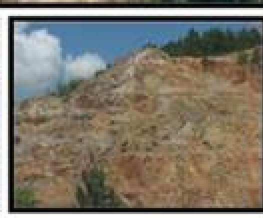
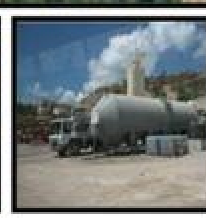
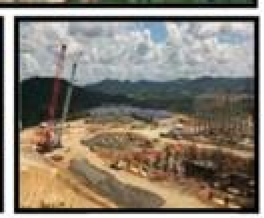
Volume I

EIA Technical Review Guideline: Non-Metal and Metal Mining

Regional Document prepared under CAFTA DR Environmental Cooperation Program to Strengthen Environmental Impact Assessment (EIA) Review







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EIA Technical Review Guidelines: Non-Metal and Metal Mining

Volume I

The EIA Technical Review Guidelines for Non-Metal and Metal Mining were developed as part of a regional collaboration to better ensure proposed mining projects undergoing review by government officials, non-governmental organizations and the general public successfully identify, avoid, prevent and/or mitigate potential adverse impacts and enhance potential beneficial impacts throughout the life of the projects. The guidelines are part of a broader program to strengthen environmental impact assessment (EIA) review under environmental cooperation agreements associated with the "CAFTA-DR" free trade agreement between the United States and five countries in Central America and the Dominican Republic.

The guidelines and example terms of reference were prepared by regional experts from the CAFTA-DR countries and the United States in both the government organizations responsible for the environment and mining and leading academics designated by the respective Ministers supported by the U.S. Agency for International Development (U.S. AID) contract for the Environment and Labor Excellence Program and grant with the Central America Commission for Environment and Development (CCAD). The guidelines draw upon existing materials from within and outside these countries and from international organizations and do not represent the policies, practices or requirements of any one country or organization.

The guidelines are available in English and Spanish on the international websites of the U.S. Environmental Protection Agency (U.S. EPA), the International Network for Environmental Compliance and Enforcement (INECE), and the Central American Commission on Environment and Development (CCAD): www.epa.gov/oita/ www.inece.org/ www.sica.int/ccad/ Volume 1 contains the guidelines with a glossary and references which track with internationally recognized elements of environmental impact assessment; Volume 2 contains Appendices with detailed information on mining, requirements and standards, predictive tools, and international codes; and Volume 1, part 2 contains example Terms of Reference cross-linked to Volumes 1 and 2 for exploration and exploitation for non-metal and metal mining projects respectively for use by the countries as they prepare their own EIA program requirements.

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A. INTRODUCTION

This regional Environmental Impact Assessment (EIA) Technical Review Guideline and associated Terms of Reference for Commercial Non-Metal and Metal Mining was developed as an outgrowth of the Environmental Cooperation Agreement developed in conjunction with the free trade agreements between the United States, the Central American countries of Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua (CAFTA) and the Dominican Republic (DR). Developed by designated experts from all of the countries, it will be used as a basis for country-specific adaptation to their EIA programs.

Figure A-1: CAFTA-DR - Countries

1 BACKGROUND

The CAFTA-DR "Program to Strengthen Environmental Impact Assessment (EIA) Review" was initiated as a priority for environmental cooperation undertaken and funded in conjunction with the free trade agreements. Designed to build on related references developed for the region or for individual countries, the Program included: a) sustainable training to build skills in the preparation and review of EIA documents and processes for all participants in the process, including government officials, consultants, industry project proponents, academic institutions, NGOs and the public, b) development of EIA Technical Review Guidelines and Terms of Reference for priority sectors: mining and energy, c) country-specific consultation to provide tools and reforms to improve the efficiency and effectiveness of EIA, including deployment of EPA's GIS-based analytical tool to support EIA project screening and administrative tracking systems, d) recommendations for strengthening EIA procedures, and where necessary, regional and country EIA legal frameworks, and e) regional meetings among EIA Directors to direct and support these activities and share experiences. Work programs developed by the U.S. Environmental Protection Agency and U.S. Agency for International Development, were designed to complement other work which had been undertaken with the Central American Commission for Sustainable Development (CCAD) and the Union for the Conservation of Nature (IUCN) under a grant from the government of Sweden.

2 APPROACH

The guidelines were developed through a collaborative process consisting of three regional expert meetings for discussion followed by several rounds of review and comment on draft documents, and also benefitted from the overall guidance and active involvement of country EIA Directors. The work was supported by the U.S. Agency for International Development and their consultants under the

Environment and Labor Excellence Program (ELE). The overall approach to the development of Mining Sector EIA Review Guidelines and Terms of Reference was:

- Creation of an expert team including the designation of senior experts by the Ministers of the Environment and for the Mining Sector from each of the CAFTA-DR countries and the U.S. (drawn from U.S. EPA's senior expert EIA Reviewers and sector experts from within EPA and the Department of the Interior's Office of Surface Mining, Regulation and Enforcement), including the opportunity for CAFTA-DR country officials also to include the designation of a key academic institution relied upon by the countries for relevant expertise in the mining sector
- Organization of three regional expert meetings to review and guide all work products drafted with the assistance of a U.S. AID's Environment and Labor Excellence program, Chemonics International
- Identification of existing resource materials, standards, practices, laws and guidelines related to assessing the environmental impacts from commercial scale mining
- Development of baseline information on current practice, anticipated growth, existing standards and guidance, norms, permits and mitigation requirements related to commercial scale mining in the CAFTA-DR countries and use this to assess the likely impact of adoption of the regional guidelines
- Development of information on alternatives for pollution control and environmental protection drawn from benchmark organizations, development banks and countries including international practices established by industry, the World Bank, the Inter American Development Bank, the U.S., the European Union and other countries identified by the team of experts as being most relevant
- Development of options to achieve the benefits of requiring siting, design, construction, operation and closure/reclamation and site reuse approaches which eliminate, reduce, mitigate and/or compensate the adverse direct, indirect and/or cumulative adverse environmental impacts related to mining based on best international practice through a EIA Review guideline and Terms of Reference
- Adaptation of these guidelines following country-specific training workshops to be held by CCAD and the individual countries

3 OBJECTIVES OF PRIORITY SECTOR EIA GUIDELINES

Specific objectives of these guidelines included:

- Improve environmental performance in the sector
- Improve EIA document quality and quality of EIA Decision making for the Mining Sector
- Improve efficiency and effectiveness of the EIA process for the mining sector by clarifying expectations, providing detailed guidelines and aligning preparation and review
- Tailor guidelines to needs of CAFTA-DR countries
- Provide technical guidelines for the identification of environmental, social and economic impacts of the mining sector activities
- Identify potential for avoidance and mitigation for adverse environmental, social and economic impacts from the mining sector in relation to established requirements of law and industry best practice to empower options for consideration by industry and government officials
- Encourage public participation throughout the process, a specific priority and request of CAFTA-DR country officials

4 SCOPE AND CONTENTS OF MINING GUIDELINES

The guidelines address:

- Non-metal and metal mining on a commercial scale of materials relevant to minerals found in CAFTA-DR countries (Note: EPA also supports the development of mining methods which reduce or eliminate the use of mercury in artisanal gold mining activities through its participation in the UNEP/UNIDO program (http://www.globalmercuryproject.org/front_page.htm) and the World Bank's Community and Small Scale Mining (CASM) program (see http://www.artisanalmining.org/index.cfm).USEPA is developing and testing technology to recycle and capture mercury, and hopes the high price of mercury will be an incentive to significantly reduce this source of contamination.)
- The full scope of mining activities, including exploration and exploitation, construction, operation, closure/reclamation, and post-closure care
- Documentation of the proposed project and its alternatives to support impact assessment and improve decision making
- Identifying and evaluating potential environmental social, cultural and economic impacts; and
- Evaluating the full range of sustainable environmental measures to prevent, reduce and/or mitigate impacts
- The need for enforceable and auditable commitment language in an EIA to ensure that promised actions will be taken by a project proponent and that their adequacy can be determined over time
- Example terms of reference for development of non-metal and metal mining EIAs that are cross-linked to the details provided in the guidelines

The guidelines are organized around each aspect of what is typically required in an EIA document. The guidelines are divided into eight sections with accompanying appendices. These sections include:

A. Introduction
B. EIA Procedures and Public Participation
C. Project and Alternatives Description
D. Environmental Setting
E. Potential Impacts
F. Assessing Impacts
G. Mitigation and Monitoring Measures
H. Environmental Management Plans
I. References and Glossary of Terms
J. Example Terms of Reference for Non-Metal and Metal Mining

With appendices entitled:

1. What is Mining
2. Overview of Mining Activities in CAFTA-DR Countries
3. Requirements and Standards Applicable to Mining Internationally and Within CAFTA-DR Countries, US And Other Countries and international organizations
4. Erosion And Sedimentation
5. GARD Guide (Guidelines for Acid Rain Discharges)
6. Sampling And Analysis Plan
7. International Cyanide Code
8. World Bank Financial Surety

5 ACKNOWLEDGEMENTS

The EIA Technical Review Guidelines for Metals and Non-Metals Mining and associated Terms of Reference were developed by experts designated by their Ministers from the environmental and sector agencies of the United States and countries in Central America and the Dominican Republic that are parties to the CAFTA-DR Free Trade Agreements. Following development of the regional EIA mining documents, the Central American Commission on Environment and Development (CCAD) will host workshops in each of the CAFTA-DR countries and they will adopt these guidelines for their own use.

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B. EIA PROCESS AND PUBLIC PARTICIPATION

This section describes the general process and practices common to Environmental Impact Assessment (EIA) procedures in CAFTA-DR countries, along with likely trends future directions of those programs as part of the evolution of the EIA process that has been seen internationally. Because this guideline and Terms of Reference were developed as regional products of designated experts from the CAFTA-DR countries they can be adapted to the unique features in each country's EIA laws and procedures.

1 EIA PROCEDURES

No work may begin, that is no site clearing, site preparation or construction, before the Environmental Impact Assessment (EIA) process is complete and government agencies have either approved or provided conditioned approval of a proposed project.

1.1 Project Proponents: From Project Initiation to the EIA Application

As illustrated in Figure B-1, a project proponent initiates the idea for a project based on a purpose and need for the action; in this instance some anticipated market for a particular mineral and expected profits from the extraction and sale of product with assumed levels of refinement, transportation and profit. Between the idea and the application for EIA to the government for approval as defined in Table B-1 ("Responsibility" in the EIA Process), the project proponent will be exploring alternatives to meet the purpose and need of the project, as well as the economic and technical feasibility of the project and securing property and/or mineral rights if it is not already in their possession. It is during this early stage that environmental, social and economic impacts should be introduced, and alternatives developed -- even before an application is made for EIA. Many problems can be avoided through wise selection of location, site and operations design, and anticipation of issues such as closure taking the whole of the environmental setting into account early in the process. If environmental consultants or environmental impact expertise are brought in late in the process, at the stage when the proponent needs to prepare an application and an EIA document for approval, it limits the opportunities to build environmental, social and economic considerations into the project proposal as an integral part of developing project feasibility. This is universally considered to be a short sighted practice. Projects which require substantial financing often will have fatal flaw analyses of all sorts performed, including environmental. Some of the outcome of such analyses also feeds the narrative on Project Alternatives and why some of the alternatives were rejected.

1.2 EIA Application, Screening and Categorization

Each CAFTA-DR country has established its own EIA regulations and guidelines defining different circumstances and procedures for particular types of projects and situations. These regulations distinguish the size and nature of proposed projects or the types of projected impacts for which the full environmental impact assessment procedure and which types of projects or impacts might justify a streamlined procedure based on potential lower level of impact and nature of the proposed activity. Projects usually fall within one of three categories, some of which are further subdivided: A usually is high impact, B1 and B2, medium impact and C low impact but this varies by country. Screening is the process used by government officials to review an application for EIA to determine the appropriate categorization. For the most part, commercial mining activities are usually considered among those projects with potentially high or high medium impact.

Figure B-1: The Environmental Impact Assessment Process

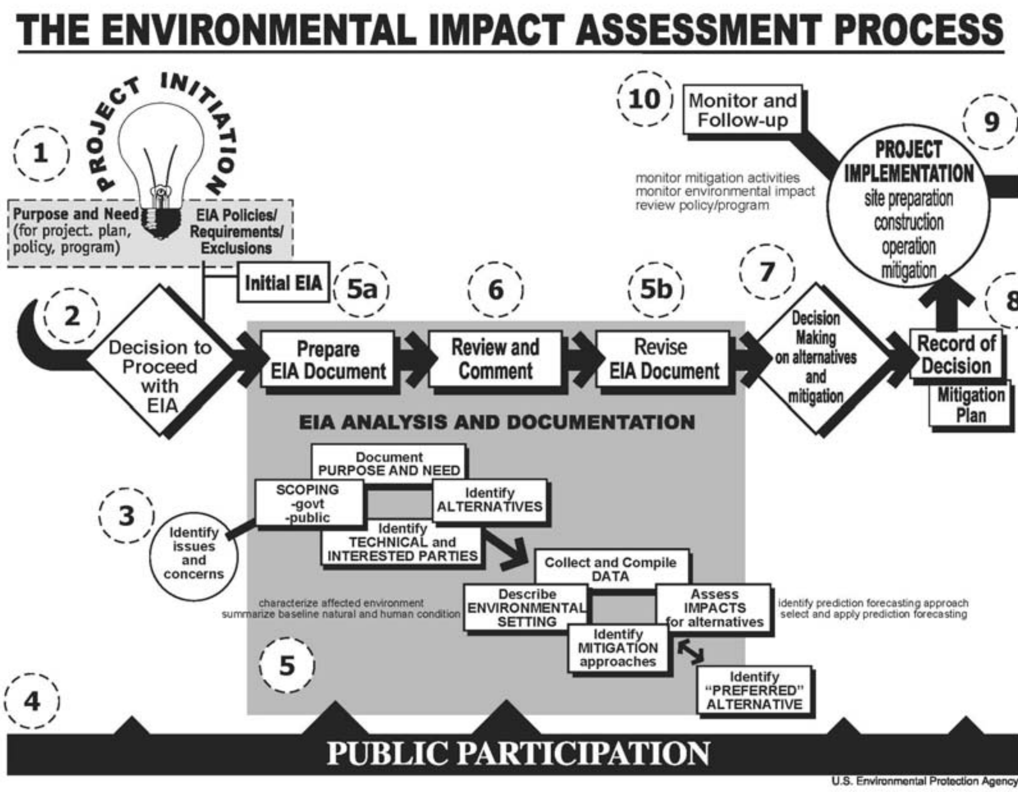


Table B-1: "Responsibility" in the EIA Process

	Project Proponent	Government
4 Public Participation throughout	1 Initiate Project	
	2 Prepare EIA Application	2 Screening: Review EIA Application and Categorization
	3 Scope EIA Issues	3 Prepare Terms of Reference and Scope EIA issues
	5a Prepare and Submit EIA Document	
		6 Review EIA Document
	5b Correct deficiencies and respond to comment	
		7 Decision on Project
		8 Incorporate commitments into legal agreements
	9 Implementation of Project, Environmental Measures and financial assurance	
	10 Correct violation	10 Auditing, compliance monitoring and enforcement

1.3 Scoping of EIA and Terms of Reference

Scoping is a process used to identify the important issues on which the EIA analysis should focus and those on which it would not be informative to focus. Although any preparer of an EIA would have to engage in a scoping process, the term often is used to describe a process of consultation with interested and affected stakeholders in the project, in the area and infrastructure potentially affected by the project and in the potentially affected resources. In CAFTA-DR countries of Central America and the Dominican Republic, government officials issue a Terms of Reference to help guide the preparation of an EIA document, in essence a form of scoping which usually includes a requirement for the project proponent to engage the public and stakeholders, including local governments and NGOs and tribal leaders, before proceeding to prepare the EIA document just for this purpose. In guidelines issued by the International Finance Corporation and as a practice in the U.S. and some CAFTA-DR countries, the project proponent would carry out public scoping early in the process for the most significant types of projects, presumably to be able to influence alternative project concept, design, operation and/or closure and influence the Terms of Reference for undertaking the EIA. Section B2 in this section of the guideline expands on public participation during the scoping process.

1.4 Public Participation Throughout the Process

EIA is intended to be a transparent process with the opportunity for public involvement from the earliest stages of project development. It is customary for the Terms of Reference to include requirements for the project proponent to engage the public and to document the results of this outreach process in the EIA document. Countries will usually provide a formal opportunity for a public hearing after the EIA document is reviewed by government staff and determined to be complete. The Model Terms of Reference included in this guideline emphasizes the importance of involving the public as early as possible to ensure that opportunities for reconciling economic, social and environmental concerns can be considered. A special section on Public Participation is included in this guideline under Section B2.

1.5 Preparation and Submission of the EIA Document

The structure of EIA documentation of analysis has been fairly standardized over the many years it has been adopted as a practice. It includes:

- Executive Summary
- Project Description, purpose and need, alternatives
- Environmental Setting
- Assessment of Impacts, Mitigation and Monitoring
- Commitment Document: Environmental Management Plan, which contains a facility-wide monitoring plan and a facility-wide mitigation plan, which addresses mitigation for environmental and socio-economic resources.

In countries in Central America and the Dominican Republic, deficiencies in an EIA document are usually addressed through additional supplemental submissions of Annexes and correspondence. If deficiencies are sufficiently significant an EIA document might be rejected and the project proponent would restart the entire process. In the U.S. a draft EIA document is submitted for both government and public review and a final document is then submitted which includes the response to comments and any additional analysis that is needed.

1.6 EIA Document Review

Government EIA Reviewers have an independent review function to determine if an EIA submitted by a project proponent: a) complies with minimum requirements under country laws, regulations, and procedures, b) is complete, c) is accurate, d) is adequate for decision makers to be able to make informed decisions and choices, including alternatives that might serve to avoid adverse impacts, and reasonable commitments to mitigation for adverse impacts that cannot be avoided, e) distinguishes what may be a significant concern from those that are less significant, f) provides a sufficient basis for assuring that commitments to environmental measures will be met, taking into account not only the EIA but any additional supporting documents such as an Environmental Management Plan, including those measures which are integrated in the project design, operations and closure, monitoring and reporting, pollution control measures and their maintenance, infrastructure investment and the like.

1.7 Decision on Project

In the decision making process which is informed by the EIA analysis, the actual decision on the project and its rationale are important, particularly if the EIA analysis is not just to be a paper exercise. It therefore is very important that the consideration of alternatives, impacts and their mitigation be written in a clear and accessible manner to the range of stakeholders who are making decisions related to the project. Part of the decision process is engagement of stakeholders within and outside government in a timely and constructive manner, allowing for the type of give and take needed to address and find acceptable solutions to diverse interests.

1.8 Commitment Language for Environmental Measures

Countries differ on the vehicles they use to establish and hold project proponents accountable for commitments made during the EIA process, ranging from reliance on the EIA document itself to a document from the government establishing project environmental feasibility which highlights commitments, the environmental management plan, a mitigation plan, an environmental permit, concession and/or contract.

1.9 Implementation of Environmental Measures

The EIA process objectives can only be achieved if promises and assumptions made in an approved EIA document are followed in practice. Commitments are usually secured with financial guarantees. The commitment to implement environmental measures runs throughout the process from site preparation to closure. It is the responsibility of the project proponent to implement measures unless the commitments are assigned and agreed to by other parties such as might be the case in the provision of adequate infrastructure to address needs to treat liquid and solid waste from a site, or to construct a road.

1.10 Auditing, Monitoring and Follow-up Enforcement of Commitments

Countries employ a mix of mechanisms to ensure that commitments in the EIA document are followed, including: including short and long term monitoring and reporting in the commitments by project proponents; creating and certifying third party auditors and defining their roles in the process; government inspection; and sometimes monitoring by the community or NGOs to assure compliance. It is not sufficient to monitor compliance with commitments, and failure to meet commitments should be followed by enforcement for failure to comply in order to compel actions needed to protect environmental, socio-economic and cultural interests. For this system to work, commitments in the EIA should be written in a manner which clearly provides the basis for an independent audit and also clarity for the project proponent to ensure it is clear what they will be undertaking and when.

2 PUBLIC PARTICIPATION

2.1 Introduction

Public participation and stakeholder involvement is an essential and integral part of the EIA process and CAFTA-DR countries have adopted policies, regulations and procedures to require that this occurs throughout the EIA process. Reviewers should ensure that minimum requirements are met, that key stakeholders and important issues have not been ignored or under-represented, and that opportunities for effectively resolving underlying conflicts are provided. The process for engaging the public and other stakeholders fails if it is undertaken as an afterthought or poorly implemented or viewed as a one-time event. Opening up real opportunities for engagement by the public, local governments, and interested and affected institutions requires a degree of openness and disclosure which can be uncomfortable for some who fear that it might open the door to unnecessary complication, higher costs and loss of control. However, the clear lessons from failed public participation processes are just the reverse: if the public is engaged early, and in an open and transparent manner, the process can help to avoid both unnecessary conflict and potential financial hardship due to project delays and occasionally even permit denial. This chapter will refer to public and stakeholder involvement interchangeably, but requirements for and the timing of participation for different subgroups may vary.

Section B2 addresses requirements for public participation. Included in this chapter are:

1. Requirements for participation;
2. Methods for identifying and engaging affected and interested publics; and
3. Reporting on and responsiveness to public comments.

2.2 Requirements for Public Participation

Public participation requirements of individual countries should be identified and followed. Because there is no easy formula for describing what is required to be successful in a given situation, legal requirements for public participation are formulated as minimum requirements of law, and generally do not reflect best practices designed to meet the full goals of public participation as an ongoing process. To address the need to tailor a public participation plan to the circumstances some CAFTA DR countries require that the project proponent develop and implement such a plan. The EIA should document the steps taken to meet requirements and overall goals of public participation including: when, who was involved, what the comments were and how they were considered.

Reviewers should carefully examine:

- Were requirements for public participation identified and complied with?
- Was timing of public notice sufficient to allow meaningful comment?
- What documents and information were disclosed and when?
- Are there obvious concerned publics that were not involved and consulted?
- Were opportunities to address public concerns and information overlooked?

Public participation requirements may include:

- General Requirements to include the public in the EIA process
- Public Notification: Rules about the use of media to announce the EIA process and the points of participation for the public and requirements for the Ministry or the owner/developer to announce the public consultations in national and local media. Public participation and consultation ideally should be initiated at the scoping stage of the EIA process, before steps are taken to prepare the EIA document. This can be accomplished through a public notice of intent to prepare an EIA for a specific action. Such a notice of intent should include a description of the proposal and describe how the public may participate in the process
- Public Consultation: Rules about the consultations and observations that the public presents
- Public Disclosure: Requirements that the Ministry or the owner/developer publish the EIA for review during the public consultations
- Public Written Comment: Requirements for the public to have the opportunity to submit written comments to the Ministry and the owner/developer in addition to the consultations. Requirements may specify whether solicitation of comments from the public should take place in formal public hearings, or may allow or encourage informal workshops or information sessions
- Public Hearings: Most laws on public participation provide for the opportunity for a public hearing. This is a formal legal process with little opportunity, if at all, for give and take discussion on options, alternatives and assumptions. It is for that reason it is considered by most experts on public participation to be the least effective means for actual public involvement
- Consideration of Public Comments: Requirements for public comments to be considered in the review by the government if they have a sound basis
- Allocation of costs: Rules about who needs to pay, i.e. the owner/developer generally should pay for the consultations with some exception where the Ministry pays.

2.3 Methods for Identifying and Engaging Affected and Interested Public

Successful public participation processes are built upon plans developed and tailored to a specific project or program. This section addresses: (1) the identification of stakeholders, taking into account the goals and objectives of the specific project or program that is being analyzed in the assessment and the potential issues of concern; and (2) methods, or the tools and techniques to engage the identified stakeholders, when those tools are employed, including roles and responsibilities.

2.3.1 Stakeholder Identification

Project proponents and their consultants should make a diligent effort to identify and engage individuals and groups both within and outside of government who

Potential stakeholders to be considered:

- persons living and working in the vicinity of the project
    - individual citizens with specific interests
    - local residents and property owners
    - local businesses and schools
- local, provincial, tribal, and national governmental agencies, including regulators and those responsible for infrastructure such as roads, water, solid waste
- citizen, civic, or religious groups representing affected communities
- NGOs with specific interests
- environmentalists and conservation groups interested in protection and management of sensitive ecosystems and protected areas
- recreational users and organizations
- farmers, fishermen, and others who utilize a potentially affected resource
- industry groups such as fisheries, forestry, and mining
- technical experts
- low income, minority, people who may be disproportionately affected
- indigenous peoples

might either be affected by or interested in a proposed project and its potential impacts. The geographic scope should include the areas in and around the project, from the perspective of both political and natural resource boundaries, in other words, the full geographic scope of each of the natural and human resources potentially affected by the proposed action. Identifying the specific issues presented by a proposed project or program will help to reveal the key stakeholders, and the stakeholders also will help to identify issues for analysis. Additional stakeholders will be discovered throughout the entire assessment process and should be included in subsequent public participation activities.

2.3.2 Engagement Methods and Timing

A variety of tools and techniques can be utilized during the public process depending upon the level of public participation sought, which can range from merely providing information to working in a collaborative relationship. Although laws and regulations might only require a formal public hearing, "talking at the public" is not a substitute for active listening. That is why public hearings are historically poor ways to engage the public, and it is best to augment formal procedures with other processes to enable the give and take of dialogue and discussion. Cultural nuances may make other types of outreach helpful and informative, such as home visits with elders or people who do not trust public meetings.

Three consistent lessons learned for effective public participation process are to:

- Adapt the process to meet the needs of the circumstances
- Reach out to and understand the audience
- Start early in the EIA process

To be effective, public participation should be tailored to the particular audiences and meet the goals of the specific public engagement or communication, and those goals should be clear. Communications which are early, clear and responsive both to information provided and concerns raised are essential to build trust. The selection and timing of methods used to engage stakeholders and the broader public should result in: a) encouragement to offer information important to assessing impacts and developing alternatives, b) transparency about what is proposed, its potential impacts and means of addressing them, and c) a clear message to all members of the public that their input is important and useful throughout the EIA process.

Scoping occurs early in the EIA process to identify key issues, and to focus and bound the assessment. Many of the CAFTA-DR countries require project proponents and their consultants to engage the public during this phase, before beginning work on the EIA. Scoping typically is conducted in a meeting or series of meetings involving the project proponent, the public, and the responsible government agencies. The structure of the meetings may vary depending on the nature and complexity of the proposed action and on the number of interested participants. Small-scale scoping meetings might be conducted like business conferences, with participants contributing in informal discussions of the issues. Large-scale scoping meetings might require a more formal atmosphere, like that of a public hearing, where interested parties are afforded the opportunity to present testimony.

Other types of scoping meetings could include "workshops," with participants in small work groups exploring different alternatives and designs. Meetings may need to include interpreters to translate information for people who do not speak the language in which the meeting is being conducted, as is the case with all procedural and analytical stages of the EIA process.

Public participation tools often used in an EIA process:

- public meetings
- public hearings
- small group meetings or workshops
- community advisory panels
- news releases, newsletters with public comment forms, fact sheet, flyers
- media – feature stories, interviews, public service announcements
- project/program Web sites
- public comment periods soliciting written comment letters
- information repositories or clearinghouses
- speakers bureaus
- surveys
- mailing lists
- briefings by and for public officials
- use of social networking such as facebook, twitter, etc.

There are several guidelines that have been developed by the CAFTA DR countries (e.g. Guatemala) and international organizations concerning the planning and implementation of public participation which are noted in the reference list. Public Participation Tool Kits are available from EPA in different languages at http://www.epa.gov/international/toolkit and from the International Association for Public Participation at http://iap2.affiniscape.com/associations/4748/files/06Dec_Toolbox.pdf Also see http://www.epa.gov/care/library/community_culture.pdf

2.4 Reporting on and Responsiveness to Public Comments

Public input should be reflected in changes in the assessment, the project or program, or to commitments for mitigation. Project proponents should document specific steps taken to engage the public and other stakeholders, and the timing of those engagements, both before preparing the EIA and during its development. Included in the annexes of the EIA should be a summary of public outreach activities, audience, number of persons, organizations involved, concerns raised, responses to comments and, if required, actual copies of written comments received. Reporting on comments obtained through any of the methods identified above should be sufficiently clear to enable an EIA reviewer and the public to assess responsiveness to comments, including whether they were understood, whether they were found to be appropriate or not and why, and if appropriate, what actions were taken to respond to them and whether those actions are sufficient to fully address the concerns. Several approaches might be acceptable to summarize or include actual transcripts and copies of oral and written comments and to demonstrate responsiveness through narrative, tables and cross-references to specific changes.

C. PROJECT AND ALTERNATIVES DESCRIPTION

1 INTRODUCTION

Environmental Impact Assessment starts with the description of the project to provide the context and sufficient detail about all the components of the project to support a credible assessment of impacts for both the proposed actions and reasonable and feasible alternatives. This section contains some of the most important information of the EIA since it provides the core data for forecasting potential environmental impacts, and for reducing, eliminating or mitigating those impacts.

The main elements of the description of the proposed project and alternatives should include:

- Purpose and need: A clear and concise statement with supporting information on the justification and objectives of the project
- Description of the proposed project detailing:
  - how it meets the purpose and need
  - facility and engineering design details in sufficient detail to support an accurate identification and assessment of impacts
  - coverage of all phases of the project both in chronological time from site preparation to construction to operation to closure and also phases if there are plans to increase the capacity at later points in time
  - expected physical releases into the environment
- Description of project alternatives: an identification of alternatives for meeting the purpose and need, which are economically and technically feasible, and sufficient detail for the most appropriate and representative alternatives to permit comparative assessment of impacts. This can include modifications to the proposed project or entirely different projects to meet the purpose and need.

ENGINEERING DESIGN

Whether a sand and gravel operation or a major gold mine, appropriate environmental practices for a mining operation begin with an appropriate engineering design. This design should take into account:

- The mining method – albeit surface, underground, in-situ or dredging
- Processing
- The disposal of waste rock and tailings
- Transportation facilities
- Water control – surface and groundwater
- Mine support facilities
- The final restoration plan
- Post-closure facilities and activities
- Manpower needs

The ultimate goal of the design is to provide a blueprint for the mine to operate in an environmentally and economically appropriate fashion while restoring the land to its intended land use.

Engineering design in an EIA should present a clear understanding as to how the mine is going to operate from start to finish. Flow charts should show the path of the ore from removal through collection, transportation, and beneficiation and other processing, and load-out and delivery. Maps and plan views should be developed to show the layout of the mine and processing facilities. The design should show year by year activities as the mine expands and restoration takes place. Activities to take place during the first five years should be presented in detail as well as a general approach for various activities for the "life of mine."

Metal Mine Design	Non-metal Mine Design
• Mine layout • Pit wall stability • Processing • Water control and treatment (ARD) • Chemical management • Haul roads • Heap leach, waste rock and tailings dam design • Noise reduction • Final restoration – pit lake, grading post-closure	• Pit wall stability • River conditions for dredging operations • Erosion and sediment control • Spill prevention and control • Access roads • Topsoil and Overburden handling • Noise reduction • Final restoration

- Documentation of the economic viability of the proposed project.

The proposed engineering design would already include information describing the design and operation of a proposed mining project and its alternatives. Usually, by the time an EIA is being prepared, much of the preliminary planning and engineering design have been completed by the proponent to prove economic feasibility. The designs and construction plans may not be detailed enough for actual construction and implementation, but all aspects of the plan will have been contemplated and preliminary power generation or transmission system designs will have been prepared and compiled. The plan likely will also contain information on support facilities and labor needs.

2 DOCUMENTATION OF PURPOSE AND NEED

In describing the underlying purpose and need, the EIA should be more specific than assertions that more mined minerals might be needed. The assessment of impacts will be different based on the responses to several questions that need to be made clear in the EIA:

- Who needs the materials and for what purpose?
- Where is the mined material needed and what form(s) must it take to meet the need?
- How much mined material is needed and when are different quantities and quality needed?
- What are the levels of uncertainty in the assessment of needs?

The purpose and need description also should help to explain whether the proposed project is a new project, an expansion or a replacement/maintenance of an existing project, and whether and why the project might be phased in over time and this information is an important aspect of the project description. It will also help to clarify for the project description who the intended audience is for the mined material being generated and/or distributed, i.e. will it be for local use or for users at a distance? Will it be used domestically or exported to other countries?

3 PROJECT AND ALTERNATIVES DESCRIPTION

This section of the EIA should provide Information on the proposed project and alternatives sufficient not only to describe how they meet the purpose and need but as a basis for identifying and assessing their impact(s). This project description should include the nature, size and type of project and all related facilities and activities, its design, construction, operation, site design and land area, subsequent anticipated expansion and closure as well as the profile of direct releases into the environment, employment, resource and waste streams, related transportation and the like, which are elaborated below. Additional detail on mining technology is provided in Appendix A.

The Project Description section of the EIA should begin with an overview of the proposed activities and a general description of background information to place the proposed mining activities in context. Overview information includes a general description of the overall mining activity including identification of each component, mining activity layout, schematic of the mining operation, ore and waste flowcharts, initial construction sequencing, life of the mining operation, general location, and access. Background information includes pre-mining land uses, land ownership, ore body geologic information, and applicable laws, regulations and best practices. In addition, other alternatives should also be identified to the proposed actions. These could include "Do Nothing," an alternative location, or other actions as appropriate.

The general location and access should be presented on an overview map, which places the activity in its geographic context. The mining activity layout should show the various locations of the mining operation components such as the mine, processing sites/facilities, disposal sites, transportation, ancillary facilities, etc. This information should be presented in a scale that allows the reviewer to understand each component in relationship to the other components, including natural features such as topography, existing structures and communities, water bodies, wetlands, and flood plains. This context helps in assessing appropriate placement of proposed facilities. A simple summary table showing the type, quantity and size of each component can also be useful for understanding the general context of the operation.

Flow charts should show the path of the ore from removal through collection, transportation, beneficiation and other processing, and load-out and delivery. The flow charts should include the flow of waste material from generation through treatment and disposal. Applicable mining and environmental regulations and Best Available Practices should be cited in this section.

Initial construction sequencing should be presented, including the scheduling of construction for the various components of the mining operation including roads, repair shops, warehouses and other support facilities, power sources and transmission lines, water sources and conveyances, material handling systems, processing facilities, mine development, etc.

Information on the geology of the ore body provides necessary background for understanding the proposed mining and processing. Information on the local and regional geological setting should be included in the "Environmental Setting" section of the EIA, but information on the ore body, as it relates to the design and sequencing or phasing of the mine, should be presented in this section. This information includes:

- Geology of mine area
- Cross-sections of the geology of the mine area including soil horizons
- Spatial delineation of the mineralized area (ore body) including depth to the top of the ore body.
- Isopach maps of reserves
- Types of rock, mineralization and any structural deformation by local folding and faulting
- Grade of ore by region within the ore body
- Types and quantities of ore that will be extracted and processed during different phases of the project
- Estimated quantities of final products to be produced, by product type and in ounces, pounds or tons (as appropriate to the mineral)
- Estimated quantities of waste rock and overburden to be disposed during different phases of the project

3.1 Overall Project Description Information

Typically by the time an EIA is started much of the preliminary design work has been completed by the project proponent to prove economic feasibility and support bankability of the project. The designs and construction plans may not be entirely complete but most if not all of the details required for environmental impact assessment as noted above should be available.

- Project Facilities should describe:
    - Size
    - Type of project
    - Buildings to be constructed, their dimensions and building materials
    - How will it be built, manpower, sources of materials, storage on or off site
    - Employment for the project, where it will be coming from, level of skills
    - Access rights
    - Dimensions and land area affected
    - Design on the site with maps and geospatial information (longitude and latitude)
- Project Operations: The description should elaborate:
    - Energy (fuel and renewable) sources
    - Processing of energy sources to produce electricity as appropriate
    - Technologies employed and their profile of air and water releases and waste streams
    - Infrastructure plans to manage water, air and waste and resulting levels of release into the environment
    - Emissions, effluents, wastes and other physical factors resulting from construction and operation of the power plant or transmission line
- Initial construction sequencing should be presented, including the scheduling of construction for the various components of the power generation or transmission line component. This should include:
    - Roads
    - Repair shops
    - Warehouses and other support facilities
    - Power sources
    - Pollution reduction and control systems
    - Transmission lines to be accessed or built
    - Water sources and conveyances
    - Material handling systems
    - Processing facilities, etc.
    - Quantitative and qualitative information on the degree of site clearing and vegetation removed from the site at any point in time, plans for sequencing site clearing and resulting changes in plant cover and non-permeable surfaces for all phases
- The project and its geographic, ecological, social, and temporal context includes any offsite investments that may be required, for example:
    - Dedicated and shared pipelines
    - Access roads
    - Sources of power for the operation
    - Water supply
    - Housing
    - Raw material and product storage facilities
    - The need for any plans for wastewater treatment
    - The need for and any plans waste management
    - Storage of fuels and hazardous materials
    - Resettlement plan or indigenous peoples development plan
- Detailed maps with site design and detailed topographical and special mapping relating the proposed project to the geology of the project area: This will of course be an important

element of the "Environmental Setting" section of the EIA. Information presented should include, but not necessarily be limited to:
  - Local and regional geology
  - Soil characterizations
  - Geotechnical zone

  This information will be critical for superimposing on the baseline environment later to estimate or predict the net environmental and socio-economic impact, which may ultimately be positive, negative or neutral.
- Transportation Information including the mode of transport location and the intensity of transport from trucks, pipelines, ships, etc., including
  - Transport of raw materials
  - Transport of the mined materials, the intended users of the mined materials, and how the minerals generated from a project will get to its intended users
- Details on Engineering Design: The Project Description section of the EIA should use engineering design plans to present detailed information about the proposed project.

3.2 Project Scope: All Project Phases and Related or Connected Actions

All mining projects include the following phases:

- Design engineering
- Environmental impact assessment and permitting
- Site Preparation
- Construction
- Operation and maintenance
- Possible expansions
- Reclamation and Closure

All phases and details about them should be provided.

All related or connected actions should be addressed in the EIA. There may be different entities and project proponents responsible for different aspects of proposed projects and alternatives. Even if there are different entities involved the test is whether the proposed project X would still be proposed if another project Y were not also proposed. So, for example, if a mine project is proposed to provide building materials for the building of a new road or a new hydroelectric dam the two projects should be assessed at the same time either by cross referencing in separate EIA documents or within a single, integrated document.

4 PROJECT ALTERNATIVES

4.1 Identification and Assessment

Consideration of alternatives is the "heart" of the EIA process and is a requirement of country EIA laws and procedures to foster sustainable development and improved decision making to reconcile economic, environmental and social concerns. This requirement to consider alternatives only pertains to economically and technically feasible alternatives and usually only a subset of alternatives considered would be taken to full analysis of impacts. Project evaluation should, at a minimum, include those as well as a no-action alternative that provides a baseline for assessing the consequences of not taking the proposed action. It does not mean that nothing will happen as a result of the project not moving forward. Project alternatives offer opportunities to avoid or reduce adverse environmental, social and economic impacts of the project. Given the public participation requirements of the EIA process, it would also be important for the project proponent to solicit public comment on the proposed alternatives analysis.

There are several issues to consider in determining the scope of alternatives that will need to be addressed. All EIAs for mining should include:

a) No Action Alternative: the analysis of the no-action alternative, which represents the reasonable impacts, projected into the future, of not taking the proposed action. What would happen in the future if the proposed project or action is not approved or withdrawn?

b) Reasonable technically and economically feasible project options that would reduce potential adverse environmental and socioeconomic impacts such as alternative designs, technology, site design and facility design options for the project location including proposals by stakeholders, for modifications or new project options posing lower impact.

Alternatives

Analyzing alternatives is important to exploring opportunities to avoid environmental, social and economic concerns rather than just mitigate them for a specific proposal. Alternatives are particularly important given the significant potential impacts of mining projects. Alternatives should include:

- No action alternative: what happens in absence of the proposed actions
- Modified project
  - alternative size and sequencing of the project
  - alternative location/sites
  - alternative site design/facility design or use
  - alternative site access, storage
  - alternative and combined energy mix
- Alternative Project
  - alternative technologies
  - alternative energy source or fuel mix
  - alternative connections to related infrastructure
  - alternative project at alternative location or site

4.2 Alternative Methods of Mining

The mining method may be surface or open-pit, underground, or in-situ. The mining method will be determined largely by the physical characteristics of the ore body and geology such as depth to the ore body, surface topography, geologic structure and location. The mining method should be substantiated by the project proponent in terms of these characteristics.

Detailed design information, including site plans, should be provided. The type of information that should be included for surface or open-pit and underground mining is summarized in Table C-1.

Table C-1: Information included in the Proposed Engineering Design

Component	Surface or Open-pit Mining	Underground Mining
Mine Design	Benches (sizes by year) Slopes (stability, angles and lengths) Area and depth by year (table and map) Map showing mining sequence Typical pit cross-section (showing stripping/benching) Transport/access ramps and in-mine roads Pit backfilling sequences	Detailed descriptions of method • Stoping • Cut and fill • Room and pillar • Slock caving Location of the shafts (primary and secondary) Map showing tunnel extensions by year Roof support

Table C-1: Information included in the Proposed Engineering Design

<table>
<tr><th>Component</th><th>Surface or Open-pit Mining</th><th>Underground Mining</th></tr>
<tr><td>Clearing and Grubbing</td><td>Area by year
Methods
Topsoil stockpiling
Disposal or salvaging of debris</td><td>Area by year
Methods
Topsoil stockpiling
Disposal or salvaging of debris</td></tr>
<tr><td>Excavation</td><td>Methods
Blasting program and schedule</td><td>Methods
Blasting program and schedule</td></tr>
<tr><td>Hauling</td><td>Haul road construction map and specifications
Estimated quantities by year:
• Ore
• Overburden
• Waste Rock</td><td>Haul road construction map and specifications
Estimated quantities by year:
• Ore
• Waste Rock</td></tr>
<tr><td>Water and Dewatering</td><td>Water supply (needs, quantity, source, treatment, storage and transport)
Dewatering (how, quantity, predicted cone of depression, transport, treatment, and disposal)
See Water Facilities section below for other water components</td><td>Water supply (needs, quantity, source, treatment, storage and transport)
Dewatering (how, quantity, predicted cone of depression, transport, treatment, and disposal)
See Water Facilities section below for other water components</td></tr>
<tr><td>Equipment</td><td>Roster, specifying type and quantity by: size, motor size, and fuel requirements for each activity:
• Clearing and grubbing
• Excavation
• Hauling
o Vehicles (plus average trips per day)
o In-pit conveyors
• Personnel transport
• Dewatering
• Dust control
• Power generation</td><td>Roster, specifying type, size, quantity and fuel requirements (type and quantity) for each activity:
• Clearing and grubbing
• Excavation
• Hauling
o Vehicles (plus average trips per day)
o In-mine conveyors
o Lifts
• Personnel transport
▪ To mine entrance
▪ Inside mine
• Dewatering
• Dust control
• Ventilation
• Power generation
• Compressed air</td></tr>
<tr><td>Onsite Support Facilities</td><td>Offices, storage, machinery housing, repair shops, fuel stations, etc. (Design specifics in Mining Facility section)
Designs of facilities (including containment and emergency response provisions)
• Fuel
• Explosives
• Hazardous materials</td><td>Offices, storage, repair shops, fuel stations, machinery housing, lifts, etc. (may be elaborated in Mining Facility section)
Designs of facilities (including containment and emergency response provisions)
• Fuel
• Explosives
• Hazardous materials</td></tr>
<tr><td>Operations</td><td>Hours per day
Shifts per day</td><td>Hours per day
Shifts per day</td></tr>
<tr><td>Other</td><td>Lighting if nighttime operations are proposed (including source of energy)
Health and Safety
Dust control measures
Water and air quality monitoring</td><td>Lighting (including source of energy)
Mine communications
Health and Safety
Dust control
Subsidence monitoring
Water and air quality monitoring</td></tr>
<tr><td>Associated Appendices</td><td>Slope Stability Analysis</td><td>Roof Stability Analysis
Subsidence Prediction Study</td></tr>
</table>

The engineering design for a quarry is much the same as for an open-pit mine but usually on a smaller scale. Basic facets for design include:

- Site preparation – top soil removal, runoff control, erosion and sediment control, etc.
- Haul and access road construction – grade control, runoff control, erosion and sediment control, and dust control.
- Blasting and excavation – pit design, erosion and sediment, dust, fumes and exhaust, and accidental spills.
- Crushing and sizing – dust and noise control.
- Closure – grading and revegetation.

BLAST VIBRATION REDUCTION
(For noise, dust and debris control)

Blasting generates both ground and air vibrations. A blasting plan for each mine should be based on site-specific conditions to reduce noise and vibrations that may cause disturbances potentially harmful to structures, humans and wildlife. Steps that should be taken include:

- Provide safety protocols and ensure their use during blasting operations such as safety zones to prevent unauthorized entry, warning signals to alarm nearby workers and residents of impending blasts and all clear signals to note when the area is safe to reenter.
- Conduct blasting only during hours agreed to in consultation with local communities.
- Limit the size of explosive charges to minimize vibrations.
- Confine explosive charges to allow for natural attenuation to reduce-noise and dust or debris at the source and impacts to nearby residents.
- Enclose or shield sources of noise from blasting, including measures such as the construction of berms around the site.
- Ensure that blasts do not exceed acceptable national or international vibration criteria --by way of example limit ground vibrations to below 12.5 mm/s (peak particle velocity) and limit air vibrations to 133 dB.
- Implement a monitoring program to assess the effectiveness of these measures against national or International standards so that the need for improvements in noise and vibration reduction can be identified and implemented. Use monitoring equipment compliant with the International Society of Explosives Engineers standard "Performance Specifications for Blasting Seismographs."

Additional information on blasting rules, regulation and research is available at the United States Office of Surface Mining Reclamation and Enforcement web site at http://www.arblast.osmre.gov/

4.3 Dredging

When sand and gravel is excavated using dredging, other factors should be considered in the engineering design. These include:

1. Operational plan – including areas to be dredged, operational hours, procedures to be used when woody debris and fallen trees are encountered, daily and weekly operating frequencies, average upstream dredge movement, and time necessary to dredge the entire area

2. Equipment roster

3. River or shoreline access – including stream bank disturbance; erosion control; timing and extent of clearing, grubbing and other disturbance to the riparian vegetation; and temporary stream crossings (design and materials). Stream beds should not be used as transportation routes for construction equipment.

4. River diversions and flood control – including instream berms

5. Transportation plan

6. Off loading and storage areas – Often barges are used to transport the sand and gravel to a port – these port facilities need to be designed properly.

7. Waste disposal - Certain fractions of the sand may be difficult to market and may have to be treated as waste. Material should not be placed in a location or manner so as to impair surface water flow into or out of any wetland area. Dredged material should not be stored or stockpiled on the gravel bed, streambed or stream banks. In addition, litter, construction debris, and construction chemicals exposed to stormwater should be managed and picked up prior to potential storm events (e.g., forecasted by local weather reports), or otherwise prevented from becoming a pollutant source for stormwater discharges (e.g., screening outfalls, daily pick-up, etc.).

8. Sediment control plan – Sediment should be prevented from entering the stream. Erosion and sediment controls should be designed according to the size and slope of disturbed or drainage areas to detain runoff and trap sediment and should be properly selected, installed, and maintained in accordance with good engineering practices. Erosion and sediment control measures should be place and functional before earth moving operations begin, and should be constructed and maintained throughout the construction period. This includes temporary measures, which could be removed at the beginning of the work day, but should be replaced at the end of the work day.

9. Material Management and Spill Prevention plans – including measures to ensure that all materials used are free of contaminants, petroleum products or other chemical pollutants are prevented from entering water, and spills are immediately addressed and prevented from polluting of water

10. Restoration Plan – including timing and plans for removal of structures, removal of materials used for the temporary crossing, recontouring, and restoration and stabilization of stream banks

4.4 In-situ Mining

Solution or in-situ mining entails pumping a chemical solution via a system of injection wells into intact rock to dissolve the metals from the ore body, and then pumping the pregnant solution out through a system of extraction wells. The product is then recovered through further processing. The process varies with the type of host rock and ore. In-situ mining can be used to extract water-soluble salts (using water), uranium (using acid or a carbonate such as sodium bicarbonate), and copper (using acid). In-situ mining is not particularly relevant to CAFTA DR countries and so is generally not covered in this guideline. Some of the information that should be included in the Proposed Engineering Design for in-situ mining is the same as for other mining methods, including clearing and grubbing, equipment rosters, onsite support facilities, power needs, operating needs and health and safety programs. Other design components, however, are unique to in-situ mining. These include injection and pumping rates, recovery and monitoring well locations and designs, chemical specifications, injection and recovery program, etc.

5 PROCESSING

5.1 Beneficiation Facilities

Beneficiation facilities and processes are dependent on the type of ore being mined. Typical beneficiation includes one or a combination of the following processes: crushing; milling; washing; filtration; sorting; sizing; magnetic separation; pressure oxidation; flotation; leaching; gravity concentration; and agglomeration (pelletizing, sintering, briquetting, or nodulizing).

The Engineering Design should identify each type of beneficiation that will be used for the proposed project and alternatives. It should present a schematic of the beneficiation processes including means of transport between steps and an elaboration of the flow charts presented in the overview, with more details for ore, other inputs and waste flows through the processing facilities. For each type of processing and means of transport, detailed designs should be presented including individual facility schematics (showing locations and sizes of component parts) and design and operational details. The design and operational details for each unit should include:

- Area to be temporarily disturbed during construction and occupied by the facility,
- Clearing and grubbing, including disposal of debris,
- Construction activities, including timing,
- Volumes of ore to be treated per unit of time (e.g., tons per day),
- Volumes of waste (solid and liquid) to be generated per unit of time (e.g., tons per day),
- Equipment roster specifying type and quantity by: size, motor size, and fuel requirements for each type of equipment (including power generation equipment),
- Chemical additives (types, volumes/time, recovery, etc.),
- Chemical composition of aqueous solutions,
- Containment structures for processes using aqueous solutions,
- Water use requirements,
- Wastewater treatment facilities,
- Air emission controls,
- Health and safety,
- Dust control plan (construction and operation),
- Water and air quality monitoring programs.
- Leaching methods include tank or vat, dump, and heap operations. For dump and heap leaching operations, in addition to the information listed above, detailed design information is required for the containment provisions for the dumps and heaps, including liner design, stability analysis of each structure, construction and design details of each structure (dimensions, volume, slopes) by year, and conveyance of leaching solutions to and recovery of pregnant solutions from these containments.

This section should also identify all onsite support facilities (offices, laboratories, warehouses, etc.) in the beneficiation area, although the details of those facilities can be described in the Mining Facilities section.

5.2 Mineral Processing

Mineral processing may occur onsite and is specific to the metal being mined. For example for copper processing, there may be smelters or solvent extraction and electrowinning (SX-EW) plants. Designs, operating program, construction, waste stream analysis and basically the same type of information required for beneficiation facilities should be included in the Proposed Engineering Design for these facilities. For smelters, the design should include controls for stack and fugitive air emissions.

6 STOCKPILES, DUMPS AND TAILINGS

Disturbed rock and earth from mines are major sources of dust, erosion, sedimentation and contamination, especially acid rock drainage, which is widely associated with metals mining. This section of the Engineering Design should include information describing ore stockpiles, tailings (reagent residue), dumps and piles, waste rock dumps, and any heap leach areas that are part of the mine design. The design details should include:

- Location of all stockpiles, dumps, and tailings structures
- Clearing and grubbing, including disposal of debris
- Engineering design of structures, including dump foundations and drainage structures, and justification for the design
- Transport ramps onto structures
- Stability analysis of each structure
- Construction and design details of structure (dimensions, volume, slopes) by year
- Chemical and physical characterization of materials in tailings, dumps and piles
- Potential for pollutants and contaminants
- Design to prevent pollution and contamination (water, air, and direct contact)
- Equipment roster specifying type and quantity by: size, motor size, and fuel requirements for each type of equipment
- Water and air quality monitoring programs
- Location and design of monitoring wells and air monitors

TAILINGS MANAGEMENT DESIGN

There are several components to be included in an engineering design for tailings. These include:

- Physical and chemical characteristics of the tailings material, including metal leaching and acidic drainage potential, as well as the potential for liquefaction; hydrology and hydrogeology, including local climatic conditions and extreme weather events (projections of increased extreme weather events as a result of global climate change should also be included);
- Foundation geology and geotechnical considerations, as well as seismic data and earthquake risk;
- Viability and characteristics of construction materials;
- Topography of the tailings management facility and adjacent areas;
- Maximize retention time of waste water to allow for settling of suspended solids and the natural degradation of contaminants such as ammonia and cyanide;
- Long-term monitoring and inspection of containment structures for tailings management facilities;
- Long-term stability even during adverse climatic conditions (hurricanes, etc.). Stringent engineering standards should be employed including having structure withstand a probable maximum flood (PMF) event and being designed to remain structurally stable in the event of a maximum credible earthquake (MCE).
- Measures to prevent wildlife exposure to contaminated tailings ponds and seepage;
- A discussion on whether wet tailings or dry tailing disposal is best method to be used for the particular site (for information of these two methods of tailings disposal please see the following webpages:
  - Dry Tailings
    - http://www.rosemontcopper.com/assets/docs/reports/Tailings_Dry_Stacks_White_Paper.pdf
    - http://www.bape.gouv.qc.ca/sections/mandats/Mines_Malartic/documents/PR5.1_annexe7K-1.pdf
  - Wet tailings
    - http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/tailings.pdf
  - Thickened Tailings
    - http://findarticles.com/p/articles/mi_qa5382/is_200712/ai_n21302540/

Additional tailings management can be found on the GARD webpage:
http://www.gardguide.com/index.php/Chapter_6

7 TRANSPORTATION FACILITIES

In-mine transport and dump/pile access ramps should be addressed in the Mining Methods and Stockpiles, Dumps and Tailings sections of the Engineering Design, but other onsite transport facilities should be addressed in this section, including onsite roads, train, tram, conveyors, and waterways. If the mine will require new access routes, these should also be included in this section. This section should contain a map of transportation routes that will be constructed and maintained by the mining operation, indicating the type and size of each route as well as the timing of its construction.

7.1 Roads

There are several types of onsite roads used in mining: primary and secondary roads used forhaul roads and mine and facility access and smaller roads used for accessing remote sites for monitoring. For each of these roads, the Engineering Design should include maps and specific design information including:

- Timing of construction

- Road surface and shoulder width and barriers
- Grade specifications
- Construction methods including clearing and grubbing
- Construction materials (if waste rock will be used, include geochemical specifications it should meet, e.g., net neutralizing potential to acid generating potential should be at least 3:1)
- Compaction specifications
- Stream crossings and associated designs
- Sedimentation and erosion prevention structures and practices
- Stabilization methods for cuts and fills
- Operations program with traffic volume, operating speeds and trip times

Typical elevations should be provided for each type and situation of road displaying construction materials, levels of compaction and erosion and sedimentation features. This section should also include the following general information about the road system:

- Dust control measures for construction and operation
- Maintenance measures
- Roster for construction and maintenance equipment, specifying type and quantity by: size, motor size, and fuel requirements for each type of equipment

7.2 Transportation by Rail

If a railroad is to be constructed, information will need to be provided concerning its construction and alignment, including a map of its location. Necessary design criteria include:

- Timing of construction
- Roadbed width
- Roadbed construction method including clearing and grubbing
- Roadbed materials
- Grade and maximum grade
- Tightest curves
- Track construction materials
- Turnouts and sidings
- Railroad communications and signaling
- Designs, including typical elevations of:
    - Road crossings
    - Stream crossings and associated designs
    - Sedimentation and erosion prevention structures and practices
- Stabilization methods for cuts and fills
- Maintenance
- Dust control measures during construction
- Borrow pits
    - Location and size (area and volume of material)
    - Operation
    - Sedimentation and erosion controls
    - Closure plan

- Construction equipment roster specifying type and quantity by: size, motor size, and fuel requirements for each type of equipment

An operations program should address traffic volume, operating speeds and trip times. The train itself should be described in terms of the type and amount of cars and locomotives, the overall length, the average tons per car and per train, the number of trips per week it would be operated.

If an existing railroad is to be used, improvements and changes to the existing operations will need to be indicated in terms of the aspects outlined in the above paragraphs.

7.3 Conveyors

Conveyors play an important role in mining for transporting materials. In-mine and in-pit conveyors should be addressed in the Mining Methods section. Some mines, however, use overland conveyors moving materials from the mine to the beneficiation facility or even to a load-out facility for transportation from the mine to its destination. Maps showing the locations of these conveyors and complete design details, including source of energy for operation and dust control measures, should be included in this section. Where conveyors cross water bodies, conveyors should be covered to prevent water contamination.

7.4 Barges and Waterways

Ore may be shipped by barges which will require a complete description of design, construction, and operation of loading docks as well as rosters of boats used to move barges, specifying type and quantity by: size, motor size, and fuel requirements.

8 WATER-CONTROL FACILITIES

Water control is a cross-cutting issue for mining and thus warrants its own section in the Engineering Design. This section should include information on design, construction and maintenance of appropriate water-control measures including stream relocations, collection ditches and sedimentation ponds, diversions, culverts and activities that would minimize erosion and sedimentation. The design should address run-on, runoff and seepage. The type of information that should be provided for each type of facility is detailed in each subsection.

8.1 Sediment and Water-Control Facility

- Location of all facilities
- An analysis showing that the smallest amount of land as possible will be disturbed at one time
- Methods to reduce runoff, run-on, sedimentation and erosion
- Method of retaining sediment
- Method for diverting runoff from the disturbed areas
- Method for diverting surface water, including stormwater, around the disturbed area
- Method for preventing seepage
- Method for treating and maintaining roads for reducing runoff, erosion, and dust
- All supporting engineering designs, methodology and justification for methodology
- Methods for closure and restoration
- Monitoring and maintenance plans

8.2 Temporary Ponds and Permanent Impoundments

- Number of each type of impoundment
- Location, size and capacity of each structure
- Material to be used, and its source
- Use of each structure
- Design, design criteria and justification
- Engineering drawings
- Water discharge treatment facilities
- Methods for closure and restoration
- Monitoring and maintenance programs

8.3 Culverts, Dikes and Diversions

- Number of each type of structure
- Location and size of each structure
- Methodology for design
- Typical construction: cuts, fills, materials and their sources, compaction
- Timing of construction
- Typical elevations
- Grades for diversions
- Methods for closure and restoration
- Monitoring and maintenance programs

8.4 Groundwater Management

- Dewatering requirements – volume
- Dewatering well locations, pumping requirements for each well, electricity requirements, staging of activities, and discharge pipeline design
- Water chemistry and water treatment requirements
- Discharge location for dewater systems
- Methodology for design – groundwater model and projected drawdowns
- Monitoring and maintenance programs

9 MINE SUPPORT FACILITIES

Mining operations will have many ancillary structures such as office, toilet facilities, bath houses, laboratories, shops, vehicle maintenance areas, warehouses, storage buildings, storage areas, power generation and transmission facilities, and fueling facilities. These may be located at the mine, processing facilities, and loading and unloading areas, or in a separate area. The mine may also have employee housing and support facilities (stores, restaurants, recreational facilities, etc.). Many of these facilities will require water systems, sewage treatment facilities and solid waste collection and disposal. Some of them, such as vehicle maintenance, storage areas, power generation, and fueling facilities, may generate hazardous wastes including solvents, lubricants, hydraulic fluids, anti-freeze, spent tires and wash water. Others, such as warehouses, storage buildings and fueling stations may store hazardous products (fuels, chemicals and explosives) that will require containment and emergency procedures.

The Engineering Design should include a description of each type of facility including its location, design, and associated services (water, sewage, solid waste disposal, etc.). It should include a description of areas that will be temporarily disturbed during construction as well as those areas that will be occupied by the facilities. It should detail how wastes from these facilities will be managed and disposed. It should also include containment designs and emergency response provisions for all facilities in which hazardous substances will be stored and handled as well as those that may generate hazardous wastes. This section should also contain the mine:

- Hazardous Waste Management Program
- Solid Waste Management Program
- Spill Prevention Program

10 RESTORATION AND CLOSURE PLAN

The Engineering Design should include a restoration plan describing the size of the area to be restored and the plans and schedule for restoration. The restoration plan should include, but not be limited to, the following types of structures:

- Pits and quarries
- Waste rock dumps
- Stockpiles
- Tailings impoundments
- Heap leach pads
- Solid waste disposal facilities
- Facilities
- Roads
- Electrical structures
- Water conveyance and treatment structures

The EIA should also discuss the restoration costs for each restoration activity and describe financial assurance for the project to ensure funds will be available to close and restore the site by a third party if the mine company cannot complete the job.

11 MANPOWER AND LOCAL PURCHASES

The Engineering Design should present information on the number and type of employees that will be hired by the mine, during all phases of mine life, and the level at which the mine will be relying upon local businesses to provide goods and services. This information is necessary for assessing the social impacts of the proposed mine.

D. ENVIRONMENTAL SETTING

1 INTRODUCTION

A detailed description of the "Environmental Setting" for a mining project is an important aspect of an Environmental Impact Assessment (EIA). The information presented in the Environmental Setting should not be encyclopedic, but rather the specific, detailed information that is necessary to predict impacts and ultimately against which to monitor impacts. Towards this end, this section should include an environmental baseline for geology, soils, surface water, groundwater, air quality, climatic conditions, ecosystems, cultural and historical resources, transportation, land use, and socio-economic conditions that could be affected by the alternatives under consideration. This baseline aids in focusing attention on critical environmental and socioeconomic factors, understanding how the mine might affect the environment, and determining how best to avoid or mitigate potential problems. In addition, description of the current environment, adjusted by expected changes in the absence of the proposed project, aids in the determination of potential cumulative environmental impacts that might occur should there be other impact causing activities to those same resources and how to minimize these cumulative impacts.

ENVIRONMENTAL SETTING

In order to predict potential impacts of a mining operation it is important to have detailed information on the environmental setting to provide conditions for:

Physical Environment
- Geology and Soils
- Surface and ground water
- Air and climate
- Noise and Vibration

Biological Environment
- Vegetation/Flora
- Fish and Wildlife/Fauna
- Ecosystems (Terrestrial/Wetlands/Aquatic/Marine)
- Endangered species and habitats
- Protected Areas

Socio-Economic-Cultural Environment
- Socioeconomic conditions
- Socioeconomic Resources (including Tourism)
- Social Infrastructure
- Transportation
- Land use
- Cultural and historical resources

The details on how each of these is addressed in the EIA is dependent on the complexity of the area, the nature of the mining operation (small or large, in an urban environment or rural, etc.), social issues and regulatory requirements. The period of baseline data collection for water resources, air, climate, and ecosystems (flora, fauna, wildlife, etc.) should be significant enough so that determination of long-term impacts can be made and may require data to be collected over a period of one to five years.

Metal Mining

Special emphasis should be given in the development of baseline studies at metal mines to provide information needed to assess the potential of mining wastes to leach trace metals into the environment under acidic or non-acidic conditions. Because of the long-term implications of acid rock drainage it is especially important for the mining company to follow internationally recognized procedures such as those presented in the GARD guide as attached to this guideline.

SPECIAL CASE – River Mining or Dredging

River mining or dredging can have a profound effect on rivers including downstream water users, bridges, and aquatic life. Baseline data should include:
- Base flow, peak flows, and extent of flooding.
- Bed load and suspended sediment load
- Flood plain delineation
- Wetlands delineation
- Water users – quantity and quality of water required for irrigation, domestic, municipal, and industrial use
- Aquatic life – species and diversification
- Other pertinent information

2 GEOLOGY

Understanding the geology of a mine site is not only important in development of the ore body but also in understanding the environmental setting for the EIA. The geology section should provide information about the geologic formations in which the mine will be located and in the immediate vicinity of the mine. The regional geology should be presented on a topographic map on which the mine plan is overlaid, to provide the geologic context of the activities. Other geologic information for the EIA includes:

- A delineation of the geomorphology of the mine site and surrounding areas including the topography, flood plains, and other features
- A description of the regional geology – lithology and structure
- Cross sections and descriptions of the formations, major geologic structures and aquifers;
- Descriptions of the stratagraphic sections that will be mined
- Descriptions of all lithologic units to be encountered during mining including depositional history, stratigraphy, and geomechanical properties
- Description of the geochemistry of the various rock units (This information will be used in the assessment of the potential for acid rock drainage (ARD) and acid mine drainage (AMD), discussed in the following section.)

QUARRIES FOR SAND, GRAVEL, AND OTHER CONSTRUCTION MATERIALS

As with metallic ore mining, an understanding of the environmental setting for sand and gravel or other construction materials is very important towards evaluating the potential environmental impact of the operation. Surface water, groundwater, and soil resources should be understood thoroughly as well as the ecological, climatic, and socio-economic conditions. The two major differences are that sand and gravel operations are often located near population centers and dredging operations can have more impact on rivers and shorelines. In an urban setting, usually the two major concerns for a sand and gravel operation are dust and noise. It is therefore important to develop the following information:

- Baseline dust and noise levels
- Wind direction and wind speed
- Maps showing the locations of schools, businesses, churches, parks, historic and cultural places, etc.

For dredging operations, it is important to understand:

- The flow and water quality characteristics of the river or stream, including sediment transport characteristics
- The average time required to fill the dredge hole and how it could be affected by periods of low rainfall or low sediment
- The length of stream permitted to dredge
- Ocean currents if dredging operation is in the coastal zone
- The type of materials in the sediments to be dredge including grain size and chemical nature
- The geomorphology of the river, stream or coastal zone
- Locations of wetlands
- The nature of the aquatic ecosystem
- Fish production and market
- The geology, hydrology, soil, air quality, and ecology of dredge spoil sites

3 WASTE ROCK, WALL ROCK AND ORE CHARACTERISTICS

An important part of baseline studies is to characterize the geochemistry of the waste rock, wall rock and ore in order to determine the potential for leaching of metals and other contaminants at the mine. This includes the potential for acid rock drainage (ARD) and acid mine drainage (AMD) as well as the potential for leaching under non-acidic conditions. This takes a thorough understanding of the geology of the mine site including all stratigraphic layers to be encountered during the mining operation.

Waste rock, wall rock and ore should be analyzed for acid-base potential so that adequate systems can be designed to manage runoff and seepage for waste dumps, stockpiles and tailings. Different types of rock require different types of testing. For instance prediction of ARD for low-sulphide, low-neutralization potential mine wastes is methodologically different from that for normal sulphidic mining wastes and appropriate analytical methods should be chosen based on representative samples.

In order for this evaluation to be meaningful, the sample material should be representative of the entire range of material deposited in a waste disposal facility. To develop a representative sampling program, the following factors should be considered within the mine area:

- Lithological variation
- Mineralogical variation
- Extent of "sulfide" mineralization
- Color variation
- Degree of fracturing
- Degree of oxidation
- Extent of secondary mineralization

Drill core samples collected during initial ore body definition may be used for initial material characterization. During exploration, a portion of the samples collected from those materials that have been sent to the assay lab should be saved. In addition, samples should be saved from those materials known to be waste. These materials should be composited based on those factors outlined above.

The number of representative samples is dependent on the size of the proposed mine and the spatial variation and number of different lithologic units throughout the mine area of the waste material, and based on the characterization of both waste and non-waste material. Table D-1 is the minimum number of samples for each lithologic unit that should be sampled to characterize rock that will be mined, as suggested by Price and Errington (1994). Samples should be representative of each different type of mineralogy (for example, addressing the range of hydrothermal and supergene alteration for each lithology) (Maest,et al, 2005). It should be noted that this is considered a guideline and that any operation should depend on professional judgment to ultimately determine the right number of samples.

Furthermore, sample compositing is not recommended unless the mined material is homogeneous in size and composition (e.g., sulfides and carbonate homogeneously disseminated), and from a single process (e.g., autoclaved and non-autoclaved tailings should not be composited) (Price and Errington, 1994; Maest et al, 2005).

Table D-1: Example of Recommended Minimum Number of Samples of Each Mineralogy Type for Geochemical Characterization of Mined Materials for Potential Environmental Impact. (Price and Errington, 1994).

Mass of Each Separate Mineralogy Type (tonnes)	Minimum number of samples
<10,000	**3**
<100,000	**8**
<1,000,000	**26**
10,000,000	**80**

Several static and kinetic models have been developed to analyze the representative samples to determine the potential for acid drainage. These include:

- Static Acid Rock Drainage Tests
    - Modified acid-base accounting (Lawrence, 1989)
    - USEPA Standard acid-base accounting (Sobek et, 1978)

- Net acid production test (Steffen, Robertson and Kirsten (B.C.) Inc. and B.C. Research and Development, 1992)
- Net acid generation test (Steffen, Robertson and Kirsten (B.C.) Inc. and B.C. Research and Development, 1992)
- Diagnostic mineralogy to identify: sulphur mineral speciation, non-iron bearing sulphides, and the reactivity of sulphide minerals (Yager et al, 2008)
- BC Research Inc. Initial Test (chemical) Procedure for evaluating acid production potential of ore and waste rock (Mills, undated)
- BC Research Inc. Confirmation Test Procedure (Mills, undated)
- Coastech Research Modified Biological Oxidation Test Procedure (Coastech)
- Lapakko Neutralization Potential Test Procedure (Mills, undated)

- Kinetic Acid Rock Drainage Tests
    - Controlled tests in the laboratory including:
        - Standard humidity cell testing (ASTM D5744-96)
        - Column leach testing (sub-aqueous, sub-aerial)
    - Large Scale on-site weathering tests using test plots

The selection of the appropriate method is dependent of the nature of the material and should be based on professional judgment. Although these tests should be conducted to provide information on the Environmental Setting, it is important to note that these analyses are not a one time effort. Acid generation potential models are not fully reliable, and life of mine ARD testing should be conducted to be sure that ARD does not begin.

Mining waste streams such as tailings piles and phosphor gypsum stacks can also contain appreciable quantities of radionuclides. The radioactivity of a representative sample of the waste rock, wall rock and ore, measured as total radiation of a particular type, such as gross alpha or gross beta and the activities of individual nuclides, should be tested and the results reported in this section of the EIA.

RADIOACTIVE MATERIAL

The potential for radiological contamination of air and water is usually at a minimum for most mining projects including mining for precious metals and construction material. Even for uranium mining, whether open-pit or in-situ, environmental concerns are much the same as any other type of mine. Uranium, itself, is not strongly radioactive. However, precautions should be made to prevent release of radioactive substances into the environment. In initial baseline monitoring for any type of mining, the operator should evaluate the potential for radiological substances at the mine sites. If necessary, measurement of concentrations of radioactive materials occurring in biota, in soil and rocks, in air and in surface and ground waters should be determined. If present, it may to necessary to “special handle” materials to minimize release of contaminants into the environment. “Special materials “plans may have to be developed to control dust and sediment from leaving the site as well as to provide monitoring programs to detect any releases. In addition, to ensure the health and safety of workers, all workers would be required to wear radiological emission detection badges, and radiological detection devices should be placed on all air monitoring equipment. For additional information see http://www.epa.gov/rpdweb00/tenorm/uranium.html.

For the EIA the following questions should be answered:

- Is there a potential for ARD from the waste rock and stockpiled material?
    - How was this determined?
    - Were the tests appropriate and representative?
    - How much rock is potentially acid-generating? How much is acid neutralizing?

- Will the wall rock produce ARD?
- If there will be a post-mining pit lake, what will the water quality be during different post-mining periods?
- How erosive is the waste rock and stockpiles material?
- Have leachability tests been performed on wastes for metals, metalloids, sulfates, and other potential pollutants?
- What are the likely contaminants and their concentrations from each rock type?
- Have radionuclide levels been determined?

4 SOILS

A mining operation exposes soils to erosion (wind and water) and can be a source of contamination to air and can be deposited on exposed soil and plant surfaces and in water bodies. During baseline data collection it is important to collect information on the erosion potential of the soils, the chemical composition of each soil type, and the availability and suitability of soils for use during restoration and revegetation. If soil maps are available for the mine site, these should be presented and evaluated. If not, a soil survey should be completed showing soil type, grain size distribution, engineering properties, depth of various horizons, erosion potential, vegetative growth potential, etc. Particular care should be given to studying tropical soil structure and chemistry since such soils are very sensitive to degradation.

Because metals naturally occur in all soils, background samples for total metals should be obtained for later comparison for all metal mining proposals. Organic contaminants and certain inorganics such as cyanide, are presumed not to be naturally occurring, and background sampling for these constituents is seldom performed unless another source of contamination is suspected.

Basic questions that should be answered in the EIA process include:

- Have soils in the mine project area been adequately characterized (location, uses, classification, etc.)?
- How much soil will be needed for restoration and revegetation, and will there be enough suitable soil for these activities?
- If not, where will soil be borrowed from?
- If soil will not be suitable for successful restoration and revegetation, what amendments will be needed and where/how will they be obtained?
- Has the erosion potential for these soils been determined?
- Is there enough soil information for runoff models and sediment transport models?
- For metal mining, what are baseline concentrations of metals and other constituents?

5 SURFACE WATER

The Environmental Setting section should include an evaluation of surface water resources in the direct vicinity of the mine. This should include the analysis of the watershed characteristics including water quality, flow characteristics, soils, vegetation, and impervious cover. This information should be included on topographic maps which should include all surface water resources and floodplains in the cumulative impact area overlaid with the proposed mine facilities including all monitoring stations and discharge points.

All nearby rivers, streams, wetlands and other water bodies should be identified as well as the current uses of the water. In addition, regional data and appropriate models should be used to determine baseline rainfall, runoff and erosion characteristics as well as flooding characteristics of rivers and streams nearby and adjacent to the mine. This information is important for siting of facilities out of the floodplain and the design of diversion ditches, sediment ponds, and for water supply potential.

Watershed Approach

It is important to evaluate impacts of a mining operation in relation to the entire watershed. Watershed management involves both the quantity of water (surface and ground water) available and the quality of these waters. Understanding the impact of mining on both the quantity and quality of water should take into account the cumulative impacts of other mines, different land uses, industry, etc., located in the same watershed.

A watershed-based mine discharge impact assessment approach would be similar to that related to permitting a discharge using a watershed approach and consists of the following eight steps:

- Determine the boundaries of the watershed
- Determine the nature and extent of pollutants discharged throughout the watershed
- Determine the potential additional pollutants discharge from the proposed mine
- Identify stakeholders involved in and encourage their participation
- Collect and analyze data for permit development
- Develop permit conditions and documentation
- Issue the discharge permit
- Measure and report progress

For additional information of the watershed approach to discharge permitting please see: http://www.nesc.wvu.edu/pdf/WW/publications/pipline/PL_FA06.pdf

An important aspect of an EIA is the development and presentation of baseline surface water monitoring data, which should be collected prior to disturbance. All existing historic water quality and flow data for the project impact area (including the cumulative impact area) should be collected and compiled to help define the baseline. These data should be augmented by the results of a surface water monitoring program conducted at specific sites in the project area. Monitoring of baseline conditions should take place for at least a year so that seasonal fluctuations in flow and water quality can be determined.

Prior to implementing the baseline monitoring program, a "Sampling and Analysis Plan" should be developed. This plan would define sample locations, sampling techniques, chemical parameters, and analytical methods. Sample locations should be located upstream and immediately downstream of potential pollutant sources (including controlled and uncontrolled discharges and potentially seeps/groundwater recharge). The selection of chemical parameters to be monitored is dependent on the nature of the material to be mined and its potential to be discharged to surface water either directly or in stormwater runoff. Monitored parameters should include: field parameters (pH, specific conductance, temperature, etc.) and laboratory analyzed parameters (total dissolved solids, total suspended solids, selected trace metals, major cations/ anions), and perhaps other parameters depending on the nature of the operation (see Table D-1 and Appendix F). If the waste rock analyses indicate the presence of radioactive materials, the water should also be sampled for gross beta, gross alpha, Radium 226, and total Uranium.

Table D-2: Suggested Water Quality Parameter for Laboratory Analysis

Parameter	EPA Method	Detection Limit	Preservative	Metal Mines	Non-Metal Mines
Antimony	204.2	0.01 mg/l	HNO3 to	‹	
Arsenic	206.2	0.001 mg/l	HNO3 to	‹	
Barium	208.1 /	0.1 mg/l	HNO3 to	‹	
Beryllium	210.1 /	0.001 mg/l	HNO3 to	‹	
Boron	200.7	0.1 mg/l	HNO3 to	‹	
Cadmium	213.1 /	0.0001	HNO3 to	‹	
Calcium	215.1 /	1 mg/l	None	‹	‹
Chromium	218.1 /	0.001 mg/l	HNO3 to	‹	
Cobalt	219.1 /	0.01 mg/l	HNO3 to	‹	
Copper	220.1 /	0.001 mg/l	HNO3 to	‹	
Iron	236.1 /	0.03 mg/l	HNO3 to	‹	
Lead	239.2 /	0.002 mg/l	HNO3 to	‹	
Magnesium	242.1 /	1 mg/l	None	‹	‹
Manganese	243.1	0.005 mg/l	HNO3 to	‹	‹
Mercury	245.2	0.0001	HNO3 to	‹	
Molybdenum	246.2 /	0.005 mg/l	HNO3 to	‹	
Nickel	249.1	0.005 mg/l	HNO3 to	‹	
Potassium	258.1 /	1 mg/l	None	‹	
Selenium	270.3	0.001 mg/l	HNO3 to	‹	
Silver	272.2 /	0.0005	HNO3 to	‹	
Sodium	273.1 /	1 mg/l	None	‹	
Thallium	279.2	0.002 mg/l	HNO3 to	‹	
Tin	282.1 /	0.1 mg/l	HNO3 to	‹	
Vanadium	286.1 /	0.1 mg/l	HNO3 to	‹	
Zinc	289.1 /	0.0001	HNO3 to	‹	
Alkalinity,	305.1	1 mg/l	None	‹	‹
Bicarbonate	(305.1)	1 mg/l	None	‹	‹
Carbonate	(305.1)	1 mg/l	None	‹	‹
Chloride	300.0	1 mg/l	None	‹	‹
Conductance,	120.1	1	None	‹	‹
Cyanide,	335.3	0.005 mg/l	NaOH to	‹	
Cyanide,	(ASTM	0.005 mg/l	NaOH to	‹	
Fluoride	340.2	0.1 mg/l	None	‹	‹
Hardness,	130.2	1 mg/l	HNO3 to	‹	‹
Ammonia as	350.1	0.1 mg/l	H2SO4 to	‹	‹
Nitrite +	353.2	0.05 mg/l	H2SO4 to	‹	‹
TKN	351.3	0.1 mg/l	H2SO4 to	‹	‹
pH	150.1	0.1 S.U.	None	‹	‹
Phosphorus,	365.1	0.01 mg/l	H2SO4 to	‹	‹
TDS	160.1	1 mg/l	None	‹	‹
Silica	370.1 /	0.1 mg/l	None	‹	‹
Sulfate	300.0	1 mg/l	None	‹	‹
Sulfide	376.1	1 mg/l	2 ml Zinc	‹	
Turbidity	180.1	0.01 NTU	None	‹	‹

The environmental setting section for surface water should answer the following questions:

- Have sufficient baseline data been collected to establish the surface water flow rates (including seasonal variability) and water quality (including sediments) prior to disturbance?
- Has the water balance been calculated?
- Has the physical condition of rivers, streams and other water bodies within the project area been determined?
- What are the designated and actual uses of surface water in the project area and downstream?

6 GROUNDWATER

Characterization of the baseline groundwater resources in the mine project area requires descriptions of aquifers (bedrock and alluvial) including their geology, aquifer characteristics (hydraulic characteristics), and the flow regime/direction for each aquifer. The influences of geologic structures (faults, contacts, bedrock fracturing, etc) and surface water bodies should also be mapped or determined.

Modeling of aquifers and vadose zones is required to predict groundwater impacts. To that end, the Environmental Setting section of the EIA should contain the necessary information on the aquifer and vadose zone parameters that will be needed for modeling. The necessary parameters will depend on the type modeling that will be required, which should be selected based on the nature of the mine and potential impacts. For instance, for an open pit mine that extends below the water table, a groundwater flow model (analytical or numeric) should be selected to determine the potential impacts to nearby wells as well as predict water inflow into the mine and discharge requirements. In addition, a hydrochemistry model should be employed to predict final pit lake quality, as well as pit lake quality at various intervals during the period (decades or even hundreds of years) before the lake reaches equilibrium. Any model used requires good data to make realistic predictions.

All wells and springs in the area should be mapped and information provided on their flows, water levels and uses. These maps should be overlayed with the topography and should cover the defined cumulative impact area. For wells, depth and construction information should be presented. The EIA should also indicate which ones have been monitored and which ones will be monitored during and after operations. This information can then be used, along with the locations of potential contaminant sources, to determine potential impacts as well as the location of up-gradient and down-gradient monitoring wells, which should be included in the monitoring plan for the mining operation.

As with surface water, an important aspect of the EIA is the development and presentation of baseline water monitoring data, collected prior to disturbance. All existing data on quantity and quality of water from springs and wells in the vicinity of the proposed mine should be collected and reported in the EIA to help define the baseline. Water quality in all springs and nearby wells should be reported at least quarterly for at least one year (and preferably two years) to determine baseline quality and chemistry. In addition, maps showing variations on a seasonal basis of water quality and groundwater levels should be included.

If data for existing wells and springs are not available, a “Sampling and Analysis Plan” should be prepared and a sampling program implemented. The sampling should include water levels and flow rates as well as chemical parameters such as pH, temperature, specific conductance, selected trace metals, sulfides, major cations and anions, TSS, etc. (see Table D-1). The selection of chemical parameters to be monitored is dependent on the nature of the mining activity and the material to be mined and its potential to contaminate the aquifer. For instance, for a gold mine operation, sampling of trace metals and metalloids such as arsenic and antimony may be required. For a limestone mine, alkalinity and total dissolved solids may be the primary concerns.

In the EIA, the following questions should be answered:

- Has a well and spring survey been completed in the cumulative impact area?
- What are the locations of all wells and springs in the area and what are their designated and actual uses (particularly those down gradient from the mining operation)?
- Has groundwater flow and consumptive use been quantified?
- Has the hydrogeology of the site been mapped and clearly delineated?
- Has baseline groundwater quality been determined?
- What are the uses of groundwater, particularly down gradient from the mining operation?

7 AIR QUALITY AND CLIMATIC CONDITIONS

Understanding climatic conditions at a mine site is important for the design of a long-term air monitoring program, developing a water balance for the site, and designing water/erosion control structures. During the baseline data collection period, climatic data for local weather stations should be gathered and analyzed. These data should include at least historic rainfall data (total precipitation, rainfall intensity, and duration), wind direction and speed, solar radiation, evaporation rates, barometric pressure, and temperature variations. For large mining proposals, if no data are available near the mine site, a weather station should be established and baseline data should be collected for at least one year to reflect the seasonal changes at the site. All sampling site and weather station locations should be depicted on a map in the EIA.

Air monitoring should be conducted, both upwind and downwind of the mining operation. Monitoring should include the use of high volume samplers and/or other methods to collect samples of air borne particulates and gases that may be emitted from the mining operations. Sampling may be either continuous or by grab or composite samples. Selection of monitoring locations requires an understanding of site-specific meteorological conditions that can affect pollutant fate and transport.

The following questions about baseline air quality and climatic conditions should be answered in the EIA:

- Are there sufficient climatic data available for the design of a long-term air monitoring program?
- Are historic rainfall data sufficient to develop runoff models for surface water control and structure design?
- Are data available to develop water balances for the various features at the mine site?
- Are there enough data to develop air models to evaluate the transport and fate of potential air pollutants?

8 ECOSYSTEMS

The Environmental Setting information for ecosystems should include information on aquatic, terrestrial and wetland ecosystems in the vicinity of the mine. The challenge for development of an EIA for a mining operation is to qualitatively evaluate and record the local ecosystems and their biodiversity, often in the absence of clear protective designations. This involves looking at a range of criteria to determine whether the site is of local, regional, national or international importance. According the International Council on Mining and Metals (2006), in evaluating baseline conditions of ecosystems, where aquatic, terrestrial or wetlands systems are present, the following steps should be taken:

- Obtain readily available information on biodiversity through review of maps and publications available online.
- Identify whether the site or surrounding area falls within a protected area – that is, whether it is an area designated for biodiversity protection at a local, national, regional or international level.
- Identify whether the site or surrounding area is not currently protected but has been identified by governments or other stakeholders as having a high biodiversity conservation priority.
- Identify whether the site or surrounding area has particular species that may be under threat (although the area may not currently be officially protected).
- Review legal provisions relating to biodiversity.
- Elicit the views of stakeholders on whether the site or surrounding area has rare, threatened, or culturally important species.
- Include maps of all habitats and key species locations, protected areas, migration corridors, seasonal use areas (mating, nesting, etc.)
- Describe timing of important seasonal activities (nesting, breeding, migration, etc.) for species that could be affected by mining activities.
- Determine the following ecological characteristics of the project area (including the cumulative impact area for each resource):
    - Species/habitat richness
    - Vegetation communities
    - Animal populations
    - Species endemism
    - Keystone species (i.e. species that play a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass)
    - Rarity of any species or habitat
    - Size of each habitat
    - Population size for important species or species of concern
    - Fragility of the ecosystem
    - Existing condition of each habitat and its value

The evaluation of any ecosystem whether aquatic, terrestrial, or wetland is dependent upon professional judgment and requires the involvement of trained ecologists. In areas where there is little or no information available, considerable field work is required to collect the information listed above. The field collection efforts may require multi-year efforts.

The ecosystem section of the environmental setting should answer the following questions:

- Have baseline studies been conducted to characterize aquatic, terrestrial and wetland species and habitats?
- Are there any threatened, endangered, or rare species and/or critical habitats in the area?

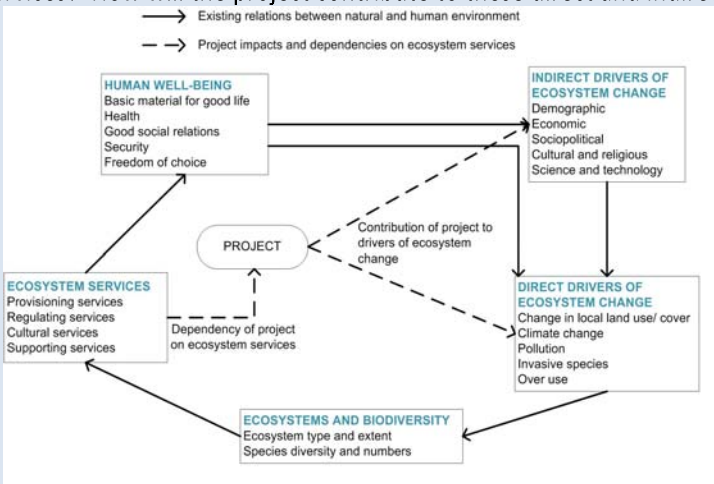
Beyond looking at these components individually, an EIA needs to be integrated, i.e. to address the relationships between biophysical, social and economic aspects in assessing project impacts (IAIA 1999). Addressing these relationships relies on an integrated description of the environmental setting as well as integrated impact assessment (see box on the ecosystem services approach).

ECOSYSTEM SERVICES APPROACH: PULLING IT ALL TOGETHER

In the context of environmental impact assessments, the ecosystem services approach helps EIA practitioners to go beyond biodiversity and ecosystems to identify and understand the ways natural and human environment interrelate by providing a more systematic and integrated assessment of project impacts and dependencies on ecosystem services and the consequence for the people who benefit from these services. It integrates these aspects by explicitly linking ecosystem services (the benefits people derive from ecosystems), their contribution to human well-being, and the ways in which people impact ecosystems' capacity to provide those services. The approach relies on a suite of tools such as a conceptual framework linking drivers of change, ecosystems and biodiversity, ecosystem services, and human well-being (MA 2005); guidelines for private sector companies to assess risks and opportunities related to ecosystem services (Hanson et al. 2008), and manual for conducting ecosystem services assessments (UNEP to be published).

From description of the environmental setting to the impact assessment, the ecosystem services approach can lead the EIA practitioner through a new set of questions organized around the conceptual framework shown below:

- What are the ecosystem services important for local communities? Which services will the project potentially impact in a significant way? How does the impact on one ecosystem service affect the supply and use of other ecosystem services?
- What is the underlying level of biodiversity and the current capacity of the ecosystems to continue to provide ecosystem services?
- What are the consequences of these ecosystem service impacts on human well-being, for example what are the effects on livelihoods, income, and security?
- What are the direct and indirect drivers of ecosystem change affecting the supply and use of ecosystem services? How will the project contribute to these direct and indirect drivers of change?



Conceptual framework to assess ecosystem services
(adapted from the Millennium Ecosystem Assessment, MA 2005)

Since ecosystem services by definition are linked to different beneficiaries, any ecosystem service changes can then be explicitly translated into a gain or loss of human well-being.

9 CULTURAL AND HISTORICAL RESOURCES

Aspects of the physical environment that relate to human culture and society along with the social institutions that form communities constitute cultural and historic resources (King and Rafuse 1994). The cultural and historic resources that should be included in the Environmental Setting are archeological and historical sites and structures and traditional cultural lifestyles and resources associated with those lifestyles.

All cultural or historical resources in the vicinity of the mine should be identified, mapped and described. These may be structures or sites, including:

- Archeological sites
- Historic buildings
- Burial grounds
- Sacred or ceremonial sites
- Sites used for the collection of materials used in ceremonies or traditional lifestyles
- Sites that are important because of their roles in traditional stories

During the preparation of the EIA, views should be solicited from stakeholders on whether the site or surrounding area has important traditional or cultural value.

10 TRANSPORTATION

The Environmental Setting section of the EIA should present basic information on the existing transportation system in the area of the mine, including roads, railroads, air strips, airports and pipelines. Each existing transportation system component should be described in terms of its location, name, type and intensity of use, and communities it connects. The baseline should also include information on conditions including sediment control or erosion problems. The location of the system components should be shown on a map. If the project is anticipated to generate a significant amount of additional traffic or to signficantly disrupt traffic an analysis of existing traffic patterns may also be necessary.

If there are improvements scheduled for any of the system components, which are not part of the mining proposal, these improvements should be described in this section. The description should include the nature and location of the improvements and the entity who will be doing the improvements. If there is on-going maintenance to any component of the existing transportation system, this should also be described in terms of the type and frequency and the entity doing the maintenance.

11 LAND USE

The site of the mine and the surrounding vicinity support a variety of existing land uses. These land uses should be inventoried, mapped and described in the EIA. Existing land uses in the area that may be affected by mining include:

- Parks
- Wildlife refuges
- Forest reserves
- Hunting areas
- Farms
- Grazing land
- Utility corridors
- Roads
- Human settlements
- Industrial facilities

The productivity of natural areas and agricultural land that could be affected by the mine should be assessed as part of the existing conditions, to create a baseline for determining the direct, indirect, and cumulative impacts, and for developing mitigation measures and restoring the post-mining environment.

12 SOCIO-ECONOMIC CONDITIONS

The EIA should describe the existing social and economic conditions in the vicinity of the mine. This should include:

- Population characteristics (size, gender and age distribution)
- Cultural characteristics (religion, ethnic composition, etc.)
- Economic activities (employers, employment and incomes)
    - Regional/local
    - On the proposed mining site
- Tax base
- Crime rates
- Public services in nearby communities (schools, water and sewer systems, health facilities, etc.)
- Community organizations in the mining vicinity
- Skills, services and goods availability in the communities
- Distribution of relevant skills and professions in the local workforce
- Housing
- Epidemiological study (for large projects)

Historic and current data on these aspects should be presented, to identify any trends in the socio-economic situation.

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E. POTENTIAL IMPACTS

1 INTRODUCTION

Mining, particularly surface mining has impacts similar to any activity that disturbs the land surface such as erosion and associated turbidity and sedimentation in streams and water bodies, dust, and vehicle/machinery air emissions. The mining industry, however, also has unique environmental impacts such as the potential for acid rock drainage, releases from cyanide leaching units, structural failure, etc. With some exceptions, the environmental impacts may last for years or decades after mining ends or are irreversible, permanent features of the environment. These impacts are site-specific and determined by the geology, hydrology, hydrogeology, climate, and human and wildlife populations in the vicinity of the mine.

This chapter reviews potential impacts from mining, the important pathways of pollution which affect natural resources, and humans in terms of social/economic/cultural resources.

ANALYZING AND PREPARING FOR POTENTIAL RISK: USE OF BOUNDING AND SCENARIOS

EIAs for mining projects should include an analysis of risks. The analysis should represent the range of potential impacts of potential accidents and destructive natural events, including those from likely scenarios as well as those from low-probability, high-consequence scenarios. (The latter are sometimes referred to as “worst case scenarios” but this term can be misleading.) The analysis of risk should be considered in the design of all structures as well as in the development of spill and catastrophic failure contingency plans. Modern mining projects utilize state-of-the-art models to predict the potential environmental impacts to water, air, and other resources as well as potential exposures to populations at risk. To avoid under-predicting impacts, models use conservative assumptions and analyze potential accidents or natural disasters with the most severe consequences reasonably foreseeable to occur. These analyses enable the identification of controls to protect human health and the environment even under these unlikely but foreseeable situations. This analytical approach ensures that the risk analyses in the EIA “bound” the potential risks. That is, the analysis represents the full range of risks and will not under-predict the most severe consequences. Policy decisions are inherent in carrying out this type of analysis as to the threshold for defining a reasonable set of assumptions in developing these scenarios.

This approach has been used to design control technologies, tailings basins, stockpiles, processing plants, emission controls, and closure activities. In the case of accidental spills, dam failure, fires, hurricanes, unforeseen weather events, earthquakes, volcanic eruptions and other events, contingency plans should be applied to:

- Emergency notification and evacuation
- Fire control
- Spill cleanup – it is recommended that spill kits are kept at strategic locations throughout the mine site
- Warning systems
- Medical support
- Other items dealing with the health and safety of the mine workers and the local community

In addition, a program should be developed to train mine personnel how to react to emergency situations.

In evaluating these scenarios, the regulator should be aware of the environmental and socio-economic setting of the mine to ensure that the conservative assumptions made to develop the scenarios are reasonable. For instance, water management experts reviewing an EIA risk analysis for a mine often require that impoundments are designed to handle runoff from a maximum probable rainfall event. The calculation of such an event is based on many years of data. These data may not be available for a particular drainage and information should be gathered from other similar areas if available. In addition, “climate change” may increase the frequency of large storm events possibly making historic data less reliable for predictive purposes. It takes professional judgment to ensure that the right approach is taken. It is also important for the reviewers to ensure that in case of a disaster or emergency that contingency plans are in place.

2 POTENTIAL IMPACTS

Mining operations have impacts on the natural and human environments in each phase of the process which should be taken into account. The impact assessment should account for all of the activities involved in the project, including the specific technologies in the project description for the proposed project and the alternatives. Many of the impacts of mining operations are well documented. The EIA should define direct, indirect and cumulative impacts as defined as:

- Direct impacts are due to a specific project-related activity in the same place and time as the project
- Indirect impacts are due to actions resulting from direct impacts, but occur outside the time and space for the project including impacts whose cause may be several times removed from project actions
- Cumulative impacts are the incremental impacts of the proposed project when added to past, present and future activities and their impacts on a particular resource

This should be done for the proposed project and alternatives, and for every phase of the mining cycle as presented in Figure E-1, including exploration, site development, construction, operation, closure ,and post-closure with direct, indirect and cumulative impacts. Tables E-1 through E-4 summarize some of the potential impacts of industrial mining on the natural and human environments.

Figure E-1: The Mining Cycle (Env. Canada, 2009)

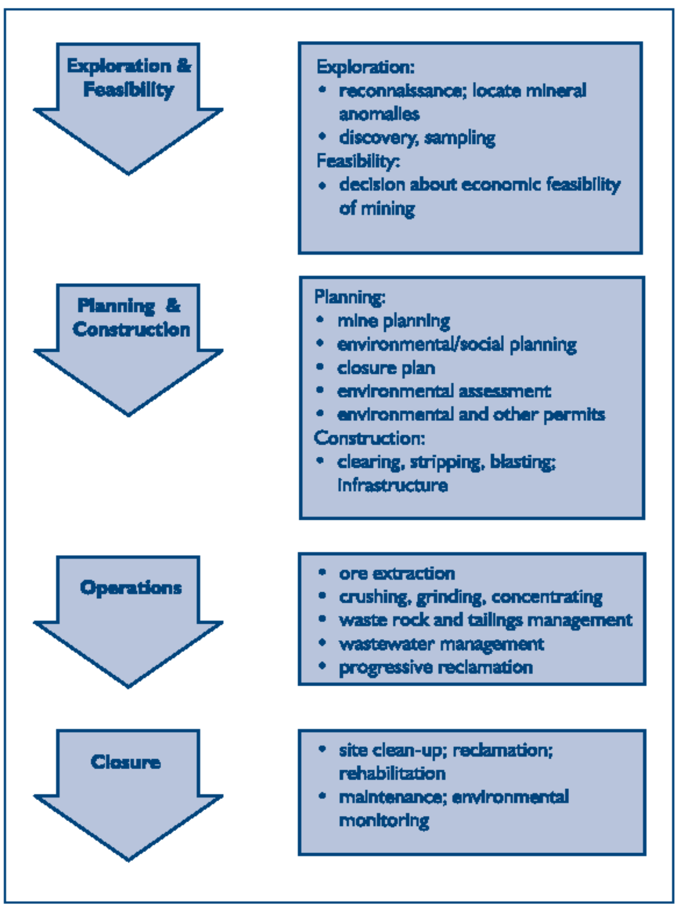


Table E-1: Environmental Concerns from Mine Exploration

Action	Affected Environment	Environmental Concerns
CONSTRUCTION ACTIVITIES		
Camp, road, airstrip, drill pad and staging area construction Line cutting Topsoil removal	Soils and Geology Water Quality Vegetation Fish and Wildlife Land Use Air Quality Cultural Noise and Vibration Aesthetics Health and Safety	Erosion and Sedimentation Modification of streams and rivers due to crossings Spills Deforestation and loss or disturbance of habitat Fire Equipment emissions and fugitive dust Cultural and heritage site disturbance Noise and vibration from construction activities Aesthetic/visual impacts Health and safety of workers transported to the site, using equipment and working in inhospitable environments
EXPLORATORY PROGRAMS		
Geophysical surveys Reconnaissance mapping and sampling Aerial photography	Water Quality Vegetation Fish and Wildlife	Erosion and sedimentation from off-road vehicle use Impacts on vegetation from off-road vehicle use Disturbance of wildlife from surface and airborne surveys
Trenching, tunneling, pitting and drilling to collect samples	Soils and Geology Water Quality Vegetation Fish and Wildlife Land Use Air Quality Cultural Noise and Vibration Aesthetics Health and Safety	Acid generation from exposed sulfide materials Erosion and sedimentation Metals leaching into surface water and groundwater Spills or leaks from mud pits Groundwater contamination from drilling fluids Deforestation and loss or disturbance of habitat Scarring of land in remote locations Equipment emissions and fugitive dust Cultural and heritage site disturbance Traditional uses disrupted Noise and vibration from drilling and blasting Health and safety of workers using equipment and working in inhospitable environments
Experimental mine	Same as for a large mine accept on a smaller scale (see Table G.2)	Same as for a large mine accept on a smaller scale (see Table G.2)
Transportation	Water Quality Air Quality Health and Safety	Spills Emissions from vehicles and fugitive dust Transportation accidents
CAMP ACTIVITIES		
Camp operation	Fish and Wildlife	Animals attracted to garbage and food waste Migratory patterns, breeding/nesting behavior affected by presence of humans and noise from helicopters, planes and drill rigs Increased hunting and fishing (food for workers)
Solid and human waste disposal	Water Quality Aquatic Biota	Water quality degradation Depletion of aquatic biota from spills
Fuel storage and handling	Water Quality Aquatic Biota	Water quality degradation from spills Depletion of aquatic biota
Water supply	Water Quantity	Depletion of nearby water sources
Energy production	Air Quality	Emissions from generators
Transportation	Water Quality Air Quality Health and Safety	Spills Emissions from vehicles and fugitive dust Transportation accidents

Table E-2: Environmental Concerns from Mine Development

Action	Affected Environment	Environmental Concerns
CONSTRUCTION ACTIVITIES		
Construction of buildings, workshops, processing plant, and permanent camp	Soils and Geology Water Quality Vegetation Fish and Wildlife Land Use Air Quality Cultural Noise and Vibration Aesthetics Health and Safety	Erosion and sedimentation Spills Deforestation and loss of habitat Fire Equipment emissions and fugitive dust Cultural and heritage site disturbance Noise and vibration from construction activities Aesthetic/visual impacts Health and safety of workers transported to the site, using equipment and working in inhospitable environments
Construction of site access roads and power lines	Soils and Geology Water Quality Vegetation Fish and Wildlife Land Use Air Quality Cultural Noise and Vibration Aesthetics	Erosion and sedimentation Modification of streams and rivers due to crossings Acid generation from exposed sulfide materials Spills Deforestation and loss or disturbance of habitat Increased road access in remote areas may lead to: ▪ Increased fishing/hunting, stressing populations ▪ Human invasion of previously inaccessible areas Fire Equipment emissions and fugitive dust Cultural and heritage site disturbance Noise and vibration from construction activities Aesthetic/visual impacts Health and safety of workers transported to the site, using equipment and working in inhospitable environments
TRANSPORTATION		
Operation of vehicles and equipment	Water Quality Air Quality Health and Safety	Stream crossings Vehicle emissions and fugitive dust Transportation accidents
Fuel and chemical transportation, handling, and storage	Water Quality Air Quality Health and Safety	Spills and stream crossings Potential releases of volatile organic compounds and hazardous substances Transportation accidents
MINE PREPARATION		
Site preparation (topsoil and overburden removal)	Soils and Geology Water Quality Vegetation Fish and Wildlife	Erosion and sediment from site as well as waste dump areas Acid generation from exposed sulfide materials at site and at waste dump areas and metals leaching into surface water and ground water Modification of drainage patterns, streams and rivers Deforestation and loss or disturbance of habitat Disruption and dislocation local wildlife and migratory wildlife
Drainage control	Water Quality Water Quantity	Erosion and sedimentation Modification of drainage patterns, streams and rivers Changes in flood patterns
Initial dewatering	Water Quality Water Quantity	Increased total dissolved solids and potentially trace metals Increased volumes of water to surface streams Downstream erosion and changes in stream morphology and floodplains due to increased volume Drawdown of water table and depletion of springs, seeps, wells and streams
Blasting	Fish and Wildlife Air Quality Noise and Vibration	Noise and vibration from blasting disturbing human settlements and wildlife Fugitive dust

CAMP ACTIVITES		
Camp operation	Fish and Wildlife	Animals attracted to garbage and food waste
		Migratory patterns, breeding/nesting behavior affected by presence of humans and noise from helicopters, planes and drill rigs
		Increased hunting and fishing (food for workers)
Solid and human waste disposal	Water Quality Aquatic Biota	Water quality degradation Depletion of aquatic biota
Fuel storage	Water Quality Aquatic Biota	Water quality degradation from spills Depletion of aquatic biota from spills
Water supply	Water Quantity	Depletion of nearby water sources
Energy production	Air Quality	Emissions from generators
Transportation	Water Quality Air Quality Health and Safety	Spills
		Emissions from vehicles and fugitive dust
		Transportation accidents

Table E-3: Environmental Concerns from Mine Operation

Action	Affected Environment	Environmental Concerns
MINING ACTIVITES		
Land disturbance from any type of mine involving excavation or dredging	Soils and Geology Water Quality Water Quantity Vegetation Fish and Wildlife Land Use Air Quality Cultural Noise and Vibration Aesthetics Health and Safety	Erosion and sedimentation including increased streambed erosion
		Spills/overflows from ponds during storm events or electricity failures
		Degradation of groundwater and surface water quality
		Lowering of water table, reduced well production, decreased stream, seep and spring flows
		Deforestation and loss of habitat
		Disruption of migration routes and nesting/breeding activities
		Areas made unproductive for non-mine uses, including fishing in the case of dredging
		Increased landslide and dam failure potential
		Equipment emissions and fugitive dust
		Cultural and heritage sites destruction
		Traditional uses disrupted
		Noise and vibration from blasting and other mining activities
		Open pits, in-stream dredging and other unsightly facilities
		Health and safety of workers transported to the site, using equipment and working in inhospitable environments
Land disturbance from waste disposal from hard rock mining activities including heap leach, waste rock and tailings dam facilities	Soils and Geology Water Quality Water Quantity Vegetation Fish and Wildlife Land Use Cultural Aesthetics Health and Safety	Erosion and sedimentation
		Spills/overflows from ponds during storm events or electricity failures
		Containment failures (e.g. dam breaches)
		Acid rock drainage potential (metal and coal mining)
		Cyanide contamination of groundwater and surface water (Metal Mining)
		Increased potential for trace metals/other contaminants
		Deforestation and loss of habitat
		Poisoning of birds and other wildlife
		Disruption of migration routes/nesting/breeding activities

Table E-3: Environmental Concerns from Mine Operation

Action	Affected Environment	Environmental Concerns
		Areas made unproductive for non-mine uses
		Disturbance or destruction of cultural and heritage sites
		Traditional uses disrupted
		Tailings dams and rock waste disposal sites are unsightly
		Health and safety of workers transported to the site, using equipment and working in inhospitable environments
Mining, power generation, processing, and transport	Air quality	Emissions from vehicles and machinery
		Fugitive dust
		Odors
Drainage and dewatering	Water Quality Water Quantity Aquatic Biota	Increased total dissolve solids and potentially trace metals
		Increased volumes of water to surface streams
		Salt water intrusion
		Downstream erosion and changes in stream morphology and floodplains due to increased volume
		Disturbance of spawning grounds and wetlands
		Lower of water table, reduced well production, decreased stream, seep and spring flows
TRANSPORTATION		
Operation of vehicles and equipment	Water Quality Air Quality Health and Safety	Disturbance (erosion and sedimentation) at stream crossings
		Vehicle emissions and fugitive dust
		Transportation accidents
Fuel and chemical transportation, handling, and storage	Water Quality Air Quality Health and Safety	Spills at stream crossings and in other sensitive areas
		Potential releases of volatile organic compounds and hazardous substances.
		Transportation accidents
CAMP ACTIVITIES		
Camp and mine operation	Fish and Wildlife	Animals attracted to garbage and food waste
		Migratory patterns, breeding/nesting behavior affected by presence of humans and noise from helicopters, planes and drill rigs
		Increased hunting and fishing (food for workers)
	Socioeconomic Land Use	Increased employment opportunities at mine
		Increased indirect employment
		Land use pressures
		Pressure on agricultural and forest resources
		In-migration causing pressure on local community infrastructure and social/cultural changes
Solid and human waste disposal	Water Quality Aquatic Biota	Water quality degradation
		Depletion of aquatic biota
Fuel storage and handling	Water Quality Aquatic Biota	Water quality degradation from spills
		Depletion of aquatic biota from spills
Water supply	Water Quantity	Depletion of nearby water sources
Energy production	Air Quality	Emissions from generators
Transportation	Water Quality Air Quality Health and Safety	Spills
		Emissions from vehicles and fugitive dust
		Transportation accidents

Table E-4: Environmental Concerns due to Mine Closure

Action	Affected Environment	Environmental Concerns
REMOVAL, BACKFILLING AND SEALING		
Sealing of shafts, inclines and declines, or ventilation raises to prevent unauthorized access	Soils and Geology Water Quality Air Quality	Effects of seepage from backfill Formation of potentially unstable plugs Contaminated mine water drainage Emissions from equipment, and fugitive dust Health and safety of workers
Backfilling of pits with waste rock	Soils and Geology Water Quality Wildlife Air Quality	Slope and bench stability Groundwater and rainwater contamination Concern about unauthorized access Wildlife entrapment Contamination of groundwater or surface water by backfilled waste rock Health and safety of workers
Removal of buildings and foundations	Soils and Geology Water Quality Air Quality	Emissions from equipment, and fugitive dust Health and safety of workers
Clean-up of workshops, fuel and reagents	Soils and Geology Water Quality Air Quality	Emissions from equipment, and fugitive dust Health and safety of workers Potential for hazardous spills
Disposal of scrap and waste materials	Soils and Geology Water Quality Air Quality	Emissions from equipment and fugitive dust Health and safety of workers Potential for hazardous spills
Rehabilitation of waste rock facilities	Soils and Geology Water Quality Air Quality	Slope stability Erosion and sedimentation Effects of contaminant leaching on surface water and groundwater Dust generation Visual impacts
Rehabilitation of tailings dam and heap leach facilities	Soils and Geology Water Quality Air Quality	Dam stability Changes in tailings geochemistry Effects of seepage past the dam and from the base of the facility to groundwater and surface water Discharge of contaminated water to groundwater and surface water Dust generation Potential for wildlife entrapment and poisoning and unauthorized human entry
Restoration of surface drainage	Soils and Geology Water Quality Air Quality	Long term stability of restored drainage, especially around mine facilities such as pits, waste rock, tailings, and heap leach pads Erosion and sedimentation Emissions from equipment, and fugitive dust Health and safety of workers
Removal of water treatment facilities	Soils and Geology	Erosion and sedimentation Emissions from equipment, and fugitive dust Health and safety of workers
Removal of infrastructure	Soils and Geology	Erosion and sedimentation Emissions from equipment, and fugitive dust Health and safety of workers
RESTORATION ACTIVITIES		
Rehabilitation	Soils and Geology Water Quality Water Quantity Vegetation and Wildlife Land Use Air Quality Noise and Vibration	Subsidence of underground workings Long-term stability of waste rock piles and mining slopes Erosion and Sedimentation Interim and final pit lake water quality, effects on wildlife (e.g. poisoning) and on groundwater or surface water from flow-through pit waste Trace metals Acid rock drainage potential (metal and coal mines)

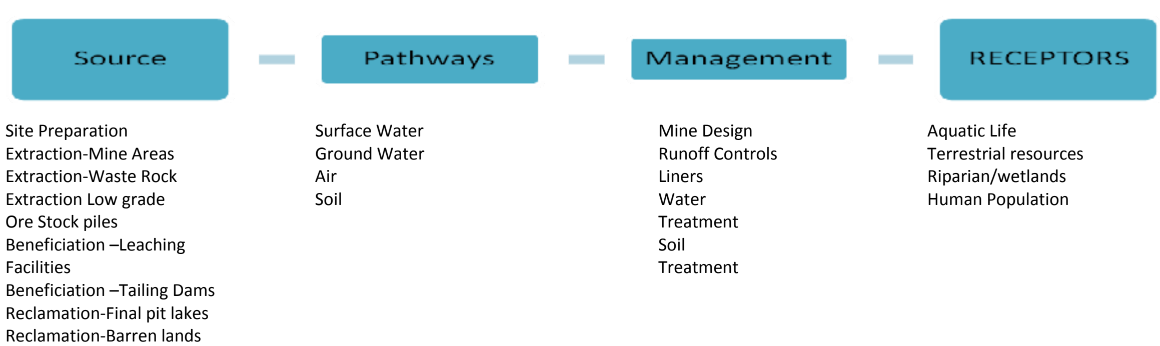
Table E-4: Environmental Concerns due to Mine Closure

Action	Affected Environment	Environmental Concerns
		Containment failures
		Disposal/discharge of heap leach and tailings drain down solutions
		Degradation of surface water and groundwater (ARD and trace metals)
		Long-term changes to groundwater balance (loss through pit lake evaporation)
		Failure of vegetation to properly reestablish
		Failure to meet final land use requirements
		Emissions from vehicles and machinery
		Fugitive dust
		Odors
		Noise from restoration activities
	Socioeconomic	Change in labor force requirements
		Stress on community to recover
		Risk of abandonment of towns and infrastructure
POST CLOSURE		
Long-term maintenance of water treatment facilities	Water Quality	Potential for facilities to contaminate surface water and groundwater with ARD, suspended solids, trace metals, and other contaminants
Long-term maintenance of slopes, drainage control and vegetation	Water Quality Air Quality	Maintenance sometimes increases erosion
		Emission from vehicles
		Fugitive dust
Source: Environment Canada 2009		

3 UNDERSTANDING THE PATHWAYS TO THE ENVIRONMENT

Each mining process outlined in Tables E-1 through E-4 provides a potential source for pollution, which is transported to the environment and to potential receptors. As illustrated in Figure E-1, these potential pollution sources include tailings, waste rock, heap leach pads, pit areas, and underground workings. Pathways are water (surface water and groundwater), air, and direct contact with contaminated soils. Receptors include people, wildlife, domestic animals, and vegetation. The following sections describe how pollution from mining sources is transported via these pathways to potential receptors.

Figure E-2: Conceptual Model of Sources, Pathways, Mitigation, and Receptors for a Mining Operation (USEPA, 2008)



4 IMPACTS

4.1 Surface Water and Groundwater

There are numerous types of pollutants that can be released into surface water and groundwater from a mining operation. These include suspended solids and toxic pollutants including metals, cyanide, nitrates, and other contaminants. There are three basic processes in which these contaminants can be released into surface water and groundwater from a mining operation:

1. Erosion and Sedimentation - For most industrial mining operations, a large area of land is often disturbed exposing large quantities of barren soil and rocks to erosion. Water erosion can either be caused by the direct impact of rain drops (splash erosion), by concentrated flow forming rills and gullies, or by sheet flows. The end result is sediment enters streams and lakes impacting fish and aquatic plant life and clogging waterways. Erosion also can be caused by wind, which can blow dust directly into surface water or deposit it on land from which it is subsequently moved into surface water during runoff events. Sediment and dust may also be laden with metals and other pollutants which may be released during transport or deposition.

2. Acidic and Non-acidic Drainage - Acid Rock Drainage and Acid Mine Drainage occur when sulfide-containing minerals such as pyrite, which is common to many mine sites, are exposed to air and water and form acids. When this process occurs within a mine it is called Acid Mine Drainage (AMD). When it occurs in waste rock and tailings piles it is known as Acid Rock Drainage (ARD). In general, sulfide-containing minerals, which may be naturally-occurring in the ore, waste rock and wall rock, may react with water and oxygen to create ferrous ions and sulfuric acid. With bacteria acting as a catalyst, the ferrous ions react further with oxygen, producing hydrated iron oxide. This combination of iron oxide and sulfuric acid can contaminate surface water producing a low pH level and a high concentration of sulfate, iron, and heavy metals. Some metals and metalloids and other contaminants may also be released under non-acid conditions. The resulting contamination of surrounding water sources with acids, dissolved metals, metalloids and other contaminants can kill plants and fish and, in serious cases, poison humans who drink contaminated water or eat fish and plants from polluted rivers and streams.

3. Spillage Due to Accidents – On a mine site, potentially hazardous materials are transported to mine sites and stored in tanks or ponds, or within tailings ponds. A spill or loss of containment can release potential contaminants to the environment. This can happen as a result of a transportation accident, pipeline failure, tailings dam failure, a leaky tank or impoundment. As a result of a spill or loss of containment, contaminants such a cyanide, sulfuric acid, pregnant solution, petrochemicals, or solvents could saturate soils or runoff into nearby surface waters.

As presented in Table E-5, during each phase of mining there is a potential to impact surface water and groundwater as described in more detail below.

Table E-5: General Environmental Impacts of Mining (Based on USEPA, 1995)

Mining Process	Water Pollution	Air Pollution	Soil	Land, Habitat, Wildlife
Site Preparation	Increased turbidity from erosion due to removal of vegetation	Exhaust and dust from construction vehicles	Exposure to erosion and compaction Loss of soil profile	Deforestation and habitat loss from road and site construction Loss of soil profile
Blasting/ Excavation	Acid Mine Drainage (AMD) Mineral and chemical contamination Increased turbidity from erosion of soils Petroleum wastes from trucks Surface water and ground water contamination from blasting chemicals, runoff and waste water discharges	Dust blown to surrounding area Exhaust from heavy machinery	Loss of soil profile Overburden if not reused Increase in soil erosion	Landscape changes Loss of habitat or migration routes Increase in soil erosion Loss of plant population from dust and water pollution Reduction in groundwater and surface water resulting from pumping for dewatering or for use in processing Loss of drinking water, stock water, or irrigation resources Loss of fish population from water pollution Nearby structural damages from vibration and settling Competition for land use
Crushing/ Concentration	Leachate and acid waste water discharges from waste rock dumps and tailings	Exhaust and dust created during transportation	Loss of soil profile	Landscape changes Loss of habitat or migration corridors Loss of plant, fish, or wildlife populations from water pollution
Leaching	Surface water and ground water pollution from ruptures in pipes or ponds holding leach solution	Heavy metals in dust (i.e. dry or wet-deposited) and run off into surface water and leaches into ground water	Sludges from neutralization of contaminated water	Loss of plant population from water pollution Loss of fish and water fowl population from water pollution Loss of terrestrial habitat through soil contamination and destruction of cover/food.

4.1.1 Site Preparation

Site preparation involves many factors that could have a negative impact on surface water and groundwater. These include:

- Deforestation – the removal of trees and other vegetation makes soil more susceptible to erosion and subsequent sedimentation in streams
- Exposing soil – the removal of topsoil and overburden exposes barren materials to erosion and subsequent sedimentation. Acid rock drainage may also be a problem if certain conditions exist

- Dewatering – in large open pit mines, wells are often drilled up to a year before mining begins These wells are pumped lowering the water table, and the water is often discharged into surface water drainages and may increase erosion of the banks and stream bed, increase sediment loadings, or change stream constituent concentrations or temperature. Such pumping can also have an impact on water quantity in wells and springs in the mine vicinity.

4.1.2 Extraction - Mine Workings

When mining occurs below the water table, mine water is pumped from underground and surface operations and often discharged after treatment to surface water. When operations cease, mine workings may overflow and untreated mine water and runoff from mined areas may be discharged. In pits excavated below the water table, post-mining pit lakes can form as the water table recovers. If the waters in the workings were subject to acid formation, the occurrence of AMD may cause acidic conditions and enhance pollutant mobility; however, toxic loadings can also occur under neutral conditions. In addition, residues from blasting within the workings can elevate nitrate concentrations.

These contaminated waters can also seep into the groundwater system via fractures or seepage from above or if pit lake water moves through the pit into adjacent groundwater. Mine waters may infiltrate and contaminate aquifers and associated wells. On the converse, aquifers may infiltrate mine workings, causing drawdown to the aquifer and affecting the water level in some wells. The aquifer may experience drawdown from years of mine dewatering practices also affecting water levels in wells.

4.1.3 Extraction – Dredging

The activity of dredging can create the following principal impacts to the environment:

- Release of toxic chemicals (including heavy metals and PCB) from bottom sediments into the water column
- Short term increases in turbidity, which can affect aquatic species metabolism and interfere with spawning
- Secondary effects from water column contamination of uptake of heavy metals, DDT and other persistent organic toxins, via food chain uptake and subsequent concentrations of these toxins in higher organisms including humans
- Secondary impacts to marsh productivity from sedimentation
- Tertiary impacts to avifauna which may prey upon contaminated aquatic organisms
- Secondary impacts to aquatic and benthic organisms' metabolism and mortality
- Possible contamination of dredge spoils sites
- Siltation caused by dredging can affect fresh water intakes

To evaluate potential impacts and given that many sand and gravel locations are in urban areas, it is important to ask the following questions:

1. Will the project increase the risk of erosion resulting in water sources becoming turbid or muddy and affect fresh water intakes?

2. Have plans been established to reduce the discharges to water and are these measures considered sufficient?
3. Have the impacts on drinking water or water sources for agriculture and aquaculture been considered?

4.1.4 Extraction - Waste Rock/Overburden Piles/Low Grade Ore Stock Piles

Waste rock and overburden are usually placed in storage piles or fill structures adjacent to or near the mine workings or open pit. Materials in many cases are end-dumped into angle-of-repose waste rock dumps that are often located on the slopes of natural drainages. These units are generally unlined. Potential pollutant loadings in runoff and seepage from waste rock piles can include sediment as well as metals and sulfates and are dependent on the site-specific mineralogy and erosion potential of the material. Where sulfur mineralization is present, ARD can occur increasing the likelihood of polluted surface water and groundwater.

The location of waste rock areas and low grade ore stock piles and the provision of containment structures will determine if these facilities can result in surface water and groundwater contamination. If erosion from the structures goes unchecked and the area drains into streams, lakes, or wetlands then surface water contamination (sedimentation and chemical) can occur with resulting water quality degradation and possible impacts on flooding.

4.1.5 Beneficiation – Leach Sites

Leach sites, including dump and heap leach pads, have the potential to release highly concentrated levels of acids and heavy metals into water sources. The leaching process mimics acid drainage although it is conducted under much more aggressive conditions, using high concentrations of acid, base, or cyanide to extract metals from ore. Modern day leaching facilities are designed with synthetic liners and recycle the cyanide or other leaching agent. However, failures can occur due to improper liner placement, climatic events such as catastrophic rainfall and seismic events. Since leaching produces large volumes of contaminated water, the failure of a leaching facility could cause considerable environmental impact. However, most of the environmental problems associated with leaching are caused by leakage, spillage, or seepage of the leaching solution at various stages of the process. Potential problems include:

- Seepage of solutions through soils and liners beneath leach piles
- Leakage from solution-holding ponds and transfer channels
- Spills from ruptured pipes and recovery equipment
- Pond overflow caused by excessive runoff
- Ruptures of dams or liners in solution holding ponds

In addition, unless effective detoxification procedures are used, spent ore piles can cause releases of residual acids, bases, or cyanide. In addition to the leaching agents, other pollutants (including heavy metals) can be mobilized in the leaching process and may be released to surface water or ground water through spills or leaks (during operations) and through seepage/runoff from spent ore (after closure). Where sulfide mineralization occurs, there is potential for ARD. Cyanide degradation can also lead to nitrate contamination.

4.1.6 Beneficiation – Tailings Dams

Tailings are pollutant laden slurries from the beneficiation processes and should not be disposed of in rivers or water bodies. Usually they are retained in impoundments that are often constructed in natural drainages. Alternatives to tailings disposal in drainages should be explored. Impoundment designs usually include under drains and controlled discharges (especially in high precipitation areas). However, tailings impoundments are nearly always accompanied by unavoidable seepage through or beneath the dam structure, with resulting contamination of surface water and groundwater. Fine tailings can be more susceptible to leaching and entrainment of particulates, and thus can be a greater source of contamination than coarser waste rock materials.

Contaminants associated with tailings include heavy metals, arsenic, and radionuclides. ARD can occur if sulfide mineralization is encountered and may enhance metals mobility. Residual mill reagents may also be present in the tailings; however, they typically do not contribute significant pollutant loadings. When the outside slopes of dams are constructed of tailings or other mining wastes, discharges and runoff from these areas can also affect water quality.

Finally, tailings are typically transported to impoundments by pipeline. The supernatant solution in tailings ponds is collected, reclaimed and returned to the mill by pipeline. If the supernatant solution remains in the tailings ponds, it can poison waterfowl and other wildlife that come in contact with it. Pipe failures may lead to surface water impacts if pipelines are located in drainages or if the spilled material comes in contact with runoff. Pipe failures can also lead to groundwater contamination via seepage. Therefore, as a result, dewatered or paste tailing disposal may be a less environmentally damaging alternative.

4.1.7 Thermal Processes

Thermal processes used in some gold mining can release significant amounts of mercury in air emissions, which can then be deposited locally or regionally into surface water or onto land where it can eventually be transported into surface waters. Bioaccumulation of mercury in fish can adversely affect humans who eat the fish.

4.1.8 Transportation

Impacts from transportation of materials and people and transportation facilities associated with a mining project are two-fold. The existing transportation routes and methods may be affected by increased use of the existing facilities and impacts associated with increased use. In addition, the creation and use of new transportation facilities have the potential to affect most aspects of the existing environment. Many types of transportation facilities may be associated with a mining project, and some of the more common facilities include: roads, ramps, railroads, pipelines, slurry lines, conveyors, airstrips, helicopter pads, and the use of waterways.

Construction of new transportation facilities for most of the methods of transportation at mines would affect landforms and the general topography by creating cuts and fills. Vegetation and soils would be impacted from disturbance and removal during construction and the life of the facility. Impacts could include the degradation of surface water quality from erosion and sedimentation caused by the construction and use of transportation facilities. Spills from use of the roads, pipelines, or railways could also contribute to surface water and groundwater degradation.

4.2 Air and Noise

As presented in Table E-5 air pollution can occur at mining sites during excavation, beneficiation, and transportation. The main air and noise concerns include:

AIR EMISSIONS AT MINES

Description of the problem: Particulate material, gaseous emissions, and fugitive dust which is spread by prevailing winds. The emissions may contain heavy metals such as zinc, lead, mercury and other substances which pose a health risk to nearby residents.

Source of the Problems: Exposed soils and rock faces, vehicles, generators, and other emitters.

Environmental Impacts: Elevated levels of lead and other trace metals are found downwind in soils and desposited dusts in school yards, class room, and other locations where direct contact occurs with inhabitants, particularly children, posing a health risk.

Key Issues:

1. What are the potential contaminants that might be found in the dust and exhaust fumes at the site?
2. Is there enough air monitoring data – wind direction, velocity, etc – to predict downwind impacts of the mining operations?
3. Which dispersion model(s) is most appropriate to be use to make long term projections?
4. How many people live directly downwind from the site who might be at risk?

- Dust - Dust is created at all stages of the mining process, including land clearing, road construction, excavation, blasting, crushing grinding, dumping and transportation. Despite the best attempts to control dust, there are areas in any mining operation where there are elevated dust concentrations. A large portion of dust is made up of large particles, with diameters greater than 10 microns. This coarse dust usually settles gravitationally within a few hundred meters of the source. The smaller particle size fractions (PM10), however, can be carried by wind in dust clouds for great distances and may be deposited on or near populated areas. The dust may contain heavy metals. As a result, human health and/or environmental problems may arise through direct inhalation, soil deposition, deposition on plants or accumulation within a water body.

- Emissions from Vehicles and Mining Equipment - Particulate and gaseous air pollutant emissions are associated with vehicle and equipment exhaust. Particulate emissions (including PM10 emissions), carbon monoxide, unburned hydrocarbons (volatile organic compounds), nitrogen oxides and sulfur dioxide result from fuel combustion in vehicles, heavy equipment (including crushers and grinders), and generators associated with mining. For underground operations, a serious hazard results from exhaust gases released by vehicles and mining equipment as well as from fumes produced during blasting. These exhausts produce carbon monoxide and nitrogen oxide gas that can collect in underground cavities. Workers exposed to high concentrations of these gases risk serious illness and death.

  PM10 emission rates may be modeled for the various parts of the mining process: dust generated during overburden, waste rock and ore removal as well as operation of vehicles on unpaved roads; emissions from operation of vehicles, heavy equipment, mining shovels or excavators, conveyors, crushers and grinders, and generators.

- Organic and Chemical Fumes and Gases - Hydrometallurgical beneficiation processes may create large quantities of sulfur dioxide, carbon monoxide and organic and chemical fume emissions. Gold and silver leaching operations can produce hydrogen cyanide gas. In addition, modern mining techniques require the use of a variety of hazardous chemicals for ore processing such as acids and cyanide, which, in the event of an accidental spill can result in fumes which can impact mine employees and nearby residents. Thermal processes such as autoclaves, roasters, and carbon regeneration kilns can release mercury and other hazardous air pollutants.

- Smelter Emissions - Smelting, without controls, can produce a large amount of particulate matter and heavy metals. Thermal processes also can release significant amounts of mercury, which can then be deposited locally or regionally, or can contribute to global atmospheric mercury.

- Noise - Explosives and heavy machinery are used regularly at mining sites, resulting in potentially harmful amounts of noise pollution. Miners subject to high noise levels for extended periods of time may become permanently deaf. Noise also can affect wildlife by causing stress and disrupting behavior.

- Vibration - The use of explosives for excavation is common in surface mining and causes significant vibration. Control of vibration damage to natural formations and manmade structures is therefore an important environmental consideration. Damage to natural formations has been observed up to 500 meters away from blasting sites. Many mines limit the number of explosions, using millisecond delays between blasts to minimize concussion and noise, especially near population centers, natural scenic formations, wells, and stream channels.

4.3 Soils

Soils can be impacted by surface and underground mining operations (see Table E-5). They can be eroded by wind and water and contaminated by leaching solutions, solvents, fuels, and mine water. Soil erosion due to wind and water occurs on surface disturbances associated with surface mining operations and underground operations (such as mine portals) and by runoff associated with the discharges of mine water. When mine water, runoff, and drainage from waste rock, tailings piles and beneficiation facilities come in contact with soils, toxic metals and other hazardous materials in these waste streams can be transferred to the soils. Emissions from stacks may contribute to contamination of soils, even off of the mine site. Common contaminants include heavy metals (cadmium, lead, etc.), arsenic, and radionuclides. Contact of ARD with soils can lower both the pH and the cation exchange capacity of the soils. Contaminated soil can affect restoration of mine lands and can cause illness if directly handled or ingested by humans. Soil should be stockpiled for use in restoration, but profile and structure are destroyed when soil is removed for mine pits and facilities.

4.4 Ecosystems

As presented in Table E-5, mining operations can impact aquatic, terrestrial and wetland ecosystems. The primary pathways of such impacts, as shown in Figure 1, are contamination of water, air and soil. However, habitat can also be impacted by resource modifications, increased human activity in the vicinity of the mine and increased pressure on natural resources in the habitat, due to human population increases associated with the mine.

4.4.1 Aquatic Life

In general terms, aquatic life is defined as some mammals, reptiles, fish and benthic macro invertebrates that live in an aquatic environment. Phytoplankton and other life forms can also be considered, depending on the aquatic habitat. Changes in water quality affect aquatic resources by increasing the loading of sediment or toxic/hazardous materials (metals) to streams and water bodies , decreasing the oxygen in the water, and/or changing the temperature. Physical modifications in the resources can also impact aquatic habitats, such as modifying shade, pool and riffle sequences, flow of ephemeral, intermittent, or perennial streams due to discharges or mine dewatering and disrupting flows into or the size of wetlands or other water bodies. Impacts may result in changes to relative abundance of species or biological diversity. If post-mining pit lakes become contaminated, fish, birds, and other animals could be adversely affected by pH, metals, and other contaminants.

Cyanide, widely used in silver and gold leaching operations, can significantly impact aquatic ecosystems. When released to the soil, surface water or groundwater, cyanide may mobilize heavy metals. Thus cyanide in ponds and ditches as well as cyanide spills that contaminate soil and get into runoff presents a hazard to aquatic plant and animal life.

Aquatic ecosystems can also be impacted if the mining operation increases resource demands (such as overfishing) or introduces other secondary impacts (such as clothing washing or recreational use) that displaces species or disrupts habitats.

4.4.2 Terrestrial Resources

Terrestrial resources mainly consist of vegetation and wildlife. The distribution of vegetation is dependent on the local climatic regime, soils, slope, and aspect. Impacts to vegetation are mainly associated with the land-clearing activities conducted in advance of mining operations but dust can also affect vegetation by covering leaves and preventing carbon dioxide/oxygen exchange. Impacts to wildlife include:

- Habitat loss, degradation and alteration associated with the destruction of vegetation
- Disturbance of migration corridors by mining activities and transport (roads, rails, pipelines, conveyers, etc.)
- General displacement from surrounding, otherwise undisturbed areas and disruption during mating or nesting seasons due to increased noise and human activity
- Increased mortality associated with contamination of soil, vegetation and water, direct contact with solution ponds and tailings impoundments, and direct animal hits by mining or commuting vehicles
- Construction of poles for power transmission lines can provide perches for predatory birds, which can affect prey populations

In addition, increased human activities for recreation or hunting in surrounding, otherwise undisturbed areas can result in reduction of wildlife habitat. Plant communities can be impacted if they are gathered for food, construction, fuel or medicinal uses. Development of new roads to access mines also may open previously inaccessible areas to human development, thus having even wider impact on terrestrial ecosystems.

4.4.3 Riparian/Wetlands

Native vegetation can be divided into upland and lowland communities. Upland communities consist of forests, shrublands and grasslands. Lowland vegetation occurring within drainages forms riparian (streamside) communities, including wetlands. Wetlands and riparian areas are usually the most productive and diverse vegetation types within an ecosystem. Impacts to wetlands due to mining operations may occur directly or indirectly.

Direct impacts can include wetland destruction through removal for development of surface mining, draining as a result of mine dewatering or changes in stream flow or aquifer conditions, or filling as a result of construction of a tailings impoundment or waste rock dumps. Sedimentation can also impact wetland resources as a result of uncontrolled runoff and erosion from the mining site or scouring and head cutting from poorly designed stream diversions or discharge outfalls.

Indirect impacts on riparian and wetland resources can occur from increased human activities in those habitats, including recreation and gathering of plant materials for food, construction, fuel or medicinal uses.

4.5 Human Health

The pathway for human health impacts are the contamination of water, air and soil as presented above. The people most susceptible to the environmental impacts of mining are the workers. Dust, fumes, exhaust, noise, direct contact with contaminated soils, and explosives all pose a human health risk to workers. Nearby communities may also be affected by dust, releases of toxic chemicals in water supplies, bioaccumulation of toxics in fish eaten by residents, and toxic chemical spills due to transportation accidents.

4.6 Socio-Economic Impacts

The social and economic impacts of a mining project can be both positive and negative. Socio-economic impacts can vary by location and size of the mine, length of the project from construction to closure, manpower requirements, the opportunities the mining company has for the local community employment and involvement, and the existing character and structure of the community.

Positive impacts can include:

- Increased individual incomes
  - Direct employment at the mine
  - Increased purchases from local businesses
  - Other economic activities stimulated in the community as a result of the mine.
- Employment opportunities (short- and long-term for local residents)
- Workers need to be trained and provided with health and safety equipment
- Increased tax base
- Resource royalties
- Opportunity for a community development agreement with the mining company

Negative impacts can include:

- Displacement and relocation of current residents or community resources

- Displacement or disruption of people's livelihoods (e.g., fishing, hunting, grazing, farming, forestry)
- Strain on existing houses, infrastructure, and services as a result of increased population
- Public finance requirements –more infrastructure may need to be built and maintained to meet the demands of increased population for public education and public services (water, sanitation, roads, etc.)
- Increased traffic and truck trips (safety, noise, exhaust)
- Reduction in quality of life for residents from visual and noise impacts
- Increased crime (drugs, alcohol, prostitution, etc.)
- Creation of a mining camp may breakup family units

Some impacts can be both a positive and negative such as:

- Potential for population increase
    - Increased tax base (positive)
    - Change in character of community (negative)
- Housing availability
    - Improved housing market in the short-run (positive)
    - Abandoned housing after mine closure (negative)
- Change in religious, ethnic or cultural makeup of community
    - Diversity (positive)
    - Conflicts (negative)

Impact analysis and policy considerations that may be valid for the general population may not adequately capture important impacts on subsets of society. For these vulnerable populations, efforts to protect their environmental health and wellbeing requires further investigation into their special relationship to the environment to assess whether predicted impacts may fall disproportionately heavily. Impacts that may not be considered significant for the general population may overlook potentially significant impacts on these populations without this special focus. (In the context of the United States, the populations which may be disproportionately affected are referred to as " environmental justice communities". Whether these impacts can be anticipated from proposed mining projects depends upon the area of influence of the impacts of the proposed project and the use of the affected resources by populations which may be disproportionately affected typically indigenous peoples, minority or low-income groups.

4.7 Cultural and Historic Resources

Impacts on cultural, ceremonial and historic resources include any direct or indirect alteration of archeological and historical sites or structures or traditional cultural lifestyles and resources associated with those lifestyles. Cultural and historic resources include: archeological sites, historic buildings, burial grounds, sacred or ceremonial sites, areas used for the collection of materials used in ceremonies or traditional lifestyles, and sites that are important because of their roles in traditional stories. Examples of adverse effects to cultural and historical resources from mining include:

- Damage and alteration
- Removal from historic location
- Introduction of visual or audible elements that diminish integrity
- Neglect that causes deterioration

4.8 Land Use

Mining may impact local land use. Clearly, land use on the mining site itself will be modified for the life of the mine, and in many cases, for years after mine closure. Some impacts may only occur during the life of the mine, and can be reestablished after mine closure, such as livestock grazing, wildlife habitat, hunting, and agriculture. However, in some areas of the mine (for instance on waste piles and in open-pit excavations) even some of these uses may not be reestablished for many years after mine closure. These impacts become long-term impacts. Other long-term impacts can include those associated with roads, rails and other ancillary facilities that may stay in place and be used after restoration.

Mining can impact land use on properties adjacent to the mine as well as properties through which mining roads, rails, or other conveyances may pass. Land use in these areas can be impacted by visibility, noise, odor, air pollution, and water contamination.

Mining can also result in indirect impacts on land use, caused by increased pressure on natural resources. A mining operation needs employees and those employees need support facilities, all of which in turn increase the population in the area, with associated increased pressures on natural resources and land uses in the vicinity of the mine. The development of new roads also may open up previously inaccessible areas to development.

4.9 Identifying Cumulative Impacts

Cumulative effects are those effects on the environment that result from the incremental effect of the action when added to other past, present, and reasonably foreseeable future actions regardless of what a project proponent undertakes. Cumulative effects can result from individually minor, but collectively significant actions, taking place over a period of time.

Mining projects can contribute to cumulative effects when their effects overlap with those of other activities in space, or time, or both. Effects can be either direct or indirect. Direct effects are those that occur in the same place and at the same time and are a direct result of the proposed action. For example, water flows downstream of a mining operation might be affected by reduced by increased water usage at the mine, in concert with reduced spillage at a dam and irrigation withdrawals. Indirect effects can occur at a distance from the proposed action, or the effects may appear some time after the proposed action occurs. For example, an upstream timber harvest area and upstream water sewage treatment plant may affect water quality, in addition to the effects on water quality from the proposed mine. A series of mining and hydropower projects on the same water body can have a significant effect on the quantity and flow of water downstream potentially contributing to increased risk of flooding, erosion and sedimentation, loss of fish habitat and the like.

4.9.1 Identifying resources that have potential for cumulative impacts

Resources which may require the analysis of cumulative effects described in Chapter F may be identified through the results of any scoping meetings, site visits, and public interest in a particular resource; and through consultation with the agencies and non-governmental organizations (NGOs) familiar with or responsible for those resources. Table E-6 provides a set of factors to consider in identifying potential cumulative impacts.

Additional guidance on defining cumulative analysis resources can be found in *Considering Cumulative Effects under the National Environmental Policy Act* (Council on Environmental Quality, 1997). This document is available on the web at http://ceq.eh.doe.gov/nepa/ccenepa/ccenepa An example of the affected environment, or a resource, where mining operations may cause a cumulative and additive impact would be groundwater usage. In the project area there already may exist wells that the mining project proposes to use, which are tapping the same aquifer already being used for irrigation, industrial, and municipal uses. Pumping of that same aquifer for mine dewatering, processing, and workforce use may produce a cumulative impact. These uses, when evaluated separately, may not produce a noticeable or measurable decline in the groundwater elevation. However, if these usages are modeled together with the estimated volumes per year of each use and over the time period of planned use, the model may show a cumulative impact of widespread and significant decline in groundwater elevation. A cumulative impact for groundwater, widespread and significant decline in water elevation, then may produce an impact to surface water elevation by lowering stream levels and base flows in nearby streams and springs if there is a hydrologic connection between the aquifer and streams or springs. Declines in groundwater elevations, causing declines in base flows in neighboring streams may produce an impact to habitat critical to fish and wildlife or vegetation, thereby impacting certain species of fish, wildlife and vegetation.

Examples of cumulative effects:

- incremental loss of wetlands
- degradation of rangeland from multiple grazing allotments and the invasion of exotic weeds
- population declines in nesting birds from multiple tree harvests within the same land unit
- increased regional acidic deposition from emissions and changing climate patterns
- blocking of fish passage by multiple hydropower dams and reservoirs in the same river basin
- cumulative commercial and residential development and highway construction associated with encroaching development outside of urban areas
- increased soil erosion and stream sedimentation from multiple logging operations in the same watershed
- change in neighborhood socio-cultural character resulting from ongoing local development including construction
- degraded recreational experience from overcrowding and reduced visibility

Table E-6. Identifying Potential Cumulative Effects Issues Related to a Proposed Action

1. What is the value of the affected resource or ecosystem? Is it:
   - protected by legislation or planning goals?
   - ecologically important?
   - culturally important?
   - economically important?
   - important to the well-being of a human community?

2. Is the proposed action one of several similar past, present, or future actions in the same geographic area?

3. Do other activities (whether governmental or private) in the region have environmental effects similar to those of the proposed action?

4. Will the proposed action (in combination with other planned activities) affect any natural resources; cultural resources; social or economic units; or ecosystems of regional, national, or global public concern? Examples: release of chlorofluorocarbons to the atmosphere; conversion of wetland habitat to farmland located in a migratory waterfowl flyway.

5. Have any recent or ongoing EIA analyses of similar actions or nearby actions identified important adverse or beneficial cumulative effect issues?

6. Has the impact been historically significant, such that the importance of the resource is defined by past loss, past gain, or investments to restore resources?

7. Might the proposed action involve any of the following cumulative effects issues?
   - long range transport of air pollutants resulting in ecosystem acidification or eutrophication
   - air emissions resulting in degradation of regional air quality
   - release of greenhouse gases resulting in climate modification
   - loading large water bodies or watersheds with discharges of sediment, thermal, and toxic pollutants
   - reduction or contamination of groundwater supplies
   - changes in hydrological regimes of major rivers or estuaries
   - long-term containment and disposal of hazardous wastes
   - mobilization of persistent or bioaccumulated substances through the food chain
   - decreases in the quantity and quality of soils
   - loss of natural habitats or historic character through residential, commercial, and industrial development
   - social, economic, or cultural effects on low-income or minority communities resulting from ongoing
   - development
   - habitat fragmentation from infrastructure construction or changes in land use
   - habitat degradation from grazing, timber harvesting, and other consumptive uses
   - disruption of migrating fish and wildlife populations
   - loss of biological diversity

Source: Edited from Table 2.1, Council on Environmental Quality, Considering Cumulative Effects under the NEPA Policy Act, January 1997

4.9.2 Geographic Scope of Cumulative Analysis

For each resource identified the EIA will need to identify the appropriate geographic and temporal scope of analysis for those resources. Without spatial boundaries (geographic), a cumulative effects assessment would be global, and while this may be appropriate for some issues such as global climate change, it is not appropriate for most other issues. The EIA should briefly describe how those resources might be cumulatively affected and explain the geographic scope of analysis.

To determine spatial boundaries, consideration should be given to the distance the effect can travel in the context of resource effects from other activities that might affect a wide area. Specifically, the EIA should:

- describe how the area(s) that may be affected by the proposed action (impact zone) was determined
- list the cumulative effects resources within that area that could be affected by the proposed action
- determine the geographic area outside of the impact zone that is occupied by those resources
- consider the management plans and jurisdictions of other agencies for the cumulatively affected resource

The EIA should:

- discuss the location of other mining projects and other major developmental activities within the area
- include a schematic diagram of these developments and/or list them in a table
- briefly describe how the proposed project interacts, affects, or is affected by, these other resource developments

The length of discussion should reflect the significance of the interaction. Details of the effects of these interactions should be included in the Environmental Effects section.

4.9.3 Regional, Sector or Strategic Assessment

Regional, sector, or strategic social and environmental assessment may be available to provide the additional perspective in addition to the social and environmental impact assessment. Regional assessment is conducted when a project or series of projects are expected to have a significant regional impact or influence regional development (e.g., an urban area, a watershed, or a coastal zone), and is also appropriate where the region of influence spans two or more countries or where impacts are likely to occur beyond the host country. Sector assessment is useful where several projects are proposed in the same or related sector (e.g., power, transport, or agriculture) in the same country, either by the client alone or by the client and others. Strategic assessment examines impacts and risks associated with a particular strategy, policy, plan, or program, often involving both the public and private sectors. Regional, sector, or strategic assessment may be necessary to evaluate and compare the impact of alternative development options, assess legal and institutional aspects relevant to the impacts and risks, and recommend broad measures for future social and environmental management. Particular attention is paid to potential cumulative impacts of multiple activities. These assessments are typically carried out by the public sector, though they may be called for in some complex and high risks private sector projects.

F. ASSESSING IMPACTS

1 OVERVIEW OF USING PREDICTION TOOLS AN EIA

Impact assessment employs predictive tools to determine the magnitude, duration, extent and significance of potential impacts on the natural and human environment.

Impact assessment for mining activities differs from impact assessment carried out for other activities because of the sheer extent and duration of mining activities and the fact that many of its impacts are irreversible. Therefore, it is important to get it right.

ASSESSING THE IMPACTS OF COMMERCIAL MINING

Impact assessment employs predictive tools to determine the magnitude, duration, extent and significance of potential impacts on the natural and human environment. These tools can be quantitative – as in the case of analytical or numeric air and water models, semi-quantitative based on the results of surveys used to evaluate socio-economic impacts, or qualitative based on professional judgment.

Metal Mines

For large scale metal mines, numeric and analytical models as well as semi-quantitative/ qualitative approaches are used to assess:

- The effects of pit dewatering on the water table.
- Solute transport of pollutants in surface and ground water.
- Extent of air pollution due to fugitive dust and emissions from vehicles.
- Potential for acid and non-acid mine drainage
- Soil loss
- Sediment transport
- Socio-economic impacts
- Noise impacts

Non-Metal Mines

Depending on the kind and size of operation, many approaches used for metal mines to assess impacts are relevant. Because many of these operations are in urban or near or within rivers emphasis is placed on:

- Air pollution modeling
- Surface water and sediment transport modeling
- Noise modeling
- Socio-economic impacts

1.1 Ground Rules

The EIA should assess as appropriate the direct, indirect and cumulative impacts for the proposed project including alternatives and for every phase of the project: exploration, site development, construction, operation, closure and post-closure.

Ground Rules for predicting impacts:

1. Greater detail and analysis should be included for those impacts that are potentially significant.
2. It will be important to identify uncertainties to lay the groundwork for decisions about the project, proposed mitigation, monitoring and contingency measures.
3. The assessment of impacts builds on and indeed depends on a complete and accurate description of the project, alternatives and the information on the environmental setting. The assessment may take into account proposed mitigation incorporated into the siting, design and processes and procedures, but to the extent that this is done in the assessment of impacts, those actions should be included as well in the Environmental Management Plan and/or section of the EIA which describes the commitments of the project manager to mitigation activities. In other words, you cannot assume for purposes of analysis that the impact is half of what it would otherwise be because of a control device and fail to include that control device in the mitigation that is committed to for the project. Control technologies proposed also are often part of the project alternatives addressed, which should balance cost against benefits.

4. Key assumptions should be explicit in the EIA. Because prediction is only as good as the assumptions and the appropriateness of the tools, all of this information should be explicitly spelled out in the EIA for the reviewer and decision maker. Although a range of predictive tools may be available; however, the user should justify and validate or qualify the tools and data used. There is a range of environmental features that may be unique to the project site which should also be considered. The tools selected should be justified and appropriate to the site location and situation.

5. Cumulative impacts should be considered.

To employ predictive tools it usually is necessary to calculate intermediary factors such as the resulting direct emissions or releases into the environment from a given set of activities, or, the area and type of land disturbance, number of employees that may be required during construction phases, and other factors. By applying these intermediary factors to what is known about the environmental setting, predictive tools provide quantitative and qualitative information on the impacts based upon known or anticipated relationships.

1.2 Geographic Boundaries for Assessment of Impacts

Determining the geographic boundaries and time periods depends on the characteristics of the resources affected, the magnitude and scale of the project's impacts, and the environmental setting. In practice, a combination of natural and institutional boundaries may be required to adequately consider both potential impacts and possible mitigation measures. Ultimately, the scope of the analysis will depend on an understanding of how the effects are occurring in the assessment area.

Development of process flow diagrams (PFDs) and associated plot plans is essential to understanding the "footprint" of a project, and potential impacts. Sources, pollutant transport mechanisms and potential impacts within the project boundary and within the area of influence can be more easily understood and addressed if the assessment starts with such graphic overviews of the project. Outputs of numerical predictive models can also be overlaid on plot plans and maps of surrounding areas.

Generally, the scope of analysis for assessing cumulative impacts will be broader than the scope of analysis used in assessing direct or indirect effects. To avoid extending data and analytical requirements beyond those relevant to decision making, a practical delineation of the spatial and temporal scales is needed. The selection of geographic boundaries and time period should be, whenever possible, based on the natural boundaries of resources of concern and the period of time that the proposed action's impacts may persist, even beyond the project life. The EIA document should delineate appropriate geographic areas including natural ecological boundaries, whenever possible, and should evaluate the time period of the project's effects.

Spatial and temporal boundaries should not be overly restricted in cumulative impact analysis. The EIA reviewer can determine an appropriate spatial scope of the cumulative impact analysis by considering how the resources are being affected. This determination involves two basic steps:

1. Identifying a geographic area that includes resources potentially affected by the proposed project and

2. Extending that area, when necessary, to include the same and other resources affected by the combined impacts of the project and other actions

In practice, the areas for several target species or components of the ecosystem can often be captured by a single eco-region or watershed. For example, an impact assessment for a forest plan modification may have to be expanded beyond its administrative forest management unit. Instead, the scope of the assessment might consider the entire watershed for the area covering portions of wilderness areas, national or state parks, other federal lands, and private holdings. Boundaries would be based on the resources of concern and the characteristics of the specific area to be assessed. EIA reviewers should recommend that the proper spatial scope of the analysis include geographic areas that sustain the resources of concern. Importantly, the geographical boundaries should not be extended to the point that the analysis becomes unwieldy and useless for decision-making. In many cases, the analysis should use an ecological region boundary that focuses on the natural units that constitute the resources of concern. The area of influence may differ among the resources being analyzed. Determining the temporal scope requires estimating the length of time the effects of the proposed action may last. More specifically, this length of time extends as long as the effects may singly, or in combination with other potential effects, be significant on the resources of concern. At the point where the contribution of effects of the action, or combination of all actions, to the cumulative impact is not significant the analysis should stop. Because the important factor in determining cumulative impact is the condition of the resource (i.e., to what extent it is degraded), analysis should extend until the resource has recovered from the impact of the proposed action.

1.3 Baseline

Impacts are always assessed against a baseline. The baseline is a "no action" baseline, in the absence of the proposed project, and considering other changes predicted to take place in the absence of the proposal. The baseline for assessing impacts is different from the existing environmental setting in that it does consider other changes that may occur in the future but independent of the project, e.g., other project start-ups, closures or major modifications. The geographic and political boundaries for assessing project impacts will depend upon the affected resource and the nature of the potential impacts and may also be influenced by the distances specified by the organization responsible for EIA review, likely specified in the Terms of Reference and/or EIA application form.

Section D, "ENVIRONMENTAL SETTING," goes into considerable detail on baseline data requirements. Information for these items is extremely important in assessing the environmental impacts of a mining project. By way of an example, a comparison of predicted and actual water quality at hardrock mines in the United States by Maest et al (2006) indicates that the reliability of predictions in Environmental Impact Statements is largely dependent on the quality of the baseline data. Failure to predict water quality problems, particularly acid rock drainage, was due to a lack of hydrologic and geologic characterization for both surface water and groundwater causing an overestimation of dilution and inaccurate determination of the size of design precipitation events. To make suitable predictions in terms of the impacts on air, noise levels, ecology, and potential land use, it is also important to have sufficient data.

1.4 Identifying and applying predictive techniques

Assessment of impacts is accomplished by using a variety of predictive techniques, with results compared to accepted criterion, to evaluate the significance of an impact. There are a range of predictive techniques that can be used including experts, extrapolation from past trends/statistical models, and modeling of the resource. This guideline identifies where it is imperative to use models for assessing impacts and if appropriate, which models should be used to predict impacts because of the specific nature of mining. This is elaborated on in Section 3.

1.5 Evaluation of the significance of the impacts

In assessing impacts of a mining operation to any resource, it is important to determine the magnitude and significance of the impact.

- If regulatory criteria exist (e.g., air quality criteria, water quality criteria, radiation exposure criteria), these can serve as benchmarks against which impacts can be measured. Exceeding the criteria would be considered significant. Impacts may or may not be considered significant if no exceedence occurred. Many of the CAFTA DR countries lack standards that might be used for criteria. This guideline provides a range of standards used internationally, and for a range of countries that may be used for this purpose in lieu of country standards in the absence of regulatory criteria. Information relating to this is presented on the CD-ROM, which has been provided with this guideline.

- If adequate data and analytical procedures are available, specific thresholds that indicate degradation of the resources of concern should be included in the EIA analysis. The thresholds should be practical, scientifically defensible, and fit the scale of the analysis. Thresholds may be set as specific numerical standards (e.g., dissolved oxygen content to assess water quality), qualitative standards that consider biological components of an ecosystem (e.g., riparian condition and presence of particular biophysical attributes), and/or desired management goals (e.g., open space or unaltered habitat). Thresholds should be represented by a measurement that can report the change in resource condition in meaningful units. This change is then evaluated in terms of both the total threshold beyond which the resource degrades to unacceptable levels and the incremental contribution of the proposed action to reaching that threshold. The measurement should be scientifically based.

- Establishing criteria for insignificant and significant impacts may also rely on professional judgment, but these should be well defined in the assessment. Criteria often need to be established separately for each resource. Some agencies have established significance criteria that are applied to all resource areas. Some examples include:

  - **Area of Influence:** This could be based on the area of disturbance, proximity to local communities, proximity to surface water bodies or other factors such as the estimated decline in the water table or the aerial extent of an air pollution plume based on model projections. In general, for mining operations, any impact that causes offsite damage is considered a serious impact. This could include flyrock that passes the permit/mine boundaries, or impacts on water wells or cultural resources outside the mine area. This could also include the entire length of roads used to transport material including their construction if needed.
  - **Percentage of Resource Affected:** This can include habitat, land use, and water resources.
  - **Persistence of Impacts:** Permanent or long-term changes are usually more significant than temporary ones. The ability of the resource to recover after the activities are complete is related to this effect.
  - **Sensitivity of Resources:** Impacts to sensitive resources are usually more significant than

impacts to those that are relatively resilient to impacts.

- **Status of Resources:** Impacts to rare or limited resources are usually considered more significant than impacts to common or abundant resources.
- **Regulatory Status:** Impacts to resources that are protected (e.g., endangered species, wetlands, air quality, cultural resources, water quality) typically are considered more significant than impacts to those without regulatory status. Note that many resources with regulatory status are rare or limited.
- **Societal Value:** Some resources have societal value, such as sacred sites, traditional subsistence resources, and recreational areas.

For some purposes qualitative assessment criteria may be used such as:

None: No discernable or measurable impacts.
Small: Environmental effects are at the lower limits of detection or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
Moderate: Environmental effects are sufficient to noticeably alter important attributes of the resource but not to destabilize them.
Large: Environmental effects are clearly noticeable and are sufficient to destabilize the resource.

For wildlife, a similar set of criteria was used by a USA regulatory authority, the Bureau of Land Management, in assessing the significance of impacts resulting from oil shale and tar sands mine development:

Small Impact: This is an impact that is limited to the immediate project area, affects a relatively small proportion of the local population (less than 10%), and does not result in a measurable change in carrying capacity or population size in the affected area.
Moderate Impact: This is an impact that extends beyond the immediate project area, affects an intermediate proportion of the local population (10 to 30%), and results in a measurable but moderate (not destabilizing) change in carrying capacity or population size in the affected area.
Large Impact: This is an impact that extends beyond the immediate project area, could affect more than 30% of a local population, and could result in a large, measurable, and destabilizing change in carrying capacity or population size in the affected area.

2 APPROACHES THAT CAN BE USED IN PREDICTING IMPACTS

Prediction of impacts due to mining on ecological, socioeconomic, cultural, land use, geologic, and visual resources is usually based on professional judgment as well as on existing literature, field studies, surveys, trend analysis or measured resource responses in other geographic areas. Accurate prediction is the key to determining the response to a mining operation, and may require professional judgment. Tools such as GIS and graphics generated from comprehensive databases are useful toward visualization and determination of the magnitude of potential impacts. However, to assess impacts to air and water resources as well as potential risks to humans and biota, analytical and numeric modeling approaches are used. The following presents a brief overview of how analytical methods can be used in assessing impacts to the air and water resources.

2.1 Air Resources

In evaluating the potential impacts of a mining operation to air quality, prediction should made to determine the extent to where the ambient air quality standards are not compromised. The predictions should identify the areas of maximum pollution impact and assess the likelihood of air pollution from the plant, dumps, materials handling facilities, vehicles or blasting and the impacts this could have on the potential impact sites. Although analytical approaches can be used, international experience indicates that numeric modeling is the most appropriate method to evaluate the impacts of a mining operation on air resources. Quantitative models can be used to calculate the dispersion of fugitive dust or other contaminants in air and to compare the results to numerical air quality standards. As a point of reference, international accepted standards for various pollutants are presented on the CD-ROM included with this guideline.

Initially, the Gaussian analytical model was developed in the 1930's http://en.wikipedia.org/wiki/Air_pollution_dispersion_terminology - cite_note-2 and still is the most commonly used model type. It assumes that the air pollutant dispersion has a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution. Gaussian models are most often used for predicting the dispersion of continuous, buoyant air pollution plumes originating from ground-level or elevated sources. Gaussian models may also be used for predicting the dispersion of non-continuous air pollution plumes (called puff models). The primary algorithm used in Gaussian modeling is the Generalized Dispersion Equation for A Continuous Point-Source Plume and can be found in Turner (1994). Over time, other numeric air dispersion models have been developed. Table F-1 presents a list of commonly used models. Most of these models are free and available on the US EPA website and can be down loaded following the links on the table.

Table F-1: Air Pollution Models

Model	Link	Description
AERMOD	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.
CALPUFF	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	A non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.
BLP	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	A Gaussian plume dispersion model designed to handle unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary line sources are important.
CALINE3	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	A steady-state Gaussian dispersion model designed to determine air pollution concentrations at receptor locations downwind of highways located in relatively uncomplicated terrain.
CAL3QHC/CAL3QHCR	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	CAL3QHC is a CALINE3 based CO model with queuing and hot spot calculations and with a traffic model to calculate delays and queues that occur at signalized intersections; CAL3QHCR is a more refined version based on CAL3QHC that requires local meteorological data.
CTDMPLUS	http://www.epa.gov/scram001/dispersion_prefrec.htm#rec	Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions.
ISC3	http://www.epa.gov/ttncatc1/cica/9904e.html (In Spanish)	The Industrial Source Complex Model (ISC3) is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial complex. ISC3 operates in both long-term and short-term modes.

Model	Link	Description
SCREEN3	http://www.epa.gov/ttncatc1/cica/9904e.html (in Spanish)	SCREEN3 is a single source Gaussian plume model which provides maximum ground-level concentrations for point, area, flare, and volume sources.
PCRAMMET	http://www.epa.gov/ttncatc1/cica/9904e.html (in Spanish)	PCRAMMET is a preprocessor for meteorological data that is used with the Industrial Source Complex 3 (ISC3) regulatory model and other EPA models.

Note: Other models used for vehicle emissions ,e.g. MODAL, and complex pollutant interactions and photochemical reactions.

If numerical modeling is used, it is recommended that model selection be based on:

- Off-the-shelf – The model would not require any development programming
- Easy to use - Containing a good pre-processor to make data input easy, and a good post-processor that allows output to be placed on maps or in understandable data tables
- Post-processing for presentations – Clear presentations are key to getting decision maker's attention
- Capable of being coupled to GIS – As mention earlier, GIS applications in mining are becoming more popular
- PC-based – The model should be able to run on IBM-compatible computers

It is important in the development of an EIA that models are used wisely and that the results are not accepted without strenuous review. Needless to say, the advantage of using models is that sensitivity analyses can be performed and "what-if" scenarios can be modeled to identify the nature and extent of impacts and identify which variables contribute the most uncertainty to the results. When limited baseline data are available or the exact nature of the mining operation is not known, impact determinations using models should be based on a number of assumptions. Each of the assumptions has some uncertainty associated with it. To compensate for these uncertainties, conservative assumptions are usually made to ensure that impacts are not underestimated. Even with conservative assumptions, impacts that are poorly understood (e.g., the response of resources to the environmental changes brought about by the project is not known) can be underestimated or improperly characterized. Conservative assumptions can result in greatly overestimating impacts and unnecessary costs for a project if mitigations are not properly directed and scaled to the impact.

Different countries may also require or accept certain models. It is imperative that such requirements or preferences be determined well in advance of performance of modeling. This will assure that adequate time is allowed to collect input data required by the model(s) and that results are accepted by organizations that the EIA.

2.2 Surface Water

When assessing surface water impacts, three overriding questions should be asked:

1. Will the mining project alter surface water flow in the catchment?
2. Will the mining project affect surface water quality in the catchment?
3. Is there a less damaging alternative?

If the answer to question #1 or #2 is yes, an effort should be made to determine the magnitude and nature of the impact. This includes but is not limited to:

- An estimate of all dewatering volumes and discharges of polluted water and the impact of these on the receiving water body

- Estimates should be made on the long and the short-term effects of diversions and water treatment facilities (impoundments) on the river or streams including its flood plain characteristics and its structural stability as well as affects on the water table
- Changes in quality and quantity of surface water in receiving streams
- Affects of flood characteristics of the watershed
- Estimates of sediment yield and potential impacts downstream This is particularly true for dredging operations during which extraction of sand and gravel in the river bed basically changes the regimen of the river or stream and unless controlled increases the suspended sediment loading in a stream.

Based on the results of these analyses, indicators of water quality and quantity should be used to set thresholds. For water quality, specific concentrations and levels of pH, nitrogen, phosphorous, turbidity, dissolved oxygen, and temperature can be used. Thresholds for a decline in water quality can take the form of size and amount of riparian buffer zones. Condition of riparian zones and changes in percent of buffer areas can indicate a decline in water quality due to soil erosion, sediment loading, and contaminant runoff. Numerical standards for dissolved oxygen and water temperature could be used to determine significance of impacts to coldwater fisheries. Narrative standards of stream condition would be used to determine thresholds for successful fish spawning or other defined uses. This information can also be used to determine potential impacts to downstream water supplies.

The assessment of impacts to surface water can be done either analytically or using numerical models. Analytical approaches include the development of water balance or using accepted formulas. More sophisticated numerical models can also be used within the constraints as outlined above for air pollution models.

CYANIDE

Predicting the potential impacts of a cyanide release to the environment involves complex water balance, mass loading studies, solute transport models, and air dispersion modeling. The determination of the best analytical method(s) that should be used is dependent on the design of the process (heap or batch) and the baseline conditions of the site in terms of geology, hydrogeology, surface water, and climatic condition. To help ensure that cyanide is managed properly to reduce potential impacts, a voluntary organization entitled the "**International Cyanide Management Code For The Manufacture, Transport and Use of Cyanide In The Production of Gold**" has developed a "Code of Practice." Information on this code can be found at http://www.cyanidecode.org.

Water Balance: An accurate understanding of the site water balance is necessary to successfully manage storm runoff, stream flows, and point and non-point source pollutant discharges from a mine site. The water balance for typical mining operations will address natural system and process waters. Natural system waters are fed to the site through rainfall, seeps and springs, groundwater and surface water. Water is lost from the system through surface water runoff, infiltration, and evaporation. Each of these factors is quite variable and difficult to predict. Process water on the other hand is reasonably constant and predictable. For hard rock mines, process system waters include make-up water, chemical reagent water, operational start-up water, water stored in waste piles, water retained in tailings, and mine waters (miscellaneous inflows). An overall site water balance superimposes these two systems to account for all waters at the site. A mine site water balance should recognize that water may be stored in various facilities during mine operations. For example, in a heap leach operation, water is stored in the process ponds, the heap leach, and the ore itself. Water is lost from the system water through evaporation; facilities such as spray systems and process ponds may result in significant evaporative losses. Natural precipitation that falls on facilities such as heap leach pads or process ponds increases the total amount of water in the system as do any liquid chemical additives that are used in the processing of ore. During temporary or permanent shutdowns, water collected in the facilities, including the ore itself, will drain and should be stored in the process ponds. In heap leach operations, the ore should be rinsed with water or chemical solutions to neutralize the environmental impacts of chemical reagents remaining in the ore. For a tailings basin/milling type operation, inflows include tailings water, runoff, and other types of waters such as mine water that are often co-managed with tailings. Losses include water retained in tailings, seepage (to groundwater beneath the tailings dam), pond evaporation, and recirculation waters. Spreadsheets are a common way to evaluate water balances on the site. What-if scenarios can be easily run based on probabilities of rainfall events occurring and changeable weather patterns such as those associated with climate change.

Analytical Approach: The following methods are used to determine changes in runoff characteristics and sediment yield due to mining. The method described by the SCS (1972) is the most common technique for estimating the volume of excess precipitation (i.e., runoff) after losses to infiltration and surface storage. The method involves estimating soil-types within a watershed and applying an appropriate runoff curve number to calculate the volume of excess precipitation for that soil and vegetation cover type. This method was developed for agricultural uses and can be used for mine properties if enough data are available to estimate curve numbers. Curve numbers are approximate values that do not adequately distinguish the hydrologic conditions that occur on different range and forest sites and across different land uses for these sites.

A more appropriate technique for developing and analyzing runoff at mine sites utilizes the unit hydrograph approach. A unit hydrograph is a hydrograph of runoff resulting from a unit of rainfall excess that is distributed uniformly over a watershed or sub-basin in a specified duration of time (Barfield et al., 1981). Unit hydrographs are used to represent the runoff characteristics for particular basins. They are identified by the duration of precipitation excess that was used to generate them; for example, a 1-hour or a 20-minute unit hydrograph. The duration of excess precipitation, calculated from actual precipitation events or from design storms, is applied to a unit hydrograph to produce a runoff hydrograph representing a storm of that duration. For example, 2 hours of precipitation excess could be applied to a 2-hour unit hydrograph to produce an actual runoff hydrograph. This runoff volume can be used as input to route flows down a channel and through an outlet or for direct input to the design of a structure.

Common methods to develop and use unit hydrographs are described by Snyder (1938), Clark (1945), and SCS (1972). Unit hydrographs or average hydrographs can also be developed from actual stream flow runoff records for basins or sub-basins. The SCS (1972) method is perhaps the most commonly applied method to develop unit hydrographs and produce runoff hydrographs. The SCS (1972) publication recommended using the SCS Type I, Type I-A or Type II curves for creating design storms and using the curve number method to determine precipitation excess. Most mine site designs will require use of more rigorous techniques for determining precipitation excess than those proposed by SCS (1972).

Another technique to determine runoff from basins or sub-basins is the Kinematic Wave Method. This method applies the kinematic wave interpretation of the equations for motion (Linsley et al., 1975) to provide estimates of runoff from basins. If applied correctly, the method can provide more accurate estimates of runoff than many of the unit hydrograph procedures described above, depending on the data available for the site. The method, however, requires detailed site knowledge and the use of several assumptions and good professional judgment in its application.

As previously indicated, only peak runoff rates for a given frequency of occurrence are used to design many smaller hydrologic facilities, such as conveyance features, road culverts, or diversion ditches around a mine operation. The hydrograph methods listed above can be used to obtain peak runoff rates, but other methods are often employed to provide quick, simple estimates of these values.

A common method to estimate peak runoff rates is the Rational Method. This method uses a formula to estimate peak runoff from a basin or watershed:

$$Q = C\, i\, A \quad \text{(A-1)}$$

where Q is the peak runoff rate as cubic feet per second, C is the run-off coefficient, *i* is the rainfall intensity as inches per hour, and A is the drainage area of the basin expressed as acres.

A comprehensive description of the method is given by the Water Pollution Control Federation (1969). The coefficient C is termed the runoff coefficient and is designed to represent factors such as interception, infiltration, surface detention, and antecedent soil moisture conditions. Use of a single coefficient to represent all of these dynamic and interrelated processes produces a result that can only be used as an approximation. Importantly, the method makes several inappropriate assumptions that do not apply to large basins or watersheds, including: (1) rainfall occurs uniformly over a drainage area, (2) the peak rate of runoff can be determined by averaging rainfall intensity over a time period equal to the time of concentration (t_c), where t_c is the time required for precipitation excess from the most remote point of the watershed to contribute to runoff at the measured point, and (3) the frequency of runoff is the same as the frequency of the rainfall used in the equation (i.e., no consideration is made for storage considerations or flow routing through a watershed) (Barfield et al., 1981). A detailed discussion of the potential problems and assumptions made by using this method has been outlined by McPherson (1969).

Other methods commonly used to estimate peak runoff are the SCS TR-20 (SCS, 1972) and SCS TR-55 methods (SCS, 1975). Like the Rational Method, these techniques are commonly used because of their simplicity. The SCS TR-55 method was primarily derived for use in urban situations and for the design of small detention basins. A major assumption of the method is that only runoff curve numbers are used to calculate excess precipitation. In effect, the watershed or sub-basin is represented by a uniform land use, soil type, and cover, which generally may not be true for most watersheds or sub-basins.

The Rational Method and the SCS methods generally lack the level of accuracy required to design most structures and compute a water balance at mine sites. This is because they employ a number of assumptions that are not well suited to large watersheds with variable conditions. However, these methods are commonly used because they are simple to apply and both Barfield et al. (1981) and Van Zyl et al. (1988) suggest that they are suitable for the design of small road culverts or non-critical catchments at mines. Van Zyl et al. (1988) suggested that the Rational Method can be used to design catchments of less than 5 to 10 acres. It is important that the design engineer and the hydrologist exercise good professional judgment when choosing a method for determining runoff as discussed above. Techniques should be sufficiently robust to match the particular design criteria. It is particularly important that critical structures not be designed using runoff input estimates made by extrapolating an approximation, such as that produced by the Rational Method, to areas or situations where it is not appropriate. Robust methods that employ a site specific unit hydrograph or the Kinematic Wave Method will produce more accurate hydrological designs, but will take more time.

As for water quality, baseline studies as described in Section D (Environmental Setting) determining the potential acid rock drainage and metal release can be used to make predictions on water quality characteristics from operations. For potential sedimentation, the rill, interiill, erosion, and sedimentation can be estimated analytically using Revised Universal Soil Loss equation (RUSLE) developed by the US Soil conservation Service. The use of this method is described in detail on the CD-ROM presented with this guideline.

SOIL LOSS

Predicting soil loss and sediment due to rainfall erosion is an important aspect in accessing the impacts of mining.

The Revised Universal Soil Loss Equation (RUSLE) is an empirical equation developed by the U.S. Department of Agriculture (USDA, 1997) that predicts annual erosion (tons/acre/yr) resulting from sheet and rill erosion in croplands. The RUSLE employs a series of factors, each quantifying one or more of the important soil loss processes and their interactions, combined to yield an overall estimate of soil loss. The equation is (USDA, 1997):

$$A = R * K * (LS) * C * P$$

where

- *A* = Annual soil loss (tons/acre) resulting from sheet and rill erosion;
- *R* = Rainfall-runoff erosivity factor measuring the effect of rainfall on erosion. The R factor is computed using the rainfall energy and the maximum 30 minutes intensity (EI30);
- *K* = Soil erodibility factor measuring the resistance of the soil to detachment and transportation by raindrop impact and surface runoff. Soil erodibility is a function of the inherent soil properties, including organic matter content, particle size, permeability, etc. In the USDA soils data sets, two K factors are given, Kw and Kf. Soil erodibility factors (Kw) and (Kf) quantify soil detachment by runoff and raindrop impact. These erodibility factors are indexes used to predict the long-term average soil loss, from sheet and rill erosion under crop systems and conservation techniques. Factor Kw applies to the whole soil, and Kf applies only the fine-earth fraction, which is the <2.0 mm fraction (USDA, 1997).
- *L* = Slope length factor accounting for the effects of slope length on the rate of erosion;
- *S* = Slope steepness factor accounting for the effects of slope angle on erosion rates.
- *C* = Cover management factor accounting for the influence of soil and cover management, such as tillage practices, cropping types, crop rotation, fallow, etc., on soil erosion rates. The C-factor is derived from land-use/land-cover types.
- *P* = Erosion control factor accounting for the influence of support practices such as contouring, strip cropping, terracing, etc.

Numeric Models. There are several numeric and analytical computer models that are available both in the public domain and commercially that can be used to estimate impacts to surface water from mining operations. These models have been used to assess impacts of mining to aquatic biology based on changes to chemistry, environmental effects of trace metal loading, contaminant transport, sedimentation and deposition, changes to flood plains, flooding characteristic, and others. Table F-2 presents a list of models that are commonly used. Most of these models are available for down load on the web pages indicated on the table.

Table F-2: Surface Water Computer Models

Model	Link	Description
EXAMS	www.epa.gov/ceampubl/swater/exams	Aquatic biology, assessment, biology, chemistry, compliance, environmental effects, metals, NPS related, permits, pesticides, point source(s), rivers, streams, surface water, test/analysis
HSCTM2D	www.epa.gov/ceampubl/swater/hsctm2d	Hydrology, sediment, contaminant, transport, finite element model, river, estuary
HSPF	www.epa.gov/ceampubl/swater/hspf	Assessment, biology, compliance, deposition, discharge, environmental effects, estuaries, hydrology, lakes, metals, monitoring, NPS related, NPDES, nutrients, permits, pesticides, point source(s), rivers, sediment, streams, surface water, test/analysis, TMDL related, toxicity
HSPF Toolkit	www.epa.gov/athens/research/modeling/ftable	Assessment, compliance, discharge, environmental effects, hydrology, permits, rivers, sediment, streams, surface water, TMDL related, toxicity
PRZM3	www.epa.gov/ceampubl/gwater/przm3	Assessment, discharge, environmental effects, hydrology, land use management, metals, pesticides, surface water, test/analysis
QUAL2K	www.epa.gov/athens/wwqtsc/html/qual2k.html	Aquatic biology, assessment, compliance, discharge, environmental effects, hydrology, NPS related, point source(s), surface water, test/analysis, TMDL related
RUSLE2	www.ars.gov/research/docs/htm?docid=6010	Rill, interrill, erosion, sediment, overland flow, climate, soil, topography, land use
SERAFM	www.epa.gov/ceampubl/swater/serafm	Exposure, assessment, mercury, hg, surface water, pond, stream, river
Visual Plumes	www.epa.gov/ceampubl/swater/vplume	Surface, water, jet, plume, model, quality, contaminant, TMDL
WASP	www.epa.gov/athens/wwqtsc/html/wasp.html	Aquatic biology, assessment, compliance, discharge, environmental effects, hydrology, metals, NPS related, point source(s), surface water, test/analysis, TMDL related
HEC-RAS	http://www.hec.usace.army.mil/software	HEC-RAS is a computer program models the hydraulics of water flow through natural rivers and other channels. The program is one-dimensional, meaning that there is no direct modeling of the hydraulic effect of cross section shape changes, bends, and other two- and three-dimensional aspects of flow.
SMS (Surface Water Modeling System)	www.ems-i.com. (available in Spanish)	The Surface Water Modeling System (SMS) is a comprehensive environment for one-, two-, and three-dimensional hydrodynamic modeling. A pre- and post-processor for surface water modeling and design, SMS includes 2D finite element, 2D finite difference, 3D finite element and 1D backwater modeling tools. The model allows for flood analysis, wave analysis, and hurricane analysis. SMS also includes a generic model interface, which can be used to support other models which have not been officially incorporated into the system.
Watershed Modeling Software (WMS)	www.ems-i.com.(available in Spanish)	The Watershed Modeling System software is a comprehensive graphical modeling environment for all phases of watershed hydrology and hydraulics. The WMS software includes powerful tools to automate modeling processes such as automated basin delineation, geometric parameter calculations, GIS overlay computations (CN, rainfall depth, roughness coefficients, etc.), cross-section extraction from terrain data, and other. Hydraulic models supported in the WMS software include HEC-RAS and CE QUAL W2.
BASINS	**http://water.epa.gov/scitech/datait/models/basins/index.cfm**	The Watershed Model System software is comprehensive for both point and non-point sources. a multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package

2.3 Groundwater

As described in Section D (Environmental Setting), most mine sites are located in regions with complex hydrogeologic conditions. A thorough understanding of the site hydrogeology is required to adequately characterize and evaluate potential impacts. Aquifer pump tests and drawdown tests of wells need to be conducted under steady-state or transient conditions to determine aquifer characteristics. If possible, it is important that these tests be performed at the pumping rates that would be used by a mining operation and for durations adequate to determine regional impacts from drawdown and potential changes in flow direction. These tests require prior installation of an appropriate network of observation wells. Transmissivities, storage coefficients and vertical and horizontal hydraulic conductivities can be calculated from properly designed pump tests. These measurements are necessary to determine the volume and rate of groundwater discharge expected during mining operations and to evaluate environmental impacts. Tests should be performed for all aquifers that could be affected by the mining operation at a mine site to ensure adequate characterization of the relationships between hydrostratigraphic units (US EPA, 2003).

Characterization studies should define the relationships between groundwater and surface water, including identifying springs and seeps. Significant sources or sinks to the surface water system also need to be identified. Hydrogeological characterizations should include geologic descriptions of the site and the region. Descriptions of rock types, intensity and depth of weathering, and the abundance and orientation of faults, fractures, and joints provide a basis for impact analysis and monitoring. Although difficult to evaluate, the hydrological effects of fractures, joints, and faults are especially important to distinguish. Water moves more easily through faults, fractures and dissolution zones, collectively termed secondary permeability, than through rock matrices. Secondary permeability can present significant problems for mining facility designs because it can result in a greater amount of groundwater discharge than originally predicted. For example, faults that juxtapose rocks with greatly different hydrogeological properties can cause abrupt changes in flow characteristics that need to be incorporated into facility designs.

As with air and surface water resources, analytical and numerical approaches can be used in assessing groundwater.

Analytical Approach. A common method to analyze groundwater in relation to a mine relies on a simple analytical solution in which the mine pit is approximated as a well. This method uses the constant-head Jacob-Lowman (1952) equation to calculate flow rates. Although not as sophisticated as a numerical (modeling) solution, this method gives a good approximation of the rate of water inflow to a proposed mine. It generally yields a conservative overestimate of the pumping rates required to dewater a mine (Hanna et al., 1994). A second method uses the technique of interfering wells, where each drift face of the proposed mine is considered to be a well. The cumulative production of the simulated wells is used to estimate the total influx into the mine and the extent of drawdown. In addition, an understanding of groundwater can be gained by developing a water balance for the site as described above. Finally, implications of the effects of groundwater quality can be gained based on field studies as described in Section D (Environmental Setting) using methods such as acid rock drainage and leaching tests.

Numerical Approach: The use of computer models has increased the accuracy of hydrogeological analyses and impact predictions and speeded solution of the complex mathematical relations through use of numerical solution methods. However, computer modeling has not changed the fundamental analytical equations used to characterize aquifers and determine groundwater quantities. Models are used to determine drawdown in the aquifer, contaminate transport, final pit lake water quality, and other factors. Table F-3 presents a brief description of groundwater models used to assess impacts of mining that are available through the public domain and commercially. More detailed description of these modes is given on the CD-ROM included with this guideline.

Table F-3: Groundwater and Geochemical Models

Model	Link	Description
MODFLOW	http://water.usgs.gov/software/lists/groundwater	MODFLOW is a finite-difference code developed by the United States Geological Survey (McDonald and Harbaugh, 1988). MODFLOW is a widely accepted numerical flow modeling code and has been used around the world to evaluate the impacts of mining. MODFLOW translates conceptual model(s) of the site into numerical models using discretization of space and time. Discretization of the spatial domain is done by constructing a grid designating cells of specified width, length, and thickness.
MT3D	http://water.usgs.gov/software/lists/groundwater	MT3D is a solute transport code also linked to the MODFLOW base model. The flow domain using MODFLOW is linked to MT3D, which then simulates contaminant transport using dispersion and chemical reactions.
Visual MODFLOW	www.visual-modflow.com. (available in Spanish)	Allows for applications in 3D groundwater flow and contaminant transport modeling utilizing an easy to use graphical user interface. Information is available for this package through Scientific Software Group.
GW Vistas	www.esinternational.com/groundwater-vistas.html (classes are available in Spanish)	This software is for 3D groundwater flow and contaminant transport modeling, calibration and optimization using the MODFLOW suite of codes. The advanced version of Groundwater Vistas provides the ideal groundwater risk assessment tool. Information of this software is available through ESI Lt.
GMS (Groundwater Modeling *System)* **-**	www.ems-i.com	GMS provides software tools for every phase of a groundwater simulation including site characterization, model development, calibration, post-processing, and visualization. GMS supports both finite-difference and finite-element models in 2D and 3D including MODFLOW 2000, MODPATH, MT3DMS/RT3D, SEAM3D, ART3D, UTCHEM, FEMWATER, PEST, UCODE, MODAEM and SEEP2D. Information is available through Environmental Monitoring Systems, Inc.
PHEEQE	http://toxics.usgs.gov/highlights/treatise_contributions.html	PHREEQE is a USGS computer program designed to model geochemical reactions. Based on an ion pairing aqueous model, PHREEQE can calculate pH, redox potential, and mass transfer as a function of the reaction process. The composition of solutions in equilibrium with multiple phases can also be calculated in PHREEQE. The aqueous model, including elements, aqueous species, and mineral phases is exterior to the computer code and is completely user-definable.
PYROX	http://www.science.uwaterloo.ca/research/ggr/ReactiveTransportModelling/PYROX/PYROX.html	PYROX is a numerical model that simulates one-dimensional, kinetically controlled diffusion of oxygen into the vadose zone of mine tailings and the subsequent oxidation of sulfide minerals, such as pyrite.
HYDROGEOCHEM	http://www.scisoftware.com/products/hydrogeochem_overview/hydrogeochem_overview.html	**HYDROGEOCHEM** is a coupled model of hydrologic transport and geochemical reaction in saturated-unsaturated media media.

2.4 Solid Waste

The principal solid wastes from mining are waste rock and tailings. The environmental impacts from these two wastes are principally impacts to surface and groundwater, and possibly to air. See those subsections on how to model those impacts.

2.5 Noise and Vibration

According to the U.S. Occupational Safety and Healthy Administration OSHA (2006) exposure to high levels of noise for long durations may lead to hearing loss, create physical and psychological stress, reduce productivity, interfere with communication, and contribute to accidents and injuries by making it difficult to hear warning signals. Noise can also adversely affect wildlife. To analyze noise from a mining site, baseline monitoring and operational monitoring is necessary. This information can be analyzed using empirical or numerical modeling technique. Point source propagation can be analyzed using basic analytical equations; however, numerical modeling techniques have been developed for multi-sources. The results of the models are then compared to the appropriate standards. For instance, the maximum permissible occupational noise exposure limit is in the range of 90-85 dB(A) L_{eq} for 8 hour per day (40 hour per week). The A-weighted decibel scale approximates the sensitivity of the human ear to various frequencies from 32 to 20,000 Hertz (Hz).

Most advanced models provide graphic outputs of noise impacts (isophons), which can then be overlaid on maps of critical receptors. Noise standards are typically expressed as dB(A); however, it is advisable to produce impacts based on octave bands as well, as dB(A) are based on a weighted summation of all bands, and knowledge of the octave band analysis for specific sources is useful in devising the proper noise control strategy. Octave band sound power level data are typically available from manufacturers of most power plant equipment, e.g., turbines (gas, oil, steam, water and wind), generators, fans and blowers, and transformers.

Just as there are many types and sources of noise, there are many noise models. The most broadly applicable noise model is the Computer Aided Noise Abatement (CadnaA) model. http://www.datakustik.com/en/products/cadnaa. There are also simpler models based on the sound pressure levels (SPL) measured at known distances and at known directions from a noise source, with subsequent calculation of attenuation as a function of distance from the noise source. Traffic-specific models are also available, for example the US Federal Highway Administration (FHWA) Traffic Noise Model (TNM) http://www.fhwa.dot.gov/environment/noise/tnm/index.htm.

2.6 Soils and Geology

Evaluation of impacts due to mining on soils and geology is usually based on professional judgment as well as on existing literature, field studies, surveys, trend analysis or measured resource responses in other geographic areas. Tools such as GIS and graphics generated from comprehensive databases are useful toward visualization and determination of the magnitude of potential impacts.

Soil: For soils, it is important to understand the potential for soil loss due to wind and water erosion as well as the potential for loss of productivity. For wind erosion, the equation (WEQ) expressed in function form is:

E = f (I, K, C, L, V)

Where: E is the potential average annual soil loss, I is the soil erodibility index, K is the soil ridge roughness factor, C is the climate factor, L is unsheltered distance across a field, and V is the equivalent vegetative cover (NRCS-ARC, undated).

Because field erodibility varies with field conditions, a procedure to solve WEQ for periods of less than one year was devised. In this procedure, a series of factor values are selected to describe successive management periods in which both management factors and vegetative covers are nearly constant. Erosive wind energy distribution is used to derive a weighted soil loss for each period. Soil losses for the management periods over a year are added to estimate annual erosion. Soil loss from the periods also can be added for a multi-year rotation, and the loss divided by the number of years to obtain an average annual estimate.

The US Natural Resources Conservation Service has also developed the Wind Erosion Prediction System (WEPS), which is designed to be a replacement for WEQ. Unlike WEQ, WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, and erosion. It is a user friendly program that has the capability of simulating spatial and temporal variability of field conditions and soil loss/deposition within a field. WEPS can also simulate complex field shapes, barriers not on the field boundaries, and complex topographies. The saltation, creep, suspension, and PM10 components of eroding materials can also be reported separately by direction in WEPS. WEPS is designed to be used under a wide range of conditions in the U.S. and easily adapted to other parts of the world. For soil loss due to erosion due to water, estimation can be done using RUSLE described above.

Geochemistry: Studies for the EIA should be concerned with chemical elements and gases in the mining environment and their sources, dispersion and distribution; chemical forms and pathways into water, agricultural crops and animals; and their possible impacts to plants, animals and humans. Geochemical data may be used to identify and locate sources of contaminants to the environment from mining and past and current industrial activities and modeled to predict impacts. Geochemical data

ACID ROCK DRAINAGE

Predicting the impact of acid rock drainage involves leaching and analyzing samples and using field studies and complex solute transport and hydrochemical modeling (Tables H-2 and H-1). The development of such a program is described in detail in Chapter 5 of the GARD Guide (INAP, 2009), which can be found on the CD-ROM made available with this guideline.

In general terms, hydrogeochemical modeling is conducted using site-specific information to the maximum extent possible. This hydrogeochemical modeling results in prediction of contaminant concentrations at the point of discharge and is combined with groundwater solute transport modeling to determine concentrations at a number of predetermined locations (e.g., compliance points) or receptors, which are in turn compared to appropriate standards. Through the use of multiple input values, sensitivity analyses, and “what-if” scenarios, a range of outcomes can be generated, bracketing the likely extent of water quality compositions and potential impacts.

If predicted concentrations meet standards, additional mitigation measures will likely not be required. If, however, predicted concentrations exceed standards, mitigation measures will be necessary and their effectiveness should be evaluated using predictive modeling and active monitoring during and after mine operation.

may be used to predict contaminant bioavailablity. To determine the source and extent of the impact, geochemical mapping of soils, streams, aquifers, and agricultural products may be performed. It is important to inventory possible contaminants and study the mechanisms of mobilization.

Geochemical studies would consider mine rock chemistry and minor and trace element geochemistry, mine tailings, waste streams, dust from processes such as smelters and in pit crushers, and water interactions. It is important to study the mechanisms of mobilization of toxic metals. Models that may be used for analysis are listed in Tables G-1, G-2, and G-3.

Geology : Toward the evaluation of potential impacts to geologic resources it important to have a thorough understanding of the geologic hazards that are or could be at the site. These include:

Landslide hazards: Types of movements and depths, such as shallow or deep-seated, translational or rotational landslides, slumps, debris flows, earth flows, mass wasting, etc. It is important that the mining does not increase the potential the hazards on and off site. Analytical and numerical approaches should be used to analyze this potential problem.

Seismic hazard: Potential for strong ground shaking, surface rupture, fault creep, and/or liquefaction. Deterministic seismic hazard analysis methods should be used to estimate most expected seismic hazards.

Volcanic hazards: Potential for molten rock, rock fragments being propelled great distances, dust, gases, ashfall, fumeroles, landslides and mudflows. Potential for volcanic activity in the area should be assessed by a literature search.

Other geologic hazards (e.g., subsidence, rock fall): Hazard areas may have been identified in the process of developing local critical or sensitive area ordinances, and the most current information should be obtained. In some localities, hazard areas are not delineated on maps, but are defined in terms of landscape characteristics (e.g., slope, geologic unit, field indicators); in these instances, hazard areas should be mapped by identifying where the defining characteristics apply to the project area.

Economic Resources/mineral hazards: It is important potential resources are not excluded due to improper mining techniques, placement of facilities, or due to landslides caused by the mining operation.

2.7 Biologic Resources (Wildlife, Vegetation and Habitat)

As with soils and geology, biological impact assessments are based on studies, literature review and professional judgment. As described in Section D (Environmental Setting), baseline studies generally include listing of plants and animals present in core and buffer areas of the proposed project site. The identified species are then checked for their status according to the IUCN list of threat categories: endemic, endangered, vulnerable, rare, indeterminate and insufficiently known. In certain cases it is also considered desirable to conduct vegetation analysis using standard phytosociological methods. Frequency, density, dominance, importance value index and life form are the most commonly used vegetation study parameters. Computations of dominance indices provide information about the structure and stability of the vegetation. In case of aquatic ecosystems the measurement of primary productivity is also included in EIA. Vicinity of the site to protected areas and forests and existence of wildlife corridors, etc., are also recorded. Data on these parameters provide a broad understanding of the status of the vegetation and wildlife of the area.

Though desirable, diversity of habitats, ecosystems, distribution of species in various trophic levels, regeneration status of trees, viability of populations, and identification of keystone species are not studied in most EIAs. These parameters may provide vital clues for assessment of the value of the ecosystem to be modified after the activity is put in place. The functional attributes of the ecosystems, such as rates of primary productivity, respiration, export and import of materials, nutrient turn over rates, ratio of productivity and biomass, pyramids of biomass, energy, population, etc., are also not included in most EIAs. Another generally ignored but quite important aspect of EIA is extent of dependency of the local people on the bioresources of the project site, such as collection of firewood, non-wood forest products (NWFPs), medicinal plants, etc.

Assessment of the impacts of policy changes and legislation often needs a different methodology of data collection and interpretation as their impacts are generally on a much larger geographical area. Remote sensing and GIS technique can be more useful in assessment of policy impacts. Baseline data on the biological components likely to be impacted by the policy change can be compared with the same set of data collected on later dates. Satellite imageries can come in handy for such works. In this case interviews with knowledgeable persons and group discussions may also help in finding out the impact on biodiversity of the region, particularly forest area and status and abundance of wildlife. Similar to policy changes, changes in tax regime, incentives for export and promotion of commercial farming, etc., also deserve to be included in EIA. Exemption of EIA based on size of the activity of the project needs to be reviewed particularly when several small units are established in a compact area.

2.8 Socioeconomics

When an activity, such as mining, is expected to accelerate social change at the local level, it is necessary to have detailed (sometimes household level) socio-economic and cultural data from the directly affected communities for the baseline, and to develop trend data to assess whether the potential mining impacts may continue or alter those trends in a significant way.

Social impacts cannot usually be assessed through secondary data on infrastructure and social services. The results from detailed family level surveys, focus group discussions and key informant interviews, participant observation, stakeholder consultations, secondary data, and other direct data collection methods should be analyzed carefully (Joyce, 2001).

As data are collected, trends based on gender, age groups, economic status, and proximity to the project should be analyzed. This analysis can be accomplished using statistical models or, as what has been found more recently to be effective, the use of Geographical Information Systems (GIS). According to Joyce et al (2001), the problem with using a strictly qualitative approach has issues:

- Greater difficulty of predicting social behavior and response as compared to impacts on the biophysical elements, such as water or animals
- The fact that social impacts are as much to do with the perceptions people or groups have about an activity as they are to do with the actual facts and substantive reality of a situation

- The fabric of social interactions and social well-being (today being recognized and labeled as "social capital") which are in the end where many social impacts take place, can only be measured or evaluated through qualitative and participatory processes

As the causation gets more distant, it is less clear how directly responsible a given project or activity is for that impact and its mitigation, and less clear how effective mitigation measures taken by one player would be (Joyce, et. al. 2001).

Again, according to Joyce et al (2001), the measure of significance is the most difficult/critical part of socioeconomic impact assessment. Impacts should be described in terms of the level of intensity of an impact, the directionality (positive or negative), the duration, and its geographic extension. Significance is necessarily defined using professional judgment. Towards this end, categories of impacts are defined and a determination can be made as to what constitutes a short, medium and long term impact, and the reasons for the designation. This is where participation by locals becomes important in determining what is significant to them. Based on the significance of the impact(s) conclusions can be drawn and mitigation measures can be designed.

Other socioeconomic impacts that should be assessed include:

Land use - A mining project, whether a small sand and gravel pit or a large open pit mine, if not restored properly can abruptly change the land use of an area forever. To understand the impacts of mining on land use, it is important to be able to visualize and calculate potential changes that may occur. This can be done by developing maps that show pre-mining, mining, and post-mining land use. In many countries, geographic information system (GIS) is used extensively for this purpose. GIS captures, stores, analyzes, manages, and presents data that is linked to location. GIS applications are tools that allow users to create interactive queries (user created searches), analyze spatial information, edit data, maps, and present the results of all these operations. A GIS includes mapping software and its application with remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and other tools.

Population and Housing - The key to understanding the potential impact to the local population and housing is having a good understanding of the work force required for the operation. Simple calculations can then be made to determine changes in demographics over the life of the mine.

Infrastructure Capacity - Simple calculations can be done to compare demands on roads, hospitals, wastewater treatment, water supply and waste management against capacity. However, these calculations should take into account direct demands from the project for every phase of the project including construction, operation and closure, as well as demands from anticipated induced growth as an indirect impact of the proposed mine and demands into the future in the absence of the project.

Employment – Having a good understanding of the work force required for each phase of mining is required to determine what additional labor may be required for schools, hospitals, support industries, etc.

Transportation – Transportation studies are required to determine impacts on traffic and roads due to commuting, the hauling of materials to and from the mine, and indirect impacts such as population growth.

2.9 Cultural and Historical

Effects are usually defined as direct or indirect alterations to characteristics of an historical or archeological site or cultural resource. Effects are adverse when the integrity is affected or the quality diminished. For the impact evaluation of cultural resources, information may be obtained during the scoping and public process, by interviewing community leaders and indigenous populations, and by conducting literature review. Impacts to historical and archeological sites and cultural resources are evaluated with respect to their magnitude and significance according to Section 3.2 of Section G. For cultural resources, it is important to consider impacts that may affect the transmission and retention of local values. These potential impacts to the transmission and retention of local values may be caused by impacts to plants, animals, geology and water resources that may be used for traditional cultural purposes by certain populations.

2.10 Vulnerable Populations (Environmental Justice)

Vulnerable populations (environmental justice) concerns are introduced in Chapter E section 4.5 as the potential of disproportionate high and adverse effects on certain populations, typically indigenous, minority and/or low income populations. Economic effects and cultural impacts are analyzed as part of the socioeconomic assessment and would include topics such as employment, revenue, economic development, etc. Environmental impacts are addressed in the environmental sections of the EIA. In the Environmental Justice section of an EIA, the impacts that would most affect this population are acknowledged. Generally, adverse impacts are more intense to the environmental justice population, and the economic effects are usually greater.

There are two types of sources of what is considered environmental justice impacts. The first type of impact derives from the differences in life style that might typically be found among indigenous peoples and minority groups. For example, these groups might rely more heavily on the affected environment for sustenance or have greater access to the environment which may increase their exposure to harmful substances where those are identified in the environmental impact assessment. Another context in which the environmental justice analysis may be appropriate is to address minority and low income populations whose life styles or low income status may make them more vulnerable to adverse impacts. If they start with poor health or poor access to medical care, the impacts of adverse environmental impacts may fall more heavily on them. Often these populations live in locations in which many polluting sources may be co-located. They may lack the language or political access to represent their interests before the government. These populations are generally less resilient than the larger population's in the surrounding environment because of their economic circumstances in their ability to mitigate adverse impacts using their own resources.

2.11 Health and Safety

Mining and mineral processing operations always pose an inherent risk to health and safety. Analysis of the impacts is accomplished by inventorying:

- The opportunity for exposure to dust, noise, and chemicals
- The opportunity for accidents from working with large equipment and from labor routine

This assessment takes into account proposed measures to reduce these risks, but if that is done, then the measures used to reduce or prevent impacts SHOULD be included in the mitigation section in terms which reflect commitment of the mine proponent to carry them out effectively.

Impacts to health and safety are identified in regulations that are in place to minimize the effects to workers and people in surrounding areas. Laws and regulations are a large factor in determining the policies and procedures that may need to be implemented to ensure that risk is minimized.

Other aspects associated with mining may produce impacts. These include:

Blasting - Impacts from blasting should be inventoried and addressed. Some of the potential impacts result from noise, vibration, dust, and explosives handling and storage. Mitigation by announcing blasting schedules, proper storage and locating seismographs for recording will go toward reducing the impacts. Impacts from transportation may be traffic accidents or aircraft accidents.

Natural Hazards - There are natural hazards that should be addressed such as working in extreme temperatures, flash flooding and dangerous wildlife such as poisonous snakes.

Solid, Liquid and Hazardous Waste – Solid, liquid and hazardous waste also pose hazards to Health and Safety and should be addressed.

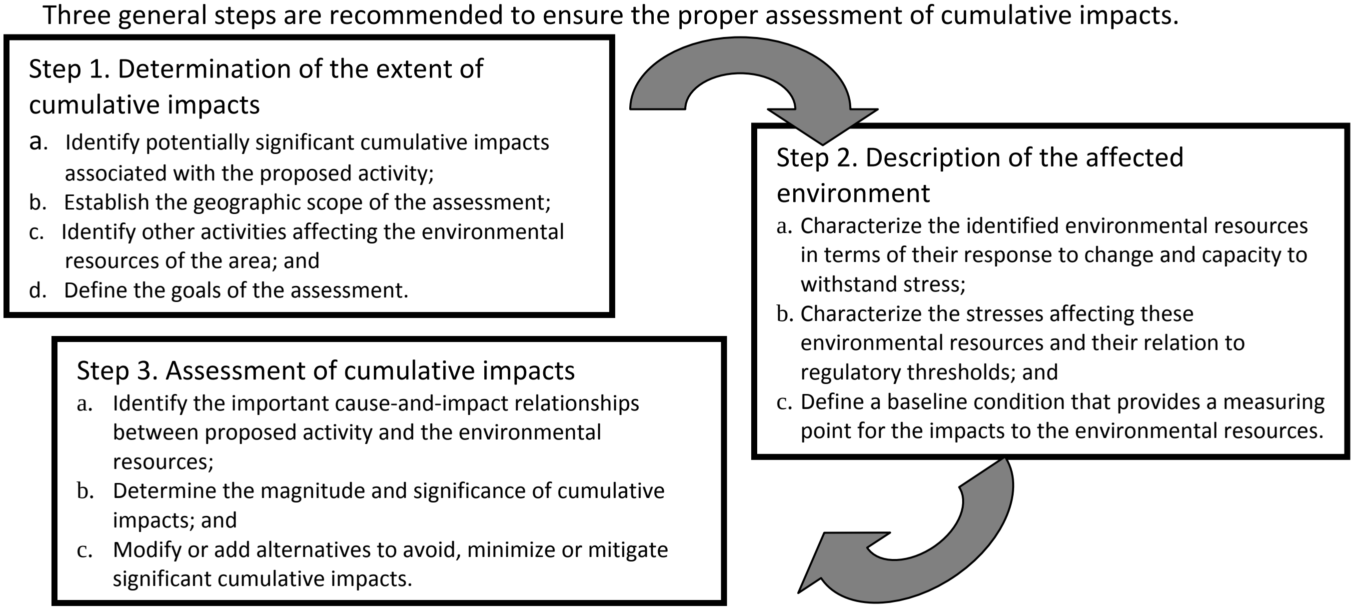
Even with regulations, policies, procedures, reporting, training and monitoring in place, accidents happen. Having measures in place that address accidents and emergencies will go toward reducing the scope of an impact.

2.12 Cumulative Impacts Assessment Methods

In summary:

- Predictive tools and methods used for cumulative impact assessment are similar to those used to predict impacts generally, but the input parameters are different in that they include all past, present and predicted future actions affecting the resource.
- The analysis is focused and applied where it is most useful through a process of identifying which resources may be significantly affected and applying more detailed assessments to those resources for which cumulative impact assessment is most important.

Three general steps are recommended to ensure the proper assessment of cumulative impacts.



In reviewing cumulative impacts analysis, the United States EPA reviewers focus on the specific resources and ecological components that can be affected by the incremental effects of the proposed mine project and other actions in the same geographic area (USEPA, 1999). In general, reviewers focus on four main aspects. These include:

- Resource and Ecosystem Components
- Geographic Boundaries and Time Period
- Past, Present, And Reasonably Foreseeable Actions
- Using Thresholds to Assess Resource Degradation

The following presents a brief description of these.

2.12.1 Resource and Ecosystem Components

An EIA analysis should identify the resources and ecosystem components cumulatively impacted by the proposed action and other actions. In general, the reviewer determines which resources are cumulatively affected by considering:

1. Is the resource especially vulnerable to incremental effects?
2. Is the proposed action one of several similar actions in the same geographic area?
3. Do other activities in the area have similar effects on the resource?
4. Have these effects been historically significant for this resource?
5. Have other analyses in the area identified a cumulative effects concern?

The following alterations would likely initiate cumulative effects in wetlands or watersheds:

- Changes in sediment transport
- Alteration of discharge and retention rates of water
- Changes in velocity of water moving through the system
- Disposal of organic pollutants where uptake is controlled by biological processes
- Disposal of chemicals that easily separate from sediment and other materials to which they are attached
- Filling of wetlands that result in increased pollutant loadings

Resources of concern may also be identified by considering actions related to mining that alter ecological processes and therefore can be expected to produce cumulative effects. Changing hydrologic patterns, for example, is likely to elicit cumulative effects.

The analysis should be expanded for only those resources that are significantly affected. In similar fashion, ecosystem components should be considered when they are significantly affected by cumulative impacts. The measure of cumulative effects is any change to the function of these ecosystem components. To ensure the inclusion of the resources that may be most susceptible, cumulative impacts can be anticipated by considering where cumulative effects are likely to occur and what actions would most likely produce cumulative effects.

The EIA document should identify which resources or ecosystem components of concern might be affected by the proposed action or its alternatives within the project area. Once these resources have been identified, consideration should be given to the ecological requirements needed to sustain the resources. It is important that the EIA document consider these broader ecological requirements when assessing how the project and other actions may cumulatively affect the resources of concern. Often these ecological requirements may extend beyond the boundaries of the project area, but reasonable limits should be made to the scope of the analysis.

2.12.2 Geographic Boundaries and Time Period

Geographic boundaries and time periods also used in cumulative impact analysis should be based on all resources of concern and all of the actions that may contribute, along with the project effects, to cumulative impacts. There are no set or required formulas for determining the appropriate scope of the cumulative impact analysis. Both geographic boundaries and time periods need to be defined on a case-by-case basis.

2.12.3 Describing the Condition of the Environment

The EIA analysis should establish the magnitude and significance of cumulative impacts by comparing the environment in its naturally occurring state with the expected impacts of the proposed action when combined with the impacts of other actions. Use of a "benchmark" or "baseline" for purposes of comparing conditions is an essential part of any environmental analysis. If it is not possible to establish the "naturally occurring" condition, a description of a modified but ecologically sustainable condition can be used in the analysis. In this context, ecologically sustainable means the system supports biological processes, maintains its level of biological productivity, functions with minimal external management, and repairs itself when stressed.

While a description of past environmental conditions is usually included in EIA documents, it is seldom used to fully assess how the system has changed from previous conditions. The comparison of the environmental condition and expected environmental impacts can be incorporated into the environmental consequences or affected environment sections of EIA documents. EIA reviewers should determine whether the EIA analysis accurately depicts the condition of the environment used to assess cumulative impacts. In addition, reviewers should determine whether EIA documents incorporate the cumulative effects of all relevant past activities into the affected environment section. For the evaluation of the environmental consequences to be useful, it is important that the analysis also incorporate the degree that the existing ecosystem will change over time under each alternative.

Different methods of depicting the environmental condition are acceptable. The condition of the environment should, however, address one or more of the following:

- How the affected environment functions naturally and whether it has been significantly degraded
- The specific characteristics of the affected environment and the extent of change, if any, that has occurred in that environment
- A description of the natural condition of the environment or, if that is not available, some modified, but ecologically sustainable, condition to serve as a benchmark

Two practical methods for depicting the environmental condition include use of the no-action alternative and an environmental reference point. Historically, the no-action alternative (as reflecting existing conditions) has usually been used as a benchmark for comparing the proposed action and alternatives to existing conditions. The no-action alternative can be an effective benchmark if it incorporates the cumulative effects of past activities and accurately depicts the condition of the environment.

Another approach for describing the environmental condition is to use an environmental reference point that would be incorporated into the environmental consequences and affected environment sections of the document. The natural condition of the ecosystem, or some modified but sustainable ecosystem condition, can be described as the environmental reference point. In analyzing environmental impacts, this environmental reference point would not necessarily be an alternative. Instead, it would serve as a benchmark in assessing the environmental impacts associated with each of the alternatives. Specifically, the analysis would evaluate the degree of degradation from the environmental reference point (i.e., natural ecosystem condition) that has resulted from past actions. Then the relative difference among alternatives would be determined for not only changes compared to the existing condition but also changes critical to maintaining or restoring the desired, sustainable condition.

Determining what environmental condition to use in the assessment may not be immediately clear. Choosing and describing a condition should be based on the specific characteristics of the area. In addition, the choice of condition can be constrained by limited resources and information. For these reasons, the environmental condition described by the environmental reference point or no-action alternative should be constructed on a case-by-case basis so that it represents an ecosystem able to sustain itself in the larger context of activities in the region. In this respect, there is no predetermined point in time that automatically should represent the environmental condition. In addition, it may not be practical to use a pristine condition in many situations.

Depending on whether the information is reasonably obtainable, the environmental condition chosen may be a pristine environment, or at the very least, a minimally functioning ecosystem that will not further degrade. The use of the environmental condition to compare alternatives is not an academic exercise, but one that can most effectively modify alternatives and help decision making. Examples of conditions might include before project, before "substantial" development, or a reference ecosystem that is comparable to the project area. Selecting the best environmental condition for comparative purposes can be based on the following:

- Consider what the environment would look like or how it would behave without serious human alteration
- Factor in the dynamic nature of the environment
- Define the distinct characteristics and attributes of the environment that best represent that particular type of environment (focus on characteristics and attributes that have to do with function)
- Use available or reasonably obtainable information

2.12.4 Using Thresholds to Assess Resource Degradation

Qualitative and quantitative thresholds can be used to indicate whether a resource(s) of concern has been degraded and whether the combination of the action's impacts with other impacts may result in a serious deterioration of environmental functions. In the context of EIA reviews, thresholds can be used to determine if the cumulative impacts of an action can be significant and if the resource can be degraded to unacceptable levels. EIA reviewers should determine whether the analysis included specific thresholds required under law or by agency regulations or otherwise used by the agency. In the absence of specific thresholds, the analysis should include a description of whether or not the resource is significantly affected and how that determination was made.

Since cumulative impacts often occur at the landscape or regional level, thresholds should be developed at similar scales whenever possible. Indicators at a landscape level can be used to develop thresholds as well as assess the condition of the environment. Using the following landscape indicators, thresholds can be crafted by determining the levels, percentages, or amount of each that indicate a significant impact for a particular area. Examples of thresholds include:

- The total change in land cover is a simple indicator of biotic integrity; thresholds for areas with high alterations would generally be lower than areas that are not as degraded; if open space or pristine areas are a management goal then the threshold would be a small percentage change in land cover.

- Patch size distribution and distances between patches are important indicators of species change and level of disturbance. Thresholds would be set to determine the characteristics of an area needed to support a given plant or animal species.

- Estimates of fragmentation and connectivity can reveal the magnitude of disturbance, ability of species to survive in an area, and ecological integrity. Thresholds would indicate a decrease in cover pattern, loss of connectivity, or amount of fragmentation that would significantly degrade an area.

Determining a threshold beyond which cumulative effects significantly degrade a resource, ecosystem, or human community is sometimes very difficult because of a lack of data. Without a definitive threshold, the EIA practitioner should compare the cumulative effects of multiple actions with appropriate national, regional, state, or community goals to determine whether the total effect is significant. These desired conditions can best be defined by the cooperative efforts of agency officials, project proponents, environmental analysts, non-governmental organizations, and the public through the EIA process. The cumulative impact of small scale mining operations on the integrity of a river segment is an example of a threshold that is goal related. Viewed in isolation as an individual action, such small scale mining which dredges non-metal rocks and gravel from a river bed may not individually significantly diminish the flow, spawning, and other characteristics of the water body and indeed may be beneficial to the overall flow of the river. But the cumulative effect of a whole series of such small scale mining actions can significantly erode the stream bed, speed the flow of water, increase erosion and sedimentation downstream and result in significant increased risk of flooding and mud slides not to mention the effect on fish spawning in the river.

Table F-4: Primary and Special Methods for Analyzing Cumulative Impacts

Primary Methods	Description	Strengths	Weaknesses
1 Questionnaires, interviews, and panels	Questionnaires, interviews and panels are useful for gathering the wide range of information on multiple actions and resources needed to address cumulative effects. Brainstorming sessions, interviews with knowledgeable individuals, and group	▪ Flexible ▪ Can deal with subjective information	▪ Cannot quantify Comparison of alternatives is subjective

Primary Methods	Description	Strengths	Weaknesses
	consensus building activities can help identify the important cumulative effects issues in the region.		
2 Checklists	Checklists help identify potential cumulative effects by providing a list of common or likely effects and juxtaposing multiple actions and resources...	▪ Systematic ▪ Concise	▪ Can be inflexible ▪ Do not address- interactions or cause-effect relationships ▪ Potentially dangerous for the analyst that uses them as a shortcut to thorough scoping and conceptualization of cumulative effects problems
3 Matrices	Matrices use the familiar tabular format to organize and quantify the interactions between human activities and resources of concern. Once even relatively complex numerical data are obtained, matrices are well-suited to combining the values in individual cells of the matrix (through matrix algebra) to evaluate the cumulative effects of multiple actions on individual resources, ecosystems, and human communities.	▪ Comprehensive presentation ▪ Comparison of alternatives ▪ Address multiple proiects	▪ Do not oddress space or time ▪ Can be cumbersome ▪ Do not address cause-effect relationships
4 Networks and System Diagrams	Networks and system diagrams are an excellent method for delineating the cause-and-effect relationships resulting in cumulative effects; they allow the user to analyze the multiple, subsidiary effects of various actions and trace indirect effects to resources that accumulate from direct effects on other resources.	▪ Facilitate- conceptualization ▪ Address cause –effect relationships ▪ Identify indirect effects	▪ No likelihood for secondary effects ▪ Problem of comparable units ▪ Do not address space or time
5 Modeling	Modeling is a powerful technique for quantifying the cause-and-effect relationships leading to cumulative effects, can take the form of mathematical equations describing cumulative processes such as soil erosion, or may constitute an expert system that	▪ Can give unequivocal results ▪ Addresses cause – effect relationships ▪ Quantification ▪ Can integrate time and space	▪ Need a lot of data ▪ Can be expensive ▪ Intractable with many interactions

Primary Methods	Description	Strengths	Weaknesses
	computes the effect of various project scenarios based on a program of logical decisions.		
6 Trends Analysis	Trends analysis assesses the status of a resource, ecosystem, and human community over time and usually results in a graphical projection of past or future conditions. Changes in the occurrence or intensity of stressors over the same time period can also be determined. Trends can help the analyst identify cumulative effects problems, establish appropriate environmental baselines, or project future cumulative effects.	▪ Addresses accumulation over time ▪ Problem identification ▪ Baseline determination	▪ Need a lot of data in relevant system ▪ Extrapolation of system thresholds is still largely subjective
7 Overlay Mapping	Overlay mapping and geographic information systems (GIS) incorporate locational information into cumulative effects analysis and help set the boundaries of the analysis, analyze landscape parameters, and identify areas where effects will be greatest. Map overlays can be based on either the accumulation of stresses in certain areas or on the suitability of each land unit for development.	▪ Addresses spatial pattern and proximity of effects ▪ Effective visual presentation ▪ Can optimize development options	▪ Limited to effects based on location ▪ Do not explicitly address indirect effects ▪ Difficult to address magnitude of effects
8 Carrying Capacity	Carrying capacity analysis identifies thresholds (as constraints on development) and provides mechanisms to monitor the incremental use of unused capacity. Carrying capacity in the ecological context is defined as the threshold of stress below which populations and ecosystem functions can be sustained. In the social context, the carrying capacity of a region is measured by the level of services (including ecological services) desired by the populace.	▪ True measure of cumulative effects against threshold ▪ Addresses effects in system context ▪ Addresses time factors	▪ Rarely can measure capacity directly ▪ May be multiple thresholds ▪ Requisite regional data are often absent

Primary Methods	Description	Strengths	Weaknesses
9 Ecosystem Analysis	Ecosystem analysis explicitly addresses biodiversity and ecosystem sustainability. The ecosystem approach uses natural boundaries (such as watersheds and ecoregions) and applies new ecological indicators (such as indices of biotic integrity and landscape pattern). Ecosystem analysis entails the broad regional perspective and holistic thinking that are required for successful cumulative effects analysis.	▪ Uses regional scale and full range of components and interactions ▪ Addresses space and time ▪ Addresses ecosystem sustainability	▪ Limited to natural systems ▪ Often requires species surrogates for system ▪ Data intensive ▪ Landscape ecosystem indicators still under development
10 Economic Impact Analysis	Economic impact analysis is an important component of analyzing cumulative effects because the economic well-being of a local community depends on many different actions. The three primary steps in conducting an economic impact analysis are (1) establishing the region of influence, (2) modeling the economic effects, and (3) determining the significance of the effects. Economic models play an important role in these impact assessments and range from simple to sophisticated.	▪ Addresses economic issues ▪ Models provide definitive quantified results	▪ Utility and accuracy of results dependent on data quality and model assumptions ▪ Usually do not address nonmarket values
11 Social Impact Analysis	Social impact analysis addresses cumulative effects related to the sustainability of human communities by (1) focusing on key social variables such as population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources; and (2) projecting future effects using social analysis techniques such as linear trend projections, population multiplier methods, scenarios, expert testimony, and simulation modeling.	▪ Addresses social issues ▪ Models provide definitive, quantified results	▪ Utility and accuracy of results dependent on data quality and model assumptions ▪ Social values are highly variable

G. MITIGATION AND MONITORING MEASURES

1 INTRODUCTION

Mitigation measures, in simple terms, are actions that can be taken to avoid, minimize, control and/or compensate the impact of a mine or quarry to people, places and the environment. The International Association for Impact Assessment (IAIA) defines an environmental impact assessment as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made." It is the final approved EIA that is the basis for the future inspection and enforcement actions. The commitments to mitigation and assuring they are carried out effectively is one of the outcomes of the EIA process. The particular language defining proposed mitigation and anticipated effectiveness and timing is critical to successful outcomes, as is accompanying requirements for monitoring, reporting and record keeping.

Mitigation Measures for Commercial Mining

This section addresses actions to be taken to minimize impacts to the affected environment from sand and gravel, metals and non-metals mines. Addressed in this section are:

-Mitigation measures for:

- Exploration
- Construction and Operations
- Restoration
- Post-Closure

- Monitoring and oversight
- Financial assurance

Metal Mines

Emphasis is placed on mitigation activities in managing acid and non-acid mine drainage and, when cyanide is used, abiding by international standards. Because of the potential long-term effects of metal leaching under acid and non-acid conditions, long-term monitoring and financial assurance are considered very important.

Non-metal Mines

Emphasis is placed on mitigation with main concerns being dust control, erosion and sediment control, and noise reduction.

Project proponents should always be encouraged to avoid adverse impacts through good siting and project design. These practices should be spelled out clearly in the EIA through operational programs with monitoring plans in place should unavoidable impacts occur. Unavoidable impacts require mitigation. The mitigation of the impacts is necessary in all phases of mine development, operation and closure. It is important that the EIA identify and define all mitigation measures for a specific mine project. A mitigation measure could be the selection of an environmentally preferred alternative, the incorporation of specific design modifications or actions in the mine permit, or actions carried out during the mining operation based on mining conditions or regulatory decisions. Results of monitoring may trigger further action if these results indicate there are problems that were not anticipated in the EIA.

In the development of an EIA, it is important that, wherever possible, performance standards are established. These standards can be based on domestic or international norms and should be provided by the proponent. Examples of performance standards for the protection of water, air and other resources are provided in the CD accompanying this guideline. To assess compliance with the performance expectations, monitoring should take place. Towards this end, monitoring plans should be developed by the proponent and approved by the government agency, so that mitigation measures are set in force by the EIA and an appropriate level of financial surety can be established. The scope of monitoring depends upon aspects of the operations and the resources of the affected environment. Monitoring plans include an outline of objectives, a plan to meet the stated objectives, criteria for evaluation, a procedure to respond to monitoring results that do not meet the accepted criteria, and financial assurance. Monitoring and monitoring plans are addressed in detail in sub-section G-6, Monitoring and Oversight.

The following sub-sections present how mitigation measures and financial assurance can be established to minimize environmental impacts for each phase of a mining operation and is based on protocols developed by the USEPA, the World Bank and the International Council on Mining and Minerals. The sections are organized to address:

- Exploration
- The Mining Operation including management of water, hazardous materials, air resources etc.
- Restoration
- Post-closure
- Monitoring and oversight
- Financial assurance
- Auditable/Enforceable commitment language: The final subsection, G-7, addresses the level of detail of mitigation descriptions in the EIA document and, depending upon whether this EIA will be used directly as a basis for follow up audits and inspection for enforcement of monitoring and mitigation measures, it provides additional guidance as to what is needed to make these commitments auditable and enforceable.

2 EXPLORATION

In general, mining exploration receives the least amount of scrutiny from government agencies, NGOs and the public. However, exploration is increasingly competing with other land uses, human development and ecological resources. Many exploration projects are developed by companies with little government oversight and few formal corporate environmental and social policies. This situation, in some cases, has led to significant negative environmental impacts.

Mineral exploration for metals, non-metals and sand and gravel mines begins with geological reconnaissance. Mapping and hand sampling are accomplished during this phase of exploration. For various types of mineral deposits geophysical applications are used to assess the potential presence of an ore body. To better define the mineral deposit the reconnaissance phase is often followed by taking larger, bulk samples of the material using various drilling techniques, tunneling and test pits.

The early stages of exploration are relatively benign with regard to surface disturbance but may generate transportation-related issues. Significant surface disturbance can occur in the final stages of exploration, where drill rigs, trenches and/or tunnels may be used to sample the material that may be mined. If mineral exploration reaches the drilling or tunneling stage, regulatory agencies should require oversight and financial assurance to mitigate potential environmental damage.

To avoid significant environmental damage (e.g., from drilling, road building, trenching, test pits and tunneling), it is important that accepted methods are used to mitigate negative impacts and protect the environment. Such practices include proper construction and restoration of exploration roads; recycling of drilling muds and fluids; and full environmental assessment of projects with significant environmental disturbance, such as exploration trenches, tunnels and test pits.

In general, the following steps should be implemented prior to and during exploration activities (Miranda et al 2005):

- Experience dictates that the number one impact of exploration activities is the production of sediment from the erosion of exploration roads and drill pads. Roads and pads are often built without regard to the erosion and sediment control. Mitigation measures such as the use of silt fencing, straw bales, grade control, avoidance of introduction of noxious weed and other appropriate management practices should be planned for and in place from the beginning of the construction activity. Steps which can be taken to mitigate the impacts of exploration are presented in Table G-1.

- To cover the lasting environmental impacts of exploration, companies should provide adequate financial guarantees to pay for prompt cleanup, restoration, and long-term monitoring and maintenance. Without financial guarantees for exploration, there is no practical way to accomplish the desired cleanup, should it be required. The financial guarantees could consist of bonds that apply to a specific project area. Bonds can be posted for multiple exploration projects, but should be tracked to ensure that the total amount needed does not exceed the total financial bond obligation. Even when financial guarantees for exploration are required, regulators should monitor exploration projects to detect damage.

Table G-1: Exploration Activities and Mitigation Measures

Activity (Description)	General Impacts	Affected Resource	Mitigation Measures	Notes
Reconnaissance mapping and sampling: (Use of light vehicles for on- and off-road travel to map and area and obtain small, hand-sized rock samples.)	Negligible amounts of emissions, dust and noise from vehicles. Slight disturbance to vegetation and wildlife, and possibility of slight erosion and sedimentation from off–road vehicle use.	Vegetation	Avoid disturbance of sensitive vegetation and minimize overall disturbance by staying on roads, especially during wet periods and rainy seasons.	Impacts during this phase of exploration are expected to be negligible to small , but should be acknowledged in the EIA
		Wildlife	Stay away from specific areas during breeding season for species of interest.	
		Surface Water	Erosion and Sedimentation control measures which address staying on roads to the extent possible.	
Aerial photography: (Detailed maps may require aerial photography which may require the use of helicopters and light vehicles for placing degradable	Negligible amounts of emissions, dust and noise from helicopters and light vehicles. Slight disturbance to vegetation and wildlife, and	Vegetation	Avoid disturbance of sensitive vegetation and minimize overall disturbance by staying on roads, especially during wet periods and rainy seasons.	Impacts during this phase of exploration are expected to be negligible to small, but should be described in the EIA.
		Wildlife	Stay away from specific areas during breeding season for species of interest.	

Table G-1: Exploration Activities and Mitigation Measures

Activity (Description)	General Impacts	Affected Resource	Mitigation Measures	Notes
or removable panels on the ground to mark locations. Airplanes are used to photograph area.)	possibility of slight erosion and sedimentation from off–road vehicle use. No impacts from panels because they will be removed.	Surface Water	Erosion and sedimentation control measures which address staying on roads to the extent possible.	
Construction of access roads, drills pads and staging areas for bulk sampling from drill holes, test pits or test tunnels, and labor camps: (Construction requires use of heavy equipment including dozers and backhoes and possibly some drilling and blasting. Labor camps may require temporary housing, sewage treatment and solid waste disposal.)	Exhaust emissions, dust, and noise during construction. Erosion and sedimentation. Noise and vibration levels associated with blasting. Disturbance to vegetation and wildlife. Possible impacts to cultural sites and traditional uses. Impacts to ground and surface water from temporary living arrangements and excavations and drilling.	Vegetation	Pre-disturbance surveys, revegetation and monitoring.	Impacts from this phase are greater than geological reconnaissance and aerial photography and should be addressed in the EIA. Financial Assurance would be required. Restoration would be required. Measures for these activities should be included in the EIA.
		Wildlife	Protection of sensitive species or species of interest.	
		Surface Water	Erosion and sedimentation controls such as silt fencing, straw bales, and grade control, with appropriate management practices as outlined in Table I-6. Sewage treatment and solid waste management at labor camps.	
		Groundwater	Sewage treatment and solid waste management at labor camps.	
		Air Quality	Dust control measures.	
		Noise and Vibration	Restricted hours of operation of heavy equipment and blasting if exploration is in a populated area. May include seismic monitoring.	
		Cultural and Historical	Pre-disturbance surveys of pads, roads and camp locations and mitigation by avoidance of sites. When avoidance is not possible, excavation of sites.	
Drilling to collect samples (Requires rigs, water trucks, mud trucks, geophysical testing trucks, and mud pits.	Exhaust emissions, dust, and noise. Disturbance to vegetation and wildlife. Possible impacts to groundwater and surface water associated with drilling fluids and mud disposal. Possible impacts to traditional uses.	Vegetation	Pre-disturbance surveys, revegetation and monitoring.	Financial Assurance would be required. Monitoring revegetation would be required. Monitoring groundwater and surface water may be required depending upon the proximity of the drill holes to resources. Measures for these activities should be included in the EIA.
		Wildlife	Protection of sensitive species or species of interest.	
		Surface Water	Treatment/disposal of mud and fluid.	
		Groundwater	Management of drilling fluids. Drill hole plugging.	
		Air Quality	Dust control measures.	
		Noise and Vibration	Restricted hours of operation if exploration is in a populated area.	
		Cultural and Historical	A program may be required to address operational impacts on indigenous people in the immediate area.	

Table G-1: Exploration Activities and Mitigation Measures

Activity (Description)	General Impacts	Affected Resource	Mitigation Measures	Notes
Tunneling and test pits for collecting samples (Usually requires drilling and blasting. Use of excavation equipment creates waste piles. Sometimes crushers and conveyors are used for sample preparation.)	Exhaust emissions, dust, and noise. Disturbance to vegetation and wildlife. Possible impacts to groundwater and surface water associated with drilling, blasting and excavation. Possible seismic impacts and subsidence. Possible impacts to cultural sites and traditional uses.	Vegetation	Pre-disturbance surveys, revegetation and monitoring.	Financial Assurance would be required. Monitoring revegetation would be required. Monitoring of dust emissions, surface water, groundwater, noise and seismic activity may all be required. Measures for these activities should be included in the EIA.
		Wildlife	Protection of sensitive species or species of interest.	
		Surface Water	Erosion and sedimentation controls such as silt fencing, straw bales, and grade control, with appropriate best management practices as outlined in Table G-2. Control of acid and other drainage from waste rock.	
		Groundwater	Control of acid and other drainage from waste rock.	
		Air Quality	Dust control measures for construction equipment, crushers and conveyors.	
		Noise and Vibration	Restricted hours of operation if exploration is in a populated area.	
		Cultural and Historical	Pre-disturbance surveys of pads, roads and camp locations and mitigation by avoidance of sites. When avoidance is not possible, excavation of sites. A program may be required to address operational impacts on indigenous people in the immediate area.	
Test mine and restoration of test mine: (Creation of a small mine with on-site crushing and sometimes smaller scale metallurgical processes for crushing, grinding and extraction. Extensive use of heavy equipment during test mining. Use of heavy equipment to restore land to postmining land use. Removal of facilities.)	Impacts are approximately those of a mine only on a much smaller scale. (See Table E-2)		Mitigation measures are approximately those of a mine only on a much smaller scale. (See Table G-2)	Financial Assurance required. Detailed monitoring plans for all resources of the affected environment would be required and included in the EIA.

Table G-1: Exploration Activities and Mitigation Measures

Activity (Description)	General Impacts	Affected Resource	Mitigation Measures	Notes
Restoration of roads drill pads, test pits, tunnel sites and labor camps: (Use of heavy equipment to reclaim sites.)	Impacts from dust, emissions, sedimentation, erosion, noise, wildlife.	Vegetation	Revegetation of disturbed areas (roads, pads, camps, etc.) and monitoring.	Financial Assurance continues to be in place during this phase. Monitoring resources would be necessary in this phase. Monitoring plans are an integral part of the EIA and should be included in the document.
		Wildlife	Restoration of disturbed habitats.	
		Surface Water	Control sedimentation and erosion during restoration. Replacement of temporary structure (silt fencing, straw bales, etc.) with permanent structures where necessary. Possible restoration of natural contours and drainage patterns at disturbed sites. Acid and other drainage from metals waste rock may need to be monitored and controlled.	
		Groundwater	Removal of sewage treatment and solid waste disposal facilities at labor camps. Restoration of waste to avoid contamination to groundwater.	
		Air Quality	Dust control measures.	
		Noise and Vibration	Restricted hours of operation if exploration is in a populated area.	
		Cultural and Historical	Restoration of access to cultural sites and traditional uses.	
Monitoring: (Use of light-use vehicles on and off road to take samples and complete surveys.)	Negligible amounts of emissions, dust and noise from vehicles. Slight disturbance to vegetation and wildlife, and possibility of slight erosion and sedimentation from off–road vehicle use.	Vegetation	Avoid disturbance of sensitive vegetation and minimize overall disturbance by staying on roads, especially during wet periods and rainy seasons.	Financial Assurance continues to be in place during this phase.
		Wildlife	Stay away from specific areas during breeding season for species of interest.	
		Surface Water	Erosion and sedimentation control program which addresses staying on roads to the extent possible.	

3 THE MINING OPERATION

3.1 General

Mitigation measures are required for a mining operation to reduce impacts of the mine to the affected environment: water, air, land, soil and geologic, biologic, land, cultural, visual and human resources. A comprehensive table of mitigation measures that can be taken throughout the mining process is presented in Table G-2. This table is general and can be applied to any type of mining operation (aggregate, non-metal and metal). In addition to these measures, mitigation can be achieved through regulatory and corporate action. These actions can include using "appropriate management practices" in managing water, air pollution control, noise reduction, waste, cyanide and acid rock drainage. In addition, mitigation efforts can be greatly enhanced if companies practice "prior informed consent" which according the Environmental Law Institute (2003) refers "to the right of a local community to be informed about mining operations on a full and timely basis and to approve a mining operation prior to the commencement of operation. This includes participation in setting the terms and conditions addressing the economic, social, and environmental impacts of all phases of mining and post-mining operations."

BEST PRACTICES

Environment Canada has established an Environmental Code of Practice for Metal Mines. This Code was published under the *Canadian Environmental Protection Act (CEPA*) in June, 2009 and complements the *Metal Mining Effluent Regulations*. The Code addresses all phases of the mining life cycle from exploration through closure and covers a broad spectrum of environmental aspects ranging from water, waste and air management to climate change and biodiversity. The Code includes a comprehensive set of recommendations to facilitate and encourage continual improvement in environmental performance of mining facilities. The Code's recommendations collectively represent Environment Canada's position on critical steps to address the environmental impacts of mining activities across Canada and internationally (Environment Canada, 2009, European Commission, 2009).

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
Air	**Dust Control** Surface access roads and on-site roads with aggregate materials, wherever appropriate. • Minimize disturbed areas	**Dust Control Measures** At a minimum the dust control measures would require these mitigation measures: • Use dust abatement techniques on unpaved, unvegetated surfaces to minimize airborne dust and during earthmoving activities, prior to clearing, before excavating, backfilling, compacting, or grading, and during blasting. • Post and enforce speed limits to reduce airborne fugitive dust from vehicular traffic. • Reestablish vegetation of disturbed areas as soon as possible after disturbance with timeframes set in the EIA. • Keep soil moist while loading into dump trucks. • Keep soil loads below the freeboard of the truck. • Tighten gate seals on dump trucks. • Cover dump trucks before traveling on public roads. • Cover construction materials and stockpiled soils if they are a source of fugitive dust. • Train workers to handle construction materials and debris to reduce fugitive emissions. • Employ water injection or rotoclones on all drills. • Use chutes, drapes, or other means to enclose conveyor transfer points, screens, and crushers. • Cover all conveyors. • Develop a long-term monitoring program that ensures the above steps meet regulatory requirements
	Emissions Control • Fuel efficiency, types of fuels, types of equipment, emissions controls, and equipment maintenance programs.	**Emissions Control Program** • At a minimum the program would address methods for reduction of greenhouse gas emissions and pollutants such as CO, CO_2, NOx, SOx, and VOC. • Develop a monitoring program that ensures greenhouse gas emission are minimized.

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
Water	**Sediment and Erosion Control** • Identify and avoid unstable slopes and local factors that can cause slope instability (groundwater conditions, precipitation, seismic activity, slope angles, and geologic structure). • Minimize the planned amount of land to be disturbed as much as possible. • Use special construction techniques in areas of steep slopes, erodible soils, and stream crossings. • Identify and employ slope stabilization practices for use during mining. • Construct drainage ditches only where necessary. Use appropriate structures at culvert outlets to prevent erosion. • Do not alter existing drainage systems, especially in sensitive areas such as erodible soils or steep slopes. • Permanent impoundments, including seep discharges, should meet the performance standards including having water quality suitable for the intended post-mining use. • Construct sedimentation structures near the disturbed area to impound surface water runoff and sediment.	**Sediment and Erosion Management program:** At a minimum the program should include best management practices, such as: • Best Management Practices will be implemented to control erosion from vehicular traffic; roads and pads will be sited to minimize impacts; construction will avoid cut/fill to the extent possible, minimizing area disturbed by roads and drill pads; roads and pads will be located away from surface waters where possible; buffer zones will be maintained near surface waters **[Ministry specify how many meters from surface waters buffers will extend]**; construction will be limited to dry periods; slopes will be stabilized; appropriate management practices for stream crossing will be used **[Ministry specify]**. • Topsoil will be removed during mining and decommissioning activities and used to reclaim disturbed areas. • Side slopes and benches of heap leach pads, waste rock piles, stockpiles, and tailings impoundments will be designed to be stable and minimize erosion. • Disposal areas for excess excavation materials will be sited in approved areas to control erosion and minimize leaching of hazardous materials. • Disturbed soils will be restored as soon as possible after disturbance. • Catch basins, drainage ditches, and culverts will be cleaned and maintained regularly. • Strip-mined or contour-mined areas will be backfilled or recontoured with excess excavation material generated during construction. • Borrow material will be obtained only from authorized and permitted sites. All wetlands will be delineated and clearly marked throughout project construction and operation in order to remain undisturbed. • Wetlands will not be disturbed and a **[X meter]** buffer shall be maintained between all wetlands and surface disturbance. • All aquatic/riparian/wetland habitat disturbed or destroyed by mining activities will be fully restored or fully compensated for by the mining company. • The quality and quantity of mine effluent streams discharged to the environment, including stormwater, and overall mine works drainage will be managed and treated to meet the applicable water quality standards specified in the Monitoring Plan. • Discharges to surface water will not result in contaminant concentrations in excess of water quality standards specified in the Monitoring Plan outside a scientifically

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
		established mixing zone. • Mining company will closely monitor activities near aquifer recharge areas to reduce potential contamination of the aquifer. • Oil and grease traps or sumps will be installed and maintained in proper working order at refueling facilities, workshops, fuel storage depots, and containment areas, and spill kits shall be kept on site and available with emergency response plans. • Sanitary wastewater will be managed via reuse or routing into septic or surface treatment. • All pesticides used for the project will meet international standards for nonpersistent, immobile pesticides.
Water (cont.)	**Water Quality Control Measures** • Minimize effects to wells and stream or spring flow from draw down of groundwater table due to pit dewatering, groundwater use, reduction in groundwater recharge area, and direct or indirect blockage/ diversion of upstream source water flow.	**Water Quality Management** • Identify minimum flow requirements for streams and springs based upon comprehensive analysis and designation of the flow necessary to sustain a healthy aquatic and riparian environment for each of these water bodies. • If a reduction in the flow of a stream or spring below the designated threshold flow is determined to be the result of mining operations, the mining company will enhance or repair the affected water resources in an amount equal to or greater than the designated threshold flow. • The mining company will monitor and report its mitigation activities to ensure the effectiveness of the implemented measures. If initial measures are deemed inadequate by the Ministry, the mining company will implement additional measures until mitigation meets the designated threshold flow. • Mitigation measures may include, but are not limited to: o Acquisition of necessary water for the mining process from an alternate source/aquifer, thus allowing natural recharge to occur. o Import of water from an alternate source to supplement the impacted flow. o Implementation of stormwater best management practices that reduce impervious surface area and encourage the infiltration of stormwater to allow restoration of the location's natural hydrology (only to be implemented in those areas where either the stormwater is not contaminated by acid/heavy metals/other toxins, or where these contaminants can be sufficiently and consistently filtered from the water). o The potentiometric surface of the groundwater in the cumulative impact area will be monitored throughout mine operations and for as long after closure as the water table

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
		elevation continues to decrease. If groundwater wells or water rights are adversely affected by mining activities, the mining company will improve the existing well or install a new well such that the flow and value of the resource are completely compensated for.
	Acid Rock Drainage and Leachate Measures (metal and coal mines) • Determine potential for acid rock drainage • Handle earth materials and runoff in a manner that minimizes the formation of acid mine drainage.	**Acid Rock Drainage, tailings and leachate management** At a minimum: • No sample will exceed any water quality standard specified in **[Table X]** of the Monitoring Plan . • If sample results indicate actual or potential for contamination of groundwater or surface water from the project facilities, Mining Company will verbally report such evidence to the Ministry within **[three working days]** of determining that the monitoring data indicate such impact. • Within **[10 working days]** of notifying the Ministry of the water quality impacts and/or trends, Mining Company will implement prevention, treatment and/or control measures to ensure cessation of water quality degradation and restoration of water quality to water quality standards specified in [**Table X]** of the Monitoring Plan. • Contaminant prevention, treatment and control technologies may include, but are not limited to: o A groundwater or surface water extraction and treatment operation. o A cap or cover system to preclude meteoric water from infiltrating into waste rock, spent ore, or tailings. o Rehandling of waste rock in order to move it to a location where it does not pose a threat to water quality. o Construction of a man-made wetland system to filter acidified or toxic runoff. Monitoring of representative samples of substrate will be conducted annually to determine the concentrations of heavy metals and persistent bioaccumulative toxins. Monitoring results will be submitted to the Ministry. If contaminant concentrations pose a threat to the wetland ecosystem, the mining company will implement measures to destroy, recover, recycle, or dispose of the contaminants, if determined necessary by the Ministry. o Further monitoring will be implemented to demonstrate contaminant prevention methods are effective and that affected water has been fully captured and controlled. The Mining Company will present a contaminant control and monitoring plan to the Ministry for approval prior to implementation. The approved plan will continue to be implemented until the risk of further contamination has been shown to be negligible

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
		and approved by the Ministry **[or other Ministry standard]**. If contaminants are predicted to be released to surface water or groundwater after mine closure, the mining company will establish a long-term trust fund to ensure funds are available as long as needed to manage the control and monitoring plan to prevent degradation of water quality. • If mine will result in the development of a pit-lake, the mining company will control pit-lake water quality such that water quality standards in **[Table X in Monitoring Plan]** are not exceeded. If the pit lake model predicts pit lake water quality would not meet applicable standards, the mining company will include the pit lake contaminant control and monitoring plan in the EIA. The pit lake contaminant control and monitoring plan will ensure that there is no flow of contaminated water from the pit lake into the surrounding environment (groundwater aquifer or surface water. The **m**ining company will manage the pit lake water quality control and monitoring plan and establish a long-term trust fund to ensure pit lake water quality meets the applicable standards in perpetuity.
Acoustic	**Acoustic** • Proponents of a mine project should take measurements to assess the existing background noise levels at a given site and compare them with the potential noise levels associated with the proposed project. Nearby residences and likely sensitive receptors should be identified at this time. • Locate all stationary construction or mining equipment (i.e., compressors and generators) as far as practicable from nearby residences and other sensitive receptors.	**Noise Control program** Noise control program should: • Limit noisy activities (including blasting) to the least noise-sensitive times of day (weekdays only between 7 a.m. and 10 p.m.). • All equipment should have sound-control devices no less effective than those provided on the original equipment. Muffle and maintain all construction equipment used. • Notify nearby residents in advance when blasting or other noisy activities are required. • Whenever feasible, schedule different noisy activities (e.g., blasting and earthmoving) to occur at the same time, since additional sources of noise generally do not add a significant amount of noise. That is, less-frequent noisy activities would be less annoying than frequent less-noisy activities. • To the extent feasible, route heavy truck and rail traffic supporting mining activities as far as possible away from residences and their sensitive receptors.
Cultural and Historic	**Cultural and Historic** • Conduct a records search to determine the presence of known archaeological sites and historic structures within the area of potential effect. Identify the need for an archaeological and/or architectural	**Cultural and Historic Program** Cultural/historic resources program should address the following: • Plan mine development to avoid significant cultural resources. If avoidance is not possible, conduct appropriate cultural resource recovery operations or alternate

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
	survey. Conduct a survey, if needed. • Determine whether sites and structures within the area of potential effect are significant historic places. • Consult with local government and indigence peoples early in the planning process to identify traditional cultural properties, sacred landscapes, and other issues and concerns regarding the proposed mine. • Prepare a cultural resources management plan, if cultural resources are present at the mine site or along access routes or if areas with a high potential to contain cultural material have been identified. • Use existing roads to the maximum extent feasible to avoid additional surface disturbance.	mitigations. • Periodic monitoring of significant cultural resources in the vicinity of the mine (including areas where new road access has been provided) may be required to reduce the potential for looting and vandalism. Should loss or damage be detected, consult with the appropriate authorities. • An unexpected discovery of cultural resources during any phase of the project will result in a work stoppage in the vicinity of the find until the resources can be evaluated by a professional archaeologist. Educate workers and the public on the consequences of unauthorized collection of artifacts. • During all phases of the project, keep equipment and vehicles within the limits of the initially disturbed areas.
Soils/ Geologic	**Soils** • Minimize vegetation removal. • Design runoff control features to minimize soil erosion. • Use special construction techniques in areas of steep slopes, erodible soils, and stream crossings.	**Topsoil Management** Soil management program should include the following provisions: • Save topsoil removed at the start of the project and use it to reclaim disturbed areas upon completion of mining activities. • Restore or apply protective covering on disturbed soils as quickly as possible. • Apply erosion controls to reduce soil erosion from vehicular traffic and other mining activities (e.g., jute netting, silt fences, and check dams). • Stabilize all areas of disturbed soil using weed-free native shrubs, grasses, and forbs.
	Geology • Identify unstable slopes and local factors that can cause slope instability (groundwater conditions, precipitation, seismic activity, slope angles, and geologic structure). • Minimize the planned amount of land to be disturbed as much as possible. Existing roads and borrow pits and quarries should be used to obtain aggregate materials for surfacing roads and equipment staging areas. Minimize vegetation	**Geologic Mitigation** Mitigation for geologic resource includes: • Avoid creating excessive slopes during excavation and blasting operations. • Dispose of excess excavation materials in approved areas to control erosion and minimize leaching of hazardous materials. • Clean and maintain catch basins, drainage ditches, and culverts regularly. • Reestablish the original grade and drainage pattern to the extent practicable. • Backfill or recontour strip-mined or contour-mined areas, any foundations, and trenches, preferably with excess excavation material generated during

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
	removal. • Place access roads to follow natural topography, and avoid or minimize side hill cuts. New roads should avoid going straight up grades in excess of 10%. Design roads with eventual restoration in mind. • Do not locate leach pads, tailings, waste rock or process facilities near adverse geologic conditions such as landslides and active faults.	construction. • Obtain borrow material from authorized and permitted sites.
Biologic/ Ecologic	**Wildlife, Ecology and Vegetation** • Use existing facilities (e.g., access roads, parking lots, graded areas) to the extent possible to minimize new disturbance. • Use existing information on species and habitats and contacts with appropriate agencies to identify potentially sensitive ecological resources in the project area. • Conduct pre-disturbance surveys and site facilities away from important ecological resources (e.g., wetlands, water bodies, important upland habitats, sensitive species populations). • Establish protective buffers to exclude unintentional disturbance of important resources. • Minimize the amount of land disturbance. • Prevent water contamination (see Water section above), so as to prevent impact on aquatic systems. • Bury electrical supply lines in a manner that minimizes additional surface disturbance. Use overhead lines in cases where the burial of lines would result in further habitat disturbance. • Minimize or reduce habitat fragmentation and interruption of wildlife corridors.	**Wildlife, Ecology and Vegetation Management** Wildlife, ecologic, vegetation management program should: • Educate workers regarding the occurrence of important resources in the area and the importance of protection. • Schedule activities to avoid disturbance of resources during critical periods of the day (e.g., night) or year (e.g., breeding or nesting season). • Include a program to instruct employees, contractors, and site visitors to avoid harassment and disturbance of wildlife, especially during reproductive (e.g. courtship, nesting) seasons. In addition, control pets to avoid harassment and disturbance of wildlife. • Limit pesticide use to nonpersistent, immobile pesticides and apply in accordance with label and application permit directions and stipulations for terrestrial and aquatic applications. • Apply spill prevention practices and response actions in refueling and vehicle-use areas to minimize accidental contamination of habitats. • Include a site restoration plan that addresses both interim and final restoration requirements and that identifies revegetation, soil stabilization and erosion reduction measures. Revegetation plan should specify location, types and densities of species (with a preference towards native species), mulching requirements, success criteria with monitoring requirements, and contingency measures if criteria are not met. It should also identify responsible parties for implementation and monitoring. Ensure that interim restoration of disturbed areas is conducted as soon as possible following facility construction. • Include a program for control of noxious weeds and invasive plants, which could occur as a result of new surface disturbance activities at the site. The program

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
		should address requirements for cleaning all vehicles before entering the project area, monitoring, and methods for treating infestations. Require the use of certified weed-free mulching. Prohibit the use of fill materials from areas with known invasive vegetation problems. • Reforest riparian zones with species appropriate to the native habitats and species. • Establish or maintain functional wildlife corridors.
Land	**Land Use** • Contact local stakeholders early in the process to identify sensitive land uses, issues and local plans and ordinances. • Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices. • Consolidate infrastructure requirements (e.g., roads) for efficient use of land. • Evaluate current transportation systems and access routes. • Establish a restoration plan to ensure that all impact areas are restored.	**Land Program requirements:** Land program should: • Implement a restoration plan. • Compensate farmers and ranchers for crop or forage losses and restore lost agricultural lands at the end of the project. • Compensate property owners for relocation of their homes in the event the relocation is unavoidable. • If underground mining occurs beneath developed areas on the surface, measures may be needed in the project design to reduce or avoid unacceptable surface impacts caused by subsidence.
Visual	**Visual** • Involve the public in decision making regarding visual site design elements for proposed mine project and future restoration plans. Possible approaches include conducting public forums; offering tours; using computer simulation and visualization techniques in public presentations; and conducting surveys regarding public perceptions and attitudes about mining. • Integrate the site design with the surrounding landscape. • To the extent practicable, avoid placing large operations buildings on high land features and along "skylines" that are visible from nearby sensitive viewpoints. Design and construct	**Visual Program** Visual program should: • Minimize ground disturbance and control erosion by avoiding steep slopes and by minimizing the amount of surface disturbance needed for infrastructure (e.g., roads, electrical lines). Keep equipment and vehicles within the limits of the initially disturbed areas. • Restore disturbed surfaces as closely as possible to their original contour and revegetate them immediately after or contemporaneously with disturbance activities. • Use dust suppression techniques to minimize impacts of vehicular traffic and wind on roads and exposed soils. • Maintain the right-of-way with low-growing natural vegetation that requires minimal maintenance and that is consistent with local vegetation.

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
	conspicuous components of the project to harmonize with desirable or acceptable characteristics of the surrounding environment. • Bury electrical lines on the site in a manner that minimizes additional surface disturbance. • Consider aesthetic offsets as a mitigation option in situations where visual impacts are unavoidable, or where alternative mitigation options are only partially effective or uneconomical.	• Maintain the site during operation of the mine. Inoperative equipment and poor housekeeping, in general, creates a poor image of the activity in the eyes of the public. • Depending on the situation, consider minimizing the amount of vehicular traffic and human activity. • Develop and implement a decommissioning program that includes the removal of all aboveground facilities and full restoration of the site. • Return access roads and the mine site to as near natural contours as feasible. Revegetate all disturbed areas with plant species appropriate to the site.
Transporta-tion	**Transportation** • Prepare an access road siting study and management program incorporating road design, construction, and maintenance standards. • Plan to use existing roads to the extent possible. • Develop a transportation program, particularly for the oversized and overweight components specific to a mine. The program should consider component sizes, weights, origin, destination, and unique handling requirements. It should also evaluate alternate transportation approaches (barge, rail). • Develop a traffic management program for site access roads and for use of main public roads. The program should incorporate consultation with local planning authorities regarding traffic, in general, and specific issues (such as school bus routes).	**Transportation Program** Transportation program should: • Limit traffic to roads indicated specifically for the project. Limit use of unimproved roads to emergency use only. • Instruct and require all personnel and contractors to adhere to speed limits to ensure safe and efficient traffic flow. • Limit mine-related vehicle traffic on public roadways to off-peak commuting times to minimize impacts on local commuters.
Hazardous Materials	**Hazardous Materials** • Prepare a comprehensive list of all hazardous materials to be used, stored, transported, or disposed of during all phases of activity. • Develop a hazardous materials program providing for adequate storage, use, transportation and disposal (interim and final) for each item in the comprehensive list.	**Hazard Materials Management** Hazardous Materials Management should: • Describe procedures and responsibilities for hazardous materials determination, inspection and waste minimization. • Identify specifics regarding local and national emergency response requirements. • Include a spill prevention and response plan for storage, use and transfer of fuel and hazardous materials , including spill prevention measures, training

Table G-2: Mining Impact Mitigation Measures

Affected Environment	Potential Siting and Design Measures	Potential Follow up Monitoring, Best Practices and Mitigation Measures
	• Identify potential solid and liquid waste streams and develop determination, inspection and waste minimization procedures. • Provide secondary containment for all on-site hazardous materials and waste storage, including fuel. • Develop waste-specific management and disposal requirements.	requirements, material -specific spill response actions, spill response kits, and notifications to authorities. • Develop a stormwater management plan to ensure compliance with regulations and prevent off-site migration of contaminated stormwater or increased soil erosion. • Include a pesticide management plan with a recycling strategy to be practiced by workers during all project phases. • Containerize and periodically remove wastes for disposal at appropriate off-site permitted disposal facilities, if available. • Document accidental releases as to cause, corrective actions taken, and resulting environmental or health and safety impacts.
Human Health and Safety	**Health and Safety** • Conduct a safety assessment to describe potential safety issues (site access, construction, work practices, security, transportation of heavy equipment, traffic management, emergency procedures, and fire control and management. • Consult with local planning authorities regarding traffic. Address specific issues (e.g., school bus routes and stops) in a traffic management plan. • Identify issues specific to underground mines (e.g., potential for flooding, subsidence, oxygen deficiency) and design mitigation.	**Health and Safety Program** Health and Safety program should address: • All of the safety issues identified in the assessment and all applicable safety standards set forth by local governments and the relevant mine, safety and health administration.

Based on (USDI -TEEIC found in http://teeic.anl.gov) and IFC (2007)

3.2 Water Resources Management

WATER MANAGEMENT AT MINES (IFC, 2007)

- Establish a water balance (including probable climatic events) for the mine and related process plant circuit and use this to inform infrastructure design;
- Develop a Sustainable Water Supply Management Plan to minimize impact to natural systems by managing water use, avoiding depletion of aquifers, and minimizing impacts to water users;
- Minimize the amount of make-up water;
- Consider reuse, recycling, and treatment of process water where feasible (e.g. return of supernatant from tailings pond to process plant);
- Consider the potential impact to the water balance prior to commencing any dewatering activities;
- Consult with key stakeholders (e.g. government, civil society, and potentially affected communities) to understand any conflicting water use demands and the communities' dependency on water resources and/or conservation requirements that may exist in the area.

As mentioned in previous sections, it has long been recognized by regulators and mining companies that impacts of mining-related contamination of water resources are a major concern. In general, most mining operations try to contain contamination within the mine site and minimize impact to water resources. However, water contamination is the most common environmental impact from mining. Basic impact concerns include:

- Water is the principal pathway that contamination due to mining can be transferred to the environment. Sediment generated by erosion of cleared areas is a primary concern of aggregate mines, non-metallic mines, and hard rock mines. Metals that have been relatively immobile in unexposed rocks can leach into surface water and ground waters in large quantities through the formation of acid rock drainage when mined rock is exposed to air and water.

- Water consumption is a concern, especially in water-scarce regions. Large mines typically consume significant amounts of water in processing mined ore. Some mining operations consume an excess amount of water than what is necessary, which in turn has the potential to be contaminated.

Table G-2 presents several mitigation measures that could be implemented to reduce impacts to water resources. In addition, Table G-3 presents mitigation measures that are more related to regulatory and operational commitments than to protecting waters in the direct vicinities of the mine, and these should be addressed in the EIA.

Table G-3: Operational and Regulatory Based Measures for Water Resources

Potential Operational and Regulatory Measure	Description
Certification	The upper management of the mine should certify that water treatment, or groundwater pumping, will not be required in perpetuity to meet surface water or groundwater quality standards beyond the boundary of the mine and that predictive models are sound.
Minimization of Water Usage	Minimizing water consumption should be a stated goal of development plans for proposed mines, and for the operating plans of existing mines. NGOs, the general public, local and regional government are concerned with water conservation and sustainability, and minimizing water consumption leads to cost savings and greater operational reliability.
Minimization of Mine Dewatering	Alternative approaches should be evaluated to minimize mine dewatering to prevent undesirable impacts on ground and surface water. Dewatering to facilitate the development of large open pits can deplete groundwater resources, decrease discharge from nearby springs, and form pit lakes after mine abandonment. Although this may result in additional water resources for present surface water users, it can come at the cost of a significant loss in groundwater available for future uses. How excess dewatered water is handled (e.g., discharged to surface stream, recharged to groundwater through percolation basins, etc.) should be carefully considered to minimize negative impacts. In addition, contamination may make the water unsuitable for non-mining uses.
Prediction of Acid Rock Drainage and Other Contaminated Leachate	Accurate prediction of the quality of leachate, including acid and non-acid drainage, is the key to prevention and mitigation of contaminated water resources at mining operations. Adequate geochemical sampling and testing for the potential generation of acid rock drainage and other contaminants is critical. General information regarding the evaluation of acid rock drainage was presented in Chapter F of this Guideline. In addition, the International Network for Acid Prevention (INAP) and the Global Alliance have developed a draft Global Acid Rock Drainage (GARD) Guide that consolidates current best practice in the management of contaminants produced by sulphide mineral oxidation. The Guide is a practical "how to" summary and the "state-of-the art" reference for the mining industry, regulators, NGO's and the public. At this time, the GARD Guide (INAP, 2009) is in draft stage and is available for review and comment on http://www.gardguide.com. In addition, special attention should be given to mineralization of leacheate under neutral or alkaline conditions.

Source: www.frameworkforresponsiblemining.org

3.3 Air Pollution Control

The primary air contaminants at modern mines are fugitive dust, greenhouse gases and mercury. It has been shown that:

- Dust can pose human health problems in surface mining operations, although not to the same extent as in underground mining. At most surface mines road watering is done to suppress dust during warm weather. Excessive dust can create a nuisance for communities located near some mines, especially in areas where roads are unpaved. Monitoring of air emissions is generally poor. While companies employ sophisticated modeling techniques to predict air emissions, detailed monitoring data are often lacking. In addition, what is available is not readily accessible by the public, making verification of compliance with regulations difficult.

- Silica dust poses problems in underground mining. Problems with dust pollution in underground mining are often related to the lack of, or inadequate enforcement of, health and safety regulations.
- A sizable share of the energy used in extraction, refining, and processing metals comes from burning fossil fuels such as coal and oil, which contributes to global climate change. World Bank guidelines recommend that companies seek to reduce greenhouse gas emissions such as CO, CO_2, NOx, NxO, SOx, VOCx as presented in www.UNEP.org.
- The metal mining industry in the United States is responsible for approximately 9 percent of the mercury air emissions by U.S. industry, according to reports submitted to the U.S. Toxic Release Inventory. Much of this is due to mercury emitted from high temperature ore processing methods.

Table G-2 presents several mitigation measures which could be implemented to reduce impacts to air quality. In addition, Table G-4 presents mitigation measures that are more related to regulatory and corporate commitments to protecting the air pathway in the direct vicinity of the mine. These types of commitments should be addressed in the EIA.

Table G-4: Operational and Regulatory Based Measures for Air Resources

Potential Operational and Regulatory Measure	Description
Monitoring	Airborne emissions should be monitored and reported, and these reports should include metals as well as particulates and greenhouse gases. Some companies already report greenhouse gas emissions as a part of their annual sustainability reports. Monitoring and reporting would assist in the mitigation of impacts if they occur.
Reduce Energy Consumption of Use Renewable Energy Resources	Greenhouse gas reduction is associated with a reduction in energy use, resulting in potentially significant cost savings. Energy conservation rather than substitution from renewable sources would provide the greatest opportunity for reductions in greenhouse gas emissions. Some opportunities for substitution with renewable energy sources exist (e.g., hydro- and wind power), but these are site specific. Because companies stand to gain financially from energy conservation measures, energy and greenhouse gas reduction should be an explicit management goal for each mine site.

Source: www.frameworkforresponsiblemining.org

3.4 Noise and Vibration Reduction

Because many mines are located in remote areas, noise pollution is generally not a major issue. However, aggregate mines and an increasing number of metallic mines are posing noise problems because they are encroaching on populated areas. Noise, especially from blasting and the movement of large vehicles, is recognized as a potential problem when the mine is near populated areas. Therefore, noise levels should be recognized as a mine management issue. Where mines are near populated areas, companies should adopt quantitative noise guidelines. There are no universally accepted noise standards, and noise regulations can be applied at the local level. Regulatory action to implement maximum noise level limits at the project boundaries should be considered to mitigate noise from mining operations.

3.5 Waste Management

Mine operators generally seek to provide safe containment for tailings and waste rock, to minimize off-site contamination due to this waste, and to have hazardous materials spill emergency response measures in place. Issues on waste management fall into two categories (Miranda et al, 2005):

1. The timing, degree of public participation, and methodology involved with safe containment of mining wastes and emergency planning; and
2. Contentious waste disposal practices, particularly surface water and marine disposal.

MINE WASTE MANAGEMENT

Mines generate large volumes of waste. Structures such as waste rock dumps, tailing impoundments/ dams, and containment facilities should be planned, designed, and operated such that geotechnical risks and environmental impacts are appropriately assessed and managed throughout the entire mine cycle. Solid wastes may be generated in any phase of the mine cycle. The most significant waste generating mining activities will likely occur during the operational phases, which require the movement of large amounts overburden. Creation of waste rock facilities should be planned with appropriate terrace and lift height specifications based on the nature of the material and local geotechnical considerations to minimize erosion and reduce safety risks. This includes the management of Potentially Acid Generating wastes (IFC, 2007).

All mines have waste management issues. These issues involve not only waste rock, tailings, and spent ore, but also solid waste such as garbage and unwanted machinery, and human waste generated by workers. Mitigation measures for these waste management issues are presented in Table G-2.

3.5.1 Metals Mines

Metals mines may pose significant issues different from non-metals mines and quarries resulting from the waste rock and processes used in metals mining. For metals mines, it has been recognized by mining companies, international financial institutions, and NGO's that tailings impoundments and waste rock dumps should be constructed to minimize threats to public and worker safety, and to decrease the costs of long-term maintenance. According to the International Finance Corporation (IFC) (2007), management of mine tailings and waste dumps include the following actions:

- Design, operation, and maintenance of structures according to internationally recognized standards based on a risk assessment strategy. Appropriate independent review should be undertaken at design and construction stages with ongoing monitoring of both the physical structure and water quality, during operation and decommissioning.
- Where structures are located in areas with a risk of high seismic loadings, the independent review should include a check on the maximum design earthquake assumptions and the stability of the structure to ensure that during seismic events there will be no uncontrolled release of tailings.
- Design of tailings storage and waste rock facilities should take into account the specific risks and hazards associated with geotechnical stability or hydraulic failure and the associated risks to downstream economic assets, ecosystems and human health and safety. Environmental considerations should thus also consider emergency preparedness and response planning and containment/mitigation measures in case of catastrophic release of tailings or supernatant waters.
- Any diversion drains, ditches and stream channels to divert water from surrounding catchment areas away from the tailings and waste rock structures should be built to the

flood event recurrence interval standards. Usually, these diversions are designed for 100-year runoff event but could vary by country.

- Design specifications should take into consideration the probable maximum flood event and the required freeboard to safely contain it (depending on site specific risks) across the planned life of the tailings dam, including its decommissioned phase.
- Where potential liquefaction risks exist, including risks associated with seismic behavior, the design specification should take into consideration the maximum design earthquake.
- On-land disposal should be in a system that can isolate acid-generating material from oxidation or percolating water, such as a tailings impoundment with dam and subsequent dewatering and capping. On-land disposal alternatives should be designed, constructed and operated according to internationally recognized geotechnical safety standards.

In addition, tailings impoundments and waste rock dumps should be constructed in a manner that minimizes the release of contaminants by including liners if seepage would result in groundwater or surface water contamination. Waste facilities should have adequate monitoring and seepage collection systems to detect and collect any contaminants released in the immediate vicinity. According to the IFC (2007), this would include:

- Consideration of seepage management and related stability analysis in design and operation of tailings storage facilities. This is likely to require a piezometer based monitoring system for seepage water levels within the structure wall and downstream of it, which should be maintained throughout its life cycle.
- Consideration of zero discharge tailings facilities and completion of a full water balance and risk assessment for the mine process circuit including storage reservoirs and tailings dams.
- Consideration of use of natural or synthetic liners to minimize risks.
- Consideration of thickening or formation of paste to be backfilled into pits or underground workings during mine progression.
- Utilization at decommissioned leach pads of a combination of surface management systems, seepage collection and active or passive treatment systems to ensure that post-closure water quality is maintained.

As illustrated in Figure G-1, there is a potential for acid rock and acid mine drainage during several phases on the mining and beneficiation process. If at all possible, net acid-generating material should be segregated and/or isolated in waste facilities. However, implementing this goal still poses challenges. For example, some mines still rely solely on the neutralization of potentially acid-generating material by mixing it with acid-consuming material. This approach often fails because dissolution rates of the acid-generating minerals and the neutralizing minerals differ, and there is insufficient neutralizing capacity within the waste rock to neutralize the acidic drainage that is generated. Because there is often no backup program for halting contamination if the mixing approach fails, acid rock drainage continues to pose problems in many mines. Some mines choose to backfill open pits with acid generating waste rock to an elevation below the recovered water table, thereby depriving the waste rock of oxygen and preventing acid generation. Many mines are also deficient in identifying and keeping records on the placement of potentially acid-generating material in waste dumps, which can make mitigating problems that arise after mine closure more difficult, costly, and less effective. Planning, testing and record keeping for potentially acid-generating material should be a transparent part of the mine operating process. The GARD Guide (INAP, 2009), referenced in Table G-3, addresses the mitigation of these issues.

In addition, there is a potential for contaminated leachate to be produced by mine waste and wall rock under non-acidic conditions. Some measures implemented to prevent acid mine drainage may not be effective at preventing contaminated leachate under non-acidic conditions. Therefore, design solutions to prevent all contaminated leachate (acidic or non-acidic) should be considered. Such solutions may include:

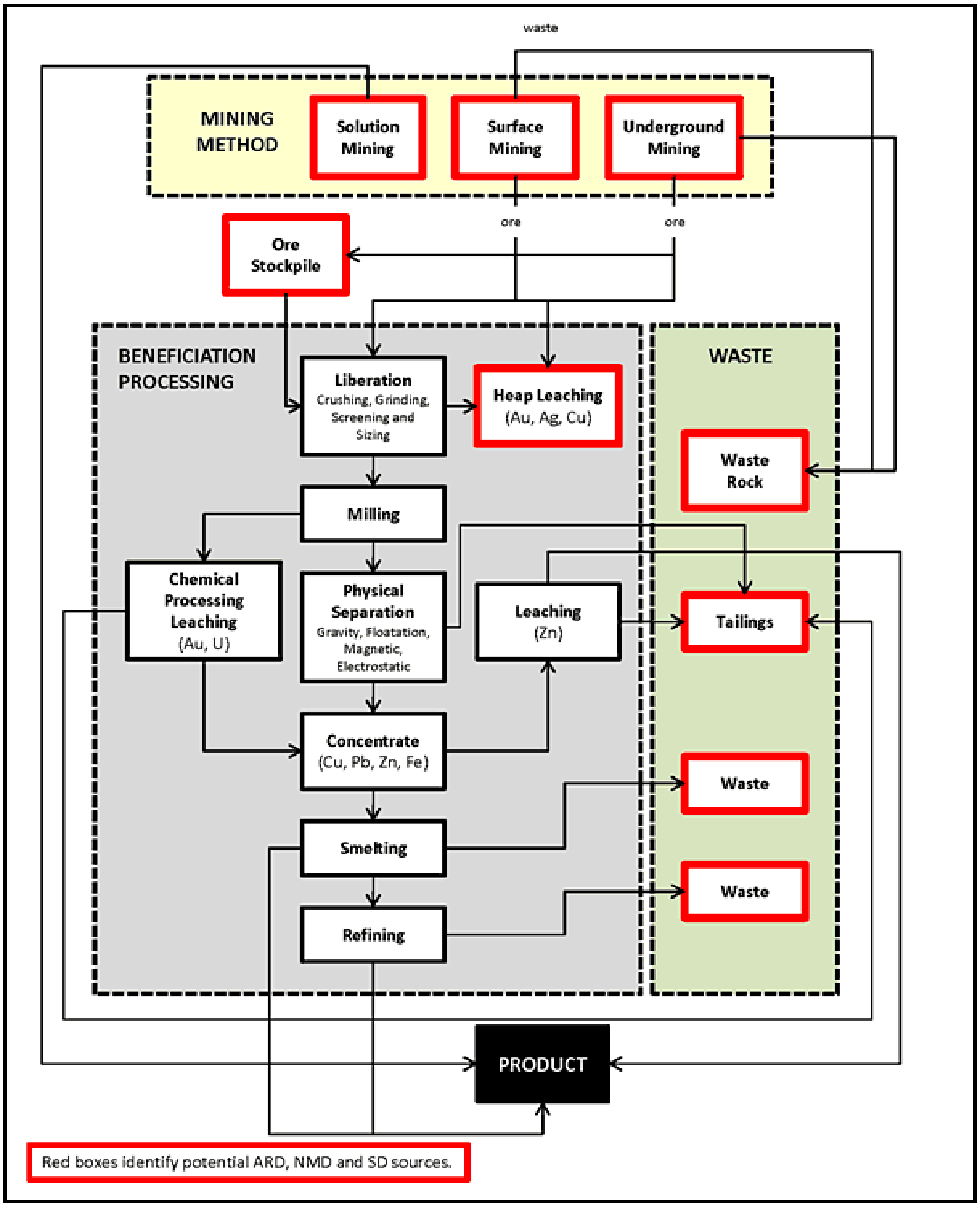
- Relocation of facilities to take advantage of, or avoid, certain geologic or hydrologic features
- Appropriate cover to prevent or minimize infiltration of meteoric water into, and contaminant leaching from, waste material
- Bottom liners and leachate capture systems to preclude, to the extent practicable, the transmission of any contamination to groundwater or surface water. The evaluation should discuss whether any leachate recovered by this alternative would be treated, discharged, or used in mine operations
- Groundwater capture systems (e.g., slurry walls, French drains, groundwater wells). Hydrological characterization (e.g., geologic structures, flow preferences, etc.) would be needed to properly design and determine the effectiveness of a capture system
- Treatment systems (passive and/or active) targeted for each contaminant of concern. If long-term or perpetual pumping or treatment would be necessary, this design solution should not be permitted

Finally, according to Miranda et al (2005), the following should be included in the mitigation programs of the mining project:

- ***Hazardous material minimization, disposal, and emergency response programs should be made publicly available.*** Spill response programs should be publicly available, and such programs should be regularly tested in direct coordination with local communities to ensure that critical communication links are operational.
- ***Rivers or lakes should not be used for the disposal of mine waste***. Disposal of mine waste, tailings and/or waste rock, into rivers and lakes has been extremely controversial for many years. While there has been significant pressure for an industry-wide ban on surface waste disposal, there is no clear commitment by industry and governments to avoid this practice in future projects. Financial institutions have adopted an approach of not categorically eliminating surface water waste disposal as an option, but endorsing it only when justified by an environmental analysis.
- ***Companies should not engage in shallow-water marine waste disposal***. Marine waste disposal should not be used unless an independent assessment can demonstrate minimal environmental and social risks. Marine waste disposal involves dumping tailings or waste rock into the marine environment. The debate is based on the distinction between shallow and deep marine disposal, where “shallow” is usually described as the depth at which light still penetrates (approximately 100 meters below the surface) and “deep” is defined as the zone below which light cannot penetrate. Disposal of waste at shallow depths has been shown to significantly affect marine life. Given that shallow marine environments are among the most biologically diverse ecosystems, shallow-water marine dumping should not be permitted. The impact of tailings and waste rock dumped at deeper depths is largely unknown, particularly because the deep sea is more difficult to access, and the relationship between deep sea organisms and other aquatic organisms is poorly understood. The World Bank has stated that marine dumping is

acceptable when justified by an environmental analysis and, therefore, may be permitted under some circumstances when justified.

Figure G-1 Mining Processes and Acid Generation Potential (INAP, 2009)



3.5.2 Gold Mines, Cyanide Management

The use of cyanide, primarily in gold processing, has been a focal point for highlighting mining related contamination because many jurisdictions have experienced significant water pollution problems associated with cyanide spills, and because the public is familiar with the acute toxicity associated with its use. Notwithstanding the toxicity of cyanide, heavy metal contamination is much more prevalent in mining operations and is of greater concern, owing to its persistence and impact on the environment. However, the public has tended to focus less on the impacts of heavy metal contamination than on cyanide.

As presented in Table G-5, International Cyanide Bans, some states of the USA and some countries have prohibited the use of cyanide. If this were to be adopted, gold processing would have to be done by:

- Another chemical lixiviant equivalent to cyanide to dissolve gold from host rock – all of which have greater potential environmental impacts than cyanide
- Using only gravity methods, which are only viable for separating larger gold particles from host rock
- Shipping all ore to a smelter for pyro-metallurgical separation (used only when base metals such as copper are also present in the ore)

Table G-5: International Cyanide Bans

State or Country	Comment
Montana	Banned in 1998 for open pit and leaching at new mines and for mine expansion
Colorado	Banned in 5 counties
Wisconsin	Banned in 2001 at all mines
Turkey	Banned in 1994 for gold production
Czech Republic	Banned in 2002 for leaching
Argentina	2003 moratorium in Chubut Province
Germany	Banned in 2002 for leaching
Costa Rica	Banned in 2002 for leaching
Philippines	2002, 25 year moratorium
Argentina	2007, Lower House of Representatives issued a ban

These processing approaches would be significantly more costly for miners, either because they are more expensive than cyanide processing or, in the case of gravity methods, they are cheaper but would result in recovering less gold. As a result, their use would raise the market price of gold.

Most commercial mine operators recognize that cyanide levels should be reduced from processed material before waste is discharged into tailings ponds. They are aware that measures such as netting or floating covers should be used to protect wildlife on open processing ponds. They are also aware that mines should utilize sound cyanide storage, safety and transportation management.

A number of significant efforts to develop guidelines for cyanide management have been launched in recent years. The most notable is the International Cyanide Management Code (International Cyanide Institute, 2008) prepared under the direction of a multi-stakeholder Steering Committee, whose members were chosen by the United Nations Environment Program (UNEP) and the International Council on Metals and the Environment (ICME), the predecessor organization to the ICMM. The Code is a voluntary program for gold mining companies developed with strong industry participation. The IFC has recommended that companies abide by the Code.

The Code contains standards of practice for cyanide management covering Production (purchasing), Transportation, Handling and Storage, Operations Decommissioning, Worker Safety, Emergency Response, Training and Public Consultation and Discussion. Mines that adopt the code are required to develop policies, procedures and plans with the amount of detail necessary to implement the Code's standards of practice and be able to pass a third-party audit as required by the Code. The policy statement should state that the company intends to comply with the Code; identify the method with which the policy is to be implemented; state under whose authority and reasons the policy and method can be altered; list the responsible department heads for purchasing, transporting, training, etc.; and identify how often the policy will be reviewed. Detailed plans for cyanide handling, construction of facilities and processes should be created by management to address the Code. Detailed operations measures should be developed to ensure that each standard is met.

The Code focuses exclusively on the safe management of cyanide and cyanidation mill tailings and leach solutions. Companies that adopt the Code should have their mining operations that use cyanide to recover gold audited by an independent third party to determine the status of Code implementation, although auditors are selected and paid for by the company. Those operations that meet the Code requirements can be certified. A unique trademark symbol can then be utilized by the certified operation. Audit results are made public to inform stakeholders of the status of cyanide management practices at the certified operation. Adoption of the Cyanide Code will help in reducing the number of cyanide transportation accidents, which itself will be a significant improvement. In some instances augmentation of the Code may be warranted, for example, several major species of cyanide byproducts (e.g., cyanate and thiocyanate) that pose significant contamination risks are not included in the monitoring; and there are no comprehensive guidelines for cyanide waste disposal facility closure.

In addition to the Code, Environment Australia and the South African Chamber of Mines have also published cyanide management guideline documents. Table G-6 presents the minimum components of a cyanide management plan.

Table G-6: Cyanide Plan for Operations

Requirement for Cyanide Plan	Description
Description of the mine	Includes historical mining in the area; recent and past mining methods and time frame; and current mine plan.
Description of the mill	Descriptions of all milling and processing such as: a. Circuits: course recovery, flotation, carbon-in-leach, carbon-in-pulp b. Crushing: tons per day, water use, primary crushing, semi autonomous grinding (SAG) c. SAG: underflow, slurry, tailings, loaded carbon, pregnant solution.
Description of impoundments	Includes location, historical use, design criteria, construction, and measures to protect ground water, surface water, soils and wildlife.
Description of Facilities (tanks, pipes, liners, concrete)	Develop Quality Assurance/Quality Control (QA/QC) procedures for the suitability of construction materials and adequacy of construction. Provide Engineering designs. Remediation plan description in case of spill. Explanation of site selection to minimize potential impacts to the environment in case of an accident.
Description of Transportation	Detailed plan of method cyanide is moved to and around mine and mill.
Protection of Human Health Plan	Standard Operating Procedure (SOP) for transporting and handling cyanide that would include contingency planning; inspections; preventable maintenance; list of all cyanide related tasks; description of cyanide processes and systems; destruction in tailings and disposal.
Standard Operating Procedures (SOPs)	SOPs need to address normal and abnormal conditions of operations at mill and mine that may lead to an emergency release. SOPs should include: a. Inspections, check lists, and restriction of access for people and wildlife b. Zero discharge design c. QA/QC for leaching and tailings storage d. Monitoring program for wildlife e. Worker safety plan with fans, eyewashes, extinguishers, maps signage, showers f. Emergency Response plan with First Responder plan, periodic trainings and drills g. Internal reporting procedures with management, regulatory agency and outside responders' contact information h. Training personnel and keeping records of training.
Decommissioning and Restoration Plan	Procedures, schedule, detoxification plan, cleaning of equipment, pond removal and financial surety to cover estimates of decommissioning.

3.5.3 Non-metals Mines

Generally, plans for management of cyanide, ARD and other leachates are not required for sand and gravel mines and non-metal mines. Waste rock disposal areas for these mines would be designed and sited according to minimize sedimentation to existing bodies of water and waterways and for stability for safety. Hazardous waste, solid waste, spill prevention programs and emergency response programs would still be required to address wastes associated with garbage, human waste, fuels and other chemicals associated with non-metals mining.

4 RESTORATION

Restoration of mined sites is a generally accepted activity, although universal restoration standards do not exist. Discussions over the adequacy of restoration often include:

- The post-mining land use that is selected for restored mine lands
- Whether re-contoured mine lands should be revegetated
- The timing of the restoration process – at what interval it should occur after ore removal. Best practice is to do this concurrent with operations for surface mining
- Whether open pits should be backfilled with waste in a way that does not degrade the environment
- How much money should be set aside to guarantee that restoration is accomplished, and what form of financial surety is required for this guarantee
- What the acceptable slopes will be for re-contouring the land to prevent erosion and mudslides.
- What the acceptable vegetation will be, the number, types (species) and density of plants; how they will be maintained and a determination of whether this effort has been successful or needs to be repeated or revised

A mine restoration plan should be included in the EIA so that all impacts of the project, including impacts to the post-mining environment, and all measures and costs to mitigate those impacts are disclosed before the project is approved. A financial guarantee to ensure that the plan can be executed if the mine operator becomes insolvent, or abandons the site, should also be posted before mining is allowed to begin. The restoration plan, including costs, should be updated frequently throughout the mining period. Restoration planning typically includes re-contouring the slopes of waste dumps and backfills to stable angles; however, the angle at which a slope is considered stable is sometimes an issue and should be determined based on geotechnical studies and agreed to prior to restoration.

Reestablishing vegetation to approximate pre-mining conditions is a generally accepted goal, but this practice is often planned only when it is clear that erosion of regraded slopes will occur. Backfilling of mined out underground areas and open pits is done only when it is economically competitive with waste storage options in other mine areas. Consultation with stakeholders is a common goal for all sectors, but there are different opinions on the timing and means by which this should occur.

As presented in Table H-1, mitigation for the restoration phase begins during the restoration planning process, particularly with respect to the timing for developing a restoration plan, ensuring appropriate post-mine land uses, and backfilling mine sites with mined out material. Basic steps include:

- Development of a restoration plan before operations begin, including detailed cost estimates (Miranda et al, 2005). The plan should be periodically revised to update restoration practices and costs. Early drafting of the plan is important because the mine operator, regulators and the public need to know what the area will look like after restoration, whether the proposed restoration scheme is technically feasible and affordable, and whether there are sufficient funds to carry out the restoration tasks if the operator were to go bankrupt. Because a pre-mining restoration plan is largely conceptual, it is important to periodically update the plan goals, technical implementation details, and projected costs. At a minimum, formal restoration updates should occur on a three- to five-year timeframe, or any time when significant changes are made to the mine plan.

- Re-contouring and stabilizing disturbed areas using acceptable management practices for erosion and sediment control, as presented in Table G-7. In addition, restoration should include the salvage, storage and replacement of topsoil or other acceptable growth medium. Quantitative standards should be established for revegetation in the restoration plan, including success criteria, and clear measures, to be implemented if these standards are not met, should be specified.

Table G-7: Management Practices for Erosion and Sediment Control on Mine Sites

Category	Potential Management Practices
Surface Stabilization Dust control	Mulching Riprap Sodding Surface roughening Temporary gravel construction access Temporary and permanent seeding Topsoiling
Runoff Control and Conveyance	Grass-lined channel Hardened channel Paved flume (chute) Runoff diversion Temporary slope drain
Outlet Protection	Level spreader Outlet stabilization structure
Sediment Traps and Barriers	Brush barrier Check dam Grade stabilization structure Sediment basin/rock dam Sediment trap Temporary block and gravel drop inlet protection Temporary fabric drop inlet protection Temporary sod drop inlet protection Vegetated filter strip
Stream Protection	Check dam Grade stabilization structure Stream bank stabilization Stablized stream crossings

- If a post-mining pit lake may form, an ecological risk assessment should be conducted for the EIA to predict impacts to aquatic resources and wildlife. Where wall rock could generate contaminated leachate, companies should backfill the mine pit if this would minimize the likelihood and environmental impact of contaminated leachate.

- Assess and mitigate danger of land subsidence associated with underground mining. Subsidence due to the collapse of abandoned mine workings can cause significant long-term environmental damage by allowing water to flow unimpeded into mine workings, leaching contaminants as water travels through the mine site. In some cases, collapse can cause safety problems and property damage. From both an environmental and physical risk management standpoint, backfilling mined-out areas that are likely to cause surface subsidence constitutes good practice for underground mines.
- Backfilling of pits and underground working should be evaluated as alternative to minimize size of waste facilities. In some cases, this action may be more economic than creating a new waste rock facility. At this time, the World Bank and some NGO's support this approach. Backfilling options should be evaluated to ensure that contaminated or acid-generating materials are not disposed of in a manner that will degrade surface water or groundwater.

5 POST-CLOSURE

Post-closure issues have often been ignored in mine closure planning, especially at the pre-mine planning stage. Post-closure issues are generally categorized as monitoring and maintenance, water treatment and catastrophic events. Monitoring and maintenance issues include long-term water quality sampling, geotechnical inspections of tailings dams and waste rock facilities and minor repair work such as regrading the slopes of dams and waste dumps and revegetation where primary seeding or planting have failed. If water treatment is required, significant financing will be necessary after the mine has closed. Long-term water treatment may more than double the cost of mine closure, which is why some people advocate not allowing the development of mines requiring perpetual water treatment. If the company were to abandon the site without providing sufficient funds for perpetual water treatment, governments and taxpayers would be forced to pay these costs in perpetuity.

Financial sureties are not generally required for catastrophic events such as earthquakes, floods, tailings dam failures or the unanticipated onset of acid mine drainage after mine closure. Where such incidents have occurred the public has generally been responsible for a large part of the cleanup costs. One response to this situation would be the creation of a national fund or financial pool to pay for catastrophic events.

Companies do not consistently address post-closure monitoring and maintenance issues as part of restoration planning, and a financial surety is not consistently provided to address potential post-closure problems. Now, many EIAs have begun including post-closure plans and costs in their analyses but still some companies assume that if post-mining water treatment is not required closing a mine will result in no corporate financial or legal obligation for post-closure activities.

The ICMM (2006) considers that two types of integration need to take place in planning for post-closure. These include:

1. The integration of social and environmental considerations into the closure approach
2. The integration of closure considerations into an operation's lifecycle planning and engineering processes

Restoration plans should include plans for post-closure monitoring and maintenance of all mine facilities, including surface and underground mine workings, tailings, leach pads, and waste disposal facilities and should include planning for and financing of long-term monitoring and maintenance.

Consideration should be also given to the impact of closure on the local community. To ensure this, it is important to have strong local community and other stakeholder involvement in closure planning. Consulting with and involving local stakeholders from an early stage is very important in producing a closed site that is supported by all parties.

According the ICMM (2006), the length of time allowed in closure plans for the continuation of post-closure monitoring is an important related issue. To consider a program as "sustainable" implies that it should be durable and this can only be measured over time. Most companies plan ahead for monitoring for about five to ten years. This timeframe is established by operations and determined by considering when enough time has passed to achieve a reasonable post-closure situation. However, in some jurisdictions, for example in the United States, there is an expectation that companies will be responsible in perpetuity for environmental impacts associated with mining. It is, therefore, important to determine how long environmental impacts may take to manifest themselves and develop monitoring criteria and financial assurance for monitoring activities accordingly.

For further information, the ICMM (2008) developed an integrated approach to mine closure. This is available in Spanish and is included on the CD distributed with these guidelines.

6 MONITORING AND OVERSIGHT

Controversy surrounding monitoring is usually related to several issues:

1. Monitoring data are almost always collected by the mining company.
2. Mining companies consider some monitoring data to be confidential, especially those data that are not explicitly required by regulatory authorities.
3. The public is not normally allowed access to the mine site to collect its own samples.

With respect to oversight, mines should comply with all monitoring requirements specified by regulatory agencies, and companies should provide timely reports to regulatory agencies. All stakeholders consider compliance with monitoring requirements to be important, and the plans for conducting, recording and reporting monitoring results should take into account who will receive this information and when. Table H-1 presents commitments that could be made by mining companies and regulatory agencies for mitigation in response to monitoring.

Governments will use one of three mechanisms either separately or in combination to hold a mining operation accountable for the results of monitoring performance against established criteria:

- Enforceable requirements: These are monitoring results which are directly enforceable by a government through inspection and prosecution. They may be subject to civil or criminal penalties. The monitoring should conform to the requirements.
- Audits: Many countries use requirements for independent third party audits.
- Citizen suits: If the mining operation is to be held accountable for performance through citizen suits, it may be helpful to provide citizens with access to monitoring results.

Monitoring measures for the affected resources are necessary for the EIA so that the results can be used to determine if the criteria for the potential results of the mitigation measures are being met. The measures should address all phases of the mining proposal: exploration, operations, restoration, and post-restoration. The scope of monitoring depends on the location and complexity of the operation and the severity of the potential impacts. Monitoring results will determine if:

- Mitigation measures are performing as predicted, thus triggering release of financial assurance by the regulatory authority.
- Mitigation measures need to be adjusted to reach the criteria goals.
- Enforcement is needed.

As such, the monitoring plans should be designed to meet the following objectives:

- To demonstrate compliance with the approved exploration, operations, and reclamation and other national or local environmental laws and regulations
- To provide early detection of potential problems
- To supply information that will assist in directing corrective actions should they become necessary, including after the mine is closed

Information about the monitoring that will be carried out should be detailed to ensure it will be useful, timely and accurate. Monitoring can be detailed for specific mitigation measures or can be pulled together into an integrated "Monitoring Plan". Where applicable, commitments to conduct monitoring should include:

- Details on type and location of monitoring devices
- Sampling parameters and frequency
- Analytical methods and detection limits
- Quality assurance and quality control procedures
- Reporting procedures (to whom, how often, etc.)
- Who will conduct and pay for monitoring
- Procedures to respond to adverse monitoring results. Actionable levels, i.e. performance criteria that will be used to interpret and act upon the results of monitoring within a specified timeframe. For example, if contamination levels will be used to trigger the implementation of prevention/treatment and control measures, they should be specified along with the nature of expected follow up action.

One of the values of monitoring is the early detection of potential problems. A good way to mitigate water quality impacts, for example, is to detect trends in samples and take early corrective action before violations of the performance standards occur. The monitoring plans should be tied to the specific mitigation measures so that, if monitoring indicates problems (e.g., if water quality standards are violated or are about to be violated), specific corrective action procedures will be implemented by the owner/operator. It should <u>not</u> be left vague (e.g, "the company will work with the ministry to resolve the problem" is too vague).

The plans for monitoring should also include the standards and criteria that should be met. Examples of monitoring programs which may be necessary include:

- Surface water and groundwater quality and quantity
- Air quality
- Revegetation success
- Stability
- Vibration levels from blasting
- Noise levels
- Wildlife mortality and other wildlife impacts

Financial assurances should be provided to ensure adequate funds will be available to implement the monitoring plan and mitigate for detected problems both during and after the mining operations. Some problems may not show up for many years (e.g., groundwater contamination), so in some cases monitoring may need to be conducted for many years after mine closure. How long the funds are held can vary based on the type of operation and the modeling predictions. The need for a contingency fund for long-term mitigation measures should also be seriously considered if there is possibility for impacts such as acid rock drainage, which can last in perpetuity.

7 FINANCIAL ASURANCE

A financial guarantee is a critical component of the restoration and post-closure process because it can be used to cover the costs of closure should the mine operator be unable to do so. The mining sector is vulnerable to significant fluctuations in prices, particularly for metal mining, and many companies have gone bankrupt, sometimes before mine closure or restoration is complete. Because closing a mine can typically cost tens of millions of dollars, regulators need a dependable source of funds to pay for the physical restoration of the mine site as well as the necessary oversight by government officials. Since mine closure is the responsibility of the mine operator, these costs are not included in the budgets of regulatory agencies. In addition, if monitoring, maintenance, and/or treatment activities will be required after mine closure over a long-term (decades or even in perpetuity), a long-term trust fund should be established at the start of the mining project to ensure funds will be available as long as they are needed to conduct this work. (Miranda et. al. (2009))

7.1 Financial Guarantees for Restoration

Government agencies need financial sureties that are readily available to ensure that mine restoration occurs. Should a mining company default on its closure commitments, funds may be required immediately for an outside contractor to operate and maintain mine facilities, such as water treatment plants. Restoration and post-closure activities conducted by an outside contractor cost more than activities conducted by the mining company because the contractor or the government itself will have mobilization and other costs that the mining company did not have while it was operating the mine. Therefore, the restoration cost estimate upon which the surety is based should be calculated to include the costs of a third party conducting the work. It should also be accurate and up to date. Unfortunately, errors in these calculations have required millions of dollars of taxpayer subsidy to close bankrupt mines.

Requiring financial sureties for large mines is an accepted practice in the CAFTA-DR countries, although opinions differ regarding the form of surety. Governments have employed a number of financial vehicles to meet surety requirements. These vehicles generally take two forms: independently guaranteed sureties and sureties guaranteed by mining companies. Because mining companies can and do go bankrupt, NGOs and governments favor sureties that are independent of the company operating the mine, usually in the form of a bond, letter of credit, cash deposit or some combination of these instruments. In circumstances in which the mining industry has found it difficult to obtain bonds for mining operations, some companies are seeking approval of corporate guarantees – i.e., a financial surety guaranteed by the mine operator and in such cases governments should assess the additional risks posed by relying on these instruments since they would be unavailable should the company go bankrupt.

The financial sector has not developed specific requirements for mine sureties, although banks risk significant loss of capital if a mining company were to declare bankruptcy while still holding outstanding loans. Finally, considerable information is available on the calculation of the financial surety for any mine project. Basic information on this is presented on presented on a CD accompanying these guidelines. Because of problems encountered with financial sureties some academics and leading NGOs have urged for more government and public scrutiny, some of which are presented in Table G-8.

Table G-8: NGO Recommendations for Financial Surety

Potential Operational and Regulatory Measure	Description
Review	Financial sureties should be reviewed and upgraded on a regular basis by the permitting agency, and the results of the review should be publicly disclosed. The mining industry and governments should work more closely with NGOs to implement realistic review schedules and procedures for reviewing financial sureties.
Public Awareness	The public should have the right to comment on the adequacy of the restoration and closure plan and the long-term post-closure plan, the adequacy of the financial surety, and completion of restoration activities prior to release of the financial surety.
Guarantees	Financial surety instruments should be independently guaranteed, reliable, and readily liquid. Sureties should be regularly evaluated by independent analysts using accepted accounting methods. Self-bonding or corporate guarantees should not be permitted.
Release	Financial sureties should not be released until restoration and closure are complete, all impacts have been mitigated, and cleanup has been shown to be effective for a sufficient period of time after mine closure.

Source: www.frameworkforresponsiblemining.org

7.2 Financial Guarantees for Long-Term Post-Closure Activities

Long-term trust funds should be required if post-closure monitoring, operations and maintenance are needed over the long term or in perpetuity. These are separate mechanisms from restoration bonds. Whereas restoration bonds are released after the restoration requirements have been completed by the mining company, a long-term trust fund is established so that the corpus and its earnings are available for as long as needed (decades or even in perpetuity). Specific details of the long-term trust fund are critical to determining whether sufficient funds will be available to implement the post-closure plan over the long term or in perpetuity. These include:

(a) requirements for timing of payments into the trust fund
(b) how the government agency ensures that the trust fund is bankruptcy remote
(c) acceptable financial instruments
(d) legal structure of the trust for tax purposes
(e) who will pay the taxes on trust earnings and trust fees and expenses
(f) how taxes and trust fees will be paid on the trust if the mining company goes out of business
(g) who will make investment decisions if the operator is no longer viable
(h) if the government controls the investment decisions, what legal and ethical issues arise from the agency controlling investment decisions about investments in private companies, voting stock and similar issues if the trust owns stock

(i) the identity of the trust fund beneficiaries
(j) the identity and corporate structure of the operator with responsibility/ liability for financial assurance at this site

8 AUDITABLE AND ENFORCEABLE COMMITMENT LANGUAGE

An acceptable EIA document should not merely repeat the list of generic mitigation measures listed in the tables above. The accompanying text should describe the level of detail necessary for a reviewer to assure that the proposed mitigation meets its intended purpose, that the mitigation will be adequate to address the underlying environmental, economic or social issues. Nor will this generic language provide the kind of information needed by an auditor to confirm that obligations have been met, or an inspector to determine whether the project proponent is fulfilling its responsibility and commitments.

The wording and detail in the EIA document becomes even more critical in the absence of a connected permit or other means for government to independently craft and/or negotiate commitment language for proposed mitigation. Therefore, understanding the extent to which a country will rely on the EIA document itself to hold project proponents accountable for mitigation is important.

This section provides examples of the kinds of detail a reviewer should look for in determining whether commitment language will be sufficient to ensure that promised actions will be taken by a project proponent and that their adequacy can be determined over time.

The proposed mitigation should be clear about:

Who: The party responsible for taking action should be clearly assigned.

- Is the project proponent relying on the community to take certain actions?
- What is to happen when the project proponent is gone, after closure?

When: Timing issues are very important. Without a timeframe nothing will happen and whatever does happen may not be adequate:

- How long after mine closure would the project proponent monitor effluent of acid mine drainage? X years following closure? Until effluent is proven to be negligible?
- When would revegetation and regrading take place? Concurrently as the ore is extracted from a specific location? At the end of the mining operation? This could make a big difference in environmental impact, as concurrent restoration is much preferred and more effective.
- When would remedial action be taken if monitoring indicates there is a problem?
- Would it be within days? Weeks? Months? Would the operation need to shut down in the interim? Who would decide this?

What: Effectiveness will depend largely on what is being proposed:

- What performance standards will be used to interpret monitoring results?
- What level of treatment/control will be purchased and installed?
- What technology will be used and will it be sufficient to prevent, treat, or control the kind of contaminants that will be found in the effluent? Or emissions?

- What size wastewater treatment plant or drinking water treatment plant will be built and will it be sufficient for the expected flow?
- Are the species being used for revegetation indigenous to the area?

How: What resource commitments will be made to ensure that measures will be undertaken at the levels indicated?

- What financial commitments are made? What financial instrument is being used to guarantee adequate funds will be available to implement all commitments? How will financial guarantees be increased if they need to be adjusted during or after operations?
- Specify the staffing, management and oversight commitments.
- Specify all equipment commitments.

The following subsections present examples of language for financial assurance, water quality monitoring, restoration and revegetation, which could be used to ensure that the commitment language in the EIA is reviewable, auditable and enforceable.

8.1 Financial Assurance Example

The EIA shall include an estimate of the financial assurance needed to environmentally close and restore the site assuming a third party would undertake this effort should a sudden bankruptcy occur. Prior to the opening of the mine, the mine owner/operator shall prepare and submit to the government a financial assurance document that includes a financial assurance mechanism to which the government shall have direct access for the full value of the financial assurance costs to environmentally close and restore the site. Based on the performance of the financial assurance mechanism or new information indicating necessary revisions to the long-tem management plan, the government may update the amount needed in the financial assurance mechanism.

Key aspects of what makes this commitment language auditable/enforceable:

- Submittal of a financial assurance cost estimate which is part of the EIA process
- Review by the public and government of the financial assurance cost estimate
- Commitment of the mine owner/operator to fully fund the financial assurance at the opening of the mine

Based on environmental performance the financial assurance may be increased or decreased over the life of the mine to reflect improvements or degradation of environmental management.

8.1.1 Water Quality Monitoring Example

Table G-9 is an example of the location, type, sampling depth, purpose, and monitoring frequency for each monitoring site, as required in a mine-specific sampling and analysis plan. Also see Appendix F of this Guidance for further detail on what the plan should address. The plan should specify requirements such as:

- Groundwater monitoring wells shall be installed at A, B, C, D, etc. **[specify locations]**.

- Surface waters (streams, lakes, springs, and seeps) shall be monitored at E, F, G, H, etc. **[specify locations].**
- Piezometers shall be installed at I, J, K, etc. **[specify locations].**

Table G-9: Example of a Water Resource Monitoring Program

Site	Type	Sampling Depth	Monitoring Purpose	Monitoring Frequency
A	Well	300-400 feet	Downgradient of leach pad	Quarterly
B	Well	250-350 feet	Downgradient of waste rock pile	Quarterly
E	Maria Spring	0 feet (surface)	Adjacent to waste rock pile	Semi-annually
G	Jose Creek	0-2 feet	Upgradient of mine (baseline)	Annually
H	Jose Creek	0-2 feet	Downgradient of tailings impoundment	Annually
I	Piezometer	300-400 feet	Water table change resulting from pit dewatering	Quarterly

- Mining Company shall conduct all sampling as specified in the [**mine-specific sampling and analysis plan – See Appendix F of this Guidance].**
- Mining Company shall implement the [**mine-specific sampling and analysis plan**] throughout exploitation [or exploration if this is an exploration plan] and closure/restoration, and up to **[X years]** after mine closure, as determined by the Ministry.
- Mining Company shall conduct sampling at all sampling sites specified in Table X at the frequencies specified in Table G-9, and analyze all samples for the constituents in Table G-10, as required in the **[mine-specific sampling and analysis plan]. [Example only -- Ministry may wish to add or delete constituents, and will need to assign applicable water quality standards for each constituent].**
- All protocols in the **[mine-specific sampling and analysis plan]** shall be followed during sampling and analysis.
- Mining Company shall submit all sampling results to the Ministry within **[10 working days]** of receipt of sampling results from the analytical laboratory.
- Mining Company shall summarize the monitoring data and conduct trend analyses for all constituents in an annual report and submit it to the Ministry by **[date]** of each year.

Table G-10: Example of Monitoring Analytics [Example only – Fill in standards as appropriate. Ministry may wish to add or delete constituents, or revise water quality standards]

Constituent	Water Quality Standard (units)
Alkalinity (as CaCO3)	**Fill in standards as appropriate**
Total Suspended Solids	
Antimony	
Barium	
Boron	
Calcium	
Chromium	
Fluoride	
Lead	
Manganese	
Nickel	
pH (+ or - 0.1 standard units) Standard Units	
Selenium	
Sodium	
Thallium	
Weak Acid Dissociable (WAD) Cyanide	
Bicarbonate	
Aluminum	
Arsenic	
Beryllium	
Cadmium	
Chloride	
Copper	
Iron	
Magnesium	
Mercury	
Nitrate (NO3+NO2 as N)	
Potassium	
Silver	
Sulfate	
Total Dissolved Solids	
Zinc	
Turbidity	

8.1.2 Restoration Example

8.1.2.1 Stabilization of surface areas

(a) All exposed surface areas will be protected and stabilized to effectively control erosion and air pollution attendant to erosion.

(b) Rills and gullies, which form in areas that have been regraded and topsoiled and which either (1) disrupt the approved post-mining land use or the reestablishment of the vegetative cover, or (2) cause or contribute to a violation of water quality standards for receiving streams will be filled, regraded, or otherwise stabilized; topsoil will be replaced; and the areas will be reseeded or replanted.

8.1.2.2 Landslides and other damage

(a) An undisturbed natural barrier will be provided beginning at the elevation of the lowest bench to be mined and extending from the outslope for **[X distance** - determined by the Ministry**]** to assure stability. The barrier will be retained in place to prevent slides and erosion.

(b) At any time a slide occurs which may have a potential adverse affect on public property, health, safety, or the environment, the person who conducts the surface mining activities will notify the Ministry by the fastest available means and comply with any remedial measures required by the Ministry.

8.1.2.3 Contemporaneous restoration

Restoration efforts, including but not limited to backfilling, grading, topsoil replacement, and revegetation, on all land that is disturbed by surface mining activities shall occur as contemporaneously as practicable with mining operations

8.1.2.4 Backfilling and grading: timing

Rough backfilling and grading for surface mining activities should be completed within **[X period of time]** after the ore has been removed from the pit.

8.1.2.5 Backfilling and grading

Disturbed areas will be backfilled and graded to: (a) Achieve the approximate original contour; (b) Eliminate depressions except if they are needed to retain moisture, minimize erosion, create and enhance wildlife habitat, or assist revegetation in small depressions or (previously mined highwalls) of this section; (c) Achieve a post-mining slope to prevent slides; (d) Minimize erosion and water pollution both on and off the site; and (e) Support the approved post-mining land use.

8.1.2.6 Revegetation

Following backfilling and regrading, the slopes shall be prepared for an appropriate seed mixture designed for the mine site and final land use. The seed mixture if possible shall consist of native species without noxious weeds. Weed-free straw or other type of mulching material shall be placed over seeded areas to retain moisture and reduce erosion, if appropriate. Seeding shall be done at the appropriate time of time of year to ensure rapid growth.

Long-term revegetation monitoring of reclaimed areas will be done annually over the life of the project and up to **[five years]** after closure to ensure revegetation meets project specific performance standards. Long-term revegetation monitoring will consist of the following: collecting annual data over the life of the project and for **[five years after closure]** on existing and newly restored areas; documenting trends in vegetation parameters over time; identifying areas where revegetation may be failing; and providing recommendations for maintaining revegetated areas. Monitoring reports will contain:

- Monitoring locations and justification
- Area-wide monitoring and cover sampling data will be recorded on field forms
- Cover sampling method using either the Point-Quadrat Method, 35mm Slide Method,
- Bitterlich’s Variable Radius Method, or other method approved by the Ministry. Each method will use transects that will be established in reclaimed and undisturbed areas. In restored areas, sample transects and sample locations will be located to represent a one-dimensional “square grid” pattern
- Quality assurance and control measures including field duplicates, error limits, and statistical validity
- Measures to be taken if results do not meet expectations

H. ENVIRONMENTAL MANAGEMENT PLAN

An Environmental Management Plan (EMP), might be required as part of the submission of the EIA, may be required to accompany it, or may even be called something different. As presented in the Table H-1, an EMP consists of a series of components or plans. These include plans for water management, vegetation removal, blasting, mitigation, monitoring, and others. The EMP serves to combine elements of environmental management that might be built into the actual design of the mine and its infrastructure, monitoring and mitigation as adopted by the project proponent. As described in Table H-1, each of these plans requires certain inputs. Throughout these guidelines, approaches are presented to assist reviewers of these plans to ensure that each of these plans meets the goals of the overall EIA. Table H-1 in particular presents mitigation approaches that should be considered in these plans. Finally, it is recognized that each CAFTA-DR country has its own basic requirements for an EMP which may vary somewhat from what is presented below. However, the basic concepts presented in this table should be considered when developing environmental management components for various types of mines.

It is important that any financial assurance measures, which are usually separate from the EMP, be reviewed for consistency with the elements of the EMP, particularly that financing will support commitments to long term monitoring and maintenance, which may need to continue even post-closure.

Table H-1: Components of an Environment Management Plan

PLAN		INPUT
WATER QUALITY MANAGEMENT	General	• Describe measures to be implemented to manage water; and • Identify and assess how to divert natural runoff away from the mine site to prevent pollution of this water.
	Water Use and Recycling	• Describe methods to be used to minimize the volume of fresh water that is used for ore processing and to maximize the recycling of water; and • Describe how to avoid or minimize the use of reagents that require treatment prior to effluent discharge.
	Water quality	• Predict metal leaching and acidic drainage potential based on the identification and description of all geological materials (including wall rock, waste rock, and overburden) to be excavated, exposed or otherwise disturbed by mining; • Present timing and conditions during which metal leaching and acidic drainage are expected to occur; and • Determine other potentially harmful components in mine wastewater, including processing reagents, ammonia, algae-promoting substances, thiosalts, chlorides and elevated pH.
	Monitoring	• Provide a water monitoring program indicating the locations on site maps of potential mine water and seepage sampling stations and mine waste areas; • Develop a Sampling and Analysis Plan for water sampling, handling and analyses protocols (where analyses are completed by outside laboratories, metal mines should have copies of the protocols used); • Develop a database that is updated as sampling is undertaken including hydro-climatological data including but not limited to rainfall, air temperature, solar radiation, relative humidity, wind direction and speed, evaporation, water levels in wells, stream flow and water quality;

Table H-1: Components of an Environment Management Plan

PLAN		INPUT
		• Provide a methodology to calibrate hydrological models that were used in planning the water management system.
WASTEWATER MANAGEMENT	Diversion and Wastewater Stream Consolidation	• Define how best to consolidate treatment for all wastewater sources; • Describe methodologies such as the use of ditches or dikes to divert all clean streams and drainage runoff away from areas of possible contamination, and locate these structures on maps; • Define and locate on maps effluent discharge points and their relationship to environmentally sensitive areas; and • Show typical ditches and water holding facilities designed for extreme runoff events (100-year or maximum probable runoff events).
	Wastewater	Develop a wastewater treatment plan based on: • The water management plan; • The results of prediction of wastewater quality; • The waste rock and tailings disposal plans; • Relevant regulatory requirements for effluent quality; and • Relevant environmental performance indicators, including any water quality objectives.
	Domestic Wastewater and Sewage Disposal	• Develop a plan for sewage or domestic wastewater treatment with the objective that these facilities are to prevent the contamination of surface water and groundwater, including drinking water supplies, and meet all applicable regulatory standards. Sludge from the treatment of sewage and domestic wastewater should be disposed of in an acceptable manner. • Define a program for sludge disposal on site or in a landfill. If acceptable, it may be used as cover material for tailings or waste rock, or it may be disposed of off site.
	Long-term Wastewater Treatment	At sites where it is determined that long-term treatment of wastewater will be necessary during post-closure, a long-term wastewater treatment plan should be developed and implemented. This plan should include the following elements: • Identification of roles and responsibilities of persons to be involved in operation and maintenance of the treatment system; • Identification of the type of treatment system to be used; • Identification of any by-products from the treatment system, such as treatment sludge, and management plans for the disposal of those by-products; • Identification of routine maintenance activities to be conducted on the treatment system and the frequency; • Identification of monitoring to assess ongoing performance of the treatment system and the frequency; • Identification of reporting requirements for internal management and regulatory agencies; and • Description of contingency plans to address any problems associated with the treatment system. Consideration should be given to the implementation of a passive treatment system. In some cases, these systems may have lower maintenance requirements than traditional treatment systems, although all systems do require some degree of ongoing maintenance.

Table H-1: Components of an Environment Management Plan

PLAN		INPUT
GEOLOGY AND SOILS	Soil and Overburden Management	• Provide site-specific procedures to ensure that overburden (non-acid), particularly organic soils, excavated from the mine site during construction is preserved and stockpiled for future reuse in site rehabilitation. • Show stockpiles on map. • Describe how erosion and sedimentation will be limited. • Define measures to be put in place to ensure that stockpiled material is not contaminated during mine operations.
	Erosion and Sediment Control	• Determine site erosion potential and identify water bodies at risk; • Develop a recontouring plan designed to reduce the susceptibility of soil to erosion; • Define a program for revegetation and maintenance of buffer zones adjacent to water bodies for erosion control; • Develop a plan to divert site drainage away from cleared, graded, or excavated areas; • Define how the mine will use and maintain sediment barriers or sediment traps to prevent or control sedimentation and direct surface runoff from erodible areas to a settling pond prior to discharge to the environment; and • Present a monitoring and maintenance program to ensure that erosion and sediment control measures are effective.
	Geologic Materials	Develop a site-specific program for the identification and description of rock and other geological materials that will be or have been moved or exposed as a result of mining activity. This should include, for each material: • Spatial distribution of the material, as well as the estimated mass of material present; geological characterization of the material, including its mineral and chemical composition; physical characterization of the material, including grain size, particle size and structural characteristics including fracturing, faulting and material strength; • Hydraulic conductivity of the material; and • The degree of any oxidation of the material that has taken place. • All rock units and other geological materials that will be or have been moved or exposed as a result of mining activity should be tested for their metal leaching and acid generation potential. The testing program should be designed to meet site-specific needs, using a combination of static and kinetic test methods, as appropriate.
WASTE MANAGEMENT	Solid Waste	Develop a plan for the disposal of solid waste generated by the mine operation. This would include: • The location and design of a solid waste landfill and the separation of potentially hazardous wastes from the disposed of solid waste; • Wastes from on-site kitchen and dining facilities should be disposed of in a manner that does not attract wildlife. • Develop measures that should be put in place to ensure that all food wastes and food containers are properly disposed of, including those used away from kitchen and dining facilities. • Define training programs to ensure that all employees and on-site contractors are aware of the importance of proper disposal of food wastes and the importance of not feeding wildlife on site.
	Tailings (metal mines) and Waste Rock Disposal	Based on the results of site-specific programs for the prediction of water quality, develop a plan for waste rock and tailings disposal management that includes limiting the production of waste rock with acid generation or metal leaching potential. Design alternatives to accomplish this should

Table H-1: Components of an Environment Management Plan

PLAN		INPUT
		be assessed, including: • Preventing or limiting the availability of oxygen to the acid-generating material by disposing of potentially acid generating waste rock or tailings under a water cover; • Using composite covers with a saturated layer to limit infiltration of oxygen; • Blending or layering potentially acid generating material with neutralizing materials; • Segregating or encapsulating potentially acid generating or metal leaching material from other material to facilitate efficient management of material; • Appropriate engineered design of capture and treatment system for drainage from waste rock and tailings (e.g., underliners, toe drains, etc.); • Designing facilities to prevent exposure of wildlife to contaminated water in ponds, ditches, toe drains, etc.; • Diverting surface water away from storage areas to minimize flushing and volumes of effluent. Develop and present site plans for waste rock piles and tailings management facilities with locations based on: • Local and regional surface water and groundwater flow and potential surface water and groundwater contamination; • Water management scheme and preliminary water balance; • Topography; • Sites of existing (open or closed) waste rock piles; • Existing and possible future land and resource uses, including use of the receiving watershed and distance from habitation and areas of human activity; • Baseline environmental conditions, including natural flora and fauna; • Potential impacts on vegetation, wildlife, aquatic life and any downstream communities; • Condition of basin and dam foundations; deposition plane and storage volume/capacity; preliminary design of containment and water management structures; potential impact area; • Potential releases of airborne particulate matter; • Aesthetic considerations; • Mine closure considerations. The rationale for the selection of the site should be clearly documented, including discussion of alternate sites that were considered and rejected. Present designs of tailings and waste rock facilities based on: • Physical and chemical characteristics of the tailings and waste rock material, including metal leaching and acidic drainage potential, as well as the potential for liquefaction; hydrology and hydrogeology, including local climatic conditions and extreme weather events (projections of increased extreme weather events as a result of global climate change should also be included); • Foundation geology and geotechnical considerations, as well as seismic data and earthquake risk; availability and characteristics of construction materials; • Topography of the tailings management facility and adjacent areas; • Maximize retention time of waste water to allow for settling of suspended solids and the natural degradation of contaminants such as

Table H-1: Components of an Environment Management Plan

PLAN		INPUT
		ammonia and cyanide; • Long-term monitoring and inspection of containment structures for tailings and waste rock management facilities; and • Long-term stability even during adverse climatic conditions (hurricanes, etc.). Stringent engineering standards should be employed including having structure withstand a probable maximum flood (PMF) event and being designed to remain structurally stable in the event of a maximum credible earthquake (MCE).
BIOLOGICAL RESOURCES	Restoration	Develop a plan showing that progressive rehabilitation of waste rock piles and tailings management facilities is carried out during the mine operations phase, to the extent feasible. Progressive restoration activities should be carried out in a manner consistent with the site-specific objectives for mine closure and the intended post-closure land use for the site, as identified in the closure plan. The planning and implementation of progressive restoration measures should include consideration of: • The final contouring of waste rock piles, tailings, leach pads, and borrow pits; • The establishment of a final drainage system; • The establishment of wet covers or dry covers, where these cover systems are to be used to prevent or control acidic drainage; • The revegetation of exposed areas; • Progressive restoration of mine site infrastructure should be carried out during the mine operations phase, to the extent feasible. This may include roads that are no longer used and areas affected during earlier activities, such as drill pads or campsites established during the exploration or construction phases.
	Vegetation Clearing	• Develop a plan to minimize areas to be cleared; • Define on maps buffer zones of natural vegetative cover showing that at least 100 m of natural buffer zones are retained wherever possible between cleared areas and adjacent bodies of water; and • Present a plan to show that the time between clearing of an area and subsequent development is minimized.
	Environmentally Sensitive Areas	Show on plan view and use of typical drawings that all mine facilities are located and designed to avoid environmentally sensitive areas. The determination of environmentally sensitive areas should be undertaken in consultation with appropriate stakeholders, local communities and government officials.
	Revegetation	A revegetation plan should be developed for the mine, with consideration of the following: • Re-establishing soil cover on the site with consideration being given to the characteristics of the soil that will be used as well as the soil requirements of the vegetation to be established on the site. • Species used in revegetation and the resulting plant community should be consistent with the goals of mine closure and the intended post-closure use of the site. Species native to the area around the mine site should be used for this purpose, and invasive species should never be used. • Monitoring programs should be designed and implemented during mine closure to ensure that closure activities and any associated environmental effects are consistent with those predicted in the closure plan and to ensure that the objectives of mine closure are being met.

Table H-2: Components of an Environment Management Plan

PLAN		INPUT
CHEMICALS MANAGEMENT	Cyanide Management (metal mines)	Define cyanide management practices based on the International Cyanide Management Code (International Cyanide Management Institute, 2008) taking into account: • Measures to minimize the amount of cyanide required, thereby reducing reagent use and limiting concentrations in tailings; • Design and implementation of measures to manage seepage from cyanide facilities to protect surface water and groundwater; • Design and operation of cyanide treatment systems to reduce cyanide concentrations in effluent discharged to the environment; • Design and implementation of spill prevention and containment measures for process tanks and pipelines; • Measures to prevent exposure of wildlife to cyanide in ponds and ditches. If natural degradation of cyanide is to be used as a treatment method for cyanide, the tailings management facility should be designed to ensure that the retention time of the liquid phase is adequate for natural degradation to occur during high flow conditions.
	Spill Prevention and Control	Develop a plan to design and construct chemical storage and containment facilities to meet the appropriate standards, regulations and guidelines of pertinent regulatory agencies and the owner/operator's environmental policy, objectives and targets. Site-specific chemical management procedures should be developed and implemented for the safe transportation, storage, handling, use and disposal of chemicals, fuels and lubricants. As a minimum, chemical storage and containment facilities should: • Be managed to minimize the potential for spills; • Provide containment in the event of spillage and be managed to minimize opportunities for spillage; • Comply with international standards; • Ensure that incompatible materials are stored in ways to prevent accidental contact and chemical reactions with other materials; and • Minimize the probability that a spill could have a significant impact on the environment. • Ensure for maintenance shops that potential contaminants, such as used lubricants, batteries and other wastes, are properly managed with appropriate disposal mechanisms for these materials. Stores should be managed such that potentially hazardous materials are handled in accordance with procedures detailed in the environmental management system for the mine. • The Spill Prevention and Control plan should be evaluated periodically to determine possibilities to reduce the quantities of potentially harmful chemicals used.

Table H-3: Components of an Environment Management Plan

PLAN	INPUT
Access Roads	Define measures that will be designed and implemented to prevent and control erosion from roads associated with mining facilities. These measures should include: • Providing buffer zones of at least 100 m between roads and water bodies to the extent practicable; • Designing road grades and ditches to limit the potential for erosion, including avoiding road grades exceeding 12% (5% near water bodies). • Designing and constructing stream crossings for roads in a manner that protects fish and fish habitat preventing sedimentation of the streams and not obstructing movement of fish.
Pipelines	• Provide the routes of pipelines on maps. Routes should be selected so as to limit risk of harm to aquatic, terrestrial ecosystems and animal migration routes in the event of a failure. • Show that pipelines will be designed to minimize the risk of failure; • Define measures to limit impacts in the event of a failure; • Develop an inspection plan for pipelines with inspections taking place on a regular basis to ensure they are in good condition; and • Define monitoring systems to alert operators in the event of a potential problem.
Conveyor Belts	• Provide a map showing the routes of conveyor systems. Routes should be selected so as to limit risk of harm to aquatic, terrestrial ecosystems and animal migration routes, including in the event of a failure; • Describe how these routes were chosen to limit risks to the environment or human health from airborne particulate matter associated with the systems; • Define how conveyor systems will be constructed to prevent discharge of material into water bodies, and prevent or limit the release of airborne particulate matter; • Define how loading and off-loading facilities for conveyor systems will be constructed to prevent or limit the release of airborne particulate matter from loading and off-loading operations.
Facilities Monitoring	• Develop a monitoring program to check and report on the performance, status and safety of water management facilities; • Define a pipeline inspection program to evaluate flow and hydraulic integrity; • Describe a water quality and level monitoring program for retention facilities, such as tailings management facilities, sedimentation ponds and polishing ponds; • Describe inspection measures for drainage ditches and dikes to evaluate sediment accumulation and bank erosion and damage; • Develop an inspection program for tailings and waste rock management facilities with regard to performance monitoring, instability indicators, stability monitoring, tailings deposition, water management and control, and quality of effluent; • Provide construction controls, including the use of a construction management program; • Provide quality assurance and quality control measures for all aspects of operations, monitoring and inspections; • Ensure that the potential of waste rock and tailings for metal leaching and acidic drainage is continually assessed;

Table H-3: Components of an Environment Management Plan

PLAN		INPUT
		• Develop a plan to collect data required for modeling; assess the level of acid generation when oxidizing reactions are occurring, and assess acidity and reaction products that are potentially available to migrate; • Describe how to evaluate the effectiveness of measures that have been implemented to prevent and control metal leaching and acidic drainage; • Describe how to continually characterize treatment sludge to determine whether there are potential leaching concerns; • Describe disposal and monitoring of sludge from treatment of acid generating wastes; • Develop a plan to identify potential sources of ammonia, including explosives and cyanate hydrolysis and monitor accordingly; • Provide a monitoring program to ensure the mine meets the International Cyanide Code; • Provide a monitoring program for thiosalts;
AIR QUALITY AND CLIMATE	Climate Change (Carbon reduction)	Develop strategies for reducing carbon releases to the atmosphere and describe how they will be implemented. The carbon reduction plan should address the use of heavy equipment, including vehicles that are fuel efficient and/or use alternative fuel. Define methods to reduce greenhouse emission as described below under the Emission Control Plan.
	Emissions Control	Develop site-specific plans to be implemented to minimize releases of air borne emissions, including greenhouse gases. Plans should describe: • Potential sources of releases of airborne emissions, including greenhouse gases; • Factors that may influence releases of airborne emissions, including greenhouse gases; • Measures to minimize releases of airborne emissions, including greenhouse gases. Engines in vehicles and stationary equipment should be maintained and operated in a manner that minimizes emissions of air contaminants, particularly: total particulate matter (TPM); particulate matter less than or equal to 10 microns (PM • 10); particulate matter less than or equal to 2.5 microns (PM • 2.5); sulphur oxides (SO • x); nitrogen oxides (NO • x); volatile organic compounds (VOCs); carbon monoxide (CO), carbon dioxide (CO2) and other greenhouse gases; • The applicable standard for each air contaminant, consistent with national or international standard. For example, in Canada the concentration of particulate matter less than 2.5 microns in size (PM2.5) should not exceed 15 ìg/m^3 (24-hour averaging time) outside the boundary of a mining facility; • Monitoring and reporting programs for releases of airborne emissions, including greenhouse gases; • Mechanisms to incorporate the results of monitoring programs into further improvements to measures to minimize releases; and • Mechanisms to periodically update the plans.
	Particulates	Develop site-specific plans to be implemented to minimize releases of airborne particulate matter. These plans should describe: • Potential sources of releases of airborne particulate matter, including specific activities and specific components of mine infrastructure; • Factors that may influence releases of airborne particulate matter, including climate and wind;

Table H-3: Components of an Environment Management Plan

PLAN		INPUT
		• Potential risks to the environment and human health from releases of airborne particulate matter; • Measures to minimize releases of airborne particulate matter from the sources identified; • Monitoring programs for local weather, for consideration in the ongoing management of releases of airborne particulate matter; • Monitoring and reporting programs for releases of airborne particulate matter and for environmental impacts of releases; • Mechanisms to incorporate the results of monitoring programs into further improvements to measures to minimize releases; and • Mechanisms to periodically update the plans..
NOISE AND VIBRATION	Noise	Define site-specific assessments to be conducted to identify sources, or potential sources, of noise; and measures should be implemented to reduce noise levels from these sources. Such measures should include consideration of: • Elimination of noise sources; • The purchase of equipment with improved noise characteristics; • Proper maintenance of equipment; • Enclosure or shielding of sources of noise; • Suppression of the noise at source; locating noise sources to allow natural attenuation to reduce levels to potential recipients; and • The operation of noise sources only during hours agreed to in consultation with local communities. Monitoring should be conducted to assess the effectiveness of these measures and, if national or related international standards are exceeded, so that improvements in noise reduction can be made. For mines in areas where ground vibration and noise from blasting are not regulated, ensure that blasts do not exceed acceptable criteria. For example, ground vibration of 12.5 mm/sec peak particle velocity measured below grade or less than 1 metre above grade; and concussion noise of a maximum of 128 dB.
	Blasting Plan	• Provide safety protocols that ensure their use during blasting operations such as safety zones to prevent unauthorized entry, warning signals to alarm nearby workers and residents of impending blasts and all clear signals to note when the area is safe to reenter • Define blasting times during hours agreed to in consultation with local communities. • Define the size of explosive charges to minimize vibrations. • Allow for natural attenuation of explosive charges to reduce-noise and dust or debris at the source and impacts to nearby residents. • Provide for the enclosure or shield sources of noise from blasting including the construction of berms around the site. • Ensure that blasts do not exceed acceptable national or international vibration criteria. For example limit ground vibrations to below 12.5 mm/s peak particle velocity, and limit air vibrations to 133 dB. • Provide a monitoring program to assess the effectiveness of these measures against national or international standards so that the need for improvements in noise and vibration reduction can be identified and implemented. Use monitoring equipment compliant with the International Society of Explosives Engineers standard "Performance Specifications for Blasting Seismographs."

Table H-4: Components of an Environment Management Plan

PLAN	INPUT
Temporary and Long-term Mine Closure	• Develop a program that requires that the anticipated costs of mine closure are re-evaluated regularly throughout the mine life cycle. The mine owner/operator should ensure that adequate funds are available to cover all closure costs, and the amounts of any security deposits should be adjusted accordingly. • For mines where it is determined that long-term monitoring, maintenance or effluent treatment will be necessary post closure, mechanisms should be identified and implemented that will ensure that adequate and stable long-term funding is available for these activities. In determining funding levels required, consideration should be given to contingency requirements in the event of changes in economic conditions, system failures, or major repair work post closure. • Develop a plan for the care and maintenance of the mine site in the event that mine operations are suspended or the mine otherwise becomes inactive. The plan should include continued monitoring and assessment of the environmental performance of the site, as well as the maintenance of all environmental controls necessary to ensure continued compliance with relevant regulatory requirements. • The final mine closure plan should address the following environmental aspects: underground and open pit mine workings; ore processing facilities and site infrastructure; waste rock piles and tailings management facilities; sludge disposal areas as well as ongoing and post-closure sludge disposal requirements; water management facilities; landfill and waste disposal facilities; and exploration areas.
Decommissioning	• Describe a decommissioning program for underground and open pit mines showing that any contamination associated with vehicle and equipment operations and maintenance will be remediated. • Describe how underground mine workings will be secured with signs being posted warning the public of potential dangers associated with the facility and how excess will be limited. • Describe the risk of subsidence in underground mines and what measures will be taken to limit this from occurring (e.g. the backfilling of underground voids.) • Develop a plan for closing open pits to prevent unauthorized access and to protect public safety. Consider backfilling , installing fencing and berms, and other design measures to protect the public. • State how signs will be posted warning the public of potential dangers associated with the site. • Describe the potential for mine water discharges, where mine water discharge is predicted, flow rates, predicted water quality, and plans for long-term prevention or treatment. • Develop a plan that shows how on-site facilities and equipment that are no longer needed will be removed and disposed of in a safe manner. • Develop a plan for the rehabilitation of roads, runways or railways that will not be preserved for post-closure use with bridges, culverts and pipes being removed so that natural stream flow is restored, and stream banks are stabilized with vegetation or by using rip-rap. In addition, the plan should show that surfaces, shoulders, escarpments, steep slopes, regular and irregular benches, etc., are to be rehabilitated to prevent erosion with surfaces and shoulders

Table H-4: Components of an Environment Management Plan

PLAN	INPUT
	being scarified, graded into natural contours, and revegetated. • Define a program that shows how electrical infrastructure, including pylons, electrical cables and transformers, will be dismantled and removed, except in cases where this infrastructure is to be preserved for post-closure land use or will be needed for post-closure monitoring, inspection and maintenance. If polychlorinated biphenyls (PCBs) were used on site, any equipment and soils contaminated with PCBs should be disposed of in accordance with relevant regulatory requirements. • Describe a program that shows how waste from the decommissioning of ore processing facilities and site infrastructure, such as waste from the demolition of buildings and the removal of equipment, will be removed from the site and stored in an appropriate waste disposal site or disposed of on site in an appropriate manner in accordance with relevant regulatory requirements. If material is disposed of on site, the location and contents of the disposal site should be documented.
Long-term Monitoring and Maintenance	At sites where long-term risks are identified a long-term monitoring and maintenance plan for waste rock piles, leach pads, open pits, and tailings management facilities should be developed and implemented, as appropriate, to ensure post-closure monitoring and maintenance of these facilities. This plan should include the following elements: • Identification of roles and responsibilities of persons to be involved in monitoring and maintenance; • Identification of aspects to be monitored and the frequency; • Identification of routine maintenance activities to be conducted and the frequency; • Description of contingency plans to address any problems identified during routine maintenance and monitoring; • Description of financial assurance to ensure funds will be available as long as needed (e.g., in perpetuity) to cover the cost of full implementation of the long-term monitoring and maintenance plan. The plan should show that at the end of the mine operations phase, plans for management of waste rock and tailings to prevent, control and treat metal leaching and acidic drainage should be re-evaluated and revised as necessary, to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider: • The results of the re-evaluation of the performance of these facilities; • The performance of progressive reclamation to date; and • Possible alternative technologies for closure. At sites where there is an identified long-term risk of metal leaching or acidic drainage, the site-specific monitoring program should be revised and updated to ensure that monitoring will be consistent with objectives and plans of mine closure and post closure. The revised plans should include the following elements: • Identification of roles and responsibilities of persons to be involved in monitoring; • Identification of parameters to be monitored and the frequency; and • Description of contingency plans to address any problems identified during routine monitoring.

Table H-5: Components of an Environment Management Plan

	PLAN	INPUT
CONTINGENCY PLANS	Contingency plans are those put in place to address predicted risks should other mitigation measures in the environmental management plan fail to be adequate. It assumes that risk identification and risk reduction have been addressed in other parts of the EIA.	
	Performance-related Contingency Plans	Plans to describe the steps that will be taken to respond to failure to • Environmental Standards are not being met • Impacts are greater than predicted • The mitigation measures and/or rehabilitation are not performing as predicted. Contingency Plans should include steps to ensure: • Persons responsible and accountable for response, their roles, contact information • Steps to be taken to minimize adverse environmental and socio-economic-cultural harm • Timely response • Commitment of staff and resources such as equipment on hand or accessible as needed for response • Appropriate notification of officials • Appropriate notification of the public
	Risks from Natural Disasters	For risks identified within the impact assessment, including risks from: • Hurricaines • Flooding • Mudslides • Seismic activity--earthquakes • Tsunamis • Volcanic Activity Contingency plans should include: • Persons responsible and accountable for response, their roles, contact information and alternates • Steps to be taken to minimize adverse environmental and socio-economic-cultural harm • Coordination with national and local response efforts • Equipment on hand and needed for response • Relevant training programs • Relevant notification requirements for government and the public
	Other risks	These might include risks from storage and management of hazardous or toxic chemicals, leaching into groundwater, dam or impoundment breaches etc. that may not be adequately covered in the other elements of the Environmental Management Plan

I. REFERENCES AND GLOSSARY

This chapter includes cited references, additional references and a glossary.

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3 GLOSSARY

Action: Activity to meet a specific purpose and need, which may have effects on the environment and may potentially be subject to governmental control or responsibility. For this document, the term action applies to a specific project.

Adit (drift): A horizontal, or nearly horizontal, passage driven from the surface for a working of a mine. If driven through the hill or mountainside to the surface on the opposite side, it would be a tunnel.

Aesthetic quality: A perception of beauty of natural or cultural landscape.

Affected environment: The existing conditions of the human and natural environments in the areas that could potentially have impacts.

Agglomeration: An ore concentration process based on the adhesion of pulp particles to water.

Aggradation: The deposition of sediment by running water as in the channel of a stream.

Air quality: A measure of health-related and visual characteristics of the air often derived from quantitative measurements of concentrations of specific substances.

Alluvium: Sand, gravel, silt or similar material deposited during comparatively recent geologic time by running water in the bed of a stream, river, floodplain or at the base of a mountain slope.

Alternatives: In an EIA this term refers to options for the project.

Alternative energy: Renewable energy sources such as wind, water, solar, biomass as an alternative to nonrenewable resources such as oil, gas, and coal.

Amalgamation: The process by which mercury is alloyed with some other metal to produce an amalgam. It was a widely used practice at one time for the extraction of gold and silver from pulverized ores, which has been more recently been superseded by the cyanide process.

Ambient: The environment surrounding a body but undisturbed or unaffected by it. For example, ambient air is the air surrounding the site.

Anion: A negatively charged ion.

Aquatic: Growing or living in or near the water.

Aquifer: A water-bearing rock unit that yields water in a usable quality to a well or spring.

Archeological site: A discrete location that provides physical evidence of past human use.

Ash fall: A rain of airborne volcanic ash falling from an eruption cloud; a deposit of volcanic ash resulting from such a fall and lying on the surface.

Backfill: Mine waste or rock that replaces the void left from where the ore or rock as been removed.

Base flow: The contribution of the stream discharge from groundwater seeping into the stream.

Baseline: Existing conditions against which impacts of the proposed action and its alternatives can be compared.

Bedrock: Any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

Benches: A name applied to ledges of all kinds of rock that are shaped like steps or terraces. They can be developed by natural processes or artificial processes such as excavation in mines or quarries.

Bench mark: A fixed point of reference.

Beneficiation: The dressing or processing of ores for the purpose of regulating the size; removing unwanted constituents; or improving the quality, purity or assay grade.

Best management practices: A suite of techniques that guide or may be applied to management actions to aid in achieving desired outcomes and help to protect the environmental resources by avoiding or minimizing impacts of an action.

Bioaccumulation: Refers to the accumulation of substances, such as pesticides, or other organic chemicals in an organism. Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost.

Bioavailability: Bioavailability refers to the difference between the amount of a substance or chemical, to which a plant or animal is exposed and the actual dose of the substance the entity receives.

Biodiversity: Refers to the variation of life forms within a given ecosystem. Biodiversity is often used as a measure of the health of the biological system.

Block caving: An underground mining method where a thick block of ore is cut off from the surrounding ore blocks by various methods so that it breaks off and caves under its own weight.

CAFTA-DR countries: Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras and Nicaragua.

Catchment: A reservoir to catch and retain surface water.

Cation: An ion having a positive charge.

Commercial mining: Extraction of ore for sale for a profit by a company or organization as opposed to an individual prospector removing materials for a subsistence livelihood.

Concentrates: Enriched ore after the removal of waste.

Concentration: Separation and accumulation of economic minerals from waste rock; increasing the strength of aqueous solutions by evaporating part of their water.

Contact: The place or surface where two different types of rock meet.

Creep: A slow movement of rock debris or soil due to gravity down a slope. It is usually imperceptible except for observations over a long period of time.

Crosscut: A small passageway driven in an underground mine at right angles to the main entry to connect it with a parallel entry or an air course. In general it is a passageway driven across two openings for any mining purpose.

Crushing: The reducing of ore or materials by stamps, crushers, or rolls.

Cultural resources: Remains of human activity, occupation or endeavor as reflected in districts, sites, buildings, objects, artifacts, ruins, works of art, architecture and natural features important in human events.

Cumulative impact: The impact on the environment that results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions.

Cut and fill: In earthen structures in the construction of roads or railroads on undulating ground, the sections along the road or railroad that are partly excavated and then partly filled.

Deforestation: The clearance of naturally occurring forests by the processes of logging and/or burning of trees in a forested area.

Degradation: Wearing away and generally lowering the earth's surface by the process of weathering or erosion.

Dewatering: Removing water from a mine by pumping, drainage or evaporation.

Direct impact (or effect): This impact is caused by an action that occurs at the same time and same place as the activity.

Discharge: Outflow of surface water in a stream or canal. Discharge may come from an industrial facility and may contain pollutants.

Diversion: A channel, embankment or other manmade structure used to divert water.

Drainage: Artificial or natural removal of surface water or groundwater from a certain area.

Drawdown: The decrease in the elevation of the water surface in a well, or local water table or the pressure head of an artesian well due to the removal of groundwater or decrease in the aquifer's recharge.

Drift (adit): A horizontal, or nearly horizontal, passage driven from the surface for a working of a mine. If driven through the hill or mountainside to the surface on the opposite side, it would be a tunnel.

Dump: A spoil heap at the surface of a mine. A pile or heap of waste rock material or other non-ore refuse near a mine.

Ecology: The relationship between the environment and living organisms.

Ecoregion: An area that is defined by its ecology and covers relatively large areas of land or water, and contains characteristic, geographically distinct assemblages of communities and species.

Ecosystem: A complex system of a community of plants, animals and the system's chemical and physical environment.

Effect (or impact): A modification of the existing environment caused by an action of the project. The effect, or impact, may be direct, indirect or cumulative.

Emission: Matter discharged into the atmosphere and used as a measure of air quality.

Endangered species: A plant or animal that is in danger of extinction throughout all or a significant portion of its range.

Environmental Impact Assessment (EIA): A document prepared to analyze the impacts of a proposed action and released to the public for review and comment.

Environmental Justice: Fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the enforcement of environmental laws and policies. Fair treatment means that no group should bear a disproportionate share of negative environmental consequences.

Ephemeral stream: A stream that flows only in direct response to precipitation.

Erosion: Wearing away of land by water, wind, ice or other geologic agents.

Fault: A fracture, or fracture zone, along which there has been displacement of the two sides relative to another parallel to the factures. Displacement may be centimeters or thousands of meters. In geology there are many varieties of faults.

Filtration: A process for separating liquids from solids by allowing the liquid to pass through a finely woven cloth.

Fines: A very small material produced in the breaking up of large lumps of ore. In metallurgy it is a size of particle that is smaller than a specified size.

Fines tailings: Refuse from mineral preparation of a smaller than specified size.

Flotation: A method of mineral separation in which a froth, created in water by a variety of reagents, floats some fine particles of crushed minerals whereas other minerals sink.

Floodplain: The part of a stream or river valley adjacent to the channel that is built of sediments and becomes inundated when the stream or river tops its banks.

Folding: The bending of strata. Folds usually result from compression that causes the formation of geologic structures known as anticlines, synclines, monoclines, and isoclines. Folds range in size from centimeters to thousands of meters.

Fracturing: A fracture is the character or appearance of a freshly broken surface of rock or a mineral. It is a break in the continuity of a body of rock not attended by movement on one side or the other.

Fumarole: A hole in a volcanic region from which gases and vapors issue at high temperature.

Geochemistry: The study of the chemical components of the earth's crust and mantle. It is applied to mining exploration to detect sites that indicate concentrations of the elements being sought. Geochemical exploration samples soils, rock and lake and stream sediments.

Geographic information system: A system of computer software, hardware, data and applications that capture, store, edit and analyze and has the capability to graphically display a wide array of geospatial information.

Geologic formation: A distinct rock unit that is distinguished from adjacent rock by a common characteristic such as its composition, origin, or fossils associated with the unit.

Geologic structure: Refers to the disposition of the rock formations, that is, the broad dips, folds, faults and unconformities at depth.

Geomechanical properties: Physical behaviors of soils and rock defined by the study of rock mechanics or soil mechanics which are applied to mine design, tunnel design, rock breakage, and rock drilling,etc.

Geophysical survey: In exploration, properties of the subsurface rock formations such as electrical, magnetic, seismic, thermal, etc., are measured and mapped.

Grade: The classification of an ore according to the desired or worthless material in it or according to the value. An ore which carries a great or comparatively small amount of valuable metal is called a high- or low-grade ore. In road construction the meaning is used to designate slope.

Gradient (up and down): The inclination of the rate of a regular or graded ascent or descent. A part (such as a road or pipeline) that slopes upward or downward; a rate of change of a quantity with distance.

Grassland community: An area where the vegetation is dominated by grasses and other non-woody plants. In temperate latitudes, grasslands are dominated by perennial species, whereas in warmer climates annual species form a greater component of the vegetation.

Greenhouse gas: A component of the atmosphere that contributes to the warming of the planet. Greenhouses gases may include water vapor, carbon dioxide, ozone, methane, nitrous oxide, sulfur hexafluoride and chlorofluorocarbons.

Gross alpha and beta: Gross alpha is more of a concern than gross beta for natural radioactivity in water as it refers to the radioactivity of thorium, uranium, radium and radon and descendants, while gross beta refers to screening for fission products in accidental reactor releases.

Groundwater: Subsurface water that fills available pores and openings in soils and rock to the extent that they are considered water saturated.

Grubbing: Removing all plants including the roots, stems and trunks in order to clear the land.

Habitat: A set of physical conditions in a geographical area that surrounds a species or group of species or a large community. With respect to wildlife management, major components of habitat are food, water, cover and living space.

Hard rock mining: Loosely used to distinguish excavation of ore generally from metamorphic and igneous rock as opposed to sedimentary rock.

Head cutting: Erosion where the stream or rill erodes away at the rock and soil at its headwaters in the opposite direction that it flows.

Heap leaching: A process used for recovering copper, gold, and silver from ore.

High volume samplers: Equipment used to collect particulate samples.

Historic property: A historical district, site, building or structure or prehistoric site of historical significance. It could include properties of traditional religious or cultural importance.

Hydrochemistry (chemical hydrology): The discipline of hydrology that addresses the chemical characteristics of water.

Hydrograph: In surface water hydrology a hydrograph is a time record of the amount of discharge of a stream, river or watershed outlet. Rainfall is typically the main input to a watershed and the stream flow is often considered the output of the watershed; a hydrograph is a representation of how a watershed responds to rainfall over time.

Hydrology: The science of water, standing or flowing on or beneath the surface of the earth.

Hydrometallurgy: A process involving the use of aqueous chemistry for the recovery of metals from ores, concentrates, and recycled or residual materials. Hydrometallurgy is typically divided into three general areas: leaching, solution concentration and purification, metal recovery.

Hydrophilic: Of, relating to, or having a strong affiliation for water.

Hydrostratigraphic unit: Body of rock with considerable lateral extent that acts as a reasonably distinct hydrologic system. Hydrostratigraphic units are hydraulically continuous and mappable (that is, the subsurface geology can be subdivided according to permeability). A single hydrostratigraphic unit may include a formation, part of a formation, or a group of formations.

Impact (or effect): A modification of the existing environment caused by an action of the project. The effect, or impact, may be direct, indirect or cumulative.

Impervious cover: Applied to a bed or stratum or artificial material through which water will not move under ordinary hydrostatic pressure. In hydrology it is applied to a rock that does not admit the passage of water or any other liquid under the pressures and conditions usually found in the subsurface water. Impervious rock may be of two kinds: porous like clay, or nonporous such has massive unbroken granite.

Impoundment: A naturally formed or artificially created basin that is closed or dammed to retain water, sediment or waste.

In-situ leaching: Extracting a soluble metallic compound by dissolving it from an ore that is in place in its natural and original position.

Indirect impact (or effect): An impact caused by the initial action later time or father removed in distance, but still reasonably foreseeable.

Industrial minerals: Geologic materials mined for their commercial value, which are not fuel (coal, peat) and are not sources of metals (gold, copper, lead, etc.). They are used as raw materials or as additives in a wide range of applications. Industrial minerals include minerals and rocks such as limestone, clay, talc, gypsum, barite and others.

Infrastructure: The services, equipment and facilities needed for a community or project to function such as roads, sewers, water and electrical lines.

Intermittent stream: A stream or river that flows seasonally during rainy periods and stops during dry periods.

Interill: Area on a hillside in between rills (small natural channels of water flow) that experiences sheet flow in response to rainfall.

Invasive species: Nonnative plants whose introduction may cause economic or environmental harm.

Isopach map: A map indicating, usually by the means of contour lines, the varying thickness of a designated stratigraphic unit.

Joint: A divisional plane or surface that divides rock and along which there has been no visible movement parallel to the plane or surface.

Keystone species: Species that plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass.

Leaching: Extracting a soluble metallic compound from an ore by selectively dissolving it in a suitable solvent such as water, sulfuric acid, cyanide, hydrochloric acid, etc. The solvent is usually recovered by precipitation of the metal or by other methods.

Life of mine: The estimated time period for operation of the mine.

Lithologic units: Beds of rocks that are described in terms of structure, color, mineral composition, grain size and other visible features. Lithologic units are used to correlate rocks over a distance of thousands of meters.

Load-out: A facility where ore is taken to be shipped from the mine.

Long-term impacts: Effects that substantially remain beyond short-term ground-disturbing activities**.**

Metalloid: An element, such as boron, silicon, arsenic, antimony, or tellurium, intermediate in properties between metals and nonmetals.

Milling: The grinding or crushing of ore. The term may include the operation of removing valueless or harmful constituents and preparation for market.

Mineralization: The process that takes place in the earth's crust resulting in the formation of valuable minerals or ore bodies.

Mitigation: The reduction or abatement of an impact to the environment by (a) avoiding actions or parts of actions, (b) using construction methods to limit the degree of impacts, (c) restoring an area to its pre-disturbance condition, (d) preserving or maintaining an area throughout the life of a project, (e) replacing or providing substitute resources, (f) gathering data on an archeological or paleontological site prior to disturbance.

NPDES: National Pollution Discharge Elimination System. As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating the discharge of pollutants into waters of the United States.

Nodulizing: In metallurgy, the creating of knotted, rounded or other similar shapes.

Open pit mining: A form of operation designed to extract minerals that lie near the surface and usually referring to metals.

Ore: A natural compound of minerals of which at least one is a metal; a mineral of sufficient value as to quality and quantity that may be mined at a profit.

Ore body: A mineral deposit that is a solid and continuous mass of ore that is distinguished from the surrounding rock and which may be worked at a profit.

Overburden: Layer of soil and rock containing no minerals, which overlies the ore.

pH: Denotes logarithmically the concentration of hydrogen ions in solution.

PM10: Particulate matter with an aerodynamic diameter smaller than 10 micrometers. The designation is useful because the size may outstrip the body's ability to keep them out of cells.

Particulates (particulate matter, PM): Tiny particles of solids suspended in the air. Sources of particulate matter can be man made or natural.

Pelletization: The method in which finely divided material is rolled in a drum or inclined disk so that the particles cling together and roll up into small, rounded spherical shapes.

Perennial stream: Parts of a stream or an entire stream that flows continuously and year round.

Physicochemical (physical chemistry): Scientific discipline for the explanation of macroscopic, microscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of physical concepts. Most physicochemical properties, such as boiling point, critical point, surface tension, vapor pressure, etc. (more than 20 in all), can be precisely calculated from chemical structure.

Phytoplankton: An aquatic microorganism that serves as the base of the aquatic food web providing an essential ecological function for all aquatic life. When present in high enough numbers, they may appear as a green discoloration of the water due to the presence of chlorophyll within their cells.

Pregnant solution: A metal-laden solution.

Preliminary mine planning: A step in mine development, which comes after the exploration step that shows that there is enough ore to warrant further investigation. It is generally part of the feasibility study that determines if the mineral deposit is economical based on the ore volumes and grades, construction and equipment costs, timeframe for extraction financing, etc. This step precedes final mine design, in which specific construction details and methods are determined.

Pressure oxidation: Processing technique for gold ore prior to cyanidation.

Pyrometallurgy: The thermal treatment of ore, such as in a smelter where it is melted to create a final metal product.

Quarry: An open or surface working usually for the extraction of building materials such as slate and limestone or sand and gravel.

Radionuclide (radioisotope): An unstable isotope of an element that decays spontaneously, emitting radiation.

Rare species: Plants or animals that are restricted in distribution. The species may be locally abundant in a limited area or few in number over a wide area.

Reagent: A chemical or solution used to produce a desired reaction; a substance used in assaying or in flotation.

Recharge: Replenishment of an aquifer by the addition of water through natural or artificial means.

Restoration: After mining ceases, bringing the disturbed land back to its original use or condition or to alternative uses. Restoration activities include removing structures; grading and restabilizing slopes, roads, and other disturbed areas; covering disturbed areas with growth medium or soil; and revegetating disturbed areas.

Reserves: The quantity of a mineral calculated to lie within given boundaries.

Revegetation: Establishment of a self-sustaining plant cover.

Rill: A very small channel that changes location with each flow event.

Riparian: Usually used to refer to plants of all types that grow around or in bodies of water.

Rock bolt (roof bolt): A bar, usually constructed of steel, which is inserted into a pre-drilled hole for the purpose of ground control.

Roof: The ceiling of any underground excavation.

Room and pillar: An underground mining method where the ore is mined in rooms separated by ribs (pillars). The rooms are mined when equipment is advancing and the pillars are mined while retreating. Rooms and pillars are generally parallel to each other. This method lends itself to flat, bedded deposits such as coal, iron, lead, zinc, potash, etc.

Run-on: A hydrologic term that refers both to the process whereby surface runoff infiltrates the ground as it flows, and to the portion of runoff that infiltrates. Run-on is common in arid and semi-arid areas with patchy vegetation cover and short but intense thunderstorms.

Runoff: The portion of the rainfall that is not absorbed and that may find its way to bodies of water as surface flow.

Saltation: The jumping motion of sand particles transported by air or water.

Scoping: A part of the process, which is open to the public early in the preparation of an EIA for determining the range of issues related to the proposed action and identifying significant issues to be addressed in the EIA.

Secondary mineralization: Minerals forming later than the rock in which they are found.

Sedimentation: The result when material is transported by water, wind, gravity or other means and deposited in bodies of water or on land. It is also a method of settling solids out of wastewater during treatment.

Seepage: The movement or quantity of a fluid that has moved through a porous material without the formation of definite channels.

Seep: A small spring.

Seismicity: Historical and geographic distribution of earthquakes.

Separation: Treatment of ore to make separate values (concentrates) from nonvalues (gangue, barrens, tails).

Sets: Timber frames for supporting the sides of an excavation, shaft or tunnel in an underground mine.

Shaft: An excavation of limited area compared with its depth and made for finding or mining ore, hoisting or lowering personnel and materials, or ventilating underground workings.

Shrubland community: Characterized by vegetation composed largely of shrubs, often including grasses, herbs, and geophytes (tubers).

Siding: For railroads, a low-speed track section distinct from a through route and used for auxiliary purposes.

Sintering: A metallurgical term for the bonding of adjacent surfaces of particles in a mass of metal powders by heating.

Sizing: The process of separating mixed particles into groups of particles of all the same size or into ranges of sizes.

Slag: A substance formed in any one of several ways by chemical action and fusion at furnace operating temperatures. In smelting it contains the gangue (waste) minerals and the flux (such as added limestone).

Slurry: Fine particles concentrated in a portion of the circulating water and waterborne to a treatment plant of any kind.

Smelter: A furnace in which ore is placed and metals are separated by fusion from their impurities to produce a molten metal and a molten slag.

Solvent extraction – electrowinning (**SX/EW**): A two-stage process that first extracts and upgrades copper ions from low-grade leach solutions into a concentrated electrolyte, and then deposits pure copper onto cathodes using an electrolytic procedure.

Sorting: The separation and segregation of rock fragments according to size or specific gravity. A method of separating mixtures of minerals into two or more products on the basis of velocity at which the grains will fall through a fluid medium.

Specific conductance (conductivity): The measurement of a solution's ability to conduct electricity.

Stability analysis (slope stability analysis): The resistance of a structure, bank, or heap from sliding, overturning, collapsing or failing. These studies are performed to assess the safe and economic design of manmade or natural slopes such as embankments, roadway cuts and fills, surface mines, excavations, etc., and the equilibrium conditions.

Stakeholders: Persons, groups, and organizations, who affect or can be affected by the project's actions.

Stockpile: An accumulation, or heap, of ore or mineral formed to create a reserve for loading or other purposes. A soil stockpile is an accumulation or heap of soil that has been salvaged during initial disturbance of a surface so that it can be used in site restoration.

Stope: An excavation in an underground mine usually used in highly inclined veins. Stopes are excavations of ore in a vein created by driving horizontally upon the vein in a series of workings, one above the next, or one below the next. Ore is excavated in a series of steps and each horizontal working is called a stope.

Stratigraphic section: Representation of the composition, sequence and correlation of layers of rocks.

Stripping ratio: The ratio of waste rock to ore.

Subsidence: The lowering of the surface from changes that occur underground. Common causes from human activity are pumping water, oil and gas or from the collapse of underground mines. Natural causes include dissolution of limestone (sinkholes).

Sulfide ore deposit: A mineral deposit which is a solid and continuous mass of ore that is distinguished from the surrounding rock and that may be worked at a profit and the minerals are a compound of sulfur with one ore more elements.

Supernatant solution (supernate): After mixtures are separated by centrifigal force and the more dense liquid is removed, the remaining liquid is called the supernatant solution.

Surface mine: An excavation at the surface for extraction of ore. The term includes placer, open- pit, glory-hole and strip mines.

Surface water: All bodies of water on the surface of the earth and exposed to the atmosphere such as lakes, rivers, ponds, estuaries, and seas.

Suspension: A cloudy mixture of two or more substances, usually small solid particles in a liquid medium. A suspension will generally settle on standing with the suspended matter forming a layer at the bottom of a container.

Tailings: Those portions of washed ore that are regarded as too poor in value to be treated further.

Tectonic: Pertaining to rock structures and topographic features resulting from deformation of the earth's crust.

Terrestrial ecosystem: A system of interdependent organisms which live on land and share the same habitat, functioning together with all of the physical factors of the environment.

Threshold: A value that is used as a benchmark for data. Thresholds may be set by laws, regulations or policies for water quality, air quality, noise, etc.

Topsoil: A general term applied to the surface portion of the soil. It is not defined precisely to depth and productivity except in reference to a particular soil type.

Total dissolved solids: A measurement that describes the quantity of dissolved material in a sample of water.

Total suspended solids: A water quality measurement. It is measured by pouring a determined volume of water through a filter and weighing the filter before and after to determine the amount of solids.

Trace metals: Metals in extremely small quantities, which are needed by plants and animals for survival but which, if ingested in large quantities, may be toxic. Examples of trace metals are: selenium, arsenic, iron, molybdenum, etc.

Transmissivity: The rate at which water is transmitted through a unit width of the aquifer under a unit of hydraulic gradient.

Tunnel: A long, narrow subterranean passage way. The term is loosely applied to an adit; a horizontal or inclined stone excavation for development; or to connect mine workings, seams, or shafts. It may be open to the surface at one end and used for drainage, ventilation, haulage or egress and ingress into an underground mine working.

Turbidity: The state or condition of having the transparence or translucence disturbed as when sediment in water is stirred up or when dust, haze and clouds appear in the atmosphere because of wind or vertical currents.

Underground mining: All various mining methods used below the earth's surface used to excavate ore.

Vadose zone: The unsaturated zone between the land surface and the saturated zone, extending from the top of the ground surface to the water table.

Visibility: The distance to which an observer can distinguish objects from their background.

Watershed: The land and water within the confines of a drainage divide.

Waste rock: A layer of rock containing low concentrations of ore. Depending on the ore content it is either processed or disposed.

Wetlands: Vegetation that is adapted for life in saturated soil conditions. Examples of wetlands are marshes, swamps, lakeshores, bogs, wet meadows, estuaries and riparian areas.

Working(s): A working, or workings, in mining may be a shaft, quarry, level, open cut, stope, etc.

J. EXAMPLE TERMS OF REFERENCE (TOR)

Terms of Reference are used by countries to describe both general and specific requirements for the preparation of an environmental impact assessment, in this instance tailored to proposed projects for commercial mining. Volume 1, Part 2 contains example Terms of Reference (TORs) cross-referenced to Volumes 1 and 2 of the "EIA Technical Review Guideline for Non-Metal and Metal Mining". The Example Terms of Reference are printed separately to facilitate use by countries as they prepare their own EIA program requirements for mining projects.

Two sets of example Terms of Reference (TORs) are provided, one set of TORs for Non-Metal Mining and one set of TORs for Metal Mining. In both sets there are three sections to the TOR: PART A is an overview describing general expectations for the preparation of the environmental impact assessment. PART B addresses detail for mining related to exploration and PART C addresses exploitation. The details in the example TORs address each element of the EIA analysis and documentation including what should be included in the description of the proposed project and alternatives; environmental setting; assessment of impacts; mitigation and monitoring measures; an environmental management plan; a signed commitment statement; and key supporting materials.

See Volume 1, Part 2:

1 EXAMPLE TERMS OF REFERENCE (TOR) FOR NON-METAL MINING

A. OVERVIEW
B. EXPLORATION
C. EXPLOITATION

2 EXAMPLE TERMS OF REFERENCE (TOR) FOR METAL MINING

A. OVERVIEW
B. EXPLORATION
C. EXPLOITATION

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