

WAMP

Water Asset Management Plan

Strategies & Action Plan

June 13, 2022



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Original Draft	May 30, 2022	Original Draft WAMP	Jacobs	WAMT	
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1 Executive Summary

1.1 Overview

The Great Lakes Water Authority (GLWA) Strategic Asset Management Plan (SAMP) sets forth the asset management (AM) strategic framework, improvement strategies, and business processes that the GLWA will employ to realize its vision and accomplish its mission. To define how the principles from the GLWA SAMP apply to the water system managed by GLWA, this Water System Asset Management Plan (WAMP) includes the existing state, governance business processes, specific improvement activities summarized as defined tactical recommendations, resources, and timescales required to achieve GLWA's water system AM objectives.

GLWA's regional water system is one of the largest in the United States, both in terms of water produced and population served. The system currently serves an area of 981 square miles located in eight Michigan counties and a population of nearly 4 million (or nearly 40 percent of Michigan's population). Suburban customers comprise approximately 82 percent of the population served by GLWA, and the Retail Water Customers comprise the remainder. These water system components are graphically shown in in Figure 1-1. It is comprised on 23 miles of raw water transmission mains, 800 miles of transmission mains, five water treatment plants (WTPs), and 19 Booster Stations.

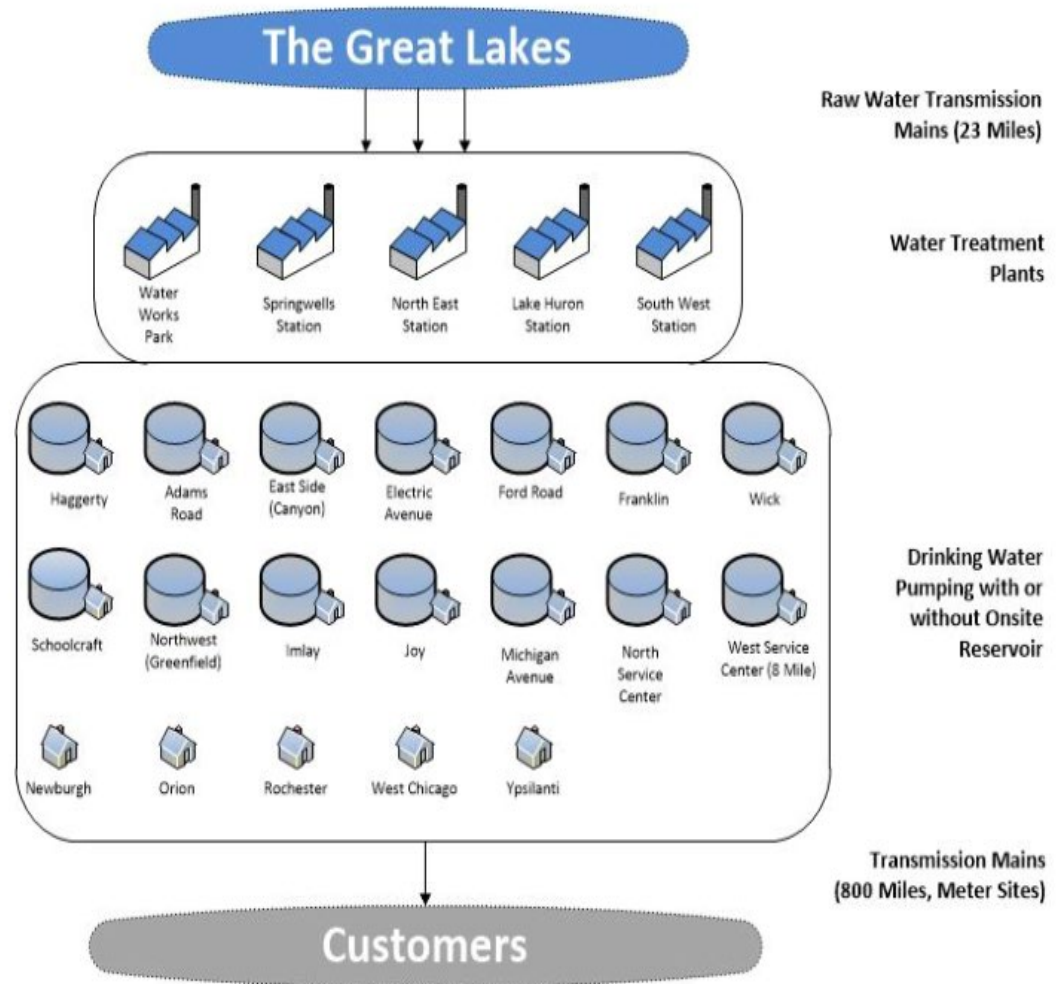


Figure 1-1: GLWA Water System Overview

1.2 Purpose of the WAMP

This WAMP serves as a guiding document for instilling AM concepts and promoting AM practices across internal and external stakeholders involved in managing water assets. It outlines activities and guidelines to meet service levels, optimize asset life cycles, and support AM decisions. It provides status information at a snapshot in time which form the basis for continuous improvement activities to progress asset management within GLWA. Designed to be useful and timely, this WAMP is a living document to be regularly updated every three years at a minimum, with amendments that can be implemented annually, if discovered, as AM drivers and organizational direction and managed assets change throughout the asset lifecycle.

The WAMP connects cost, performance, and risk while maintaining a line of sight between strategic decisions, GLWA planning documents, enhancement needs, operations and maintenance activities (O&M), and renewal and replacement requirements. Tactical Recommendations, presented as being implemented over a three-year period, together comprise the Continuous Improvement Plan in Chapter 9.0. Implementing the Tactical Recommendations reflected herein, will take commitment of staff resources by GLWA.

1.3 State of the Assets

The GLWA water system assets addressed in this WAMP are listed below and include linear and vertical assets.

Linear assets:

- Raw Water Tunnels
- Transmission Mains
- Isolation Valves
- Control Valves
- Booster Pumps
- Storage Tanks
- Raw Water Intakes
- Pressure Sensors
- Level Sensors
- Flow Meters
- Access Structures

Vertical assets:

- Water treatment plants (WTPs)
- Booster Stations

The state of the vertical assets is summarized in Table 1-1 and Figure 1-2 through Figure 1-7 for WTPs and Table 1-2 and Figure 1-8 and Figure 1-9 for Booster Stations. The information

presented represents the state of the assets at a snapshot in time, and dates for which the data is presented are identified for each. Up-to-date information may be accessed from WAM/NexGen. The state of linear assets is reflected in Linear System Improvement Program (LSIP). A summary of the asset profile is presented in Chapter 4 and includes a description of how asset condition was identified. Chapter 5 describes how asset risk scores were identified.

Table 1-1: WTPs –Age and Capacity

Water Treatment Plant	Year Placed in Operation	Rated Capacity (MGD)
Lake Huron	1974	400
Northeast	1956	300
Southwest	1964	240
Springwells	1931/1958	540
Water Works Park	2003	240

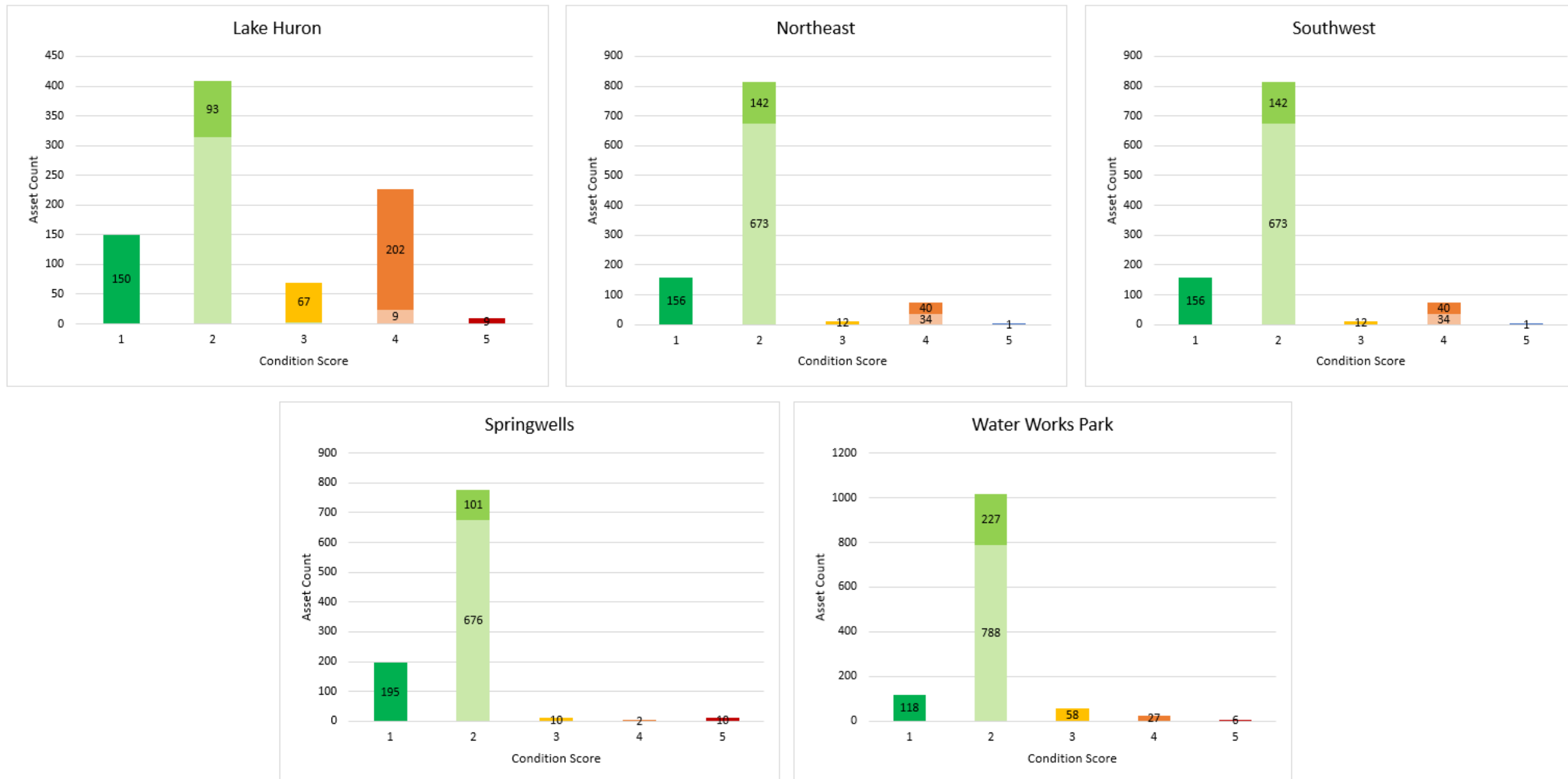


Figure 1-2: WTPs - Asset Condition b Assessment Type (based on 2021 data)



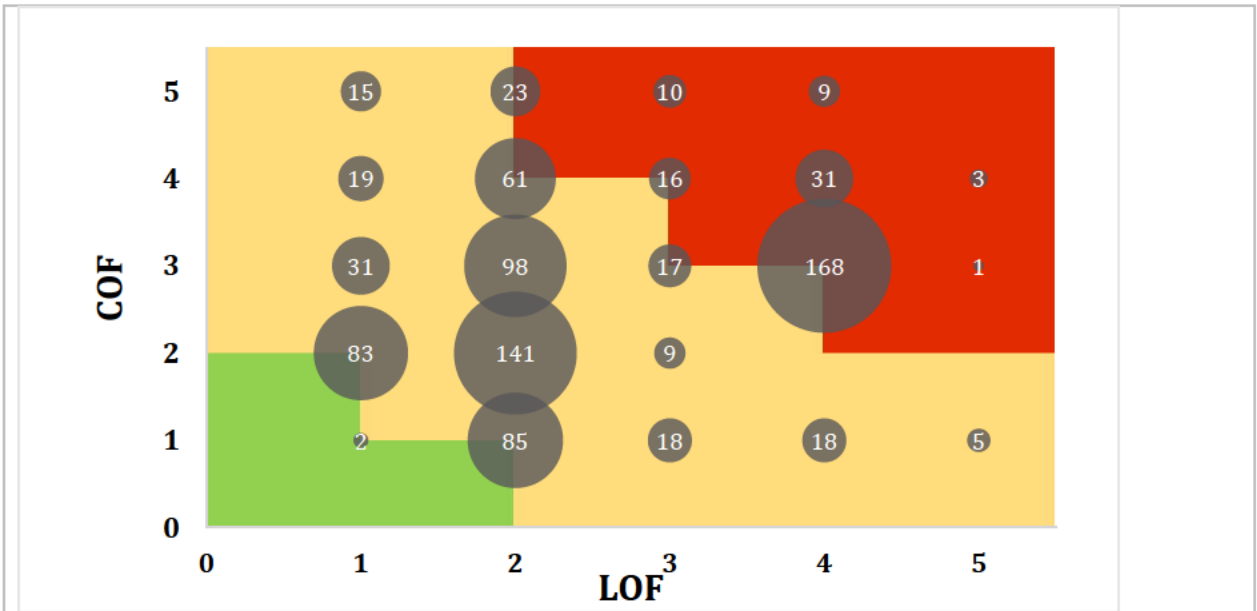


Figure 1-3: Lake Huron WTP - Asset Risk Profile (based on 2021 data)

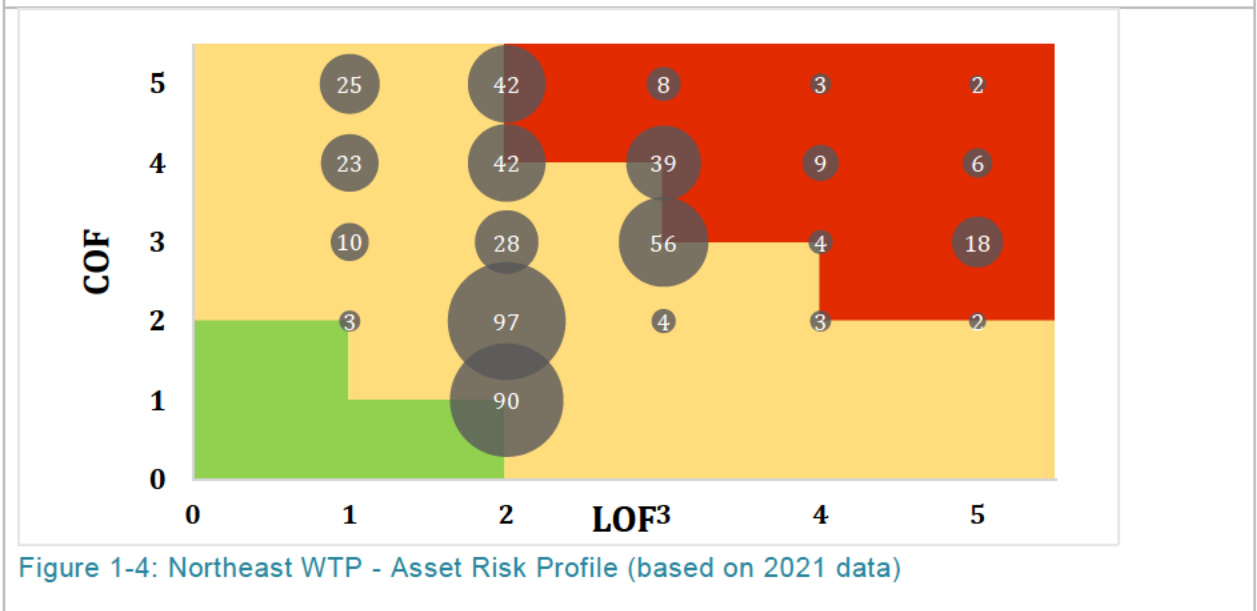


Figure 1-4: Northeast WTP - Asset Risk Profile (based on 2021 data)

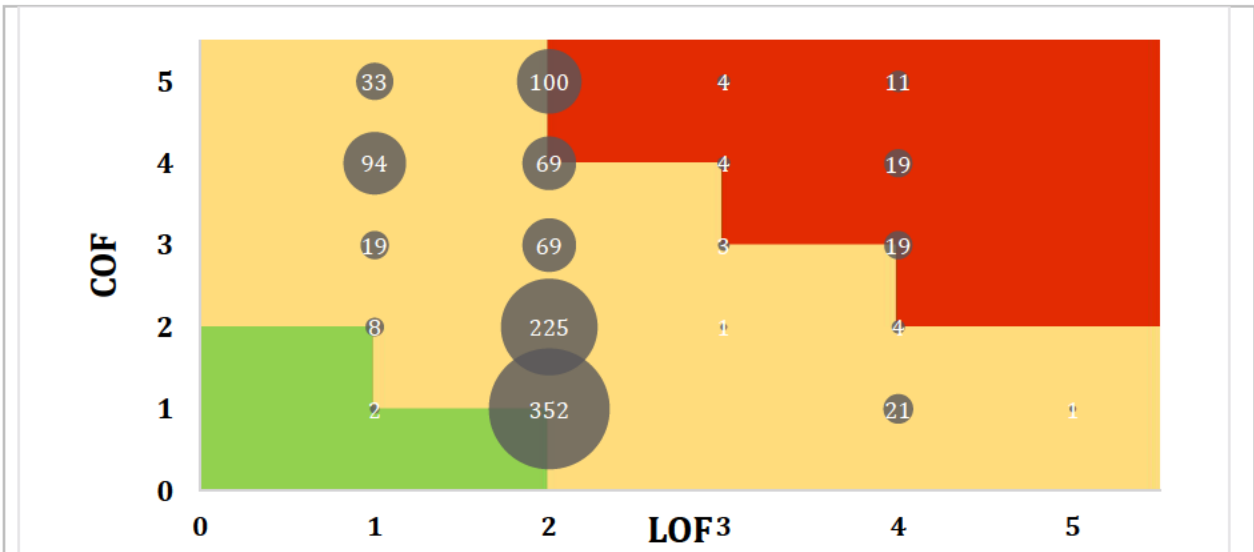


Figure 1-5: Southwest WTP - Asset Risk Profile (based on 2021 data)

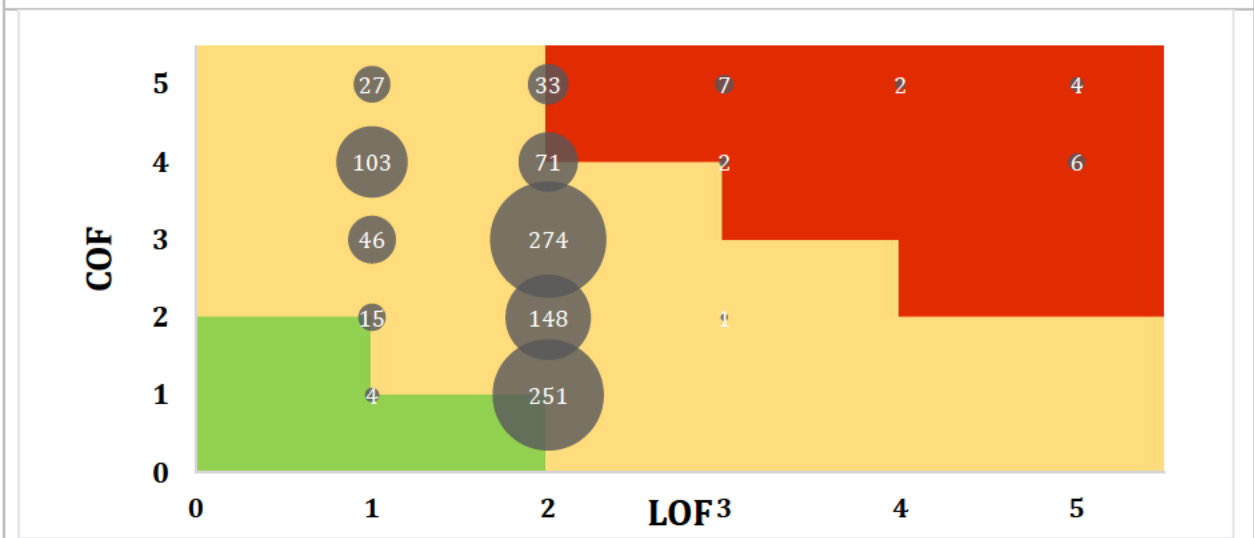


Figure 1-6: Southwest WTP - Asset Risk Profile (based on 2021 data)

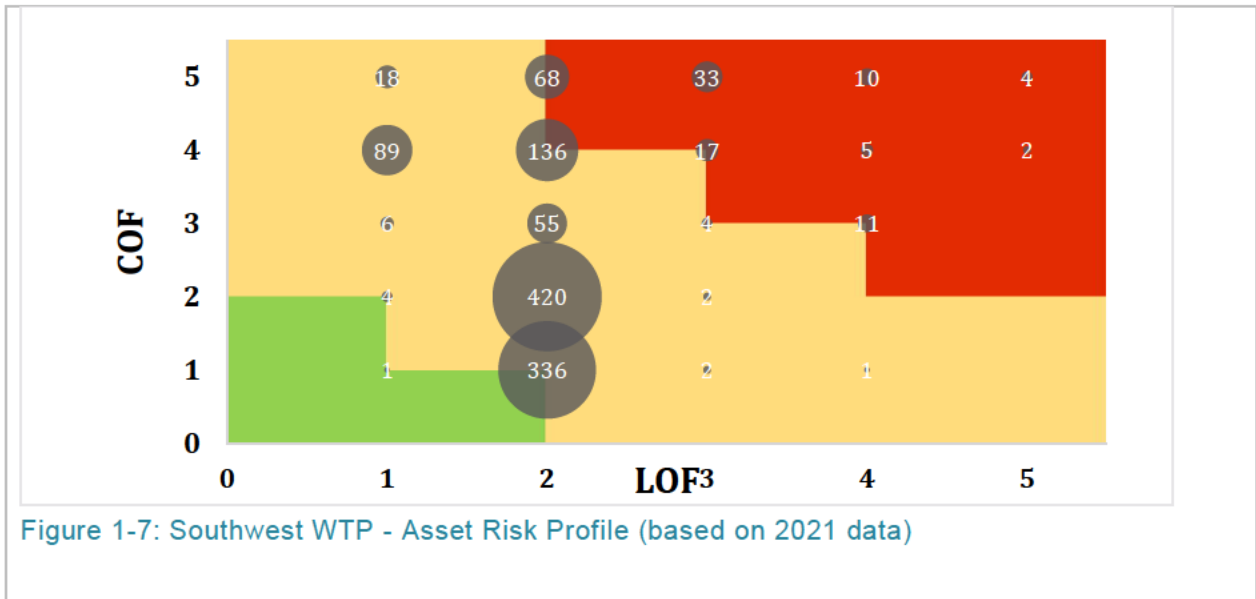


Figure 1-7: Southwest WTP - Asset Risk Profile (based on 2021 data)

Table 1-2: Booster Station Age and Capacity

Booster Stations	Year Placed in Operation	Pumping Capacity (MGD)	Storage Capacity (MG)
Adams Road	2012	92.8	10.0
Eastside	1952	30.0	10.0
Electric Avenue	1987	21.2	6.6
Ford Road	1961	108.9	10.0
Franklin	1968	164.0	10.0
Haggerty	1968	91.0	10.0
Imlay	1971	575.0	18.0
Joy Road	1970	93.5	6.0
Michigan Avenue	1961	28.8	7.0
Newburgh	1964	52.0	-
North Service Center	1962	326.5	20.0
Northwest	1952	50.4	10.0
Orion	1981	14.0	-
Rochester	1997	72.0	-
Schoolcraft	1971	80.0	10.0
West Chicago	1956	40.7	-
West Service Center	1964	265.8	20.0
Wick	1978	72.0	10.0
Ypsilanti	1986	54.0	-

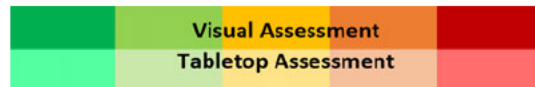
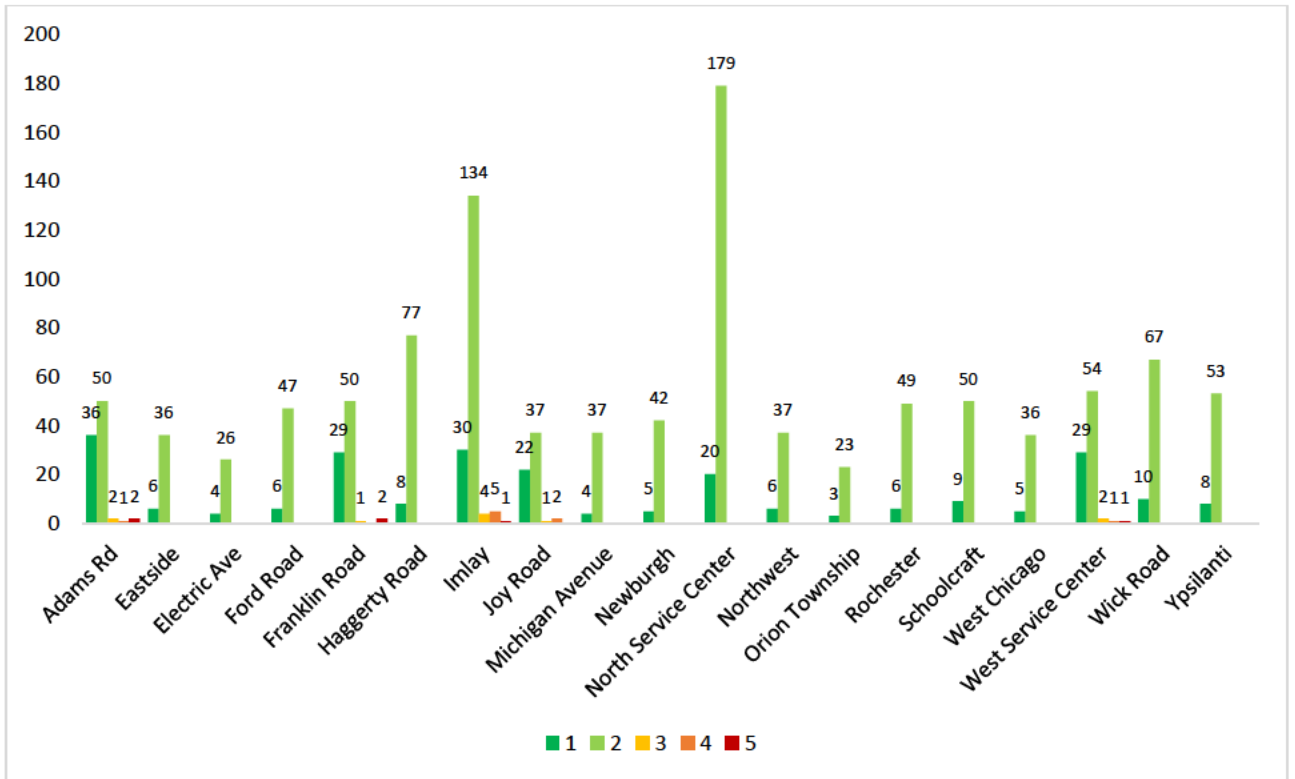
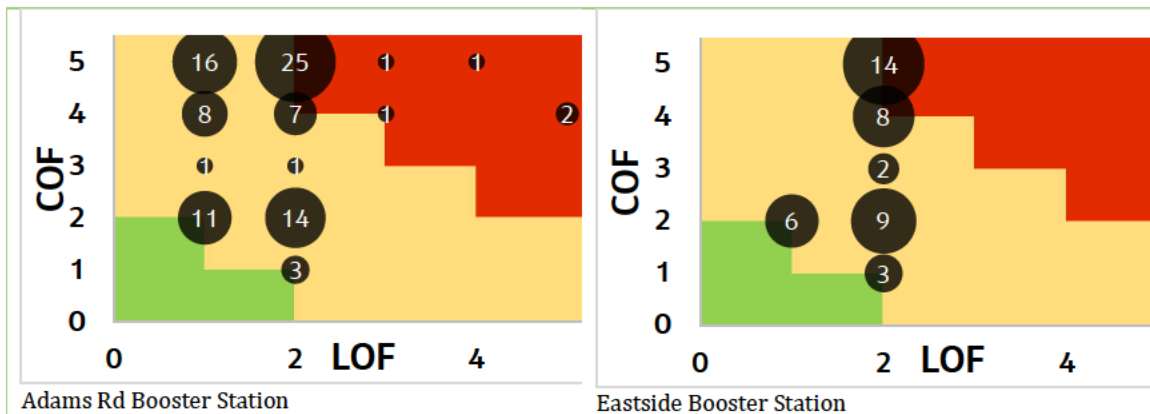
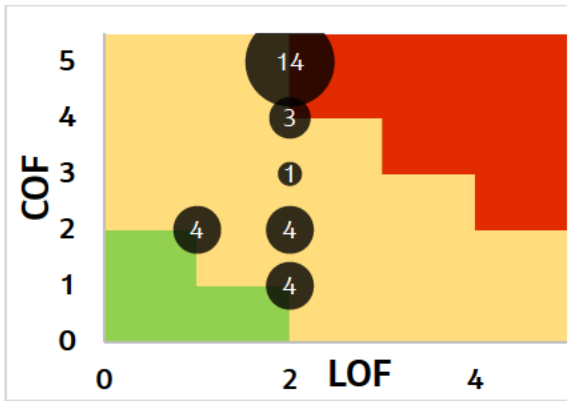


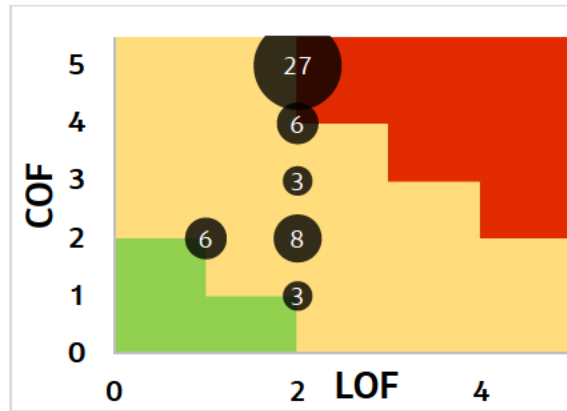
Figure 1-8: Booster Stations - Asset Condition (based on 2021 data)

Figure 1-9, below, shows the asset risk for each Booster Station.

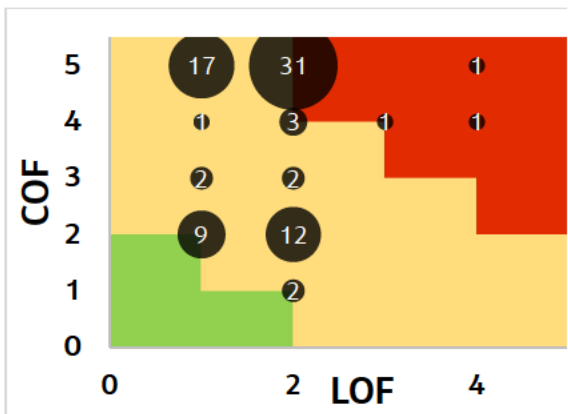




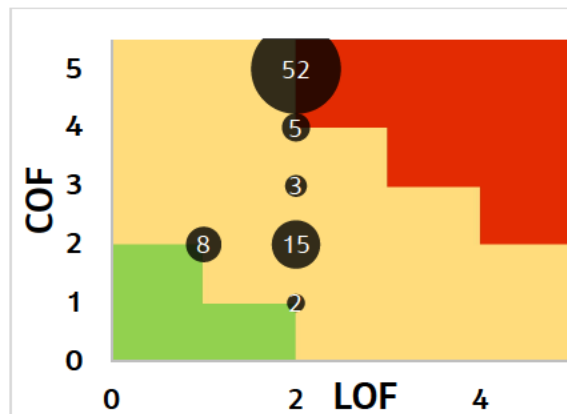
Electric Ave Booster Station



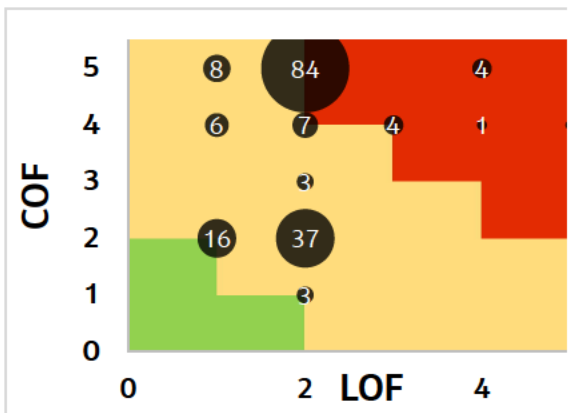
Ford Road Booster Station



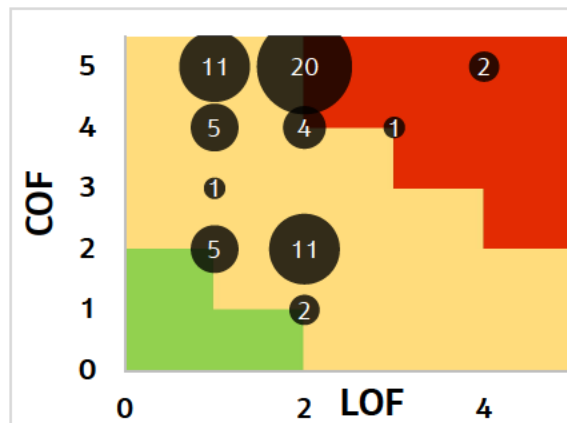
Franklin Road Booster Station



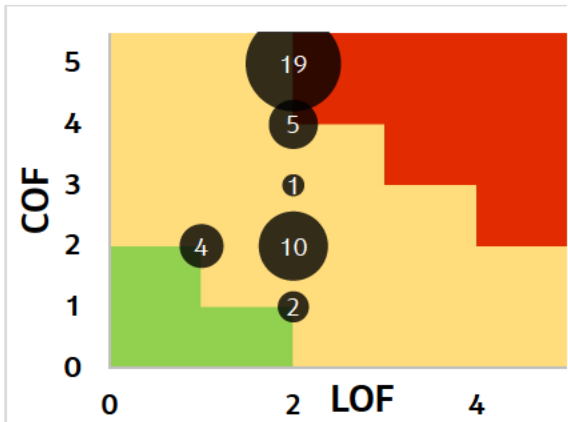
Haggerty Road Booster Station



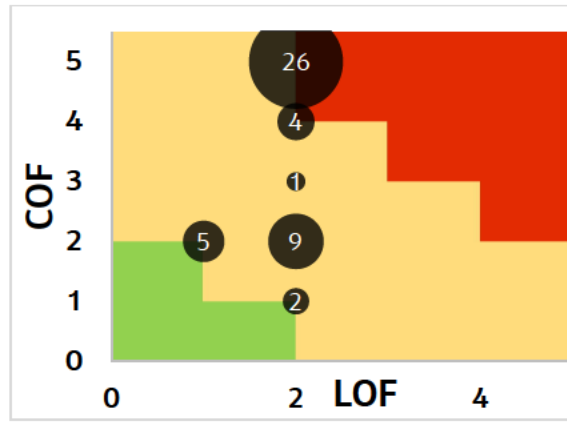
Imlay Booster Station



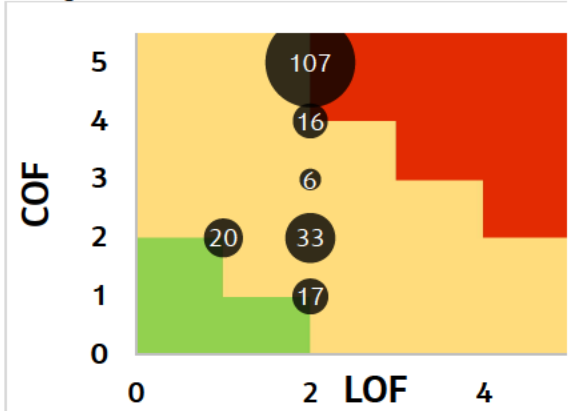
Joy Road Booster Station



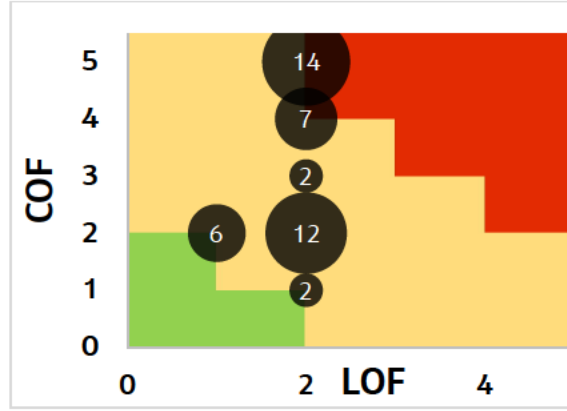
Michigan Avenue Booster Station



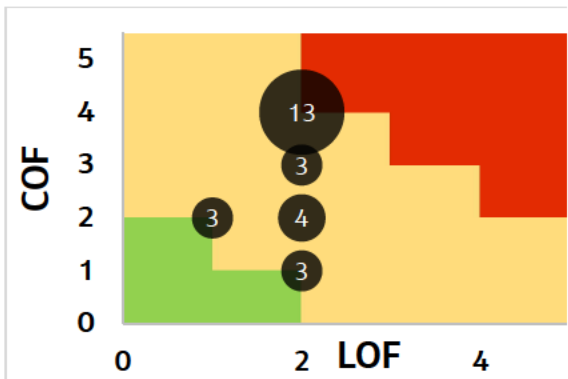
Newburgh Booster Station



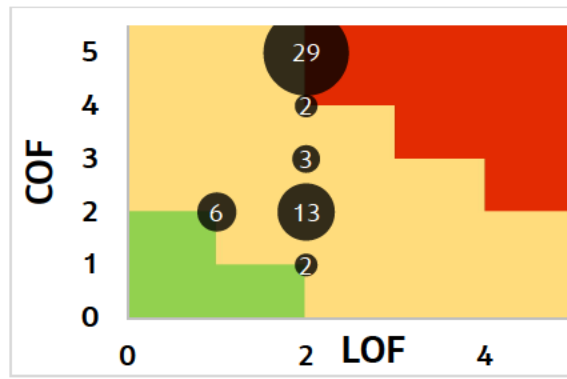
North Service Center Booster Station



Northwest Booster Station



Orion Township Booster Station



Rochester Booster Station

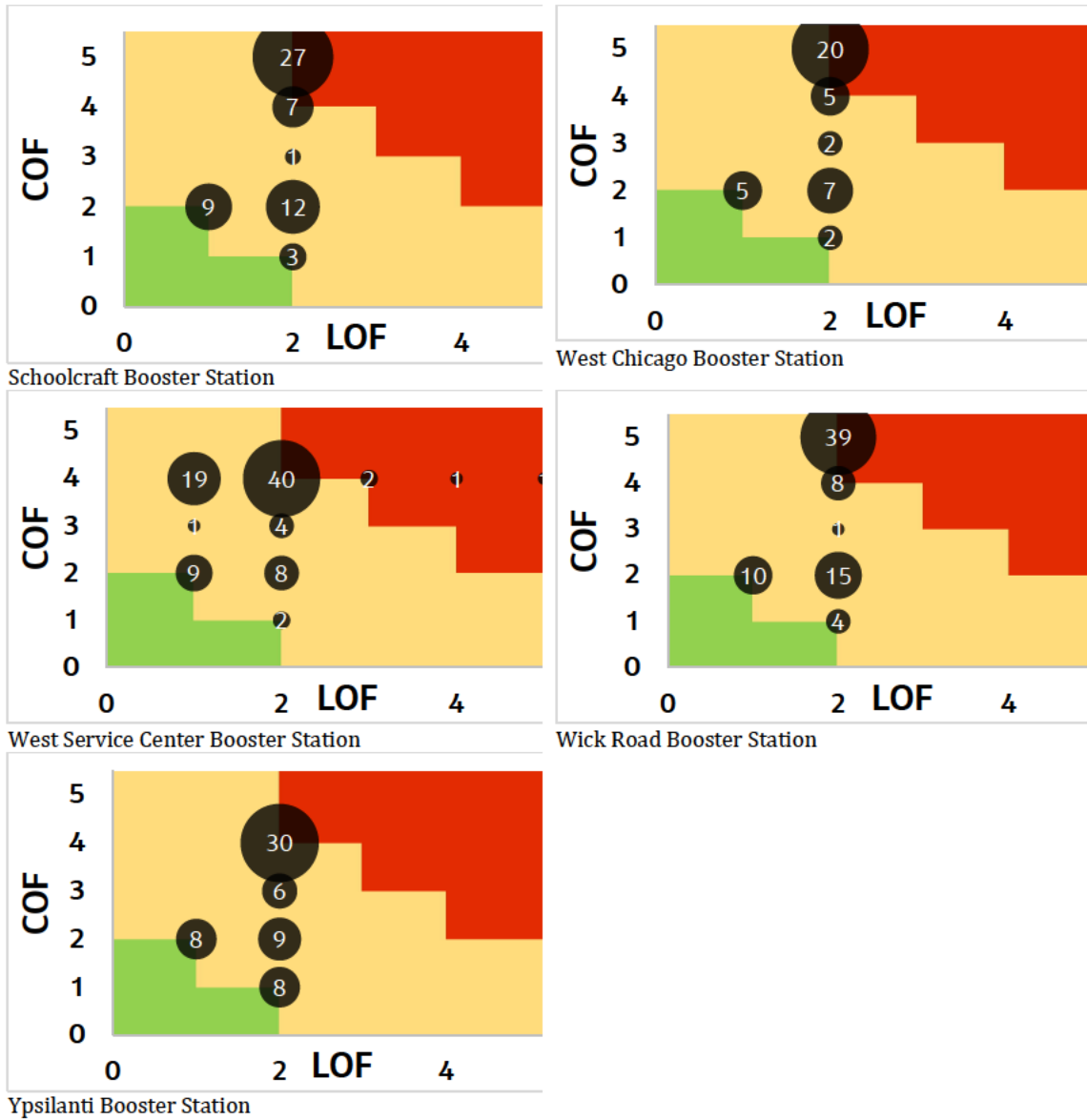


Figure 1-9: Booster Stations - Asset Risk Profile

1.4 Service Levels and Performance

Drivers are external and internal influences that affect the management of the water assets within GLWA. The drivers identified by GLWA include stakeholder expectations, regulatory compliance, future demand, enhancements, efficiency and sustainability, resilience, and meeting service levels. A summary of drivers and performance is presented in Chapter 3. A suite of technical service levels and performance indicators (PIs) related to operations and maintenance (O&M) performance and meeting defined service levels for linear and vertical assets are discussed in Chapter 6.

Currently established PIs for the water system vertical assets are presented in Table 1-3. PIs for the linear system may be accessed from LSIP. GLWA is working to develop an integrated service level framework dashboard of these metrics as part of its implementation of the new Enterprise Asset Management (EAM) system implementation NexGen, that aligns with stakeholder expectations and that can be supported by available data to drive planning and decision-making.

Table 1-3: Water System Vertical Asset Performance Indicators

Development Tier	Development Description	Water System Performance Indicators
Tier 1	Currently tracked and/or reported at an enterprise level.	<ul style="list-style-type: none"> • Maintenance Utilization Rate • Work Backlog by Hours (crew weeks) • % Preventive maintenance (PM) Completion Rate (PMs Completed vs PMs Scheduled) • % PM Work Order vs Total Work Orders • % Estimated Labor Hour Accuracy - Estimated vs Actual • Number of Backlog Work Orders by Age • % CM Estimating Accuracy • PM Labor Hours vs Total Labor Hours • Hours Reported vs Hours Available
Tier 2	Currently tracked within certain areas at GLWA, or not being tracked at all.	<ul style="list-style-type: none"> • Plant/System/Equipment Availability • Mean Time Between Failure (MTBF) • % Proactive Maintenance vs Total Maintenance Hours • % Predictive Maintenance vs Total Maintenance Hours • Total Reactive Labor Hours

Development Tier	Development Description	Water System Performance Indicators
Tier 3	Not currently tracked but will be tracked in the future as a part of the new EAM.	<ul style="list-style-type: none"> • Total Reactive Material Cost • Planned or Scheduled Hours vs Total Actual Labor Hours • Scheduled vs Available Hours • Schedule Attainment • Average Mean Time to Repair (MTTR) • Percentage of Schedule Break-in Labor Hours vs Total Scheduled Labor Hours • Average Asset Health Score • Average Remaining Asset Life

1.5 Renewals

Renewal needs are identified by scheduled replacement program (SRP) models maintained by GLWA, as described in Chapter 7. The WTPs and Booster Stations are contained in an SRP model for vertical assets (Appendix K) The linear system renewal needs are defined in a separate SRP model, Info Asset Planner (IAP).

Renewal needs for the WTPs and Booster Stations are based on 2021 asset condition data and are reflected in Figure 1-10. The five-year summary of projected CIP expenditure is based on current asset condition scores and suggests an average annual expenditure of approximately \$50 million. GLWA’s financial plan for meeting these needs may be found in the Financial Planning documentation located here ([Financial Resources - Great Lakes Water Authority \(glwater.org\)](#)).

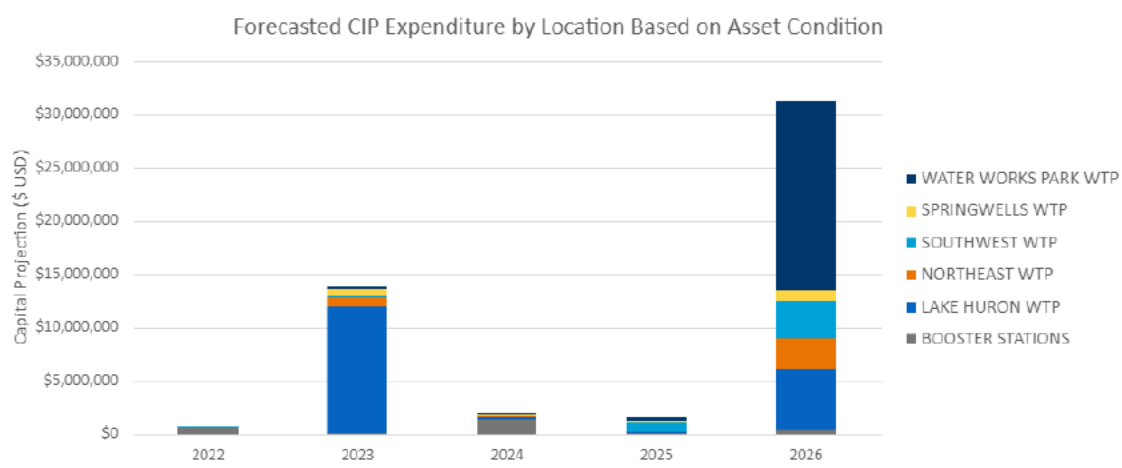


Figure 1-10: Renewals– WTPs and Booster Stations (based on 2021 data, in 2021 dollars)

1.6 WAMP - Continuous Improvement Plan

The current abbreviated Continuous Improvement Plan is shown in Table 1-4. It is comprised as a series of Tactical Recommendations to be implemented over a three-year period. Detailed descriptions of each Tactical Recommendation are included in Chapter 9.0 and a detailed Continuous Improvement Plan Tracker is included in Appendix L. Implementing the continuous improvement activities reflected herein, will take commitment of staff resources by GLWA.

The Continuous Improvement Plan aims to close a number of key gaps associated with asset management governance, service levels, condition assessments, and O&M practices that includes improvements in data quality and improvements in business processes and procedures. The WAMP Governance Business Processes are presented in Chapter 9 and Appendix Mand a summary of the roles and responsibilities is presented in Table 1-5.

Table 1-4: WAMP Continuous Improvement Plan

Tactical Recommendation #	Tactical Recommendation Title	Year 1 Activities	Year 2 Activities	Year 3 Activities
W1	WAMP - Asset Management Roles & Responsibilities	Define Asset Management Roles and Responsibilities	Assess and Refine Asset Management Champion Roles and Responsibilities	Perform Maturity Assessment Check-In
W2	WAMP - Service Levels	Develop Service Level Framework	Improve Data to Report on Service Levels	Develop Targets for Customer Service Levels
W3	WAMP - Asset Data and Information	Confirm Data Collection Needs & Address Year 1 – “Priority 1”	Collect Data to Address Data Improvement Needs Identified in Year 2 – “Priority 1 & Priority 2”	Collect Data to Address Data Improvement Needs Identified in Year 3
W4	WAMP - Digital Solutions	Configure NexGen to Display Key Data to Inform Asset Management Decision-Making	Integrate NexGen with Core Technologies and Additional Technologies	Convert WAMP to Digital Format and Additional Technologies
W5	WAMP - Condition Assessment of Non-Inspected Vertical Assets	Perform Priority #1 and Priority #2 Condition Assessments – Year 1	Perform Priority #2 Condition Assessments – Year 2	Perform Priority #2 Condition Assessments – Year 3
W6	WAMP - Asset Risk for Vertical Assets	Refine Risk Register for Vertical Assets with updated Condition Data	Assess Risk Mitigation Strategies and Refine and Risk Register	Revisit Risk Register for Vertical Assets Criteria and Refine
W7	WAMP - Maintenance & Reliability Work Management Process for Vertical Assets	Develop Improved Maintenance and Reliability Work Management Processes	Improve Planning and Scheduling Activities	Inventory Management Improvements
W8	WAMP - Maintenance Reliability Improvement Implementation for Vertical Assets	Develop and Implement FMEA and PMO Activities and Organizational Enhancements	Expand FMEA and PMO and Develop a Predictive Maintenance Strategy	Implement Predictive Maintenance Strategy
W9	WAMP - Maintenance and Reliability - Performance Measurement and Improvement for Vertical Assets	Develop Maintenance and Reliability Performance Tracking Platform with Tier 1 PIs	Develop Maintenance and Reliability Performance Tracking Platform with Tier 2 and 3 PIs	Perform Maintenance and Reliability Maturity Assessment
W10	WAMP - Scheduled Replacement Program Implementation	Update SRP Models with Year 1 Condition Assessments	Update SRP Models with Year 2 Condition Assessments and Assess SRP Model Options	Update SRP Models with Year 3 Condition Assessments and Identify and Secure New SRP Software (if needed)
W11	WAMP - Capital Improvement Program Process Improvement	Refine the CIP Process to Incorporate Results of Asset Management Analyses	Initiate Use of Asset Management Analyses Results into CIP Process	NA
W12	WAMP - Replacement Cost Database for Vertical Assets	Improve Asset Cost Data on Existing Assets in WAM/NexGen	Identify Process to Maintain Cost Data	Expand Asset Cost Data and Processes to all Assets

Table 1-5: WAMP Governance Roles and Responsibilities

Responsible Owner	Business Process - Key Responsibilities	Frequency
EAMG	1) WAMP Management – incorporate updates to each section of the WAMP every 3 years (major update); annually (July) (minor updates) and as identified	<ul style="list-style-type: none"> • Every 3 Years • Annually • As identified
EAMG	2) WAMP - Continuous Improvement Plan Implementation – ensure adherence to routine meeting schedule with identified Tactical Recommendation owners.	<ul style="list-style-type: none"> • Monthly
Local AM Group (TBD)	3) WAMP - Asset Audit Program - implement the improvements to data listed in the Asset Data and Information Improvement Tracker (Appendix D)	<ul style="list-style-type: none"> • Annually
Local AM Group (TBD)	4) WAMP - Condition Assessment Program – Vertical and Building Assets – implement visual and detailed condition assessments in alignment with the priorities listed in the WAMP - Condition Assessment Activities –Vertical Assets (Appendix F)	<ul style="list-style-type: none"> • Annually or • Failure Event • Monthly
Local AM Group (TBD)	5) WAMP - Risk and Criticality Assessment Program - follow the asset risk management and data management activities in alignment with Tactical Recommendation W6 – Asset Risk for Vertical Assets and Tactical Recommendation W3 – Asset Data and Information	<ul style="list-style-type: none"> • New asset driver affecting COF • Annual review of COF • New O&M optimization activity • New condition data
Operations and Maintenance Team Leads	6) WAMP - Strategic Maintenance and Reliability Program Manage and run the PMO Tool and use as needed following review of the Performance Indicator Report from NexGen Manage Failure Modes Effects Analysis (FMEA) development and usage following review of the Asset Failure Report from NexGen – identify and prioritize and implement development of additional FMEAs beyond the pilot activities completed in 2022.	<ul style="list-style-type: none"> • Weekly
Finance/ Maintenance Director	7) WMP - Asset Replacement and Retirement Program –determine projects for Capital Outlay or CIP	<ul style="list-style-type: none"> • As Identified
EAMG	WAMP - Scheduled Replacement Program (SRP) – update data in the SRP models on an annual basis and obtain refined future financial outlooks that can be used in the CIP Planning Process as inputs. <i>Note: This tool is reflected as part of the WAMP - Asset Replacement and Retirement Program Business Process (Appendix M).</i>	<ul style="list-style-type: none"> • Annually

2 Introduction

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The Great Lakes Water Authority (GLWA) Strategic Asset Management Plan (SAMP) establishes the asset management (AM) strategic framework, improvement strategies, and business processes that GLWA will employ to realize its vision and accomplish its mission. Figure 2-1 illustrates the example practices and activities contained in an effective asset management plan (AMP).

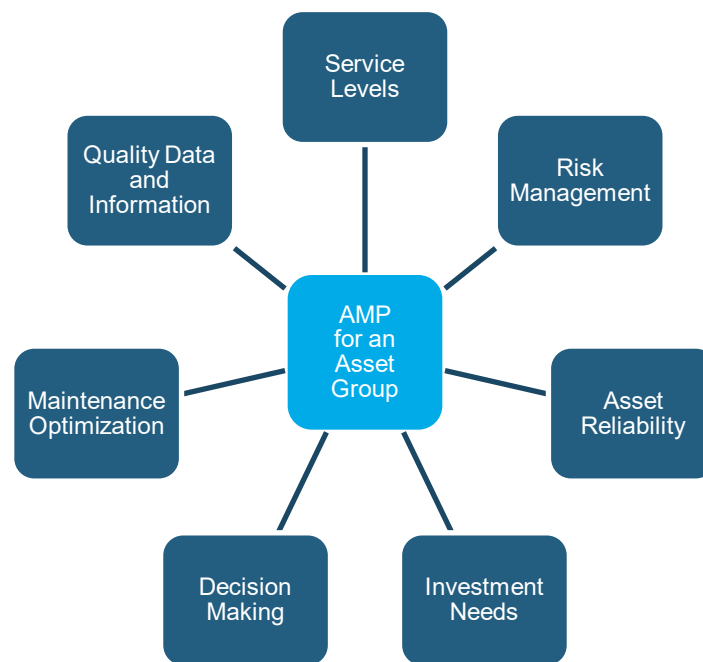


Figure 2-1: Example Practices and Activities Contained in an AMP

To define how principles in the GLWA SAMP apply to the water system managed by GLWA, this Water Asset Management Plan (WAMP) builds on the model illustrated above and includes the existing state, specific improvement activities, resources, and timescales required to achieve GLWA’s water system AM objectives. The goal is to provide the framework that will guide GLWA toward more informed decisions regarding lifecycle management of water assets from planning to decommission.

2.1 WAMP Objectives and Content

This WAMP serves as a guiding document for instilling AM concepts and promoting AM practices across internal and external stakeholders involved in managing water system assets. It outlines activities and guidelines to meet service levels, optimize asset life cycles,

and support AM decisions. Designed to be useful and timely, this WAMP is a living document to be regularly updated as AM drivers and managed assets change.

The WAMP connects cost, performance, and risk while maintaining a line of sight between strategic decisions, GLWA planning documents, enhancement needs, operations and maintenance activities (O&M), and renewal and replacement requirements. Tactical Recommendations (Chapter 9) are included that further develop AM processes. These Tactical Recommendations are laid out over a three-year time horizon with assigned owners to each. Together, the Tactical Recommendations comprise the Continuous Improvement Plan.

2.1.1 WAMP Objectives

The WAMP provides information needed to optimize resources, responsibly manage assets, and demonstrate GLWA's commitment to member partner expectations and long-term stewardship of water assets.

By documenting current and future AM strategies, the WAMP provides staff with a logical framework to support communication and justification of funding needs to maximize asset life and maintain a reliable water system. Figure 2-2 provides the specific objectives of this WAMP and includes the specific chapter where each objective is discussed.










WAMP Objectives	WAMP Chapter
 Document relevant service levels, regulatory requirements, and desired asset performance	3
 Provide short- and long-term forecasts of demand and the impact of changes in demand upon assets	3
 Propose performance indicators (PI) for the assets addressed in the WAMP, establish targets for PIs, and identify resources for PI tracking and reporting	3
 Document the assets within the asset group, their current condition, performance, and value	4
 Document the currency, quality, and completeness of data required for effective management of the assets	4
 Document the risk associated with the assets, including likelihood of failure and consequence of failure	5
 Document how GLWA treats risks, such as maintenance, rehabilitation, replacement strategies, redundancy, and contingency planning	5,6,7
 Determine resources required for risk treatment strategies and projected changes in demand, including long-term capital projections, Capital Outlay, O&M expenditures, and staffing	8
 Identify and plan for AM tactical recommendations and updates to the AM roadmap, obtain resource commitments, and establish timeframes and roles and responsibilities for improvement initiatives.	9

Figure 2-2: Summary of GLWA WAMP Objectives

2.1.2 WAMP Contents

A summary of the WAMP contents and related improvements in each component area is presented in table in Table 2-1.

The WAMP was prepared in a collaborative manner with dedicated engagement from team members. Approximately 65 GLWA staff participated in approximately 37 meetings/workshops between October 2021 and June 2022. These team members include, but are not limited to those responsible for operations, maintenance, planning, engineering, regulatory compliance, safety, and enterprise AM. A summary table of attendees and number of engagement meetings/workshops conducted is located in Appendix B.

Table 2-1: WAMP Chapters and Tactical Recommendations

Chapter	Title	Content	Tactical Recommendation
1	Executive Summary	<ul style="list-style-type: none"> <input type="checkbox"/> GLWA water system overview <input type="checkbox"/> State of the assets <input type="checkbox"/> Service levels and performance <input type="checkbox"/> Renewals <input type="checkbox"/> Continuous Improvement Plan 	<ul style="list-style-type: none"> • NA
2	Introduction	<ul style="list-style-type: none"> <input type="checkbox"/> Purpose and intent of the WAMP <input type="checkbox"/> Overview of components that are key to the development of this WAMP and future updates 	<ul style="list-style-type: none"> • NA
3	WAMP Drivers and Performance	<ul style="list-style-type: none"> <input type="checkbox"/> Overview of key drivers affecting management of water assets within GLWA, including regulatory drivers, stakeholder expectations, service levels and PIs, and future demand 	<ul style="list-style-type: none"> • W2: WAMP - Service Levels • W4: WAMP - Digital Solutions
4	Asset Profile	<ul style="list-style-type: none"> <input type="checkbox"/> Overview of the asset portfolio, including inventory, valuation, asset age, condition, type 	<ul style="list-style-type: none"> • W3: WAMP - Asset Data and Information • W4: WAMP - Digital Solutions • W5: WAMP - Condition Assessment of Non-Inspected Vertical Assets • W12: WAMP - Replacement Cost Database for Vertical Assets
5	Asset Risk	<ul style="list-style-type: none"> <input type="checkbox"/> Results of the asset risk assessments carried out for water assets <input type="checkbox"/> Risk mitigation strategies 	<ul style="list-style-type: none"> • W4: WAMP - Digital Solutions • W6: WAMP - Asset Risk for Vertical Assets
6	Operations and Maintenance	<ul style="list-style-type: none"> <input type="checkbox"/> Review of existing O&M practices <input type="checkbox"/> Key recommendations related to O&M improvements 	<ul style="list-style-type: none"> • W4: WAMP - Digital Solutions • W7: WAMP - Maintenance and Reliability Work Management Processes for Vertical Assets • W8: WAMP - Maintenance and Reliability Improvement Implementation for Vertical Assets • W9: WAMP - Maintenance and Reliability Performance Measurement and Improvement for Vertical Assets
7	Renewals	<ul style="list-style-type: none"> <input type="checkbox"/> Scheduled replacement plan (SRP) and funding forecasts over a 20-year horizon 	<ul style="list-style-type: none"> • W10: WAMP - Scheduled Replacement Program Implementation • W11: WAMP - Capital Improvement Program Process Improvement

Chapter	Title	Content	Tactical Recommendation
8	Funding	<ul style="list-style-type: none"> □ Overview of asset base spending, including: <ul style="list-style-type: none"> ○ Historical (previous 5 years) budgeted/allocated capital expenditures (CAPEX) ○ Historical operational expenditures (OPEX) 	<ul style="list-style-type: none"> • None
9	Continuous Improvement Plan	<ul style="list-style-type: none"> □ High-level improvement and monitoring actions □ Description of roles and responsibilities 	<ul style="list-style-type: none"> • W1: WAMP - Asset Management Roles & Responsibilities • W4: WAMP - Digital Solutions

2.2 WAMP Strategic Alignment

The WAMP identifies specific actions that are aligned to GLWA’s overall AM strategy. Figure 2-3 shows this relationship. GLWA’s WAMP strategic alignment begins with GLWA’s commitment to achieving its organizational vision and mission. The GLWA vision and mission is supported by GLWA’s asset management vision, mission, policy and principles, and asset management objectives. Section 1 – Introduction of the SAMP – provides the details of each ¹

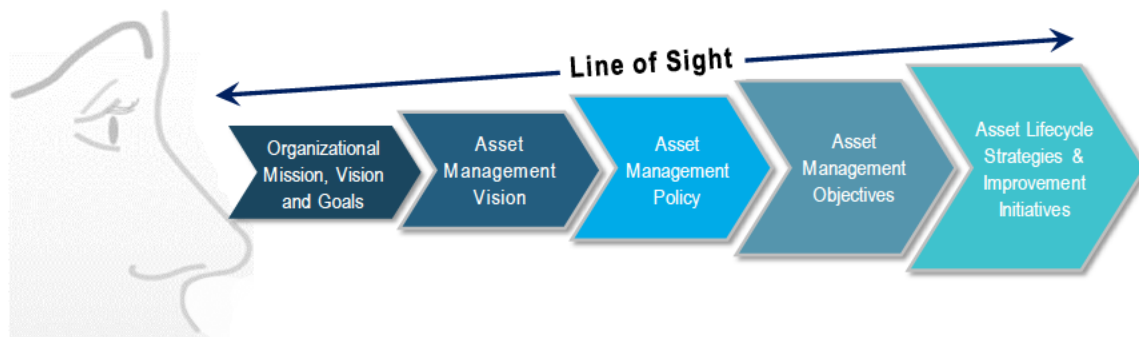


Figure 2-3: GLWA's Overall Asset Management Strategy

¹ GLWA’s vision and mission are stated in the 2019 GLWA SAMP (GLWA, 2019).

3 WAMP Drivers and Performance

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to provide an overview of the key drivers affecting management of the water assets within GLWA, including organizational boundaries, regulatory compliance, and stakeholder expectations to meet service levels.

Tactical Recommendations W2: WAMP –Service Levels and W4: WAMP – Digital Solutions

presented in Chapter 9, discuss continuous improvements designed to measure how GLWA tracks and aligns organizational and operational performance.

Tactical Recommendations:

- W2: WAMP –Service Levels
- W4: WAMP - Digital Solutions

Supporting Artifacts:

- Tier 1-3 Performance Indicators (PIs) – Chapter 3 of the WAMP
- LSIP Performance Metrics Dashboard
- Monthly EGLE Operations Reports
- Annual Statistical Reports for WTPs

3.1 Organizational Boundaries

GLWA is managing a set of water system assets that have varying degrees of age and condition, planning requirements, as well as reacting to different influencers such as future demand, climate change, security requirements and technology advancements. Each of these organizational boundary drivers is described in Table 3-1 and are the considerations when developing asset management strategies to maximize the value of the asset and provide service at defined service levels.

Table 3-1: Summary of Water System Drivers

Organizational Boundary Drivers	Context/Requirements	Impact
Aging Infrastructure	<ul style="list-style-type: none"> • GLWA’s transmission mains have an average life expectancy of 70 years and approximately 32% installed prior to 1940. • Raw Water intake facilities (1931, 1964, 1974) • Treatment Plants (1931, 1956, 1964, 1974, 2003) • Booster Stations (1952 - 2012) 	The age of the assets requires GLWA to have to different lifecycle management strategies for the varying ages.

Organizational Boundary Drivers	Context/Requirements	Impact
Plans	<p>Water Quality Plan</p> <ul style="list-style-type: none"> • Surface Water Intake Protection Plan (for all three intakes). • Partnership for Safe Water, MiWARN, and the Huron to Erie Monitoring System. • Repurpose and optimize conventional filtration capacity at four plants and converting to direct filtration at the Lake Huron plant. • After 2025, incorporate multi-barrier disinfection and conversion from chlorine gas to sodium hypochlorite. <p>Service Management Plan</p> <ul style="list-style-type: none"> • Proposes changes to the transmission system to efficiently meet wholesale customer contract requirements and projected 2035 water demands. • Changes to the transmission system allow for the repurposing of the Northeast WTP and the decommissioning of older Booster Stations that were originally part of the Wayne County water system and acquired by DWSD in 1960. • Pumping capacity in DWSD’s high lift Booster Stations exceeds 2,500 MGD, but future requirements are 1,500 MGD, so substantial idle capacity can be removed from service to reduce costs for preventive maintenance and electrical demand charges and reduce costs of future capital upgrades. • Implement improvements to add transmission redundancy and new isolation gates on transmission mains. <p>2015 Master Plan (and 2021 update)</p> <p><u>Growth</u> - Reduce water treatment capacity to align with projected water demand</p> <p><u>Potential Member Partner Utilities in Close-Proximity to GLWA Transmission area</u> - these are potential member partners that could potentially be looking to connect to GLWA.</p> <p><u>Sustainability</u> - Reduce non-revenue water</p> <p><i>Target reduction from 30% to 15% by 2035</i></p> <p><u>Efficiency</u> - Reduce energy use and energy costs</p> <p><u>Service Improvement/Resilience</u> –</p> <ul style="list-style-type: none"> • Collaborate with customers to address long standing water transmission problems • Source Water Redundancy 	<p>Asset management activities that support a Plan objective is a criterium for asset replacement decision-making.</p>

Organizational Boundary Drivers	Context/Requirements	Impact
Future Demand	Total rated treatment capacity is 1,720 MGD and firm high service pumping capacity is 2,400 MGD. Current capacities are sufficient for projected demand.	Consider how demand is distributed through the system to ensure remote pumping capacities and pipe sized are appropriate for water to be delivered to wholesale customers.
Climate Change	<p>Climate models (see 2021 Master Plan Update) predict increases in temperature and precipitation throughout the 21st century.</p> <ul style="list-style-type: none"> • Frequency and intensity of storms is anticipated • Water levels in Great Lakes and tributary surface waters are expected to fluctuate • Anticipated increase in algal blooms • GLWA performed a risk and resilience assessment of the water system in 2020 and revised the Emergency Response Plan to incorporate findings. 	The impacts of climate change require GLWA to consider how this impacts the management of water assets throughout their lifecycle.
Security Requirements	<p>GLWA performed a risk and resilience assessment in accordance with the America’s Water Infrastructure Act of 2018 and new EPA requirements released in 2019.</p> <p>In addition to many programmatic activities, there have been specific infrastructure updates such as building a fence around the Belle Isle Water Intake to increase protection against unauthorized access and potential external threats.</p>	Security requirements impact the technology and infrastructure in place to manage assets.
Technology Advancements/Support	<p>Currently, GLWA is incorporating the following technology into their investment decision-making.</p> <ul style="list-style-type: none"> • Remote monitoring • Advanced metering • Online water quality monitoring of distribution systems • Trenchless installation of pipes • New methods and materials for lining pipes • Assessment of internal and external condition of pipes without excavation • Continuous remote monitoring of pipe condition 	Technology requirements impact how GLWA manages its assets using identified technologies.

3.2 Regulatory Compliance

GLWA water operations are strictly regulated. Maintaining regulatory compliance is a major focus of GLWA and managing asset risk is a key enabler for long-term compliance and is another driver for GLWA. A summary of requirements and impacts to the management of

water system assets is reflected below. Up-to-date information about the requirements for each are available through GLWA’s Enterprise Asset Management Group (EAMG).

- Great Lakes and Energy Consent Agreement (EGLE) – impacts service levels, CIP, and O&M
- Michigan Water Asset Management Council – informs AMP content
- Michigan Infrastructure Council – informs AMP content
- America’s Water Infrastructure Act of 2018 – informs security needs
- Homeland Security –informs CIP and O&M
- Unregulated Contaminant Monitoring Requirements (UCMR) - informs CIP and O&M

3.3 Stakeholder Expectations

Consistent with its organizational vision, GLWA places great emphasis on collaboration with its member partners, team members, and other external and internal stakeholders. Stakeholder expectations is another driver for managing water system assets. In keeping with this emphasis, a workshop focused on stakeholder expectations was held on January 31, 2019. During this workshop, GLWA used a stakeholder mapping tool to score identified external and internal stakeholders in terms of their degree of influence over GLWA, as well as their level of interest.

Figure 3-1 and Figure 3-2 show the results of this stakeholder mapping; Figure 3-1 illustrates GLWA’s external stakeholders and interests, while Figure 3-2 illustrates internal stakeholders and interests.



Figure 3-1: External Stakeholders and Interests



Figure 3-2: Internal Stakeholders and Interests

To connect with stakeholders, GLWA provides outreach through its dedicated One Water Partnership Member Outreach Program. The program consists of work groups that involve members in technical service as well as financial discussions that support decision-making for GLWA’s water and water systems. To support SAMP Improvement Initiative #8 (Engagement and Networking), GLWA has designated team members working within the program, which also includes a contracted third-party facilitator responsible for sustaining the rules of collaboration and furthering the transparent exchange of information between GLWA and its members. The One Water Partnership Member Outreach Portal is available online to facilitate information sharing and ongoing communications. GLWA also holds informational workshops, hosts symposiums, and provides educational materials to the public.

Additionally, GLWA Public Affairs engages stakeholders through internal communications initiatives, proactive media relations, social media strategies, and system-wide community outreach. GLWA employs a cross-section of additional tools such as video monitors, communication centers, posters, and other media to share information with team members across the enterprise, many of whom do not sit at a desk every day.

3.4 Service Levels and Performance Indicators

Service levels (also called levels of service or LOS) are typically organized in a hierarchical structure shown in Figure 3-3.

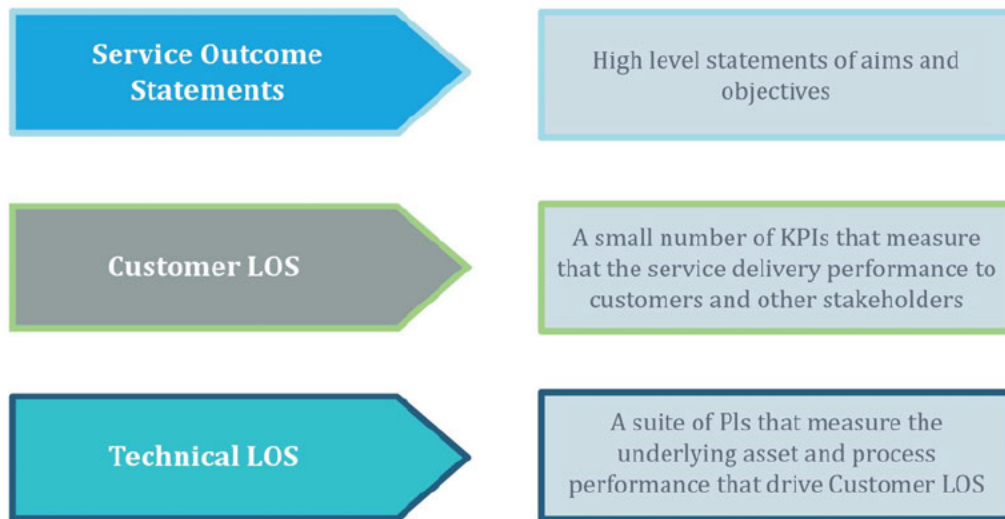


Figure 3-3: Typical Service Level Hierarchy

Note: LOS = Levels of Service; PI = Performance Indicators; KPIs = Key Performance Indicators

Currently established performance indicators (PIs) for water system vertical assets that assist with tracking service levels are presented in Table 3-2. PIs for the linear system may be accessed from LSIP. GLWA is working to develop an integrated service level framework dashboard of these metrics as part of its implementation of the new Enterprise Asset Management (EAM) system implementation NexGen, that aligns with stakeholder expectations and that can be supported by available data to drive planning and decision-making.

Table 3-2: Water System Vertical Asset Performance Indicators

Development Tier	Development Description	Water System Performance Indicators
Tier 1	Currently tracked and/or reported at an enterprise level.	<ul style="list-style-type: none"> • Maintenance Utilization Rate • Work Backlog by Hours (crew weeks) • % Preventive maintenance (PM) Completion Rate (PMs Completed vs PMs Scheduled) • % PM Work Order vs Total Work Orders • % Estimated Labor Hour Accuracy - Estimated vs Actual • Number of Backlog Work Orders by Age • % CM Estimating Accuracy • PM Labor Hours vs Total Labor Hours • Hours Reported vs Hours Available

Development Tier	Development Description	Water System Performance Indicators
Tier 2	Currently tracked within certain areas at GLWA, or not being tracked at all.	<ul style="list-style-type: none"> • Plant/System/Equipment Availability • Mean Time Between Failure (MTBF) • % Proactive Maintenance vs Total Maintenance Hours • % Predictive Maintenance vs Total Maintenance Hours • Total Reactive Labor Hours
Tier 3	Not currently tracked but will be tracked in the future as a part of the new EAM.	<ul style="list-style-type: none"> • Total Reactive Material Cost • Planned or Scheduled Hours vs Total Actual Labor Hours • Scheduled vs Available Hours • Schedule Attainment • Average Mean Time to Repair (MTTR) • Percentage of Schedule Break-in Labor Hours vs Total Scheduled Labor Hours • Average Asset Health Score • Average Remaining Asset Life

4 Asset Profile

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to provide an overview of the asset portfolio, including inventory, asset age, condition and type of key asset attributes, asset condition and assessment approach, and valuation.

Tactical Recommendations W3: WAMP - Asset Data and Information; W4: WAMP - Digital Solutions; W5: WAMP - Condition Assessment of Non-Inspected Vertical Assets and W12:

WAMP - Replacement Cost Database for Vertical Assets presented in Chapter 9 are planned to be implemented to continuously improve the way GLWA defines the water system assets and track important attribute information to inform AM decision-making.

Appendix C- WAMP Asset Data and Information Improvement Summary lists the current data and information available to GLWA staff and the WAMP Asset Data and Information Improvement Tracker referenced in Appendix D supports continuous improvement of asset data. Appendix F is supports prioritization of condition assessment activities over a three-year period to improve condition data.

Tactical Recommendations:

- W3: WAMP - Asset Data and Information
- W4: WAMP - Digital Solutions
- W5: WAMP - Condition Assessment of Non-Inspected Vertical Assets
- W12: WAMP - Replacement Cost Database for Vertical Assets

Supporting Artifacts:

- WAMP -Asset Data and Information Improvement Summary- Appendix C
- WAMP -Asset Data and Information Improvement Tracker- Appendix D
- Information Technology (IT) Master Plan
- WAMP Condition Assessment Activities - Vertical Assets - Appendix F
- Financial System

4.1 Asset Definition

To support alignment and continuity, the WAMP uses the definitions included in the GLWA SAMP. Appendix A includes acronyms.

4.2 Water System Assets

GLWA’s regional water system is one of the largest in the United States, both in terms of water produced and population served. The system currently serves an area of 981 square miles located in eight Michigan counties, with an estimated population of nearly 4 million (or about 40 percent of Michigan’s total population). Suburban customers comprise approximately 82 percent of the population served by GLWA, and the Retail Water Customers (the cities of Detroit, Dearborn, and Highland Park) comprise the remainder served by GLWA.

The regional water system draws its water from the largest fresh surface water source in North America, the Great Lakes, with Lake Huron to the north, the Detroit River to the south and Lake St. Clair to the east. With access to nearly 2 billion gallons of high-quality source water, GLWA has highly reliability and more than sufficient source water to sustain current and future demands.

The major components of the regional water system include three raw water intake tunnels, five water treatment plants, an extensive conveyance system consisting of approximately 803 miles of transmission mains along with isolation and control valves throughout the service area, 19 water Booster Stations, and 32 water storage reservoirs (14 at the water treatment plants and 18 at Booster Stations). Water flow and pressure throughout the water system are monitored and controlled by the GLWA Systems Control Center.

The GLWA water system assets addressed in this WAMP are listed below and include linear and vertical assets.

Linear assets:

- Raw Water Tunnels
- Transmission Mains
- Isolation Valves
- Control Valves
- Booster Pumps
- Storage Tanks
- Raw Water Intakes
- Pressure Sensors
- Level Sensors
- Flow Meters
- Access Structures

Vertical assets:

- Water treatment plants (WTPs)
- Booster Stations

Figure 4-1 and Figure 4-2 present maps of GLWA's linear and vertical assets and water service area.

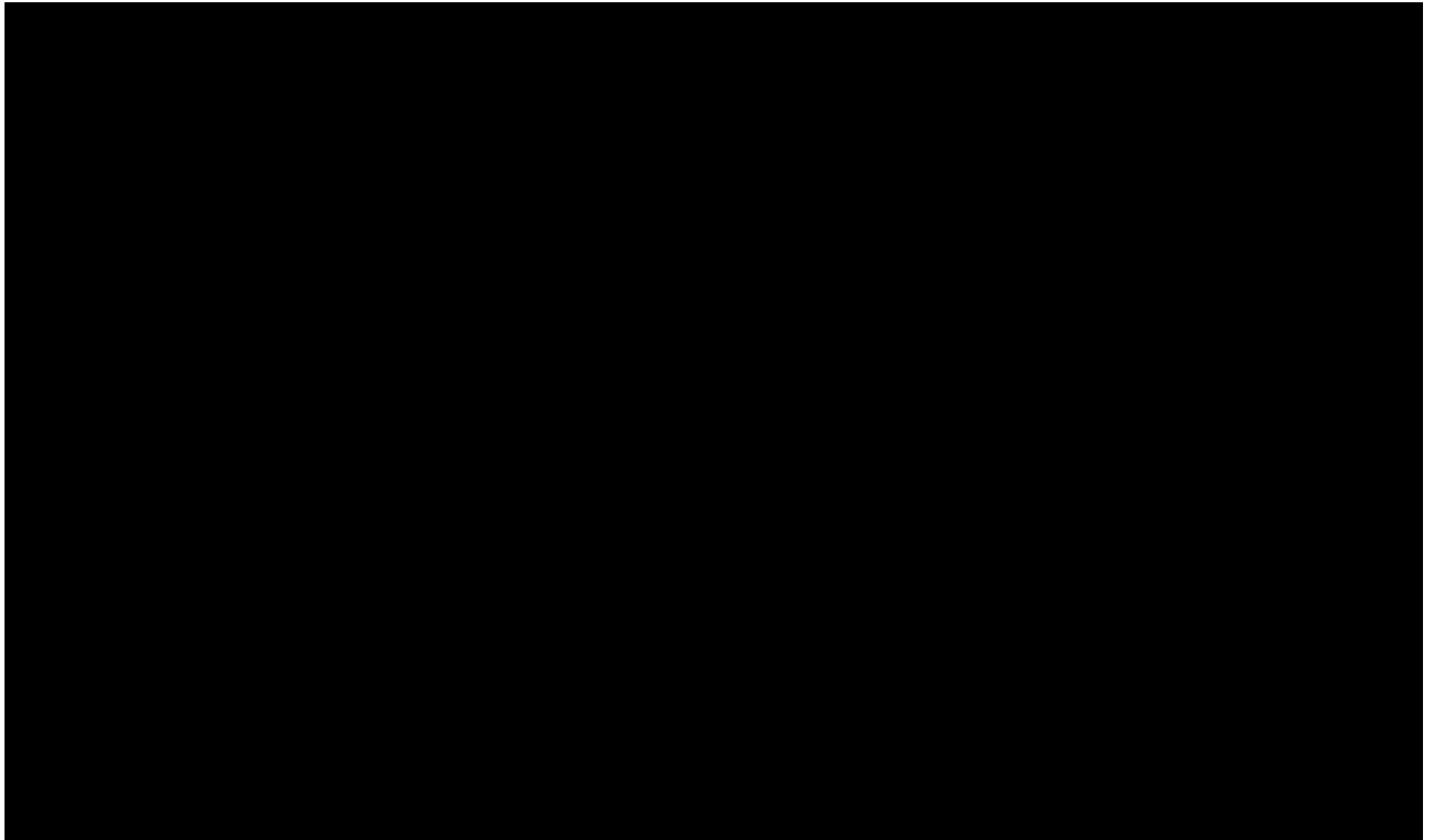


Figure 4-1: Map of Water System Linear and Vertical Assets

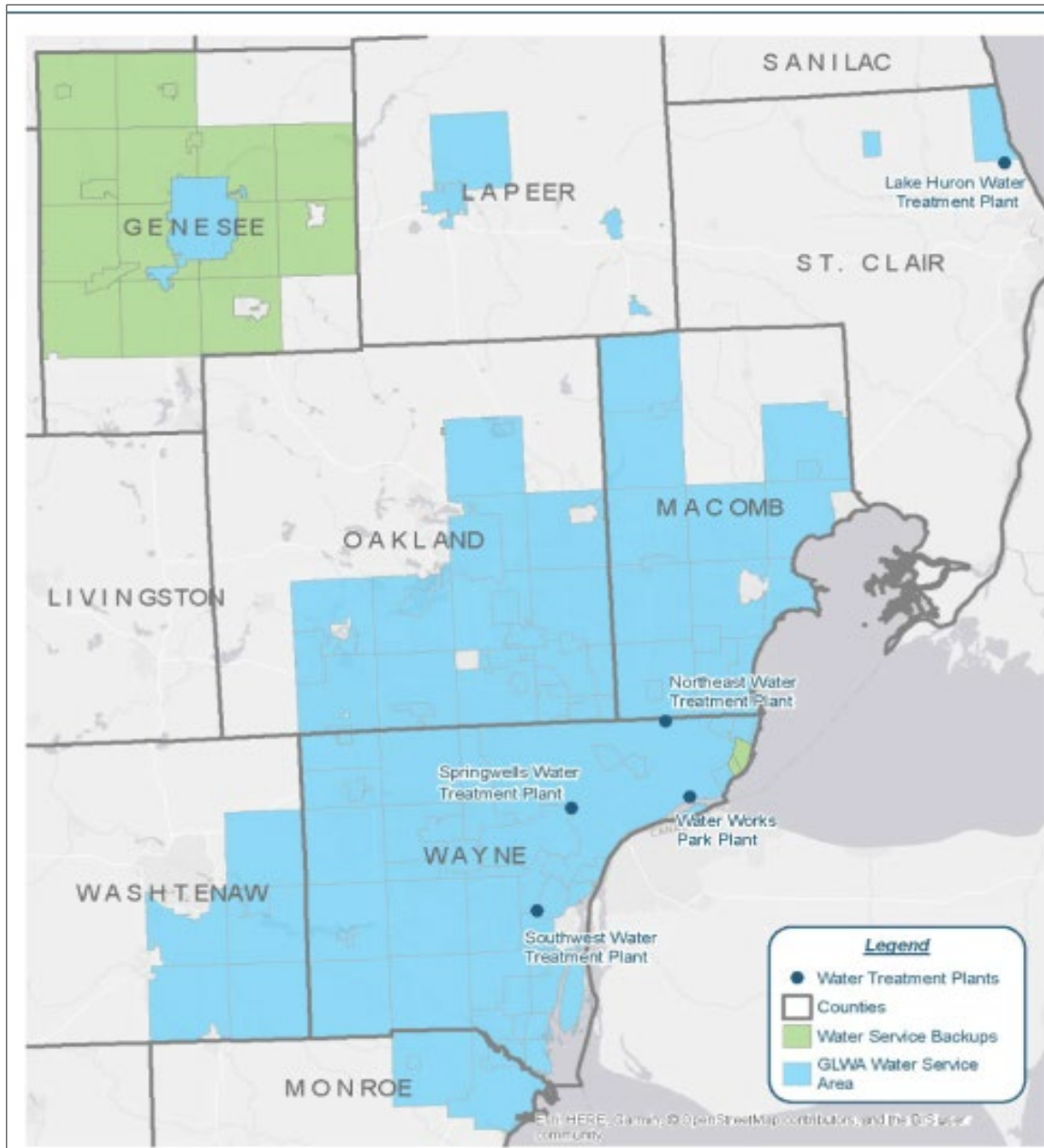


Figure 4-2: Map of GLWA's Water Service Area

4.2.1 Linear Assets

The description of the water system linear assets presented below is excerpted from the 2018 Water Asset Management Program Final document.

4.2.1.1 Water Transmission System

The GLWA Regional Water Transmission System (RWTS) consists of approximately 803 miles of water main, which are typically 24-inches in diameter and greater. Through this RWTS, GLWA transports potable water from the five water treatment facilities to the regional wholesale water customer communities, as well as the cities of Detroit, Dearborn, and Highland Park. The RWTS ranges from four inches to 120 inches in diameter, with an average age of 68 years.

The general location of the RWTS has evolved over time, with several drivers that have resulted in the current system build out. The drivers that have dictated where transmission main was built, include extending service to new customers, increasing reliability (redundancy) to existing customers, and meeting customer contract demands and pressure requirements. As a result of the redundancy driver, much of the transmission system is interconnected and flow of water can be controlled, particularly in emergency conditions, to flow in either direction. Water pressures can be boosted to overcome typical losses due to an emergency situation.

Pressure reducing valves (PRVs) regulate water pressure at critical locations throughout the RWTS. Pressure reduction is needed to protect portions of the Water System from being impacted by above normal operating pressures. Downstream of the PRVs, pressure is maintained at a relatively consistent lower pressure. Other components included as assets in the RWTS include control valves, isolation valves, air release valves, blowoffs, chambers/manholes, fire hydrants and flow meters.

4.2.1.2 System Control and Monitoring

The Systems Control Center controls and monitors the transmission of water throughout the regional water system. Systems Technicians in the Systems Control Center can remotely control the pump stations at the treatment plants and the 19 water Booster Stations to adjust flows and pressures to meet the changing demands of customer communities. Fifty-three Pressure Monitoring Sites in the transmission system provide suction/upstream and discharge/downstream pressure readings to aid in system operation.

4.2.2 Vertical Assets

The description of the water system vertical assets presented below is excerpted from the 2018 Water Asset Management Program Final document.

4.2.2.1 Intake Facilities

Three raw water intake tunnels funnel water to the WTPs and consist of approximately 23 miles of water main ranging from 120 inches to 186 inches in diameter with an average age of 78 years. The oldest tunnel was constructed in 1931, with the other two being constructed in 1964 and 1974, respectively. These tunnels are generally considered in adequate to good working order and repair. There are projects underway, or in the planning stages to assess the condition of these tunnels and make necessary repairs.

4.2.2.2 Water Treatment Plants

Raw water from the intake facilities is treated at the regional water system’s five water treatment plants, which includes screening, filtering, bacteria control, and taste and odor control. Each of the five water treatment plants in the regional water system was constructed with the capability to treat the water in accordance with federal requirements under the Safe Drinking Water Act. In the opinion of GLWA, based upon physical evaluations conducted by its consultants, no significant improvements to the WTPs are presently required to meet the Safe Drinking Water Act requirements. Each WTP is equipped with its own laboratory facilities for the examination and verification of drinking water quality standards. These laboratories are recertified every three years by the Michigan Department of Public Health. The year placed in operation and the rated capacity pertaining to the five WTPs are summarized in Table 4-1.

Table 4-1: WTP Age and Rated Capacity

Water Treatment Plant	Year Placed in Operation	Rated Capacity (MGD)
Lake Huron	1974	400
Southwest	1964	240
Northeast	1956	300
Springwells	1931/1958	540
Water Works Park	2003	240

4.2.2.3 Water Booster Stations and Reservoirs

Booster Stations are located within the regional water system and distribute water received from the WTPs to communities and other stations to meet pressure and demand requirements. Some water is diverted to reservoirs at the station until needed during times of high demand. Booster Stations repump the water in transmission mains and reservoirs to maintain needed pressures. There are 19 water Booster Stations in the GLWA transmission system. The year placed in service and capacity of each Booster Station and storage reservoir, if present, are summarized in Table 4-2.

Table 4-2: Booster Stations Age and Capacity

Booster Station/Reservoir	Year Placed in Operation	Pumping Capacity (MGD)	Storage Capacity (MG)
Adams Road	2012	92.8	10.0
Eastside	1952	30.0	10.0
Electric Avenue	1987	21.2	6.6
Ford Road	1961	108.9	10.0
Franklin	1968	164.0	10.0
Haggerty	1968	91.0	10.0
Imlay	1971	575.0	18.0
Joy Road	1970	93.5	6.0
Michigan Avenue	1961	28.8	7.0
Newburgh	1964	52.0	-
North Service Center	1962	326.5	20.0
Northwest	1952	50.4	10.0
Orion	1981	14.0	-
Rochester	1997	72.0	-
Schoolcraft	1971	80.0	10.0
West Chicago	1956	40.7	-
West Service Center	1964	265.8	20.0
Wick	1978	72.0	10.0
Ypsilanti	1986	54.0	-

4.3 Asset Hierarchy

The WAMP asset hierarchy follows the GLWA AM format. Figure 4-3 and Figure 4-4 shows examples of assets and asset groups at each level across GLWA. The WAMP asset hierarchy is a top-down organizational structure that facilitates easy rollups of costs and performance metrics. An asset or asset group one level above or below another asset or asset group has an AM parent-child relationship. The parent-child context is useful in many aspects of this WAMP, including discussions around comparing risk, O&M costs, and lifecycle costs across processes.

As shown in Figures 4-3 and 4-4, GLWA water assets are organized into a hierarchy with GLWA sitting at the top (Level 1) followed by the water system (Level 2).

Level	Enterprise Asset Examples	Vertical Asset Examples	Linear Asset Examples
1. ENTERPRISE	GLWA	GLWA	GLWA
2. FUND	Water or Wastewater	Wastewater System	Wastewater System
3. UNIT	Fleet & Field Services	Wastewater Treatment	Conveyance
4. FACILITY	Construction Equipment	Secondary Clarification System	Detroit River Interceptor
5. PROCESS	Heavy Equipment	Secondary Clarifiers Processing Equipment	Sewer District
6. INSTALLATION	Skid Steer x	Secondary Clarifier x	Pipe Segment x
7. EQUIPMENT	--	Center Drive	Manhole
8. COMPONENT	--	Collector Arms	Manhole Lid

Figure 4-3: GLWA Water Asset Hierarchy Format

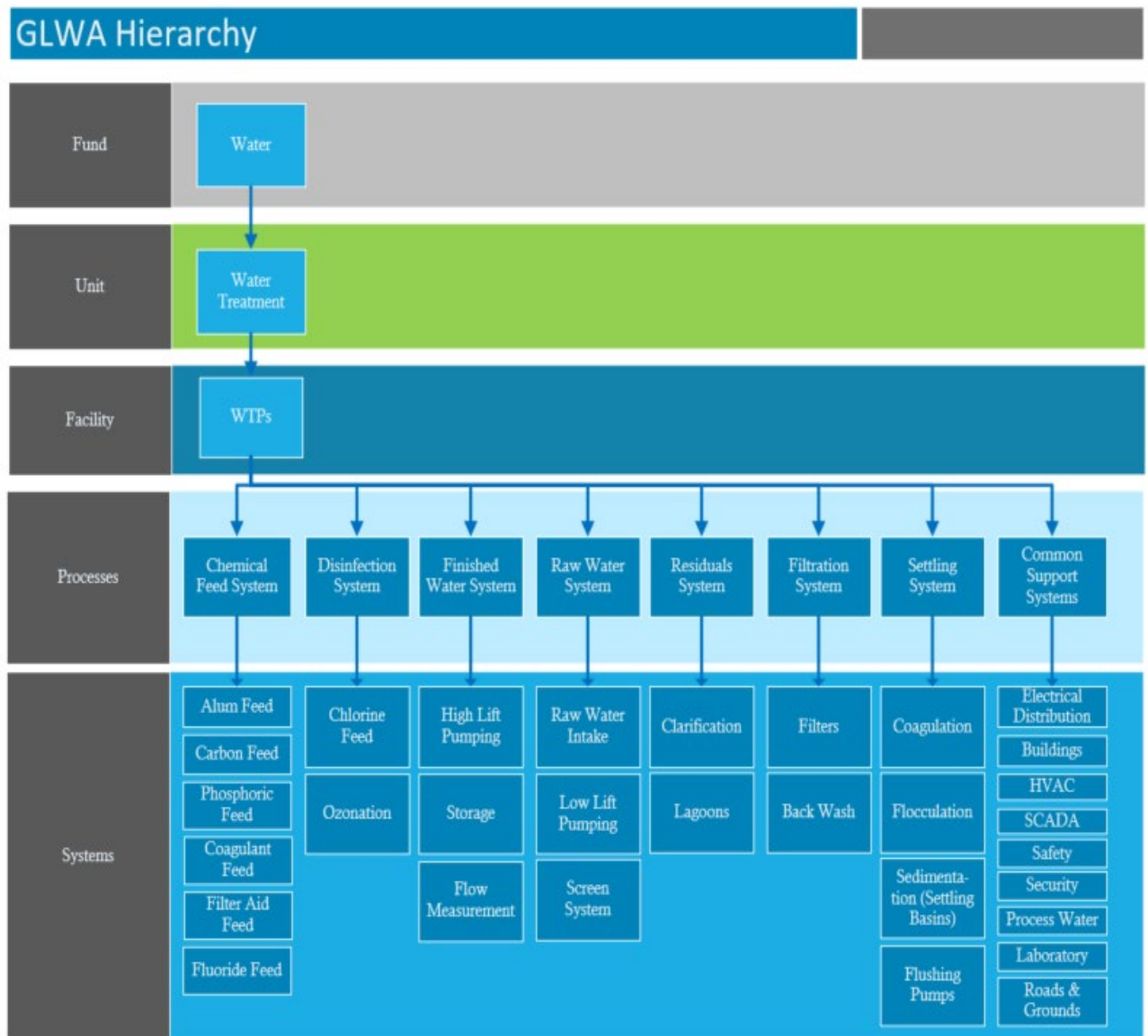


Figure 4-4: GLWA WTP Asset Hierarchy Formats

The water system is the parent asset group to two Level 3 asset groups listed in Table 4-3.

Table 4-3: WAMP Asset Groups (Level 3)

Level 3 Type	Level 3 Unit Name	Facilities and Pipeline Network
Vertical	Water Treatment Plant	<ul style="list-style-type: none"> • Raw Water System • Chemical Feed System • Residuals System • Filtration System • Settling System • Disinfection System • Finished Water System • Common Support
Vertical	Booster Station	<ul style="list-style-type: none"> • Adams Road Booster Station • Eastside Booster Station • Electric Avenue Booster Station • Ford Road Booster Station • Franklin Road Booster Station • Haggerty Road Booster Station • Inlay Booster Station • Joy Road Booster Station • Michigan Avenue Booster Station • Newburgh Booster Station • North Service Center Booster Station • Northwest Booster Station • Orion Township Booster Station • Rochester Booster Station • Schoolcraft Booster Station • West Chicago Booster Station • West Service Center Booster Station • Wick Road Booster Station • Ypsilanti Booster Station

4.4 Asset Registry

The water system linear assets are tracked in the Environmental Systems Research Institute (ESRI) ArcGIS and vertical assets are tracked in Oracle Work and Asset Management (WAM) information systems, to be replaced with NexGen in 2022.

4.4.1 Linear Asset Register

The linear asset register is under development as part of LSIP.

4.4.2 Vertical Asset Register

The vertical asset register is tracked in Oracle WAM/NexGen and includes the WTP and Booster Stations. Table 4-4 lists data fields in the vertical asset register and applicable WAM fields used as initial data sources. The vertical asset register is not a complete inventory of all assets. It focuses mostly on electrical and mechanical assets.

Table 4-4: WAMP Vertical Asset Register Field Descriptions

WAM Field Data Source ¹	Vertical Asset Register Field ²	Description
N/A	Order No.	<ul style="list-style-type: none"> Sort order for asset hierarchy
Asset ID	Asset ID	<ul style="list-style-type: none"> Assets in WAM data export use a unique alphanumeric identifier comprised of a letters and numbers up to 15 characters in length
Asset Description	ASSET_DESC	<ul style="list-style-type: none"> Short asset description
Parent Asset ID	Level 3, Level 4, Level 5, Level 6, Level 7, Level 8, Level 9	<ul style="list-style-type: none"> Parent/child asset hierarchy in descending hierarchal order from Level 3 to Level 9
Area	AREA	<ul style="list-style-type: none"> Facility identifier
Asset Type	ASSET_TYPE	<ul style="list-style-type: none"> Asset type (valve, pump, etc.)
Asset Status	STATUS	<ul style="list-style-type: none"> Operational status of asset (e.g., active, inactive). Asset records with an active status are included in the asset count quantities and results. Status 'non-asset' indicates a parent/system.
¹ Asset data fields were updated through the development of the WAMP and will be used to update fields in WAM/NexGen.		
² WAM data served as the basis of the vertical asset register.		

4.4.2.1 Water Treatment Plants

All WTP assets are assigned to one of the eight areas: Raw Water, Finished Water, Disinfection, Chemical Feed, Filtration, Residuals, Settling, and Common Support. Table 4-5 provides a short list of selected process assets by area and WTP. Figure 4-5 and Figure 4-6 shows the total asset counts by area, and the split of assets by process area for each WTP.

Table 4-5: Abbreviated List of WTP Assets by Process Area

Process Area	Asset Type	Quantity					Total
		Lake Huron	Northeast	Southwest	Springwells	Water Works Park	
Raw Water	Low Lift Pumps	4	6	6	8	5	33
	Screens	4	0	3	0	15	19
Finished Water	High Lift Pumps	9	12	7	16	13	62
Disinfection	Chlorinators/Injectors	9	8	8 chlorinators, 7 injectors	11	0	37
	Ozone Systems	0	0	0	0	7	7
	Evaporators	4	2	2	3	15	28
	Scrubbers	1	1	1	1	3	9
Chemical Feed	Chemical feed pumps	18	22	21 (6 Polymer Pumps 8 Phosphoric acid pumps 2 Alum Pumps 2 Carbon Pumps 3 Fluoride pumps)	14	29	102
	Chemical storage tanks	13	7	12	6	24	62
	Mixers	2	2	6	4	4	16
Filtration	Filters	30	48	20	88	12	198
	Backwash Pumps	12	4 (wash water pumps)	2	3	5	30
Settling	Flocculator	20	16	20	0	0	56
	Mixers	4	8	2	4	0	16
Residuals	Centrifuges	0	0	2	0	3	5
	Clarifiers	0	0	1	0	0	2
	Mixers	0	0	8	0	9	17
Common Support	Transformers	11	4	2	0	3	20
	Switchgear	8	0	4	0	2	17
	Generators	9	4	5	7	1	30

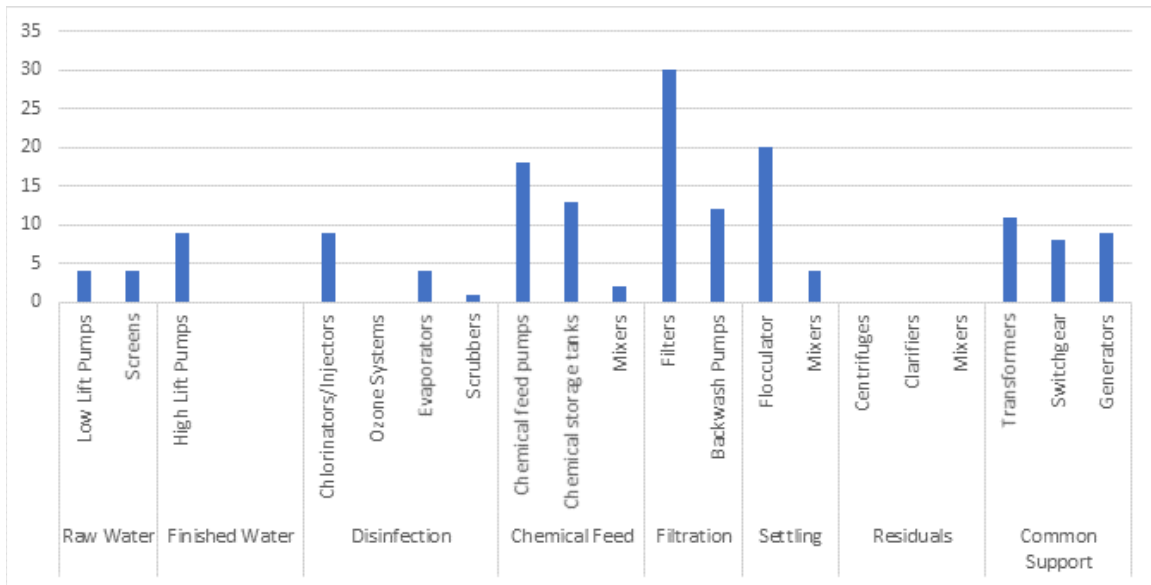


Figure 4-5: Count of Major Assets by Asset Type and Process Area for All WTPs Combined

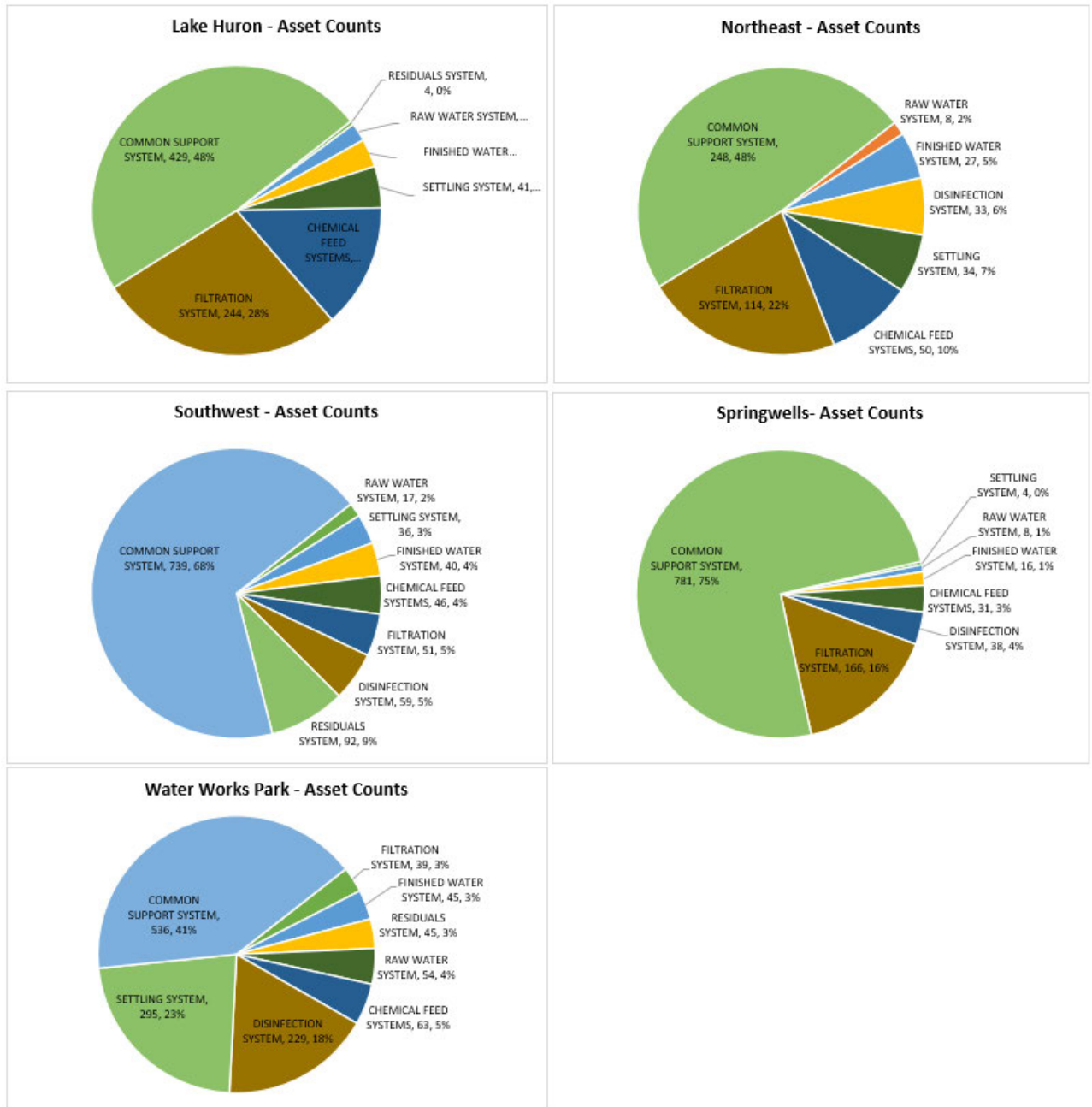


Figure 4-6: Asset Counts by WTP, by Process Area

Common Support has the highest number of assets overall (57%), followed by Filtration (13%), Settling (9%), and Common Support (20%). Raw Water has the least number of assets (2%). The full list of assets can be found in the WAMP vertical asset register discussed in Chapter 5.

4.4.2.2 Booster Stations

Table 4-6 shows the count of Booster Stations assets.

Table 4-6: Count of Booster Station Assets

Booster Stations	Asset Count
Adams Road	91
Eastside	42
Electric Avenue	30
Ford Road	53
Franklin	82
Haggerty	85
Imlay	174
Joy Road	62
Michigan Avenue	41
Newburgh	47
North Service Center	199
Northwest	43
Orion	26
Rochester	55
Schoolcraft	59
West Chicago	41
West Service Center	87
Wick	77
Ypsilanti	61

4.5 Condition

Asset condition is the primary driver for asset performance, plays a significant role in determining asset risk, and is crucial in determining strategies for O&M and asset renewals. GLWA uses condition data for identifying which assets should be placed on the CIP and are used to optimize maintenance frequencies based on whether an asset is in good or poor condition.

Asset condition assessment results for vertical assets based on condition assessments performed in 2021, are documented in a series of inspection reports and photos, both of

which have been imported into the OnBase Document Management system and linked to assets in WAM. Asset condition scores for linear assets are tracked by LSIP.

4.5.1 Linear Asset Condition

The linear asset condition scores are under development as part of LSIP.

4.5.2 Vertical Asset Condition

Vertical assets were initially prioritized for visual condition assessments using a preliminary risk score. The identified assets were then visually assessed and non-assessed assets were assigned an average condition score appropriate for assets within the WTP or Booster Station, using a table-top exercise. Appendix E describes the methodology and condition assessment activities performed in 2021. Appendix F, WAMP – Condition Assessment Activities Spreadsheet for Vertical Assets, which supports Tactical Recommendation W5: WAMP – Condition Assessment for Non-Inspected Assets, includes the list of activities to perform ongoing condition assessment over the next three years.

Table 4-7 lists the condition grades or scoring descriptions for WTP and Booster Station assets that was used to guide the visual assessments performed in 2021.

Table 4-7: Vertical Condition Grade Description

Condition Grade/Score	Condition Grade/Scoring Description
1	Like-new condition. Continuation of current maintenance and operating procedures is recommended.
2	Good condition. Some minor additional maintenance may be required. Continuation of current maintenance and operating procedures is recommended.
3	Fair condition. One or more issues that require immediate attention. Modification or adjustment of current maintenance and operating procedures may be needed to avoid recurrence of identified issues.
4	Poor condition. Planning for a major overhaul or replacement should begin. Review of current maintenance practices and procedures is recommended.
5	Very poor condition. Failure of the asset is imminent or has already occurred. Greater than 50% of the asset requires replacement.

4.5.2.1 Water Treatment Plant Condition Scores

Visual assessments accounted for approximately 39% of WTP assets, with the remaining assessments performed through tabletop analysis as reflected in Figure 4-7.

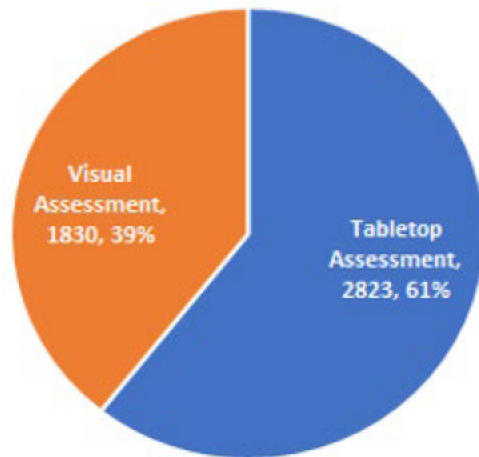


Figure 4-7: WTP Condition Assessments by Type

Figure 4-8 shows the distribution of condition scores for all WTPs and Figure 4-9 shows the distribution of condition scores for individual WTPs. Approximately 86% of all WTP assets received a condition score of 1 or 2. Lake Huron and Northeast had the highest proportion of assets with condition scores equal or greater than 3 (35% and 30% respectively).

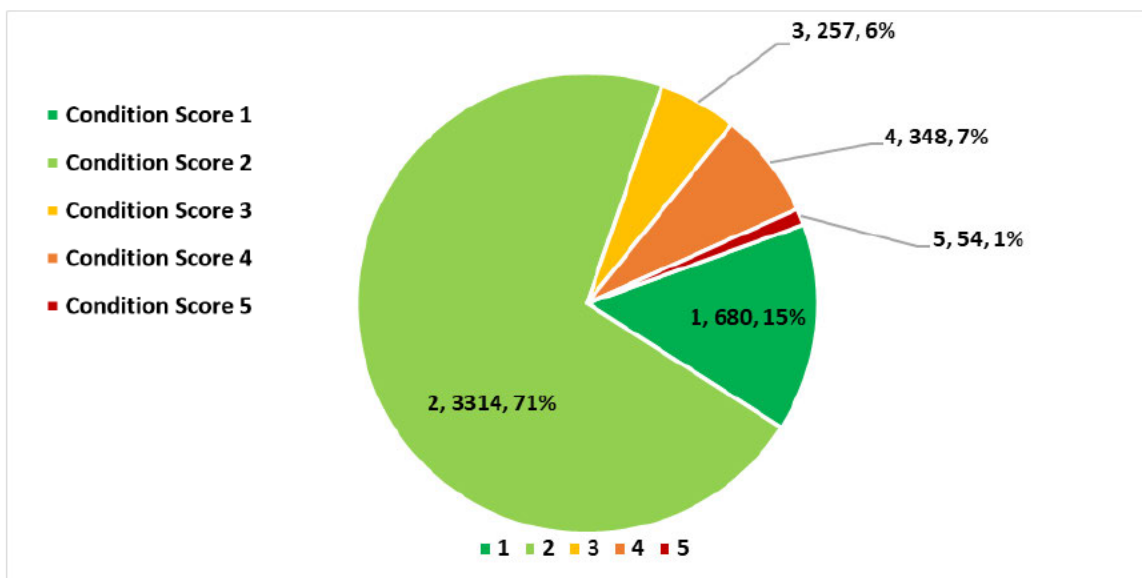


Figure 4-8: Asset Condition Scores for all WTPs Combined

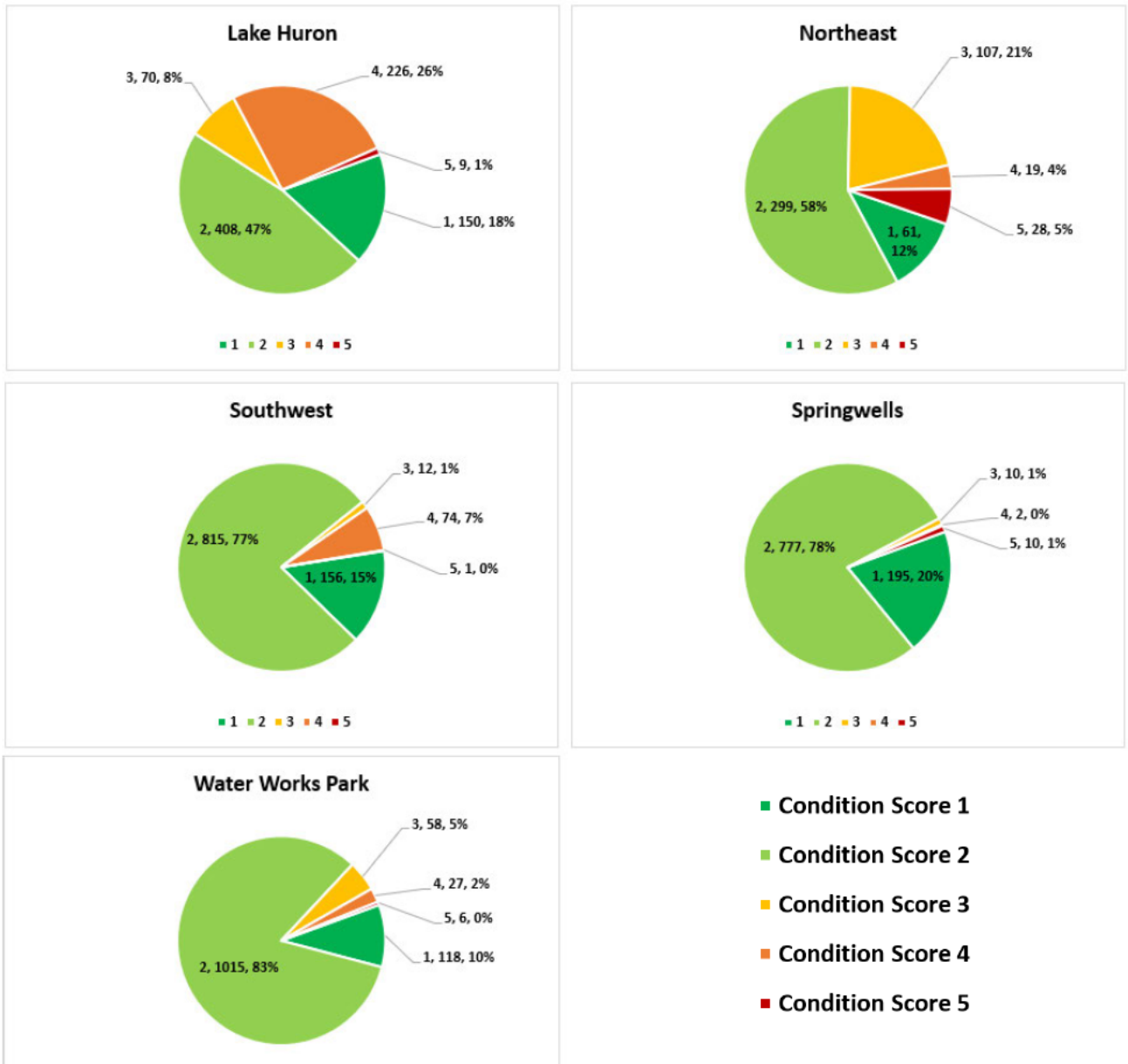


Figure 4-9: Asset Condition Scores for Individual WTPs

Figure 4-10 shows the distribution of condition scores for all WTPs by assessment type and by process area.

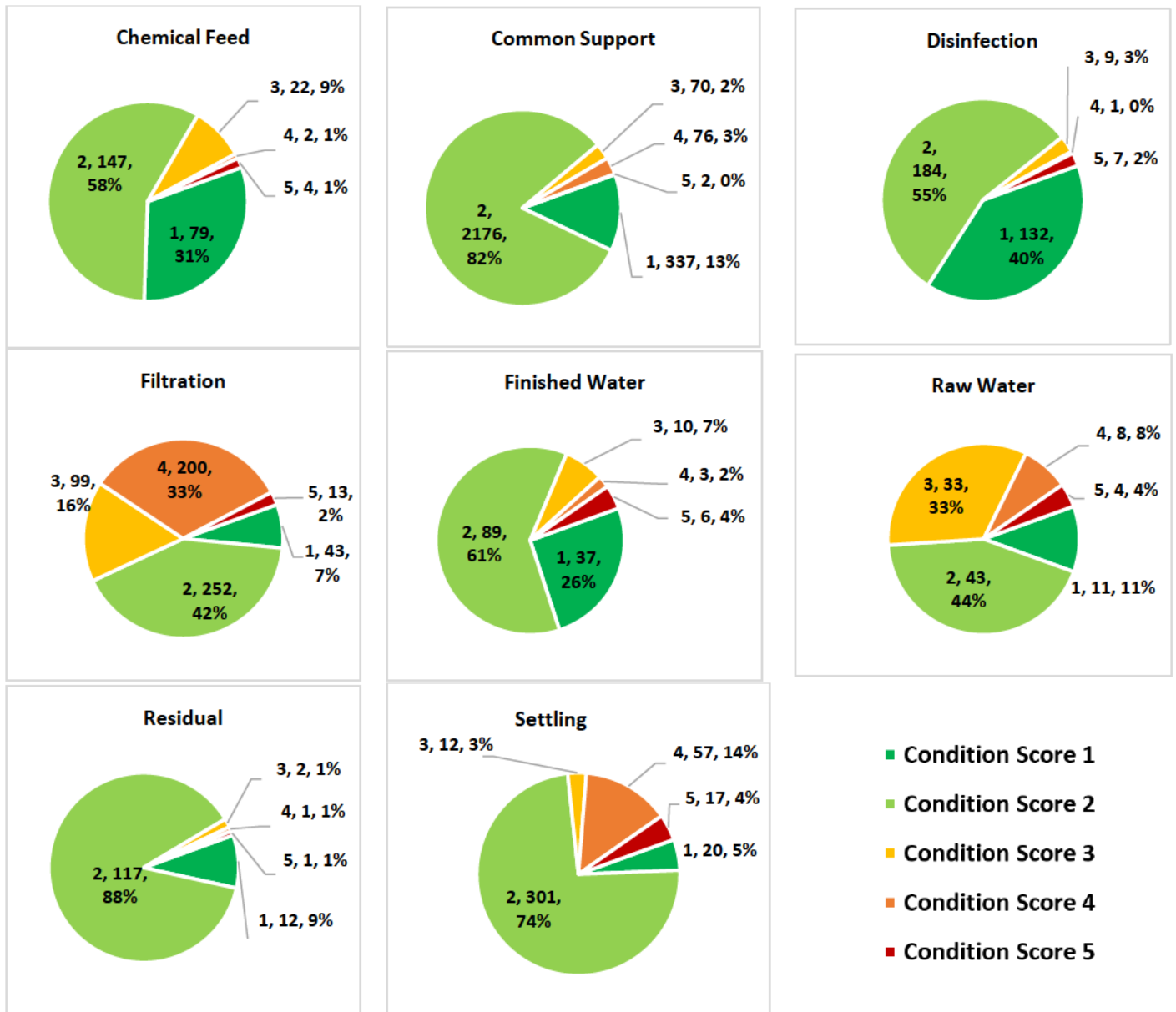


Figure 4-10: Asset Condition Scores for all WTPs by Process Area

Results indicate:

- Over half of each process area’s assets received a condition score of 1 (“very good”) or 2 (“good”).
- Filtration was an exception, with approximately 49% of assets receiving a condition score of 1 or 2.

- Filtration, Raw Water, and Settling had the highest percentages of assets with condition scores greater than 3.
- Raw Water and Settling had more than 10% of assets with a score of 4 or 5, and Filtration had more than 30% of assets with a score of 4 or 5.
- Less than 2% of total WTP assets received a condition score of 5 (“very poor”), with these mainly in the Filtration and Settling process areas.

4.5.2.2 Booster Station Condition Scores

Visual assessments accounted for approximately 18% of Booster Station assets, with the remaining assessments performed through tabletop analysis as reflected in Figure 4-11.

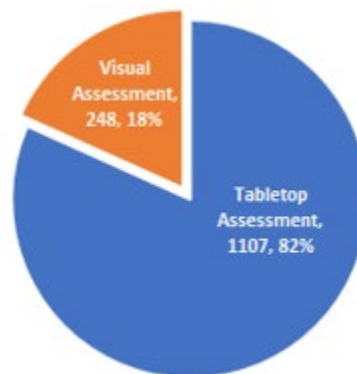


Figure 4-11: Booster Station Condition Assessments by Type

Figure 4-12 shows the distribution of condition scores for all Booster Stations. Approximately 98% of all Booster Station assets received a condition score of 1 or 2. Figure 4-13 shows scores by individual Booster Station. Results indicate:

- Approximately 95% or more of each Booster Station’s assets received a condition score of 1 (“very good”) or 2 (“good”).
- Less than 3% of all Booster Station assets had conditions scores of 3 or higher, with these mainly located at Adams Road, Imlay, and West Service Center.

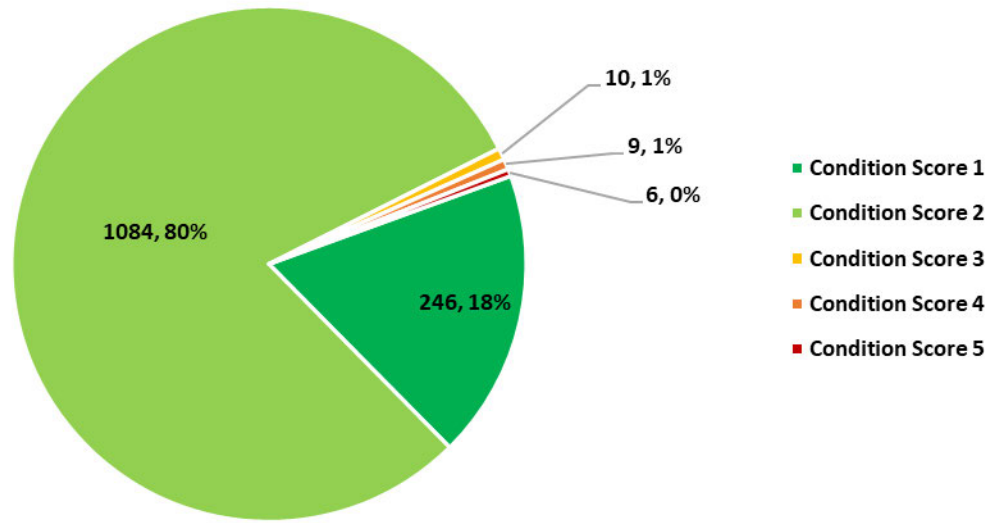


Figure 4-12: Asset Condition Scores for all Booster Stations Combined

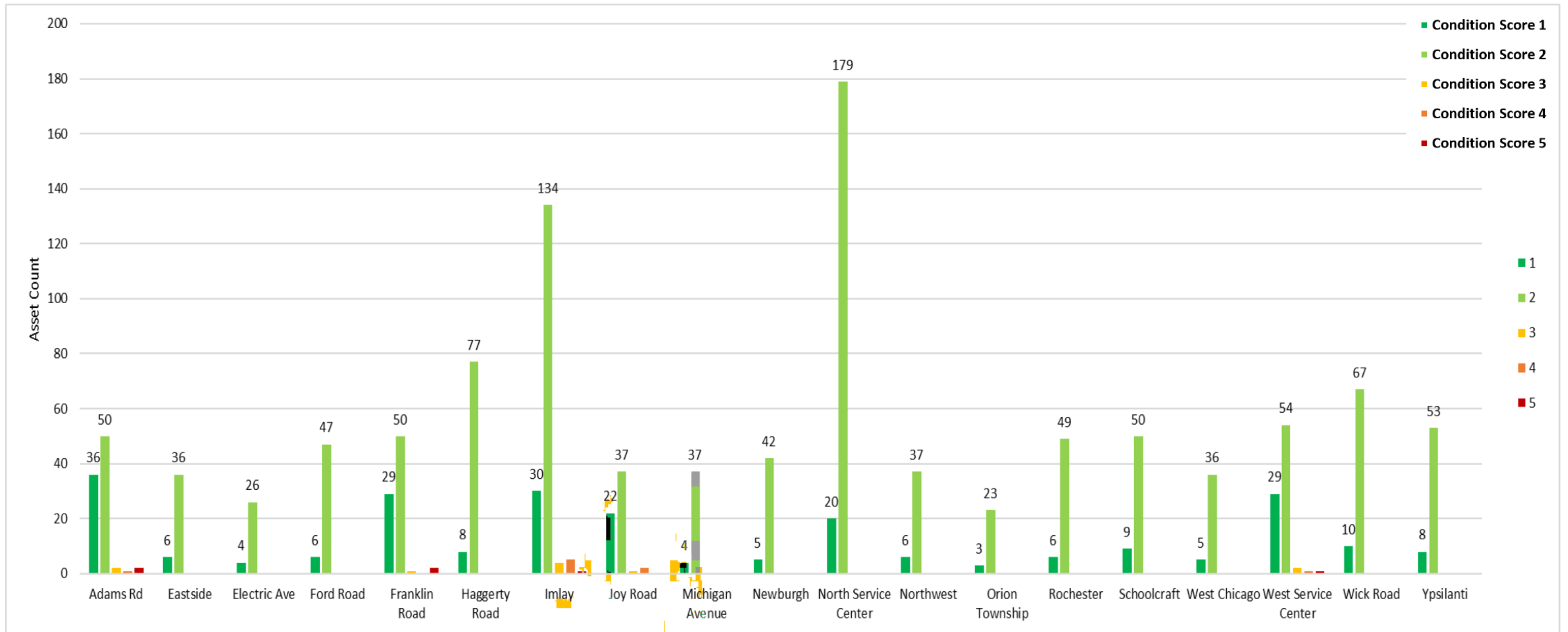


Figure 4-13: Asset Condition Scores for Individual Booster Stations

4.6 Asset Value

Asset values can roll up to a total water system cost and inform the development and use of a lifecycle model and asset renewal strategy. Chapter 7 summarizes GLWA's current lifecycle models in use. Asset values are tracked in the Financial Asset Registry and are important data points for use with the Scheduled Replacement Plan (SRP) lifecycle model.

Tactical Recommendation W12: WAMP - Replacement Cost Database for Vertical Assets is intended to support GLWA with improving alignment between the asset hierarchy and asset valuation to improve confidence in asset valuation data.

5 Asset Risk

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to provide an overview of asset risk levels associated with the asset portfolio to inform prioritization decisions for maintenance, renewals, and rehabilitations.

GLWA risk management is an iterative, continual improvement process. GLWA strives to manage risk through demonstrably improving the ability to meet objectives in a repeatable fashion. GLWA has standardized risk management guidance for organizational risk. The guidance documents are collectively known as the *GLWA Risk Management Framework*. The framework principal components include purpose, definitions, and instructions and the asset risk assessments in this WAMP align with this framework.

Asset risk is the primary metric for AM planning and decision-making. At GLWA, risk management principles established in the GLWA SAMP serve as the basis for determining asset risk.

Tactical Recommendations W4: WAMP – Digital Solutions and W6: WAMP – Asset Risk for Vertical Assets are planned to be implemented to continuously improve in the way GLWA identifies and manages water system asset risk. Appendix G includes the WAMP – Risk Register for Vertical Assets to support ongoing asset management activities.

Tactical Recommendations:

- W4: WAMP - Digital Solutions
- W6: WAMP - Asset Risk for Vertical Assets

Supporting Artifacts:

- WAMP - Risk Register for Vertical Assets – Appendix G
- CIP (to help plan and understand risk mitigation)

5.1 GLWA Risk Management and Framework

5.1.1 Risk Management Activities

Risk management activities follow a three-step process:

- 1. Risk Identification.** Identifying asset risks centers around understanding asset failure, GLWA service levels, processes, and asset performance expectations required to support service levels.
- 2. Risk Analysis.** Analyzing risk involves developing a risk score based on the likelihood that an event will occur and the consequences if the event occurs. A risk score is determined by multiplying the LOF by the COF.

$$Risk\ Score = LOF \times COF$$

- 3. Risk Treatment.** Risk treatment refers to GLWA’s chosen risk mitigation technique. Section 5.5 discusses risk treatment in further detail.

5.1.2 Risk Scoring Criteria

Risk scores are a powerful tool for the prioritization and selection of activities within a program of work, such as an inspection program, maintenance program or investment program. Risk scores are based on consequence and likelihood. As defined by GLWA through the SAMP, LOF and COF scores are determined by scoring criteria for each category of the respective LOF and COF matrices.

Likelihood Scoring. The LOF Matrix was developed as part of the SAMP to answer the question, “What is the likelihood the asset will fail?” The six categories include:

- 1. Remaining Useful Life (RUL)** — The estimate of the percent of remaining years the asset will function before requiring replacement.
- 2. Performance** — An asset’s capacity to meet system demands.
- 3. Reliability** — History of CM work orders.
- 4. Physical Condition** — The condition grade of an asset; measured on a scale of 1 to 5, with 1 being “very good” and 5 being “very poor.” Chapter 3 discusses condition grade in more detail.
- 5. Adherence to Operation and Maintenance Strategy** — Completeness of, and accordance to, written O&M strategies for asset performance.
- 6. Other** — Other sources of LOF data including, but not limited to, industry performance trends and institutional knowledge.

Due to an absence of certain data, the initial WAMP – Risk Register for Vertical Assets, the matrix categories Remaining Useful Life, Performance, History of Reliability and Adherence to O&M Strategy were designated with a weight of zero, with Condition remaining as the only factor in LOF. Tactical Recommendation W6: WAMP – Asset Risk for Vertical Assets suggests the addition of History of Reliability in future iterations.

Consequence Scoring. For asset risk, the consequence score answers the question, “How bad will it be if the asset fails?” The seven categories include:

- 1. Regulatory Compliance** — Regulatory requirements, permit obligations, or enforcement actions.
- 2. Impact to Service Levels** — GLWA’s ability to achieve service level targets.
- 3. Financial Impact** — Requirements for GLWA funds or sources of funds.
- 4. Health and Safety** — Near- and long-term health or safety impacts on the public or GLWA team members not addressed in other categories.

5. **Public Impact** — Community priorities, such as quality of life or aesthetics not addressed in other categories.
6. **Environmental Stewardship** — Near- or long-term environmental impacts not addressed in other categories.
7. **Public Trust** — Public confidence in GLWA.

Risk scores are based on consequence and likelihood, each on a scale of 1 to 5, with 5 representing the highest likelihood or consequence and 1 the lowest likelihood or consequence. Thus, a score of 25 is the highest risk score possible and represents the most severe risk. LOF and COF matrices and category scoring criteria can be found in Appendix H. The actual risk score is not as key as the distribution of risk and the prioritization of assets within the risk scoring.

5.1.3 Risk Tolerance

Risk tolerance is defined as the willingness to bear risk. Figure 5-1 is a risk severity heat map used to illustrate risk tolerance. The map shows how risk tolerance may be determined by considering the likelihood of asset failure and the consequence of that failure. For GLWA, 'Very High' and 'High' asset risk scores, equating to a score of 11 or above, are viewed to be above the GLWA tolerance level.

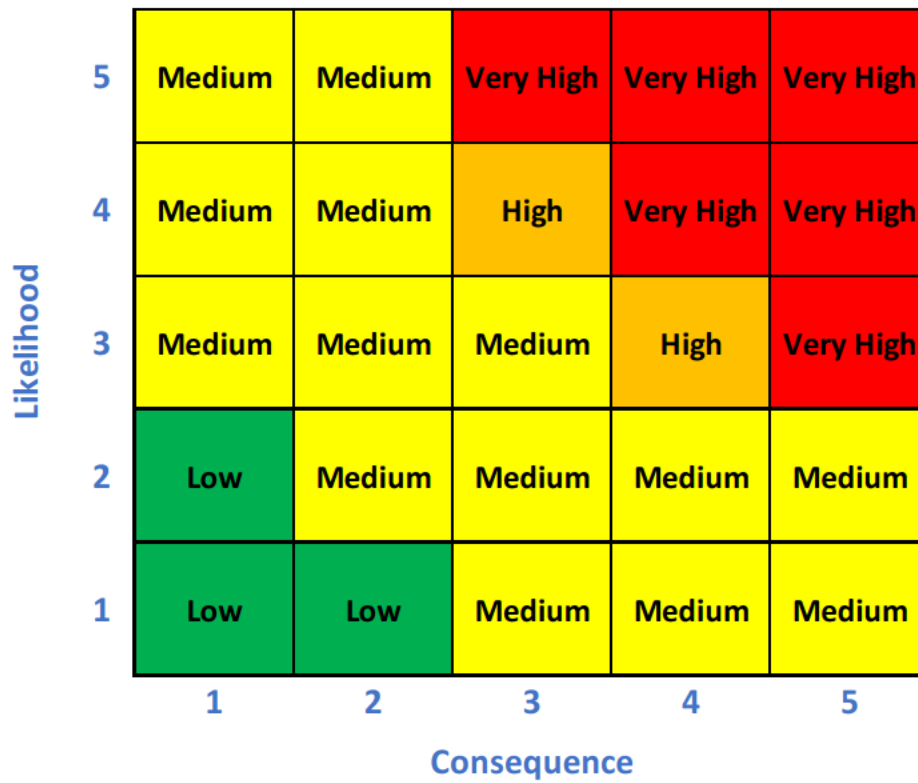


Figure 5-1: Risk Severity Heat Map

5.2 Linear Asset Risk

The linear asset risk scores are under development as part of LSIP.

5.3 Vertical Asset Risk

The risk scores for vertical assets were developed through a multi-step, iterative process as shown in described in Appendix H. Results are summarized below and included in the WAMP – Risk Register for Vertical Assets.

5.3.1 Consequence of Failure Scores

5.3.1.1 Water Treatment Plants

The calculated COF scores for the WTPs are shown Figure 5-2 and by process area in Figure 5-3.

- Approximately 51% of WTP assets received a COF score of 1 or 2
- Approximately 20% received a 3
- Approximately 29% received a 4 or 5

The higher COF scores of 4 and 5 were concentrated in the Raw Water, Finished Water, Disinfection and Common Support process areas, which contain equipment such as the low and high lift Booster Stations, chlorination, and the electrical distribution infrastructure for power, respectively.

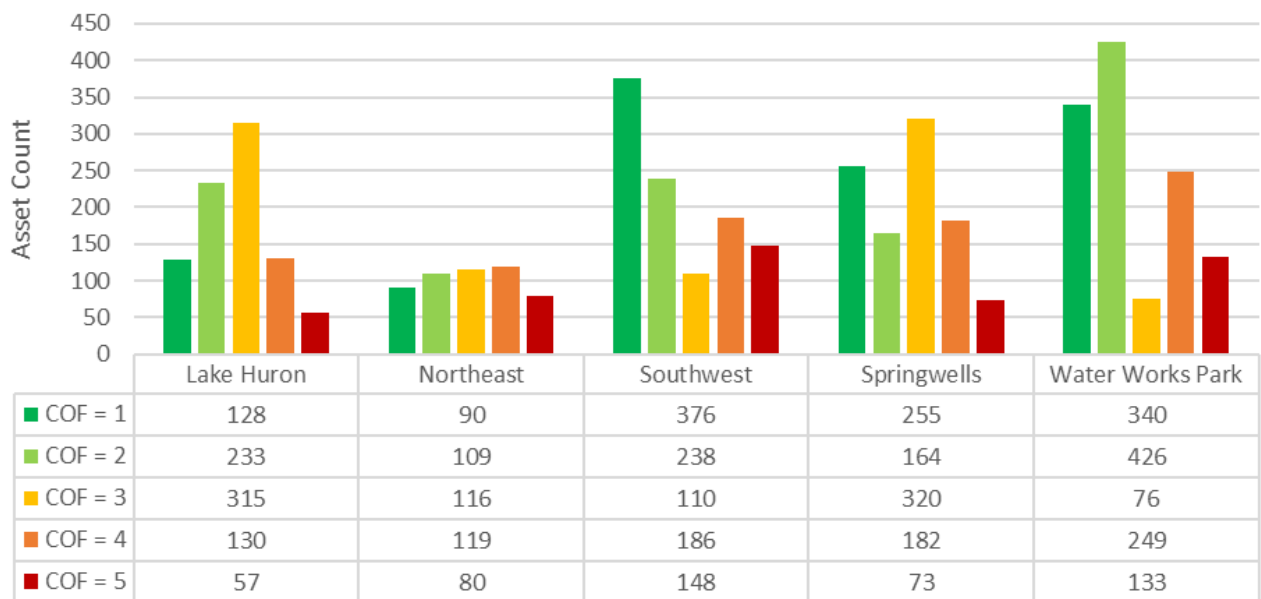


Figure 5-2: WTP Assets by COF Score

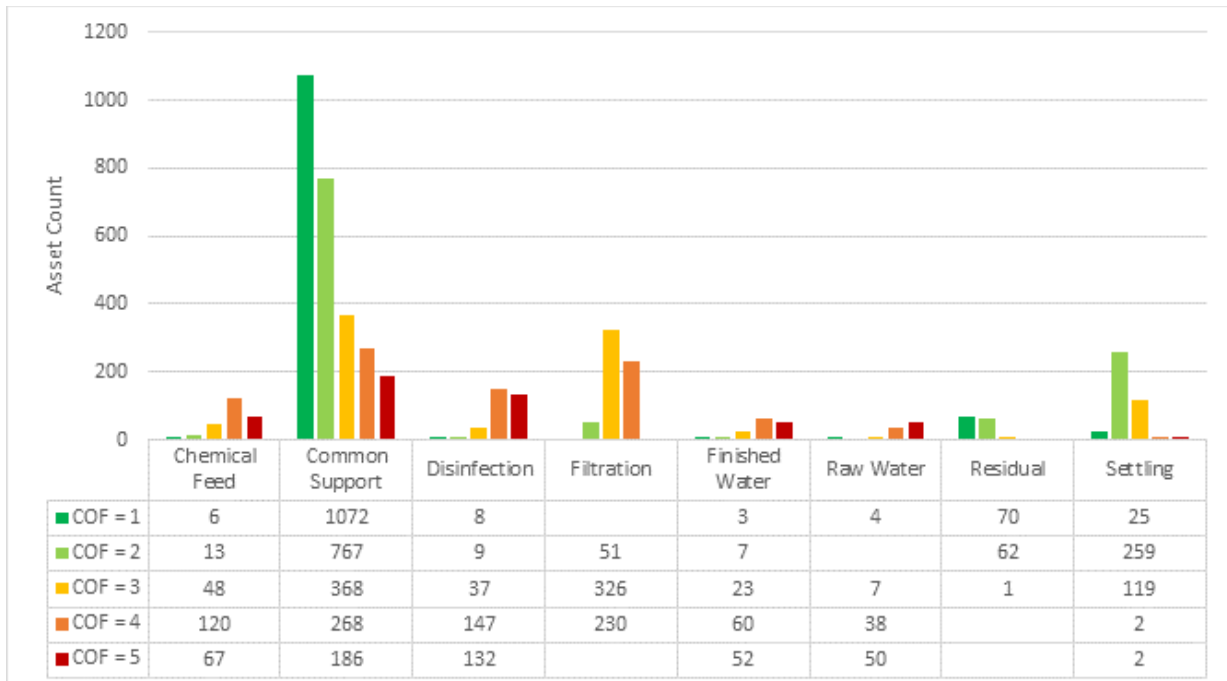


Figure 5-3: WTP Assets by Process Area by COF Score

5.3.1.2 Booster Stations

The calculated COF scores for Booster Stations are shown in Figure 5-4.

- Approximately 34% of Booster Station assets received a COF score of 1 or 2.
- Approximately 3% received a 3
- Approximately 63% received a 4 or 5

The higher COF scores of 4 and 5 occurred at the electrical distribution infrastructure, pumping systems, and facility storage wells. Imlay and North Service Center Booster Station facilities account for the highest share (28%) of the assets with a COF score of 5. Imlay and North Service Center are two of the most critical Booster Stations facilities.

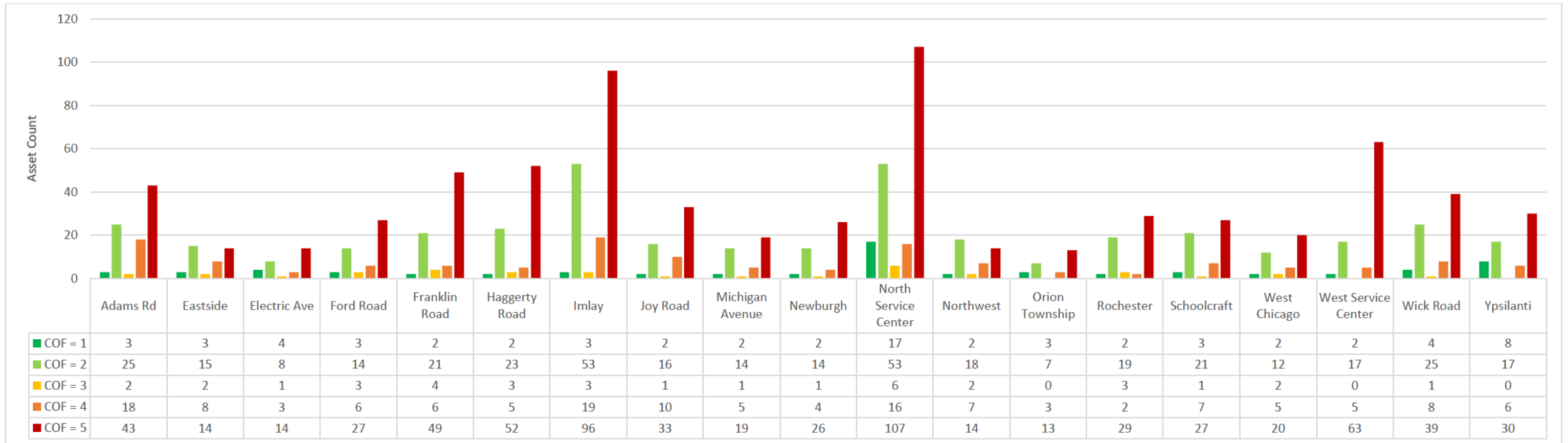


Figure 5-4: Booster Station Assets by COF Score

5.3.2 Likelihood of Failure Scores

5.3.2.1 Water Treatment Plants

The calculated LOF scores by WTP are shown in Figure 5-5 and by process area in Figure 5-6. Approximately 86% of WTP assets received a LOF score of 1 or 2, approximately 6% received a 3, and 8% received a 4 or 5. The majority of assets with a LOF score of 3 or higher were in the Filtration or Common areas.

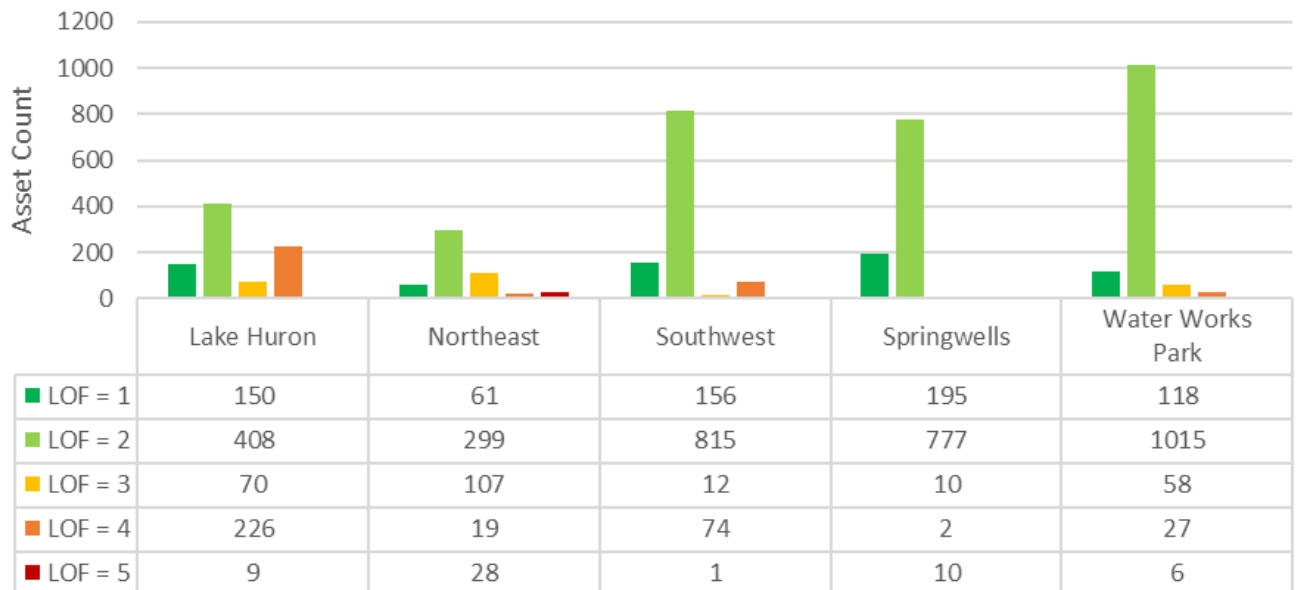


Figure 5-5: WTP Assets by LOF Scores

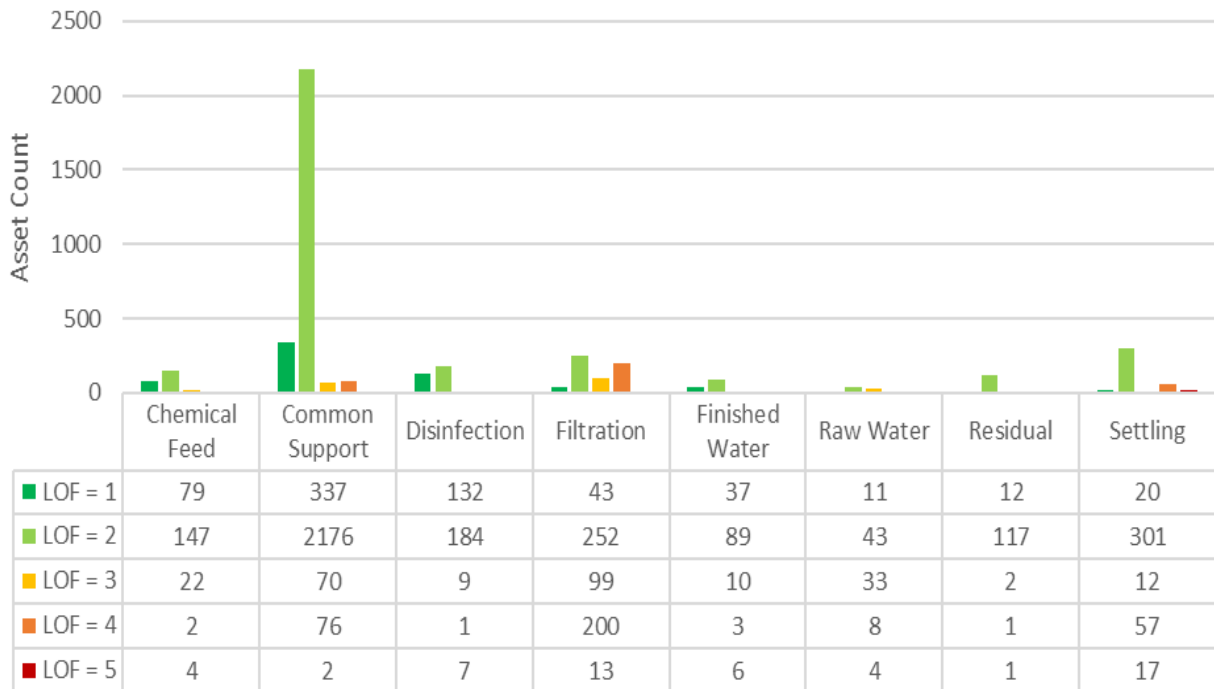


Figure 5-6: WTP Assets by Process Area by LOF Score

5.3.2.2 Booster Stations

The calculated LOF scores by Booster Station are shown in Figure 5-7. Overall, the LOF scores were very low. Approximately 98% of Booster Station assets received an LOF score of 1 or 2. Only 6 (>1%) received the maximum score of 5. The majority of the assets, which received an LOF score of 4 or 5, are at Imlay Booster Station.

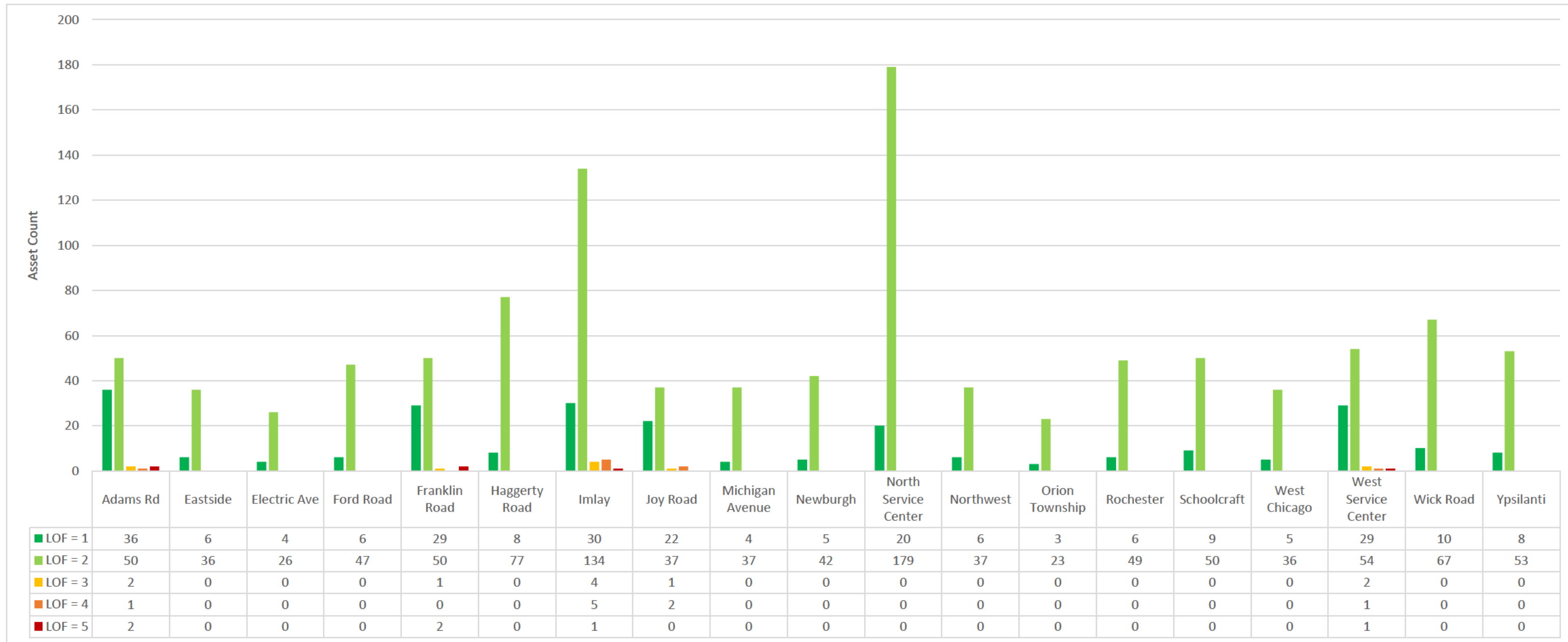


Figure 5-7: Booster Station Assets by LOF Score

5.4 Summary of Total Risk Scores

Total asset risk is the product of LOF and COF. The following equation is used to calculate total asset risk:

$$\text{Total Asset Risk} = \text{LOF} \times \text{COF}$$

5.4.1 Linear Assets

The linear asset risk register is under development as part of LSIP.

5.4.2 Vertical Assets

5.4.2.1 Water Treatment Plants

Total risk for all WTP assets is presented in Figure 5-8 and by individual WTPs in Figure 5-9 as counts of assets on the risk severity heat map and by process area for all WTPs in Figure 5-10. The number of assets that result on a particular score are presented and are in alignment with the size of the black bubble. A small proportion of the assets fall into the high-risk (red) category.

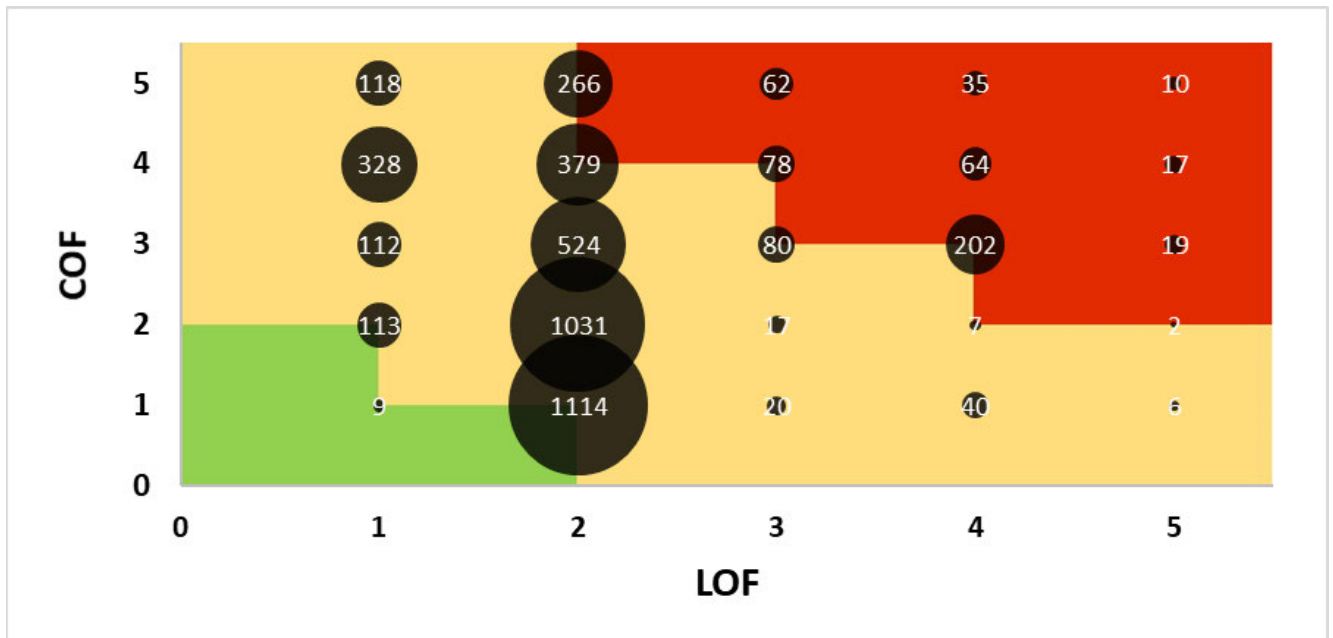


Figure 5-8: Asset Risk Scores for all WTPs Combined

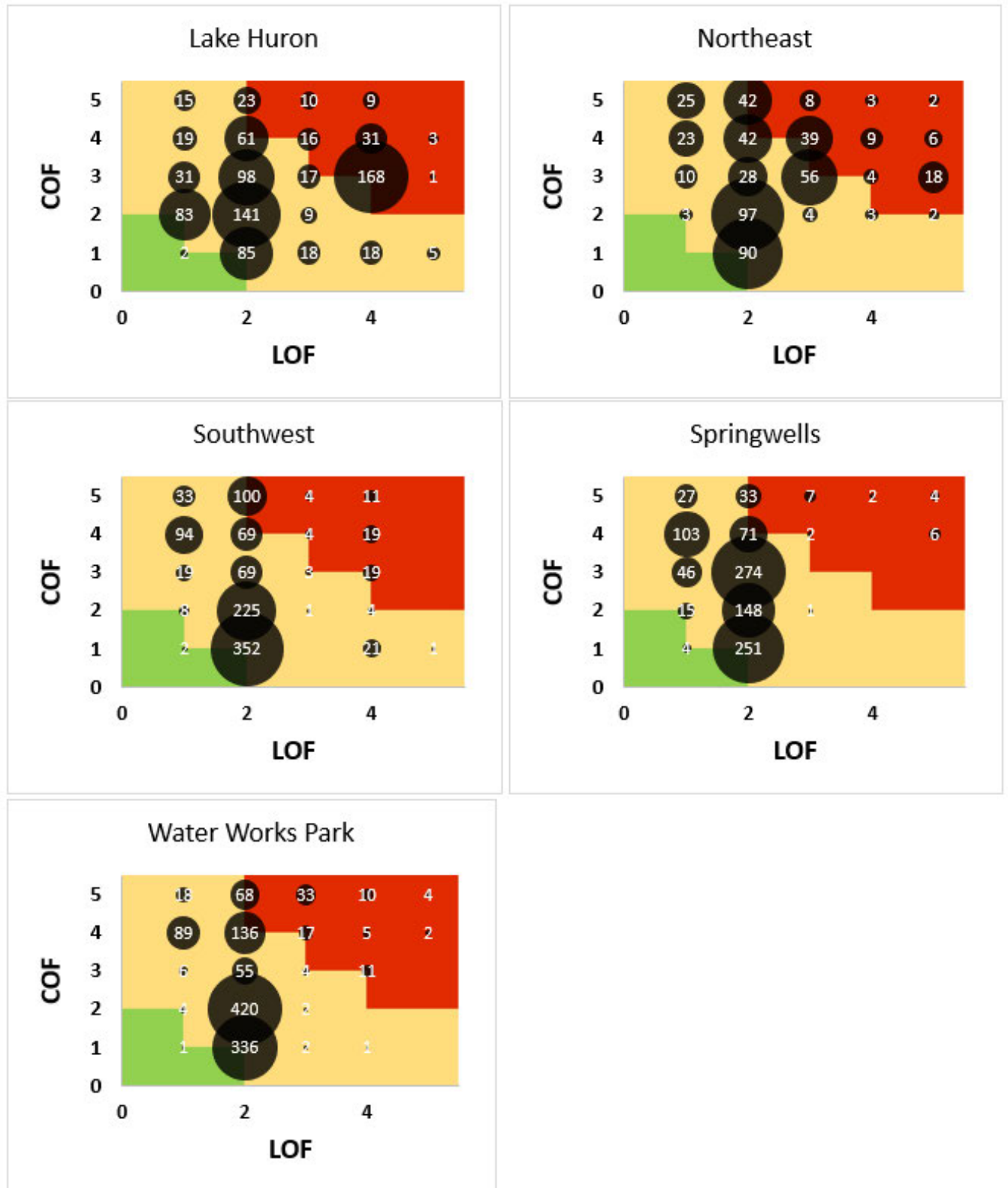


Figure 5-9: Asset Risk Scores for Individual WTPs

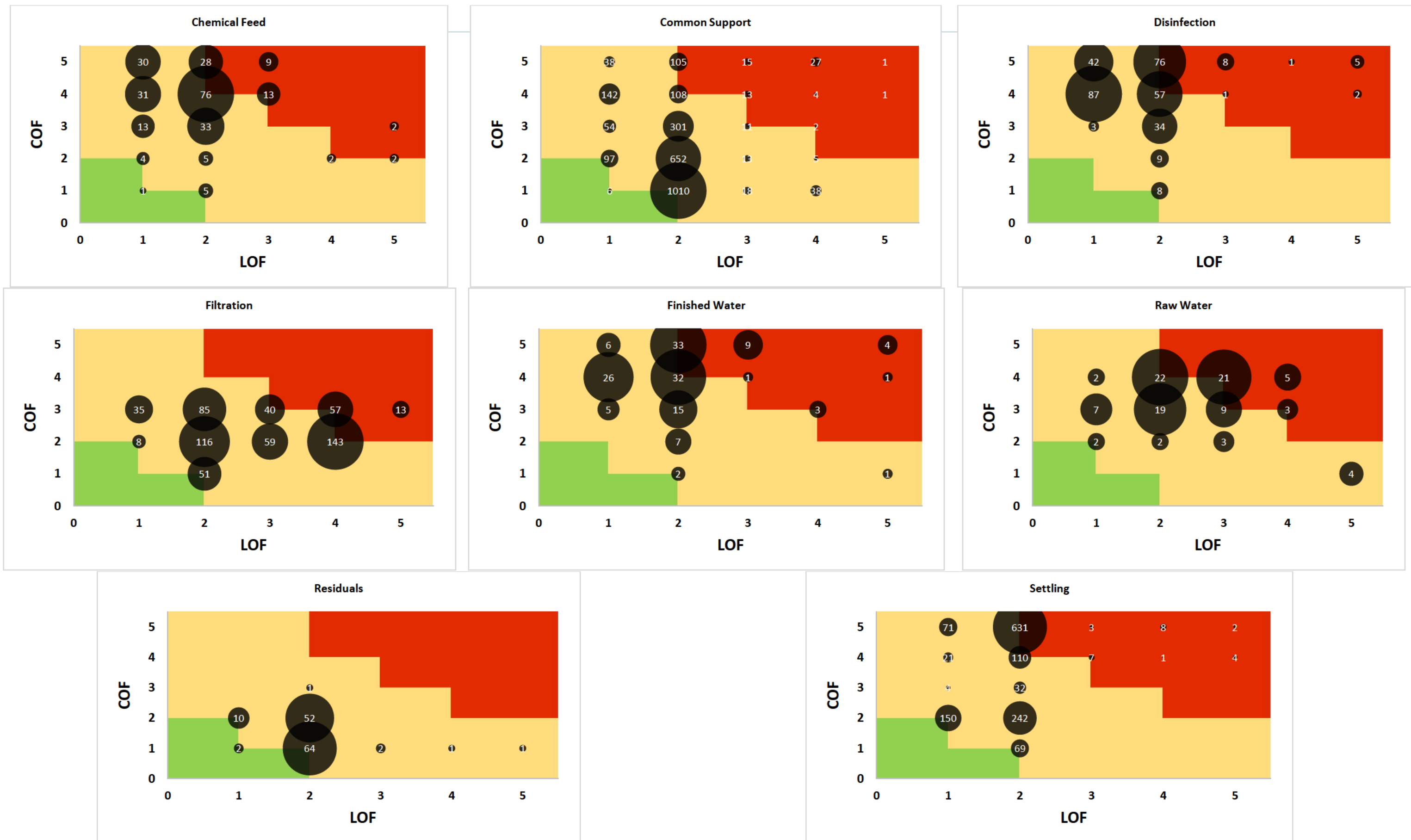


Figure 5-10: Asset Risk Scores for all WTPs by Process Area

5.4.2.2 Booster Stations

Total risk for all Booster Stations combined is presented in Figure 5-11 and by individual Booster Station in Figure 5-12 as count of assets on the risk severity heat map. This shows a similar pattern to the WTPs, with the majority of assets in the medium-risk category and a small proportion of high-risk assets. However, compared to the WTPs, a larger portion of Booster Station assets have a high COF score of 4 or greater. The majority of the highest risk assets are concentrated in Imlay and North Service Center Stations.

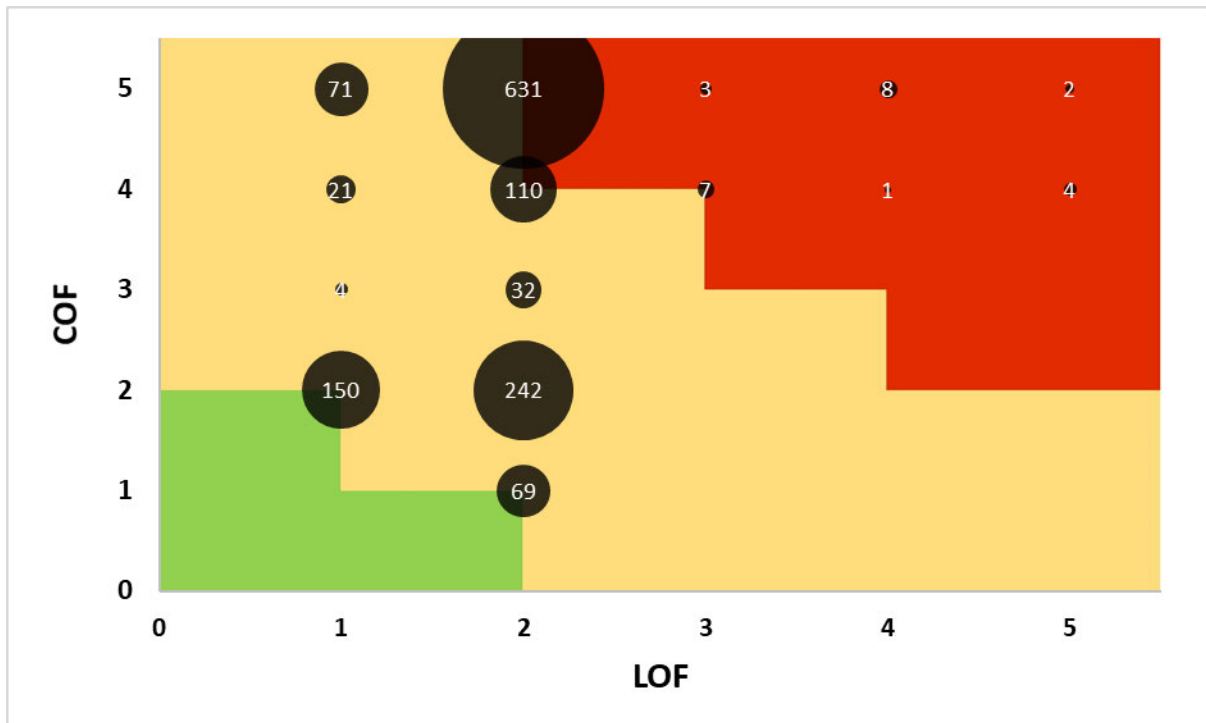
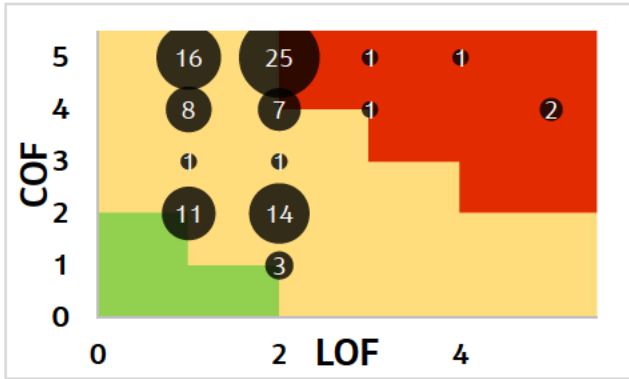
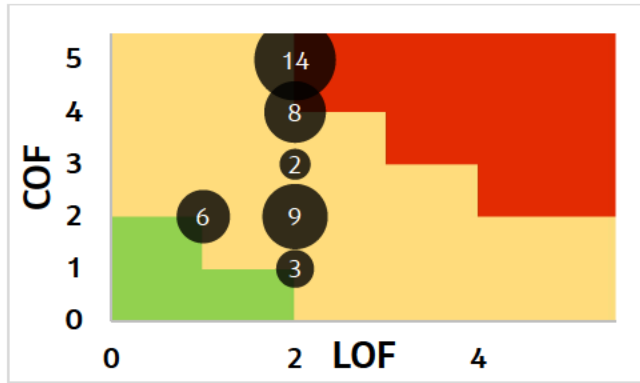


Figure 5-11: Asset Risk Scores for all Booster Stations Combined

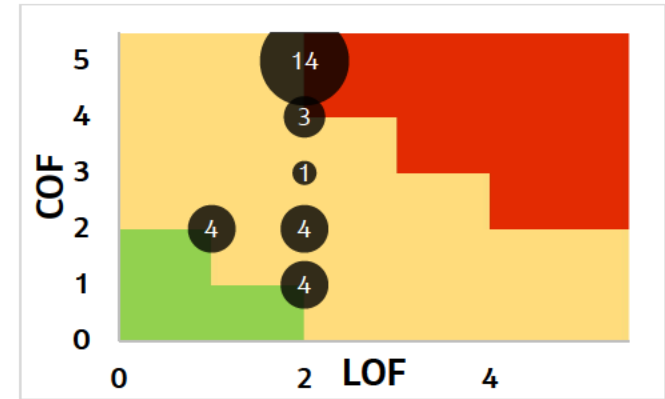
Figure 5-12 shows the asset risk scores for individual Booster Stations.



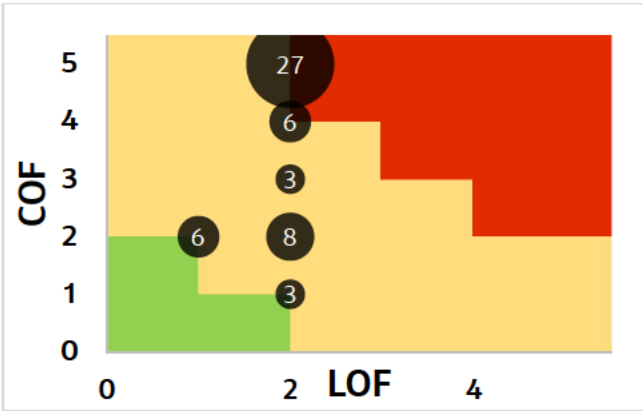
Adams Rd Booster Station



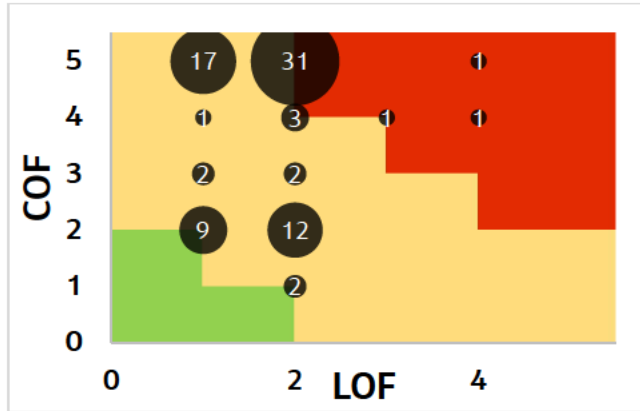
Eastside Booster Station



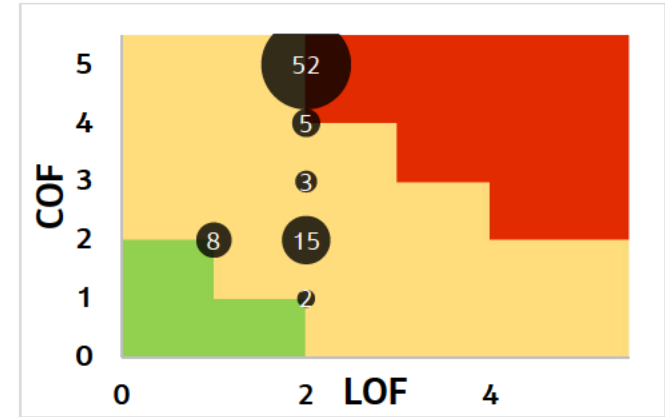
Electric Ave Booster Station



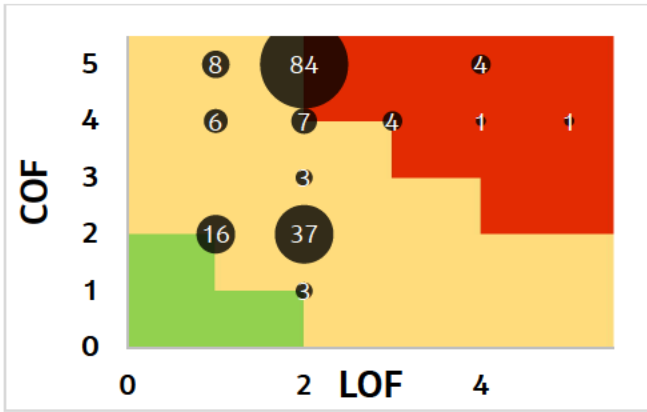
Ford Road Booster Station



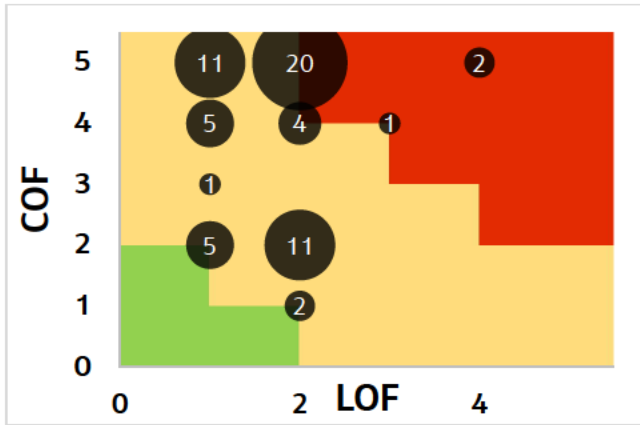
Franklin Road Booster Station



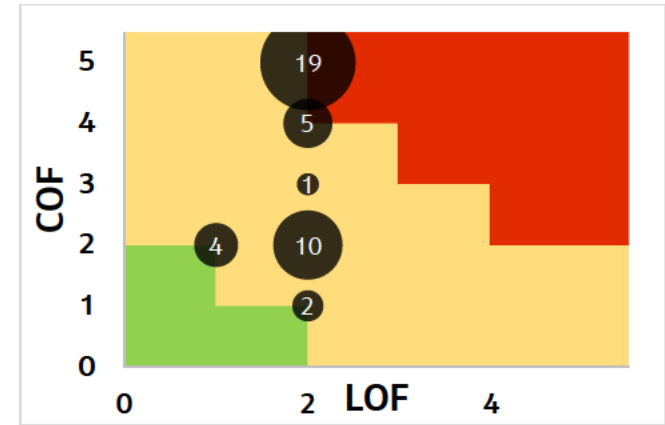
Haggerty Road Booster Station



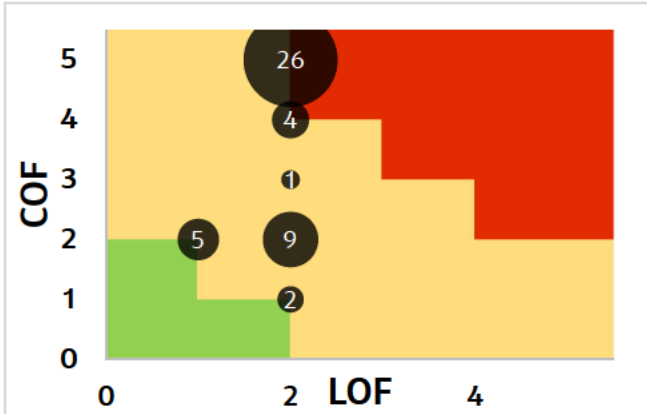
Imlay Booster Station



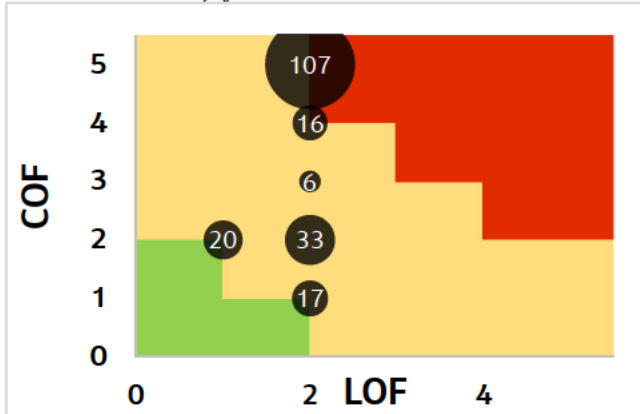
Joy Road Booster Station



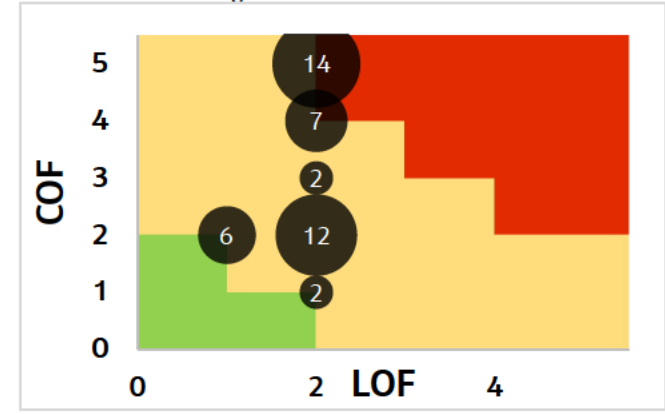
Michigan Avenue Booster Station



Newburgh Booster Station



North Service Center Booster Station



Northwest Booster Station

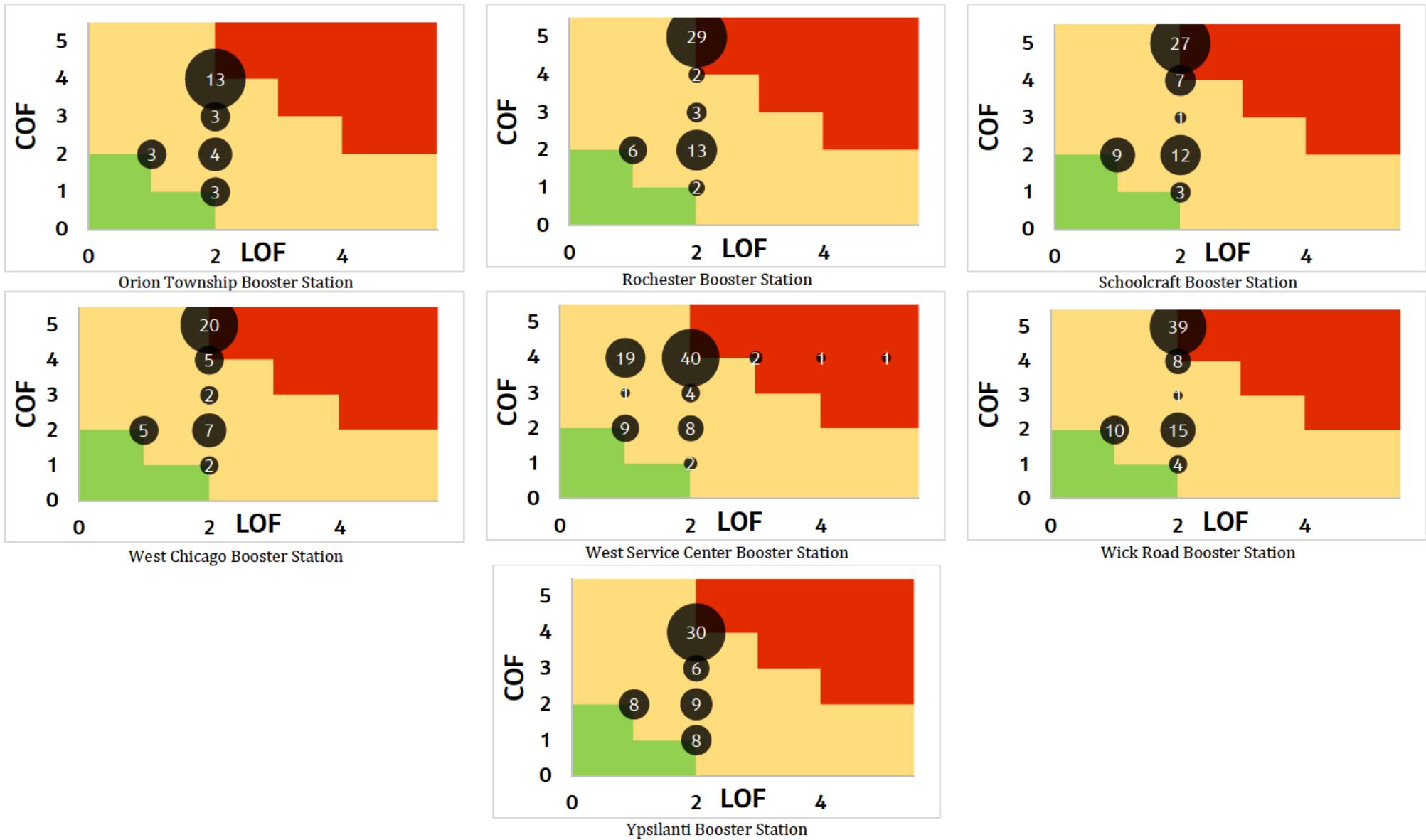


Figure 5-12: Asset Risk Scores for Individual Booster Stations

5.5 Risk Mitigation

Risk assessment and the resulting risk scores are the first steps in the overall risk management process. Understanding risk is a valuable tool for the prioritization of programs of work such as inspections, maintenance, and renewals.

Risk should be treated as an early value management activity and consideration given to a range of possible treatment options before committing to a particular solution. For utility assets, there are a range of potential treatment options that are commonly employed such as:

- Major capital projects (CIP) that address one or more risks
- Minor capital projects (Capital Outlay, Improvements and Extension (I&E))
- Emergency response plans or arrangements
- O&M strategies such as modified operational regimes or modified maintenance regimes
- Interim solutions that partially reduce risk for a short, defined period of time until a permanent solution is implemented
- Educational or other strategies that address the behavior or actions of third parties

5.5.1 Linear Assets

The linear asset risk mitigation strategy is under development as part of LSIP.

5.5.2 Vertical Assets

For the vertical assets, risk scores drive the identification of risk mitigation options, which for water system assets include:

- Asset Replacement
- Contingency Attenuation (redundancy, asset contingency plans, emergency response plans)

The risk scores that align to each mitigation option for water system assets is presented in Table 5-1.

Table 5-1: Asset Risk Mitigation Options

Risk Score	Risk Mitigation Option
If COF score is 3.5 or higher	Contingency Attenuation
If Condition Score is 4.0 or higher	Asset Replacement

The risk scoring process performed in 2022, resulted in the identification of 527 high-risk assets across WTP and Booster Stations, based on a risk score 11 or greater. Figure 5-13 shows the results of that exercise and the resulting high-risk assets. Lake Huron had the greatest number of high-risk assets and Springwells had the lowest number of high-risk assets. High-risk assets are candidates for risk mitigation.

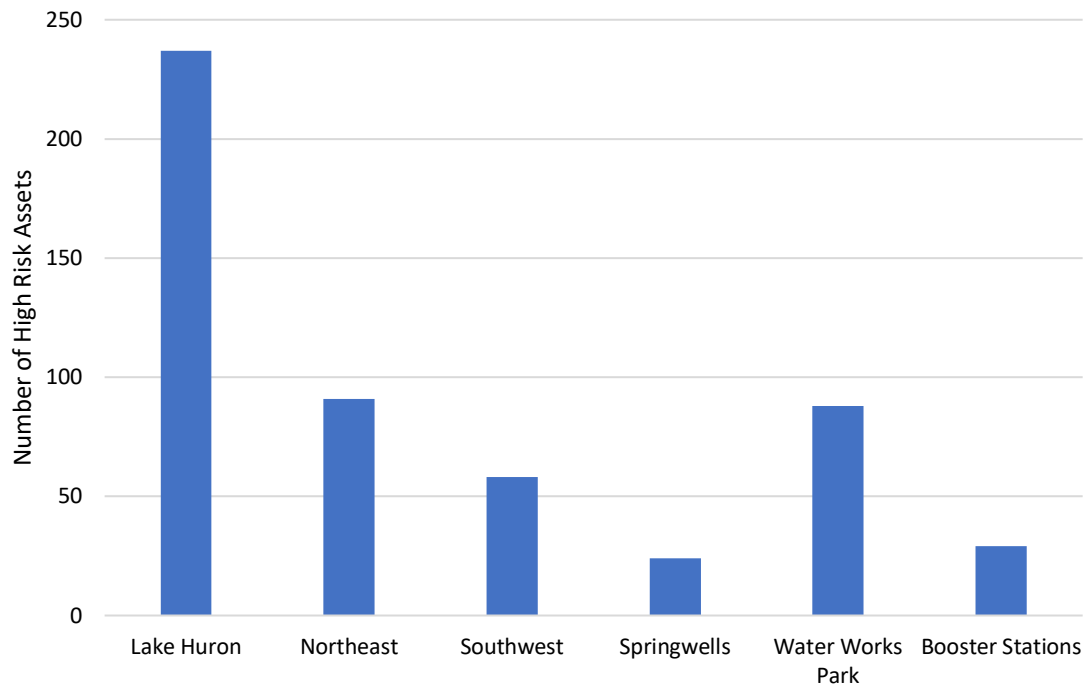


Figure 5-13: High-Risk Vertical Assets

GLWA has redundancy in place for high-risk assets that have a high COF score of 3.5 or higher. As a result, this lowers the COF scores by .5 points in the WAMP - Risk Register for Vertical Assets and is an example of contingency attenuation as a risk mitigation strategy.

Vertical assets with a high LOF score of 4.0, which are candidates for asset replacement, greater were cross-checked against the pre-existing CIP and most are addressed by projects in the CIP. Approximately 90% of these assets fell into ten asset types:

- Valves
- Filters
- Pumps
- Flocculators
- Buildings
- Storage Tanks
- Screens
- Basins
- Breakers
- Cranes

The risk scores for vertical assets have performed well for the prioritization and selection of programs and a significant number of risk correlate well with the projects in the CIP.

However, the risk scores are driven by the physical condition of the assets and so they only represent one underlying cause (aging assets) and only lead to one type of treatment (renewal at end of life). There are other risks in the asset base that are driven by alternative underlying causes (for example high flow events) and that may attract different types of treatment. Further investigation and analysis are required in order to drive out the full range of asset needs and their underlying causes and to identify the precise treatments that address the needs. GLWA has already implemented an Annual Review process at the WTP to implement this investigation and analysis.

The Annual Review process has been established to review emerging issues, prioritize mitigations, and identify funding sources. The current approach combines the use of the planned maintenance program funded through the O&M budget; a major equipment overhaul program of process equipment—including major pump assemblies and motors—funded through the Improvements and Extensions budget; and more complex process upgrades that include replacements of aging equipment that are packaged into CIP projects.

6 Operations and Maintenance

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to summarize GLWA’s existing linear and vertical asset operations and maintenance (O&M) practices and describe improvement activities in place.

A key element of AM planning is determining the most cost-effective blend of planned and unplanned maintenance. This includes regularly scheduled inspection and maintenance, as well as more significant repairs and activities associated with unexpected events. The overall O&M strategy is intended to maintain the current level of service while mitigating risk and minimizing cost. This section discusses GLWA’s strategies for operating linear and vertical assets in compliance with required service objectives.

Tactical Recommendations W4: WAMP – Digital Solutions; W7: WAMP - Maintenance & Reliability Work Management Process for Vertical Assets; W8: WAMP - Maintenance Reliability Improvement Implementation for Vertical Assets; and W9: WAMP - Maintenance and Reliability - Performance Measurement and Improvement for Vertical Assets are planned to be implemented to continuously improve in the way GLWA improves operations and maintenance activities.

Tactical Recommendations:

- W4: WAMP - Digital Solutions
- W7: WAMP - Maintenance & Reliability Work Management Process for Vertical Assets
- W8: WAMP - Maintenance Reliability Improvement Implementation for Vertical Assets
- W9: WAMP - Maintenance and Reliability - Performance Measurement and Improvement for Vertical Assets

Supporting Artifacts:

- WAMP – Governance Business Processes Appendix M
- Tier 1-3 Performance Indicators (PIs) – Chapter 3 of WAMP

6.1 Operations and Maintenance Strategies

6.1.1 O&M Strategy Guidance

GLWA administers a comprehensive preventive maintenance (PM) and corrective maintenance (CM) program for water assets. Several documents guide GLWA’s O&M strategy for its water system. For example, the 2019 Interim Wet Weather Operating Plan (IWOP) provides a roadmap for optimizing the use of regional pipelines, the WTP, water transmission, and Booster Station facilities. Operating strategies and operational planning documents are being collected or will need to be developed. Appendix C– Asset Data and Information Improvements lists the documents that need to be developed and Appendix D– Asset Data and Information Improvement Tracker assists with GLWA with tracking data improvements.

6.1.2 Linear Asset O&M Strategies

The linear asset O&M strategies are described as part of LSIP.

6.1.3 Vertical Asset O&M Strategies

GLWA optimizes strategies for operating the vertical assets, including inspection and PM schedules. PM activities are tied to individual assets and tracked in WAM/NexGen. Current PM activities are listed in Table 6-1.

Table 6-1: Vertical Asset Preventive Maintenance Activities

Current PM Activities	Actions
Time-Based Maintenance	<ul style="list-style-type: none"> • Lube oil changes • Filter changes • Belt drive inspections • Mechanical inspections • Electrical inspections • Greasing • Instrument calibration • Cleaning (motors, coils, vents, etc.) • Electrical switchgear testing and inspection • Regulatory inspections (tanks, fire systems, eyewash, cranes, emergency lighting, backflow preventers, permit related)
Condition-Based Maintenance	<ul style="list-style-type: none"> • Oil sampling and analysis • Thermographic inspection on electrical assets • Vibration monitoring and analysis • Static motor testing (Megger and Polarization Index) • Dynamic motor testing (via GE Multilin motor control systems)

GLWA reviews maintenance activities either on a periodic basis or in response to premature asset failures.

In 2022, with the assistance of Jacobs, GLWA conducted an internal self-assessment of the WTP and Booster Stations maintenance and reliability program. The results of the assessment are included in Appendix I. Prioritized continuous improvements are reflected in Tactical Recommendation W7-: WAMP – Maintenance and Reliability Work Management Processes for Vertical Assets; W8: WAMP – Maintenance and Reliability Improvement Implementation for Vertical Assets; and W9: Maintenance and Reliability Performance Measurement Improvement for Vertical Assets.

6.2 Operations and Maintenance Performance

6.2.1 Linear Assets

The linear asset O&M performance is described as part of LSIP.

6.2.2 Vertical Assets

In 2017, GLWA established the following PIs to track maintenance performance:

- Maintenance Utilization Rates
- Monthly PM Maintenance Estimated vs. Actual Hours
- PM backlog

Industry best practices suggest that PM decreases the asset failure rates and associated asset downtime related to failures; additionally, PM is typically administered at a lower cost compared to CM. Thus, GLWA has established targets for these PIs that aim to maximize the PM completion rate and optimize the ratio of PM-to-total-maintenance.

The initial target for the Water PM completion rate PI was to achieve greater than 75% completion rates of PM work orders. As work management improved, GLWA revised this target to achieve greater than 80% completion rate of PM work orders.

Figure 6-1 shows the PM completion rate from March 2021 to February 2022.

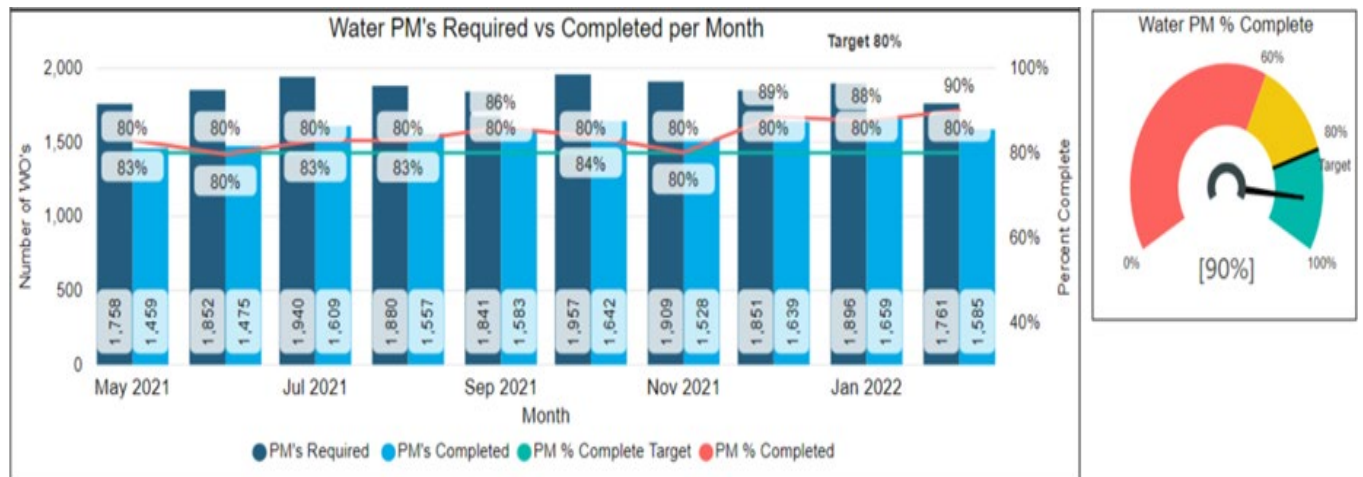


Figure 6-1: Water Preventive Maintenance Completion Monthly Performance (March 2021 to February 2022)

GLWA's maintenance program strives to balance the value of PM activities with the negative impacts of asset failures requiring CM activities. Excessive PM activities that do not improve performance or reliability provide little value and can result in increased costs and

workloads. Additionally, excessive CM activities may indicate a reactive approach to maintenance that could leave GLWA vulnerable to expensive failures. Therefore, GLWA has established the PM-to-total-maintenance ratio target of 80% to balance PM and CM activities.

The estimated time it takes to clear the maintenance backlog is a measure of the total estimated available hours, the maintenance utilization rate, and the estimated hours of backlog from work orders. The initial target clearing the maintenance backlog is four to six weeks.

Figure 6-2 also shows the total estimated available hours and Figure 6-3 shows the maintenance utilization rate for March 2021 to February 2022. Figure 6-4 shows the estimated hours of backlog from works orders, as well as the resulting duration necessary to clear the backlog. *It is noted that data accuracy and completeness can skew the results.*

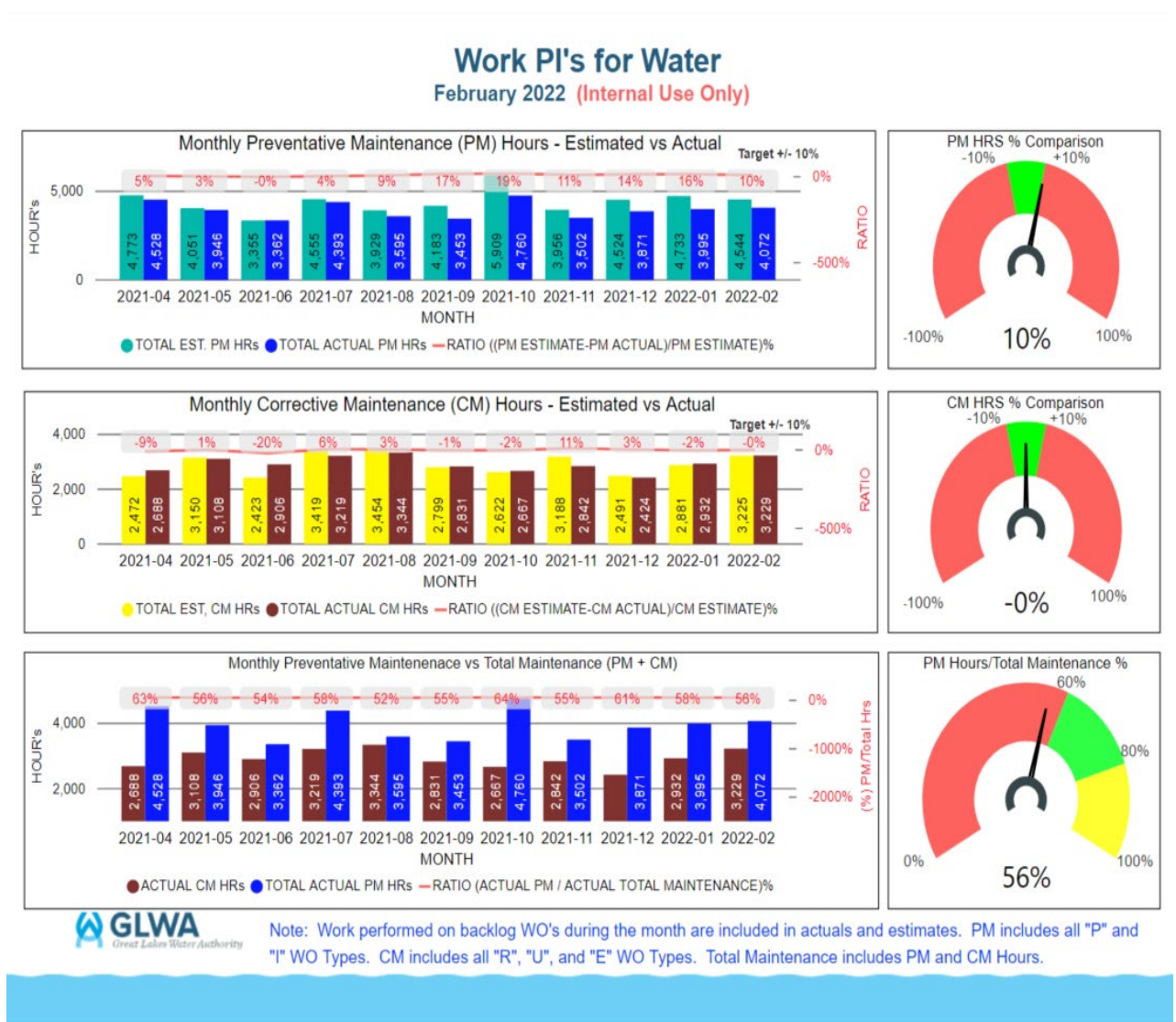
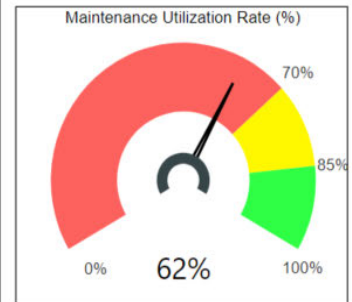
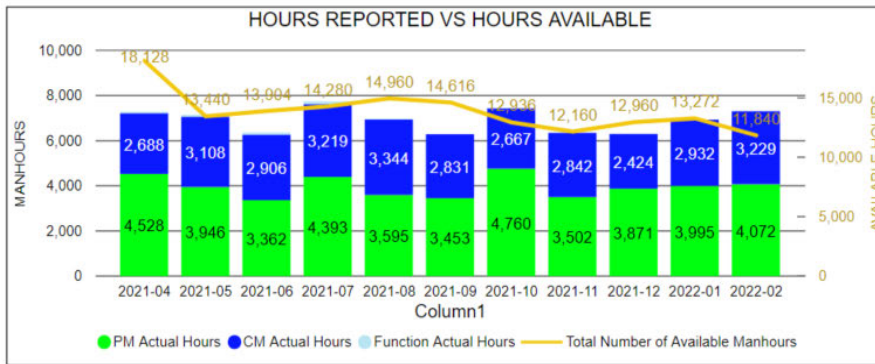
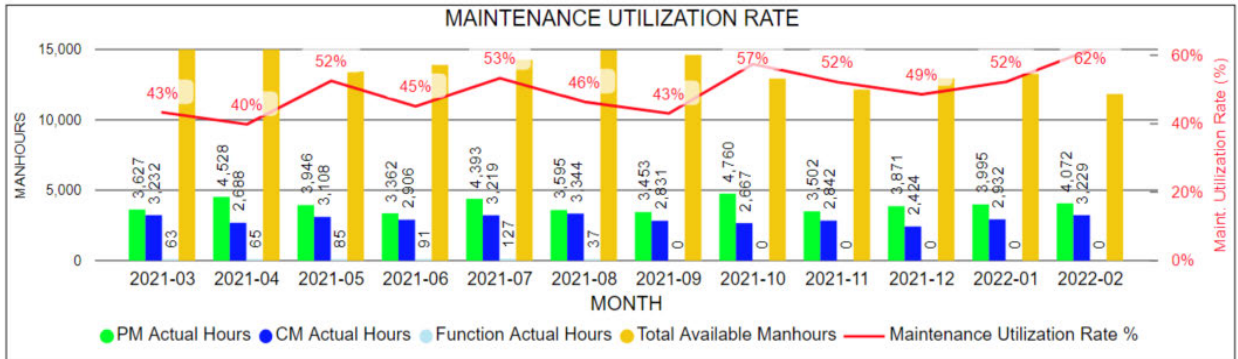


Figure 6-2: Total Estimated Available and Actual Preventive and Corrective Hours Performance

Work PI's for Water February 2022 (Internal Use Only)



Note: PM Actual Hours come from time reported against WO Type "P" & "I". CM Actual Hours comes from time reported against WO Type "R", "U", & "E". Available Hours are calculated based on the number of distinct team members who entered time for the month, multiplied by the number of average work hours available for the month. The Maintenance Utilization Rate % is calculated by adding PM and CM Hours / Total Available Hours.

Figure 6-3: Maintenance Utilization Rate Performance

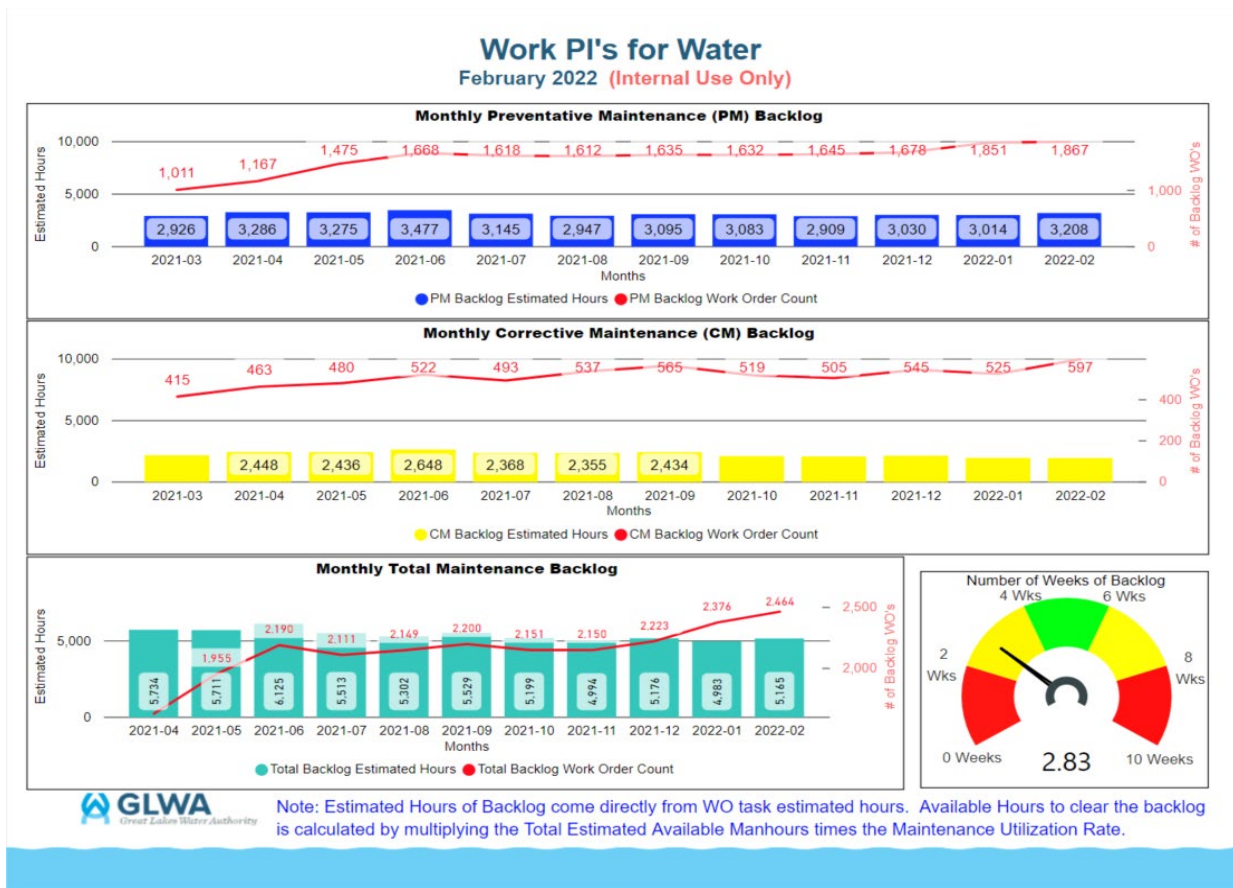


Figure 6-4: Maintenance Backlog and Time to Clear Backlog Performance

GLWA is currently working to identify additional PIs, drawing from industry maintenance best practice performance metrics. The metrics are categorized into three tiers:

- **Tier 1** – PIs are identified as needed reports which can be developed now using current WAM data and business processes
- **Tier 2** – PIs are identified as reports which may be created using WAM data after configuration changes and business process changes are made
- **Tier 3** – PIs are identified as reports which cannot be obtained with WAM data and business process changes using WAM. It is expected that these reports will be developed as part of the NexGen project

Table 6-2, Table 6-3, and Table 6-4 present the three tiers and associated PIs for each.

Table 6-2: GLWA Tier 1 Performance Indicators

PI Name	PI Objective
Maintenance Utilization Rate	To measure the ability to manage maintenance resources in a manner that generates the most value to the organization by using available resource time effectively by ensuring a high percentage of the available time is spent completing maintenance work on the assets.
Workorder Backlog by Hours (Weeks of Backlog)	To measure the ability of the maintenance team to complete the amount of maintenance work being generated in a timely manner, and to implement corrective actions if the backlog grows above the standard.
Percent PM Completion Rate (PMs Completed vs PMs Scheduled)	To measure the ability and capacity of the organization to execute the preventive maintenance strategy as designed. The factors that may influence this metric include work inefficiency, inventory issues, ineffective scheduling, inaccurate labor estimates, and resource availability.
Percent PM Workorders vs Total Workorders	To measure the PM work orders as a percentage of the total maintenance being performed.
Percent Estimated vs Actual Hours	To measure the labor estimating accuracy of the Maintenance Planning function. The estimated hours on a work order serve to provide the Maintenance Scheduler an understanding of the duration and resources required to complete the work activity, so an accurate work schedule can be developed.
Number of Backlog Workorders by Age	To measure the ability of the maintenance team to complete the amount of maintenance work being generated in a timely manner, and to implement corrective actions if the backlog grows above the standard.
Percent PM by Labor Hours vs Total Labor Hours	To measure the proactive versus reactive nature of the maintenance program.
Hours Reported vs Hours Available	To track the delta between labor hours documented within the timekeeping system and those documented within WAM against work orders. Any delta will potentially identify groups or persons that may not be documenting completed work within the WAM system.

Table 6-3: GLWA Tier 2 Performance Indicators

PI Name	PI Objective
Plant or System or Equipment Availability	To measure the ability of the organization to keep its critical assets available for service in supporting its mission.
MTBF	To measure and trend the reliability performance of a population of assets. The factors that impact this metric are many and include design, purchasing, operations, maintenance, age of assets, etc.
Percent Proactive Maintenance Hours vs Total Maintenance Hours	To track the ratio of proactive maintenance time spent working vs the total maintenance hours.
Percent Predictive Maintenance Hours vs Total Maintenance Hours	To track the LOE being expended executing predictive maintenance as compared to all other types of maintenance.
Total Reactive Labor Hours	To provide a simple measure of overall AM performance by tracking the level and trend of reactive maintenance.
Total Reactive Material Costs	To measure the value of materials consumed performing reactive maintenance work.
Average Mean Time to Repair	To provide a measure of the average time require to place a failed system or asset back into service.

Table 6-4: GLWA Tier 3 Performance Indicators

PI Name	PI Objective
Planned or Scheduled Hours vs Total Actual Labor Hours	To measure the percentage of work that is being processed through the P&S process.
Scheduled Hours vs Available Hours	To measure the percentage of available maintenance labor hours that are being scheduled via the scheduling process.
Schedule Attainment	To provide a measure of the effectiveness of the maintenance scheduling process.
Schedule Break-In Labor Hours vs Total Scheduled Labor Hours	To measure the stability of the maintenance scheduling process as compared to the reactive nature of the maintenance program.
Average Asset Health Score	To provide a measure of the average asset health indicating the effectiveness of the AM strategy.
Average Remaining Asset Life	To provide a measure of the asset remaining life in support of reliability and asset life extension.

6.3 FMEA and PMO Analysis

Failure Modes and Effects Analysis (FMEA) and Planned Maintenance Optimization (PMO) both focus on higher risk assets to determine where to redirect O&M resources in order to increase reliability and reduce overall costs. Pilot activities for FMEA and PMO have been performed as part of development of the Wastewater Asset Management Plan (WwAMP). There is an opportunity for GLWA to incorporate these activities into the way water assets are managed.

What distinguishes FMEA from PMO is the level of analysis performed and the basis used for making recommendations. As FMEA is a more detailed analysis, it is a more viable process for making difficult decisions that may have higher consequences.

The metrics that measure the success of FMEA and PMO are the same. The only metrics available immediately to either process includes impact on labor hours and number of work orders being generated to execute the strategy. The true impact of either FMEA or PMO is longer term can be measured as part of a performance measurement model.

Table 6-5 details the goals, impacts, and metrics of FMEA and PMO analysis.

Table 6-5: Goals, Impacts, and Metrics of FMEA and PMO Analysis

Goal	Impact	Metrics
Increase asset reliability and reduce number of failures	Reduce downtime	<ul style="list-style-type: none"> System or asset availability MTBF CM total labor hours
	Reduce level of CM	<ul style="list-style-type: none"> CM maintenance cost CM Work order count
	Reduce safety incidents	<ul style="list-style-type: none"> Safety metrics
	Reduce environmental incidents	<ul style="list-style-type: none"> Environmental metrics
Maintain or improve asset condition	Reduce capital replacement or overhaul	<ul style="list-style-type: none"> Capital reinvestment costs Condition assessment results
	Reduce energy consumption	<ul style="list-style-type: none"> Energy costs
Optimize use of PM resources	Increase the return on investment for PM activities	<ul style="list-style-type: none"> PM/CM ratio total (for critical equipment) PM total work order count PM total labor hours
Increase use of condition-based maintenance	Reduce occurrence of unexpected in-service failures	<ul style="list-style-type: none"> EM work order count
	Reduce occurrence of secondary damage	<ul style="list-style-type: none"> CM maintenance cost PdM-based “saves”
Improve operator practices for asset inspections during operation	Reduce occurrence of unexpected in-service failures	<ul style="list-style-type: none"> EM work order count
	Reduce occurrence of secondary damage	<ul style="list-style-type: none"> CM maintenance cost Operator based “saves”

6.3.1 Failure Modes and Effects and Analysis

An FMEA deconstructs an asset into its various sub-components and then defines the various ways a component failure is likely to occur; this failure is referred to as a “failure mode.” For example, a failure mode may be defined as bearing seizes with associated causes of lack of lubrication or misalignment of drive shaft. GLWA can use the results of an FMEA to inform maintenance activities and address failure modes before failures occur.

What is a Failure Mode?

A failure mode identifies the various ways a component failure is likely to occur. Understanding an asset’s failure mode and cause is useful when mitigating risk.

In 2021, GLWA piloted an FMEA approach for a single asset from four major process areas in the wastewater system: Primary, Secondary, Dewatering, and Incineration. GLWA selected assets for the FMEA pilot by considering asset risk scores developed for the WwAMP and input from the Water Resource Recovery Facility (WRRF) maintenance team on asset performance history, using 2020 data. This activity may be applicable to water assets and is reflected in Tactical Recommendation W8: WAMP - Maintenance and Reliability – Improvement Implementation for Vertical Assets.

6.3.2 Planned Maintenance Optimization

PMO evaluates the PM strategy across the asset population as it compares to the criticality of the assets. PMO also aims to redistribute the performance of PM from low-value activities to high-value activities in order to achieve greater value per hour of PM completed. PMO achieves this by working to identify and remove duplicate PM tasks. This includes increasing or decreasing PM intervals, applying the use of predictive maintenance (PdM) where beneficial, improving work instructions, improving operator inspections, and achieving greater overall efficiency and safety. By carefully analyzing PM tasks, PMO can streamline PM without increasing the risk of failure. Thus, PMO has the potential to significantly reduce overall annual PM hours and improve delivered service levels and performance.

GLWA’s PMO goals include the following:

- Delete maintenance tasks that provide little value
- Extend or reduce PM interval based on type of task, equipment usage, environment, and industry guidelines

- Improve PM scheduling
- Add PM and PdM, where beneficial
- Take credit for current PdM activities
- Make use of and improve operator rounds
- Reassign PM tasks that would be better served by having the Operations Department perform the task
- Make use of installed instrumentation and monitoring
- Strengthen work packages (task instructions, parts, and tools)

In 2021, GLWA embarked on an initiative to optimize PM activities for wastewater system assets. The intent of the PMO initiative for wastewater system assets was to conduct an evaluation of the existing PM program for a limited number of assets located within each of the WRRFs plant's five process areas, which include Primary, Secondary, Dewatering, Incineration, and Common Support. The PMO initiative also aimed to identify opportunities for improving the effectiveness and efficiency of the proactive maintenance activities.

The WwAMP describes the PMO methodology and PMO Tool for WRRF assets. This activity may be applicable to water assets and is reflected in Tactical Recommendation W8: WAMP - Maintenance and Reliability – Improvement Implementation for Vertical Assets.

7 Renewals

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to identify needed renewals for linear and vertical water assets. A good understanding of the life cycle behavior of each asset is needed to identify long-term renewal needs. This understanding can then be used to develop long-term life cycle models based on the replacement and rehabilitation needs of the current asset base.

Tactical Recommendations:

- W10: WAMP - Scheduled Replacement Program Implementation
- W11: WAMP - Capital Improvement Program Process Improvement

Supporting Artifacts:

- WAMP - Scheduled Replacement Program (SRP) Models (WTP and Booster Stations) and Linear Assets in Info Asset Planner (IAP) – Appendix J
- CIP
- Appendix M - WAMP Governance Business Processes

Tactical Recommendations W10: WAMP – Scheduled Replacement Program Implementation and W11: WAMP - Capital Improvement Program Process Improvement is planned to be implemented to continuously improve the way GLWA identifies needed renewals and invests in capital projects.

7.1 Scheduled Replacement Program Models

Life-cycle modeling is an approach that combines the asset condition, installation dates, expected service lives, and estimated replacement costs with an appropriate rehabilitation or replacement strategy in alignment with the asset life cycle behavior. The water system linear assets and vertical assets use different life-cycle models to inform the scheduled replacement program (SRP). Appendix J includes a description of the SRP model for vertical assets and LSIP includes a description of the SRP model used for linear assets.

Peaks of needs are useful prompts that can be used to trigger further study of the potential intervention needs and timing so that adjustments can be considered as part of GLWA CIP planning and delivery. The program is informative to the CIP and capital outlay needs for renewals. As asset condition data and asset improvement work is continuously completed, the needs as indicated by the SRP model are always evolving.

7.2 Renewal Needs

7.2.1 Linear Assets

See the LSIP for information about liner assets rehabilitation and life-cycle modeling approach.

7.2.2 Vertical Assets

A condition-based rehabilitation and renewal logic was used to identify vertical assets needing rehabilitation (see Appendix K for description of the SRP model). Replacement and rehabilitation strategies for each asset type are documented in the SRP model. For WTP and Booster Station assets, visual condition assessment work was performed in 2021 on about 2,000 assets (mostly electrical and mechanical assets) and the remaining assets (approximately 3,700) received a table-top condition assessment based on knowledge of the asset and asset type. The average table-top condition assessment score for these assets was 2.04 with individual asset scores ranging from 1.00 to 5.00. Costs were based on 2021 dollars with soft costs included.

Figure 7-1 shows the summary of vertical asset capital renewal needs for the WTPs and Booster Stations. According to the SRP model for WTPs and Booster Stations, the total estimated expenditure is about \$330 million (2021 dollars), which is equivalent to an annual average of \$16.5 million over 20 years. The highest peaks in renewal expenditures are projected for the years 2031 and 2043. This SRP model result reflects current good condition scores with most expenditures happening in the future.

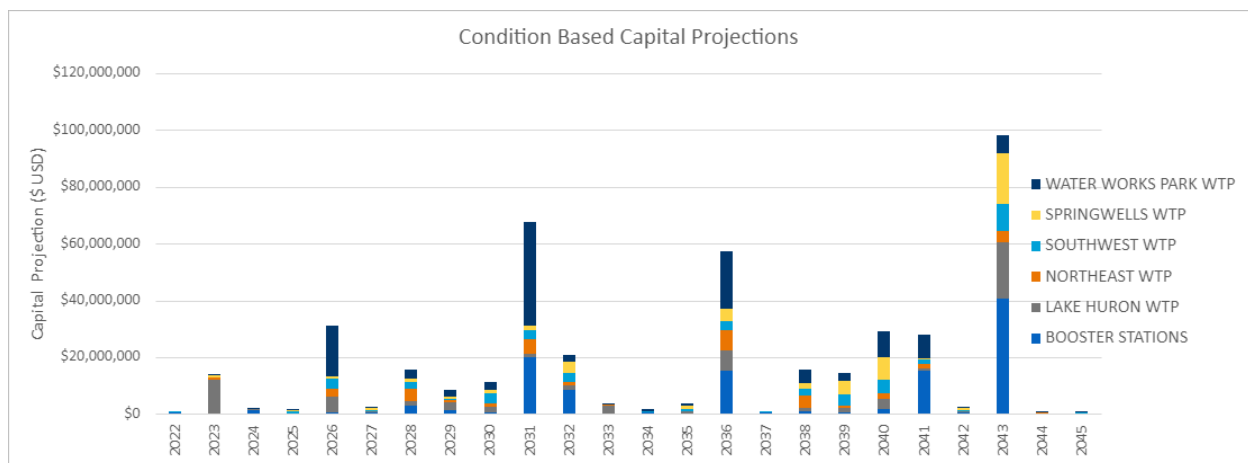


Figure 7-1: Projected Capital Costs for WTPs and Booster Stations Vertical Assets (based on 2021 data, in 2021 dollars)

A detailed breakdown of projected costs by vertical asset type is presented below.

Water Treatment Plants

The 20-year projection is shown in Figure 7-2 is based on 2021 data, in 2021 dollars. The projection includes an estimated \$258 million in renewals, which is equivalent to an annual average of \$12.9 million. This investment profile includes planned interventions in some of the building and process equipment. The investment peaks in 2031 and 2043 reflect the relatively good current condition of assets.

Peaks of needs are useful prompts that can be used to trigger further study of the potential intervention needs and timing so that adjustments can be considered as part of GLWA CIP planning and delivery. The program is informative to the CIP and capital outlay needs for renewals.

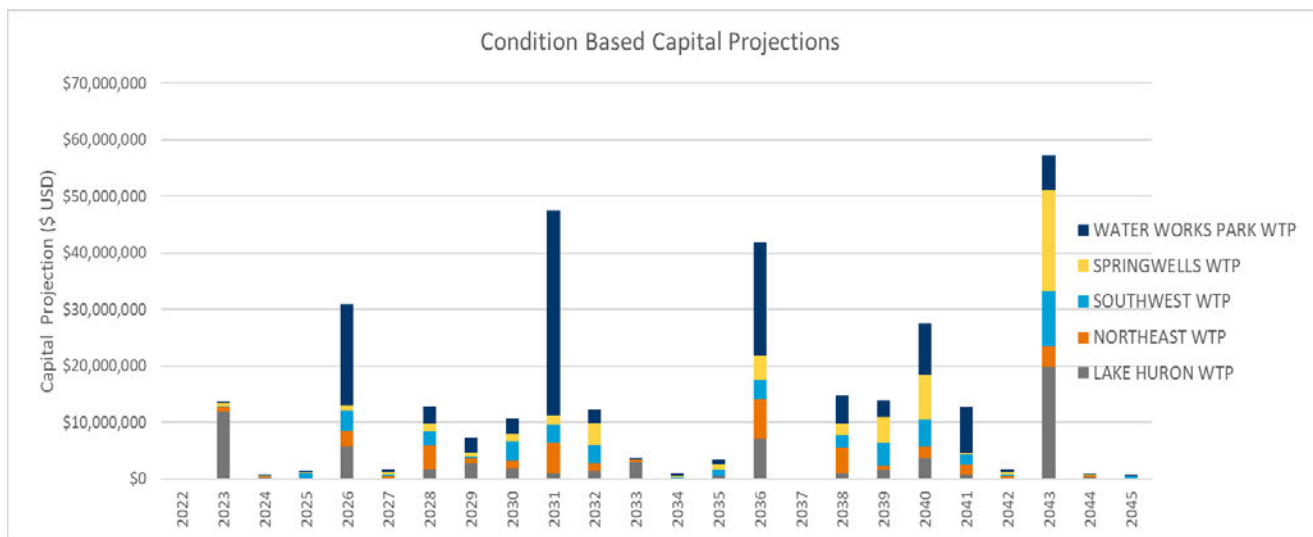


Figure 7-2: WTP Condition-Based Capital Projections (based on 2021 data, in 2021 dollars)

Booster Stations

Figure 7-3 shows the 20-year projection for Booster Station assets. The projection includes an estimated \$72.2 million in renewals, which is equivalent to an annual average of \$3.6 million based on 2021 data, in 2021 dollars. There are investment peaks in 2031 and 2043 that reflect the relatively good current condition of assets.

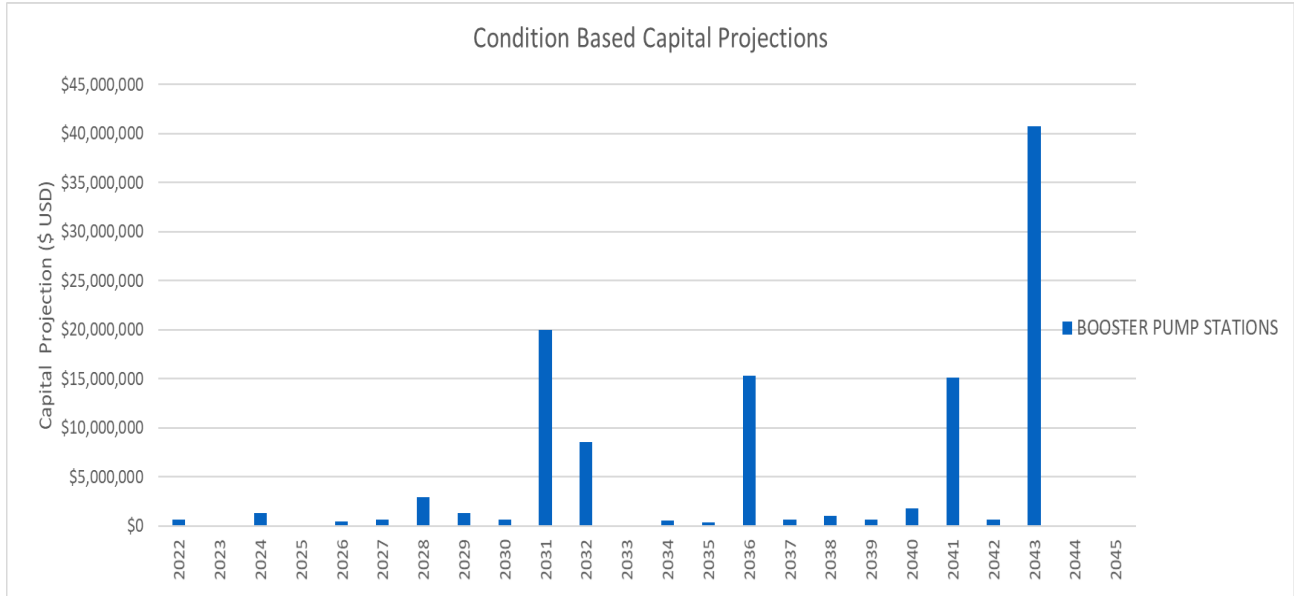


Figure 7-3: Booster Stations Condition-Based Capital Projections (based on 2021 data, in 2022 dollars)

8 Funding

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

The purpose of this section is to provide an overall financial view for the GLWA water system. It documents the most recent historical operating and capital expenditures and summarizes GLWA's allocated capital expenditures in response to renewals and enhancements drivers.

Tactical Recommendations:

- NA

Supporting Artifacts:

- Financial Plans

This chapter aims to provide visibility to maintain the existing service levels for the next 10 years².

Note: Expenditures presented in this section are sourced from published budgets and financial summaries, the CIP, and the analysis of renewal needs presented in Chapter 7. The information presented in this Chapter may contain minor gaps and omissions. Any material differences between the data provided herein and published sources has been noted.

8.1 Historical Expenditures

The following sections provide a summary of the expenditure history of the water system linear and vertical assets, including historical operating and capital expenditures from 2017 to 2020. Since GLWA began operations of the water system in 2016, efficiencies and cost management of the water system assets have significantly improved and the total cost of ownership of water system has been optimized. Financial information may be reviewed at the GLWA website [Financial Resources - Great Lakes Water Authority \(glwater.org\)](https://www.glwater.org/financial-resources).

8.1.1 Operations

The historical operating expenditures for the core programs delivering water services by expense category are shown reflected in Schedule 2b, page 117 of the 2020 financial report (<https://www.glwater.org/wp-content/uploads/2020/12/Great-Lakes-Water-Authority-2020-CAFR-FINAL-web-version.pdf>).

² The GLWA began operations in January of 2016 and therefore only information for the financial years 2017-2020 has been included in the analysis.

8.1.2 Capital

The historical capital expenditures occur through two main programs: Capital Outlay, which includes equipment and system improvements, and the CIP. Each is described below.

8.1.2.1 Capital Outlay

Capital Outlay is defined as equipment and system improvements that are not part of a CIP. GLWA uses its capital outlay to fund routine equipment replacements as well as the renewal, rehabilitation, or replacement of major process equipment. The capital outlay is intended to cover these periodic replacement and rehabilitation strategies. The Water Capital Outlay budget is found in the Biennial Budget file each year on the GLWA public web site <https://www.glwater.org/wp-content/uploads/2019/08/GLWA-FY-2020-and-FY-2021-Biennial-Budget-FINALrev8.12.2019.pdf> page 78 – 79.

8.1.2.2 Capital Improvement Plan

GLWA uses the CIP to fund the enhancement and renewal of long-lived assets. The CIP is developed annually and includes ongoing projects approved in previous years as well as new projects and programs. The CIP documentation also provides an overview of GLWA's historical CIP expenditures so that comparisons between historical expenditures and projected future expenditures can be made. The CIP budget is found in the Biennial Budget file each year on the GLWA public web site [Financial Resources - Great Lakes Water Authority \(glwater.org\)](https://www.glwater.org/financial-resources).

8.2 Forecasted Expenditures

Forecasted expenditures may be obtained from the GLWA Financial Plan ([Financial Resources - Great Lakes Water Authority \(glwater.org\)](https://www.glwater.org/financial-resources)). Revenue sources are also described. The SRP model referenced in Chapter 7 – Renewals, inform the forecasted needs.

9 Water Continuous Improvement Plan

The acronyms used throughout this document are included in Appendix A. For a Glossary of Terms, see the SAMP.

9.1 Overview

The Water Continuous Improvement Plan is comprised of a series of Tactical Recommendations starting in FY23/24, that were identified to achieve significant milestones for improving the way Great Lakes Water Authority (GLWA) manages its water system assets that include linear assets (transmission mains) and vertical assets (water treatment plants (WTP) and Booster Stations). Current asset management activities are documented in this Water Asset Management Plan (WAMP). The Water Continuous Improvement Plan aims to address a number of identified improvements including refinement of service levels based on stakeholder expectations, performing risk based determined condition assessment activities to improve GLWA's condition assessment program, and advancing operations and maintenance (O&M) practices including improving data quality, optimizing work management and asset management business processes, and maximizing use of technology. The recommendations contained herein, are focused primarily on vertical assets, as improvements to linear assets are documented in the GLWA's Linear System Integrity Program (LSIP).

A summary of the Tactical Recommendations with key supporting artifacts (tools and datasets) intended to support ongoing continuous improvement activities, are presented in Table 9-1 followed by detailed descriptions for each. Details include the purpose, benefits, and context and background for how the Tactical Recommendations were identified, related Strategic Asset Management Plan (SAMP) Initiatives the Tactical Recommendations support, tasks to guide GLWA with implementing the continuous improvement actions, and estimated internal and external resource requirements. Each Tactical Recommendation is numbered with a prefix of "W" which indicates "water".

Business Process WAMP – Continuous Improvement Plan Implementation outlines the implementation process for GLWA to follow to implement these Tactical Recommendations; it is included in Appendix M. A summary of the level of effort and estimated costs for implementation is outlined in the Staffing Plan presented in Appendix N. Implementing the continuous improvement activities reflected herein, will take commitment of staff resources by GLWA.

Tactical Recommendations:

- W1: WAMP - Asset Management Roles & Responsibilities
- W4: WAMP - Digital Solutions

Supporting Artifacts:

- WAMP - Governance Business Processes – Appendix M

Tactical Recommendations W1: WAMP – Asset Management Roles and Responsibilities and W4: WAMP – Digital Solutions are planned to be implemented to continuously improve the way GLWA manages WAMP implementation.

Table 9-1: Summary of Tactical Recommendations

Tactical Recommendation	Supporting Artifacts/Technologies
W1: WAMP - Asset Management Roles & Responsibilities	<ul style="list-style-type: none"> WAMP - Governance Business Processes – Appendix M
W2: WAMP - Service Levels	<ul style="list-style-type: none"> Tier 1-3 Performance Indicators (PIs) – <i>Chapter 3 of the WAMP</i> LSIP Performance Metrics Dashboard Monthly EGLE Operations Reports Annual Statistical Reports for WTPs
W3: WAMP - Asset Data and Information	<ul style="list-style-type: none"> WAMP -Asset Data and Information Improvement Summary- Appendix C WAMP -Asset Data and Information Improvement Tracker– Appendix D WAMP – Governance Business Processes – Appendix M
W4: WAMP - Digital Solutions	<ul style="list-style-type: none"> Information Technology (IT) Master Plan
W5: WAMP - Condition Assessment of Non-Inspected Vertical Assets	<ul style="list-style-type: none"> WAMP Condition Assessment Activities – Vertical Assets - Appendix F WAMP – Governance Business Processes –Appendix M
W6: WAMP - Asset Risk for Vertical Assets	<ul style="list-style-type: none"> WAMP - Risk Register for Vertical Assets – Appendix G WAMP – Governance Business Processes – Appendix M CIP (to help plan and understand risk mitigation)
W7: WAMP - Maintenance and Reliability Work Management Processes for Vertical Assets	<ul style="list-style-type: none"> WAMP – Governance Business Processes Appendix M
W8: WAMP - Maintenance and Reliability Improvement Implementation for Vertical Assets	<ul style="list-style-type: none"> PMO Report and Tool and FMEA Pilot Results from Wastewater Asset Management Plan (WwAMP) WAMP – Governance Business Processes -Appendix M
W9: WAMP - Maintenance and Reliability Performance Measurement and Improvement for Vertical Assets	<ul style="list-style-type: none"> Tier 1-3 Performance Indicators (PIs) – Chapter 3 of the WAMP
W10: WAMP - Scheduled Replacement Program Implementation	<ul style="list-style-type: none"> WAMP - Scheduled Replacement Program (SRP) Models (WTP and Booster Stations) and Linear Assets in Info Asset Planner (IAP) – Appendix J WAMP – Governance Business Processes – Appendix M CIP
W11: WAMP - Capital Improvement Program Process Improvement	<ul style="list-style-type: none"> WAMP – Governance Business Processes – Appendix M
W12: WAMP - Replacement Cost Database for Vertical Assets	<ul style="list-style-type: none"> Financial System

9.2 Tactical Recommendation Descriptions

This section provides details of each Tactical Recommendation and a proposed plan for implementation including resource requirements and the SAMP Improvement Initiatives they support.

9.2.1 W1: WAMP - Asset Management Roles & Responsibilities

GLWA Owner: Enterprise Asset Management Group (EAMG)

Alignment to SAMP Improvement Initiatives:

- P1 - Dedicated Asset Management (AM) Team Members within Business Units (BU)
- O6 - Future AM Assessments and Benchmarking

Supporting Artifacts: WAMP - Governance Business Processes – Appendix M

Purpose

The purpose of this Tactical Recommendation is to establish water focused asset management working relationships within the GLWA organizational structure with representatives from Planning and Operations and Maintenance (O&M) that have defined roles and responsibilities to support collaborative development and roll-out of the Tactical Recommendations included this Water Continuous Improvement Plan.

Benefits

The benefit of this Tactical Recommendation is that it establishes ownership and accountability for implementation of the Tactical Recommendations in the Water Continuous Improvement Plan so that GLWA ensures continuation of making improvements in the way it manages water system assets.

Context & Background

GLWA participated in the Water Services Association of Australia (WSAA) Asset Management Assessment and Benchmarking in 2018 and developed a 5-year program of Improvement Initiatives. Section 10.3 – Current Asset Management Maturity of the SAMP describes this effort. This assessment identified the need for GLWA to identify asset focused Asset Management Champions that work to manage asset management performance across vertical and linear assets, with specific responsibility to monitor performance indicators and bring attention to key subject matter experts within the organization when service level objectives are falling short of desired performance.

Development of the WAMP was championed by the Water Asset Management Team (WAMT), and during development of the WAMP, staff within this group with specific asset

management roles and responsibilities for implementing the WAMP and the recommendations contained therein, were identified. The resulting WAMP Governance Business Processes are included in Appendix M of the WAMP.

A water focused asset management group (Local Asset Management Group) can serve as the accountable group to monitor performance indicators and track overall asset management program performance and asset health, and then foster collaboration with each part of the organization to discuss performance related to meeting asset management service level objectives. O&M Supervisors implement data collection, condition assessment, and advanced maintenance activities, and Finance is a key player to support collaboration on funding needs and availability. Figure 9-1 depicts this recommended organizational structure reflecting roles shown in the WAMP - Governance Business Processes listed in Appendix M.

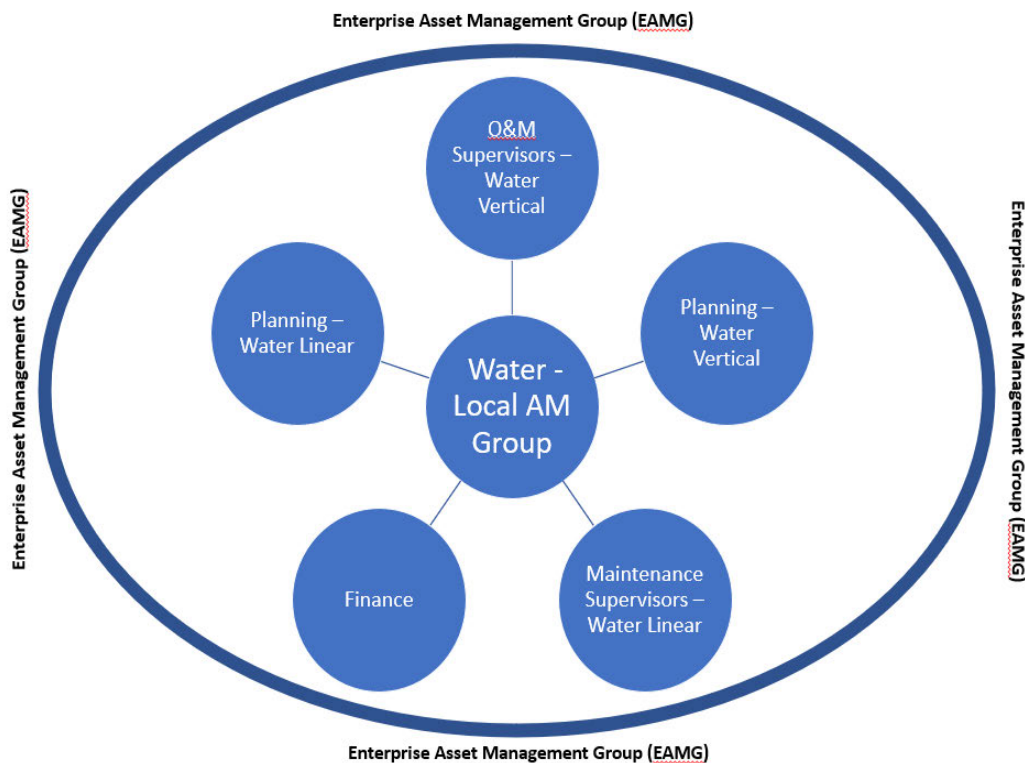


Figure 9-1: Water Asset Management Governance Structure

Table 9-2 details tasks needed to support implementation and Table 9-3 describes resources required.

Table 9-2: Tasks to Support Implementation

Year and Task
<p>Year 1- Define Asset Management Roles and Responsibilities</p> <ul style="list-style-type: none"> ▪ Discuss the role and responsibilities of water asset management focused staff for Planning and WTPs/Boosters and coordinate ways to incorporate into the existing Enterprise Asset Management Group (EAMG) structure. ▪ Identify owners of the Key Artifacts listed in Table 9-1 (supporting tools and datasets) and confirm roles with responsibilities for managing these. ▪ Develop clearly defined responsibilities for each group listed in Figure 9.1 and as defined in Appendix M- WAMP – Governance Business Processes. ▪ Implement the governance structure.
<p>Year 2 – Assess and Refine Asset Management Champion Roles and Responsibilities</p> <ul style="list-style-type: none"> ▪ Review the successes and challenges of the water asset management governance structure as part of an annual meeting and refine roles and responsibilities as needed. ▪ Discuss and document succession planning strategy for each defined role and implement.
<p>Year 3 – Perform Maturity Assessment Check-In</p> <ul style="list-style-type: none"> ▪ Review the Asset Management Assessment and Benchmarking activity performed in 2018 during SAMP development and compare to other maturity assessment methods within the industry. The results of the Maturity Assessment performed during SAMP development are documented in the “Asset Management Assessment Summary – April 18, 2019.” ▪ Conduct asset management maturity assessment and compare results to the 2019 maturity assessment.

Table 9-3: Resource Requirements for Tactical Recommendation W1: WAMP - AM Roles & Responsibilities

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
20 hours (5 staff at two, 2- hour meetings)	\$0	10 hours (5 staff at one, 2-hour meetings)	\$0	60 hours (10 staff at three, 2-hour meetings)	\$50,000 (cost to facilitate meetings for the Maturity Assessment and development of Report)

9.2.2 W2: WAMP - Service Levels

GLWA Owner: Enterprise Asset Management Group (EAMG)

Alignment to SAMP Improvement Initiatives:

- S1 - Refined Service Levels

Supporting Artifacts: Tier 1-3 PIs; LSIP Performance Metrics Dashboard; Monthly EGLE Operations Reports; Annual Statistical Reports for WTPs

Purpose

The purpose of this Tactical Recommendation is to create/refine service levels dashboards and performance targets.

Benefits

The benefit of this Tactical Recommendation is that it supports GLWA with refining service level objectives and performance targets in alignment with internal and external stakeholder expectations reflected in the SAMP to create the line-of-sight for performance tracking.

Context and Background

During development of the WAMP, it was identified that GLWA does not have detailed service levels and identified targets fully defined by service area, in alignment with internal and external stakeholder expectations. However, while the WAMP was being developed, GLWA has been actively working to define more detailed service level metrics and improve performance tracking. The metrics and service level targets for vertical assets are reflected in the Tier 1-3 PIs for vertical assets and metrics for linear assets are defined as part of the LSIP as described in Chapter 3 – Service Levels, of the WAMP.

Service levels are typically organized in a hierarchy reflected in Figure 9-2 and included in the SAMP. Identifying targets for each can be used to drive planning processes to understand the impact on costs (and prices/charges).

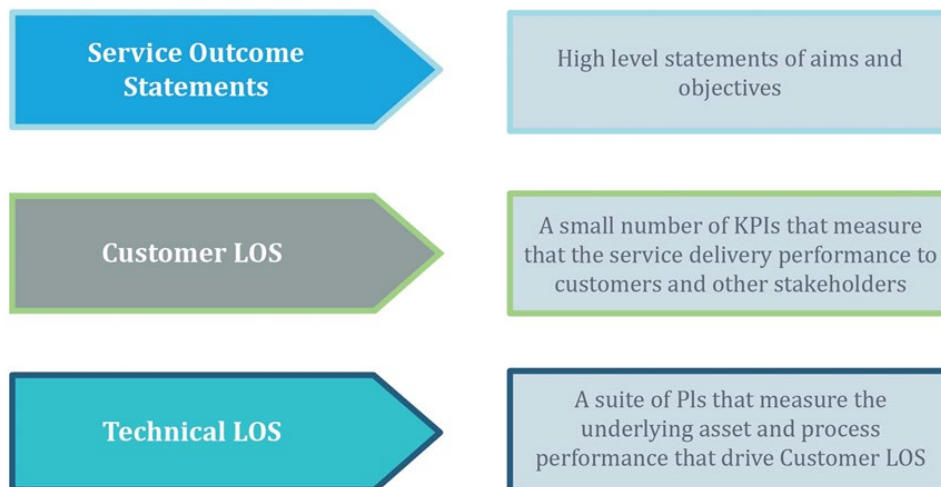


Figure 9-2: Industry Standard Service Levels Hierarchy

Note: LOS = Levels of Service; PI = Performance Indicators; KPIs = Key Performance Indicators

Customer service levels are at the heart of the performance measurement framework. A useful method for developing customer service levels is to consider the six universal

customer values reflected in Table 9-4. These are intended to be used as a series of prompts rather than a rigid template.

Table 9-4: Universal Customer Values

Universal Customer Values	
Accessibility	The ease of access to services such as the quantity per capita, proximity and allowance for customer of different abilities to access and use a service provided by the asset owner.
Reliability/Availability	The service is available as advertised. Often measured as interruptions, delays and reductions to service.
Quality	The quality of the service delivery provided by the asset owner. Meeting functional and aesthetic needs.
Customer Service	The interaction between staff and customers.
Safety	Providing a safe environment for staff and customers.
Sustainability	Environmental sustainability goals such as waste minimization, resource recovery, water/land/air pollution and greenhouse gas emissions.

Suggested Performance Indicators

Customer Water Pressure Service Levels

During development of the WAMP, it was identified that GLWA does not have detailed service levels and identified targets fully defined for water pressure service levels. The data may already exist through the Booster Station team but will need to be captured and conveyed in a dashboard format, with “drill down” capabilities by wholesale customers (of which there are many) to see specifics where service gaps exist. Metrics could be shown as overall compliance with customer pressure requirements (% compliance each day/month/quarter/year), variance from requirements, etc.

Customer Water Supply Service Levels

During development of the WAMP, it was identified that GLWA does not have detailed service levels and identified targets fully defined for water supply service levels. The data may already exist through the Monthly Operating Reports submitted to the state by each water treatment plant but will need to be captured and conveyed in a dashboard format, with “drill down” capabilities by service areas for each plant to see specifics where service gaps exist. This will also need to be combined with the linear asset teams to identify line breaks that create service interruptions. Metrics could be shown as overall compliance with customer supply requirements (% compliance each day/month/quarter/year), variance from requirements, etc.

Table 9-5: Tasks to Support Implementation

Year and Task
<p>Year 1 – Develop Service Level Framework</p> <ul style="list-style-type: none"> ▪ Collate existing relevant material for GLWA’s Water service levels (including Mindmaps and American Water Works Association (AWA) measures) ▪ Collect water service level examples from other jurisdictions ▪ Meet to discuss the current overall framework for service levels and discuss the following topics: <ul style="list-style-type: none"> ✓ A tiered approach that considers service outcome statements, customer service levels and technical service levels ✓ The use of universal customer values in establishing customer service levels ✓ Improvements based on other jurisdictions ✓ Consider adding performance metrics listed below to the State Operations Reports that include metrics about meeting disinfection goals, turbidity goals, EGLE, AWOP, fluoridation and corrosion control– see and coordinate with Tactical Recommendation W3-Asset Data and Information). <ul style="list-style-type: none"> ○ Customer Water Pressure Service Levels. ○ Customer Water Supply Service Levels. ▪ Meet with leadership to: <ul style="list-style-type: none"> ✓ Define service outcome statements and a succinct set of customer service levels aligned to internal and external stakeholder expectations ▪ Refine Tier 1-3 PIs based on input from leadership ▪ Define required data to incorporate refinements to the service levels.
<p>Year 2 – Improve Data to Report on Service Levels</p> <ul style="list-style-type: none"> ▪ Define cost effective strategies to improve datasets (incorporate into Tactical Recommendation W3: WAMP - Asset Data and Information as needed).
<p>Year 3 – Develop Targets for Customer Service Levels</p> <ul style="list-style-type: none"> ▪ Establish preliminary targets for customer service levels (and a selection of technical service levels).

Table 9-6: Resource Requirements for W2 WAMP Service Levels

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
200 hours (10 staff at 10 hours each; 50 hours of one staff to facilitate compilation of metrics; 50 hours of one staff create initial baseline of data)	\$0	20 hours (5 staff, 2, 2-hour meetings)	\$0	50 hours (10 staff at 5 one-hour meetings)	\$0

9.2.3 W3: WAMP - Asset Data and Information

GLWA Owner: Data Stewards

Alignment to SAMP Improvement Initiatives:

- D1 - AM Information System Strategies
- D6 – Asset Audit Program with Tagging Standards

Supporting Artifacts: WAMP – Asset Data and Information Improvements Summary (Appendix C); WAMP – Asset Data and Information Improvements Tracker (Appendix D); WAMP- Governance Business Processes (Appendix M)

Purpose

The purpose of this Tactical Recommendation is to actively work to address identified data improvement needs and implement strategic business processes to improve data quality and improve confidence in data integrity.

Benefits

The benefit of this Tactical Recommendation is that it addresses data improvement needs to track service level objectives and provide asset management information that improves staff decision making.

Context and Background

The WAMP – Asset Data and Information Improvement Summary is the result of an assessment performed in 2022 by reviewing gathered documentation as part of development of the WAMP. Table 9-7 summarizes the completeness and quality of the data sets that were reviewed in March – May of 2022. A resulting WAMP – Asset Data and Information Improvement Summary is listed in Appendix C and the WAMP - Asset Data and Information Improvement Tracker to support implementation of this Tactical Recommendation is described in Appendix D.

Table 9-7: Asset Data and Information Improvement Opportunities (based on 2022 Q1 review)

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
Asset hierarchy	Oracle WAM	Excellent	Complete	Updated via WAMP Development 2022
Condition Data	WAMP - Condition Assessment Spreadsheet for Vertical Assets	Good	Incomplete	Updated via WAMP Development 2022 - Condition assessment was only ~1/3 of the assets in 2022.

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
Preventive maintenance history	Oracle WAM	Excellent	Complete	None
Major maintenance history	Oracle WAM	Excellent	Complete	None
Monthly Operating Report (MOR)	Water Works Park WTP	Poor	No Data	All
	Northeast WTP	Poor	No Data	All
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All
	Springwells WTP	Poor	No Data	All
Facility Operating Plans	Water Works Park WTP	Poor	No Data	All
	Northeast WTP	Poor	No Data	All
	Lake Huron WTP	Fair	Incomplete	Overall operating strategy not available, but good SOPs
	Southwest WTP	Poor	No Data	All
	Springwells WTP	Poor	No Data	All
	Booster Stations	Excellent	Complete	None
Facility O&M Budgets	Water Works Park WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs
	Springwells WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs
	Booster Stations	Fair	Incomplete	Utilities and maintenance costs only - need asset values

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
Facility Staffing and Training Information	Water Works Park WTP	Poor	No Data	All – in alignment with other WTPs
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All – in alignment with other WTPs
	Springwells WTP	Poor	No Data	All – in alignment with other WTPs
	Booster Stations	Excellent	Complete	None
Facility Capital Plans	Water Works Park WTP	Excellent	Complete	None
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Excellent	Complete	None
	Springwells WTP	Excellent	Complete	None
	Booster Stations	Excellent	Complete	None
Reliability Data	Oracle WAM	Fair	Incomplete	Needs to be updated from 2022 analysis
Performance Data	Oracle WAM	Excellent	Incomplete	PI's and KPI's in place are excellent but several more required to meet SAMP and WAMP objectives including: Customer Water Service Pressure Levels; Customer Water Supply Service Levels; Water Production Demand Changes;

Table 9-8: Tasks to Support Implementation

Year and Task
<p>Year 1 – Confirm Data Collection Needs & Address Year 1 – “Priority 1”</p> <ul style="list-style-type: none"> ▪ Review and define data owner roles & responsibilities, including overseer/reporter of Water asset data collection and quality control progress. ▪ Establish business processes for performing asset data collection and processing activities for Year 1 as “Priority 1.” ▪ Implement asset data collection activities identified in Year 1 as “Priority 1” in the WAMP -Asset Data and Information Improvement Tracker (Appendix D). ▪ Initiate dashboard/reporting on new asset data
<p>Year 2 – Collect Data to Address Data Improvement Needs Identified in Year 2 – “Priority 1 & Priority 2”</p> <ul style="list-style-type: none"> ▪ Evaluate data collection performance from Year 1 and set goals for performance for Year 2 ▪ Establish business processes for performing asset data collection and processing activities for Year 2. ▪ Implement asset data collection activities identified in Year 2 as “Priority 1 (if not completed the previous year) & Priority 2” in the WAMP -Asset Data and Information Improvement Tracker (Appendix D). ▪ Initiate dashboard/reporting on new asset data
<p>Year 3 – Collect Data to Address Data Improvement Needs Identified in Year 3</p> <ul style="list-style-type: none"> ▪ Identify new asset data that needs to be collected. ▪ Establish business processes for performing asset data collection and processing activities for Year 3. ▪ Implement asset data collection activities identified in Year 3 as “Priority 2” in the WAMP -Asset Data and Information Improvement Tracker (Appendix D). ▪ Initiate dashboard/reporting on new asset data

Table 9-9: Resource Requirements for W3 WAMP Asset Data and Information

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
150 hours (5 staff at 10 hours each to participate in five, 2-hour meetings; 100 hours for 2 staff (50 hours each) to address needs)	\$0	150 hours (5 staff at 10 hours each to participate in five, 2-hour meetings; 100 hours for 2 staff (50 hours each) to address needs)	\$0	10 hours (5 staff at 2 hours each to participate in two, 1-hour meetings)	\$0

9.2.4 W4: WAMP - Digital Solutions

GLWA Owner: Data Stewards

Alignment to SAMP Improvement Initiatives:

- D1 – AM Information System Strategies
- D3 – Consistent Data Standards
- D7 – Useful Life of Assets
- O1 – Asset Management Plans

Supporting Artifacts: GLWA IT Master Plan

Purpose

The purpose of this Tactical Recommendation is to support GLWA with improving the use and configuration of technologies that support staff with performing work, entering critical data, and displaying data in concise reports/dashboards.

Benefits

The benefit of this Tactical Recommendation is that it supports GLWA with tracking Asset Management Program performance and readily display data to staff to support staff with day-to-day asset management decision-making.

Context and Background

During development of the WAMP, GLWA staff described business processes/activities followed to perform asset management activities and their use of existing technology. These business processes/activities were compared to other asset management focused organizations and improvements for GLWA were identified.

Table 9-10: Tasks to Support Implementation

Year and Task
<p>Year 1 – Configure NexGen to Display Key Data to Inform Asset Management Decision-Making</p> <ul style="list-style-type: none"> ▪ Create a data field in NexGen to display asset risk scores that are visible to operations and maintenance (O&M) staff. ▪ Configure NexGen to support roll-out and track Condition Assessment Program activities. ▪ Determine/finalize service level dashboard platforms that can be viewed by internal and external stakeholders to report performance aligned to service levels. Consider adding performance metrics listed in the WAMP - Asset Data and Information Improvement Summary (Appendix C) – see and coordinate with Tactical Recommendation W3-WAMP - Asset Data and Information and Tactical Recommendation W2-WAMP - Service Levels).
<p>Year 2 – Integrate NexGen with Core Technologies and Additional Technologies</p> <ul style="list-style-type: none"> ▪ Integrate NexGen to GLWA’s Project Management Information System (PMIS) to support asset onboarding and improved analytics across the asset lifecycle. ▪ Align asset hierarchies between NexGen and the financial system to improve asset valuation reporting. ▪ Create a work plan to move the WAMP into a digital format (linking all data sources and asset management strategies to provide information to staff and support workflow) ▪ Investigate the use of a laboratory information management system (LIM) system and short list options
<p>Year 3 – Convert WAMP to Digital Format</p> <ul style="list-style-type: none"> ▪ Implement the work plan to move the WAMP into a digital format. ▪ Implement the use of a LIMs

Table 9-11: Resource Requirements for W4 WAMP – Digital Solutions

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
40 hours (10 staff at four, 1-hour meetings)	\$75,000 (to configure NexGen to allow risk scores; populate NexGen with condition assessment work orders and create the service level dashboard)	60 hours (10 staff at three, 2-hour meetings – one meeting per task activity)	\$75,000 (to configure the integration with PMIS)	50 hours (5 staff at 10 hours each; over five, 2-hour meetings)	\$75,000 (to create the Asset Management Plan in a digital format)

9.2.5 W5: WAMP - Condition Assessment of Non-Inspected Vertical Assets

GLWA Owner: Local Asset Management Group (Local AM Group)

Alignment to SAMP Improvement Initiatives:

- R8 – Condition Assessment Program for Vertical Assets

Supporting Artifacts: WAMP - Condition Assessment Activities – Vertical Assets (Appendix F)
WAMP – Governance Business Processes (Appendix M)

Purpose

The purpose of this Tactical Recommendation is to perform asset condition assessment activities on all vertical assets based on defined priorities defined over a three-year period. Condition assessment priorities for linear assets are documented by LSIP.

Benefits

The benefits of this Tactical Recommendation include promoting better understanding of deterioration rates by vertical asset types, enhancing the management and prioritization of maintenance tasks, and support identification of asset renewal needs.

Context and Background

Condition assessment scheduling is based on non-inspected “active” WTP and Booster Station assets listed in the WAMP - Risk Register for Vertical Assets that received a tabletop analysis for identifying condition. Chapter 4 – Asset Profile and Chapter 5 – Asset Risk of the WAMP describe the approach and process to identifying assets for condition assessment and developing asset risk scores for vertical assets. Those that had a consequence of failure (COF) score equal to 4 or 5 were classified as “Priority #1 Condition Assessment” and scheduled to be assessed in Year 1. The remaining non-inspected assets were classified as “Priority #2 Condition Assessment” and scheduled based on location and workload leveling over the three years with assets having the highest likelihood of failure (LOF) scores being completed first. Condition assessment activities for linear assets are documented in LSIP.

The recommended condition assessment schedule details are contained in the WAMP - Condition Assessment Activities – Vertical Assets spreadsheet included in Appendix F. The spreadsheet indicates the recommended approach to assessing asset condition as either “visual” or “detailed.” The recommended approach is based on the level of assessment performed as part of the WAMP development on similar asset types. In general:

- All high COF assets (with scores of 4 or 5) were labeled as Priority #1 Condition Assessment. Priority #1 assets are to be addressed in Year 1.

- The remaining assets were labeled as Priority #2 Condition Assessment. Priority #2 assets are to be addressed in Year 1, Year 2 and Year 3 based on LOF scores, with the assets having the highest LOF scores being completed first.

Figure 9-3 and Figure 9-4 show the distribution of needed condition assessment counts by Priority #1 or Priority #2 based on 2021 assessment data for WTPs and the Booster Stations. Figure 9-5 and Figure 9-6 shows counts of condition assessments to perform by year for WTPs and Booster Stations, over a three-year period.

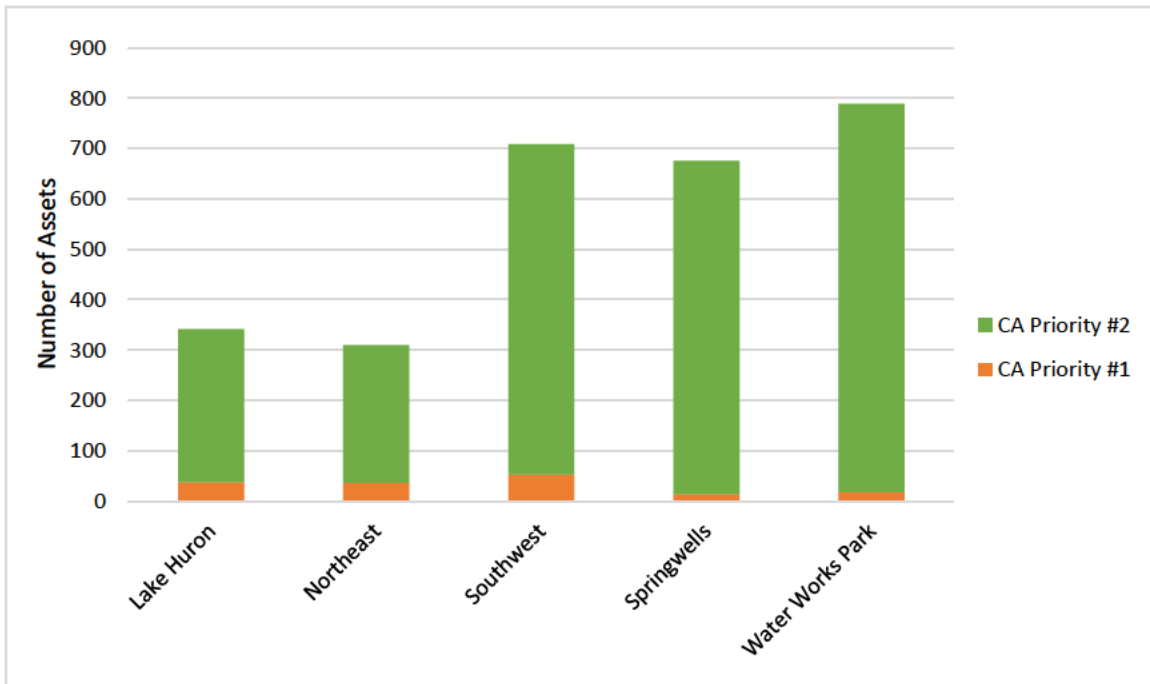


Figure 9-3: Count of Condition Assessments for WTP by Priority (based on 2021 data)

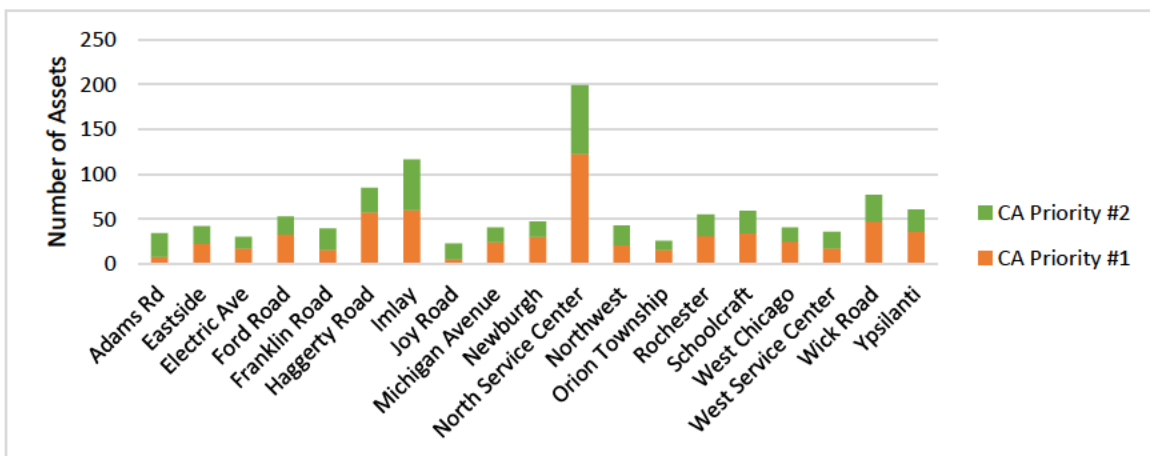


Figure 9-4: Count of Condition Assessments for Booster Stations by Priority (based on 2021 data)

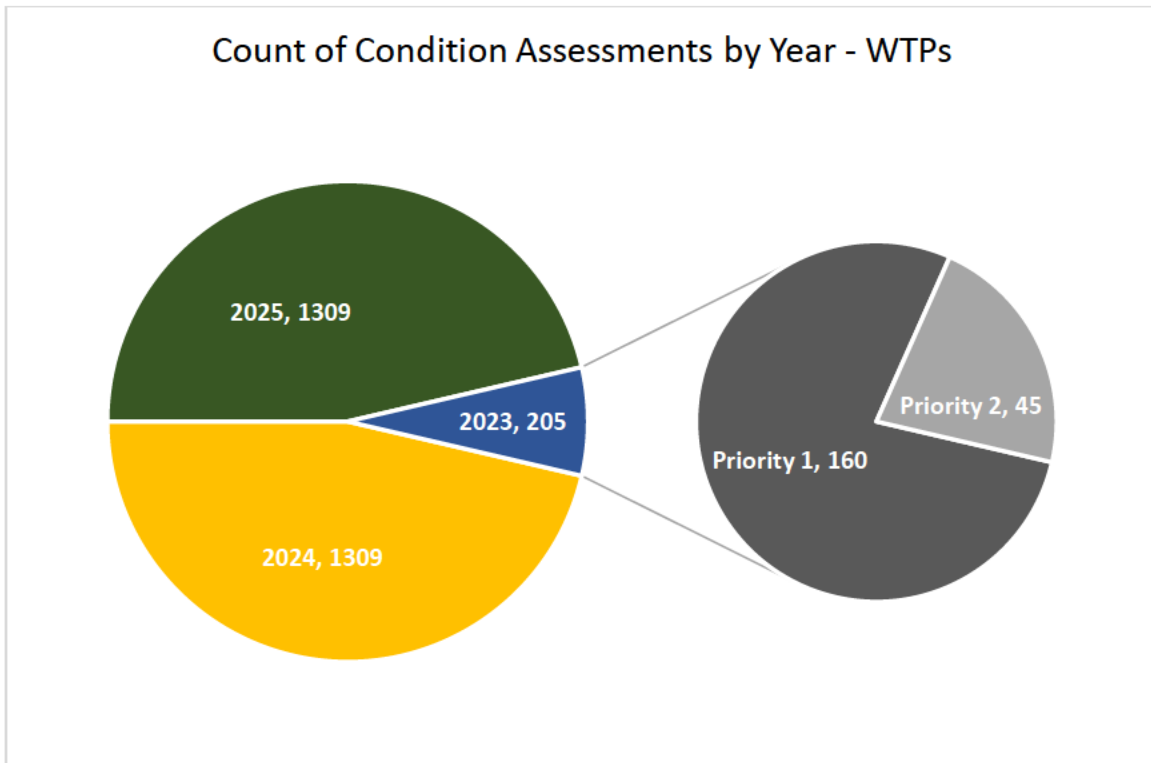


Figure 9-5: Count of Condition Assessments for WTPs by Priority (based on 2021 data)

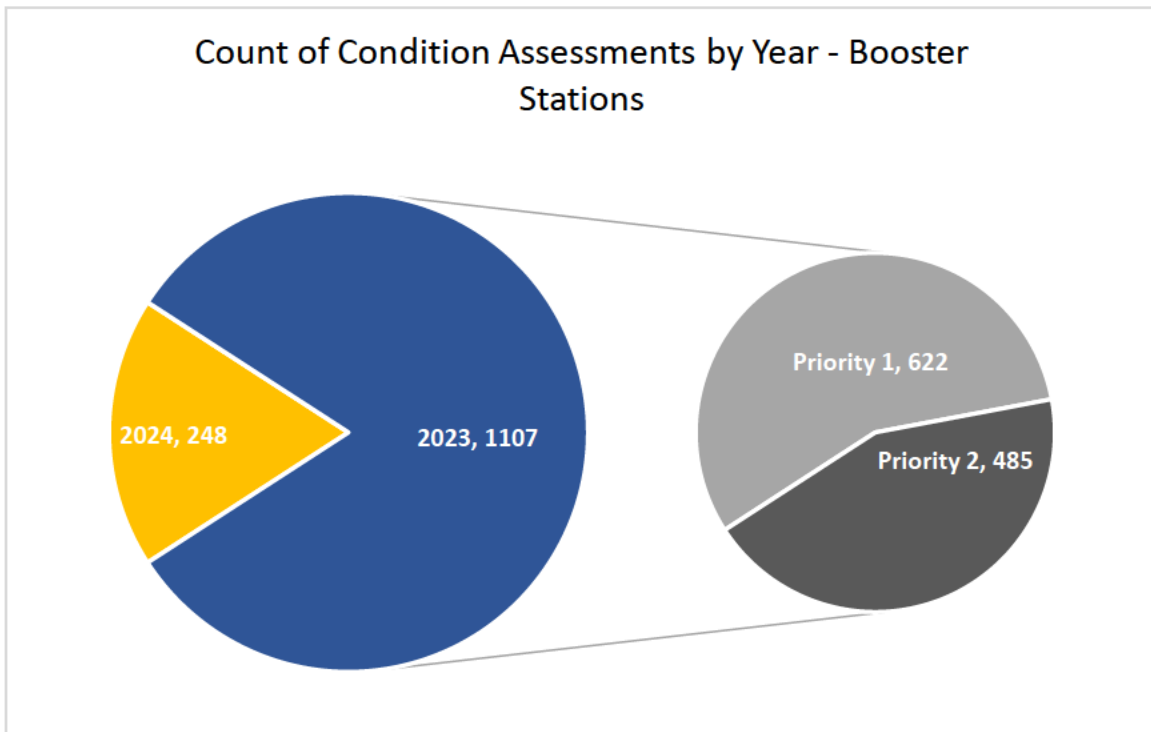


Figure 9-6: Count of Condition Assessments by Year - Booster Stations (based on 2021 data)

Table 9-12 and Figure 9-7 through Figure 9-9 show the distribution of visual and detailed condition assessments (by WTP process area and Booster Stations over a three-year period). Assets that received a visual condition assessment in 2021 are not reflected.

Asset types recommended for detailed assessments include DRIVE-ELEC, MCC, and PUMP. A detailed assessment requires the asset to be actively running and/or involves special instrumentation in addition to visual inspection. Examples of detailed assessment condition properties include infrared delta-T, insulation resistance, vibration analysis, volt and amp balance, and functionality of valves, control lights, and switches.

Table 9-12: Summary of Vertical Asset Condition Assessments

Asset Type	Year 1 – Priority 1&2		Year 2 – Priority 2		Year 3 – Priority 2
	Detailed	Visual	Detailed	Visual	Visual
Lake Huron WTP	32	51	4	239	16
Northeast WTP	8	29	22	216	34
Southwest WTP	2	51	44	611	0
Springwells WTP	2	12	19	139	504
Water Works Park WTP	9	9	15	0	755
Booster Stations	208	899	0	0	0
Total	1312		1309		1309

Figure 9-7 includes all Priority #1 and a portion of Priority #2 assets recommended for performing visual and detailed condition assessments in the first year. A high proportion of assets at the water Booster Stations are included due to these assets having a high COF.

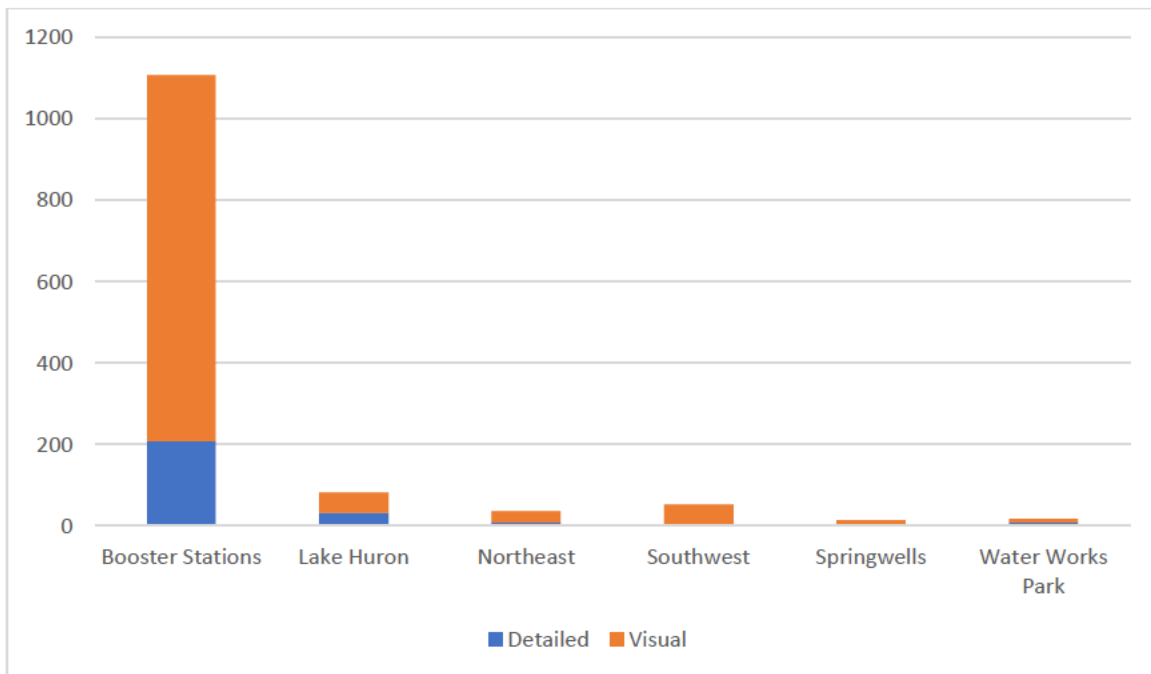


Figure 9-7: Priority 1 and 2 Condition Assessments - Year 1 (based on 2021 data)

Figure 9-8 indicates all the Priority #2 assets recommended for performing visual and detailed condition assessments is in second year. This contains a high proportion of assets at Southwest WTP due to these assets having a high COF.

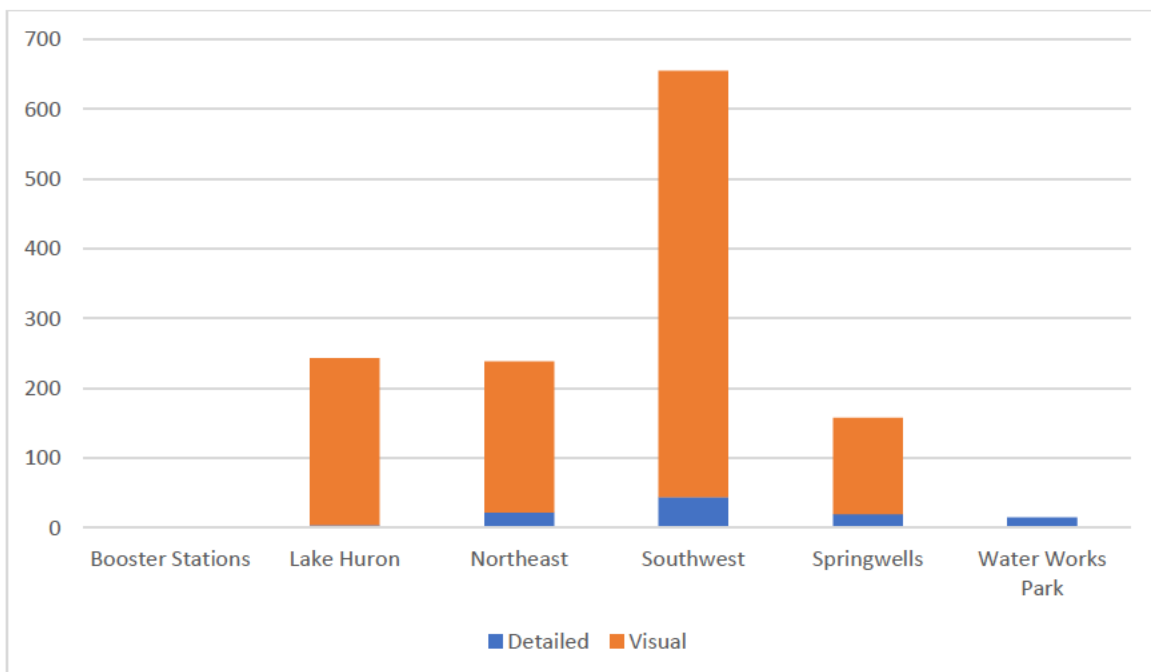


Figure 9-8: Priority 2 Condition Assessments - Year 2 (based on 2021 data)

Figure 9-9 indicates the Priority #2 assets recommended for performing visual condition assessments in the third year. There are no detailed condition assessments as all the assets recommended for these were included in the first two years. The remaining assets for visual condition assessments have a high LOF but lower compared to other identified for previous years.

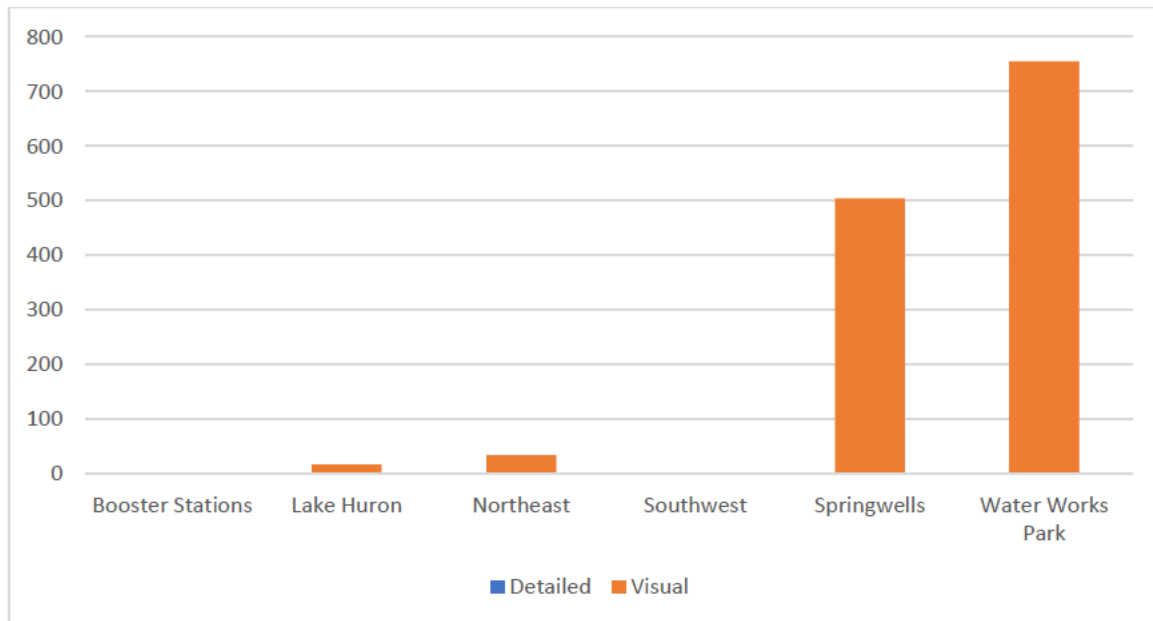


Figure 9-9: Priority 2 Condition Assessments - Year 3 (based on 2021 data)

Table 9-13: Tasks to Support Implementation

Year and Task
<p>Year 1 – Perform Priority #1 and Priority #2 Condition Assessments – Year 1</p> <ul style="list-style-type: none"> Review and confirm the condition assessment schedule for Year 1, as reflected in Condition Assessment Activities – Vertical Assets (Appendix F). Implement the condition assessment activities for Year 1.
<p>Year 2 – Perform Priority #2 Condition Assessments – Year 2</p> <ul style="list-style-type: none"> Review and confirm the condition assessment schedule for Year 2, as reflected in Condition Assessment Activities – Vertical Assets (Appendix F). Implement the condition assessment activities for Year 2.
<p>Year 3 – Perform Priority #2 Condition Assessments – Year 3</p> <ul style="list-style-type: none"> Review and confirm the condition assessment schedule for Year 3, as reflected in Condition Assessment Activities – Vertical Assets (Appendix F). Implement the condition assessment activities for Year 3.

Table 9-14: Resource Requirements for W5: WAMP Condition Assessment of Non-Inspected Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
400 hours (5 staff at 80 hours each; over a two-week period)	\$0	400 hours (5 staff at 80 hours each; over a two-week period)	\$0	500 hours (7 staff at 70 hours each; over a two-week period)	\$0

9.2.6 W6: WAMP - Asset Risk for Vertical Assets

GLWA Owner: Local Asset Management Group (Local AM Group)

Alignment to SAMP Improvement Initiatives:

- R5 – Asset Risk Identification and Analysis

Supporting Artifacts: WAMP - Risk Register for Vertical Assets (Appendix G); WAMP – Governance Business Processes (Appendix M); CIP (to help plan and understand risk mitigation)

Purpose

The purpose of this Tactical Recommendation is to further develop the asset risk profile included in the Risk Register for Vertical Assets, using improved condition data.

Benefits

The benefits of this Tactical Recommendation include refining the Risk Register for Vertical Assets results to prioritize staff decision-making around O&M and capital planning and consequently mitigate asset risk.

Context and Background

The vertical asset risk scores relied on tabletop analysis for determining approximately 65% of the vertical asset condition scores. The results are presented in Risk Register for Vertical Assets and described in Chapter 5 – Asset Risk of the WAMP. The COF scores were initially set by GLWA staff at the process level through tabletop analysis performed in October 2021, and then adjusted through multiple staff workshops. Using the data from the Risk Register for Vertical Assets, risk mitigation strategies were subsequently identified. As GLWA continues to collect asset data to identify LOF and COF, risk mitigation strategies can be continuously refined.

Each risk mitigation strategy is “triggered” by a respective numerical setpoint for affected criteria scores which is reflected in the Water - Risk Register for Vertical Assets. The setpoint represents the numerical value that is no longer acceptable in accordance with GLWA’s risk tolerance levels. A risk mitigation strategy should improve (or lower) the score below the setpoint. This is important to GLWA as the occurrence of risk events tend to cost more to manage once they occur, compared to implementing risk mitigation strategies to prevent them from occurring. The description of reduction in asset risk score per risk mitigation strategy is presented in Table 9-15 and the detailed decision-making flowchart for identifying risk mitigation strategies within the WAMP - Risk Register for Vertical Assets is presented in Figure 9-10, followed by a description of each. This methodology supports Section 6.4.1.3 – Risk Treatment and Appendix G – Asset Risk Process and Scoring Matrices, of the SAMP. *Note: The History of Reliability score is not yet being used by GLWA in the Water – Risk Register for Vertical Assets and is listed as an activity in Year 1 of this Tactical Recommendation.*

Table 9-15: Risk Mitigation Strategy Triggers and Effects

Set Point Trigger	Set Point Value	Risk Mitigation Strategy	Effect
Condition Score	≥4.0	Asset Replacement	Reduction of Condition score to a 1.
Consequence of Failure Score	≥3.5	Contingency Attenuation	Reduction of COF score by .5 points. Note: When setting up the WAMP - Risk Register for Vertical Assets, GLWA staff identified assets where redundancy is in place; COF scores were subsequently reduced by .5 points or as indicated by GLWA staff.

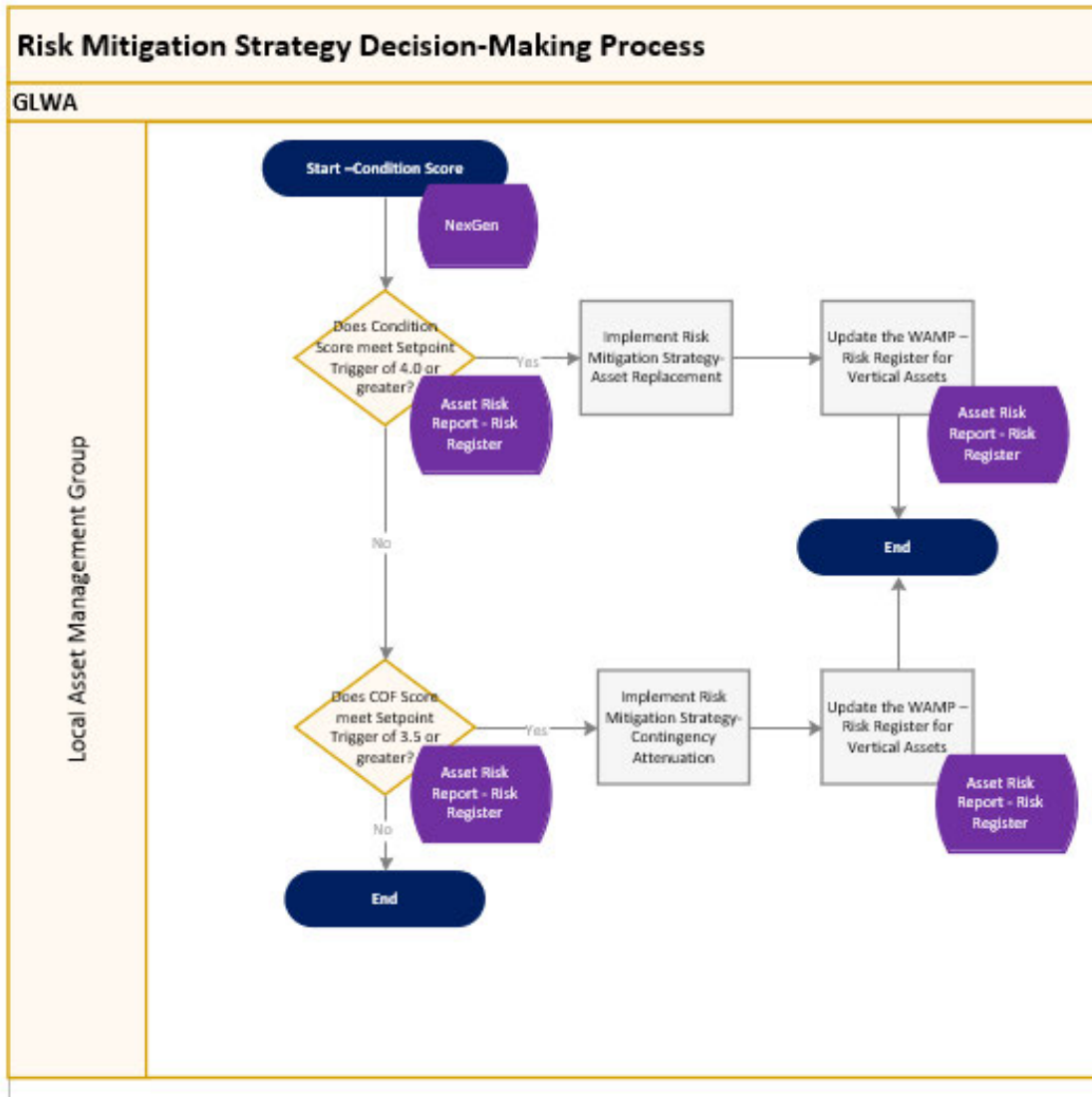


Figure 9-10: Risk Mitigation Strategy Decision-Making Process

Current risk mitigation strategies include:

Asset replacement - assets that received a visual or detailed condition score equal to 4 or higher were recommended for asset replacement. As condition scores are updated, asset replacement for risk mitigation can be continuously evaluated using the risk register tool. Assets with tabletop-analysis condition scores of 4 or higher are recommended for visual or detailed assessments over the next three years before scheduling asset replacement.

Contingency Attenuation - assets with a COF score of 3.5 or higher that received a visual or detailed assessment were recommended for contingency attenuation for risk mitigation. Contingency attenuation refers to minimizing the risk associated with asset failure. Examples of this strategy include development of an asset contingency plan or system

redundancy. Assets that have redundancy in place were adjusted in the WAMP - Risk Register for Vertical Assets down by .5 where no score adjustments were otherwise documented by GLWA reviewers. As with asset replacement, assets that received a tabletop-analysis for condition are recommended for a visual or detailed assessment before considering planning a project to reduce asset COF.

Figure 9-11 shows the combined WTP and Booster Stations asset risk scores (based on 2021 data) with and without risk mitigation in place. The figures showing “After Risk Treatment” are an ideal application of risk mitigation measures assuming unlimited resources and depending on GLWA’s application of risk mitigation over time, these figures can change. The volume of assets is represented by the bubble size and labeled with the number of assets. Green, yellow, and red chart backgrounds correspond to GLWA water risk tolerance: low, medium, and high, respectively. A detailed break-out by WTP and Booster Station are reflected in Figure 9-12 and Figure 9-13.

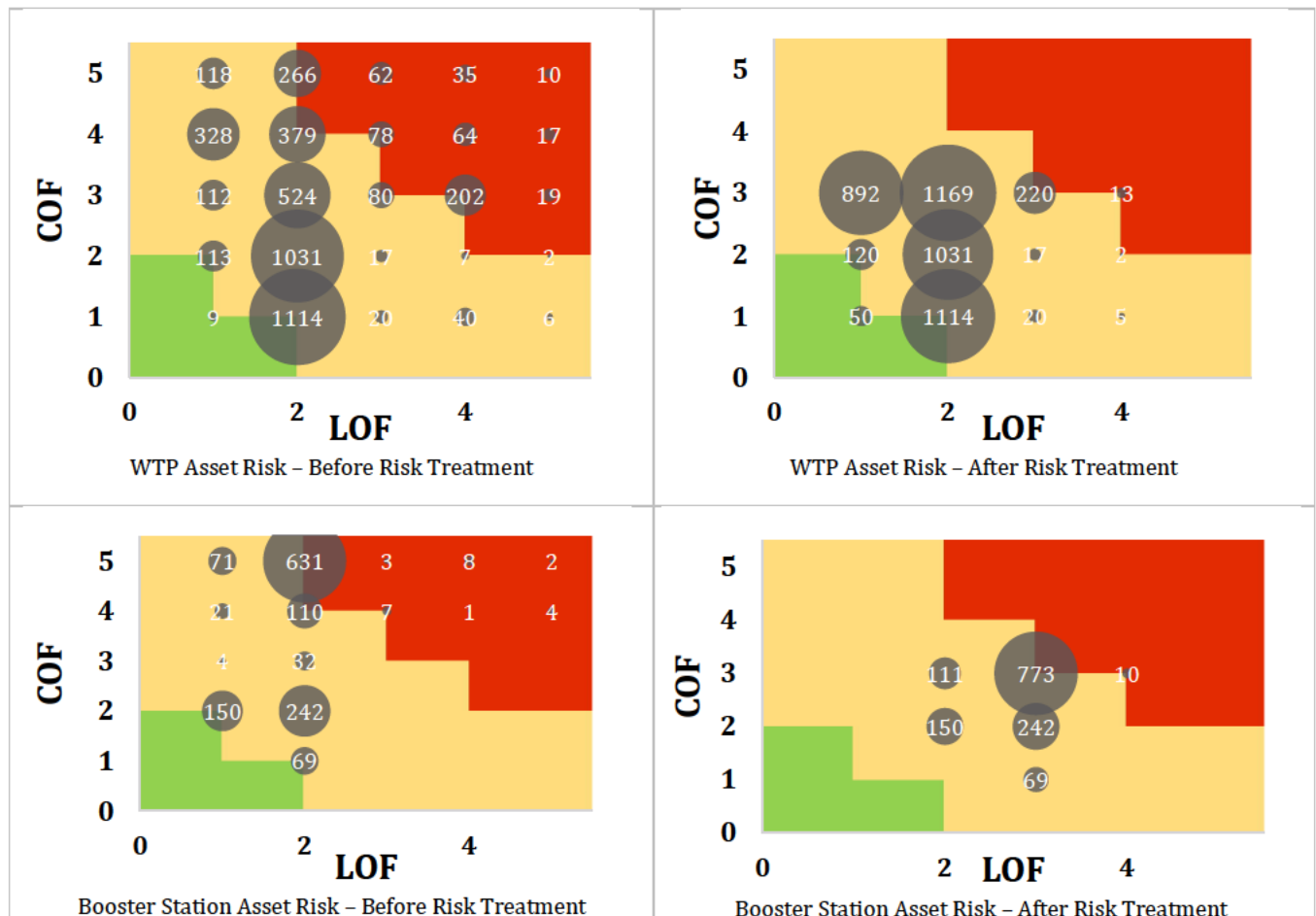
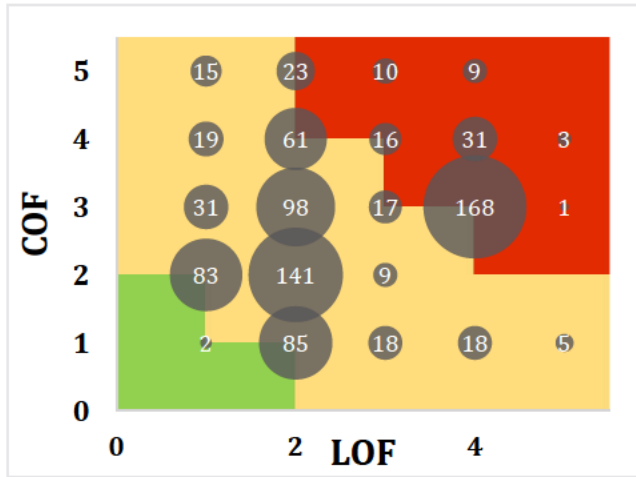
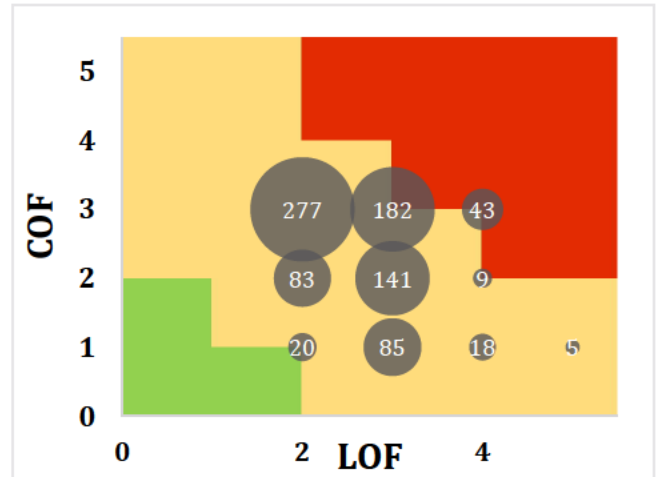


Figure 9-11: Vertical Asset Risk Before and After Risk Mitigation – Combined Scores

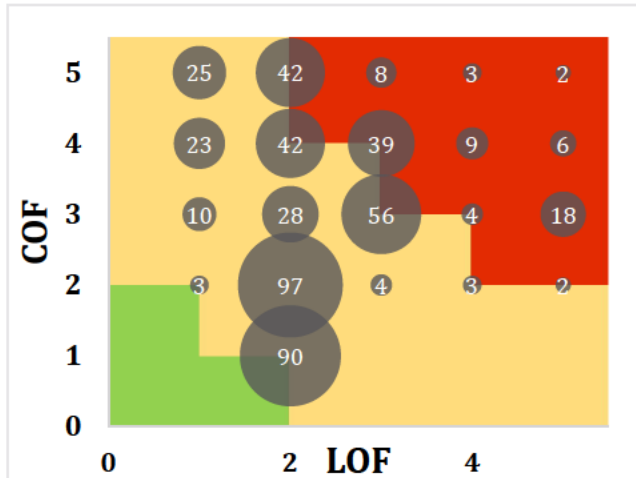
Figure 9-12, shown on the next page, displays the asset risk before and after mitigation for WTPs, based on 2021 data.



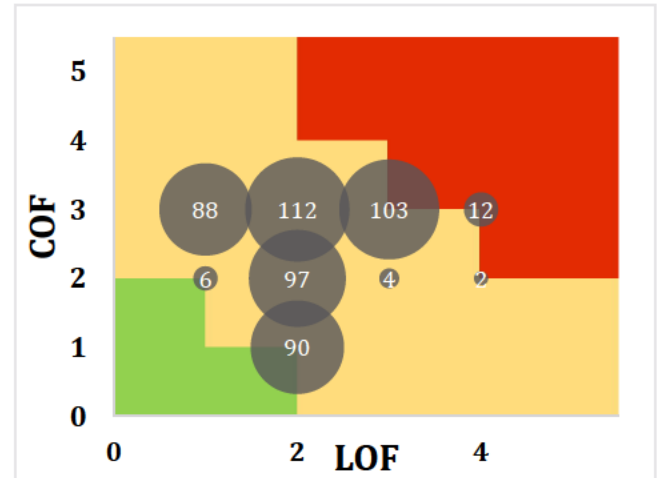
Lake Huron WTP Asset Risk - Before Risk Treatment



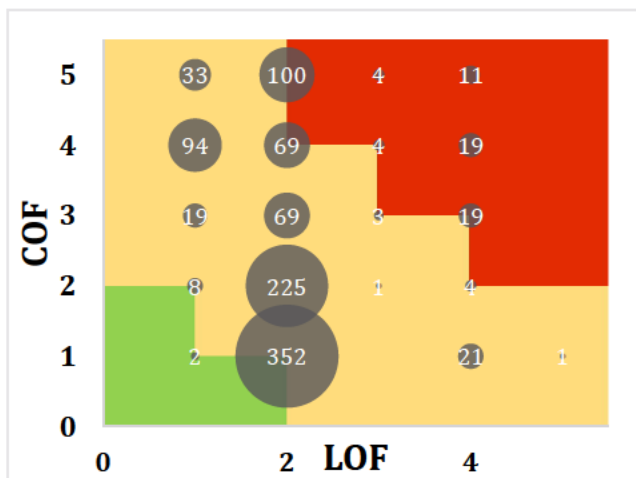
Lake Huron WTP Asset Risk - After Risk Treatment



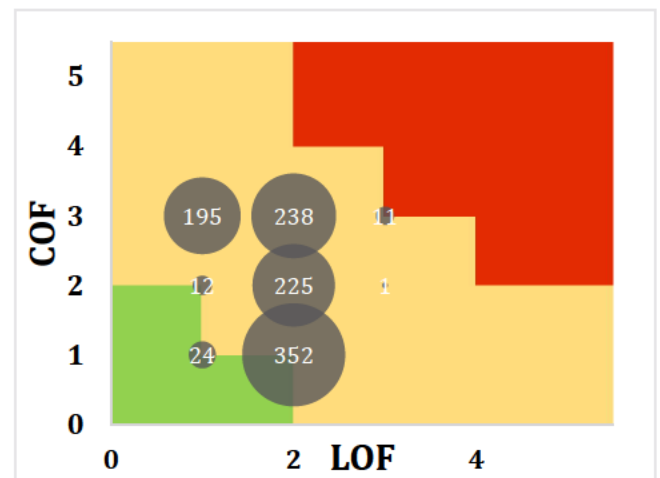
Northeast WTP Asset Risk - Before Risk Treatment



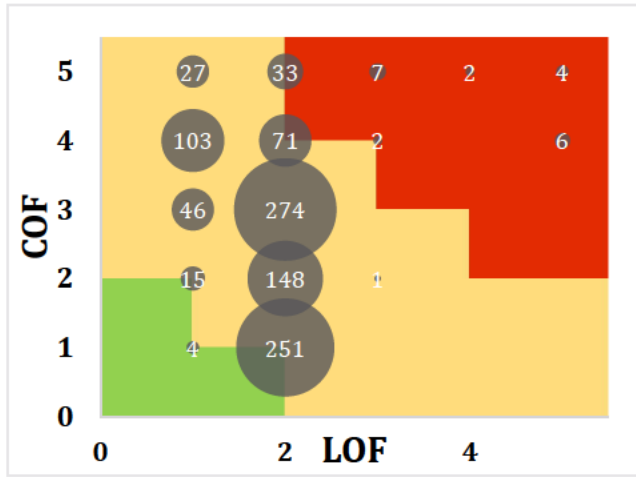
Northeast WTP Asset Risk - After Risk Treatment



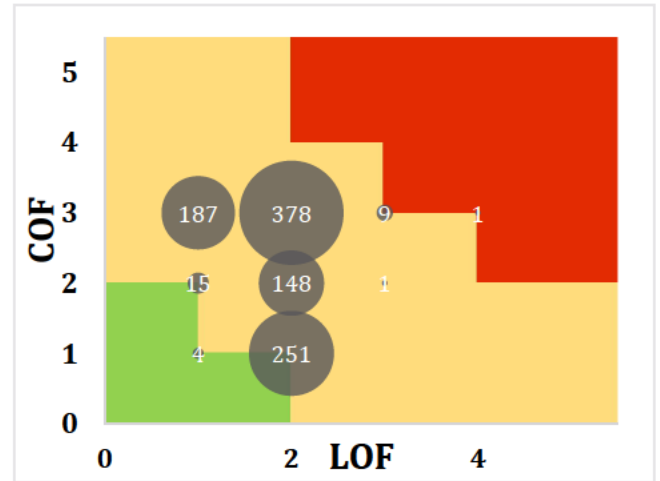
Southwest WTP Asset Risk - Before Risk Treatment



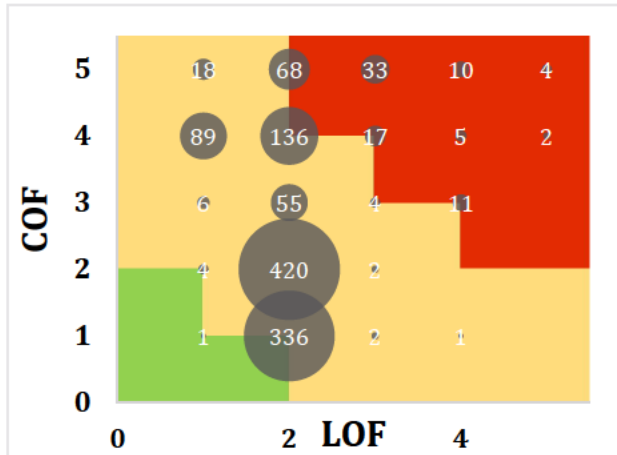
Southwest WTP Asset Risk - After Risk Treatment



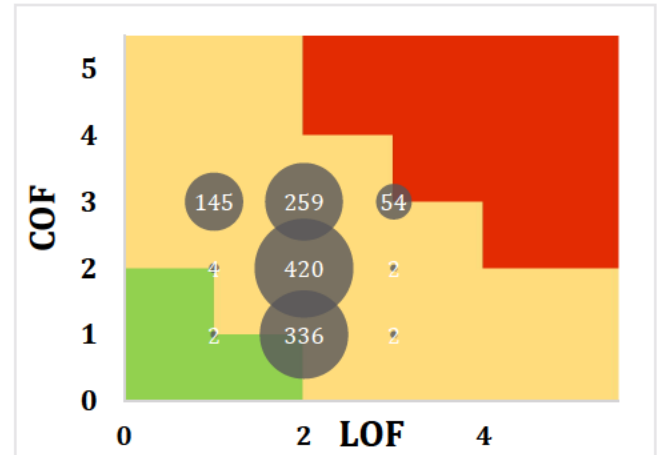
Springwells WTP Asset Risk - Before Risk Treatment



Springwells WTP Asset Risk - After Risk Treatment



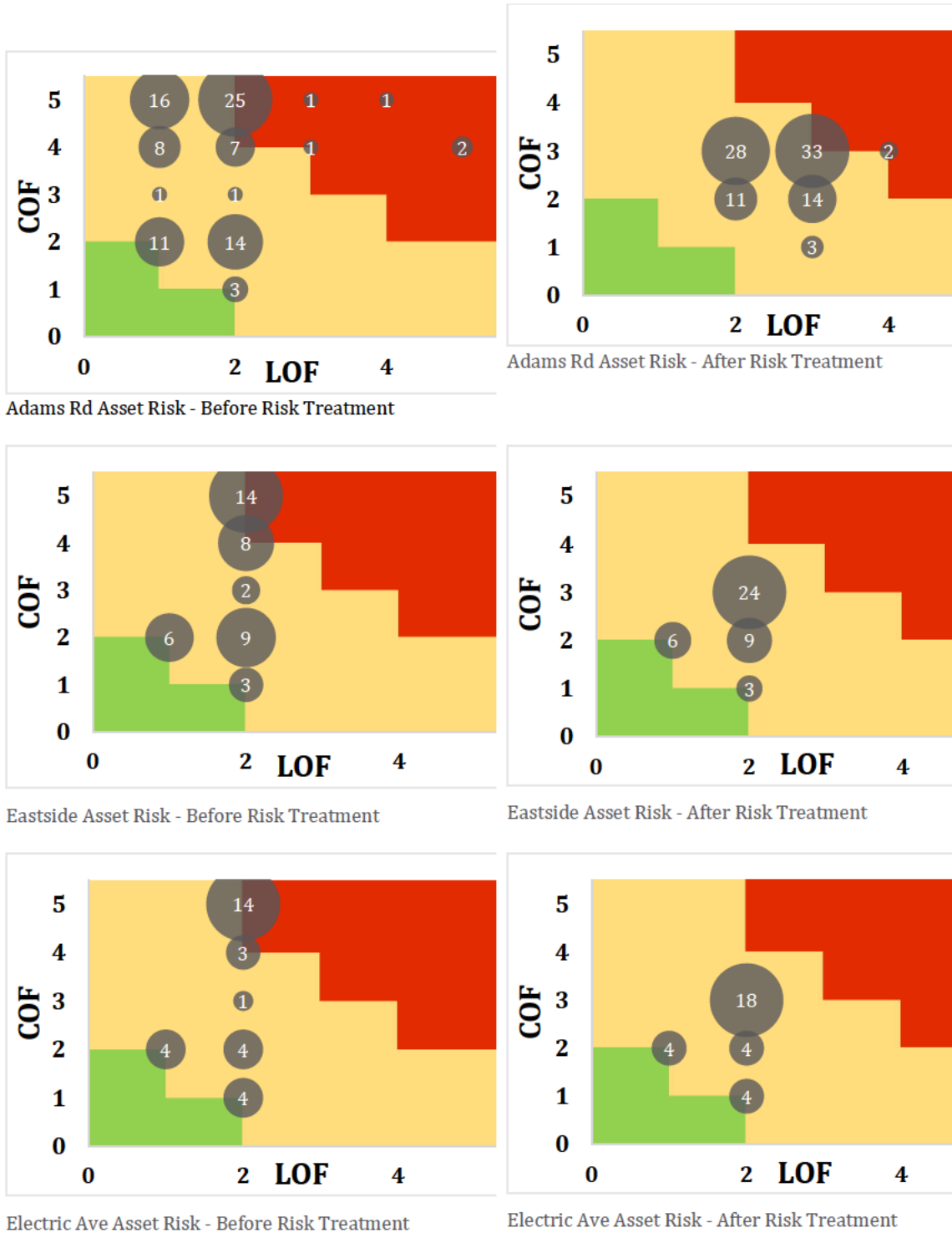
Water Works Park Asset Risk - Before Risk Treatment

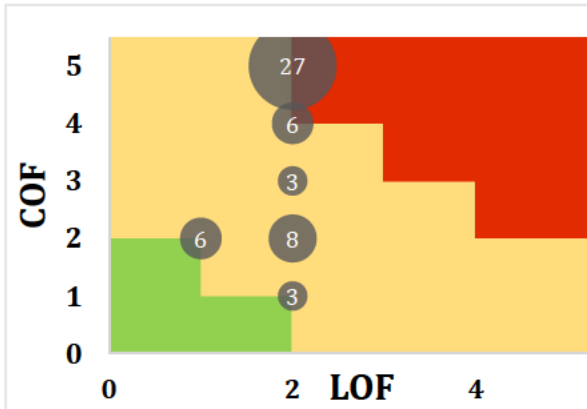


Water Works Park Asset Risk - After Risk Treatment

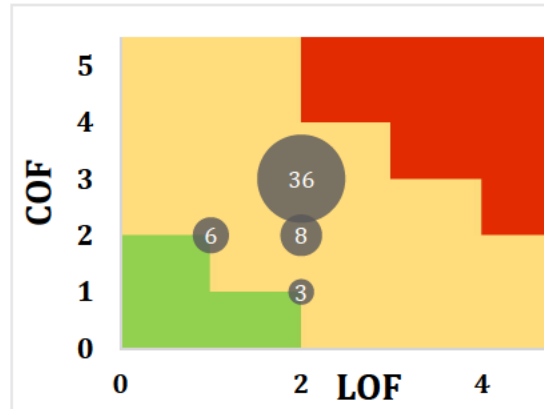
Figure 9-12: Asset Risk Before and After Risk Mitigation (based on 2021 data) - WTPs

Figure 9-13, shown below, shows the asset risk before and after risk mitigation (based on 2021 data).

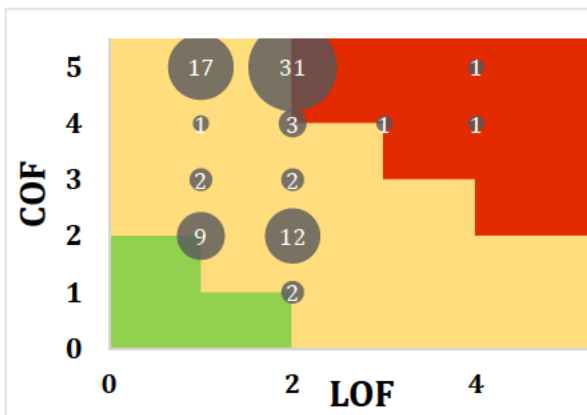




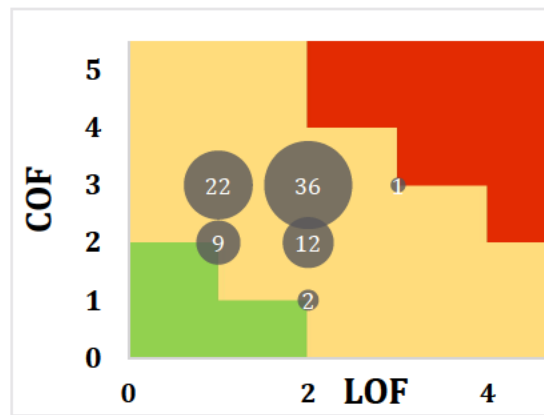
Ford Road Asset Risk - Before Risk Treatment



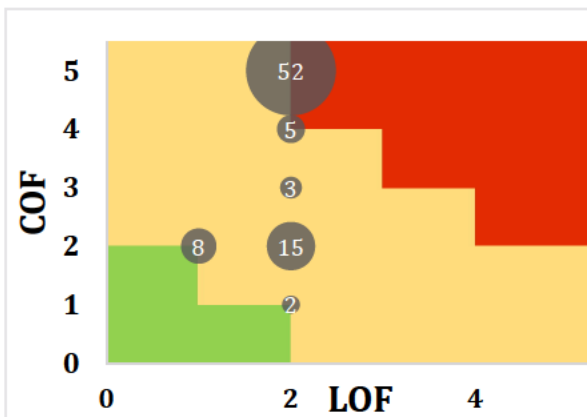
Ford Road Asset Risk - After Risk Treatment



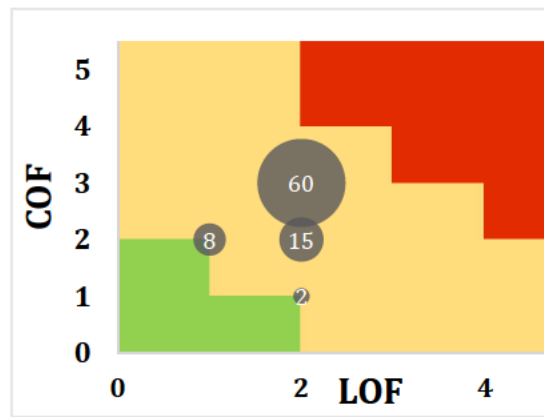
Franklin Road Asset Risk - Before Risk Treatment



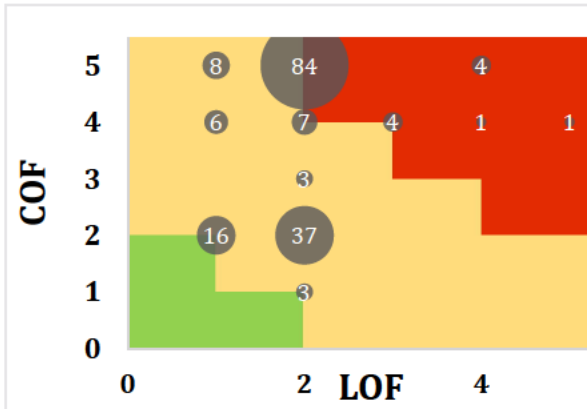
Franklin Road Asset Risk - After Risk Treatment



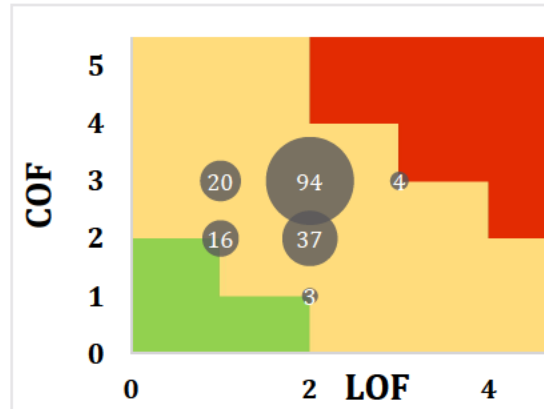
Haggerty Road Asset Risk - Before Risk Treatment



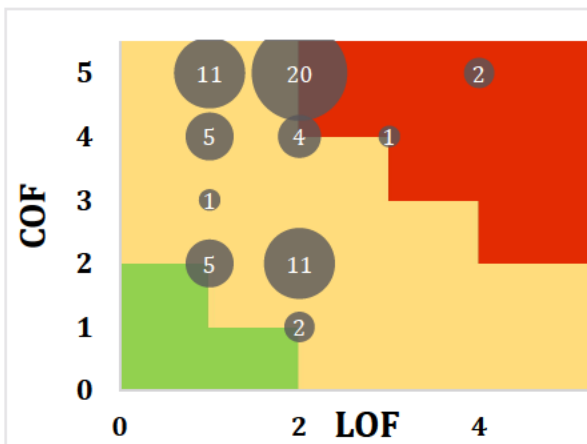
Haggerty Road Asset Risk - After Risk Treatment



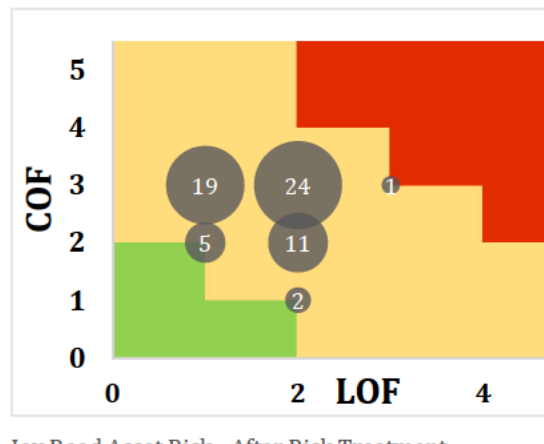
Imlay Asset Risk - Before Risk Treatment



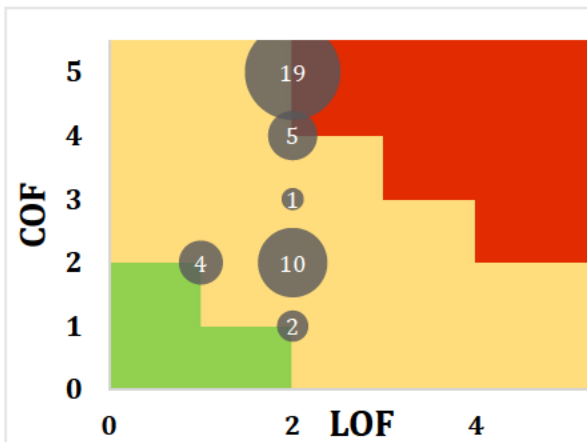
Imlay Asset Risk - After Risk Treatment



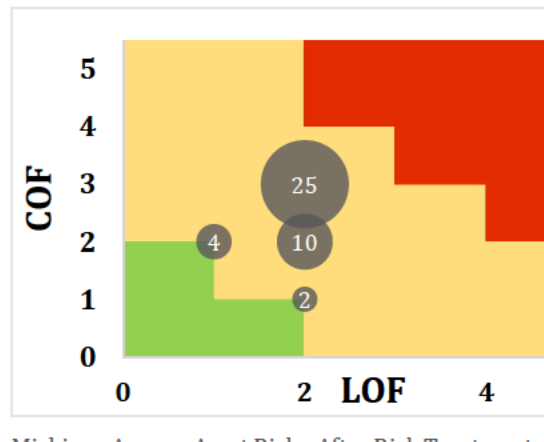
Joy Road Asset Risk - Before Risk Treatment



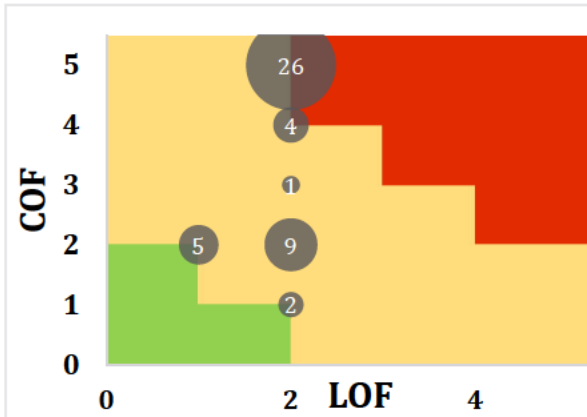
Joy Road Asset Risk - After Risk Treatment



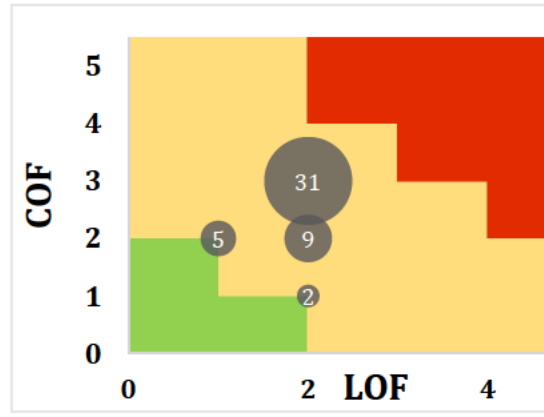
Michigan Avenue Asset Risk - Before Risk Treatment



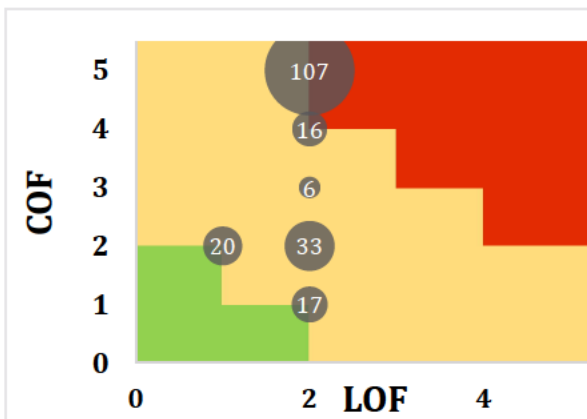
Michigan Avenue Asset Risk - After Risk Treatment



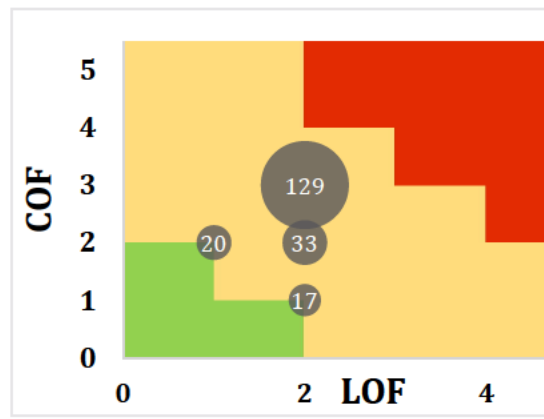
Newburgh Asset Risk - Before Risk Treatment



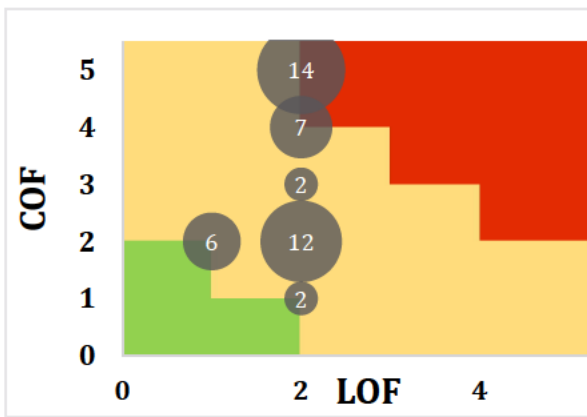
Newburgh Asset Risk - After Risk Treatment



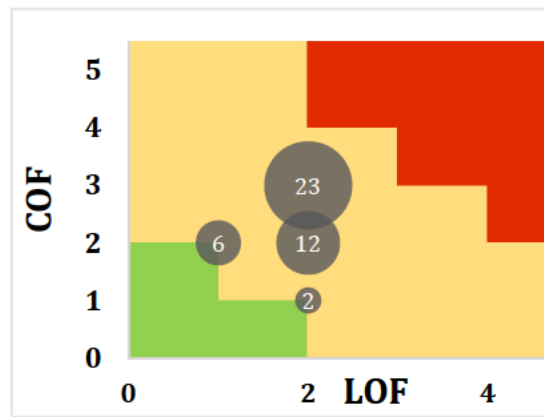
North Service Center Asset Risk - Before Risk Treatment



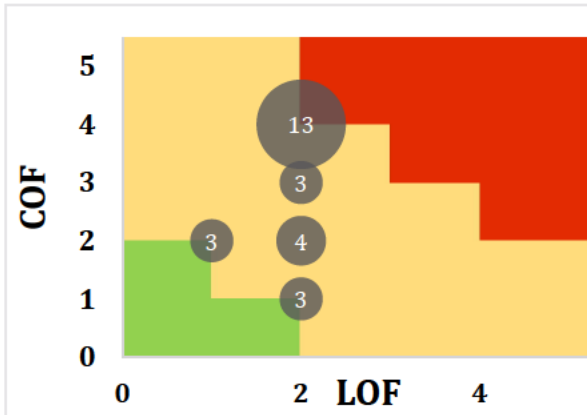
North Service Center Asset Risk - After Risk Treatment



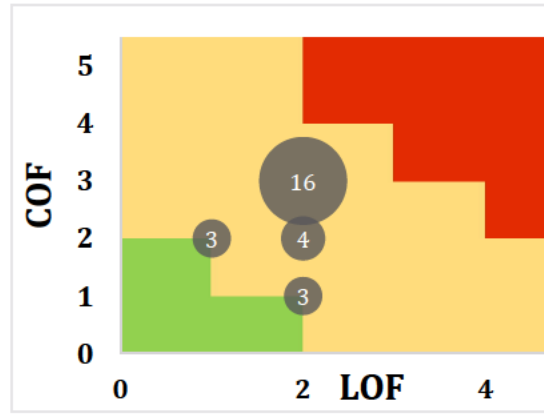
Northwest Asset Risk - Before Risk Treatment



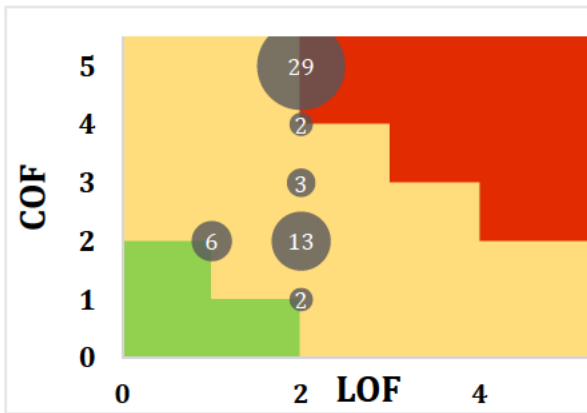
Northwest Asset Risk - After Risk Treatment



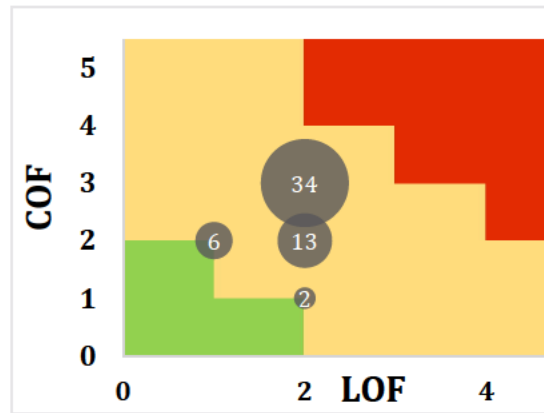
Orion Township Asset Risk - Before Risk Treatment



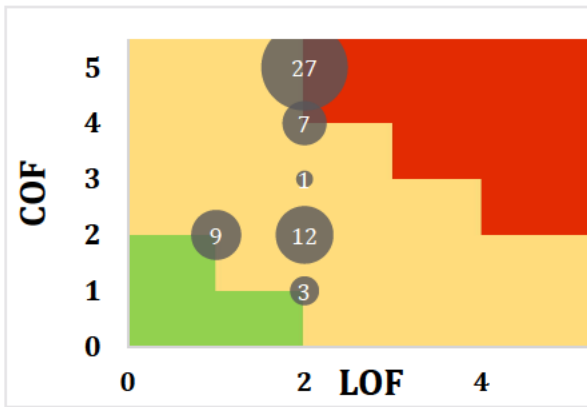
Orion Township Asset Risk - After Risk Treatment



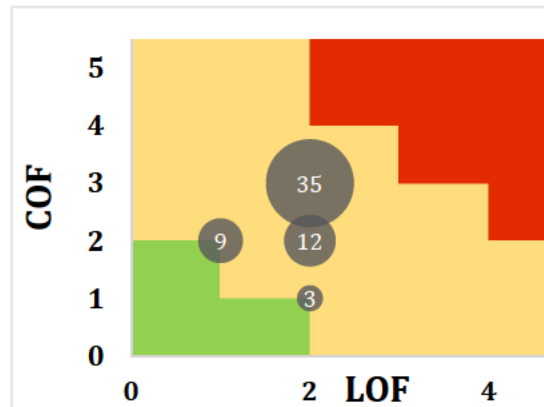
Rochester Asset Risk - Before Risk Treatment



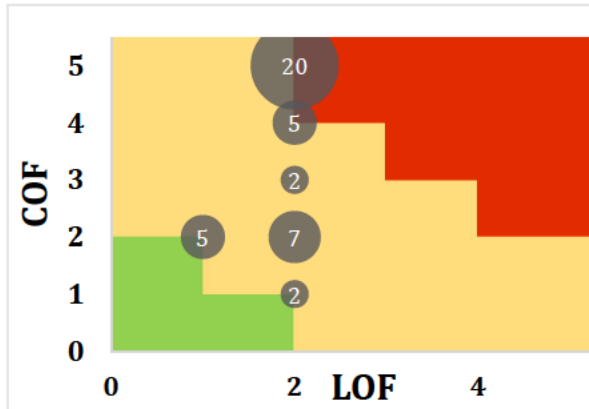
Rochester Asset Risk - After Risk Treatment



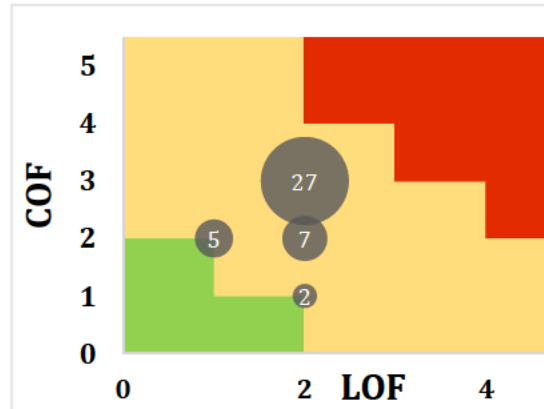
Schoolcraft Asset Risk - Before Risk Treatment



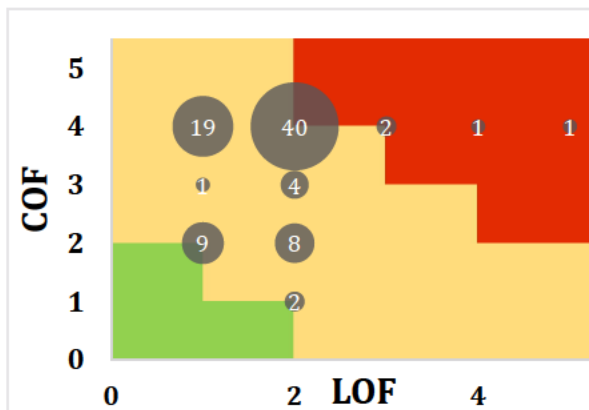
Schoolcraft Asset Risk - After Risk Treatment



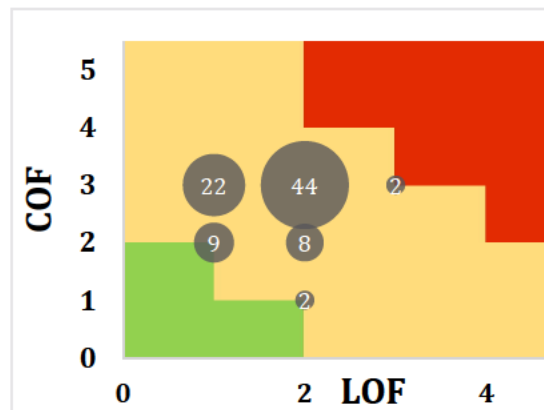
West Chicago Asset Risk - Before Risk Treatment



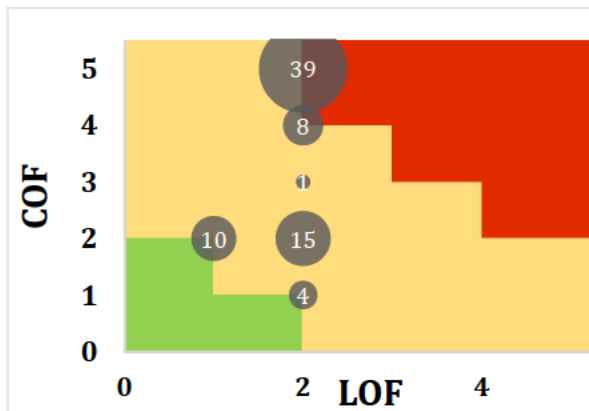
West Chicago Asset Risk - After Risk Treatment



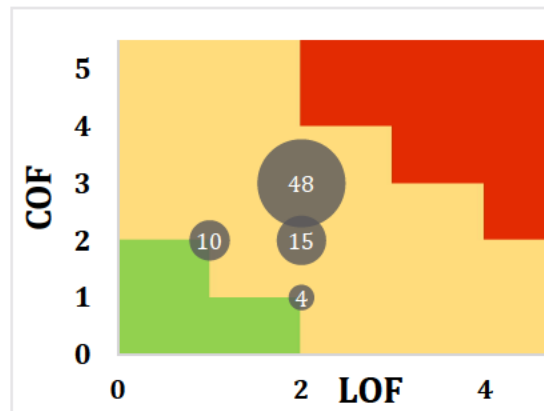
West Service Center Asset Risk - Before Risk Treatment



West Service Center Asset Risk - After Risk Treatment



Wick Road Asset Risk - Before Risk Treatment



Wick Road Asset Risk - After Risk Treatment

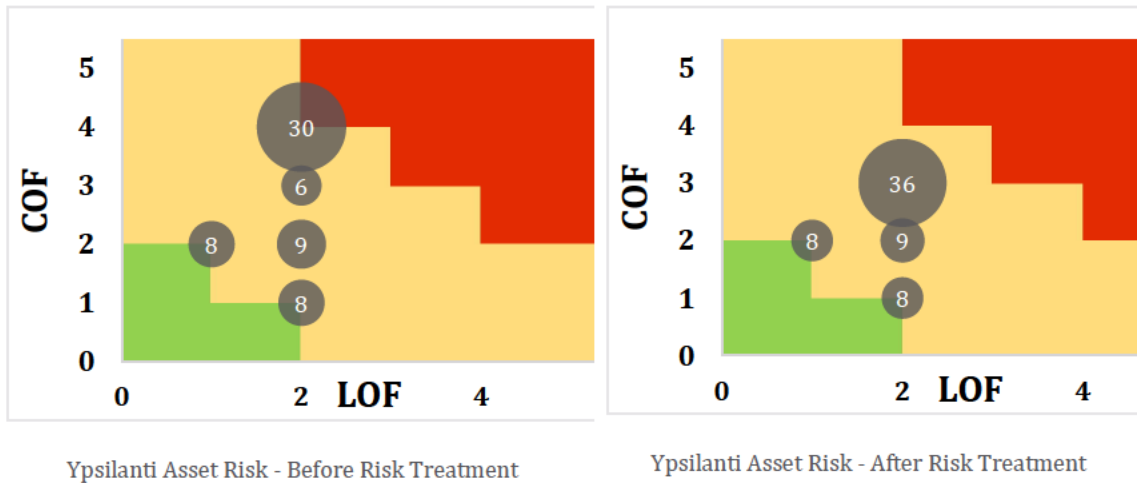


Figure 9-13: Asset Risk Before and After Risk Mitigation (based on 2021 data) – Booster Stations

Table 9-16: Tasks to Support Implementation

Year and Task
<p>Year 1 – Refine Risk Register for Vertical Assets with updated Condition Data</p> <ul style="list-style-type: none"> ▪ Incorporate Year 1 condition assessment data from condition assessment activities as reflected in the WAMP - Condition Assessment of Non-Inspected Vertical Assets (Appendix F) into the WAMP - Risk Register for Vertical Assets (Appendix G). ▪ Develop and incorporate History of Reliability scores in the WAMP - Risk Register for Vertical Assets with available data. ▪ Use results from the WAMP - Risk Register for Vertical Assets to schedule/plan asset replacements using the Scheduled Replacement Program (SRP) Model (Appendix J).
<p>Year 2 – Assess Risk Mitigation Strategies and Refine and Risk Register</p> <ul style="list-style-type: none"> ▪ Re-evaluate risk mitigation strategies included in the WAMP - Risk Register for Vertical Assets (Appendix G) and update as needed. ▪ Incorporate Year 2 condition assessment data from condition assessment activities as reflected in the WAMP - Condition Assessment of Non-Inspected Vertical Assets (Appendix F) into the WAMP - Risk Register for Vertical Assets (Appendix G). ▪ Update History of Reliability scores in the WAMP - Risk Register for Vertical Assets with any new available data. ▪ Use results from the WAMP - Risk Register for Vertical Assets to schedule/plan asset replacements using the SRP Model (Appendix J)
<p>Year 3 – Revisit Risk Register for Vertical Assets Criteria and Refine</p> <ul style="list-style-type: none"> ▪ Incorporate Year 3 condition assessment data from condition assessment activities as reflected in the WAMP - Condition Assessment of Non-Inspected Vertical Assets (Appendix F) into the WAMP - Risk Register for Vertical Assets (Appendix G). ▪ Update History of Reliability scores in the WAMP - Risk Register for Vertical Assets with any new available data. ▪ Use results from the WAMP - Risk Register for Vertical Assets to schedule/plan asset replacements using the SRP Models (Appendix J).

Table 9-17: Resource Requirements for W6: WAMP Asset Risk for Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
50 hours (2 staff at 25 hours each to update the Risk Register for Vertical Assets)	\$0	60 hours (5 staff at 2 hours each over one, 2-hour meeting; 2 staff at 25 hours each to update the Risk Register for Vertical Assets)	\$0	50 hours (2 staff at 25 hours each to update the Risk Register for Vertical Assets)	\$0

9.2.7 W7: WAMP - Maintenance and Reliability Work Management Processes for Vertical Assets

GLWA Owner: O&M Supervisors

Alignment to SAMP Improvement Initiatives:

- M2 – Formalized Work Management Policy
- M3 – Improved Planning and Scheduling Function

Supporting Artifacts: WAMP – Governance Business Processes (Appendix M)

Purpose

The purpose of this Tactical Recommendation is to define improved work management processes based on maintenance and reliability industry standards for vertical assets that can be implemented and support O&M staff as part of the roll-out of NexGen. Work management is defined as all activities starting with the identification of needed work through to completing and documenting work performed.

Benefits

The benefits of this Tactical Recommendation include defining efficiencies in performing work. The work management process should be used to support configuration of NexGen workflow routing and data fields to support needed data capture. Formal business processes and procedures for planning and scheduling of work will be implemented sometime after NexGen goes live; NexGen will need to be updated to support these activities at a later date (2023).

Context and Background

This Tactical Recommendation was identified based on a review of existing documentation and through the Maintenance & Reliability Maturity Assessment conducted in 2022 that

revealed work management processes could be advanced and standardized across similar work groups. Current O&M business processes are documented for each WTP and the Booster Stations but are in a variety of formats and states of completeness and accuracy (see Tactical Recommendation W3: WAMP - Asset Data and Information for a list of data needs and improvement plan). Further, they don't reflect the water group's specific activities in programmatic activities such as the scheduled planning program, asset replacements and retirements identification, tracking of risk and criticality, etc. There is an opportunity to standardize and formally document asset management processes to support implementation and clarify roles and responsibilities.

Results of the O&M Maintenance and Reliability Assessment from 2022 are located in Appendix I.

Table 9-18: Tasks to Support Implementation

Year and Task
<p>Year 1 - Develop Improved Maintenance and Reliability Work Management Processes</p> <ul style="list-style-type: none"> ▪ Document improved work management process that includes work identification, work planning, work scheduling, work execution, work completion, and work analysis with representatives from vertical asset work groups. These work management processes should be defined through a series of facilitated workshops to discuss and document the workflow. ▪ Update NexGen configuration to support improved work management processes. ▪ Train plant personnel on the defined work management processes. ▪ Implement an Obsolescence Review Team whose directive is to conduct broad reviews of various asset types for potential risk associated with the equipment or parts becoming obsolete and then formulate a strategy to mitigate the risk. Use asset criticality as a factor in prioritizing actions within the overall strategy. Note that electronics and instrumentation are typically those asset types affected by accelerated obsolescence. ▪ Establish a Formal Succession Planning Strategy - Based on interview responses from the O&M Maintenance and Reliability Assessment most facilities stated that there is a heavy dependency on senior (close to retirement) staff knowledge. Develop a strategy that will identify the areas of high risk in terms of knowledge loss and then implement actions to document the necessary information in the form of job plans, procedures, or training documents. Communicate and train the maintenance staff on utilizing "job plans", especially corrective maintenance job plans, to capture knowledge from the senior staff.
<p>Year 2 - Improve Planning and Scheduling Activities</p> <ul style="list-style-type: none"> ▪ Evaluate current planning and scheduling activities and identify workflow improvements as needed. ▪ Assess planning and scheduling staff resources and adjust as necessary (hire, assign, etc.) ▪ Train Planners and Schedulers on any newly identified activities. ▪ Establish a Technical Document Control Process - Based on interview responses from the O&M Maintenance and Reliability Assessment, documents are stored either as a hardcopy or electronic format in a variety of places but not in a consistent or controlled manner. Establish a formal documentation process for technical information in electronic format on a common shared drive or linked to NexGen. This would allow documents to be associated with assets and provide easy and efficient access. ▪ Improve Material Planning on Work Orders - As currently the inventory management functionality within WAM is limited, material planning within WAM/NexGen is limited and needs improvement. It is recommended that as part of implementation of NexGen, prioritize the use of material planning as it will support spare parts Kitting and improve schedule compliance.

Year and Task
<p>Year 3 – Inventory Management Improvements</p> <ul style="list-style-type: none"> ▪ Develop Bill of Materials (BOMs) in NexGen -BOMs do not exist in WAM, which causes excessive burdens on the maintenance planners when planning materials for maintenance work. Prioritize assets for BOM development based on both criticality and work history. ▪ Incorporate Spare Parts Reservations and Kitting - the pre-staging or kitting of spare parts increases maintenance technician wrench time by minimizing the wait times for collecting tools and parts to complete a work order. Implement the use of kitting as part of the NexGen implementation. ▪ Document Management of Change to Plant Configuration – there is no formal Management of Change (MOC) policy in place that provides consistent guidance for the physical or operational changes made to the plants / assets. Develop MOC policy that is coordinated with the water group as it should be consistent across GLWA.

Table 9-19: Resource Requirements for W7: WAMP Maintenance and Reliability Work Management Process for Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
520 hours (30 staff involved in 10 hours of business process development and training. And 220 hours for obsolescence and succession planning)	\$100,000 (to work with GLWA to develop business processes and update NexGen configuration and facilitate training)	100 hours (10 staff at 10 hours each that includes five, 2-hour meetings/training sessions)	\$50,000 (to work with GLWA to evaluate Planning and Scheduling activities, organizational support, and facilitate training)	200 hours	\$0

9.2.8 W8: WAMP - Implement Maintenance and Reliability Improvements for Vertical Assets

GLWA Owner: O&M Supervisors

Alignment to SAMP Improvement Initiatives:

- M2 – Formalized Work Management Policy
- M3 – Improved Planning and Scheduling Function

Supporting Artifacts: PMO Report and Tool and FMEA Pilot Results from Wastewater Asset Management Plan (WwAMP); WAMP – Governance Business Processes (Appendix M)

Purpose

The purpose of this Tactical Recommendation is to apply various reliability improvement methods designed to direct O&M resources to conducting the most effective tasks in maintaining critical asset reliability and minimizing overall operational risk. Those methods include, but are not limited to, Failure Modes and Effects Analysis (FMEA) and Planned Maintenance Optimization (PMO). Examples of these activities were performed on water system assets and can be replicated for water assets.

Benefits

The benefits of this Tactical Recommendation include focusing resources on high value activities with objectives of achieving workflow efficiencies and using data to minimize the risk of asset failures.

Context and Background

This Tactical Recommendation was identified based on a review of existing documentation and through the Maintenance & Reliability Maturity Assessment conducted in 2022 that revealed work management activities could be advanced across work groups. The current O&M activities are described in Chapter 6 – O&M Strategies of the WAMP.

Results of the O&M Maintenance and Reliability Assessment performed in 2022 are located in Appendix I.

Table 9-20: Tasks to Support Implementation

Year and Task
<p>Year 1 – Develop and Implement FMEA and PMO Activities and Organizational Enhancements</p> <ul style="list-style-type: none"> ▪ Develop & implement FMEA and PMO outputs from pilot projects on water assets, on WTP and Booster Station assets. These results are included in Appendices I and J of the WwAMP. ▪ Increase Training of Operations on Machinery and Reliability Basics - Machinery knowledge is the foundation of Operator Driven Reliability as the Operators are the first line of defense against catastrophic failures. Provide full staff of Operators training courses specific to the machinery they are responsible for and the most effective way to monitor the health of that asset.
<p>Year 2 – Expand FMEA and PMO and Develop a Predictive Maintenance Strategy</p> <ul style="list-style-type: none"> ▪ Evaluate the impact of the FMEA and PMO changes by monitoring the occurrence of asset failures and make decision on expanding PMO analysis and the development of FMEAs to other asset types. ▪ Develop Root Cause Analysis for high COF assets ▪ Define a Predictive Maintenance (PdM) strategy ▪ Define a PdM team and provide training and certification
<p>Year 3 – Implement Predictive Maintenance Strategy</p> <ul style="list-style-type: none"> ▪ Implement the PdM strategy defined in Year 2

Table 9-21: Resource Requirements for W8: WAMP Implement Maintenance and Reliability Improvements for Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
400 hours (5 staff at 40 hours each; over 18, 2-hour meetings plus 200 hours of staff training)	\$20,000 for staff Operator training	400 hours (10 staff at 40 hours each; over twenty, 2-hour meetings/trainings)	\$0	800 hours (10 staff at 80 hours each)	\$0

9.2.9 W9: WAMP - Maintenance and Reliability - Performance Measurement and Improvement for Vertical Assets

GLWA Owner: Local Asset Management Group (Local AM Group); O&M Supervisors

Alignment to SAMP Improvement Initiatives:

- S3 – Improved Performance Reporting
- O6 – Future AM Assessments and Benchmarking

Supporting Artifacts: Tier 1-3 Performance Indicators (PIs) – Chapter 3 of the WAMP

Purpose

The purpose of this Tactical Recommendation is to develop a Maintenance and Reliability Program performance monitoring system.

Benefits

The benefit of this Tactical Recommendation is that it will enable GLWA to monitor the impact of maintenance and reliability improvement activities using identified performance indicators (Tactical Recommendation W2: WAMP - Service Levels).

Context and Background

This Tactical Recommendation was identified based on a review of existing documentation and through the Maintenance & Reliability Maturity Assessment conducted in 2022 that revealed display and use of PIs by GLWA staff could be improved. The current PIs being tracked are described in Chapter 6-1– O&M Strategies of the WAMP.

Results of the O&M Maintenance and Reliability Assessment performed in 2022 are located in Appendix I.

Table 9-22: Tasks to Support Implementation

Year and Task
<p>Year 1 – Develop Maintenance and Reliability Performance Tracking Platform with Tier 1 PIs</p> <ul style="list-style-type: none"> ▪ Identify and develop a performance tracking technology platform using the defined Tier 1 PIs (Tactical Recommendation W2: WAMP - Service Levels). ▪ Identify staff responsible for monitoring Tier 1 PIs. ▪ Define follow-up actions for staff responsible for monitoring performance based on performance.
<p>Year 2 - Develop Maintenance and Reliability Performance Tracking Platform with Tier 2 and 3 PIs</p> <ul style="list-style-type: none"> ▪ Incorporate Tier 2 PIs into performance tracking platform ▪ Identify staff responsible for monitoring Tier 2 PIs. ▪ Define follow-up actions for staff responsible for monitoring performance based on performance. ▪ Incorporate Tier 3 PIs into performance tracking platform ▪ Identify staff responsible for monitoring Tier 3 PIs. ▪ Define follow-up actions for staff responsible for monitoring performance based on performance.
<p>Year 3 – Perform Maintenance and Reliability Maturity Assessment</p> <ul style="list-style-type: none"> ▪ Repeat the Maintenance & Reliability Maturity Assessment and compare to 2022 results to identify improvements that have occurred.

Table 9-23: Resource Requirements for W9: WAMP Maintenance and Reliability – Performance Measurement and Improvement for Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
40 hours (2 staff at 10 hours each to assist with set up technology platform; 5 staff at 4 hours each over two, 2-hour meetings)	\$100,000 (to develop performance tracking platform with Tier 1 metrics and facilitate governance monitoring responsibilities)	40 hours (2 staff at 10 hours each to assist with set up technology platform; 5 staff at 4 hours each over two, 2-hour meetings)	\$50,000 (to incorporate Tier 2 and Tier 3 metrics into performance tracking platform)	40 hours (10 staff at two, 2-hour meetings)	\$10,000 (to facilitate and prepare Maintenance and Reliability Maturity Assessment)

9.2.10 W10: WAMP - Scheduled Replacement Program Implementation

GLWA Owner: Local Asset Management Group (Local AM Group)

Alignment to SAMP Improvement Initiatives:

- G4 – Scheduled Replacement Program

Supporting Artifacts: Scheduled Replacement Program (SRP) Models (Appendix J); WAMP-Governance Business Processes (Appendix M); CIP

Purpose

The purpose of this Tactical Recommendation is to implement results identified in the SRP models for linear and vertical developed for pipe, WTP and Booster Stations to identify projected funding, needed to support long-term renewal needs.

Benefits

The benefits of this Tactical Recommendation include improved understanding of long-term renewal needs and financial needs projected into the future to maintain the asset profile.

Context and Background

As part of the development of Chapter 7 –Renewals of the WAMP, two SRP models were developed to help understand the long-term renewal needs; a spreadsheet-based life-cycle model was developed in 2022 for the WTP and Booster Station assets as part of the development of this WAMP. A life-cycle model for linear assets was developing using Info Asset Planner (IAP).

Because the life-cycle model for WTP and Booster Stations is spreadsheet-based, it can become challenging to use over time due to manual data entry requirements. A single commercial-off-the-shelf (COTS) software can assist with the consolidation of SRP results for both linear and vertical assets to support presentation of funding needs for the entire set of water system assets in a standardized manner.

Table 9-24: Tasks to Support Implementation

Year and Task
<p>Year 1 – Update SRP Models with Year 1 Condition Assessments</p> <ul style="list-style-type: none"> Update existing SRP models with results from Year 1 condition assessment data (Tactical Recommendation W5: WAMP - Condition Assessment for Non-Inspected Vertical Assets. Document the data management issues and opportunities.
<p>Year 2 – Update SRP Models with Year 2 Condition Assessments and Assess SRP Model Options</p> <ul style="list-style-type: none"> Update the existing SRP models with results from Year 2 condition assessment data (Tactical Recommendation W5: WAMP – Condition Assessment for Non-Inspected Vertical Assets. Document the data management issues and opportunities. Discuss COTS options and receive demonstrations from vendors and feedback from peer group organizations.
<p>Year 3 – Update SRP Models with Year 3 Condition Assessments and Identify and Secure New SRP Software (if needed)</p> <ul style="list-style-type: none"> Update existing SRP models with results from Year 3 condition assessment data (Tactical Recommendation W5: WAMP – Condition Assessment for Non-Inspected Vertical Assets. Prepare Request for Qualifications for COTS software acquisition, configuration and training (if needed).

Table 9-25: Resource Requirements for W10: WAMP Scheduled Replacement Plan Implementation

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
50 hours (5 staff at 2 hours each; over two, 1-hour meetings and 2 staff at 40 hours of working with SRP models)	\$0	50 hours (5 staff at 2 hours each; over two, 1-hour meetings and 2 staff at 40 hours of working with SRP models)	\$0	100 hours (4 staff at 4 hours each to participate in two, 2-hour meetings and 84 hours (2 staff at 42 hours each to develop RFP)	\$0

9.2.11 W11: WAMP - Capital Improvement Program (CIP) Process Improvement

GLWA Owner: Enterprise Asset Management Group (EAMG)

Alignment to SAMP Improvement Initiatives:

- R1 – Shift to Asset Risk-Driven Funding and CIP Prioritization

Supporting Artifacts: WAMP Governance Business Processes (Appendix M)

Purpose

The purpose of this Tactical Recommendation is to refine the existing CIP development process to incorporate results of condition assessment, reliability analysis, risk assessment and long-term renewals planning as inputs into the CIP identification process.

Benefits

The benefits of this Tactical Recommendation include more precise identification of capital needs using industry standard capital planning identification data inputs.

Context and Background

The approach to identifying this Tactical Recommendation is based on understanding of the existing CIP business process and inputs considered/not considered.

Table 9-26: Tasks to Support Implementation

Year and Task
<p>Year 1 – Refine the CIP Process to Incorporate Results of Asset Management Analyses</p> <ul style="list-style-type: none"> Facilitate a series of business process mapping workshops to define the CIP development process to reflect inputs coming from condition assessment activities, results from the risk register, results from the SRP models, and changes to service levels.
<p>Year 2 – Initiate Use of Asset Management Analyses Results into CIP Process</p> <ul style="list-style-type: none"> Formally implement the new CIP development process that reflects inputs identified in Year 1.
<p>Year 3</p> <ul style="list-style-type: none"> None

Table 9-27: Resource Requirements for W11: WAMP Capital Improvement Program Process Improvements

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
60 hours (6 staff to participate in five, 2-hour meetings)	\$50,000 (to facilitate process improvement meetings)	0 hours (new inputs do not require additional time to the existing CIP process)	\$0	0 hours	\$0

9.2.11.1 W12: WAMP - Replacement Cost Database for Vertical Assets

GLWA Owner: Enterprise Asset Management Group (EAMG)

Alignment to SAMP Improvement Initiatives:

- D10 – Asset Costing Improvements

Supporting Artifacts: Financial System

Purpose

The purpose of this Tactical Recommendation is to incorporate modern equivalent asset replacement costs to help monitor and report the current value of the assets.

Benefits

The benefit of this Tactical Recommendation is that it makes more accurate, asset costs for use in preparing long term renewal forecasts. Creating a simple and structured vertical asset replacement cost database can help improve the confidence of funding projections and decisions.

Context and Background

One of the data improvement needs that was identified in the development of the WAMP is a lack of robust and up-to-date replacement cost information of the vertical asset base. As a result, the long-term renewal projections could be under- or over-estimating the renewals needs of the system. The assets in WAM already have a defined hierarchy but the cost database does not extend to all assets.

This data need flows directly from a key SAMP goal for GLWA to demonstrate that lifecycle costs are declining. Given the gradual reduction in water production over time, this will be an especially challenging metric to achieve while still maintaining other level of service requirements, plus potentially more stringent regulatory requirements.

Using unit measures (cost per MG produced for instance) to take different trends into account to include all the influencing factors, while still demonstrating value to stakeholders is a consideration.

Table 9-28: Tasks to Support Implementation

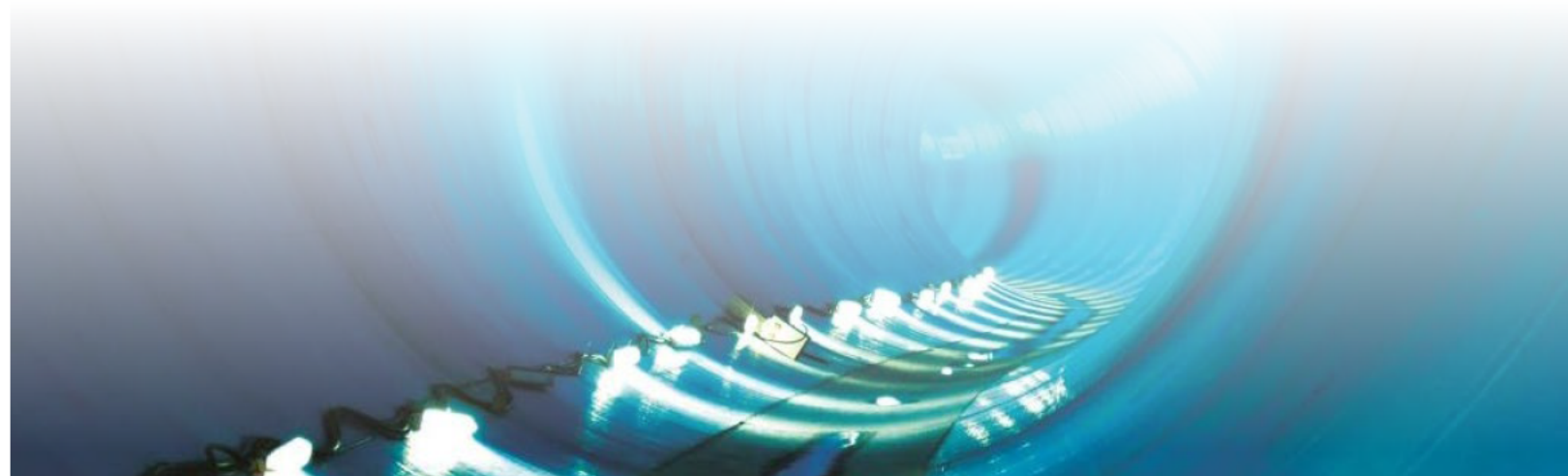
Year and Task
<p>Year 1 – Improve Asset Cost Data on Existing Assets in WAM/NexGen</p> <ul style="list-style-type: none"> ▪ Review asset hierarchy and confirm lowest level to record / track replacement costs. ▪ Identify existing cost information (project actuals, tender schedules of rates and prices, project estimates). ▪ Identify owners, maintainers, and users of the cost data. ▪ Confirm key fields and attributes (e.g., sizes) to track. ▪ Develop excel-based data collection template to record cost information. ▪ Populate data collection template from sources and inflate to current dollars. ▪ Consolidate data into a single flat excel file (the database). ▪ Analyze collected data and establish unit prices. ▪ Review and refine data fields, attributes, and collection templates.
<p>Year 2 – Identify Process to Maintain Cost Data</p> <ul style="list-style-type: none"> ▪ Establish a process for maintaining the cost database with defined roles and responsibilities, including a combination of annual escalation, updates from project actuals and a major refresh process when annual escalation becomes no longer valid.
<p>Year 3 – Expand Asset Cost Data and Processes to all Assets</p> <ul style="list-style-type: none"> ▪ Extend asset cost database to assets (i.e., civil assets) that are not currently in WAM/NexGen to achieve more complete coverage of the asset base.

Table 9-29: Resource Requirements for W12: WAMP Replacement Cost Database for Vertical Assets

Year 1		Year 2		Year 3	
Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)	Estimated GLWA Staff Resources (Hours)	Est Consultant Cost (\$)
100 hours (2 staff at 50 hours each)	\$50,000 (to support GLWA staff with the task activities)	24 hours (4 staff at three, 2-hour meetings)	\$0	40 hours (2 staff at 20 hours each)	\$0

Appendix A – Acronyms

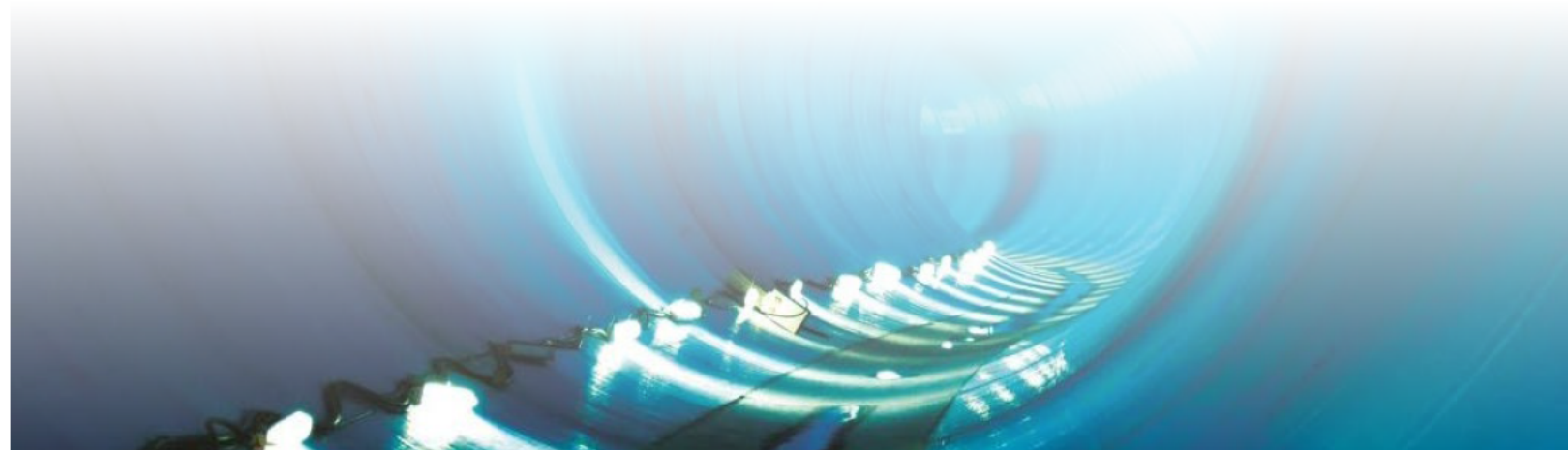
See the SAMP for a Glossary of Terms



Abbreviation	Definition
AM	Asset Management
AMLT	AM Leadership Team
AMPU	AM Program Update
BCE	Business Case Evaluation
BOM	Bill of materials
CIP	Capital Improvement Plan
CM	Corrective Maintenance
COF	Consequence of Failure
CSO	Combined Sewer Overflow
EGLE	Environment, Great Lakes, and Energy
FMEA	Failure Modes and Effects and Analysis
GIS	Geographic Information System
GLWA	Great Lakes Water Authority
GSI	Green Stormwater Infrastructure
I&E	Improvement Extension
I&M	Inspections and Maintenance
IAP	Info Asset Planner
IWOP	Interim Wet Weather Operating Plan
LOE	Level of Effort
LOF	Likelihood of Failure
MACP	Manhole Assessment Certification Program
Mg/L	Milligrams Per Liter
MOC	Management of change
MOC	Management of change
MOR	Monthly Operations Report
MTBF	Mean Time Between Failure
NASSCO	National Association of Sewer Service Companies
NPDES	National Pollution Discharge Elimination System
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
P&D	Process and Data
PACP	Pipeline Assessment Certification Program

Abbreviation	Definition
PI	Performance Indicator
PM	Preventive Maintenance
PMO	Planned Maintenance Optimization
ROP	Regional Operating Plan
RPN	Risk Priority Number
RTB	Retention Treatment Basins
RUL	Remaining Useful Life
SAMP	Strategic Asset Management Plan
SCREAM	System Condition, Risk-Enhanced Assessment Model
SDF	Screening and Disinfection Facilities
SOAP	Solomon Oldach Assessment Process
SRP	Scheduled Replacement Plan
TP	Total Phosphorous
TRC	Total Residual Chlorine
WAM	Work and Asset Management
WTP	Water Resource Recovery Facility

Appendix B – WAMP Development Participants



The initial WAMP was developed over a period of time from August 2021 to June 2022 through a series of collaborative workshops and meetings held between Jacobs and GLWA staff. A list of staff involved in the development of the initial WAMP is presented in Table B-1. A list of meetings held is presented in Table B-2.

Table B-1: WAMP Development Participants

#	Name	Area
1	Cheryl Porter	EAMG
2	Jody Caldwell	EAMG
3	William Fritz	EAMG
4	Kaisra Osman	EAMG
5	Ashley Jacqmain	EAMG
6	Kyle Hines	EAMG
7	Fadel Farhat	EAMG
8	Jason Hammond	Electrical
9	Kaydo Little	Electrical
10	Eric Griffin	Energy, Research & Innovation (ER&I)
11	Peter Fromm	Engineering
12	Paula Anderson	Facilities
13	Doug Atkinson	Facilities
14	Victoria Williams	Facilities
15	Douglas Atkinson	Facilities
16	Justin woods	Field Services
17	Katherine Miracle	Field Services
18	Christopher Steary	Lake Huron
19	Daniel Aman	Lake Huron
20	Michael Hayden	Lake Huron
21	Wallace Mencavage	Lake Huron
22	Benoy Elias	Lake Huron
23	Jonathan Moyer	Lake Huron
24	Joseph Luttrell	Lake Huron
25	Andrea Miller	Lake Huron
26	Jeffrey Dorsey	Maintenance
27	LaShone Bedford	Northeast
28	Annie Philip	Northeast
29	Candice Hobson	Northeast

#	Name	Area
30	Govind Patel	Northeast
31	William Donaldson	Northeast
32	Monick Hughes	Northeast
33	Daniel Hubbard	Northeast
34	Jeffrey Jones	Northeast
35	Torino Moore	Northeast
36	Edwin Merriweather	Operations
37	Ronald Hayes	Southwest
38	Tamika Winston	Southwest
39	Aaron Butler	Southwest
40	Pawan Kapila	Southwest
41	Lawanda Rouse	Southwest
42	Marvin Autry	Southwest
43	Dennis Wilson	Southwest
44	Shakil Ahmed	Southwest
45	Mathew Mangatt	Springwells
46	Justin Kietur	Springwells
47	Kieyona Jackson	Springwells
48	Karone Law	Springwells
49	David Joshua	Springwells
50	Marcus Carr	Springwells
51	Biren Saparia	System Control Center
52	Shondell Daniel	System Control Center
53	Anthony Troy	System Control Center
54	Dwayne Smith	System Control Center
55	Sherri Gee	Systems Planning & Design
56	Charise Collins	Water and Field Operations
57	Jerrod Wade	Water Engineering
58	Andrae Savage	Water Works Park
59	James Davis Jr.	Water Works Park
60	Reginald Bryant	Water Works Park
61	Victor Vecsernyes	Water Works Park
62	Shannon Williams	Water Works Park
63	Jonathan Harper	Water Works Park

#	Name	Area
64	Mike Dunne	Water Works Park
65	Terry Daniel	WTPs

Table B-2: WAMP Development Meetings

Meetings	# of Group Meetings	Timeframe
Asset Hierarchy	3	October 2021 – May 2022
Identification of Critical Assets (to identify critical assets to focus condition assessment activities)	3	August 2021- September 2021
Condition Assessment Results Review	7	March/April 2022
Data Gap Analysis Review	1	April 2022
Asset Risk Review	7	April 2022
Risk Mitigation Strategies	7	April 2022
Asset Renewals	2	May 2022
O&M Strategy Assessment	3	May 2022
Tactical Recommendations Review	2	May 2022
DRAFT WAMP Review	1	May 2022
WAMP Governance Business Process Review	1	June 2022

Appendix C – WAMP Asset Data and Information Improvement Summary

C.1 PURPOSE

This Asset Data and Information Improvement Summary for the Great Lakes Water Authority (GLWA) presents the data updates obtained for the latest Water Asset Management Plan (WAMP), including the revised asset hierarchy, condition assessment information for selected water facility assets, operations, and maintenance (O&M) and capital budgets for the water treatment plants (WTPs) and booster stations, and staffing information for each water facility as well. The intent is to capture the most essential information to reveal both the current status of WAMP assets, but also support the optimizing the operating context and direction within which the assets must perform, all in alignment with the Strategic Asset Management Plan (SAMP) for GLWA.

C.2 APPROACH

Once available data was collected from GLWA, Jacobs reviewed the data in detail to determine alignment with SAMP objectives and WAMP-specific goals.

Specifically, Jacobs reviewed SAMP section 6.3.6, which states that GLWA can consider asset management plans (AMPs) successful when:

- Through development of AMPs, team members are learning, the AMPs are being used, and they are living, useful documents
- GLWA can demonstrate improvement in achievement of service levels
- GLWA can demonstrate improvement in accomplishment of performance indicators
- GLWA can demonstrate responsible management of the grouping of assets covered in the AMP, including risk management
- GLWA can demonstrate decreased lifecycle cost of owning, operating, and maintaining assets, i.e., expectations of the grouping of assets are being met in the most effective and efficient manner
- GLWA can demonstrate that due regard is being given to the long-term stewardship of the grouping of assets covered in the AMP
- GLWA is making well-informed decisions on a daily basis and can develop defensible business cases
- GLWA can justify the near- and long-term funding requirements for the grouping of assets
- GLWA has confidence that regulatory compliance will be achieved in groupings of assets

- AMPs are widely understood and supported at GLWA, appropriate resources are available for their development, and AMPs form the basis for funding decisions for asset capital and O&M needs

Jacobs also reviewed SAMP section 5.2.2 to identify documented water system specific service levels:

Water System Service Levels are defined as follows:

- Provide water that is of unquestionable quality
- Provide water at a pressure that satisfies commitments
- Provide water with minimal disruptions

C.3 RESULTS

To the extent the available where data does or does not support these already defined goals, Jacobs has identified areas for improvement, described in Tactical Recommendation W3: WAMP – Asset Data and Information. A summary of these improvements is listed in Table C-1.

Table C-1: Summary of Water Asset Data and Information Areas for Improvement

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
Asset hierarchy	Oracle WAM	Excellent	Complete	Updated via WAMP Development 2022
Condition Data	WAMP - Condition Assessment Spreadsheet - Vertical Assets	Good	Incomplete	Updated via WAMP Development 2022 - Condition assessment was only ~1/3 of the assets in 2022.
Preventive maintenance history	Oracle WAM	Excellent	Complete	None
Major maintenance history	Oracle WAM	Excellent	Complete	None
Monthly Operations Reports	Water Works Park WTP	Poor	No Data	All
	Northeast WTP	Poor	No Data	All

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All
	Springwells WTP	Poor	No Data	All
Facility Operating Plans	Water Works Park WTP	Poor	No Data	All
	Northeast WTP	Poor	No Data	All
	Lake Huron WTP	Fair	Incomplete	Overall operating strategy not available, but good SOPs
	Southwest WTP	Poor	No Data	All
	Springwells WTP	Poor	No Data	All
	Booster Stations	Excellent	Complete	None
Facility O&M Budgets	Water Works Park WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals, and residuals costs
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals, and residuals costs
	Springwells WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals, and residuals costs

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
	Booster Stations	Fair	Incomplete	Utilities and maintenance costs only - need asset values
Facility Staffing and Training Information	Water Works Park WTP	Poor	No Data	All - in alignment with other WTPs
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Poor	No Data	All - in alignment with other WTPs
	Springwells WTP	Poor	No Data	All - in alignment with other WTPs
	Booster Stations	Excellent	Complete	None
Facility Capital Plans	Water Works Park WTP	Excellent	Complete	None
	Northeast WTP	Excellent	Complete	None
	Lake Huron WTP	Excellent	Complete	None
	Southwest WTP	Excellent	Complete	None
	Springwells WTP	Excellent	Complete	None
	Booster Stations	Excellent	Complete	None
Reliability Data	Oracle WAM	Fair	Incomplete	Needs to be updated from 2022 analysis

Dataset	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Data Gap (based on March-May 2022)
Performance Data	Oracle WAM	Excellent	Incomplete	PI's and KPI's in place are excellent but several more required to meet SAMP and WAMP objectives including: <ul style="list-style-type: none"> • Customer Water Service Pressure Levels; • Customer Water Supply Service Levels; • Water Production Demand Changes;

Appendix D – WAMP Asset Data and Information Improvement Tracker

The Asset Data and Information Improvement Tracker is an MS Excel file that was provided to GLWA as part of the initial WAMP development on June 10, 2022. An image of that file is presented in Figure D-1.

Data Types	Source	Quality (Poor - Good - Excellent)	Completeness (No Data - Incomplete - Complete)	Observed Gaps	Data Steward	Priority for Improving (Year 1 = Priority 1, Year 2 = Priority 2, Year 3 = Priority 3)	Related Tactical Recommendation It Supports
Asset Hierarchy	Oracle WAM	Excellent	Complete	Updated via WAMP Development 2022	TBD by GLWA	NA	MS Asset Data and Information
Condition Data	Condition Assessment Spreadsheet	Good	Incomplete	Updated via WAMP Development 2022 - Condition assessment was only ~1/3 of the assets in 2022.	TBD by GLWA	1	MS: Condition Assessment of Non-Inspected Vertical Assets
Preventive maintenance history	Oracle WAM	Excellent	Complete	None	TBD by GLWA	NA	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
Major maintenance history	Oracle WAM	Excellent	Complete	None	TBD by GLWA	NA	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
MOEs	Water Works Park WTP	Poor	No Data	All	TBD by GLWA	1	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Northeast WTP	Poor	No Data	All	TBD by GLWA	1	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Lake Huron WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Southwest WTP	Poor	No Data	All	TBD by GLWA	1	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Springwellia WTP	Poor	No Data	All	TBD by GLWA	1	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
Facility Operating Plans	Water Works Park WTP	Poor	No Data	All	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Northeast WTP	Poor	No Data	All	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Lake Huron WTP	Fair	Incomplete	Diverse operating strategy not available, but good SOPs	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Southwest WTP	Poor	No Data	All	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Springwellia WTP	Poor	No Data	All	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
Facility O&M Budgets	Booster Stations	Excellent	Complete	None	TBD by GLWA	NA	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets
	Water Works Park WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs	TBD by GLWA	1	WT 2: Replacement Cost Database for Vertical Assets
	Northeast WTP	Excellent	Complete	None	TBD by GLWA	NA	WT 2: Replacement Cost Database for Vertical Assets
	Lake Huron WTP	Excellent	Complete	None	TBD by GLWA	NA	WT 2: Replacement Cost Database for Vertical Assets
	Southwest WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs	TBD by GLWA	1	WT 2: Replacement Cost Database for Vertical Assets
Facility Staffing & Training Info	Springwellia WTP	Poor	No Data	All - Need asset values, and annual labor, maintenance, utilities, chemicals and residuals costs	TBD by GLWA	1	WT 2: Replacement Cost Database for Vertical Assets
	Booster Stations	Fair	Incomplete	Utilities and maintenance costs only - need asset values	TBD by GLWA	1	WT 2: Replacement Cost Database for Vertical Assets
	Water Works Park WTP	Poor	No Data	All - In alignment with other WTPs	TBD by GLWA	1	MS: Asset Management Roles & Responsibilities
	Northeast WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Asset Management Roles & Responsibilities
	Lake Huron WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Asset Management Roles & Responsibilities
Facility Capital Plans	Southwest WTP	Poor	No Data	All - In alignment with other WTPs	TBD by GLWA	1	WT: Asset Management Roles & Responsibilities
	Springwellia WTP	Poor	No Data	All - In alignment with other WTPs	TBD by GLWA	1	WT: Asset Management Roles & Responsibilities
	Booster Stations	Excellent	Complete	None	TBD by GLWA	NA	MS: Asset Management Roles & Responsibilities
	Water Works Park WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
	Northeast WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
	Lake Huron WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
	Southwest WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
Reliability data	Springwellia WTP	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
	Booster Stations	Excellent	Complete	None	TBD by GLWA	NA	MS: Scheduled Replacement Program Implementation
	Oracle WAM	Fair	Incomplete	Needs to be updated from 2022 analysis	TBD by GLWA	2	MS: Maintenance and Reliability Improvement Implementation for Vertical Assets

Figure D-1: WAMP Asset Data and Information Improvement Tracker

Appendix E – WAMP Vertical Asset Condition Assessment Methodology

In support of the Great Lakes Water Authority (GLWA) Asset Management Planning Program, Jacobs performed condition assessments at GLWA’s five water treatment plants (WTPs) and select booster stations. Assessments were performed in November 2021 at the selected booster stations and WTPs listed in Table E-1 and Table E-2.

The condition assessment process used by Jacobs is based on research published in the International Infrastructure Management Manual (IIMM) 2006 edition. The basis for assessing the condition of assets is the development of a set of asset specific questions that focus on the visual and measurable indicators of an assets condition. For this condition assessment, only visual indicators were used.

Table E-1: Booster Stations

Booster Stations	No. of Assets Assessed
Imlay	59
Northwest	58
Adams Road	55
Joy Road	39
Franklin Road	43
Total	254

Table E-2: Water Treatment Plants

WTPs	No. of Assets Assessed
Northeast	235
Lake Huron	297
Water Works Park	531
Southwest	391
Springwells	344
Total	1798

For each asset type assessed, a set of assessment criteria or assessment questions and answers was assigned. To maintain alignment in the condition assessment process across GLWA facilities, Jacobs matched asset types being assessed for the WTPs with the asset type questions used in the Combined Sewer Overflow (CSO) visual assessment and the Water Resource Recovery Facility (WRRF) pilot project.

All assessment questions were assigned 2 to 5 answers that describe the level of degradation observable for the question. The answer which represents the best condition is assigned a score of 1 and the answer representing the worst observable condition is

assigned a score of 5. The score for each answered question rolls up to an overall condition score. In the event a question did not apply to a particular asset the question is answered as NA (not applicable). In this case, the question was not scored, and questions weights were recalculated to accurately average the condition score.

Visual assessment can be very effective when the assets are assessed repeatedly on a regular schedule using the same asset type question sets, trends will appear that can be used for future repair and replacement planning and to identify potential issues with maintenance procedures.

Assets that receive poor visual condition assessment scores are noted and recommended for additional investigation in order to better understand asset risk. Additional investigations could include detailed condition assessments, manufacturer assessments, or detailed look into asset work orders.

Once the overall asset condition scores were calculated and averaged, the assets were grouped into one of 5 asset Condition Categories. Table E-3 lists the condition category groups assets and the applicable range of scores.

Table E-3: Condition Categories

Min Score	Max Score	Condition Score Category
1.00	1.49	Condition 1
1.50	2.49	Condition 2
2.50	3.49	Condition 3
3.50	4.49	Condition 4
4.50	5.00	Condition 5

Each condition category has been found to have specific indications as to the assets remaining useful life and future maintenance requirements. The percent of service life remaining and general maintenance recommendations for each category are shown in Table E-4.

Table E-4: Condition Description and Remaining Service Life

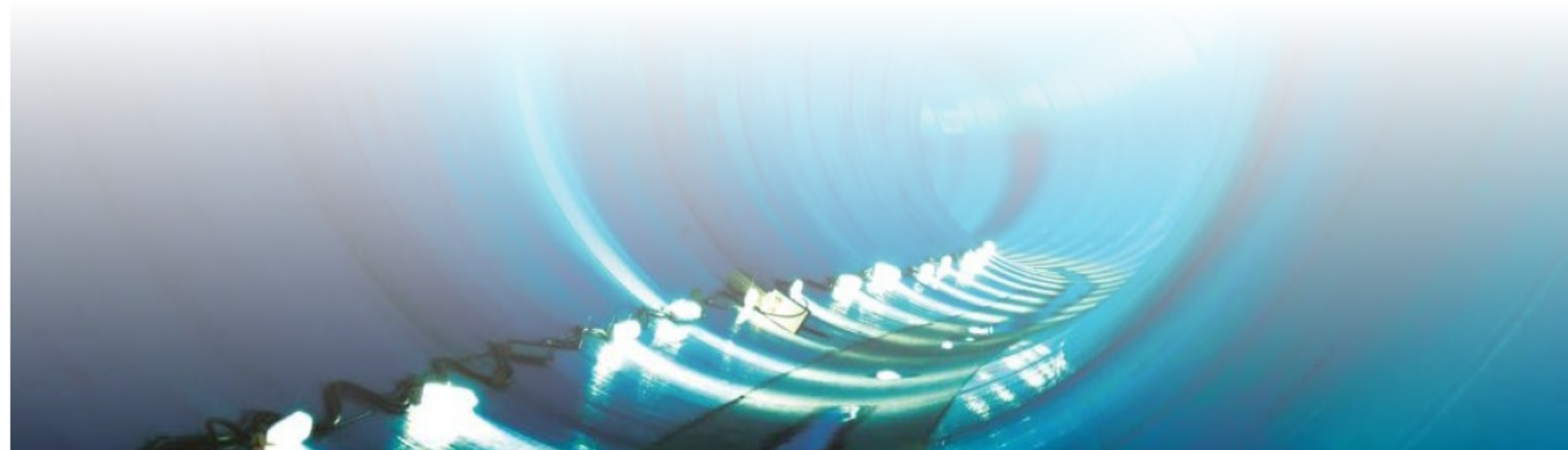
Condition Score Category	Description	Remaining Useful Life
1	Indicates the asset is new or in like new condition. Continuation of current maintenance practices and operating procedures is recommended	>90%
2	Indicates the asset is in good condition. Some minor additional maintenance may be required, continue the current maintenance and operating procedures	75%
3	Indicates the asset is in fair condition. Asset has one or more issues requiring immediate attention. The current maintenance and operating procedures or intervals may need to be modified or adjusted to avoid recurrence of identified issues.	50%
4	Indicates the asset is in poor condition. Planning for rehabilitation or replacement should begin. Review of current maintenance practices and procedures is recommended. If this is a critical asset a predictive maintenance program should be evaluated to prevent reaching this condition in the future.	30%
5	Indicates the asset is in very poor condition. Failure of the asset is imminent or has already occurred. Greater than 50% of the asset is requires replacement. If this is a critical asset a predictive maintenance program should be evaluated to prevent reaching this condition in the future.	5% or less

Survey Flags were also used for this assessment to identify an asset status and drive a predefined assessment score. The Survey Flags used in the assessment were:

- **Not Functional** – Condition Score 3, for assets that were not available for service or offline at the time of inspection but in otherwise good condition.
- **Partially Evaluated** – Condition Score 3, for assets that could not be fully assessed because of accessibility
- **Out of Service for Repair** – Condition Score 4, for assets that were out of service and under repair

No complete plant or process was assessed; therefore, the results are representative of plant conditions and not inclusive of all plant assets. No predictive testing or performance testing was performed as part of this assessment.

Appendix F – WAMP Condition Assessment Activities – Vertical Assets

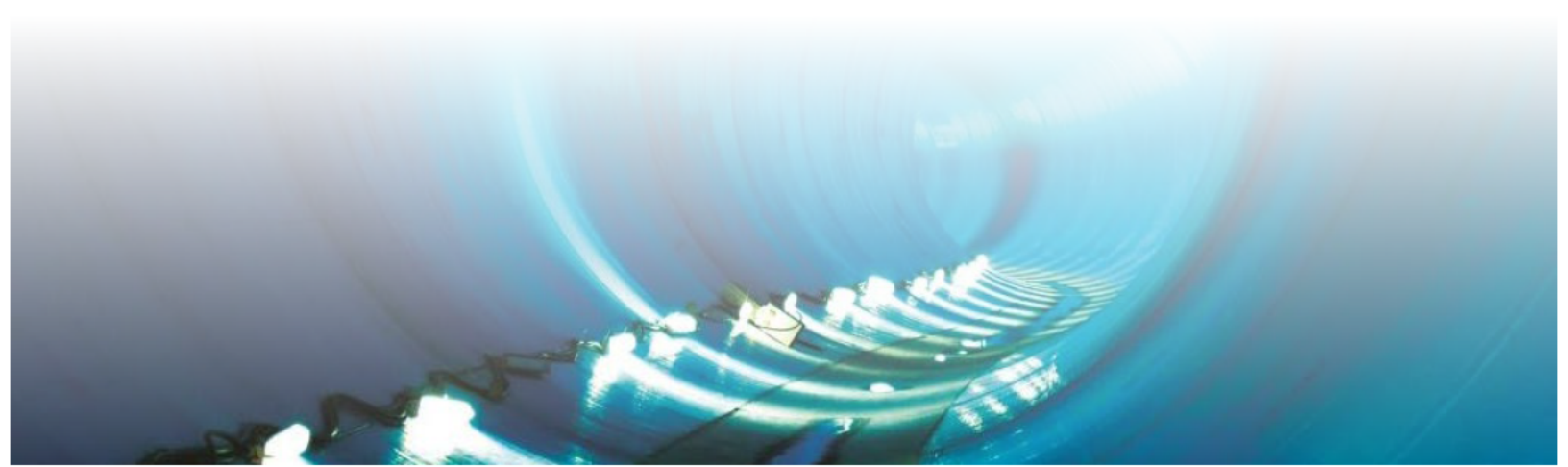


The Condition Assessment Activities – Vertical Assets spreadsheet is an MS Excel file that was provided to GLWA as part of the initial WAMP development on June 10, 2022. A representative image of that file with key column headings is presented in Figure F-1.

	A	B	C	D	U	V	X	Y	Z	AA	AB		
1	Filter for "ACTIVE" status only.			WAMP			CA Priority COF Threshold	Condition Assessment Schedule					
2									3.50		Condition Assessment Type by Year		
3													
4	WAMP Process Area	WAMP Asset Type	WAMP Asset Status	Asset ID	2021 Condition Assessment Tier	2021 Condition Assessment Survey Flags	Condition Assessment Priority	Schedule	Year 1	Year 2	Year 3		
5													
8		BUILDING	ACTIVE	100000001501021	1- Tabletop		CA Priority #1	2023	Visual				
11	COMMON SUPPORT	COMPRESSOR	ACTIVE	BEXX01106001	2- Visual								
12	COMMON SUPPORT	COMPRESSOR	ACTIVE	BE01106000	2- Visual								
13	COMMON SUPPORT	WATERHTR	ACTIVE	B0XX01110001	1- Tabletop		CA Priority #2	2023	Visual				
14	COMMON SUPPORT	PUMP	ACTIVE	BEXX01112003	2- Visual	Out Of Service For Repair							
15	COMMON SUPPORT	PUMP	ACTIVE	100000001502456	2- Visual								
16	COMMON SUPPORT	PUMP	ACTIVE	BEXX01112001	2- Visual								
17	COMMON SUPPORT	PUMP	ACTIVE	BEXX01112002	2- Visual								

Figure F-1: WAMP Condition Assessment Activities – Vertical Assets Spreadsheet

Appendix G – WAMP Risk Register for Vertical Assets



The Risk Register – Vertical Assets spreadsheet is an MS Excel file that was provided to GLWA as part of the initial WAMP development on June 10, 2022. A representative image of that file with key column headings is presented in Figure G-1.

	A	B	C	D	O	P	Q	R	T	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1	BEFORE EVALUATING ASSET RISK &				VAMP					Risk Mitigation										
2	1. Clear all filters. 2. Sort by WAMP Asset Status. 3. Filter for "ACTIVE" status only.				LOF Criteria Weights					Inputs for Risk Tolerance			Inputs for Risk Treatment Scores							
3					0% 100%					3.50 4.00 3.50			3.00 1.00 2.00							
4	VAMP Process Area	VAMP Asset Type	VAMP Asset Status	Asset ID	VAMP COF (includes final round of GLWA feedback)	Priority	Calculated Asset LOF Score (weighted criteria)	Calculated VAMP Risk (LOF x COF)	Condition Assessment at Priority	COF Tolerance	Condition Tolerance	HoR Tolerance	Risk Reduction with Contingency Attenuation	Risk Reduction with Asset Replacement	Risk Reduction with O&M Improvement	Risk Reduction with All Potential Risk	New COF	New LOF (Rounded)	New Risk	
5																				
1750	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL041	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1751	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL042	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1752	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL043	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1753	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL044	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1754	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL045	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1755	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL046	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1756	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL047	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	
1757	DISINFECTION SYSTEM	SCALE	Active	CHM001CHL048	1.00	4.11	2.00	2.00				High Score			0.0	0.0	10	2.0	2.0	

Figure G-1: WAMP Risk Register – Vertical Assets

Appendix H – WAMP Risk Assessment Methodology

Total asset risk is the product of LOF and COF. The following equation is used to calculate total asset risk: *Total Asset Risk = LOF x COF*

The following sections in this appendix detail the COF and LOF scoring categories, criteria, and data for linear and vertical assets. CSO assets are discussed separately from the rest of the vertical (WTP and Booster Station) assets due to differences in desktop analysis approaches for COF and discussion related to the GLWA 2021 CS-299 CSO Facilities Assessment.

H.1 LINEAR ASSETS

The linear asset risk register is under development as part of LSIP.

H.2 VERTICAL ASSETS

Total asset risk results are summarized in Chapter 5.

Averaged GLWA staff COF scores for each Level 5 Process was used to assign a COF score to each child asset (Level 6, Level 7, Level 8) through a tabletop analysis known as Solomon Oldach Assessment Process (SOAP). SOAP holds that a child asset failure will not have a greater consequence than a parent asset failure. The SOAP relationship rules are listed and described in Table H-1.

Table H-1: SOAP COF Relationship Rules

Asset COF Parent/Child Relationship	Relationship Criteria
COFCHILD = COFPARENT	Equipment failure causes immediate system functional failure (no time to react to failure)
COFCHILD = COFPARENT - 1	Equipment failure may contribute to eventual system functional failure (have time to react to failure) or Equipment failure does not cause system functional failure but repair will cause a long duration disruption to system operation
COFCHILD = COFPARENT - 2	Equipment failure does not cause system functional failure but repair will cause a short duration disruption to system operation
COFCHILD = 1	Equipment failure has minimal or no impact on system operation*
*Lowest criticality score to be assigned is no less than 1	

SOAP was applied to each of the seven (7) GLWA COF criteria. During the review and feedback workshops, process-specific staff input was used to modify COF criteria scores to better reflect consequence of failure experienced during operation for specific assets.

H.2.1 LOF SCORING

The WAMP vertical asset LOF matrix includes five, weighted categories: Remaining Useful Life, Performance, History of Reliability, Physical Condition, and Adherence to O&M Strategy. Due to an absence of meaningful initial data, the matrix categories Remaining Useful Life, Performance, History of Reliability and Adherence to O&M Strategy were designated a weight of zero, with Condition remaining as the only factor in LOF. Categories were scored on a scale from 1 to 5, where 5 is the most severe.

Table H-2 describes the data used to assign the category scores in the LOF matrix. Physical Condition scores were based on condition grade results from either tabletop or visual assessments. High COF assets were prioritized for visual assessments, with the remainder assigned desktop scores based on the average condition scores within the asset's respective process area.

Table H-2: Vertical Asset LOF Matrix

Category	Weight	Score = 1	Score = 2	Score = 3	Score = 4	Score = 5
Remaining Useful Life	0.0	81% to 100%	51% to 80%	21% to 50%	6% to 20%	0% to 5%
Performance	0.0	Sufficient capacity to meet average and peak flow requirements. Appropriate utilization and function.	Under-utilized or oversized, causing O&M issues.	Meets current functional demand but has limited degradation availability.	-	Unable to meet current average capacity needs. Functionally failed.
History of Reliability	0.0	No unscheduled corrective work order events within 12 months.	-	1 to 3 unscheduled corrective work order events within 12 months.	-	More than three unscheduled corrective work order events within 12 months.
Physical Condition	1.0	Very good. Condition Grade 1. New or nearly new. Only normal maintenance required.	Good. Condition Grade 2. Minor wear.	Fair. Condition Grade 3. Major wear impacting level of service.	Poor. Condition Grade 4. Unable to meet level of service life. Failure imminent.	Very poor. Grade 5. Requires complete rehabilitation or replacement. Failed.
Adherence to O&M Strategy	0.0	Complete, up-to-date, written, performed, and reviewed at least 3 cycles.	Complete, written, up-to-date, performed, and reviewed at least one time.	Developed but not fully vetted.	Written, but outdated.	No written procedures, or procedures are not being used.

H.2.2 RISK PROCESS AND SCORE UTILIZATION

The WTP and booster station asset risk determination involved multiple series of staff workshops, multiple tabletop analysis, prioritization of high-risk assets for further assessment, and several iterations of asset risk score calculations. Figure H-1 illustrates the general risk process flow.

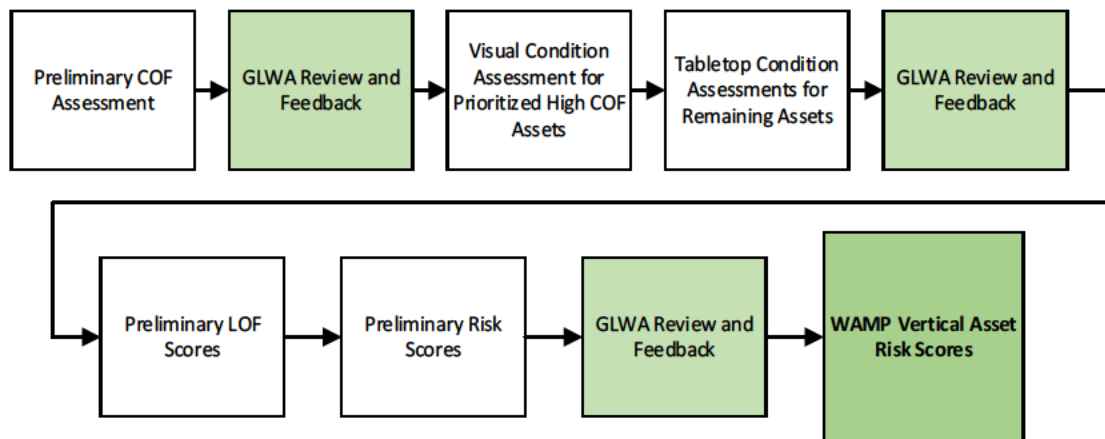


Figure H-1: Vertical Asset Risk Process Diagram

The continuous feedback loop from GLWA staff also provided updates to the vertical asset register including updates to asset statuses, asset types, asset descriptions, modifications to the asset hierarchy, and the addition of missing asset records.

Vertical total asset risk scores were plotted on a Risk Severity Heat Map in Chapter 5. The heat map shows the quantity of assets that reside at each product combination of COF and LOF. For example, if a significant portion of assets have a total asset risk score of 8, with COF = 2 and LOF = 4, renewal could be an appropriate risk treatment. Additionally, if the factors were reversed and COF = 4 and LOF = 2, improving resiliency could be a risk treatment strategy. Understanding where the bulk of assets fall on the heat map is informative for targeting O&M strategies.

Appendix I – WAMP - O&M Maintenance and Reliability Assessment Results

I.1 PURPOSE

This Operations and Maintenance (O&M) Maintenance and Reliability (M&R) Assessment Summary for the Great Lakes Water Authority (GLWA) presents the assessment results based on a 40-element assessment tool established to assess maintenance and reliability activities within an organization, as it was facilitated with Great Lakes Water Authority (GLWA) staff in May 2022 at each of the water treatment plants (WTPs). The assessment results are presented in this summary, and continuous improvement actions based on these results are documented in Chapter 9.0 – WAMP – Continuous Improvement Plan.

I.2 APPROACH

The approach for how Jacobs performed the maintenance and reliability assessment is described below. The assessment is supported by the Jacobs CAMRA+ assessment tool which is designed to measure maintenance and reliability performance against three sets of performance criteria, Low, Medium, and High. The CAMRA+ assessment has been used at numerous water and wastewater utilities for development of their maintenance and reliability improvement strategy.

The M&R assessment process evaluates maintenance, operations, and reliability functions of the asset management program using the following eight major categories;

1. Organizational Readiness
2. CMMS Database Management
3. Work Management
4. Maintenance and Reliability
5. Operator Driven Reliability
6. Inventory Management
7. Planning and Scheduling
8. Metrics and Performance

Each assessment element includes three (3) levels of performance criteria (low, medium, and high) with the following scoring values providing a narrower range within each level.

LOW (RED) – 1, 2, 3 **MED (YELLOW) – 4, 5, 6** **HIGH (GREEN) – 7, 8, 9**

The assessment scored each of the following seven water “groups” individually and then averaged the scores to develop the overall water organization performance.

- Water Operations – non-plant specific staff
- Booster Stations
- Lake Huron WTP
- Northeast WTP
- Southwest WTP

- Springwells WTP
- Waterworks Park WTP

The M&R assessment was conducted via a 2-hour conference call where attendees from the 7 water groups scored their group’s performance against each of the 40 elements.

1. Jacobs modified its existing assessment tool (CAMRA+) to tailor the assessment questions to GLWA WTP staff.
2. Jacobs submitted the assessment questions to the EAMG for review.
3. Jacobs facilitated breakout working sessions with GLWA plant staff so that each WTP could answer the same questions independently, as appropriately for the WTP they work at.
4. Results were compiled and are presented in this document.

I.3 RESULTS

The results of the O&M M&R Assessment performed in May 2022, are presented in Figure I-1, Figure I-2, and Figure I-3. The “spider” diagrams depict low performance toward the center, and good performance toward the outer ring. As overall performance improves, the diagram will expand and become more concentric in shape. Overlaying a new chart over an old chart provides a visual representation of change in performance, good or bad.

Description	Category	AVG	Water Operations	Booster Stations	Lake Huron WTP	Northeast WTP	Springwells WTP	Southwest WTP	Waterworks Park WTP
Organizational Readiness	OR	4.8	3.8	4.2	5.8	4.2	4.3	6.3	5.0
Database Management	DB	3.5	4.3	2.5	2.3	4.5	3.5	3.3	4.2
Work Management	WM	6.8	7.8	6.2	6.5	6.3	6.7	6.3	7.8
Maintenance & Reliability	MR	5.5	5.8	4.5	6.0	5.7	6.3	4.3	5.8
Operator Driven Reliability	ODR	4.5	6.8	5.0	7.1	5.4	6.2	5.8	5.0
Inventory Management	IM	4.8	5.4	4.6	3.8	5.0	3.4	1.6	5.2
Planning and Scheduling	PS	5.8	7.5	4.0	6.3	6.3	5.8	5.5	5.5
Metrics and Performance	MP	6.5	7.0	5.0	7.0	4.5	8.5	6.5	7.5

Scoring ranges: Low (Red) 1<>3.5, Med (Yellow) 3.6<>6.5, High (Green) 6.6<>9.0

Figure I-1: Combined M&R Assessment Category Average Scores

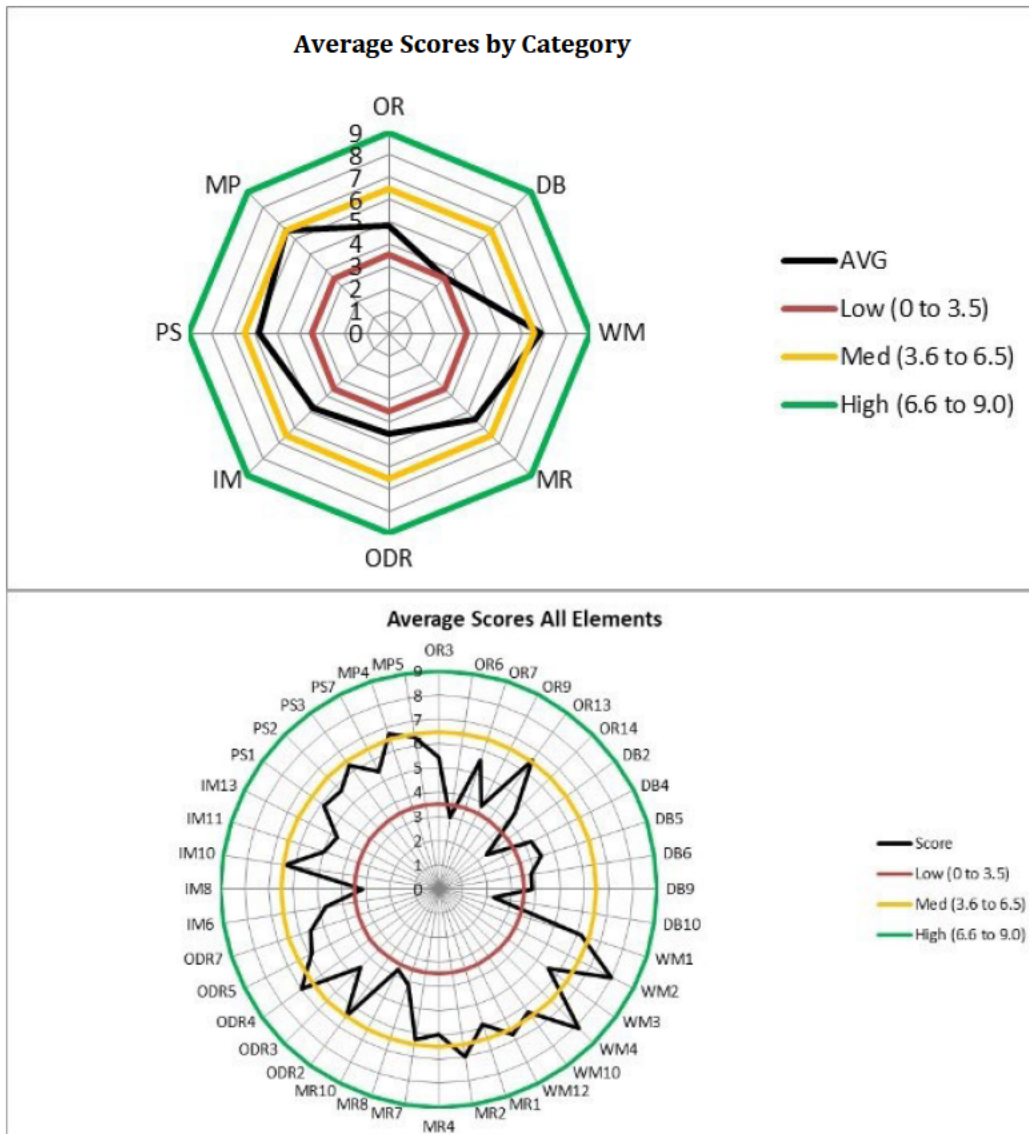


Figure I-2: Combined M&R Assessment Category Average Scores - Spider Diagrams

The results across the organization indicate that GLWA is mid-performance in 7 of the 8 assessment categories, which when compared to other organizational assessments is very good, with Work Management being the strongest. Figure I-3 provides the more detailed average scores by individual element for each group. The areas with the most opportunity for improvement include:

- Organizational Readiness,
- CMMS Database Management,
- Maintenance & Reliability Management, and
- Inventory Management

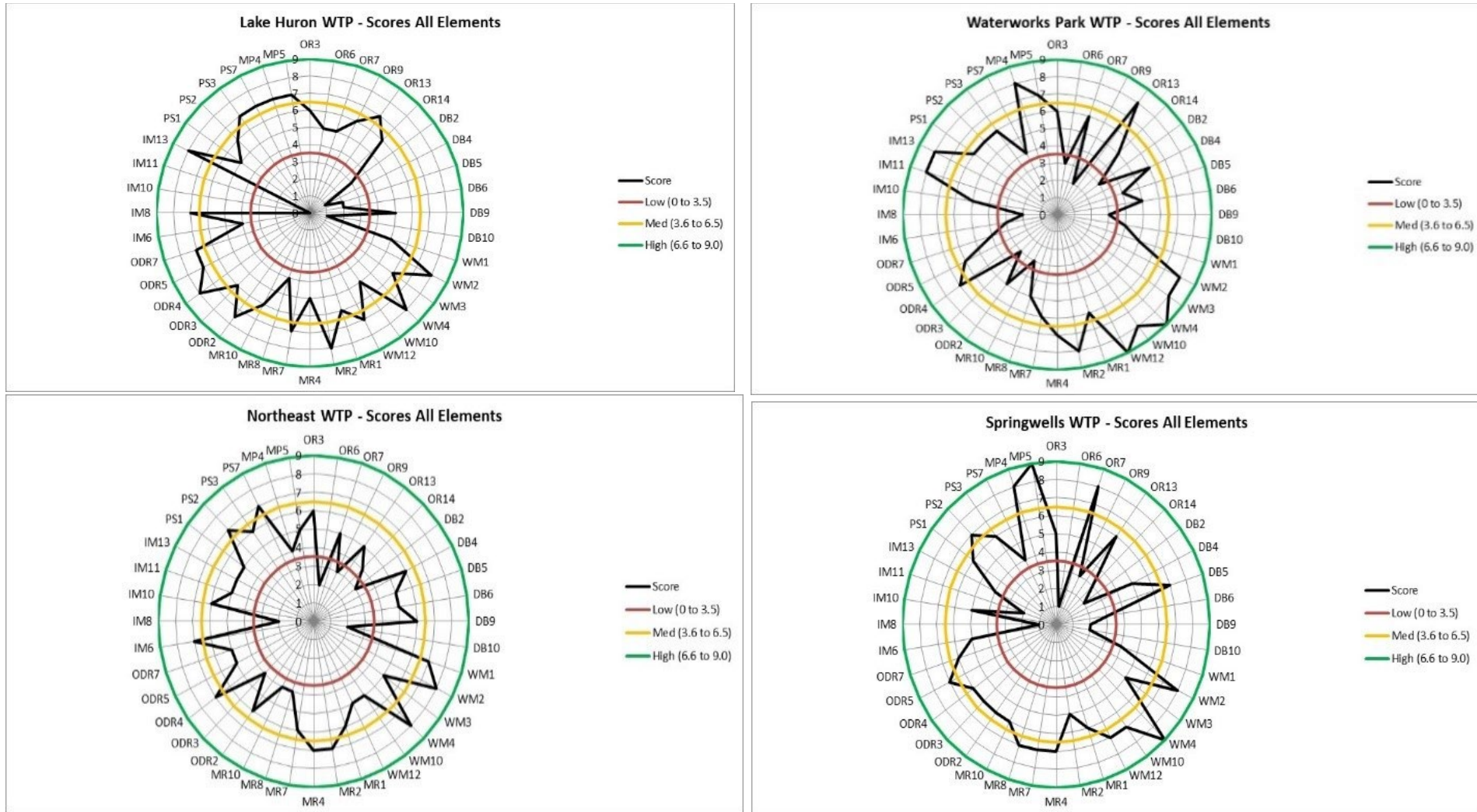


Figure I-3: M&R Assessment Element Average Scores by WTP/Booster Stations (continued on next page)

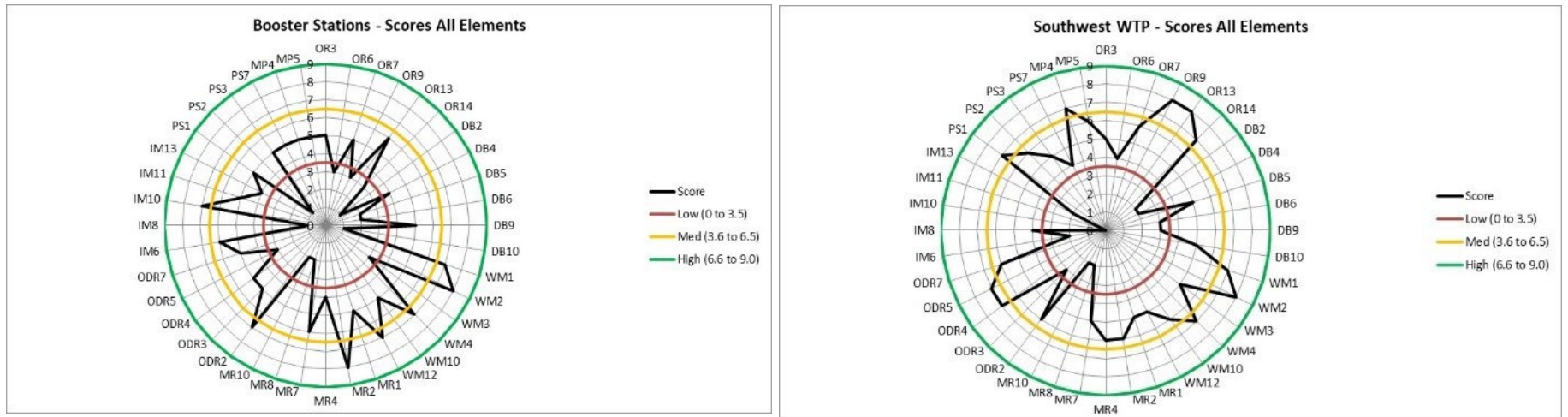


Figure I-3: M&R Assessment Element Average Scores by WTP/Booster Stations

I.4 CONCLUSION

Based on the results of the assessment, priority areas for continuous improvement are described in three Tactical Recommendations included in Chapter 9.0 of the WAMP:

- W7-: WAMP – Maintenance and Reliability Work Management Processes for Vertical Assets;
- W8: WAMP – Maintenance and Reliability Improvement Implementation for Vertical Assets;
- W9: Maintenance and Reliability Performance Measurement Improvement for Vertical Assets.

Appendix J – WAMP Scheduled Replacement Program (SRP) Model for Vertical Assets

The Scheduled Plan Replacement Model for Vertical Assets is an MS Excel file that was provided to GLWA as part of the initial WAMP development on June 10, 2022. A representative image of that file with key column headings is presented in Figure J-1.

Location		Asset Hierarchy			Asset Hierarchy			Historical Data					Cost Data				
Plant	Level 1: Process Area	Level 2: Level 4	Functional Group	Asset	Status	Asset ID	Asset Category	Asset Type	Year of Construction	Condition Grade	Date of Condition Assessment	CIP Number Notes	CIP Cost Data Source(s)	CIP Construction Status	Cost Data Source	Cost Base Year	Asset Replacement Cost Estimate (\$)
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION		ADAMS ROAD BOOSTER STATION	ACTIV	100000001501021	Building Structural / Architectural	BUILDING 1		2	2021				GLWA Database	2021	\$ 250,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	COMPRESSOR, AIR, ADAMS ROAD BOOSTER STATION	ACTIV	BE020106001	Building Mechanical	COMPRESSOR		2	2021				GLWA Database	2021	\$ 15,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	COMPRESSOR, AIR, ADAMS ROAD BOOSTER STATION, SOUTH-WEST CORNER OF PUMP ROOM	ACTIV	BE0106000	Building Mechanical	COMPRESSOR		1	2021				GLWA Database	2021	\$ 15,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	HEATER, WATER, ADAMS ROAD BOOSTER STATION, ABOVE BATHROOM IN ELECTRICAL SERVICE ROOM	ACTIV	BE020110001	Building Mechanical	WATER HEATER		2	2021				GLWA Database	2021	\$ 2,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	HP WATER PUMP #1, ADAMS ROAD BOOSTER STATION	ACTIV	BE020110203	Process Mechanical	PUMP		5	2021				Jacobs Database	2021	\$ 50,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	PUMP, SUMP, #3, SMP-3, ADAMS ROAD BOOSTER STATION, PIPE GALLERY, UNDER RESTROOM	ACTIV	100000001502456	Process Mechanical	PUMP		1	2021				GLWA Database	2021	\$ 50,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	PUMP, SUMP, SMP-1, ADAMS ROAD BOOSTER STATION, EAST SIDE OF BUILDING IN BASEMENT, DUPLEX UNIT	ACTIV	BE020112001	Process Mechanical	PUMP		2	2021				GLWA Database	2021	\$ 50,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	PUMP, SUMP, SMP-2, ADAMS ROAD BOOSTER STATION, EAST SIDE OF BUILDING IN BASEMENT, DUPLEX UNIT	ACTIV	BE020112002	Process Mechanical	PUMP		2	2021				GLWA Database	2021	\$ 50,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	TANK, HIGH PRESSURE WATER, ADAMS ROAD BOOSTER STATION, SV SIDE OF PUMP ROOM	ACTIV	101000000	Process Mechanical	TANK-PRESS		5	2021				GLWA Database	2021	\$ 500,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	BREAKER, MAIN, LI VFD, ADAMS ROAD BOOSTER STATION, ELECTRICAL SERVICE ROOM, 4800V	ACTIV	DE37010B004	Electrical Systems	CIRCUIT BREAKER		2	2021				Jacobs Database	2021	\$ 100,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	DRIVE, VFD, LI PUMP, ADAMS ROAD BOOSTER STATION, ELECTRICAL SERVICE ROOM, 4800V	ACTIV	DE38010C007	Electrical Systems	DRIVE-ELEC		1	2021				GLWA Database	2021	\$ 100,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	MCC, CONTACTOR, LI, ADAMS ROAD BOOSTER STATION, ELECTRICAL SERVICE ROOM, 4800V	ACTIV	DE72010C004	Electrical Systems	MCC		2	2021				Jacobs Database	2021	\$ 250,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	MOTOR, ELECTRIC, PUMP L1, ADAMS ROAD BOOSTER STATION, PUMP L1 BRUSHLESS A/C, 750HP, IDEAL 531068-0, FRAME 3000-15	ACTIV	100000001502364	Electrical Systems	DRIVE-ELEC		1	2021				GLWA Database	2021	\$ 100,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	PUMP, CENTRIFUGAL, PUMP L1, ADAMS ROAD BOOSTER STATION, PUMP L1 SPLIT CASE VOLUTEMPELLOR, ISX16, GLVA-003776, ALLIS CHALMERS, 10-330-504, 312-06416-1, TYPE V/SH	ACTIV	100000001502365	Process Mechanical	PUMP		2	2021				Jacobs Database	2021	\$ 50,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	TRANSFORMER, VFD, LI, ADAMS ROAD BOOSTER STATION, ELECTRICAL SERVICE ROOM	ACTIV	DE38010T004	Electrical Systems	SWITCHGEAR		1	2021				GLWA Database	2021	\$ 75,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	VALVE, CONE, PUMP L1, ADAMS ROAD BOOSTER STATION, LI PUMP, 16", CONTROL VALVE, GLVA-003777, AC MFG-ALLIS CHALMERS, VB2942	ACTIV	100000001502363	Process Mechanical	VALVE		1	2021				Jacobs Database	2021	\$ 30,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	VALVE, GATE, PUMP L1, ADAMS ROAD BOOSTER STATION, LI PUMP, 24", DISCHARGE ISOLATION VALVE, 201CV, TURNS TO CLOSE	ACTIV	100000001502362	Process Mechanical	VALVE		1	2021				GLWA Database	2021	\$ 30,000
V-BPS-ADM	BOOSTER PUMP STATIONS	ADAMS ROAD BOOSTER STATION	PUMPING SYSTEM	CONTROL, POWER, R-1, AUTO POWER FACTOR ADJUSTER, ADAMS ROAD BOOSTER STATION	ACTIV	100000001502226	Instrumentation / Control	CONTROL PANEL /		1	2021				GLWA Database	2021	\$ 30,000

Figure J-1: SRP Model for Vertical Assets

Appendix K – WAMP Scheduled Replacement Program (SRP) Methodology

K.1 VERTICAL ASSETS

K.1.1 ESTIMATING COSTS

The WAMP SRP model is in 2021 dollars, non-escalating.

Many assets are replaced within the 20-year planning period but not all

Asset replacement costs were from:

- 2013 CSO SRP with costs escalated to 2021 values – most of these were from vendor quotes and this was about 25% of the total asset count
- Current vendor quotes, quotes from recent pricing GLWA received
- Prices from recent Jacobs projects

K.2 SRP STRATEGY

Figure K-1, Figure K-2 and Figure K-3 reflect the three strategies available in the SRP model. Strategy 2 was not used for the WAMP.

K.2.1 STRATEGY 1 – DEFINED MIDLIFE AND END OF LIFE INTERVENTIONS

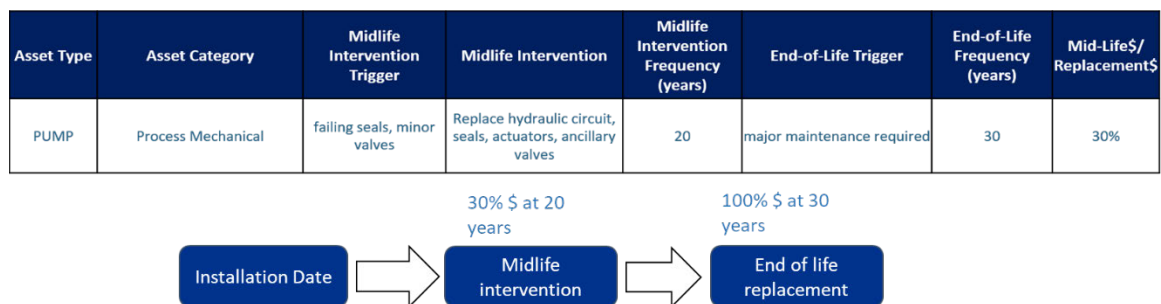


Figure K-1: SRP Strategy 1 Example

K.2.2 STRATEGY 2– AGGREGATED LOW-VALUE/HIGH-VOLUME ASSETS

Typically used for low cost, high-volume assets (e.g., analyzers), investment profile is based replacement and end of life.

Asset Type	Asset Category	Midlife Intervention Trigger	Midlife Intervention	Midlife Intervention Frequency (years)	End-of-Life Trigger	End-of-Life Frequency (years)	Mid-Life\$/ Replacement\$	Strategy 2 annual allocation (Annual\$/ Replacement\$)
HVAC FAN	Building Mechanical	N/A	N/A	N/A	Failure to function.	25	N/A	4%

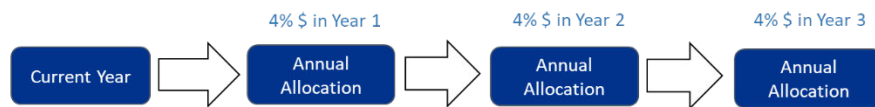


Figure K-2: SRP Strategy 2 Example

K.2.3 STRATEGY 3 – HIGH-VALUE STRUCTURAL ASSETS

Typically used for high-value structural assets that are not typically replaced at end of life.

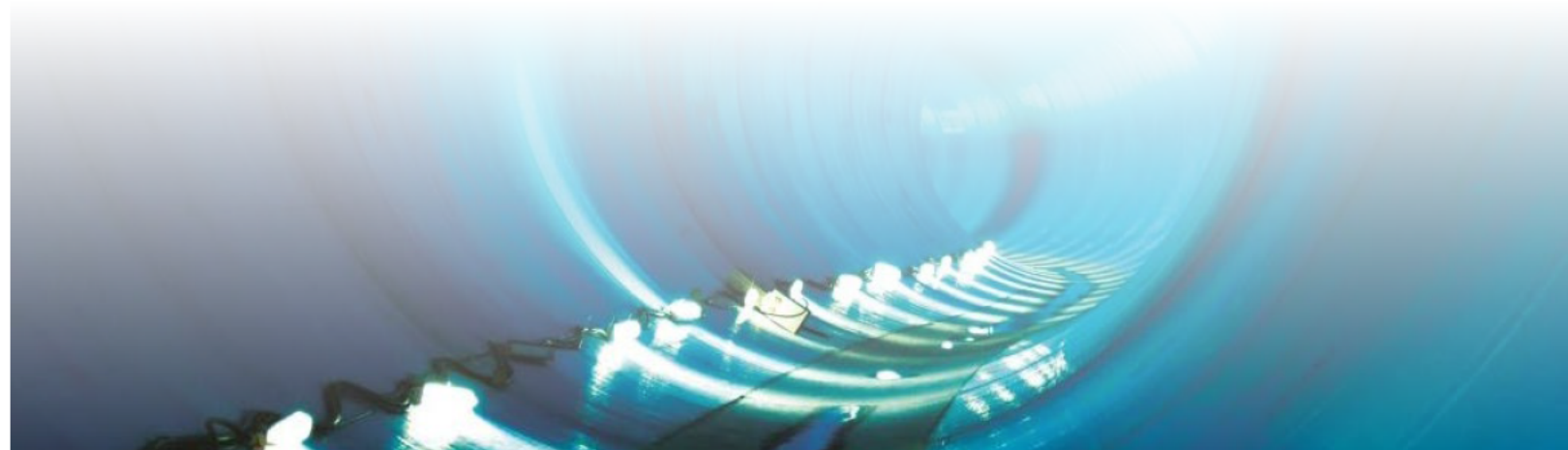
Asset Type	Asset Category	Midlife Intervention Trigger	Midlife Intervention	Midlife Intervention Frequency (years)	End-of-Life Trigger	End-of-Life Frequency (years)	Mid-Life\$/ Replacement\$	Strategy 3		
								Intervention\$/ Replacement\$	Intervention frequency (years)	cumulative intervention \$ over lifespan / replacement \$
BUILDING	Building Structural / Architectural	N/A	N/A	N/A	N/A	80	N/A	0.5%	5	8



Figure K-3: SRP Strategy 3 Example

8% of replacement value, spent to extend the asset life over the nominal lifespan in 5-year increments (0.5% each 5-year).

Appendix L – WAMP Continuous Improvement Plan Tracker

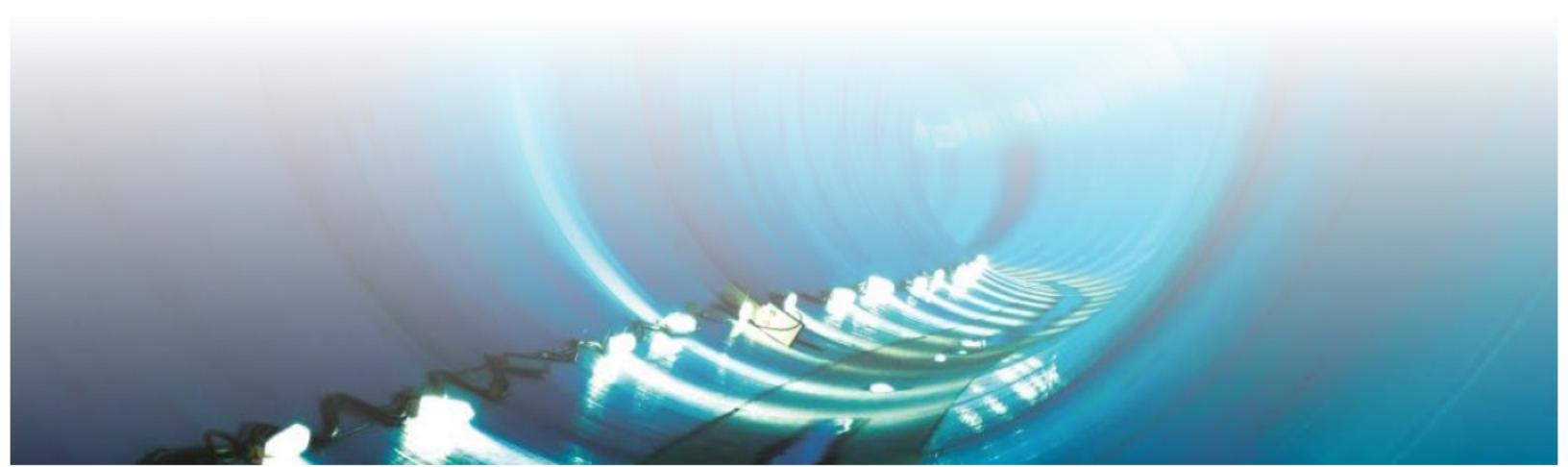


The Continuous Improvement Plan Tracker is an MS Excel file that was provided to GLWA as part of the initial WAMP development on June 10, 2022. A representative image of that file with key column headings is presented in Figure L-1.

Water Continuous Improvement Plan Tracker												
Tactical Recommendation #	Tactical Recommendation Title	Related SAMP #	GLWA Owner	YEAR 1			YEAR 2			YEAR 3		
				Actions	Estimated Labor Hours (Total GLWA)	Estimated Consultant Cost	Actions	Estimated Labor Hours (Total GLWA)	Estimated Consultant Cost	Actions	Estimated Labor Hours (Total GLWA)	Estimated Consultant Cost
01	Basin Management Roles Responsibilities	01-Basins Basin Management (BM) Team Members with Business Units (BU) 04-Facility BM Recommendations and Breakdown	Enterprise Basin Management Group	<p>Year 1- Define Basin Management Roles and Responsibilities Discuss the roles and responsibilities of water asset management personnel for Planning and O&M of Basins and coordinate with the existing Enterprise Basin Management Group (EBMG) structure. Identify sources of the Key Performance Indicators (KPIs) and establish metrics with responsibilities for managing them. Develop clearly defined responsibilities for each role listed in Figure 2.4 and as defined in Appendix B- WAMP - Governance Business Processes. Implement the governance structure.</p>	11	1	<p>Year 2- Review and Refine Basin Management Roles and Responsibilities Review the structure and delivery of the roles and management processes identified as part of a annual review and refine roles and responsibilities as needed. Discuss and document succession planning strategy for each defined role and implement.</p>	11	1	<p>Year 3- Perform Monthly Operational Checks Review the Basin Management Roles and Breakdown activities performed in 2024 during SAMP development and compare to other monthly operational metrics within the industry. The results of the Monthly Operational Checks SAMP development are documented in the "Basin Management Operational Summary - April 16, 2025." Conduct asset management activity operational and compare results to the monthly operational breakdown in the "Basin Management Operational Summary - April 16, 2025."</p>	11	1
02	Service Levels	02-Optimal Service Levels	Enterprise Basin Management Group	<p>Year 1- Develop Service Level Framework Collaborate with external subject matter experts (SMEs) to define service levels (including Minimum and Maximum) for Water Works Business Units (WBU) resources. Collaborate with service level examples from other jurisdictions. Identify factors that would affect the framework for service levels and discuss the following topics: - Risk-based approach that considers service volume, customer service levels and technical service levels. - The use of external customer surveys in establishing customer service levels. - Regulatory and other performance metrics that relate to the State Operations Report that include metrics about meeting demand goals, including quality, O&M, R&D, R&P, Hazardous and service outages and coordinate with Tactical Recommendation 03- Basin Data and Information. - Customer Water Pressure Service Levels. - Customer Water Supply Service Levels. - Meet with leadership to: - Review service volume standards and a annual set of customer service levels aligned to internal and external stakeholder expectations. - Review Tier 1-5 PPIs based on input from leadership. - Review required data to support performance in the service levels.</p>	20	1	<p>Year 2- Improve Data to Support Service Levels Review and identify data gaps to improve data quality (interoperable data, Tactical Recommendation 02-SAMP- Basin Data, and Information as needed).</p>	20	1	<p>Year 3- Develop Targets for Customer Service Levels Establish performance targets for customer service levels (and a set of technical service levels).</p>	20	1

Figure L-1: Continuous Improvement Tracker

Appendix M – WAMP Governance Business Processes



M.1 OVERVIEW

The Water Continuous Improvement Plan is comprised of a series of Tactical Recommendations starting in FY22/23, that were identified to achieve significant milestones for improving the way Great Lakes Water Authority (GLWA) manages its water system assets that include linear (pipe) and vertical assets (water treatment plants (WTPs) and booster stations. Current asset management activities are identified in the Water Asset Management Plan (WAMP).

The Water Continuous Improvement Plan aims to service levels a number of key gaps including refinement of service levels based on stakeholder expectations, performing targeted condition assessment activities to improve GLWA’s condition assessment program, and refining operations and maintenance (O&M) practices that focus on improving data quality, business processes, and use of technology.

M.2 PURPOSE OF ASSET MANAGEMENT GOVERNANCE BUSINESS PROCESSES

The purpose of documenting the related asset management business processes is to support staff with performing water asset management continuous improvement activities. These business processes focus primarily on vertical assets and is complemented by a separate set of business processes for linear assets under GLWA’s Linear System Integrity Program (LSIP).

M.3 BUSINESS PROCESSES

Seven (7) business processes are described herein (Sections 1.3.1 – 1.3.7). A list of these business processes is reflected in Table M-1 along with responsible owner, or lead of the business processes, and a listing of key responsibilities.

Table M-1: Water Asset Management Plan Governance Business Processes

Responsible Owner	Business Process - Key Responsibilities	Frequency
EAMG	1. WAMP Management – incorporate updates to each section of the WAMP every 3 years (major update); annually (July) (minor updates) and as identified	<ul style="list-style-type: none"> ▪ Every 3 Years ▪ Annually ▪ As identified
EAMG	2. WAMP - Continuous Improvement Plan Implementation – ensure adherence to routine meeting schedule with identified Tactical Recommendation owners.	<ul style="list-style-type: none"> ▪ Monthly
Local AM Group (TBD)	3. WAMP - Asset Audit Program - implement the improvements to data listed in the Asset Data and Information Improvement Tracker	<ul style="list-style-type: none"> ▪ Annually

Responsible Owner	Business Process - Key Responsibilities	Frequency
Local AM Group (TBD)	4. WAMP - Condition Assessment Program – Vertical and Building Assets – implement visual and detailed condition assessments in alignment with the priorities listed in the WAMP - Condition Assessment Activities – Vertical Assets	<ul style="list-style-type: none"> ▪ Annually or ▪ Failure Event ▪ Monthly
Local AM Group (TBD)	5. WAMP - Risk and Criticality Assessment Program - follow the asset risk management and data management activities in alignment with Tactical Recommendation W6 – Asset Risk for Vertical Assets and Tactical Recommendation W3 – Asset Data and Information	<ul style="list-style-type: none"> ▪ New asset driver affecting COF ▪ Annual review of COF ▪ New O&M optimization activity ▪ New condition data
Operations and Maintenance Team Leads	6. WAMP - Strategic Maintenance and Reliability Program Manage and run the PMO Tool and use as needed following review of the Performance Indicator Report from NexGen Manage Failure Modes Effects Analysis (FMEA) development and usage following review of the Asset Failure Report from NexGen – identify and prioritize and implement development of additional FMEAs beyond the pilot activities completed in 2022.	<ul style="list-style-type: none"> ▪ Weekly
Finance/ Maintenance Director	7. WMP - Asset Replacement and Retirement Program – determine projects for Capital Outlay or CIP	<ul style="list-style-type: none"> ▪ As Identified
EAMG	8. WAMP - Scheduled Replacement Program (SRP) – update data in the SRP models on an annual basis and obtain refined future financial outlooks that can be used in the CIP Planning Process as inputs. <i>Note: This tool is reflected as part of the WAMP - Asset Replacement and Retirement Program Business Process.</i>	<ul style="list-style-type: none"> ▪ Annually

M.3.1 WAMP MANAGEMENT

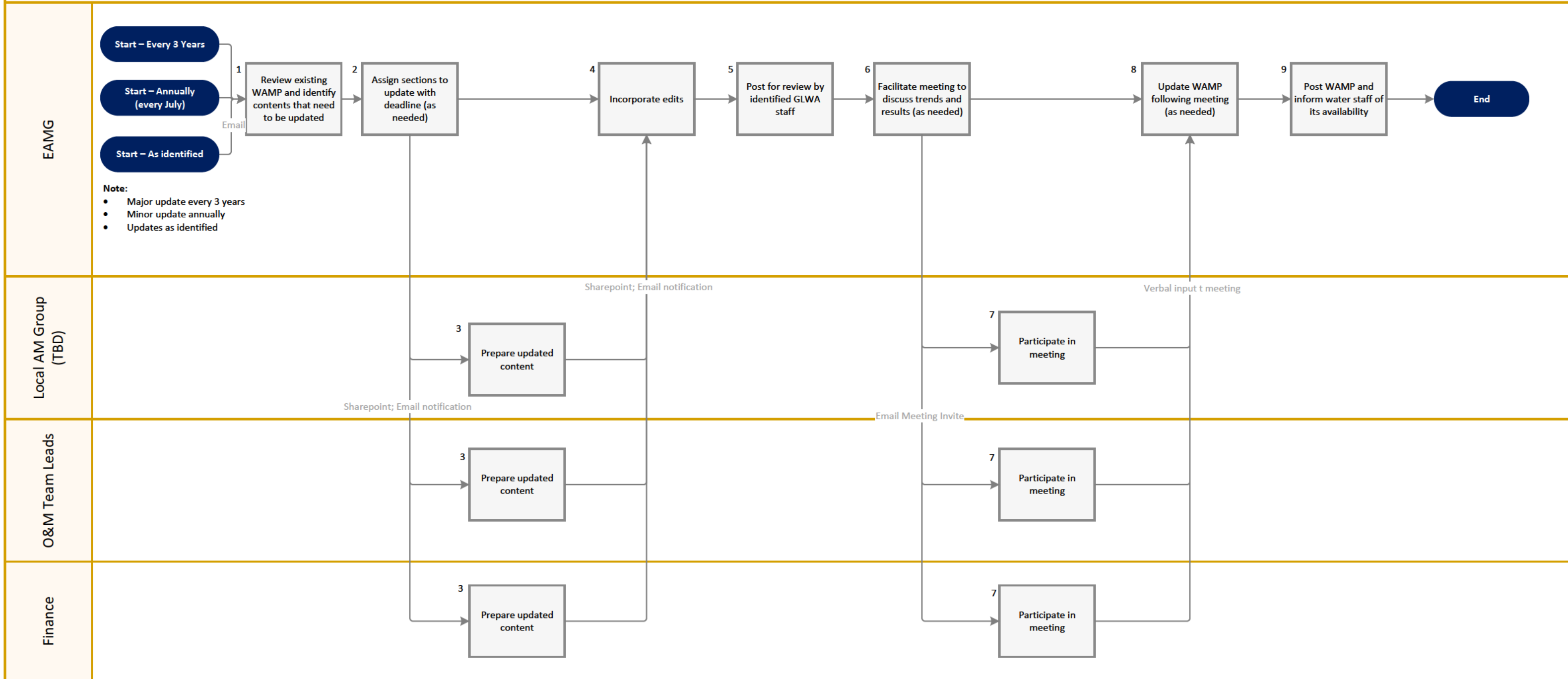
Table M-2 describes the WAMP Management Business Process. Figure M-1 depicts this process visually. This business process is to be updated as it changes over time.

Table M-2 Business Process Description – WAMP Management

WAMP Management	
Objective	To update the Water Asset Management Plan (WAMP) with up to date and accurate information and obtain comprehensive analysis of the asset management activities and projection of future continuous improvement actions.
Description of Process	<p>Trigger: Every 3 Years, Annually, or As Identified</p> <p>EAMG – Review WAMP and identify needed updates</p> <p>EAMG - Assign sections to update with deadline</p> <p>Local AM Group/O&M Supervisors/Finance – Prepare updated content</p> <p>EAMG – incorporate edits</p> <p>EAMG - Post for review by identified GLWA staff</p> <p>EAMG – Facilitate meeting to discuss trends and results</p> <p>Local AM Group (TBD)/O&M Team Leads/Finance – participate in meeting</p> <p>EAMG – Update the WAMP following the meeting as needed</p> <p>EAMG- post WAMP and inform water staff of its availability</p>
Roles	
Process Sponsor	Enterprise Asset Management Group (EAMG)
Process Users	Local Asset Management (AM) Group (TBD); O&M Team Leads Finance
Timing	
Starting Event	Every three years, annually, or as identified
Ending Event	Updated WAMP - posted

Business Process: Water Asset Management Plan (WAMP) Management

GLWA



M.3.2 WAMP CONTINUOUS IMPROVEMENT PLAN IMPLEMENTATION

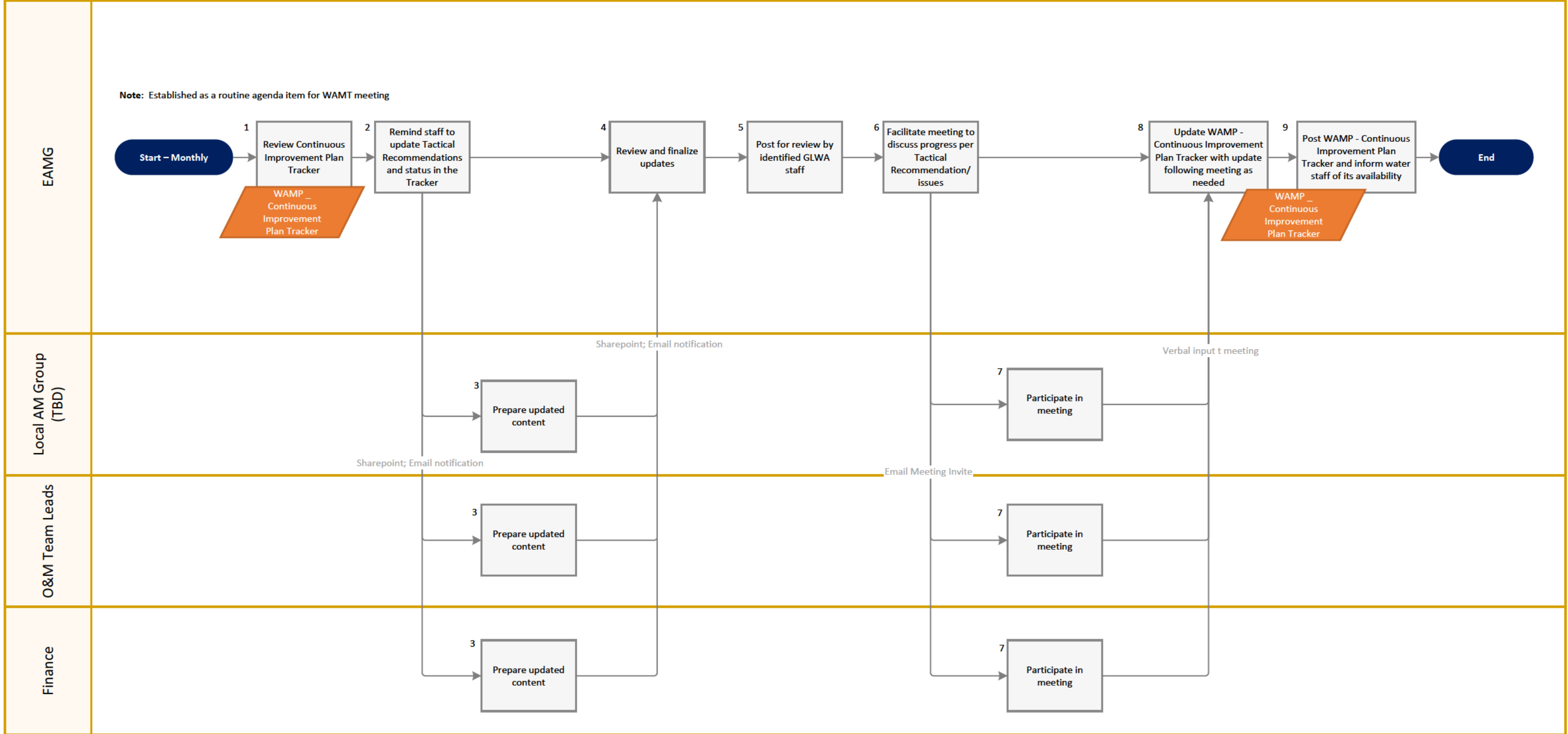
Table M-3 describes the WAMP Continuous Improvement Plan Implementation Business Process. Figure M-2 depicts this process visually. This business process is to be updated as it changes over time.

Table M-3 Business Process Description – WAMP Continuous Improvement Plan Implementation

WAMP - Continuous Improvement Plan Implementation	
Objective	To support implementation of the WAMP Continuous Improvement Plan through a defined business process.
Description of Process	<p>Trigger: Monthly</p> <p>EAMG – Review WAMP Continuous Improvement Plan Tracker</p> <p>EAMG – Remind staff to update Tactical Recommendations status in the WAMP Continuous Improvement Tracker</p> <p>Local AM Group (TBD)/O&M Team Leads/Finance – Prepare updated content</p> <p>EAMG – review and finalize edits</p> <p>EAMG - Post for review by identified GLWA staff</p> <p>EAMG – Facilitate meeting to discuss progress per Tactical Recommendation/issues</p> <p>Local AM Group (TBD)/O&M Team Leads/Finance – participate in meeting</p> <p>EAMG – Update the WAMP – Continuous Improvement Plan Tracker with updates following the meeting as needed</p> <p>EAMG- post WAMP- Continuous Improvement Plan Tracker and inform water staff of its availability</p>
Roles	
Process Sponsor	Enterprise Asset Management Group (EAMG)
Process Users	Local Asset Management Group (TBD) O&M Team Leads Finance
Timing	
Starting Event	Monthly
Ending Event	Updated WAMP – Continuous Improvement Plan - posted

Business Process: Water Asset Management Plan (WAMP) Continuous Improvement Plan Implementation

GLWA



M.3.3 WAMP - ASSET AUDIT PROGRAM

Table M-4 describes the WAMP - Asset Audit Program Business Process. Figure M-3 depicts this process visually. This business process is to be updated as it changes over time.

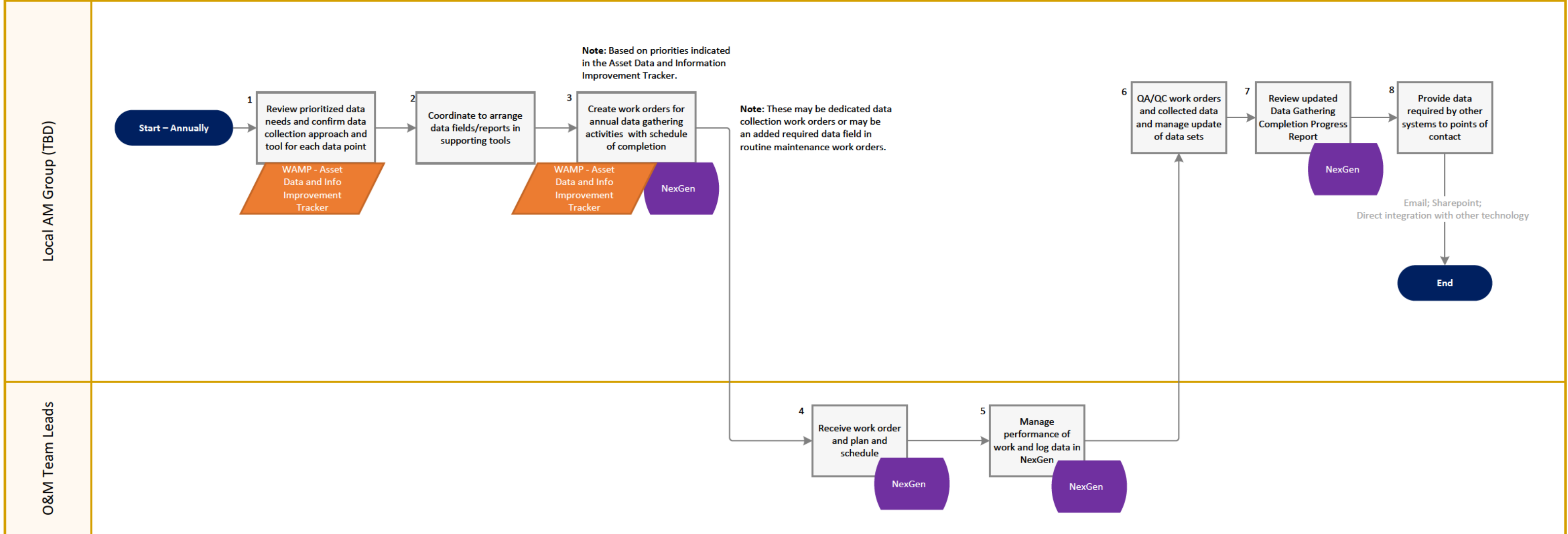
Table M-4 Business Process Description – WAMP - Asset Audit Program

WAMP - Asset Audit Program	
Objective	To methodically and systematically gather missing data on assets (to address quality or completeness issues) and improve the datasets used by GLWA to inform asset management decision-making.
Description of Process	<p>Local AM Group (TBD): Review prioritized data needs and confirm data collection approach and tool for each data point</p> <p>Local AM Group (TBD): Coordinate to arrange data fields/reports in supporting tools</p> <p>Local AMG (TBD): Create work orders for annual data gathering activities with schedule of completion</p> <p>O&M Team Leads: Receive work order and plan and schedule (includes use of Contractors)</p> <p>O&M Team Leads: Manage performance of work and log data in NexGen</p> <p>Local AM Group (TBD): QA/QC work orders and collected data and manage update of data sets</p> <p>Local AM Group (TBD): Review updated Data Gathering Completion Progress Report</p> <p>Local AM Group (TBD): Provide data required by other systems to points of contact</p>
Roles	
Process Sponsor	Local AM Group (TBD)
Process Users	Local AM Group (TBD); O&M Team Leads
Timing	
Starting Event	Annually
Ending Event	Updated datasets

Business Process: Water Asset Management Plan (WAMP) - Asset Audit Program

GLWA

This business process should be revisited/included in at the time of NexGen configuration so that configuration supports this programmatic asset management activity.



M.3.4 WAMP - CONDITION ASSESSMENT PROGRAM – VERTICAL AND BUILDING ASSETS

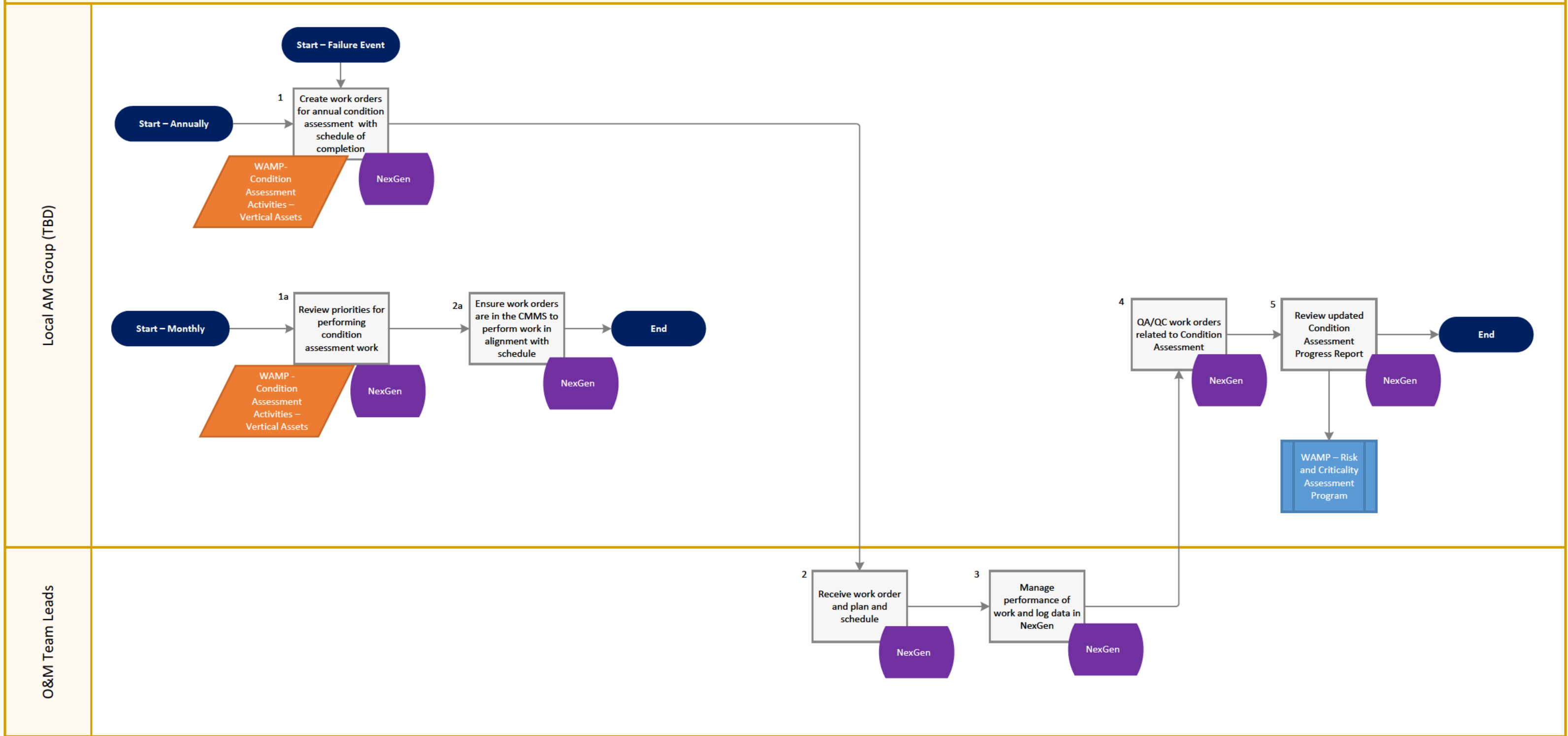
Table M-5 describes the WAMP Condition Assessment Program Business Process. Figure M-4 depicts this process visually. This business process is to be updated as it changes over time.

Table M-5 Business Process Description – WAMP Condition Assessment Program – Vertical and Building Assets

WAMP – Condition Assessment Program – Vertical and Building Assets	
Objective	To methodically and systematically gather condition assessment information on water system assets and improve the datasets and analytical tool used by GLWA to track or use asset condition data.
Description of Process	<p>Trigger: Annually, Monthly, or Failure Event Local AM Group (TBD): Create work orders for annual condition assessment with schedule of completion O&M Team Leads: Receive work order and plan and schedule O&M Team Leads: Manage performance of work and log data in NexGen Local AM Group (TBD): QA/QC work orders related to Condition Assessment Local AM Group (TBD): Review updated Condition Assessment Progress Report</p> <p>Trigger: Monthly Local AM Group (TBD): Review priorities for performing condition assessment work Local AM Group (TBD): Ensure work orders are in NexGen to perform work in alignment with schedule</p>
Roles	
Process Sponsor	Local AM Group (TBD)
Process Users	Local AM Group (TBD) O&M Team Leads
Timing	
Starting Event	Annually Monthly Failure Event
Ending Event	Updated Condition Assessment Progress Report

Business Process: Water Asset Management Plan (WAMP) Condition Assessment Program – Vertical Assets

GLWA *This business process should be revisited/included in at the time of NexGen configuration so that configuration supports this programmatic asset management activity.*



M.3.5 WAMP - RISK AND CRITICALITY ASSESSMENT PROGRAM

Table M-6 describes the WAMP - Risk and Criticality Assessment Program Business Process. Figure M-5 depicts this process visually. This business process is to be updated as it changes over time.

Table M-6 Business Process Description – WAMP - Risk and Criticality Assessment Program

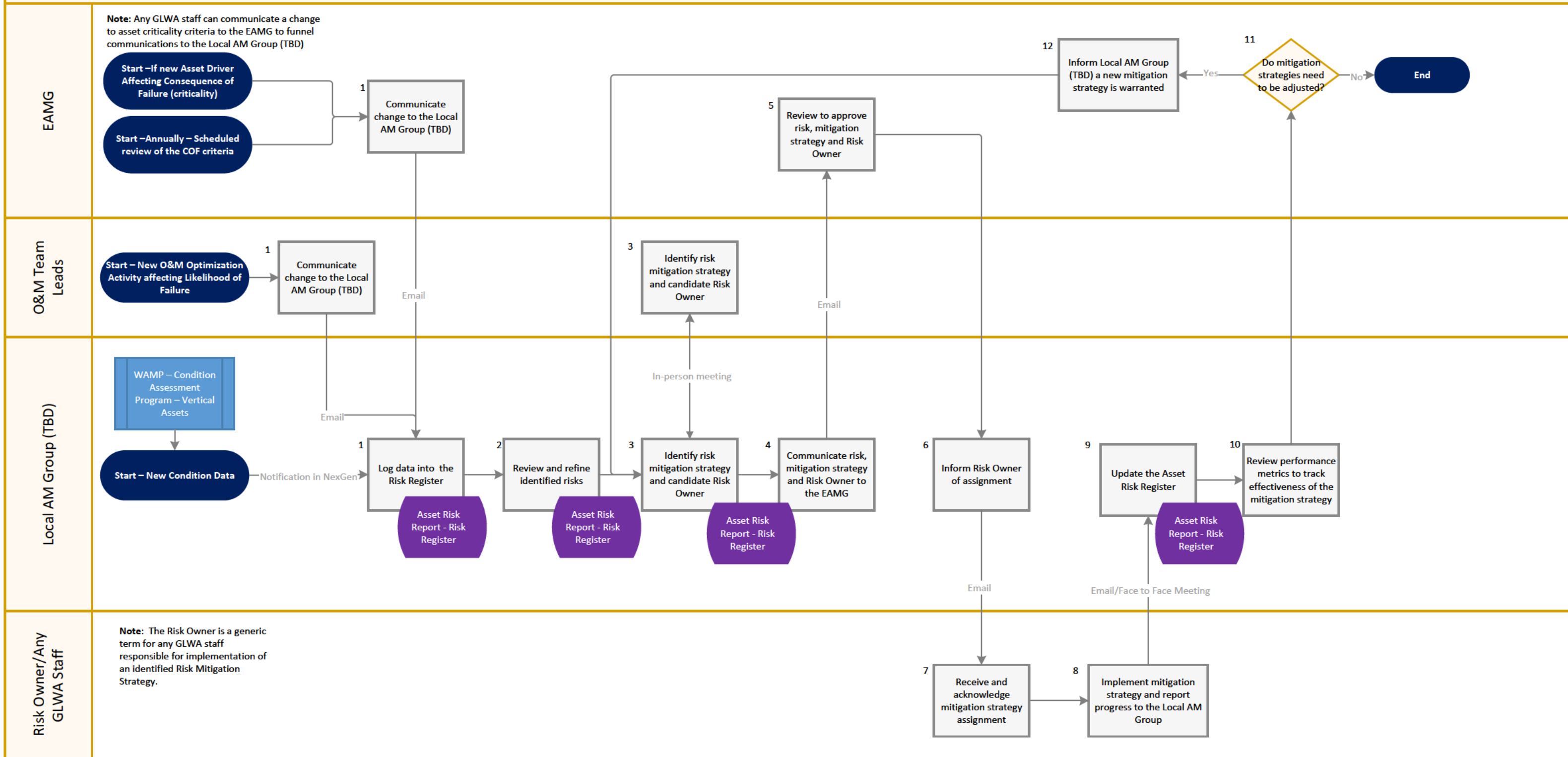
WAMP - Risk and Criticality Assessment Program	
Objective	To maintain and accurate risk register and use the results to trigger identification of risk mitigation strategies so that the overall risk profile associated with water assets is formally managed.
Description of Process	<p>Trigger: EAMG: communicates change on criticality to the Local AM Group (TBD) (any GLWA staff can identify a change and funnel communication to the EAMG)</p> <p>Trigger: Annual review of COF criteria</p> <p>Trigger: O&M Team Leads communicate change in maintenance that impacts the LOF to the Local AM Group (TBD)</p> <p>Trigger: Local AM Group (TBD): New condition data has been generated</p> <p>Local AM Group (TBD): Log updates to the WAMP – Risk Register</p> <p>Local AM Group (TBD): Review and refine identified risks</p> <p>Local AM Group (TBD)/O&M Team Leads: Identify risk mitigation strategy and candidate Risk Owner</p> <p>Local AM Group (TBD): Communicate risk, mitigation strategy and Risk Owner to the EAMG</p> <p>EAMG: Review to approve risk, mitigation strategy and Risk Owner</p> <p>Local AM Group (TBD): Inform Risk Owner of assignment</p> <p>Risk Owner/GLWA Staff: Receive and acknowledge mitigation strategy assignment</p> <p>Risk Owner/GLWA Staff: Implement mitigation strategy and report progress to the Local AM Group (TBD)</p> <p>Local AM Group (TBD): Update the Asset Risk Register</p> <p>Local AM Group (TBD): Review performance metrics to track effectiveness of the mitigation strategy</p> <p>EAMG: Do mitigation strategies need to be adjusted?</p> <p>EAMG: Inform Local AM Group (TBD) a new mitigation strategy is warranted (return to step 3)</p>
Roles	

WAMP - Risk and Criticality Assessment Program	
Process Sponsor	Local AM Group (TBD)
Process Users	Local AM Group (TBD) O&M Team Leads Risk Owner/GLWA Staff Enterprise Asset Management Group (EAMG)
Timing	
Starting Event	Whenever an asset driver that impacts consequence of failure of criticality of an asset; or when condition score information is updated
Ending Event	Updated WAMP-Risk Register

Business Process: Water Asset Management Plan (WAMP) - Risk and Criticality Assessment Program

GLWA

This business process should be revisited/included in at the time of NexGen configuration so that configuration supports this programmatic asset management activity.



M.3.6 WAMP - STRATEGIC MAINTENANCE AND RELIABILITY PROGRAM

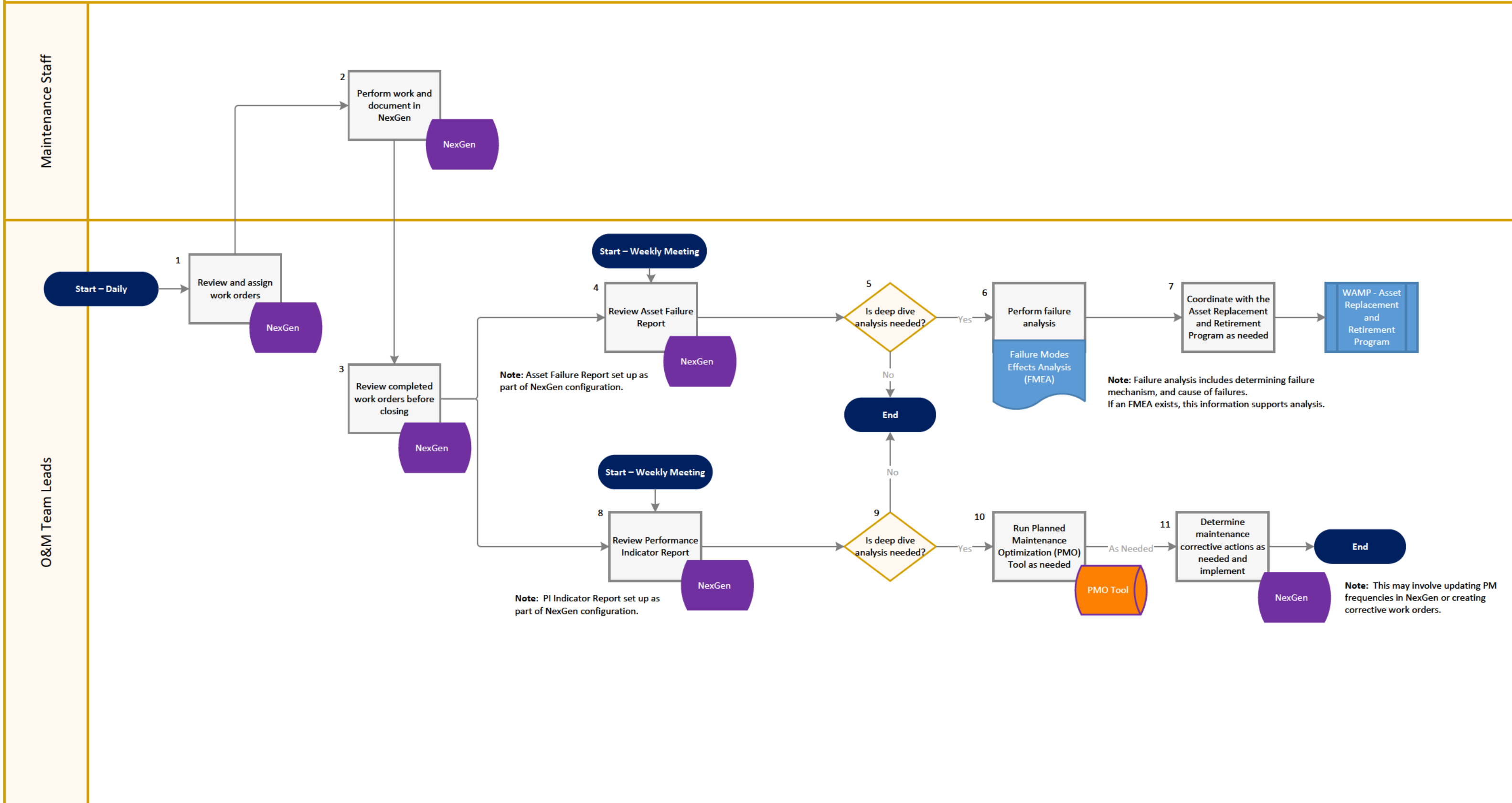
Table M-7 describes the WAMP Strategic Maintenance and Reliability Program Business Process. Figure M-6 depicts this process visually. This business process is to be updated as it changes over time.

Table M-7 Business Process Description – WAMP Strategic Maintenance and Reliability Program

WAMP – Strategic Maintenance and Reliability Program	
Objective	To implement strategic maintenance and reliability program best practices starting with development of Failure Modes Effects Analysis (FMEA) and running Planned Maintenance Optimization (PMO) analyses.
Description of Process	<p>Trigger: Daily O&M Team Leads: Review and assign work orders Maintenance Staff: Perform work and document in NexGen O&M Team Leads: Review completed work orders before closing</p> <p>Trigger: Weekly O&M Team Leads: Review Asset Failure Report O&M Team Leads: Is deep dive analysis needed? O&M Team Leads: Perform failure analysis O&M Team Leads: Coordinate with the Asset Replacement and Retirement Program as needed</p> <p>Trigger: Weekly O&M Team Leads: Review Performance Indicator Report O&M Team Leads: Is deep dive analysis needed? O&M Team Leads: Run Planned Maintenance Optimization (PMO) Tool as needed O&M Team Leads: Determine maintenance corrective actions as needed and implement</p>
Roles	
Process Sponsor	O&M Team Lead
Process Users	O&M Team Lead Maintenance Staff
Timing	
Starting Event	Daily Weekly
Ending Event	Coordination with the WAMP – Asset Replacement and Retirement Program Updated work orders in NexGen

Business Process: Water Asset Management Plan (WAMP) - Strategic Maintenance and Reliability Program

GLWA This business process should be revisited/included in at the time of NexGen configuration so that configuration supports this programmatic asset management activity.



M.3.7 WAMP - ASSET REPLACEMENT AND RETIREMENT PROGRAM

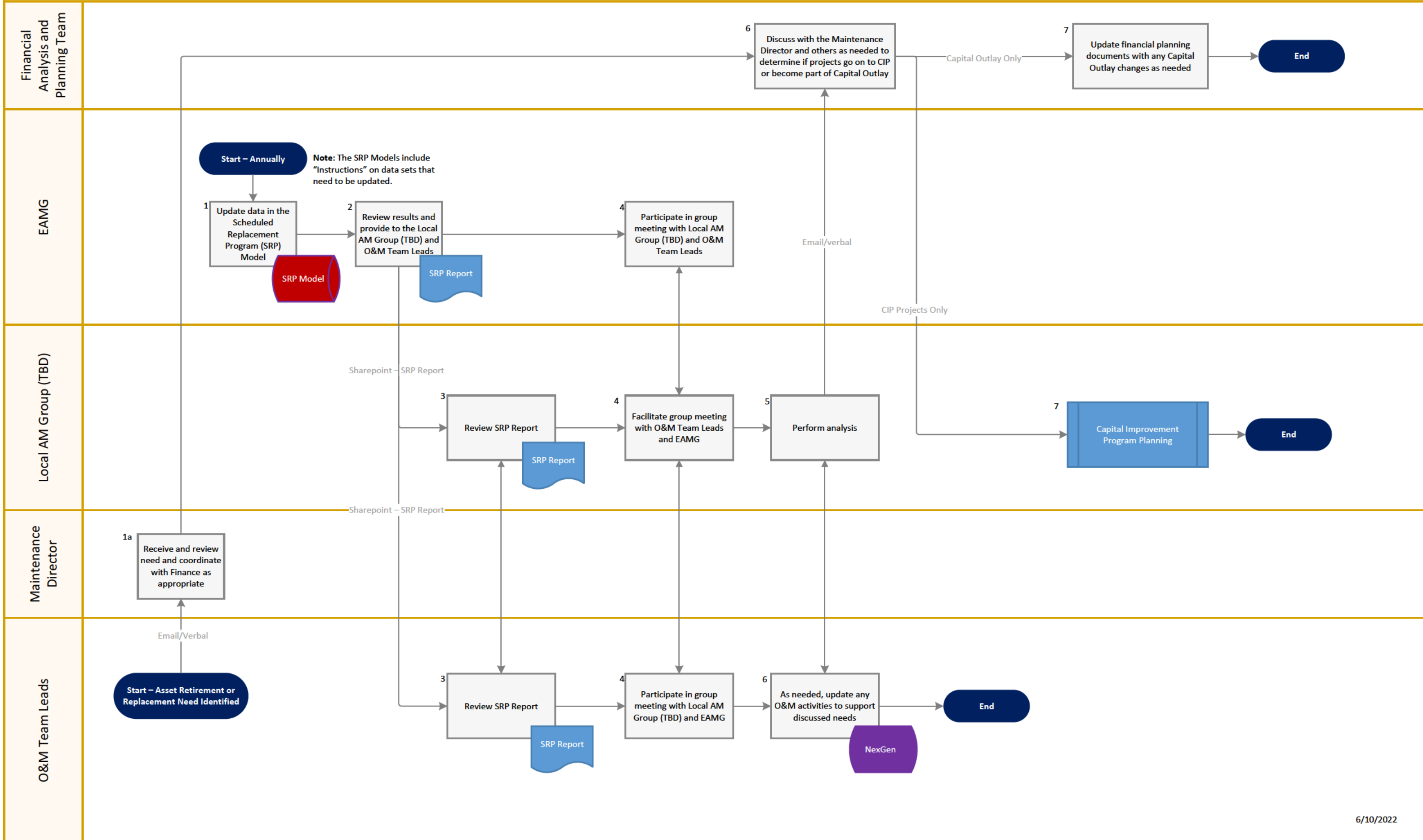
Table M-8 describes the WAMP - Asset Replacement and Retirement Program Business Process. Figure M-7 depicts this process visually. This business process is to be updated as it changes over time.

Table M-8 Business Process Description – WAMP - Asset Replacement and Retirement Program

WAMP –Asset Replacement and Retirement Program	
Objective	To identify assets that need replacement or retirement.
Description of Process	<p>Trigger: Annually EAMG: Update data in the Scheduled Replacement Program (SRP) Model EAMG: Review results and provide to the Local AM Group and O&M Team Leads Local AM Group (TBD) and O&M Team Leads: Review SRP Report Local AM Group (TBD): Facilitate meeting EAMG and O&M Team Leads: Participate in meeting Local AM Group (TBD): Perform analysis Finance: Discuss with the Maintenance Director and others as needed to determine if projects go on to CIP or become part of Capital Outlay O&M Team Leads: As needed, update any O&M activities to support discussed needs If Capital Outlay - Finance: Update financial planning documents with any Capital Outlay changes as needed If CIP - Local AM Group (TBD) - move project through CIP Process Trigger: As Identified by O&M Team Leads – need for asset replacement or retirement 1a. Maintenance Director: Receive and review need and coordinate with Finance as appropriate <i>Continue to step 6 (above)</i></p>
Roles	
Process Sponsor	EAMG
Process Users	Local AM Group (TBD) O&M Team Leads EAMG Financial Planning and Analysis Team Maintenance Director
Timing	
Starting Event	As Identified Annually
Ending Event	Asset Replacement and Retirement forecast Updated Capital Outlay Budget (potential) Updated CIP (potential) Updated O&M change (potential)

Business Process: Water Asset Management Plan (WAMP) - Asset Replacement and Retirement (R&R) Program

GLWA *This business process should be revisited/included in at the time of NexGen configuration so that configuration supports this programmatic asset management activity.*



Appendix N – WAMP Continuous Improvement Plan Staffing Plan

The Continuous Improvement Plan Staffing Plan is presented in Table N-1 and is a listing of estimated staff resources required to implement the WAMP Continuous Improvement Plan. The staffing plan is contained within and excerpted from the Continuous Improvement Plan Tracker (Appendix L) and Chapter 9.0 of the WAMP.

Table N-1: Continuous Improvement Plan Staffing Plan

Tac Rec #	Year 1		Year 2		Year 3	
	Est Labor Hours (GLWA)	Description	Est Labor Hours (GLWA)	Description	Est Labor Hours (GLWA)	Description
W1	20	5 staff at two, 2- hour meetings	10	5 staff at one, 2-hour meetings	60	10 staff at three, 2-hour meetings
W2	200	10 staff at 10 hours each; 50 hours of one staff to facilitate compilation of metrics; 50 hours of one staff create initial baseline of data	20	5 staff, 2, 2-hour meetings	50	10 staff at 5 one-hour meetings
W3	150	5 staff at 10 hours each to participate in five, 2-hour meetings; 100 hours for 2 staff (50 hours each) to address needs	150	5 staff at 10 hours each to participate in five, 2-hour meetings; 100 hours for 2 staff (50 hours each) to address needs	10	5 staff at 2 hours each to participate in two, 1-hour meetings
W4	40	10 staff at four, 1-hour meetings	60	10 staff at three, 2-hour meetings – one meeting per task activity	50	5 staff at 10 hours each; over five, 2-hour meetings
W5	400	5 staff at 80 hours each; over a two-week period	400	5 staff at 80 hours each; over a two-week period	500	7 staff at 70 hours each; over a two- week period
W6	50	2 staff at 25 hours each to update the Risk Register for Vertical Assets	60	5 staff at 2 hours each over one, 2-hour meeting; 2 staff at 25 hours each to update the Risk Register for Vertical Assets	50	2 staff at 25 hours each to update the Risk Register for Vertical Assets

Tac Rec #	Year 1		Year 2		Year 3	
	Est Labor Hours (GLWA)	Description	Est Labor Hours (GLWA)	Description	Est Labor Hours (GLWA)	Description
W7	520	30 staff involved in 10 hours of business process development and training. And 220 hours for obsolescence and succession planning	100	10 staff at 10 hours each that includes five, 2-hour meetings/ training sessions	200	10 staff at 20 hours each that includes 10, 2-hour meetings
W8	400	5 staff at 40 hours each; over 18, 2-hour meetings plus 200 hours of staff training	400	10 staff at 40 hours each; over twenty, 2-hour meetings/trainings	800	10 staff at 80 hours each
W9	40	2 staff at 10 hours each to assist with set up technology platform; 5 staff at 4 hours each over two, 2-hour meetings	40	2 staff at 10 hours each to assist with set up technology platform; 5 staff at 4 hours each over two, 2-hour meetings	40	10 staff at two, 2-hour meetings
W10	50	5 staff at 2 hours each; over two, 1-hour meetings and 2 staff at 40 hours of working with SRP models	50	5 staff at 2 hours each; over two, 1-hour meetings and 2 staff at 40 hours of working with SRP models	100	4 staff at 4 hours each to participate in two, 2-hour meetings and 84 hours 2 staff at 42 hours each to develop RFP
W11	60	6 staff to participate in five, 2-hour meetings	0	NA	0	NA
W12	100	2 staff at 50 hours each	24	4 staff at three, 2-hour meetings	40	2 staff at 20 hours each
TOTAL	2,030 hrs		1,314 hrs		1,900 hrs	