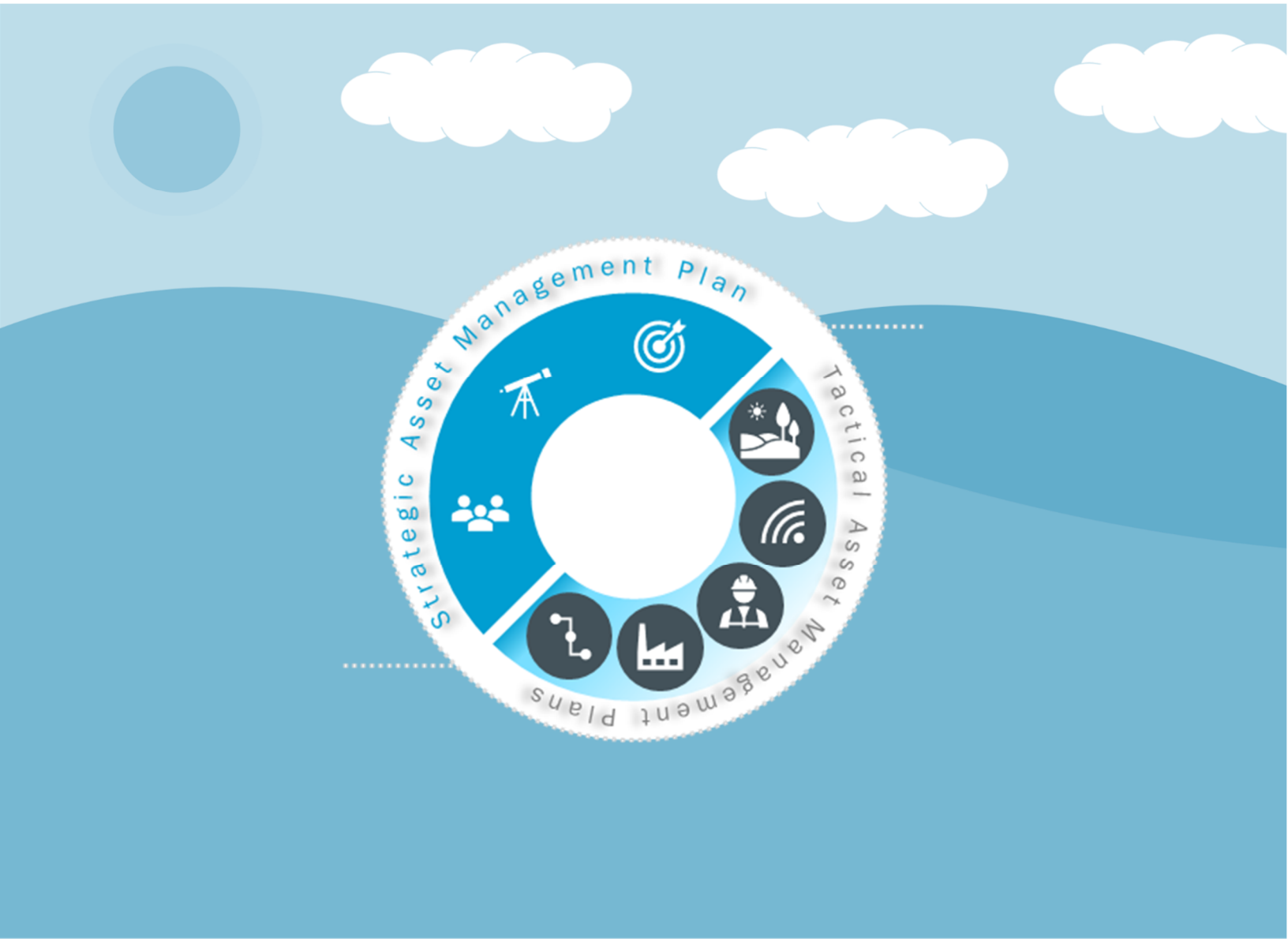
Capital Region Water

Strategic Asset Management Plan

August 2022



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Prepared for

Capital Region Water
Harrisburg, PA

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Version	Summary	Editor	Data Edited	Description of Changes
1	Initial Draft	BC		

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List of Abbreviations/ Definitions		
Asset		An item that has potential value to the organization such as equipment, buildings, etc.
Asset Management	AM	An integrated set of processes to minimize the lifecycle costs of infrastructure assets, at an acceptable level of risk, while continuously delivering established levels of service.
Asset Management Development Teams	AMDT	Asset Management teams that will be responsible for helping to implement the Asset Management Roadmap.
Asset Management Plans	AMP	Guide asset management processes at each facility or system. Each facility or system has its own tactical AMP, which includes technical elements such as: level of service measures, asset inventory, risk & criticality, O&M strategies, condition assessment, capital/engineering/rehab & replacement strategies, and information management.
Corrective maintenance	CM	Corrective maintenance
Capacity, Management, Operations and Maintenance	CMOM	A flexible, dynamic framework for municipalities to identify and incorporate widely accepted wastewater industry practices to: Better manage, operate, and maintain collection systems Investigate capacity constrained areas of the collection system (EPA)
Condition		Measure of the physical state of an asset.
Condition Assessment		Asset condition assessments involve monitoring assets periodically, and using the data collected from those inspections to determine the condition of each asset. The analysis of an asset's condition which may include categories for age, operating environment, performance, and utilization to develop a score for ranking the asset against similar assets.
Computerized Maintenance Management System	CMMS	Software that enables personnel to enhance their maintenance practices, take control of plan assets and practice expert maintenance management. A computerized system designed to enhance efficiency and effectiveness of maintenance activities. Typical features include planning, scheduling, and monitoring of work orders and maintenance needs. CRW uses Cityworks
Consequence of Failure	COF	The impact on level of service, utility, customers, or public resulting from an asset failure.
Critical Assets		Critical assets are those that have the potential to significantly impact organizational objective achievements. Criticality (i.e., the risk score) comprises two factors: (1) the likelihood of a failure, and (2) the consequence of that failure. Critical assets typically have enhanced maintenance strategies to mitigate failures.
Risk		A score formulated based on an asset's consequence and likelihood of failure.
Failure		The inability of an asset to provide the function for which it was installed.
Failure Codes		CMMS codes that designate the failure modes of an asset.
Geographic Information System	GIS	A computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location (USGS) and is the repository for CRW assets.
Level of Effort	LOE	Used in the context of this document, pertains to the number of hours that are required of personnel to implement the activity.
Likelihood of Failure	LOF	The chance of an occurrence, such as an asset failure.
Level of Service	LOS	The output or objectives the organization intends to deliver to its stakeholders (i.e., Public, Board, Rate Commission, Regulators).

List of Abbreviations/ Definitions		
Lifecycle cost		The asset life cycle covers the time span from when the asset need is determined through its eventual replacement or disuse. How the asset's life cycle is managed is dependent on the strategies and goals of its management. These strategies normally include training, maximizing utility, preventive maintenance, evaluation and when use will stop. Total cost of an asset throughout its life (includes planning, design, acquisition, O&M, rehabilitation & disposal costs).
Nine Minimum Control	NMC	Nine Minimum Control
National Pollutant Discharge Elimination System	NPDES	The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. (EPA)
Operations and Maintenance	O&M	The functions, duties, and labor associated with daily performance and preservation of assets.
Performance		A measure of whether the asset is delivering level of service requirements.
Predictive maintenance	PdM	Predictive maintenance (PdM) programs are based upon the actual condition of the equipment and a determination of when maintenance should be performed to minimize costs. New technology techniques such as ultrasound, infrared and vibration online testing make PdM a viable alternative in certain circumstances. However, for most equipment the complex metrics for making educated guesses (predictive) is provided by preventive maintenance programs. PdM programs give you the ability to monitor equipment and track conditions over time to predict when maintenance should be performed. Maintenance schedules that are created to establish high levels of asset reliability and are mostly performed while the equipment is in service. The goal is to undertake maintenance activity before the assets loses optimum performance capability, therefore extensive condition monitoring is vital.
Preventive maintenance	PM	Inspection or servicing tasks designed to prevent or mitigate equipment-specific failure modes that could lead to a functional failure. These tasks are ALWAYS pre-planned, scheduled, and performed. Maintenance programs that are designed to prevent machinery assets from malfunctioning or breaking down by planning repairs, replacing components and servicing assets so that incipient failures can be detected or corrected before they occur or develop into major defects. PM programs give you the functionality of predefining and scheduling tasks or procedures associated maintaining your equipment.
Problem, Cause, Remedy Codes	PCR Codes	The CMMS codes used for failure reporting that indicate the problem, cause, and remedy to a failure.
Rehabilitation and Renewal	R&R	Phases of an asset lifecycle that focus on fixing or replacing an asset to meet the required service
Remaining Useful Life	RUL	The useful life remaining on an asset. An estimate of the number of remaining years that an asset can perform its duty.
Roadmap Implementation Groups	RIGs	CRW development team comprised of staff who have a direct subject matter expertise in the specific AM recommendations. The RIGs align with assigned AM Category and should have representation at the front-line level with people involved in the execution of the work.
Risk		The possibility that something negative will happen to the stakeholders/organization. In asset management terms, is the product of the likelihood of failure and the consequence of failure of an asset.
Roadmap Development Team	RDT	Asset Management team that includes cross-divisional representatives involved in guiding the development of the Asset Management Roadmap.
Supervisory Control and Data Acquisition	SCADA	A computerized system often used to collect real-time maintenance information for monitoring and control of assets. "A computer system for gathering and analyzing real time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation."

List of Abbreviations/ Definitions		
Strategic Asset Management Plan	SAMP	Guides overall asset management processes to ensure consistency. Includes organizational elements such as: charter vision & goals, training, communications, engineering design & construction, capital planning & financing, project justification, and key processes and templates.
Useful Life		The amount of time that an asset can perform its function as designed.

Program Charter

The Strategic Asset Management Plan (SAMP) is the primary document that guides Capital Regional Water (CRW) efforts in the administration of asset management (AM) activities associated with facility and system assets: treatment plants, collection and distribution systems, and pump stations. It brings focus to the strategy for improved asset management, and provides the overarching framework for achieving the vision, mission, and strategic goals of the Asset Management Program, as described in the program charter. Rather than being an extensive manual of practice on asset management, the SAMP is a concise framework that creates a consistent approach for the divisions which operate and maintain the facilities and distributed systems. The SAMP framework provides the "rule book" for facility/system plans (Tactical Asset Management Plans – AMPs) to help meet the established service level expectations and other operational objectives at the lowest life cycle cost.

Section 1

Introduction

Capital Region Water (CRW) provides drinking water, stormwater, and wastewater services to the city of Harrisburg and neighboring municipalities. The protected DeHart Reservoir provides an abundant supply of source water, which is treated at the Water Services Center and distributed to 60,000 customers throughout the city of Harrisburg, and portions of Penbrook Borough, Lower Paxton Township, Swatara Township and Susquehanna Township.

CRW operates almost 230 miles of water mains that range from 6 inches to 42 inches in diameter and 1,800 fire hydrants and 20,884 service connections. Design flow of 20 MGD is treated at Dr. Robert E. Young Water Services Center Treatment Facility. There are three pumping stations namely Susquehanna River Pump Station, Gate House Pump Station, Union Square Industrial Park Booster Station.

CRW owns and operates an Advanced Wastewater Treatment Facility (AWTF), a conveyance system, and wastewater and stormwater collection system within city limits. The combined system consists of 175 miles of pipe and constitutes, 85% of the wastewater system (by length). The remaining 15% is a separate sanitary sewer system in which the sewers are directly connected to CRW's conveyance system without passing through CSO regulator structures.

This Strategic Asset Management Plan (SAMP) will guide overall asset management processes to ensure consistency including organizational elements such as: charter vision and goals, training, communications, engineering design and construction, capital planning and financing, project justification and key processes and templates.

Asset Management Definitions

"CRW's Asset Management Program is our decision-making framework designed to balance performance, risk and cost as we invest in our infrastructure with the right work at the right time for the right reasons."

(ISO 55000)

- **Asset.** Item that has potential value such as equipment, buildings, etc.
- **Condition.** Measure of the physical state of an asset.
- **Consequence.** Impact on level of service, utility, customers, or public resulting from an asset failure.
- **Failure.** Inability of an asset to provide the function for which it was installed.
- **Likelihood.** Chance of an occurrence, such as an asset failure.
- **Level of Service.** Output or objectives one intends to deliver to its stakeholders (i.e., Public, Board, Regulators).
- **Lifecycle cost.** Total cost of an asset throughout its life (incl. planning, design, acquisition, O&M, rehabilitation & disposal costs).
- **Risk value.** The combination of consequence and likelihood of a failure.

The SAMP serves several purposes:

1. Provides information about where the asset inventory data is located. Provides criticality criteria to determine individual asset inspection, replacement, and rehabilitation rankings.
2. Provides information on the established levels of service (LOS) and key performance indicators (KPIs).
3. Identifies renewal and replacement strategies and techniques. Identifies currently known data requirements and program enhancements.
4. Helps ensure that capital investments are proactive, flexible, and promote the most efficient use of available resources.
5. In recognition of the fact that each facility and system owned and operated has specific assets, conditions, and requirements under which they are operated, the management of these facility and system assets are also governed by a Tactical Asset Management Plan (AMP). The AMP structure is like that of the SAMP, but the SAMP provides a standardized approach for the overall asset management framework and business rules across facilities and systems; the AMP describes the specifics for asset management at a particular location and identifies actions that are being implemented to achieve the standards and goals herein listed. **The SAMP is intended as a guidance document to develop and implement the facility and system AMPs. It provides the ground rules to help achieve the vision of the Asset Management Program.** Figure 1-1 depicts the relationship between the SAMP and AMPs.

Figure 1-1. SAMP and AMPs Relationship.

6. The fundamental components of the SAMP are shown in Figure 1-2, and include Operations and Maintenance, Organizational Framework, Decision Making and Capital Planning topics, and Information Systems and Data Management topics.

In addition to the SAMP and AMPs, an Implementation Plan, or Roadmap, defines the sequencing, scheduling, and prioritization of asset management program activities. The AM Roadmap includes prioritized SAMP improvement strategies recommended for the ultimate fulfillment of a successful AM program. The Roadmap Development Team (RDT) will need to periodically review, reprioritize and/or adjust the SAMP, AMPs and Roadmap as conditions change.

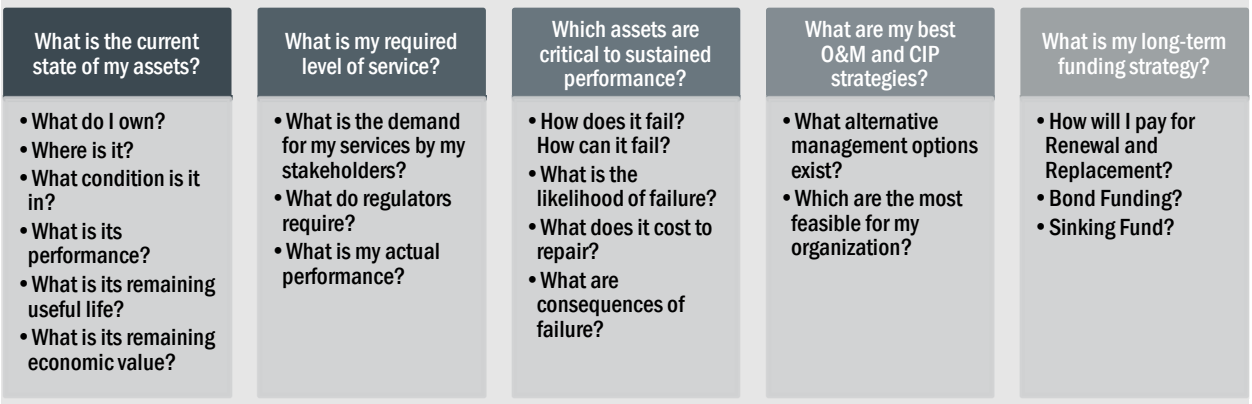
Figure 1-2. Asset Management Plan Components

1.1 Asset Management Overview

For purposes of using this SAMP as a guide for managing CRW's facility and system assets, asset management is defined as the following:

> Asset Management is a systematic process of operating, maintaining, and upgrading assets cost-effectively, including the practice of managing assets so that the greatest return is achieved with the objective of providing the best possible service to internal and external customers.[1]

Asset management helps organizations answer and address the questions:



The sections of the SAMP align with asset management industry standards: International Infrastructure Management Manual (IIMM) provides insight and examples of asset management practices and International Standards Organization (ISO) 55000 provides a broad framework for topics that should be addressed as part of a sound AM program.

[1] This definition is in alignment with IIMM and ISO 55000 asset definitions.

1.2 Asset Management Workflow

A typical path to achieve AM program excellence is shown in Figure 1-3. The key AM fundamentals are shown on the top row (i.e., organizational objectives, LOS, asset inventory and hierarchy, and risk assessment). Without those overarching objectives and procedures in place, it is difficult to implement an effective AM program. As such, the first step in an AM program is to develop the organizational objectives. The RDT collaboratively developed their organizational objectives: asset management program vision, mission, and goals. Those elements are the guiding force behind the decisions that are made for the short- and long-term needs of the asset management program. The LOS, asset inventory and hierarchy, and risk assessment build on those foundational elements.

The remainder of the activities (condition assessment and monitoring, maintenance strategies, operations and maintenance, business case justification and project prioritization) are the bulk of the AM program. The workflow helps guide sequencing of the AM program execution.

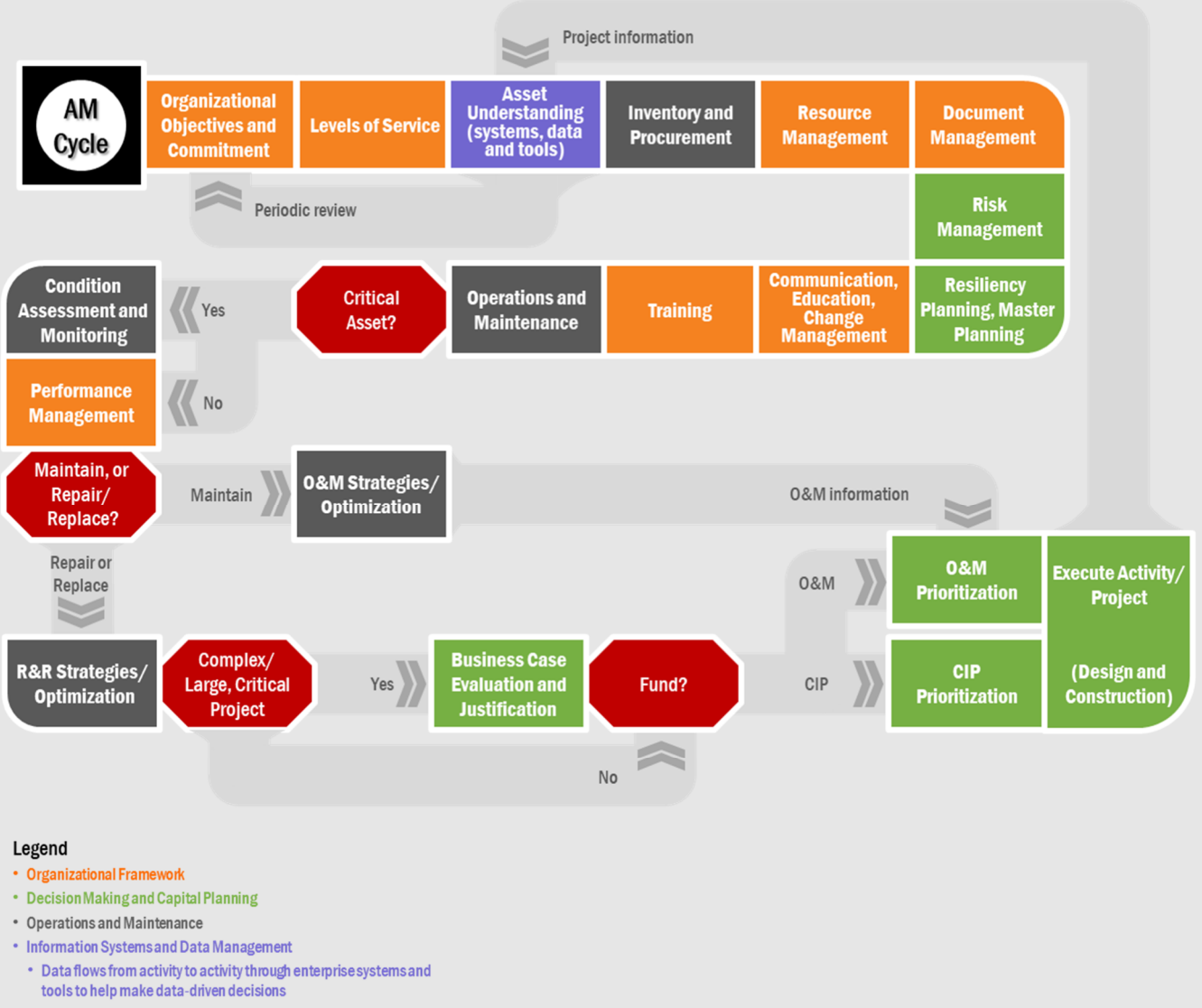


Figure 1-3. Asset Management Framework

1.3 SAMP Development and Maintenance

1.3.1 Development

The original contents of this SAMP were prepared by the Organizational Framework RIG members and representatives from sections throughout the organization with meetings and activities facilitated by Brown and Caldwell (BC). The meetings and activities were implemented to obtain input for the sections contained within this SAMP and included the establishment of a practical process to maintain and update the SAMP over time.

1.3.2 Administration

Managing the SAMP is a dynamic process of continuous planning, implementation, evaluation, and resultant adaptation to changing conditions and lessons learned. Through the active maintenance of this SAMP document, the Asset Management Program will continue to be refined and responsive to changing priorities. The RDT will conduct annual SAMP update meetings for the purposes of holistically reviewing and updating this SAMP, with specific actions listed in Table 1-1 and depicted in Figure 1-2

Table 1-1. SAMP Administration Duties

Topic	Action	Activities	Responsible Person
Monthly Status Sessions			
	Identify changes	Identify changes to SAMP defined process, section, workflow, or activity	All Requestors
	Record and document needs	Record identified changes in the AM change log and assign to appropriate RIG Champion	Requestor – Records, AM Group – Assigns
		Evaluate identified change for inclusion in the annual update to the SAMP and elevate to RDT as appropriate for consideration	RIG Champion
	Approve changes	Approve or reject the changes for inclusion in the annual SAMP update and memorialize the decision in the change log	RDT
	Communicate change decision	Communicate the RDT decision on recommended change items to the RIGs	AM Group
Annual Review Process			
	Review SAMP and change log	Meet to review status of the SAMP	OF RIG
		Identify successes in SAMP and AM Program implementation	All RIGs
		Identify ways to address gaps in recommendations	All RIGs
		Confirm roles and responsibilities are still appropriate	OF RIG Champion
		Compile logged updates/changes/edits to the SAMP	AM Group
	Identify and document needs	Discuss newly needed improvement activities	RIG Champion
		Confirm priorities	RDT
	Update the SAMP	Review recommended changes to the SAMP	RIG Champions

Table 1-1. SAMP Administration Duties			
Topic	**Action**	**Activities**	**Responsible Person**
		Approve changes recommended to the SAMP	RDT
		Incorporate approved changes into the SAMP on an annual basis	OF RIG
	Communication	Communicate SAMP changes to all staff	AM Group

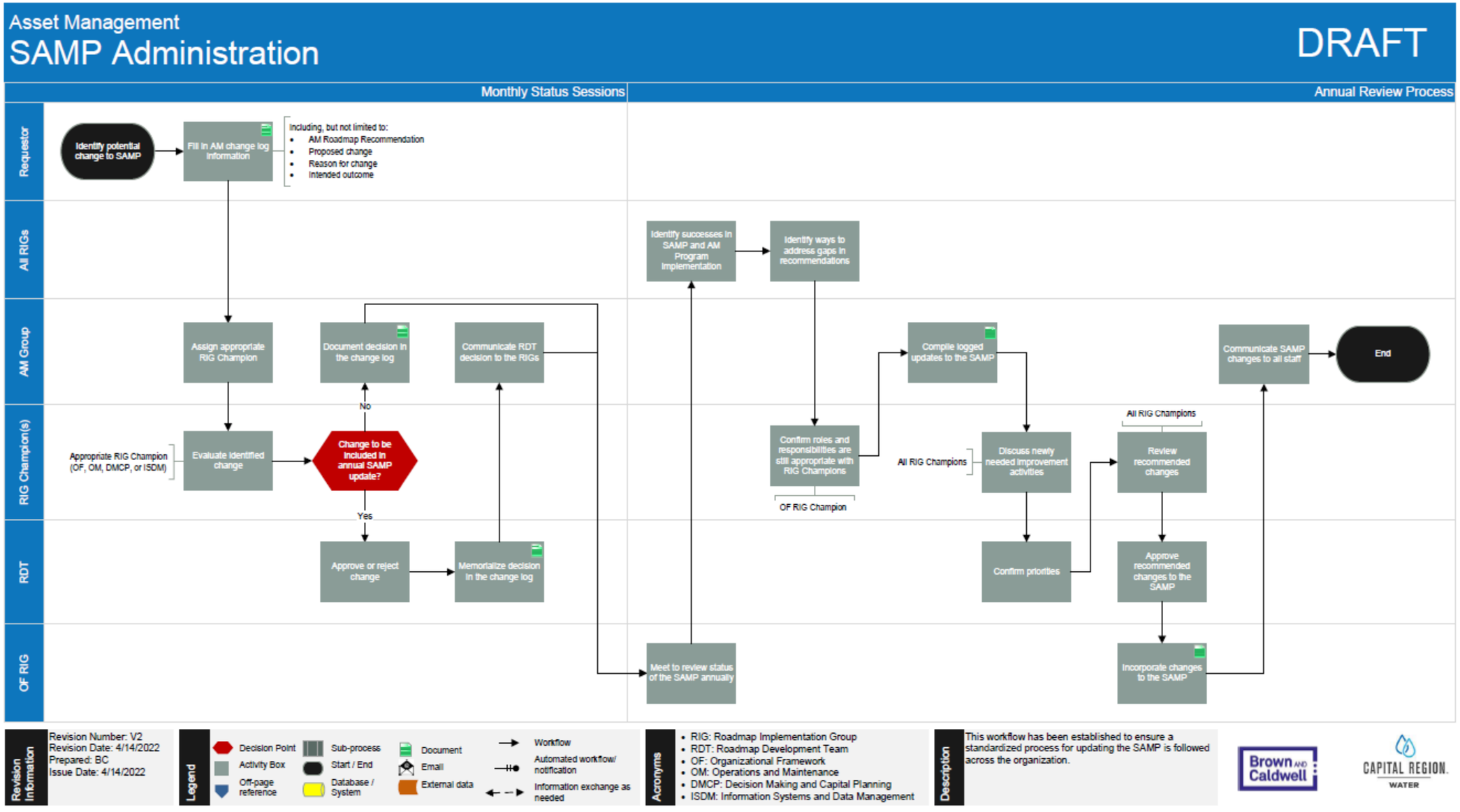


Figure 1-4. SAMP Administrative Process

1.3.3 Continuous Improvement Process

Continuous improvement is a vital part of any AM program. It is a best practice that helps utilities focus on a systematic way of making small adjustments and improvements to AM activities. Typical steps in a continuous improvement process are shown below in Figure 1-5.

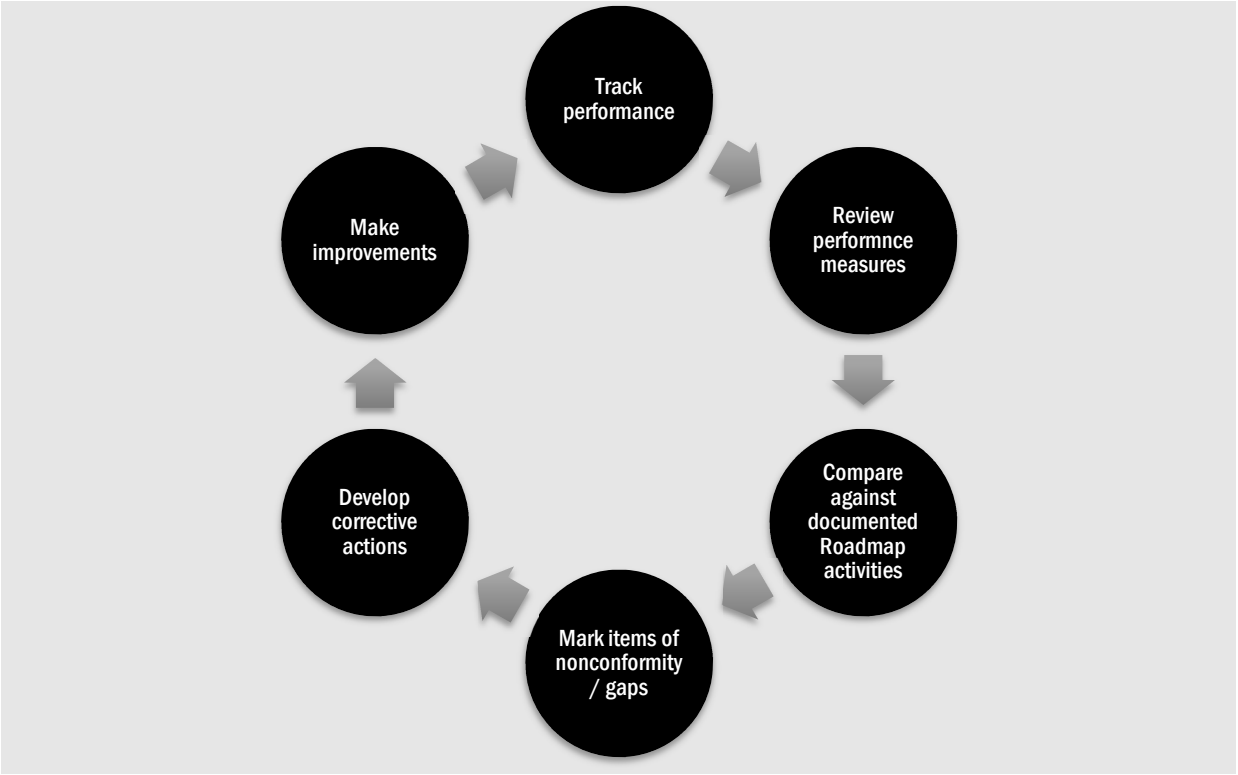


Figure 1-5. Continuous Improvement Cycle

Section 2

Organizational Framework

A successful, high-functioning asset management program depends on having a well though-out Organizational Framework. This includes having commitment from leadership; a solid understanding of organizational culture and an effective change management plan; comprehensive communications and document management procedures; levels of service and performance measures that allow the organization to track, understand and modify performance based on reliable data; and the right resources in place to make the AM program successful.

2.1 Leadership and Commitment

A vital step in building and maintaining a successful asset management program is getting support from leadership within the organization and from the governing body. To that end, it is important that the governing body understands the objectives of AM and treats it as a policy priority. CRW has defined goals/vision/mission for achievement in each AM performance area in the CRW Asset Management Roadmap. All levels of management have been trained on and understand the importance of AM and support activities to make improvements.

2.2 Culture and Change Management

Asset management is as much about culture as it is procedure. Uniformity, consistency, and repeatability, where needed, can be a challenge to achieve. As such, success relies on a greater involvement and participation of staff and the individuals serving as change agents more so than any other program. Culture change is therefore a critical element of success. Communication, training, education, and visibility by all personnel will be critical throughout implementation. Change management and communication methodologies are vital to a successful asset management program. A separate Management of Change (MoC) Plan is included in the asset management supporting documents.

2.3 Communications

A separate Communication Plan is included in the asset management supporting documents and ensures efficient use of available resources by identifying stakeholders, establishing clear messages, identifying effective communication methods, and anticipating critical issues. This Communication Plan also provides the methodology and details for communications with internal personnel during development and implementation of the AM Program.

The Plan can easily be used as a tool for communicating key messages and action items to the staff responsible for the development, implementation, and sustainability of the AM Program. The Communications Plan also includes a schedule of what communication activities are required to meet the AM Program Vision, Mission, and Goals (see Program Charter).

2.4 Document Management

Asset management topics and processes are identified, understood, evaluated, and documented. These include:

- The SAMP and the AMPs are located at: Asset Management Plans - Strategic and Tactical.

- Wastewater Collection and Conveyance System AMP, January 2020
- Water Transmission and Distribution System AMP, July 2020

Included in the AM Roadmap are identified AM gaps, and all associated elements (resources, responsibilities, reporting, etc.) have been specified.

- Asset Management Roadmap is located AM Roadmap.

Document management is a considered process that is readily understood and available throughout the organization.

- General document management practices are documented, and the file is located on the server
- General document management practices are documented, and the file is located on the intranet at DOCUMENT RECORDS LIBRARY.

2.5 Levels of Service and Performance Evaluation

A foundational part of asset management is the development of Levels of Service (LOS) that document desired performance of various programs and help inform decisions. LOS are any organizational services that a stakeholder perceives as valuable and that can be defined and measured. LOS usually relates to quality, quantity, reliability, responsiveness, environmental acceptability, and cost. LOS set expectations for managing assets and the outcomes that one strives to achieve.

The LOS developed as part of this SAMP focuses on standards for facilities and systems specifically related to asset management. Additional LOS measures that may impact the organization (such as budgeting, general workplace training, etc.) are not listed within this document since they are tracked and reported through other programs and groups in the organization.

Each of the documents and LOS listed in the following sections are assigned to one of the four aspects of the Balanced Scorecard (BSC), which is an industry standard approach to developing, managing, and tracking performance measures. BSC looks at organizational service and performance through four components: stakeholder, internal processes, employee learning and growth, and financial. Maintaining the four dimensions of the BSC provides a broader industry-accepted perspective and is consistent with the LOS and measures listed herein.

Definitions

Level of Service:

The description of the service output for a particular activity or service area against which performance is measured. (NAMS, 2007 - Developing Levels of Service and Performance Measures)

Key performance indicator:

Measurable value that demonstrates utility effectiveness in achieving goals and objectives.

Performance measure:

A qualitative or quantitative measure used to measure actual performance against a standard or other target.

Used to indicate how the organization is doing in relation to delivering levels of service.

Metric:

The numbers or values that can be summed and/or averaged, such as dollars, distances, durations, and temperatures, etc.

Performance Target:

A specific quantifiable target for performance, used in reference to a performance measure.

Considerations

- Consistent with business goals and objectives
- Clear and understandable
- Rewards the right behaviors: efficiency and effectiveness
- Forward-looking
- Follows SMART:

Simple -- Measurable -- Accurate, Achievable -- Responsive, Realistic, Relevant -- Targeted, Timebound

2.5.1 Information Sources

Table 2-1 lists the regulations, policies and plans that establish the LOS expectations and subsequent rules for managing assets

Table 2-1. Regulations, Polices and Plans Impacting Asset Management

Regulation/Policy/Plan	Description	BSC Dimension *
Strategic Business and Operating Plans	Sets the strategic objectives for the next few fiscal years	P
Consulting Engineer's Annual Report (CEAR)	Annual reports for CRW's water and wastewater system as required by a Trust Indenture to provide advice and recommendations as to the proper maintenance, repair, and operation during the fiscal year and estimate the amounts of money that should be expended.	P/F
Clean Water Act	Federal legislation defining conveyance and treatment standards	S
Department of Environmental Protection, Water Supply Manual 383-2125-108	State legislation defining design standards/requirements for Community System Design standards	S
CSO Long Term Control Plan (LTCP)	LTCPs are required under the Environmental Protection Agency's combined sewer overflow (CSO) Control Policy and is part of the CSO control strategy to reduce the frequency, duration, and intensity of CSO events	S
NPDES permits- Wastewater Discharge and Stormwater (MS4)	Permits for plants include performance criteria, discharge limits, and stormwater program requirements	P/S
Consent decree	Federal mandate relating to collection systems and pump station activities	S
Civil Service Rules	Personnel Rules for utility	E
CMOM master plan	Planning document for addressing Capacity, Maintenance, Operating and Management concerns and system issues; sets stage for some capital program requirements	P
Utility Charter	Defines the need and creation of the utility	S
Air permits (Title V)	State legislation defining air quality standards	S
FEMA – flood plain regulations	Defines LOS requirements for areas within the 100-year flood plain	S
Corps of Engineers – agreement	Defines level of service requirements for flood protection	P/S
Collective Bargaining Agreement	Labor agreements with various trade unions	E
Tri-County Regional Plan	Regional plan developed by Tri-County Regional Planning Commission (TCRPC)	S
AM Charter	Sets the strategic goals/objectives of the Asset Management program	P
Health & Safety Manual	Defines safety, environment, and health standards for staff	P
Annual Operating Budget	A zero-based budget that defines expected expenditures for the fiscal year	F

Table 2-1. Regulations, Polices and Plans Impacting Asset Management		
Regulation/Policy/Plan	Description	BSC Dimension *
GASB 34	Governmental standards that define asset recognition and accounting requirements	F
Rate Study	Cost of service and rate differential study for financial master planning	S
Training program	Development programs for apprentice and leadership personnel aimed at equipping staff with necessary skills to be successful	E
Standard Operating Procedures	Train personnel on the latest operating procedures handling water and wastewater assets.	E
Customer satisfaction survey	Performance and opportunities for improvement feedback from customers receiving service	S
Water Quality Report / Consumer Confidence Report	Water distribution system performance and opportunities for improvement feedback from customers receiving service	S
American Water Infrastructure Act	Risk and Resilience assessment and update emergency response plan	S
Lead and Copper Rule	Replace lead service lines to meet the new lead and copper rule. Under the new rule at least 3 percent of lead service lines must be replaced each year when 10 percent of sampling results are above 15 ppb.	S
AWTF Emergency shutdown plan	Emergency Shutdown Procedures for Advanced Wastewater Treatment Facility and Front Street, Spring Creek, and City Island Pump Stations.	S
Spill Prevention Contingency and Control Plan-	Spill prevention and response plan within the WTP and WWTP.	S
Water, Wastewater and Stormwater Master Plans	Planning documents for addressing water, wastewater, and stormwater planning and sets stage for some capital program requirements	P/S
Chapter 94 Municipal Wasteload Management Report	PADEP Ch. 94 Report Municipal Wasteload Management Annual Report to fulfill regulatory reporting requirements	P/S
Nine Minimum Control Plan (NMC)	Plan that outlines compliance with National COS Control Policy	P/S
Operation & Maintenance Manual (OMM)	CRW's plan describing current O&M practices for employees	P
Capital Improvement Plan	Summary of identified capital projects including general schedule, funding required, and scope of task	F
General Management Policy - Capital Assets	Defines when capitalization is appropriate, depreciation cycle, etc.	F
Purchasing ordinance	Rules and regulations related to the procurement process	F

** Balanced scorecard dimensions: E→ employee learning and growth; F→ financial; P→ internal processes; S→ stakeholders*

2.5.2 Levels of Service and Performance Measures

The LOS and corresponding performance measures were developed and agreed upon by RDT. They are listed below and are designed to be tracked and reported at an organizational level. Facility- and system-specific LOS and the related performance measures, which are available in the AMPs, roll up to the overall LOS.

Table 2.2 lists the LOS and related performance measures that will be tracked at the organizational level.

Table 2-2. Levels of Service aligned with Strategic Goals					
CRW Strategic Goal	LOS Description	Performance Measure	Description	Reporting frequency	Target*
Public Health and the Environment	Achieve or exceed all environmental and public health requirements in our drinking water, wastewater, and stormwater services	Violations caused by asset failures	Number of violations caused by asset failures / total number of violations	Monthly	TBD
		Near Misses (vertical assets)	Number of regulatory parameters within upper/lower warning limit of permit (vertical assets only)	Monthly	TBD
		Monitoring and Reporting Compliance	Number of reporting activities completed by due date / total reporting activities scheduled	Monthly	TBD
		Monitoring and Reporting Compliance	Number of sampling data points missed	Monthly	TBD
Infrastructure Stability	Operate and maintain assets in an efficient, sustainable, and resilient way	Work Order Compliance	Number work orders completed by the due date / total work orders due for a given period	Monthly	TBD
		Equipment Failures/Breakdowns	Number of equipment failures or breakdowns in a period	Monthly	TBD
		Workorder Backlog	Number of weeks of planned maintenance work (by craft) available for assignment to staff	Monthly	TBD
		Planned Maintenance vs. Corrective Maintenance	Percentage of planned maintenance vs corrective maintenance	Monthly	TBD
	Undertake prudent and affordable renewal and replacement projects targeted for the long-term viability of the CRW assets	Asset Renewal and Replacement Rate	Actual expenditures (or total amount of funds reserved for R/R for assets) / total present worth of R/R for assets	Monthly	TBD
		CIP Spending	Total annualized capital spending / approved CIP budget	Monthly	TBD
		Operations Spending	Total annualized operations spending / approved operations budget	Monthly	TBD
Customers and Stakeholders	Provide financial resources for CRW customers that qualify for assistance	Customer Assistance	Number of customers receiving relief from the Customer Assistance Program (CAP)/month	Monthly	TBD
		Shut-off for Non-payment	Percentage of customer accounts shutoff for non-payment/month	Monthly	TBD
		CAP Assistance vs. Total Debt	Dollar value of the assistance relief as it relates to total debt (internal and external assistance dollars)	Monthly	TBD
	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community	Stakeholder Interactions	Number of interactions (community outreach and education) with defined stakeholders / total number of planned interactions	Monthly	TBD
		Service Request Completion	Average time to correct all CRW-related service issues	Monthly	TBD
		Media Stories	Number of CRW driven stories/posts (traditional and social media) related to the utility during the reporting period	Monthly	TBD

Table 2-2. Levels of Service aligned with Strategic Goals					
CRW Strategic Goal	LOS Description	Performance Measure	Description	Reporting frequency	Target*
		Customer Satisfaction	Number of Technical Service Complaints per 1000 Customer Accounts	Monthly	TBD
		Number of Insurance Claims	Number of insurance claims compared to industry average	Monthly	TBD
		Severity of Insurance Claims	Severity (financial) of insurance claims compared to industry average	Monthly	TBD
Workforce	Develop and strive for a highly productive workforce through safe work practices, training, and growth opportunities	Training Compliance	Number of employees that completed each required training by the deadline / number of employees required to complete the training	Monthly	TBD
		Safety Metrics	Safety metrics include incidents, worker comp claims, and days off due to work-related issues / days worked	Monthly	TBD
		Succession Planning	Number key positions with a formal succession plan/total key positions	Monthly	TBD
	Attract staff that are representative of CRW's service area and provide a work environment that promotes growth, equity, and stability	Vacant Positions	Number of vacant positions, by job category / total number of positions	Monthly	TBD
		Employee Diversity	Ethnic and gender diversity percentages for the utility (also includes employees residing within service area)	Monthly	TBD
		Employee Turnover Rate	Percentage of employees that leave the utility either voluntary or involuntary during the reporting period	Monthly	TBD
		Time to Hire	Average number of days from decision to hire until new employee is at work	Monthly	TBD
Efficient Use of Resources	Execute the mission of CRW using risk informed decisions that provide best value to our customers, stakeholders, and organization	Critical Assets with high-risk value (future)	Dollar value of critical assets with high-risk score / total dollar value of critical assets	Monthly	Future measure
		Critical asset with high-risk score	Number of critical assets with high-risk score / total number of critical assets	Monthly	TBD

**Target reflects annual value Performance Evaluation*

Performance measures are specific indicators used to demonstrate how an organization is doing. They are written in a clear, easy to understand language so that they may be shared with a wide audience – both internally and externally. Each division is responsible for accurately collecting, analyzing, and reporting facility and system data required to properly calculate performance measures identified in this document and in the timeframe determined by the RDT. While some of these metrics are not currently being tracked, the information should be collected where possible in anticipation of greater measure reporting and communication.

The data associated with a performance measure is typically collected through various systems and groups and stored in an asset management system for trending and reporting. **Appendix A** includes a summary of the measure definitions and data requirements for tracking LOS and performance measures

2.5.3 Regulatory Reporting

Methods (data collection, reporting) to comply with regulatory requirements are established and documented in the organization. Regulatory requirements and pending requirements are continuously monitored and communicated.

2.6 Resource Management

Adequate staff, equipment and tools are available to develop and sustain an AM program (includes development, training, monitoring, controlling, reporting, auditing, and updating and improving the AM program).

2.6.1 Resources

The primary staff involved in asset management along with a brief description of their roles are shown in Figure 2-1, and in Table 2.3.

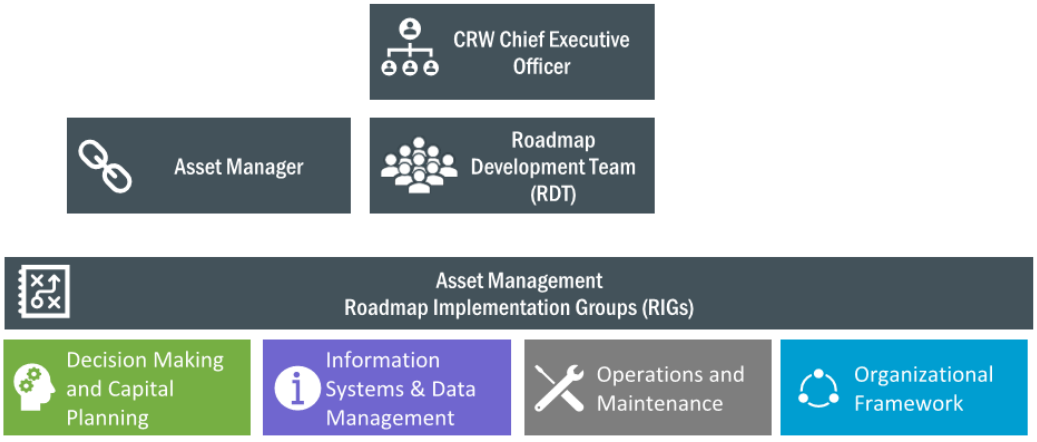


Figure 2-1. Asset Management organizational roles.

SAMP implementation responsibilities will fall to the staff/groups referred to in Figure 2-1. Specific responsibilities and required actions are listed in Table 2.3.

Table 2-3. SAMP Responsibilities by Role

CRW SAMP Activities (Year 1) Starting January 1, 2023	CEO	RDT	AM	RIG	Div
Guide the development of the AM program	s	s	AM	s	
Provide resources for AM program and ensure staff have the training required to understand their assigned roles	CEO	s	s		
Communicate progress to Board as required	CEO		s		
Review and provide input on the communications materials to CRW staff related to AM program		RDT	s	s	SI
Develop and institute AM communication and management of change plans		s	s	OF RIG	
Serve as a liaison between the RDT, RIGs, staff, and other CRW departments and outside consultant services			AM		
Participate in RDT meetings to oversee implementation of the Roadmap Implementation Plan		RDT	s		
Approve criteria that impacts AM Program at the strategic level (i.e., goals, risk, consequence and likelihood of failure criteria, LOS, etc.)		RDT	s	s	
Monitor and measure the performance of the AM program as it is implemented, and revise performance measures as needed		s	AM	s	
Participate in AM training	s	s	AM	s	s
Provide support to workflow process			s		SS
Provide support to enterprise systems			s		IT
Provide CMMS and GIS application support and subject matter expertise			s		GIS and AM
Identify issues during AM implementation and provide feedback to supervisors. Supervisory staff will provide a list of identified issues to RIG/AM for revision consideration. *†		s	s	s	All
Make annual revisions to the SAMP as required.*		RDT	s	s	

Role (solid = Primary; hatched = support)

Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4

*Follow procedures noted in Table 1-1

†Follow procedures in the AM Communications Plan

LEGEND

Approximate Level of Effort

a	As needed support	*Partipcipation may be needed periodically (as needed), and should include pre-notice for planning and scheduling the assistance*
l	Low LOE	*Minimal participation needed in scheduled meetings (approximately 1-3 a period)*
m	Medium LOE	*Participation needed in scheduled meetings, and may require work outside of the working sessions (approximately 1-3 a period)*
h	High LOE	*Participation needed in scheduled meetings, and requires significant work outside of the working sessions (approximately 3-5 a period)*

Roles

CEO	*Chief Executive Officer*
RDT	*AM Roadmap Development Team*
AM	*Asset Manager/Team*
DMCP, ISDM, OF, OM	*AM Roadmap Implementation Groups*

Divisional Engagement

SS	*Shared Services*
Fin	*Finance*
Eng	*Engineering*
Op	*Operations*
SI	*Strategic Initiatives*

2.6.2 Training

Staff require introductory and ongoing training so that they can be successful in their roles in executing their work. The training required to help advance the asset management program is summarized in Table 2-4.

Table 2-4. Summary of Training Needs

Topic	Training	Description	Recipients	Frequency
Asset Management	AM awareness training	A systematic approach for educating and motivating the work force to generate both direct and indirect value for the AM program has been established. The gap between needed AM competencies and staff capability are well understood at all levels of the organization and there is a plan to fill these gaps.	All	Initial, new hire
	Business Case Justification and Evaluation	Introductory training on monetized risk, Consequence of Failure, risk of failure and benefit scoring.	Engineering and Operations	Annually
	Systems knowledge-CMMS GIS SCADA Customer Billing Accounting	Understand how the utility's major systems are used to support the asset management program and overall utility mission	All	Annually
	Performance measures	Understand how to view and analyze the available LOS and performance measures	All	Annually
Organizational and Leadership	Change management	Periodic review of Management of Change Plan	RDT and RIG	Annually
	Communications	Periodic review of Communication Plan	Engineering, operations and RDT	Annually
Job Specific	Training development plan based on job classification	• Health and Safety • Technical Licenses and Certifications • Job Specific Technical • Emergency Response	All	Per plan

2.7 Business Continuity

CRW has evaluated threats to its operations, the community, and the environment that may impact the organization. CRW has a clear understanding of prevention activities and procedures to mitigate impacts to the organization and has documented them in a business continuity plan that covers staffing, systems and technology, and procedures related to communications, operations and financial decision making.

2.8 Continuous Improvement

People	Process	Technology
• Revist staffing assignments on an annual basis as part of the Asset Management Program review process.		

Section 3

Information Systems and Data Management

This section defines the high-level information associated with asset management-related data, tools, and systems. This includes the assets that comprise the facilities and systems, and the general hierarchy of managed assets that should be followed. Detailed asset inventories are managed and contained within the computerized maintenance management system (CMMS) and specific critical asset inventories are documented within the AMPs.

3.1 Overview

Organizations use a combination of systems, tools, and data to support day-to-day operations. The data collected are valuable repositories of information and used to support elements of the AM program. Table 3-1 shows the relationship of the AM categories with the enterprise systems, tools, and data along with the specific systems, tools, and data in use.

Table 3-1. Asset Management Systems, Tools, and Data

AM Element	Systems	Tools	Data
Organizational Framework			
Communications	• Everbridge Emergency Notification system	• Emails • Messages • Calls	• Incident log
Culture and Change Management	• SharePoint • ArcGIS Survey 123	• AM Change Management Plan • AM Communications Plan	• Organizational structure • Emails • Feedback surveys
Document Management	• CRW File Servers • Munilink • Munis • Teams • SharePoint	• Water and Wastewater Regulations • SOPs • Purchase Orders • Customer billing • Reporting/Dashboards	• Asset attributes • Operation costs • Regulations • Operational procedures • Accounting • Customer billing
Leadership and Commitment	• SharePoint	• AM Communications Plan • CRW Strategic Plan	• Roles and communication strategies

Table 3-1. Asset Management Systems, Tools, and Data			
AM Element	Systems	Tools	Data
Levels of Service and Performance Evaluation	• CMMS-Cityworks • GIS • Customer Information System-Muni-link • Finance • Regulatory/Permitting	• LOS • CIP • PowerBI Dashboards • Monthly Reports	• Asset Attributes • Condition Data • Maintenance History • Annual operating budget • Water and Wastewater regulations • Regulatory data
Resource Management	• HR- Inova • Timekeeping-Inova	• Employee Development and CRW Training program	• Employee time • Employee training
Business Continuity	• NA	• Strategic Business and Operating Plans • Customer Satisfaction Survey	• Technology, staff, and operational changes • Communication with stakeholders
Information Systems and Data Management			
Inventory and Asset Profile	• CMMS-Cityworks • GIS • CIS-Muni-link • CCTV-WinCan • Fleet Tracking-Verizon Network Fleet • Document Management System	• Data collection Tools • As- built • Reporting/Dashboards	• Asset Attributes • Asset Classes • Asset Hierarchy • Asset Naming • Condition Data • Existing document repository including file plan
Decision Making and Capital Planning			
Risk Management	• CMMS- Cityworks • GIS • Operation Insights- Module within Cityworks	• High risk assets • Overflow reporting • Real Time Controls	• Consequence of Failure (COF) • Likelihood of Failure (LOF) • Asset Attributes • Condition Data • Maintenance History
CIP Development and Prioritization	• Rate Models-Arcadis • Hydraulic Models-WaterGEMS • SCADA-WIMS • CIS-Muni-link	• Business Case Project Justification • Prioritization • Replacement Planning Model • 10-year CIP • Rate Study • Condition Assessment	• Levels of Service (LOS) • Condition Data • Useful Life • Refurbishment Schemes • R&R Needs • Capacity info • Registry of assets requiring R&R and associated costs • CIP project by priority and cost

Table 3-1. Asset Management Systems, Tools, and Data			
AM Element	Systems	Tools	Data
Design and Construction	• CMMS • GIS • Finance	• CIP/Budgeting • As-builts • Water design manual-specifications and details • Sewer design manual-specifications and details	• Install Date • Replacement Cost • Asset Attributes • Maintenance History/Costs • R&R Costs • As built
Funding	• Assetic Predictor (included in AMPs, but not a system that CRW will use going forward) • Rate Studies • Finance	• Replacement Planning Model	• Budget • CIP
Operations and Maintenance			
Operations and Maintenance Strategies	• CMMS • GIS • Finance • SCADA • Inventory • CCTV	• Condition Assessment module tools • Reporting/Dashboards • CIP/Budgeting	• Asset Attributes • Condition Data • Maintenance History/Costs • O&M Manuals • PM Schedules • Job Plans • Labor Rates • Failure Coding
Inventory / Warehouse	• Inventory • Finance • CMMS	• Bar code / QR scanner	• Materials inventory
Optimization	• CMMS • GIS • SCADA	• Data Collection Tools	• Condition Data • Asset Attributes • PCR Codes • Condition Assessment Ratings

3.2 Systems

Various information systems are used to gather, manage, and maintain asset management data. All facilities staff will use the systems indicated in Table 3-2 for their intended use in the management of assets. Organizationally the use of core database repositories is key to data governance in support of collaboration and analysis. In cases where primary separate spreadsheets are used as working files for alteration, transformation and producing outputs, discovered edits of principal data necessitate preservation for updating the repository. Retaining edits of core data in working files in lieu of the defined information management systems will misrepresent critical end products for all.

Table 3-2. Enterprise Information Systems			
Type	**Product**	**Links to other systems**	**Description**
CMMS	Cityworks	GIS Mobile IPS app Wincan – in the future	Primary system used for work management. It also contains asset information and is the system of record for all managed facility assets.
GIS	ESRI ArcGIS Platform (ArcGIS Enterprise and ArcGIS Online	Innovyze InfoAsset Planner Cityworks	• System of record for all managed distributed system assets • Assets synced with IPS using Geo Administrator tool • Provides map-based applications as primary interface for viewing linear asset data
CIS	Muni-link	NONE	Billing and account information
Document Management System	Microsoft SharePoint	Office365	File plans for managing documents through their life-cycle in accordance with the Municipal Records Manual.
SCADA	WIMS / Hach	NONE	WIMS pulls data to produce report outputs
Hydraulic Models	WaterGEMS	NONE	
Finance	Munis- Accounting System Munilink – Customer Billing	API to interface in future	Other products = interfaces for BoA (Pcard), CS Fixed Assets (does not interface)
Rate Models		NONE	CRW provided inputs from financial systems with consultation
Inventory	Material and Equipment Leaf in Cityworks Granger service for vending machines (PPE) readouts	NONE	Parts and materials associated with work orders are documented and tracked in the CMMS.
HR	Paycor/Inova	NONE	
Timekeeping	Paycor/Inova	NONE	
Legal	Part of Document Mgmt. Sys	NONE	Contracts MOU/Legal Documents
Fleet Management	Cityworks for maintenance and inv Verizon Network Fleet for location tracking	GIS	Used to track fleet assets and related maintenance
Regulatory/Permitting	WIMS Document Mgmt. Sys – EPA/PADEP portals	NONE	Reports. WIMS used for Water Quality reporting, will be used for Wastewater in future

3.3 Tools

All facilities staff will use the tools indicated in Table 3-3 for their intended use in the collection and analysis of asset data.

- User-friendly methods exist for entering and retrieving asset information for all users. Users have a clear understanding of which systems to use for data management.

- Data collection tools are readily available and used to streamline the process of data input and improve accuracy of information in the systems and databases.

Table 3-3. Enterprise Tools

Type	Product	Description
Data Collection Tools	• Hardware-Laptops • Tablets • GIS, • Data Prep Tools (prepackaged scripts) • Cityworks • Excel • SQL	Cityworks Administrator executes Data Prep Tools to create feature classes for Cityworks Operational Insights. GIS Manager publishes the new GIS service(s) to Cityworks upon completion of Data Prep Tools.
As-builts	• CAD files • PDFs	As-builts of existing facilities are saved as CAD files or pdfs
Criticality	• Cityworks Operational Insights	Pipelines are scored based on proximity to Critical Customers, Apartment Buildings, Railroads, and natural waterways.
Risk Matrix	• Cityworks Operational Insights	Operational Insights provides organizations with a means to identify and assess high-risk assets and to establish maintenance strategies to increase their lifespan. With its tie to ArcGIS, the results can be displayed on a map so that capital improvement funding can be prioritized and applied spatially and accurately
CIP/Budgeting	• Business Case Project Justification • Prioritization • 10-year CIP • Rate Study	Projects are prioritized by a triple bottom line approach for high-risk assets. Social, Financial and Environmental consequences of an asset's failure can be expressed and quantified applying the TBL approach.
Business Case Project Justification	• CIP	
Prioritization	• Assetic Predictor • Cityworks operational Insights • Innovyze – InfoAsset Planner	Once assets have been assigned a priority level from 1-5, the next step is to determine the highest priority assets within each priority zone. This is accomplished by reviewing relative BRE scores for each asset in each zone. Assets with a higher BRE within a zone are given priority
Replacement Planning Model	• GIS • Cityworks • Innovyze – InfoAsset Planner	
LOS	• AWWA Benchmarking Utility Survey	
Demand Forecasting	• CIP	
Condition Assessment	• CMMS • GIS • CCTV	
Dashboards	• MS Power BI	Power BI is used for visualization of R&R reports

3.4 Data

3.4.1 Asset Definition

A working definition of an asset was developed (Figure 3-1). It is intended to describe the criteria under which an item would be considered an asset. If any one of the three criteria below is met, then the item is considered an asset.

Examples of assets would include dams, intakes, equipment, vehicles, structures, tanks, distribution piping, storage tanks, sewers, green infrastructure, instrumentation, technology, and information, etc. Assets may include an assembly of components that are operated, maintained, and managed together.

Linear assets could be split into separate assets when a) changes in materials, size, or install date for point repairs exist or b) physical break in linear feature caused by a manhole, fitting, valve, pump station, meter, or treatment plant exist. Lampholes, covers and bends do not split a linear asset into multiple assets.

Asset	Critical Asset
• Something with a value of greater than $5000, with an expected life greater than 5 or more years, • Or • The item is of high importance to the mission of the utility. • And/or • Something that is operated, maintained, and managed to provide a consistent, reliable, and safe service to our customers.	• Assets that have either been identified as such through the Risk Management process (described later in this document) and that affects health and safety or regulatory compliance.

Figure 3-1. Asset Definitions.

3.4.2 Asset Inventory

An asset inventory has been developed and is managed in the GIS in conjunction with the Cityworks, CMMS for both vertical and horizontal assets. Asset inventory information is comprised of different characteristics including the attributes describing the assets, the hierarchy in which assets are organized, and naming conventions used to identify and link data to assets. The inventory is vital to a successful AM program.

Figure 3-2 shows how the different asset characteristics relate to create a complete picture of the CRW asset inventory. Each of these components is described in the following sections.

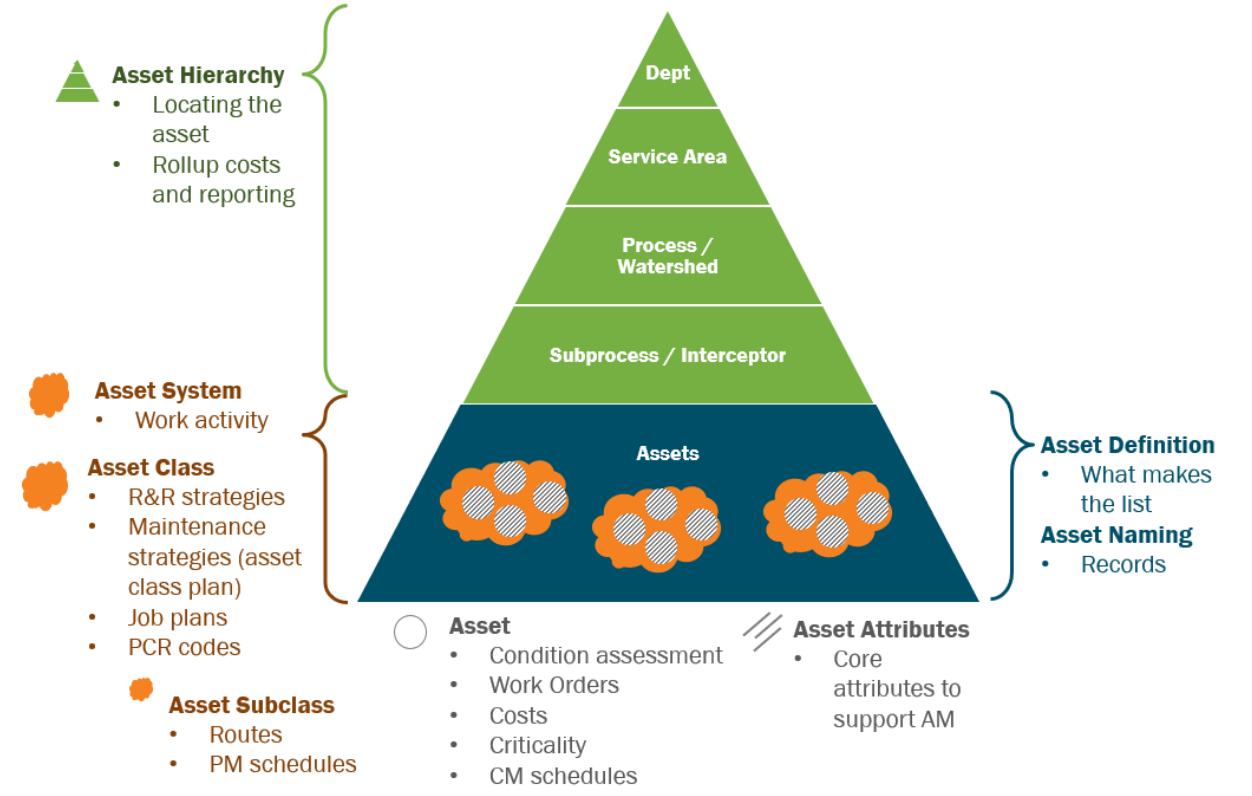


Figure 3-2 Asset Inventory Components

3.4.3 Required Asset Data

Assets are documented with a set of attributes that describe what is known about the asset. These attributes vary between asset classes: some attributes may only apply to one asset type, while other "core attributes" that represent the essential details apply to all asset types in support of the asset management program. The core attributes fall into four categories:

- Core attributes – attributes to be collected for all assets
- Physical attributes – attributes to be collected for specific types of assets which will vary by asset class which will be further defined in the TAMPs
- Financial attributes – attributes relating to the cost of the asset and warranty information
- Asset Management attributes – attributes pertaining to asset management principles such as condition and risk
- The list of required asset attributes is included in **Appendix B**.

Templates are to be used for importing equipment, spare parts, and job plan data into Cityworks. Contractors are required to deliver completed asset information in a compatible format prior to final payment. This will allow for all new equipment to be brought into Cityworks with the proper information and job plans.

3.4.4 Asset Classes

The separation of assets into distinct asset classes is an essential component of managing the asset inventory as it defines the level of information detail to be collected for each type of asset and forms the basis for remaining useful life analysis and R&R planning.

3.4.4.1 Vertical Assets

Asset classes are identified for all assets, and definitions of the class have been documented. Table 3-4 includes a list of vertical asset classes, which are stored as "object classes", or stand-alone tables in the GIS geodatabase.

Table 3-4. Asset Classes – Vertical Water

Actuator	Heat Trace	Security
Drive Belts	Instrumentation	Structure
Building General	Mechanical	Transmitter
Building	Mixer	Tank
Control Panel	Motor	Valve
Drives	Pneumatic	Ventilation
Electrical	Pipe	Vehicles
Facilities	Pump	VFD
Feeder	Scale	Weir Flume
Filter	Screen	

Table 3-5. Asset Classes – Vertical Wastewater

Actuator	Heat Trace	Screen
Belt	Instrumentation	Solenoid
Building General	Lab Equipment	Structure
Buildings	Laboratory Equipment	Tank
Control Panel	Motor	Transmitter
Electrical	Mixer	Vaporizer
Feeder	Pipe	Valve
Filter	Pneumatic	Vehicles
Gearbox	Pump	VFD
Generator	Sampler	Weir Flume
HVAC	Safety	
Heat Exchanger	Scale	

3.4.4.2 Horizontal Assets

CRW's horizontal assets are stored as GIS "feature classes" in the GIS geodatabase. Table 3-6 lists the horizontal asset classes.

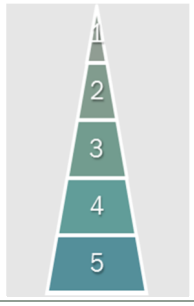
Table 3-6. Horizontal Asset Classes				
System	Water	Sanitary	Storm	Combined
Feature Class	Booster Pump Fitting Hydrant Hydrant Valves Lateral Lateral Valves Manhole Meter Meter Pit Pipe Release Valves Tank Valves Valve Operator	Cleanout Junction Lateral Manhole Pipe Pump Station Valve	Cleanout Inlet Junction Manhole Outfall Pipe Pump Station Swale Valve	Outfall CSO Chamber

3.4.5 Hierarchy

Standardizing the asset hierarchy provides order to the asset registry, and a means by which metrics can be rolled up for reporting. Typically, there are two hierarchies housed in a CMMS: (1) the location hierarchy and (2) the equipment class hierarchy.

- The location hierarchy defines where a piece of equipment lives within the organization's universe:
  - An example is the "walk-to" location that is defined by where the asset is physically located, such as a water treatment plant, headworks building 1, floor 2, or room 1.
  - Another way to create a location hierarchy is to use the processes to define the location, such as water treatment plant, raw water system, or influent pumps.
- The equipment class hierarchy defines where the asset lives within a class of assets:
  - A well-defined equipment class hierarchy allows PMs to be written at a higher hierarchy level, and CMs to be written at lower level.
    - Assigning PM to a higher level allows planners to understand which components (i.e., assets) have upcoming PM tasks scheduled that the maintenance staff can perform during unscheduled down time—making the work more efficient.
    - Assigning CM to the lowest level, failure modes can be identified and analyzed, which can help set the asset maintenance strategy.
  - An example class hierarchy is pumps → submersible pumps → influent pump 1.

ISO 14224 defines both the location and equipment class hierarchy for reliability-centered maintenance for petrochemical operations. Table 3-7 identifies the levels of the ISO 14224 hierarchy, shows the split between the location and equipment class information, and provides examples of the levels in the ISO 14224 hierarchy.

Table 3-7. ISO 14224 Hierarchy Level Definitions			
Category	Level	Name	Definition
Use location data		Industry	Type of main industry
		Business category	Type of business or processing stream
		Installation	Type of facility
		Plant or unit	Type of plant or unit
		Section or system	Main section/system of the plant
Equipment sub-division		Equipment class/unit	Class of similar equipment; each equipment class contains comparable equipment units
		Sub-unit	A sub-system necessary for the equipment unit to function
		Component or maintainable item [a]	The group of parts of the equipment unit that are commonly maintained (i.e., repaired or restored) as a whole
		Part [b]	A single piece of equipment

a. For some types of equipment, there might not be a maintainable item. For example, if the equipment class is piping, there may be no maintainable item, but the part can be "elbow."

b. While this level can be useful in some cases, it is considered optional in this standard.

Facility Hierarchy

CRW uses slightly different hierarchies for the Advanced Water Treatment Facility (AWTF) and Water Services Center (WSC) facilities, but they both contain a process/subprocess level (though with minimally different names for the levels). The hierarchies that have been developed are adequate for each group. Table 3-8 shows the levels for the AWTF and WSC.

Table 3-8. Facility Hierarchy Levels				
Level	Water	Description	Wastewater	Description
1	Upper-Level Process	Main water process (ex: Raw Water, Treatment, etc.)	Wastewater Section	Area within Wastewater (ex: Treatment, Collection, etc.)
2	Sublevel Process	Subprocess (ex: Intake, Flow Controls etc.)	Process	Process area for treatment or name of facility for pumping stations (ex: Prelim Process, Spring Creek, etc.)
3	Asset System	Asset System – can be a facility or building/area within the facility (ex: Riverfront Pump Station, Pipe Gallery, etc.)	Subprocess	Treatment subprocess – not used for other areas (ex: Grit Removal, Disinfection, etc.)

The following standard location hierarchy for facilities has been established. Figure 3-3 shows a graphic representation of the AWTF hierarchy.

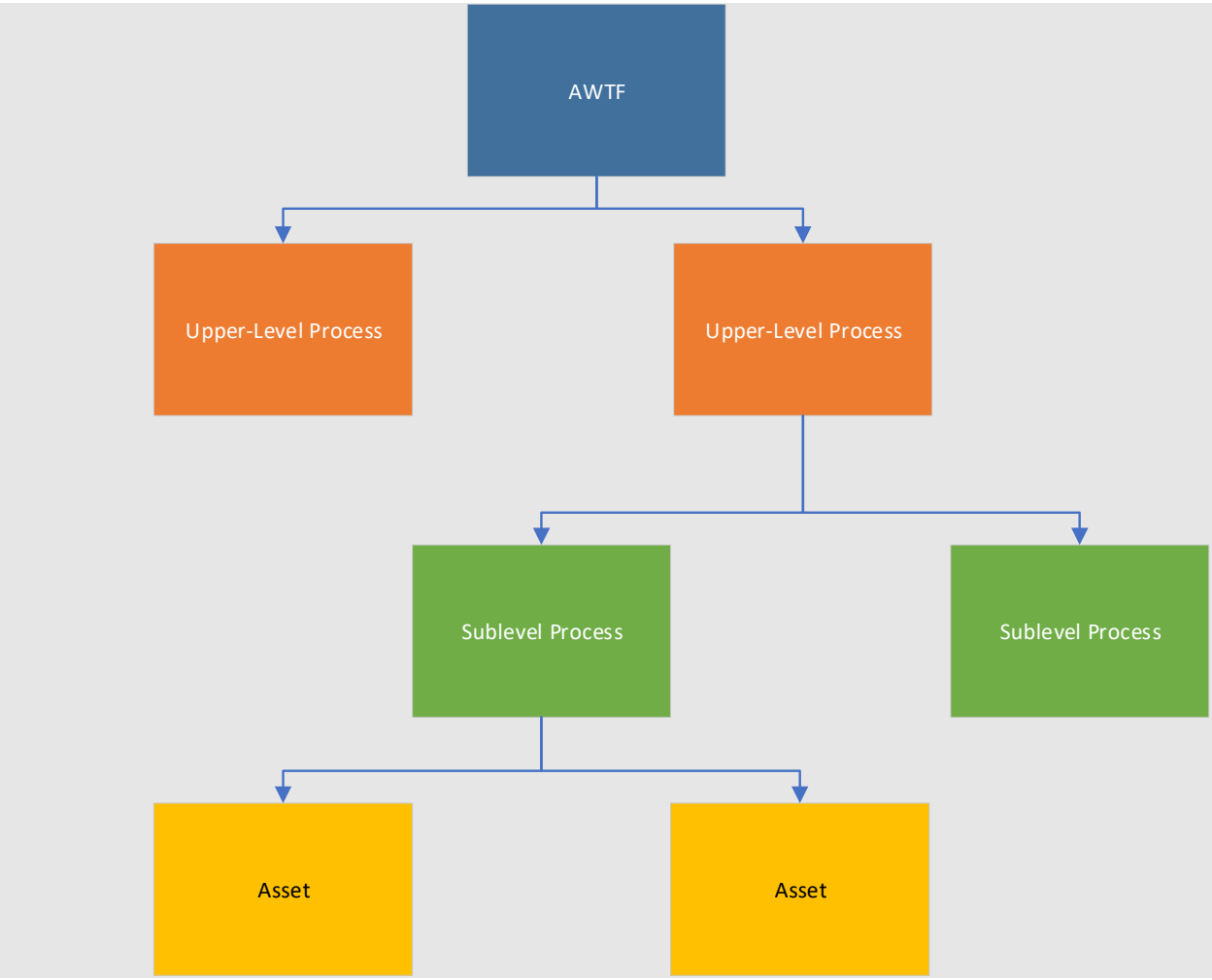


Figure 3-3. AWTF Hierarchy

Figure 3-4 shows a graphic representation of the WSC hierarchy.

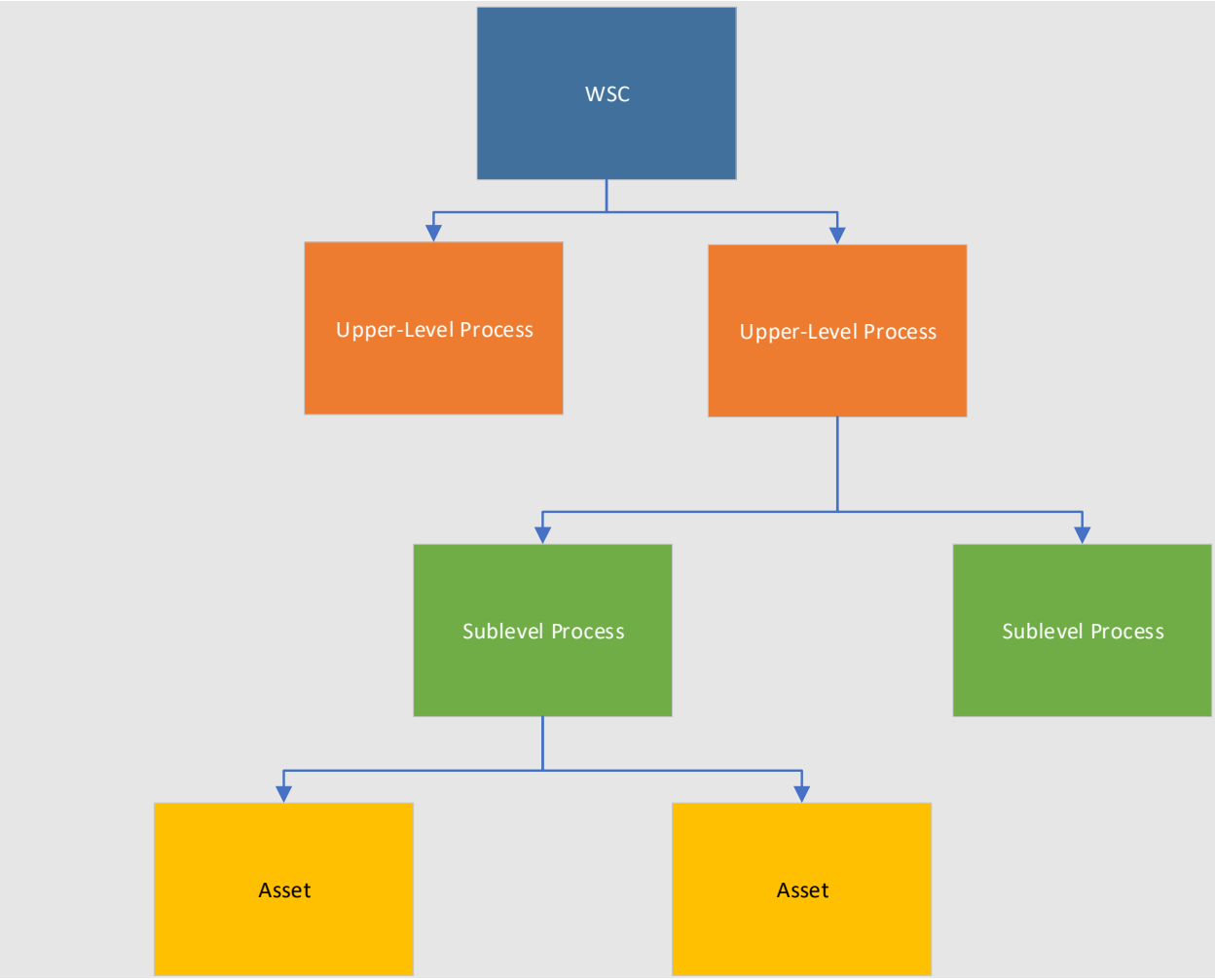


Figure 3-4. WSC Hierarchy

Distributed System Hierarchy

The horizontal assets do not track a location hierarchy via asset attributes, but the position of an asset in the system (watershed, interceptor, basin, etc.) can be determined through spatial queries in GIS.

Naming Convention

Assets are assigned names comprised of a combination of an asset class abbreviation followed by a 6-digit unique integer that is generated from an “N+1” auto-incrementing sequence. An example ID for a water line would be: “WL-000365”.

A Crystal Report is used to keep track of the next available number to avoid assignment of duplicate IDs.

3.4.6 Asset Commissioning and Decommissioning Process

The asset commissioning and decommissioning business process to be performed is as follows:

- The asset commissioning and decommissioning business process includes personnel from Engineering, GIS, Operations and Finance.
- Depending on the type of asset (capital or other) contractors and construction managers may be involved in the asset commissioning process.
- The process is similar for commissioning and decommissioning, and centers around developing a work order to initiate the processes and trigger personnel to add or remove assets from the CMMS, SCADA, GIS, inventory, and balance sheets.
- A list of information needed to add a new asset to GIS is included in **Appendix B**.

Process flow diagrams describing the asset commissioning and decommissioning process are shown in Figure 3-5 and Figure 3-6. All facility/systems divisions will adopt these process steps as the procedure for asset commissioning and decommissioning.

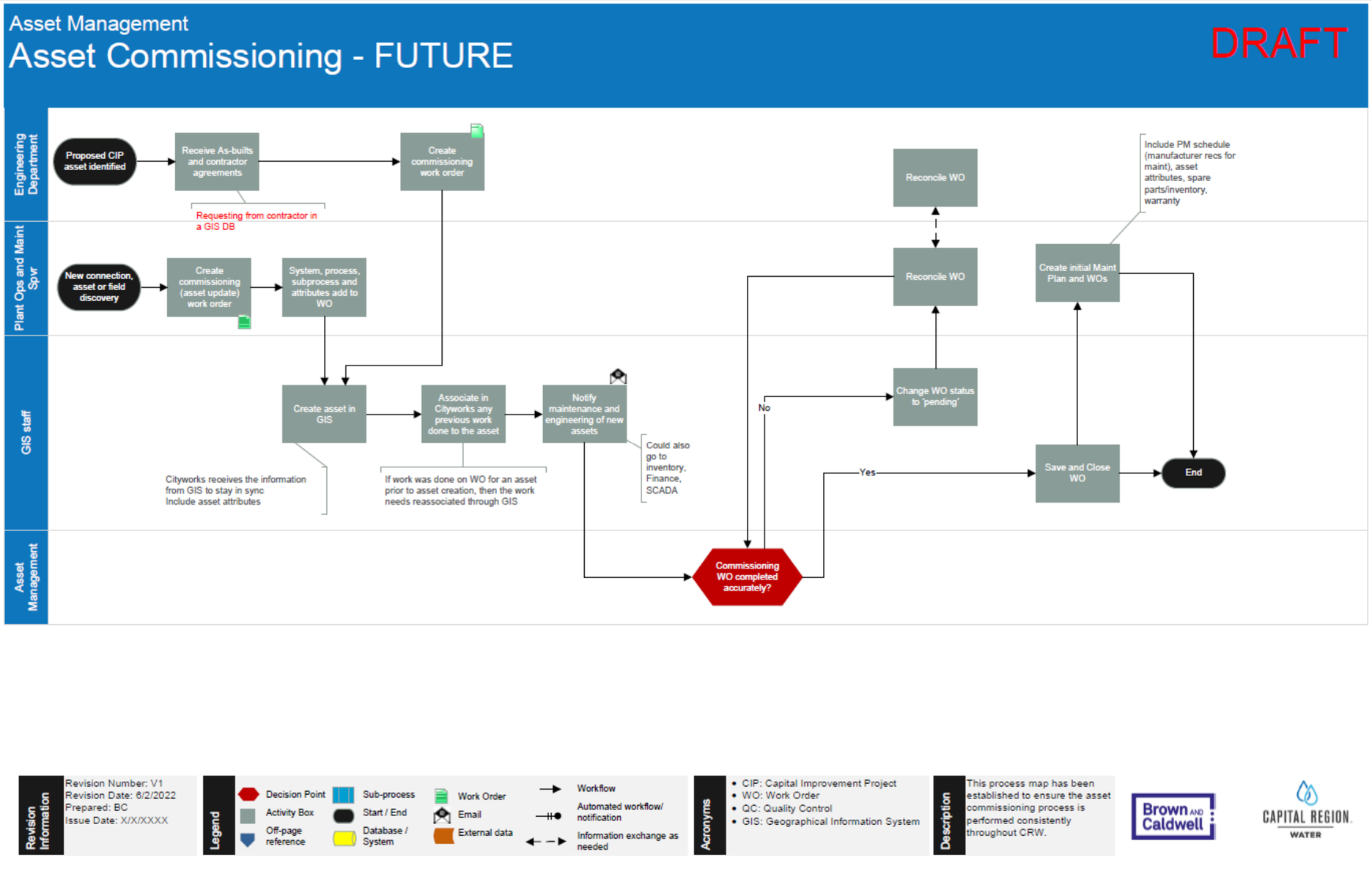


Figure 3-5. Asset Commissioning - Future State

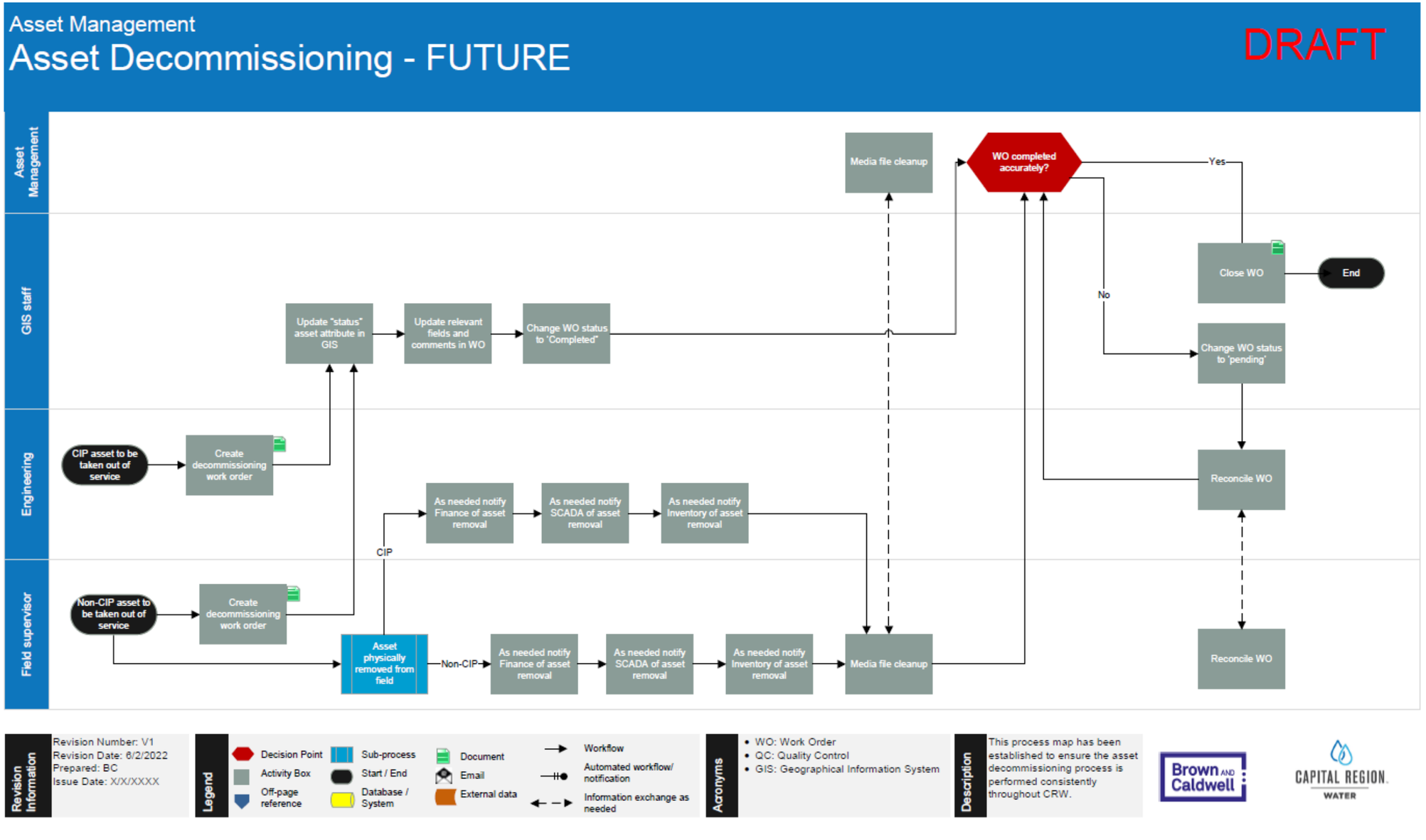


Figure 3-6. Asset Decommissioning - Future State

3.5 Continuous Improvement

People	Process	Technology
	• The asset hierarchy will be reviewed for each TAMP to assure compliance with this hierarchy so that costs and other data can appropriately be rolled up. Inconsistencies that are found in this analysis will be resolved during tactical AMP implementation to assure consistency. • Develop an asset creation template that contains all required data needed for new assets to be entered into GIS. • Develop an SOP for providing the asset creation form to contractors to complete when installing new assets and entering the data into Cityworks. • Document all hierarchies in an SOP. • Verify all assets have hierarchy attributes correctly assigned. • Develop SOP documentation for the assignment of asset IDs	• Make sure to capture valves in GIS • Update the horizontal asset classes once the GIS schema revisions made as part of migrating to the Esri Utility Network Migration ahve been implemented • Update the asset ID scheme documentation to include the new ID scheme reflecting the revised GIS schema once it has been implemented • Update water service line GIS schema to accomodate material determination and line replacement tracking as part of the Lead and Copper Rule Revision program

Section 4

Operations and Maintenance

A critical component of an asset management program is a standardized and repetitive maintenance program. Facilities and systems managers will implement the best appropriate maintenance practices in the areas identified below across all assets to support achieving and exceeding asset useful lifecycles.

4.1 Operations Strategy

Operational procedures are defined for the facilities and systems and are included in the appropriate O&M manuals which are developed in conjunction with the construction of a new system or updates as part of a rehabilitation project. The development of these documents is discussed in Section 5. The operational costs are tracked to the facility (or asset where appropriate and available) and analyzed using the Cityworks system. Operational practices are outlined in several CRW documents including the Drinking Water O&M Manual and Collections and Conveyance O&M Manual.

Operational strategies and processes are reviewed periodically through a continual improvement process and appropriate updates are made to O&M manuals and procedures. CRW also uses SCADA which contains the parameters and control points that were envisioned in the design of the facilities. Operational performance is assessed periodically to minimize maintenance expenses caused by operational factors.

4.2 Maintenance Strategy

Performing optimal maintenance for each asset is the goal of a maintenance strategy. Establishing, performing preventive and corrective maintenance effectively, scheduling and tracking work in the CMMS, and understanding costs associated with the maintenance is part of that overall strategy. In general, the asset, its intended service, historical reliability, and criticality influence the strategies used during its life. Maintenance strategies will tend to evolve (optimized) for various assets as overall asset program knowledge increases.

4.2.1 Asset Class Plans/Job Plans

As a future state item, CRW will continue to enhance their maintenance strategy by developing specific plans for managed asset classes. Currently, CRW uses a combination of manufacturer provided maintenance recommendations and staff experience to develop maintenance strategies for assets. CRW would like to continue to document and standardize their maintenance strategies and attach this information to the asset records for ready access by staff. Asset Class plans (long- interval activities) and Job Plans (short interval activities) include the following information:

- Manufacturer's recommended schedule
- Seasonal operations
- Availability of equipment
- Timing/need
- Condition/age
- Institutional knowledge

Short-interval Activities (Job Plans). Includes activities/tasks with standard labor hours, parts and materials for preventive maintenance, calibration, adjustment, cleaning, and condition assessment. Allowances for planned levels of corrective maintenance are also included.

Job Plans will be used to standardize how work is performed on each asset class, assist in planning and scheduling work, and capture institutional knowledge. Job Plans should be created for all maintenance strategies based on the manufacturer's recommendations contained in the Operations and Maintenance manual along with institutional knowledge, especially where environmental conditions impact equipment performance. Job Plans will be linked to the appropriate preventive maintenance work order in Cityworks and include the following information:

- Personnel
- Duration
- Tools/Equipment
- Materials
- Parts
- Tolerances/Thresholds

Long-interval Activities. Asset Class Plans include years and estimated costs of long-interval refurbishments and replacement. Costs include salvage values (if any) and disposal costs.

4.2.2 Work Order Priority Types

CRW has refined their work order priority codes and now uses templates to assign work priorities. The rules governing work order priority are readily understood by CRW staff and assignments are dynamic based upon the daily activities within the facilities and in the Collection and Conveyance and Distribution Systems. CRW assigns work order priority codes in Cityworks as noted in Table 4-1 includes a description of the priority codes. The priority code value within a Cityworks activity can be changed by anyone assigned edit permissions which is the vast majority of Cityworks users.

Table 4-1. CMMS Priority Codes

Number	Description	Definition	Response Time	Schedule Responsibility
1	Low	• As defined by WO template • General Preventative Maintenance work • Noncritical assets or systems	As staff are available once Moderate and High priority WOs are completed	Maintenance supervisor reviews WOs and assigns accordingly
2	Moderate	• As defined by WO template • Critical assets that do not require immediate action due to redundancy or facility operations requirements	Within 24-48 hours of WO generation	Maintenance supervisor reviews WOs and assigns accordingly
3	High	• As defined by WO template • All vertical assets at the AWTF and WSC are classified as high priority • Emergency work orders • REPAIR work orders	Immediate repair as appropriate	Maintenance supervisor reviews WOs and assigns accordingly on daily basis

4.2.3 Maintenance Management Types

CRW will adopt the use of the maintenance categories in Table 4-2 for CRW assets. Using the appropriate maintenance activity on each asset will increase the reliability of the system and can extend the useful life of an asset. Having a standardized set of maintenance criteria also provides the foundation for developing performance measures that can be used for analyzing maintenance performance. Workflows for the maintenance categories are included in **Appendix C**.

Table 4-2. Maintenance Management Types

Maintenance Category	Description	Application	Examples
Preventative Maintenance (PM)	Preventive maintenance (PM) is an equipment maintenance strategy based on replacing or restoring an asset at a fixed interval (calendar or hours of operation) which will be planned and scheduled in Cityworks. Trends in assessed condition, long-term cost estimates and near-term schedules for corrective maintenance, along with cost and risk analyses, are used to update intervals for preventive maintenance.	All PMs are planned and scheduled weekly, bi-weekly, monthly, semi-annual, and annual schedule exists to adjust workload and account for seasonal outages. Some PM activities may trigger a CM for follow up work such as changing drive belts.	• Hot spot manholes • Hydrant Flushing • CSOs • Lubrication • Instrument calibration • Seasonal maintenance activities
Corrective Maintenance (CM)	Used to repair assets and restore to its designed LOS. Corrective maintenance is an intrusive action used to correct an asset failure and is used to keep assets in a ready state to meet capacity and regulatory requirements.	With the exceptions of emergencies, corrective maintenance will be planned and scheduled to ensure all parts and materials are ready before work begins	• Emergency work • Necessary repairs identified in PM tasks and inspections
Run to Failure (RTF)	No planned maintenance. Assets will be run to failure and immediately replaced with stocked spares. Run to Failure (RTF) is a maintenance strategy that is used on less critical equipment where the other maintenance activities are not cost effective. This strategy does require stocking or having access to replacement assets within a specified amount of time.	May use this strategy on noncritical assets.	• Sump pump hoses • Circuit breakers • Electric motors
Predictive Maintenance (PdM)	Predictive maintenance (PdM) and condition monitoring are used interchangeably in the maintenance industry and provide valuable information in support of an asset management program. Typically, predictive technologies are non-intrusive and inform O&M staff how an asset is performing, predicts required maintenance activities, increases reliability, and avoids unanticipated failures.	All PdMs are planned and scheduled monthly and annual schedule exists to adjust workload and account for seasonal outages. PdM technologies can be used on critical or appropriate assets. Some PdM is completed as part of a PM.	• Oil analysis • PACP and condition assessment on linear assets. • Infrared thermography • Acoustic testing

4.2.4 Work Scheduling

Currently, O&M Supervisors schedule all work to allow for identification of resource issues, and effective issuing and tracking of work performed. Work orders are reviewed daily, and schedule adjustments are made as appropriate. Work scheduling between vertical and linear assets does

differ at CRW with the primary driver for linear being regulatory required efforts in the Collections and Conveyance System.

4.2.5 Maintenance Costs

Costs for equipment and labor are being tracked in Cityworks for work orders and inspections. CRW uses the Equipment, Labor and Material, ELM module in Cityworks to track equipment to support maintenance, labor to maintain/fix assets, and materials to support maintenance activities. Currently, materials are not being fully captured in the ELM module due to transmission of invoices and reconciliation of this information in Cityworks.

Accurately collecting costs associated with maintenance activities is an important piece of information that can be used to develop annual maintenance budgets and to determine if replacement vs. continuing to do extra maintenance is more cost effective. The ability to efficiently do this costing depends on the implementation of the Cityworks storeroom module.

4.3 Inventory/Warehouse

Parts and materials associated with work orders are documented and tracked in several systems at CRW. Finance tracks assets and equipment with a value of $5,000 or greater on an annual basis. CRW is in the process of creating a material inventory for drinking water and wastewater systems that can be used in either Cityworks Storeroom or Munis Warehouse module for tracking parts associated with assets. Policies and procedures for the purchasing of parts and materials for use within maintenance activities are documented.

4.4 Optimization

4.4.1 Vertical Asset Condition Assessment Methods

Monitoring and assessing asset condition provides essential information to decision-makers regarding when to repair, rehabilitate and replace assets. In addition to making rehabilitation and replacement decisions, condition assessment also informs asset managers on how best to operate and maintain an asset. For example, condition assessment results may indicate there is a need to adjust preventive maintenance schedules.

Monitoring and assessing the condition of critical vertical assets at facilities and systems will be performed through two approaches:

- **Visual Inspection.** A sensory evaluation of an asset to determine whether further action, including condition monitoring, is needed.
- **Condition Monitoring.** The collection and analysis of data to identify a change in the condition and/or performance of the asset over time.

Divisions will conduct a baseline condition assessment on critical assets using the visual inspection approach in accordance with the Condition Assessment Guidance Manual (**Appendix D**). They may perform ongoing condition monitoring to identify changes in condition and performance over time using the methods deemed appropriate for different asset types.

Vertical assets where this approach will be used are shown in Figure 4-1.

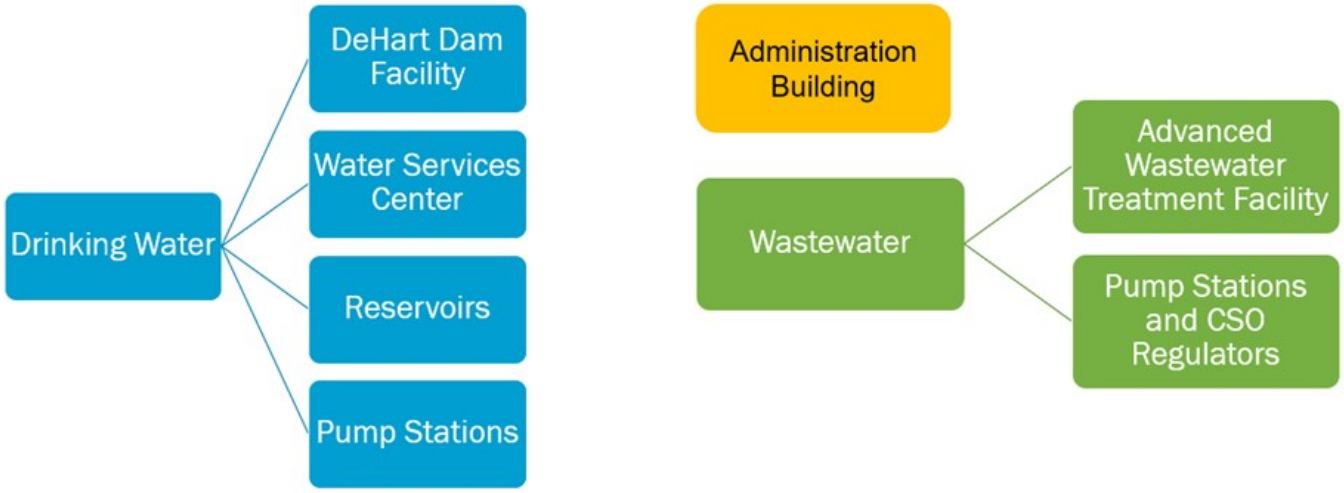


Figure 4-1. CRW Facilities where Vertical Condition Ratings will be Applied

The condition assessment approaches and how the standard ratings are to be used within each approach are described in more detail below.

Condition Assessment Ratings

Standardized condition, and recommendation ratings have been established to ensure consistent documentation of asset condition. A standardized approach supports planning and prioritization of renewal and replacement decisions. When conducting visual inspection and condition monitoring, the assessment team at a particular location should document their findings using the standardized condition assessment format that includes the ratings listed in Table 4-3. Condition assessment data is to be documented in the CMMS. Based on the results of the visual inspection or condition monitoring, a recommendation should be made using the recommendation ratings included in the rating description as a starting point.

Table 4-3. Standard Ratings

Rating	Rating Description
1 Very Good Condition	Like new with little signs of wear. Monitor asset condition and no further action required at present.
2 Good Condition	Minor defects evident. Monitor and trend asset condition for possible additional actions.
3 Fair Condition	Normal signs of wear for age of asset. Continue to monitor asset condition and evaluate for rehabilitation.
4 Poor Condition	Significant defects are evident. Continue to monitor asset condition, repair as needed and expediate plan for rehabilitation or replacement.
5 Very Poor Condition	Asset has failed or shows excessive wear and should be replaced as soon as possible.

Routine (Sensory) Inspection

Sensory inspection involves the use of visual, auditory, tactile, and olfactory senses to document the physical state of an asset (e.g., condition) and determine whether an asset is delivering its LOS requirements (e.g., performance). At a minimum, the following will be noted by staff if observed during an inspection:

- Vibration
- Abnormal temperature
- Noise
- Corrosion
- Wear and material loss
- Leaking
- Belts loose
- Cavitation
- Odor

Assessment teams are to use these observations to support and justify the selection of condition, performance, and recommendation ratings. The sensory inspection approach is used to establish a baseline condition for critical assets and to assess the condition of assets over time where detailed condition monitoring is not warranted.

Condition Monitoring

Condition monitoring involves tracking specific asset parameters (i.e., vibration or temperature) over time with the goal of identifying changes that may indicate an impending failure. Figure 4-2 illustrates how condition monitoring may be used to predict an asset failure over time.

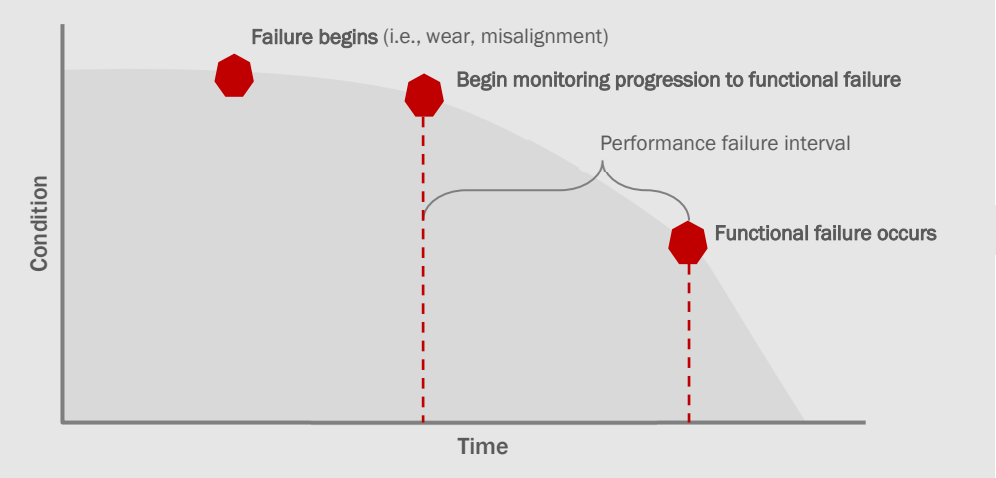


Figure 4-2. Performance Failure Curve

Managers may use condition monitoring as part of a predictive maintenance strategy (see Section 4.2.3) to predict and avoid unanticipated failures and intervene before catastrophic failures occur. Specifically, condition monitoring is used to:

- Identify hidden failures
- Predict maintenance activities
- Avoid unanticipated failures
- Inform maintenance and operations how equipment is running
- Increase efficiency in performing work (planned vs. unplanned)
- Increase reliability
- Reduce lifecycle costs
- Extend equipment life
- Minimize environmental (regulatory) impact
- Make sure equipment is installed to spec (acceptance testing)
- Make knowledge-based decisions

As noted in Table 4-4, CRW uses the following condition monitoring approaches to predict asset failure.

Table 4-4. Condition Monitoring Approaches at CRW

Analysis	Asset Type	Frequency	CRW able to Perform?	CRW Equipment?
Performance Testing	Pumps	Qtrly @ WSC for finished water and backwash pumps	No (Contracted)	AWTF - No, WSC - Yes
Battery Check	UPS	Replace units when they Fail.	Yes	Yes
Boiler Water/Cooling Water Loops	Boilers	Monthly cooling tower	No (Contracted)	No
Laser Alignment Check	Pumps/Motors	Currently during installation	No (Contracted)	No
Load Testing	Generators	30-day Full load	No (Service Contract)	No
Meg and Current Testing	Motors	Currently trouble shooting only	Yes	Yes
Oil Analysis	Engine/Generators (over 400KW), transformers	WSC-Quarterly on our routine service contract through vendor contract	No (Service Contract)	No
Physical Dimension Measurement	Pump Wear Rings	During rebuilds	No (Contracted for Larger Equipment)	No
Run Testing	Transformers	Regulations every 5 years	No	No
Relay Test	Switchgear	Needs contracted	AWTF - Yes, WSC-No	No
Thermography/IR	Substations, MCCs, Switchgear	WSC-Yearly and some testing in-house	AWTF – No WSC – limited capability	No

Table 4-4. Condition Monitoring Approaches at CRW				
Analysis	Asset Type	Frequency	CRW able to Perform?	CRW Equipment?
Vibration (external/internal)	Rotating Equipment	Devices equipped	AWTF - Built-in for some equipment WSC-some	Yes

Condition Assessment Evaluation Process

Data collection associated with routine (sensory) inspection and condition monitoring activities will be documented in the CMMS. Routine (sensory) inspection data will routinely be collected by operations and maintenance staff. Operations and maintenance staff will collect ongoing condition monitoring data and, in some instances, use contracted resources for monitoring requiring specialized equipment and expertise. Condition monitoring data is to be documented in the inspection module in the CMMS. Figure 4-3 illustrates the visual inspection and condition monitoring process.

All divisions will adopt these process steps as the SOP for routine (sensory) inspection and condition monitoring.

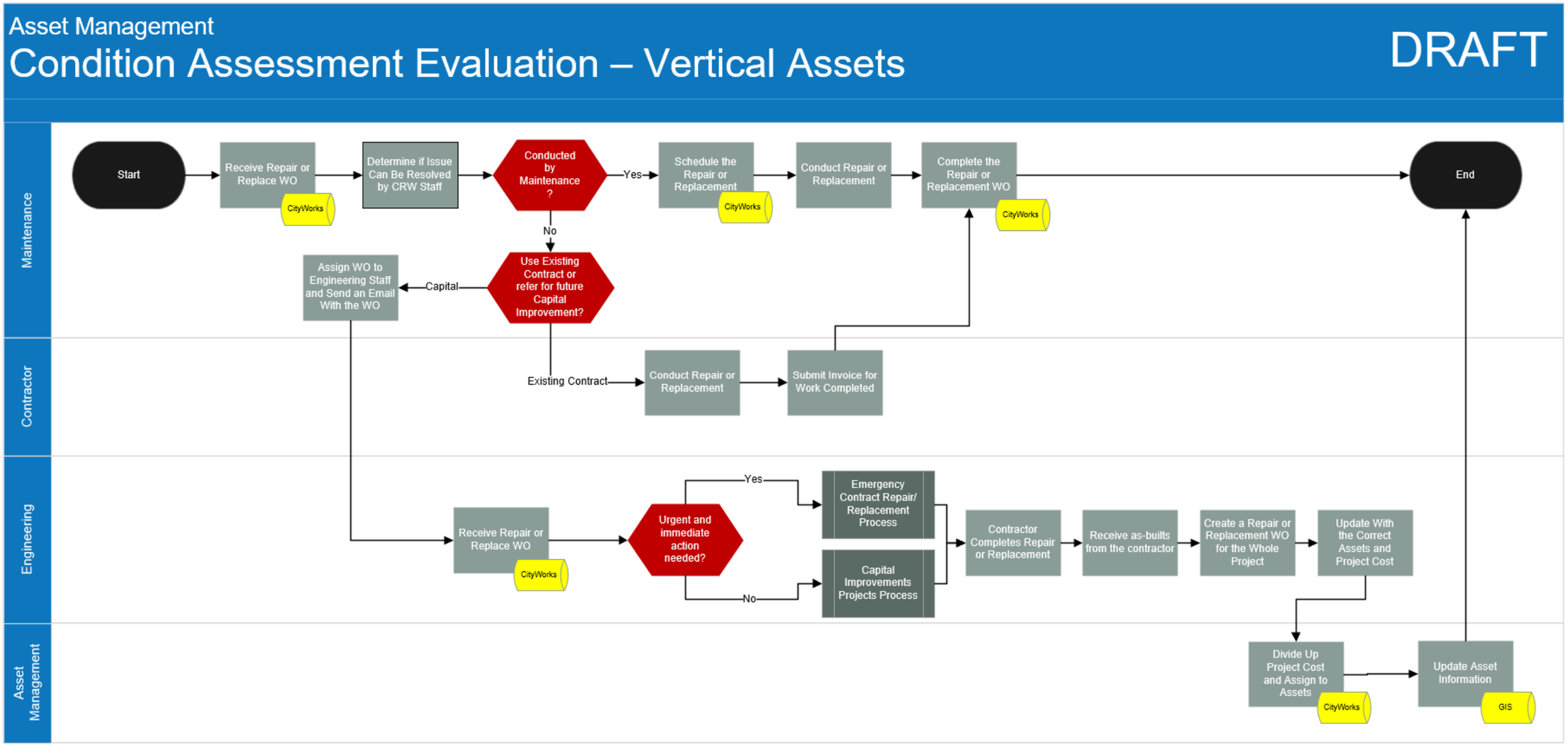


Figure 4-3. Vertical Asset Condition Assessment Evaluation Process

4.4.2 Linear Asset Condition Assessment Methods

Gravity Pipe Condition Assessment

Closed Circuit Television (CCTV) inspections are conducted to assess the condition of gravity pipelines. Inspections are conducted based on the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification program (PACP), Manhole Assessment and Certification Program (MACP), and Lateral Assessment and Certification Program (LACP). The NASSCO rating system is used to identify the types and severity of the defects found during the inspection. The NASSCO defect coding provides a level of consistency in the defect rating, and confidence in the data that allows staff reviewing the inspection records to make informed analyses and decisions. The PACP quick rating is used to prioritize repairs and replacements. The NASSCO methodology uses a 1 to 5 scale which allows the scores to be integrated and compared with the vertical asset condition scores defined in the previous section.

Pressure Pipe Condition Assessment

The assessment of water mains and force mains creates a unique challenge due to the inaccessibility of the inside of the pipe during typical operating conditions. Assessment usually requires access to the inside or outside of the pipe and can include destructive and non-destructive testing. There are dozens of technologies currently being used in some manner for inspection of pressure pipelines. Most of these were originally developed for use in potable water mains or in petrochemical pressure mains and are now being adapted for use in force mains. These technologies can be categorized into the following groups:

- Acoustic (leak detection; and air/gas entrainment and pocket detection)
- Electromagnetic and Ultrasonic Thickness (wall thickness measurement, wall loss calculation)
- Visual (structural defect detection)
- External Corrosion Testing Methods (wall thickness measurement, wall loss calculation)

Due to the variety of technologies and approaches that may be implemented to assess pressure pipes, standardized condition ratings like those used for gravity pipes are not readily available. The findings of pressure pipe assessments will need to be adapted to the ratings presented in Section 4.4.1 and assigned a score using the 1 to 5 scale.

Linear assets and the corresponding assessment approaches are shown in Figure 4-4

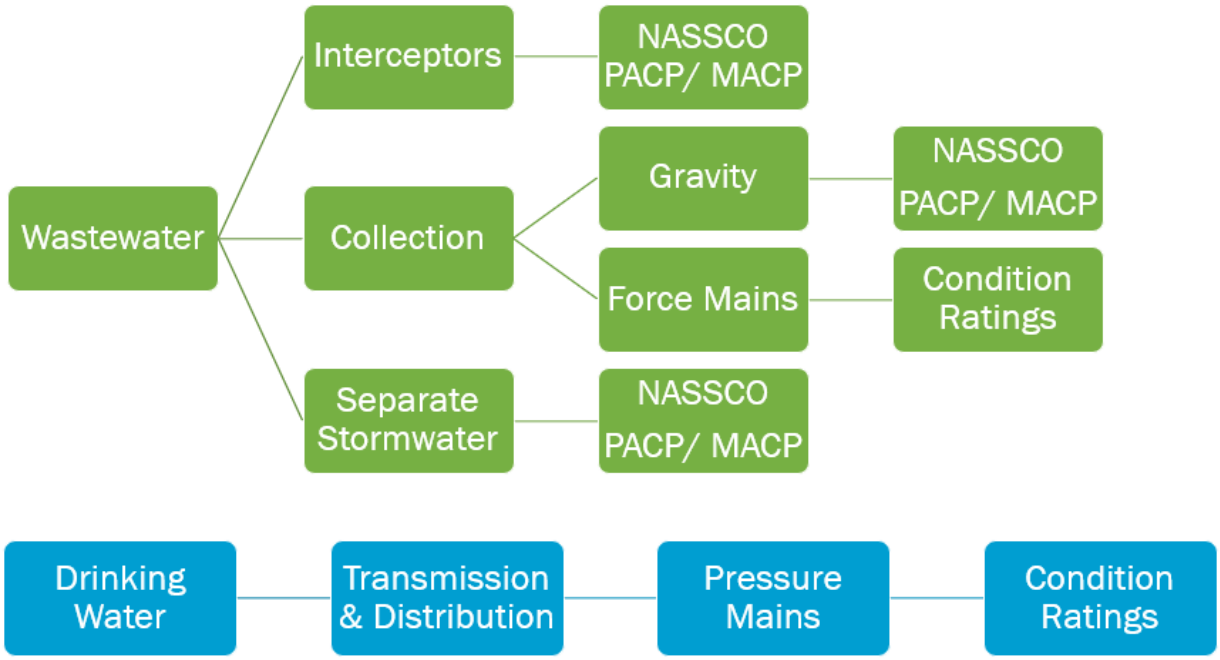


Figure 4-4. CRW Linear Assets and Type of Condition Ratings that will be Applied

Condition Assessment Evaluation Process

Data collection associated with the assessment of linear assets will be documented in the CMMS. Maintenance staff will routinely collect gravity main CCTV inspection data. Pressure pipe assessment data will typically be collected using contracted resources for assessment requiring specialized equipment and expertise. Figure 4-5 illustrates the linear asset condition assessment evaluation process.

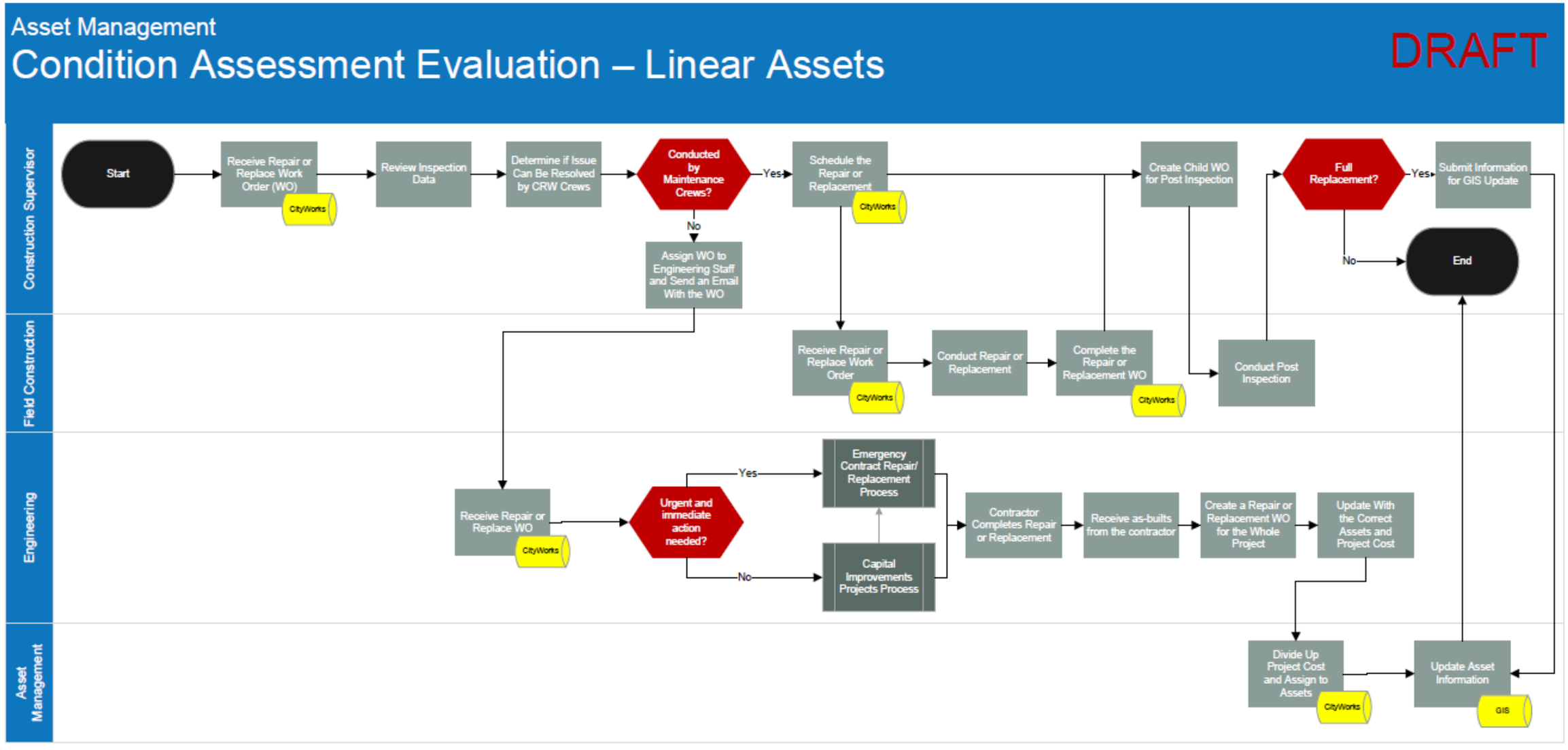


Figure 4-5. Linear Asset Condition Assessment Evaluation Process

4.4.3 Root Cause Failure Analysis

Failure Codes

Failure codes also known as Problem, Cause, and Resolution (PCR) codes are used to assist with trouble shooting failures and trending like failures across the CRW divisions. The key to successfully using PCR codes is having a set of standard codes for each asset class. A standardized set of PCR codes has been developed for both linear and vertical assets and are included in **Appendix E.** When CRW staff initiate a work order in Cityworks, they will be required to apply the appropriate problem code. Prior to the technician closing out a work order they will have to apply the appropriate cause and remedy code.

PCR codes assist in the following

- Track and trend asset failures
- Identify the causes of failure
- Change maintenance procedures to reduce failures
- Identify problem manufacturers and equipment

Root Cause Analysis

PCR codes will be used as part of completing root cause failure analysis (RCFA) on critical assets. Using failure codes and performing RCFA, CRW staff can make data-driven decisions related to adjustments to maintenance and operations procedures, engineering designs, and equipment selections to assist in reducing equipment failure. Figure 4-6 depicts a future failure reporting and analysis process that CRW can use to assess the root cause failure of assets.

All divisions will assign properly trained staff to complete this analysis on a periodic basis to support the AM program and continuous improvement of the operations and maintenance program.

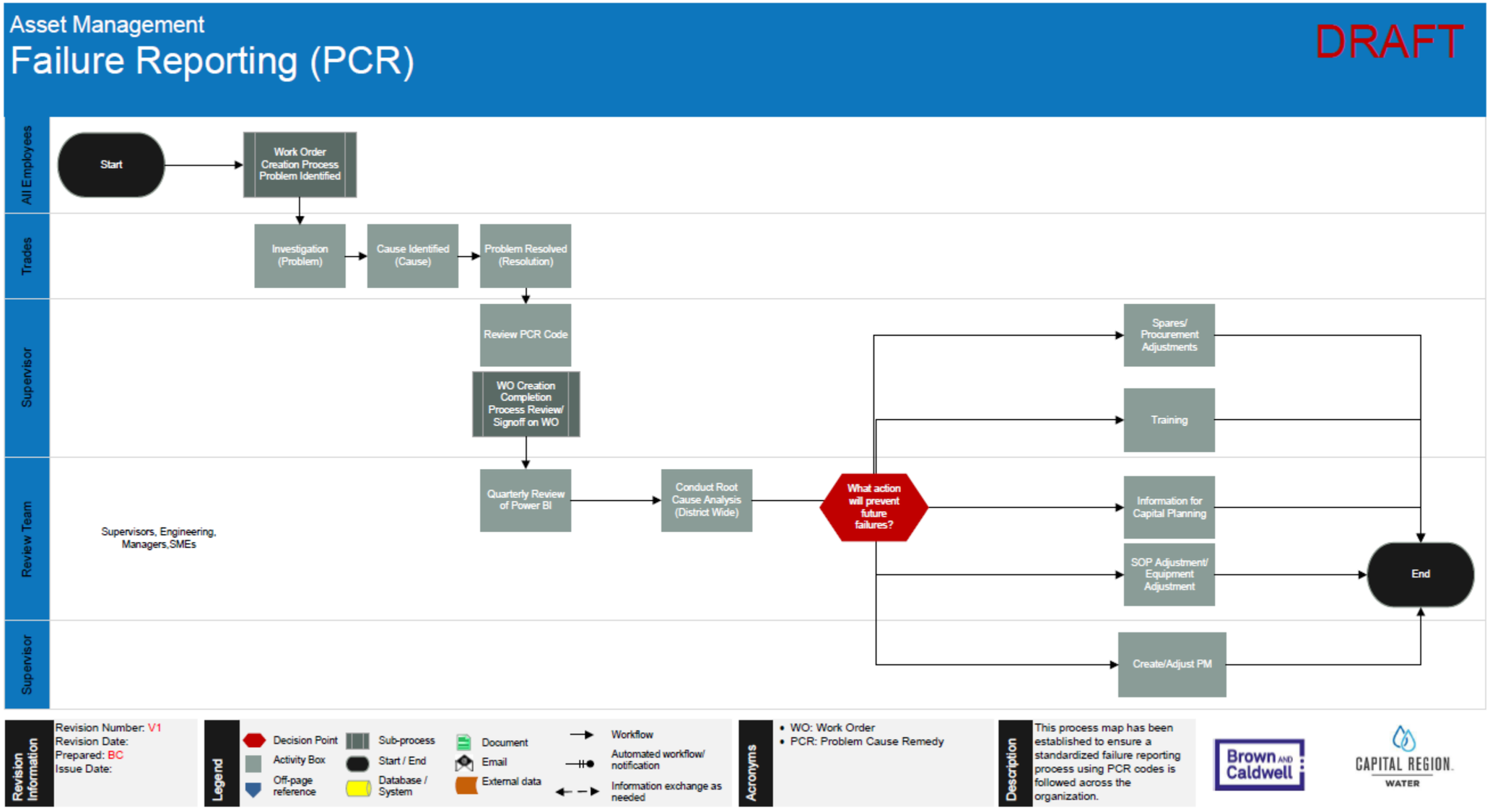


Figure 4-6. Failure Reporting (PCR) Process Future State

4.5 Continuous Improvement

People	Process	Technology
• Ensure staff have the approprate trainng to complete planning /scheduling and RCFA. • Ensure staff have the appropriate training to complete visual inspetion of critical assets.	• Based on trending and tracking of the applicable condition assessment parameters, staff will update the baseline condition, performance and recommendation ratings established for critical assets during inspections when there is an observed change in the parameter that warrants further action. • Based on PCR code information and RCFA, staff will update maintenance strategies to increase asset availabilty and decrease asset down time.	• Staff will evaluate the availablity of predictive technology and optomize mainteannce strategies by apply the approprate predictive maintnenace technology to move towards condition based maintenance

Section 5

Decision Making and Capital Planning

An asset management capital planning strategy includes both long-term and near-term components to address rehabilitation and replacement (R/R) needs. Long-term R/R plans involve identifying the aggregate R/R needs of each facility and system over the next fifty years, which helps establish needed funding levels. Near-term capital planning involves the identification and justification of specific R/R projects, prioritization of those projects using the risk-based prioritization criteria, and the development of a five-year capital program. Asset commissioning and decommissioning reflects how new assets are delivered and old assets are retired as part of the engineering design and construction process.

5.1 Risk Management

This section describes the risk management strategies used to manage risk at the facilities and systems. This approach to risk management involves the development of a risk register and risk-based prioritization for each facility and system.

5.1.1 Risk Policy

As part of the Asset Management Policy, CRW leads practices that are focused on seeking the lowest total life-cycle cost of ownership for infrastructure assets while delivering services and minimizing risk to the community. A key guiding principle for sustainable asset management is to understand and manage CRW's business risk exposure. This is accomplished by:

- Identifying and focusing on those assets that are critical to CRW's service levels and prioritizing their management to prevent their failures.
- Identifying, understanding, and managing the business risks associated with operating CRW's resources.

CRW will be developing a risk policy as a future state development task.

5.1.2 Risk Register

A risk register is used to document areas that have the potential to impact service levels, regulatory compliance, financial objectives, and other business objectives. The register includes the following—details are described in each AMP:

- **High level risk.** Describes an event that may occur and cause a negative impact on the facility/system
- **Impacts.** Describes the impact the event may have on the facility/system if it occurs

Definitions

Risk relates to the consequence of an event happening and the certainty that it will happen. Within the context of asset management, risk is defined as the "likelihood" that an asset is unable to provide the function for which it was installed, combined with the impacts resulting from the asset failure.

- **Risk Register.** Documents the high-level risks to the organization, likelihood and consequence of occurrence and any risk mitigation measures.
- **Risk-based Prioritization.** Process for setting priorities and ranking assets using likelihood and consequence of failure criteria.

- **Likelihood Rating (LR).** Value that quantifies the certainty that the event may occur as low (1), moderate (3), or high (5)
- **Consequence Rating (CR).** Value that quantifies the severity of the impact of the event as low (1), moderate (3) or high (5)
- **Risk Rating.** The result of multiplying the likelihood rating by the consequence rating
- **Risk Mitigation Measures.** Options for reducing the certainty and/or impact of the event.

Table 5-1 provides an organizational risk register to be used by facilities and systems. It also includes an example event to illustrate the use of the risk register. As part of the development of the AMPs, each Division will be responsible for developing an appropriate risk register and mitigation actions for their facilities. The Organizational Risk Register should be reviewed and revised as part of the annual SAMP update.

Table 5-1. Organizational Risk Register

Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
Organizational	Loss of institutional knowledge/ asset records	• Lower productivity • Equipment breakdowns/repair times • Violations • Operational issues due to inexperience • Budgetary impacts for hiring 3rd parties • Safety and injuries • Lost information requiring reproduction • Lost shop drawings	5	5	25	• Scanning documents, electronic backup • Records management, documentation attachment in Cityworks • Training employees • Sustainable documentation • SOP documentation • Retention planning, succession planning • Apprenticeship programs
Capacity	Exceeding capacity of the existing stormwater system beyond the flood protection system.	• Structural or road flooding • Property damage • Public health and safety • Economic impacts	5	5	25	• Capital improvements (i.e., Drainage/ stormwater pump station) • Facility planning/ Master Plan for flood protection • Public education on safety measures • Early warning system
Failure	Failure of aging infrastructure	• Loss of treatment	5	5	25	• Identify assets in need of repair and replacement before failure
Failure	Large diameter structural failure (cave-ins, collapse) of gravity sewer	• Public health and safety • Regulatory impacts • Economic impacts • Public relations impacts	5	5	25	• • Proactive inspection • Risk based rehabilitation or replacement • Soil testing and/or

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
						geotechnical assessment/modeling • Forensics on failures after they happen for lessons learned (i.e., like materials failing)
Failure	Dry weather CSO discharges to waters of the US	• Public health and safety • Regulatory impacts • Economic impacts • Environmental impacts	5	5	25	• Preventive maintenance • Visual inspection • Flow meters in manholes • Visual inspection and calibration of flow meters • Level sensors upstream of the dam to identify CSO before it occurs
Organizational	Insufficient staff and/or insufficient qualified and trained staff for mission critical duties	• Increased overtime • Equipment/assets degrade due to deferred maintenance • Increased costs for contractors/outsourced resources • Loss of system knowledge • Increased costs for repairs and running assets to failure • Opportunity and innovation costs	5	5	25	• Staffing and skills studies • Update engineering standards to include FTE estimate and required skills and training with new facilities and/or equipment • Documented Standard operating procedures and training on those SOPs • Testing and recertification as appropriate • Relationships with community partners for skill development • Outsource staffing, if needed
Failure	Structural failure (cave-ins/collapse) of stormwater pipes	• • Structural or road flooding • Property damage • Public health and safety • Economic impacts	5	5	25	• • Condition assessment • Facility planning • Capital improvements • Critical assets and spare parts availability
Failure	Water Main Break	• Economic impacts • Community/neighborhood impacts • Reputation/Public relations impact • Public health and safety	5	3	15	• Condition assessment • Contingency/Emergency Response Plans • Forensics on failures after they happen for lessons learned • Valve Exercising

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
						• Testing and assessment • Soil Testing and/or geotechnical assessment /modeling
Failure	Regional (large diameter) force main breaks reaching waters of the US	• Environmental impacts. Potential discharge to creeks, rivers, and streams • Economic impacts • Community/neighborhood impacts • Reputation/public relations impact • Public health and safety	5	3	15	• Contingency/Emergency Response Plans • Force main walks (visual assessment) and ARV inspections performed annually • Forensics on failures after they happen for lessons learned • Engineering standard changes for ARV material and replacement of stainless steel ARVs to prevent corrosion • Testing and assessment • Soil testing and/or geotechnical assessment/modeling
Financial	Insufficient capital funding	• Regulatory impacts • Health and safety impacts • Public relation impacts	3	5	15	• Public education • Potential for use of grant funding or low interest loans • Look for efficiency gains, including controlling the scope and schedule • Potential innovative approaches that are more efficient • Planning, prioritization, and justification of projects
Financial	Capital delays and/or overruns of construction projects	• Regulatory impacts • Economic impacts • Public relations impact • Public health and safety • Operational impacts	3	5	15	• Implement Construction Project Risk Registers • Involve O&M in the design process • Project planning • Follow PM procedures
Treatment	Odor issues	• Customer complaints • Regulatory impacts	3	5	15	• • Chemical treatment • Source determination • FOG Program

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
						• Address untrapped catch basins • Proactive watering down in dry times • Public education • Odor eliminators
Capacity	Insufficient design capacity at a wastewater treatment plant	• Economic impacts, including development • Regulatory impacts • Odor issues • Public health and safety • Capital impacts • Health and safety	5	3	15	• Facility planning and hydraulic modeling • Capital improvements • Monitoring of future development and determination of available capacity • Monitor regulatory changes that could impact capacity
Safety	Serious Injury	• Lost Time • Costs • Low employee morale • Loss of productivity	5	3	15	• Safety program • Standard operating procedures • Safety Inspections • Safety Training • General policies • Job Plan specific safety protocols are needed
Natural	Widespread power outages with generator failure or lack of standby power	• Structural or road flooding • Property damage • Public health and safety • Economic impacts • Environmental impacts	5	3	15	• Capital projects to add more generators and standby power capabilities (portable and onsite) • Contingency and emergency response plans • Preventive maintenance and testing/inspections of generators • Prioritize critical sites where standby power would be needed • Solar power
Systems and Data	Unauthorized access to information systems	• Economic impacts • Reputation impacts • Public health and safety • Regulatory impacts	5	3	15	• System backups • Security • More frequent and robust cybersecurity training • Review of appropriate staff responsibilities, access, and clearances • Business Continuity Plan

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
Systems and Data	Information systems going down for extended period during high priority event	• Economic impacts • Reputation impacts • Public health and safety • Regulatory impacts	5	3	15	• Emergency and contingency plans • Redundancy • Documented manual processes • Business Continuity Plan
Failure	Damage to operational and/or administrative facilities	• Disrupts operation • Public health and safety • Regulatory impacts • Economic impacts	5	3	15	• Emergency Response Plan • Business Continuity Plan • Redundancy • Emergency Action Plans (Facility and/or asset specific)
Treatment	Lack of available land for expansion and/or new facilities	• Economic impacts • Reputation impacts • Delay to project schedules • Regulatory impacts	3	5	15	• Proactively search for available land adjacent to facilities • Negotiate/buy options with adjacent landowners • Monitor and prevent encroachment on existing facilities • Identify areas where expansion might be needed as part of Facility Planning
Third Party	Sabotage and/or vandalism at a facility	• Public health and safety • Economic impacts • Public relations	5	3	15	• Security monitoring • Identify key locations where stolen equipment is sold • Analyze existing reports on vandalism and theft to identify key locations • Fences, locks, etc. to secure facilities
Third Party	Third-party damages critical collection system infrastructure	• Public health and safety • Environmental impacts • Economic impacts • Public relations impacts • Regulatory impacts	5	3	15	• Contingency and emergency response plans • Put a deterrent in place, including legal/enforcement actions • Full and accurate asset inventory • Processes associated with utility locates
Treatment	Loss of solid disposal options	• Solids backup at plant • Permit violations, odor issues • Treatment compromised	3	3	9	• Cake could be hauled to the back of plant for storage if necessary • Landfill and land application options
Natural	Tornado	• Potential personnel injury • Loss of plant operations • Equipment damage • Loss of plant access	3	3	9	• Emergency plan

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
Failure	Spill or discharge	• Permit violation • Personnel Safety	3	3	9	• SOP's, Good operations
Treatment	Changing regulatory requirements (i.e., nutrients)	• Higher cost (CIP and Operations) • New permits	3	3	9	• Current plant designed for addition of nutrient process
Natural	Complete Loss of utility power for 24 hours (both feeds)	• Permit violation • Would need to reseed the plant	5	1	5	• Redundant feeds with auto transfer • PMs on electrical equipment • Knowledgeable staff • Storage capability • Generator power for control building
Capacity	Insufficient design capacity in the collection system	• Public health and safety • Regulatory impacts • Economic impacts, including development • Public relations impacts • Basement backups	1	5	5	• Facility planning and hydraulic modeling • Capital improvements • Monitoring of future development and determination of available capacity
Systems and Data	Internal Data Controls (SCADA)	• Loss of system monitoring and controls	5	1	5	
Systems and Data	Loss of utilities (communication)	• Loss of internet more critical • CMMS/GIS/Email depend on internet connection • Phones on same line as internet	1	5	5	• Cell phones could be used as backup for communication
Organizational	Damage to private property	• Plant failure may cause basement backups	1	5	5	• Bypass if there is a plant failure
Treatment	Major Permit violation (NPDES, air permit, etc.)	• Reporting and communications with the regulatory authority • Negative publicity • Fines • Notice of Violation • Potential need for operational changes/capital improvements • Stricter permit for chronic violations • Enforcement/Consent Decree potential	3	1	3	• Environmental compliance work order system • Standard operating procedures • Training staff
Third Party	Terrorist attack	• Potential personnel injury • Loss of plant operations	3	1	3	• Emergency plan

Table 5-1. Organizational Risk Register						
Risk ID	High Level Risk	Description of Impact	Consequence Rating (1,3,5)	Likelihood Rating (1,3,5)	Risk Rating (CR x LR)	Risk Mitigation Action
		• Equipment damage • Danger to personnel				
Safety	Fire	• Loss of records • Personnel safety • Loss of treatment	3	1	3	• Fire risk minimal in process areas • Fire alarms in key areas • Fire extinguishers throughout plant
Organizational	Legal action (manhole or RF)	• Bad Publicity • Fines	1	3	3	• Meet permit conditions • Good plant operations, SOP's • Training
Natural	Earthquake	• Potential personnel injury • Loss of plant operations • Equipment damage • Loss of plant access	3	1	3	• Emergency plan • Newer equipment and buildings designed to current code
Natural	Flooding	• Facilities would be underwater	1	1	1	• Trailer mounted pump available for recovery • A flood emergency plan is in place.
Financial	Exceeding allocated budget	• Defer other work • Schedule delays • Rate impacts	1	1	1	• Budget planning • Contingencies • Budget tracking
Treatment	Loss of utilities (potable water)	• Solids will back up in the plant • Loss of showers, drinking water, toilets	1	1	1	• Bottled water can be brought in for personnel • Portable toilets can be brought in

5.1.3 Risk-Based Prioritization

Standardized risk criteria are used to identify critical equipment at each facility and system, and to prioritize identified projects and maintenance programs. The consequence of failure (COF) criteria is defined in Table 5-2 and identify the impact a failure may have on level of service. Likelihood of failure (LOF) criteria are defined in Table 5-3.

Each facility and system should apply the LOF and COF criteria to identify the highest priority assets as shown in Figure 5-1.

Figure 5-1. Risk-Based Prioritization Steps.

The outcome of this process is a risk-ranking of assets that can be used to prioritize condition assessment activities, operations and maintenance activities, spare parts inventories, and risk-mitigation projects (such as replacement/rehabilitation). Criticality ratings are also to be used to determine the priority and timeframe for corrective actions as part of capital planning. As part of the development of the TAMPs, each division will be responsible for developing prioritized assets for their facilities.

Table 5-2. Consequence of Failure Criteria

Category	Criteria	Description	Negligible - 1	Low - 2	Moderate - 3	High - 4	Very High - 5	Weight (must sum to 100)
Environmental	Regulatory Compliance	Regulatory compliance: Overflows Permit Violations USACE Violations MS4 Violations Consent Decree Violation/Stipulated Penalties	Short duration, contained within facility. No violation.	Minor disruption, few complaints, short process upset, local regulatory fines.	Substantial disruption, numerous complaints, prolonged process recovery. Violation or fines.	Major disruption, temporary/partial loss of process, 0–6-month recovery time. Violation, fines and/or prosecution.	Major disruption, complete loss of process,> 6-month recovery time. Inability to operate.	15
	Environmental Impact	Severity and duration of impact to the environment. Includes volume of permitted combined sewer overflow (CSO), dry weather overflow (DWO), sanitary sewer overflow (SSO), unauthorized release.	Negligible impact on the environment. CSO, DWO, SSO, or unauthorized release less than or equal to 1K gals.	Minor recoverable, ecological impact. CSO, DWO, SSO, or unauthorized release greater than 1K gals., but less than or equal to 10K gals.	Minor environmental damage, short term effect. CSO, DWO, SSO, or unauthorized release greater than 10K gals., but less than or equal to 250K gals.	Medium to long term environmental damage. CSO, DWO, SSO, or unauthorized release greater than 250K gallons, but less than or equal to 1M gals.	Significant environmental impact with long term effects. CSO, DWO, SSO, or unauthorized release greater than 1M gals.	15
Social	Customers Affected	Number of customers, assets, and/or facilities impacted due to a failure.	Less than 10 services affected. Localized impact.	Up to 100 services affected.	Up to 1,000 services affected. Multiple systems/areas impacted. One	Up to 2,500 services affected. Two critical customers out of service.	More than 2,500 services affected. Facility-wide/system-wide disruption. More than two	15

Table 5-2. Consequence of Failure Criteria								
Category	Criteria	Description	Negligible - 1	Low - 2	Moderate - 3	High - 4	Very High - 5	Weight (must sum to 100)
							critical customers out of service.	
	Public Image	Media coverage based on number of people affected, environmental impacts, financial loss, lawsuits	Public inquiry or complaint. No media coverage.	Multiple public inquiries or complaints. No media coverage.	1 to 2 days local adverse media. Correspondence from State and/or local officials.	Multi-agency interests and/or > 2 days exposure across multiple social media platforms.	Broad adverse media, Neighboring jurisdictions impacted. Impact to Bond Ratings.	15
	Health and Safety	Public health and safety impacts, employee safety, regulatory compliance.	First aid required (cut, bruise, topical rash)	Minor injury (Sprain, stitches)	Moderate injury (broken bone) or illness lasting several days	Severe injury or illness with permanent damage	Fatality, localized illness impacting multiple individuals	15
Financial	Financial Impact	**Internal Financial Impact** - Total repair, rehabilitation and/or replacement costs. Increased operational costs. **External Impact** - Lost revenue, liability costs, fines, property damage	Less than $20K	$20K to $100K	$100 to $200K	$200K to $1M	$1M or greater	25

Table 5-3. Likelihood of Failure Criteria								
	Criteria	Description	Negligible - 1	Low - 2	Moderate - 3	High - 4	Very High - 5	Weight (must sum to 100)
	Proactive Maintenance and Inspection History	Proactive maintenance, testing or inspections completed in accordance with plans.	Consistent Preventive Maintenance and inspection scheduled and performed	--	Preventive Maintenance and inspection scheduled, but infrequently performed	--	No planned preventive maintenance or inspection	25
	Historical Asset Failure	Frequency of asset failure under normal operating conditions based on historical asset operation and	No known failures in the last 2 years	--	1 failure in the last 2 years	--	2 or more failures in the last 2 years	30

Table 5-3. Likelihood of Failure Criteria								
	Criteria	Description	Negligible - 1	Low - 2	Moderate - 3	High - 4	Very High - 5	Weight (must sum to 100)
		maintenance records.						
	Life Remaining	Remaining useful life based on the age of the asset.	New or like new. Greater than 80% of useful life remaining	80% to 60% useful life remaining	60% to 40% useful life remaining	20% to 40% useful life remaining	At end of life or nearing end of life. Less than 20% of useful life remaining	15
	Usage/Run Times	Frequency of use as an indicator of operational and/or capacity issues.	Low run times	--	Moderate run times	--	High run times	15
	Capacity	Meets desired capacity requirements.	Significant available capacity during peak conditions	Available capacity during peak conditions	At capacity during peak conditions	At capacity during average conditions	Exceeds capacity during average conditions	15

5.1.4 Consequence of Failure Analysis

The COF criteria used to identify the impact a failure may have on level of service. Each facility/system should apply the COF criteria to identify the highest priority locations as follows:

1. List the locations, systems, and assets for each facility.
2. Review each COF scoring criteria and review the criteria description. (Table 5-2)
3. Assign a COF score (1= best or least, and 5= worst or most) to each criterion at the location/system level.
4. Weights for each criterion are already established.

COF Criteria	Score	Weight	COF Score
Regulatory Compliance	3	0.15	0.45
Environmental Impact	3	0.15	0.45
Customers Affected	3	0.15	0.45
Public Image	4	0.15	0.60
Health and Safety	3	0.15	0.45
Financial Impact	2	0.25	0.50
		LOF Total	2.90

5. A COF score will be calculated for each location/system for facilities with vertical assets. A COF score will be calculated for each asset for linear assets.
6. Review the applied COF scores and verify that the score is appropriate for the location/system.
7. Populate the data within the CMMS.

5.1.5 Likelihood of Failure Analysis

The COF criteria used to identify the impact a failure may have on level of service. Each facility/system should apply the LOF criteria to identify the highest priority locations (based on COF) as follows.

1. List the assets for each facility, starting with the high COF locations identified previously.
2. Review each LOF scoring criteria and review the criteria description. (Table 5.3)
3. Assign a LOF score (1= best or least, and 5= worst or most) to each criterion.

LOF Criteria	Score	Weight	LOF Score
Proactive Maintenance & Inspection History	3	0.25	0.75
Historical Asset Failure	1	0.30	0.30
Life Remaining	3	0.15	0.45
Usage/Run Times	4	0.15	0.60
Capacity	2	0.15	0.30
		LOF Total	2.4

4. Weights for each criterion are already established.
5. A LOF score will be calculated for each asset.
6. Review the applied LOF scores and verify that the score is appropriate for the location/system.
7. Populate the data within the CMMS.

5.1.6 Risk Score Analysis

Once the COF and LOF criteria have been applied to locations and assets at each facility/system they are placed on the risk matrix (Figure 5-2). The thresholds shown below are examples and will be established by CRW at a future date.

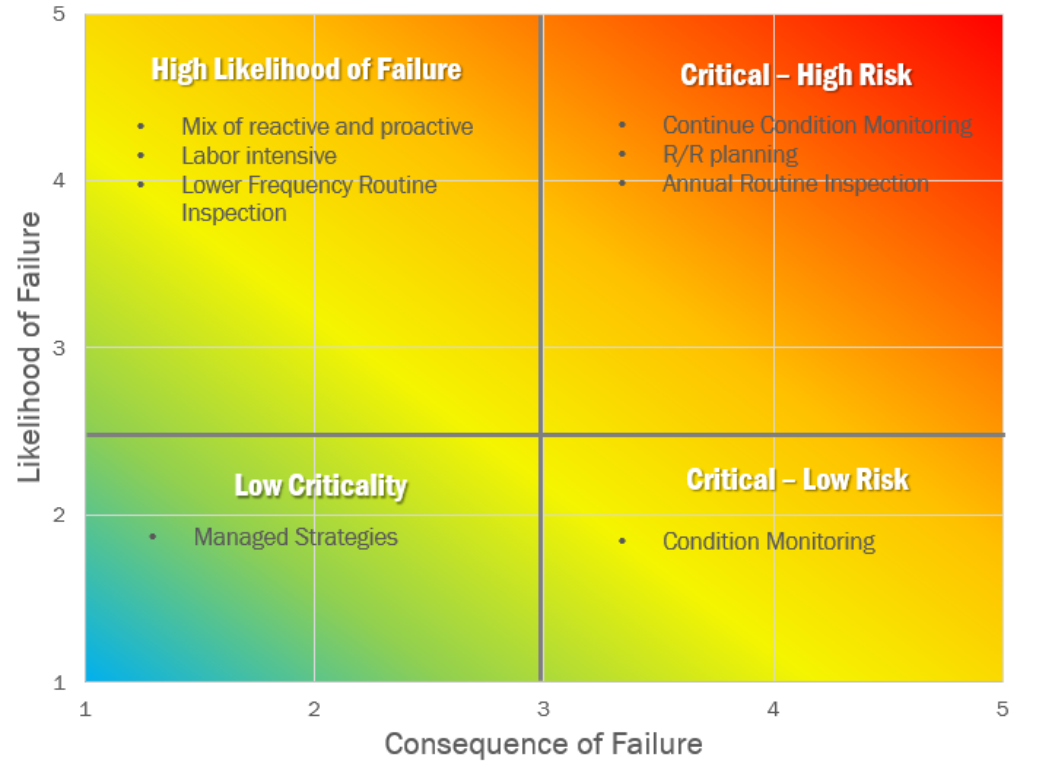


Figure 5-2. Asset Risk Matrix.

It should be noted that COF will be static year to year and only significantly change when processes are modified, or facilities built/abandoned. LOF, on the other hand, is more dynamic in nature and over time will move towards a higher score. The asset LOF scores will be influenced by the asset condition rating.

The outcome of this process is a risk-ranking of assets that can be used to prioritize condition assessment activities, operations and maintenance activities, spare parts inventories, and risk-mitigation projects (such as replacement/rehabilitation). Criticality ratings are also to be used to determine the priority and timeframe for corrective actions as part of capital planning.

Critical—High Risk Assets	Critical—Low Risk Assets	High Likelihood of Failure Assets	Low Criticality Assets
• COF score greater than 3 and LOF score greater than 2.5. • Assets are vital to the operation and take priority over other assets. Assets need to be very reliable and maintenance activities focused on eliminating the potential for failures. As the asset condition rating becomes worse, rehab/replacement plans need to be put in place to sustain operations.	• COF score greater than 3 and LOF score less than 2.5. • These assets are important to the operation; however the likelihood of failure is lower than critical assets. Assets within this group are good candidates for condition monitoring. This monitoring is the trigger for maintenance activities or R&R plans.	• COF score less than 3 and LOF score of greater than 2.5. • These assets are less vital to the operation; however, can become a focal point due to the frequency (i.e., likelihood) of failure and require significant resources (time and materials) to sustain.	• COF score less than 3 and LOF score less than 2.5. • Assets in this group are less vital to the operation and are unlikely to fail.

5.2 CIP Development and Prioritization Process

5.2.1 Rehabilitation and Renewal Process: Long-term Capital Project Planning

Long-term R/R plans for critical assets should be developed for each facility and system. R/R plans should be comprised of estimated R/R costs for each critical asset over a designated period (i.e., 50-year horizon). The example shown in Figure 5-3, illustrates the various anticipated R/R costs over the lifecycle of a single asset.

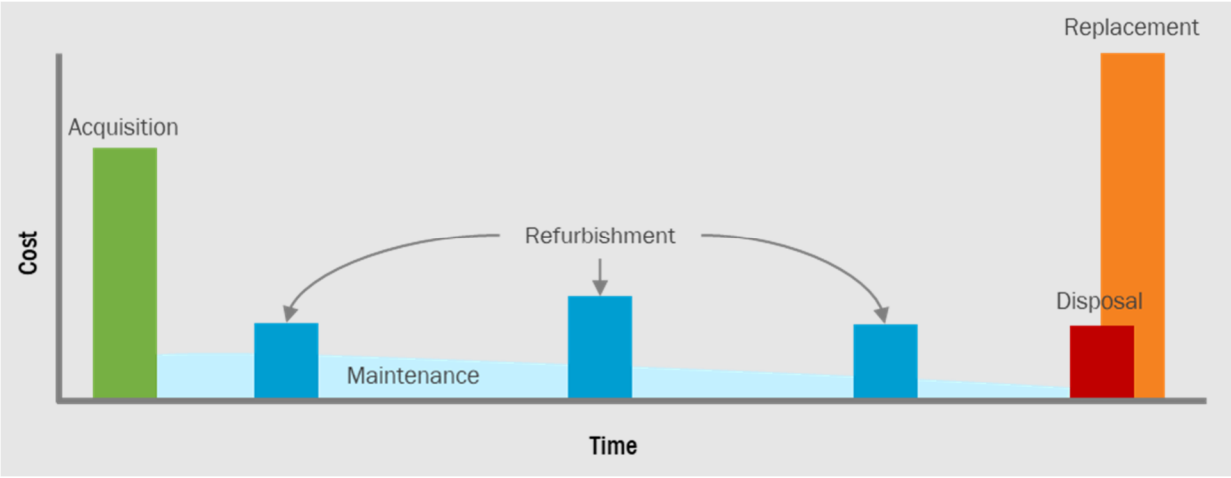


Figure 5-3. Typical costs incurred in an asset lifecycle.

The steps to be used by staff to develop long-term R/R plans for critical assets are shown in Figure 5-4.

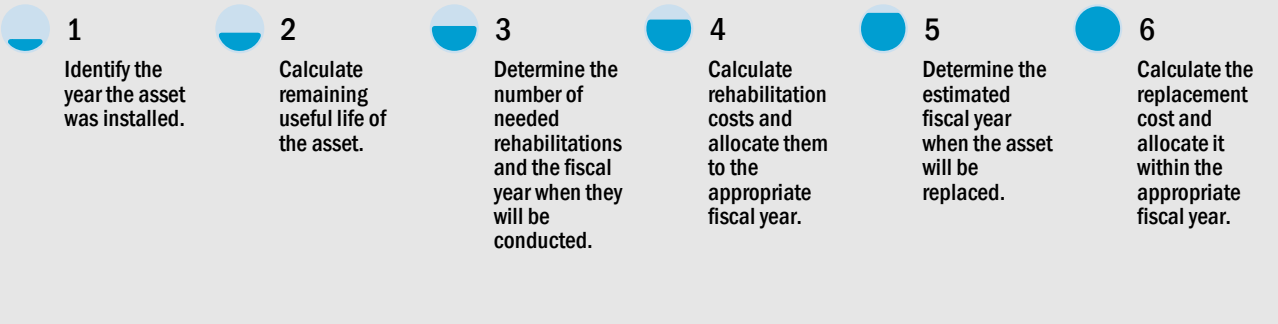


Figure 5-4. Long-term R/R Planning Process.

The table included in **Appendix F** has been developed for use by facilities and systems managers to develop planning level estimates for use in R/R plan development. It includes the following key pieces of information that each facility/system will need to establish an R/R plan for critical assets.

- **Asset Class Name.** Describes a group or type of assets with similar characteristics
- **Number of Rehabs.** The number of rebuilds or refurbishments that the asset will undergo during its lifetime.
- **Rehabilitation Interval.** Describes how frequently the rehabilitation will occur, in years.
- **Rehabilitation Cost Percent of Replacement Cost.** Provides the assumed percent of the replacement cost that will be used to estimate the rehabilitation cost.
- **Rehabilitation Cost.** The replacement cost multiplied by the Rehabilitation Cost Percent.
- **Asset Useful Life.** Typical life, in years, of an asset assuming that a reasonable and normal level of preventive maintenance is performed.
- **Replacement Cost.** Typical cost to purchase a new asset when the existing asset is decommissioned.
- **Condition and Performance Ratings.** When condition and/or performance information is available, the remaining useful life of an asset may be adjusted based on the observed condition/performance of the asset. In these instances, the R/R plan should be adjusted to reflect the updated remaining useful life. Each facility/system will be responsible for developing R/R plans for critical assets in the timeframe determined by the RDT.

5.2.2 Capital Project Request and Evaluation

Providing a sound business case for projects is essential to developing and delivering a healthy, sustainable capital program. A standardized approach to justifying needs/projects has been developed to allow staff to determine project priorities and make the case for funding projects. A Capital Project Request form for use by staff to facilitate this process is included in **Appendix G**.

- Required for all capital assets/projects (Cost >$5k+, Estimated useful life >3yrs), when approved informs the 10-year capital plan and funding needs. Single form can be used for multiple assets if the assets are individually identified and reasonably grouped.
- Staff will be trained on the business case justification process following the details noted in Table 2-4.

5.2.3 Project Prioritization Process

Developing and prioritizing the resulting CIPs involves operations and maintenance, engineers, finance, and management. The compiled CIP is based on division needs and the Capital Request forms (see Section 5.2.5).

- Operations and Engineering collaboratively complete the Capital Request Form (**Appendix G**) for long-term (within the 10-year forecast) or significant capital project.
- The completed forms are sent to Finance for review and tabulation into a preliminary budgetary CIP. Finance then attempts to balance budgets within current rates.
- Finance then returns the preliminary CIP to Operations and Engineering to determine project prioritization.
- The prioritized list, along with the corresponding Project ID Sheets and Business Case Justification forms, should then be submitted to the Finance for inclusion in the overall 10-year capital program.

5.2.4 Growth and Forecasting

Analyses of growth and necessary capacity are performed on a scheduled basis and used to determine the funding needs. Forecasting is done using optimization tools (capacity planning, asset acquisition, maintenance analysis, R&R alternatives, etc.).

Periodic analyses are undertaken of the financial results and used to determine future costs of assets and asset operation and maintenance costs. Procedures to review the trend in funding plans and available funds are done to update the funding plan and policies.

5.2.5 Forecasting Long-term R/R Needs

Periodic analyses are undertaken to determine future costs of asset renewal and replacement, including asset maintenance costs. Procedures to review the trend in funding needs and available funds are available.

5.2.6 Budget Strategy

Once an asset R/R need has been justified, an integral part of the process is deciding the budget source. All legally available delivery methods are considered, such as in-house, design and construct, design-build (DB), design-build-own (DBO), design-build-own-operate (DBOO), and selection made with due consideration of comparative lifecycle costs. Includes leasing and buying of equipment.

There are several types of funding methods available to support the AM program. Table 5-4 provides details about potential budget options.

Table 5-4. Budget Strategy

Budget	Description	Application
Operations	Budget used for standard O&M of assets -rehabilitation and replacement	
Capital Program	Budget process for specific asset R/R projects over longer planning horizon (3-5 years). Engagement with Engineering for asset R/R sequencing within capital program.	In-house, design and construct, design-build (DB), design-build-own (DBO), design-build-own-operate (DBOO)

5.3 Design and Construction

The capital improvement program plays a significant role in the inclusion of new and replacement assets and infrastructure. The design and construction processes include opportunities for compiling asset information and making it available to the asset management effort prior to startup. The workflow shown in Figures 5-5 through 5-12 describes how asset management information is included in project design and construction.

5.3.1 Design Requirements

The design process defines what assets will be constructed and added to the CRW hierarchy. During design, the specifics of these assets are typically not yet known but decisions on what the contractor will provide are determined as the contract specifications take shape. The design process will define requirements including, startup and commissioning activities, asset data attributes, spare parts, staff training, warranty specifications, etc. The design drawings should identify assets by the standard hierarchical enumeration scheme to facilitate inclusion into the GIS and the CMMS database.

Other important decisions can be facilitated during the design process through engagement of the O&M staff. For some projects, considerations on staffing numbers or skills will be identified. Maintenance of operations during construction and safety concerns associated with the construction or long-term operations also are understood during design, offering the opportunity to make plans well ahead of startup.

It is essential that the design community serving CRW understands the ultimate use of asset information and what form it is required to be delivered. This will help to achieve consistency in the information associated with the new assets that are constructed. Figures 5-5 through 5-8 depict the design process at CRW.

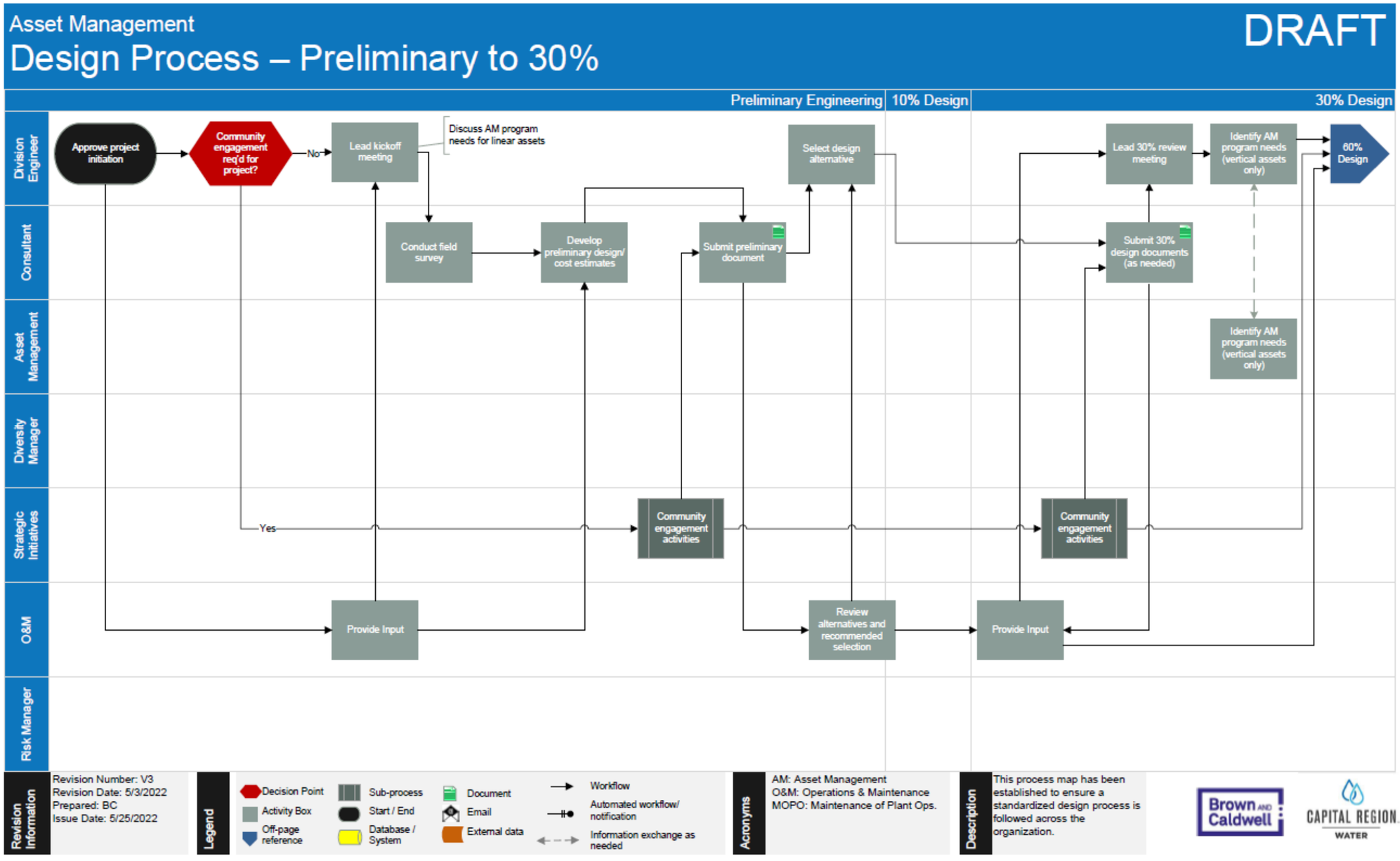


Figure 5-5. Design Process - Preliminary Design to 30% Design Stage

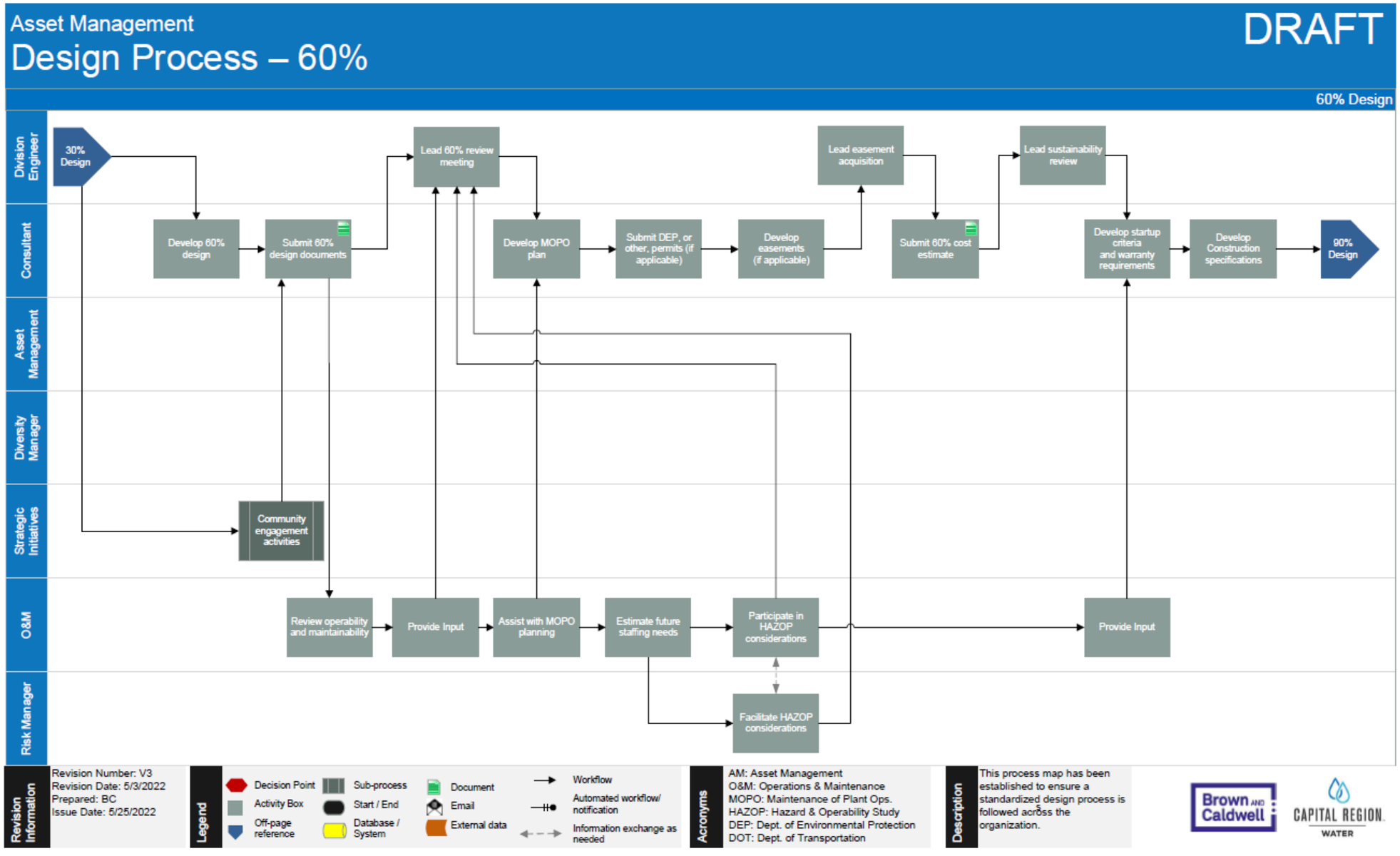


Figure 5-6. Design Process - 60% Design Stage

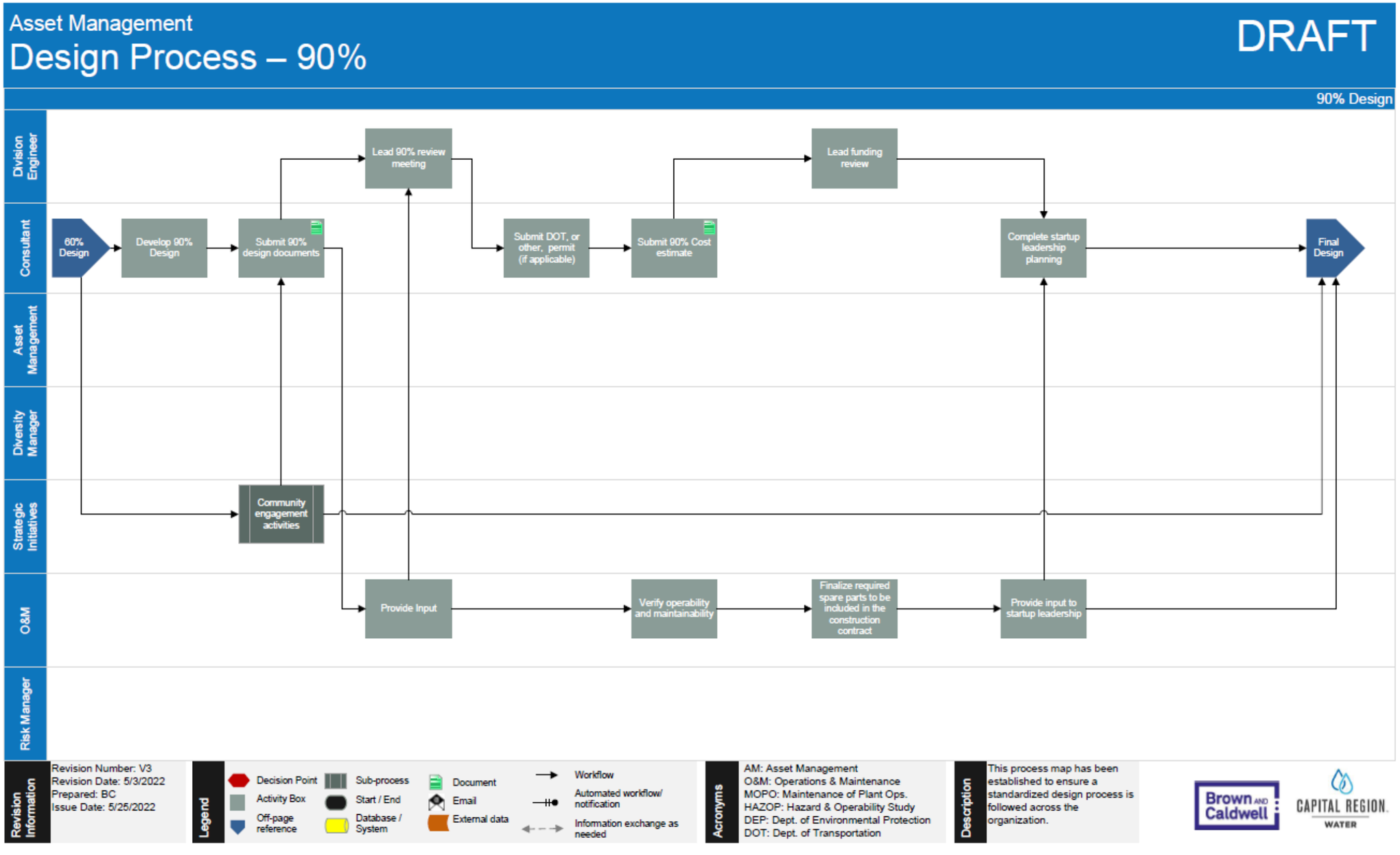


Figure 5-7. Design Process - 90% Design Stage

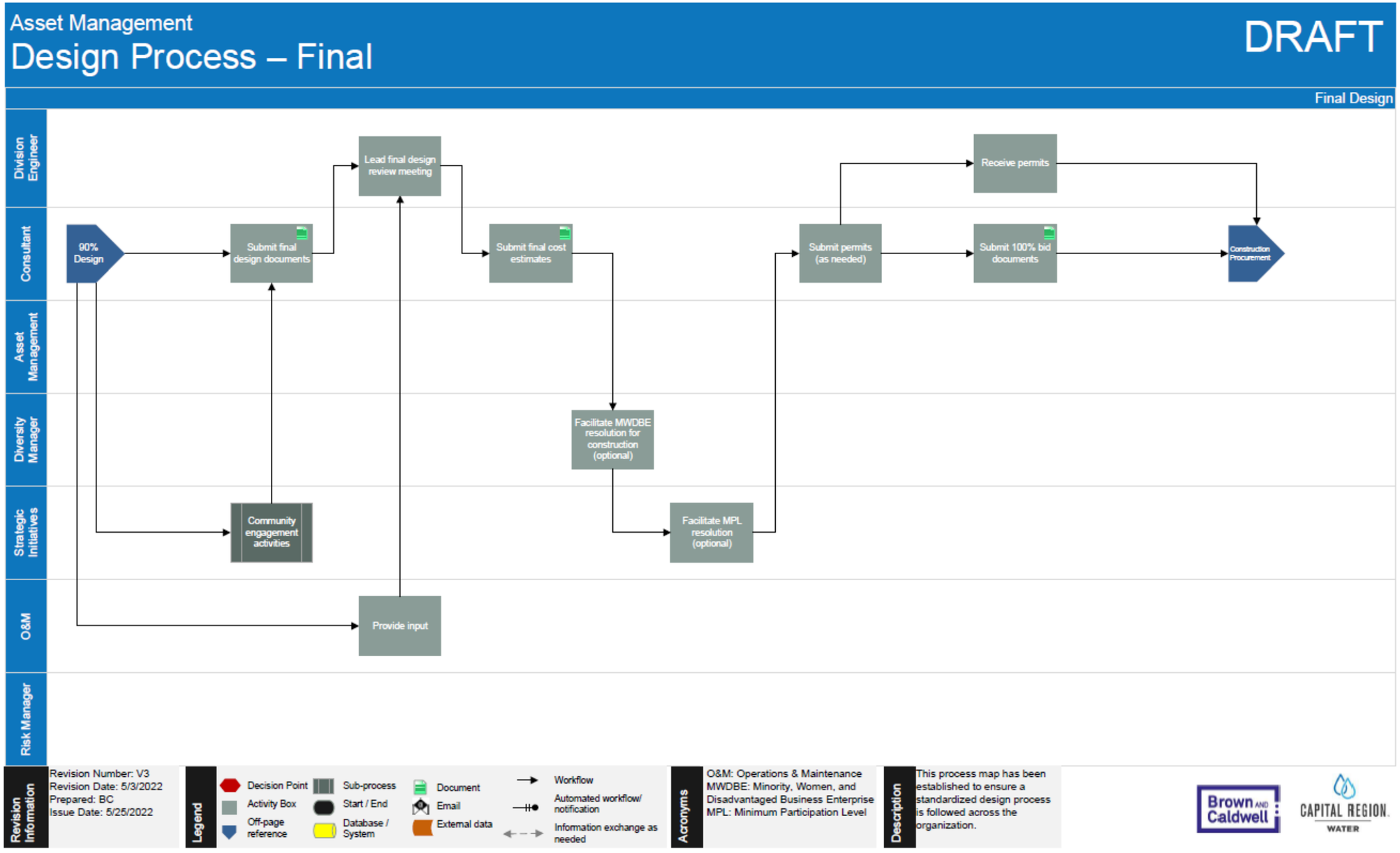


Figure 5-8. Design Process Final Design Stage

5.3.2 Construction Requirements

It is in construction that all the specific details regarding new assets becomes clear. Facility/system projects are delivered with asset listings in accord with the enumeration scheme provided for in the design. Significant attribute data may be required of the contractor to inform that asset management effort that will exist during the life of the assets (see **Appendix B**). Acquisition costs and lifecycle data at the asset level are delivered along with the asset listings.

The transmission of required assets and asset attributes to the owner must be complete and done per the specification standard. To ensure this, construction management and or consultant engineer activities geared to quality review and assurance of this information are essential.

During construction, activities to support successful testing, commissioning, and training should be planned, as appropriate with the owners O&M staff. Planning should consider the maintenance of operations during the startup, an assessment of startup readiness agreed upon by all parties, appropriate staff availability, timeframes for training, etc. These planning activities should occur well ahead of the scheduled startup of new assets. Figures 5-9 through 5-12 depict the construction process at CRW.

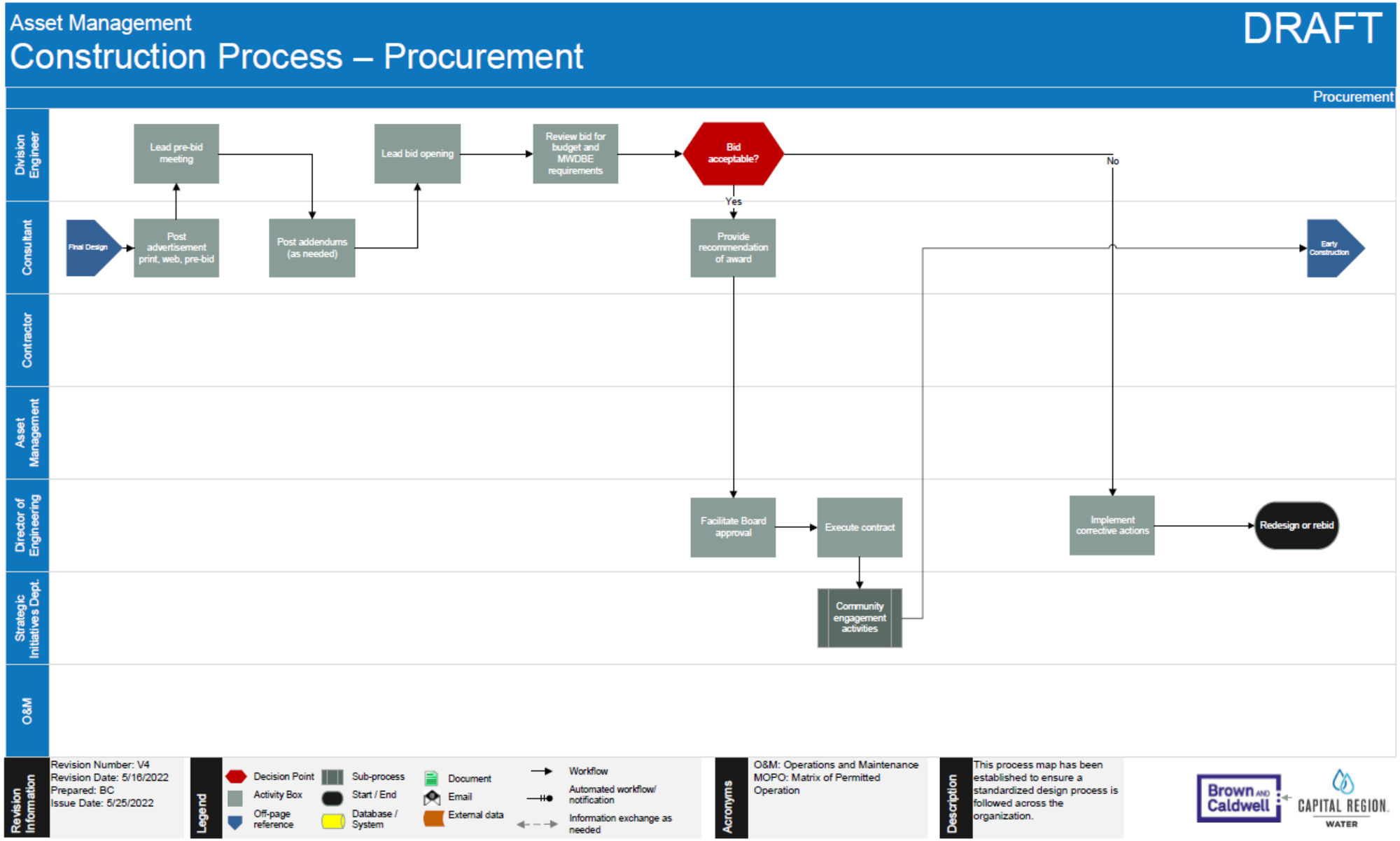


Figure 5-9. Construction Phase Procurement

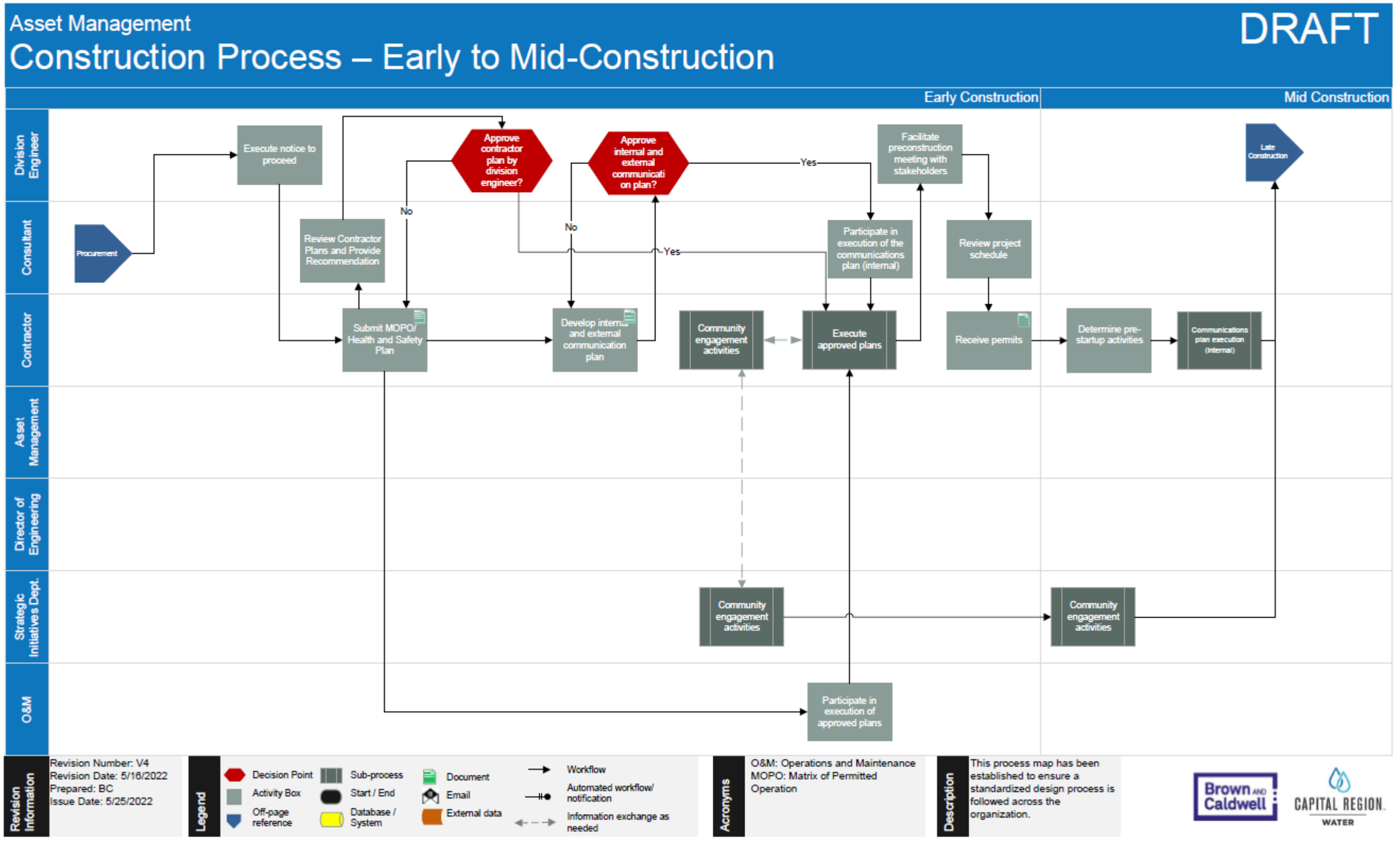


Figure 5-10. Construction Phase Early to Mid-Construction

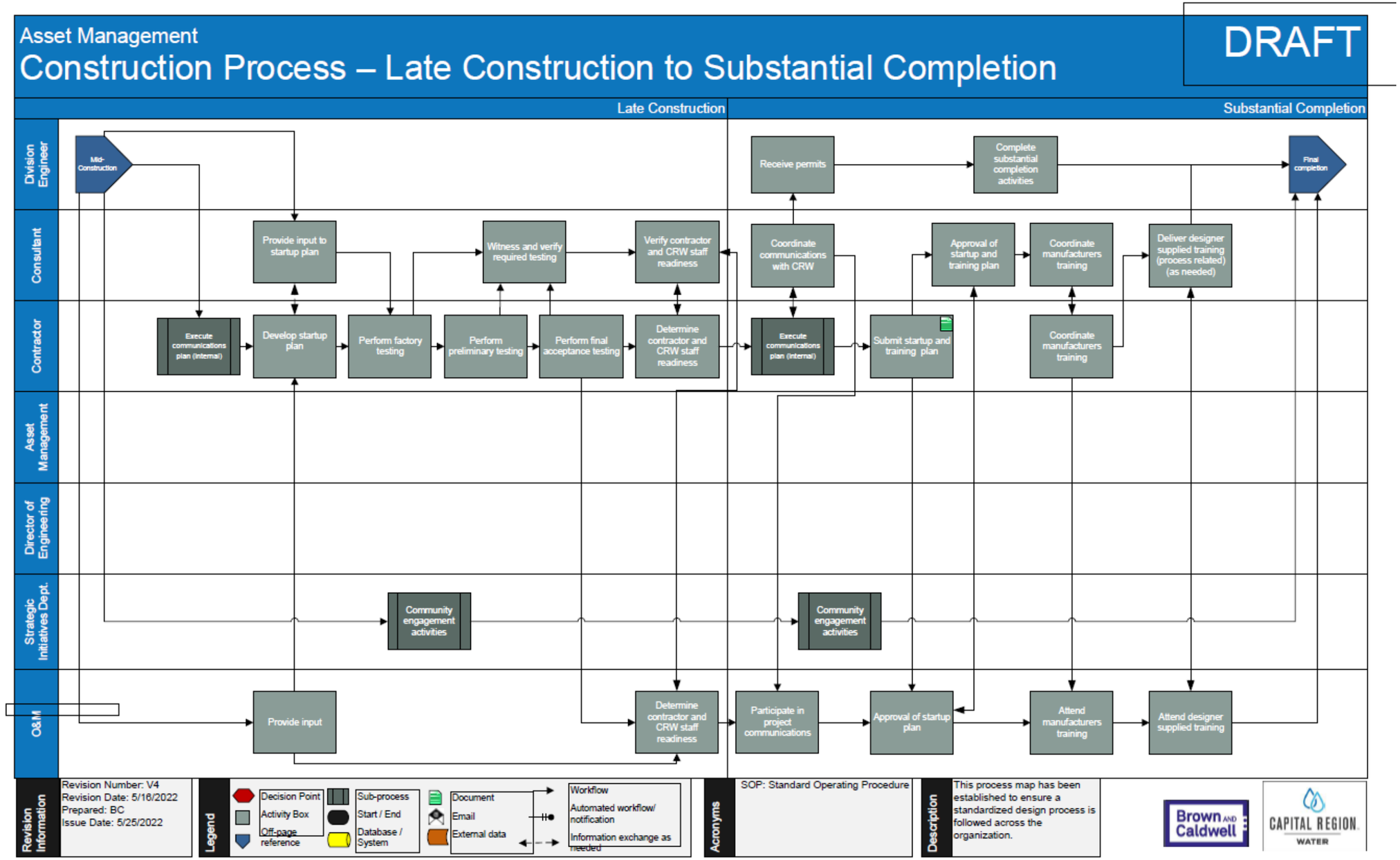


Figure 5-11. Construction Phase - Late Construction to Substantial Completion

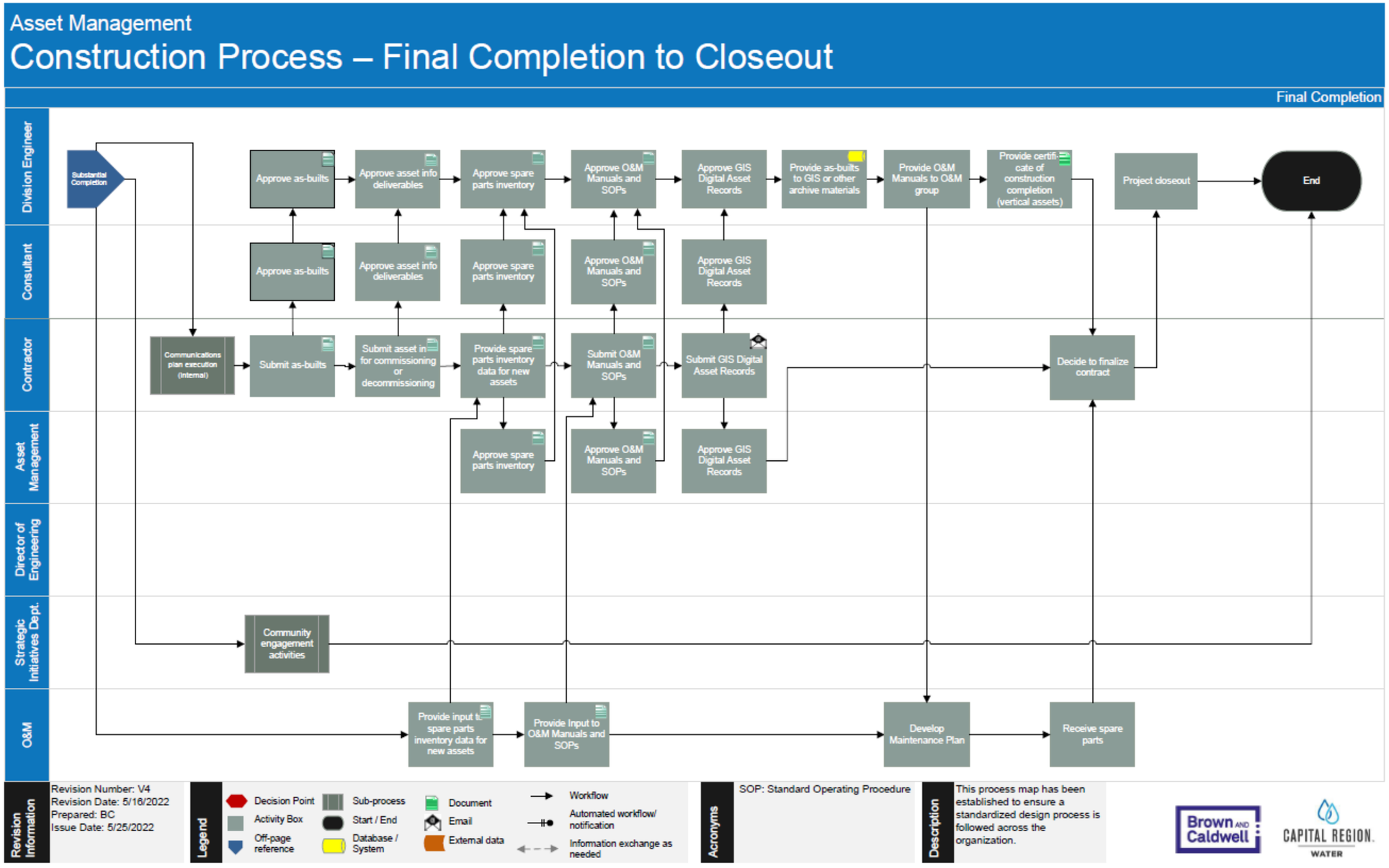


Figure 5-12. Construction Phase - Final Completion to Closeout

5.3.3 Operating Manuals, Procedures, and Guarantees

Where appropriate, design and construction requirements will include delivery of operating and maintenance manuals, guarantee information, and asset data which were defined in the design process. Additionally, in some cases, the contract specification may require the development of maintenance and/or operating procedures that are included in the above-mentioned training and then memorialized for inclusion in standard operating procedures or in the CMMS as maintenance job plans. As required, training materials and visuals should be turned over to the owner for their use. When contractor or designer supplied training will be extensive, the specifications may require that it be recorded for periodic refresher training.

When contact specifications require the delivery of operating manuals, procedures and/or warranty information it is essential that they be delivered prior to startup. Substantial completion and turnover of assets should require this documentation.

5.3.4 R/R Costs and Attributes

R/R costs, including indirect costs, are recorded in the asset history. This information is best obtained during the completion of a capital investment. Future decisions regarding renewal and/or replacement of assets will rely upon these costs and attributes.

The life extension (if any) brought about by the R/R work of the underlying asset is estimated at the end of the project. The remaining useful life of the asset is updated and may be included in revisions to the financial fixed asset inventory. This is used to appropriately increase the book value of the financials and start added depreciation of the newly renewed assets.

5.4 Continuous Improvement

People	Process	Technology
	• The COF and LOF scores of individual facility/system assets need to be reviewed on a periodic basis to ensure that the critical assets at each facility are being evaluated appropriately. As the asset management program evolves, the number of critical assets may expand or contract based on priorities. Additionally, as processes are modified at facilities, it will be appropriate to re-evaluate the COF and LOF of assets to ensure that they are designated appropriately. At a minimum, each facility will conduct annual COF and LOF review meeting for purposes of reviewing and updating the COF and LOF scores, with specific actions listed in the table below. • The table included in Appendix E should be re-evaluated on an annual basis and/or updated as appropriate when additional information regarding project costing is available.	

Section 6

Limitations

This document was prepared solely for Capital Region Water in accordance with professional standards at the time the services were performed and in accordance with the contract between Capital Region Water and Brown and Caldwell dated August 25, 2021. This document is governed by the specific scope of work authorized by Capital Region Water; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Capital Region Water and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Appendix A: Measure Definition Sheets

Capital Region Water
Asset Management Program
SAMP Level of Service (LOS) Performance Measures

Metric No.	Priority (H/M/L)	Strategic Goal Category	Value Statement	Detailed LOS_CRW	Internal / External statement	Measure Name	Equation	Description	Type	In AWWA Utility Benchmarking Survey	(2017) AWWA Median Value	Data Available	Data Source	Target	Actual	Reporting Frequency
SAMP-01		Public Health and the Environment	Protect and support the long-term health of our community and environment	Achieve or exceed all environmental and public health requirements in our drinking water, wastewater, and stormwater services		Violations caused by asset failures	Number of violations caused by asset failures / total number of violations	Measure of violations that occur due to asset failures, specifically. Indicates violations that may be preventable with implementation of AM practices.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-02		Public Health and the Environment	Protect and support the long-term health of our community and environment	Achieve or exceed all environmental and public health requirements in our drinking water, wastewater, and stormwater services		Near Misses (vertical assets)	Number of regulatory parameters within upper/lower warning limit of permit (vertical assets only)	Measure of regulatory parameters relative to permit requirements. Indicates when action is needed to ensure permit compliance.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-03		Public Health and the Environment	Protect and support the long-term health of our community and environment	Achieve or exceed all environmental and public health requirements in our drinking water, wastewater, and stormwater services		Monitoring and Reporting Compliance	Number of reporting activities completed by due date / total reporting activities scheduled	Measure of reporting activities completed on time. Indicates compliance with reporting requirements.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-04		Public Health and the Environment	Protect and support the long-term health of our community and environment	Achieve or exceed all environmental and public health requirements in our drinking water, wastewater, and stormwater services		Monitoring and Reporting Compliance	Number of sampling data points missed	Measure of sampling data points missed. Indicates potential monitoring and reporting compliance issues.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-05		Infrastructure Stability	Proactively maintain and improve our infrastructure	Operate and maintain assets in an efficient, sustainable, and resilient way		Work Order Compliance	Number work orders completed by the due date / total work orders due for a given period	Measure of work orders completed on time. Indicates work order compliance and overall O&M performance.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-06		Infrastructure Stability	Proactively maintain and improve our infrastructure	Operate and maintain assets in an efficient, sustainable, and resilient way		Equipment Failures/Breakdowns	Number of equipment failures or breakdowns in a period	Measure of equipment failures or breakdowns. Indicates state of CRW's assets and overall O&M performance.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-07		Infrastructure Stability	Proactively maintain and improve our infrastructure	Operate and maintain assets in an efficient, sustainable, and resilient way		Workorder Backlog	Number of weeks of planned maintenance work (by craft) available for assignment to staff	Measure of planned maintenance work backlog. Indicates resource needs and overall O&M performance.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-08		Infrastructure Stability	Proactively maintain and improve our infrastructure	Operate and maintain assets in an efficient, sustainable, and resilient way		Planned Maintenance vs. Corrective Maintenance	Percentage of planned maintenance vs corrective maintenance	Measure to track level of preventative maintenance in comparison to corrective maintenance to ensure that an optimal effort and investment is focused on preventive maintenance.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-09		Infrastructure Stability	Proactively maintain and improve our infrastructure	Undertake prudent and affordable renewal and replacement projects targeted for the long-term viability of the CRW assets		Asset Renewal and Replacement Rate	Actual expenditures (or total amount of funds reserved for R/R for assets) / total present worth of R/R for assets	Measure of rehabilitation and renewal expenditure over time. Relative to the average age of assets and when they are reaching their expected useful life.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-10		Infrastructure Stability	Make prudent investments to improve the system.	Undertake prudent and affordable renewal and replacement projects targeted for the long-term viability of the CRW assets		CIP Spending	Total annualized capital spending / approved CIP budget	Measure of capital spending versus budget. Indicates appropriate spending of funds to improve state of CRW's assets.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-11		Infrastructure Stability	Make prudent investments to improve the system.	Undertake prudent and affordable renewal and replacement projects targeted for the long-term viability of the CRW assets		Operations Spending	Total annualized operations spending / approved operations budget	Measure of operations spending versus budget. Indicates appropriate spending of funds to efficiently operate and maintain CRW's assets.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-12		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Provide financial resources for CRW customers that qualify for assistance		Customer Assistance	Number of customers receiving relief from the Customer Assistance Program (CAP)/month	Measure of CRW's assistance to qualifying customers. Indicates CRW's level of support to customers in need.	LOS	N		Y	?	TBD		Monthly
SAMP-13		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Provide financial resources for CRW customers that qualify for assistance		Shut-off for Non-payment	Percentage of customer accounts shutoff for non-payment/month	Measure of customers with non-payment status. Indicates potential future customer support needs from CRW.	LOS	N		Y	?	TBD		Monthly
SAMP-14		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Provide financial resources for CRW customers that qualify for assistance		CAP Assistance vs. Total Debt	Dollar value of the assistance relief as it relates to total debt (internal and external assistance dollars)	Measure of customer assistance relative to customer debt. Indicates CRW's level of support to customers in need.	LOS	N		Y	?	TBD		Monthly
SAMP-15		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Stakeholder Interactions	Number of interactions (community outreach and education) with defined stakeholders / total number of planned interactions	Measure of amount of interaction with stakeholders. Indicates level of engagement with the community.	LOS	N		Y	Cityworks, Tracking spreadsheet	TBD		Monthly
SAMP-16		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Service Request Completion	Average time to correct all CRW-related service issues	Measure of time to correct service issues. Indicates CRW responsiveness and commitment to the community.	LOS	N		Y	Cityworks	TBD		Monthly
SAMP-17		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Media Stories	Number of CRW driven stories/posts (traditional and social media) related to the utility during the reporting period	Measure of CRW stories/posts. Indicates level of engagement with the community.	LOS	N		Y	Tracking spreadsheet	TBD		Monthly
SAMP-18		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Customer Satisfaction	Number of Technical Service Complaints per 1000 Customer Accounts	Measure of the performance of CRW's services. Can be caused by many factors.	LOS	N		Y	Cityworks	TBD		Monthly

Capital Region Water
Asset Management Program
SAMP Level of Service (LOS) Performance Measures

Metric No.	Priority (H/M/L)	Strategic Goal Category	Value Statement	Detailed LOS_CRW	Internal / External statement	Measure Name	Equation	Description	Type	In AWWA Utility Benchmarking Survey	(2017) AWWA Median Value	Data Available	Data Source	Target	Actual	Reporting Frequency
SAMP-19		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Number of Insurance Claims	Number of insurance claims compared to industry average	Measure of insurance claims. Indicates performance of CRW's services.	LOS	N		Y	?	TBD		Monthly
SAMP-20		Customers and Stakeholders	Ensure customer and stakeholder confidence through engagement and by demonstrating value to our community.	Ensure customer and stakeholder confidence through engagement and demonstration of value to our community		Severity of Insurance Claims	Severity (financial) of insurance claims compared to industry average	Measure of severity of insurance claims. Indicates performance of CRW's services.	LOS	N		Y	?	TBD		Monthly
SAMP-21		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Develop and strive for a highly productive workforce through safe work practices, training, and growth opportunities		Training Compliance	Number of employees that completed each required training by the deadline / number of employees required to complete the training	Measure of training completed by a due date. Indicates priority of employee training at CRW.	LOS	N		?	?	TBD		Monthly
SAMP-22		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Develop and strive for a highly productive workforce through safe work practices, training, and growth opportunities		Safety Metrics	Safety metrics include incidents, worker comp claims, and days off due to work-related issues / days worked	Measure of safety incidents, claims, and issues. Indicates status of safety culture at CRW.	LOS	N		Y	?	TBD		Monthly
SAMP-23		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Develop and strive for a highly productive workforce through safe work practices, training, and growth opportunities		Succession Planning	Number key positions with a formal succession plan/total key positions	Measure of formal succession planning. Indicates ability to handle turnover and sustain a productive workforce.	LOS	N		?	?	TBD		Monthly
SAMP-24		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Attract staff that are representative of CRW's service area and provide a work environment that promotes growth, equity, and stability		Vacant Positions	Number of vacant positions, by job category / total number of positions	Measure of vacant positions. Indicates ability to grow the workforce at CRW, as needed.	LOS	N		Y	?	TBD		Monthly
SAMP-25		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Attract staff that are representative of CRW's service area and provide a work environment that promotes growth, equity, and stability		Employee Diversity	Ethnic and gender diversity percentages for the utility (also includes employees residing within service area)	Measure of employee ethnic and gender diversity. Indicates employment of local residents and equitable practices across the organization.	LOS	N		Y	?	TBD		Monthly
SAMP-26		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Attract staff that are representative of CRW's service area and provide a work environment that promotes growth, equity, and stability		Employee Turnover Rate	Percentage of employees that leave the utility either voluntary or involuntary during the reporting period	Measure of employees leaving the utility. Indicates ability to retain and promote staff.	LOS	N		Y	?	TBD		Monthly
SAMP-27		Workforce	Attract, develop, and retain a skilled, dedicated, and unified CReW	Attract staff that are representative of CRW's service area and provide a work environment that promotes growth, equity, and stability		Time to Hire	Average number of days from decision to hire until new employee is at work	Measure of time from hiring decision to employee start date. Indicates efficiency of initial onboarding process.	LOS	N		Y	?	TBD		Monthly
SAMP-28		Efficient Use of Resources		Execute the mission of CRW using risk informed decisions that provide best value to our customers, stakeholders, and organization		Critical Assets with high-risk value (future)	Dollar value of critical assets with high-risk score / total dollar value of critical assets	Measure of dollar value of high-risk, critical assets. Indicates potential funding needs due to asset failures.	LOS			N	?	TBD		Future measure
SAMP-28		Efficient Use of Resources	Optimize the use of our resources thourgh innovative technologies, effective processes, and sustainable solutions	Execute the mission of CRW using risk informed decisions that provide best value to our customers, stakeholders, and organization		Critical asset with high-risk score	Number of critical assets with high-risk score / total number of critical assets	Measure of number of high-risk, critical assets. Indicates potential funding needs due to asset failures.	LOS	N		N	?	TBD		Monthly

Appendix B: Required Asset Attributes

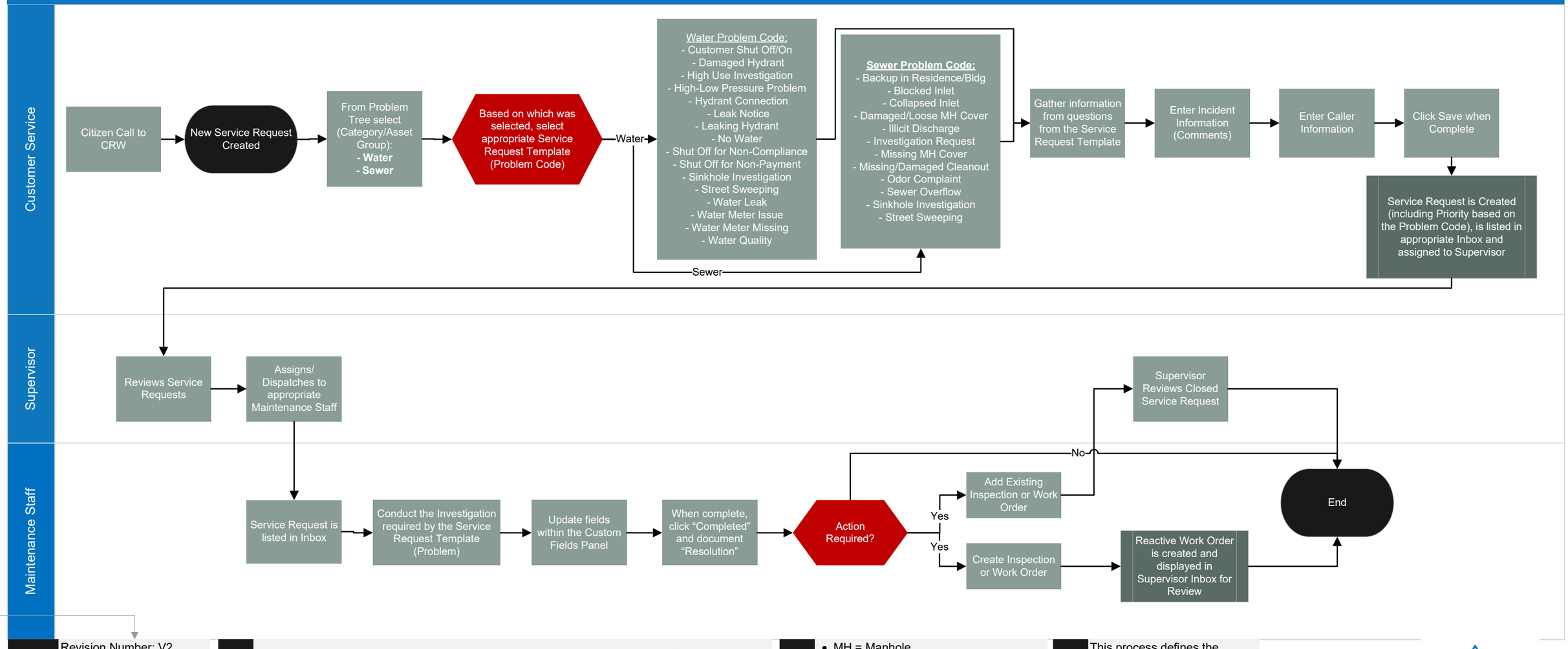
Required Vertical Asset Attributes		
Attribute	Description	Notes
Asset ID	System ID of the asset	
Name	Descriptive name of the asset	
Asset Type	Type of asset (asset class)	
Status	In/Out of service	
Material	Material of the asset, if applicable	
Manufacturer	Manufacturer of the asset, if applicable	
Model Number	Model number of the asset, if applicable	
Serial Number	Serial number of the asset, if applicable	
Installation Date	The date the asset was installed	
Purchase Cost	Purchase cost of the asset	This includes design cost, etc.
Replacement Cost	Replacement cost of the asset	Replacement cost of the equipment
Warranty Start Date	Date the warranty starts, if applicable	
Warranty End Date	Date the warranty ends, if applicable	
Physical Condition	Physical condition of the asset	
Performance Condition	Performance Condition of the asset	Potentially use predictive maintenance information
Criticality	Criticality of the asset	Either risk score or flag indicating whether the asset is a critical asset or not
Rehab Date	Date the asset was rehabilitated	

Required/Core Horizontal Asset Attributes		
Logical Attribute Name	Required?	Description
Asset ID	Yes	Unique identifier for the asset
Asset Name	No	Name commonly used to describe the asset in conversation
Asset Group	Yes	Type of asset (per Esri Utility Network)
Asset Type	Yes	Sub-type of asset (per Esri Utility Network)
Ownership / Responsibility	Yes	Agency with ownership and/or maintenance responsibility for an asset
Location	Yes	Description of the general location of the asset (interceptor, watershed, basin)
Critical Asset	No	Is the asset is considered critical?
Condition	No	Most recent condition rating/score for the asset
Risk Rating	No	Risk calculated based on COF and LOF
Installation Date	Yes	Date asset/equipment was installed
Status	Yes	The state of the asset in its lifecycle

Appendix C: Maintenance Strategy Workflows

Asset Management

Corrective Maintenance – Cityworks Service Requests (Linear Assets)



Revision Information

Revision Number: V2
Revision Date: 6/17/2022
Prepared: BC
Issue Date: 6/17/2022

Legend

- Decision Point
- Activity Box
- Off-page reference
- Sub-process
- Start / End
- Database / System
- Document
- Email
- External data
- Workflow
- Automated workflow/ notification
- Information exchange as needed

Acronyms

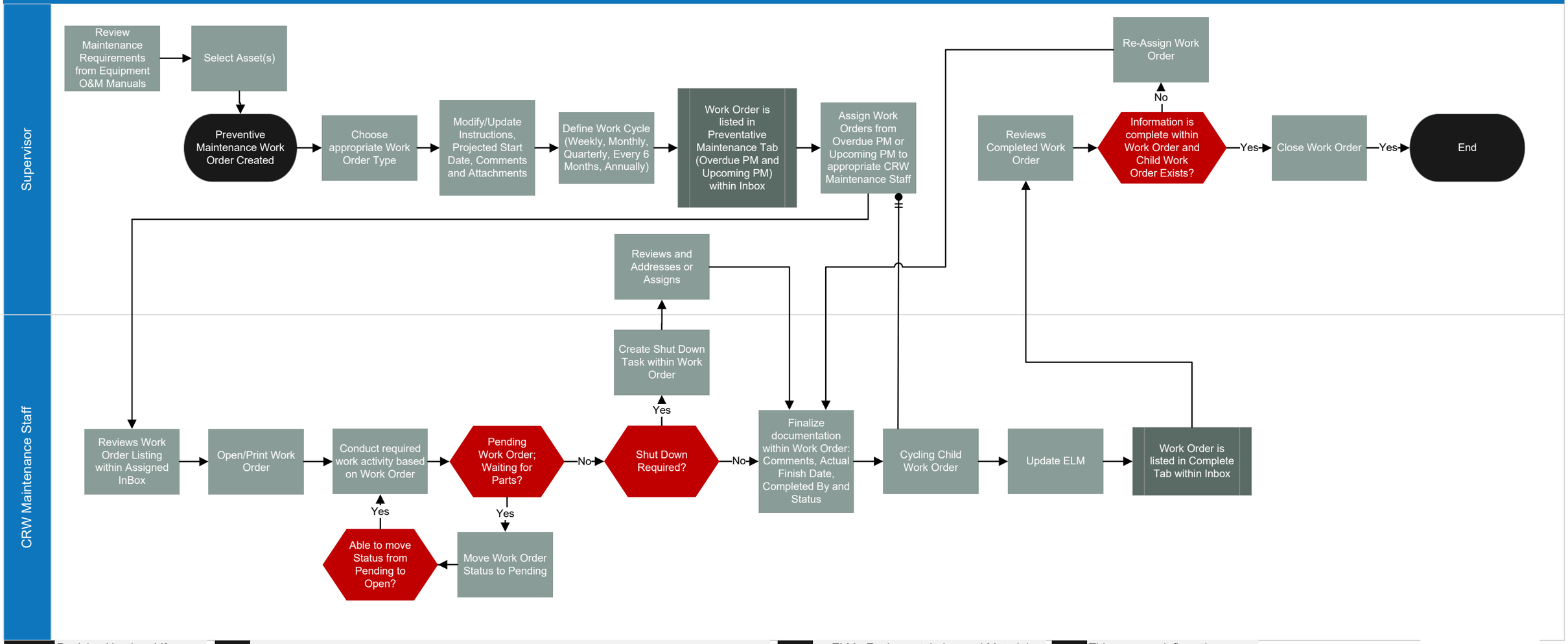
- MH = Manhole
- Bldg = Building

Description

This process defines the workflow for the Service Request activities within CRW using Cityworks.

Asset Management

Preventative Maintenance - Cityworks



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- Activity Box
- Off-page reference
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- Database / System
- Document
- Email
- External data
- Workflow
- Automated workflow/ notification
- Information exchange as needed

Acronyms

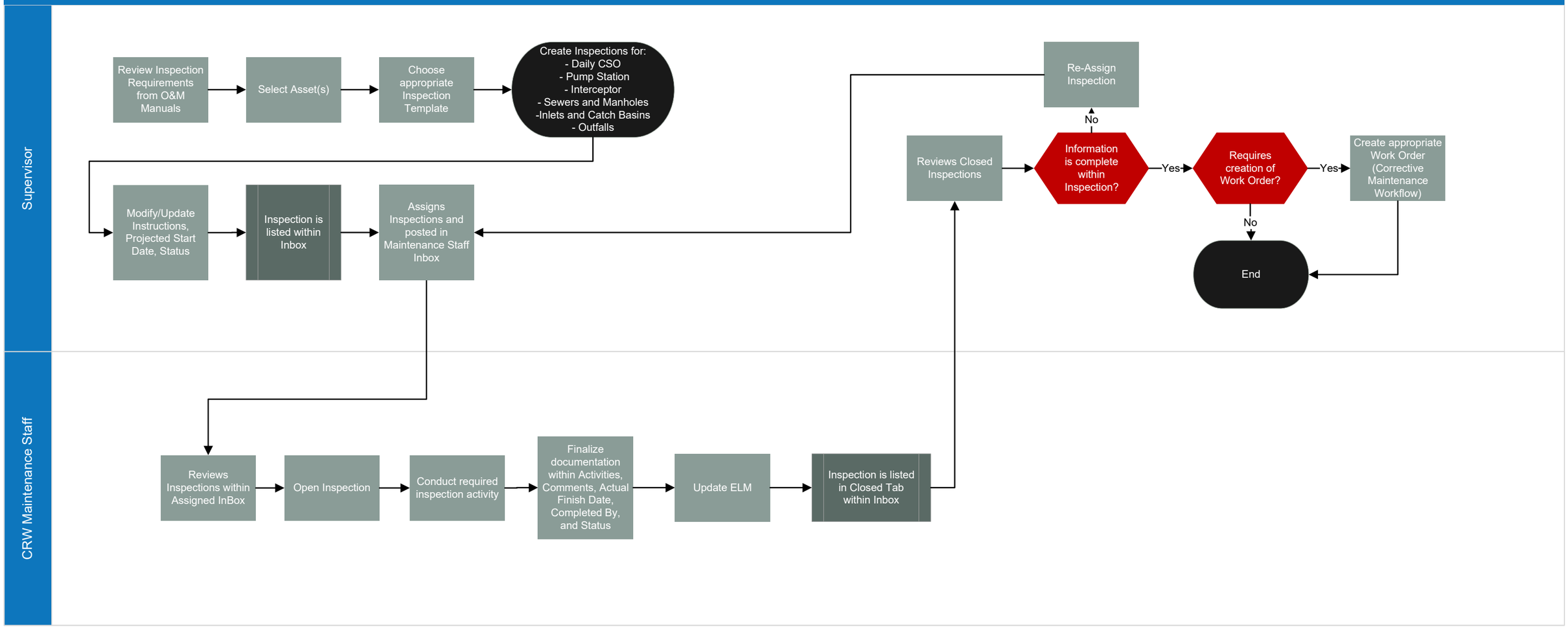
- ELM: Equipment, Labor and Materials

Description

This process defines the workflow for the Preventive Maintenance activities within CRW using Cityworks.

Asset Management

Preventative Maintenance (Inspections) - Cityworks



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- Decision Point
- Activity Box
- Off-page reference
- Sub-process
- Start / End
- Database / System
- Document
- Email
- External data
- Workflow
- Automated workflow/ notification
- Information exchange as needed

Acronyms

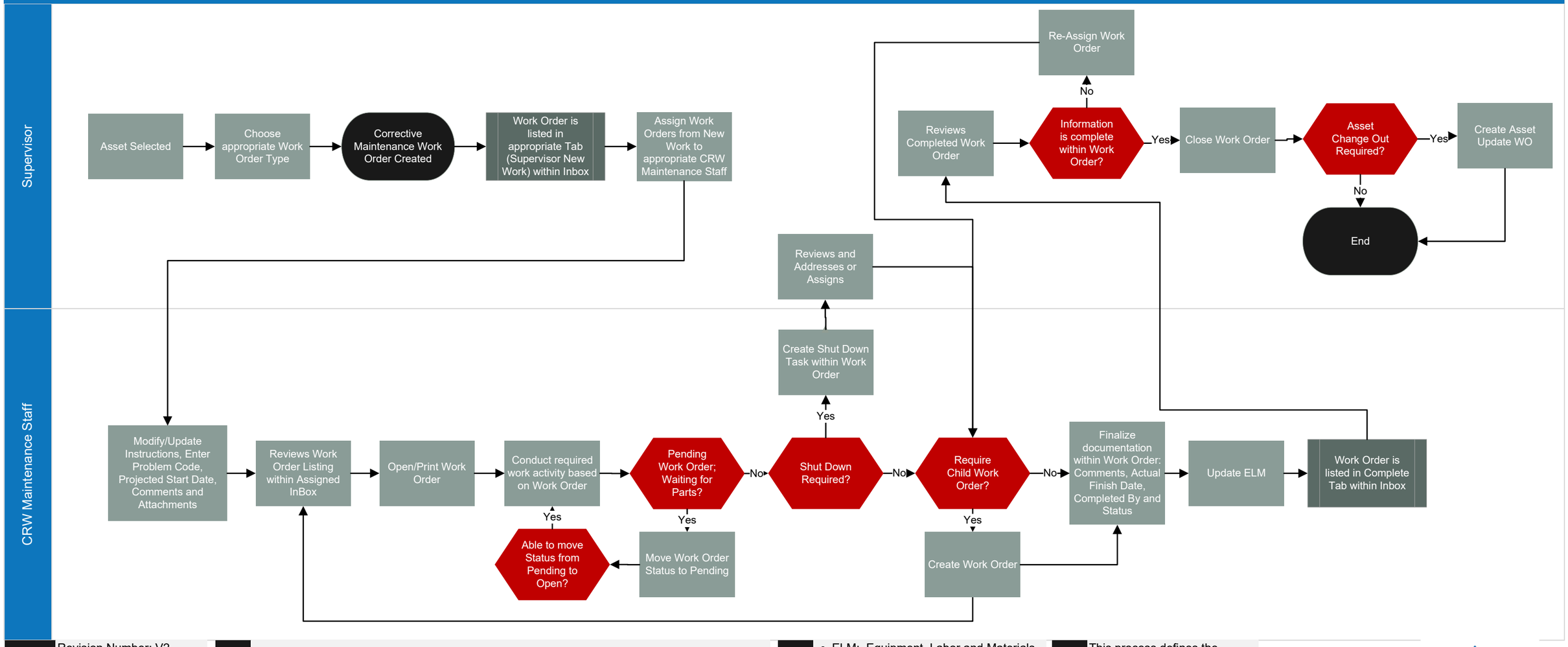
- ELM: Equipment, Labor and Materials

Description

This process defines the workflow for the Preventive Maintenance (Inspections) activities within CRW using Cityworks.

Asset Management

Corrective Maintenance – Cityworks Work Orders



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Legend

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- Start / End
- Database / System
- Document
- Email
- External data
- Workflow
- Automated workflow/ notification
- Information exchange as needed

Acronyms

- ELM: Equipment, Labor and Materials

Description

This process defines the workflow for the Corrective Maintenance activities within CRW using Cityworks.

Appendix D: Condition Assessment Guidance Document

Condition Assessment Guidance Manual

Prepared for
Capital Region Water
July 15, 2022

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Section 1

Purpose

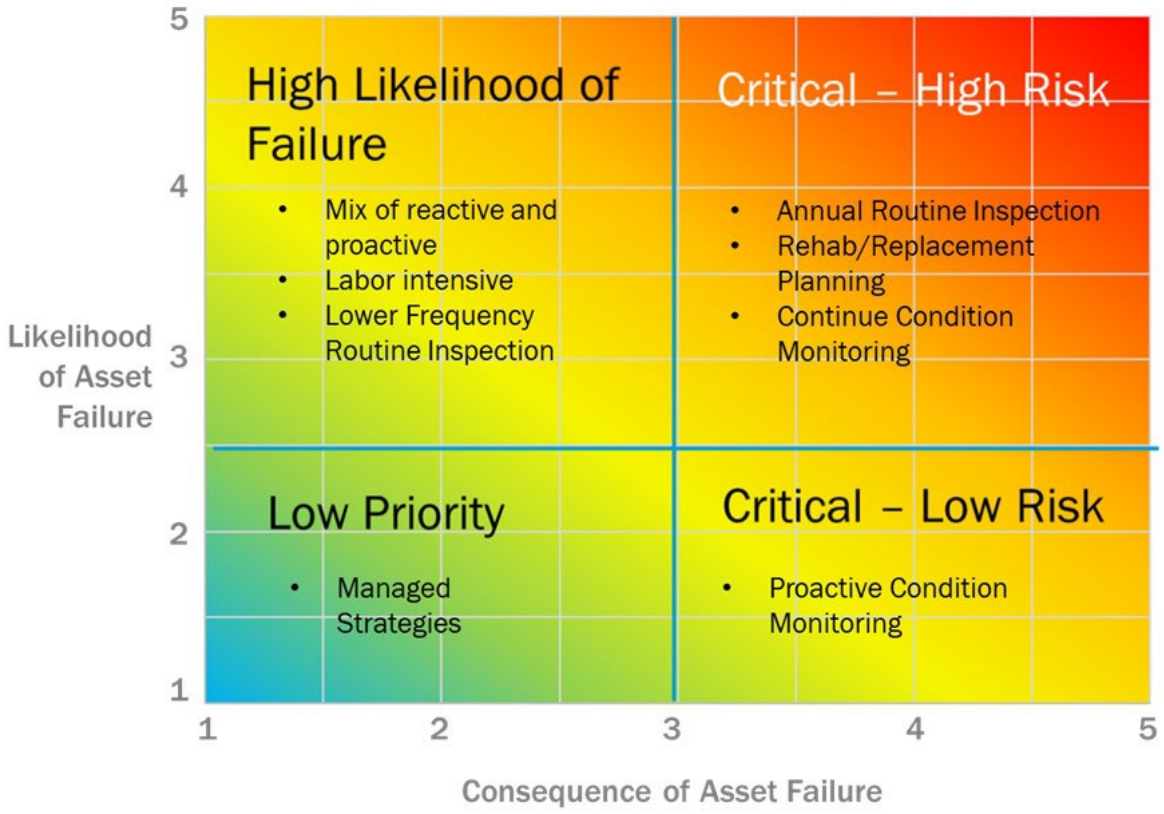
The purpose of this document is to provide a reference guide for Capital Region Water (CRW) staff scoring the physical condition of critical vertical assets through the Visual Inspection process. This guidance works in conjunction with several other documents developed as part of the Asset Management program including the Strategic Asset Management Plan (SAMP) and facility or system specific Tactical Asset Management plans (TAMP). Vertical assets where this approach will be used are shown in Figure 1-1.

Figure 1-1. CRW Facilities Where Vertical Condition Ratings Will Be Applied.

CRW has identified critical assets for each facility based upon assigned CoF and LoF scores based on the following formula:

$$\text{Risk} = \text{CoF} \times \text{LoF}$$

Assets with a certain risk threshold have been identified as 'critical-high risk' assets identified for visual inspection. These critical-high risk assets will be inspected as established in the facility specific TAMP. A list of critical high-risk assets is available in each facility specific TAMP and constitute the list of assets that will be assessed as part of the Visual Inspection.



Visual Inspection will also be performed on the high likelihood of failure assets, however at a lower frequency of inspection that will be based on the previous condition rating. To initiate the process all high likelihood of failure assets will be inspected as established in Appendix B. Those assets with a poor condition rating will have their cycles shortened; those assets with good condition ratings will have their cycles lengthened. Critical – low risk assets will implement a proactive condition monitoring program, while managed strategies will be used for low priority assets.

1.1 Visual Inspection Benefits

Visual inspection is a sensory level inspection of the assets to document the baseline condition of the assets. Table 1.1 provides a summary of the reasons and details for visual inspection.

Table 1-1. Visual Inspection Benefits

Reason	Details
Ensure Consistency	• Standardized assessment methodology across all facilities • "Poor Condition" at Pump Station A should mean the same thing as "Poor Condition" at Pump Station B
Document Asset History	• Physical state and performance of our assets not "in someone's head"
Inform Key Programs	• Maintenance – adjust frequency and priority of PMs • Capital – adjust priority of capital improvements
Avoid Surprises	• Verify results of desktop likelihood of failure scoring • Minimize costly catastrophic failures and emergency repairs • Predict resource needs (maintenance, rehab, renewal)

Cost-Effective "Triage"	• Trigger more detailed assessment and/or follow-up • Understand urgency/timing of corrective actions

1.2 Roles and Responsibilities

The primary staff responsible for conducting visual inspection of critical assets at CRW and a brief description are listed below.

- Maintenance – Maintenance staff are responsible for conducting the visual inspection, documenting visual inspection observations, assigning condition scores, conducting repairs or replacements for any issues that are identified, and/or referring issues that cannot be addressed in-house to Engineering.
- Engineering – Engineering staff are responsible for addressing condition assessment findings referred by Maintenance requiring contracted resources either through an Emergency Contract or through a Capital Improvements Project. Engineering administers the project and works with the Contractor to implement the needed improvements.
- Contractor – Contractors work with Engineering to conduct repairs or replacements through an Emergency Contract or through a Capital Improvements Project.
- Asset Management – Asset Management staff make any needed changes and updates to the asset data in the CMMS based on the rehabilitation and replacement of the assessed assets. Staff also support any data management needs during the collection of the asset condition data.

Section 2

Visual Inspection Scoring and Criteria

The purpose of this section is to summarize the guidelines for conducting a Visual Inspection for mechanical, electrical, structural, instrumentation and controls (I&C), and earthen feature assets.

2.1 Visual Inspection Process

The physical condition of the asset is the current state of repair and operation of the asset as influenced by age, operating environment, and historical maintenance. A Visual Inspection will be the first step in the evaluation of the physical condition of an asset and a baseline inspection will occur initially and then at a frequency as set forth in the facility specific TAMP. In practice, the assessor must initially determine if the asset is operational and functioning as intended. The general process for conducting the inspection is summarized below:

- Identify assets to inspect and schedule the inspection
- Perform inspection
- Assign condition ratings
- Record inspection data and condition ratings using the Computerized Maintenance Management System (CMMS)
- Review and analyze the data
- Identify assets that warrant follow-up work order
- Adjust assessment frequency, as needed.

2.2 Scoring Descriptions

All visual inspections are evaluated on a 1 to 5 scale. Assets receiving a condition score of 1 are in good condition and assets receiving a condition score of a 5 are in very poor condition. An asset with a score of 2 to 4 is intended to represent the observed condition between those good and very poor condition ratings. The following scoring descriptions apply to all asset types for Visual Inspection of CRW assets:

Table 2-1. Standard Ratings	
Rating	**Rating Description**
1 - Very Good Condition	Like new with little signs of wear. Monitor asset condition and no further action required at present.
2 - Good Condition	Minor defects evident. Monitor and trend asset condition for possible additional actions.
3 - Fair Condition	Normal signs of wear for age of asset. Continue to monitor asset condition and evaluate for rehabilitation.
4 - Poor Condition	Significant defects are evident. Continue to monitor asset condition, repair as needed and expediate plan for rehabilitation or replacement.
5 - Very Poor Condition	Asset has failed or shows excessive wear and should be replaced as soon as possible.

2.2.1 Mechanical Assets

The following table summarizes the criteria and scoring approach for a Visual Inspection of mechanical assets which include pumps, motors, HVAC, grinders, etc.:

Table 2-2. Mechanical Visual Condition Assessment							
Criteria	**Evaluation**	**1**	**2**	**3**	**4**	**5**	**Weight**
Corrosion	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%	10
	Structural (loss of metal)	None or minor surface only	Multiple minor Surface	Significant corrosion affecting structure	Multiple Significant corrosion affecting structure	Major Corrosion compromising structure	
Leakage	Gaskets / Connections	None or historic	_	Significant leakage but equipment still operating	-	Leakage level will impact equipment operation imminently	25
	Holes / Failures	-	-	1 location	>1 location	>3 locations	
	Packing Gland/mechanical seal	Normal leakage	-	Excessive leakage with adjustment available	-	Excessive leakage with no adjustment available	
Vibration/ Noise	Noise	Within what is considered normal	-	Higher than what is expected during normal operations	-	Abnormal noise not associated with normal operation	25

Table 2-2. Mechanical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Vibration (measured using installed sensors)	Within Normal Operating Range	-		-	Above normal operating range	
	Vibration Apparent with Noise	None or normal vibration	-	Moderate (vibration level sensed but within operating standards)	-	Severe vibration (level measured beyond acceptable limits)	
	Non-Structural Damage	-	-	Yes	-	-	
	Structural Damage	-	-	-	-	Yes	
Heat	Measured using installed temperature gauges or heat gun (if available) with equipment operating at least 1 hour	Within Normal Operating Range (Typical 140-180)	-	10-20 degrees above normal operating range	-	>20 degrees above normal	15
Concrete Support	Surface Cracking / Loose Grout	Presence of surface cracks or loose grout	Multiple surface cracks	Potential loss of asset anchor point	Asset stability compromised due to surface cracks	Asset stability failed due to surface cracks	10
	Spalling	<10%	10%-50%	>50% - 75%	>75%; stability compromised	>95%; Asset stability failed	
	Through Cracks	Presence of through cracks	Multiple through cracks	Foundation settling	Equipment stability compromised	Equipment stability failed	
	Missing Pieces (within 6 inches of equipment mounts)	-	-	-	1 or more	3 or more	
Metal Supports	Surface Corrosion	<10%	10%-50%	50%-75%	>75%	>95%	10
	Structural Corrosion	-	-	<25%	>=25%	>=50%	
	Missing/Broken Anchors	-	-	<25%	>=25%	>=50%	
Painting/coating	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%	5
Corrosion	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%	10
	Structural (loss of metal)	None or minor surface only	Multiple minor Surface	Significant corrosion affecting structure	Multiple Significant corrosion affecting structure	Major Corrosion compromising structure	

Table 2-2. Mechanical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
Leakage	Gaskets / Connections	None or historic	_	Significant leakage but equipment still operating	-	Leakage level will impact equipment operation imminently	25
	Holes / Failures	-	-	1 location	>1 location	>3 locations	
	Packing Gland/mechanical seal	Normal leakage	-	Excessive leakage with adjustment available	-	Excessive leakage with no adjustment available	
Vibration/Noise	Noise	Within what is considered normal	-	Higher than what is expected during normal operations	-	Abnormal noise not associated with normal operation	25
	Vibration (measured using installed sensors)	Within Normal Operating Range	-		-	Above normal operating range	
	Vibration Apparent with Noise	None or normal vibration	-	Moderate (vibration level sensed but within operating standards)	-	Severe vibration (level measured beyond acceptable limits)	
	Non-Structural Damage	-	-	Yes	-	-	
	Structural Damage	-	-	-	-	Yes	
Heat	Measured using installed temperature gauges or heat gun (if available) with equipment operating at least 1 hour	Within Normal Operating Range (Typical 140-180)	-	10-20 degrees above normal operating range	-	>20 degrees above normal	15
Concrete Support	Surface Cracking / Loose Grout	Presence of surface cracks or loose grout	Multiple surface cracks	Potential loss of asset anchor point	Asset stability compromised due to surface cracks	Asset stability failed due to surface cracks	10
	Spalling	<10%	10%-50%	>50% - 75%	>75%; stability compromised	>95%; Asset stability failed	
	Through Cracks	Presence of through cracks	Multiple through cracks	Foundation settling	Equipment stability compromised	Equipment stability failed	

Table 2-2. Mechanical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Missing Pieces (within 6 inches of equipment mounts)	-	-	-	1 or more	3 or more	
Metal Supports	Surface Corrosion	<10%	10%-50%	50%-75%	>75%	>95%	10
	Structural Corrosion	-	-	<25%	>=25%	>=50%	
	Missing/Broken Anchors	-	-	<25%	>=25%	>=50%	
Painting/coating	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%	5

Photographs depicting mechanical assets with scores corresponding to 1 (good) to 5 (very poor) are included in Appendix A.

2.3 Electrical Assets

The following table summarizes the criteria and scoring approach for a Visual Inspection for an electrical asset:

Table 2-3. Electrical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
Corrosion	Surface only (enclosure)	<10%	10%-50%	>50% - 75%	>75%	>95%	10
	Structural	None or minor surface only	Multiple minor Surface	Significant corrosion affecting structure	Multiple Significant corrosion affecting structure	Major Corrosion	
	Connections	<10%	10%-50%	>50% - 75%	>75%	>95%	
Leakage	Transformer/Connection Leaks	None or historic	_	Significant leakage but equipment still operating	-	Leakage level will impact equipment operation imminently	15
Vibration/Noise	Vibration (use handheld monitor)	None or normal vibration	-	Moderate (vibration level sensed but within operating standards	-	Severe vibration level measured beyond acceptable limits	5

Table 2-3. Electrical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Motors noise level while operating	Normal	-	Moderate (Indicating eqmt condition issue	-	Severe noise level (indicating imminent issue)	
Electrical Damage	Evidence of Overheating	Within spec limits	-	Abnormal heat, but asset is still operating and possible cause for concern	-	Exceeding spec limits	25
	Evidence of Arcing	None	-	Evidence of arcing, but asset is still operating and possible cause for concern	-	Evidence of arcing, asset inoperable	
	Grounding Missing/Damaged	Minor ground connection damage, No loss of gnd connection	-	Corrosion evident, but grounding can be cleaned	-	Total loss of eqmt grounding	
	Cooling System	Ambient temperature is appropriate for asset operations	-	Operating temperature is above normal for asset operations	-	Ambient temperature significantly above asset operating condition and/or loss of cooling system	
	Connections Loose/Broken	Cover off or missing	-	Connection loose or exposed or not properly dressed	-	Connections broken	
Concrete Supports	Surface Cracking / Loose Grout	Presence of surface cracks or loose grout	Multiple surface cracks	Potential loss of equipment anchor point	Equipment stability compromised due to surface cracks	Equipment stability failed due to surface cracks	5
	Through Cracks	Presence of through cracks	Multiple through cracks	Foundation settling	Equipment stability compromised	Equipment stability failed	
Metal Supports	Surface Corrosion	<10%	10%-50%	>50%-75%	>75%	>95%	5

Table 2-3. Electrical Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Structural Corrosion	Presence of corrosion	>10%	<25%	>=25%	>=50%	
	Supports/Unistrut/channel	Support moving or vibrating	support anchor loose or severely corroded	Single Support not performing function	Supporting system compromised	Supporting system failed	
Housekeeping (Cleanliness)	Evidence of dust	None	-	Minimal	Minor	Severe	5
	Evidence of pests	None	Evidence of pests, but no current activity	Present- no damage to asset	Present- minor damage. Corrective action required by asset still operating	Present- significant damage and asset not operating	
	Evidence of water damage	None	-	Evidence of moisture	-	Standing water	
Smell	Chemical, burning, etc.	Normal	-	-	-	Abnormal	10
Loose/Unsupported Conduit	Conduit damaged or not properly secured	None	-	Signs of damage, but asset functional	-	Holes in conduit or broken conduit, asset not functional	5
Exposed Wiring	Signs of exposure, cut, frayed, cracked, split, uncovered, etc.	None	-	Good	-	Insulation is significantly damaged or bare wire	15

Photographs depicting electrical assets with scores corresponding to 1 (good) to 5 (very poor) are included in Appendix A.

2.4 Structural Assets

The following table summarizes the criteria and scoring approach for a Visual Inspection for structural assets:

Table 2-4. Structural Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
Paint/Coating	Missing paint or coating	<10%	10%-50%	>50% - 75%	>75%	>95%	5
Leakage	Cracks/Joints/Penetrations/Failures	None or Historic only	Damp	Drip or seep	Stream >1 loc	Stream >3 loc	15

Table 2-4. Structural Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
Concrete/Masonry Surface Damage/Joint Damage	Cracking (Width of crack)	< 1/16 inches	1/16-1/8 inches	1/8-1/4 inches	>1/4 inches	>1/2 inches	15
	Exposed Reinforcement	-	-	1 location	>1 location	>3 locations	
	Spalling, Exposed Aggregate., Pitting, Delamination, Freeze/Thaw Damage	<10%	10%-50%	>50% - 75%	>75%	>95%	
	Settling/Heaving	-	-	1 location	>1 location	>3 locations	
Metal Damage	Cracking	-	-	1 location	>1 location	>3 locations	15
	Fatigue/Connection Failure	-	-	1 location	>1 location	>3 locations	
	Seating (gate and valves)	Fully seated	minor wear	wear with minor leakage	significant leakage, but manageable	complete bypass of gate or valve	
	Deformation	<10%	10-50%	>50% - 75%	>75%	>95%	
	Corrosion/Metal Loss	<10%	10-50%	>50% - 75%	>75%	>95%	
Wood Damage	Dry Rot	-	-	1 location	>1 location	>3 locations	5
	Warping/Splitting	-	-	1 location	>1 location	>3 locations	
	Biological Growth (algae)	<10%	10-50%	>50% - 75%	>75%	>95%	
	Connection Failure (nail pops)	-	-	1 location	>1 location	>3 locations	
	Loss of Section	<10%	10-50%	>50% - 75%	>75%	>95%	
Water/Drainage	Evidence of Standing Water along Foundation, walkways, driveways (soil settling)	Inadequate grass cover	-	Swale; <1-foot wide and 1-inch deep	-	Ponded; >2-foot wide and 3-inches deep	5
Asphalt Surfaces	Sealer Missing	<10%	10-50%	>50% - 75%	>75%	>95%	5
	Roadbed Failure	<10%	10-50%	>50% - 75%	>75%	>95%	
	Cracking	<10%	10-50%	>50% - 75%	>75%	>95%	

Table 2-4. Structural Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Heaving/potholes	None or <2 inches deep	-	>2 inches deep and less than 12-inch diameter	-	>6 inches deep and >12-inches in diameter	
	Aggregate Exposure	<10%	10-50%	>50% - 75%	>75%	>95%	
Roof Condition	Ponding	<10%	10-50%	>50% - 75%	>75%	>95%	10
	Shingle Grit Loss/cracking	<10%	10-50%	>50% - 75%	>75%	>95%	
	Missing Shingles	-	-	<10	>10	>20	
	Dry Rot of Rubber Membrane	-	-	1 location	>1 location	>3 locations	
	Metal roofing damage	-	-	1 location	>1 location	>3 locations	
	Torn/split Membrane	-	-	1 location	>1 location	>3 locations	
	Flashing Issues	-	-	1 location	>1 location	>3 locations	
	Attic space Issues/leaks	-	-	1 location	>1 location	>3 locations	
Windows/doors	Broken Glass	None	-	Cracked	-	Broken or Missing	10
	Caulking	None or minor issues	-	Noticeable/ loose caulking	-	>50% caulk loose or missing	
	Leakage	None	-	Moisture present between window panes	-	Leaking	
	Warpage/alignment/rot	None or minor issues	-	Issue noted, but still functional	-	Not functional	
	Hardware Issues	None or minor issues	-	Issue noted, but still functional	-	Not functional	
Security and Fencing	Fence Damage	None or minor issues	-	Issue noted, but still functional	-	Asset not functional and security risk	15

Table 2-4. Structural Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Gate	None or minor issues	-	Issue noted, but still functional	-	Asset not functional and security risk	
	Access issues (lock, actuator, scanner)	None or minor issues	Asset functional	Asset functional, but signs of wear	Significant condition issues noted, but asset functional	Missing, damaged, or cut and asset not functional	

Photographs depicting structural assets with scores corresponding to 1 (good) to 5 (very poor) are included in Appendix A.

2.5 Instrumentation and Control Assets

The following table summarizes the criteria and scoring approach for a Visual Inspection of instrument and control assets which include meters, PLCs, control centers, etc.:

Table 2-5. Instrumentation and Control Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
Corrosion	Surface only (enclosure)	<10%	10%-50%	>50% - 75%	>75%	>95%	10
	Structural	None or minor surface only	Multiple minor Surface	Significant corrosion affecting structure	Multiple Significant corrosion affecting structure	Major Corrosion	
	Connections	<10%	10%-50%	>50% - 75%	>75%	>95%	
Mounted Instruments	Damaged/non functional devices	No Damage	-	Environmental interference present (dirt, grease, etc.) and can be restored with cleaning	-	Not functioning	20
Concrete Supports	Presence of surface cracks or loose grout	Multiple surface cracks	Potential loss of equipment anchor point	Equipment stability compromised due to surface cracks	Equipment stability failed due to surface cracks	Equipment stability failed due to surface cracks	5
	Presence of through cracks	Multiple through cracks	Foundation settling	Equipment stability compromised	Equipment stability failed	Equipment stability failed	
Metal Supports	Surface Corrosion	<10%	10%-50%	>50%-75%	>75%	>95%	5

Table 2-5. Instrumentation and Control Visual Condition Assessment							
Criteria	Evaluation	1	2	3	4	5	Weight
	Structural Corrosion	Presence of corrosion	>10%	<25%	>=25%	>=50%	
	Supports/Unistrut/channel	Support moving or vibrating	support anchor loose or severely corroded	Single Support not performing function	Supporting system compromised	Supporting system failed	
Housekeeping (Cleanliness)	Evidence of dust	None	-	Minimal	Minor	Severe	5
	Evidence of pests	None	Evidence of pests, but no current activity	Present- no damage to asset	Present- minor damage. Corrective action required by asset still functional	Present- significant damage and asset not functional	
	Evidence of water damage	None	-	Evidence of moisture	-	Standing water	
Loose/Unsupported Conduit	Conduit damaged or not properly secured	None	-	Signs of damage, but asset functional	-	Holes in conduit or broken conduit, asset not functional	5
Human Machine Interface (HMI)	Display	No Damage	Dirt/sludge on display screen or touchpad	Pixilation or touch screen/keypad not operating as designed, but unit has limited functionality	Sun fade or scratches/cracks on the screen	Not functioning	25
Battery Life	Status	Charged		Low Battery Alarm		Drained	5
Communications (modem, ethernet, etc.)	Signal	No damage, operational	-	Damaged equipment/loose connections	-	Not functioning	20

Photographs depicting instrumentation and control assets with scores corresponding to 1 (good) to 5 (very poor) are included in Appendix A.

2.6 Earthen Feature Assets

Earthen feature assets will be included in future versions of this document.

Section 3

Visual Inspection Documentation

3.1 Visual Inspection Form

The following form was developed for the visual inspection of the critical assets at each plant and the pump stations. A consolidated assessment form was created to capture process mechanical, structural, and electrical condition of an asset, as applicable. Inspection efforts will utilize a mobile inspection form with the same criteria and entry fields. An example Visual Inspection Form is shown below:

MECHANICAL - VISUAL INSPECTION ASSESSMENT FORM

Asset ID		Asset Description:	
Assessor's Name:		Date of Assessment:	____/____/_____

Photos *(keep photo size low (~2 mb) - turn time/date stamp on)*

Did you take a photo? yes no (If yes, attach to work order) Extra photos for major damage (all 5's) or project specific purposes? yes no

(Circle one score in every row. If not applicable, circle the choice in column 1.)

Criteria	Evaluation	1	2	3	4	5
Corrosion	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%
	Structural (loss of metal)	None or minor surface only	Multiple minor Surface	Significant corrosion affecting structure	Multiple Significant corrosion affecting structure	Major Corrosion compromising structure
Leakage	Gaskets / Connections	None or historic	-	Significant leakage to eqmt still operating	-	Leakage level will impact equipment operation imminently
	Holes / Failures	-	-	1 location	>1 location	>3 locations
	Packing Gland/mechanical seal	Normal leakage	-	Excessive leakage with adjustment available	-	Excessive leakage with no adjustment available
Vibration/Noise	Noise	Within what is considered normal	-	Higher than what is expected during normal operations	-	Abnormal noise not associated with normal operation
	Vibration (measured using installed sensors)	Within Normal Operating Range	-		-	Above normal operating range
	Vibration Apparent with Noise	None or normal vibration	-	Moderate (vibration level sensed but within operating standards)	-	Severe vibration (level measured beyond acceptable limits)
	Non-Structural Damage	-	-	Yes	-	-
	Structural Damage	-	-	-	-	Yes
Heat	Measured using installed temperature gauges or heat gun (if available) with equipment operating at least 1 hour	Within Normal Operating Range (Typical 140-180)	-	10-20 degrees above normal operating range	-	>20 degrees above normal
Concrete Support	Surface Cracking / Loose Grout	Presence of surface cracks or loose grout	Multiple surface cracks	Potential loss of asset anchor point	Asset stability compromised due to surface cracks	Asset stability failed due to surface cracks
	Spalling	<10%	10%-50%	>50% - 75%	>75%; stability compromised	>95%; Asset stability failed
	Through Cracks	Presence of through cracks	Multiple through cracks	Foundation settling	Equipment stability compromised	Equipment stability failed
	Missing Pieces (within 6 inches of equipment mounts)	-	-	-	1 or more	3 or more
Metal Supports	Surface Corrosion	<10%	10%-50%	50%-75%	>75%	>95%
	Structural Corrosion	-	-	<25%	>=25%	>=50%
	Missing/Broken Anchors	-	-	<25%	>=25%	>=50%
Painting/coating	Surface only	<10%	10%-50%	>50% - 75%	>75%	>95%

ADDITIONAL COMMENTS:

3.2 Visual Inspection Equipment

Following completion of the Visual Inspection activities, data and photos should be available for review in the CMMS. Note- assets that are rated a '5' for one or more criteria will require a work order for additional evaluation. Although Visual Inspection is a sensory level assessment, some equipment may be useful to document the asset condition. At a minimum, the assessor should have the following equipment available for use during a Visual Inspection:

- Digital Camera to photo document observed asset condition
- Tape Measure to evaluate structural cracking.
- Flashlight to provide additional lighting as necessary
- Temperature gun to assess temperature of equipment
- Rag or cloth to wipe away debris or material from an asset tag
- Small Wire Brush to assess presence of historic leakage

3.3 Photo Documentation

It is important to document the asset condition during a Visual Inspection and digital cameras will be provided to document observed conditions for possible review during follow-up. Photos will also be loaded into the CMMS on the work order to document asset condition over time. The following guidelines should be followed regarding photo documentation:

- Set camera at lowest megapixel setting (1-2 MB).
- Set-up date stamping
- Record photo number on assessment sheet
- Rename photo to Asset ID after downloading
- Take photos sparingly:
    - One photo minimum per group and one per structure.

Additional photo of individual assets in very poor condition- all assets scoring a 5 require additional photos for engineering referral.

3.4 Program Execution

Condition assessment approaches and intervals will be established based on the Condition Assessment Methods in Appendix B. Assets will be scheduled in the CMMS as a recurring work order for planning and tracking.

Asset CoF and LoF will be re-evaluated on an annual basis to group assets accordingly on the matrix. Visual Inspections will be performed on critical – high risk and high likelihood of failure asset categories.

Section 4

Post-Visual Inspection Analysis

The purpose of this section is to summarize the guidelines for conducting analysis and follow-up after the Visual Inspections have been completed and the results have been compiled.

4.1 Condition Assessment Evaluation Process

An overview of the condition assessment evaluation process is provided in Figure 4-1. A detailed description of the key steps in the process is provided in the sections that follow.

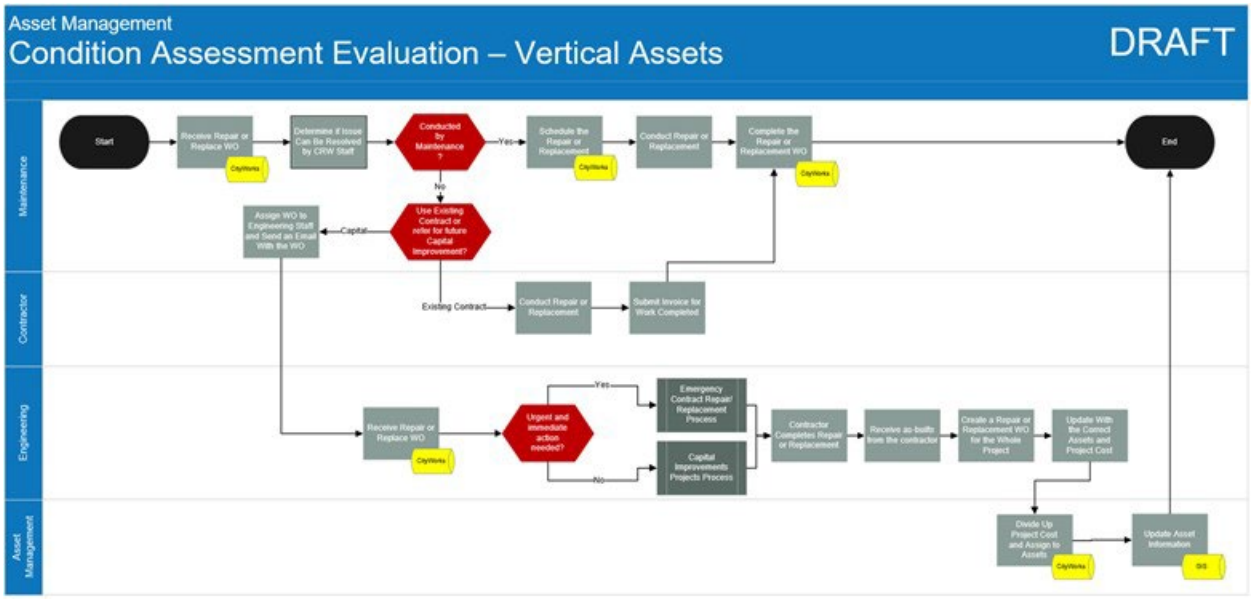


Figure 4-1. Condition Assessment Evaluation Process

4.2 Overall Condition Score

An overall condition score will be calculated in the CMMS for each asset that was inspected as follows:

- The highest score for each criterion is the score for that criteria.
- The criteria score is multiplied by the weight of that criteria.
- The weighted criteria score is totaled for the asset and is used as the overall condition score.
- If multiple asset inspection types apply to the asset being assessed, then both are performed, and the higher score is used for the asset.

4.3 Scoring Analysis

Analysis of the scores will include not only high scores (i.e., '5's) but also looking at score trends over time. Once the overall condition score has been calculated, it can be compared to the historical scores to identify changes in condition over time to predict asset failure before it happens and to

determine the best timing for mitigation activities such as repair, rehabilitation, replacement, and modification of the maintenance strategy for that asset.

4.4 Physical Condition Scores

As the physical condition scores of critical high-risk and high likelihood of failure assets are monitored and trended over time, the following recommended actions may be taken for the given scoring ranges:

- 1: Monitor asset condition and no further action required at present.
- 2: Monitor and trend asset condition for possible additional actions. Consider if asset is a good candidate for condition monitoring*, set the visual inspection frequency to 2 years.
- 3: Continue to monitor asset condition and evaluate for rehabilitation. Consider if asset is a good candidate for condition monitoring*, continue with 1-year visual inspection frequency
- 4: Continue to monitor asset condition, repair as needed and expediate plan for rehabilitation or replacement. Develop estimate of remaining useful life, develop scope/plan for rehabilitation and replacement, develop costs to plan timing for budget/funding needs, continue 1-year visual inspection frequency until repairs can be made
- 5: Immediate corrective action required. Asset should be replaced as soon as possible.

*Note: Condition monitoring readings of concern should trigger a work order for conducting a visual inspection as part of troubleshooting the issue.

4.5 Engineering Follow-up and Troubleshooting

As shown in the Visual Inspection process (Section 2.1), the Engineering Division will receive an Engineering Referral Work Order in instances where the asset receives an individual observation score of five (5) for any criteria category. The Post-Visual Inspection Analysis and Follow-up process shown in Figure 4-1 includes the steps to be taken by engineering. The outcome of the follow-up activities conducted by engineering may include:

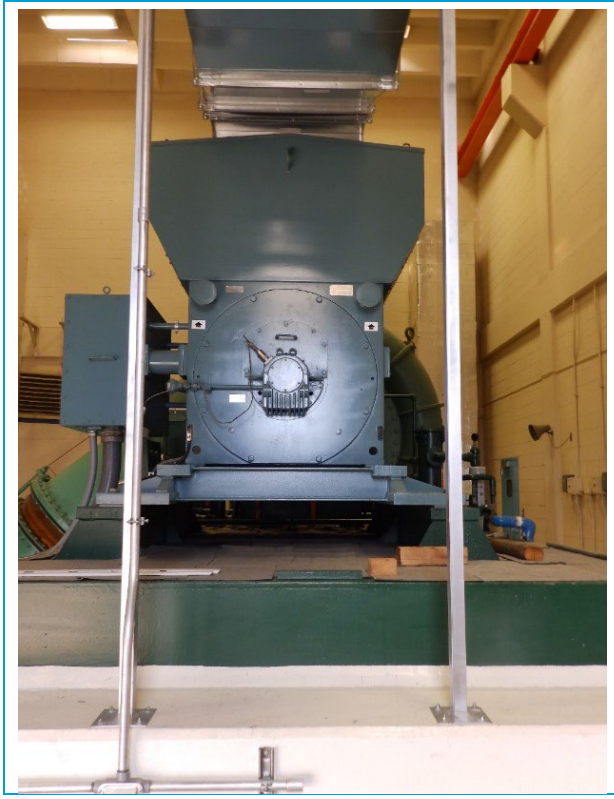
- Verification of score
- Referral for repair by CRW maintenance staff
- Scoping and planning for rehabilitation and replacement by CRW staff or outside contractor within the plant budget
- Scoping and planning for rehabilitation and replacement for referral to CIP
- Referral for adjustment of maintenance strategy
- Rescoring of asset upon maintenance, rehabilitation, or replacement

Appendix A: Condition Reference Photographs

Mechanical Assets in Very Good Condition

Table A.1 Mechanical Asset in Very Good Condition: Score = 1	
	<10% Surface corrosion and historic leakage only noted.
	No corrosion or leakage noted.

Table A.1 Mechanical Asset in Very Good Condition: Score = 1	
	No corrosion; new asset.
	<10% corrosion and evidence of historic leakage.

Table A.1 Mechanical Asset in Very Good Condition: Score = 1	
	No signs for vibration. Corrosion <10% and historic only leakage noted.

Mechanical Equipment in Good Condition

Table A.2: Mechanical Equipment in Good Condition: Score = 2	
	Surface corrosion 10-50%, evaluate for recoating.

Mechanical Equipment in Fair Condition

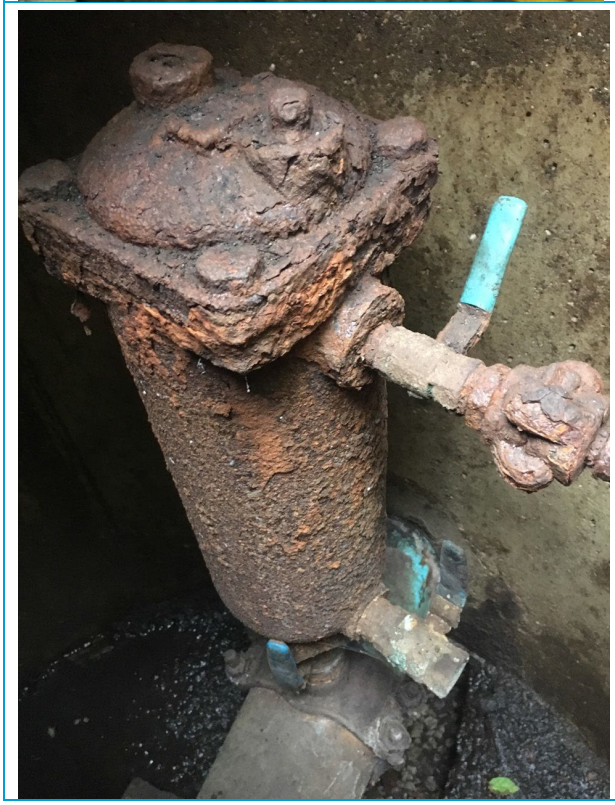
Table A.3: Mechanical Equipment in Fair Condition: Score = 3	
	Leakage noted (drip only).

Mechanical Equipment in Poor Condition

Table A.4: Mechanical Equipment in Poor Condition: Score = 4	
	Leakage and metal support structural corrosion >=25% noted.
	Surface corrosion noted, but not compromising the asset. Evaluate for recoating.

Mechanical Equipment in Very Poor Condition

Table A.5: Mechanical Equipment in Very Poor Condition: Score = 5	
	Major corrosion compromising structure, structural corrosion >50%
	Stream leakage noted.
	Major corrosion compromising structure, structural corrosion >50%

Table A.5: Mechanical Equipment in Very Poor Condition: Score = 5	
	Major structural corrosion compromising structure, Coating missing >95%
	Major structural corrosion compromising structure, Coating missing >95%

Electrical Equipment in Very Good Condition

Table A.6: Electrical Equipment in Very Good Condition: Score = 1	
	Local control panel with no corrosion. Like new condition.
	No evidence of corrosion; covers and panels in good condition. No evidence of leakage or visible damage.

Table A.6: Electrical Equipment in Very Good Condition: Score = 1

Minor surface only corrosion and panels in good condition. No visible damage or loose conduit.

Electrical Equipment in Good Condition

Table A.7: Electrical Equipment in Good Condition: Score = 2	
	Surface corrosion (<50%), no leakage or visible damage noted.

Electrical Equipment in Fair Condition

Table A.8: Electrical Equipment in Fair Condition: Score = 3	
	Evident signs of corrosion.

Electrical Equipment in Poor Condition

Table A.9: Electrical Equipment in Poor Condition: Score = 4	
	Multiple significant structural corrosion affecting structure. Metal supports structural corrosion >25%

Electrical Equipment in Very Poor Condition

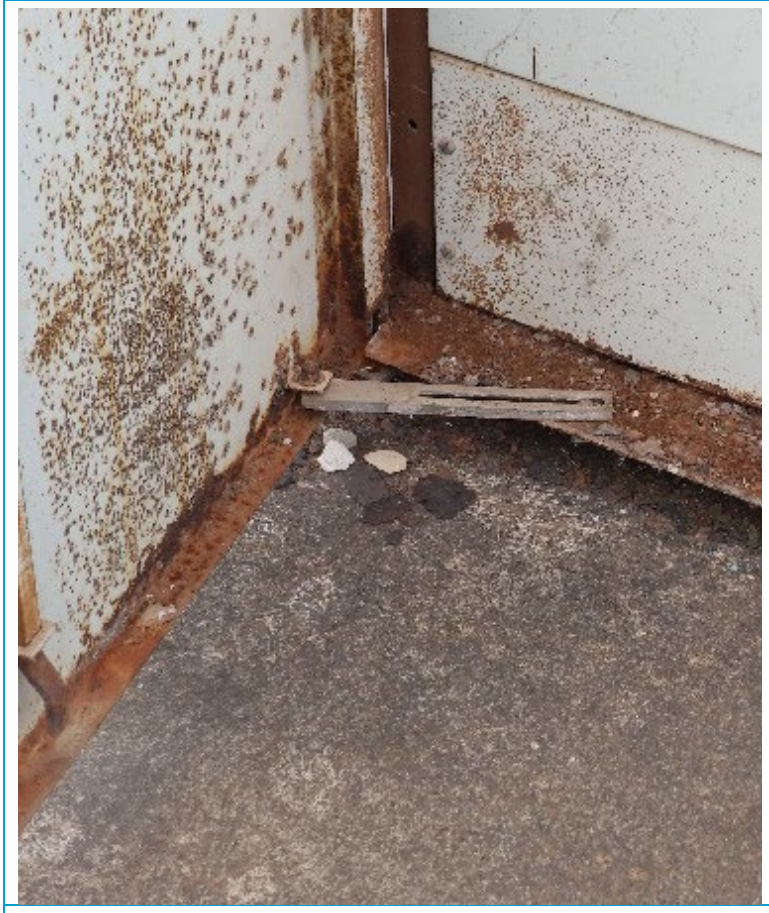
Table A.10: Electrical Equipment in Very Poor Condition: Score = 5	
	Corrosion on inside of panel that compromises asset. Corrosion has completed eroded metal.
	Evidence of pests that compromise asset performance

Table A.10: Electrical Equipment in Very Poor Condition: Score = 5	
	Visible Damage on exterior of panel, Evidence of overheating/arcing exceeding spec limits.

Structural Assets in Very Good Condition

Table A.11: Structural Asset in Very Good Condition: Score = 1	
	Concrete shows no signs of spalling, cracking, leakage, or exposed rebar.
	Concrete pedestal showing no signs of cracking, leakage, or spalling.

Table A.11: Structural Asset in Very Good Condition: Score = 1	
	<10% spalling of concrete, no cracks observed, no exposed rebar. No structural corrosion observed.
	Concrete cracking <1/16 inches, spalling <10%, metal loss <10%

Structural Assets in Good Condition

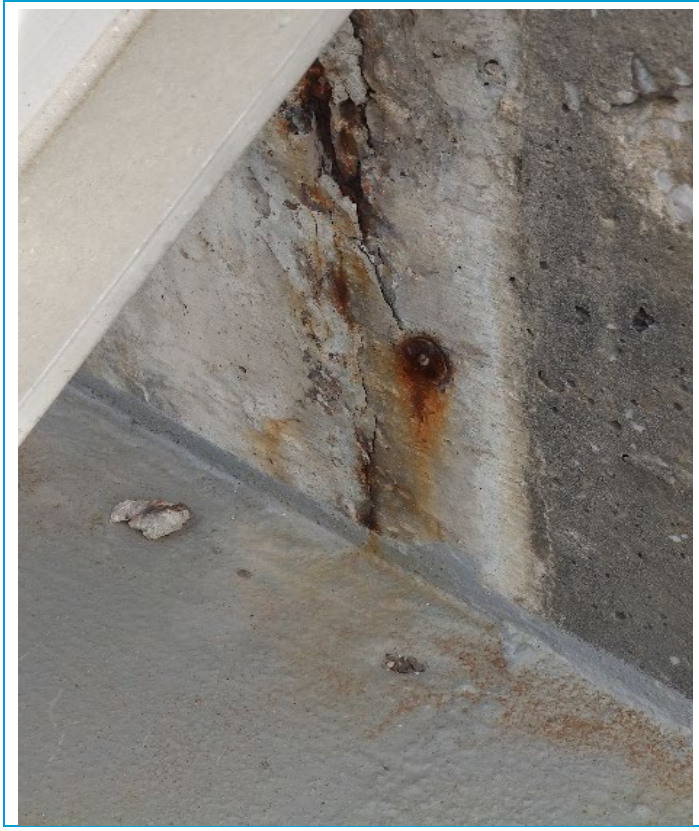
Table A.12: Structural Assets in Good Condition: Score = 2	
	Security access issues, asset functional
	Cracks >1/16-inch and >10% spalling.

(Metal Housing)
Metal corrosion 10-50%

Structural Assets in Fair Condition

Table A.13: Structural Assets in Fair Condition: Score = 3	
	Concrete showing some (<25%) spalling and evidence of cracking.
	Moderate surface corrosion 10-50%, Missing paint >50%-75%

Table A.13: Structural Assets in Fair Condition: Score = 3



Exposed rebar at one location with >50-75% concrete spalling.

Structural Assets in Poor Condition

Table A.14: Structural Assets in Poor Condition: Score = 4	
	Cracking > ¼ inch
	(concrete basin) Concrete cracking >1/4-inch, spalling >75%

Table A.14: Structural Assets in Poor Condition: Score = 4

Structural Asset in Very Poor Condition

Table A.15: Structural Asset in Very Poor Condition: Score = 5	
	Exposed reinforcement >3 locations, cracking > ½ inch
	(metal platform) Metal corrosion >95%, missing coating >95%, metal fatigue >3 locations

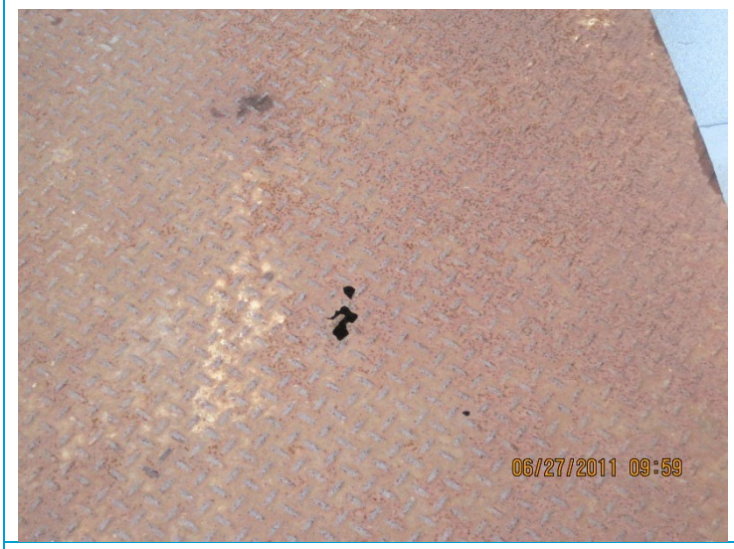
Table A.15: Structural Asset in Very Poor Condition: Score = 5	
	
	Connection failure >3 locations, corrosion/metal lost >95%
	Concrete cracking > ½ inch, freeze/thaw damage >95%, metal loss >95%, water damage >2-foot wide and 3-inches deep

Table A.15: Structural Asset in Very Poor Condition: Score = 5	
	Connection failure >3 locations,
	Concrete cracking >1/2inch, damage >95%
	Concrete crack >1/2 inch

Instrument and Control Assets in Very Good Condition

Table A.16: Instrumentation and Control Assets in Very Good Condition: Score = 1	
	Corrosion none or minor surface only, no damage,
	Corrosion none or minor surface only, no damage,

Instrumentation and Controls Assets in Good Condition

Table A.17: Instrumentation and Control Assets in Good Condition: Score = 2

Good housekeeping, no evident damage. PLC cabinet has minor external corrosion.

Instrumentation and Controls Assets in Fair Condition

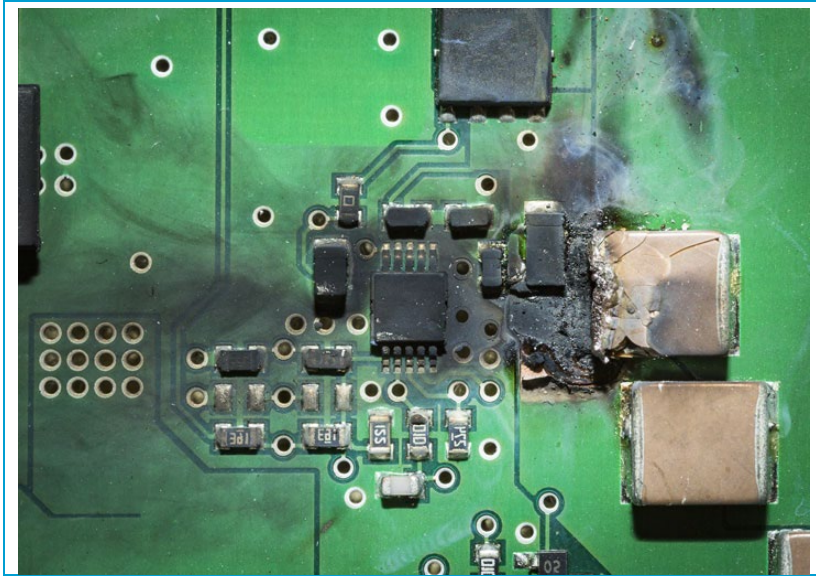
Table A.18: Instrumentation and Control Assets in Fair Condition: Score = 3

Slow response and outdated screen, but unit functional

Instrumentation and Controls Assets in Poor Condition

Table A.19: Instrumentation and Control Assets in Poor Condition: Score = 4	
	Damaged HMI screen with scratches evident.

Instrumentation and Controls Assets in Very Poor Condition

Table A.20: Instrumentation and Control Assets in Very Poor Condition: Score = 5	
	Surge damaged PLC board.

Appendix B: Condition Assessment Methods

Table B-1. Condition Assessment Techniques (Vertical Assets)				
Analysis	Asset Type	Data Source	CRW or Contractor?	Typical Data Collection Frequency*
Visual Inspection	All Equipment	Visual condition	CRW	As determined in TAMPs
Performance Testing	Pumps	Performance data	Contractor	6-month or annual
Battery Check	UPS	Instrument measured	CRW	Quarterly
Boiler Water/Cooling Water Loops	Boilers	Analytical results	Contractor	Monthly or Quarterly
Laser Alignment Check	Pumps/motors	Instrument measured	Contractor	Annual
Load Testing	Generators	Instrument measured	Contractor	Weekly or monthly
Insulation (Meg) and Current Testing	Motors	Instrument measured	CRW	Annual
Oil Analysis	Engine/ generators	Analytical results	Contractor	Annual
Physical Dimension Measurement	Pump wear rings	Direct measure	Contractor	Annual
Relay Tests	Switchgear	Instrument measured	CRW	Annual
Thermography/Infrared	Substations, MCCs, switchgear	Instrument measured	CRW	Annual
Vibration (external and on-line)	Rotating equipment	Instrument measured	CRW	Annual (if not built-in)

*Note: Inspection frequency will vary based on the asset type and the risk rating (consequence and likelihood of failure).

Appendix E: Problem, Cause, Resolution Codes

Appendix E- Sewer Collection & Water Distribution Problem, Cause, Resolution Lists

Fill in only when there is a problem - done by the person creating the work order	Fill in when the problem is diagnosed - done by person receiving the work order	Required on all - fill in the result of work performed on all work orders PM or CM
Problem	**Cause**	**Resolution**
Adjustment Needed	Abnormal Conditions	Abandon
Broken / Damaged	Animals	Adjust
Dirty/Debris/Overgrowth	Contractor/Third Party	CCTV
Flood	Debris/Obstructions	Clean
Hard to Operate	Design Flaw	Close
Inaccurate Reading	Improper Installation/Construction	Disinfect/Dose
Joint Failure	Improper PM Cycle	Exercise
Leaking / Seepage	Inflow/Infiltration	Flow/Flush
Mechanical Failure	Lubrication (Excessive/Lack of)	Locate/Stake
No Service / Not Working	Operator Error	Lubricate
Odor	Packing	No Action
Overflowing / Surcharge	Poor Soils	Open
Pressure (High, Low, None)	Procedures Incorrect	Operate
Pressure (Low, None)	Roots	Paint
Settlement/Erosion	Transient Pressure	Pull Meter
Stoppage	Age/Wear/Use	Relocate
Unable to Locate / Missing	Capacity	Remove Debris/ Obstruction
Vandalism/Theft	Condition	Remove/Decommission
Water Quality	Corrosion	Repair
	Cross Contamination	Replace
	Defective Material	Restore Surface
	FOG	Seal/Grout
	Hardware (Stem/Rounded Nut)	Turn On/Off
	Incorrect Records	
	Joint Failure	
	Mud/Silt/Sludge	
	Other Structural Failure	
	Poor Housekeeping	
	Power Failure	
	Structural Failure	
	Traffic Load	

Appendix E- Problem, Cause, Resolution Lists
Advanced Wastewater Treatment Facility

Problem: The nature of the maintenance or repair issue.	Cause: The underlying reason for a specific issue.	Resolution: The solution to the problem as reflected in work task detail and overall job content of the work order.
Fill in only when there is a problem - done by the person creating the work order	Fill in when the problem is diagnosed - done by person receiving the work order	Required on all - fill in the result of work performed on all work orders PM or CM

AWTF Problem
Air Leak
Alarm or Problem Indicator
Broken/Damaged
Communication Failure
Dirt or Foreign Matter Problem
Equipment Adjustment Required
Equipment Cutting Out
Equipment Jammed
Equipment PC or Microprocessor Hung Up
Excessive Lubrication
Excessive Noise
Excessive Vibration
Function (Lack of/None)
Hard to Operate
Heat
Lack of Lubrication
Leak/Seepage (Air, Oil, Water)
Loose
Loose or Broken Connection or Wire
Misalignment
No Air
No Power
Odor

AWTF Cause
Abnormal Conditions
Age/Wear/Use
Capacity
Contractor/Third Party Damage
Corrosion
Dead Battery
Debris/Obstructions (Animals/Trash/Sticks)
Defective Material
Design Flaw
Electrical Issue / Failure
Hardware (Stem/Rounded Nut)
Improper Installation/Construction
Improper PM Cycle
Mechanical Issues / Failure
Operator Error
Poor Housekeeping
Power Outage
Procedures Incorrect
Structural Issues / Failure
Vandalism

AWTF *REQUIRED FIELD* Resolution
Adjust
Adjust Operational Settings
Clean
Lubricate
No Action
Operate
Refer to Contractor
Rehab /Fabricate
Relocate
Remove Obstruction
Repair
Replace

Appendix E- Problem, Casue, Resolution Lists
Water Services Center

Problem: The nature of the maintenance or repair issue.	Cause: The underlying reason for a specific issue.	Resolution: The solution to the problem as reflected in work task detail and overall job content of the work order.
Fill in only when there is a problem - done by the person creating the work order	Fill in when the problem is diagnosed - done by person receiving the work order	Required on all - fill in the result of work performed on all work orders PM or CM

WSC Problem
Air Leak
Alarm or Problem Indicator
Broken/Damaged
Communication Failure
Dirt or Foreign Matter Problem
Equipment Adjustment Required
Equipment Cutting Out
Equipment Jammed
Equipment PC or Microprocessor Hung Up
Excessive Lubrication
Excessive Noise
Excessive Vibration
Fluid Level
Function (Lack of/None)
Hard to Operate
Lack of Lubrication
Leak/Seepage (Air, Oil, Water)
Loose
Loose or Broken Connection or Wire
Misalignment
No Air
No Power
Water Quality
Oil Leak
Overheating or Smoking

WSC Cause
Abnormal Conditions
Age/Wear/Use
Capacity
Contractor/Third Party Damage
Corrosion
Debris/Obstructions (Animals/Trash/Sticks)
Defective Material
Design Flaw
Electrical Issue / Failure
Hardware (Stem/Rounded Nut)
Improper Installation/Construction
Improper PM Cycle
Joint Failure
Mechanical Issues / Failure
Operator Error
Poor Housekeeping
Power Outage
Procedures Incorrect
Structural Issues / Failure
Vandalism
Weather

WSC *REQUIRED FIELD* Resolution
Adjust
Adjust Operational Settings
Clean
Lubricate
No Action
Operate
Refer to Contractor
Rehab /Fabricate
Relocate
Remove Obstruction
Repair
Replace

Appendix F: Rehabilitation and Renewal Schedule- Template Placeholder

Appendix F

Asset Classes Rehabilitation and Renewal Schedule

Appendix F: Asset Classes with R/R Schema							
Asset Type		Useful Life (Years)	Replacement Cost	Replacement Cost Unit	Rehabilitation Interval (Years)	Rehab Cost (Or Percent of Replacement Cost)	Notes
Vertical							
Horizontal-Water							
Horizontal-Sewer							

Appendix G: Capital Budget Request Form

CAPITAL REGION WATER

CAPITAL PROJECT REQUEST/CHANGE FORM for FISCAL YEAR 2022

Directors/Managers must complete one form for every project. To be considered as a Capital Project, the following should apply: 1) Cost exceeds $5,000
2) Estimated useful life over three years

% of Total (Typically 100%)		Type of Project (Check One):		Project is:	
Water		System Expansion		New Request	
Wastewater		Process Improvement		Change in Priority	
Stormwater		Regulatory Requirement		Change in Cost	
Administrative		Replacement		Change in Timing	
		Other - Identify			

Project Name: _____

Project Location: _____

Requested By: _____ **Date of Request:** _____

Project Description/Justification/Benefits/Alternatives:

Anticipated Project Milestones:

Projected Start Date : _____
50% Completion Date: _____
Project Completion Date: _____

Priority:

High _____
Medium _____
Low _____

Anticipated Costs:	L-T-D (thru FY'21)	FY'22	FY'23	FY'24	FY'25	FY'26
Engineering-Design						
Construction Mgmt						
Material						
Contract Labor						
Internal Labor						
Sub-Total	$ -	$ -	$ -	$ -	$ -	$ -
Less: Contributions						
Less: Grants						
Less: Asset Trade-in						
Sub-Total	$ -	$ -	$ -	$ -	$ -	$ -
Net Cash Outlay	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

Anticipated Costs:	FY'27	FY'28	FY'29	FY'30	FY'31	Project Total
Engineering-Design						$ -
Construction Mgmt						$ -
Material						$ -
Contract Labor						$ -
Internal Labor						$ -
Sub-Total	$ -	$ -	$ -	$ -	$ -	$ -
Less: Contributions						$ -
Less: Grants						$ -
Less: Asset Disposal						$ -
Sub-Total	$ -	$ -	$ -	$ -	$ -	$ -
Net Cash Outlay	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

Anticipated changes in operational costs resulting from asset - personnel needs, inc/dec in maintenance costs, chemicals, etc:

Approvals: **Date:**

Director _____ _____
CFO _____ _____
CEO _____ _____

Accounting GL Project Code: _____

Prepared by:

Brown AND Caldwell

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