A Guide to the Management of Tailings Facilities

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The Mining Association of Canada

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Foreword

It is with pleasure that I present, on behalf of the members of The Mining Association of Canada (MAC), A Guide to the Management of Tailings Facilities. This Guide is the result of many months of collaboration by a 19-member team of Canadian mining industry practitioners and experts. We owe a debt of gratitude to the team members for the skill, expertise, dedication and enthusiasm which they brought to the task of building consensus in the industry in what is a technical and complex area.

In keeping with MAC's continuing commitment to sustainable development, the Guide was developed as an extension of MAC's Environmental Policy and Environmental Management Framework, specifically applied to tailings management. It encourages mining companies to practise safe and environmentally responsible management of tailings facilities through the development of customized, site-specific management systems. This approach can help the industry develop effective self-regulation, demonstrate due diligence, complement government regulations, practise continuous improvement, and protect the environment and the public.

Although the Guide reflects principles and practices from a variety of sources, it is uniquely designed for the mining industry, incorporating a management system approach rather than a purely technical one. I trust that the industry and others will find it a useful contribution to improving performance in this area.

Gordon R. Peeling, President & CEO
The Mining Association of Canada

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Preface

In June 1996, The Mining Association of Canada (MAC) Board of Directors established a task force to promote the safe and environmentally responsible management of tailings and mine rock.

The task force determined that engineering capability exists and generally is applied throughout the Canadian mining industry in the safe design, construction, operation and closure of tailings facilities. The key to managing tailings is consistent application of that engineering capability within an effective management framework through the full life cycle.

To promote the exchange of information and best practices, the task force arranged two workshops, one on management of tailings and mine rock (December 1996) and another on tailings risk assessment (May 1997). These workshops and related consultations identified the need for a guide to tailings management.

A Guide to the Management of Tailings Facilities was developed through a collaborative effort by representatives of the Canadian mining industry, through MAC, to provide guidance on good practices for the safe and environmentally responsible management of tailings facilities. Its purpose is threefold: to provide information on safe and environmentally responsible management of tailings facilities; to help companies develop tailings management systems that include environmental and safety criteria; and to improve the consistency of application of sound engineering and management principles to tailings facilities.

The Guide reflects sound management practices already in place. It adopts principles and approaches from sources that include mining company manuals, proceedings of the two workshops, the MAC Environmental Policy and Environmental Management Framework, the ISO 14000 Essentials, Canadian Dam Association (CDA) draft Dam Safety Guidelines (September 1997), and international guidelines and standards.

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Introduction

Tailings facilities provide a window on the mining industry. They tell a story to the public about how the industry manages its activities. They also pose a risk that must be managed for the long term. The mining industry has the technology to safely design, build, operate and decommission tailings facilities. This technology must be consistently applied for the safe and environmentally responsible management of tailings.

One way to do this is to establish a comprehensive tailings management system, one that individual companies may adapt and implement under often widely ranging conditions. Through this approach, the industry can develop effective self-regulation, demonstrate due diligence, complement government regulations, and protect the environment and the public. Perhaps more importantly, this will also help individual companies to integrate environmental and safety considerations in a consistent way with continuous improvement in their tailings operations.

Since tailings facilities are site-specific and complex, involving unique environmental settings and physical characteristics, their effective management depends on applying both managerial and technical expertise. No set of generic recommendations can be fully applicable to every operation. A Guide to the Management of Tailings Facilities provides a basis for the development of customized tailings management systems to address the specific needs of individual mining companies. Professional and/or expert advice should be obtained in order to be sure that each company's specific needs are addressed.

Scope and Applicability

This Guide includes:

- a framework of management principles, policies and objectives;
- checklists for implementing the framework through the life cycle of a tailings facility; and
- lists of technical considerations.

The Guide is an extension of The Mining Association of Canada (MAC) Environmental Policy and the MAC Environmental Management Framework specifically applied to tailings management. It is designed to help member companies to assure themselves that they are managing their tailings facilities responsibly and safely, and to demonstrate this to regulators and the public. It will help companies practise due diligence.

This Guide presents a framework to manage tailings facilities in a safe and environmentally responsible manner through the full life cycle of a tailings facility: from site selection and design, through construction and operation, to eventual decommissioning and closure. It is meant to be adapted to specific sites, individual company policies, and local regulatory and community requirements.

The framework is expanded into a series of management action checklists addressing the various stages of the life cycle. These checklists, at any stage, can be used for developing operating procedures and manuals; exposing gaps within existing procedures; identifying training requirements; communicating with stakeholders; obtaining permits; conducting internal audits; and aiding compliance and due diligence.

Appended to the document are lists of technical considerations that address environmental setting, facility design and operating aspects typically encountered

through the various stages of a tailings facility life cycle. The management framework addresses these technical considerations in varying degrees of detail, sometimes revisiting them at different stages in the life cycle.

The Guide is not a technical manual; it does not contain or suggest performance criteria. It is not a comprehensive authority on tailings management, nor is it intended to replace professional expertise or regulatory requirements. Mining companies and tailings facility owners are encouraged to adapt and extend the principles contained in this Guide to meet their own site and operational requirements, incorporating appropriate site-specific performance measures.

A Framework to Manage Tailings

A guiding principle of tailings management must be continual improvement in operational, safety and environmental performance, supported by periodical review and evaluation. This chapter presents the key elements of a framework to manage tailings facilities, which is the foundation for the management action checklists that follow, and which addresses tailings management through the full life cycle. The essentials of this framework are illustrated in Figure 1.

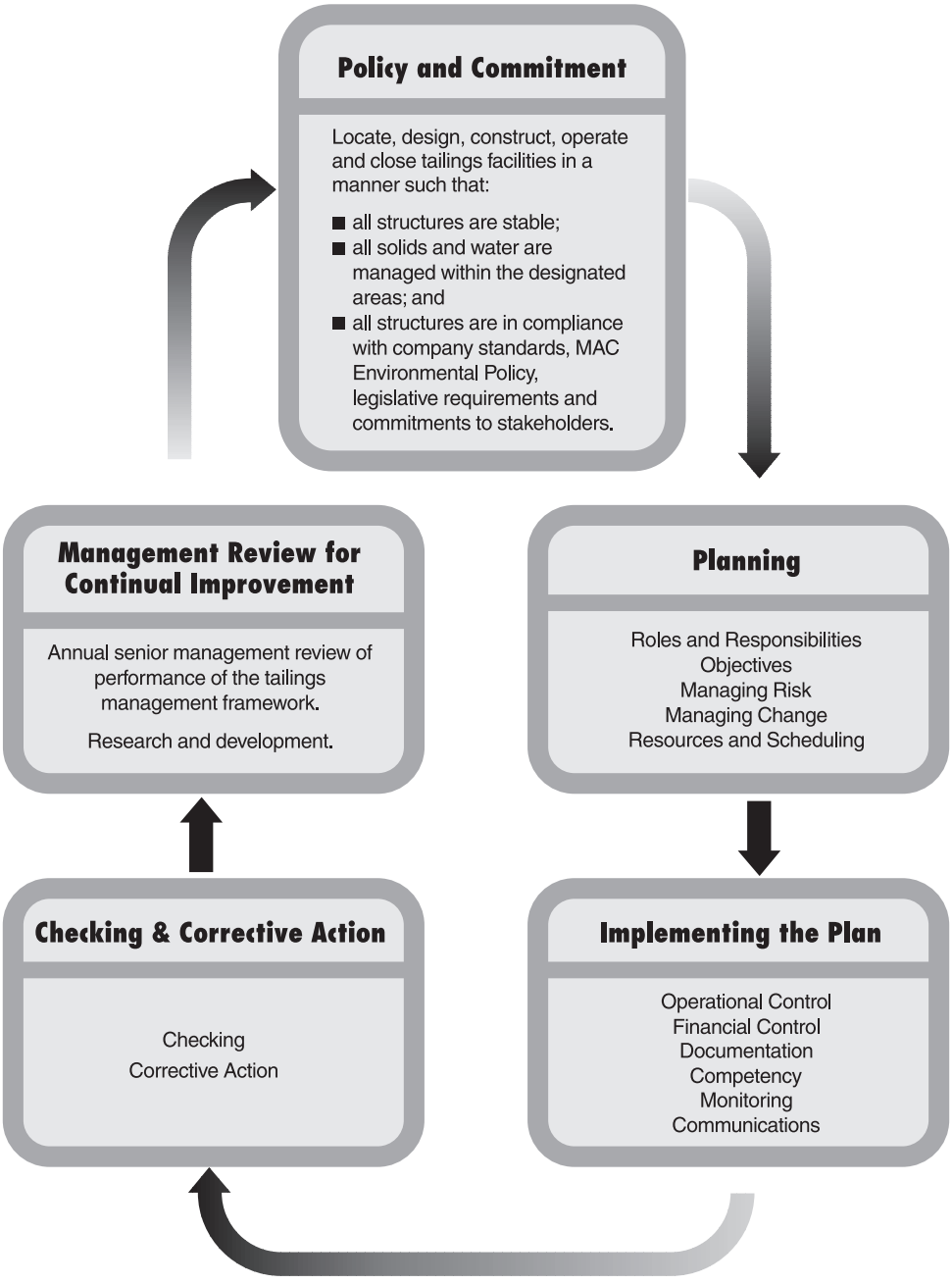

Figure 1: Elements of the Tailings Management Framework

Policy and Commitment

Member companies of The Mining Association of Canada will ensure that their policies include a commitment to:

- implement the principles outlined in this framework;
- locate, design, construct, operate and close tailings facilities in a manner such that:
  - all structures are stable;
  - all solids and water are managed within the designated areas intended in the design; and
  - all structures are in compliance with company standards, the MAC Environmental Policy, legislative requirements and commitments to stakeholders;
- take responsibility for implementing this framework through the commitments and actions of their employees; and
- establish an ongoing program of review and continual improvement to manage health, safety and environmental risks associated with tailings facilities.

Planning

Roles and Responsibilities

Establish a tailings management team with clearly defined roles, responsibilities and authorities to implement the framework through all stages in the tailings facility life cycle.

Objectives

Plan tailings facilities in accordance with this framework, company standards, legislative requirements, and sound engineering and environmental practices.

Identify and assess significant environmental and safety aspects, and their associated risks.

Prepare and document tailings facility plans, including descriptions of:

- aspects, objectives, targets and performance measures;
- permits and approvals;
- roles and responsibilities of key personnel;
- site selection and characterization criteria;
- safety, environmental and engineering design criteria;
- as-built records;
- communication procedures with senior management and external stakeholders;
- construction, operating and decommissioning procedures and documentation requirements;
- monitoring, inspection, reporting and review requirements; and
- knowledge and skills (awareness, training and competence) requirements and training records.

Consult external stakeholders in the identification of appropriate community expectations for tailings facilities.

Design tailings facilities for eventual closure to protect public health and safety, to mitigate negative environmental impacts and to meet acceptable post-closure use within a feasible technical and economic framework.

Managing Risk

Conduct risk assessment, including identification and evaluation of possible failure modes. Plan for risk management to:

- minimize the likelihood of adverse safety or environmental impacts;
- detect and respond to potential failures; and
- establish contingency and emergency preparedness plans to deal with significant events.

Managing Change

Prepare and document procedures to manage changes made to approved designs and plans during implementation.

Resources and Scheduling

Provide the essential resources and schedule for effective and efficient implementation of a tailings management framework, including staffing, specialized skills development, technology and financial resources.

Implementing the Plan

Operational Control

Select a site, design, construct, operate, decommission and close tailings facilities in accordance with the approved design, plans, sound engineering and environmental practices, and the management framework.

Identify, evaluate the impact of, and document changes made to approved designs and plans.

Acquire all required permits and approvals.

Financial Control

Implement a financial control system to track capital and operating costs toward meeting the objectives of tailings management.

Documentation

Prepare, maintain, periodically review and revise the required documents, including as-built drawings. Maintain current versions of all documents at identified locations. Promptly remove from use obsolete versions of documents.

Competency

Employ qualified personnel for tailings facility design, construction, operation and closure. Provide appropriate training to all personnel, including contractors and suppliers, whose work may significantly affect the tailings facility, on:

- tailings facility management plans, permits and approval requirements;
- the importance of conformance to design;
- potential risks;
- significant actual and potential environmental impacts;
- emergency preparedness and response requirements; and
- their individual roles and responsibilities in achieving conformance with the requirements.

Monitoring

Put in place procedures to routinely inspect, monitor, test, record, evaluate and report on a regular basis key characteristics of the tailings facility; include tracking of performance, operational controls and conformance with targets and objectives.

Calibrate equipment to ensure the reliability of data from monitoring and inspections.

Communications

Establish and maintain communication procedures for all personnel who have roles and responsibilities in implementing the tailings management plan, including reporting of significant information and decisions to senior management and external stakeholders.

Checking and Corrective Action

Checking

In addition to routine monitoring and inspections, inspect and review on a periodic basis the entire tailings facility to:

- examine facility implementation and conformance to plans and regulatory requirements;
- re-visit the facility design, construction, operation and closure plans and programs;
- re-evaluate downstream risks (which may change during the life of the facility);
- update consideration of possible failure modes, risk assessment and risk management; and
- identify items requiring corrective action.

Communicate promptly the results of inspections and review to senior management.

Corrective Action

Address items identified during inspections, reviews or audits that require corrective action. Develop and implement action plans for these items, and record upon completion.

Management Review for Continual Improvement

Implement an annual senior management review of the adequacy of policies, objectives and performance of the tailings management framework. Ensure that the scope of this review is appropriate to the level of identified risk. Address the possible need for changes to policies, objectives and other elements in light of inspection reports, changing circumstances, recommendations and the commitment to continual improvement.

Encourage ongoing environmental and safety research to effect continual improvement.

Managing through the Life Cycle of a Tailings Facility

Mining companies face the challenge of effectively and efficiently managing tailings facilities through a life cycle, from initial site selection and design, through construction and operation to eventual decommissioning and closure, as illustrated schematically in Figure 2.

The tailings management framework presented in the preceding chapter provides the essential elements for managing through all stages in the tailings facility life cycle. There is an ongoing need for planning the work to be done on the facility, specific implementation activities, checking and review. The integration of what is to be managed, and how to effectively manage through the life cycle, is of key importance. Figure 3 on the following page illustrates the application of the tailings management framework through the life cycle of a tailings facility.

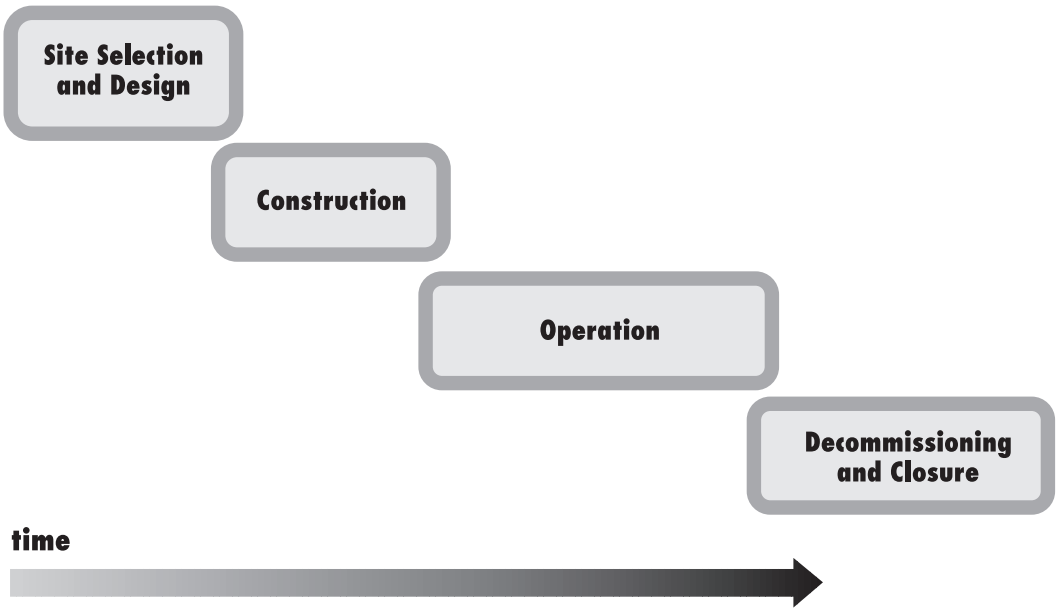

Figure 2: Stages in the Life Cycle of a Tailings Facility

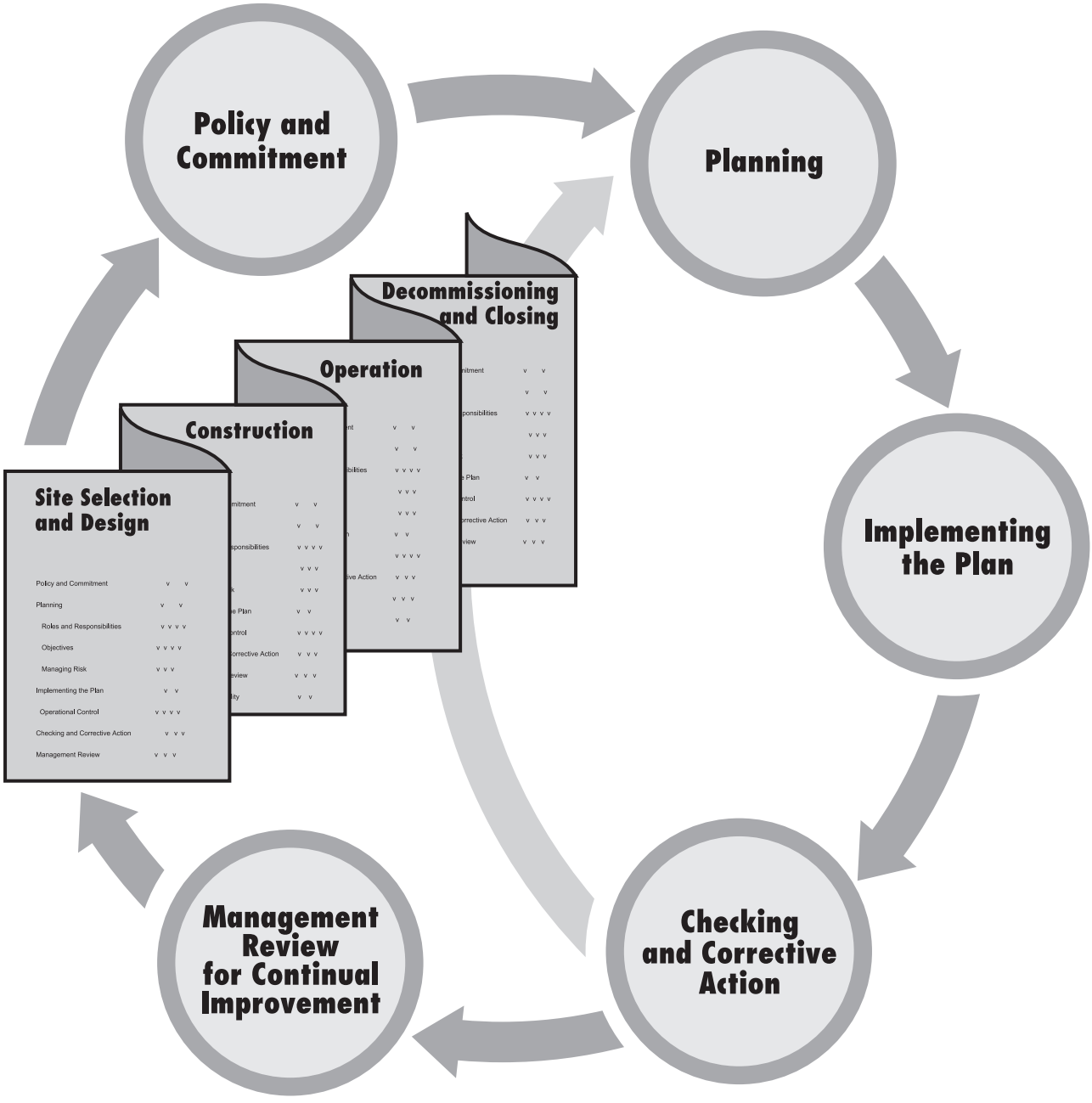

Figure 3: Application of the Tailings Management Framework through the Life Cycle

Principal responsibility for the management of tailings may rest with different groups within a company, and emphasis may shift as a result of different corporate units managing tailings facilities through the respective stages of the life cycle. For example, in early stages, site selection, preliminary and final design, and initial approvals are often managed by headquarters-based project development teams, supported by consultants. Initial tailings facility construction is usually managed on-site by a mine project development and construction management team, again often with significant reliance on consultants. With the transition to operations, although dam construction might continue through the operating life as successive lifts are added, management of tailings facilities is usually under the control of site operations, with reduced reliance on outside services. A specific project team, supported by consultants, takes the lead in preparing for decommissioning and closure of tailings facilities, and in managing long-term maintenance.

The management framework is therefore presented in four checklists focussing on the respective life cycle stages of a tailings facility:

- site selection and design;
- construction;
- operation; and
- decommissioning and closure.

At each stage in the tailings facility life cycle, implementation of the management system using the checklists requires that actions be planned within the context of policies and commitments, implemented in accordance with plans, checked and corrected, and subjected to management review.

Implementing the Framework

The tailings management framework has been designed for application through the full life cycle of a tailings facility. This may begin at any stage. Companies are encouraged to implement the framework at the earliest opportunity.

In practice, the framework is implemented through the use of the checklists, which follow this chapter:

- Checklist for Site Selection and Design of a Tailings Facility;
- Checklist for Construction of a Tailings Facility;
- Checklist for Operating a Tailings Facility; and
- Checklist for Decommissioning and Closing a Tailings Facility.

The checklists comprise six columns, addressing key elements for ensuring effective implementation of the management framework:

- **Management Action** - activities requiring management attention, derived from the management framework;
- **Responsibility** - the company official responsible and accountable for the management action;
- **Performance Measure** - indicator of progress toward a management action target or objective, quantified where practicable, that should be set in order to track performance;
- **Schedule** - the time frame for completion of significant milestones for a management action, which may include specific delivery dates or times, and/or frequency of ongoing or periodic activities such as monitoring and reviews;
- **Technical Considerations** - reference to lists of Technical Considerations, A through E; and
- **References** - additional technical, managerial and regulatory information relevant to the management action.

The checklists can be adapted to suit the requirements of specific sites, company policies, and local regulatory and community requirements.

A tailings facility owner or operator may fill out and customize the checklist, as appropriate, by:

- confirming and/or customizing the relevant management actions;
- assigning responsibility and authority for the management actions to individuals within the organization;
- determining relevant performance measures, quantified where practicable, to ensure that objectives are targeted, tracked and met;
- identifying the schedule requirements;
- referring to indicated Technical Considerations (A through E) as a basis for determining requirements, responsibilities and performance measures; and
- adding references applicable to the site and operations in the form of company standards and procedures, environmental policies, regulatory and permit requirements, commitments to stakeholders and selected documentation, such as the Canadian Dam Association's Dam Safety Guidelines, etc.

The checklists provide the basis for developing a customized management framework to address a company's tailings management and operating needs. Completing the checklists is essential to implementation of the tailings management framework. The process of completing the checklists will help identify gaps and/or deficiencies in existing tailings management.

When fully implemented, this framework will ensure continual improvement in the safe and environmentally responsible management of tailings facilities.

CHECKLIST FOR SITE SELECTION AND DESIGN OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Policy and Commitment					
Select a site and design a tailings facility in accordance with sound engineering practice, in compliance with company standards, the MAC Environmental Policy, the MAC tailings management framework, permits, legislative requirements and commitments to stakeholders.					
Consult external stakeholders on tailings facility site selection and design, and incorporate where feasible their views/expectations into the site selection and design.				C	
Establish an ongoing program of review and continual improvement.					
Planning					
ROLES AND RESPONSIBILITIES					
Identify prime responsibility for implementing this component of the tailings management framework.					
Assign a project manager responsible for the tailings facility site selection and design, including decommissioning and closure, who will:					
■ define the scope of the work;				A B C D E	
■ identify the resources and schedule required;				A B C D E	
■ define the roles and assign responsibilities for the site selection and design team;				A B C D E	
■ assemble a qualified project team to complete the site selection, design and associated studies; and				A B C D E	
■ define the interaction and communication strategy between the design team and management.					
OBJECTIVES					
Develop site selection and design criteria.					
Establish a process for site selection, evaluation and risk assessment of design options, including:					
■ implementation of appropriate quality assurance/quality control procedures for collection and interpretation of environmental, scientific and engineering data;					
■ identification of constraints and possible failure modes;					
■ establishment of procedures to review site selection and designs in view of incremental data or criteria; and					
■ environmental assessment.					

CHECKLIST FOR SITE SELECTION AND DESIGN OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
OBJECTIVES continued					
Develop plans for a tailings facility design and management system that meet the criteria of this framework and permitting requirements, and include:					
■ communication procedures with senior management and stakeholders;					
■ construction, operating, maintenance and closure systems, procedures and documentation requirements;					
■ comprehensive risk assessment and risk management plans;					
■ monitoring, inspection, reporting and review requirements; and					
■ knowledge and skills (awareness, training and competence) requirements and training records.					
Establish an appropriate process of external stakeholder consultation for site selection and design.					
MANAGING RISK					
Evaluate hazards associated with the site selection and design.				C	
Develop detection, emergency preparedness and response plans.				C	
MANAGING CHANGE					
Prepare procedures to identify and document changes made to approved plans and procedures for site selection and design of the tailings facility.				C	
RESOURCES AND SCHEDULING					
Determine required resources and schedule to conduct site selection and design.				A C D	
Implementing the Plan					
SITE SELECTION AND DESIGN CONTROL					
Select an appropriate site, including conceptual risk assessment.				A B C D E	
In accordance with the objectives:					
■ design the tailings facility;				B C D	
■ develop a closure plan; and				B C D	
■ conduct a comprehensive risk assessment.				B C D	

CHECKLIST FOR SITE SELECTION AND DESIGN OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
SITE SELECTION AND DESIGN CONTROL continued					
Obtain approvals for the site selection and design.					
Implement project management control to:					
■ review the progress of the work;					
■ identify deviations from the plan, schedule and budget;					
■ approve modifications to the plans; and					
■ ensure that work meets design objectives and criteria.					
FINANCIAL CONTROL					
Implement project cost controls for the site selection and design works.					
DOCUMENTATION					
Document the site selection and design.				A B C D E	
Implement a document management procedure for site selection and design.					
Maintain files and a registry of information, correspondence and studies, including submissions to regulatory agencies.					
Establish a review and approval system for interim and preliminary drawings.					
COMPETENCY					
Use professionals qualified in the appropriate technical and scientific disciplines for site selection and design.					
Identify and communicate to the design team the potential risks and environmental impacts, and appropriate mitigative/contingency options to minimize risk.				A B C	
MONITORING					
Monitor the integration of design elements to ensure that site selection and design objectives are met.				A C	
Develop short-, medium- and long-term stability monitoring programs (including special programs after major events such as earthquakes, hurricanes and floods) which may impact on design.				C D	

CHECKLIST FOR SITE SELECTION AND DESIGN OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
COMMUNICATIONS					
Establish and maintain a reporting procedure to team members and senior management.					
Establish appropriate procedures for external communications.					
Checking and Corrective Action					
CHECKING					
Review site selection and design activities. The level of review, whether internal or external, will reflect the level of risk associated with the design and the potential for environmental, human or health impacts.				A C D E	
Identify further studies and research required to confirm design concepts.					
CORRECTIVE ACTION					
Develop and implement action plans, and record corrective action to address non-conformance items.					
Management Review for Continual Improvement					
Establish an ongoing program of review to ensure that health, safety and environmental risks associated with tailings facilities are appropriately addressed in accordance with this framework during site selection and design.					
If aspects of the design are novel or untried, undertake appropriate supplementary field investigations and research and establish a framework to review design at critical stages.					

CHECKLIST FOR CONSTRUCTION OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Policy and Commitment					
Construct the tailings facility as per design and in a safe and environmentally acceptable manner, in compliance with company standards, the MAC Environmental Policy, the MAC tailings management framework, permits, legislative requirements and commitments to stakeholders.					
Inform external stakeholders on the tailings facility construction.					
Establish an ongoing program of review and continual improvement.					
Planning					
ROLES AND RESPONSIBILITIES					
Identify prime responsibility for implementing this component of the tailings management framework.					
Assign a project manager responsible for the tailings facility construction.					
The project manager will establish a team that includes environment, health and safety personnel, builders, inspection personnel and engineers, and assign roles and responsibilities for the team, including:					
■ ongoing liaison with the design team regarding design changes and site supervision;				C D E	
■ selection of contractors;				C D E	
■ quality control;				C D E	
■ environmental protection;				C D E	
■ construction supervision;				C D E	
■ temporary works, including drainage provision;				C D E	
■ instrumentation;				C D E	
■ commissioning/transition to operations;				C D E	
■ construction/operation strategy (one-time vs. ongoing); and				C D E	
■ project documentation, including changes to design and management.				C D E	

CHECKLIST FOR CONSTRUCTION OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
OBJECTIVES					
Establish criteria and procedures that ensure tailings facility construction will be in conformance with design, and will:					
■ meet legal requirements, operating licences, legislation, policies, codes of practice and commitments to stakeholders;					
■ facilitate implementation of the closure plan;					
■ provide continued protection of public health and safety;					
■ prevent or minimize adverse environmental impact; and					
■ achieve the specified performance.					
Establish an appropriate process of information dissemination to external stakeholders.					
PLANNING FOR CONSTRUCTION					
Prepare detailed plans for construction of the tailings facility to:					
■ establish a quality control system for construction;				C E	
■ check and approve deviations from design;				C D	
■ produce as-built drawings and construction reports;				C D E	
■ ensure availability of suitable quality and quantity of construction materials;				D	
■ install instrumentation;				C D E	
■ meet environmental objectives;					
■ obtain all required construction permits;					
■ specify contractor bonding requirements; and					
■ establish contractor tendering procedures.					
MANAGING RISK					
Prior to the start of construction, evaluate risks inherent in the construction of the tailings facility.				C	
Develop and implement detection, emergency preparedness and response programs for the construction works.				C	

CHECKLIST FOR CONSTRUCTION OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
MANAGING CHANGE					
Prepare procedures to identify and document changes made to approved plans and procedures for construction of the tailings facility.				C	
RESOURCES AND SCHEDULING					
Determine required resources and schedule to construct the tailings facility.				C D	
Implementing the Plan					
CONSTRUCTION CONTROL					
Obtain approvals and permits.					
Construct the tailings facility in conformance with design and plans.				C D E	
Implement project management to:					
■ review the progress of the work;				E	
■ ensure that work meets design and plan specifications;				C D E	
■ identify deviations from the plan, schedule and budget; and					
■ approve modifications to the design and plans.					
FINANCIAL CONTROL					
Implement financial control measures and project cost schedule for tailings facility construction and field change notifications.					
DOCUMENTATION					
Implement document control to ensure that appropriate documents are prepared, maintained and accessible, including:					
■ submissions to regulatory agencies;					
■ training records;					
■ Quality Assurance / Quality Control reports, construction reports, photos, videos, etc.;				E	
■ monitoring results;				E	

CHECKLIST FOR CONSTRUCTION OF A TAILINGS FACILITY

Implementing the Plan

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
DOCUMENTATION continued					
■ conditions encountered;					
■ unusual or special conditions;					
■ design changes; and				E	
■ as-built drawings and construction reports.				E	
COMPETENCY					
Assign qualified personnel to construct the tailings facility.					
Ensure that the team members understand the design intent and are aware of potential health, safety and environmental risks.					
Identify training needs and conduct training as appropriate.					
MONITORING					
Implement monitoring programs to:					
■ review instrumentation and construction data as per design requirements and assumptions;				E	
■ establish permanent survey control;				E	
■ install required instrumentation, take readings and record data; and				E	
■ ensure that the Quality Assurance / Quality Control programs are followed and that materials, instrumentation and construction meet design specifications.				E	
Establish a routine inspection program for assessing environmental and safety performance of the construction, specifically identifying and reporting construction deficiencies, unusual and/or unsafe conditions.				E	
COMMUNICATIONS					
Establish and maintain a reporting procedure to team members and senior management.					
Implement appropriate procedures for external communications.					

CHECKLIST FOR CONSTRUCTION OF A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Checking and Corrective Action					
CHECKING					
In addition to the routine inspection program, make periodic inspection and review of the tailings facility, including verification of design assumptions against actual field conditions to provide a basis for proving or updating the design and/or monitoring program.				D	
Prior to construction of high-risk structures, or if problems occur, consider an independent review of design and construction.				C D	
CORRECTIVE ACTION					
Develop and implement action plans, and record corrective action to address non-conformance items.					
Management Review for Continual Improvement					
Review the program of construction, including project management, to check for areas of potential improvement.					

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Policy and Commitment					
Operate the tailings impoundment facility in a manner such that all structures are stable, all solids and water are managed within the area designated in the design, and in compliance with company standards, the MAC Environmental Policy, the MAC tailings management framework, legislative requirements and commitments to stakeholders.					
Inform external stakeholders on the tailings facility operations.					
Establish an ongoing program of review and continual improvement.					
Planning					
ROLES AND RESPONSIBILITIES					
Identify prime responsibility for implementing this component of the tailings management framework.					
Assign a project manager responsible for the tailings facility operations.					
The project manager will ensure responsibilities are assigned for:					
■ operation of the tailings facility;					
■ physical stability of the tailings facility;					
■ emergency preparedness and response;					
■ monitoring systems, documentation, interpretation and response;					
■ maintenance;					
■ ongoing expert support for geotechnical, hydrogeological, hydrological and environmental issues; and					
■ communications, both internally and to external stakeholders on:					
◆ routine performance issues;					
◆ emergency actions;					
◆ regulatory compliance and/or incident reporting; and					
◆ the closure plan.					

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
OBJECTIVES					
Develop plans to operate in conformance with design, and to:					
■ meet legal requirements, operating licences, legislation, policies, codes of practice and commitments to stakeholders;					
■ integrate preparation for eventual decommissioning and closure into ongoing operations;					
■ provide continued protection of public health and safety;					
■ prevent or minimize adverse environmental impact; and					
■ achieve specified performance.					
Establish an appropriate process of information dissemination to external stakeholders.					
PLANNING FOR OPERATION					
Review design documents, as-built construction drawings, conceptual operating and closure plans, environmental assessment and commitments to stakeholders.				C D E	
Prepare, review and update on a regular basis detailed plans for operation of the tailings facility:					
■ water management plan;				C	
■ tailings deposition plan;				C	
■ environmental control and monitoring plan;				C D E	
■ dam stability monitoring plan; and				D E	
■ closure plan, both progressive rehabilitation and eventual decommissioning.				C D	
Determine maintenance requirements for mechanical, civil works and electronic devices.					
Establish a calibration program for all key instrumentation.				E	

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
MANAGING RISK					
Conduct comprehensive risk assessment to:					
■ evaluate the risks associated with possible failure modes for both the operating and closure stages;				C D	
■ identify possible impacts on the environment, health and safety;				C D	
■ determine operating parameters critical to these failure modes and possible impacts; and				C D E	
■ develop control strategies to reassess the design and/or manage the identified risks.				C	
Develop and test detection, emergency preparedness and response plans, including communications plans, for the operations.				C	
MANAGING CHANGE					
Prepare procedures to identify and document changes made to approved plans and procedures for operating the tailings facility.				C	
RESOURCES AND SCHEDULING					
Determine required resources and schedule to operate the tailings facility.					
Develop operational budgets and schedules for:					
■ updating plans;					
■ preventive maintenance;					
■ water control activities;					
■ monitoring activities; and					
■ inspections.					

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
OPERATIONAL CONTROL					
Obtain approvals and permits.					
Operate the tailings facility in conformance with the design specifications, plans and legal requirements.					
Implement management control to:					
■ identify and respond to deviations from the plan, schedule and budget; and					
■ approve modifications to the plans.					
Establish preventive maintenance schedule and reporting system.					
Verify emergency preparedness plan requirements.				C	
Implement operational procedures and controls to manage:					
■ flood control;				C E	
■ water balance;				C E	
■ contaminant mass balance;				C E	
■ groundwater;				C E	
■ tailings deposition;				C E	
■ physical stability;				C E	
■ dust;				C E	
■ site security; and				C E	
■ wildlife protection.				C E	
FINANCIAL CONTROL					
Implement financial control measures and cost schedule for tailings facility operations.					

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
DOCUMENTATION					
Implement documentation control to ensure that appropriate documents are prepared, maintained and accessible, including:					
■ submissions to and from regulatory agencies;					
■ training records;					
■ Quality Assurance / Quality Control reports, construction reports, photos, videos, etc.;				E	
■ monitoring results and analysis;				E	
■ unusual or special conditions;					
■ conditions actually encountered in the field;					
■ as-built drawings and records;				E	
■ modifications to the tailings facility design and operating plan; and				E	
■ communications with external stakeholders.				E	
COMPETENCY					
Establish competency requirements.					
Assign qualified personnel to operate the tailings facility.					
Identify training needs and provide adequate training to all personnel to fulfil their roles in operating the tailings facility, including health, safety and environment.					
MONITORING					
Establish and maintain a program to monitor and analyze, on a regular basis, the key elements of the tailings facility, including:					
■ tailings characteristics;				B E	
■ tailings structures and appurtenances;				D E	
■ seepage; and				C E	
■ water.				C E	

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
MONITORING continued					
Establish and maintain a data storage, validation and reporting system.				E	
Establish and maintain a routine inspection program for assessing ongoing environmental and safety performance of the impoundment and appurtenant structures, including all critical structures such as dams, dykes, ditches, ponds, pipes, spillways and decant structures.				E	
Establish and maintain Quality Assurance / Quality Control procedures for environmental monitoring.				E	
COMMUNICATIONS					
Define the reporting relationships.					
Establish and maintain procedures and schedules for reporting on the performance of the tailings facility to team members and senior management.					
Establish appropriate procedures for external communications.					
Establish clear guidelines for reporting of exceptions.					
Checking and Corrective Action					
CHECKING					
In addition to the routine inspection program, establish an annual inspection of the tailings facility by an engineer experienced in the design, maintenance and operation of the tailings facility.				E	
Conduct a periodic review of the tailings facility, including verification of design assumptions against actual field conditions (e.g. water quality, sedimentation) to provide a basis for verifying or updating the design and/or monitoring program.				A B C D E	
Review and revise inspection programs as required after changes in design or methods during and after construction, and when the pond level exceeds specified critical elevation.					

CHECKLIST FOR OPERATING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Checking and Corrective Action					
CORRECTIVE ACTION					
Develop action plans, and implement and record corrective action to address non-conformance items identified through routine and/or periodic inspections and reviews.					
Management Review for Continual Improvement					
Review annually the tailings management framework for conformance to objectives and to identify opportunities for continual improvement.					
Identify and conduct research and/or operational activities aimed at continual improvement.					

CHECKLIST FOR DECOMMISSIONING AND CLOSING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Policy and Commitment					
Decommission and close the tailings facility in such a manner that all remaining dams and associated structures are safe and stable. All solids and water will be managed within the area designated in the closure plan, and in compliance with company standards, the MAC Environmental Policy, the MAC tailings management framework, legislative requirements and commitments to stakeholders.					
Consult external stakeholders on the tailings facility closure and decommissioning plan, and incorporate where feasible stakeholder views/expectations.					
Establish an ongoing program of review and continual improvement.					
Planning					
ROLES AND RESPONSIBILITIES					
Identify prime responsibility for implementing this component of the tailings management framework.					
Assign a project manager responsible for the overall decommissioning and closure of the tailings facility.					
The project manager will ensure responsibilities are assigned for:					
■ completion of development of the tailings facility closure plan and cost estimate;					
■ obtaining approvals;					
■ tailings facility decommissioning and closure;					
■ emergency preparedness;					
■ construction;					
■ long-term maintenance;					
■ ongoing support for monitoring, geotechnics, hydrology, hydrogeology, chemistry, impact assessment and revegetation;					
■ financial assurance; and					
■ communications and stakeholder consultations.					

CHECKLIST FOR DECOMMISSIONING AND CLOSING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
OBJECTIVES					
Close the tailings facility in conformance with design, and to:					
■ meet legal requirements, operating licences, legislation, policies, codes of practice and commitments to stakeholders;					
■ effectively enable surrender of the land or transfer to non-mining use consistent with regional land-use objectives or approved uses, or provide for long-term care and maintenance;					
■ ensure long-term stability of dams and related tailings facilities;					
■ protect public health and safety;					
■ minimize adverse environmental impact; and					
■ achieve the specified technical performance and decommissioning financial requirements.					
Establish an appropriate process of external stakeholder consultation for land-use and public accessibility issues.					
PLANNING FOR CLOSURE					
Prepare detailed plans for implementation of closure:					
■ revisit the approved design;				C	
■ identify "new" environmental concerns that have become apparent through operations since the design was approved;				C	
■ identify potential environmental impacts that may be caused by the implementation of closure;				C	
■ review alternative technology for closure;				C	
■ review performance of progressive reclamation to date;				C	
■ develop a detailed monitoring and surveillance plan to verify that closure meets objectives;				C	
■ detail items to be documented and reported; and				C	
■ outline the long-term care and maintenance requirements, including maintenance requirements for dams, hydraulic structures and appurtenances, revegetation, erosion control and treatment systems.				C	

CHECKLIST FOR DECOMMISSIONING AND CLOSING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Planning					
PLANNING FOR CLOSURE continued					
Obtain all permits, licences and approvals required.					
Establish required financial assurance.					
Establish responsibility for long-term care and maintenance.					
Provide rehabilitation work schedule for facilities no longer required.				C	
Develop a plan to control contaminant release.				C	
Ensure that final land-use issues are determined (e.g. restoration for recreation, agriculture, forestry and wildlife habitat, commercial / industrial use or residential) in consultation with stakeholders.				C	
Ensure that inherent dangers and hazards are identified and mitigative measures developed.				C	
MANAGING RISK					
Conduct a comprehensive risk assessment for decommissioning and closure to:					
■ evaluate the risks associated with possible failure modes;				C	
■ identify possible impacts on the environment, health and safety;				C	
■ determine parameters critical to these failure modes and possible impacts; and				C	
■ develop control strategies to manage the identified risks.				C	
Develop, test and maintain detection, emergency preparedness and response plans.				C	
MANAGING CHANGE					
Prepare procedures to identify and document changes made to approved plans and procedures for decommissioning and closing the tailings facility.				C	
RESOURCES AND SCHEDULING					
Determine required resources and schedule for decommissioning and closure of the tailings facility, or alternately for long-term care.					
Develop detailed closure budget estimates and schedule for:					
■ decommissioning/rehabilitation/closure by activity; and					
■ monitoring the closure.				E	
Assess the adequacy of the closure financial assurance.					

CHECKLIST FOR DECOMMISSIONING AND CLOSING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
CLOSURE CONTROL					
Decommission and close the tailings facility as per detailed closure design and plans.					
Obtain approvals and permits.					
Implement management control to:					
■ review the progress of the work;				C E	
■ ensure that work meets design and plan specifications;				C E	
■ identify deviations from the plans, schedule and budget; and				C E	
■ approve modifications to the design and plans.				C E	
Implement a preventive maintenance schedule and reporting system.					
Assign responsibility for long-term care and maintenance, including emergency response and communications plans.					
FINANCIAL CONTROL					
Implement financial control measures and project cost schedule for tailings facility decommissioning and closure.					
DOCUMENTATION					
Implement a documentation management procedure to ensure that all appropriate documents are prepared, maintained and kept accessible, including:					
■ submissions to regulatory agencies;					
■ training records;					
■ Quality Assurance / Quality Control reports, construction reports, photos, videos, etc.;				E	
■ monitoring results;				E	
■ unusual or special conditions; and					
■ as-built drawings for closure.				E	
All deviations from the closure plan requirements should be recorded.					
Prepare reports and reviews on the progress of the closure as required.					
Prepare and retain final as-built drawings and construction reports.					

CHECKLIST FOR DECOMMISSIONING AND CLOSING A TAILINGS FACILITY

Management Action	Responsibility	Performance Measure	Schedule	Technical Considerations	References
Implementing the Plan					
COMPETENCY					
Assign qualified personnel to decommission and close the tailings facility, or alternately for long-term care.					
Review competency and identify training needs.					
Provide appropriate training, including health, safety and environmental aspects.					
MONITORING					
Implement a program for monitoring physical and environmental stability during and after the closure period.				E	
Perform routine inspections to ensure conformance of implementation with the closure plan.				E	
COMMUNICATIONS					
Establish and maintain reporting procedures on implementing the closure plan, and effectiveness of the closure plan.					
Establish and maintain communications within the organization.					
Establish and maintain communications with external stakeholders.					
Checking and Corrective Action					
CHECKING					
Perform a comprehensive inspection and review to measure effectiveness of the closure against designed performance measures.				E	
CORRECTIVE ACTION					
Develop action plans, and implement and record corrective action to address non-conformance items identified through routine and/or periodic inspections and reviews.					
Management Review for Continual Improvement					
Conduct regular reviews of the management framework for closure.					
Assess the adequacy of the management framework for long-term care.					

Technical Considerations

A - Environmental Baseline

The following is a summary of considerations for collecting and collating environmental baseline information for use in site selection, design and operation. This same baseline information is important for the development of closure plans and environmental monitoring programs. More comprehensive lists may be found in specific environmental assessment guidelines.

EXISTING RESOURCES AND USE

Identify existing resources and land uses within the tailings facility area and within the greater potential impact area.

Land and Water Use: Identify current and historical uses, including recreation, parks, aboriginal traditional use and land claims, human habitation, drinking water sources, archaeological considerations, mining, logging, farming, hunting and fishing.

Land Tenure: Establish the right to acquire the necessary land for a tailings disposal facility. Identify land ownership and mineral rights, which may include mining claims; land-use permits; easements, including those for power lines and transportation corridors; Crown land; and aboriginal land claims.

BASELINE SCIENTIFIC DATA

Compile baseline environmental scientific data relevant to the tailings project area.

Physical

Climate - temperature, wind, precipitation, evaporation, return period floods, precipitation and runoff, air quality.

Water - hydrology, watershed delineation and flow patterns, stream flow, lake bathymetry, hydrogeology (groundwater) characteristics, surface water and sediment quality.

Land forms - including muskeg, peat or talus slopes.

Geology and geochemistry - surficial deposits (type, location, density, permeability), stratigraphy, geomorphology, mineral and petroleum resources, background elemental content.

Topography - regional and detailed topographic maps, stereo aerial photography, satellite imagery.

Soils - soils sampling and characterization.

Natural hazards - landslides, avalanches, seismic events, flood potential, frost action.

Biological

Ecosystem identification.

Terrestrial survey - flora, natural pastures, fauna, endangered and threatened species, migratory species.

Aquatic survey - benthos, macro-invertebrates, fish, aquatic plants.

BASELINE SOCIO-ECONOMIC DATA

Compile baseline socio-economic data relevant to the tailings project area, including historical background, population, regional economy (e.g. health, education, culture, demography). Identify socio-economic issues which might arise for the tailings project.

B - Mill Tailings Characteristics

The following examples of ore, mine rock (if used for dam construction or co-disposal) and tailings characterization information may be useful in design.

Ore and Mine Rock Characterization: Reserves; mineralogy; chemical properties; physical and engineering properties (e.g. strength, gradation, slaking potential); acid generating potential; leachable contaminants; ore, low-grade ore and mine rock quantity and schedule.

Tailings Characterization: Daily/annual throughput and total quantity; size distribution; % solids; density of solids; specific gravity; plasticity; liquid phase chemistry; acid generating potential.

Mill Operation Characteristics: Reagents used; water recirculation requirements; mill treatment processes (e.g. cyanide destruction); miscellaneous inflows to tailings basin; pipes and appurtenances; potential for pit and/or underground backfilling; % of disposal to surface facility vs. backfill.

C - Tailings Facility Studies and Plans

The following is a summary of typical studies and plans which should be developed in the design of a tailings facility to an adequate level of detail relevant to each stage (conceptual, preliminary and detailed design) to enable approvals, then maintained throughout operation and closure:

- site selection documentation;
- environmental assessment;
- risk assessment;
- emergency preparedness plan;
- deposition plan;
- water balance and management plan; and
- decommissioning and closure plan.

The plan contents listed are suggested minimums. There may be additional aspects which should be included.

SITE SELECTION

Select a preferred site. Prepare a clearly documented rationale for selection, including discussion of alternate sites studied and rejected. Compile all relevant government legislation, regulation and guideline documents. Identify public perception issues related to the project (internal and external stakeholder requirements).

Environmental Considerations: Effluent treatment requirements; surface water contamination; groundwater contamination (hydrogeological containment); historical use of the receiving watershed; background environmental conditions; impact on vegetation, wildlife and aquatic life; natural flora and fauna; archaeological considerations; potential dust problems; aesthetic considerations; conceptual water balance.

Planning Considerations: Accessibility (road construction); distance from the mill; relative elevation from the mill; distance from habitation and areas of human activity; topography; existing land and resource use; property ownership and mineral rights; aboriginal land claims; transportation corridors, power lines, etc.; watershed and surface area considerations; volumetric capacity; dam volume/storage capacity ratio; geology, including potential ore bodies; construction material availability; conflict with mining activity; dam foundation conditions; basin foundation conditions; downstream hazards; hydrology; groundwater, contaminant seepage; potential impact area; human and environmental risk; water management scheme and preliminary water balance; operational plan; deposition plan; preliminary containment and water management structures; preliminary cost estimate based on preliminary considerations; conceptual risk assessment.

Decommissioning/Reclamation Considerations: Flood routing requirements; revegetation potential; long-term stability; ease of establishing permanent drainage; reduction and/or control of acid drainage and other contaminants; dust control; long-term maintenance, monitoring and treatment requirements.

D**evelopment, Operating and Closure Cost Considerations:** Capital cost; cost of tailings transport; tailings facility operating and maintenance costs; closure costs; cost per tonne of ore milled.

ENVIRONMENTAL ASSESSMENT

In order to obtain stakeholder and regulatory acceptance for siting a new tailings facility, it is often necessary to conduct an environmental assessment, which can be a complex process involving federal and/or provincial regulators. The environmental assessment process requires integration of knowledge about the project as it is being designed, the natural and social environments in which the project is situated, and community and stakeholder concerns.

At the environmental assessment stage, tailings facilities are usually components of a larger, integrated project. The following is a summary of some significant aspects related to tailings which should be addressed in an environmental assessment: environmental baseline; mill tailings aspects; tailings facility site selection, with a clearly documented rationale for the selected site; and conceptual tailings facility design.

The environmental assessment should address the projected impacts of the tailings facility on the environment, including physical impacts; physiography; climate; air quality; noise; hydrology; hydrogeology; water quality; biological impacts; aquatic life; vegetation; wildlife; archaeological impacts; socio-economic impacts; land-use impacts.

RISK ASSESSMENT

Risk assessment addresses what could go wrong (i.e. hazards or failure modes) with a facility and its associated plans and procedures; what are the probabilities of failure; and what are the consequences of failure. Risk assessment provides a basis for the development of risk management, including communication, contingency, mitigation and emergency response plans.

Risk should be assessed (and managed) through each phase of the life cycle of the tailings facility. However, the intensity of assessment may vary at different stages, depending on the objectives of the review, complexity of the issue and the extent of information available.

Scope and Purpose of Assessment: Determine and document the scope and purpose of the risk assessment. Identify all stakeholders in the risk assessment.

Risk Assessment Team: An experienced, multi-disciplinary risk assessment team is required to determine potential failure modes, probabilities and consequences of failure. The team might typically include the tailings dam designer, construction contractor, operators, environmental and management staff and, in cases of detailed assessments, a risk assessment specialist. Consequence evaluation will involve environmental staff and specialists including, in some cases, health experts and cost engineers. Involving tailings operating staff is critical for a risk assessment of an existing tailings facility in order to incorporate their knowledge and experience of the facility.

Evaluation Criteria: Develop criteria to guide the evaluation of findings and establish levels of acceptable or unacceptable risk. High probability, high consequence failure modes would obviously be of concern, but low probability, high consequence modes may also require examination. Potential human health and safety, environmental impact or business (e.g. downtime, reputation, property damage) consequences should be considered.

Methodology: Risk assessment may be qualitative (subjective ratings of probability, consequence and overall risk) or quantitative (numeric values of probability and dollar values for consequences). A simple qualitative assessment may be appropriate to evaluate a number of potential tailings pond sites whereas a detailed quantitative assessment would be more appropriate for a proposed major modification to an existing tailings dam.

Commonly practised methodologies for risk assessment include process/system checklists; system design models; safety reviews; relative ranking; preliminary hazard analysis; "what-if" analysis; hazard and operability (HAZOP) studies; failure modes, effects (and criticality) analysis - FMEA, FMECA; probabilistic simulation analysis; fault-tree analysis; event-tree analysis; cause-consequence analysis; and human error analysis.

Potential triggers and failure modes:
Reservoir overtopping - landslide into reservoir generates a wave which overtops the dam; wave action overtops dam; perimeter bypass system fails and water enters reservoir, exceeding capacity of spillway or storage, or an external creek diversion failed and water entered reservoir; pond allowed to reach crest of dam; discharge from top end of pond to save dam height; blocked outlet structures; precipitation exceeds storage capacity; water balance not maintained.

Dam instability (upstream or downstream) - seepage causes piping and removes dam material (i.e. filter fails); seepage raises pore pressures and causes shallow instability; seepage raises pore pressures and causes deep instability; seismic liquefaction of dams; seismic deformation of dams; seismic liquefaction of tailings leads to erosion; seismic liquefaction of tailings applies horizontal thrust to dam; non-seismic liquefaction of dam due to straining or increased pore pressures; seepage failure raises pore pressures and triggers a slide; construction pore pressures rise and slope moves; saturation of uncompacted fill either by first fill or rain or snow encapsulated in dam fill melts, dam settles, overtops; uncontrolled toe erosion retrogresses; dam face erodes due to uncontrolled precipitation or snow melt.

Foundation instability - Karst collapses beneath dam; collapse due to mine subsidence allows tailings to escape into mine or void; sliding on weak soil or liner interface; compression of weak soils leads to cracking of dam; permafrost degrades; construction pore pressures rise and foundations move; seepage through a poor membrane or pervious soils into groundwater system, bypassing seepage recovery systems; seismic liquefaction of foundations; seismic deformation of foundations; non-seismic liquefaction of foundations.

Structural failures - piping around a culvert or decant pipe; reclaim tower fails; pumps fail due to loss of power; pipeline or conduit fails; landslide blocks spillway; ice blocks spillway.

Power failure.

Probability of Failure: Estimate the probability of failure for each potential failure mode based on past experience with facility, experience with similar facilities, engineering analysis and professional judgment.

Consequences of Failure: Estimate consequences of failure for each potential failure mode, including consideration of impacts on health and safety of workers, contractors and general public; environmental impacts including consideration of assimilative capacity and environmental sensitivity of site; and business impacts.

Link to Operations: Identify operating, maintenance, inspection and incident response (e.g. unusual occurrences) procedures which could reduce risk; and parameters and operating characteristics to be measured, monitored and documented to provide early warning of potential failure.

Reporting: Results of risk assessments should be clearly presented and summarized for both operating and management personnel.

EMERGENCY PREPAREDNESS PLAN

It is of prime importance to be ready for emergencies and to have appropriate contingency and emergency preparedness plans in place. Emergency preparedness includes preparation both for on-site incidents and for incidents having off-site implications, including dam breach. Contingency and emergency preparedness plans should be reviewed on a periodic basis, tested, and widely distributed within an organization and to potentially affected external stakeholders.

The site's emergency preparedness plan should integrate the tailings facility aspects into the overall site emergency preparedness plan and should include, but not be limited to, the following:

- identification of planning coordinator, team and organizational structure;
- identification of emergency organization, roles and responsibilities;
- identification of requirements of legislation, codes of practice, notification and reporting obligations;
- identification of available resources;
- mutual aid agreements;
- public relations plan;
- telephone lists;
- establishment of communication system for notifications and for post-notification purposes;
- risk analysis for on-site and off-site effects;
- inundation study, maps and tables for both physical and environmental releases (including dam break);
- basis for activation of emergency plan and emergency decision making;
- training of personnel;
- investigation and evaluation of incidents and accidents; and
- restoration of safe operating conditions.

TAILINGS DEPOSITION PLAN

Tailings Deposition Plan: A tailings basin deposition plan is developed for the expected mine life. Deposition plans can allow for the staging of dam lifts over the life of the mine to accommodate long-term storage of tailings solids, maintain adequate solids storage capacity, and allow adequate polishing of supernatant during operation of the mine. Incorporate appropriate consideration for expanded requirements and/or capacity.

Deposition plan development requires tailings slurry quantity and density and production information estimated from the process/mill water balance, including provisions for estimating uncertainty and contingencies. The basic parameters should be validated and updated on a periodic or regular basis.

WATER BALANCE AND MANAGEMENT PLAN

Hydrology: Hydrology data, including the delineation of tailings site catchment area(s) and all potential water sources, both natural and process, are used in the development of a water/contaminant balance and design of tailings facility components. Establish and document design parameters, then monitor actual experience to identify variances, validate projections and anticipate potential problems.

Design Flood: The appropriate Environmental Design Flood and Inflow Design Flood need to be identified, with reference to current design standards and in consultation with regulatory agencies. Design flood considerations should be consistently applied through all stages of the life cycle. Storage requirements, operating freeboard and spillway design are based on the hydrology of the watershed.

Water Balance: Complete a water balance study. Specify requirements for ongoing data collection for the mill and tailings basin water balance calibration purposes.

Surface Water Management Plan: Complete a water management plan detailing appropriate designs and strategies, where required, for seepage collection; reclaim/pump-back systems; treatment/discharge systems, including all water conveyance systems; and water retention and discharge strategy, including operating parameters.

Contaminant Balance and Release: The contaminant balance provides estimates of contaminant release to surface and groundwater. Develop, where required, a plan to control contaminant release within acceptable levels.

Effluent Criteria: Establish effluent criteria for the tailings facility, with reference to regulatory requirements and operating licences and permits, including dissolved and suspended matter, including thiosalts; suspended solids; effluent quality; periods of discharge; bacterial and biological levels; and toxicity.

CLOSURE PLAN

Closure plans and performance criteria need to be developed in the early stages of facility design, and then verified and updated periodically through the operating life of the facility in preparation for decommissioning and closure. Closure is usually covered by regulations, and the following are general considerations applicable to development of closure plans. In some circumstances, closure may not be possible and decommissioning followed by long-term care may have to be done. This will require similar plans and controls as for closure.

Elements of a Closure Plan: Determine background data, including history of site, infrastructure, process flow controls, system operations, mineralogy, topography; hydrology/water management; hydrogeology; soil capability; revegetation; impact assessment; long-term maintenance; geotechnics; chemistry and geochemistry; monitoring program; communications; financial assurance; stakeholder consultation; potential end land use; and closure technology (i.e. dry cover, flooded, wetlands, perpetual treatment, vegetative cover).

Aspects of Dam Stability for Closure: Closure plans require a thorough re-assessment of facility and dam stability under closure conditions. All aspects of the facility and dam stability must be reviewed. In particular, the actual performance of the dams in service, including deformation, seepage, foundation and sidewalls, must be checked against design projections as well as against projected post-closure conditions. Design loads might be different after decommissioning and closure.

Structural monitoring and inspections should be continued for all facilities and dams until they are decommissioned and thereafter as appropriate. Identify and delineate any requirements for continuing inspection and/or monitoring of remaining structures after closure.

Prepare action plans to deal with shortcomings in closure quality and/or difficulties in complying with closure specifications.

Examine the consequences of closure of the facilities on emergency preparedness procedures, and update as appropriate. Ensure continuing availability of design, construction and operating records after closure for structures remaining in place.

D - Dam and Appurtenant Structures Design

The following considerations relate to dam and containment basin design. The list may not apply to all sites or all situations. It is up to the design professional to decide which aspects apply. Site-specific conditions may require the use of additional criteria.

DESIGN INPUT CONSIDERATIONS

Compile information relating to the dam site from literature survey and field/laboratory investigation programs.

Hydrology and Hydrogeology: Hydrological and hydrogeology studies; water balance; water quality; design flood; freeboard requirements; drought design (i.e. water cover requirement); catchment runoff and diversion arrangements; deposition plan; erosion management plan.

Foundations, Geology and Geotechnical Engineering: Geomorphology; regional and local geology, faults; stratigraphy; bedrock and soil characteristics; geotechnical information, including compressibility, shear strength, angle of friction, grain size, density, plasticity, fractures, liquefaction potential, permeabilities, erosion potential, hydraulic fracture.

Construction Materials: Assess the availability of naturally occurring construction materials. Assess the engineering characteristics of tailings and borrow materials, grout/concrete or other liner material (both natural and synthetic), such as grain size; density; volume; shear strength; permeability; acid generating potential; chemical reactivity (acid generating potential, reaction with pond water, thiosalt generating potential); wind and water erosion potential.

Determine potential detrimental effects of tailings and/or process water on construction materials. Consider environmental impacts, stability and rehabilitation requirements for the use of any construction materials.

Topography: Regional and topographical mapping and air photos.

Special Environmental Considerations: Seismic risk; seismic attenuation of foundation strata and construction materials; liquefaction potential of foundation strata and construction materials; climatic conditions, including extreme values to be expected; wind and wave actions; permafrost effects; frost.

Seepage: Establish maximum allowable seepage objectives for environmental and structural requirements. Identify requirements for pervious vs. impervious materials and construction methods. Develop a seepage management plan.

DESIGN ELEMENTS

Determine design parameters, including dam classification, stability, earthquake criteria, factors of safety, design permeabilities, acid rock drainage, wildlife, dust and closure considerations as outlined in the following sections.

Stability: Analyze the stability of the foundation, dam and appurtenances under conditions covering construction, operations and closure; and under static and dynamic conditions, including consideration of wave, frost/ice action and rapid drawdown. Establish density and compaction targets.

Foundation Preparation: Determine the requirements for preparation of the dam and pond foundations prior to construction of the tailings dam and pond, including consideration of vegetation removal, including merchantable timber; excavation of organic soils; cut-off walls; groundwater control and containment; bedrock cleaning and slush grouting; high-pressure grouting; diversion wells; diversion channels; dewatering requirements; stability; constructability; other special construction requirements.

Seepage Analysis and Management: Assess the requirement for seepage control, including into groundwater, consideration of water chemistry and acid generating potential. Plan for implementation of appropriate measures, as warranted, such as filter design; cut-off wall; grout curtain; ditching; low permeability core; interception wells.

Appurtenances: Design, as required, for spillways; towers; pipelines (e.g. vacuum breakers, secondary containment); maximum flood-handling requirements; gates and valves; siphons; pumps; natural hazards (e.g. debris, beavers, ice blockage).

Dam Design: Type of dam; design philosophy; criteria for major elements.

Dam Construction Plan: Develop a plan for executing the initial dam construction and subsequent dam lifts, including sequencing and requirements for stability monitoring. Establish a construction methodology, schedule and anticipated costs. Determine potential environmental impacts due to construction of the proposed design.

Dam Monitoring Systems: Piezometers; inclinometers; settlements gauges; seepage flow monitoring; temperature (permafrost, frost penetration, heating).

Failure Mode Analysis: Analyze potential dam failure modes during construction, during operation, in its final condition and after closure.

Design for Closure: Co-ordinate design elements with planning for eventual decommissioning and closure.

E - Control and Monitoring

Quality Assurance/Quality Control (QA/QC) Plan: Maintain construction drawings and as-built construction records throughout construction, operation and closure phases in an orderly and secure fashion, including revisions to construction drawings; test results; meeting minutes; construction photographs; monitoring notes.

Construction Control: Typical components of a construction management system include planning and scheduling; survey control (layout, as-built records); grouting monitoring; foundation preparation monitoring; material quality control; compaction control; instrumentation monitoring and data synthesis; record keeping; construction safety; construction environmental criteria.

Dust Control: Minimize dust releases from the tailings facility. This may include keeping the tailings wet and/or using short- or long-term chemical or organic covers.

Inspection of Tailings Dams
Performance monitoring - visual inspection - high frequency; groundwater pressure (pore water pressure); seepage; deformation (settlement and stability); weather influence; seismic events (after the fact); special inspection programs after major events (earthquakes, hurricanes, spring breakup, floods).

Indicators of instability - soft zones and boils along the toe; dirty sediment in seepage; increased seepage rates; new areas of seepage; longitudinal and transverse cracking; settlement.

Areas requiring special attention - spillways; decant structures; drain and pressure relief wells; concrete structures; pipes and conduits through dams; rip rap areas; siphons; weirs; trees and animal holes.

Stability Monitoring Program Plans: Location of control stations; schedule (control period and inspection); type of monitoring (visual inspections, measures and parameters); appropriate level of instrumentation (e.g. piezometers) with clearly identified purpose; inspection methods, data compilation and evaluation; persons responsible for monitoring; data storage and reporting systems; criteria to assess monitoring program.

Water Quality Plan
Hydrology - severe storm events and drought events; necessary information and parameters for water management activities; criteria to manage water levels within safe limits, including any required daily or seasonal water level control.

Water control - ensure that water can be safely managed within the confines of the system; prevent damage to all structures; review and revise as required after changes in design or methods, during and after construction program, when the pond level exceeds specified critical elevations, after major storm or spring melt events.

Perimeter dam seepage - evaluate potential for seepage from the tailings area; define levels and characteristics of acceptable seepage; prepare action plans to deal with deviations from design seepage. Performance measures include control of seepage to within design rates, and monitoring and controls to ensure that systems are performing as per design.

Tailings Deposition Plan: Ensure efficient use of the tailings capacity. Provide for long- and short-term scheduling of dam lifts. Ensure effective closure of the facility. Develop and validate against actual field conditions at pre-set intervals a schedule for deposition of the tailings and a filling curve (volume/elevation/ graph).

Glossary

Acid Rock Drainage (ARD) Drainage of acid water containing dissolved metals as a result of natural oxidation of sulphide found in waste rock, ore and tailings exposed to air and water.

Appurtenances Structures and equipment within a tailings facility, other than the dam itself. They include, but are not limited to, such facilities as pipelines, spillways, drains, intake towers, tunnels, canals, low-level outlets, and water treatment, control and release facilities. Also included are mechanical and electrical control and standby power supply equipment.

As-built drawings Engineering drawings portraying the facility as constructed, including all changes from the original engineering drawings implemented during construction of a facility.

Aspect Element of an organization's activities, products or services that can interact with the environment.

Continual improvement The process of enhancing the tailings management system to achieve improvements in overall tailings disposal performance.

Emergency A situation which endangers life, property, the environment or the integrity of a tailings facility, and requires immediate action.

Environmental impact Change to the environment, adverse or beneficial, wholly or partially resulting from activities, projects and developments.

Life cycle The continuum from initial conceptual design through construction and operations to closure of a tailings facility.

Owner The person, company, organization or entity which is responsible for control, operation and maintenance of the tailings facility.

Risk The combination of the probability of occurrence and the adverse consequences of a specified event which would be detrimental to operations, the public or environmental health and safety.

Significant aspect An aspect that has or can have a significant environmental impact.

Tailings facility All structures, components and facilities functionally pertaining to tailings impoundments, including, but not limited, to dams, spillways, decant structures, other water control and treatment structures, and tailings lines.

The Mining Association of Canada Environmental Policy

Member companies of The Mining Association of Canada are committed to sustainable development which embodies protection of human health, the natural environment and a prosperous economy. In all jurisdictions, in addition to complying with legislative requirements, member companies will diligently apply technically proven and economically feasible measures to advance protection of the environment throughout exploration, mining, processing, manufacturing and closure. The member companies of The Mining Association of Canada will:

Corporate Priority

Recognize environmental management as an important corporate priority and establish policies, programs and practices for conducting business in an environmentally sound manner.

Integrated Management

Integrate environmental policies, programs and practices into all activities of the organization.

Environmental Management

Monitor the performance of environmental programs and management systems to ensure compliance with company and legislative requirements and this policy.

Continual Improvement

Establish an ongoing program of review and improvement of environmental performance, taking into account technical and economic developments, scientific understanding and environmental effects of operations.

Efficiency

Develop, design and operate facilities based upon the efficient use of energy, resources and materials.

Risk Management

Identify, assess and manage environmental risks.

Incident Management

Develop, maintain and test emergency preparedness plans to ensure protection of the environment, workers and the public.

Research

Support research to advance understanding of industry's impact on the environment and to reduce harmful effects through improved practices and technologies.

Technology Transfer

Contribute to the dissemination of environmentally sound technology and management methods.

Public Policy

Work with government and the public to develop effective, efficient and equitable measures to protect the environment based on sound science.

Contractors and Suppliers

Require contractors to comply with corporate environmental requirements and work co-operatively with suppliers to identify opportunities to improve environmental performance.

Communications

Encourage dialogue on environmental issues with employees and the public and be responsive to concerns.

Employees

Ensure that all employees understand and are able to fulfil their environmental responsibilities.

Closure

Reclaim sites in accordance with site-specific criteria in a planned and timely manner.

The Mining Association of Canada Environmental Management Framework

A Guide for Member Companies

Member companies of the Mining Association of Canada (MAC) support the concept of sustainable development, which seeks to enhance society through economic development and environmental protection. We believe that mineral products are essential for the development of a sustainable economy. Protection of the environment is an essential consideration in the management of our business.

While member companies have been managing environmental aspects of their activities for decades, there is a recognized need for an environmental policy and management guidelines to help to ensure the consistent integration of environmental considerations into each company's planning of projects and operations management. In support of its Environmental Policy, MAC has developed an Environmental Management Framework that includes four essential aspects of environmental management: 1. Leadership and Commitment, 2. Planning, 3. Implementation, 4. Monitoring, Assessment and Improvement.

MAC recognizes that member companies differ with respect to operating environments and business structures. However, there are common underlying principles of environmental management which should be applied. This framework is intended to help companies integrate environmental management strategies into existing management structures.

1. Leadership and Commitment

KEY POINTS:

- Policy - endorsement, communication and review
- Accountability

POLICY

Member companies are signatories to MAC's Environmental Policy which will be reviewed periodically to ensure that it is current and relevant to the activities, products and services of the industry.

Each member company should adopt an environmental policy that is consistent with MAC's Environmental Policy and appropriate to the nature of its activities. Member companies are responsible for communicating the policy to employees and contractors and to make it available to other important stakeholders, such as governments and communities in which they operate.

ACCOUNTABILITY AND RESPONSIBILITY

Each member company should establish an appropriate organizational structure to effectively manage the implementation and maintenance of obligations under its environmental policy. The organizational structure of each member company should be designed to address environmental issues, with clearly defined authority and responsibility. Each member company should establish and maintain a system for receiving, documenting and responding to internal and external stakeholder communications on environmental issues.

2. Planning

KEY POINTS:

- All business areas
- Consider - risks, regulatory requirements, stakeholder expectations
- Develop procedures - risks, regulations
- Incident Response and Emergency Preparedness

Member companies should include environmental considerations in planning all phases of their business activities, including exploration, development, operation and closure. Member companies should establish and maintain procedures to track environmental issues related to their activities, including the assessment of environmental risks, legal requirements and stakeholder expectations.

Planning should be carried out in accordance with priorized objectives and established performance goals. In addition, member companies' business planning should allocate appropriate financial and human resources to carry out environmental management functions, including preparation, documentation and dissemination of relevant procedures.

Member companies should develop and maintain effective procedures with respect to accidents and emergency situations. These procedures should emphasize prevention and be based on the known range of potential incidents arising from the company's activities, appropriate prevention programs and effective counter measures.

Each member company should regularly review and revise emergency preparedness procedures.

3. Implementation

KEY POINTS:

- Defined responsibilities and integrated activities
- Documented procedures
- Training
- Communication
- Information

Organizational structures should be established to implement environmental activities through the assignment of responsibility in a manner which integrates environmental with other business objectives. Operational procedures should include documented, adequate and regularly updated technical information and, where appropriate, environmental management practices for employees whose responsibilities require it.

Employee training and awareness are required for effective implementation of environmental policies and for good environmental performance. Accordingly, companies should identify training needs that reflect each company's environmental performance objectives. Training programs should be documented, procedure manuals maintained and retraining schedules established. Training procedures should convey an understanding of the company's environmental policy and the importance of complying with policy objectives and regulatory requirements.

Member companies should develop and maintain a system to inform employees about relevant environmental aspects of the company's activities. Member companies should encourage and facilitate dialogue with stakeholders, including local communities on environmental issues related to their activities.

4. Monitoring, Assessment and Improvement

KEY POINTS:

- Monitor results
- Assess conformance with - policy, objectives, goals
- Encourage continuous improvement

Member companies should establish and maintain procedures to regularly monitor the effectiveness of their environmental programs. In particular, companies should conduct regular audits to determine conformity with their stated objectives, company policies, environmental performance goals and regulatory requirements.

Member companies should use environmental performance assessments to encourage and promote improvement within their individual operations and throughout each company as a whole. Deficiencies noted in the assessments should be addressed in an appropriate and timely manner and actions taken should be documented. Follow-up procedures should be established to ensure that deficiencies have been addressed and actions completed.

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