Developing an

Operation, Maintenance, and Surveillance Manual

for Tailings and Water Management Facilities

VERSION 2.1

The Mining Association of Canada

Developing an

Operation, Maintenance, and Surveillance Manual

for Tailings and Water Management Facilities

VERSION 2.1

Version date: March 2021

NOTICE TO READERS:

The electronic version of this document has enhanced features to improve the usability of the document:

- hyperlinks to external websites and documents;
- hyperlinks to other sections of the document; and
- pop-up boxes with definitions of key terms that appear when the cursor passes over them.

Please note that the pop-up boxes are not functional in the current (2021) Adobe Reader apps for iPad and iPhone, so they will not appear. Additionally, if the document is previewed as an email attachment using the Apple Mail app, the pop-ups will be visible at all times, blocking portions of the text. If using an Apple mobile device, we recommend opening the document in the Adobe Reader app, or using the Apple-friendly version available at "*http://mining.ca/oms-guide*".

The Mining Association of Canada

CHANGES IN VERSION 2.1

Version 2.1 is an update to the second edition of Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities (the OMS Guide) released in 2019. Updates were undertaken concurrent with revisions in Version 3.2 of *A Guide to the Management of Tailings Facilities* (the Tailings Guide).

The Tailings Guide was revised to improve alignment between the tailings management component of MAC's *Towards Sustainable Mining® (TSM®)* program and the *Global Industry Standard on Tailings Management (the Standard)*, released in August 2020.

The most significant change is the moving of text on control of documented information (formerly Section 2.7 of the OMS Guide) to the Tailings Guide. This was moved as this guidance is applicable to documented information other than OMS manuals.

In addition:

- In Section 2.4.3, discussing linkages with other systems, a reference to site-wide environmental and social management systems was added to improve alignment with the Standard.
- Examples of potential roles and responsibilities of the Responsible Person and Engineer of Record were deleted and incorporated into Version 3.2 of the Tailings Guide.
- Section 3.1.2, discussing communications, was deleted and incorporated into Version 3.2 of the Tailings Guide. The associated appendix was also moved to the Tailings Guide.

Foreword

It is with pleasure that I present, on behalf of the Mining Association of Canada (MAC), the second edition of *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide).

The first edition of the OMS Guide was released in 2003 as a companion piece to MAC's 1998 ***A Guide to the Management of Tailings Facilities*** (the Tailings Guide). The OMS Guide provides guidance on developing site-specific operation, maintenance, and surveillance (OMS) manuals which are essential to implementing the tailings management framework described in the Tailings Guide.

The Tailings Guide and the OMS Guide are stand-alone best practice documents that can be applied by MAC members and non-MAC members alike, for the responsible management of tailings facilities anywhere in the world.

In 2015, MAC undertook a review of the Tailings Guide and the OMS Guide, as well as the *Towards Sustainable Mining® (TSM®) Tailings Management Protocol*. The revised Protocol and the third edition of the Tailings Guide were released in 2017, and this second edition of the OMS Guide builds on the best practices described in the third edition of the Tailings Guide. The second edition provides strengthened guidance on the development of site-specific OMS manuals that, when implemented throughout the life cycle of a tailings facility:

- provide a mechanism for the effective implementation of a tailings management system;
- provide a mechanism to meet tailings management performance objectives and manage risk;
- support effective decision-making for responsible tailings management; and
- support the management of changes associated with tailings management.

Revisions to the Tailings Guide and the OMS Guide were undertaken by MAC's Tailings Working Group (TWG), which consists of more than 50 representatives of MAC members and associate members. Collectively, TWG members have a tremendous depth and breadth of experience and expertise in tailings management in Canada and around the world. We are extremely grateful to the members of the TWG for their dedication and commitment to responsible tailings management, and for the contributions of their knowledge, wisdom and time, without which the updated Tailings Guide and OMS Guide would not be possible.

Updating the Tailings Guide and OMS Guide is an important step in continual improvement, providing best practices to optimize tailings facility performance and manage risk. I trust that MAC members and others will find both documents to be invaluable tools for improving tailings management. Our industry is continually working towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment and human health, in Canada and abroad.

Pierre Gratton

President & CEO

The Mining Association of Canada

Preface

Context

The first edition of MAC's *Guide to the Management of Tailings Facilities*, released in 1998, was developed to:

- provide a framework for the management of tailings facilities;
- help Owners of tailings facilities develop tailings management systems that include environmental and safety criteria; and
- improve the consistency of application of reasonable and prudent engineering and management principles to tailings facilities.

In 2003 MAC introduced *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide) as a companion document to the Tailings Guide, providing guidance on preparing site-specific manuals that outline procedures for the responsible operation, maintenance, and surveillance (OMS) of tailings and water management facilities.

MAC established the *Towards Sustainable Mining® (TSM®)* initiative in 2004. *TSM* is a performance system that helps mining companies evaluate and manage their environmental and social responsibilities. It provides a set of tools and indicators to drive performance and ensure that mining risks are managed effectively. Additional information on TSM is available at *www.mining.ca/towards-sustainable-mining*.

Tailings management is a core component of *TSM*. Performance indicators for tailings management are described in the *TSM Tailings Management Protocol*. The Protocol refers to, and is supported by, the Tailings Guide and the OMS Guide. The tailings management component of *TSM* provides a strong and consistent message to tailings facility Owners, operators, and contractors: the key to safe and environmentally responsible management of tailings is the consistent application of engineering capability within an effective management system and throughout the full life cycle of a facility.

In 2011, the second edition of the Tailings Guide was released, aligning the original Tailings Guide with *TSM* principles and terminology, and with the OMS Guide. The OMS Guide was also re-released in 2011, although the document was not revised.

Review of the Tailings Management Component of *TSM*

In August 2014, a tailings dam foundation failure occurred at the Mount Polley Mine in British Columbia. Soon after, the MAC Board of Directors initiated a review of the tailings management component of *TSM*, to identify any improvements that could be made to prevent such an event from happening again. This review, formally launched in March 2015, consisted of two parts:

- an external review by an Independent Tailings Review Task Force established by the MAC Board of Directors; and
- an internal review by MAC's Tailings Working Group.

The *Report of the Towards Sustainable Mining Tailings Review Task Force* was presented to the MAC Board of Directors in November 2015 and included 29 recommendations for improvements to the Protocol, Tailings Guide and OMS Guide.

Once both reviews were complete the Tailings Working Group revised the Tailings Guide, leading to the third edition of the Guide. The Protocol was also revised, and both were released in 2017.

The third edition of the Tailings Guide retains a strong emphasis on management systems, and it has an increased emphasis on technical aspects, especially those critical to the physical and chemical stability of tailings facilities. The third edition also updates the tailings management framework presented in the Tailings Guide as a tool to help in the implementation of site-specific tailings management systems. Descriptions of the elements of the framework are strengthened and clarified, and the framework is more aligned with the *ISO 14001 Environmental Management System* standard. The third edition also strengthens concepts that were described in previous editions and introduces others.

Second Edition of the OMS Guide

This second edition of the OMS Guide reflects the experiences of developing and implementing OMS manuals since the first edition was released and embodies lessons about what makes an OMS manual an effective and useful document. The most important consideration is that an OMS manual must be developed on a site-specific basis, reflect the unique conditions of the tailings facility to which it is applied, is used on a continuous basis, and is up-to-date. An effective OMS manual cannot be written using a generic, "cookie cutter" approach, nor can it be effective if it is out-of-date, or goes unused on a day-to-day basis.

The second edition of the OMS Guide emphasizes that, to be effective, OMS manuals need to be:

- written with input from those who will use them, and incorporate their specialized knowledge of the site, to make the manual more useful, and to help prevent that specialized knowledge from being lost through personnel changes;
- written in a clear, comprehensible manner; and
- written, organized, and made available in a manner that is readily accessible, such as the use of modules, and taking advantage of the capabilities of electronic documents.

This edition of the OMS Guide is closely aligned with the third edition of the Tailings Guide and builds on themes described in the Tailings Guide, creating a stronger conceptual framework for OMS manuals to integrate with tailings management systems.

Risk-Based Approach: The Tailings Guide emphasizes the importance of managing tailings facilities in a manner commensurate with the risks they may pose across the life cycle. The OMS Guide links OMS activities to the risk profile of a specific tailings facility, with the risk management plan included as a key consideration in developing and implementing an OMS manual.

Critical Controls: The Tailings Guide describes a framework for implementation of critical controls, which are risk controls that are crucial to preventing high-consequence events or mitigating the consequences of such an event. The OMS Guide emphasizes that critical controls and associated performance indicators need to be considered in developing and implementing an OMS manual, while also providing a basis for decision-making based on surveillance data.

Managing Change: The Tailings Guide emphasizes the fundamental importance of having systems in place to manage change, including organizational or personnel changes, as well as changes which could impact the risk profile of a tailings facility. The OMS Guide stresses that an effective OMS manual that is implemented as intended can be a valuable tool to help manage change.

Life Cycle Approach: The Tailings Guide emphasizes the importance of a life cycle approach to tailings management, with conceptual planning for tailings management beginning early in the planning cycle of a proposed mine and driven by the risks that need to be managed, as well as the closure objectives. The OMS Guides emphasizes that conceptual plans for OMS activities should also be developed during conceptual planning, and OMS manuals need be updated regularly throughout the life cycle of a facility. An out-of-date OMS manual creates risk.

The OMS Guide is written as a stand-alone document which can provide value even at sites not implementing a tailings management system as described in the Tailings Guide. Developing and implementing a site-specific OMS manual in the absence of a tailings management system can be an important step to improving tailings management and reducing risks.

The development and implementation of a site-specific tailings management system is a best practice for tailings management. However, the development and implementation of an OMS manual is essential to the implementation of a tailings management system. Thus, it is best practice to implement a tailings management system and OMS activities in a coordinated, aligned manner as the most effective means of managing risk, improving performance, and driving continual improvement in tailings management. MAC strongly encourages the implementation of the Tailings Guide and the OMS Guide together to optimize performance and manage risk.

To ensure alignment with the second edition of the OMS Guide, and to strengthen guidance regarding emergency preparedness, the third edition of the Tailings Guide was also updated. Version 3.1 of the Tailings Guide was released at the same time as the second edition of the OMS Guide. An updated version of the Protocol was also released which reflects a shift in emergency preparedness guidance from the OMS Guide to the Tailings Guide.

Implementation of *TSM* is required for MAC members for their Canadian operations. Thus, for MAC members applying *TSM*, implementation of the Tailings Guide and the OMS Guide is required, together with implementation of the *TSM Tailings Management Protocol,* to provide an even greater level of assurance of effective and responsible tailings management.

Non-MAC members have full access to all *TSM* documents, including those related to tailings management. Any Owner of a tailings facility, at any life-cycle phase, is encouraged to use these guidance documents to support their tailings management activities.

Table of Contents

1 Introduction

Tailings and associated water management facilities (hereafter referred to collectively as "tailings facilities" as per the definition below) are integral components of mining and ore processing operations. They must be managed throughout their life cycle to ensure their safe and environmentally responsible management. Responsible management includes the prevention of adverse impacts to human health and safety, the environment, and infrastructure.

Operation, maintenance, and surveillance (OMS) are fundamental to the day-to-day management of tailings facilities. To be effective in contributing to responsible tailings management, OMS activities must be:

- planned in a manner that considers the performance objectives and risk management plan of the tailings facility;
- designed to support and be integrated with a site-specific tailings management system;
- clearly documented in a site-specific OMS manual;
- consistently implemented as described in an OMS manual;
- linked to a decision-making framework for tailings management; and
- reviewed and updated, as appropriate, on a regular basis.

An effective OMS manual:

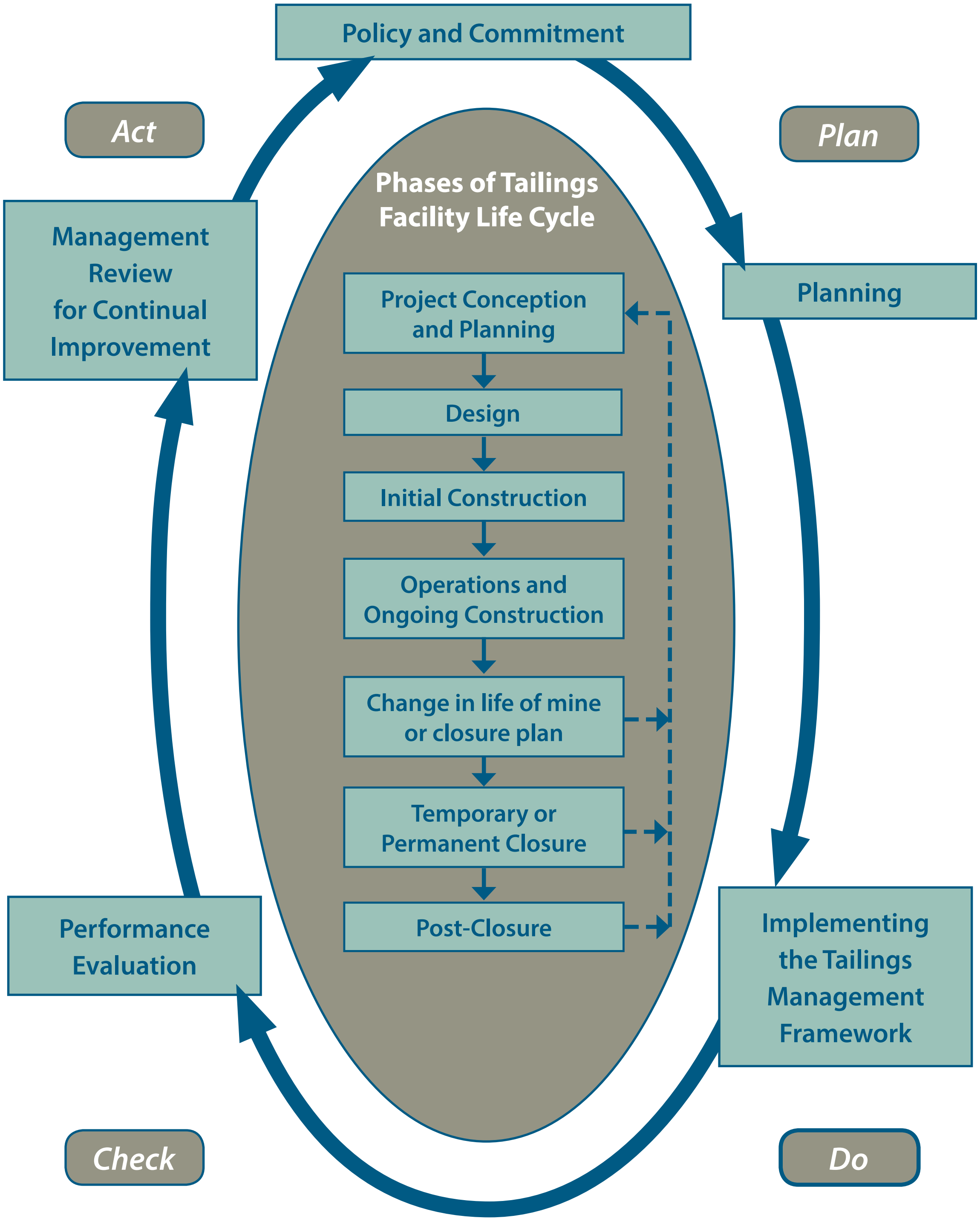
- provides a framework for OMS activities related to tailings management;
- documents and communicates OMS practices to Owners, their employees, contractors, and consultants involved in tailings management;
- provides a basis for measuring performance of the facility and for effective decision-making for tailings management; and
- documents the roles, responsibilities, and levels of authority of personnel who perform key activities related to tailings management.

1.1 The Tailings Guide

The Mining Association of Canada's (MAC's) *A Guide to the Management of Tailings Facilities* (the Tailings Guide) describes a tailings management framework that provides the basis for Owners to implement a site-specific tailings management system. Elements of this framework, illustrated in Figure 1, are:

- Policy and Commitment;
- Planning;
- Implementing the Tailings Management Framework;
- Performance Evaluation; and
- Management Review for Continual Improvement.

Figure 1: Elements of the Tailings Management Framework



1.2 The OMS Guide

This OMS Guide recommends rationale, organization and contents for developing an effective site-specific OMS manual. Owners of tailings facilities are encouraged to use this OMS Guide to prepare their own site-specific OMS manuals.

The OMS Guide emphasizes that OMS activities must be planned, designed, and implemented in an integrated manner, consistent with the design intent, performance objectives, risk management plan, critical controls, the current conditions, and closure objectives of the tailings facility. Outcomes of OMS activities are used to support decision-making for responsible tailings management across all phases of the life cycle.

The objective of the OMS Guide, together with the Tailings Guide, is to continually work towards optimizing tailings facility performance and managing risk. This approach will also minimize potential harm attributable to tailings management.

Minimizing harm encompasses both physical and chemical performance and risks associated with tailings facilities, including:

- **zero** catastrophic failures of tailings facilities; and
- **no significant** adverse effects on the environment or human health.

The OMS Guide does not replace professional expertise or legal requirements. Owners of tailings facilities must obtain qualified professional advice, including legal, to be sure that each facility's specific conditions are understood and appropriately addressed.

The Tailings Guide and the OMS Guide are not specific to Canadian conditions, and these Guides can be effectively applied to tailings management anywhere in the world. In addition, while written for tailings and associated water management facilities, many aspects of the Tailings Guide and the OMS Guide are equally applicable to the responsible management of other types of facilities, such as waste rock disposal areas, and heap leach facilities.

Tailings facility: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

Operation: Includes activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water. The term "operation" applies throughout all phases of the life cycle of a tailings facility and is not limited to the operations and ongoing construction phase of the life cycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

Maintenance: Includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Surveillance: Includes the inspection and monitoring (i.e., collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision-making and verify whether performance objectives and risk management objectives, including critical controls, are being met.

2 Life Cycle Management of an OMS Manual

2.1 What is an OMS Manual?

2.1.1 Objective of an OMS Manual

An OMS manual is intended to facilitate improved risk management and tailings facility performance, achieving the design intent, and meeting legal requirements, corporate policy, and commitments to communities of interest (COI). To achieve this, an OMS manual defines and describes:

- roles, responsibilities, and levels of authority of personnel who perform activities related to tailings management;
- the components of the facility covered in the scope of the OMS manual; and
- plans, procedures and processes for:
  - the operation, maintenance, and surveillance of the tailings facility to ensure that it functions in accordance with its design, meets performance objectives, regulatory and corporate policy obligations, supports the risk management plan, and links to emergency preparedness;
  - evaluating performance of the facility, and reporting performance results; and
  - managing change.

2.1.2 Elements of an Effective OMS Manual

An OMS manual is developed by and for those responsible for tailings management. It is a "hands on" practical document used by personnel involved in tailings management. OMS manuals are written in a clear, accessible manner, such that they are effective tools used by personnel on a day-to-day basis. An OMS manual is as concise as practical and includes information regarding how more detailed information can be accessed. Regular review and updating of an OMS manual are required to ensure it is up-to-date at all times.

> **Personnel** includes employees, contractors and consultants (e.g., designer, Engineer-of-Record) and includes those with direct responsibilities for tailings management as well as those with indirect responsibilities whose roles may be related in some manner to tailings management (e.g., heavy equipment operators working on or adjacent to tailings facilities).

An OMS manual is not written for regulators or the public, although an Owner may share components of an OMS manual. Specific components may address legal requirements, but these requirements must not drive the development, content, or implementation of the manual.

It is essential that an OMS manual be aligned with the risk profile of the tailings facility to which it is applied, as further discussed in *Section 2.2.2*. Linking the facility's risk management plan with OMS activities is at the core of an effective OMS manual. This includes specifying actions to be taken if performance criteria or critical controls are not met, including the potential implementation of the site's emergency response plan (see Section 5.2 of the Tailings Guide).

There are a range of other factors that also need to be considered in developing an OMS manual, including the design intent of the facility, legal requirements, corporate policy, and commitments to COI.

OMS manuals require regular reviews and updates. This is consistent with the evolving nature of the risk profile of tailings facilities throughout their life cycle. Additional guidance on reviewing and updating OMS manuals is provided in *Section 2.6*.

An OMS manual clearly describes the boundaries of its scope of application. The scope needs to include all operational controls that can influence the performance and risk management of the tailings facility (e.g., tailings transport, placement of tailings in the facility, physical containment of the tailings, water management and reclaim, erosion and dust control). The scope is defined on a site-specific basis, taking into account the characteristics and life cycle stage of the tailings facility and linkages with other relevant plans and procedures (see *Section 2.4.3*). Scope may be defined geographically (e.g., all activities within a specified geographic area are defined as within the scope of the OMS manual). The scope may also be defined organizationally (e.g., road maintenance may be outside the scope of the OMS, even for roads required to access the tailings facility).

An OMS manual for a tailings facility is one of many documents that describe plans and procedures for various activities at a mine site. As described further in *Section 2.4.3*, linkages between the OMS manual and these other plans and procedures need to be clearly described.

In summary, an effective OMS manual:

- is site-specific, not "off-the-shelf" and:
  - aligned with the design intent and the life cycle phase of the facility;
  - addresses the specific conditions and circumstances of the site;
  - reflects the risk profile of the facility, build upon the risk management plan, and integrates critical controls;
  - contains or links to all information needed to conduct OMS activities; and
  - integrates the knowledge and experience of personnel who have worked on the site;
- defines roles, responsibilities, and levels of authority for personnel involved in tailings management;
- is integrated with overall site plans and procedures;
- provides a basis to make informed decisions about tailings management;
- is written:
  - by employees with specific and detailed knowledge of the tailings facility, with input from consultants or other third-parties as appropriate;
  - for personnel directly involved in tailings management, and not for other audiences such as regulators, senior management, or COI;
  - in a clear, concise, easily understandable manner;
- is easily accessible to users, including in electronic format;
- is accurate and up-to-date;
- is a controlled document, with mechanisms to ensure that all personnel are working with the most up-to-date version;

- is improved over time, reflecting feedback from performance evaluations, action plans to address deficiencies or for continual improvement, and lessons learned by personnel involved in tailings management; and
- it GETS USED.

It should be noted that this OMS Guide is not intended to be prescriptive. However, the term "need" is used in many places to emphasize elements that the authors believe an OMS manual needs to include or address to be effective.

2.1.3 Life Cycle Approach

As described in Section 2.3 of the Tailings Guide, Owners face the challenge of responsible management of tailings facilities throughout all phases of their life cycle. The progression of the life cycle of a tailings facility is often not linear. For example, changes such as enlargements of the footprint of tailings facilities, care and maintenance suspensions (and subsequent re-starts), or process and technology changes may occur. The dynamic nature of the life cycle of tailings facilities means that a systematic, risk-based management approach is essential, with OMS activities planned and implemented to address the particular risk management needs of each life cycle phase.

An OMS manual needs to be in-place and ready to be implemented at the beginning of the operations and ongoing construction phase. An OMS manual may also be implemented during the initial construction phase. An effective OMS manual is also an invaluable tool for any planned or unplanned interruptions in operations that may occur. The life cycle of an OMS manual is further discussed in *Appendix 1*.

2.2 Overarching Principles

2.2.1 Linkages to Tailings Management Systems

As described in the Tailings Guide, implementation of a site-specific tailings management system is a best practice for responsible tailings management, providing a rigorous, systematic approach to facilitate:

- implementation of appropriate levels of corporate accountability and operational responsibility and authority for tailings management;
- improved facility performance, and conformance with facility performance objectives, legal requirements, corporate policy, and commitments to COI;
- effective risk management; and
- continual improvement in tailings management.

Implementing site-specific OMS activities is an essential tool to implement a tailings management system. The tailings management system provides an overall framework, but an OMS is needed to make that framework function on a day-to-day basis.

An OMS manual can be implemented in the absence of a tailings management system, but without such an overall framework it will be more difficult to:

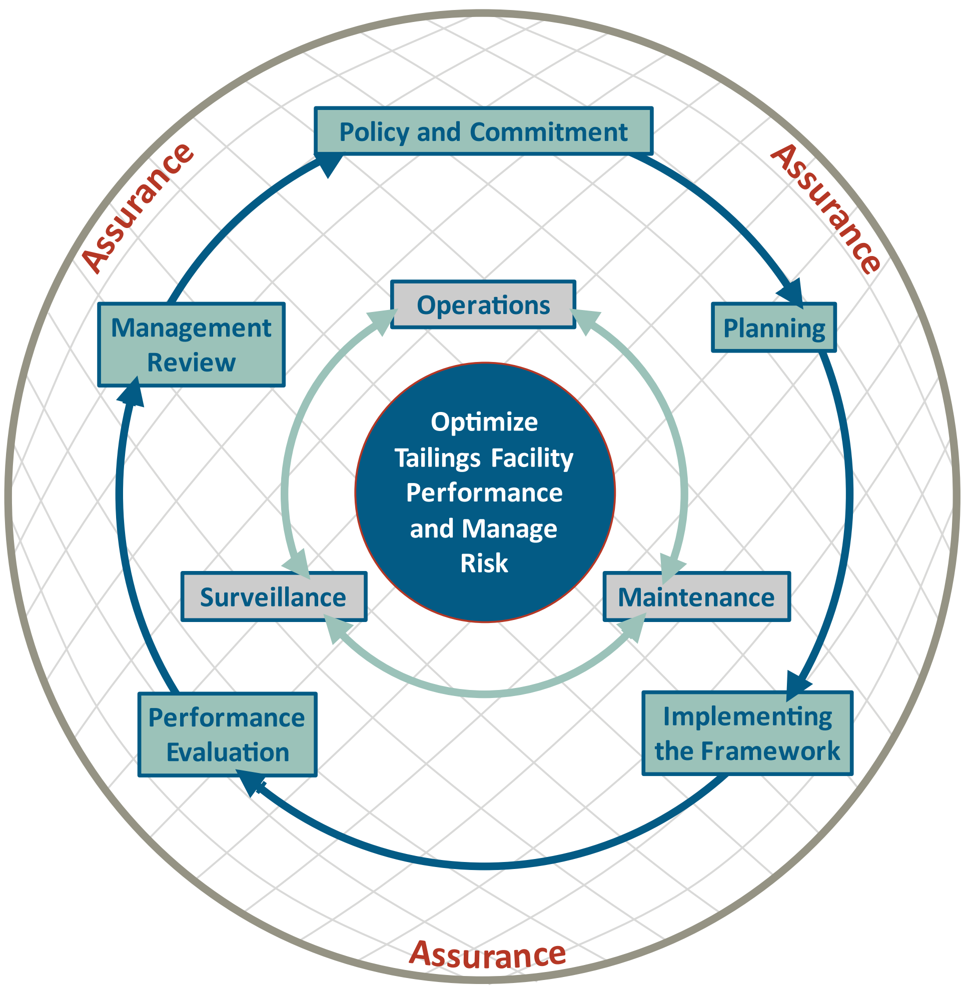
- manage risk;
- set and meet performance objectives;
- know if performance objectives are being met;

- make informed and timely decisions; and
- improve performance.

To optimize tailings facility performance and manage risk, it is best practice to implement a site-specific tailings management system supported by an OMS manual. When implemented together, a tailings management system and OMS are intimately linked, as illustrated in Figure 2. The tailings management system, including the risk management plan and critical controls, define OMS activities. In turn, OMS activities operationalize the tailings management system and inform the Performance Evaluation element of the management system. The Management Review for Continual Improvement may lead to the development of action plans to improve both the tailings management system and the OMS manual. The grid pattern underlying Figure 2 signifies the many layers and directions of linkages between the two.

At sites implementing both a tailings management system and an OMS manual, activities described in the OMS manual must be aligned with and support the tailings management system. However, an OMS manual needs to remain a practical document, with those linkages to the tailings management system not explicitly described in the OMS manual.

Figure 2: Linkages between as tailings management system and OMS activities



2.2.2 Risk Management and Critical Controls

The assessment and management of risk and subsequent development and implementation of risk management plans are essential to effective tailings management (see Sections 2.2.1, 4.1 and Appendix 1 of the Tailings Guide). An OMS manual must be aligned with the risk management plan as OMS activities are essential to the implementation of the plan. As the risk management plan is revised throughout the life cycle, the OMS manual must be revised accordingly.

A risk management plan identifies mitigation measures to:

- eliminate or avoid risk to the extent practicable;
- reduce risk by minimizing the likelihood or potential consequence of an unwanted event or condition that poses a risk; and
- detect, respond to, and minimize the consequences if an unwanted event or condition occurs that poses a risk.

A critical control is defined in the Tailings Guide as "a risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls." Those risk controls defined as critical will be determined on a site-specific basis, based on the risk assessment. Critical controls are further described in Section 4.1 of the Tailings Guide, and examples of possible critical controls are provided in *Appendix 2* of this Guide. The key steps in the identification, development, and implementation of critical controls are to identify and evaluate:

- potential high-consequence events and associated plausible failure modes;
- critical controls for each plausible failure mode;
- performance indicators associated with these controls;
- actions to implement the controls; and
- pre-defined actions to be taken if performance is outside the specified range.

An OMS manual defines all critical controls for that facility, and for each control describes:

- associated OMS activities;
- performance criteria, measurable performance indicators, and surveillance requirements; and
- actions to be taken if performance is out of specified ranges, indicating that control has been lost or that a loss of control may be imminent.

Operation and maintenance activities for critical controls are inextricably linked to surveillance: without surveillance, there is no control. Consequently, implicit in the description of operation and maintenance components of critical controls management are the associated surveillance activities.

If control is lost, this may constitute an emergency and the emergency response plan (see Section 5.2 of the Tailings Guide and *Section 4* of this Guide) would be implemented. Circumstances that would constitute an emergency must be identified during the risk assessment and linkages to the emergency response plan need to be described in the corresponding critical control procedures.

For some performance criteria a series of trigger levels of increasing concern/severity may be described, rather than a single trigger level. Using this approach, surveillance results would be categorized as reflecting normal, upset or emergency conditions. Emergency conditions would trigger the implementation of the emergency response plan. Upset conditions may represent a range of performance between normal and emergency. An Owner may define various alert or action levels within upset conditions. This concept is described further in *Appendix 3* using the example of a Trigger Action Response Plan (TARP).

In incorporating concepts such as critical controls into a tailings management system and corresponding OMS activities, it is important that such concepts be effectively implemented. However, there are other closely aligned concepts that use different terminology. For example, some Owners develop and implement Trigger Response Action Plans (TARPs). It is the concept that is essential, and not the terminology used to describe it.

2.2.3 Managing Change

Change is a source of risk and needs to be effectively managed. Tailings facilities change on an ongoing basis throughout their life cycle, and the broader environment within which tailings facilities exist is also changing. Changes in personnel or organizational structure, including the Owner's employees, contractors and consultants, as well as changes in ownership.

Changes may be substantial and their potential implications for tailings management evident and planned for, such as a decision to extend the life of a mine and the associated tailings facility. However, the cumulative impacts on risk of incremental or gradual changes can be underappreciated or unanticipated. This ties to the concept of normalization of deviance, in which people become so accustomed to deviations from normal or expected behaviour that deviation becomes the norm[1]. In the context of tailings management, this can mean that over time, repeated deviations from performance criteria (e.g., a less than acceptable freeboard) can become the norm as personnel become accustomed to these deviations. In the face of a lack of consequences (e.g., the dam didn't fail) a complacent attitude can take hold. Vigilance, training, and effective communications are vital to avoiding complacency and ensuring that deviations from performance criteria do not become the accepted norm.

Section 4.5 of the Tailings Guide provides guidance on the development and implementation of processes to manage change. In the context of OMS manuals, there are two facets to managing change:

- OMS manuals are tools to help manage change; and
- OMS manuals need to reflect change.

OMS Manuals as Tools to Manage Change

The development and ongoing review of OMS manuals address transitions between life cycle phases. Other potential changes, such as the potential for temporary shutdown of operations, also need to be addressed (see *Appendix 1*). The development and review process also addresses the need to revise OMS activities to reflect planned changes, such as increase an in mining rate, increases in tailings dam height, or progressive reclamation activities. It is difficult to plan for every plausible change that may occur, but an effective OMS manual provides a basis from which to manage change, whether anticipated or not. In the

1. "Normalization of deviance means that people within the organization become so much accustomed to a deviant behavior that they don't consider it as deviant, despite the fact that they far exceed their own rules for the elementary safety" *https://sma.nasa.gov/docs/default-source/safety-messages/safetymessage-normalizationofdeviance-2014-11-03b.pdf?sfvrsn=4*

event of changes, including deviations of performance, that were not anticipated and not addressed in an OMS manual, relevant sections of an OMS manual should be referred to, to guide and inform an effective response to the change.

OMS manuals are valuable in helping to manage changes in personnel. An OMS manual documents the site-specific knowledge of OMS activities acquired by personnel. In addition, an OMS manual is a tool for training personnel to understand the tailings facility and their specific roles and responsibilities related to tailings management.

OMS, particularly surveillance activities, helps identify changes that must be managed, including those linked to performance objectives, risk controls, and critical controls. These may include gradual or incremental changes such as changes in performance.

OMS Manuals Need to Reflect Changes

An outdated OMS manual is a risk to any tailings facility. If OMS activities being implemented are not reflective of current conditions, resulting management actions may be at odds with the risk management plan and associated critical controls required for intended performance of the facility. Review and updating of OMS manuals is further discussed in *Section 2.6*, and control of documented information is further discussed in Section 4.6 of the Tailings Guide.

2.3 Informing Decision-Making

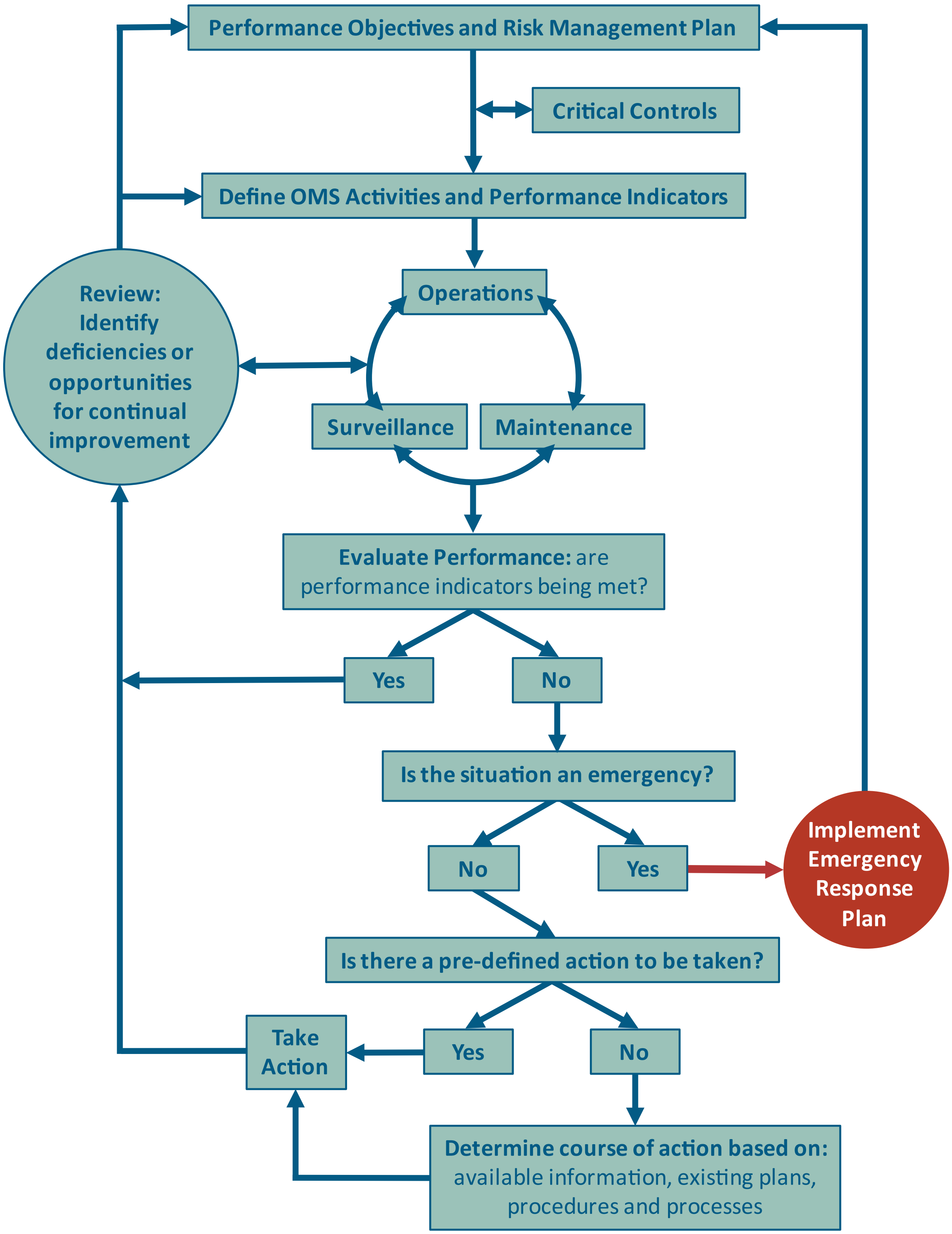
To minimize harm, optimize tailings facility performance and manage risk, Owners must make informed decisions about tailings management. A tailings management system provides a governance framework for decision-making and OMS activities play an essential role in providing information. Without a rigorous approach to decision-making for tailings management, informed by surveillance results, there is an increased risk that decisions:

- are based on incomplete or inaccurate information;
- are ad hoc and short-sighted in nature; and
- may fail to support the objectives of optimizing performance and managing risk.

Outcomes of OMS activities provide a basis to make informed decisions, based on the performance objectives and the risk management plan, and informed by a range of inputs, including:

- design intent/criteria of the facility;
- updated risk assessment;
- closure and post-closure objectives;
- performance of the facility;
- the life cycle phase of the facility;
- legal requirements;
- corporate policy; and
- commitments to COI.

Figure 3: Decision-making framework for tailings management



A rigorous approach to decisions provides a structured, consistent mechanism for decision-making, helping to ensure that decisions are taken by persons with the appropriate authority and competencies, and are based on relevant information. Such an approach can be inclusive of the full range of decisions associated with tailings management, including those with pre-defined management actions based on surveillance results. In the case of an un-anticipated event or surveillance outcome, an OMS manual and decision-making framework can help inform an appropriate response.

To facilitate decision-making an OMS manual describes the accountability, roles, and responsibilities of those making decisions, including the limits of their decision-making authority, and the lines of communications across the organization. These aspects are addressed further in *Section 3.1*.

A generic decision-making framework for tailings management is illustrated in Figure 3. This is an illustrative example only, with simplified "yes/no" decision points. The reality may be more complex, but the intent is to visually capture how decisions are made, and where OMS fits in that process.

The observational method offers one possible conceptual approach and framework for decision-making. This method is summarized in *Appendix 4*.

2.4 Developing an OMS Manual

2.4.1 Owner-led Development Team

Development of an OMS manual is led by a team of employees (as opposed to contractors or consultants) with responsibilities for various aspects of tailings management at the site[2], and there needs to be one person with designated lead responsibility for the OMS manual – the owner of the OMS manual.

Specific third-party expertise should be sought for certain aspects of an OMS manual. For example, input from the designer and Engineer-of-Record (EoR) is necessary. If members of the development team do not have sufficient experience in developing an OMS manual, then it would be appropriate to hire a contractor to work with them in a supporting or advisory role, rather than hire a third-party to take over its development.

The development team must be multidisciplinary and reflect all aspects related to tailings management and coordinated with other aspects of site operations that relate to tailings. For the development of an initial OMS manual for a new tailings facility, the team would include those involved in planning the tailings facility. Once operational experience is gained, the team includes those directly involved in tailings management so that the updated OMS manual reflects actual conditions and practices.

An effective OMS manual must not be written from a single technical perspective. Rather, it needs to be reflective of the risk profile of the facility and identify OMS activities to address those risks, be they physical or chemical, or both. For example, an OMS manual must not focus solely on geotechnical aspects of tailings management if there are chemical risks to be managed.

To prepare an OMS manual, the development team may draw on information from a wide range of sources, as described in *Appendix 5*.

2. The development team should engage personnel with responsibilities related to permitting activities and regulatory affairs. This will help to ensure communications between these groups and help ensure that the OMS activities address legal requirements.

2.4.2 Usability and Accessibility of OMS Manuals

An OMS manual needs to provide the right information in a clear, well-written manner, and it needs to be presented in a usable structure and format that is readily accessible to personnel involved in tailings management.

> The target audience for an OMS manual is all personnel involved in tailings management, including those new to the tailings facility and those who are less experienced or have less specialized competencies, and who may not be fully aware of the "big picture" of tailings management and the potential consequences of not conducting OMS activities in accordance with design intent and performance objectives.

The development team needs to write an OMS manual in a manner that addresses the needs of the intended audience, including:

- writing an OMS manual in clear, concise language, using maps, figures, photos or tables as appropriate to illustrate;
- providing the right level of detail, with links to how more detailed information can be accessed (e.g., surveillance section addresses the need to calibrate instruments, but calibration procedures can be provided through links to documentation from the instrument manufacturer);
- identifying the potential risks and consequences of not conducting OMS activities as prescribed in the OMS manual; and
- focusing on information directly related to OMS activities, avoiding unnecessary description of broader concepts related to tailings management (e.g., tailings management system).

The information contained in an OMS manual needs to be sufficiently detailed to allow personnel to properly operate and maintain the facility and to understand through surveillance when situations are developing that may require action, and whom to contact.

One key consideration in making an OMS manual accessible is how it is structured. In this regard, "manual" may not be the most appropriate term since it implies a single document. Given the complexity and variety of OMS activities across the life cycle of tailings facilities, compiling an OMS manual as a single document may be a barrier to making the manual accessible. It may be better to structure an OMS manual as a series or system of linked modules, with each module addressing a specific topic or type of activity and reflecting input from personnel involved in that activity. For example, a short module specific to surveillance of piezometers in a tailings dam is more accessible to personnel responsible for that surveillance than embedding that information in a larger and more all-inclusive manual. Similarly, OMS activities specific to a temporary shut-down and subsequent re-start could be described in a separate module that would be implemented only in the event of such a shut-down.

For a modular approach to be effective, each module must clearly state where it fits in relation to other modules and what the linkages are. Flowcharts showing the linkages and communication pathways between the different modules may be used to help ensure proper flow of information and an understanding amongst users of who is responsible for what activities associated with the facility.

Although a modular approach is potentially more decentralized in structure than having a single manual, there must still be a designated owner of the OMS manual, and the modules need to be managed as controlled documents, as described in Section 4.6 of the Tailings Guide.

The final consideration in accessibility of an OMS manual is the format in which it is made available to personnel. The most appropriate format will depend on the site, the degree of information management support available, on-site availability of portable computers or mobile devices, and availability of mobile networks or wireless internet connectivity on-site.

In some cases, the most appropriate format may be to have an OMS manual available in paper copy only, even if a modular approach is used. However, providing an OMS manual only as a paper document has significant limitations:

- Document control is more challenging. If personnel have paper copies, it is challenging to ensure that all paper copies are up-to-date when changes are made.
- Using paper copies makes it impossible to hyper-link to relevant documents, so the development team will have to decide if those documents are to be included in the OMS manual. In the example above about instrument calibration procedures, if paper copies are used the development team may opt to include those procedures in the paper copy of the OMS manual, adding to the size of the OMS manual.

If the Owner has the technologies in place to do so, it is preferable to distribute an OMS manual electronically. This will make it easier to address document control and linking with other documents and makes it easier to distribute the manual. An electronic version available on a range of devices will make it easier for personnel to access relevant content and associated reference materials. Potential options that allow document control include:

- a PDF (portable document format) document with hyperlinks to other sections or modules and to reference documents, and automatically updated when a device is connected to the Owner's network; or
- a web-based system of OMS modules, accessible via mobile network or wireless internet (e.g., a "wiki" type of structure, such as that used for the *Global Acid Rock Drainage (GARD) Guide)*.

2.4.3 Linkages to Other Systems

An OMS manual needs to clearly describe linkages with other relevant plans and procedures, how these other plans and procedures (see examples below) relate to tailings management and OMS activities, and associated roles, responsibilities and communications procedures across the various personnel or groups responsible, in order to:

- avoid duplication;
- ensure consistency of implementation of related activities;
- prevent any gaps that can impact tailings management; and
- provide clear documentation of these linkages to ensure continuity in the event that personnel, or that plans and procedures outside the scope of the OMS manual, change.

The development team needs to collaborate with other groups on site to ensure that these other plans and procedures (see examples below) do not conflict with those in the OMS manual, and with the broader objectives of responsible tailings management.

Examples of Linkages:

- If mine water is managed in the tailings facility, and aspects of the risk profile are related to water, then the OMS manual needs to reflect this and linkages with plans and procedures for mine water management needs to be clearly described. Those responsible for tailings management will need to collaborate with those responsible for ore extraction operations to ensure alignment of plans and procedures and ensure that the overall environmental management objectives are met.
- Tailings characteristics, such as grain size and in many cases the percentage of solids, are determined in the ore processing facility. Specifications regarding these parameters are important to meeting the design intent of the tailings facility, and deviations can impact the risk profile. Those responsible for tailings management need to collaborate with those responsible for ore processing to ensure that these specifications, and the implications of not meeting these specifications, are understood, and that changes in tailings characteristics do not compromise tailings facility performance.

2.5 Implementation of an OMS Manual

An OMS manual is only effective if it is properly and consistently implemented. This requires that the manual is accessible, as described above, and that all personnel expected to use the manual:

- are aware of its purpose and importance;
- know how to access the OMS manual;
- understand their roles, responsibilities, and level of authority related to tailings management;
- have the knowledge and competence to fulfill their roles and responsibilities; and
- understand the OMS activities they are engaged in.

Training is needed to help ensure that personnel have the necessary knowledge, skills and competencies to fulfill their roles and responsibilities related to tailings management. There are three components to training:

- training for new personnel;
- refresher training at a frequency determined by the Owner, taking into account the risk profile of the facility; and
- training associated with updates to the OMS manual.

Training addresses both:

- general aspects, such as the Owner's policy and commitments related to tailings management, and the overall goals of responsible tailings management; and
- specific aspects (e.g., technical, communications, management) related to the roles and responsibilities of individual personnel.

Training may be carried out using in-house resources but there may be a need to involve external parties such as the designer or EoR in development of the training materials. Owners may consider some form of evaluation of personnel on their knowledge of the content of the OMS manual to demonstrate competency. A tracking mechanism needs to be in place (e.g., training needs matrix) to ensure that all relevant personnel receive appropriate training.

The Owner needs to have a roll-out strategy, including a training component, for a new OMS manual or any significant revisions to the OMS manual.

It may be more appropriate to address these training requirements in a separate training program, as described in Section 4.10 of the Tailings Guide. Regardless of where an Owner describes these training requirements, is it essential that appropriate training be provided.

2.6 Reviews and Updates of an OMS Manual

Regular reviews of an OMS manual must be undertaken. The frequency of reviews will vary depending on the risk profile of the facility and the life cycle phase. Frequency needs to be prescribed by the Owner to ensure that reviews are conducted on a pre-determined schedule. Annual reviews are considered a best practice for tailings facilities in the operating and ongoing construction phase. Given the range of activities occurring as the closure plan is implemented, it may be appropriate to continue with annual reviews during the closure phase. Reviews of OMS manuals may be less frequent during the post-closure phase, depending on the risk profile and site conditions.

In addition to scheduled reviews, a review may be triggered by a significant event or departure from expected conditions (e.g., a significant increase in ore production rate, leading to an increase in the volume of tailings being produced).

In conducting reviews, the development team needs to consider a wide range of information, including:

- performance of the facility;
- deviations from the approved design;
- the current life cycle phase of the facility (see *Section 2.1.3* and *Appendix 1*);
- status of progressive reclamation activities;
- relevant advice and recommendations from site inspections, Independent Review, audit, and evaluation of effectiveness;
- changes since the last review in:
  - site conditions;
  - ore processing or tailings characteristics;
  - characteristics of the tailings facility (e.g., increased dam height since the last review);
  - performance objectives and indicators;
  - risk profile of the tailings facility;
  - critical controls;
  - personnel or organizational structure;
  - methodologies and technologies for OMS activities;
  - legal requirements;
  - COI perspectives; and
  - closure plan;
- plans to address any gaps or deficiencies in performance;

- plans for continual improvement; and
- future plans for the tailings facility.

An OMS manual must document site-specific knowledge, experience, and lessons-learned of personnel. This helps to manage changes in personnel, by documenting site memory and accumulated knowledge so that it can be passed on to new personnel.

When reviewing an OMS manual, the development team needs to consider practical experiences and lessons related to OMS activities by obtaining input from a range of users of the OMS manual including key roles such as the EoR and personnel involved in day-to-day OMS activities.

At sites where a tailings management system is in place (see *Section 2.2.1*) the Performance Evaluation and the Management Review for Continual Improvement may inform the review of the OMS manual, including identifying deficiencies or opportunities for continual improvement.

When reviewing an OMS manual and considering changes, the potential impacts of proposed changes on the risk profile of the tailings facility need to be considered (see Section 4.5 of the Tailings Guide). This includes consideration of the potential cumulative impacts of past changes or deviations. This helps to reduce the risk of complacency in the conduct of OMS activities, and to reduce the potential for short-term operational decisions to increase risk. If any changes are made to the OMS manual which could impact the risk profile, the rationale for these changes need to be documented, and the decision to make these changes needs to be taken at a level commensurate with the associated change in the risk profile.

Reviews of an OMS manual may lead to updates to the entire manual, or to certain modules. An OMS manual may also need to be updated in response to:

- planned changes, such as changes in surveillance instrumentation or methodologies, or introduction of new instrumentation or methodologies;
- changes in personnel or roles referred to in the OMS manual; and
- other changes that may occur that need to be addressed prior to the next scheduled review of the OMS manual.

Updates, such as those related to changes in personnel, need to be completed in a timely manner, and may be more frequent than updates to address outcomes of reviews of an OMS manual.

3 Contents of an Effective OMS Manual

This section addresses aspects to be considered by an OMS manual development team in developing a site-specific OMS manual. The structure of this section may provide a potential outline of the structure of an OMS manual, but as described in *Section 2.4.2,* it is up to the development team to identify the best way to structure their OMS manual.

The sections below provide guidance for an OMS manual development team. However, given the wide range of conditions under which tailings facilities are operated, and the different OMS requirements across the life cycle of any given facility, there are few specific OMS activities that may be considered universally applicable.

3.1 OMS Governance

3.1.1 Roles, Responsibilities, and Authority

Personnel involved in tailings management need to understand their roles and their lines of communications and relationships with others with direct or indirect roles related to tailings management. An OMS manual describes:

- tasks and functions related to OMS activities;
- roles, responsibilities, and level of authority of personnel or groups that assume these tasks and functions, including the Responsible Person(s) and the EoR, and other key personnel involved in tailings management; and
- functional relationships and lines of communications:
    - between personnel and groups involved in OMS activities;
    - with personnel and groups outside the scope of the OMS manual and involved in activities that may affect tailings management; and
    - with external parties, including regulators and COIs.

In describing roles, responsibilities, levels of authority, and relationships, an OMS manual development team should focus on functional relationships, rather than organizational relationships as typically described in organizational charts. This approach may be useful for overcoming functional and communications silos that may be unintentionally reinforced by organizational structures.

An OMS manual development team may opt to use a responsibility assignment matrix or RACI (responsible, accountable, consulted, informed) matrix to describe roles and relationships between employees, and also with contractors and consultants, including the designer and EoR (see *Appendix 6*).

An OMS manual clearly describes the relationship between the Owner (specifically the Responsible Person(s)) and their contractors and consultants. This is particularly important with respect to the collection and analysis of surveillance data linked to critical controls management.

An OMS manual needs to clearly address:

- Who is responsible for surveillance data acquisition and analysis?
- What are the lines of communications for reporting in the event that results are outside the range specified for the critical control performance criterion?
- If critical control performance criteria are exceeded:
  - What actions are the Responsible Person(s) and other personnel expected to take?
  - What actions are the contractor or consultant expected to take?

Actions to be taken by the Responsible Person(s) and other employees must be clearly described so that appropriate action can be taken in the event that the contractor or consultant cannot be contacted in a timely manner.

3.1.2 Tracking of OMS Activities

An OMS manual describes processes and procedures to track the implementation of OMS activities, including identifying:

- Who is accountable for ensuring the activity is conducted as required?
- Who is responsible for carrying out the activity?
- What is the schedule at which the activity is to be conducted?
- How is implementation of the activity tracked, and how and when is that information reported to the accountable person?

The tracking system provides a mechanism to assure the accountable person that the activity has been conducted as scheduled. The tracking system needs to include a mechanism to flag occurrences when the activity has not been conducted as scheduled, providing the accountable person with the information they need, in a timely manner, to be able to take appropriate action.

3.1.3 Quality Management

A quality management plan needs to be in place to address a wide range of aspects related to tailings management, including OMS activities. There are two components to quality management: quality assurance (QA) and quality control (QC).

Quality, quality assurance and quality control are defined in the ISO 9000 Quality Management Standard as follows:

Quality: the degree to which a set of inherent characteristics fulfils requirements.

Quality assurance (QA): all those planned and systematic activities implemented to provide adequate confidence that the entity will fulfill requirements for quality

Quality control (QC): the operational techniques and activities that are used to fulfill requirements for quality.

QA ensures that you are doing the right things, the right way. QC ensures that your results are what you require.

An OMS manual needs to describe quality management requirements, processes, and procedures for OMS activities. For maintenance, this could include, for example, describing procedures to verify that maintenance activities have been conducted as specified (e.g., the correct amount of oil was added during an oil change). For surveillance, the quality management plan would include information such as:

- required frequency and methodology for calibration of instruments; and
- protocols or standard operating procedures to collection of samples for laboratory analysis to prevent cross-contamination, sample preservation requirements, and procedures to document chain of custody.

3.1.4 Reporting

An OMS manual describes reporting relationships between different individuals and business units with direct and indirect roles related to tailings management. An OMS manual also describes, in a more detailed manner, reporting relationships and how information related to specific OMS activities needs to flow. An OMS manual also needs to describe processes and procedures for reporting outcomes of OMS activities.

An OMS manual must clearly describe reporting requirements for any surveillance results that are outside the expected range of observations or performance, as these results may be indicative of upset conditions or a potential emergency. Any such results must be communicated in a timely manner so that appropriate decisions can be taken by those with the responsibility and authority to act under the circumstances.

3.1.5 Training and Competence

An OMS manual describes minimum knowledge and competency requirements for each position with defined responsibilities. These requirements can be described using attributes for each position, which can assist in recruiting personnel with the appropriate knowledge and competencies and can also help personnel identify career development goals and opportunities which may help with staff retention.

As discussed in *Section 2.5* and in Section 4.10 of the Tailings Guide, training requirements need to be identified to ensure that competencies are met and updated or renewed as appropriate. Training programs need to be developed and implemented to ensure that appropriate training is provided to personnel working at the facility.

3.1.6 Succession Planning

Changes in personnel can be a source of risk for tailings management, and succession planning is a tool to help manage that risk. The development and implementation of succession plans would typically be outside the scope of an OMS manual. However, an OMS manual development team needs to identify roles or positions for which succession planning would be important to manage risks. An OMS manual describes knowledge and competency requirements, transition plans, and handover procedures for those roles or positions.

3.1.7 Resources and Scheduling

For effective development and implementation of an OMS manual, and for reviews and updates, the Owner needs to identify, secure, and regularly review adequacy of:

- human resources, external contractors, and consultants;
- condition, function, and suitability of equipment;
- financial resources; and
- schedules of OMS activities.

Descriptions of resource requirements, such as personnel and financial resources, should not be described in an OMS manual. However, an OMS manual can be used as a basis to estimate, justify, and secure required resources.

Schedules of OMS activities are described in an OMS manual. See *Sections 3.3*, *3.4* and *3.5*.

3.1.8 Occupational Health and Safety

The conduct of OMS activities can present unique occupational health and safety challenges. For example, surveillance activities may present risks not typically faced by other personnel working at mine sites, from working on or around water, to the risk of encounters with large animals. In conducting OMS activities, as in all other activities on mine sites, safety must be paramount.

It is essential that all OMS activities be conducted in accordance with best practices for occupational health and safety, and in conformance with the Owner's standards and requirements. Such activities must also be conducted in compliance with applicable legal requirements. Personnel must be provided with appropriate training.

3.2 Tailings Facility Description

There are many factors that could affect the performance and risk profile of a tailings facility throughout its life cycle, including (see *Appendix 7* for further examples):

- site conditions, including climate;
- COI perspectives;
- legal requirements and commitments;
- tailings facility characteristics;
- tailings facility performance; and
- future plans and how they may impact the tailings facility.

Understanding such information is essential to the responsible management of tailings and effective management of change. This information needs to be clearly documented, maintained, and retained.

An OMS manual refers to or summarizes this information and, if referenced, provides direction (potentially in the form of electronic links) to facilitate access and retrieval of pertinent information. The objective of this summary is to provide context, linking OMS activities to the risk profile of the facility, performance objectives, critical controls, legal requirements, etc., to help ensure that personnel understand the potential implications for tailings management of their individual role, responsibilities, level of authority, and actions.

3.3 Operation

Tailings facility operation includes activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water. The term "operation" applies throughout all phases of the life cycle of a tailings facility and is not limited to the operations and ongoing construction phase of the life cycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

This component of an OMS manual defines and describes plans and procedures for implementing operating controls that enable the tailings facility to be operated in accordance with the design intent, performance objectives, risk management plan, and critical controls for the facility.

3.3.1 Performance Objectives

Performance objectives are overall goals, arising from the Owner's policy and commitment, which are quantified where possible. Performance objectives are established based on:

- design intent of the tailings facility;
- environmental requirements;
- risk assessment and the level of acceptable impact and risk;
- risk management plan; and
- closure plan and post-closure land use.

Performance objectives need to be developed in collaboration with the EoR, Responsible Person(s), and other key personnel. Table 1 provides examples of possible operational controls to be addressed by performance objectives.

Performance indicators are measurable and quantifiable performance requirements that arise from the performance objectives that need to be defined and met to achieve the objectives. Performance criteria specify the expected or acceptable range of performance for each indicator and ranges of performance that may require that some specific corrective action be taken (i.e., link to critical controls, TARPs, etc.).

Table 1: Examples of operational controls to be addressed by performance objectives

Tailings transportation and placement
■ placement schedule and calibration
■ performance of dewatering systems
■ tailings characteristics (e.g., grain size, water content, chemical properties, sub-aerial and sub-aquatic beach angle, tailings dry density, strength, etc.)
■ performance of tailings transportation systems (e.g., pipeline, conveyor belt)
■ performance of associated electrical and mechanical systems (e.g., pumps, motors)
■ placement requirements (e.g., compaction, water content, trafficability)

Tailings containment
■ foundation specifications ■ construction specifications ■ construction material availability and scheduling of expansions (e.g., stack armoring, increases in dam height, new cells) ■ perimeter slopes ■ compaction activities ■ erosion control measures ■ dust control measures ■ measures to prevent wildlife access (e.g., bird deterrents)
Water management
■ water balance audits and calibration ■ freeboard and beach width ■ water discharge, volume and quality (normal operating conditions and special circumstances) ■ seepage control and collection ■ reclaim water management
Surveillance
■ surveillance requirements for operational performance indicators ■ thresholds for performance criteria to trigger pre-defined actions
Other
■ procedures to respond to unusual operating conditions (e.g., extreme cold, high rainfall, drought, high winds) ■ progressive reclamation activities

3.3.2 Operating Procedures

The management of every tailings facility needs to follow a range of standard operating procedures (SOPs) that best reflect the characteristics of that facility and support the performance objectives and risk management plan. A typical approach is to develop a suite of SOPs that serve as the foundation of a well-managed facility. The SOPs described in an OMS manual will be dependent on the life cycle phase of the tailings facility.

> A standard operating procedure (SOP) is a set of established or prescribed methods to be followed routinely for the performance of designated operations or in designated situations. They may include procedures, standards, practices, protocols, instructions, rules, etc. The use of SOPs is intended to achieve quality outputs and consistent performance, while reducing the potential for misunderstanding and miscommunication. To be effective, SOPs must be consistently applied by all relevant personnel, and any changes to SOPs must be clearly documented and communicated.

SOPs describe performance indicators and pre-defined actions (e.g., TARPs) to be taken if associated performance criteria deviate from defined ranges. SOPs include a description of the potential ramifications of not responding to a deviation.

SOPs are controlled documents that are reviewed as required and are included or referenced in an OMS manual.

Occupational health and safety and environmental considerations need to be described in SOPs and underpinned in the underlying risk assessment for a given tailings facility.

SOPs will vary from site-to-site and can be broadly classified into three general areas as described in the following subsections.

3.3.2.1 Tailings Transportation and Placement

A tailings transportation and placement plan needs to be developed based on the design intent, performance objectives and risk management plan, and is referenced and summarized in the OMS manual. Specific practices to implement the plan are described in SOPs and in an OMS manual, such as practices to:

- mitigate potential dust generation from the transport and placement of stacked tailings[3] (e.g., seasonal deposition restrictions);
- prevent freezing of tailings pipelines (e.g., specific pumping or placement practices for cold weather conditions); and
- adjust practices if there is a short-term lack of suitable cyclone sand to construct containment structures, due to variations in the ore feed.

The summary provided in the OMS manual covers the expected life of the plan and either demonstrates adequate capacity for the mining plan or emphasizes remaining capacity and the expected update frequency and date of latest update. The short-term (e.g., up to 24 months) tailings transportation and placement plan is implemented through SOPs.

SOPs for tailings transportation and placement describe the relevant elements of the tailings facility and performance objectives and indicators for tailings transportation and placement, such as:

- the expected tailings and/or water characteristics;
- the tailings and/or water transport and handling system;
- personnel and equipment required to effectively meet the performance objectives; and
- a summary of the life-of-mine placement plan, together with detailed, current-year annual plans identifying discharge locations, discharge schedule and planned construction, with reference to supporting reports and plans.

> During operation of a facility, the tailings may vary in physical, chemical and mineralogical characteristics. Representative samples of tailings need to 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 transportation and placement plan (e.g., a change in the tailings specific gravity can affect the deposition slope of the material), effluent quality or the closure plan.

3. Stacked tailings refers to a tailings facility where the tailings have been sufficiently dewatered that they can be transported by truck or conveyor belt. This includes tailings that have been dewatered by filtering, centrifuging, air drying, or other means.

3.3.2.2 Ongoing Construction of Tailings Facility

An OMS manual identifies requirements and plans for staged tailings facility construction during the operations and ongoing construction phase of the life cycle, to maintain adequate solids storage capacity and water management, including:

- method(s) of stacking, hydraulic placement, and/or dam construction;
- schedule of facility expansions;
- material and equipment required;
- construction management procedures; and
- quality assurance and quality control measures and activities (e.g., documentation, as-built survey records).

An OMS manual describes performance objectives and indicators that the tailings facility construction plan and schedule are based on, and acceptable performance ranges for those indicators.

An OMS manual may also be developed for the initial construction phase of the life cycle.

3.3.2.3 Management of Water

Water must be effectively managed for all tailings facilities, regardless of the type of facility (e.g., stack, impoundment of slurry or thickened tailings). An OMS manual describes procedures for management of water associated with a tailings facility (see the definition of tailings facility) under normal operating conditions, as well as under circumstances such as abnormal runoff, severe precipitation events, rapid snow melt, or drought. An OMS manual must include a description of the expected water balance, including identification of all inputs, inventory of pond and interstitial water, and outflows.

An OMS manual describes the operating controls required to manage water under all operating and upset conditions. It also describes performance objectives and indicators for water management, and acceptable performance ranges for those indicators.

3.3.3 Site Access

An OMS manual describes procedures to control access to the tailings facility to assure facility integrity and safety of personnel and the general public. Hazards or safety restrictions related to human or wildlife contact with tailings and associated water need to be addressed, including risk to personnel working on or adjacent to the tailings facility. An OMS manual also describes procedures for third-party access where this is required for traditional uses or under landholder agreements.

3.4 Maintenance

Maintenance includes preventative, predictive, and corrective activities carried out to provide continued proper operation of all infrastructure, or to adjust infrastructure to ensure operation in conformance with performance objectives. The objective of maintenance is to provide preventative and corrective means to achieve performance objectives and manage risk throughout the life cycle of a tailings facility.

The maintenance component of an OMS manual identifies and describes:

- all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.) within the scope of the OMS manual (see *Section 3.3*) that has maintenance requirements; and
- preventative, predictive, and corrective maintenance activities.

There are three categories of maintenance activities:

Preventative maintenance: planned, recurring maintenance activities conducted at a fixed or approximate frequency and not typically arising from results of surveillance activities. Examples include:

- regularly scheduled oil change on a pump, as per manufacturers specifications; and
- calibration and maintenance of surveillance instruments.

Predictive maintenance: pre-defined maintenance conducted in response to results of surveillance activities that measure the condition of a specific component against performance criteria. Examples include:

- replacement of a section of tailings pipeline based on monitoring of the pipe thickness;
- removal of debris from a spillway based on debris accumulation; and
- removal of trees from dams or other structures.

Corrective maintenance: repair of tailings facility components to prevent further deterioration and ensure their operation in conformance with performance objectives. The need for corrective maintenance is based on surveillance activities, with surveillance results identifying the need and urgency of maintenance. Pre-defined actions based on surveillance results and performance criteria (e.g., TARPs) may include specific maintenance activities. Examples include:

- repair of erosion gullies;
- settling of a section of a dam or other containment structure, such that it is lower than the designed elevation;
- unplugging of toe drains; and
- replacement of a broken pump or failed section of pipeline.

The distinction between predictive and corrective maintenance may be arbitrary in some cases. However, both underscore the importance of ensuring that the maintenance section describes procedures for the timely analysis and communication of surveillance results so that maintenance activities can be undertaken.

Maintenance requirements are informed by the performance objectives and risk management plan. For example, failure modes and effects analysis (FMEA) combined with a bow-tie assessment (see Appendix 1 of the Tailings Guide) can be used to help identify requirements for preventative and predictive maintenance. This approach can also be used to identify potential corrective maintenance for events which have a high likelihood of occurring during the life of the facility, such as:

- power or communications failures;
- precipitate fouling;
- plugging of toe drains;
- deteriorating condition of surveillance equipment;
- damage from burrowing animals; or
- erosion gullies.

Examples of tailings facility components that should be considered for inclusion in the maintenance plan on a site-specific basis are provided in Table 2.

An OMS manual identifies maintenance activities that are within the scope of the manual and identifies those maintenance activities that could impact tailings management and are addressed in other related plans or procedures. For maintenance activities not addressed in the OMS manual, the OMS manual describes roles, responsibilities, and communications to ensure that those maintenance activities are carried out in a manner consistent with the requirements for tailings management. Examples of maintenance activities that may be outside the scope of an OMS manual include maintenance of:

- access roads;
- electrical system and supply;
- trucks for construction or hauling of filtered tailings;
- tailings thickener or filters; and
- pipelines.

Table 2: Examples of tailings facility components that may require maintenance

Some of these examples, such as maintenance of surveillance equipment, are applicable to any tailings facility. Other examples are specific to certain types of facilities using specific technologies (e.g., conveyors or filters).

Tailings transportation and placement
■ dewatering infrastructure (e.g., thickeners, filters) ■ tailings pipeline (e.g., wear and thickness) ■ paste plant ■ pumps ■ conveyors ■ classifiers ■ haul trucks
Tailings containment
■ dams, embankments or other containment structures (e.g., repair erosion, remove unwanted vegetation) ■ drains ■ seepage barriers
Water management
■ ditches and diversions ■ associated water storage facilities (e.g., seepage collection ponds, settling ponds) ■ evaporators ■ water control structures ■ pipelines ■ pumps, including reclaim

Surveillance
■ geotechnical instruments
■ air quality monitoring equipment
■ meteorological data instrumentation
■ data management, access and retention
Access and required equipment
■ roads, trails
■ heavy equipment and light vehicles
■ power supply and transmission
■ communications infrastructure

3.4.1 Description of Maintenance Activities

For all categories of maintenance activities, an OMS manual describes (or links to relevant references):

- the nature of the activity and the specific maintenance requirements (e.g., refer to manufacturers maintenance specifications, SOPs);
- location of the infrastructure requiring maintenance;
- qualifications or competencies required to conduct the maintenance (e.g., must be an electrician, must be certified to work in enclosed spaces);
- safety hazards and procedures;
- personnel or groups responsible for carrying out the maintenance;
- resources required to conduct the maintenance (e.g., equipment, materials, personnel);
- communications procedures associated with maintenance activities that potentially affect other activities;
    - e.g., for maintenance that requires that power be disrupted, what other infrastructure will be affected, when will it be affected, for how long, and when will power be restored, and who will need to know this.
- tracking and documentation requirements, such as:
    - tracking to ensure activity was completed in a timely manner;
    - documentation of the condition of the equipment or other observations made by personnel doing the maintenance;
    - documentation to demonstrate the activity was carried out appropriately; and
    - recommendations from personnel doing the maintenance;
- reporting requirements:
    - information to be reported;
    - how information should be reported;
    - to whom information needs to be reported; and
    - reporting timelines

For preventative maintenance, an OMS manual also describes the frequency at which the maintenance activity is to be conducted.

For predictive maintenance an OMS manual also describes:

- pre-defined maintenance activities that are conducted based on results of surveillance activities (e.g., clearing of snow, clearing of debris from spillways); and
- linkages with surveillance activities, including:
  - associated surveillance parameters;
  - performance criteria linked to the need to carry out the maintenance; and
  - communications procedures to ensure that results of surveillance activities, and recommendations for maintenance, are documented and reported in a timely manner so that the maintenance activity can be carried out.

For corrective maintenance, an OMS manual also describes:

- likely, credible events based on risk assessment and critical controls;
- for each event, the pre-defined corrective maintenance activities;
- surveillance activities associated with those events;
- communications procedures to ensure that:
  - results of surveillance activities are documented and reported in a timely manner;
  - necessary resources are mobilized; and
  - corrective maintenance is carried out.
- procedures to return to normal operation (if applicable).

While predictive and corrective maintenance are linked to surveillance results, these maintenance activities could include maintenance of surveillance instruments if surveillance results indicate that an instrument is no longer functioning or is not functioning reliably.

An OMS manual identifies materials (e.g., parts, filter material, rip rap) that must be kept in inventory on site to prevent delay in maintenance of components tied to critical controls. In addition, resources identified in emergency response plans must be kept in inventory on site, in the event that an emergency occurs.

> 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 are covered in emergency response plans.

3.4.2 Documentation Associated with Maintenance

An OMS manual describes the information to be collected and recorded as part of the conduct of maintenance activities. Checklists or report forms may be included in an OMS manual or referenced. Examples of maintenance documentation include:

- equipment logs;
- work history;
- frequency and cause of problems;
- component reliability;
- quality control records;
- communications and activity records;
- photographic summaries and/or videos;
- inventory of spares, materials, tools and equipment; and
- change orders.

3.5 Surveillance

Surveillance involves the inspection and monitoring (i.e., collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision making and verify whether performance objectives and risk management objectives, including critical controls, are being met. Surveillance results are used to identify trends and behaviours that are indicative of the tailings facility's actual performance.

An effective surveillance program is:

- conducted by a range of personnel with direct and indirect responsibilities related to tailings management;
- applied across the life cycle of a tailings facility, while adapting to the specific surveillance needs of each phase and changing site conditions;
- based on site-specific performance objectives and the risk management plan; and
- used to inform decision-making related to tailings management, based on the clear, timely reporting of surveillance results.

3.5.1 Design Considerations for a Surveillance Program

Surveillance activities must be aligned with the design intent, performance objectives and risk management plan, including critical controls. A failure to conduct surveillance of the necessary parameters or conducting surveillance at an inadequate frequency could result in a failure to identify instances where action needs to be taken. Similarly, a failure to analyze and report results in a timely manner could result in actions being taken too late, if at all, leading to a loss of control.

On the other hand, the collection of too much data or unnecessary data can increase the burden of data analysis, add to the amount of data that must be stored and managed, increase costs, and be a distraction.

Collection of data that is not helpful to understand the performance of the tailings facility can make it more difficult to understand the "story" that the data are describing and may be a hindrance to taking action in a timely manner when action is needed.

When designing or reviewing a surveillance program, the following questions should be considered:

- What do you need to know? Why do you need to know it? What will this information or data tell you?
  - What information do you need to understand the performance of the tailings facility?
  - What are the performance objectives, criteria and indicators for the risk controls and critical controls for the tailings facility?
- Who needs to know it, and why?
  - In some cases, different business units may need the same data, but for different reasons and at different frequencies. For example, those responsible for ore processing may need to know the grain size of material coming out of the grinding circuit on an hourly basis. Those responsible for tailings management need similar data, but on a much less frequent basis.
- What types of information do you need that can be acquired through direct, visual observation of the tailings facility? For this type of information:
  - How often should visual observations or inspections be made to give you the information you need?
  - What should the person(s) observing or inspecting be looking for?
  - Who should they tell if they see something of potential concern?
- What types of information do you need that can only be acquired indirectly, through measurement of associated parameters or analysis of samples? For example, if you need to know if water is moving through a tailings dam, what do you need to measure?
  - What methodologies can be used to collect the data needed to provide this information?
  - How frequently does this data need to be collected to provide the information you need?
- How does this data need to be analyzed? How frequently does it need to be analyzed to provide the information you need?
- What form do the results need to be presented in to allow you to understand what the information is telling you, how it relates to other information, and what it is telling about the performance of the tailings facility?

Personnel involved in surveillance must understand the expected range of observations or performance of surveillance parameters relevant to their role, so that they can identify any observations or performance outside that expected range, indicating the potential for upset or emergency conditions or a loss of control. They must also understand:

- reporting requirements in such circumstances; and
- pre-defined actions, if any, that they are to take in response to such circumstances.

As described in *Section 2.3*, surveillance results are used to make informed decisions about tailings management. As such, results are compared with specific performance criteria, such as those defined for critical controls or TARPs. A TARP may be developed and implemented which defines trigger levels for each operational and critical control of the tailings facility. A TARP should provide clear guidance on how to react under the identified deviating conditions reported. Outcomes of surveillance activities may trigger action required to improve or mitigate observed conditions or to initiate the emergency response plan.

3.5.2 Surveillance Activities

There are two types of surveillance activities, which are further discussed below:

- site observation and inspections; and
- instrument monitoring.

3.5.2.1 Site Observation and Inspections

Site observation and inspections are used to identify and track visible changes in the condition of the tailings facility. Site observation and inspections include the direct observations by personnel on or adjacent to tailings facilities and may also include observations from helicopters, and photos/videos taken from unmanned airborne vehicles (UAVs/drones and satellites), or surveillance cameras. Examples are provided in Table 3.

Site observation and inspections are an integral part of the surveillance program and may provide the first indication of changing or adverse conditions, particularly where instrument monitoring is scarce or absent, or where adverse conditions develop outside the area of sensitivity of instruments present.

Site Observation

Site observation is conducted by all personnel working on or adjacent to a tailings facility as part of their daily activities, maintaining awareness of the facility in the course of carrying out their duties. While primarily visual in nature, site observation could also include other observations, such as sound (e.g., sound of running water). Personnel, including those who do not have specialized training and competencies related to tailings management (e.g., equipment operators, security personnel) need to be provided with training in site observation to ensure that they understand what is "normal" for the tailings facility, and understand the types of changes that, if observed, need to be documented and reported.

This whole-team approach to site observation can be invaluable. Every person observing a tailings facility can make meaningful observations, as those seeing the facility on a daily basis are often not tailings management specialists. Changes or potentially adverse conditions can develop rapidly between inspections.

Table 3: Examples of changes that may be observed through site observation and inspections

Changes potentially related to physical risks
■ changes in pond level and freeboard ■ evidence of deformation or changes in the condition of dams or other containment structures (e.g., bulges, cracks, sinkholes) ■ evidence of newly formed or expanding areas of erosion ■ evidence of piping or unexpected water movement through dams or other containment structures
Changes potentially related to chemical risks
■ evidence of newly formed seeps, or changes in seeps, and evidence of any changes in seepage characteristics (e.g., higher turbidity, indicated higher suspended solids in the seepage)
Changes related to tailings or water transport
■ condition of tailings lines, spigots and associated infrastructure for tailings transport and deposition ■ condition of pumps for tailings or water ■ any indications of leaks from tailings or water lines ■ condition of the water reclaim infrastructure (e.g., reclaim barge)
Changes related to flora and fauna
■ evidence of wildlife activity or changes in wildlife activity (e.g., birds using tailings ponds, animal burrows, animals grazing on reclaimed areas) ■ changes in nature or extent of vegetation (e.g., tree seedlings growing on a tailings dam)
Changes related to surveillance instrumentation
■ condition of surveillance instruments and associated protections around surveillance instruments (e.g., covers, barriers to prevent vehicle damage) ■ condition of power supplies for instruments (e.g., damage solar panels or above ground power lines) ■ condition of communications infrastructure associated with instruments (e.g., damage to antennas)

For site observation an OMS manual describes:

- processes and procedures for documenting observations;
    - e.g., a checklist may be provided to personnel with instructions for written and photographic documentation of observed conditions; and
- processes for reporting any observations that have been documented.

Inspections

Inspections are conducted by engineers or other personnel with appropriate training and competency and are more rigorous than site observation. These may be ground-based or airborne, depending on the scope and objectives of the inspection.

Routine inspections are conducted on a pre-defined schedule (e.g., a weekly inspection of perimeter dams), and may target specific activities (e.g., daily inspection of tailings pipelines). Their objective is to identify any conditions that might indicate changes in tailings facility performance and therefore require follow-up. Of particular significance are new occurrences or observed changes in erosion, sinkholes, boils, seepage, slope slumping or sliding, settlement, displacements or cracking of structural components, clogging of drains and relief wells, etc.

Special inspections are conducted during (if safe and practical to do so) and after unusual or extreme events that may impact the facility (e.g., heavy rainfall, windstorms, rapid snow melt, seismic events, exceedance of minimum freeboard). Significant changes to normal operations, nearby construction activity, or other unusual events might also trigger special inspections.

For routine and special inspections, an OMS manual describes the:

- scope and objective of the inspection;
- frequency for conducting routine inspections (e.g., could be once or more per shift for some types of inspections, weekly, monthly or quarterly for others);
- circumstances that would trigger the need for special inspections;
- conditions or aspects to be observed as part of the inspection; and
- processes and procedures for documenting and reporting results of inspections.

More comprehensive technical inspections, integrating inspections and results of instrument monitoring, may be conducted by the Responsible Person(s), other qualified personnel, the EoR, third party experts, or Independent Reviewers, to have a more complete understanding of the facility's performance and identify deficiencies in performance or opportunities for improvement. Such technical inspections include dam safety inspections (DSIs), dam safety reviews (DSRs), audits, evaluations of effectiveness, and Independent Reviews.

An OMS manual defines the frequency and scope of DSIs, DSRs, and any other technical inspections.

3.5.2.2 Instrument Monitoring

Instrument monitoring provides information on parameters or characteristics that cannot be detected through site observation or inspections (e.g., groundwater movement, water quality), cannot be observed with sufficient precision and accuracy (e.g., movement or settling of a tailings dam), or need to be monitored at high frequency or continuously (e.g., bird monitoring to activate deterrent systems).

The objective of instrument monitoring is to collect data to be used to assess the performance of the facility against the performance objectives and indicators, the risk management plan, and critical controls for the tailings facility. Instrument monitoring and site observation and inspections function together as a comprehensive data set to enable assessment of facility performance and provide a basis for informed decisions. All are essential, and none of these forms of surveillance can be neglected if performance objectives are to be met and risks are to be managed.

Examples of types of information that can be collected through instrument monitoring are provided in Table 4.

For instrument monitoring, an OMS manual describes:

- parameters to be included as part of instrument monitoring, including those not directly related to the tailings facility (e.g., meteorological data, seismic monitoring);
- the frequency of data acquisition for each parameter;
- instrument(s) to be used for each parameter;
- who is responsible for data acquisition for each parameter;
- locations of instruments, or locations where samples are to be collected (e.g., sampling of pore water quality);
- methodology and procedures for data acquisition, including those related to quality management (e.g., instrument calibration, sample collection and preservation protocols);
- processes and procedures for documenting the results of instrument surveillance, and the interpretation of results; and
- who is responsible for documenting the results.

The design and implementation of instrument monitoring needs to consider the implications of disruptions to the acquisition of data linked to critical controls. Contingency plans need to be developed to ensure continuity of data acquisition in the event of a disruption (e.g., damage or malfunction of the instrument, inability to access the instrument location, or a loss of power).

3.5.3 Analysis of Surveillance Results, Communications, and Decision-Making

For the effective use of surveillance results in tailings management and decision-making, results must be collated, examined, analyzed, and reported in a timely and effective manner.

For all surveillance activities, an OMS manual describes:

- the expected range of observations or performance of surveillance parameters, so any results outside that range can be identified and reported;
- methodology and procedures for data analysis, including comparisons with expected performance and critical controls;
- who is responsible for data analysis for each parameter;
- form in which surveillance results and analysis need to be reported (e.g., written report, graph, table);
- timeframes for data analysis and reporting; and
- procedures for reporting results if:
    - observations and performance are within the expected range; and
    - any observations or performance are outside the expected range.
- who is responsible for reporting; and
- to whom the reports are to be provided.

Table 4: Examples of information that can be collected using instrument monitoring

Direct collection of information
■ instruments within or adjacent to the tailings facility, providing information on movement (deformation and stability) within the facility, dam, or other containment structures, movement of water through or under the facility, and pore pressure with the tailings facility and dams or other containment structures ■ instruments to measure in-situ tailings characteristics, such as density and degree of compaction ■ instruments in the ore processing facility providing information on tailings characteristics (e.g., grain size and percent solids) ■ instruments to measure temperature profiles within tailings facilities or dams or other containment structures ■ instruments to measure flow rates of tailings or water in pipelines, and pressure within pipelines ■ instruments on and off site to assess air quality (e.g., amount of particulate matter in the air) ■ surveys conducted to measure: ● ice or snow cover ● extent of vegetation cover ● bathymetry of tailings ponds ● beach slope ● height and slope of dams or other containment structures
Collection of information from remote sensing
■ satellite-based radar used to measure movement or deformation of tailings dams ■ data acquired from airborne surveys (e.g., LIDAR (Light Detection and Ranging) to generate detailed topographical maps)
Collection of information based on laboratory analyses
■ water quality analysis of tailings porewater, seepage, surface runoff, etc. ■ chemical and mineralogical characteristics of tailings (e.g., acid generating potential) ■ characteristics of materials to be used for construction of dams or other containment structures
Collection of information not directly related to the tailings facility but relevant to tailings management
■ meteorological data ■ seismic monitoring ■ monitoring of hazards, such as avalanche risk
Collection of information related to the conduct of OMS activities:
■ power supply for pumps, surveillance instruments and other infrastructure related to tailings management ■ communications systems, including communications with surveillance instruments

The frequency of certain surveillance activities may be increased if results are outside the expected range and such an increase in frequency is one of the pre-defined actions to be taken. In addition, there may be other circumstances where it would be appropriate to increase the frequency of surveillance (e.g., surveillance of certain geotechnical parameters if there is a seismic event above a specified magnitude). An OMS manual describes the conditions under which the frequency of monitoring of certain parameters needs to be increased, and the conditions under which normal frequency can be resumed. Personnel responsible for taking these actions are also identified, as are the reporting requirements.

In analyzing and reviewing the results of surveillance it is important to avoid tunnel vision, and carefully consider the information that surveillance results provide. Those reviewing results need to think beyond the potential outcomes identified through risk assessment and be open to the possibility that the information provided by surveillance is pointing to a potential risk that had not been anticipated.

4 Linkages with the Emergency Response Plan

As described in Section 5.2 of the Tailings Guide, the development and testing of emergency response plans (ERPs) are essential to responsible tailings management.

An emergency is a situation that poses an impending or immediate risk to health, life, property, or the environment and which requires urgent intervention to prevent or limit the expected adverse outcomes.

Examples of possible emergencies associated with tailings facilities include:

- slope or foundation failure;
- extreme precipitation events;
- earthquakes;
- overtopping from storm events or erosion from a tailings pipeline;
- seepage;
- internal erosion;
- uncontrolled release of water;
- a sudden change in instrument monitoring results that are identified as outside the expected, normal or questionable parameter range and indicates that any of the above critical conditions (or other potential failure modes) may be imminent; and
- other events typically linked to the loss of one or more critical controls.

Circumstances that would constitute an emergency are site-specific. The definition of an emergency that would trigger implementation of emergency response measures is linked to the risk profile of the facility. Depending on the nature of the failure modes and controls, there may be a rapid transition from "normal" conditions to an emergency, or there may be a series of warning levels with pre-defined actions to retain control and prevent an emergency. Thus, like OMS manual development, development of an ERP is driven by the risk assessment for the tailings facility, the risk management plan, and performance criteria for critical controls, TARPs, etc.

An ERP describes measures the Owner and, in some cases, external parties will take to prepare for an emergency, and to respond if an emergency occurs. An ERP is distinctly different than an OMS manual, but closely linked. An ERP describes:

- potential emergencies and associated impacts that could occur;
- measures to prepare for a potential emergency;
- measures to respond to emergency situations and to prevent and mitigate on and offsite environmental and safety impacts associated with emergency situations;
- procedures related to site access and communications in the event of an emergency;
- roles and responsibilities; and
- notification procedures and warning systems.

An ERP must be developed for each tailings facility and can be integrated with the overall site-wide ERP. An ERP for tailings facilities may be included in an OMS manual, but it may in many cases be best practice to maintain the ERP as a separate document, to ensure that it is:

- readily accessible in the event that an emergency occurs;
- administered and prepared by the appropriate personnel/groups;
- directed towards the appropriate audience; and
- more easily updated, based on the outcomes of reviewing and testing the plans.

OMS manuals typically address conditions related to operation under normal or upset conditions, as opposed to emergency situations, but an OMS manual and ERP for a given tailings facility must be aligned and the OMS manual must contain necessary information to facilitate the transition from normal or upset conditions to an emergency. In particular, an OMS manual needs to describe, for each plausible potential emergency situation:

- the performance, occurrences, or observations that would result in an emergency being declared;
- roles and responsibilities of key personnel in transition from normal or upset conditions to an emergency; and
- actions to be taken to transition from normal or upset conditions to an emergency situation.

It may not be possible to anticipate all potential emergency situations. However, an OMS manual and ERP need to be sufficiently robust to be adaptable to unanticipated emergencies.

Glossary

Accountability: The answerability of an individual for their own performance and that of any personnel they direct, and for the completion of specified deliverables or tasks in accordance with defined expectations. An accountable person may delegate responsibility for completion of the deliverable or task, but not the accountability.

Accountable Executive Officer: An executive-level person (e.g., CEO, COO, Vice President) designated by the Board of Directors or Governance Level who is ultimately accountable for tailings management, and the development and implementation of the systems needed for responsible tailings management. This accountability cannot be delegated. This Officer:

- needs to be aware of key outcomes of tailings facility risk assessments and how these risks are being managed;
- has accountability and responsibility for putting in place an appropriate management structure;
- delegates responsibility and authority for tailings management and defines the personnel responsibilities, authority, and reporting relationships to implement the systems needed for responsible tailings management through all phases in the facility life cycle; and
- demonstrates to the Board of Directors/Governance level whether tailings are managed responsibly.

Audit: The formal, systematic and documented examination of a tailings facility's conformance with explicit, agreed, prescribed criteria, often requirements stipulated in law, or in the Owner's tailings management system. Audits evaluate and report on the degree of conformance with stipulated criteria, based on the systematic collection and documentation of relevant evidence. Audits involve some degree of judgment but are not designed to determine root cause of deficiencies, or to evaluate management system effectiveness.

Authority: The power to make decisions, assign responsibilities, or delegate some or all authority, as appropriate. The ability to act on behalf of the Owner.

Best Available/Applicable Practice (BAP): Management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

Best Available Technology (BAT): The site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle and supports an environmentally and economically viable mining operation.

Communities of Interest (COI): COI include all individuals and groups who have an interest in, or believe they may be affected by, decisions respecting the management of operations. Facility COI may include, but are not restricted to:

- indigenous peoples;
- community members;
- under-represented groups;
- employees;

- contractors/suppliers;
- neighbours;
- local environmental organizations and other non-governmental organizations (NGO); and
- local governments and institutions.

Other COI may include:

- suppliers;
- customers;
- regional or national environmental organizations and other non-governmental organizations (NGO);
- governments;
- the financial community; and
- shareholders.

Continual improvement: The process of implementing incremental improvements and standardization to achieve better environmental and management system performance.

Critical control: A risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls. Critical controls may be technical, operational, or governance-based. Critical control management is a governance approach to managing high-consequence risks relating to an operation or business.

Dam Safety Review (DSR): A systematic review and evaluation, carried out at scheduled intervals, of all aspects of design, construction, operation, maintenance, and surveillance, and other relevant processes and systems affecting a dam, to evaluate the design criteria with current standards, operational compliance with design intent, stability and functionality of the dam, and to identify appropriate remedial measures.

Dam Safety Inspection (DSI): An inspection of a dam to observe its condition relative to its performance objectives. A DSI is intended to be more thorough than a routine inspection, and includes detailed visual examination of the dam, surveillance instrumentation, and a review of surveillance results. The report of a DSI may include recommendations for maintenance, repairs, investigation, or further surveillance. DSIs are generally carried out by engineers and may be carried out by the Engineer-of-Record.

Documented information: Information of importance that is required to be controlled and maintained by the organization. Documented information can refer to the tailings management system and its processes, documentation, and records.

Emergency: A situation that poses an impending or immediate risk to health, life, property, and/or the environment, and which requires urgent intervention to prevent or limit the expected adverse outcomes.

Engineer-of-Record: The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

For tailings facilities that include retention structures/dams, the EoR is responsible for Dam Safety Inspections and associated reports. The EoR should also participate in the facility's risk assessments and be accessible to ers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process.

Evaluation of Effectiveness: An evaluation of effectiveness goes beyond determining whether a condition has been met and includes an assessment of whether tailings management is achieving the intended results. It considers both the extent to which planned activities have been realized, and the extent to which performance objectives and indicators have been achieved.

Independent Review: Provides independent, objective, expert commentary, advice, and, potentially, recommendations to assist in identifying, understanding, and managing risks associated with tailings facilities. This information is provided to the Owner to:

- facilitate informed management decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care; and
- ensure that the Accountable Executive Officer has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the tailings management system, independent of the teams (employees, consultants, and contractors) responsible for planning, designing, constructing, operating, and maintaining the facility

Legal Requirement: Any law, statute, ordinance, decree, requirement, order, judgment, rule, or regulation of, and the terms of any license or permit issued by, any governmental authority.

Life cycle: The succession of phases in the life of a tailings facility, consisting of: project conception and planning, design, initial construction, operation and ongoing construction, closure, and post-closure. At some sites, the life cycle may also include temporary closure. In the case of tailings facilities, the life cycle, including the closure, and post-closure phases, can extend to decades or centuries, unless the facility is removed at some point in the future if tailings are reprocessed or relocated.

Project Conception and Planning: Begins at the outset of planning of a proposed mine and is integrated with conception and planning for the overall site, including the mine plan and plans for ore processing. The phase includes the use of rigorous decision-making tools to support selection of the location for the tailings facility, and the BAT to be used for tailings management.

Design: Begins once the location and BAT for the tailings facility have been selected and occurs in concert with detailed planning of all aspects of the proposed mine. Detailed engineering designs are prepared for all aspects of the tailings facility and associated infrastructure.

Initial Construction: Construction of structures and infrastructure that need to be in place before tailings placement commences. This includes, for example, removal of vegetation and organic soils, and construction of starter dams, tailings pipelines, access roads, and associated water management infrastructure.

Operations and Ongoing Construction: Tailings are transported to and placed in, the tailings facility. Tailings dams may be raised, or new tailings cells added as per the design. The operations and ongoing construction phase of a tailings facility typically coincides with the period of commercial operations of the mine.

Standby Care and Maintenance: The mine has ceased commercial operations and the placement of tailings into the facility is not occurring. The Owner expects to resume commercial operations at some point in the future, so surveillance and monitoring of the tailings facility continue, but the facility and associated infrastructure are not decommissioned, and the closure plan is not implemented.

Closure: Begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- transitioning for operations to permanent closure;
- removal of infrastructure such as pipelines;
- changes to water management or treatment; and
- recontouring or revegetation of tailings and any containment structures or other structural elements.

Post-closure: Begins when decommissioning work is complete, the closure plan has been implemented, and the tailings facility has transitioned to long-term maintenance and surveillance. During post-closure, responsibility for a tailings facility could transfer to jurisdictional control.

Maintenance: Includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Operation: Includes the activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water. The term "operation" applies throughout all phases of the life cycle of a tailings facility and is not limited to the operations and ongoing construction phase of the life cycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

Owner: The company, partnership, or individual who has legal possession or is the legal holder of a tailings facility under law in the applicable jurisdiction where the facility is located. For example, the company, partnership or individual that owns the mine from which the tailings and wastewater are generated is the owner of those tailings and can be considered the Owner of the tailings facility.

In the case of joint ventures or similar projects, they may be more than one company involved in Ownership. In such cases, the Owner would comprise all companies that are represented on the Board of Directors and are involved in decision-making.

Quality: The degree to which a set of inherent characteristics fulfils requirement.

Quality assurance (QA): All those planned and systematic activities implemented to provide adequate confidence that the entity will fulfill requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfill requirements for quality.

Responsibility: The duty or obligation of an individual or organization to perform an assigned duty or task in accordance with defined expectations, and which has a consequence if expectations are not met. An individual or organization with responsibility is accountable to the person that delegated that responsibility to them.

Responsible Person: Identifies the scope of work and budget requirements (subject to final approval) for all aspects of tailings management, including the Engineer-of-Record, and will delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel. The Responsible Person(s) has clearly defined, delegated responsibility for tailings management and appropriate qualifications.

As a minimum, the Owner needs to designate one Responsible Person for each tailings facility. There may also be a designated Responsible Person at the corporate level.

Risk: A potential negative impact, detrimental to operations, a facility, the environment, public health or safety that may arise from some present process or future event. When evaluating risk, both the potential severity and consequence of the impact and its probability of occurrence are considered.

Risk controls: Measures put in place to either:

- prevent or reduce the likelihood of the occurrence of an unwanted event; or
- reduce or mitigate the negative consequences if the unwanted event does occur.

Risks need to be managed via controls, and risk controls should have designated owners and defined accountabilities. Some risk controls are designated as critical controls.

Standard operating procedure (SOP): A set of established or prescribed methods to be followed routinely for the performance of designated operations or in designated situations. They may include procedures, standards, practices, protocols, instructions, rules, etc.

Surveillance: Includes the inspection and monitoring (i.e., collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision making and verify whether performance objectives and risk management objectives, including critical controls, are being met.

Tailings: A byproduct of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur.

Tailings facility: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

Trigger Action Response Plan (TARP): A TARP is a tool to manage risk controls, including critical controls. TARPs provide pre-defined trigger levels for performance criteria that are based on the risk controls and critical controls of the tailings facility. The trigger levels are developed based on the performance objectives and risk management plan for the tailings facility. TARPs describe actions to be taken if trigger levels are exceeded (performance is outside the normal range), to prevent a loss of control. A range of actions is pre-defined, based on the magnitude of the exceedance of the trigger level.

Appendix 1: Life Cycle of an OMS Manual

As stated in *Section 2.1.3*, an OMS manual needs to be in place and ready to be implemented at the beginning of the operations and ongoing construction phase. However, there are important considerations for OMS manual development, implementation, and updates across the life cycle of a tailings facility, from project conception and planning through to post-closure.

Project Conception and Planning Phase

The outcome of the project conception and planning phase is the identification of a single alternative for tailings management that represents the optimum combination of tailings management technology and tailings facility location.

For new tailings facilities or life extensions of existing facilities, development of a conceptual plan for OMS should begin during the project conception and planning phase. The intent at this phase is not to develop a detailed OMS manual – this would be out of step with the overall planning and design process. Rather, the objective is to consider, at a high level, the OMS requirements of each tailings management alternative considered in this phase.

This facilitates the development of an OMS manual that is aligned with the risk management plan, the closure plan and post-closure land use, and is appropriate to the facility location and technologies used. It also allows consideration of the conceptual OMS activities in the context of the alternatives under consideration, providing an opportunity to identify potential OMS challenges that could be considered in the decision about the tailings management technology or facility location selected, or be averted through refinements to the facility design.

Design Phase

During the design phase aspects relevant to the intended construction and operation of the tailings facility are planned and designed in detail. For some tailings facilities there may be more than one design phase through the life cycle of the facility. During the design phase, specific OMS requirements for each life cycle phase should be identified, and a preliminary version of the OMS manual should be developed. This version of the manual provides a foundation for OMS across the life cycle.

It is recommended that the preliminary version of the OMS manual include components (e.g., modules as per *Section 2.4.2*) for each subsequent life cycle phase, since the OMS requirements of each phase would be different. This includes:

- a detailed module for initial construction, if the Owner intends to apply OMS at this phase;
- a detailed module for the operations and ongoing construction phase;
- modules for the closure and post-closure phases, developed at a level of detail commensurate with the level of detail of the closure plan; and
- a module to address temporary shut-down of mine operations, and associated care and maintenance of the tailings facility.

During the design phase, the OMS manual development team should consider surveillance needs (including consideration of the risk management plan and critical controls) and identify surveillance methods and technologies. It is crucial that planning for surveillance begin before the initial construction phase, since some surveillance instrumentation may need to be installed during the initial construction phase, and some surveillance activities may need to commence during that phase.

Initial Construction Phase

As stated in *Section 2.1.3*, some Owners may choose to develop and implement OMS during the initial construction phase. OMS activities for this phase would be distinct, and although some would carry through into the operations and ongoing construction phase, this would be a separate OMS component or module. At the end of this phase, this module may be removed from the OMS manual and archived. However, it is essential that surveillance information, and information on "as-built" conditions be retained and accessible, as necessary through subsequent life cycle phases.

During the initial construction phase, the OMS module for the operations and ongoing construction phase may be refined and updated, particularly to reflect "as-built" conditions and surveillance results, and to reflect any changes to other relevant aspects of the operation, such as refinements to plans for ore processing as the ore processing facility is constructed and commissioned.

Operations and Ongoing Construction Phase

The transition from the initial construction phase to the operations and ongoing construction phase can be a particularly dynamic period in the life cycle, and the OMS manual should be updated accordingly and implemented through this transition.

During the operations and ongoing construction phase the OMS modules for closure and post-closure should be updated and refined as the closure plan is refined and developed in greater detail. These updates should also reflect the status of progressive reclamation activities that have been undertaken.

If the company expects to continue in the operations and ongoing construction phase of the life cycle for several decades, then the closure and post-closure modules of the OMS manual can be more conceptual than in the case of a facility expected to enter the closure phase within a decade or less. At the same time, unforeseen occurrences can impact the timing of mine closure so some form of closure/post-closure planning from an OMS perspective needs to be reflected throughout the life cycle of the tailings facility even if only at a conceptual level.

As the permanent closure of the facility approaches, the closure plan and the OMS module for closure should be finalized to ensure a smooth transition and appropriate risk management during the closure phase, as well as effective management of change as responsible personnel and contractors change.

At the permanent end of the operations and ongoing construction phase, the OMS modules for this phase and for temporary shutdown may be removed from the OMS manual and archived.

Temporary Suspension of Operations

The OMS manual should address the potential for temporary shut-down of mine operations, and associated care and maintenance of the tailings facility. This should include OMS activities in the event of a short-term, emergency such down (e.g., due to wildfires in close proximity to the facility), and OMS activities in the event of a longer-term shutdown of unknown duration (e.g., due to low commodity prices). This component of the OMS manual may never be implemented but having a plan for OMS in the event of a temporary shutdown is essential to ensure that risks are appropriately managed during this transition, which can be quite sudden, and during the period of the shut down. This component of the OMS manual should also address the re-start of operations.

Closure and Post-Closure Phases

The post-production OMS manual should address closure and post-closure OMS activities. This is an important aspect that should not be overlooked or left to be developed soon before closure. As described in Section 2.2.4 of the Tailings Guide, designing and operating tailings facilities for closure is a key tool to managing risks after operations cease, meeting closure objectives, and achieving planned post-closure land uses. The OMS manual should reflect the evolution of the closure plan, from the project conception and planning phase through to the end of operations. This is important to ensure that OMS activities during operations and ongoing construction are consistent with the closure plan, lay the foundation for the implementation of the closure plan, and address progressive reclamation activities to be implemented prior to closure.

The OMS activities for the closure phase will be distinct. Some, such as certain maintenance and surveillance activities, will carry forward from the operations and ongoing construction phase. Some OMS activities during previous phases will not be relevant to the closure phase, while others may be unique to the closure phase, such as OMS activities associated with the removal of infrastructure.

During the closure phase, the OMS module for post-closure should be updated and refined to reflect actual closure conditions.

At the end of the closure phase, the OMS module for that phase may be removed from the OMS manual and archived.

The component of the OMS manual for the post-closure phase takes a very long-term view but should be reviewed and updated periodically, based on outcomes of maintenance and surveillance activities, and changing conditions.

For post-closure, the OMS manual should consider OMS requirements associated with a potential relinquishment of the tailings facility to government responsibility. In the event of relinquishment, the OMS manual and other records would be handed over to the responsible government authorities to ensure that risks are appropriately managed through that transition, and to provide the necessary information to inform appropriate risk management following relinquishment.

Appendix 2: Examples of Critical Controls for OMS Activities

As described in Section 4.1 of the Tailings Guide, the designation of critical controls is an Owner and tailings facility-specific exercise. Risk controls are typically designated as critical controls if:

- implementation of the control would significantly reduce the likelihood or consequence of an unwanted event or condition that poses unacceptable risk;
- removal or failure of the control would significantly increase the likelihood or consequences of an unwanted event or condition that poses an unacceptable risk, despite the presence of other controls;
- the control would prevent more than one failure mode, or would mitigate more than one consequence; or
- other controls are dependent upon the control in question.

Examples of possible critical controls for OMS activities are provided below.

Operation

- Minimum beach length
- Appropriate tailings properties (pulp density and fines content)
- Maximum beach length (if dust management is a need)
- Tailings pipeline location from dam crest (prevent erosion of the crest if pipe breaks)
- Minimum dam crest raise to ensure adequate dam safety freeboard
- Tailings deposition patterns to avoid excessive fines
- Tailings beach compaction
- Maximum rate of rise: monthly/annually
- Minimum freeboard
- Minimum decant and water treatment rates
- Emergency response resources

Maintenance

- Dam crest repair
- Erosion gully repair
- Tailings slope erosion removal from drainage infrastructure
- Access availability (snow removal)
- Tailings line movement or replacement cycle
- Ditch maintenance/sediment removal
- Tailings pond decant system (normal conditions and emergency)

Surveillance

- Appropriate types and spacing of instruments
- Defined instrument alarm levels
- Defined instrument reading frequencies
- Pipe rupture alarms (visual monitoring, flow rate and pressure)
- Tailings pond levels
- Precipitation and snow pack
- Decant settings/rates
- Seepage rates and turbidity

Management

- Defined roles and responsibilities
- Defined budget
- Construction authorizations (fill placement or excavation)
- Protocols to address management of unusual or upset conditions or problems
- Emergency response plans

Appendix 3: Trigger Action Response Plans

Surveillance results are used to make informed decisions about tailings management. These results may be used in a trigger action response plan (TARP) that has defined trigger levels for performance indicators that are based on the critical controls of the tailings facility. The critical controls and their trigger levels are based on the performance objectives and risk management plan for the tailings facility.

The TARP describes pre-defined risk management actions to be taken if trigger levels are exceeded (performance is outside the normal range) to prevent a loss of control.

A series of escalating qualitative risk levels are described for each performance indicator. For each performance indicator and each risk level there are pre-defined risk management actions. The number of risk levels are dependent upon the performance indicator, the risk management plan, and the associated critical control. An example of a four risk-level framework is:

- **Green – Acceptable Situation.** Performance is in line with performance objectives.
- **Yellow – Minor Risk Situation.** There may be a pre-defined risk management action that can be taken, or the pre-defined action may be to increase the frequency of surveillance and analysis. Other surveillance activities may be undertaken. Surveillance results and corresponding actions are documented and reported.
- **Orange – Moderate Risk Situation.** Pre-defined risk management actions are implemented. Surveillance activities may be intensified to monitor the performance indicator in question, related performance criteria, and the effectiveness of the risk management action implemented. Expert advice may be sought as appropriate, including from the designer and EoR. Risk management actions are implemented, and results of follow-up surveillance activities are documented and reported. The accumulation or combination of moderate risk situations could lead to a high-risk situation and threshold values will need to be assessed accordingly.
- **Red – High Risk Situation.** An imminent loss of control or a loss of control has occurred. Depending on the potential consequence, this may trigger a very significant pre-defined risk management action (e.g., ceasing ore processing operations) or it may trigger the implementation of the ERP. It is important to note that the accumulation or combination of moderate risk situations could lead to a high-risk situation and threshold values will need to be assessed accordingly.

The concept of defining risk levels is illustrated in *Figure A.3.1*.

The overall process for establishing TARPs is similar to that described in *Section 2.2.2* for critical controls:

- define the hazards or failure modes;
- for each failure mode define the risk levels; and
- describe pre-defined actions for each trigger level.

An example TARP with performance indicators related to critical controls for a tailings facility is shown in Table A.3.1. It is noted that the information shown in the example TARP is not exhaustive or tailored for any specific site. The risk controls for which TARPs are developed, the performance indicators and criteria, risk levels, pre-defined actions, and notification procedures are determined on a site-specific basis.

Figure A.3.1: Illustration of the concept of defining risk levels to establish TARPs. Note that performance for a given parameter may not be normally distributed, and there may only be performance at the high or low end of the curve which is defined as outside the acceptable situation (e.g., freeboard of a tailings dam).

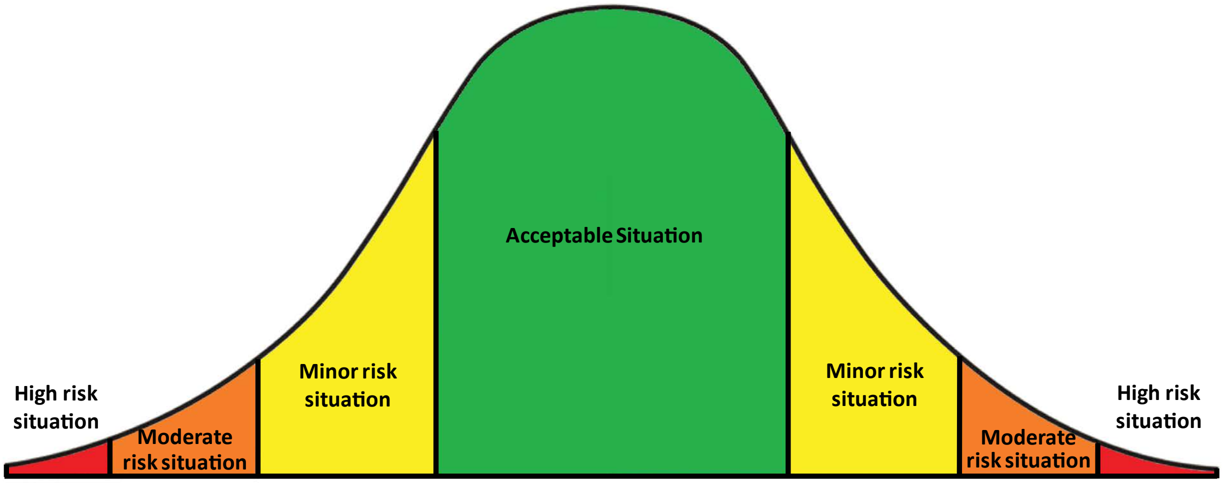


Table A.1.1: Example TARPs with performance indicators related to critical controls, and pre-defined actions for various risk-levels.

Indicator/ Control	Acceptable situation	Low risk situation	Moderate risk situation	High risk situation
Tailings facility freeboard	Water level stable and below maximum operating level	Water level exceeds maximum normal operating level	Water level exceeds 50% of the maximum emergency storage volume	Water level exceeds the maximum emergency storage volume
Beach length	Within design requirements.	Minimum beach length violated for less than 1 week per quarter.	Minimum beach length violated for less than 1 week per month.	Minimum beach length violated for more than 2 consecutive weeks.
Displacement, sloughing, or bulging of dam crest and/or downstream slope	None visible. Surveillance results within design limits and range of historic trends.	Visible displacement, sloughing, or bulging. Surveillance results increasing from range of historic trends.	Toe displacement related to sloughing. Bulging of downstream slope >0.5 m in height. Surveillance results continuously increasing from range of historic results.	Toe displacement related to sloughing >3 m from original location. Bulging of downstream slope >2 m in height.
Sinkhole in dam crest or downstream slope	Not visible.	Visible	Sinkhole diameter > 0.5 m in diameter.	Sinkhole diameter >1 m in diameter.
Seepage through dam	Seepage is clear. Seepage in location of historic locations. Seepage rate is within design limits and range of historic trends.	Seepage is turbid. Seepage is new area relative to historic performance. Seepage rate is higher than historic trends.	Same as previous situation plus ongoing increased seepage rate from historic trends.	Accumulation or combination of moderate-risk situations could lead to a high-risk situation and threshold values need to be assessed accordingly
Examples of Pre-Defined Actions				
	Surveillance activities and frequencies according to OMS manual.	Increased surveillance frequencies. • Surveillance results to be immediately provided to EoR for review. • EoR to visit site to assess the situation. • Document location, photograph, and survey area of concern. • Identify potential cause(s). • Implement engineering review. • Plan and take appropriate mitigation measures with engineering review.	All items from previous situation plus: • Suspend activities in area of concern. • Reassess thresholds and conditions for high risk situation taking into account the conditions observed and interactions of various items.	All items from previous situation plus: • Temporary evacuation of non-essential personnel from tailings facility. • Prepare to initialize ERP.
Personnel Notified				
	• Responsible Person • Process Plant Manager Environmental Manager • EoR	All personnel from previous situation plus: • COIs • Regulators • Independent Reviewer(s) • Accountable Executive Officer	All personnel from previous situation plus: • First Responders • Emergency Response Personnel	All personnel from previous situation.

Appendix 4: Overview of the Observational Method

The Observational Method is a design approach most often used in geotechnical engineering, which is sometimes applied through the construction and operating phases of the life cycle of a tailings facility. When correctly applied it becomes a key consideration in the development of critical controls or TARPs.

For mine tailings facilities that are designed, constructed and operated using the Observational Method, the surveillance program is a core component. Baecher and Christian (2003) provide a succinct summary of the essential aspects of the Observational Method:

"The observational method grew out of the fact that it is not feasible in many geotechnical applications to assume very conservative values of the loads and material properties and design for those conditions. The resulting design is often physically or financially impossible to build. Instead the engineer makes reasonable estimates of the parameters and the amounts by which they could deviate from the expected values. Then the design is based on expected values – or on some conservative but feasible extension of the expected values – but provision is made for action to deal with the occurrence of loads or resistances that fall outside the design range. During construction and operation of the facility, observations of its performance are made so that appropriate corrective action can be made. This is not simply a matter of designing for an expected set of conditions and doing something to fix any troubles that arise. It involves considering the effects of the possible range of values of the parameters and having in place a plan to deal with occurrences that fall outside of the expected range. It requires the ongoing involvement of the designers during the construction and operation of the facility."

To properly apply the Observational Method, the anticipated behaviour of the structure (deformations, pore-water pressures, etc.) must be understood, as well as the range of potential deviations from the anticipated behaviour and the likely causes of those deviations. It requires having an engineering model (mathematical or conceptual) that is regularly tested against the surveillance observations.

The Observational Method can be applicable to physical (structural) components of a tailings facility such as overall stability, as well as environmental controls such as seepage mitigation.

Peck (1969) and Morgenstern (1994) note pitfalls in application of the Observational Method:

- The engineer must select in advance appropriate courses of action for all foreseeable deviations of the real conditions, and devise solutions to all problems that could arise, but that will remain undisclosed until the field observations are made. If those hypothetical problems cannot be resolved, the design must be based on the least favourable conditions, and the owner cannot gain the advantages in cost or time associated with the Observational Method.
- If the phenomena governing the performance of the system are complex, extra effort is required in designing the surveillance system to avoid incorrectly measuring the parameters and arriving at an incorrect conclusion regarding the performance of the system.

The Observational Method is not applicable in cases where the failure mechanism is brittle (e.g., static or dynamic liquefaction of critical stability elements of a facility) and could evolve more rapidly than could be observed or responded to with contingency measures, or where other physical or economic constraints preclude the timely and effective application of contingency measures.

References:

Baecher and Christian. 2003. *Reliability and Statistics in Geotechnical Engineering*. Wiley.

CEN. EN 1997-1:2004 Eurocode 7: *Geotechnical design – Part 1: General rules*. Brussels: European Committee for Standardisation; 2004.

Christian, J.T. 2004. *Geotechnical Engineering Reliability: How Well Do We Know What We Are Doing?* Journal of Geotechnical and Geoenvironmental Engineering, ASCE. 130(10): 985-1003.

Morgenstern, N.R. 1994. *The observational method in Environmental Geotechnics*. First International Congress on Environmental Geotechnics – Edmonton. 963-976.

Peck, R.B. 1969. *Advantages and Limitations of the Observational Method in Applied Soil Mechanics*. Géotechnique. 19(2): 171-187.

Appendix 5: OMS Manual Information Sources

The information needed to inform the development of an OMS manual can be drawn from a variety of sources. The conceptual design and conceptual closure plan, and later the detailed design, as well as information from the environmental assessment and permitting of the facility will provide much of the initial information for the first version of an OMS manual, along with information on how the Owner intends to operate the facility.

As the facility evolves this information will be supplemented with a variety of information including but not limited to:

- operational information (e.g., tailings grind-size and percent solids, reagents used and present in the tailings, geochemical characteristics of the tailings);
- operational water balance;
- current design reports;
- as-built documentation (including drawings);
- performance objectives;
- risk assessment, risk management plan and critical controls;
- best practices for surveillance (e.g., methods, instruments, frequency, data analysis);
- best practices related to SOPs;
- manufacturers documentation on maintenance of equipment, calibration of surveillance instruments, etc;
- behavior of the facility; and
- other resources, depending on the jurisdiction and Owner's requirements, such as:
  - *Canadian Dam Association (CDA)*:
    - CDA Dam Safety Guidelines 2007 (2013 Edition); and
    - Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014);
  - *International Commission on Large Dams* (ICOLD);
  - *Australian National Committee on Large Dams* (ANCOLD);
  - *International Standards Organization* (ISO);
    - *ISO 9000 – Quality Management*;
    - *ISO 14000 – Environmental Management*; and
    - *ISO 31000 – Risk Management*;
  - *International Code for Cyanide Management*;
  - *Environment and Climate Change Canada*;
  - *Western Australia Department of Mines and Petroleum*;
  - *Australian Government Leading Practice Sustainable Development Program for the Mining Industry*;

- South African National Standards SANS 10286 1998;
- US Bureau of Reclamation;
- US Army Corps of Engineers;
- *US Federal Emergency Management Agency*; and
- *European Union directive* and *BAT reference document* on mine waste management.

Further, while every OMS manual needs to be site-specific, effective OMS manuals from other facilities can be excellent starting templates, provided that they are not used in a "cut and paste" manner, resulting in the inclusion of activities that are not compatible with or appropriate to the tailings facility to which the new OMS manual is to be applied.

Appendix 6: RACI Matrix Approach for Describing Roles and Relationships

One of the essential elements of effective tailings management is how the various individuals involved in tailings management relate to one another in their day-to-day function. Having a formal process that describes how these relationships should best occur based upon the roles of the individuals involved is considered a best practice. One form of this best practice is to use a

A RACI (**R**=Responsible, **A**=Accountable, **C**=Consulted, **I**=Informed) Matrix or Responsibility Assignment Matrix. A RACI matrix is a delegation tool used to identify each task, milestone, or decision point, and develop, document and communicate roles and responsibilities for each.

The components of the matrix are:

R	**Who is Responsible?** The person(s) assigned to do the work	**The doers**
A	**Who is Accountable?** The person who makes the final decision and is ultimately answerable	**The buck stops here!**
C	**Who is Consulted?** The person(s) who must be consulted before a decision or action is taken	**Two-way communications**
I	**Who is Informed?** The person(s) who must be informed that a decision or action has been taken	**One-way communications**

The steps to developing a RACI matrix are:

1) Identify all the tasks involved in tailings management and list them on the left-hand side of the matrix.
2) Identify who is collectively involved in tailings management (either functional roles or specific individuals) and list them across the top of the matrix.
3) For each task, identifying who has the responsibility, the accountability, and who will be consulted and informed. Fill in the cells of the matrix accordingly.
4) Ensure every task has a role responsible and a role accountable for it – a task without an "R" and an "A" is an unmanaged task that creates risk.
5) No tasks should have more than one role accountable (the "A"). Resolve any conflicts where there is more than one for a particular task.
6) Share, discuss and agree on the RACI Matrix with appropriate personnel.

An example of a RACI matrix is provided in Table A.6.1.

There are a number of potential advantages to using a RACI approach for roles and relationships related to tailings management. Developing and implementing a RACI matrix for tailings management and OMS activities can help:

- clarify and simplify lines of communications and mitigate the risk of communications breakdowns (see *Section 3.1.2*);
- the Responsible Person(s) in delegating responsibility for various tasks, potentially reducing the work-load or stress-load on that person;
- ensure that roles and responsibilities are clearly described across organizational silos, helping to ensure effective function across those siloes; and
- establish clear expectations for all involved in the various tasks, milestones and decision points:
    - everyone needs to clearly understand where they are involved, and with which tasks;
    - everyone needs to understand who is ultimately accountable for a task, which can help avoid confusion or communications problems; and
    - it sets clear expectations for those who will be consulted or informed, so that they understand their roles and what information they will receive.

To be effective, there are a number of factors that should be considered in developing and implementing a RACI matrix:

- There should not be too many roles or personnel identified as responsible for each task. This will create confusion and communications problems.
- All tasks must have assigned roles or personnel:
    - someone needs to be accountable for each task;
    - at least one person needs to be responsible for each task; and
    - it may not always be necessary to identify persons who should be consulted or informed. This can be determined on a task-specific basis.
- Do not assign the Responsible Person(s) as responsible for too many tasks:
    - they need to delegate to be effective; and
    - give careful consideration to what responsibilities can be delegated to other personnel, but clearly define their functional relationship with the Responsible Person(s).
- Do not confuse responsible and accountable:
    - have a clear understanding of each term and be consistent in the application of those terms in assigning who is accountable and responsible for each task.
- Carefully consider who needs to be consulted and who needs to be informed:
    - if someone does not need to be consulted, inform them;
    - however, persons may want a greater role and want to be consulted rather than informed; and
    - involve those persons in the development process and negotiate their roles as necessary to avoid problems in implementation.

Table A.6.1: Example of a template for a RACI matrix. The level of detail in both the tasks and roles identified is up to the Owner to determine on a site-specific basis.

	Roles							
Tasks	**Accountable Exec. Officer**	**Responsible Person(s)**	**EoR**	**Independent Reviewer(s)**	**Ore Processing**	**Operation Personnel**	**Maintenance Personnel**	**Surveillance Personnel**
Operation								
Tailings transport								
Tailings placement								
Water management								
Ongoing construction								
Progressive reclamation								
Maintenance								
Tailings transport								
Containment structures								
Water management								
Surveillance								
Site observation								
Routine inspections								
Dam safety inspections								
Instrument monitoring								
Data analysis								

Appendix 7: Factors that Could Influence Tailings Management

As described in *Section 3.2*, there is a range of factors that could affect tailings managements and tailings facility performance. Examples are listed below.

Site Conditions Outside the Owner's Control

- climate impacts of climate change, and future projections for climate change;
- local and regional hydrology and hydrogeology;
- topography and landforms;
- bedrock and surficial geology and geochemistry;
- natural hazards that could impact the tailings facility;
- local and regional aquatic and terrestrial ecosystems;
- communities potentially impacted by the tailings facility, including those downstream and downwind;
- infrastructure off the mine site that could be impacted;
- commercial and recreational land use; and
- archeological resources.

COI Considerations

- COI concerns related to tailings management, including potential effects on:
  - water quality, including drinking water;
  - wildlife, including birds and large mammals that may use tailings facilities;
  - fish, including the safety of fish for consumption; and
  - air quality.
- Indigenous considerations, including:
  - land claims;
  - agreements with Indigenous communities;
  - traditional land use in the area for harvesting, cultural and spiritual purposes; and
  - Indigenous engagement in environmental management and monitoring.
- risks of the tailings facility to nearby communities, including risks in the event of a catastrophic failure of the tailings facility.

Legal Requirements and Commitments

Understanding relevant legal requirements and the Owner's commitments related to tailings management is necessary to:

- provide context for OMS activities that are related to legal requirements and commitments;
- help ensure that those responsible for tailings management are aware of legal requirements and commitments; and
- align OMS activities towards ensuring conformance with all legal requirements and commitments related to tailings management.

Tailings Facility Characteristics

Basic information:

- location and physical setting of the tailings facility;
- type of ore and rate of ore processing;
- ore processing methods used, including reagents used;
- treatments applied to tailings before transportation to the tailings facility (e.g., cyanide destruction, desulphurization);
- tailings management technology used, and the water content of the tailings;
- tailings characteristics, particularly the potential for acid generation and metal leaching;
- tailings transportation method used (e.g., pipeline, truck);
- tailings deposition methods;
- size of the tailings facility and anticipated life; and
- methods/structures used to contain the tailings and any associated water.

Design and history of the tailings facility:

- the rationale for selection of technology and facility location;
- the original design intent of the facility, including:
  - how the design addressed the site conditions, and legal requirements and commitments described above;
  - engineering basis for the design; and
  - conceptual closure plan and post-closure land-use.
- relevant details related to initial construction, and operations and ongoing construction;
- any deviations from the original design of the tailings facility and associated infrastructure, and the rationale for those deviations;
- water management plan;
- any salient problems, or unique or unanticipated circumstances that have been encountered; and
- status of implementation of the closure plan, including progressive reclamation.

Risk profile and risk management:

- the risk profile of the facility;
- how risks are managed, including:
  - how risks are addressed through the design of the facility;
  - how risks continue to be managed in light of any deviations from the original design;
  - risk management plan; and
  - risk controls and critical controls;
- performance objectives; and
- emergency response plan.

Closure:

- closure objectives and post-closure land-use; and
- the closure plan, including updates to the closure plan.

Information available for old tailings facilities may be quite different compared to new facilities. Some of the information above may not be available for older facilities, while there may be other information not listed above that is relevant to those facilities. It is up to the Owner to determine the most relevant information to be included for each tailings facility.

Tailings Facility Performance

- tailings facility performance against performance objectives;
- effectiveness of risk management measures, including critical controls;
- compliance with legal requirements, and conformance with plans and commitments;
- status of action plans to address:
  - actions to ensure performance objectives are met;
  - actions to address non-conformity with requirements, standards, policy, or commitments; and
  - opportunities for continual improvement.
- Changes to the OMS manual made in response to Performance Evaluation, and Management Review for Continual Improvement, including changes to implement action plans.

Future Plans

- expansions of capacity as per the original design (e.g., increases in height of tailings dams or other containment structures, expansion into new tailings cells);
- expansions of capacity not included in the original design (i.e., expansion of capacity for mine life extension);
- changes in ore characteristics (e.g., different acid generating potential in ore from a newly mined ore zone);
- changes in ore processing (e.g., processing rate, reagents used);

- changes in tailings management technology (e.g., reductions in water content of tailings, desulphurization of tailings);
- progressive reclamation;
- changes made in response to changes in legal requirements or commitments;
- changes made in response to past or current performance of the tailings facility;
- changes in the closure plan and risk management plans during closure and post-closure; and
- other plans that could affect the performance or risk profile of the tailings facility.

The Mining Association of Canada

www.mining.ca