KAYUGA SOLUTION

LIVERMORE CALIFORNIA

City of Livermore

Public Works Department

Water Resources Division

Potable Water System

Asset Management Plan

2016

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Introduction

The City of Livermore's Public Works Department, Water Resources Division (WRD) has been strengthening its asset management program to foster more efficient use of its financial and physical assets. WRD's asset management efforts began with an asset management pilot program intended as a proof-of-concept project. The pilot program focused on the wastewater collection system. WRD has since expanded its asset management program to include the potable, recycled, and water reclamation plant assets. This Potable Water System Asset Management Plan will cover the potable water system assets.

Asset Inventory

WRD manages approximately 31,859 potable water system assets, which includes approximately 155 miles of pipes, 5 pump stations, and 4 reservoirs at 3 sites.

Distribution Asset Inventory

Asset	Quantity	Length
Hydrants	1,427	
Laterals	1,633	11.7 mi
Mains	4,083	143.2 mi
Meters	9,848	
Pressure Reducing Stations	38	
Services	9,848	
Structures/Stations	70	
Valves	4,500	

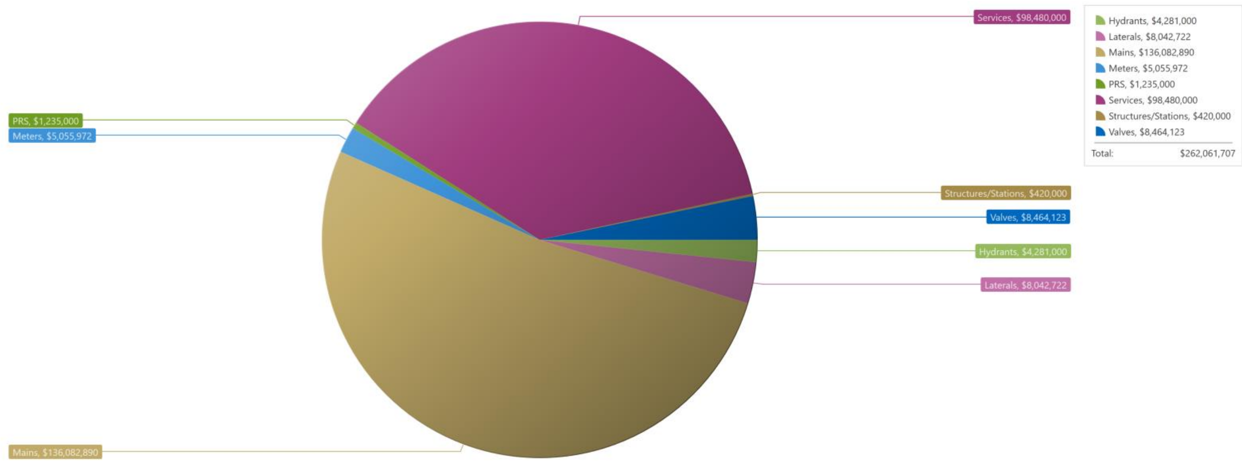
Remote Facility Asset Inventory

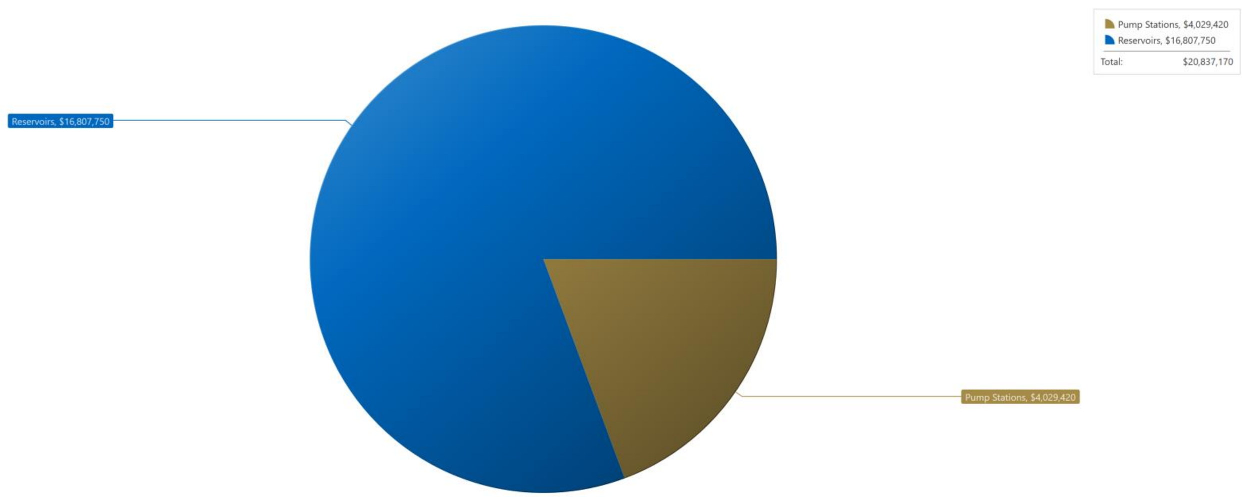
Facility	Quantity
Airway Pump Station	57
Altamont Pump Station	59
Oakville Pump Station	69
Trevarno Pump Station	40
Vasco Pump Station	102
Altamont Reservoir	30
Dalton Reservoir	33
Doolan Reservoir	22

Replacement Cost

The total value of the potable water system is approximately $282.9 million. This total value is the result of summing up the individual asset costs for the system.

The following figure shows the asset valuation for the potable water distribution system assets. The potable water distribution system has a valuation of approximately $262 million. The next figure shows the valuation of the potable water remote facilities. The total valuation of the potable water remote facilities assets is approximately $21 million.

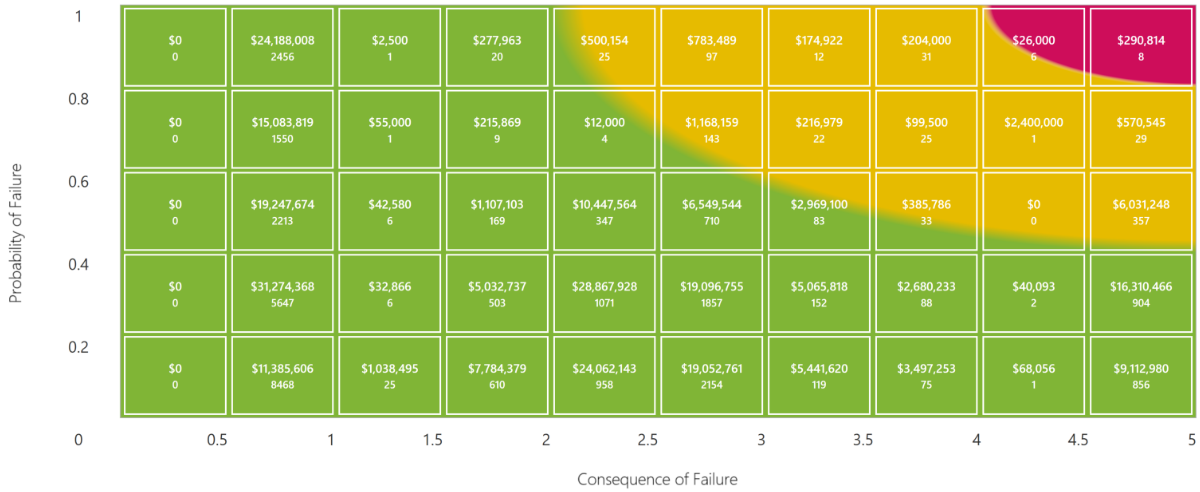




Risk

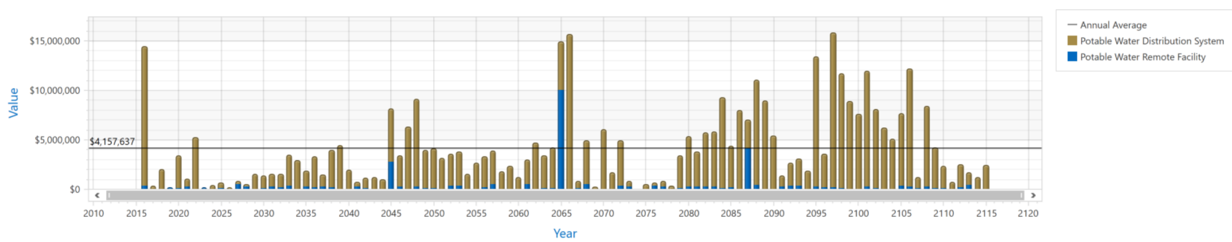
Risk is the term used to describe and quantify the risks associated with the management of assets. Risk is comprised of three major factors: probability of failure, consequence of failure, and redundancy. The probability of failure (PoF) measures an asset's likelihood of or timing to failure. The consequence of failure (CoF) evaluates the direct and indirect impacts of a failure. Redundancy, the presence of backup equipment, helps to decrease the overall risks of a failure. A risk score from 0 (low risk) and 5 (high risk) is assigned to each asset in the asset register to help prioritize the needs of the assets under limited resources.

The following figure shows the risk results developed from the PoF and CoF scores. The matrix below shows the WRD asset risk scores categorized by low, medium, and high risk. The assets in the red zone of the risk matrix represent the assets with the highest likelihood and highest impact of failure.



Long-Range Analysis

The long-range analysis can also give WRD an idea of its budgetary needs in a defendable and transparent way. With the long-range analysis, WRD can share its future needs with its stakeholders. The following figure presents the annual replacement and rehabilitation needs for the potable water assets. There is a large peak in 2016 of approximately $14.5 million, which is comprised mostly of service replacement.



The following table presents the average annual financial needs of WRD's assets over 10-year, 30-year, 50-year, and 100-year planning horizons.

Planning Horizon	Annual Average
10	$ 2.8 million
30	$2.4 million
50	$ 3.0 million
100	$ 4.2 million

1 Introduction

The City of Livermore's Public Works Department, Water Resources Division (WRD) has been strengthening its asset management program to foster more efficient use of its financial and physical assets. WRD first embarked on its asset management journey over five years ago. To begin its asset management efforts, WRD initiated a project to develop an asset management roadmap. By benchmarking against asset management leading practices, WRD's strengths and weaknesses were identified. A prioritized list of improvement efforts was generated and scheduled. These projects included the following tasks:

- Develop an asset hierarchy and asset data standards
- Perform asset inventory and establish an asset register
- Review maintenance practices and identify improvement opportunities
- Audit inventory practices and identify improvement opportunities
- Develop an asset management plan
- Improve the Computerized Maintenance Management System (CMMS)

The improvement projects focused on developing the asset data foundation and implementing sound asset management processes. Since establishing the asset management roadmap, WRD started to implement the recommended projects. To begin the task of developing an asset management plan, WRD initiated a pilot project. The pilot asset management plan focused on the wastewater collection system, and it established the processes, data foundation, methodologies, and format for the entire asset management plan. With the approval of the pilot asset management plan, WRD expanded the plan to other asset types (i.e., water distribution, treatment, storm water). WRD will produce four asset management plans: the Wastewater Collection Asset Management Plan, the Water Distribution Asset Management Plan, the Treatment Plant Asset Management Plan, and the Recycled Water Asset Management Plan.

This Potable Water Asset Management Plan will focus on the potable water distribution and remote facility assets. The analysis in this asset management plan does not incorporate hydraulic modelling results.

1.1 Background

WRD works to meet the City of Livermore's water, wastewater, and storm water utility needs. WRD delivers drinking water to more than 28,800 customers in Livermore; the California Water Service Company serves the balance of water users in Livermore. Recycled water is delivered to more than 60 customers, which includes the City of Livermore's golf course, airport, and many other landscape irrigation sites. Recycled water also provides fire protection for 22 commercial/industrial buildings.

All of the sewage generated in the City of Livermore is collected and treated at the Livermore Water Reclamation Plant, which is operated and maintained by the Division. The treated wastewater that is not recycled is sent through the Livermore Amador Valley Water Management Agency (LAVWMA) pipeline for disposal in the San Francisco Bay. Division staff maintains the storm water and sanitary sewer systems. The Division also administers a number of mandated regulatory requirements, including industrial pretreatment, pollution prevention, and storm water programs. Figure 1-1 highlights WRD's service area.

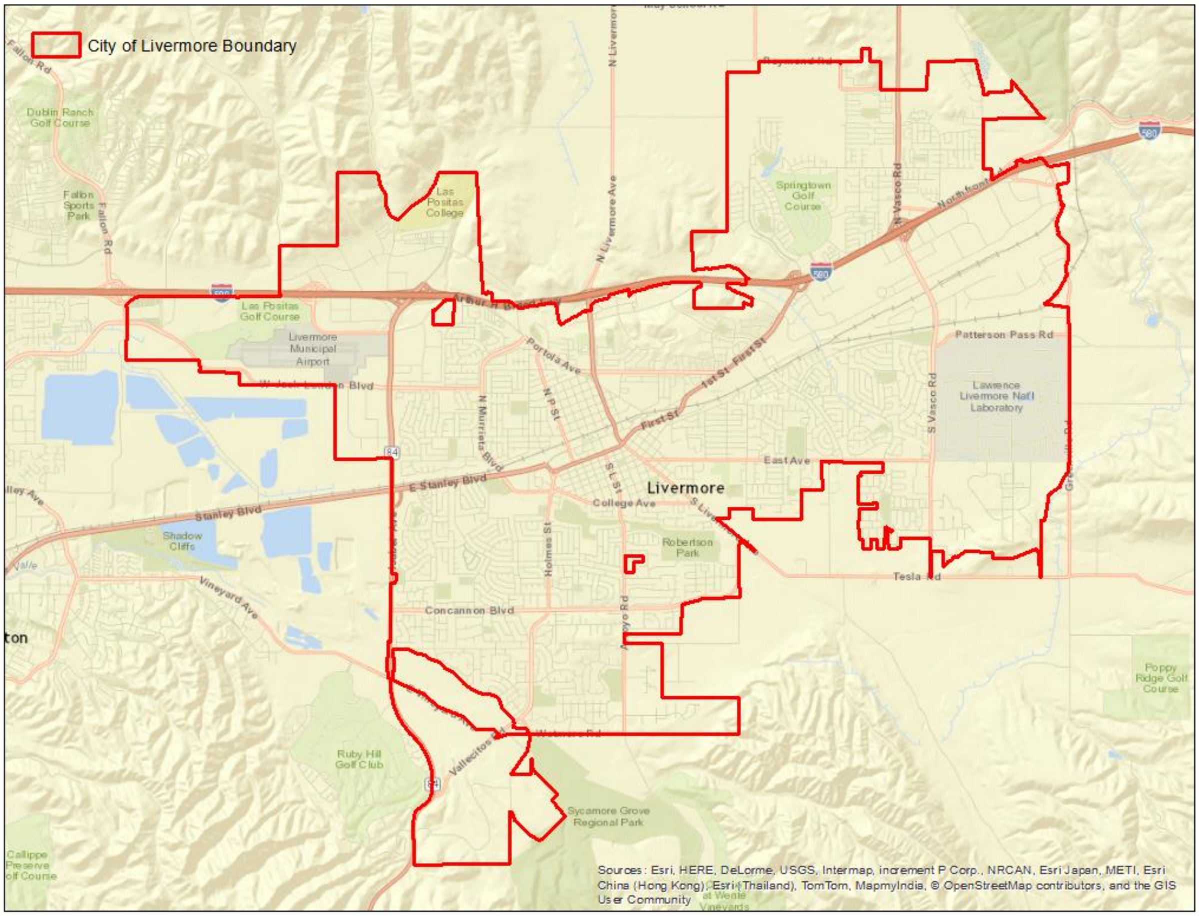


Figure 1-1 City of Livermore

The City of Livermore built its first wastewater treatment plant in 1942. The first plant was located near Rincon and Pine Streets in then-unincorporated Alameda County at the west end of Livermore. In 1958, as residential development moved closer to the treatment plant, it was replaced by a 2.5 million gallons per day (MGD) trickling filter plant built at the current 101 W. Jack London Blvd. location in Livermore. Over the years, the trickling filter plant has undergone substantial facility improvements to more effectively and efficiently manage collection, treatment and disposal of the community's wastewater. Today, the Livermore Water Reclamation Plant is an activated sludge plant with a design capacity of 8.5 MGD. In 1974, tertiary treatment and recycled water storage facilities were constructed and the city began providing recycled water for non-potable water use in the city's Livermore Municipal Water service area. From the late 1950's to the late 1970's, treated wastewater was discharged into the Arroyo Mocho, a tributary of the Alameda Creek watershed. To eliminate the need to discharge to the Arroyo Mocho, a regional export system for treated wastewater was constructed by the Livermore Amador Valley Water Management Agency (LAVWMA) in the 1970's.

1.2 Asset Management Program Goal

The goal of WRD's asset management program was to shift from reactive to proactive planning and management of its assets. Specifically, WRD wanted to do the following:

- Gain better understanding of the current state and the future needs of the infrastructure
- Proactively identify the asset replacement and rehabilitation needs and plan the budget and resources accordingly
- Understand the probability and consequence of failure of each asset so that WRD can manage high risk assets before failure and minimize the WRD's overall risk profile
- Minimize the life cycle cost through efficient and effective management strategies
- Develop a consistent and defendable methodology for prioritizing work and capital budget expenditure
- Focus on high benefit-to-cost ratio to ensure the budget is spent in the right place, for the right reason, at the right time, and at the right cost

In essence, WRD wanted to gain better understanding of the current and future asset needs, asset risk profile, appropriate levels of service, cost to provide services, and financial requirements to sustain the delivery of services.

1.3 Asset Management Plan

An asset management plan is a long-range planning document that provides a framework for understanding the assets an organization owns, services it provides, risks it assumes, and financial investments it requires. An asset management plan can help an organization move from reactive to proactive management of its physical and financial resources. This transition requires answers to the following questions:

- What is an asset? What is not an asset?
- Which assets need to be managed?
- What are the conditions of the assets?
- What maintenance and capital work is required? When and how much?
- How long until the assets need to be renewed?
- Which assets are critical?
- What levels of service must be provided?
- Are the current maintenance practices sufficient to sustain the service level?
- How should the assets be managed to provide services in the most efficient way?
- How can the asset data and maintenance system be updated to better facilitate maintenance practices?
- How much funding is necessary to sustain the delivery of services?
- Are there adequate resources to provide the services?

The answers to these questions help in the development of an asset management plan. An asset management plan is meant to be a living document. As assets are replaced and maintenance is performed, the asset management plan will reflect the updated conditions of the assets and the associated risk profile. With this process, the asset management plan will grow and change with the organization and system for which it is written.

2 Asset Inventory and Valuation

This chapter provides an overview of the potable water assets owned and managed by WRD. It documents what assets are owned and managed, as well as the assets' ages, conditions, and replacement costs. The information documented in this chapter, along with the life cycle cost logic, drives the life cycle cost analysis.

2.1 Asset Register

The asset register is a central database that tracks all the assets. It is the basic building block of an asset management program. An asset register records all of the organization's managed assets and the key attributes used to support asset management decisions. It also forms links between all asset-related applications (e.g., CMMS, GIS) through a unique asset identification number, the Asset ID.

All of WRD's potable water system assets were consolidated in the asset register. During the consolidation process, data gaps were identified (e.g., missing installation year, pipe material, size). Working closely with engineering and O&M staff, mitigation strategies were developed and used to fill in the critical gaps. Once verified data becomes available, WRD plans to replace the assumed data.

Key components of an asset register include the asset hierarchy and asset inventory. Details of these components are presented in the following sub-sections.

2.1.1 Asset Hierarchy

The asset hierarchy allows WRD to organize and easily navigate through its asset register. As shown in the figure, the potable water assets are organized by distribution assets and remote facility assets. The distribution assets are further organized into asset categories (e.g., hydrants, laterals, mains). The remote facility assets are further categorized into pump station and reservoir assets.

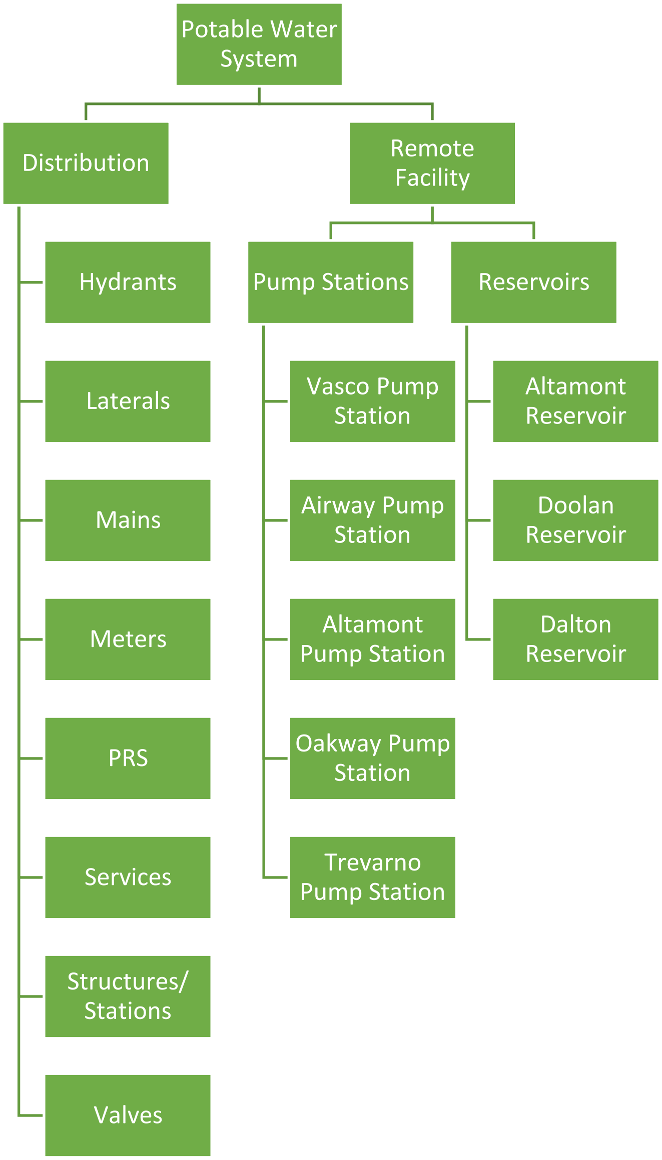


Figure 2-1 Potable Water System Asset Hierarchy

General asset hierarchies for the pump stations and reservoirs are illustrated below.

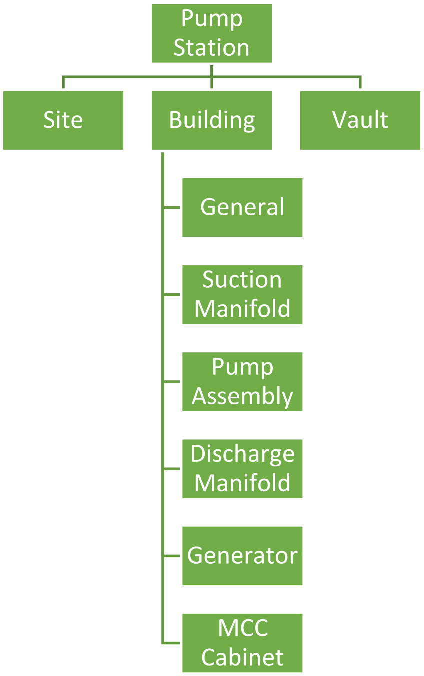


Figure 2-2 Pump Station Asset Hierarchy

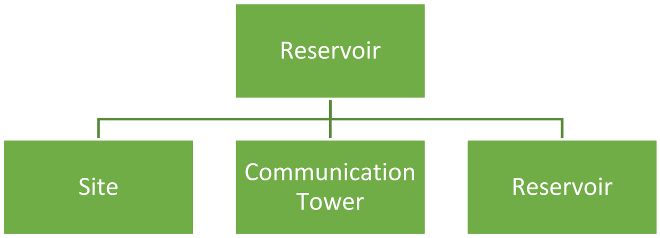


Figure 2-3 Reservoir Asset Hierarchy

2.1.2 Asset Inventory

Once the asset data was gathered and organized into the hierarchy, the initial asset register was developed. Data was gathered from GIS.

The potable water system is comprised of 31,859 assets, which includes approximately 155 miles of mains and laterals. The following table shows a sample of the assets in the distribution system.

Table 2-1 Potable Water Distribution Asset Inventory

Asset	Quantity	Length
Hydrants	1,427	
Laterals	1,633	11.7 mi
Mains	4,083	143.2 mi
Meters	9,848	
Pressure Reducing Stations (PRS)	38	
Services	9,848	
Structures/Stations (e.g., Vaults, Cathodic Protection)	70	
Valves	4,500	

The following tables show a summary of the assets in the remote facilities. As shown in the table below, the potable water system remote facilities include 5 pump stations and 4 reservoirs at 3 sites. Altamont and Dalton Reservoirs are both entirely potable water reservoirs. The Doolan Reservoir site also has 2 recycled water reservoirs; only the assets that are part of the potable water reservoir and the Doolan Reservoir site are included in the potable water asset register.

Table 2-2 Potable Water Remote Facilities Asset Quantity

Facility	Quantity
Airway Pump Station	57
Altamont Pump Station	59
Oakville Pump Station	69
Trevarno Pump Station	40
Vasco Pump Station	102
Altamont Reservoir	30
Dalton Reservoir	33
Doolan Reservoir	22

Table 2-3 Potable Water Remote Facilities Asset Inventory

Asset	Quantity	Asset	Quantity
Building	6	HMI	2
Access Hatch	3	HVAC	2
Actuator	3	Instrumentation	32
Antenna	1	Irrigation Controller	3
Backflow Preventer	4	Ladder	1
Cabinet	3	Lighting	6
Cathodic Protection	4	MCC	32
Communication	1	Motor	21
Compressor	1	Pavement	9
Control Panel	5	PLC	3
Controller	38	Probe	1
Crane	3	Pump	21
Driveway	1	Reservoir	4
Fan	3	SCADA	11
Fence	5	Security System	3
Fencing	4	Seismic Joint	1
Fire Protection	2	Sump Pump	3
Flow Meter	3	Tank	1
Fuel Tank	2	Transformer	4
Gate	6	UPS	2
Generator	4	Valve	140
Generator Fuel Tank	2	Vault	5
Grating	1		

2.2 Installation Profile

The installation profile gives a historical view of the assets. The installation profile displays the ages of the assets, and also illustrates the installation trends. When installation information was not available, assumptions were made based on neighboring assets. Service installation years were estimated based on the installation year of the main to which they were connected.

The figure below shows the installation of the potable water system, both distribution and remote facilities, by replacement cost. The replacement costs are represented in 2016 dollars and do not reflect actual installation costs. As shown in the graph, the earliest installation dates of the currently existing assets are in the early 1960's. Growth of the potable water system slowed until the 1980's. Starting in the early 1980's, the City of Livermore invested more heavily in its water infrastructure system. This figure also reveals that WRD has assets that are over 50 years old.

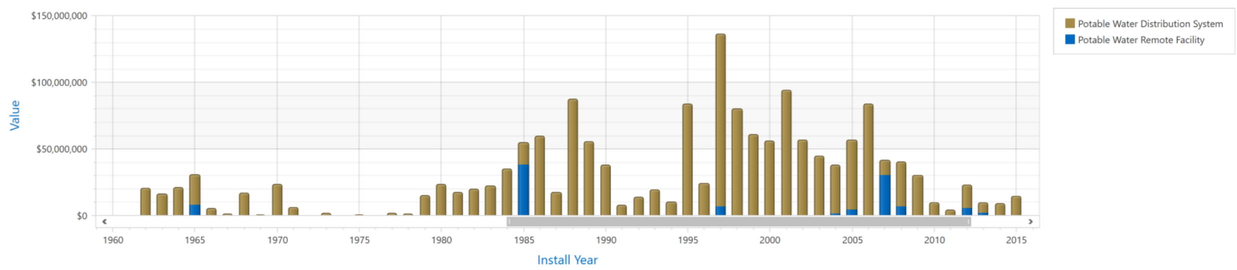


Figure 2-4 Potable Water System Installation Profile

The following graph presents the asset installation profile for the potable water distribution system. The earliest installed assets in the potable water system were installed in 1962. A significant investment in the water distribution system took place during and after 1995, meaning that much of the system assets are 20 years old or newer.

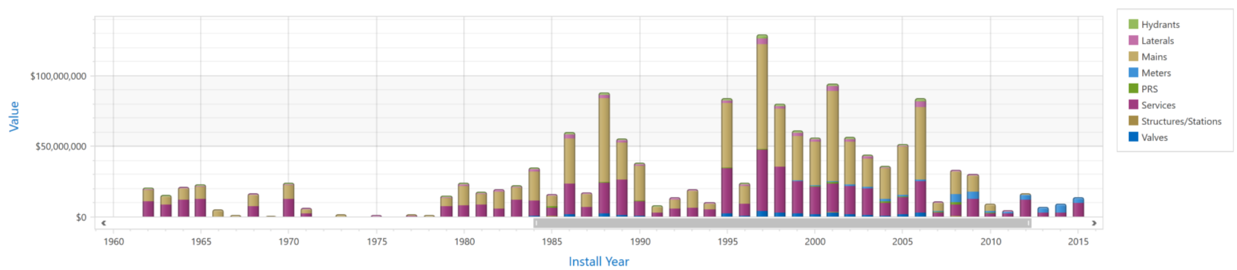


Figure 2-5 Potable Water Distribution System Installation Profile

The following figure shows the installation profile for the potable water remote facilities. Developed in the early 1960's, Trevarno Pump Station is the system's oldest station. The remaining potable water pump stations were installed between 1997 and 2013. Of the reservoirs, Dalton Reservoir was constructed the earliest in 1965. In 1985, Altamont Reservoir was added, and expansion took place at Altamont Reservoir in 2004. Much of Doolan Reservoir was upgraded in 2008. According to this installation profile, many of the assets at Altamont and Doolan were installed relatively recently, and it is expected that these assets will be in relatively good condition.

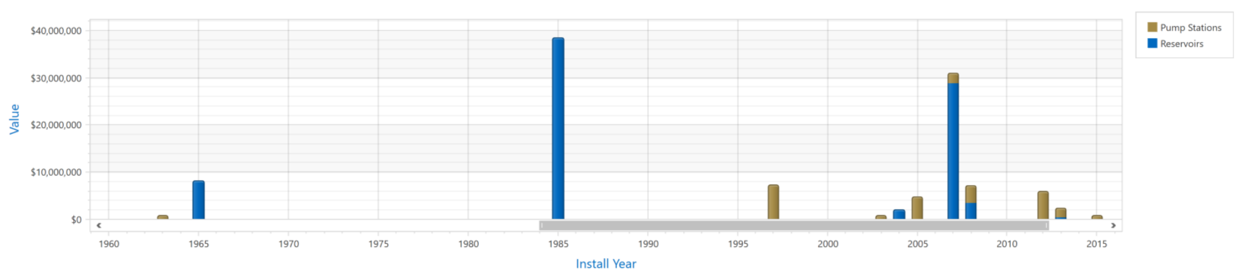


Figure 2-6 Potable Water System Remote Facilities Installation Profile

2.3 Consumption Profile

While the installation profile presents the past, the consumption profile presents the current state of the assets. The consumption profile shows how much of the asset's useful life remains. A consumption profile is useful for highlighting the number of assets that are reaching the ends of their useful lives and will soon need replacement. Asset consumption is calculated based on the condition or, when condition is not available, the age of the asset versus its useful life.

The following figure presents an illustration of the overall consumption profile of the potable water system assets. Many of the assets have used 50% or less of their useful lives. However, there are approximately $25 million worth of assets that have consumed 85% or more of their useful lives. These assets are generally part of the distribution system.

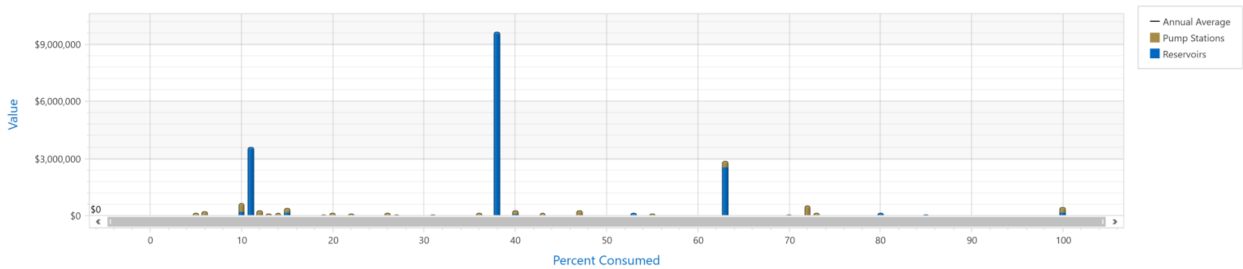


Figure 2-7 Potable Water System Consumption Profile

2.4 Replacement Cost

Along with a general understanding of the state of WRD's potable water system assets, an understanding of the financial requirements for the replacement of these assets gives WRD the ability to plan for its future needs. Asset valuation is a key component of asset management. This information gives an organization the ability to understand the magnitude of the investment made and reinvestment in the future.

In the asset register, each asset received an estimated a replacement cost in current year dollars. The estimated replacement cost represented the amount WRD will need to budget to replace the asset at the asset level. The estimated cost does not consider the costs at the project level (e.g., insurance, engineering, mobilization). The system valuation was represented based on summing up the replacement costs in the asset register. Using this methodology, the total value of the potable water system is approximately $282.9 million.

The following figure shows the asset valuation for the potable water distribution system assets. The potable water distribution system has a valuation of approximately $262 million. Water mains make up the most of the value of the distribution system at $136 million, followed by services at approximately $98.5 million. The remaining valuation is made up of laterals, valves, hydrants, meters, PRS, and structures.

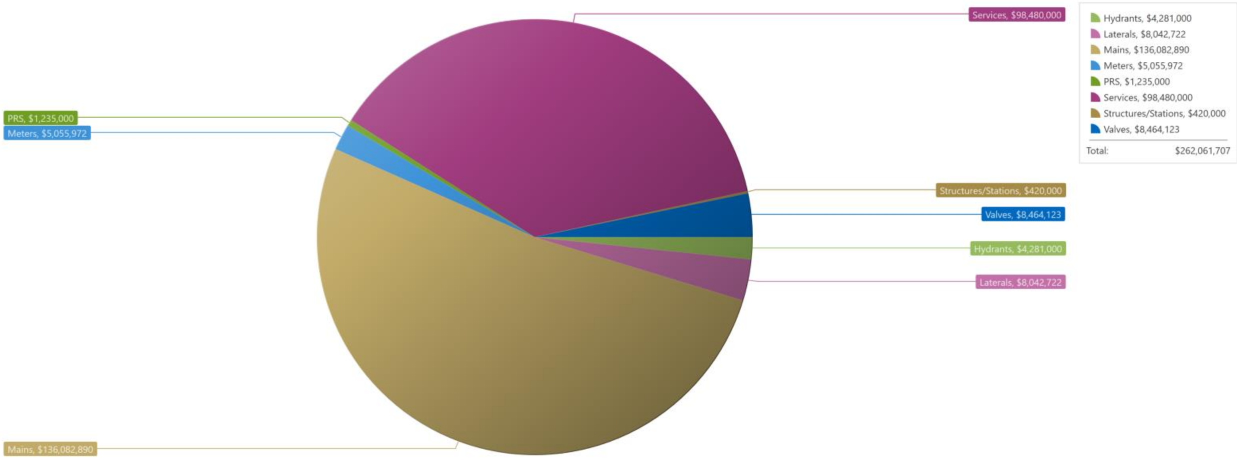


Figure 2-8 Potable Water Distribution System Valuation

The following figure shows the valuation of the potable water remote facilities. The total valuation of the potable water remote facilities assets is approximately $21 million. Vasco Pump Station has the highest valuation of the pump stations at approximately $1.5 million. In contrast, Trevarno Pump Station has the lowest valuation at $403,700. Amongst the reservoirs, Altamont Reservoir has the highest valuation at approximately $10 million, followed by Doolan Reservoir ($4 million) and Dalton Reservoir ($2.8 million).

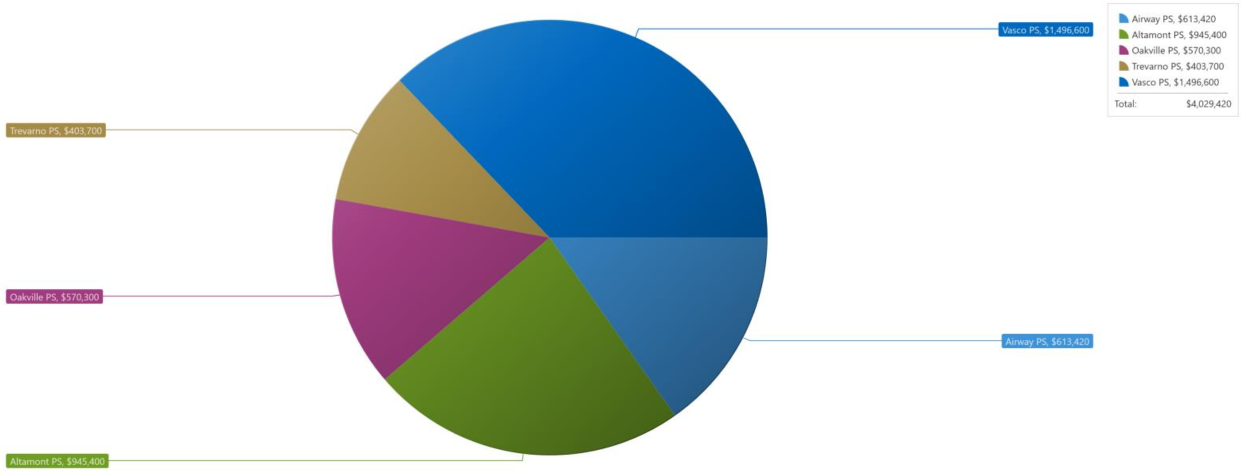


Figure 2-9 Potable Water Pump Station Replacement Cost

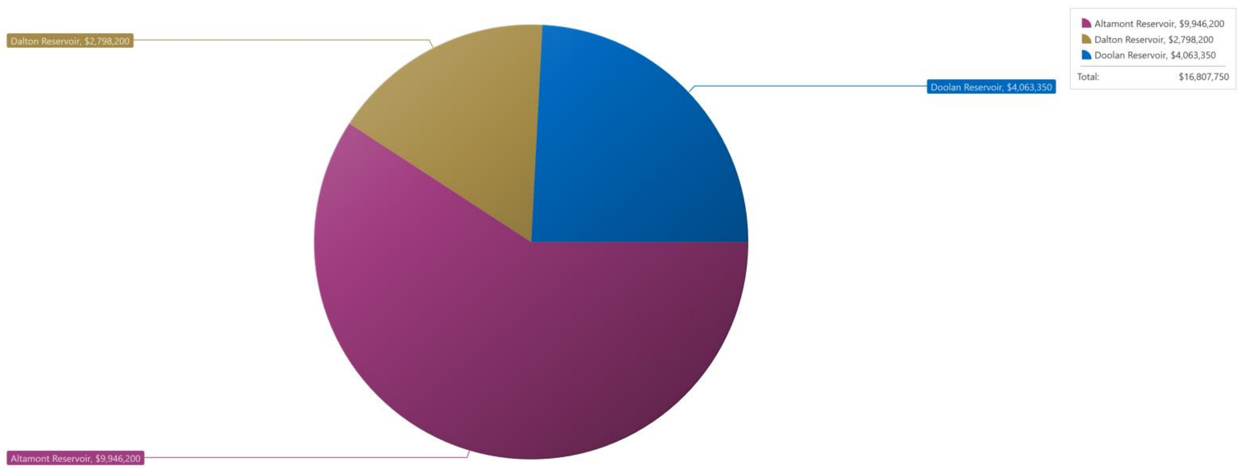


Figure 2-10 Potable Water Reservoir Replacement Cost

3 Level of Service

Levels of service are a set of commitments WRD intends to provide to its customers and stakeholders. They include specific performance metrics to allow WRD to measure how well it is achieving the target performance. Defined levels of service can be used to track the performance of WRD activities and identify areas where activities are not in alignment with the mission or goals of the organization.

WRD set the following mission for its services:

"To protect public health and the environment through effective utility systems operation in a responsible, efficient, and sustainable manner."

As part of the pilot asset management program, WRD established levels of service for its wastewater collections system. In the future, WRD will establish levels of service for its other asset management systems. It is important to establish these levels of service in order to understand what to measure, which establishes the relationship between the levels of service and the cost to provide the service. Once established, this relationship can be evaluated to determine the optimum service at the lowest life cycle cost and risk.

4 Risk Assessment

This chapter provides an understanding of the potable water system asset risk profile. Risk is a key element of asset management. It is used to prioritize budgets and resources in a transparent and consistent way. The objectives of a risk assessment are as follows:

1. Identify assets representing the greatest risk to the organization

2. Promote efficient use of resources by focusing on high-risk assets (i.e., capital and operational expenditures, staff hours)

3. Highlight assets requiring detailed condition assessment or renewal

4. Prioritize inspection, cleaning, and preventative maintenance schedules

5. Develop and apply appropriate risk management strategies

4.1 Methodology

Risk is the term used to describe and quantify the risks associated with the management of assets. Risk is comprised of three major factors: probability of failure, consequence of failure, and redundancy. The probability of failure measures an asset's likelihood of or timing to failure. The consequence of failure evaluates the direct and indirect impacts of a failure. Redundancy, the presence of backup equipment, helps to decrease the overall risks of a failure. A risk score is assigned to each asset in the asset register to help prioritize the needs of the assets under limited resources.

4.2 Probability of Failure

A combination of condition-based and age-based approaches has been utilized to calculate Probability of Failure (PoF).

The assets were assigned condition scores based on a scale of 1 (new or excellent condition) to 5 (virtually unserviceable or failed). The table below shows the general guidelines used for the condition assessment process.

Table 4-1 Condition Score Guidelines

Score	Description
1	New or Excellent Condition
2	Minor Defects Only
3	Moderate Deterioration
4	Significant Deterioration
5	Virtually Unserviceable

Certain assets that were deemed to be in major asset classes (e.g., pumps, motors, valves) were given individualized condition matrices. These condition matrices are included in Appendix A.

When condition data was available, the PoF was calculated utilizing the condition score. Where the condition data was not available, an age-based methodology using the asset's useful life and age and a deterioration curve was used to estimate the PoF.

To develop an understanding of the condition of the remote facilities, each facility was visited and inventoried. Visual condition assessment was performed where possible to establish the condition of each asset. Depending on the asset, inspectors looked for signs of leakage, heat, vibration, noise, and wear. Each inspected asset received a condition score to represent the current state of the asset. These condition scores were later converted to PoF scores to indicate the urgency of the renewal activity.

The following maps show the PoF level of the potable water distribution system.

Figure 4-1 below maps the potable water mains. As is shown in the figure, most of the potable water mains have a low PoF score. The figure shows two areas that contain medium PoF potable water mains, and there are a few segments of pipe in the southeast area under WRD's jurisdiction that have high PoF. It is very difficult to do a condition assessment on mains due to the possibility of water service disruption during the assessment process. As such, it is very typical to drive the PoF estimation process based on age. As reflected in the installation profile presented in Figure 2-4, the relatively young pipe age for most of the mains leads to the relatively low PoF. However, there are some mains that are known to need replacement in the near future. The most prominent high PoF main is a cast iron pipe installed in the 1960's that is known to be in poor condition.

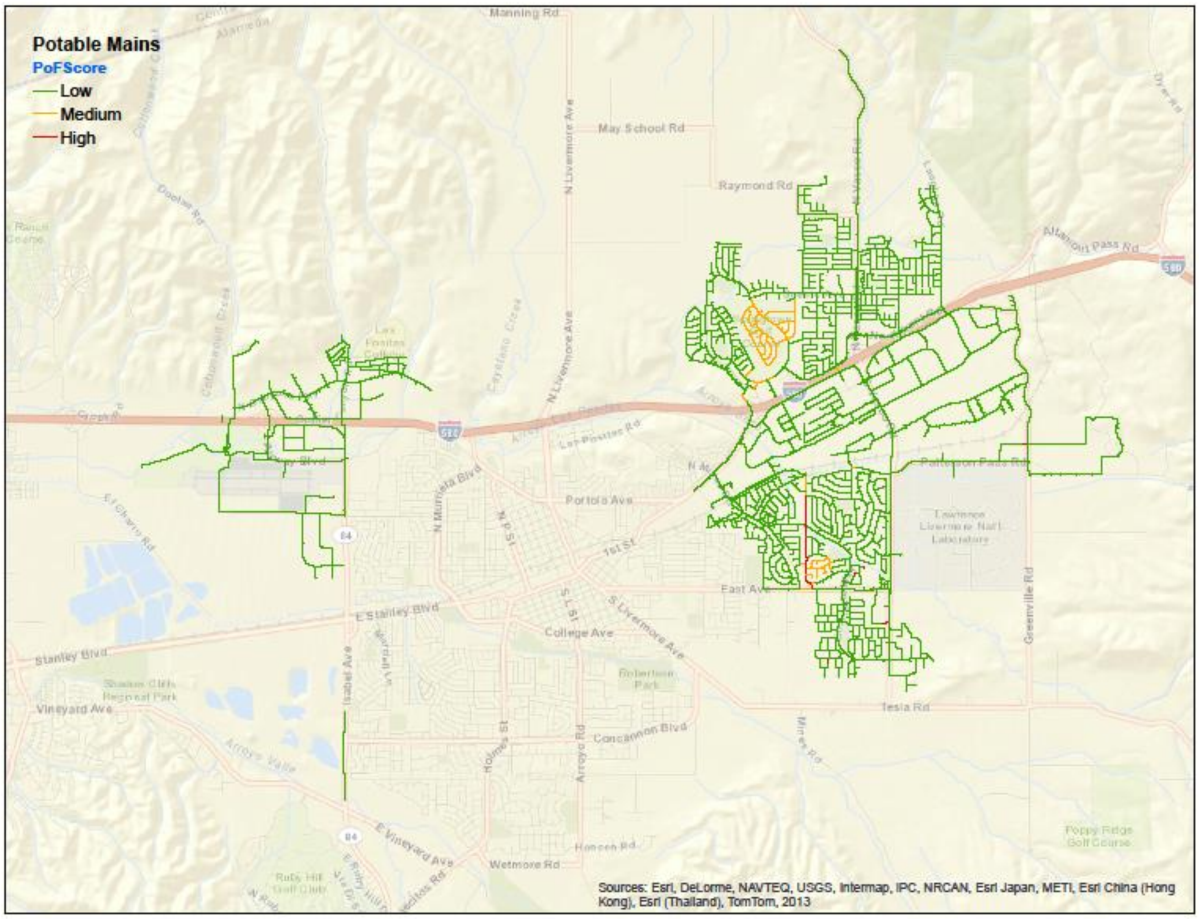


Figure 4-1 Potable Water Mains PoF Map

Figure 4-2 below shows the potable water hydrant PoF levels. Similar to water mains, many of the hydrants do not yet have high PoF scores. Most have low PoF, while the medium PoF hydrants are concentrated in two older areas of WRD's service district.

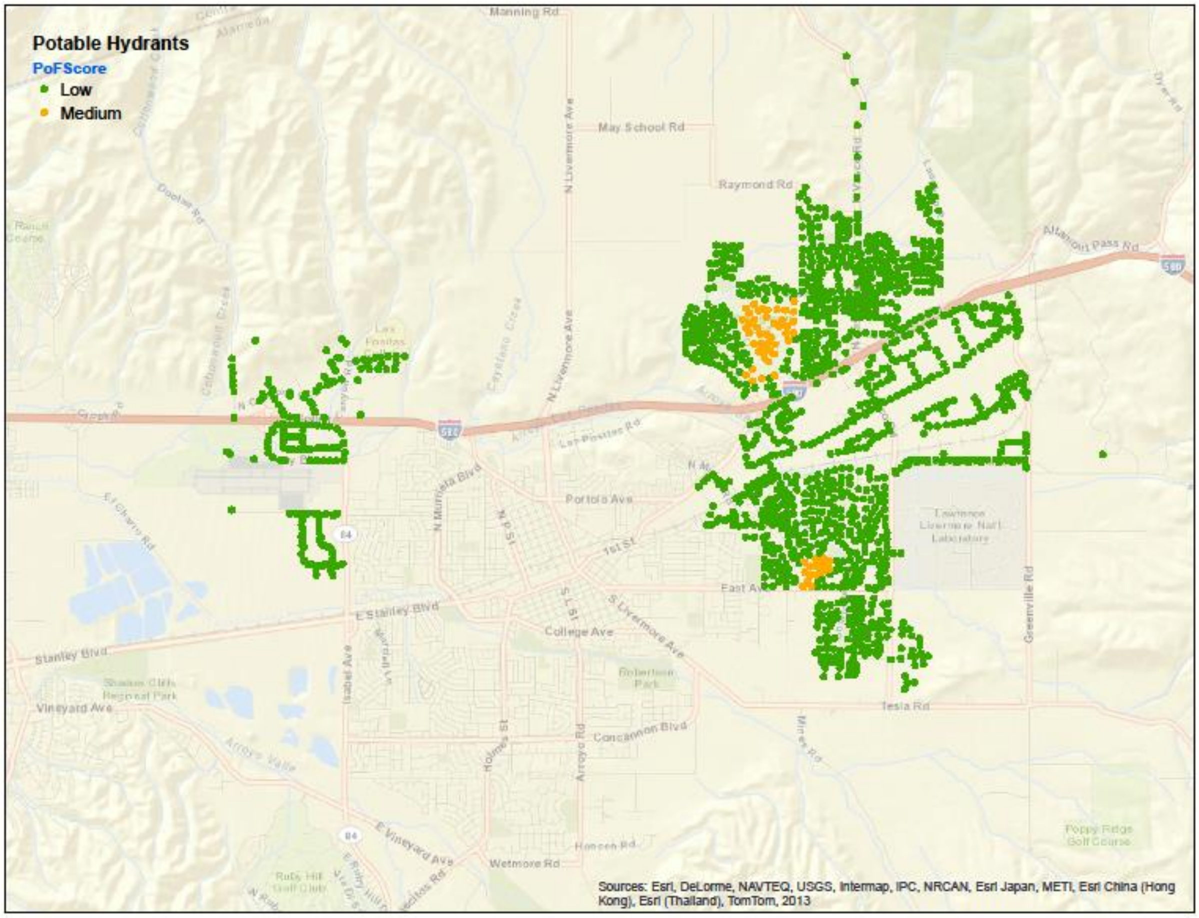


Figure 4-2 Potable Water Hydrants PoF Map

Figure 4-3 shows a map of the PoF scores of the valves. Similar to water mains, most of the valves have low PoF scores. Also similar to water mains, the medium and high PoF assets are clustered in two main areas. Both of these areas contain older assets that were installed in the 1960's.

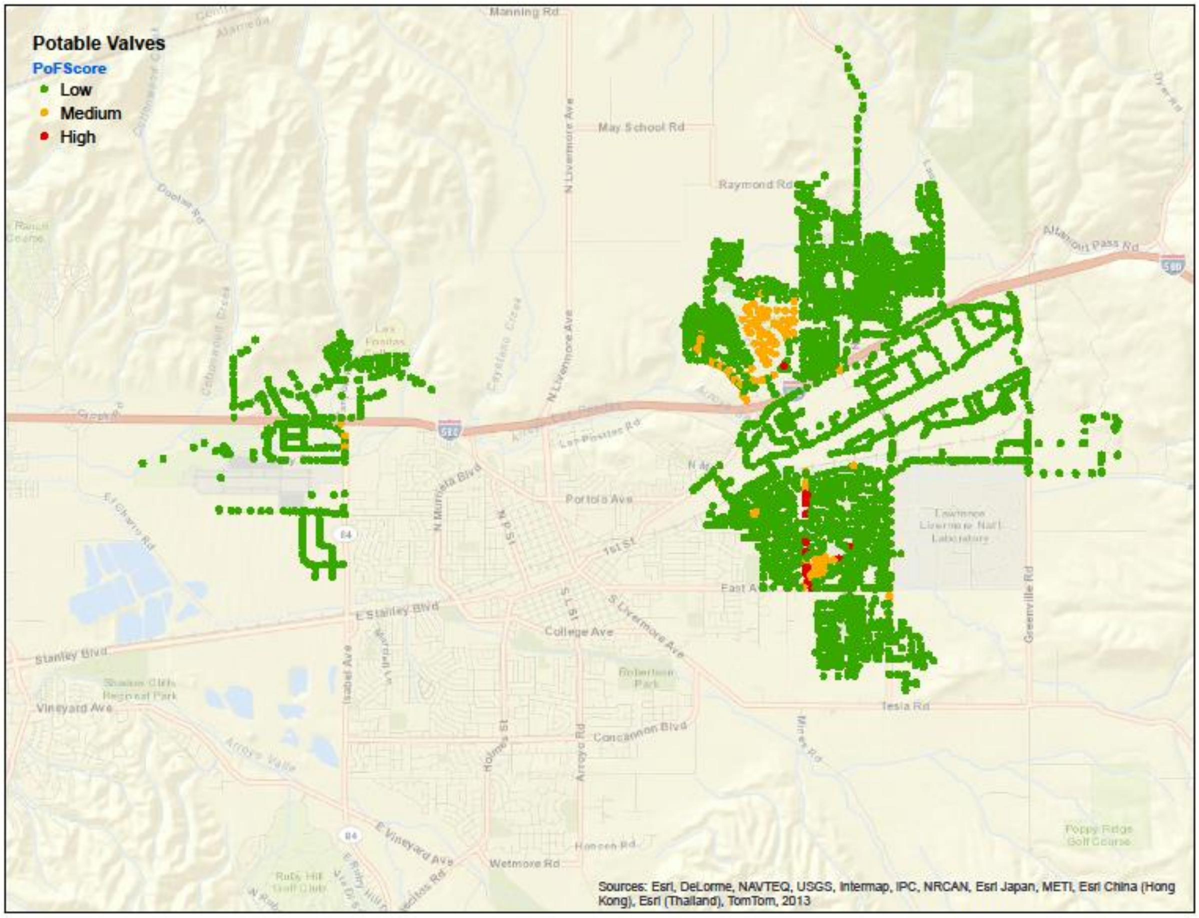


Figure 4-3 Potable Water Valves PoF Map

Figure 4-4 Potable Water Meter PoF Map displays a map of the potable water meters. Most of the potable water meters have low PoF. Nearly 60% of the meters were installed after 2000, which contributes to the high number of low PoF assets. As shown in the map, a relatively small number of meters have medium or high PoF.

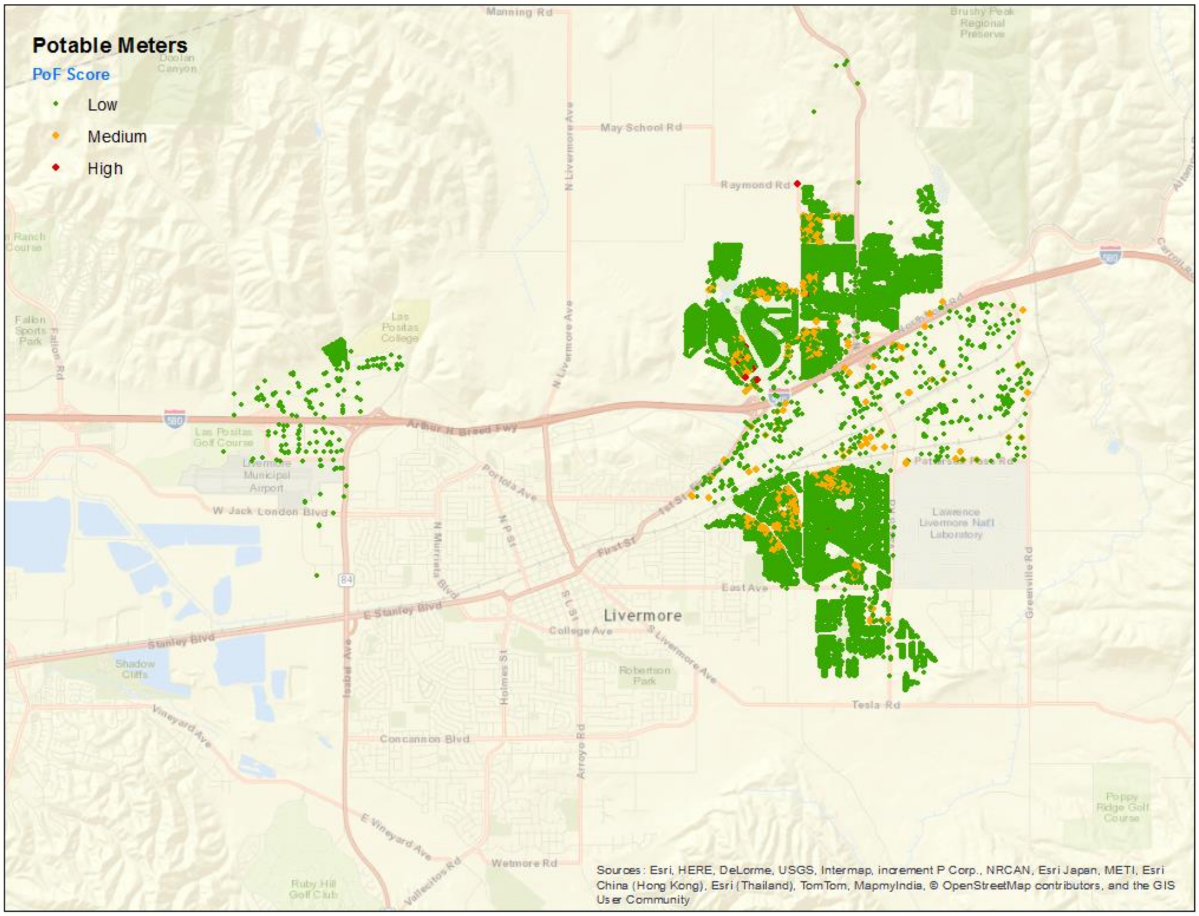


Figure 4-4 Potable Water Meter PoF Map

Figure 4-5 below shows the PoF map of the potable water services. As is shown in the map, there are a high number of services that have high PoF. These services are estimated to fail in the near future.

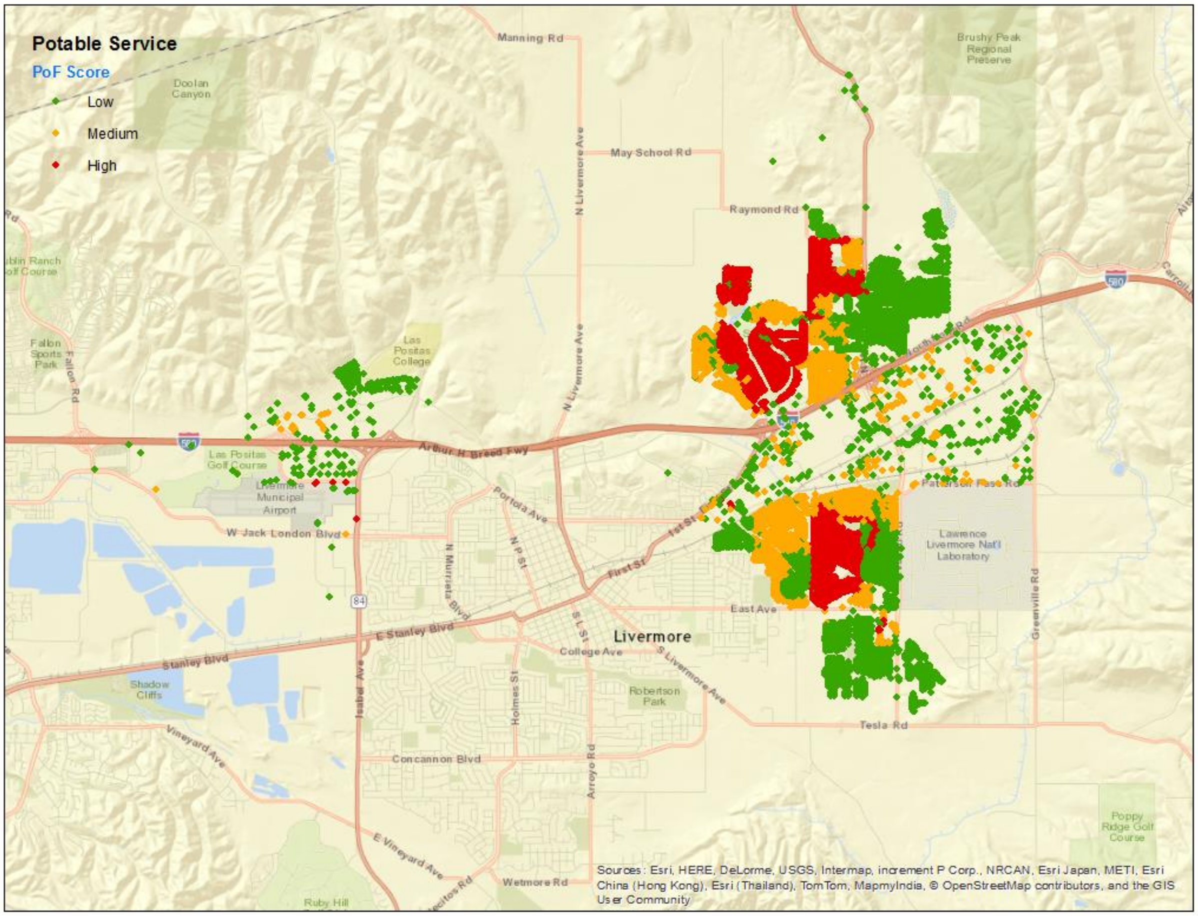


Figure 4-5 Potable Water Services PoF Map

Figure 4-6 and Figure 4-7 show the PoF analyses for the remote facility assets. Airway, Altamont, Oakville, and Vasco pump stations all have high numbers of assets that have a low probability of failure. All of the facilities, except for Altamont pump station, have some high PoF assets. As shown in Figure 4-7 and Figure 4-8, however, although most of the facilities have a significant number of assets with high PoF, the high PoF assets represent a relatively low percentage of the replacement cost. Although many of the assets are likely to fail in the near future, the financial needs for these replacements is relatively little.

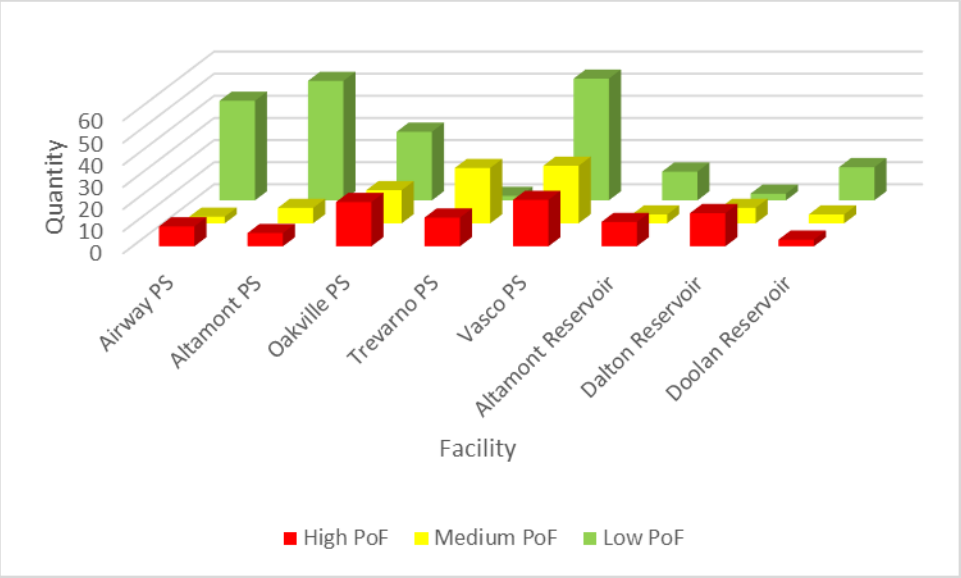


Figure 4-6 Remote Facility PoF Level by Quantity

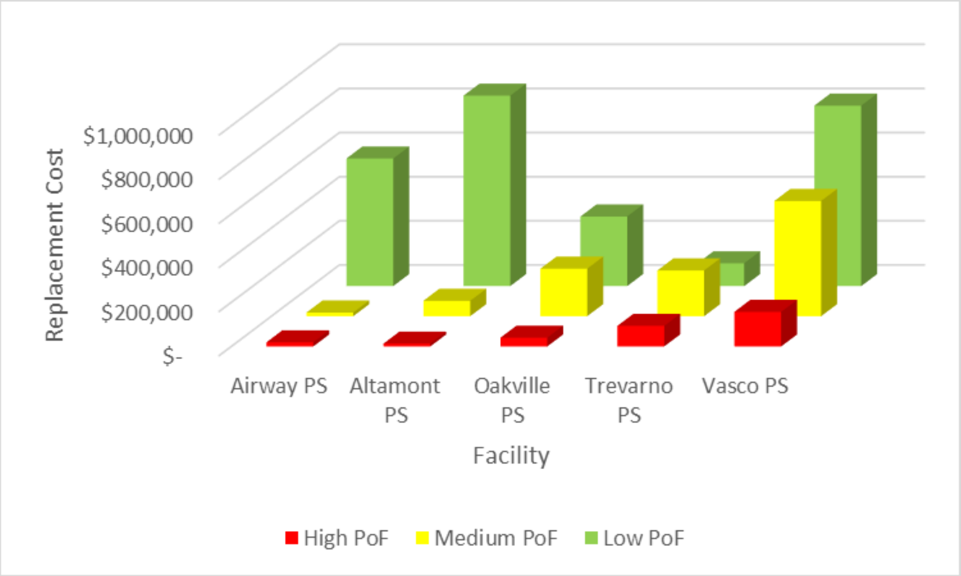


Figure 4-7 Pump Station PoF Level by Replacement Cost

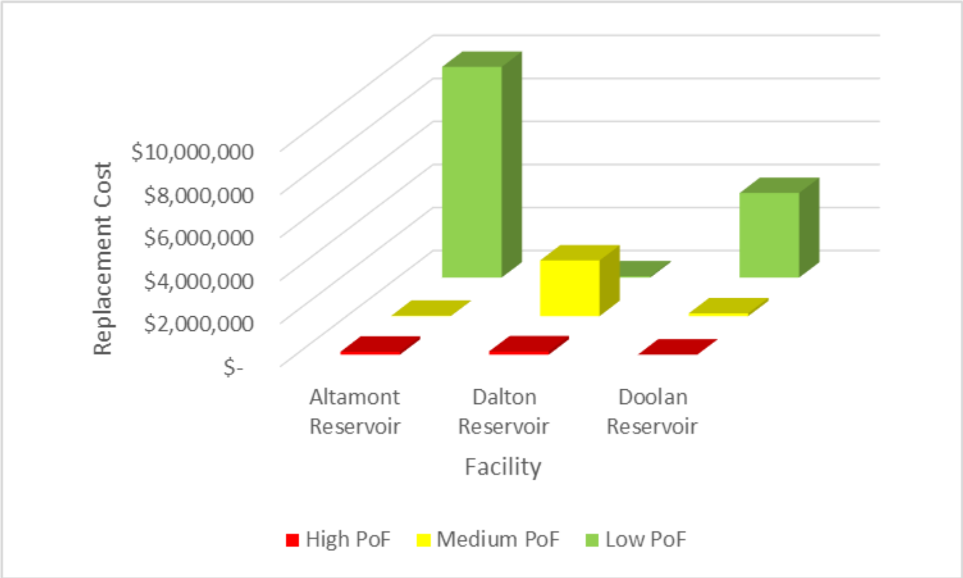


Figure 4-8 Reservoir PoF Level by Replacement Cost

4.3 Consequence of Failure

The Consequence of Failure (CoF) measures the direct and indirect impacts of an asset failure from triple bottom line (economic, social, and environmental) perspectives. CoF provides an indication of the asset criticality. It is used to help prioritize the need under limited resources and/or budget.

Mains and Laterals

The CoF scores of the potable water system mains and laterals were determined through the consideration of several different factors. The factors used to assess consequence of failure for mains and laterals included the following:

- Proximity to water bodies – a spill entering a water body (e.g., ponds, streams, creeks) can have high environmental consequence.
- Proximity to freeways and major roads – a spill disrupting traffic flow has high social and economic consequences.
- Proximity to railroads – this factor was used to highlight areas where an impact of failure would result in high social and economic consequences.
- Size of pipe – the greater the size of the pipe, the greater the impact of failure as a larger diameter carries a greater water volume.
- Zoning / land use – this factor considers the zoning or the use of the land at the location of the pipe. The location has a huge impact on the social, economic, and environmental consequences. This factor is used to highlight pipes near businesses, hospitals, schools, etc., where failure impact can be greater.

Working with WRD staff, the consequence of failure factors were weighted, and the factors were assigned for each pipe segment. Numerous iterations and adjustments took place to produce a result that aligned with WRD's knowledge and expectations.

The overall risk scores were developed based on a scale of 1 (low CoF) to 5 (high CoF).

The following table shows the weight each factor was given to determine the overall CoF score.

Table 4-2 Mains and Laterals CoF Weighting Factors

CoF Factors	Weighting
Zoning	20%
Street	20%
Creek	20%
Pipe Size	40%

The following tables show the CoF scores assigned to each factor for the potable water pipes.

Table 4-3 Zoning CoF Factor

Zoning Classification	CoF Score
Industrial	4
Commercial	5
Residential	3
Mixed Use	4
Airport	2
Planned Development	3
Public and Quasi-Public	2
Open Space	1

Table 4-4 Street CoF Factor

Street Classification	CoF Score
Freeway & Freeway Ramp	5
Freeway	5
Freeway Ramp	5
Railroad	5
State Route	4
State Route Ramp	4
Arterial	3
Collector	3
Residential Collector	2

Street Classification	CoF Score
Local	2
Access Road	1
Rural Route	1
Rural	1

Table 4-5 Creek CoF Factor

Creek Classification	CoF Score
Creek/Channel	4

Table 4-6 Pipe Size CoF Factor

Pipe Diameter (in)	CoF Score
0.625	2
0.75	2
1	2
1.5	2
2	2
3	2
4	2
5	2
6	3
8	3
9	3
10	3
12	3
14	4
15	4
16	4
18	5
20	5
24	5
42	5

Fire hydrant laterals were assigned the same CoF score as the hydrants (i.e., 5).

Other Assets

The following table shows some of the CoF scores assigned to other asset classes. In addition, valves were assigned a CoF score of 1, 3, or 5 based on the CoF of the pipe to which they were connected.

Table 4-7 Other Asset CoF Scores

Type	CoF
Hydrant	5
Meter (≤ 1 in)	1
Meter (2 - 4 in)	3
Meter (6 - 12 in)	4
Service (≤ 1 in)	1
Service (1.5 - 4 in)	1
Service (6 - 12 in)	3
Structures/Stations	3.5

Remote Facilities

A two-tiered CoF scoring methodology was utilized for the remote facilities. At the first level, facility criticality was assessed. Each facility was ranked based on the significance of the facilities with respect to one another. A priority score of 1 indicates WRD's most critical facilities. Failure of these facilities will result in significant impact. Once the facility criticality was assessed, the criticality of assets was evaluated. Each asset received a criticality score between 1 to 5. The scores were combined to determine the overall CoF score for each asset.

The priority ranking for each remote facility is shown in the table below. WRD's two most important pump stations are Altamont and Vasco. These pump stations are followed by Airway, Oakville, and Trevarno, respectively. Trevarno was ranked lowest because this station serves as a backup; there is enough capacity in other pump stations to provide services in case of Trevarno's failure.

Altamont Reservoir is WRD's most critical reservoir. The failure of Altamont Reservoir will result in significant impact to water services. Doolan and Dalton follow Altamont on the priority ranking.

Table 4-8 Remote Facility Priority

Facility	Priority
Pump Stations	
Vasco – Zone 2 & 3	1
Altamont – Zone 3	1
Airway – Zone 1	2
Oakville – Zone 3	4
Trevarno – Zone 2	5
Reservoirs	
Altamont – Zone 2 & 3	1
Doolan – Zone 1	2
Dalton – Zone 2	3

The CoF scores for each asset class in the remote facilities is presented in the table below. Assets with a CoF score of 5 indicates that the facility will not be able to perform its function in the case of asset failure. A lower CoF score indicates that the facility will still be able to function even if the asset fails.

Table 4-9 Facility Asset Class CoF Scores

Asset Class	CoF	Asset Class	CoF
Emergency Generator	5	VFD	3
MCC	5	Backflow device	2
Pump	5	Building	2
Pump Motor	5	Control Panel	2
Reservoir	5	HMI	2
Seismic Joint	5	Meters	2
Submersible Pump	5	UPS	2
Transformer	5	Vaults / Pits	2
Valve	5	Camera / Radio / Computer	1
Wet well	5	Cathodic Protection	1
PLC	4	Compressor	1
SCADA	4	Crane / Hoist	1
Valve Actuator	4	Entry Gate	1
Instrumentation	3	Fence	1
Sensors / Switches	3	HVAC / Fans	1
Surge tank / Pressure tank	3	Ladder	1
Transmitters	3	Pavement / Concrete	1

The following figures give a detailed look at the CoF levels of the potable water assets.

Figure 4-9 below shows a map of the potable water main CoF scores. The CoF scores were based on multiple factors, including proximity to roads, pipe diameter, and zoning. Most of the potable water mains have low or medium CoF; a few mains, marked in red, have high CoF. These high CoF mains cross major roads or are the mains that are connected to the reservoirs.

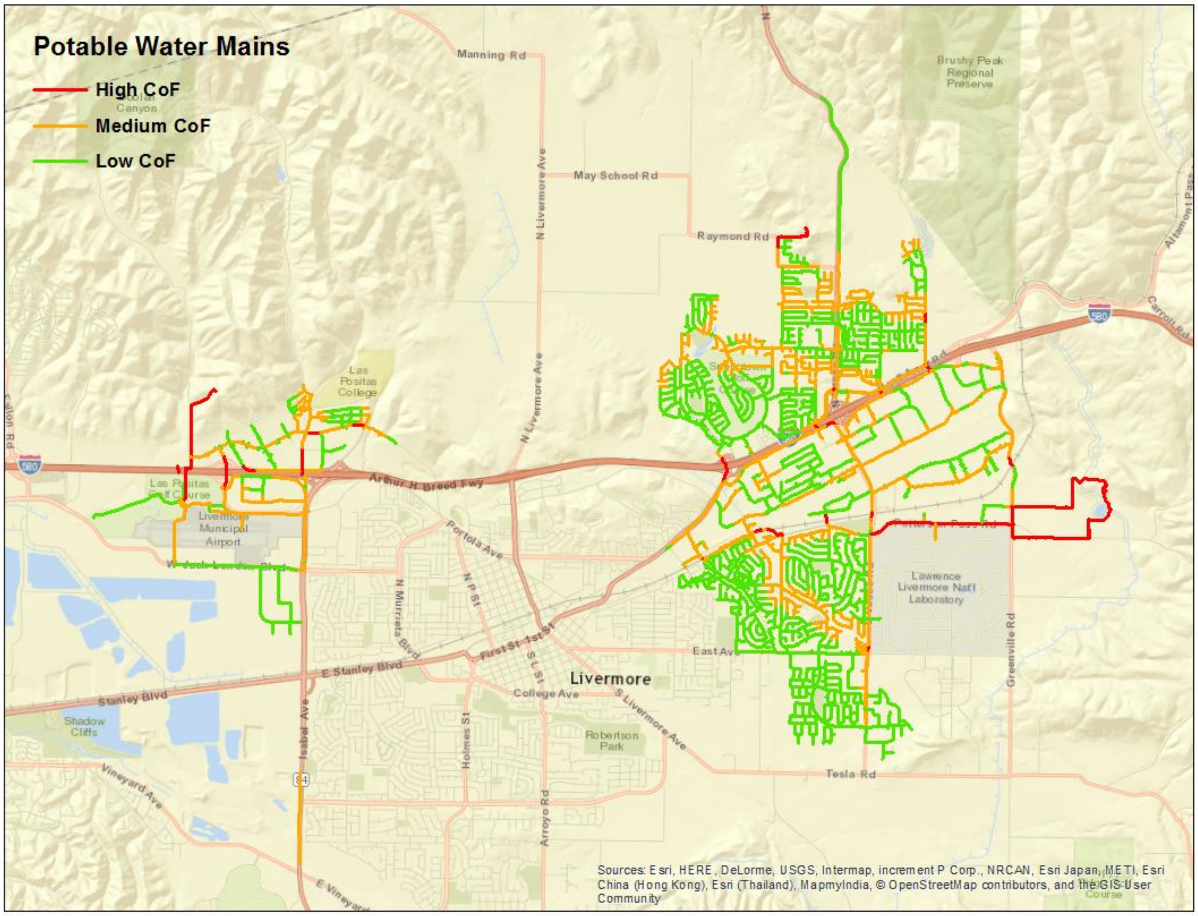


Figure 4-9 Potable Water Main CoF Map

Figure 4-10 shows the CoF scores of the potable water valves. As shown in the map, a large number of the valves have a low CoF. The medium CoF valves generally correspond to the medium CoF mains in the map above. The high CoF valves were identified by staff as critical valves and are regularly exercised to minimize risk.

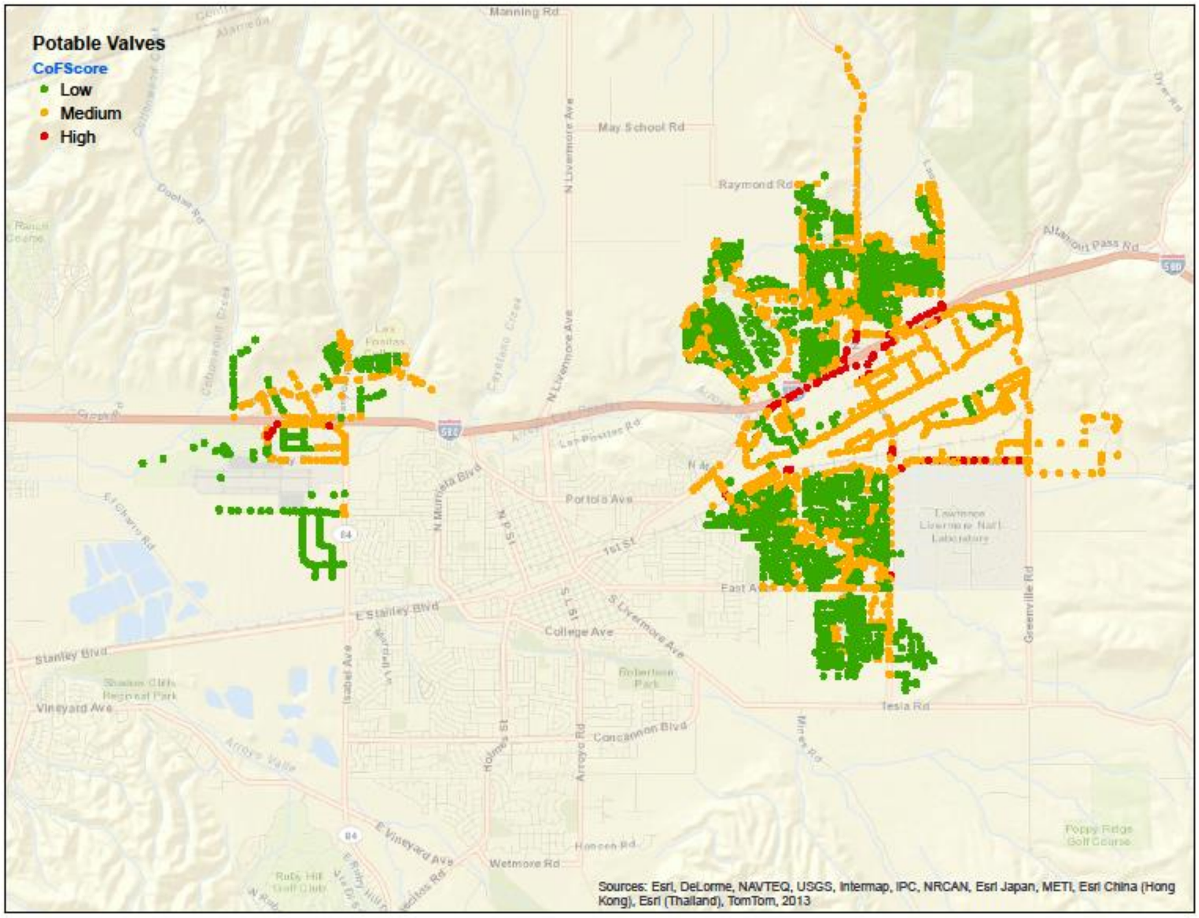


Figure 4-10 Potable Water Valve CoF Map

Figure 4-11 below shows the CoF scores of the potable water meters. Most of the meters were assigned a low CoF score, while most of the remaining meters received a medium CoF score.

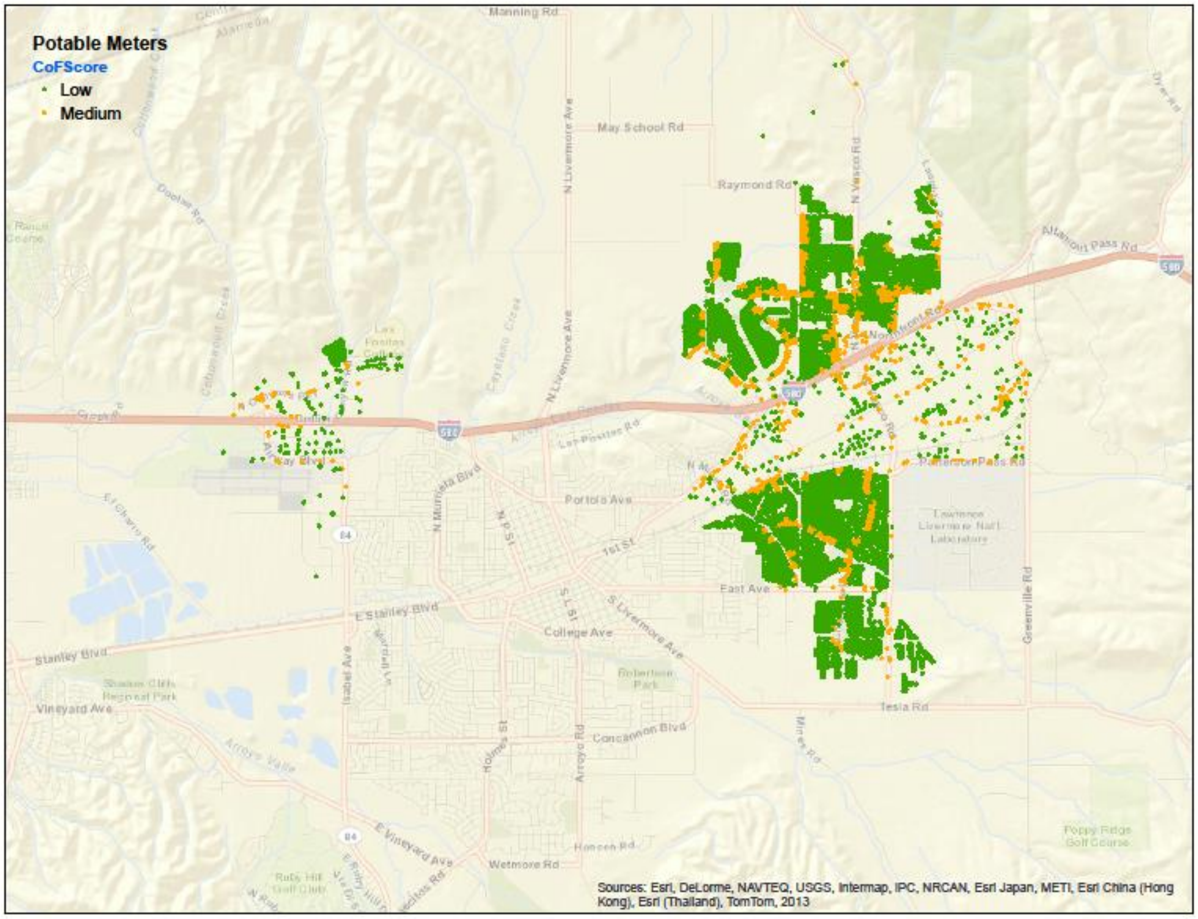


Figure 4-11 Potable Water Meter CoF Map

Figure 4-12 below shows the map of the CoF scores of the services. Most of the services have a diameter of less than 1 inch and so were given low CoF scores. The large diameter services, 4 inches and larger, were assigned a high CoF score and are marked in red.

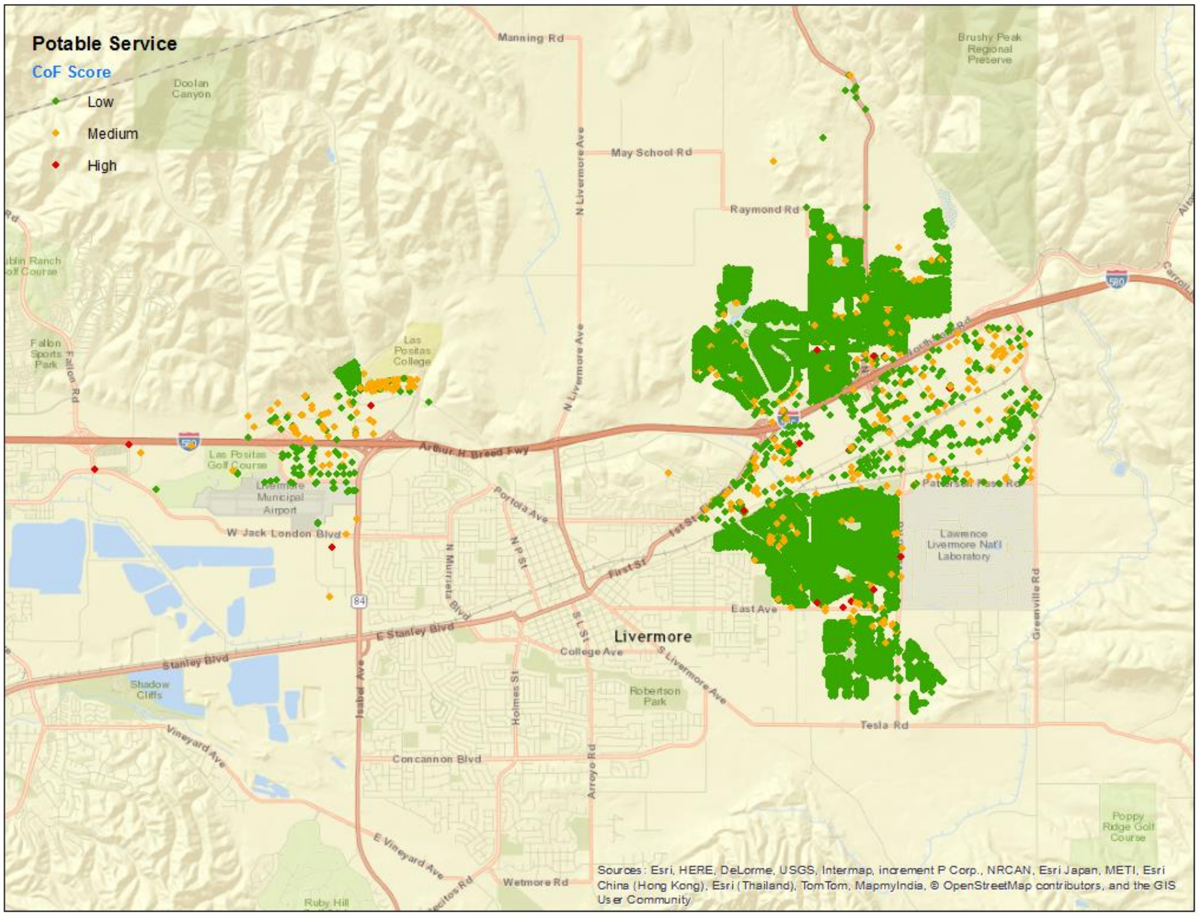


Figure 4-12 Potable Water Service CoF Map

The following graphs present the CoF scores for the remote facility assets. As shown in Figure 4-13, Airway, Altamont, and Vasco pump stations have high numbers of assets with high CoF (e.g., pumps, motors, valves). Trevarno has no high CoF assets because the entire facility is a back-up station, and the overall facility criticality is lower than the other pump stations. All three of the reservoirs have a high number of high CoF assets. These assets also present a relatively high percentage of the total replacement cost of the reservoirs. The reservoir tanks represent most of the high CoF asset replacement costs.

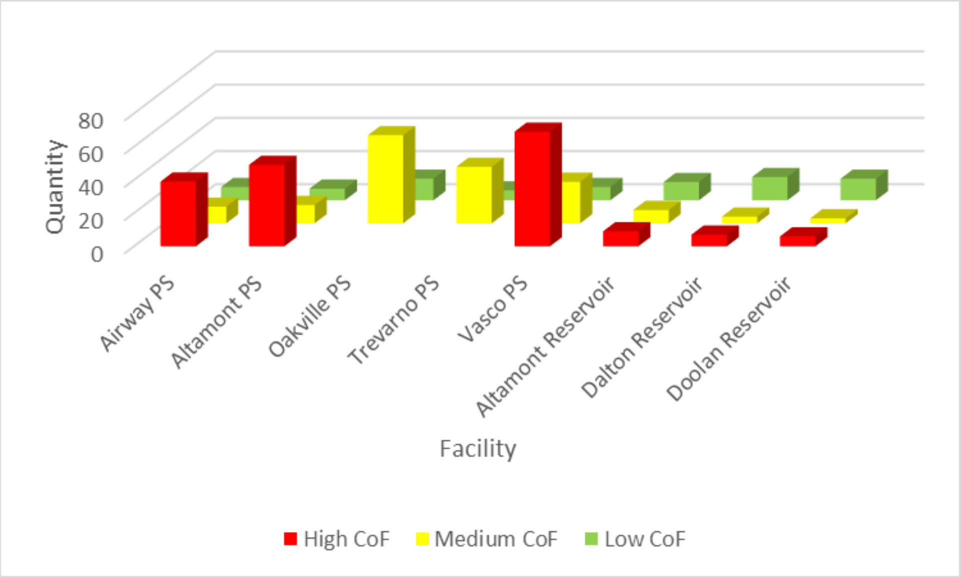


Figure 4-13 Remote Facility CoF Level by Quantity

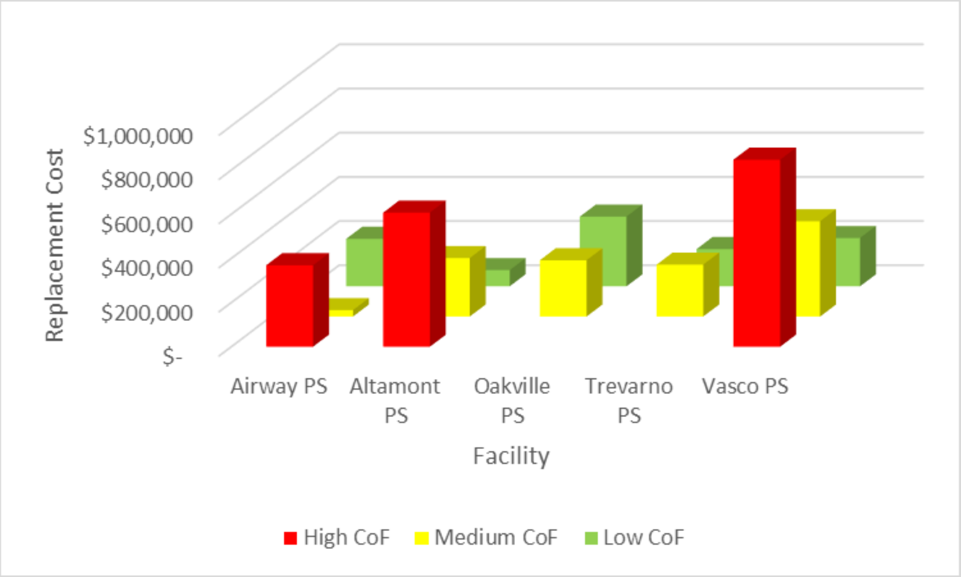


Figure 4-14 Pump Station CoF Level by Replacement Cost

Figure 4-15 Reservoir CoF Level by Replacement Cost

The following tables show a summary of the high CoF assets with a CoF score of 4 or above.

As is shown in the table below, the high CoF assets represent 9% of the total replacement cost of the distribution system. All of the hydrants have high CoF. In contrast, the high CoF services represent less than 1% of the total replacement cost for services.

Table 4-10 Distribution System High CoF Assets

Asset	High CoF Replacement Cost	Percent of Replacement Cost for Entire Asset Class
Hydrants	$ 4,281,000	100%
Laterals	$ 7,199,746	90%
Mains	$ 12,803,148	9%
Meters	$ 109,667	2%
PRS	$ 760,000	62%
Services	$ 240,000	<1%
Valves	$ 766,187	9%

The table below shows the replacement cost of the high CoF assets in each remote facility and the percentage of the total replacement cost of the facility. As is shown in the table, high CoF assets account for more than half of the replacement cost in most of the remote facilities. The reservoir sites in particular have high dollar amounts attached to high CoF asset replacement due to the high replacement cost of the tanks. As mentioned previously, Trevarno has no high CoF assets because the entire facility is a back-up station and the overall facility criticality is lower than the other pump stations.

Table 4-11 Remote Facilities High CoF Assets

Facility	High CoF Replacement Cost	Percent of Total Facility Replacement Cost
Airway PS	$ 369,200	60%
Altamont PS	$ 607,300	64%
Oakville PS		0%
Trevarno PS		0%
Vasco PS	$ 846,900	57%
Altamont Reservoir	$ 9,624,200	97%
Dalton Reservoir	$ 2,426,000	87%
Doolan Reservoir	$ 3,621,000	89%

4.4 Risk

The following figure shows the risk results developed from the PoF and CoF scores. The matrix below shows the potable water asset risk scores categorized by low, medium, and high risk. The assets in the red zone of the risk matrix represent the assets with the highest likelihood and highest impact of failure.

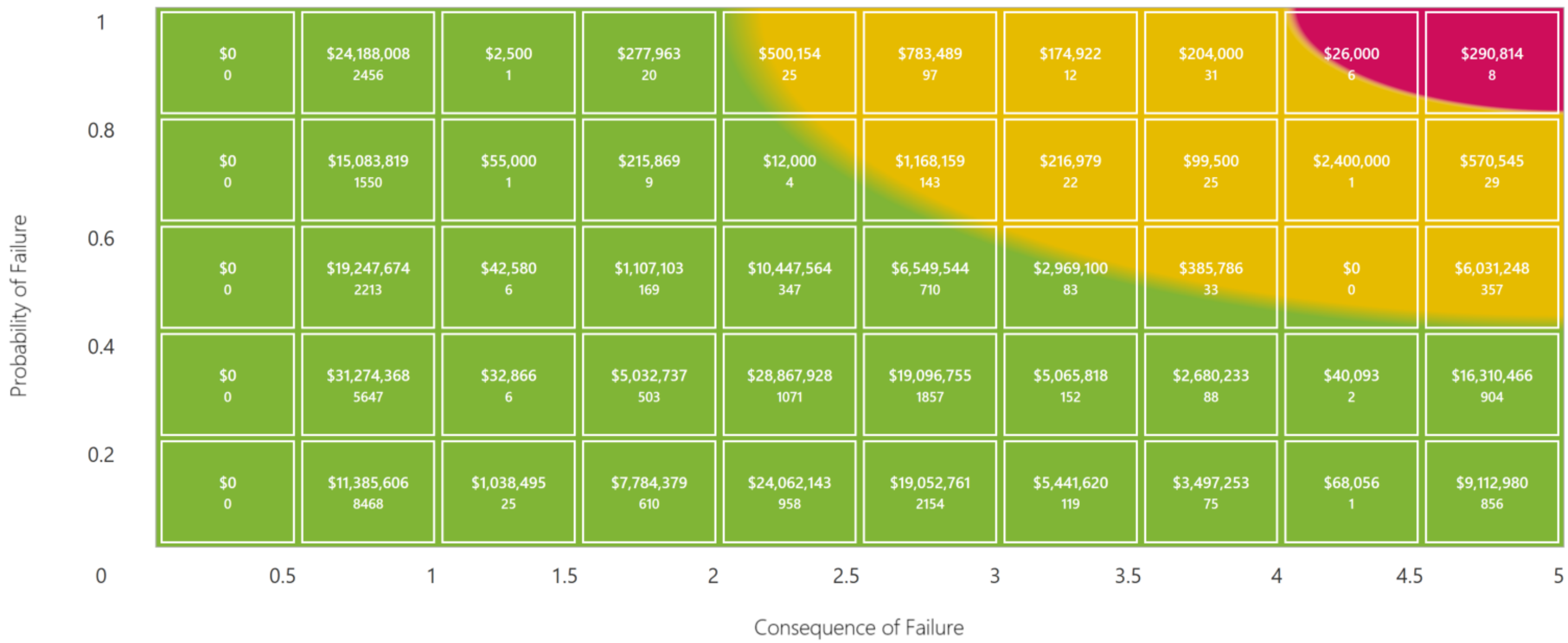


Figure 4-16 Risk Matrix

Figure 4-16, many of the assets are categorized as low risk. The total value of the high risk assets with a risk score of 4 and above is approximately $467,000. These assets have the highest likelihood and highest impact of failure, and should be managed accordingly.

The following figures present the risk results for the potable water distribution assets.

Figure 4-17 below shows the risk for the potable water mains. Although there are both high PoF and CoF mains, the combined scores resulted in low to medium risk water mains, as shown in the map.

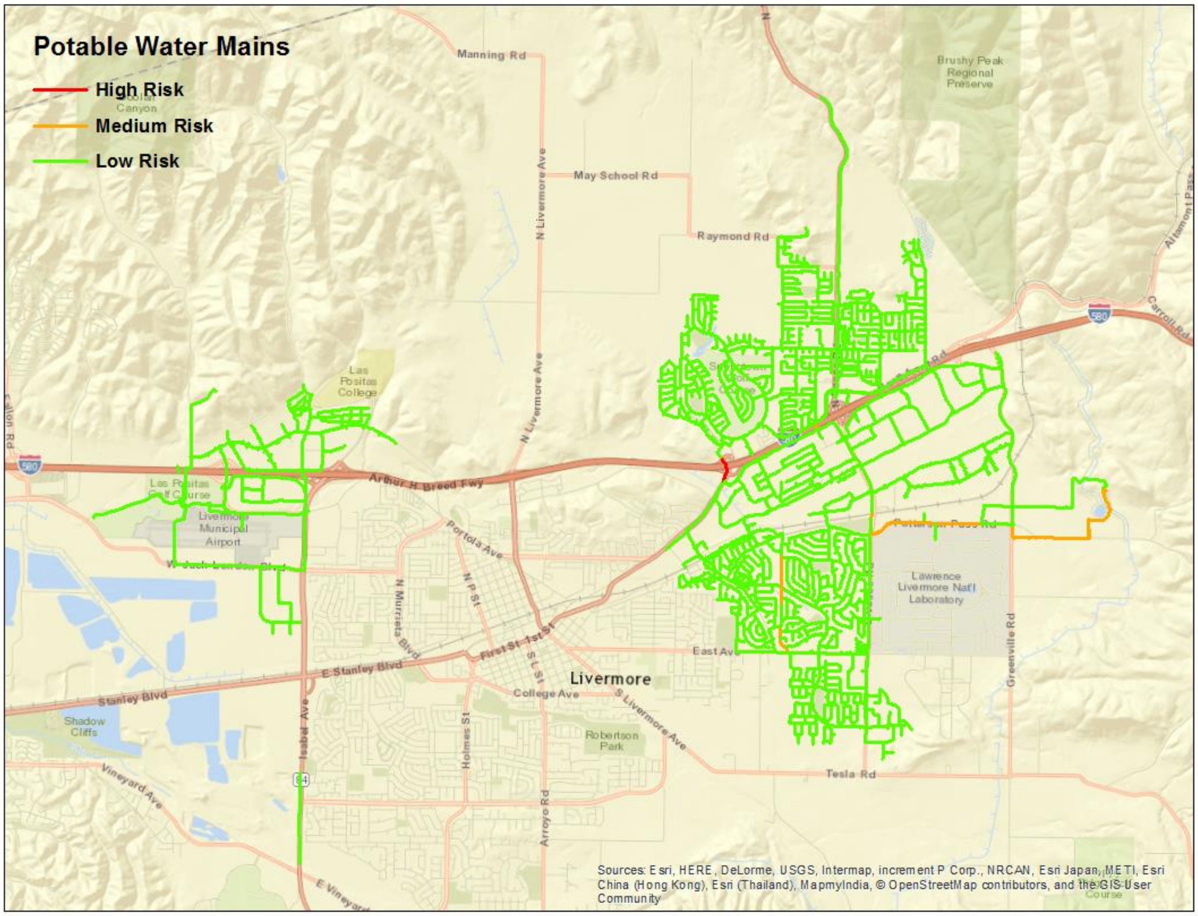


Figure 4-17 Potable Water Main Risk Map

Figure 4-18 below shows the risk scores for the potable water hydrants. As shown in the map, all of the hydrants are low to medium risk.

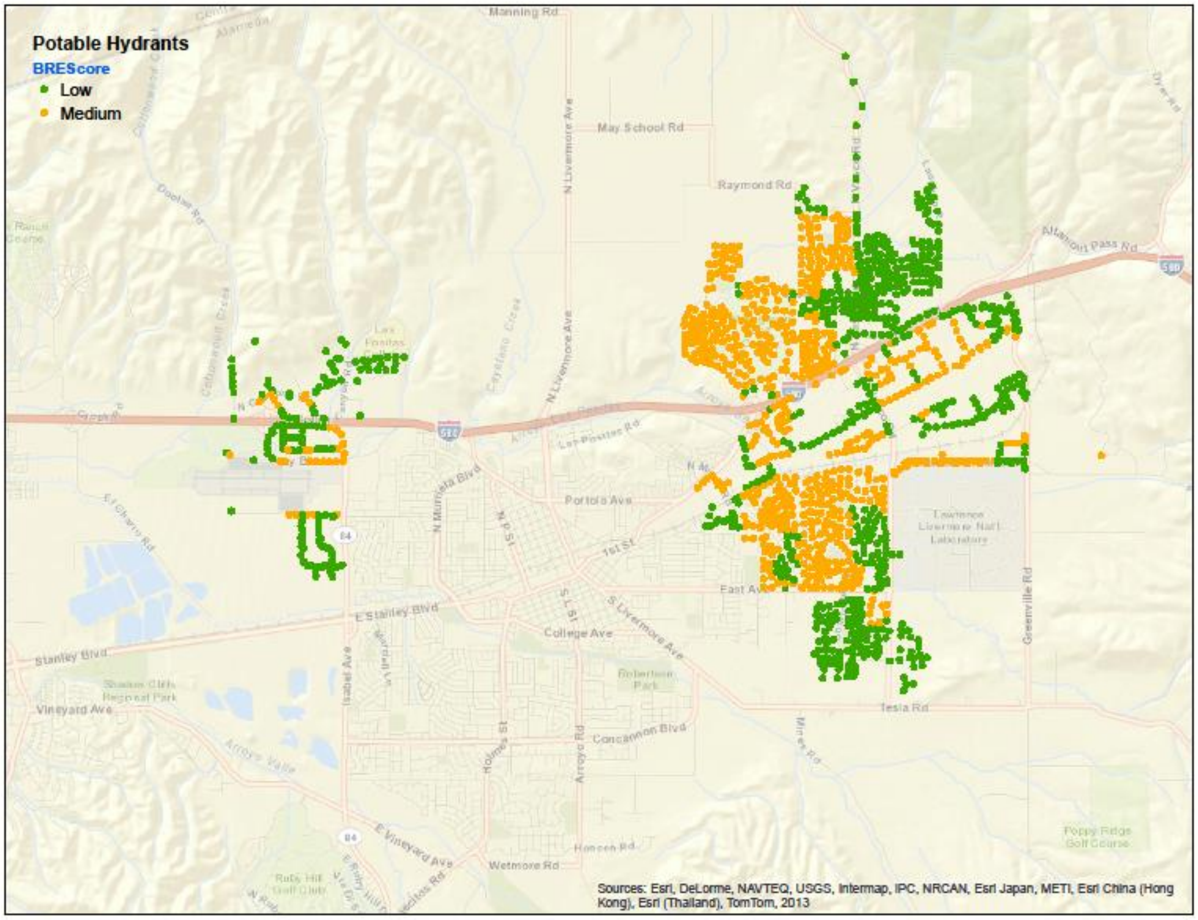


Figure 4-18 Potable Water Hydrant Risk Map

Figure 4-19 below shows the risk map for the potable water valves. Most of the valves are low risk, while the rest of the valves are medium risk. None of the valves received high risk scores.

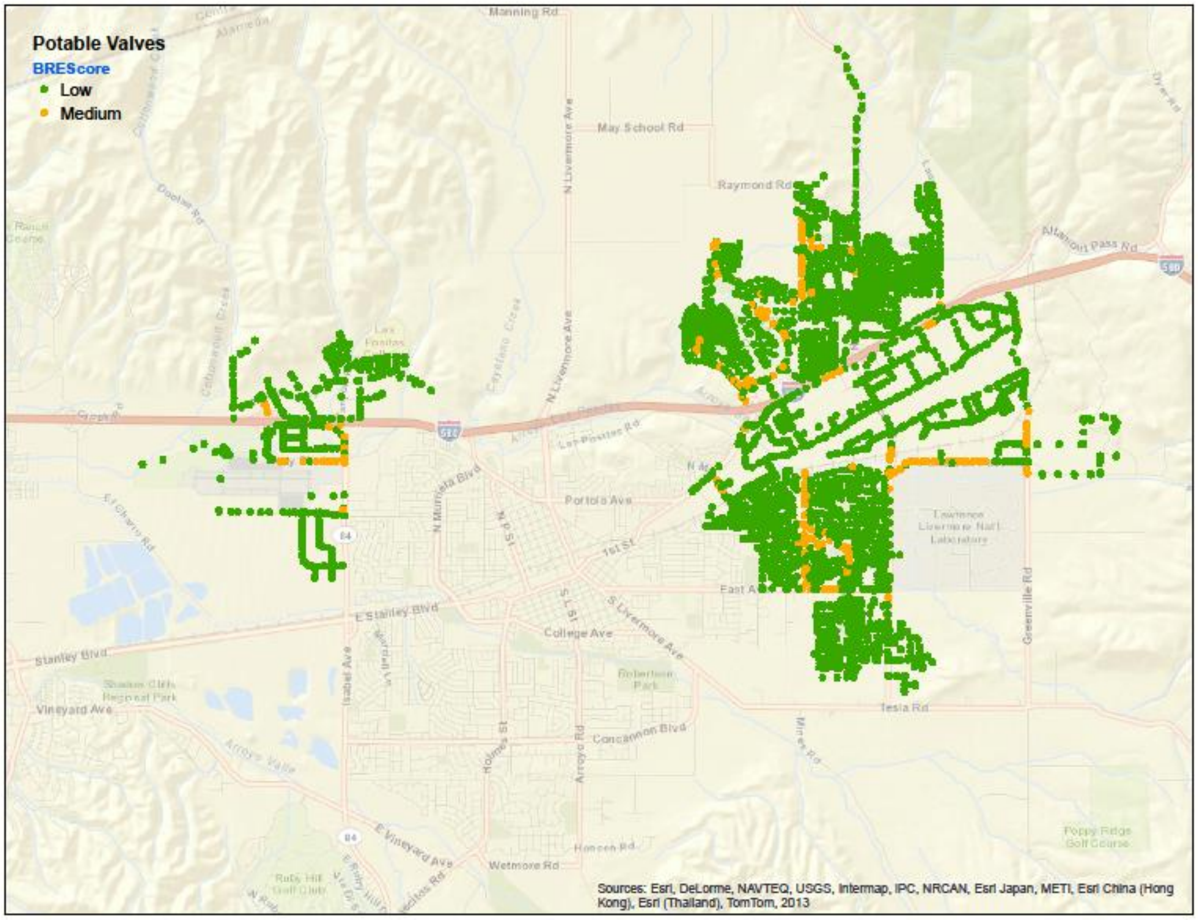


Figure 4-19 Potable Water Valves Risk Map

Figure 4-20 below shows the risk map for the potable water meters. Many of the meters received low PoF and CoF scores. As such, most of the meters received low risk scores, as shown in the map. However, a portion of the meters received medium risk scores.

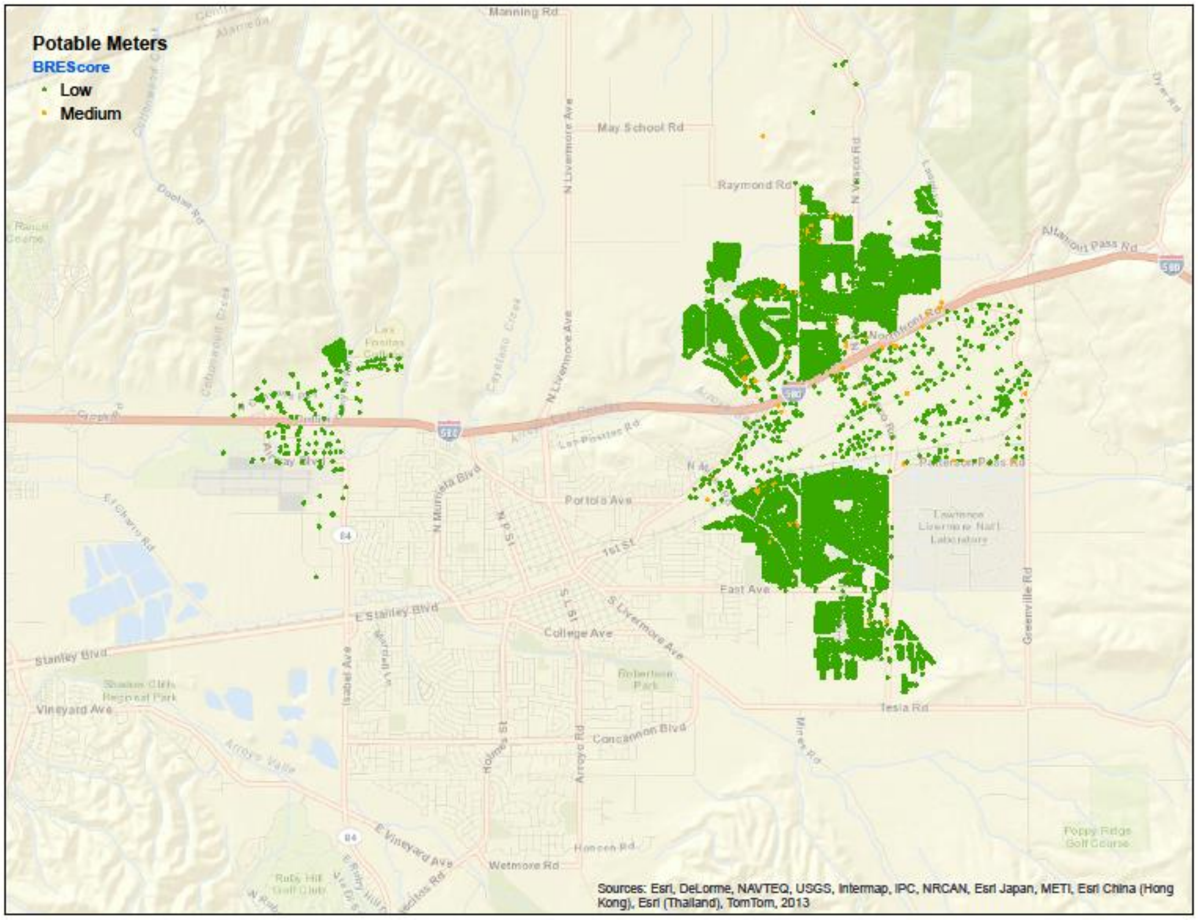


Figure 4-20 Potable Water Meter Risk Map

Figure 4-21 below shows the risk map for the services. Although as significant number of meters received high PoF scores, many of these meters received low CoF scores, which resulted in low risk scores.

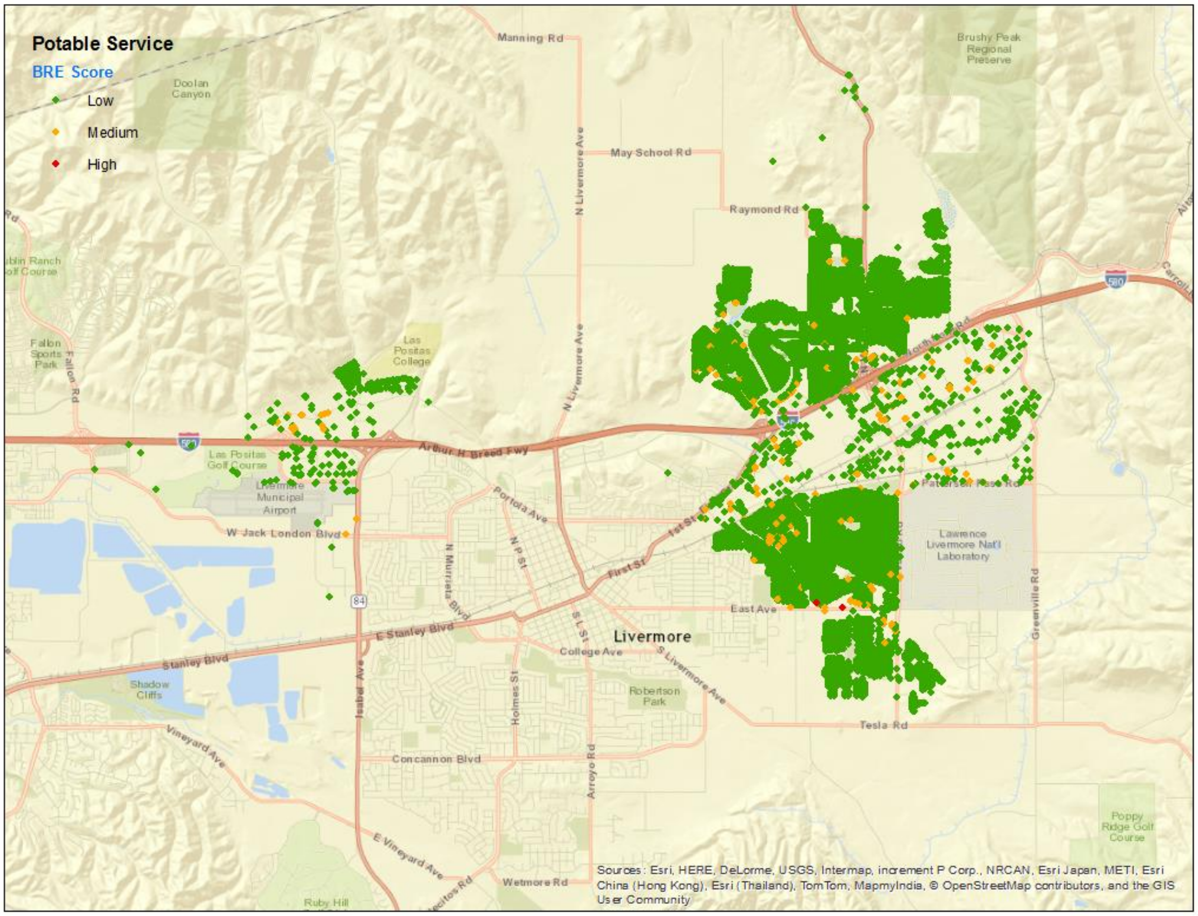


Figure 4-21 Potable Water Services Risk Map

The figures below show the risk profiles for the potable water remote facilities assets. Of the remote facilities, only Altamont and Dalton Reservoirs have high risk assets. As shown in Figure 4-24, these assets make up a very small portion of the replacement cost of the entire site.

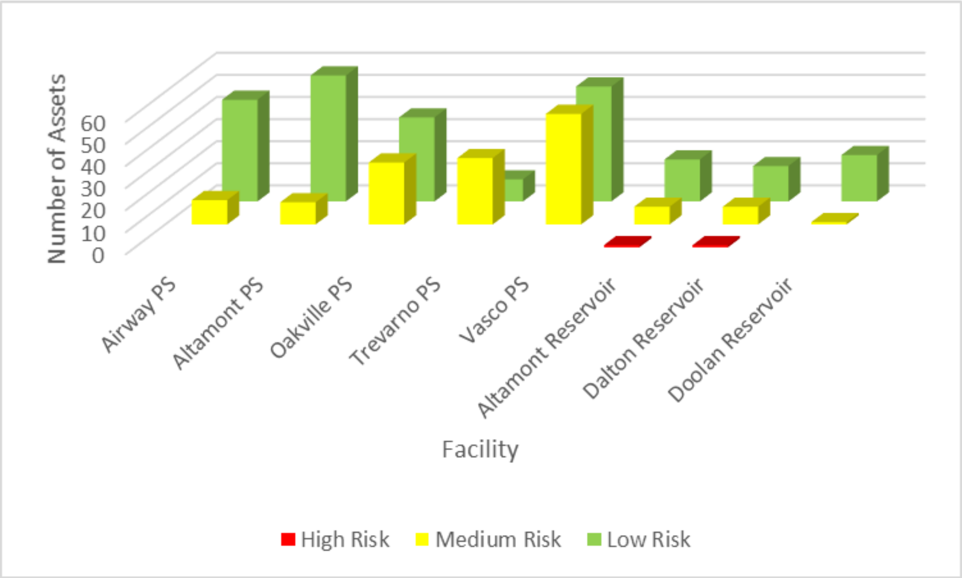


Figure 4-22 Remote Facility Risk Level by Quantity

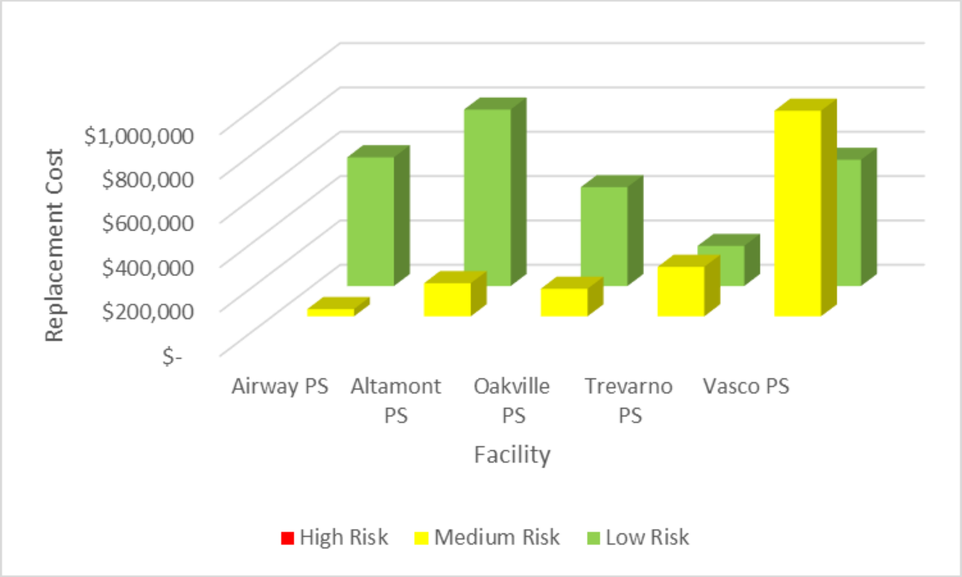


Figure 4-23 Pump Station Risk Level by Replacement Cost

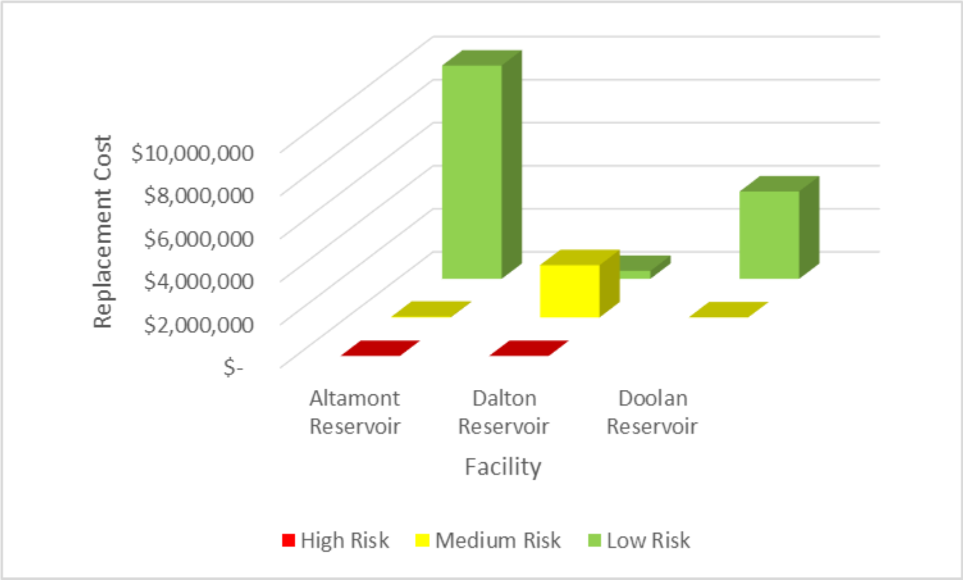


Figure 4-24 Reservoir Risk Level by Replacement Cost

5 Life Cycle Cost Analysis

Life cycle analysis was performed to estimate the future budget for replacement and rehabilitation. The calculation methodology looks at the cost over the life of an asset. The costs may include installation, maintenance, rehabilitation, and replacement. The logic of the life cycle cost is illustrated in the figure below. After the initial installation, the asset will degrade over time. In order to raise the condition back to an acceptable level, an investment is made in the form of maintenance or rehabilitation. An asset can only accept certain number of rehabilitations before its inevitable replacement at the end of its useful life.

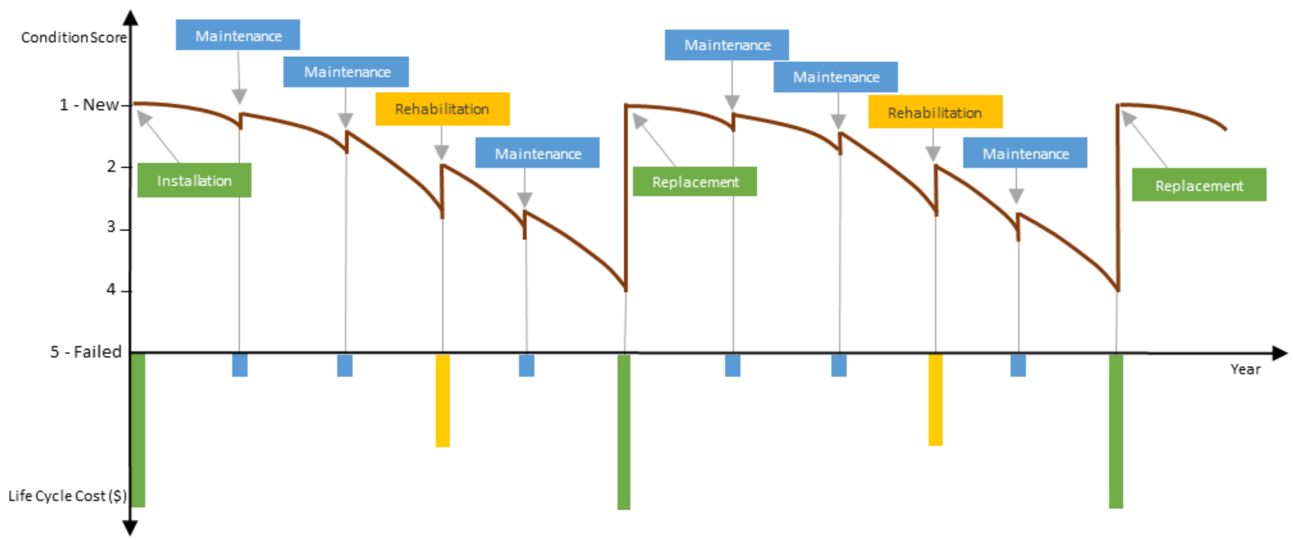


Figure 5-1 Life Cycle Cost Logic Illustration

Life cycle cost logic was developed for each of WRD's assets. The logic is comprised of replacement, rehabilitation, and maintenance and inspection activities, as well as the cost and frequency of these activities. The logic was developed based on asset class (e.g., valves, meters, mains).

The logic utilized for the potable water distribution system life cycle cost analyses can be found in Appendix B.

6 Long-Range Analysis

Utilizing the life cycle logic, long-range asset renewal needs (e.g., rehabilitation, replacement) are projected. By understanding the future financial needs, WRD will be able to plan for future financial needs to mitigate risk. The long-range analysis can also give WRD an idea of its budgetary needs in a defendable and transparent way. With the long-range analysis, WRD can share its future needs with its stakeholders.

Figure 6-1 below shows the long-range annual need profile, which presents the asset rehabilitation and replacement activities that are predicted to be needed in the next 100 years. Replacement costs are presented in 2016 dollars. There is a large peak in 2016 of approximately $14.5 million, which is comprised mostly of distribution assets. The average annual needs over the 100-year planning horizon is approximately $4.2 million.

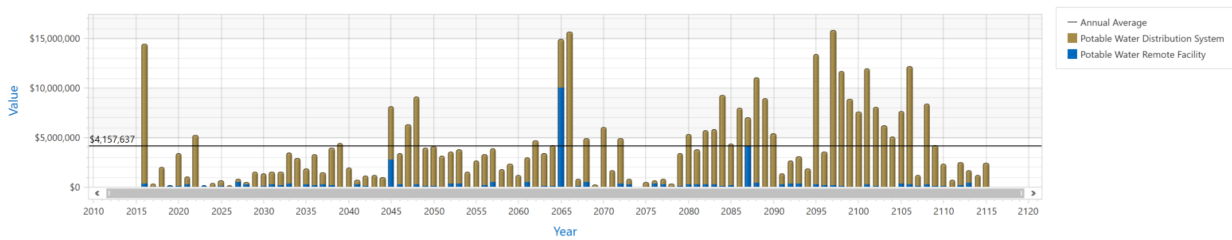


Figure 6-1 Long-Range Financial Needs

The following graph shows the future needs of the potable water distribution system. The average annual needs for the distribution assets is approximately $3.8 million. The large peak in cost of approximately $14 million in 2016 as well as the costs for the first 30 years are comprised mostly of service replacement.

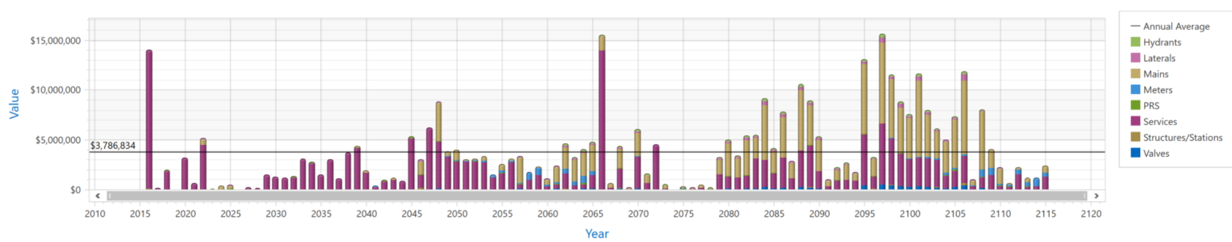


Figure 6-2 Potable Water Distribution System Long-Range Financial Needs

Figure 6-3 below shows the work backlog. The peak in service replacement costs in 2016 shown in Figure 6-2 is due to the backlog of service replacement over the past 4 years. These services are estimated to have exceeded their useful lives and are in need of replacement.

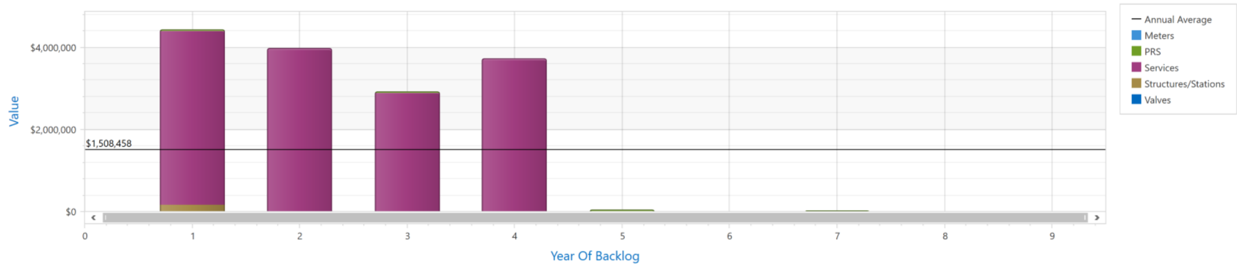


Figure 6-3 Backlog Work

Figure 6-4 below shows the potable water remote facilities assets long range financial needs over a 100-year planning horizon. The average annual needs for these pumping stations is estimated to be approximately $370,000. The various peaks represent years in which high-cost assets (e.g., reservoir tanks, MCC, buildings) are predicted to require replacement.

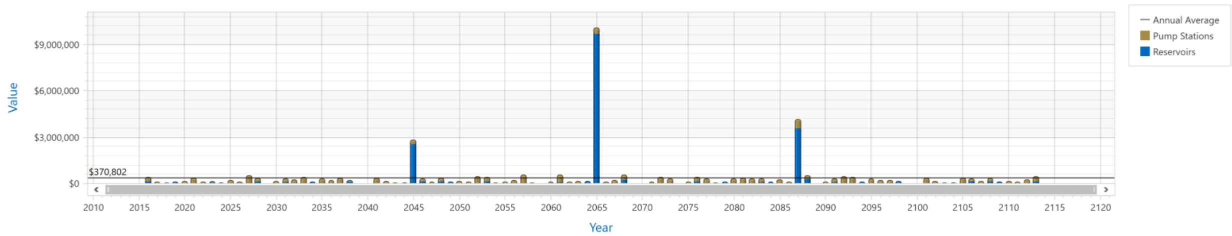


Figure 6-4 Potable Water Remote Facilities Long-Range Financial Needs

Figure 6-5 below shows the potable water remote facilities assets long range financial needs over a 20-year planning horizon. The shorter planning horizon gives a more accurate picture of the average annual needs by leaving out the large reservoir replacement activities. The average annual needs over a 20-year span is approximately $210,000.

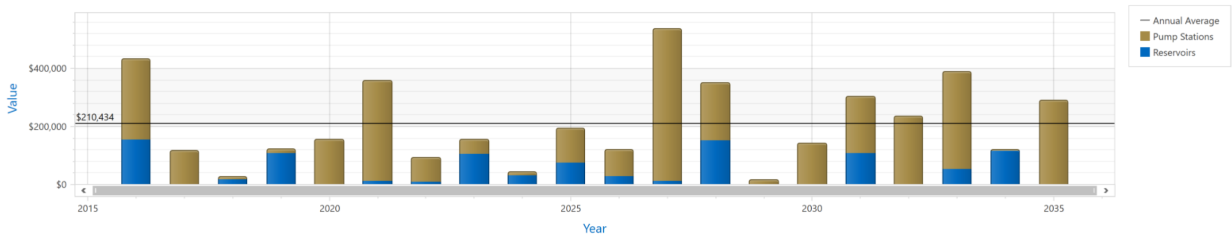


Figure 6-5 Potable Water Remote Facilities 20-Year Prediction

The following table presents the average annual financial needs of the potable water assets over 10-year, 30-year, 50-year, and 100-year planning horizons. The shorter planning horizons give a more practical look at the short-term needs of the system. Over the next 10 years, the annual average financial need is approximately $2.7 million.

Table 6-1 Average Annual Needs

Planning Horizon	Annual Average
10	$ 2.8 million
30	$2.4 million
50	$ 3.0 million
100	$ 4.2 million

Appendix A

Condition Matrices

The following tables present the matrices used to assess the condition of assets in major asset classes.

Pump	1	2	3	4	5
Leakage	None	Visible wear at seals, but no signs of leakage	Moisture at seals/joints	Water dripping or pooling on floor	Water squirting / Running
Corrosion / Deterioration	Like new	Some minor corrosion	Moderate corrosion, minor shaft wear	Significant corrosion / deterioration affecting integrity	Extreme corrosion, extreme casing deterioration, significant shaft wear
Vibration	None detectable	Minor vibration to touch, not visible	Visible Vibration	Vibration transferred to connecting equipment	Vibration damage, extreme rattling
Noise	No unusual noise	Slight whine/rumble	Noticeable noise, audible from a yard away	Moderate whine/rattle	Loud, rattling due to vibration
Temperature	Cool or room temp	Warm, normal	Heat detected by hand	Uncomfortable to touch	Too hot to touch

Motor	1	2	3	4	5
Corrosion / Deterioration	Like new, clean and free of dust or dirt	Some wear or deterioration, moderate dirt build up, no seal wear, mounts and alignment appear correct	Heavy dirt build up, worn seals, visible corrosion, slight deterioration in mounts	Packing or seal issues, motor appears misaligned, extreme dirt build up, breaks in casing	Extreme corrosion, extreme misalignment, missing seals, broken mounts

Motor	1	2	3	4	5
Vibration	No unusual vibration detectable	Minor vibration detected	Moderate vibration, possible imbalance	Considerable vibration (wristwatch shakes), significant imbalance	Major vibration, extreme imbalance
Noise	No unusual noises detected.	Slight whine/rattle detected.	Moderate whine/rattle detected, easily heard over pump noise.	Loud whine/rattle.	Disturbingly loud operation/vibra tions.
Temperature	No unusual temperature detected, no burning smell	Minimal heat from casing using hand, no burning smell	Heat detected by hand, no burning smell, ventilation openings clogged	Heat detected by hand is uncomfortable, minor burning smell, heavy clogging of ventilation openings	Heat too high to assess by hand, major burning smell
Bearings / Shaft	Lubricant looks like it was recently applies	Slight discoloration of lubricant	Dust or dirt present in lubricant, satisfactory amount of lubricant	Less than normal lubrication, bearing looks dry, heavy dust or dirt build up, shaft misaligned	No lubricant, broken bearing, wobbling shaft

Wet Well / Concrete Vault	1	2	3	4	5
Surface Appearance / Coating	Surface appears new	Minor wear or deterioration with no impact	Visible deterioration, minor spalling, evidence of corrosion or cracks in coating	Major spalling or crumbling, exposed rebar, significant corrosion, major loss of coating	Surface deterioration affecting structural integrity, complete loss of coating

Wet Well / Concrete Vault	1	2	3	4	5
Shape / Movement	No evidence of movement	Some evidence of movement, no impact on structure	Measurable movement with minor impact on structure	Displacement with impact on structure, noticeable change in shape of structure	Deterioration affecting structural integrity
Ceiling / Covering / Hatch / Roof / Grating	No cracks	Hairline / normal shrinkage cracks, minor weeping	1 to 3 inch structural cracks, no impact on structure, minor leakage	Numerous 3+ inch cracks, major cracks impacting structure or significant leakage	Major cracks that threaten structure integrity, potential failure
Components (stairs, vents, instruments, etc.)	Components in excellent condition	Minor wear of components	Moderate wear of components, moderate instrument or cabling wear, poor ventilation	Significant wear of components, cracked or broken stairs, broken instruments or cabling, broken vents	Major failures in components, missing vents, important components broken

Generator	1	2	3	4	5
Enclosure / Casing / Frame / Seating	No protective enclosure / coating wear, no deterioration of seating	Minor enclosure wear, minor coating flaking, very minor rust or corrosion, minor seal wear	Cracking or flaking of coating, noticeable deterioration of seals or joints, noticeable rust or corrosion, minor holes in enclosure, indication of leaks	Major coating flaking or exposed metal surface, poor joints or hinges, cracks or holes, abundance of dirt or water inside, noticeable leaks, major corrosion	Loss of coating, major corrosion, major holes or cracks, standing water, broken joints or hinges

Generator	1	2	3	4	5
Engine	Like new	Minor wear to a few components, operates as expected	Minor issues when starting engine, moderate wear of components, slightly unusual noises when operating	Corrosion of key components, issues starting, concerning noises when operating	Sever corrosion, multiple attempts before starting,
Transfer Switch / Wiring	Wire coating clean and pliable, switch looks new	Minor signs of wire discoloration or cracking, switch flips easily	Significant wire discoloration and cracking, minor sticking in switch, minor wear in switch	Wire coating brittle, some loss or coating, switch hard to flip, corrosion of switch or connections	Exposed wiring, switch won't flip, major corrosion of switch or connections
Temperature / Noise (if operating)	Normal	Slightly elevated	Significantly elevated	Evidence of heat damage, rattling of engine	Overheating, shutdowns

MCC	1	2	3	4	5
Enclosure	No protective enclosure / coating wear, no deterioration of seating, clean (no dust or cobwebs)	Minor enclosure wear, minor coating flaking, very minor rust or corrosion, minor seal wear, some dust and cobwebs	Cracking or flaking of coating, noticeable deterioration of seals or joints, noticeable rust or corrosion, minor holes in enclosure, indication of leaks, dust, cobwebs, dirt	Major coating flaking or exposed metal surface, poor joints or hinges, cracks or holes, abundance of dirt, feces, or water inside, noticeable leaks, major corrosion	Loss of coating, major corrosion, major holes or cracks, standing water, broken joints or hinges, dirty, animal feces

MCC	1	2	3	4	5
Internal Components	Like new	Minor fading or wear of components, switches operate without sticking	Some corrosion or wear of components, slight sticking of switches	Significant wear or deterioration of internal components, switches are hard to flip, displays are broken	Can't operate switches
Temperature	No unusual temperature detected	Minimal heat from casing using hand	Heat detected by hand, ventilation openings clogged	Heat detected by hand is uncomfortable, minor burning smell, heavy clogging of ventilation openings	Heat too high to assess by hand, major burning smell
Noise	Excellent ventilation, normal operating noise	Slight hum, nothing unusual	Loud hum, hum louder in some parts, unusual sounds	Very loud hum, concerning noises	Rattling or whining, very concerning noises
Cabling	Coating clean and pliable	Minor signs of discoloration or cracking	Significant discoloration and cracking	Coating brittle, some metal exposed	Significant loss of coating or evidence of damage

VFD	1	2	3	4	5
Temperature	No unusual temperature detected	Minimal heat from casing using hand	Heat detected by hand, ventilation openings clogged	Heat detected by hand is uncomfortable, minor burning smell, heavy clogging of ventilation openings	Heat too high to assess by hand, major burning smell
Noise	Excellent ventilation, normal operating noise	Slight hum, nothing unusual	Loud hum, hum louder in some parts, unusual sounds	Very loud hum, concerning noises	Rattling or whining, very concerning noises

VFD	1	2	3	4	5
Internal Components	Like new	Light dust on components, no presence of moisture	Moderate dirt or dust on components, slight presence of moisture inside enclosure	Heavy dirt or dust on components, moisture on components, visible leaks in enclosure	Potentially clogged vents or fans from dirt, pooled water on components
Connection / Cabling / HIM	Coating clean and pliable, all connections are tight	Minor signs of discoloration or cracking, tight connections	Significant discoloration and cracking, a connection looks loose	Coating brittle, some metal exposed, multiple connects look loose, screws are loose	Significant loss of coating or evidence of damage, screws missing

SCADA	1	2	3	4	5
PLCs / RTUs	Components are clean, well ventilated, operating at normal temperature, and all connections are tight	Slight dust or wear of components, normal operating temperature, secure connections	Moderate dust buildup on interior components, heavy buildup on ventilation opening, warm to the touch, slightly wiggle of connections	Heavy dust or dirt build up on interior components, blacked ventilation opening, hot to the touch, loose connections	Interior components need to be cleaned, enclosure is not allowing ventilation, overheating or too hot to touch, missing connections or cords
Radios / Telemetry / Antenna	Like new, no issues	Slight wear or visual deterioration of components	Components show moderate wear or deterioration, components making noise or hum, small breaks in data communication with HMI or receiver	Components look very worn or deteriorated, components making lots of noise, intermittent loss of data communication	Broken components, unreliable data transfer

SCADA	1	2	3	4	5
HMI Unit / Computer	HMI / Computer like new	HMI / Computer slightly dirty, enclosure shows light wear	HMI / Computer shows moderate wear, dirt build up, makes uncommon computer noises	Dirt on HMI / Computer interferes with functionality, makes audible noise over operating equipment, control feature don't work properly	HMI / Computer won't respond, can't control equipment through HMI / Computer
Switches / Gauges / Sensors / Transducers	All components like new	Components more than a year old	Some readings unreliable, some components inactive, no components broken	Multiple broken components, un-calibrated components	No readings

Valve	1	2	3	4	5
Seals	No observable deterioration, seals in excellent condition	Minor wear of corrosion on sealing elements	Signs of past leakage, not currently leaking	Minor leak detected, seals look worn	Excessive leaking, seal missing or fully deteriorated
Supports / Bolts / Coating	Coating like new, no defects	Coating showing signed of aging	Coating flaking, minor metal exposure, visible rust or corrosion	Major loss of coating, major metal exposure, evident corrosion	Complete loss of coating, loss of metal due to corrosion, broken bolts, major corrosion
Operation	Operates like new	Operates OK	Difficulty in operating, possible internal build-up	Requires mechanical tool to fully close	Does not fully close, can't operate, stuck open or closed

Tank	1	2	3	4	5
Seals / Leaks	No leaks / roof, access hatch, and vent screen seals in excellent condition	Evidence of past leakage / seals look worn	Minor leakage detectable / significant seal deterioration	Significant leakage, water below tank / some cracked or missing roof, access hatch, or vent screen seals	Major leaks, potential failure / cracked or missing roof, access hatch, or vent screen seals
Cracks / Holes	No cracks	Minor or hairline cracks	Measurable structural cracks, no impact on structure	Major cracks impacting structure	Major cracks that threaten structure integrity, potential failure
Coating / Corrosion	Surface appears new	Minor loss of coating or loose paint, very minimal rust or corrosion	Large areas of rust or corrosion, not affecting structure, major loss of coating or paint	One or more areas of advanced corrosion, with loss of metal, evidence of pitting, complete loss of coating or paint	Corrosion impacting structural integrity
Braces / Supports	Supports or braces look new	Some evidence of movement, no impact on structure	Corrosion or deterioration of supports or braces, measurable movement of tank with minor impact on structure	Compromised supports or braces, displacement of tank with impact on structure	Broken supports or braces, deterioration affecting structural integrity
Valving / Piping	Valving and piping look new	Slight wear or corrosion of valving and piping	Moderate corrosion of valving and piping	Major rust or corrosion of valving and piping, non-working valves	Broken or inoperable valving or piping, possible failure

Concrete / Brick / CMU Building or Structure	1	2	3	4	5
Exterior Walls	No cracks / Surface appears new	Hairline/ normal shrinkage cracks, minor wear	Measurable structural cracks, no impact on structure, minor leakage, minor spalling, evidence of corrosion	Major cracks impacting structure or significant leakage, major spalling or crumbling, holes or exposed rebar, significant corrosion	Major cracks or surface deterioration that threaten structure integrity, potential failure
Roof / Covering	No evidence of leaks or deterioration	Indication of minor leaks through roof, minor defects noticed in covering, water pooling on roof	Minor leaks observed, visible holes or cracks in roof or covering, potential sag in covering	Significant leaks, water inside structure, fist-size holes or 6-inch cracks in covering, measurable sag in covering	Major leaks with potential for damage, standing water in structure, major sag in covering
Structure / Foundation	No evidence of structure or foundation deterioration	Some evidence of foundation movement, no impact on structure components	Measurable movement with minor impact on structure components, corrosion of structure components or supports	Displacement of foundation with impact on structure components, advanced corrosion of structure components or supports	Deterioration affecting structural integrity of foundation or structure
Building Components (windows, doors, vents, etc.)	Components in excellent condition	Minor wear of building components, no cracks in windows, doors and latch properly	Moderate wear of building components, minor cracks in windows, missing door or window seals, door won't latch	Significant wear of building components, cracked or broken windows, broken doors	Major failures in building components, missing windows, missing doors, missing vents, important components broken

PRV	1	2	3	4	5
Vault / Enclosure	Structure appears new	Minor wear or deterioration with no impact to structure	Visible deterioration, minor spalling, evidence of corrosion or cracks, evidence of leaks in walls	Major spalling or crumbling, exposed rebar, significant corrosion, cracks or holes impacting structure, significant leakage coming from walls	Surface deterioration affecting structural integrity, major cracks that threaten structure integrity, potential failure
Hatch / Roof / Grating / Covering	No evidence of leaks, new condition	Indication of minor leaks, covering has slight wear, cover easy to open	Observed minor leaks, rust or corrosion of covering	Significant leaks and water below, significant rust or corrosion of covering, difficulty opening cover	Leaks with potential for damage, crack or holes in covering, potential covering failure, cover won't open
Valve Operation	Valve operates like new	Smooth operation, no slamming	Valve operating, minor adjustments needed to speed or feed rates	Unacceptable operation, valve slamming or not opening in acceptable range of speed	Valve has failed, non-operational
Seals / Flanges	No leakage or cracks, new condition	Minor wet spots or evidence of leakage, possible seal issues	Minor leakage, seals show significant signs of wear	Significant leakage, water below valve from leakage, seals not working properly	Major leaks, standing water in vault caused by leak, seals in poor condition

PRV	1	2	3	4	5
Instruments / Indicators	Indicators like new	Indicators in good condition, fully functioning	Indicators hard to read, readings are unreliable	Indicators need to be calibrated, can't read indicators, leaking	Indicators are broken or non-operational, unable to get reading, major leaking at indicators

Reservoir	1	2	3	4	5
Covering / Access Points	No leaks, covering, access hatch, overflows and vent screen seals in excellent condition	Evidence of past leakage, seals look worn	Minor leakage detectable in covering, covering shows significant wear, seal deterioration	Significant cover leakage, covering in poor condition, some cracked or broken access hatch, overflow or vent screens	Major leaks, potential covering failure, holes in covering, missing access hatch, overflow or vent screens
Structure Coating / Corrosion	Excellent condition, coating or paint like new	Minor loose or flaky coating or paint, no signs of leaks, no visible corrosion	Minor spalled concrete or steel corrosion, significant coating or paint loss, signs of past leaks	Significant spalled concrete or steel corrosion, loss of majority of coating or paint, visible leak, pitting, holes or cracks in structure	Major cracks in structure, significant leaking, major corrosion, potential failure
Foundation / Structural Supports	Foundation and supports in excellent condition	Minor wear of foundation or supports, not structural issues	Visible corrosion of supports, minor corrosion or cracks in foundation, possible movement of foundation	Minor erosion around foundation, significant corrosion of supports, large cracks or corrosion of foundation, measurable movement of foundation or structure	Significant erosion around foundation, major corrosion of supports, major cracks foundation, potential failure

Reservoir	1	2	3	4	5
Valves / Pipes	All valves and pipes in excellent condition	Minor deterioration of valves or pipes, no signs of leaks	Minor rust or corrosion, evidence of past leaks	Valves difficult to operate, significant corrosion, visible leakage	Non-operational valves, clogged pipes, major corrosion, major leakage, potential failure
Internal Coating / Corrosion	Excellent condition, coating or paint like new	Minor loose or flaky coating or paint, no signs of leaks, no visible corrosion	Minor spalled concrete or steel corrosion, significant coating or paint loss, signs of past leaks	Significant spalled concrete or steel corrosion, loss of majority of coating or paint, visible leak, pitting, holes or cracks in structure	Major cracks in structure, significant leaking, major corrosion, potential failure
Internal Braces / Supports	Braces and supports in excellent condition	Minor wear of braces or supports, not structural issues	Visible corrosion of braces or supports, minor corrosion, possible movement of foundation	Significant corrosion of braces or supports, large cracks or corrosion, measurable movement of foundation or structure	Major corrosion of braces or supports, potential failure

Appendix B

The following tables describe the life cycle cost logic for each asset class.

Hydrants

Asset Class	Activity	Frequency (Years)
Hydrant	Replacement	100

Laterals

Asset Class	Activity	Frequency (Years)
Lateral - ACP	Replacement	100
Lateral - CI	Replacement	60
Lateral - PVC	Replacement	100
Lateral - Steel	Replacement	60

Mains

Asset Class	Activity	Frequency (Years)
Main - CI	Replacement	60
Main - DI	Replacement	100
Main - PVC	Replacement	100
Main - STEEL	Replacement	60

Meters

Asset Class	Activity	Frequency (Years)
Meter – Large	Replacement	60
Meter - Small	Replacement	50

Process Structures

Asset Class	Activity	Frequency (Years)	Activity	Frequency (Years)
Valve Assembly	Replacement	60	Rehabilitation	7
Vault	Replacement	100		

Services

Asset Class	Activity	Frequency (Years)
Service - Large	Replacement	60
Service - Small	Replacement	50

Structures/Stations

Asset Class	Activity	Frequency (Years)
Anode	Replacement	30
ETS	Replacement	30
SS	Replacement	30

Valves

Asset Class	Activity	Frequency (Years)
Valve – Large, ACP	Replacement	100
Valve – Large, BV	Replacement	60
Valve – Large, CI	Replacement	60
Valve – Large, PVC	Replacement	100
Valve – Large, RCP	Replacement	90
Valve – Large, Steel	Replacement	60
Valve – Small	Replacement	50

Remote Facilities

Asset Class	Activity	Frequency (Years)	Activity	Frequency (Years)
Actuator	Replacement	15		
Antenna	Replacement	10		
Backflow	Replacement	50		
Building	Replacement	75	Rehabilitation	15
Cabinet	Replacement	15		
Cathodic Protection	Replacement	30		
Communication	Replacement	10		
Compressor	Replacement	15		
Control panel	Replacement	20		
Controller	Replacement	5		
Crane	Replacement	50		
Fan	Replacement	10		
Fence	Replacement	20		
Flowmeter	Replacement	20		
Fuel	Replacement	30	Rehabilitation	10
Gate	Replacement	20	Rehabilitation	10
Gen	Replacement	30	Rehabilitation	5
HMI	Replacement	15		
Light	Replacement	30	Rehabilitation	5
MCC	Replacement	20		
Motor – Large	Replacement	20	Rehabilitation	10
Motor - Small	Replacement	10		
Pavement	Replacement	80	Rehabilitation	20
PLC	Replacement	10		
Probe	Replacement	5		

Asset Class	Activity	Frequency (Years)	Activity	Frequency (Years)
Pump – Large	Replacement	40	Rehabilitation	20
Pump – Small	Replacement	15		
Reservoir	Replacement	80	Rehabilitation	80
SCADA	Replacement	15		
Security	Replacement	5		
Sump pump	Replacement	10		
Tank	Replacement	50	Rehabilitation	10
Transformer	Replacement	20		
Valve - Large	Replacement	60		
Valve – Small	Replacement	50		
Vault	Replacement	100		
VFD	Replacement	15		
Hatch	Replacement	40		
Cathodic	Replacement	30		