APPENDIX B.4D: Tailings Management Operation, Maintenance and Surveillance Manual

CASINO PROJECT

TAILINGS MANAGEMENT FACILITY

OPERATION, MAINTENANCE AND SURVEILLANCE MANUAL

PRELIMINARY DRAFT

Prepared by:

Casino Mining Corporation

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Foreword

The Casino Project, Tailings Management Facility Operation, Maintenance and Surveillance Manual for Tailings (OM&S Manual) will be developed as a companion guide to the Guide to the Management of the Casino Tailings Facility (TMF Guide). Both guides are based upon the Mining Association of Canada's (MAC) guidelines for the design & management of tailings facilities. CMC wishes to acknowledge and thank the MAC for use of their guides and their support in our development of project specific guides, consistent with the MAC guidelines.

This document is intended to provide guidance to those responsible for the management and operation of the Casino tailings management facility (TMF) to enable them to meet the objectives and commitments articulated in the Guide to the Management of the Casino Tailings Facility.

The guide focus is a site-specific operation, maintenance and surveillance (OM&S) manual and an integral component of an overall tailings management system. The document is designed to assist operations to comply with government regulation and corporate policy, demonstrate voluntary self-regulation and due diligence, practise continual improvement, and protect employees, the environment and the public.

Casino Mining Corporation

Preface

The OM&S Manual is being developed to provide a comprehensive and detailed guidance for the management, operation, and documentation of the Casino TMF from the initial construction, through on-going construction during operations, and ultimately the close-out of the facility. The OM&S Manual is intended to assist the management and operators in the understanding of the design intent, safety and environmental requirements, and regulatory obligations and commitments. Guidance is also provided on how to document operations and construction activities in detail to demonstrate full compliance with the design requirements and operating license conditions.

The OM&S Manual, together with the TMF Guide details how inevitable changes to the design or operating procedures are to be addressed to ensure the design integrity is maintained. The OM&S Manual is a revision controlled document. Any and all changes must be approved by the individual responsible for revision control and distribution of this document. The OM&S Manual, as presented here, represents a preliminary draft intended to illustrate the scope and content of the fully developed document. Further development of this document will take place during the detailed engineering phase of the Casino Project when the necessary design documents and other material necessary for the development of the manual becomes available.

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1 - INTRODUCTION

Tailings and water management facilities are integral components of mine and mill operations. They must be managed for the long term to ensure that safe and environmentally responsible stewardship is achieved. Toward this end, in 1998, The Mining Association of Canada (MAC) published *A Guide to the Management of Tailings Facilities* (MAC, 2011a), which recommended the implementation of a tailings management framework (Figure 1-1) to integrate environmental and safety considerations into each stage of the life cycle of a tailings facility, from initial site selection and design, through construction and operation, to eventual decommissioning and closure. Actions should be planned within the context of policies and commitments, implemented in accordance with plans, checked and corrected, and subjected to management review.

The document, *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (MAC, 2011b) has been compiled to provide additional guidance for preparing manuals that outline procedures for the safe operation, maintenance and surveillance (OM&S) of tailings and water management facilities.

The OM&S Manual will provide the planning context for its application through the facility's life cycle (Figure 1-2). It will be in place upon commissioning, and maintained thereafter until closure, providing a clear, documented framework for actions. It will also provide a sound basis for measuring performance and demonstrating due diligence.

The level of detail of an OM&S Manual will reflect site requirements. It will be kept current and revised periodically with a view to continual improvement. Need for revision may be triggered, for example, by changes in dam classification, operational performance, personnel or organizational structure, regulatory or social considerations, or following changes in life cycle and/or design philosophy.

Figure 1-1 Elements of the Tailings Management Framework

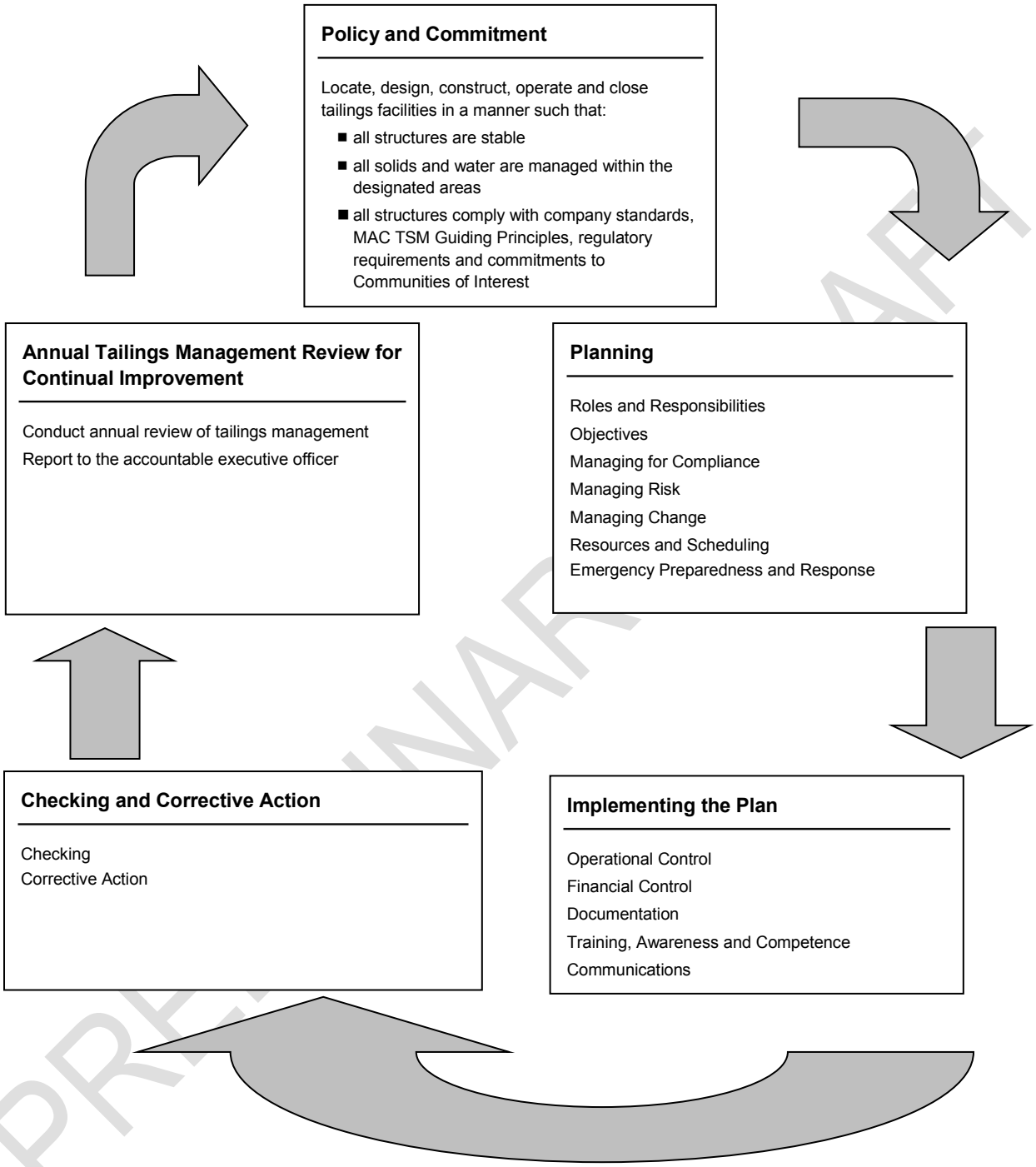
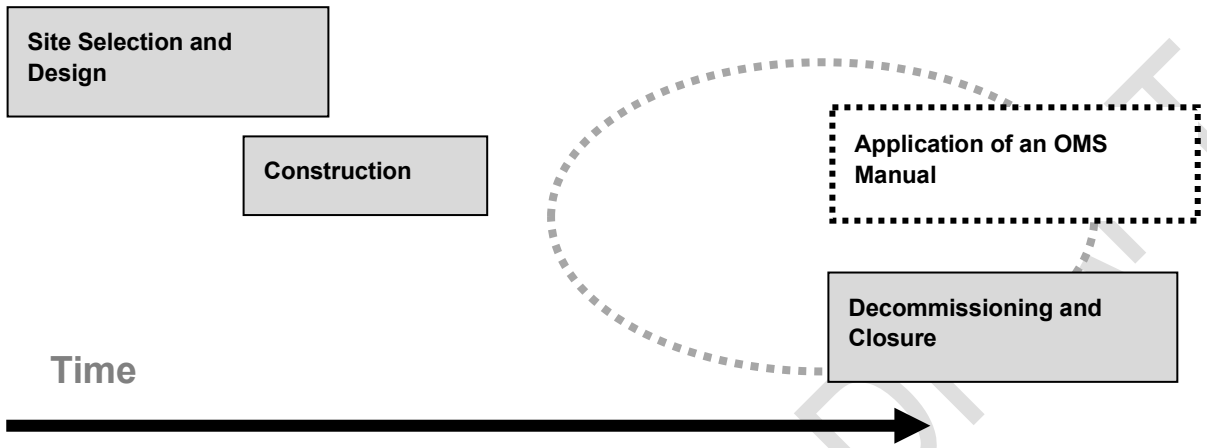


Figure 1-2 Application of an OM&S Manual through the life cycle of a tailings or water management facility



This document serves as a guide to the preparation of an OM&S Manual as a component of an overall site management framework. It recommends rationale, organization and contents for an OM&S Manual, and describes procedures that should be addressed. Tailings and water management facility owners are encouraged to use this guide to prepare their own site-specific OM&S Manual.

This guide does not replace professional expertise. Professional advice should be obtained in order to be sure that site and operational requirements are addressed and all regulatory requirements are met.

Regulatory requirements establish minimum standards for safety and environmental performance of tailings and water management facilities. The OM&S Manual will include reference to all relevant regulatory requirements and, to facilitate due diligence, delineate the performance measures that will demonstrate these requirements are being met.

The OM&S Manual will incorporate the principles outlined in *A Guide to the Management of Tailings Facilities* (MAC, 2011a), which require tailings facilities to be located, designed, constructed, operated and closed in a manner such that:

- all structures are stable;
- all solids and water are managed within the designated areas intended in the design; and
- all structures are in compliance with company standards, the MAC Environmental Policy, regulatory requirements and commitments to stakeholders.

2 - PREPARING AN OM&S MANUAL

The preparation of the OM&S Manual requires:

- setting up a team to develop the OM&S Manual;
- establishing objectives, a realistic budget and schedule to develop the manual;
- compiling information from many sources, within the company and beyond;
- establishing procedures for implementing, controlling and updating the OM&S Manual; and
- assuring that operational, engineering, corporate and regulatory issues are addressed.

These requirements are detailed further below.

2.1. OM&S MANUAL DEVELOPMENT TEAM

One individual should be assigned primary responsibility for the preparation of the OM&S Manual. This person should be actively assisted by a broader team with representation from the facility designers, site operations personnel, management and others having a direct interest in the performance and management of the facility.

2.2. OBJECTIVE OF AN OM&S MANUAL

The objective of the OM&S Manual is to define and describe:

- roles and responsibilities of personnel assigned to the facility;
- procedures and processes for managing change;
- the key components of the facility;
- procedures required to operate, monitor the performance of, and maintain a facility to ensure that it functions in accordance with its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; and
- requirements for analysis and documentation of the performance of the facility.

The OM&S Manual will present information in a clear, logical and user-friendly manner. Any supporting documentation will be clearly referenced. The reader should be able to identify easily what is required and how to access the information needed.

The OM&S Manual will enable the performance of a facility to be compared to expectations, design criteria and operating intent, particularly in the event of significant incidents.

2.3. RESOURCES AND SCHEDULING

A realistic budget and an achievable schedule should be established for preparation of the OM&S Manual, as well as for its maintenance, continual improvement, periodic review and update.

2.4. OM&S MANUAL CONTROL AND UPDATE

The OM&S Manual will be a controlled document, with specified procedures for:

- distributing and filing the manual and supporting documents;
- reviewing and updating the manual; and
- removing and archiving out-of-date materials.

OM&S procedures and requirements should be reviewed and the manual updated regularly, consistent with continual improvement, and particularly after significant incidents.

Annual tailings and water management system reviews should include evaluation of the OM&S Manual.

3 - ROLES AND RESPONSIBILITIES

3.1. ORGANIZATION, STRUCTURE, INDIVIDUAL RESPONSIBILITIES

This section of the OM&S Manual will describe the site management structure. Individuals having responsibilities for operation, maintenance, surveillance or emergency preparedness and response of the facility will be identified. All individuals (including external advisors and service providers) will be listed by name, position within the organization, roles, responsibilities and contact information.

Organization charts showing reporting links within the organization and communication links to external organizations will be provided.

It is essential for the integrity of operations that the facility management structure and individual roles, responsibilities and required competencies of personnel be clearly defined, such as in the table below.

Personnel need to understand the factors that constitute sound performance of a tailings or water management facility, how deviations from expected performance may indicate developing problems, and their individual roles in the OM&S. A new member of the team should be able to comprehend readily the facility management, organization and reporting structures, and be able to contact the appropriate management personnel using the information provided.

Typical Designated Personnel for OM&S	**Operation**	**Maintenance**	**Surveillance**	**Emergency Preparedness**
Mine/mill general manager				
Tailings area supervisors				
Tailings engineers and technicians				
Environmental engineers and coordinators				
Personnel responsible for facility inspections				
Personnel responsible for dam raising				
Tailings area operators and foremen				
Water management/treatment area operators and foremen				
Mill foremen (attending tailings discharge and recycle water requirements)				
Tailings backfill plant operators				
Site emergency/security personnel				
External advisors/consultants				
Mechanical/electrical foremen				
Electricians				
Mechanics				
Heavy equipment operators				

Typical Designated Personnel for OM&S	**Operation**	**Maintenance**	**Surveillance**	**Emergency Preparedness**
Scientists				
Administration support				
External liaison/public affairs personnel				
Legal and regulatory affairs personnel				
Engineer(s) of record				

3.2. COMPETENCY AND TRAINING

The OM&S Manual will set minimum knowledge and competency requirements for each position with defined responsibilities.

Procedures will be defined to ensure that appropriate training is provided to all personnel working at the facility, including contractors and suppliers, and that all personnel have an appropriate understanding of the OM&S Manual and their respective roles and responsibilities. The responsibility of all site personnel to be continually aware of visual indications of facility performance will be highlighted.

3.3. MANAGING CHANGE

This section will outline the procedures to track tailings management facility changes. Revisions to design during operations will follow a defined review and approval process, appropriately involving company management, site personnel and regulators.

Procedures for making changes to design or operating plans, such as where conditions encountered in the field differ from design will be defined. The process of changing design will include obtaining authorization of the changes.

Responsibility for reviewing, updating and improving the OM&S Manual, to respond to the following will be identified:

- evolution of design through capacity changes, operational efficiencies, closure requirements, performance feedback and life-cycle changes;
- incorporation of as-built records of construction;
- variation of performance from design;
- changes in site management organization, facility description, roles and responsibilities, and operating and reporting procedures;
- suggestions for improvement;
- succession planning/training; and
- regulatory change.

4 - FACILITY DESCRIPTION

This section will provide essential information about the facility – site conditions and facility components, regulatory requirements, basis of design and design criteria, construction history, and location of all relevant documentation. The facility description may be presented in summary format with reference to more detailed information in supporting documents and reports.

4.1. FACILITY OVERVIEW

This sub-section will provide an overview of the facility, setting the context of its surroundings, related operations and its history, including those details provided in the table below.

Typical Facility Overview
Ownership – current and historic Location Site layout plan, showing the major components and appurtenances of the tailings or water management facility, mine, mill, drainage features and access roads The broader site context, including: • mine, mill, smelter and/or refinery operations and process • ore type • tailings output • history – changes to ore type, mining, milling and processing Features within the site area, such as topography, creeks, streams, rivers, lakes, roadways, ditches, pipeline corridors and utility corridors, which are not part of the actual facility History of design, construction and operation, key milestones and significant changes

4.2. SITE CONDITIONS

The physical site conditions that provide the basis for design and operation of the facility will be described. Extensive information may be available on site conditions, the essential elements of which will be summarized, with reference to supporting documents for additional detail, including those details outlined in the table below.

Typical Site Conditions
Climate – temperature, wind, precipitation, evaporation, seasonal and extreme events, precipitation and runoff, air quality Water • hydrology – regional creeks, streams, rivers, ponds and lakes, marine conditions, catchment area, downstream areas that may be affected, and water flow, volume, chemistry/quality, and biology

- hydrogeology – aquifers, and water flow, volume, direction and chemistry/quality

Land forms – topography, including muskeg, peat or talus slopes

Geology and geochemistry – surficial deposits and bedrock characteristics (moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests), stratigraphy, geomorphology, mineral and petroleum resources, background elemental content

Natural hazards – landslides, avalanches and debris torrents, seismicity, flood potential, frost action, wind, ice movement, frazil ice

Surrounding land and water tenure and use

Biological – ecosystem identification, flora and fauna

Location, and essential supporting field and analytical program data related to the site, as listed in the table below, will be provided.

Typical Site Reference Data
Grid system and contour maps
Datum, location of survey benchmarks
Test hole logs and locations, drill holes, penetration holes, core holes, auger holes, geophysical tests, test pits, etc.
Instrumentation type and location: piezometers, inclinometers, settlement gauges, flow gauges, etc.
Geophysical surveys
Tailings/soil/rock conditions or characteristics – moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests
Groundwater and surface water sampling points
Regulatory compliance points
Water characteristics, naturally occurring background
Weather

4.3. FACILITY COMPONENTS

A listing of significant equipment and structures that comprise the facility, including those associated with tailings delivery and tailings or water management, as per the table below, will be provided.

Typical Components of a Facility		
Tailings/Water Management		
Dams, dykes and containment structures	Culverts	Seepage reclaim pumping and ditch systems
Tailings beaches	Drains	

Perimeter containment slopes	Drop structures	Decant structures
Dam crest	Liners	Spillways
Starter dykes, berms	Control structures	Siphons
Impoundment area	Tailings and water pipelines	Reclaim barge
Appurtenances	Pumps and pump houses	Creek diversions
Vegetation	Pipeline bridges	Ditch diversion
Dust control systems	Water	Water treatment plant
Ditches		
Infrastructure		
Utility corridors	Power supply, main and backup	Enclosures
Gas lines	Telecommunications	Signage
Product lines	Transmission lines	Gates
Roads, ramps, railroads	Switches	Fences
Buildings		
Instrumentation		
Piezometers	Inclinometers	Slurry density gauges
Groundwater wells	Surface movement monuments	Water-level gauges
Weirs	Computerized controls	

Relevant supporting data and references for components of the facility in a summary table, including appurtenances and instrumentation types, as per the table below, will be provided.

Typical Component Details
Important component dimensions
Pipeline diameter, thickness and composition
Type of dam, method of construction, failure consequence classification
Plans, maps, photographs and drawings which show the location of fixed equipment and structures, above ground and buried
Tailings and construction material characteristics and capacity
Date of construction/installation
Where to find:

- design/construction documents, manuals and drawings
- basis of design/design criteria
- as-built documents – manuals, drawings and specifications

4.4. REGULATORY REQUIREMENTS

All regulatory approvals will be listed. Their purpose, compliance and reporting requirements, and respective periods of applicability will be described. Reference to the personnel responsible for ensuring compliance, permit tracking procedures, and the locations of all regulatory documentation will be included. See the table below for details of typical regulatory compliance issues.

Typical Regulatory Compliance Issues	
Financial assurance	Vegetation, wildlife and fish impacts
Environmental assessment	Progressive reclamation
Water import and usage	Decommissioning and closure
Receiving water and effluent criteria (surface and groundwater)	Dust, steam and fugitive emissions
Water recycling	Noise and odour tolerance
Dam safety	Hazardous materials and designated substances
Land use and disturbance	Regulatory reporting
Waste management	Community outreach

4.5. BASIS OF DESIGN AND DESIGN CRITERIA

Assumptions are generally made to facilitate the initial design of a tailings or water management facility, which may be carried out when there are only limited data available on the site conditions, tailings characteristics and the longer term operational and closure requirements of the site. As additional data is generated during the construction and operation phases of the facility, these assumptions can be verified or adjusted, which may lead to changes in design.

Changes to the documented design may have significant impact on facility risk, and should therefore be implemented only after due consideration, approved by the EOR, management approval and regulatory authorization.

Closure requirements also influence the operating design of a facility. Therefore, the design basis and criteria for closure, including decommissioning and reclamation, approved by the Regulator, will be included in the OM&S Manual. Closure plans often evolve through the operation stage of the facility. Changes in design must be approved by the EOR and the Regulator; all changes will be tracked in the OM&S Manual.

The basis of design and design criteria of the facility will be described as follows (see tables below for more details):

- **basis of design** addresses conditions imposed by the site, requirements of the project, and regulations; and
- **design criteria** are standards set by engineering practice and/or regulation, in accordance with the basis of design.

Modifications to the design along with associated risk assessments and management authorization for such changes will be documented.

Sufficient information to conduct the following will be provided:

- convey the capacity and the design basis of the tailings or water management facility;
- ensure that the current design criteria are always available to enable comparison of performance of the facility with design intent; and
- guide review of the design as necessary to assess the need for changes in design or OM&S procedures.
- document that proposed changes are duly approved by the EOR and authorized by the Regulator.

References to supporting documents, including initial and subsequent design and engineering reports which describe the basis of design and details of changes, will be provided.

Basis of Design **Site conditions and requirements or limitations of the project**		
Site Characteristics		
Basin capacity, footprint, hydrology, operational life Siting constraints, natural hazards Climatic considerations	Elevation change and distance from mill Foundation conditions Surficial and bedrock geology	
Operating Requirements		
Ore reserve, life of mine, annual through-put Tailings pulp density in delivery pipeline Tailings production and basin filling rates, impoundment raising schedule Tailings characteristics, including gradation, chemistry, mineralogy, dry settled density Tailings deposition procedures – cycloning, spigotting, cell construction,	Slurry water chemistry Dam crest width Tailings beach width and slope Water quality standards for surface and groundwater Water balance, mill reclaim water rate, treatment plant capacity Water management (including diversion works, outlet structures	Regulations Acid-generating potential Pond retention time, pond chemistry Pond seepage control measures, perimeter surface and groundwater chemistry requirements Catchment area runoff diversion

Basis of Design **Site conditions and requirements or limitations of the project**		
end discharge	and freeboard requirements) Pond freeboard, settlement and consolidation	requirements Decommissioning, closure and reclamation

Design Criteria **Standards set by engineering practice and/or regulation**
Maximum height and slopes of dam and tailings Dam construction materials Dam construction methods Seismic design criteria Development stages, seepage and deformation limits Liquefaction and compaction Influent flood storage and routing criteria Factor of safety for perimeter slopes for operation and closure Impoundment failure consequence classification Acceptable risk Triggers for seismic or flood events that require site inspection & reporting

4.6. CONSTRUCTION HISTORY

A summary of the construction history of a facility, including, as available, reference to any problems or unique circumstances encountered, and a description of the construction procedures will be provided, as outlined in the table below. Ongoing inspection and review will expand the documented record over time.

Typical Construction History Data
Dates of construction General description of the construction Engineer of record, construction contractor Size, scale, complexity and ease (or difficulty) of construction of each stage Summary of the key elements of the facility that were constructed

Type and source of construction materials Summary of problems or unique circumstances encountered, including natural (ground conditions, weather, etc.) or human-made (changes from approved design, construction methods differing from standard, etc.) conditions List of supporting documentation providing more specific details relating to the construction • investigations, designs, specifications, as-built records, photographs, etc. • list of key individuals supervising and documenting the construction • stage construction linkages to tailings and water management, etc.

4.7. DOCUMENT CONTROL

The impact of decisions made in designing and managing tailings and water management facilities accrue over long periods of time. Resulting impacts may not be evident until some future date. It is, therefore, important that essential information be passed on to future operators so that operating methodologies and past intentions are not lost with time.

Documentation provides the means to rely less on a person's memory, and more on a formalized system from which knowledge can be transferred.

This section will define procedures for the management and retention of information, data, design and performance documents, both hard copy and electronic, including the revision or version number, location, circulation, archiving and backup practices. The basis and schedule for retention of essential information, and removal and archiving of non-essential information, during the life of the facility will be included.

The availability and access controls for key documents, as summarized in the table below, to ensure both continued accessibility and integrity of the data record, and to avoid files being lost, removed or misplaced will be delineated. The method for retrieving information from electronic databases will be described.

Up-to-date listings of pertinent supporting documents and reports, together with the locations of the documents and reports not bound into the manual will be provided.

Typical Reference Documents and Reports	
Site investigation, geological and environmental baseline reports	Photographic documentation
Environmental assessment	Dam inspection and dam safety review reports
Laboratory and field testing results	Environmental control and monitoring
Design reports	Instrumentation, surveillance and monitoring manuals and reports
Design drawings	Risk assessments and reports
Design & construction specifications	Serious incident reports
Testing protocols & records	Emergency preparedness, response and contingency plans
Construction reports	

Periodic survey of monitoring monuments	Decommissioning and closure plan
Seismic activity measurements	
Hydrological and meteorological reports	
Vendor manuals and drawings	
Tailings deposition and water management plans	

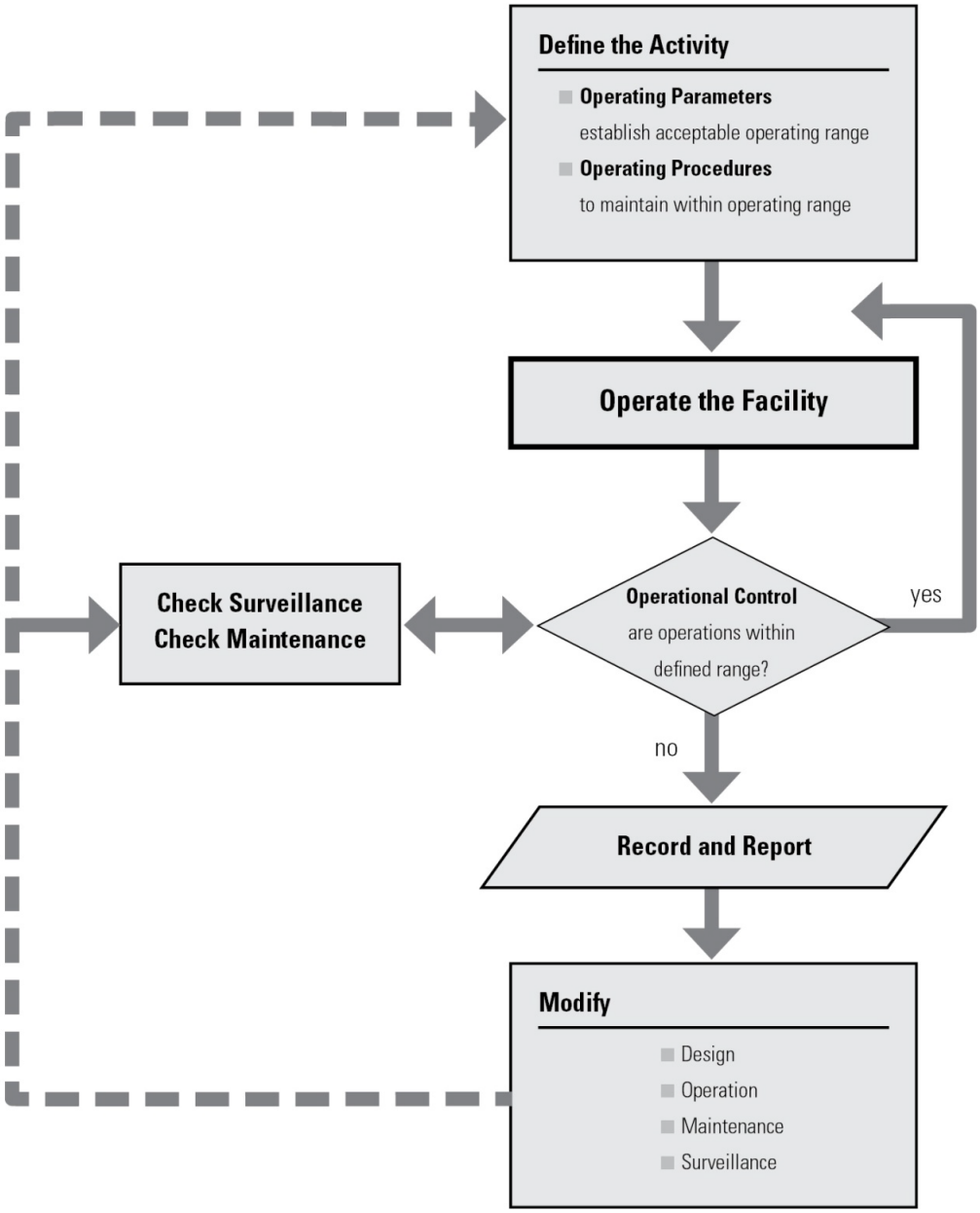
5 - OPERATION

The operation plan for a tailings or water management facility will address the transport and containment of tailings, solid waste, process water, effluents and residues, and the recycle of process water.

5.1. OBJECTIVE

This section will define operating standards and procedures in accordance with design criteria, regulatory requirements, company policies and sound operating practices, encompassing all significant aspects of, and activities for, the economical, safe and environmentally responsible disposal and storage of tailings and management of water (Figure 5-1).

Figure 5-1 Operation flowchart



5.2. TAILINGS TRANSPORT AND DEPOSITION

During operation of a facility, the tailings might vary in physical, chemical and mineralogical characteristics. Representative samples of tailings will be collected periodically for analysis. These analyses will be useful to verify any change in the physical, chemical and mineralogical characteristics of the tailings that could impact the deposition plan (a modification in the tailings specific gravity can affect the deposition slope of the material), tailings deposit density, the final effluent water quality or the rehabilitation strategy.

This section will describe the deposition plan, with details provided as summarized in the tables below. A summary of the full life-cycle deposition plan, together with detailed, current-year annual plans identifying discharge locations, discharge schedule and planned construction, with reference to supporting reports and plans will be provided.

Key operating parameters and procedures, and a schedule for periodic review against design will be identified.

Typical Tailings Transport and Deposition Parameters
Tailings slurry quantity and flow rate projections
Pumping and pipeline operating pressures
Slurry density and other physical and chemical properties, temperature
Tailings gradation, mineralogy, specific gravity, density, angularity, clay content and plasticity, acid-generating and metal-leaching potential
Tailings deposition technique and compaction
Tailings beach and underwater slopes
Maximum beach crest elevation
Maximum and minimum beach width
Chemical properties of tailings pore water and decant water

Typical Tailings Transport and Deposition Procedures
Tailings deposition • dam safety • staging of dam lifts • solids storage capacity • water recycling • water treatment requirements • cell construction, spigotting, contained beaching

- compaction
- Operating instructions for pipes, pumps, etc.
- tailings line relocation
- line pressure
- pulp density
- pipe rotation
- valve openings
- vacuum breaks
- measures to prevent line or pump sanding or freezing
- measures to flush or thaw lines

Response to deviations in physical, chemical or mineralogical properties from the design

Response to unusual operating conditions, such as severe winter conditions, periods of high rainfall, drought, and high winds

Mechanical functions, such as line rotation, line relocation and valve openings

5.3. DAM AND BASIN RAISING

This section will identify requirements and plans for staged dam construction over the life of the facility (see tables below), to maintain adequate solids storage capacity and allow adequate polishing of supernatant during operation, including:

- methods of dam construction – spigotting, cell construction, upstream, downstream, etc.;
- tailings deposition procedures, taking into consideration dam safety – staging of dam lifts, solid storage capacity, water recycling and water treatment requirements; and
- quality control measures to ensure that the construction is completed properly.

Typical Dam and Basin Raising Parameters	
Maximum and minimum height	Phreatic surface and pore water pressures
Dam-raising schedule	Beach width
Construction material sources	Foundation and dam building material characteristics
Placed material density	Slurry density
Perimeter slopes	Tailings delivery volume
Progressive reclamation	
Typical Dam and Basin Raising Procedures	

Erosion control Compaction Material placement, spigotting, cell construction, single point discharge	Site preparation, vegetation/overburden removal, earth and rock fill Filter construction Instrumentation installation and/or extension

5.4. WATER MANAGEMENT

This section will describe procedures for management of water flow through a facility under normal operating practice, as well as under special circumstances such as spring runoff, severe rainfall events or drought. Describe water balance, including identification of all inputs, inventory of pond and interstitial water, and outflows.

Key operating parameters and operating procedures (tables below) related to water balance and water management for the facility, including spillways, decant systems, siphons, ditches, swales and drop structures will be identified. Reference to supporting reports and plans will be provided.

Typical Water Management Operating Parameters
Minimum freeboard Stage storage curves Maximum and minimum operating water levels and beach widths (seasonal considerations, wind, flood and drought events, and the treatment schedule) Tables of target pond levels Water discharge, volume and quality (normal operating conditions and special circumstances)

Typical Water Management Operating Procedures
Control of inflows and outflows Flood routing Seepage water return Reclaim water

5.5. ENVIRONMENTAL PROTECTION

This section will define parameters and procedures to protect the environment by controlling tailings and water through treatment and management (see tables below). Regulatory reporting requirements will be documented.

Typical Environmental Protection Parameters
Water/effluent discharge quality and flow rate

Chemical properties of tailings pore water, groundwater, seepage and decant water
Dust/particulate loading, quantity and quality
Fog or steam emission criteria
Basin footprint
Biomass/biodiversity, wildlife, aquatic life, livestock and habitat

Typical Environmental Protection Procedures
Treatment plant • unit operations • reagent addition • instrumentation and process control
Surface water, groundwater and seepage collection, treatment and transport, including pump back
Dust abatement
Fog or steam abatement
Wildlife, aquatic life and livestock protection
Handling of hazardous materials and designated substances
Reclamation and revegetation
Progressive rehabilitation

5.6. SAFETY AND SECURITY

This section will define parameters and procedures to control site access, to assure both facility integrity and safety of site personnel and the general public. Details to address hazards or safety restrictions related to human contact with tailings or decant materials (see table below), including risk to personnel walking or operating equipment at the facility will be provided.

Typical Safety and Security Parameters	
Site access and egress limitations	Signage, fencing and gates
Workplace hazards	Security patrols
Personal protective equipment	Workplace safe operating procedures

5.7. DOCUMENTATION

This section will define information to be collected and recorded as part of the facility's operation (see table below). Checklists and report forms might be included or referenced.

Typical Operation Documentation
Quality control records and statistical summaries
Instrumentation records, daily diary entries
Communications and activity records
Photographic summaries and/or videos
Schedules
Change orders, memos, reports
As-constructed drawings and reports, especially of dam raising

5.8. REPORTING

Define operating performance information to be reported.

Specify procedures for reporting of:

- operational conditions requiring maintenance; and
- observations which may identify significant change in conditions at the facility.

6 - MAINTENANCE

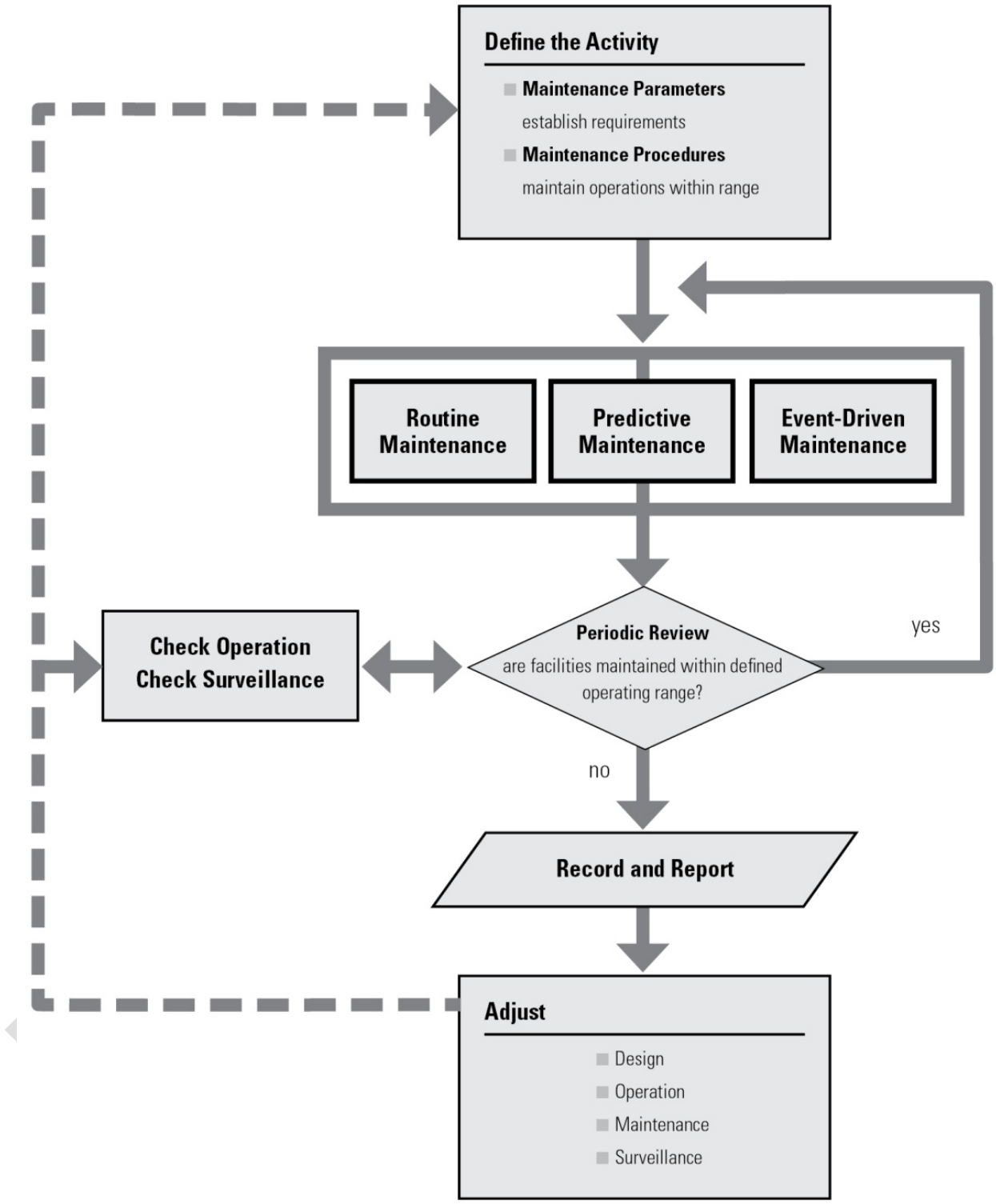
The maintenance program for a tailings or water management facility will identify and describe critical parts, routine, predictive and event-driven maintenance, and operating and surveillance observations for all civil, mechanical, electrical and instrumentation components of the facility (Figure 6-1).

6.1. OBJECTIVE

Key maintenance parameters and procedures will be identified to ensure that the individual components of a facility are maintained in accordance with performance criteria, company standards, legislative requirements and sound operating practices (see typical contents in table below). Maintenance plans will be tailored to unique facility characteristics and site conditions.

Typical Contents of a Maintenance Plan	
Statement of objective Overall responsibility for maintenance • maintenance organization chart • position, name and contact information • required qualifications and familiarity with the OM&S Manual Inventory of components subject to maintenance, and for each component • where it is located • when it should be maintained • if routine or predictive maintenance, what frequency • if event-driven maintenance, what trigger • reference standards	• design or performance standards • equipment operating and maintenance manuals Schedule for checking emergency equipment and critical spare parts list What is to be documented • component condition • maintenance action undertaken, standard met • recommendation for next action Reporting • to whom • when • how, and in what form

Figure 6-1 Maintenance flowchart



6.2. MAINTENANCE PARAMETERS

This section will define maintenance parameters that address civil, mechanical, electrical and instrumentation requirements, as outlined in the table below.

Typical Maintenance Parameters	
Site access	Process and surveillance instrumentation controls
Ditch, spillway and drop structure capacity	Switches, interlocks and meters
Support structure integrity	Erosion
Equipment availability and reliability	Vegetation
Pipeline wear and thickness criteria	Design economic life
Minimal tailings line thickness, and associated requirements	

6.3. ROUTINE AND PREDICTIVE MAINTENANCE

Predictive maintenance utilizes feedback from the following, to assist in the identification of on-time servicing needs to avoid costly, lengthy or untimely breakdowns:

- Equipment operating history;
- Maintenance effort (costs); and
- Site conditions.

A key component of maintenance planning is preparedness to respond to breakdowns, incidents or conditions requiring maintenance. It is important, however, to distinguish between requirements for maintenance and emergency response; maintenance actions do not address emergency situations, which should be covered in the emergency preparedness plan and/or emergency response plan.

This section will outline routine and predictive maintenance procedures for all identified components of the facility, specifying:

- prioritization, based on risks and consequences;
- material and equipment availability;
- maintenance action plans, including repairs and replacement as required; and
- documentation of maintenance undertaken.

6.4. EVENT-DRIVEN MAINTENANCE

This section will provide procedures to address conditions or incidents requiring maintenance, which may arise from observations from other OM&S activities, and result in planned or unplanned maintenance actions, specifying:

- prioritization, based on risks and consequences;

- maintenance team “call-out” procedures;
- material and equipment availability;
- maintenance action plans, including repairs and replacement as required;
- lock-out and safety procedures/concerns;
- return to normal operation; and
- documentation of maintenance undertaken.

6.5. DOCUMENTATION

Information to be collected and recorded as part of the facility’s maintenance will be defined, with typical requirements outlined in the table below. Checklists and report forms might be included or referenced.

Typical Maintenance Documentation	
Up-to-date equipment logs	Photographic summaries and/or videos
Work history	Inventory of spares, materials, tools and equipment
Frequency and cause of problems	Critical spares list
Component reliability	Schedules
Quality control records	Change orders
Daily diary entries	Memos
Communications and activity records	Reports

6.6. REPORTING

This section will define maintenance information to be reported and will specify procedures for:

- reporting operational conditions requiring maintenance; and
- reporting significant observations from maintenance activities, including greater than expected maintenance requirements and excess event-driven maintenance.

Such reporting may be instrumental in identifying and dealing with changed conditions at the facility.

7 - SURVEILLANCE

Surveillance involves inspection and monitoring of the operation, structural integrity and safety of a facility (Figure 7-1). It consists of both qualitative and quantitative comparison of actual to expected behaviour. It must be a designed program, fully integrated with operation and maintenance activities, consistent with life cycle and regulatory requirements.

Regular review of surveillance information can provide an early indication of performance trends that, although within specification, warrant further evaluation or action.

All personnel working at a tailings or water management facility should be involved in surveillance as a routine part of daily activities, maintaining visual awareness of the facility in the course of their regular and/or routine duties, in addition to surveillance-specific site engineering, instrument monitoring, analysis, inspection, periodic review and oversight.

Surveillance is not a substitute for design; it is a necessary component of good design practice which, to be effective, must be implemented through a designed program.

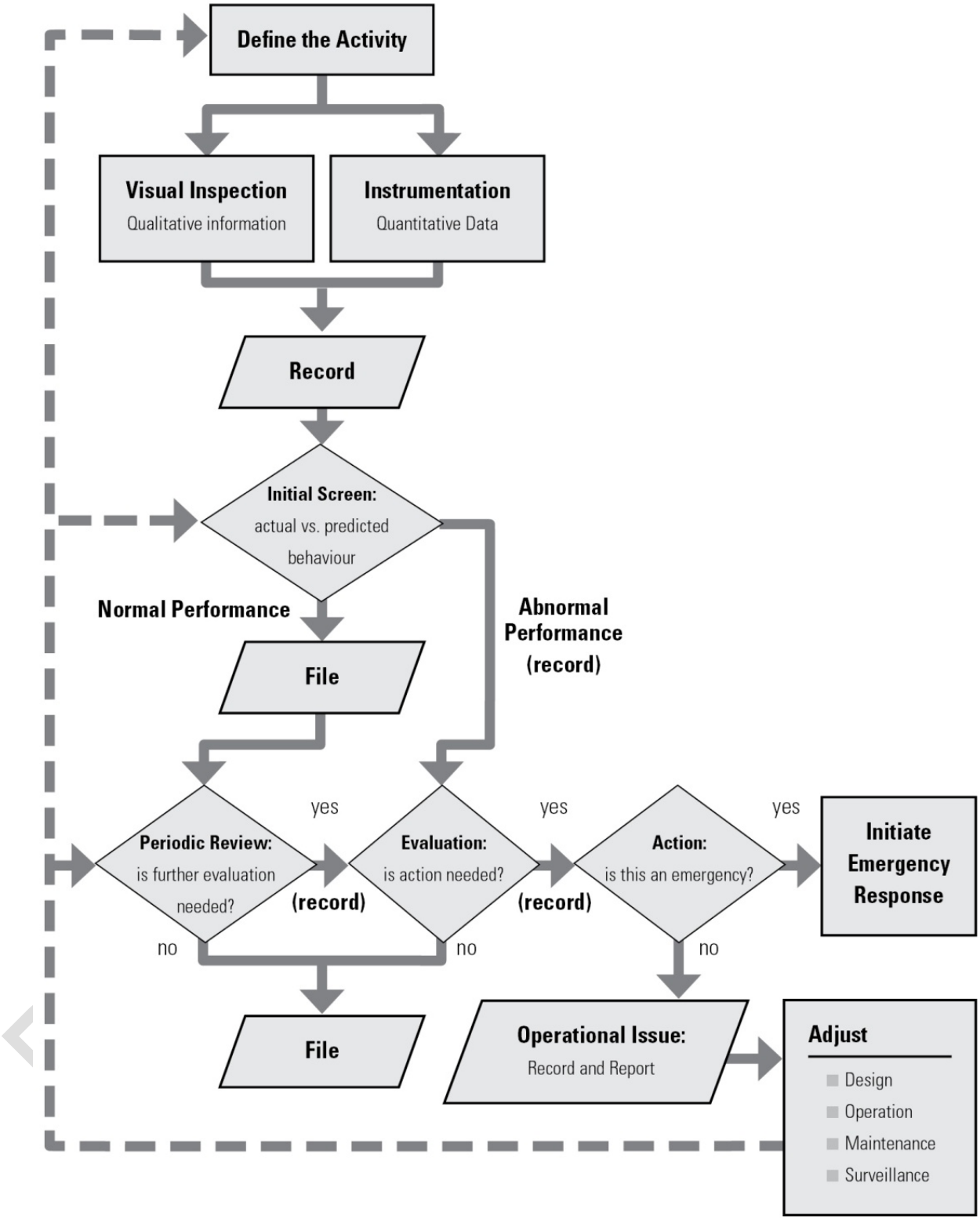
7.1. OBJECTIVE

This section will identify key surveillance parameters and procedures for:

- monitoring the operation, safety and environmental performance of tailings and water management facilities;
- promptly identifying and evaluating deviations from expected behaviour that affect operational safety, structural integrity and environmental performance of the facility; and
- reporting significant observations for response.

Personnel will be made aware of the need to report and act on observed departures from expected behaviour.

Figure 7-1 Surveillance Flowchart



7.2. SURVEILLANCE PARAMETERS

This section will identify and describe potential failure modes for assessment and inclusion in a surveillance program. The key parameters of surveillance to support the operation of the facility, building on the identified modes of failure will be defined.

There are key performance parameters for which expected behaviour can be monitored – freeboard, seepage rate, containment structure displacements, pore pressures, and chemistry of the seepage and the surrounding surface water, and these details will be provided, as summarized in the table below.

Typical Surveillance Parameters
Explanation and illustration of how failure could develop, together with probable triggers, visual and instrumentation effects
Visual observations
Surface – cracking, bulging, depressions, sink holes, vegetation Slope erosion Water levels Seepage – new seepage areas, changes in seepage area Beach slopes Classification of possible observations which would be consistent with expected behaviour, and which would not
Instrumentation
Slope displacement – survey monuments, slope inclinometers Pore pressure monitoring – standpipes, pneumatics Seismic monitoring Water quality monitoring – surface, borehole, turbidity Biological monitoring Dust sampling Weather Communications Power supply Pipeline flow and pressure Water levels

7.3. SURVEILLANCE PROCEDURES

Surveillance provides a backstop to design and operation. It provides the trigger to change operations and/or maintenance, or to initiate emergency response. It consists of a series of procedures that must be clearly defined and followed. Preparation of a surveillance program is an essential part of facility design.

Surveillance consists of both routine and event-driven procedures. Visual inspections and instrument reading which are integral to, and done as part of, routine surveillance may also be essential within the context of event-driven surveillance. Information provided related to surveillance procedures is detailed in the table below.

Typical Surveillance Procedures
Visual monitoring and Inspection
Routine visual monitoring by site personnel Periodic inspections by engineering and/or specialist personnel
Instrument measurement
Surveying Instrument reading Material testing
Data collation and analysis
Initial screening of visual inspection observations and field data as collected to determine that operations are within performance criteria Periodic follow-up screening of collated observations and data to determine trends as related to performance criteria
Periodic inspection and review
Of collected observations from visual inspection and instrument readings Of total facility performance Of continuing validity of facility design and performance criteria, including for surveillance
Documentation
Reporting

7.4. VISUAL MONITORING

Visual monitoring is not just a specialist activity – all site personnel should be trained to observe and document the performance of the facility, providing at least qualitative awareness of departures from normal performance of the tailings or water management facility, or from performance criteria.

This section will outline the types of visual indicators of which site personnel should be routinely aware. For example, appearance of, or changes to cracks, slumps, seepage and/or anomalous vegetation within the tailings or water management area or its immediate vicinity could provide a trigger for specific site inspection.

The following information will also be specified:

- The frequency of visual inspections.
- The mode of recording visual inspections, preferably on standard forms or checklists, which encourage quantification of observations where appropriate, such as width of cracks, seepage area, volume, colour and clarity, etc.
- Criteria for initial screening and reporting of observations.
- The frequency, mode of reporting and documentation standards for routine visual inspection of the entire facility by engineering and/or specialist personnel.
- Conditions, such as suspension of operation or closure of the facility, during which the frequency of routine inspections may be changed.
- Procedures for required action in the event of any sudden change in behaviour, such as abnormal water levels, increased seepage, crest drops, slumping and cracking, which may require specific incident reporting, and which would normally trigger some action.
- Criteria which trigger special event-driven inspections, along with the required documentation and follow-up. Such events typically include first filling, earthquake, extreme precipitation, flood or operational upsets. Facility performance through these events is especially important as it defines the capacity to cope with extreme events.

7.5. INSTRUMENT MEASUREMENT

Instrument measurement and monitoring quantifies facility behaviour in comparison to performance criteria, and extends operational observation to beneath the surface, beyond the range of visual inspection. Information to be included in the OM&S Manual regarding instrument measurements is summarized in the table below.

Typical Instrument Measurement and Monitoring	
Surveying of • beach profile, pond level and bathymetry • ice and snow cover • dam profile • settlement and displacement	Sampling and testing • tailings characteristics and properties • tailings mineralogy, in situ density and gradation • water chemistry Flow measurements

Typical Instrument Measurement and Monitoring	
• wildlife and aquatics • vegetation	Piezometers Slope inclinometers Settlement gauges Thermistors Meteorological stations

A complete listing of all instrumentation, will be provided, including:

- instrument identification;
- location identified on a site plan;
- record of installation, date installed, surveyed position, test hole depth, elevation of top of hole, diameter, backfill details, instrument type, depth, serial number;
- data collection and validation procedures;
- frequency of monitoring;
- data reduction and interpretation procedures;
- calibration issues; and
- data management and storage.

Data collection, instrument reading and monitoring frequencies with regard to design, operating requirements and site conditions will be specified, as will criteria for initial screening of instrumentation readings in the field at the time of collection, and the basis for rechecking of anomalous readings (which should remain on record).

7.6. COLLATION AND ANALYSIS OF DATA

Data are not collected just to fill log books – they are collected to be used, and will help future operation, maintenance and surveillance to operate more efficiently and effectively, while managing risk and change.

It is not sufficient to simply collect data. The data should be screened in the field to identify both false data and critical situations. This should be followed by collation of data collected from various points around a facility and analysis against overall performance criteria.

This OM&S Manual section will specify procedures for initial screening, data documentation and collation from visual inspection and instrument measurement. Data reduction and analysis parameters will be defined, and criteria for analysis of visual observation and inspection reports and instrument measurements against performance criteria will be specified. Parameter ranges representing the following will be defined:

- (acceptable) normal performance, normal follow-up;
- abnormal performance, additional surveillance or evaluation to be initiated;
- abnormal performance, change in operation, maintenance and/or facility design to be initiated; and
- abnormal performance, emergency alert and actions to be taken.

A schedule for periodic review of collated visual observation and inspection reports and instrument measurements, to analyze data and facility performance trends will be established.

Documentation and reporting procedures for analysis of visual observation and inspection reports and instrument measurements will be specified.

7.7. PERIODIC INSPECTION AND REVIEW

This section of the OM&S Manual will:

- Identify the periodic basis for facility inspection and review, considering site and operating characteristics, jurisdiction and consequence classification.
- Establish a schedule for regular periodic inspection of the tailings or water management facility and audit of the surveillance program results by a qualified engineer who is familiar with the tailings facility.
- Establish criteria for independent checks of the facility and the surveillance program to be done after significant events such as earthquakes, floods and significant operational upsets.
- Establish a schedule and criteria for comprehensive review of the facility – typically, every five to ten years as per failure consequence classification or by regulation. This comprehensive review should provide independent verification of the safety and environmental performance of the facility, the adequacy of the surveillance program, and the adequacy of delivery of OM&S within the management framework, plus review and analysis of the facility design with respect to current standards and possible failure modes.

7.8. DOCUMENTATION

The surveillance program must include clear identification of trigger points or changes for mandatory communication between those who monitor performance and those who control the means to improve performance. The surveillance program must be linked to the emergency response plan so that action is initiated if the performance of the facility falls below design standard.

Documentation standards for surveillance, including for recording of the following will be established:

- observations from routine visual observation (departures from or exceptions to normal conditions);
- instrumentation monitoring and testing;
- evaluations;
- inspections; and
- reviews.

Where practicable, standard forms and checklists will be provided.

A hard copy (paper) and electronic filing system for all inspection reports, photographic and video records, incident reports, instrumentation readings, instrumentation plots, annual inspections and third-party reviews, so that they can be quickly retrieved for review and in the case of an emergency will be established.

Procedures for initiating emergency response alerts, reporting operational performance that meets expectations, and reporting conditions requiring adjustment to design, operation, maintenance or surveillance will be specified. As will reporting procedures and schedule for regulatory requirements.

8 - EMERGENCY PLANNING AND RESPONSE

Tailings and water management facilities pose a risk that must be managed. Despite best efforts to ensure that facilities are designed, operated and closed safely and responsibly, it is important to have emergency preparedness and response plans and procedures in place in the event of an incident. A site's overall emergency preparedness and response plans will include plans and procedures for the tailings management facility specifically and these, in turn, will be part of the OM&S Manual.

The emergency preparedness and response plans will identify the actions to be taken by the owner/ operator and responsibilities assigned to appropriate individuals at the site, as well as those of other agencies and affected parties.

Emergency preparedness and response (EPR) plans will be defined to identify the potential for accidents, to respond in emergency situations, and to prevent and mitigate the environmental and safety impacts, both on- and off-site, associated with emergency situations. Typical contents are detailed in the table below.

Warning signs with reference to potential tailings and water management facility failure modes or emergencies – both from a structural failure and failure due to environmental impacts will be listed and classified. Examples include:

- equipment failure;
- slope or foundation failure;
- overtopping;
- power line failure;
- seepage or piping;
- loss of process control; and
- flooding.

Warning signs and potential emergencies are site-specific. For each one listed and classified, the appropriate actions and responses will be identified.

A "call-out" process as appropriate, in the event of an incident will be specified and initiated. Lines of communication within the site (involving, for example, management, operations, engineers, consultants) and names, positions, telephone numbers (work and home) and e-mail addresses will be detailed. Relevant off-site contacts, such as contractors or equipment suppliers will be provided.

The process for notifying affected external stakeholders – municipalities, government agencies, local organizations, first aid, fire department, ambulance, other individuals, etc. – including telephone numbers and e-mail addresses will be provided.

Verification and follow-up procedures to ensure that appropriate parties have been contacted will be established, and the call-out process will be kept up to date.

Contingency plans will be developed and maintained as part of EPR plans. The plans will be tested for effectiveness, regularly reviewed and updated as appropriate.

The contingency and EPR plans will be widely distributed to appropriate personnel within the organization, as well as to potentially affected external stakeholders.

Typical Contents of Emergency Preparedness and Response Plans
Identification of failure modes
Identification of roles and responsibilities
Identification of requirements of legislation, codes of practice, notification and reporting obligations
Identification of available resources
Mutual aid agreements
Public relations plans
Telephone lists
Establishment of communication system for notifications and for post-notification purposes
Risk analysis for on-site and off-site effects
Inundation study, maps and tables for both physical and environmental releases (including dam break)
Basis for activation of emergency response plan and emergency decision making
Training of personnel
Investigation and evaluation of incidents and accidents
Contingency plans
Restoration of safe operating conditions
Validation drills, test of the system

9 - REFERENCES

Mining Association of Canada (MAC). 2011a. A Guide to the Management of Tailings Facilities; Second Edition. Mining Association of Canada. Ottawa. www.mining.ca

Mining Association of Canada (MAC). 2011b. Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities. Mining Association of Canada. Ottawa. www.mining.ca