City of Benicia Water Master Plan Update and Major Facility Condition Assessment

June 2020

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City of Benicia

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Executive Summary

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TECHNICAL MEMORANDUM NO. 0 – WATER MASTER PLAN UPDATE EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY INTRODUCTION

The City of Benicia Water Master Plan Update and Major Facility Condition Assessment (Water Master Plan Update, Master Plan Update or Update) consists of a series of technical memoranda (TMs), listed below. This Executive Summary covers TM 1 through TM 12, as listed below.

- Water Master Plan Update Introduction
- TM 0 – Water Master Plan Update Executive Summary
- TM 1 – Water Study Area Planning Parameters
- TM 2 – Potential Future Regulatory Requirements and Impacts on WTP
- TM 3 – Condition Assessment Framework
- TM 4 – Condition Assessment of Raw Water Supply
- TM 5 – Condition Assessment of Water Distribution System
- TM 6 – Condition Assessment of Booster Pump Stations
- TM 7 – Condition Assessment of Treated Water Tanks & Reservoirs
- TM 8 – Condition Assessment of Water Treatment Plant
- TM 9 – Water Distribution System Model
- TM 10 – Water Sustainability and Resiliency Assessment

- TM 11 – Municipal Financing for Water Systems
- TM 12 – Proposed Capital Improvement Program

Tables and Figures are retained as numbered from the original TMs. However, because some are removed for succinctness, numbering is discontinuous.

TM 1 – WATER STUDY AREA PLANNING PARAMETERS

The purpose of TM 1 is to define the purpose, objectives, methodology, process, water study area, and planning parameters of the City of Benicia (City) Water Master Plan Update (Water Master Plan Update, Master Plan Update, or Update). This Water Master Plan Update will provide an outline of priority and strategic projects to allow the City to efficiently and effectively operate the water system under future development conditions. The Master Plan and Master Plan Update serve as a data baseline for future policy decisions. These documents provide professional assessments and recommendations, but project implementation decisions are reserved for policy makers.

The Update process includes infrastructure site inspections, condition assessments, and an overall asset evaluation including an on-going condition assessment and monitoring schedule. The Capital Improvement Program (CIP) projects developed include previously identified projects in addition to those identified as part of this Master Plan Update.

Water Master Plan Update Objectives

The objectives of the Water Master Plan Update are to:

- Perform site inspections, record data, and assess the condition of essential water system infrastructure to provide improvement recommendations and where applicable, identify project alternatives.
- Provide an asset management-based evaluation of the water equipment and facilities using a methodology for civil, mechanical, structural, electrical, and instrumentation components of each infrastructure area.
- Develop an on-going condition assessment and monitoring schedule based on the results of the asset evaluation and discussions with City operations, maintenance, and engineering staff.
- Identify priority and strategic projects including expansion and upgrades to existing infrastructure and construction of new infrastructure to meet system demands.
- Review results and level of service evaluation criteria of the City's water distribution system hydraulic model to identify hydraulic deficiencies such as low or high pressure zones, potential points of flow restrictions, etc.
- Provide a capital forecast for the next 20-years (up to 2040), including opinions of probable cost.

PROJECT BACKGROUND

The City of Benicia provides potable and non-potable water to retail customers throughout the City boundary. The City's Urban Water Management Plan (UWMP) details that the water service area is roughly 16 square miles. The water system serves 9,725 customer accounts (as of April 2020), which includes 8,490 residential accounts and 1,235 other account classifications (multi-family, mobile home, commercial, industrial, irrigation, and municipal). The water system consists of a raw water transmission system, a water treatment plant, storage tanks or reservoirs, booster pumps and a water distribution system. The City owns and operates all aspects of the water facilities, except the North Bay Aqueduct (NBA) Cordelia Pumping Plant and the Barker Slough Pumping Plant, which are owned and operated by the State Department of Water Resources. The water system is further described below.

RAW WATER TRANSMISSION SYSTEM

The raw water transmission system delivers raw water to the City and consists of three pump stations and a raw water transmission line. The three raw water sources include:

State Water Project (Lake Oroville)

Most of the City's water supply comes from the State Water Project, State Water Project surface water is diverted from Barker Slough on the Sacramento-San Joaquin River Delta to the NBA, which then transfers the raw water to the Cordelia Forebay. The City's component of the NBA Cordelia Pumping Plant (CPP) has a total capacity of 32.0 cfs (20.7 million gallons per day [mgd]) and transmits water from the Cordelia Forebay to the raw water transmission line. The cities of Napa, Vallejo, Fairfield, and Vacaville also receive rw water through the CPP.

Solano Project (Lake Berryessa)

The Solano Project supplements the City's surface water supply. The Cordelia Pump Station diverts water from the Putah South Canal at Terminal Reservoir and conveys untreated surface water to the City's WTP through the same raw water transmission line used by the CPP. The Cordelia Pump Station has a total rated design capacity of 28.5 cfs (18.4 mgd).

Lake Herman

Sulphur Springs Creek is the City's only local source of water. Surface water is diverted at Lake Herman and transmitted to either the WTP for treatment and distribution, or to the Valero refinery for industrial uses. Excess water from the raw water transmission line can temporarily be stored in Lake Herman for future use.

WATER TREATMENT PLANT

The City's WTP was constructed in 1971 with an original design capacity of 6 mgd. In 1989, the capacity of the plant was expanded to 12 mgd and additional reliability and redundancy improvements occurred in 2006. Several smaller improvements were made at the WTP, including the most recent 2014 Influent Improvements Project, which added a 42-inch modulating butterfly valve for flow control to the WTP, a new chemical injection header in the Flash Mix Room, and new slide gates at Filters 1 and 2. The major facilities of the conventional surface WTP include an inlet diversion structure, flash mix and splitter structure, two flocculation and sedimentation basins, two clarifiers (which have been taken off-line and are no longer used), six dual-media filters, a chemical feed building with laboratory facilities, filter control center, chemical storage, 250kW standby generator, chlorine gas disinfection system and chlorine contact tank, clearwell, backwash tanks and pumps, washwater holding basin, washwater recovery pump station, PLC-based Supervisory Control and Data Acquisition (SCADA) system, and six sludge drying lagoons.

WATER DISTRIBUTION SYSTEM

The water distribution system includes three main pressure (i.e., service) zones with seven intermediate pressure zones, three booster pump stations, eight pressure reducing valves stations, six treated water storage tanks/reservoirs, and approximately 160 miles of water distribution pipelines ranging from 4 to 30-inches in diameter.

The existing water distribution system serves three main pressure (i.e., service) zones in the City and there are three existing booster pump stations which deliver water to Zones 2 and 3. The P-1 Pump Station delivers water to Zone 2 from Zone 1. The P-2 Pump Station and P-3 Pump Station deliver water to Zone 3 from Zone 2 and from Zone 1, respectively. The seven intermediate pressure zones are located in Zone 3 and are supplied by P-3 and P-2 Pump Stations. There are several pressure reducing valve stations in Zone 3 due to the variance in ground elevation. There is also a pressure reducing valve station to supply all of Zone 2 from Zone 3, which was installed by the City in 1996 for when the Zone 2 R-2 Reservoir is out of service.

In each main pressure zone, there is a storage reservoir to provide water during peak demand periods as well as fire and emergency storage capacity. The existing six treated water storage tanks/reservoirs include the chlorine contact tank, clearwell, R-1 Reservoir, R-2 Reservoir, R-3A Reservoir, and R-3B Reservoir. These six treated water storage tanks/reservoirs provide a total capacity of 12.8 million gallons.

WATER MASTER PLAN

The City of Benicia completed the existing Water Master Plan in 2012. This existing Master Plan serves as the foundation of this Water Master Plan Update. The 2012 Master Plan provides the foundation on which the City has based decisions regarding construction, operation, and maintenance of the water conveyance, treatment facilities, storage and distribution system consistent with the goals, policies, and programs of the City's General Plan.

The 2012 Water Master Plan outline is organized into eight sections, as described in **Table 1-1**.

Table 1-1 2012 Master Plan Outline

Section	Title	Description	Summary
1	Introduction	Overview of key objectives and outline of the report	
2	Water Demand Forecasts	Summary of the study area characteristics and current/project water demands	The population projection in 2035 was 30,100 with 11,680 households. Presented historical and projected water demands through 2035 (described more in Section 3.5 of this TM). Described the City's future land use based on the City's General Plan and the December 2011 Zoning Map.
3	Water Supply Sources	Overview of the existing water supplies, reliability of the existing water supply, and potential future water supply and storage opportunities	City's water supply sources include the State Water Project, Settlement Water, Solano Project (City of Vallejo and Solano Irrigation District), and Lake Herman. The review indicated that the City had sufficient supply to meet demand. However, since the City is at the end of long conveyance facilities, the system could be susceptible to regulatory, judicial, and equipment disruption impacts. The section described possible reliable long and short-term water supplies.
4	Existing Water System Facilities	Description of the water distribution system, raw water transmission system, and water treatment plant	
5	Distribution System Evaluation	Evaluation of the treated water storage and pumping capacity using a hydraulic model	Identified four existing projects that were either in planning, design, under construction, or part of the City's Water main rehabilitation project. Recommended projects included nine pipeline projects, one pump station project for P-2 Pump Station, two storage projects, new development projects, and raw water transmission system improvements.
6	Water Treatment Plant	Evaluation of the WTP, including plant capacity, regulatory compliance and safety, treatment process performance, sludge treatment and disposal, electrical system and controls, and operations	Nine improvement projects were recommended, included four operational improvement projects identified by plant personnel. The costs of each project ranged from $150,000 to $3,510,000.
7	Sustainability and Climate Change	Assessed how water demand management, increasing water facility efficiencies, and using renewable energy resources could help the City achieve its Climate Action Plan goals	Made three recommendations regarding volume reduction, one recommendation for water reuse, one recommendation for timing of water use, one recommendation for a wind and solar potential analysis, one recommendation for climate change and adaptation, and one recommendation regarding the emergency action plan.
8	Capital Improvement Program	Recommended a 10-year Capital improvement Program based on the evaluation results discussed in Sections 5 and 6	Twelve CIP projects for the water distribution system were recommended for a total of $7,179,000 (with an additional $482,000 provided by the Connection Fee Fund). Nine CIP projects for the WTP were recommended for a total of $8,025,000.

PLANNING DATA SUMMARY

This current Master Plan Update is based on data from the previous 2012 Water Master Plan. An overview of the planning data utilized for this Master Plan Update is summarized below. The only changes from the 2012 Master Plan are the population projections and the water demand projections were extended to 2040 and buildout.

STUDY AREA

The study area of this Master Plan Update encompasses the area within the City of Benicia's city limits. All future development is assumed to occur within the existing city limit boundary. There is no change from the 2012 Master Plan.

LAND USE AND FUTURE DEVELOPMENT AREAS

The 2012 Water Master Plan obtained future land use information from the City's General Plan and the December 2011 Zoning Map. The land uses and the respective demand factors are shown in **Table 1-2**. There is no change from the 2012 Master Plan.

Table 1-2 Water Use Factors

Land use	Demand Factor	
	gpd/du [1]	gpd/ac [1]
Open Space	-	0
Park	-	1,700
Public and Semi-Public	-	700
Single Family Residential	300	-
Medium Density Residential	240	-
High Density Residential	-	2,750
Planned Development	-	0
Community Commercial	-	1,300
Office Commercial	-	775
General Commercial	-	1,850
Downtown Commercial	-	2,500
Waterfront Commercia;	-	1,450
Limited Industrial	-	200
General Industrial	-	425
Water Related Industrial	-	200
Industrial park	-	2,500
Town Core – Open	-	0
Valero Buffer	-	0
Neighborhood General	-	1,400
Neighborhood General – Open	-	0

[1] gpd/du: gallons per day per dwelling unit; gpd/ac: gallons per day per acre.

Since the City is almost entirely built out, future growth mostly includes small infill projects. The 2012 Water Master Plan details the 500-acre Benicia Business Park, which was proposed to include 35-acres of commercial uses, 150 acres of limited industrial uses, and 315- acres of open space. The UWMP also describes the Northern Gateway project, which was proposed in early 2016 and was proposed to include just over 600 residential units and 170 acres of industrial and commercial use to be developed in the northeastern area of the City.

STUDY PERIOD

The study period of this Master Plan Update is projected to year 2040 and at buildout conditions. Buildout includes any additional future development that may occur within the City beyond 2040.

POPULATION

The City of Benicia population data used in this Master Plan Update is presented in **Table 1-3**.

Table 1-3 Historical and Projected Population Data

2010 [1]	2015	2020	2025	2030	2035	2040	Buildout [2]
26,997	27,485	27,991	28,515	29,060	29,626	30,214	32,000

[1] Actual 2010 census population data from which the remaining population data is projected at a rate of 0.355% annually.
[2] It is assumed that residential infill will be limited after 2040 and the City will be near or at buildout. Total buildout population assumes the 2040 population projection plus 5%.

These data were prepared using the initial 2010 census population of approximately 26,997 people and a projected population growth rate of 0.355% per year provided by the City. Using the 2010 census data and the growth rate, the 2040 population is projected to be 30,214 people. Except for the 2010 data, all values are projections.

WATER DEMAND PROJECTIONS

The historic and projected water demands are presented in **Table 1-4.** This table shows the total annual raw water demand projections starting in 2010 (from the 2012 Water Master Plan) to 2040 for treated water, Valero raw water, operations and emergencies, and unaccounted for water.

Table 1-4 Total Annual Raw Water Demand Forecast by Year and Water Type [1]

Scenario	Annual Demand (AFY)						
	2010	2015	2020	2025	2030	2035	2040
Baseline							
Treated Water	4,183	4,247	4,315	4,382	4,455	4,505	4,556
Valero Raw Water	4,792	5,296	5,800	5,800	5,800	5,800	5,800
Operations and Emergency	441	441	441	441	441	441	441
Unaccounted for Water	1,447	1,109	1,173	1,180	1,188	1,194	1,201
Baseline Demand Total	**10,863**	**11,093**	**11,729**	**11,803**	**11,884**	**11,940**	**11,998**
High Demand							
Treated Water	4,272	4,337	4,407	4,475	4,550	4,601	4,653
Valero Raw Water	5,271	5,826	6,380	6,380	6,380	6,380	6,380
Operations and Emergency	441	441	441	441	441	441	441
Unaccounted for Water	1,447	1,109	1,173	1,180	1,188	1,194	1,201
High Demand Total	**11,431**	**11,713**	**12,401**	**12,476**	**12,559**	**12,616**	**12,675**
Low Demand							
Treated Water	3,012	3,058	3,107	3,155	3,208	3,244	3,280
Valero Raw Water	4,313	4,766	5,220	5,220	5,220	5,220	5,220
Operations and Emergency	441	441	441	441	441	441	441
Unaccounted for Water	1,302	998	1,056	1,062	1,069	1,075	1,081
Low Demand Total	**9,068**	**9,263**	**9,824**	**9,878**	**9,938**	**9,980**	**10,022**

[1] 2010 through 2035 demands are from the 2012 Water Master Plan. 2040 demands were estimated based on the projection trends observed in the 2012 Water Master Plan.

Table 1-5 and **Table 1-6** show a summary of historic and projected average day, maximum day, and peak hour demands for treated water and total raw water, respectively. The average day demands are based on the baseline value for treated water for the respective year. The maximum day demands were estimated utilizing a peaking factor of 1.5 compared to the average day demands. The peak hour demands were estimated utilizing a peaking factor of 1.6 compared to the maximum day demands.

Table 1-5 Existing and Projected Average Day, Maximum Day, and Peak Hour Demands for Treated Water

Demand Type	2010 Demand (mgd) [1]	Projected 2040 Demand (mgd) [2]
Average Day	3.7	4.1
Maximum Day	5.6	6.1
Peak hour	9.0	9.8

[1] Source: 2012 Water Master Plan

[2] Projected demands for 2040 were based off the estimated 2040 treated water demand from **Table 1-4**.

Table 1-6 Existing and Projected Average Day, Maximum Day, and Peak Hour Demands for Total Raw Water

Demand Type	2010 Demand (mgd) [1]	Projected 2040 Demand (mgd) [2]
Average Day	9.7	10.7
Maximum Day	14.5	16.1
Peak hour	23.3	25.7

[1] Source: 2012 Water Master Plan

[2] Projected demands for 2040 were based off the estimated 2040 total raw water demand from **Table 1-4**.

TM 2 – FUTURE REGULATORY REQUIREMENTS AND IMPACTS ON WTP

The purpose of TM 2 is to evaluate implications posed by current and potential future regulations on water treatment processes as they relate to the City’s WTP. The objectives of the evaluations presented herein, are to identify aspects of the WTP treatment processes and/or their operation that may cause non-compliance with current regulatory or potential future requirements.

CURRENT PERMITS

The City WTP treats water pursuant to a Domestic Water Supply Permit issued by the State Water Resources Control Board – Division of Drinking Water (Permit Number CA4810001). Other significant permits related to water treatment operations include:

- **Air Quality Permit:** The California Air Resources Board (CARB), Bay Area Air Quality Management District (BAAQMD) regulates atmospheric emissions (e.g. use of diesel generators, compressor emissions, etc.)

- **CalARP:** Solano County operates the California Accidental Release Program (CalARP) on behalf of the State of California, Environmental Protection Agency. The City is subject to this program because the WTP uses gaseous chlorine disinfection system.

The foregoing documents and associated information, to the extent provided by the City, are evaluated herein with respect to their control/regulation of Benicia WTP treatment processes now and in the near-term future.

POTENTIAL FUTURE REGULATIONS

The California State Water Resources Control Board lists the following upcoming Drinking Water Regulations as planned or in process of implementation:

- Perchlorate Detection Limit for Purposes of Reporting: Reduces the reporting limit for perchlorate from 0.004 mg/L to 0.002 mg/L.
- Revised Total Coliform Rule: Amends guidelines for sampling frequency and reporting of coliform numbers for various treatment systems.
- Lead and Copper Rule: Provides monitoring and reporting requirements for lead and copper in water systems.
- Cross Connection Control Regulation: Provides updates to Policy Handbook for cross connection control in water systems.

Other active projects related to development or review of California Drinking Water Regulations include a review of the perchlorate maximum contaminant level (MCL), microplastics in drinking water, contaminant MCLs, and direct potable water reuse.

POTENTIAL IMPACTS OF NEW REGULATIONS ON WTP OPERATIONS AND CAPITAL IMPROVEMENTS PROJECTS

This update to the Water Master Plan and CIP development does not include a review of unit treatment processes at a design level; it focuses on performance and condition assessment. The City's WTP is considered a fully conventional water treatment plant with conventional flocculation and sedimentation followed by filtration and it meets current rules and regulations regarding water quality for a potable system. Recommended improvements resulting from the condition assessment of treatment, storage, and conveyance infrastructure will not adversely affect capacity or effectiveness in treating and distributing potable water. It does not appear that the WTP needs to be upgraded at this time based on the current state of regulation, and draft documents available related to potentially changing treatment standards.

CONCLUSIONS

There are no anticipated regulations related to future compliance with the City's water facilities, or capacity limitations, that will require CIP projects. However, on-going monitoring of permit requirements and industry trends related to water quality and human health that may affect the City's ability to maintain compliance should be performed.

TM 3 – CONDITION ASSESSMENT FRAMEWORK

TM 3 provides a framework for the assessment of the conditions of water assets in order to:

- Determine the extent of damage of the assets (if any).
- Estimate the remaining useful life.
- Determine the risk of failure.
- Formulate remedies for the problems observed and set priorities.

CONDITION ASSESSMENT APPROACH

Except for yard piping, condition assessment included reviewing existing information (record drawings of various improvement phases, reports, operational data, permits, etc.) and field inspection of key assets by a multi-discipline engineering team (mechanical, structural, electrical/instrumentation, and corrosion engineering). The team interviewed operations personnel regarding known issues and maintenance history of major unit processes.

A systematic procedure was used to gather asset information that are specific to each discipline. Asset information such as the adequacy of the equipment/structure for the intended purpose, the condition of the asset, any known issues were gathered and documented. To standardize the process of determining an assets condition, a tailored inspection form was developed and used.

ASSET DEFINITION AND INVENTORY DEVELOPMENT

Asset inventory of the WTP was developed and classified by treatment process through a review of plant documents in collaboration with the City’s operations staff. A detailed asset inventory for the raw water supply, distribution system, booster pump stations, treated tanks, and the WTP are presented in Technical Memorandum No. 4, 5, 6, 7, and 8, respectively.

The condition of the assets is based on visual inspection (signs of leakage, corrosion), adequacy of intended purpose, efficiency, repair history, etc. The rating scale used in the condition assessment of each asset is shown in **Table 3-1**.

Table 3-1 Asset Condition Rating

Description	Condition Rating
Excellent: Only normal maintenance required	1
Good: Minor defects (maintenance is approx. 5% of the asset value)	2
Fair: Moderate maintenance (maintenance is 10% - 20 % of the asset value)	3
Poor: Significant Deterioration (maintenance is 20% - 40 % of the asset value)	4
Unserviceable	5

The Asset rating took into consideration the asset age, observed physical condition, and operational input from City staff. The visual condition inspection results are augmented by a review of operational data and equipment maintenance history to determine performance and reliability.

ESTIMATED REMAINING LIFE

Each asset has an original useful life (OUL), which is the number of years an asset is expected to be in service. The OUL values for different types of assets are presented in **Table 3-2**.

Table 3-2 Original Useful Life Values

Asset Class	Original Useful Life (Years)
Civil/Site	50 [1]
Electrical	25-35 [2]
Mechanical	25-35 [2]
Structural - concrete	50
Yard piping	50-75 [2]
Cathodic/Corrosion	25

[1] Does not include road surfaces, which require more frequent standard repair or replacement cost

[2] Depending on the type of equipment.

If assets are well maintained, their evaluated remaining useful life (ERUL) can be extended. On the other hand, if the asset is deteriorating at a faster pace than expected, then the ERUL is expected to be shortened. The ERUL will be determined based on a theoretical asset decay curve and the condition of the asset at the time of inspection. **Figure 3-1** shows an example of an asset (e.g., pump) that has an original life of 25 years that was installed in year 2000 and inspected in 2019. Based on the original decay curve, the asset should have condition rating of 3 and a remaining useful life of 6 years (end of useful life is 2025). If at the time of inspection, the condition rating was better than expected (i.e., 2), the modified decay curve (parallel red curve above the original decay curve) would indicate that the remaining useful life can be extended to 2029.

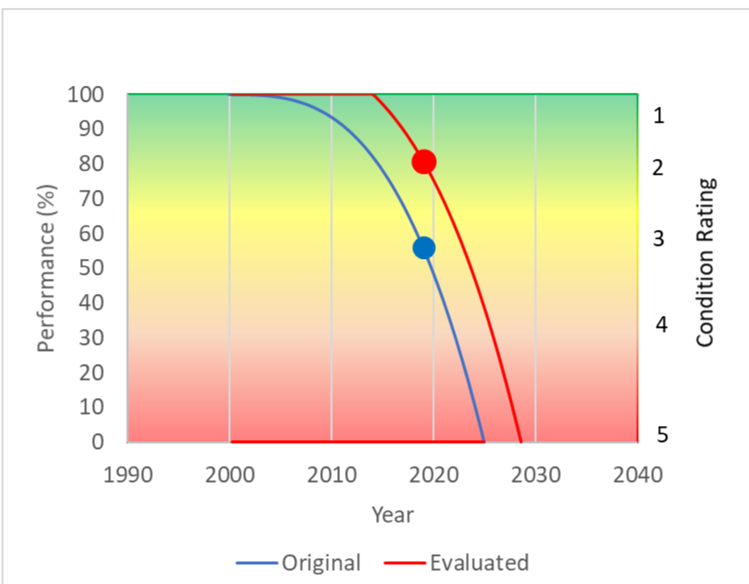

Figure 3-1 ERUL when Evaluated Condition is Better than Expected

DETERMINATION OF RISK

Risk is the mathematical product of the probability of failure and the consequence of failure. Risk is a relative number used to identify the assets, which have a high probability and/or consequence of failure. If a redundant unit is available, this risk is mitigated, and the risk is reduced. The equation used to determine the risk associated with an asset is as follows:

$$Risk = \frac{\text{Probability of Failure X Consequence of Failure X Redundancy Reduction Factor}}{25} X\ 100$$

Generally, assets with a high-risk score should be higher on the priority list for capital improvements.

Probability of Failure

The probability or likelihood of asset failure can occur due to physical failure, performance failure, or technological obsolescence. The probability of failure is inversely proportional to the ERUL, per industry standard. The probability of failure score is shown in **Table 3-3**.

Table 3-3 Probability of Failure Score

ERUL (Years)	Probability of Failure	Score
20	Very Low	1
15	Low	2
10	Moderate	3
5	High	4
Less than 5	Very High	5

Consequence of Failure

A score will be assigned based on the following four categories: public health and safety; reduced level of service; regulatory compliance; cost of repairs.

The consequence of failure scoring scale used for each asset is shown in **Table 3-4**. The score for an asset ranges from 5 points (severe consequence) to 1 point (negligible consequence).

Table 3-4 Consequence of Failure Score

Consequence of Failure	Score
Negligible	1
Low	2
Moderate	3
High	4
Severe	5

Redundancy

Redundancy is a factor that will be used to lower the risk. This factor will be assigned a value of 0.5 if there is a full redundant unit and will be assigned 1.0 if there is no redundant unit. Some of the pump stations (i.e., the booster pump stations and Lake Herman Pump Station) do not have full redundancy, and therefore receive a different redundancy factor. For example, if a pump station has four pumps (three duty and one standby), then the redundancy factor is 0.75, and if a pump station has three pumps (two duty and one standby), then the redundancy factor is 0.67.

YARD PIPING CONDITION ASSESSMENT APPROACH

An inventory of the buried yard piping with associated age, material, redundancy, service, and diameter is developed. The information compiled in the yard piping inventory was then used to develop the condition rating and risk. The distribution system condition assessment uses a similar approach, which is further described in TM 5 Condition Assessment of Water Distribution System.

YARD PIPING ASSET CONDITION RATING

Since it was not possible to visually inspect the underground piping or employ other methods of inspection (beyond the scope of this Master Plan Update), the ranking scale used in the yard piping condition assessment was based on age, as shown in **Table 3-1**.

Table 3-1 Yard Piping Condition Rating

Age	Condition Rating
Less than 20 years old	Excellent (1)
Between 20 and 40 years old	Good (2)
Between 40 and 60 years old	Fair (3)
Between 60 and 70 years old	Poor (4)
More than 70 years old	Possible Eminent Failure (5)

PROBABILITY OF FAILURE FOR YARD PIPING

The probability or likelihood of pipe failure will be based on the condition as shown in **Table 3-5**.

Table 3-5 Probability of Failure Score for Pipes

Condition Rating	Probability of Failure	Score
Excellent	Very Low	1
Good	Low	2
Fair	Moderate	3
Poor	High	4
Possible Eminent Failure	Very High	5

CONSEQUENCE OF FAILURE FOR YARD PIPING

For the purposes of this analysis, consequence of failure score is assigned to reflect the criticality of a yard pipe segment to the performance of the entire system. The factors considered in the development of the overall consequence of failure score are:

- **Disruption:** This factor accounts for the effect on treatment due to pipe failure.

- **Continuous service vs intermittent service:** The consequence of failure of a continuous service influent or effluent pipe will be scored the highest, whereas, a grit pipe may score lower because the grit removal system may be taken out of service intermittently.

- **Pipe Diameter:** The larger the pipe diameter, the higher the risk.

The consequence of failure factors scoring scale used for each pipe is shown in **Table 4-6**. The overall consequence of failure score will be calculated as follows:

$$Yard\ Pipe\ Consequence\ of\ Failure = \frac{Disruption\ Factor + Service\ Factor + Pipe\ Diameter\ Factor}{23} X\, 5$$

Table 4-6 Consequence of Failure Factors

Factor Description	Score
Disruption Factor	
Major disruption (for example, significantly reduced level of treatment)	10
Moderate disruption (for example, partially affects treatment, forced bypass)	8
Minor disruption (for example, no effect on treatment but causes nuisance operation)	5
Service Factor	
Continuous service	8
Intermittent service	4
Pipe Diameter Factor	
Diameter more than 30-inch	5
Diameter between 20-inch and 30-inch	3
Diameter less than 20-inch	2

The Risk factor will be calculated based on the equations presented above.

TM 4 – CONDITION ASSESSMENT OF RAW WATER SUPPLY

The purpose of this TM 4 is to document the condition assessment of the existing raw water pump stations, Laker Herman Control Tower, and Raw Water Transmission Line of the City as part of the Water Master Plan Update.

SUMMARY OF EXISTING RAW WATER SYSTEM

The City's primary raw water source is surface water from the State Water Project (SWP). The water is diverted from the Sacramento-San Joaquin River Delta through the Barker Slough Pumping Plant to the North Bay Aqueduct (NBA). The NBA transfers the raw water to the Cordelia Forebay where the NBA Cordelia Pumping Plant pumps the water to the City of Benicia. The NBA Cordelia Pumping Plant is operated by the Department of Water Resources. When water from the NBA is unavailable or has poor water quality, the City uses two other raw water sources (Lake Berryessa and Lake Herman) and pump stations. The City owns and operates the two raw water pumping stations: Lake Herman Pump Station and Cordelia Pump Station. **Table 4-7** is a summary of the existing raw water pump stations.

Table 4-7 Existing Raw Water Pump Stations

Name	Motor Manufacturer	Year	HP	RPM	Pump Manufacturer	GPM	TDH (ft)
Lake Herman PS: Pump #1	US Motor	2008	200	1785	Gould	3,600	180
Lake Herman PS: Pump #2	US Motor	2008	200	1785	Peerless	3,600	180
Lake Herman PS: Pump #3	General Electric	2005	200	1785	Peerless	3,600	180
Cordelia PS: Pump #1	Baldor-Reliance	2011	200	1785	Grundfos-PACO	3,200	180
Cordelia PS: Pump #2	Baldor Reliance	2011	200	1785	Grundfos-PACO	3,200	180
Cordelia PS: Pump #3	Westinghouse	1968	200	1776	Worthington	3,200	205
Cordelia PS: Pump #4	Louis Allis	1967	200	1770	Worthington	3,200	205

LAKE HERMAN PUMP STATION

The Lake Herman Pump Station site is located on Channel Court and surrounded by industrial manufacturer and contractor warehouses. Total parcel area of the facility is approximately 0.5 acres. The Lake Herman Pump Station is a supplemental supply pump station that conveys raw water from Lake Herman to the WTP or the Valero refinery. Lake Herman receives and stores water overflows from the NBA Cordelia Pumping Plant or Cordelia Pumping Station when the daily demand at the WTP and the Valero refinery is less than the water delivered to the Diversion Structure. The site includes three booster pumps, electrical equipment, and piping in and out of the pump station.

The Lake Herman Pump Station consists of three pumps each rated at 8.0 cfs (5.2 mgd) at 180 feet of total dynamic head. City staff routinely monitor the site for general operation and maintenance of the pumps and electrical components. A hydraulic analysis of the total plant pumping capacity was not available.

CORDELIA PUMP STATION

The Cordelia Pump Station site is located south of Putah South Canal Terminal Reservoir in Cordelia, California. The facility is adjacent to an existing pumping plant operated by the City of Vallejo to the west and an existing pumping plant operated by the State of California, that is no longer in use, to the east. The site parcel area is approximately 0.25 acres. The Cordelia Pump Station is a supplemental supply pump station (supplemental to the NBA Cordelia Pumping Plant) that conveys raw water from the Putah South Canal Terminal Reservoir to the City. The site includes four pumps (P-1, P-2, P-3, and P-4), intake screen, a surge relief system, and electrical equipment. Two of the pumps are original to the pump station installed in 1968 and have been re-built several times since then. Two of the original pumps were replaced in 2015. Each of the pumps has a 200 hp motor but the new pumps have a lower pumping capacity due to a lower pressure rating on the pumps. The maximum pump rate with all four pumps running simultaneously is 10.4 mgd. City staff routinely monitor the site for general operation and maintenance of the pumps, pipe and electrical controls.

RAW WATER TRANSMISSION LINE

The Raw Water Transmission Line (RWTL) extends approximately 65,000 feet from the Cordelia Pump Station to the Diversion Structure at the water treatment plant. This is the only conduit for pumping raw water from the Lake Berryessa source and the North Bay Aqueduct to the WTP. The Cordelia Pump Station and the RWTL were constructed in 1968 as interim projects (according to the contract documents for the Cordelia Pump Station and RWTL), but have been kept in operation as the raw water supply to the WTP. The NBA Cordelia Pumping Plant contributes to the RWTL with a 30-inch pipe just south of Highway 80, west of Highway 680.

The RWTL was originally constructed with 24- and 36-inch steel pipe with pressure ratings ranging from 175 psi at the Cordelia Pump Station, to 100 psi further up the line and on to the WTP. The 36-inch pipe was installed as pre-tensioned concrete cylinder steel pipe. The 24-inch pipe is welded steel pipe with mortar lining and coating. The RWTL contains a limited number of isolation valves along the route.

LAKE HERMAN OUTLET TOWER

The outlet tower located within Lake Herman is used to divert flow from Lake Herman to the Lake Herman Pump Station and/or allow Sulphur Springs Creek to flow through Lake Herman Dam. No records of the tower's construction could be located but a previous condition assessment of the tower performed in 1991 indicated that the original construction of the tower predated 1945, the year in which the outlet tower was modified and raised.

LAKE HERMAN BATHYMETRIC STUDY

A new bathymetric study was performed on Lake Herman in 2019. This study produced an updated contour of the lake floor and a new table relating water depth in the lake with volume of water stored and the data was delivered to the City as part of this analysis. City staff will use this table to track water volumes into and out of the lake more accurately for operational and reporting requirements. **Table 4-8** shows a version of this table at 1-foot increments of water elevation.

Table 4-8 Volume of Water Stored in Lake Herman Based on Water Elevation

Water Elevation [1] [2]	Acre Feet	Gallons
121	1,800	570,608,000
120	1,700	540,909,000
119	1,600	511,538,000
118	1,500	482,497,000
117	1,400	453,815,000
116	1,300	425,513,000
115	1,200	397,605,000
114	1,100	370,106,000
113	1,100	342,946,000
112	1,000	316,388,000
111	890	291,148,000
110	820	267,284,000
109	750	244,400,000

Water Elevation [1] [2]	Acre Feet	Gallons
108	680	222,449,000
107	620	201,029,000
106	550	180,210,000
105	490	160,168,000
104	430	140,722,000
103	370	121,971,000
102	320	104,066,000
101	270	87,061,000
100	220	70,950,000
99	170	55,831,000
98	130	41,794,000
97	89	28,954,000
96	54	17,551,000
95	25	8,286,000
94	6.9	2,252,000
93	0.6	189,000
92	0.17	55,340
91	0.08	24,840
90	0.03	9,290
89	0.01	1,820

[1] A version of this table by 1-inch increments was provided to the City and is included in **Appendix A**.
[2] Max crest height of dam is 122.0 per Lake Herman Dam Spillway and Outlet Tower construction drawings (1948).

SUMMARY OF INSPECTION FINDINGS

The summary presented below is intended to capture the observations made during the inspection of the raw water supply facilities. See the full TM for details. **Table 4-9** provides a summary of the raw water condition and ERUL of the mechanical, electrical and instrumentation, structural, and above ground piping equipment.

Table 4-9 Evaluated Remaining Useful Life of Raw Water Supply System

	MECHANICAL				ELECTRICAL AND INSTRUMENTATION			
Asset / Major Unit Process Area	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
Lake Herman Pump Station	3	1968	35	13	4	1968	35	4
Cordelia Pump Station	4	1968/2015	35	4	4	1968	35	4
Raw Water Transmission Line	4	1968	75	12	NA	NA	NA	NA
Lake Herman Control Tower	3	1945	50	11	NA	NA	NA	NA

	STRUCTURAL					ABOVE GROUND PIPING			
Asset / Major Unit Process Area	Condition of Concrete Walls or Mats	Overall Structural Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
Lake Herman Pump Station	2	2	1968	50	17	3	1968	50	12
Cordelia Pump Station	2	2	1968	50	17	3	1968	50	12
Raw Water Transmission Line	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lake Herman Control Tower	3	3	1945	50	11	NA	NA	NA	NA

SUMMARY OF RECOMMENDED IMPROVEMENTS

This section includes a summary of recommended raw water facility improvements.

LAKE HERMAN PUMP STATION (RW-001)

Below is a summary of recommended improvements for the Lake Herman Pump Station:

- Replace four (4) pumps with new pumps, motors and controls.
- Replace MCC with new NEMA 3R enclosure.
- Develop preventative maintenance program to prevent MCC and pumps from corrosion.
- Conduct yearly infrared (IR) testing on all electrical equipment and ANSI/NETA MTS testing bi-yearly.
- Conductor arc-flash study and install labels per NFPA 70E.
- Install new light poles with adequate lighting as recommended by IES and install lighting fixtures in NEMA 3R walk-in enclosure.
- Replace perimeter fence and gates.
- Remove all existing coatings and apply new coating system on all exposed piping, pumps, valves, and pipe supports.

CORDELIA PUMP STATION (RW-002)

A major renovation project at the Cordelia Raw Water Pump Station is recommended to ensure extended reliability of the pump station.

- It is recommended that the entire pump station be demolished and re-constructed as part of the CIP. The project proposed in the CIP is for the re-construction of the pump station. The estimated costs in the proposed CIP are high-level costs; more detailed design/engineering is required to confirm project parameters and planning budgets. The interim improvements detailed above are recommended if the re-construction CIP is not adopted by the City.
- The existing pump station to the east of the Cordelia Pump Station is an abandoned pump station owned by the State of California. This pump station draws water from the same suction header out of the Terminal Reservoir as the Cordelia Pump Station. It is recommended that the City approach the State about purchasing this pump station and installing new pumps and a tie-in to the RWTL. This pump station may be used to supply raw water to the WTP while the original Cordelia Pump Station is reconstructed. This second pump station will then become a redundant pump station for supplying water to the WTP.

RAW WATER TRANSMISSION LINE (RW-003, RW-004, AND RW-005)

- It is recommended that a new RWTL be constructed alongside the existing RWTL. Approximately 65,700 LF of new steel mortar coated and lined pipe will be required (approximately 9,750 LF of 30-inch diameter pipe and approximately 55,950 LF of 36-inch diameter pipe). A new pipeline will provide an increased capacity and extended reliability for another 60 – 80 years going forward. The new RWTL is recommended to be constructed in phases with sections being constructed and tied into the existing pipe. Projects may be planned to obtain rights of way where existing easements are not large enough to accommodate a parallel pipeline. This project will also provide the additional valving needed in the RWTL. The parallel RWTL is included in the proposed CIP as project RW-003. The proposed CIP is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

- Alternatively, a raw water inter-tie between the cities of Vallejo and Benicia would be another option for adding reliability of raw water supply to the WTP. Replacing the existing RWTL would require additional easement and land acquisition along much of the 65,000-plus feet alignment. A raw water intertie with Vallejo could come at a much lower cost with approximately 42,000 feet of new pipe, but with more logistical complexity due to the need for inter-city agreements and coordination. This version of the supply back-up would also have the benefit of being able to support Vallejo too (two-way flow). Negotiations with the City of Vallejo will be required to evaluate and implement this RWTL alternative, including confirmation that their water supply is sufficient to support Benicia, though this is indicated in Vallejo's UWMP. As a back-up to the RWTL, any agreement could be water neutral, allowing Benicia to receive water while working on the primary RWTL, and then reverse flow (an equal amount) when primary facilities are back on-line. Multiple arrangements for this raw water intertie could be developed. The raw water intertie with the City of Vallejo is included in the proposed CIP as a contingent project, RW-005, which may be completed in lieu of RW-003. The proposed contingent CIP is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.
- Rehabilitate the existing RWTL with spot repairs, new valves, improved cathodic protection and a new NF-61 lining system. This would be facilitated by the use of a new parallel RWTL or an alternative RWTL from the City of Vallejo. The rehabilitation of the existing RWTL is included in the proposed CIP as project RW-004.

LAKE HERMAN CONTROL TOWER (RW-006)

- It is recommended that the structure be abandoned and replaced to current building codes and industry standards based on the age of structure, past seismic evaluation and conclusions, lack of information and lack of accessibility.

ONGOING CONDITION ASSESSMENT (RW-007)

- It is recommended that every five years, City staff review the existing CIP list and consult with operation and maintenance staff on their assessment of what requires attention, with inspections as required and a focus on re-assessing the most critical pending CIP projects. The results could be adjustments to the priority or budgets of existing CIPs and/or the addition of new CIP projects. This project is not to necessarily provide a complete condition assessment, but to update the condition assessment from the previous five-year cycle.

RISK OF FAILURE

Table 4-10 shows the overall risk of failure based on the consequences of failure and probability of failure ratings. The risk of failure was calculated as detailed in TM 3 Condition Assessment Framework.

Table 4-10 Risk of Failure of the Raw Water Supply System Recommended Projects [1]

Project Number	Project Name	Overall Condition Rating Range (1-5)	Probability of Failure (1-5)	Consequence of Failure (1-5)	Risk of Failure Range (0-100)
RW-001	Lake Herman Pump Station Improvements	4	3	3	27
RW-002	Cordelia Pump Station Improvements	4	4	5	80
RW-003	Parallel Raw Water Transmission Line	4	3	5	60
RW-004	Existing Raw Water Transmission Line Rehabilitation	4	3	5	60
RW-005	Vallejo Raw Water Transmission Line Intertie	4	3	5	60
RW-006	Lake Herman Control Tower	3	3	3	36
RW-007	Ongoing Condition Assessment of the Raw Water Supply	3	3	3	36

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

TM 5 – CONDITION ASSESSMENT OF WATER DISTRIBUTION SYSTEM

The purpose of this TM 5 is to document the condition assessment of the City's existing water distribution system as part of the Water Master Plan Update. Condition Assessment of the Water Distribution System Objectives

SUMMARY OF EXISTING WATER DISTRIBUTION SYSTEM

The City's existing water distribution system is separated into three main pressure zones (i.e., service zones): Zone 1, Zone 2, and Zone 3. There are seven intermediate pressure zones served by Zone 3, which rely on eight pressure reducing valve stations for pressure and flow requirements. Water is delivered to Zone 2 and Zone 3 using three booster pump stations: P-1, P-2, and P-3. The P-1 Pump Station delivers water to Zone 2 from Zone 1. The P-2 Pump Station and P-3 Pump Station deliver water to Zone 3 from Zone 2 and from Zone 1, respectively. Storage reservoirs (tanks) are located within each main pressure zone. This TM covers the water distribution system, excluding the treated water reservoirs and booster pump stations. The water distribution system delivers potable water to the residential, business, and industrial land uses within the existing City limits. The water distribution system pipelines range in diameter from 4-inch to 30-inch. Most of the larger pipelines are constructed of asbestos cement, ductile iron and steel; the majority of the pipelines 12-inch diameter or less are constructed of cast iron, ductile iron, and polyvinyl chloride pipes.

LEAK ASSESSMENT

Leak reports and maintenance logs from April 2016 through April 2019 were provided by the City and summarized herein. The information was used to determine areas that have high concentrations of water leaks.

Many of the leaks observed by City staff can be attributed to the age of the infrastructure. Approximately 10% of water distribution pipelines are more than 60 years old and 30% of the city's water mains are more than 50 years old. Approximately 40% of the City's infrastructure has met its useful service life. 108 leaks (or approximately 46-percent of all reported leaks) observed on the main pipelines and service laterals, between April 2016 and April 2019, were likely due to age of the infrastructure.

CONDITION ASSESSMENT SUMMARY AND RECOMMENDED IMPROVEMENTS

Table 5-1 shows the respective probability of failure ratings, consequences of failure ratings, and overall risk ratings for the recommended projects. **Table 5-2** shows a summary of the recommended water distribution system projects discussed in this TM, including the ERUL. Because the Lower Arsenal part of the City was a former military base and due to that neighborhood's age, all Lower Arsenal CIP costs are increased by 30% for unknown subsurface contingency. Lower Arsenal CIPs include WD-008 and WD-012.

Table 5-1 Risk Ratings of Recommended Water Distribution Projects

Project No.	Project Name	Overall Condition Rating (1-5) [1]	Probability of Failure (1-5)	Consequences of Failure (1-5)	Risk of Failure (1-100) [1]
WD-001	Park Road Transmission Main (18 inch)	5	5	5	100
WD-002	Park Road Transmission Main (24 inch)	4	4	5	80
WD-003	Military West Zone 1 Water Main	4	4	4	64
WD-004	Drolette Way Loop	3	3	3	36
WD-005	West 7th Street Water Main	2	2	4	32
WD-006	Reliability Transmission Main from WTP	5	5	5	100
WD-007	Service Line Replacement	3	3	2	24
WD-008	Adams Street Water Main Replacement	5	5	4	80
WD-009	R-1 Old Reservoir Water Main	3	3	3	36
WD-010	East 5th Street Water Main	4	4	4	64
WD-011	Industrial Way Transmission Main Valves	2	2	4	32
WD-012	Jackson Street Reliability Loop	4	4	3	48
WD-013	Viewmont Street Water Main	5	5	4	80
WD-014	Vallejo Treated Water Intertie	5	5	5	100
WD-015	Valve Replacement (Clearview & East E Street areas)	3	3	4	48
WD-016	Ongoing Condition Assessment of the Water Distribution System	3	3	3	36

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

Table 5-2 Recommended Water Distribution Projects

Project No.	Project Name	ERUL (yrs)	Length (LF)	New Pipe Size (in)	New Material	Recommendations
WD-001	Park Road Transmission Main (18 inch)	1	2,700	18	PVC C900	Install a new 18-inch transmission main in Park Road from the National Guard Armory to Oak Road with accessible valve arrangements via open-cut construction method.
WD-002	Park Road Transmission Main (24 inch)	11	960	24	PVC C900 or DI	Perform a route study and project constraint analysis for a new 24-inch transmission main from the E. Channel Creek crossing to Bayshore Road during the Park Road sanitary sewer force main replacement project.
WD-003	Military West Zone 1 Water Main	6	1,400	12	PVC C900	Install a new 12-inch water main on Military West between West 11th Street and West 13th Street via open-cut construction method.
WD-004	Drolette Way Loop	23	250	8	PVC C900	Install an 8-inch water loop within the existing easement via open-cut construction method or trenchless method.
WD-005	West 7th Street Water Main	30	750	12	PVC C900	Install an approximately 750 LF of 12-inch water main via open-cut construction from Southampton Road in Zone III to Lori Drive under Interstate 780 to serve Zone 3A.
WD-006	Reliability Transmission Main from WTP	1	2,700	36	PVC or DI	Install a 36-inch transmission main within the existing or new easement parallel to the existing 30-inch transmission main. The existing 30-inch transmission main can be lined or rehabilitated for redundancy and additional source of water supply.
WD-007	Service Line Replacement	12	Varies	3/4	HDPE	Develop an ongoing service lateral replacement program to replace the old service laterals with new 6-inch pipes.
WD-008	Adams Street Water Main Replacement	1	1,000	14	PVC C900	Install a new 14-inch water main in Adams Street with accessible valve arrangements via open-cut construction method.
WD-009	R-1 Reservoir Water Main	11	400	14	PVC C900	Install approximately 400 LF of new 14-inch water main connecting the supply and feed lines of the old Reservoir 1 from Park Road to Jefferson Street.

Project No.	Project Name	ERUL (yrs)	Length (LF)	New Pipe Size (in)	New Material	Recommendations
WD-010	East 5th Street Water Main	6	1,700	10	PVC C900	Install a new 6-inch water main in a public right-of-way with accessible valve arrangements out from the curb and gutter alignment via open-cut construction method.
WD-011	Industrial Way Transmission Main Valves	17	2 (EA)	24	Cast Iron w/SS interior parts	Replace the existing leaking butterfly valves with new butterfly valves.
WD-012	Jackson Street Reliability Loop	6	500	14	PVC C900	Install approximately 500 LF of new 14-inch water main from Adams Street to Jackson Street via open-cut construction method.
WD-013	Viewmont Street Water Main	1	1,850	¾ and 8	PVC C900	Install a new 8-inch water main in the street with accessible valve arrangements and ¾-inch service laterals. This project can be constructed using open-cut method.
WD-014	Vallejo Intertie	-	3,600	12	PVC C900and DI	Install a new 12-inch pipeline from Vallejo Zone 600 to Benicia Zone 3 that follows a cross-country alignment.
WD-015	Valve Replacement (Clearview and East E Street areas)		100 (EA)	Varies	Cast Iron w/SS \interior parts	Replace existing 6" and larger valves in Marina Village and Clearview areas in public right-of-way
WD-016	Ongoing Condition Assessment of the Water Distribution System	-	844,800	-	-	Review the existing CIP list, consult with operation and maintenance staff on their assessment of what requires attention, with inspections as required and a focus on re-assessing the most critical pending CIP projects. The results could be adjustments to the priority or budgets of existing CIPs and/or the addition of new CIP projects.

TM 6 – CONDITION ASSESSMENT OF BOOSTER PUMP STATIONS

The purpose of this TM 6 is to document the condition assessment of the existing treated water booster pump stations (BPSs) of the City as part of the Water Master Plan Update. The condition assessment of raw water pump stations can be found in TM 4.

SUMMARY OF EXISTING BOOSTER PUMP STATIONS

The City's water distribution system is separated into three main pressure zones (i.e., service zones): Zone 1, Zone 2, and Zone 3. **Table 6-1** shows a summary of the existing BPSs.

Table 6-1 Existing Booster Pump Stations (1)

Name	Motor Manufacturer	Year	HP	RPM	Pump Manufacturer	GPM	TDH
P-1: Pump #101	General Electric	2007	100	1,790	Floway	2,200	127.5
P-1: Pump #102	General Electric	2007	100	1,790	Floway	2,200	127.5
P-1: Pump #103	General Electric	2007	100	1,790	Floway	2,200	127.5
P-2: Pump #201	Baldor Super E	2004	125	3,560	PACO	1,000	350
P-2: Pump #202	Baldor Super E	2004	125	3,565	PACO	1,000	350
P-2: Pump #203	Baldor Super E	2002	125	3,550	PACO	1,000	350
P-2: Pump #204	Baldor Super E	2002	125	3,550	PACO	1,000	350
P-3: Pump #301	General Electric	2007	125	3,570	Floway	950	403
P-3: Pump #302	General Electric	2007	125	3,570	Floway	950	403
P-3: Pump #302	General Electric	2007	125	3,570	Floway	950	403

(1) P-1, P-2 and P-3 are all operated at constant speed based on system pressure. Pneumatic tanks are not included in the pump and piping arrangement, typically used to optimize controls or for surge protection.

P-1 BOOSTER PUMP STATION SUMMARY

The P-1 Booster Pump Station is located north of the City's Corporation Yard and delivers water directly to Zone 2 from Zone 1. The BPS consists of three vertical turbine pumps (P-101, P-102, and P-103) each with a rated capacity of 2,200 gpm at a discharge head of approximately 127.5 feet. The pumps were installed in 2007 and are manufactured by Floway. The pumps are housed within a masonry block building that includes electrical panels as well as the piping, valves, and for the pump suction and discharge manifold. Below is a photograph of the interior of the existing P-1 Booster Pump Station building.

P-2 BOOSTER PUMP STATION SUMMARY

The P-2 Booster Pump Station is located across the street from the Corporation Yard, approximately 1,200 feet west of East 2nd Street and north of Tenny's Drive, and delivers water from Zone 2 to Zone 3. The BPS consists of four horizontal centrifugal pumps (P-201, P-202, P-203, and P-204) each with a rated capacity of 1,000 gpm at a discharge head of approximately 350 feet. Pumps P-201 and P-202 were installed in 2004 and pumps P-203 and P-204 were installed in 2002. All four pumps are manufactured by PACO. The pumps are housed within a masonry block building that includes electrical panels as well piping and valves for the pump suction and discharge manifolds.

P-3 BOOSTER PUMP STATION SUMMARY

The P-3 Booster Pump Station is located near the corner of Rose Drive and East 2nd Street and delivers water from Zone 1 to Zone 3. The BPS consists of three vertical turbine pumps (P-301, P-302, and P-303) each with a rated capacity of 950 gpm at a discharge head of approximately 403 feet. The pumps were installed in 2007 and are manufactured by Floway. The pumps are housed within a masonry block building that includes electrical panels as well as the piping and valves.

SUMMARY OF INSPECTION FINDINGS

Table 6-2 is a summary of the Probability of Failure Ratings, Consequence of Failure Ratings, Redundancy and overall Risk Ratings for each of the BPSs listed in this TM.

The Risk Rating for each proposed project, as shown in **Table 6-3**, is calculated as a function of the Probability of Failure Rating, Consequence of Failure Rating and Redundancy as described in TM 3 Condition Assessment Framework.

Table 6-2 Condition Assessment Summary

	MECHANICAL				ELECTRICAL AND INSTRUMENTATION			
Asset / Major Unit Process Area	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
P-1 Booster Pump Station	1	2005	35	20	2	2005	20	7
P-2 Booster Pump Station	2	1970	35	11	4	1970	20	2
P-3 Booster Pump Station	2	2005	35	16	5	2005	20	0

	STRUCTURAL				ABOVE GROUND PIPING			
Asset / Major Unit Process Area	Overall Structural Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
P-1 Booster Pump Station	1	2005	50	33	3	2005	75	33
P-2 Booster Pump Station	3	1970	50	12	3	1970	75	21
P-3 Booster Pump Station	3	1990	50	15	4	1990	75	15

Table 6-3 Risk of Failure for Booster Pump Station Projects

Project No	Project Name	Overall Remaining Useful Life (yrs)	Probability of Failure (1-5)	Consequence of Failure (1-5)	Risk of Failure Rating (0-100) [1]
BPS-001	P-1 BPS Rehabilitation	23	1	5	14
BPS-002	P-2 BPS Rehabilitation	12	4	4	48
BPS-003	P-3 BPS Rehabilitation	12	4	3	32
BPS-004	Ongoing Condition Assessment of Booster Pump Stations	-	3	3	36

[1] Failure Rating: 0-39 (green), 40-59 (yellow), 60-100 (red).

SUMMARY OF RECOMMENDED IMPROVEMENTS

Table 6-4, **Table 6-5**, and **Table 6-6** below are summaries of recommended improvements for the P-1, P-2, and P-3 Booster Pump Stations, respectively. Additionally, it is recommended that every five years, City staff review the existing CIP list and consult with operation and maintenance staff on their assessment of what requires attention, with inspections as required and a focus on re-assessing the most critical pending CIP projects. The results could be adjustments to the priority or budgets of existing CIPs and/or the addition of new CIP projects. This project is not to necessarily provide a complete condition assessment, but to update the condition assessment from the previous five-year cycle. An ongoing condition assessment CIP project (BPS-004) is included in the proposed CIP.

Table 6-4 P-1 Booster Pump Station Recommended Improvements (Project No. BPS-001)

Observation Type	Recommendation
General Site	• Remove vegetation growth on access road. • Monitor existing cracks in pavement and seal as appropriate.
Security	• Add trespassing signs to the access gate to the P-1 Booster Pump Station and R-1 Reservoir gate.
Piping	• No piping improvements are recommended.
Mechanical	• Water leak was observed at P-102
Structural	• No structural improvements are recommended.
Electrical	• Conduct ANSI/NETA MTS testing on existing SWBD/MCC. • Conductor coordination study and install arc-flash labels per NFPA 70E and NEC. • Install emergency light and exit signs with battery backup systems. • Install lighting with battery backup in valve vault. • Re-evaluate emergency loading and standby generator sizing. Upsize the generator, which is currently undersized for three 100HP motors.
Instrumentation	• Set up generator ATS to auto start on power loss. • Establish a regular calibration and verification preventative maintenance schedule, including proper calibration fittings and installation and record tags. • Remediate instrumentation installation issues and properly support all cables and flex conduit. • Install ACM module in V-100 valve actuator to allow modulating control and feedback. • Install a spread spectrum radio mesh network to facilitate more reliable SCADA network communication between facilities. • Install an intrusion switch in the V-100 valve vault. • Instrumentation should be standardized across all facilities, such as the Rosemount 3051 pressure transmitter.
Safety	• Provide a mechanism to place removable grating when removed from floor.
Coatings	• Remove all existing coatings and apply new coating system on all exposed piping, pumps, valves, ladders, and pipe supports.

Table 6-5 P-2 Booster Pump Station Recommended Improvements (Project No. BPS-002)

Observation Type	Recommendation
General Site	• Remove vegetation growth and redesign pavement section on access road. • Install grading and paving around the BPS building and around the R-2 Reservoir.
Security	• Replace chain link fence, barbed wire, gates, and padlocks. • Revise the blockage for the gap in fence near concrete swale. • Add bollards to protect infrastructure. • Add lights around building.
Piping	• Replace pipe supports and revise the layout to provide additional clearance for operator traffic. Install new piping with coating.
Mechanical	• All pumps should be replaced to newer model to ensure parts and service.
Structural	• Provide a detailed seismic evaluation and, if determined to be required, design and construct improvements to the structure in accordance with ASCE 7-41. • Repair roof insulation, leaks and efflorescence in the building
Electrical	• Replace existing SWBD and MCC with new line-up. Consolidate MCC1, MCC2, MCC3 into single MCC. • Conduct coordination study and install arc-flash labels per NFPA 70E and NEC. • Install emergency light and exit signs with battery backup systems. • Repair conduit transitions and sweep to prevent exposed conductors. • Install emergency standby generator.
Instrumentation	• Install backup alarm dialer. • Allow remote access from external network. • Install a flow meter at the discharge header and PRV2-A outlet. • Pressure transmitters should be installed at each pumps suction and discharge, on the suction and discharge headers, and at the PRV inlet and outlet. • Establish a regular calibration and verification preventative maintenance schedule, including proper calibration fittings and installation and record tags. • PRV valve position limit switches should be installed. • Install an intrusion switch in the valve vault. • Remediate instrumentation installation issues and properly support all cables and flex conduit. • Install a spread spectrum radio mesh network to facilitate more reliable SCADA network communication between facilities. • Instrumentation should be standardized across all facilities, such as the Rosemount 3051 pressure transmitter
Safety	• Move chemical drum so the eye wash station is accessible.
Coatings	• Remove all existing coatings and apply new coating system on all exposed piping, pumps, valves, ladders, and pipe supports.

Table 6-6 P-3 Booster Pump Station Recommended Improvements (Project No. BPS-003)

Observation Type	Recommendation
General Site	• Revise the access layout and repave the site.
Security	• Add electric gate to allow immediate access into BPS site without slowing before entering site due to traffic on East 2nd Street. • Replace or fix the misalignment of the gate on the south end. • Trim landscaping impacting the chain link fencing. • Replace the broken CCTV camera glass.
Piping	• Add bollards to protect above ground piping. • Replace all pipe supports.
Mechanical	• Replace all expansion joints. • Replace all ARVs. • Fix water leaks at the base of pumps
Structural	• Provide a detailed seismic evaluation and, if determined to be required, design and construct of improvements to the structure in accordance with ASCE 7-41. • Repair roof insulation, leaks and efflorescence in the building
Electrical	• Replace existing SWBD and MCC. • Provide new light fixtures, emergency lighting, and lighting signs to comply with Title 24 requirements. • Recommend installing Reduce Voltage Sort Starter instead of Full Voltage Starter to reduce loading impact on bussing when starting all three pumps simultaneously. • Alternatively, if the replacement of SWBD/MCC is not possible, recommend the following: • Establish operational testing and preventative maintenance procedures that include testing of electrical equipment to ensure safe electrical component operations. • Conduct coordination study to produce arc flash labels and circuit breaker trips setting requirements. Coordination study will also indicate with conductors are undersized and will require replacements. • Conduct NETA MTS testing on all breakers, MTS, and internal components. • Conduct fall-of-potential ground system test to measure effective grounding resistance and ensure all equipment is properly grounded. Proper grounding is critical for personnel safety and equipment protection. • Megger tests all line and load conductors and replace conductor that do not pass testing. • Note that there are no spare parts available for existing SWBD/MCC. Preventative maintenance may prolong the life of the equipment for a few years, but the equipment is at the end of expected 25-YEAR life.
Instrumentation	• Remediate instrumentation installation issues and properly support all cables and flex conduit. • Install a spread spectrum radio mesh network to facilitate more reliable SCADA network communication between facilities. • Establish a regular calibration and verification preventative maintenance schedule, including proper calibration fittings and installation and record tags. • Instrumentation should be standardized across all facilities, such as the Rosemount 3051 pressure transmitter.
Safety	• Provide a mechanism to place removable grating when removed from floor.
Coatings	• Remove all existing coatings and apply new coating system on all exposed piping, pumps, valves, ladder, and pipe supports.

TM 7 – CONDITION ASSESSMENT OF TREATED WATER TANKS & RESERVOIRS

The purpose of this TM 7 is to document the condition assessment of the existing treated water storage of the City as part of the Water Master Plan Update.

SUMMARY OF EXISTING STORAGE TANKS & RESERVOIRS

The City's existing water distribution system is separated into three main pressure zones (i.e., service zones): Zone 1, Zone 2, and Zone 3. There are seven intermediate pressure zones served by Zone 3, which rely on pressure reducing valve stations for pressure and flow requirements. Water is delivered to Zone 2 and Zone 3 using three booster pump stations: P-1, P-2, and P-3. Storage reservoirs (tanks) are located within each main pressure zone. The City tanks are as follows:

- Chlorine Contact Tank
- Clearwell
- R-1 Reservoir
- R-2 Reservoir
- R-3A – Reservoir
- R-3B – Reservoir

The Lake Herman storage tank and the abandoned Old R-1 Reservoir were not included as part of this assessment.

Table 7-1 is a summary of the pertinent data for each of the existing treated water storage tanks and reservoirs.

Table 7-1 Existing Water Distribution System Storage Tanks and Reservoirs

Pressure Zone	Name	Storage Capacity (MG)	Base Elevation (ft)	Overflow Elevation (ft)	Tank Height (ft)	Tank Diameter (ft)	Tank Construction
1	Chlorine Contact Tank	1.0	215	233	20	103	Welded Steel
1	Clearwell	3.0	215	232	20	163	Pre-stressed Concrete
1	R-1 Reservoir	3.0	193	214	25.5	160	Welded Steel
2	R-2 Reservoir	1.8	280	315	42	95	Welded Steel
3	R-3A Reservoir	1.0	563	583	23	92	Pre-stressed Concrete
3	R-3B Reservoir	3.0	563	583	23	160	Pre-stressed Concrete
	Total Capacity	**12.8**					

Table 7-2 shows a summary of the condition assessment of each treated water storage tank and **Table 7-3** shows a summary of the Probability of Failure Ratings, Consequence of Failure Ratings and overall Risk Ratings for each of the storage tanks listed in this TM.

Table 7-2 Condition Assessment Summary

	MECHANICAL				ELECTRICAL			
Tank/Reservoir	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
CCT	2	2005	35	16	3	2005	20	5
Clearwell	2	2000	35	14	3	2000	20	5
R-1	2	2005	35	16	1	2005	20	9
R-2	2	1970	35	11	5	1970	20	1
R-3A	3	1990	35	9	1	1990	20	7
R-3B	3	1990	35	9	1	1990	20	7

	STRUCTURAL				ABOVE GROUND PIPING			
Tank/Reservoir	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)
CCT	2	2005	50	27	2	2005	75	47
Clearwell	3	2000	50	17	2	2000	75	43
R-1	3	2000	50	17	3	2005	75	33
R-2	4	1970	50	6	4	1970	75	12
R-3A	3	1990	50	15	1	1990	75	45
R-3B	3	1990	50	15	NA	1990	75	NA

Table 7-3 Risk of Failure for Treated Water Storage Tank/Reservoir Projects

Project Number	Project Name	Overall Condition Rating Range (1-5) [1]	Overall Remaining Useful Life (Years)	Consequence of Failure (1-5)	Probability of Failure (1-5)	Risk of Failure (0-100) [1]
ST-001	CCT Rehabilitation	3	24	4	1	16
ST-002	Clearwell Rehabilitation	3	20	5	3	60
ST-003	R-1 Rehabilitation	3	19	5	1	20
ST-004	R-2 Rehabilitation	5	8	5	4	80
ST-005	R-3A Rehabilitation	3	19	4	2	32
ST-006	R-3B Rehabilitation	3	10	4	3	48
ST-007	Ongoing Condition Assessment of the Treated Water Tanks/Reservoirs	3	-	3	3	36

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

SUMMARY OF RECOMMENDED IMPROVEMENTS

Table 7-4 shows summary of recommended improvements for the CCT, Clearwell, R-1 Reservoir, R-2 Reservoir, and R-3A and R-3B Reservoir. Additionally, it is recommended that every five years, City staff review the existing CIP list and consult with operation and maintenance staff on their assessment of what requires attention, with inspections as required and a focus on re-assessing the most critical pending CIP projects. The results could be adjustments to the priority or budgets of existing CIPs and/or the addition of new CIP projects. This project is not to necessarily provide a complete condition assessment, but to update the condition assessment from the previous five-year cycle. An ongoing condition assessment CIP project (ST-007) is included in the proposed CIP.

Table 7-4 Summary of Recommended Projects

Observation Type	Chlorine Contact (ST-001)	Clearwell (ST-002)	R-1 (ST-003)	R-2 (ST-004)	R-3A (ST-005)	R-3B (ST-006)
General Site [1]	• Connect tank overflow piping to existing Clearwell overflow piping • Repair pavement section separation from ringwall • Pave the access road to the tank site from paved road to the lagoons • Repave the AC pavement on entire site with proper grading to divert runoff away from tank		• Monitor existing cracks in pavement • Clear debris and incorporate erosion protection measures on the north slope of existing v-ditch	• Redesign pavement section for the access road • Grade and pave entire site to ensure full access (12 ft minimum) around the tank perimeter	• Repair/replace access road from Panorama Drive • Grade and pave entire site to ensure full access (12 ft minimum) around the tank perimeter	
Security	• Repair few rails of the electric gate at the entrance to the WTP • Replace deteriorating portions of fence/gate • Add lighting at or near the tank		None	• Replace the chain-link fence and barbed wire • Replace man-gates and pad locks • Add lighting at or near the tank • Consider adding CCTV security cameras	• Repair/replace access gate at the top of the hill • Repair/replace the chain-link fence and barbed wire • Add lighting at/or near the tank access ladders and/or valving clusters	
Sanitary	None	• Replace tank overflow mesh screen	• Replace tank overflow mesh screen and overflow piping pipe support	• Replace the overflow mesh screen	None	
Mechanical	None					
Site Piping	• Consider adding removable bollards to protect exposed sampling booster pump and piping		None			
Structural	• Repair wall cracks and horizontal cracks • Inspection of the hillside to verify if stabilization is required.	None	• Repair intermittent corrosion, cracks on concrete surface, and chipped-off concrete	• Repair rust formation on anchors and supporting lug plates • Repair crack on concrete foundation	• Repair wall cracks and continuous horizontal cracks • Repair leaks (particularly Tank R-3B	
Instrumentation	• Place the transmitter inside of a proper stainless-steel cabinet	• Replace interconnecting cables with properly rates cables or routed in properly rated conduit • Consider replacing enclosure and installing a sun shade	• Rotate isolation ball valves • Use proper calibration ports	• Consider a complete site overhaul • Replace reservoir level transmitter cabinet with a proper stainless steel cabinet • Properly re-run and protect reservoir level transmitter sensing line • Properly route and support reservoir water sample line	None	
Safety	None				• Consider deactivating the cellphone towers while performing any repair work near the tank premises.	

[1] General site paving could be implemented through maintenance programs, but are included here so budget is allocated

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TM 8 – CONDITION ASSESSMENT OF WATER TREATMENT PLANT

The purpose of this TM 8 is to document the condition assessment of the existing Water Treatment Plant (WTP) facilities at the City of Benicia (City) as part of the Water Master Plan Update.

The condition scores given to the equipment and structures are used to develop a list of recommended improvements projects. These scores are also used to prioritize the projects based on the risk to operations or the health/safety of City staff and the general public.

BACKGROUND

The City owns and operates a surface WTP that provides potable water to residential, municipal, and industrial users throughout its service area. The City also provides raw (untreated) surface water to the Valero refinery, through the Diversion Structure at the WTP. The WTP has a rated maximum capacity of 12 million gallons per day (MGD) of treated water flow and an average flow rate of 3.5 MGD. In the summer of 2019, the maximum daily treated flow rate at the WTP was 5.8 MGD.

Water demands in the City of Benicia have not kept up with estimates from the 2012 Water Master Plan. There are several reasons for the lower water demands: 1) population growth in the City/water service area has been lower than anticipated; 2) water conservation efforts implemented in 2014 and 2015 have resulted in long-term conservation habits within the City; and 3) a City-wide program for installation of smart-meters on the individual service connections. Given the rated capacity of the WTP, the water conservation efforts within the service area, and limited potential for growth in the City (geographical features make expansion difficult), there is no immediate need for capacity expansion of the WTP.

The WTP was originally constructed as part of the 1968 WTP project with construction completing in 1971, with major plant upgrades/expansions in 1987 and 2007. Several small projects have also been constructed at the WTP, including the construction of a new treated water storage tank, replacement of influent gates and actuators on Filters 1 and 2 and the addition of a flow control valve and chemical feed header on the raw water line, just downstream of the Diversion Structure, among others.

The original WTP was designed as a direct filtration treatment plant but has since been upgraded to a fully conventional treatment plant (with full flocculation and sedimentation facilities). The original WTP also had two circular solids separation clarifiers, upstream of the filters. The clarifiers have been taken out of service and are no longer part of the treatment process but the pipe stubs to the clarifier are still intact. Today, the unit process at the WTP include:

- Raw water diversion
- Flocculation/sedimentation
- Filtration
- Disinfection
- Residuals/Solids storage and washwater return
- Treated water storage

Raw water is delivered to the WTP from two primary sources: Solano Project via the Putah South Canal, and the State Water Project via the North Bay Aqueduct (NBA). Solano Project water is pumped to the

WTP via the Cordelia Pump Station, which is owned and operated by the City, and through the Raw Water Transmission Line. NBA water is pumped to the WTP by the state-owned Cordelia Forebay and Pumping Station, which has a short discharge line that connects to the City's Raw Water Transmission Line.

WATER TREATMENT PLANT SITE/FACILITIES CONDITION ASSESSMENT

This section provides a summary of the findings from the condition assessment of the WTP, in addition to a new ozonation project. The condition assessment is broken down into the following unit process areas and general WTP inspections:

- General WTP Civil, Site, and Drainage
- Site Power, Electrical, and SCADA
- Raw Water Diversion Structure
- Flash Mixing and Pre-Treatment Chemical Injection
- Flocculation and Sedimentation Basins
- Filters
- Disinfection
- Solids/Residuals Storage and Pumping
- Miscellaneous Structures and Processes

EVALUATED REMAINING USEFUL LIFE OF EQUIPMENT

Table 8-1 shows the evaluated remaining useful life of the mechanical, electrical and instrumentation, structural, and above ground piping equipment for each major unit process based on the condition ratings, installation ratings, and original useful life.

Table 8-1 WTP Evaluated Remaining Useful Life of Equipment

	MECHANICAL				ELECTRICAL AND INSTRUMENTATION				STRUCTURAL			
Asset / Major Unit Process Area	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Condition	Installation Year	OUL (yrs)	ERUL (yrs)	Overall Structural Condition	Installation Year	OUL (yrs)	ERUL (yrs)
Diversion Structure	3	1968	25	5	2	1968	35	10	2	1968	50	17
Rapid Mix/Chemical Injection	2	1968	25	7	2	1968	35	10	2	1968	50	17
Flocculation Basin 1	3	1987	25	5	3	1987	35	8	2	1987	50	20
Flocculation Basin 2	2	2007	25	11	3	2007	35	13	2	2007	50	29
Sedimentation Basin 1	2	2017	25	18	3	1987	35	8	2	1987	50	20
Sedimentation Basin 2	2	2007	25	11	3	2007	35	13	2	2007	50	29
Filters 1 & 2	2	1968	25	7	2	1968	35	10	2	1968	50	17
Filters 3 & 4	4	1987	25	3	2	1968	35	10	2	1968	50	17
Filters 5 & 6	2	2007	25	11	2	1987	35	12	2	1987	50	20
Filter Pipe Gallery	3	1968	30	6	3	1968	35	7	3	1968	50	12
Backwash Tank	1	2007	50	35	2	2007	35	18	2	2007	50	29
Backwash Pumps	2	1968	35	10	2	1968	35	10	2	1968	50	17
Backwash Control Valve	3	1968	35	7	2	1968	35	10	1	1968	50	21
Chemical Storage, Feed and Disinfection	2	1987	25	8	2	1987	35	12	2	1987	50	20
Washwater Diversion Structure	2	1968	25	7	2	1968	35	10	3	1968	50	12
Solids Residuals, Storage and Pumping	2	1968	35	10	2	1968	35	10	2	1968	50	17
Influent Control Valve and Box	1	2013	35	27	2	2013	35	22	1	2013	50	41
Operations Building	2	1968	35	10	2	1968	35	10	1	1968	50	21
Chemical Building	2	1968	35	10	2	1968	35	10	1	1968	50	21
Clearwell	2	1977	50	18	2	1977	35	11	2	1977	50	18
Chlorine Contact Tank	2	1981	50	19	2	1981	35	12	1	2007	50	35
Analyzer Wastewater Tanks	2	1987	35	12	2	1987	35	12	1	1987	50	25
Energy Dissipator Box	3	1981	50	13	2	1981	35	12	3	1987	50	14
Site Civil	3	1987	25	5	1	1987	35	15	1	1987	50	25
Site Electrical	3	1968	35	7	2	1968	35	10	1	1968	50	21
SCADA system	2	2007	25	11	2	2007	25	11	1	2007	25	14

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SUMMARY OF RECOMMENDED WTP IMPROVEMENTS

The following is a summary of recommended improvement projects at the WTP. The recommended projects are the result of the condition assessment of existing facilities as well as staff interviews regarding operational procedures and challenges. The recommended improvements projects include critical improvements needed to avoid potential short-term catastrophic failures at the WTP as well as long-term maintenance equipment replacement projects and other projects in the spectrum between.

The recommended improvements projects are described briefly in **Table 8-2** below.

Table 8-2 WTP Recommended Projects

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
Diversion Structure gate and actuator replacement	The slide gates are original to the WTP and have exceeded their expected useful life. Actuators and Disconnects should also be replaced.	Raw water flow will have to be paused/disrupted during the construction project.	WTP-001
Flocculation Basin 1 gate replacement	Gates and actuators were installed in the 1988 improvements project. Gates, actuators, and disconnects have exceeded their expected useful service.	This project will require that the Floc Basin 1 be taken offline. There is redundancy with a separate treatment train.	WTP-002
Flocculation Basin 1 mixer replacement	Mixers, motors, disconnects, and FCS were installed in the 1988 improvements project. Mixer motors and disconnects show signs of corrosion.	This project will require that Floc Basin 1 be taken offline. It may also include re-configuring of the walkways between and around the mixers to meet current codes for clearance.	WTP-002
Flocculation Basin 1 redwood baffle replacement	Redwood baffles are deteriorating and need to be replaced.	This project will require that a Floc Basin be taken offline while the work is completed.	WTP-002
Sedimentation Basin 1 and 2 concrete recoating	The concrete on the interior walls of Sed Basins 1 & 2, especially around the water surface, is deteriorating and aggregate is exposed. The concrete walls need recoating to extend their service life.	The Floc/Sed Basin treatment train must be taken offline to perform the work. The walls will need to be sufficiently dry before the walls can be cleaned, and a coating applied. The coating must be NSF-61 approved.	Basin 1: WTP-002 Basin 2: WTP-003
Sedimentation Basin 2 access walkway	The troughs on Sed Basin 2 require frequent cleaning to remove algae and solids in the troughs. The troughs require spray cleaning and an access walkway would facilitate this as opposed to working from ladders.	Any maintenance in either Sed Basin requires a shut-down of that basin. Work would have to be completed when demands were sufficiently low to run on just one Floc/Sed Basin train.	WTP-003

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
Filter Basins slide gates and actuators	The filter slide gates that were installed with the original WTP construction have exceeded their expected life. A program should be implemented to change out all of the slide gates, actuators, and disconnects over a ten-year period starting with the oldest or most in need of upgrade.	There is redundancy in the filters such that gates can be isolated while work is being done on one filter (except for the inlet gate).	Filters 1 & 2: WTP-004 Filters 3 & 4: WTP-005 Filters 5 & 6: WTP-006
Filter Basins surface spray wash system and troughs	The surface spray wash support steel and troughs for all filters is corroded and needs re-coating (and possibly re-attachment to the walls)	Filters may be taken offline to complete this work one at a time.	Filters 1 & 2: WTP-004 Filters 3 & 4: WTP-005 Filters 5 & 6: WTP-006
Filter Basin wall repair	Concrete is washing away on the interior filter basin walls. Aggregate is exposed and the walls should be coated to extend the useful service life of the concrete.	Filters may be taken offline one at a time to coat interior walls. This work will require temporarily removing outlet trough and surface spray support bars as well as filter media.	Filters 1 & 2: WTP-004 Filters 3 & 4: WTP-005 Filters 5 & 6: WTP-006
Filter Pipe Gallery Improvements	Valves in the Filter Pipe Gallery installed in the original WTP construction have exceeded their expected service life. Valves and pipe in the pipe gallery all need to be recoated. Actuators need to be checked for operation and replaced as needed. Much of the original coating on the pipes in the gallery is chipping away and the pipe is corroding. Additionally, the concrete walls have experienced extensive cracking and efflorescence is occurring. Also observed was organic material (such as moss) growing in the cracks.	This is a major project that would require a complete WTP shutdown. The concrete floor in the pipe gallery will need to be chipped away in some locations to replace gaskets in flanged fittings and replace valves.	WTP-007

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
Backwash Tank Improvements	These improvements are needed for safety purposes and proper instrumentation. Lighting should be added at or near the tank. It should be considered to add removable bollards to protect exposed sampling booster pump and piping. The transmitter should be placed inside of a proper stainless steel cabinet.		WTP-008
Filter Backwash Control Valve replacement	The Filter Backwash Control Valve was installed as part of the original WTP construction. It has exceeded its expected useful life will need to be replaced to operate reliably.	This is a difficult project due to the size of the valve and the difficulty in accessing/installing it. There is limited space in the vault to work. Replacing the valve will require a complete WTP shutdown.	WTP-009
Chemical Feed piping	Chemical feed piping in the Flash Mixing Room requires more structural support. Exposed exterior PVC piping at various places around the WTP are suffering UV degradation and need to be replaced.	This work may require temporary shutdowns of some facilities but should not be a major operational disruption.	WTP-010
Sludge Drying Bed lining	One or more of the existing Sludge Drying beds shows signs of a leak. Drying beds should be lined with a concrete floor and walls reinforced with shotcrete to extend lifetime and reduce permeability. Drying beds 4 & 5 were constructed with concrete bottoms and shotcrete walls in 2005 and will not require relining.	This work will require one drying bed at a time to be taken offline for work. Work may be spread out over several years to complete.	WTP-011
Filter Backwash Solids Receiving Channel relining	The Filter Backwash Solids Receiving Channel is cracking and needs relining. The redwood baffle at the end of the channel also needs to be replaced.	WTP operations may need to be disrupted by diverting backwash solids around the channel while work is being done.	WTP-011
Operations Building Investigation	The wood roofing system has a questionable sub-diaphragm. There is evidence of water staining in the Fascia/Soffit. The condition of the wood roofing system should be investigated and repaired as needed. A seismic evaluation and retrofitting for the CMU wall removal and diaphragm tie system need to be completed as required.		WTP-012
Chemical Building Investigation	The steel roofing system has a questionable sub-diaphragm and the system doesn't have a lateral load strut system to interior CMU shear walls. There is evidence of water in the Fascia/Soffit system. There is cracking, staining and efflorescence on the CMU walls.		WTP-012

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
Dissipator Box Rehabilitation	The structure shows signs of settlement. The pipe separation also needs to be repaired and the concrete should be restored as needed. The foundation system should be evaluated by a licensed geotechnical engineer.		WTP-013
General Pipe and Equipment recoating	Generally, much of the pipe, valves, actuator stands, pumps, and motors around the WTP is in need of recoating to protect them from further corrosion.	This project will have minimal effect on WTP operations and can be scheduled and performed in phases.	WTP-014
Plantwide Concrete Rehabilitation	Recoat or rehabilitate concrete around the WTP, as needed to extend the expected useful life of the concrete. Highlighted areas of concern include the diversion structure, washwater and sludge diversion structure, and the chemical tank farm.	In general, aging concrete has begun to spall and crack in places. This is due to both settling and weather damage. To extend the life of the structures, concrete repair work is required. This will have minimal impact on WTP operations.	WTP-015
Dedicated Finish Water Sample Pump	At present, a single sample pump supplies sample water from the treated water storage reservoir to the lab as well as water to the restrooms in the Operations Building and Chemical Building. The pump and supply line are not large enough to provide sufficient flow to all points of use. The sample line should be dedicated line to the lab and a new pump should be installed to supply potable water to the Operations and Chemical Buildings.	This project will require trenching from the Clearwell up to the WTP buildings and will disrupt treatment operations. It will need to be scheduled at a time to limit impact.	WTP-016
Power Distribution Upgrade	The MSB, MCC-A, and MCC-B were installed in 1987 and have exceeded their expected useful life. There are no standards set for VFD and starter manufacturer and components, therefore requiring multiple refurbished spare parts. Recommend replacing existing distribution MSB, MCC'S and ATS to accommodate for future Ozonation.	This project will require project phases to transition power from existing equipment to MSB and MCC. Facility shutdowns will be required.	WTP-017
Emergency Standby Power Upgrade	Replace existing combustion generator with new Diesel Engine Standby Generator sized to accommodate for facility critical load.	This project will not have much effect on WTP operations and can be scheduled and performed in phases.	WTP-018

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
SCADA Improvements	There is no redundancy in the current, aging SCADA architecture. The network and communication system is currently vulnerable to potential failure. The improvements will improve reliability, redundancy, monitoring and system control.	This project will not have much effect on WTP operations and can be scheduled and performed in phases. Coordinate upgrades at the WWTP to their SCADA system and negotiate licenses and support contracts, which can be shared between the two plants.	WTP-019
Facility Site Lighting	Replace existing light fixture throughout the facility to properly illuminate electrical/mechanical working areas.	This project will not have much effect on WTP operations and can be scheduled and performed in phases.	WTP-020
Facility Electrical Safety Improvements	Various disconnects and electrical equipment throughout the facility are not up-to electrical code with respect to working clearance required by NEC Article 110-26. Recommend replacing and relocating the disconnects and electrical equipment.	This project will not have much effect on WTP operations and can be scheduled and performed in phases.	WTP-021
Facility Safety Improvements	As needed, repair the rails of the electric gate at the entrance, and replace deteriorating portions of the fence/gate.	This project will not have much effect on WTP operations and can be scheduled and performed in phases.	WTP-022
Clarifier Demolition	The clarifiers installed with the original (1968) WTP construction are no longer used in treatment operations. The clarifiers can be demolished and new treatment facilities (Ozonation, ion exchange, etc.) may be installed in those locations.	This project will be discussed further in a separate TM regarding regulatory compliance at the WTP.	WTP-023
Yard Piping Replacement	Yard piping is a critical element of the WTP. However, inspection and completion of a condition assessment without digging or other investigatory work beyond the scope of this Master Plan, is not possible. Two projects are recommended for yard piping to rehabilitate the cathodic protection system, and to inspect the existing metallic buried pipes.	Yard piping repair or replacement projects can be disruptive to WTP operations. Projects should be timed and staged to limit adverse effects to treatment processes and chemical deliveries where roadways will be torn up.	Cathodic Protection Rehabilitation WTP-024 Inspection of Buried Metallic Pipe WTP-025
Operations and Chemical Building Annual Repair and Replacement	Per City policy, this project annually reserves 3% of the replacement value of both buildings.		WTP-026

Recommended Improvements	Reason for Project	Project Details and Challenges	Project Number
Ozonation System	The conversion from gaseous chlorine to bulk liquid sodium hypochlorite solution for disinfection is expected to affect water chemistry and pre-treatment of organics in the raw water. WTP operators pre-chlorinate the water as a means to oxidize organic compounds reduce TOC in the raw water. Pre-chlorination with sodium hypochlorite has high potential to produce disinfection by-products in the water. Adding ozone disinfection as a preliminary oxidant has been proven to be effective at other treatment plants with the same source water(s). This is a high priority project to be completed in conjunction with the gas chlorine conversion project.	The addition of a new treatment process can be difficult to fit into a plant with little available head in the hydraulic profile. A preliminary engineering study and report is recommended to be conducted for hydraulic and electrical feasibility at the plant.	WTP-027
Ongoing CIP	Review the existing CIP list, consult with operation and maintenance staff on their assessment of what requires attention, with inspections as required and a focus on re-assessing the most critical pending CIP projects. The results could be adjustments to the priority or budgets of existing CIPs and/or the addition of new CIP projects.		WTP-028

Table 8-3 shows the overall risk of failure for the recommended projects based on the consequences of failure and probability of failure ratings.

Table 8-3 Risk of Failure of the WTP Recommended Projects

Project Number	Project Name	Overall Condition Rating Range (1-5) [1]	Probability of Failure (1-5)	Consequence of Failure (1-5)	Redundant Unit?	Risk of Failure Range (0-100) [1]
WTP-001	Diversion Structure	3	3	3	No	36
WTP-002	Flocculation/ Sedimentation Basin 1	3	3	4	Yes	24
WTP-003	Flocculation/ Sedimentation Basin 2	3	2	4	Yes	16
WTP-004	Filters 1 & 2	2	3	5	Yes	30
WTP-005	Filters 3 & 4	4	3	5	Yes	30
WTP-006	Filters 5 & 6	2	3	5	Yes	30
WTP-007	Filter Pipe Gallery Improvements	3	4	5	No	80
WTP-008	Backwash Tank	2	1	4	Yes	8

Project Number	Project Name	Overall Condition Rating Range (1-5) [1]	Probability of Failure (1-5)	Consequence of Failure (1-5)	Redundant Unit?	Risk of Failure Range (0-100) [1]
WTP-009	Backwash Control Valve	3	3	5	No	60
WTP-010	Chemical Storage, Feed and Disinfection	2	3	4	Yes	24
WTP-011	Solids Residuals, Storage and Pumping	2	3	4	Yes	24
WTP-012	Operations Building	2	3	3	No	36
WTP-013	Energy Dissipator Box	3	3	2	No	24
WTP-014	General Pipe and Equipment Recoating	3	2	1	No	8
WTP-015	Plantwide Concrete Rehabilitation	2	2	2	No	16
WTP-016	Dedicated Finish Water Sample Pump	4	4	3	No	48
WTP-017	Power Distribution Upgrade	3	3	3	No	36
WTP-018	Emergency Standby Power Upgrade	3	3	3	No	36
WTP-019	SCADA Improvements	4	5	3	No	60
WTP-020	Facility Site Lighting	2	3	1	No	12
WTP-021	Facility Electrical Safety Improvements	2	3	2	No	24
WTP-022	Facility Safety Improvements	2	4	1	No	16
WTP-023	Clarifier Demolition	2	2	1	No	8
WTP-024	Cathodic Protection Rehabilitation	3	4	3	No	48
WTP-025	Inspection of Buried Metallic Pipe	3	4	2	No	32
WTP-026	Operations/Chemical Building Annual Repair & Replacement	2	3	3	No	36
WTP-027	Ozonation System	N/A	N/A	N/A	N/A	N/A
WTP-028	Ongoing Condition Assessment of the WTP	3	3	3	No	36

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

TM 9 – WATER DISTRIBUTION SYSTEM MODEL

The purpose of this TM 9 is to present a summary of the City of Benicia's potable water distribution system model, its use in this Master Plan Update, and conclusions drawn from hydraulic simulations. The water distribution system model was developed as part of the 2012 Water System Master Plan (2012 Master Plan). The selected hydraulic model can perform steady-state and extended period simulations of hydraulic conditions in the distribution under flow scenarios and system configurations.

Based on the current City land use planning and buildout conditions and those modeled as part of the 2012 Master Plan, there are no significant differences or water demand changes. Therefore, no new modeling efforts are completed with the current Master Plan Update with the exception of options for a City of Vallejo water intertie.

The following summary was developed directly from information presented in the 2012 Master Plan.

MASTER PLAN MODEL

This section provides a summary of the distribution system model, modeling effort, and related information as presented within the 2012 Master Plan. The City's existing hydraulic network model was developed based on City provided water system base maps as part of the 2012 Master Plan. The model was constructed using WaterCAD, V8i, software by Bentley.

PHYSICAL NETWORK

The physical network of the existing supply and distribution system was developed using the City's GIS water network database. Model input data that describe physical system characteristics of pipelines and junction nodes were extracted from the GIS database or estimated from data provided by City staff. Junction nodes define the end points of pipes and pipe segments and represent points of entry or discharge to meet specific water demands. The water system analysis is accomplished in the model by solving a series of hydraulic equations for pressure and flow requirements throughout the network.

MODELING CRITERIA

The following criteria were used in the development, calibration, and use of the hydraulic network model:

- All pipes 8-inches in diameter and larger were included in the model, except in critical areas of the system where modeling 6-inch and 4-inch pipes was necessary to complete a loop to provide accurate flow distribution.
- Pipe lengths and nominal diameters were obtained from the existing water system base maps developed and maintained by the City.
- Pump station configurations, pump performance curves, and motor nameplate information were acquired from "as-built" plans and documentation provided by the City.
- Ground surface elevations were obtained from Light Detection and Ranging (LiDAR) data obtained from Solano County.
- Water demands are expressed in gallons per minute (gpm)

Pipe material and age were the criteria used to establish a roughness, "C" factors (Hazen Williams Coefficient), within the hydraulic model. In general, C factors ranged from 100 to 115 in older portions of the City, and 120 to 130 in newer portions of City and developing areas. All new pipes assumed a C factor of 130.

WATER DEMAND DISTRIBUTION

Water demands were distributed throughout the network model using land use data provided by the City. Land uses included single family, multi-family, commercial, industrial, parks, and open space. The land use (unit) water demand factors corresponding to each land use designation were used to project demands from specific areas, as discussed in *TM 1 – Water Study Area Planning Parameters* of this Master Plan Update.

MODEL CALIBRATION

Model calibration required that the network model meet a set of observed operating conditions. A model is considered to be calibrated if it can estimate the observed pressure and flows within a reasonable range of error. Water demands, reservoir levels, and pump operating conditions are continually changing in the City's water system. Therefore, to calibrate the model, a snapshot of the system demand and pressures at a single point in time along with specific operating conditions was needed.

City staff conducted a series of fire flow tests that were used to calibrate the model. Field data for fire hydrant elevation, static pressure, residual pressure, pitot read pressure at flow, reservoir elevations, pump station operation, and total demand per zone were collected and used to calibrate the model. The acceptable error between simulated and observed results is 10% for purposes of master planning.

DISTRIBUTION SYSTEM ANALYSIS EVALUATION CRITERIA

The calibrated model was used to evaluate the performance of the system under existing and buildout demand conditions. The model predicts pressure, flow, head loss, velocity, and other hydraulic parameters which is compared to evaluation criteria that represent the level of service for the City. System deficiencies were identified when model projections failed to meet the evaluation criteria. The level of service criteria used in the analysis of model results are presented in **Table 9-1**.

Table 9-1 Level of Service Evaluation Criteria

Criteria	Modeled Condition	Value	Notes
Minimum Pressure	Average Day Demand	40 psi	
Minimum Pressure	Maximum Day Demand	35 psi	
Minimum Pressure	Peak Hour Demand	30 psi	
Minimum Residual Pressure	Fire Flow	20 psi	
Maximum Pressure at Service Connection	All	125 psi	PRV required at 80 psi per Uniform Fire Code (UFC)
Maximum Velocity	All	8 fps	Typical
Maximum Velocity	All	12 fps	Short durations
Maximum Head Loss	All	10 ft per 1,000 ft	
Main Sizing	All	Greater of maximum day plus fire flow or peak hour demand	

MASTER PLAN SCENARIOS AND SIMULATED CONDITIONS

Twelve scenarios were developed to evaluate the water distribution system under existing demand conditions. Simulations that stress system capacity include maximum day demand, maximum day demand plus fire flow, and peak hour demand. Model simulations assume the worst-case scenario, when the level in reservoirs is at the lowest point of normal operation, feeding the system via gravity with flow from reservoirs. Maximum day demand and fire flow simulations were conducted for each pressure zone. The buildout model simulation was developed by increasing water demands in areas projected to have future development. The majority of future demand will come from infill projects within Zone 1. Some major developments, like the Benicia Business Park, are assumed to include new conveyance, booster pumping, and storage facilities from Zone 1 to provide service within the area of development. For purposes of modeling the buildout system, peak hour demands and maximum day plus fire flow were evaluated at the point where the booster pump station may be located.

CITY OF VALLEJO POTABLE WATER INTERTIE

The City of Benicia and City of Vallejo are adjacent, and each has its own self-contained water supply, treatment and distribution system. It has been identified since 1962 that both cities could benefit from an intertie between their respective distribution systems and this is codified in an Agreement, currently valid until 2025. It is assumed that it will be renewed at its expiration. The current Agreement includes 1,100 acre-feet of water per year at a rate of 3 mgd. See the 2012 Water Master Plan for additional detail and a copy of the Agreement.

INTERTIE SCENARIOS

The 2012 Master Plan identified a possible intertie alignment for the future intertie would be from Benicia Road at Columbus Parkway, crossing point under I-780, running parallel to I-780 along the frontage road, and tying into the loop at West K Street and Military West. This was proposed to be a 12-inch pipe and connects Benicia Zone 1 to Vallejo Zone 262. This intertie project is reflected in **Table 9-2**.

This Master Plan Update considered five additional potable water interconnection scenarios in addition to the one considered previously. These include:

Table 9-2 Intertie Scenarios

Intertie No.	Benicia Pressure Zone	Vallejo Pressure Zone
1	1	262 (2012 intertie scenario)
2	3	262
3	1	400
4	3	400
5	3	400 (cross country alignment)
6	3	600 (cross country alignment)

For modeling purposes, all intertie scenarios considered a 12-inch diameter pipe at 5 feet per second, which is a flow of 2.6 mgd under MDD conditions. Larger pipes could be considered, but they would require additional improvements at the point of connection to utilize the larger diameter capacity. Further, a higher velocity could be utilized to transfer more flow, such as the current Agreement target of 3 mgd. In the flow direction of Benicia to Vallejo, higher velocities incur too much head loss and neighborhood pressures can drop below 35 psi. In the flow direction of Vallejo to Benicia, some scenarios would allow higher velocities and therefore higher flows with acceptable pressures.

INTERTIE OPINIONS OF PROBABLE COST

The costs for these planning projects will vary by alignment and the complexity of the utilities the connect to and cross, land uses, and the properties and rights of way they traverse. For this analysis, the opinion of probable costs use general planning values for purposes of intertie option comparison.

For the selected intertie alternative, a refined estimate matching the CIP protocols of TM 12 are developed in that TM. Variations of these intertie scenarios that only supply Benicia are possible; they may reduce project components and associated costs, as appropriate for each scenario. These variations are not presented here but could be an extension of this analysis.

Planning level costs for the 6 Vallejo intertie scenarios are presented in **Table 9-3**.

Table 9-3 Vallejo Intertie Opinions of Probable Costs [1]

Intertie No.	Estimated Cost	CIP Project
1	$10,800,000	-
2	$11,7000,000	-
3	$15,000,000	-
4	$11,200,000	-
5	$10,500,000	-
6	$7,800,000	WD-014

[1] This is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

INTERTIE RECOMMENDATION

Based on estimated costs and simplicity, Intertie No. 6 is recommended. Transferring water at the highest-pressure zone also accommodates sharing to lower pressure zones. This intertie option was further evaluated at the target value of 3 mgd, which has been shown to be feasible under most demand conditions. However, refined modeling will be required by both cities to confirm the exact flows and pressures that can be transmitted in each direction and under what flow conditions. This will be important for operations and for the inter-city Agreement.

Governance of the intertie, and possible cost sharing, could be addressed as an amendment to the existing inter-city agreement for water service (Vallejo Agreement), or as a new standalone agreement. Additional project concept refinement and an agreement should be in place prior implementing this intertie project.

TM 10 – WATER SUSTAINABILITY AND RESILIENCY EVALUATION

The purpose of this sustainability and resiliency evaluation is to identify projects for the City that could improve the sustainability and resiliency of the City's water system. This TM serves as one of the many steps the City has taken to improve its sustainability and resiliency. It is one of twelve TMs that comprise this Water Master Plan Update based on condition assessment work, which resulted in a list of recommended CIP projects, addressing water reliability, energy sustainability, and resiliency. Draft Sustainability Action Plans (SAPs) of certain resiliency CIP projects is included in **Appendix A**. The SAPs include recommended actions to be taken during three time frames – one to five years, six to ten years, and beyond ten years.

Additionally, a triple bottom line (TBL) analysis of two water reuse project options was completed to assess the feasibility of reusing treated wastewater effluent to improve water sustainability for the City.

APPROACH & METHODOLOGY

The condition assessment work completed for the Water Master Plan Update resulted in a list of recommended projects to include in the City's CIP. The CIP projects are categorized as either a reliability, energy sustainability, or resiliency project and the reliability projects are discussed further in other TMs.

This TM provides a TBL analysis of two water reuse project options – indirect potable reuse (IPR) and non-potable reuse (NPR). Both projects can improve the water sustainability for the City and were compared by assessing each projects respective environmental, social, and economic impacts. The two projects were scored for each criterion on a scale of 1-7 with a higher number favoring the City's investment. A scale showing the descriptions of scorings for each criterion and how each project scores is provided.

CITY'S CLIMATE ACTION PLAN

The City has completed previous work towards improving its sustainability and resiliency. The 2009 Benicia Climate Action Plan (CAP) contains a section on the water and wastewater systems. The CAP includes three objectives for the City's water and wastewater systems – 1) reduce the amount of water consumed by 20% by 2020, 2) reduce the amount of emissions resulting from pumps and lift stations, and 3) reduce the amount of emissions resulting from water and wastewater plant operations by 95% by 2020. The CAP shows that the City has been consciously working towards improving its sustainability and resiliency for years. Although these objectives were targeted to be completed by this year (2020), the intent behind the objectives remains – to have a plan to address climate change at a local level.

The water condition assessment (TM 4, TM 5, TM 6, TM 7, and TM 8) resulted in recommended CIP projects (TM 12) for the water system. The recommended reliability CIP projects are discussed in further detail in the respective condition assessment TMs. This TM does not include additional assessment of the reliability projects. However, every project recommended for the City's CIP is identified as an important improvement for the City, supporting the overall sustainability goals. Most CIP projects are categorized as reliability projects. However, some reliability projects also relate to energy sustainability (e.g., replacing pumps at risk of failure with higher efficiency pumps).

RECOMMENDED SUSTAINABILITY/RESILIENCY CIP PROJECTS

Below are project descriptions of the recommended water CIP projects that were identified as resiliency projects (no projects were identified as energy sustainability for the water system). These projects relate to the objectives and strategies included in the City's CAP and/or could help improve the sustainability and/or resiliency of the water system.

Resiliency CIPs:

- ***Emergency standby generator power upgrade (WTP-018) –*** This project proposes to replace the existing combustion generator with a new diesel engine standby generator sized to accommodate the WTP's critical load. The current emergency standby generator was installed in 1987. An evaluation of the critical loads will be required for proper load shedding and to confirm the generator capacity requirements. This project would increase the resiliency of the WTP by ensuring the continued operation of the WTP in the event of an emergency.
- ***Reliability transmission main from WTP (WD-006) –*** To improve the resiliency of the distribution system, this project proposes to construct a parallel 36-inch transmission main alongside the existing 30-inch transmission main that extends from the WTP to Industrial Way. This is a critical pipeline as it is the only pipeline that conveys potable water from the WTP to Zone 1. The pipeline is nearing the end of its expected life. A parallel transmission main would improve the resiliency and reliability of the distribution system by reducing the risk of potable water service interruption if the existing pipe were to fail.
- ***Vallejo treated water intertie (WD-014) –*** The City of Benicia and the City of Vallejo each have its own self-containing water supply, treatment, and distribution. It has been identified that both of the neighboring cities could benefit from an intertie between their respective distribution systems. TM 9 evaluates six different intertie scenarios. The recommended scenario is to install a new 12-inch pipeline from Vallejo Zone 600 to Benicia Zone 3 (approximately 3,600 LF) and a booster pump station. The Vallejo Intertie project requires a route and project constraint analysis to determine the constructability issues and final alignment. An additional source of treated water would improve the resiliency of both cities by allowing for continued potable water service in the event of an emergency or failure at the WTP or the distribution system.
- ***Parallel raw water transmission line (RW-003) –*** This project proposes to improve the resiliency of the raw water supply through construction of a parallel raw water transmission line (RWTL) alongside the existing RWTL (approximately 65,000 linear feet). The RWTL is the vital artery for supplying raw water from both the North Bay Aqueduct and Terminal Reservoir to the City of Benicia's WTP. A new pipeline will provide an increased capacity and extended reliability for another 60 to 80 years. The proposed CIP assumes that the parallel RWTL would be constructed in eight phases with sections being constructed and tied into the existing pipe.
- ***Vallejo raw water transmission line intertie (RW-005, contingent project) –*** Alternatively to the parallel RWTL (RW-003), a raw water intertie between the City of Benicia and the City of Vallejo would be another option for adding reliability to the raw water supply. A second raw water source would greatly increase the security of potable water delivery to the City. A raw water intertie with Vallejo could come at a lower cost with approximately 42,000 linear feet of new pipe, but with more logistical complexity due to the need for inter-city agreements and coordination. This version of the supply back-up would also have the benefit of being able to support Vallejo (two-way flow). This project is included in the CIP as a contingent project because it requires negotiations with the City of Vallejo to evaluate and implement this RWTL alternative, including confirmation that their water supply is sufficient to support Benicia, though this is indicated in their UWMP. Multiple arrangements for this raw water intertie could be developed. If the intertie is viable and agreeable, this project would provide a more economical raw water reliability project and is recommended to be completed in lieu of project RW-003.

Although not discussed in detail here, proposed CIP RW-004 is for the rehabilitation of the existing RWTL. This project was not categorized as a resiliency project as it is considered routine maintenance and a reliability project. However, it is important to note that with either the parallel RWTL or the Vallejo intertie, the City must also rehabilitate the existing RWTL to achieve resiliency of the raw water system.

WATER REUSE TRIPLE BOTTOM LINE ANALYSIS

Water reuse could improve the City's water sustainability. Below is a triple bottom line analysis comparing the environmental, social, and economic impacts of two types of water reuse – indirect potable reuse and non-potable reuse (including industrial reuse). After a description of the two projects, the results of the TBL analysis are presented through a discussion of how each project compared for each criterion. The criteria selected include the following:

- Environmental
  - Water stress
  - Greenhouse gas (GHG) emissions
- Social
  - Potential health risks
- Economic
  - Capital costs
  - Operation and maintenance (O&M) costs
  - Institutional control over resources

NON-POTABLE REUSE (INCLUDING INDUSTRIAL REUSE) (I.E., NPR)

The June 2017 Benicia Water Reuse Study Feasibility Report by Brown and Caldwell (Water Reuse Study) studied the feasibility of implementing water reuse within the City of Benicia. The largest reuse option involved conveying recycled water to the Valero Refinery (Valero or Refinery) for cooling tower makeup water (i.e., industrial reuse). An additional reuse option studied in the Water Reuse Study involved utilizing the proposed Refinery conveyance pipeline to also convey recycled water to City customers for irrigation purposes. It was anticipated that approximately 2,000 acre-feet per year (AFY) of recycled water could be delivered to the Refinery and approximately 30-40 AFY could be utilized to offset potable water irrigation demands.

The project selected in the Water Reuse Study included treatment upgrades at the WWTP, a pump station at the WWTP, a 0.5 million gallon storage tank at the Valero Refinery, and a recycled water conveyance pipeline along City right-of-ways (ROWs). The major treatment upgrades at the WWTP included chemical addition for phosphate removal, a Modified Ludzack-Ettinger (MLE) process (nitrifying activated sludge) for ammonia removal, cloth media filtration for solids removal, and chlorination for disinfection. The NPR treatment system was sized for the Refinery's cooling tower peak month demand of 2.0 mgd. The recycled water conveyance pipeline to the refinery included approximately 14,500 linear feet of new 14-inch diameter pipe. The full Benicia Water Reuse Study Feasibility Report includes greater detail on this non-potable reuse project.

SURFACE WATER AUGMENTATION (I.E., INDIRECT POTABLE REUSE, IPR)

For the surface water augmentation project, advanced purified effluent would be sent to Lake Herman for storage before being conveyed as a raw water source to the Water Treatment Plant (WTP) for further treatment. It was assumed that the IPR system would be sized for the same flow as the NPR system (up to 2.0 mgd). Although, the IPR system may be sized differently following detailed design. Additionally, if the water elevation of Lake Herman is especially low, the amount of advanced purified effluent that may be conveyed to Lake Herman may be reduced to maintain dilution requirements with raw water volumes. The surface water regulations (California Code of Regulations Title 22, Division 4) require either a 100:1

or 10:1 dilution based on the number of log removals achieved by the treatment system. This project may require altering the City's water rights for Lake Herman per Water Right License 4900.

To achieve advanced purified effluent, upgrades would be required at the WWTP and an Advanced Water Purification Facility (AWPF) would need to be constructed. If the City chooses to pursue IPR, a detailed feasibility study should be conducted. For the purposes of this TBL analysis, it was assumed that the treatment improvements at the WWTP would include chemical addition for phosphate removal and a tertiary membrane bioreactor (TMBR). The Water Reuse Study contained a treatment alternative that included chemical addition, a TMBR, and an ultraviolet (UV) disinfection system. The chemical addition and TMBR information available for this alternative was used in this TBL analysis. It was also assumed that the AWPF would include reverse osmosis (RO) and a UV advanced oxidation process (AOP).

A recycled water pipeline from the AWPF to Lake Herman would need to be constructed. It was assumed that the AWPF would be located on or next to the WWTP. It was assumed that a portion of the 14-inch diameter pipeline alignment to the Refinery selected for the NPR project would be utilized to convey the advanced purified effluent to Lake Herman (except the portion on Valero's property) and would be extended to Lake Herman, roughly following the existing raw water pipeline alignment..

RECOMMENDATION

Figure 10-1 and **Table 10-1** are summaries of how IPR and NPR scored for each criterion with a higher score favoring the City's investment.

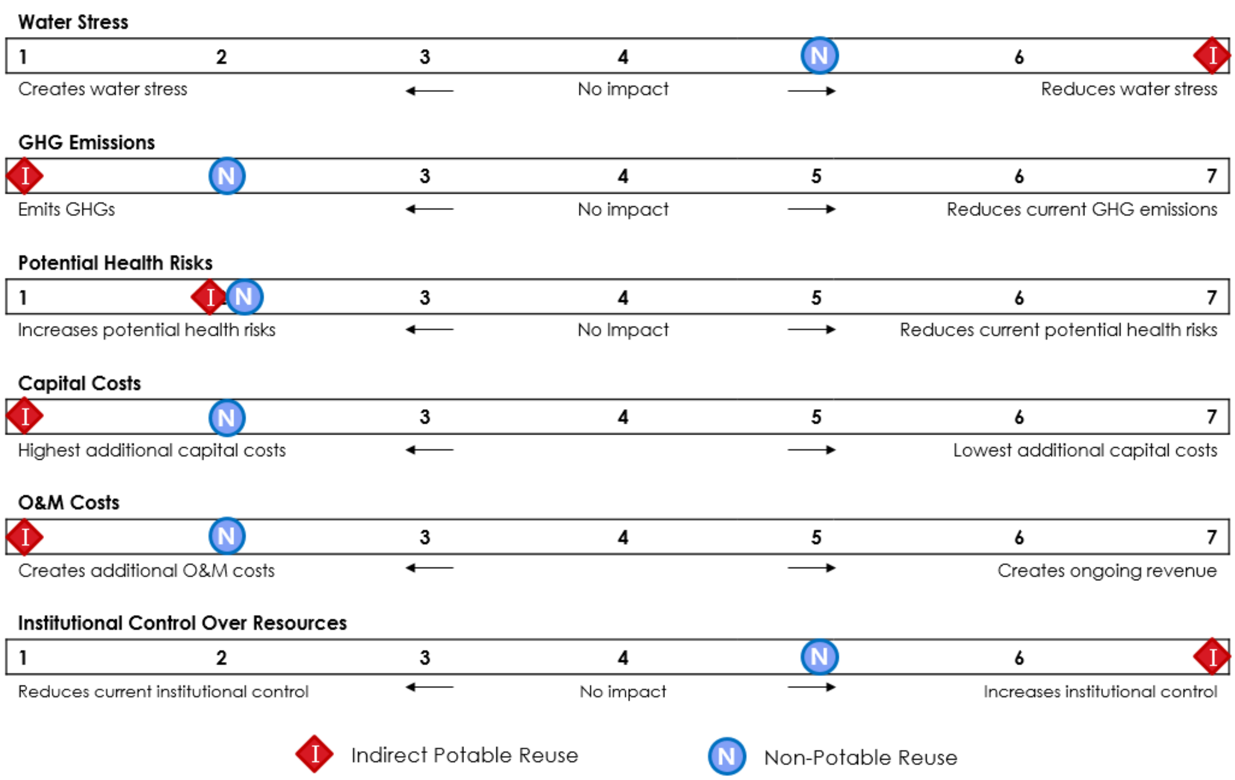

Figure 10-1 Water Reuse Project Scores

Table 10-1 Water Reuse Project Scores

Category	NPR	IPR
Water Stress	5	7
GHG Emissions	2	1
Potential Health Risks	2	2
Capital Costs	2	1
O&M Costs	2	1
Institutional Control Over Resources	5	7
Total	**18**	**19**

IPR scores higher on water stress and institutional control over resources, and NPR scores higher on GHG emissions, capital cost, and O&M costs Overall, IPR scores higher than NPR by one point. Additionally, NPR may not provide a reliable investment for the City and offers limited flexibility as compared to IPR due to having only one potential primary recycled water user. Moreover, Valero has expressed that raw water is preferred for the cooling towers over the recycled water. While Valero may be interested in receiving the recycled water, they may not commit to receiving the recycled water continuously or in perpetuity.

Draft Action Plans for the Vallejo Treated Water Intertie and the Raw Water Transmission Line were developed for discussion, completion and implementation by the City. These draft Action Plans are included in detail with the TM, with outlines as summarized below. A draft action plan for IPR was also included and included with the Wastewater Mater Plan Update (that project is related to both wastewater and water and is therefore presented in both Updates.)

VALLEJO TREATED WATER INTERTIE ACTION PLAN – DRAFT

The draft action plan includes the following sections (with additional detail in the TM):

- Project Background & Description
- Project Purpose, Justification, & Relation to City Goals & Objectives
- Project Information
- Action Plan

ACTION PLAN

Tables 1 and **2** below show the recommended actions to take during approximate years one through five, and six years and beyond, respectively. The due dates provided in these tables assumes that the project begins in July 2021 (the beginning of FY 2021/2022). The due dates will need to be updated depending on actual project commencement and as project development is refined.

Table 1 Recommended Actions to Be Taken During Years One Through Five

Step	Action	Responsible Party	Approximate Duration	Due Date
1	Coordination with the City of Vallejo	City Staff & Consultant; City of Vallejo	6 months	January 2022
2	Public Outreach Focused and deliberate campaign, with mailers, public meetings, follow-up, council presentations, etc.	City Staff & Consultant; City of Vallejo	6 months	July 2022
3	Coordination with Agencies (not necessarily complete nor are all necessarily applicable) • State Water Resources Control Board Division of Drinking Water Permitting • Bay Area Air Quality Management District • Solano County • Benicia Building Department • Vallejo Building Department • California Department of Fish and Wildlife • US Army Corps of Engineers	City Staff & Consultant	Ongoing	-
4	Procure Funding	City Staff & Consultant	6 months (preliminary coordination may proceed formal funding procurement period)	January 2023
5	Preliminary Design and Funding • Site visit and as-built drawing review • System pressure determination • Route analysis • Utility coordination • Mitigation determination • Constraint analysis • Pipeline design (material, diameter, fittings, cathodic protection, etc.)	City Staff & Consultant	6 months	July 2023
6	Detailed Design	City Staff & Consultant	6 months	January 2024
7	Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2024

Step	Action	Responsible Party	Approximate Duration	Due Date
8	Construction	City Staff, Consultant, & Contractor	1 year	July 2025
9	Project Commissioning (start-up, testing & warranty period)	City Staff, Consultant, & Contractor; City of Vallejo	1 year	July 2026

Table 2 Recommended Actions to Be Taken Beyond Year Five

Step	Action	Responsible Party	Anticipated Duration	Due Date
10	Project Use, Monitoring, Agreement Maintenance	City Staff, Consultant; City of Vallejo	Ongoing	-

RAW WATER TRANSMISSION LINE ACTION PLAN – DRAFT

The draft action plan includes the following sections (with additional detail in the TM):

- Project Background & Description
- Project Purpose, Justification, & Relation to City Goals & Objectives
- Project Information
- Action Plan

ACTION PLAN

Table 1, 2, and **3** below show the recommended actions to take during approximate years one through five, six through ten, and beyond year ten, respectively. The due dates provided in these tables assumes that the project begins in July 2021 (the beginning of FY 2021/2022). The due dates will need to be updated depending on actual project commencement and as project development is refined.

Table 1 Recommended Actions to Be Taken During Years One Through Five

Step	Action	Responsible Party	Approximate Duration	Due Date
1	Coordination with the City of Vallejo	City Staff & Consultant; City of Vallejo	6 months	January 2022
2	Public Outreach Focused and deliberate campaign, with mailers, public meetings, follow-up, council presentations, etc.	City Staff & Consultant; City of Vallejo	6 months	July 2022

Step	Action	Responsible Party	Approximate Duration	Due Date
3	Coordination with Agencies (not necessarily complete nor are all necessarily applicable) • State Water Resources Control Board Division of Drinking Water Permitting • Bay Area Air Quality Management District • Caltrans • Solano County • Benicia Building Department • California Department of Fish and Wildlife • US Army Corps of Engineers	City Staff & Consultant	Ongoing	-
4	Procure Funding	City Staff & Consultant	1 year (preliminary coordination may proceed formal funding procurement period)	July 2023
5	Preliminary Design and Funding • Site visit and as-built drawing review • System pressure determination • Route analysis • Utility coordination • Mitigation determination • Constraint analysis • Pipeline design (material, diameter, fittings, cathodic protection, etc.) The preliminary design stage will include planning/designing the entire pipeline.	City Staff & Consultant	1 year	July 2024
6	Segment 1 Detailed Design	City Staff & Consultant	6 months	January 2025
7	Segment 1 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2025
8	Segment 1 Construction	City Staff, Consultant, & Contractor	1 year	July 2026

Table 2 Recommended Actions to Be Taken During Years Six Through Ten

Step	Action	Responsible Party	Anticipated Duration	Due Date
9	Segment 2 Detailed Design	City Staff & Consultant	6 months	January 2027
10	Segment 2 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2027
11	Segment 2 Construction	City Staff, Consultant, & Contractor	1 year	July 2028
12	Segment 3 Detailed Design	City Staff & Consultant	6 months	January 2029
13	Segment 3 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2029
14	Segment 3 Construction	City Staff, Consultant, & Contractor	1 year	July 2030
15	Segment 4 Detailed Design	City Staff & Consultant	6 months	January 2031
16	Segment 4 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2031

Table 3 Recommended Actions to Be Taken Beyond Year Ten

Step	Action	Responsible Party	Anticipated Duration	Due Date
17	Segment 4 Construction	City Staff, Consultant, & Contractor	1 year	July 2032
18	Segment 5 Detailed Design	City Staff & Consultant	6 months	January 2033
19	Segment 5 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2033
20	Segment 5 Construction	City Staff, Consultant, & Contractor	1 year	July 2034
21	Segment 6 Detailed Design	City Staff & Consultant	6 months	January 2035
22	Segment 6 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2035

Step	Action	Responsible Party	Anticipated Duration	Due Date
23	Segment 6 Construction	City Staff, Consultant, & Contractor	1 year	July 2036
24	Segment 7 Detailed Design	City Staff & Consultant	6 months	January 2037
25	Segment 7 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2037
26	Segment 7 Construction	City Staff, Consultant, & Contractor	1 year	July 2038
27	Segment 8 Detailed Design	City Staff & Consultant	6 months	January 2039
28	Segment 8 Bid Period, Award, and Notice to Proceed	City Staff & Consultant	6 months	July 2039
29	Segment 8 Construction	City Staff, Consultant, & Contractor	1 year	July 2040
30	Project Commissioning (start-up, testing & warranty period)	City Staff, Consultant, & Contractor	6 months	January 2041
31	Project Use, Monitoring, Agreement Maintenance	City Staff, Consultant; City of Vallejo	Ongoing	-

TM 11 – MUNICIPAL FINANCING FOR WASTEWATER SYSTEMS

The purpose of TM 11 is to provide information on possible funding opportunities for the City's CIP and projects identified during development of the Water Master Plan Update. These opportunities include low interest loans and grants offered through various agencies, selling municipal bonds, and others. Discussion regarding how these funding arrangements can be incorporated into the development of user rates is provided, but no progress is planned or completed towards development of funds or establishment of rates; that is left to a separate process beyond the scope of this Master Plan Update.

BACKGROUND

The City's Water Operation Division provides for negotiation and management of the City's water supply contracts and for the operation, maintenance, repair, and improvement (capital) of the WTP, transmission, distribution, and storage systems.

Rate Structure and Summary

The City bills for water utility services on a bi-monthly basis (approximately every 60 days). The current bimonthly rate for a Single-Family residential account is $34.18 with a volumetric charge of $4.67 per hcf. The final rate increase (FY 2017-2021 5-year approved rates) will be 3% and is scheduled to take effect on July 1, 2020. These rates help protect the health and safety of the community and make sure the City's water utilities remain financially solvent and operational.

The City's most recent Water and Wastewater Rate Study completed in May of 2016 anticipated funding a $3.6 million of CIP between FY2017 and FY2021. To meet operating and CIP costs without taking on any debt, the Rate Study recommended annual rate increases of 20%, 16%, 10%, 3% and 3% between 2017 and 2021. The Master Plan Update has determined the City will require additional money to develop the recommended CIP projects. Cash reserves cannot fund the recommended CIP projects. Based on financial resources currently available, the City will need to secure additional capital to fund water projects and may need to raise rates to meet related financing requirements.

FUNDING OPTIONS OVERVIEW

Developing a strategic funding plan hinges on having a robust understanding of current funding sources, identifying and characterizing new funding sources, and evaluating the applicability and attractiveness of those funding sources. Funding sources can be tapped to support multiple or individual CIP projects. To secure adequate capital to fund the priority projects, the City may benefit from pursuing a suite of funding options.

The following provides a high-level overview of funding options for the City to consider.

CASH-FUNDED CAPITAL

The most direct form of capital funding is to pay for projects through available cash balances or revenue cash flows, often referred to as "pay-as-you-go" (PAYGO) funding. This funding source is very often the cheapest form of funding (except grant funding) as there is no interest expense to be paid off over time, nor administrative or issuance costs associated with procuring funding. Projects can be partially or entirely funded as PAYGO capital based on the funds available to meet the project funding needs. Funds may be generated to build a reserve and meet capital needs through a variety of sources. The 2016 Rate Study recommended a Sewer Fund Reserve Target of $4.3 million, to stabilize funding for operating, capital rehabilitation and replacement, and rates through accumulated PAYGO reserves.

Common sources of cash-funded capital include:

- Rate, fee, or assessment revenue collected by the City from rate payers.
- Development fees (also referred to as impact fees, capacity fees, capital facilities fees, among others)
- Assessments established to fund projects that provide a "special benefit"[1] to property owners of a clearly defined set of parcels.

[1] Special benefit is defined as a particular and distinct benefit over and above general benefits conferred on real property located in the district or to the public at large.

Table 11-1 below is a summary of the strengths, weaknesses, opportunities and threats (SWOT) related to Cash Funded Capital.

Table 11-1 Cash Funding SWOT

Strengths • Low Cost • Control • No external compliance requirements	**Weaknesses** • Must accrue adequate capital over time • Requires rate increases • Could delay delivery
Opportunities • Blend cash with government funding programs and bonds to reduce overall costs • Fund "local, near term, no-regrets" options with existing cash reserves	**Threats** • Unforeseen costs depleting capital reserves and delaying or preventing projects • Failure to implement adequate rate increases

DEBT FINANCING

Debt financing is a viable option to meet the planning, design, and construction funding needs to complete the proposed projects. Debt financing can come in various forms, most commonly revenue bonds, general obligation bonds, certificates of participation, or loans. Sources of debt financing include:

- Revenue Bonds
- General Obligation Bonds
- Certificates of Participation

Table 11-2 below is a summary of the strengths, weaknesses, opportunities and threats related to Municipal Bonds and COPs.

Table 11-2 Municipal Bonds and COPs SWOT

Strengths • Control • Minimal compliance requirements • Currently rates are low	**Weaknesses** • Typically higher rates than government financing programs • Inflexible repayment terms • Potentially high issuance costs
Opportunities • Blend bonds with government funding programs • Leverage current issuance trends to keep costs low • Issue numerous bonds over implementation of recommended CIP Projects to reduce capitalized interest prior to substantial completion	**Threats** • Interest rate risk exposure • Project risk impacting interest rate

GOVERNMENT FINANCING AND FUNDING

The recommended CIP projects may be strong contenders for competitive government funding programs but not all programs are a good fit. Evaluation criteria drives the assessment and comparison of potential funding options. These criteria weigh the qualitative risks and benefits, as well as the quantitative revenue and timing associated with each funding option. Key evaluation components include:

- Competitiveness – Provides a measure of how likely the City is to successfully compete for funding from the program
- Maximum Grant Award or Loan Amount - Determines the adequacy of the funding available to meet the needs of the City
- Funding Terms – Evaluates the attractiveness of anticipated loan interest rate and maturity compared to bonding
- Application Costs – Considers the level of effort necessary to effectively compete for funding. Outlines the application requirements
- Compliance Costs – Assesses the costs of grant or loan management after the funding has been secured
- Timing – Overlays the likely timing of funding program disbursements with the project cash flow requirements

Table 11-3 below is a summary of the strengths, weaknesses, opportunities and threats related to Government Funding and Financing Programs.

Table 11-3 Government Funding and Financing Programs SWOT Loans

Strengths • Low interest rates • Grant funding • Flexible repayment terms	**Weaknesses** • Application costs and requirements • Inadequate funding available to meet needs • Compliance and reporting costs • Government coordination and schedule impacts
Opportunities • Streamline project management and funding program application, reporting and compliance requirements • Reduce impact to rate payers through gradual rate increases that match flexible repayment terms • Utilize multiple programs with same compliance & reporting requirements to spread costs across greater capital contribution • Use a Water Infrastructure Finance and Innovation Act loan in a PPP	**Threats** • Decreases in funding available • Shifting program and political priorities • De-obligation of funds related to non-compliance

Sources of government financing and funding can include the following programs:

- California Drinking Water State Revolving Fund (CWSRF)
- EPA Water Infrastructure Finance and Innovation Act (WIFIA)

GRANT FUNDING

While grant programs for the purpose of funding water infrastructure projects in California do exist, they are often targeted at small disadvantaged communities or narrowly defined projects and often award limited amounts. Utilizing these programs may require some creative or out of the box type projects, solutions or collaborations. Possible grant programs include:

- DWSRF Program
- United States Bureau of Reclamation Water Reclamation and Reuse Program (Tile XVI)
- Federal Disaster Resilience and Mitigation Funding
- California Agency Grants

PUBLIC PRIVATE PARTNERSHIPS (P3)

Public Private Partnerships are an alternative means to deliver infrastructure services. P3s are rare in the US in the water sector but they do provide a real financing and project development option. This TM focuses on P3s that provide upfront capital for infrastructure projects. Design-Build-Operate (DBO), and Design-Build-Operate-Maintain (DBOM) can be considered P3s but, as those delivery approaches do not include financing (F), they are not a focus of this memo.

Typically, in a P3, a private entity assembles the delivery team and takes responsibility for project design, construction, operations and financing. A P3 project delivery approach is sometimes referred to as Design-Build-Operate-Finance, or DBOF. Private participation creates the opportunity to transfer more project risk and project responsibility from the project sponsor (City) to private partners. However, private investors will not accept regulatory, political, or disaster risk and the cost for this funding is typically paid through an operation or rate charge.

P3 financing results in higher financing costs over the life of a project compared to tax-exempt municipal debt or government financing programs. Ultimately equity returns and debt service make up a portion of the rates customers pay for their water. A P3 public sponsor must trust the design, construction, O&M savings and risk transfer, over the life of the project, will outweigh the higher financing costs.

Though newer P3 models allow for more participation from the public project sponsor, the more the City dictates development, the more the project will be built and managed like a public project, effectively minimizing the efficiencies purported to be gained through private DBOF. In order to realize those savings, the City must give up some control.

Table 11-4 below is a summary of the strengths, weaknesses, opportunities and threats associated with P3s.

Table 11-4 P3 SWOT

Strengths	Weaknesses
• Design, build, operate & maintain efficiencies resulting in cost savings • Project risk transfer • Transfer of project development and O&M responsibility • City staff directed to other projects or priorities • More flexible repayment terms	• Higher financing costs • Less control • High transaction costs • Longer project development phase
Opportunities	**Threats**
• Leverage WIFIA • Explore ownership configurations, other options and costs during development • Identify investor-partner with lower return expectations	• Stakeholder support • Political support • Regulatory changes • Force majeure/Disaster

CONCLUSION AND RECOMMENDATIONS

This narrative provides information on strategic funding sources for the City's CIP Projects. A critical next step is integrating the key financial characteristics of the CIP Projects with the most attractive funding scenario currently available to the City. Based on projects' characteristics and the funding options available, the City may be required to make critical financial decisions in the near term to effectively position for the impact of accruing and securing capital in the future.

Preliminary steps may be for the City to cash fund near term projects and position for loan, grant and bond issuances that can meet the significant capital needs associated with lager and long-term projects.

TM 12 – PROPOSED WATER CAPITAL IMPROVEMENT PROGRAM

The purpose of this TM is to present a proposed 20-year schedule of capital improvement projects and their associated estimated costs. Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the adopted City CIP and associated dates are approximate and adjustable. No CIP program, project, or schedule is final until acted on by the City Council.

SOURCES OF PROPOSED CIP PROJECTS

The sources of the proposed CIP projects are the recommended improvements from the condition assessment evaluations or other capacity, redundancy/resiliency, or value-added projects determined from the other Master Plan Update TMs and the current City five-year Capital Improvement Program (2019/2020 through 2023/2024) that was adopted on May 28, 2019. Projects and costs related to operation and maintenance or routine repair and replacement are not included with these CIP projects.

CRITERIA USED FOR PRIORITIZING PROJECTS

Each of the prospective capital projects were prioritized based on the risk posed to the community and the condition of the asset. The risk and condition rating are described in more detail in Technical Memorandum No. 3 (Condition Assessment Framework). This type of risk- based analysis aims to objectively prioritize projects and helps ensure that the most necessary projects are completed first and optimizes the CIP project schedule.

CIP COST ESTIMATING METHODOLOGY

A key element to the CIP planning process is determining budgets for each of the identified projects. The cost estimates include base/construction costs and soft costs. The engineering opinion of probable costs falls under cost estimate Classification Four (Class 4, as defined by Association for the Advancement of Cost Engineering, AACE) with an expected accuracy range of -30% to +50%. Costs include contingency and allowances for legal, admin, environmental, permitting, planning, design, construction management and inspection. All costs estimates are in 2020 dollars with an ENR construction cost index of 11392.

PROPOSED CIP SCHEDULE

A 20-year proposed schedule of the identified capital projects and their associated estimated annual costs was developed. The schedule was mostly prepared based on the risk profile for each project and smoothed projection of annual expenditures. However, in some cases, projects with lower risks are scheduled for implementation sooner than higher risk projects to address City needs. **Figure 12-1** shows the estimated annual expenditures for the five water CIP categories.

PROPOSED CIP PROJECT CATEGORIES

The cost estimates developed for all capital projects are summarized by project category (raw water, distribution system, booster pump stations, storage and treatment) in **Figure 12-2**. Of the total capital projects in the next twenty years, over 60% of the proposed costs are from the raw water supply. A break-down of the CIP costs (base cost, soft costs, and contingency) in each category is shown in **Figure 12-3**.

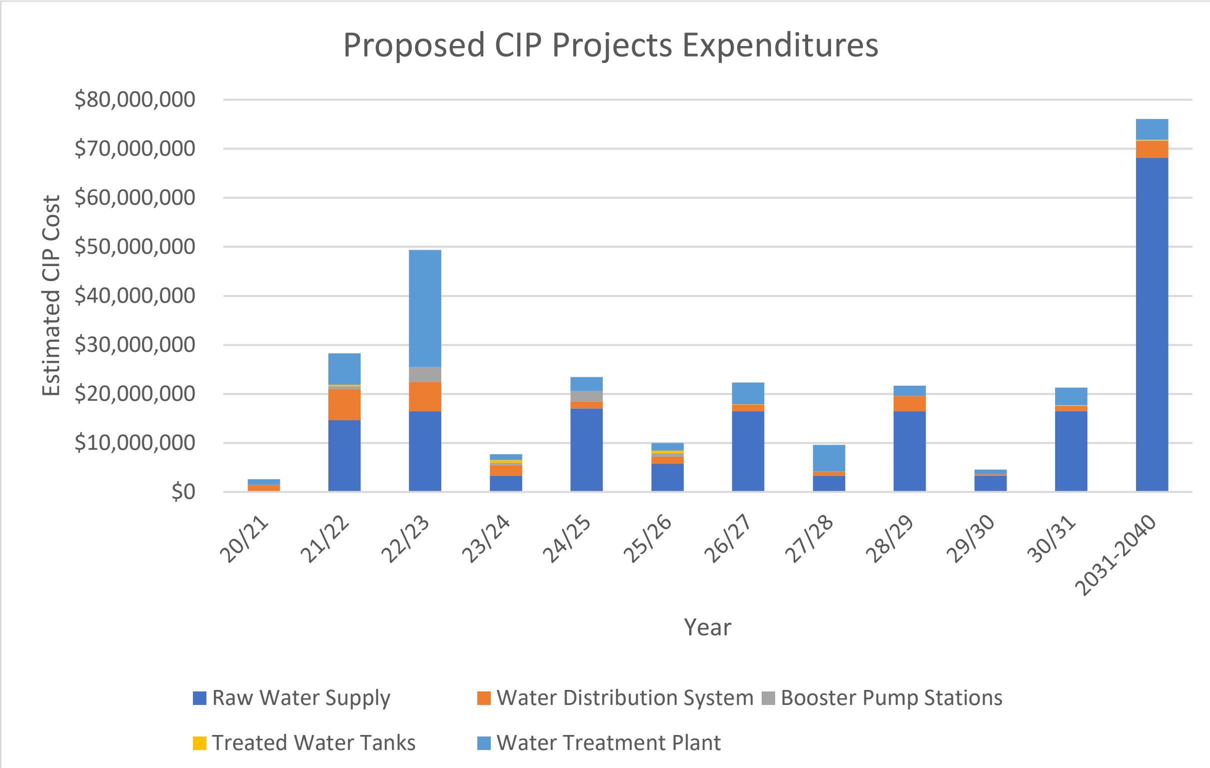

Figure 12-1 Proposed Annual Water CIP Expenditures

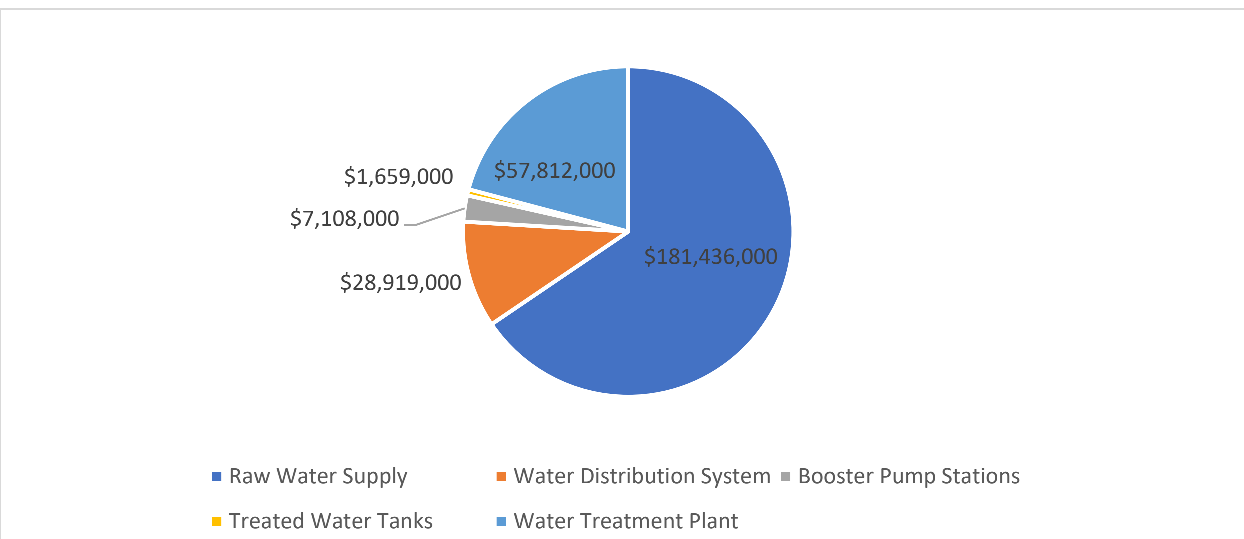

Figure 12-2 Proposed Water CIP Projects Category (Not Including Contingent Projects)

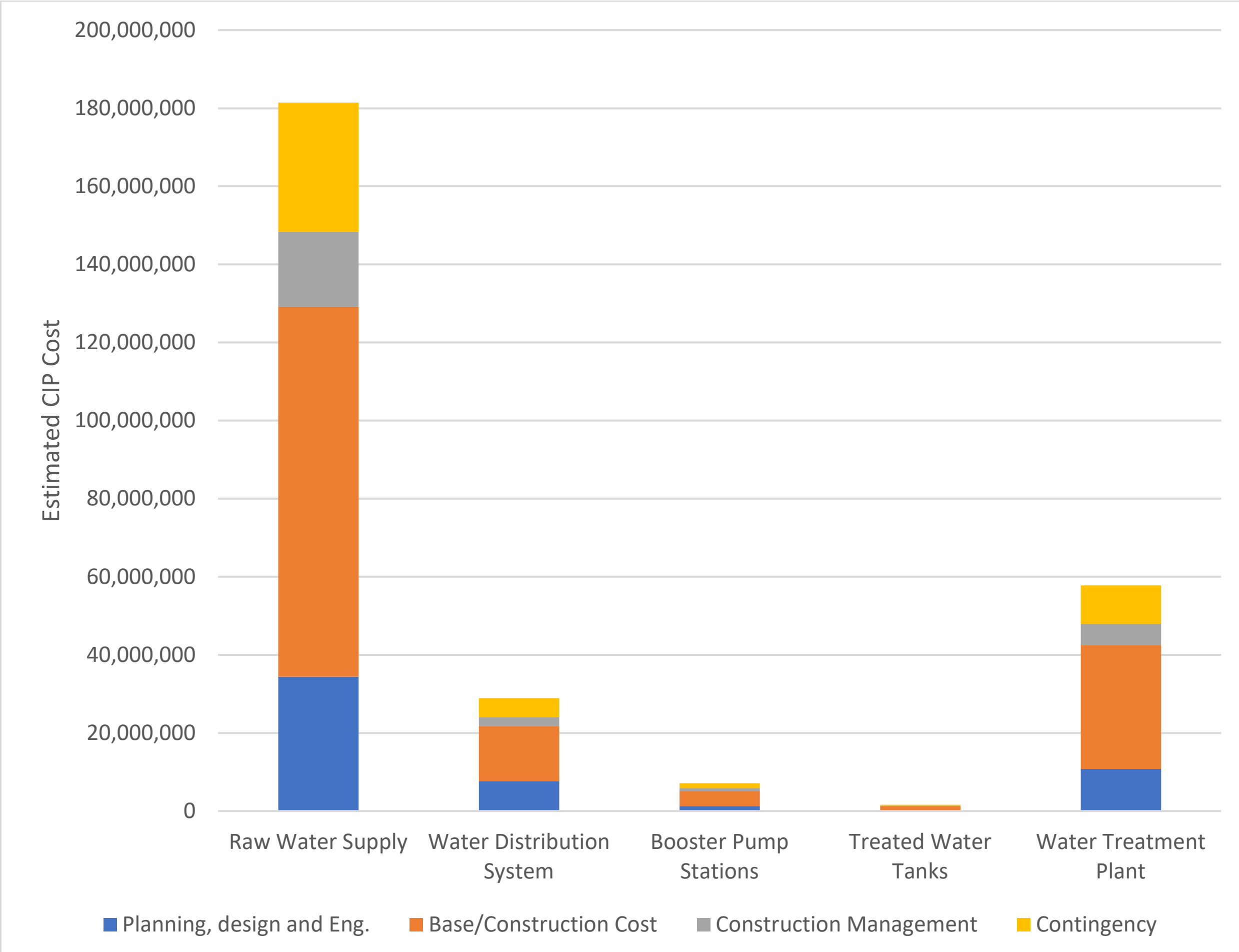

Figure 12-3 Breakdown Costs of Proposed Water CIP Projects

PROPOSED WATER CIP PROJECTS

The prioritized recommended capital projects are shown in **Table 12-1** through **Table 12-6**. The contingent projects are listed in **Table 12-7**, representing projects that are not currently required but may become required if regulations change or studies confirm their feasibility. It is important to realize that the CIP represents a snapshot of known/observable utility conditions as of early 2020. Due to the dynamic nature of the utility operations, facility needs, and priorities may change overtime. Furthermore, several of the projects identified would require additional analysis, beyond the scope of this Master Plan Update, to determine the exact scope of necessary improvement and refine final costs. In these cases, the CIP includes budgets to further evaluate those facility needs as described in other TMs.

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Table 12-1 Proposed Raw Water Supply CIP Projects [1]

Proposed Project Name	Proposed Project #	Proposed Timeline [2]												Estimated Total	Project Condition Rating Range (1-5)	Risk of Failure Range (0-100)
		20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040			
Cordelia Pump Station Improvements [5]	RW-002		$6,802,000											$6,802,000	4	80
Parallel Raw Water Transmission Line [3] [5]	RW-003		$6,882,285	$11,639,125	$2,371,211	$11,639,125	$2,371,211	$11,639,125	$2,371,211	$11,639,125	$2,371,211	$11,639,125	$42,031,007	$116,594,000	4	60
Existing Raw Water Transmission Line Rehabilitation	RW-004		$926,375	$4,842,625	$926,375	$4,842,625	$926,375	$4,842,625	$926,375	$4,842,625	$926,375	$4,842,625	$17,307,000	$46,152,000	4	60
Lake Herman Pump Station Improvements	RW-001					$560,000	$2,385,000							$2,945,000	4	27
Lake Herman Control Tower Improvements	RW-006												$8,723,000	$8,723,000	3	36
Ongoing Condition Assessment of the Raw Water Supply	RW-007						$55,000					$55,000	$110,000	$220,000	3	36
Raw Water Supply Annual Repair & Replacement [4]																
Estimated Total		$0	$14,610,660	$16,481,750	$3,297,586	$17,041,750	$5,737,586	$16,481,750	$3,297,586	$16,481,750	$3,297,586	$16,536,750	$68,171,007	$181,436,000		

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

[2] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.

[3] The total cost of the raw water supply CIP projects would be reduced accordingly if contingent project RW-005 (Vallejo Raw Water Transmission Line Intertie) is completed in lieu of project RW-003.

[4] See repair and replacement discussion below.

[5] This is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

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Table 12-2 Proposed Water Distribution System CIP Projects [1]

Proposed Project Name	Proposed Project #	Proposed Timeline [2] 20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040	Estimated Total	Project Condition Rating Range (1-5)	Risk of Failure Range (0-100)
Vallejo Treated Water Intertie [4]	WD-014		$2,380,000	$5,423,000										$7,803,000	5	100
Reliability Transmission Main from WTP	WD-006	$1,434,000	$3,964,000											$5,398,000	5	100
Park Road Transmission Main (18-inch)	WD-001			$553,000	$1,771,000									$2,324,000	5	100
Viewmont St Water Main	WD-013				$398,000	$990,000								$1,388,000	5	80
Adams Street Water Main Replacement	WD-008						$809,000							$809,000	5	80
Park Road Transmission Main (24-inch)	WD-002						$603,000	$1,351,000						$1,954,000	4	80
Military West Zone 1 Water Main	WD-003								$671,000	$2,504,000				$3,175,000	4	64
E 5th Street Water Main	WD-010								$198,000	$600,000				$798,000	4	64
Jackson St Reliability Loop	WD-012					$418,000								$418,000	4	48
Valve Replacement (Clearview & East E St areas)	WD-015												$785,000	$785,000	3	48
R-1 Old Reservoir Water Main	WD-009												$1,254,000	$1,254,000	3	36
Ongoing Condition Assessment of the Water Distribution System	WD-016						$55,000					$55,000	$110,000	$220,000	3	36
Drolette Way Loop	WD-004												$197,000	$197,000	3	36
Service Line Replacement	WD-007										$320,000	$973,000		$1,293,000	3	24
W 7th Street Water Main	WD-005												$668,000	$668,000	2	32
Industrial Way Transmission Main Valves	WD-011												$435,000	$435,000	2	32
Water Distribution System Annual Repair and Replacement [3]																
Estimated Total		$1,434,000	$6,344,000	$5,976,000	$2,169,000	$1,408,000	$1,467,000	$1,351,000	$869,000	$3,104,000	$320,000	$1,028,000	$3,449,000	$28,919,000		

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

[2] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.

[3] See repair and replacement discussion below.

[4] This is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

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Table 12-3 Proposed Booster Pump Stations CIP Projects [1]

Proposed Project Name	Proposed Project #	Proposed Timeline [2]												Estimated Total	Project Condition Rating Range (1-5)	Risk of Failure Range (0-100)
		20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040			
Booster Pump Station - 2	BPS-002		$642,000	$2,994,000										$3,636,000	5	48
Booster Pump Station - 3	BPS-003				$500,000	$2,128,000								$2,628,000	5	32
Ongoing Condition Assessment of the Booster Pump Stations	BPS-004						$55,000					$55,000	$110,000	$220,000	3	36
Booster Pump Station - 1	BPS-001						$624,000							$624,000	3	14
Booster Pump Station Annual Repair and Replacement [3]																
Estimated Total		$0	$642,000	$2,994,000	$500,000	$2,128,000	$679,000	$0	$0	$0	$0	$55,000	$110,000	$7,108,000		

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

[2] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.

[3] See repair and replacement discussion below.

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Table 12-4 Proposed Treated Water Tanks CIP Projects [1]

Proposed Project Name	Proposed Project #	Proposed Timeline [2]												Estimated Total	Project Condition Rating Range (1-5)	Risk of Failure Range (0-100)
		20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040			
R2 Reservoir	ST-004		$268,000											$268,000	5	80
Chlorine Contact Tank & Clearwell Rehabilitation	ST-001 & 002				$576,000									$576,000	3	60
R3A & R3B Reservoir	ST-005 & 006						$509,000							$509,000	3	48
Ongoing Condition Assessment of the Treated Water Tanks	ST-007						$55,000					$55,000	$110,000	$220,000	3	36
R1 Reservoir	ST-003							$86,000						$86,000	3	20
Treated Water Tanks Annual Repair & Replacement [3]																
Estimated Total		$0	$268,000	$0	$576,000	$0	$564,000	$86,000	$0	$0	$0	$55,000	$110,000	$1,659,000		

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).

[2] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.

[3] See repair and replacement discussion below.

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Table 12-5 Proposed Water Treatment Plant CIP Projects [1]

Proposed Project Name	Proposed Project #	Proposed Timeline [2]												Estimated Total	Project Condition Rating Range (1-5)	Risk of Failure Range (0-100)
		20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040			
Ozonation System [4]	WTP-027		$5,392,000	$19,376,000										$24,768,000	N/A	N/A
Filter Pipe Gallery Improvements	WTP-007		$158,000	$674,000										$832,000	3	80
WTP SCADA Improvements	WTP-019		$416,000	$1,561,000										$1,977,000	4	60
Finish Water Sample Pump	WTP-016				$406,000									$406,000	4	48
Filter Backwash Control Valve Replacement	WTP-009		$45,000	$192,000										$237,000	3	60
Filter Basin 3 & 4 Improvements	WTP-005		$193,000	$821,000										$1,014,000	4	30
Cathodic Protection Rehabilitation	WTP-024	$988,000												$988,000	3	48
Power Distribution Upgrade	WTP-017				$584,000	$2,489,000								$3,073,000	3	36
Emergency Standby Power Upgrade	WTP-018			$930,000										$930,000	3	36
Ongoing Condition Assessment of the WTP	WTP-028						$55,000					$55,000	$110,000	$220,000	3	36
Diversion Structure Gate and Actuator Replacement	WTP-001			$201,000										$201,000	3	36
Inspection of Burried Metallic Pipes	WTP-025									$1,215,000				$1,215,000	3	32
Flocculation/Sedimentation Basin 1 Improvements	WTP-002						$451,000	$1,921,000						$2,372,000	3	24
Dissipator Box Rehabilitation	WTP-013												$170,000	$170,000	3	24
Operations/Chemical Building Annual Repair & Replacement	WTP-026	$181,150	$181,150	$181,150	181150	$181,150	$181,150	$181,150	$181,150	$181,150	$181,150	$181,150	$1,630,350	$3,623,000	2	36
Operations and Chemical Building Investigations	WTP-012					$169,000								$169,000	2	36
Flocculation & Sedimentation Basin 2 Improvements	WTP-003										$600,000	$2,556,000		$3,156,000	3	16
Filter Basin 1 & 2 Improvements	WTP-004												$1,035,000	$1,035,000	2	30
Filter Basin 5 & 6 Improvements	WTP-006										$193,000	$821,000		$1,014,000	2	30
General Pipe and Equipment Recoating	WTP-014								$252,000					$252,000	3	8
Solids Residuals, Storage and Pumping	WTP-011							$1,101,000	$4,689,000					$5,790,000	2	24
Chemical Feed Piping Improvements	WTP-010						$537,000							$537,000	2	24
Facility Electrical Safety Improvements	WTP-021												$290,000	$290,000	2	24
Plantwide Concrete Rehabilitation	WTP-015												$1,022,000	$1,022,000	2	16
Facility Safety Improvements	WTP-022								$320,000					$320,000	2	16
Facility Site Lighting	WTP-020									$557,000				$557,000	2	12
Clarifier Demolition	WTP-023						$289,000	$1,233,000						$1,522,000	2	8
Filter Backwash Tank Safety Improvements	WTP-008									$122,000				$122,000	2	8
WTP Annual Repair and Replacement [3]																
Estimated Total		$1,169,150	$6,385,150	$23,936,150	$1,171,150	$2,839,150	$1,513,150	$4,436,150	$5,442,150	$2,075,150	$974,150	$3,613,150	$4,257,350	$57,812,000		

[1] Condition rating (1 & 2 green, 3 yellow, 4 & 5 red). Risk of failure (0-40 green, 41-59 yellow, 60-100 red).
[2] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.
[3] See repair and replacement discussion below.
[4] This is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

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Table 12-6 All Proposed Water CIP Project Budgets

CIP Project Category	Proposed Timeline [1]												Estimated Total
	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31	2031-2040	
Raw Water Supply	$0	$14,610,660	$16,481,750	$3,297,586	$17,041,750	$5,737,586	$16,481,750	$3,297,586	$16,481,750	$3,297,586	$16,536,750	$68,171,007	$181,436,000
Water Distribution System	$1,434,000	$6,344,000	$5,976,000	$2,169,000	$1,408,000	$1,467,000	$1,351,000	$869,000	$3,104,000	$320,000	$1,028,000	$3,449,000	$28,919,000
Booster Pump Stations	$0	$642,000	$2,994,000	$500,000	$2,128,000	$679,000	$0	$0	$0	$0	$55,000	$110,000	$7,108,000
Treated Water Tanks	$0	$268,000	$0	$576,000	$0	$564,000	$86,000	$0	$0	$0	$55,000	$110,000	$1,659,000
Water Treatment Plant	$1,169,150	$6,385,150	$23,936,150	$1,171,150	$2,839,150	$1,513,150	$4,436,150	$5,442,150	$2,075,150	$974,150	$3,613,150	$4,257,350	$57,812,000
Estimated Water Total	$2,603,150	$28,249,810	$49,387,900	$7,713,736	$23,416,900	$9,960,736	$22,354,900	$9,608,736	$21,660,900	$4,591,736	$21,287,900	$76,097,357	$276,934,000

[1] Proposed projects are loosely presented chronologically to distribute costs over time in keeping with each project's criticality or other City priorities, but final project inclusion in the CIP and associated dates are approximate and adjustable.

Table 12-7 Proposed Water Treatment Plant Contingent CIP Projects

Proposed Project Name	Proposed Project Description	Proposed Project #	Contingent Upon:	Estimated Cost
Vallejo Raw Water Transmission Line Intertie	Construct a new raw water transmission line intertie with the City of Vallejo.	RW-005	Agreement with Vallejo	$39,607,000[1]

[1] This is a high-level estimate; a feasibility study is required to confirm project parameters and planning budgets.

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REPAIR AND REPLACEMENT

Repair and replacement (R&R) budgets support reserve funds for City utilities as they require rehabilitation or replacement at or near the end of their useful lives. These funds typically support significant improvements beyond routine operation and maintenance (O&M) provided during the useful life of an asset, and the boundary between O&M and R&R funds varies by agency. For example, a booster pump station pump replacement is an O&M funded improvement for the City of Benicia, but another City may consider that an R&R project. Alternatively, the value of the equipment may tip it from an O&M project to an R&R Project. For example, a $5,000 chemical metering pump may be an O&M project, but a $50,000 booster pump improvement may be considered an R&R project.

The funds collected for R&R reserves vary significantly by agency. The City of Benicia has a policy to collect annually 3% of the utilities replacement value to support its ultimate rehabilitation or replacement. Other cities only collect a nominal amount that is not tied to the asset value and others target a specific dollar value in reserve. Many R&R budgets do not support complete utility replacement at the end of its useful life. Instead, reserves are adequate for some rehabilitation or replacement, but not for the whole utility. For the larger asset projects, it's common that new outside funding sources have to be identified specific to that project, such as loans or municipal bonds (see TM 11), which require rate adjustments at that time to cover the new funding source and debt service.

For most cities water infrastructure is among their most valuable assets. In the case of Benicia, the total water asset value is estimated at near $650 million, as shown in **Table 12.8**. Also presented in this table is the value of the City's 3% annual reserve towards these assets and the totals of the CIP projects identified in this TM on an average annual basis. CIP projects typically go towards supporting infrastructure service in perpetuity through repair and replacement of existing infrastructure and therefore directly contribute towards R&R. The difference between the City's 3% R&R reserve target and the proposed CIP projects is also presented as the R&R balance that the City may still need to collect. It would not be proposed to collect both the 3% R&R budget and the proposed CIP costs. It should be noted, however, that water CIP projects for the City of Benicia also include new projects to improve reliability, redundancy and resiliency and therefore they are not related to maintaining the useful condition (repair or replacement) of existing assets. This means that subtracting the full CIP form the annual reserve value may underestimate the needed reserve value. These details should be considered more thoroughly through the City's rate processes.

Table 12-8 Water Asset Values, 3% Annual Reserve and R&R Balance

Water Infrastructure Area	Approximate Replacement Value [1]	City 3% Annual R&R Policy	CIP Average Expenditure [2]	R&R Balance [2]
Raw Water Pump Stations	$8,000,000	$240,000	$490,000	$0
Raw Water Mains	$120,000,000	$3,600,000	$8,600,000	$0
Lake Herman Reservoir [3] [4] [5]	$70,000,000	$2,100,000	$0	$2,100,000
Water Distribution System	$320,000,000	$9,600,000	$1,400,000	$8,200,000
Water Booster Pump Stations	$12,000,000	$360,000	$400,000	$0
Water Storage	$36,000,000	$1,100,000	$80,000	$1,000,000
Water Treatment Plant	$81,000,000	$2,400,000	$2,900,000	$0
Total (Rounded)	**$650,000,000**	**$19,000,000**	**$14,000,000**	**$11,000,000**

[1] Replacement values are very approximate (+/- 50%) and include construction and soft costs (planning, design, environmental clearance and permitting, construction, start-up, contingency, engineering during construction, construction management and inspection). Land, easement and right of way costs are not included.
[2] The sum of the CIP average expenditure and the R&R balance can exceed the City 3% Annual R&R policy because in some cases the CIP includes new infrastructure for reliability and redundancy or to address new service needs such as WTP ozone addition. A refined R&R assessment would discern between existing and new assets.
[3] Lake Herman and its embankment were not evaluated as part of the condition assessment and Master Plan Update effort, which focused primarily on linear, mechanical and structural infrastructure.
[4] Lake Herman replacement value does not include environmental mitigation, which could be extensive if replaced in an unimpacted riparian drainage area. It is assumed that reservoir replacement will be in-place and no new (or limited) environmental impacts will occur. Cost do include construction and other soft costs for all reservoir components, including clearing and grubbing, foundation preparation, embankment and outlet piping.
[5] The primary embankment for Lake Herman may have a longer useful life than the 75 years shown. Useful life may be estimated at 100 years. The 75 years used here may be conservative and in agreement with the Master Plan Update Framework.

The City 3% annual reserve effectively collects 100% of the asset's value in just over 33 years, e.g. 3% per year times 33.3 years = 100%. Thirty-three years is less than the expected useful life of many of the City's water assets. For example, many pipelines can be expected to have a useful life approaching 75 years and many structures can be expected to have a useful life of approximately 50 years. These useful life terms can vary with the level of conservatism desired in City fiscal planning, but in general they have a longer useful life than 33 years. Of course, these useful life estimates are based on an industry standard of care provided as part of routine maintenance; neglect would reduce useful life projections. Also, components of every asset include elements that have shorter useful lives. For example, a storage tank may have a useful life of 50 years, but the level instruments within the tank may only have a useful life of 25 years. This could mean that the level instrument has to be rehabilitated or replaced more frequently, which may fall into the O&M funded category, and the tank itself can be included in the R&R funded category. (The approximate replacement values listed in **Table 12-8** include all components of the facility, which could allow for refinement related to the total costs that's covered through R&R reserves and the costs covered by O&M funds. That level of refinement is not discerned here, and the total costs are shown borne by R&R.)

If longer asset life spans are considered, less reserve needs to be collected each year to get to the total 100% replacement budget at the end of a useful life, as shown in **Table 12-9.** This table reflects extended life spans and associated reduced R&R budget needed each year. **Table 12-10** is a repeat of **Table 12-8** with the alternative annual R&R reserve percentages from **Table 12-9**. It can be seen in **Table 12-10** that the R&R balance is significantly less with the extended useful life annual R&R percentages than with the City policy of 3% annually.

Table 12-9 Water Asset Values, Useful Life and Alternative Annual Reserve Percentages

Water Infrastructure Area	Primary Asset Useful Life (years) [1]	Alternative Annual R&R Reserve
Raw Water Pump Stations	50	2%
Raw Water Mains	75	1.3%
Lake Herman Reservoir	75	1.3%
Water Distribution System	75	1.3%
Water Booster Pump Stations	50	2%
Water Storage	50	2%
Water Treatment Plant	50	2%

[1] Useful life is for primary structure and pipeline infrastructure, excluding mechanical equipment, electrical gear and instrumentation.

Table 12-10 Water Asset Values, Extended Useful Lives, Annual Reserve and R&R Balance

Water Infrastructure Area	Approximate Replacement Value [1]	Alternative Annual R&R Reserve [2]	CIP Average Expenditure [3]	R&R Balance [3]
Raw Water Pump Stations	$8,000,000	$160,000	$490,000	$0
Raw Water Mains	$120,000,000	$1,600,000	$8,600,000	$0
Lake Herman [4][5]]6]	$70,000,000	$900,000	$0	$900,000
Water Distribution System	$320,000,000	$4,300,000	$1,400,000	$2,900,000
Water Booster Pump Stations	$12,000,000	$240,000	$400,000	$0
Water Storage	$36,000,000	$720,000	$80,000	$640,000
Water Treatment Plant	$81,000,000	$1,600,000	$2,900,000	$0
Total (Rounded)	**$650,000,000**	**$9,500,000**	**$14,000,000**	**$4,400,000**

[1] Replacement values are very approximate (+/- 50%) and include construction and soft costs (planning, design, environmental clearance and permitting, construction, start-up, contingency, engineering during construction, construction management and inspection). Land, easement and right of way costs are not included.
[2] Reserves calculated using the percentages presented in Table 12-9.
[3] The sum of the CIP average expenditure and the R&R balance can exceed the City 3% Annual R&R policy because in some cases the CIP includes new infrastructure for reliability and redundancy or to address new service needs such as WTP ozone addition. A refined R&R assessment would discern between existing and new assets.
[3] Lake Herman and its embankment were not evaluated as part of the condition assessment and Master Plan Update effort, which focused primarily on linear, mechanical and structural infrastructure.
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[5] Lake Herman replacement value does not include environmental mitigation, which could be extensive if replaced in an unimpacted riparian drainage area. It is assumed that reservoir replacement will be in-place and no new (or limited) environmental impacts will occur. Cost do include construction and other soft costs for all reservoir components, including clearing and grubbing, foundation preparation, embankment and outlet piping.
[6] The primary embankment for Lake Herman may have a longer useful life than the 75 years shown. Useful life may be estimated at 100 years. The 75 years used here may be conservative and in agreement with the Master Plan Update Framework.

This Repair and Replacement section is included with this CIP TM to support the City's rate process, which will have to assess the appropriate reserves to include for R&R in addition to supporting O&M and CIP costs.