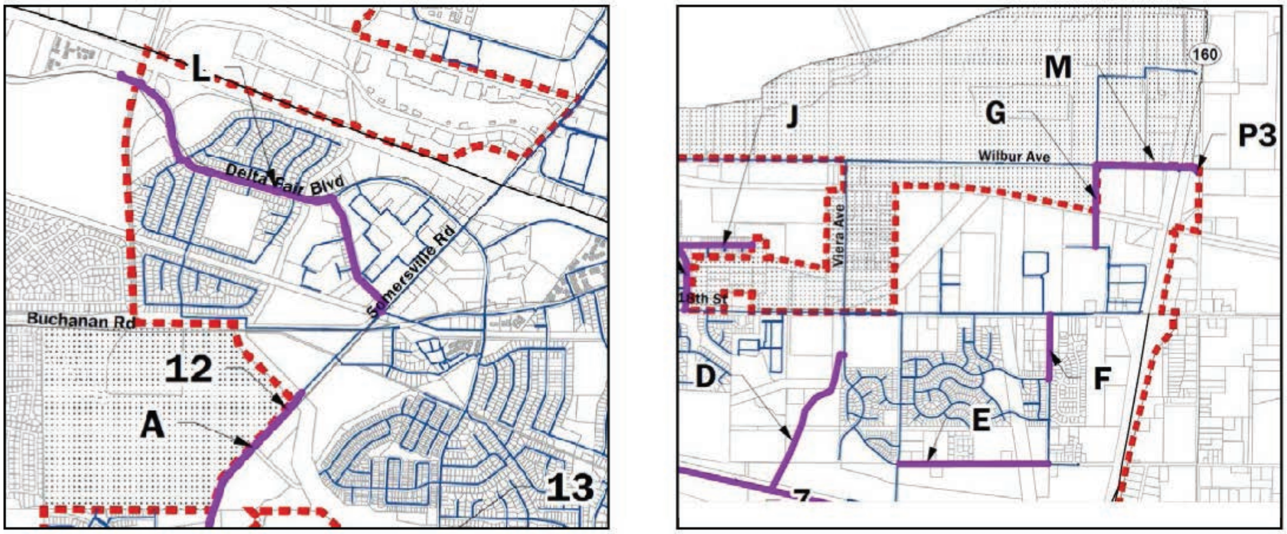

Figure C-3. Interconnection Improvements

Project L would improve interconnection with City of Pittsburg significantly. Project P3 would rehabilitate interconnection with Diablo Water District. Projects G and M would increase transmission capacity between Antioch and Diablo Water District

Project: 4. Miscellaneous Water Treatment Plant Improvements

Function: Water Treatment

Location: Water Treatment Plant (WTP)

Description: The WTP needs several improvements to address aging equipment (e.g., Plant A electrical equipment as shown in Figure C-4a), new regulations, and upgrades to existing systems for better functionality. Figure C-4b highlights other WTP improvements.

Drivers: Some existing equipment at the WTP is approaching the end if their useful life and needs replacement. City staff has identified new functionality needed for better or safer WTP operations.

Required Work: Remove and dispose of existing equipment that fails to meet current requirements and install and test new equipment.

Alternatives Considered and Alternatives Evaluation:

1. Rehabilitate existing facilities and install new equipment and systems. This alternative enhances the efficiency and safety at the WTP while preserving the City's water treatment capacity.
2. Make no modifications. This alternative requires no capital expenditure but could lead to unplanned outage for maintenance that could ultimately force the City to take parts of the WTP out of service. Postponing improvements too long eventually would lead to loss of treatment capacity and force the additional purchasing of treated water from other sources to replace lost production capacity. The City also may need to increase staffing costs to compensate for increased operations and maintenance effort.

The City selected Alternative 1 since it includes needed improvements to the WTP and promotes the ability to continue to provide the required capacity.

Estimated Capital Cost: $2,000,000

Figure C-4a. Electrical Improvements

Replacing 1960s vintage switchgear would improve water treatment plant reliability.

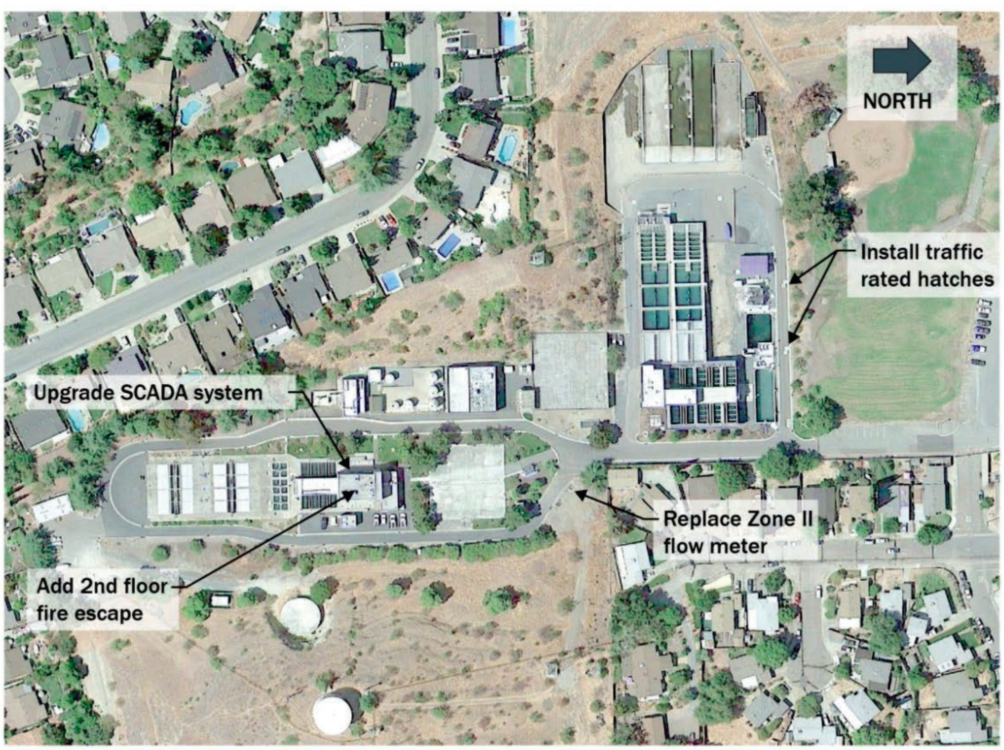

Figure C-4b. Some WTP Upgrades

Project: 5. River Pump to Water Treatment Plant (WTP) Direct Connection

Function: Raw Water Transfer from San Joaquin River to WTP

Location: Lone Tree Way at Terranova Drive

Description: Install buried pipe, valves and fitting to connect the raw water pipeline from the River Pumping Station to the raw water transfer pipeline from the Contra Costa Canal and the Antioch Municipal Reservoir.

Drivers: Modification would increase the River Pumping Station capacity without additional pumping and/or pipeline upgrades.

Required Work: Insert a tie and isolation valves into the existing buried pipelines and install a short pipe connecting between the pipelines. Also confirm that a modified diversion rate conforms to regulations.

Alternatives Considered and Alternatives Evaluation:

1. Construct the new connection and pump river water directly to the WTP.
2. Make no modifications. This alternative requires no capital expenditure but would not increase river diversion capacity to use existing water rights more fully.

The City selected Alternative 1 since it would increase River Pumping Station capacity with a very small expenditure.

Estimated Capital Cost: $150,000

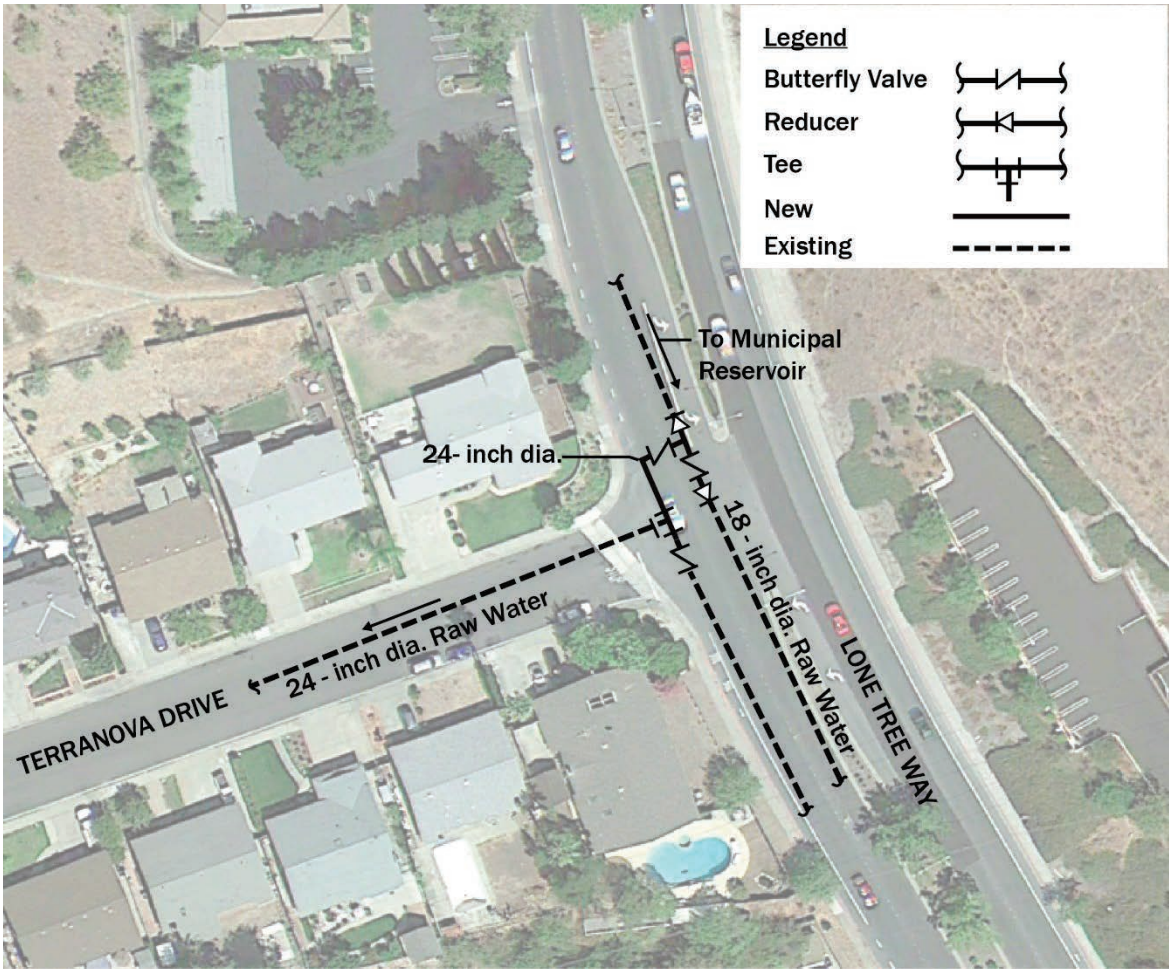

Figure C-5. Schematic of Proposed Direct Connection between 18-in-diameter River PS Pipeline and 24-in-diameter Municipal Reservoir/WTP Pipeline

Project: 6. Water Treatment Plant Sludge Handling

Function: Water Treatment

Location: Water Treatment Plant (WTP)

Description: Conduct an engineering study to determine whether the City should build new sludge thickening and dewatering facilities or continue to contract out for equipment and maintenance, determining which alternative is most cost effective. Existing sludge handling facilities are shown in Figure C-6. Design and construct a new sludge handling facility if necessary.

Drivers: The City currently contracts with KNE for equipment rental and maintenance of sludge thickening and dewatering facilities. The City needs to determine if constructing and maintaining new City-owned facilities would be more cost effective.

Required Work: Carry out an engineering study for sludge thickening and dewatering and prepare a business case evaluation of alternatives. If warranted, design and construct new sludge handling facilities.

Alternatives Considered and Alternatives Evaluation:

1. Prepare an engineering study to evaluate alternatives for sludge thickening and dewatering. This alternative would provide a cost basis for making a decision that could lead to a capital expenditure of up to $9 million.
2. Carry out no further evaluation and continue with current operations. This alternative requires no capital expenditure but leaves open the question as to which approach is most cost effective.

The City selected Alternative 1 since it wants to be sure that it selects the best approach for spending water utility funds and eliminate surface water discharges and allows optimal WTP delivery capacity.

Estimated Capital Cost: $150,000 to $9,150,000 (without and with new sludge thickening/dewatering facilities construction)

Figure C-6. Sludge Handling Improvements

Note: The estimated costs for implementing sludge dewatering is about $9 million.

Project: 7. Annual Water Main Replacement/Extension Program

Function: Water Distribution System

Location: Developed City Areas

Description: Construct replacement, parallel or new water mains, to replace deteriorated older mains, improving overall water service dependability and deliver required fire flows.

Drivers: The distribution system includes older pipelines that suffer from interior and/or exterior corrosion and are approaching the end of their useful life. Some areas of the distribution system have inadequate water main capacity to deliver current fire flow requirements since it was designed many years ago to older standards.

Required Work: Based on hydraulic modeling and field findings by City staff, design and install replacement, parallel and/or new mains in developed City areas. Coordinate water main replacement with other infrastructure projects such as sewer and roadway rehabilitation.

Alternatives Considered and Alternatives Evaluation:

1. Install replacement, parallel or new mains. This alternative preserves and enhances the distribution system delivery capacity so that the system continues to deliver high quality water reliably with adequate volume and pressure.
2. Make no modifications. This alternative requires no capital expenditure but could lead to unplanned outage for maintenance and would ultimately make it impossible for the City to satisfy public health and safety requirements.

The City selected Alternative 1 since it ensures continual deliver of high quality water for domestic, commercial, and industrial uses.

Estimated Capital Cost: $10,000,000 over next decade (2013 dollars).

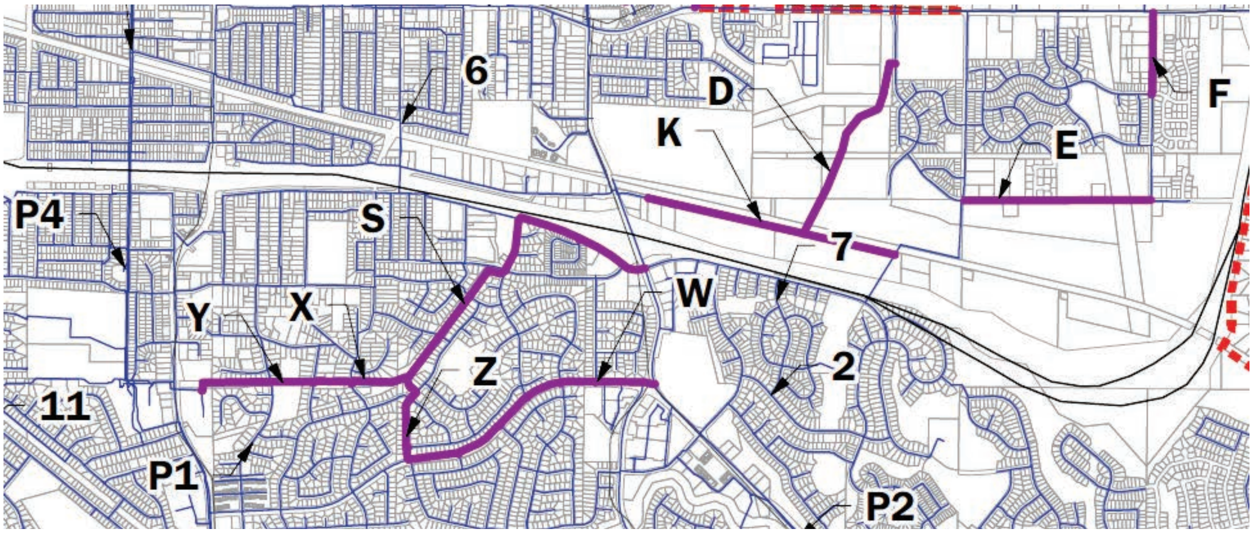

Figure C-7. Annual Water Main Replacement/Extension Program. This figure shows several proposed water main additions in Zone II.

Project: 8. Sunset Booster Pumping Station Replacement

Function: Water Distribution System

Location: East side of Sunset Lane south of Fleetwood Drive

Description: The Sunset Booster Pumping Station (BPS) is essential to water delivery to a higher elevation "island" surrounded by Zone II. The proposed replacement would be located above grade in a concrete block building with fire resistant roofing. The pumps could be configured so that discharge pressure would be controlled using variable speed drive to prevent excessive discharge pressure.

Drivers: The existing BPS is located in two below grade vaults (see Figure C-8) making maintenance access very difficult. The equipment is approaching the end of its useful life and the fire flow pump is inoperable due to the excessive pressure that it introduced into the system.. Since the BPS was constructed over 40 years ago, the facilities may not conform to current seismic design standards and applicable codes.

Required Work: Provide temporary pumping system. Remove and dispose of existing mechanical and electrical equipment and below grade vaults. Construct a new building and install new mechanical and electrical equipment, with modern control and SCADA equipment.

Alternatives Considered and Alternatives Evaluation:

1. Demolish the existing BPS and construct a new above-grade BPS.
2. Construct a new 12-inch-diameter water main to connect the Sunset Zone to Zone III East, about 4,000 feet long along City streets. This alternative is estimated to cost twice the cost for a replacement BPS.
3. Reconstruct existing facilities. This alternative would cost less than constructing a new BPS but still would leave difficult access issues unresolved.
4. Make no modifications. This alternative requires no capital expenditure but would continue to have difficult access and leave excessive pressure issues unresolved.

The City selected Alternative 1 since it addresses all identified deficiencies.

Estimated Capital Cost: $700,000

Figure C-8. Replace Below-Grade Sunset Booster Pump Station with New Above-Grade BPS

Project: 9. Pressure Reducing Stations

Function: Water Distribution System

Location: Various locations at pressure zone boundaries

Description: The City uses pressure reducing stations (PRSs) to reinforce water delivery between pressure zones especially for fire flows and backup supplies during outages, as shown in Figure C-9.

Drivers: Existing water system delivery capacity to parts of Zones I and II does not meet current City standards. Using PRSs also allows City staff to induce more circulation within the water system, improving overall system water quality.

Required Work: Install PRSs at several pressure zone boundary locations.

Alternatives Considered and Alternatives Evaluation:

1. Install new PRSs. This alternative improves the City's water system, delivery capacity and helps several areas achieve concordance with current City standards.
2. Make no modifications. This alternative requires no capital expenditure but fails to improve either delivery capacity or distribution system water quality.

The City selected Alternative 1 since it helps to improve both water delivery capacity and distribution system water quality.

Estimated Capital Cost: $640,000 (only Priority 1 projects)

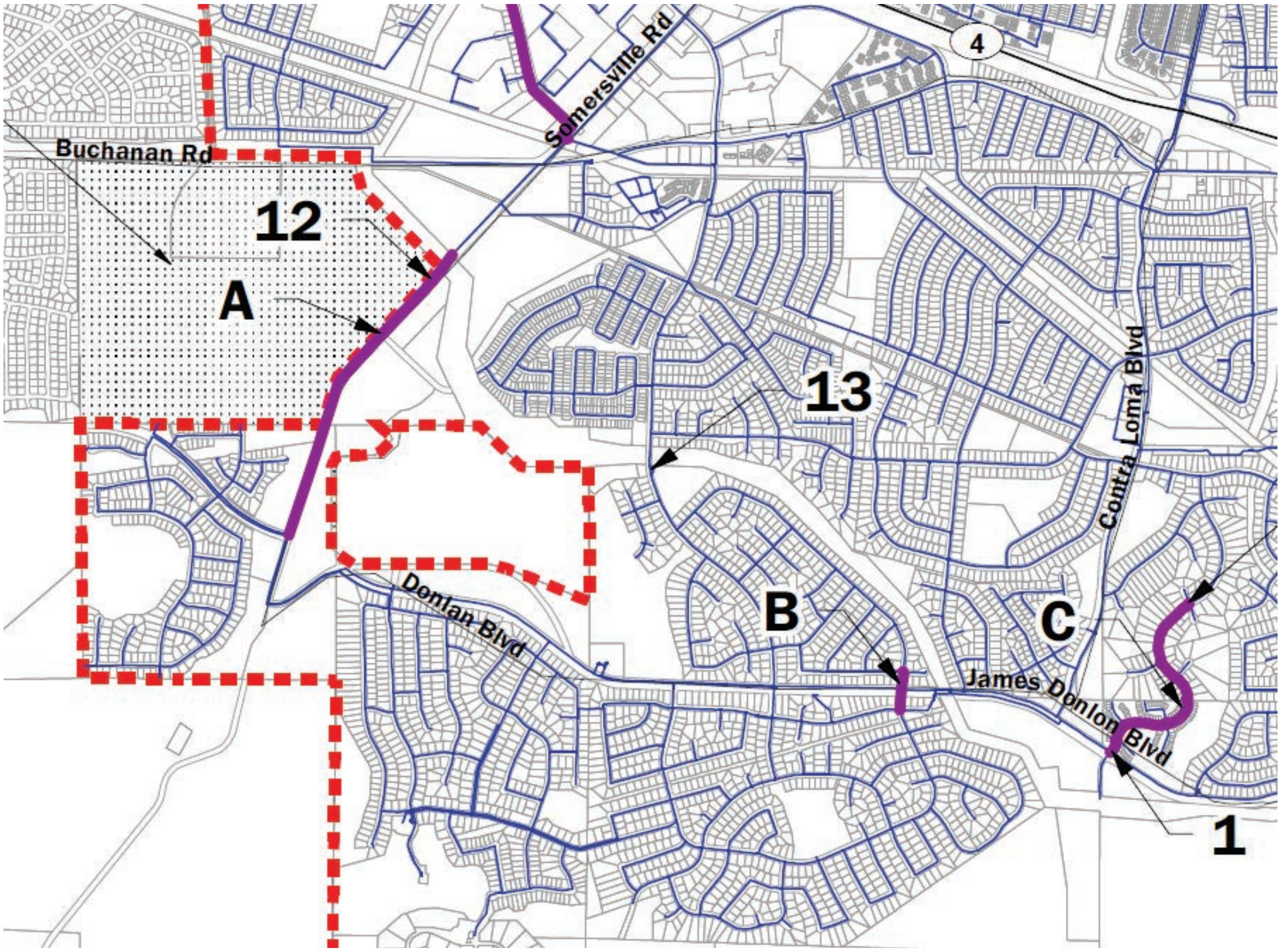

Figure C-9. Water Distribution - Pressure Reducing Stations

Number 1 refers to the proposed pressure reducing station between Zones III East and III West, on James Donlon east of Tabora. Number 13 refers to the proposed pressure reducing station between Zones II and III West on Gentrytown Drive, possibly located in the unused Gentrytown Booster Pumping Station.

Project: 10. Water System Seismic Durability Evaluation

Function: Water Treatment and Distribution

Location: Water Treatment Plant and Distribution System

Description: Study of existing facilities to determine seismic durability and identify opportunities to make cost-effective improvements to enhance durability. Cambridge Reservoir is shown in Figure C-10 as an example of which facilities could be included in the seismic durability evaluation.

Drivers: WTP and distribution facilities such as booster pumping stations and reservoirs were constructed to comply with older building codes with less stringent seismic performance requirements. Hence, some facilities may perform poorly during seismic events. Improvements may enhance performance.

Required Work: Carry out seismic evaluations to determine their existing durability and identify opportunities for cost-effective improvements.

Alternatives Considered and Alternatives Evaluation:

1. Carry out the evaluation and prioritize improvements based on cost-effectiveness and system performance needs.
2. Carry out no evaluations. This alternative requires no capital expenditure but would forego the opportunity to understand any existing system limitations and opportunities to enhance performance.

The City selected Alternative 1 since it has multiple potential benefits and leads to the best expenditure for future investments to improve system durability.

Estimated Capital Cost: $300,000 (includes $100,000 for WTP and $200,000 for reservoirs and BPSs)

Figure C-10. Seismic Durability Assessment – The assessment will include the City's water reservoirs such as Cambridge Reservoir shown above.

Project 11: Water Treatment Plant Sludge Lagoon

Function: Water Treatment

Location: Whitehaven Court

Description: Upgrade the existing sludge lagoon (see Figure C-11). Evaluate, design, and construct permanent solution to the existing earthen sludge lagoon. Including electrical, pump station, flow meter, piping to treatment plant, SCADA controls.

Drivers: The existing sludge lagoon does not provide an adequate location for discharge of flocculation/sedimentation train contents if a process upset occurs or when cleaning is required. Lagoon reconstruction would prevent a discharge to the adjacent creek.

Required Work: Install a sludge lagoon liner after recontouring the basin sides and bottom. Reconfigure site access to improve solids removal capabilities while adding a drainage pumping station to remove settled water.

Alternatives Considered and Alternatives Evaluation:

1. Rehabilitate the existing sludge lagoon.
2. Convert existing drying beds to a new sludge lagoon.
3. Make no modifications. This alternative requires no capital expenditure but would allow unacceptable discharge to surface waters.

The City selected Alternative 1 since it would provide required storage volume and eliminate unacceptable discharges to surface water.

Estimated Cost: $1,800,000

Figure C-11. Sludge Pond Upgrades

Existing sludge lagoon needs major upgrades to serve as equalization basins.

aace International

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

Recommended Practice No. 18R-97

Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries

June 15, 1998

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic standard, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, “dry” processes such as assembly and manufacturing, “soft asset” production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the significant building construction that may be a part of process plants. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is nonindustry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.
[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Figure 1. – Cost Estimate Classification Matrix for Process Industries

CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each chart, the following information is provided.

- **ANSI Standard Reference (1972) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in the chart.
- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.

CLASS 5 ESTIMATE	
ANSI Standard Reference Z94.2-1989 Name: Order of magnitude estimate (typically -30% to +50%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb. **Description:** Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. **Level of Project Definition Required:** 0% to 2% of full project definition.	**End Usage:** Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc. **Estimating Methods Used:** Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are - 20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used.

Figure 2a. – Class 5 Estimate

CLASS 4 ESTIMATE	
ANSI Standard Reference Z94.2-1989 Name: Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility, authorization, factored, pre-design, pre-study. **Description:** Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Level of Project Definition Required:** 1% to 15% of full project definition.	**End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage. **Estimating Methods Used:** Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.

Figure 2b. – Class 4 Estimate

CLASS 3 ESTIMATE	
ANSI Standard Reference Z94.2-1989 Name: Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate. **Description:** Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. **Level of Project Definition Required:** 10% to 40% of full project definition.	**End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control. **Estimating Methods Used:** Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used.

Figure 2c. – Class 3 Estimate

CLASS 2 ESTIMATE	
ANSI Standard Reference Z94.2-1989 Name: Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate. **Description:** Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Level of Project Definition Required:** 30% to 70% of full project definition.	**End Usage:** Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. **Estimating Methods Used:** Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes.

Figure 2d. – Class 2 Estimate

CLASS 1 ESTIMATE	
ANSI Standard Reference Z94.2 Name: Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate. **Description:** Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Level of Project Definition Required:** 50% to 100% of full project definition.	**End Usage:** Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. **Estimating Methods Used:** Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes.

Figure 2e. – Class 1 Estimate

COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION ↓

AACE Classification Standard	ANSI Standard Z94.0	AACE Pre-1972	Association of Cost Engineers (UK) ACostE	Norwegian Project Management Association (NFP)	American Society of Professional Estimators (ASPE)
Class 5	Order of Magnitude Estimate -30/+50	Order of Magnitude Estimate	Order of Magnitude Estimate Class IV -30/+30	Concession Estimate Exploration Estimate Feasibility Estimate	Level 1
Class 4	Budget Estimate -15/+30	Study Estimate	Study Estimate Class III -20/+20	Authorization Estimate	Level 2
Class 3		Preliminary Estimate	Budget Estimate Class II -10/+10	Master Control Estimate	Level 3
Class 2	Definitive Estimate -5/+15	Definitive Estimate	Definitive Estimate Class I -5/+5	Current Control Estimate	Level 4
Class 1		Detailed Estimate			Level 5 Level 6

Figure 3a. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	Major Consumer Products Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)
Class 5	Class S Strategic Estimate	Class V Order of Magnitude Estimate	Class A Prospect Estimate Class B Evaluation Estimate	Class V
Class 4	Class 1 Conceptual Estimate	Class IV Screening Estimate	Class C Feasibility Estimate Class D Development Estimate	Class IV
Class 3	Class 2 Semi-Detailed Estimate	Class III Primary Control Estimate	Class E Preliminary Estimate	Class III
Class 2	Class 3 Detailed Estimate	Class II Master Control Estimate	Class F Master Control Estimate	Class II
Class 1		Class I Current Control Estimate	Current Control Estimate	Class I

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	J.R. Heizelman, 1988 AACE Transactions [1]	K.T. Yeo, The Cost Engineer, 1989 [2]	Stevens & Davis, 1988 AACE Transactions [3]	P. Behrenbruck, Journal of Petroleum Technology, 1993 [4]
Class 5	Class V	Class V Order of Magnitude	Class III*	Order of Magnitude
Class 4	Class IV	Class IV Factor Estimate	Class II	Study Estimate
Class 3	Class III	Class III Office Estimate		Budget Estimate
Class 2	Class II	Class II Definitive Estimate		
Class 1	Class I	Class I Final Estimate	Class I	Control Estimate

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993

Figure 3c. – Comparison of Classification Practices

ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- Started (S): work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- Preliminary (P): work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- Complete (C): the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
General Project Data:	CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Figure 4. – Estimate Input Checklist and Maturity Matrix

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering**.
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System**.

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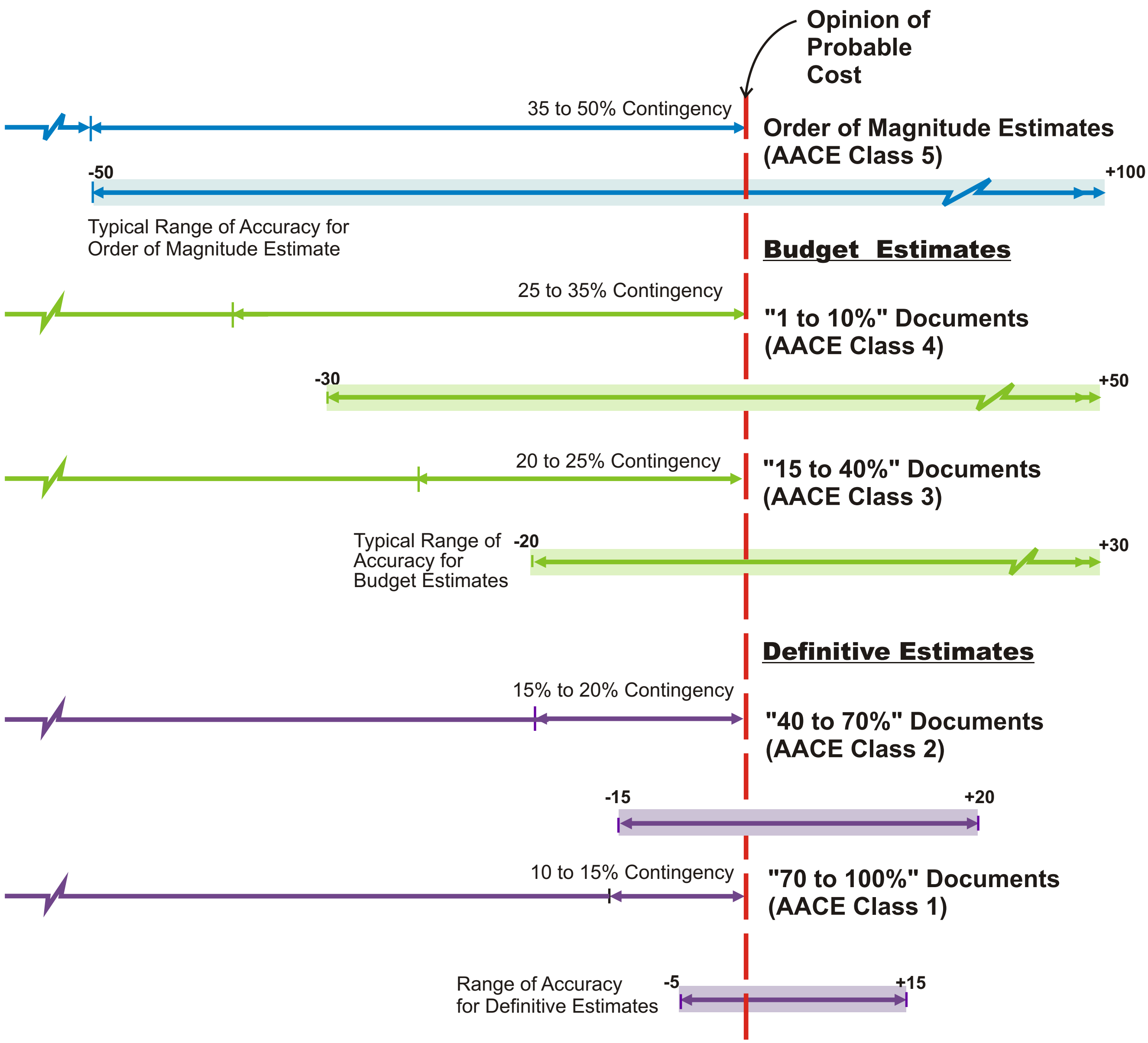

Note:

1. Contingencies shown are typical
2. Ranges of Accuracy indicated are typical values from AACE document 18R-97 (REV 02/06)

Opinions of Probable Cost
Typical Contingencies and Ranges of Accuracy

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